Deliverable 1.4. Assessment of potential improvements in efficiency and sustainability of biomass supply chains

Acronym:	ICT-BIOCHAIN
Project title:	ICT-BIOCHAIN – ICT Tools in Efficient Biomass Supply Chains for Sustainable Chemical Production
Contract Nº:	792221
Start date:	1.6.2018
Duration:	24 months

Deliverable number	D1.4
Deliverable title	Assessment of potential improvements in efficiency and sustainability of biomass supply chains
Submission due date	M18 – November 2019
Actual submission date	29/11/2019
Work Package	WP1
WP Lead Beneficiary	VTT
Dissemination Level	Public
Version	00
Authors	Catriona Clark (STR), Johan Belfrage (STR), Jacek Flak (VTT), Jennifer Attard (ITT), James Gaffey (ITT), Marta Macías Aragonés (CTA)

DOCUMENT CONTROL PAGE

Author(s)	Catriona Clark (STR), Johan Belfrage (STR), Jacek Flak (VTT), Jennifer Attard (ITT), James Gaffey (ITT), Marta Macías Aragonés (CTA)
Version history	

#	Reviewer	Comments
00	CC	Document creation

1. Executive Summary

This report analyses the efficiency and sustainability of the three identified value chains from the two regions, to recognise the ICT, IoT and Industry 4.0 development needs in biomass supply.

This was a multi-step process that involved the input of results and analysis of all previous tasks within the Work Package namely:

- T1.1 Regional State of the Art in the ICT, IoT and Industry 4.0 practices in Biomass Supply Chains
- T1.2 Pan-European State of the Art in ICT, IoT and Industry 4.0 solutions for Biomass Supply Chains
- T1.3 ICT, IoT and Industry 4.0 needs and opportunities in Biomass Supply Chains
- T1.4 Region specific data models

Through analysis of the previous task results, opportunities with highest potential for improvement of efficiency and sustainability of the different supply chains were identified, including the associated barriers, challenges and required enablers. The resultant report considers all steps of the biomass supply chain including production, storage, transport, biomass trading, processing, distribution and chain integration.

Content

2. Acronyms and abbreviations

ICT	Information and Communication Technology
IoT	Internet of Things
MDR	Model Demonstrator Region

3. Introduction

In order to achieve the potential of the bioeconomy significant improvements in biomass supply chains are required at both regional and pan-European level. These improvements can be achieved through a combination of activities including building of networks of suppliers, end users and technology providers, integration of ICT, IoT and Industry 4.0 technology into the supply chains and identifying sources of relevant biomass that is economically viable and sustainable.

Within tasks T1.1 and T1.2 of the project, the regional and pan-European state of the art in ICT, IoT, and Industry 4.0 solutions for biomass supply chains was mapped and presented in report D1.1 "***Assessment of the current ICT, IoT, and Industry 4.0 solutions in European biomass utilization***". This report contains details over approx. 80 examples of relevant technologies, products and services detailing both their current and potential applications within the biomass supply chain. Within Task 1.3 the needs and opportunities of the use of ICT, IoT and Industry 4.0 within the biomass supply chains were assessed. This was achieved through stakeholder interviews, questionnaires and regional workshops where potential users expressed their needs and share their concerns and issues regarding the adoption of new technologies, along with the identification of several barriers that may hinder adoption. This information has been presented in D1.3 "***ICT, IoT and Industry 4.0 Technology Opportunities for Improvement of Biomass Utilisation***". Finally, within Task 1.4 Bioresource Mapping Tools were developed for each of the two model demonstrator regions to map raw material and bioresource arisings across Ireland and Andalusia down to the local county/provincial level for six identified value chains (three from each region). The models look at both material arisings and bioresource arisings for resources critical to biorefining including carbohydrates, proteins, fats, C5 and C6 sugars. The output of this task is presented in D1.2 "***Report on Region Specific Data Models***".

This report brings together all the output from the previous Work Package 1 tasks listed above by assessing the particular opportunities with highest potential for improvements of efficiency and sustainability of the different biomass supply chains. The related drivers, barriers and challenges together with needed enablers - technological or other will be also identified. Specific European opportunities will be highlighted and prioritized for future development.

4. Methodology

In order to assess the ICT, IoT and Industry 4.0 opportunities will the highest potential for improvements of efficiency and sustainability within the regional biomass supply chains the following steps were completed:

- Assessment of the regional and pan-European technologies identified within D1.1
- Classify the potential of the technology as high, medium or low using multi-criteria decision analysis
- Identifying potential technology solutions for the different stages of the supply chain for all six value chains within the two demonstrator regions

4.1. Assessment of the regional and pan-European technologies

The technologies identified within D1.1 "***Assessment of the current ICT, IoT, and Industry 4.0 solutions in European biomass utilization***" was split into five categories namely Regional-Ireland, Regional-Spain, Pan-European basic, Pan-European complex and Pan-European online platforms/databases and were assessed using the following criteria:

- Benefits (efficiency)
- Environmental impact (sustainability)
- Cost factor
- Potential availability within MDR
- Supply Chain stage

Each technology was ranked as either having high, medium or low potential for all of the above criteria as illustrated in Table 1, Table 2, Table 3 and Table 4.

Table 1: Assessment of Regional and Pan-European Technologies

	Technology	Benefits (efficiency)	Environmental impact (sustainability)	Cost factor	In use?	(Potentially) available in one the MDRs?	Supply chain stage
REGIONAL - IRELAND	Rapid Biomass Analysis	Rapid analysis method for the determination of lignocellulosic	Can help technology providers select the best	60-150 $/€ per sample	Y	Y	multiple
	"Life cycle assessment of biomass-to-energy systems in Ireland modelled	The project uses tactical and spatial optimisation model to determine the	Potential to evaluate and reduce factors including	N/A	N	Y	chain integration/optimisation
	Brash to bioproducts (MarEI)	Integrated process model-GIS-LCA to determine optimum supply chain for	Offsetting fossil use in the chemical industry and	N/A	TRL 6-7	Y	chain integration/optimisation
	Modelling Performance Characteristics of Biomass Haulage in Ireland for	Analysis of characteristics of timber trucking in Ireland, to estimate the	Potential to reduce CO2 emissions by choosing the	N/A	N	Y	transport
	"Managing the moisture content of wood biomass for the optimisation	Development of linear programming model to optimise tactically the	Supports optimal supply chain making biomass supply	N/A	N	Y	chain integration/optimisation
	Bio-SNG	Aids decision-making in planning and sizing Bio-SNG plants,	Full LCA, CO2 emissions reduced, reducing waste	N/A	N	Y	other
	GENCOMM	Online map-based decision support tool (DST) to guide investments in	Offset fossil fuel use in transport and reduce wasted	N/A	N	Y	storage
	Freshbox	The Integrated Sensor Kit was developed to monitor some key	potential to reduce waste by monitoring environmental	€450 to €550 in its current form, would decrease in cost with a higher	TRL 7	Y	transport
REGIONAL - SPAIN	Olivia	Olivia is a tool that help the farmer to: 1, optimize the irrigation and	Reduce CO2 emissions / reduce N applied to the land	Less than 1% of total production costs	TRL 7	Y	multiple
	Smart system for prediction and routes optimization in solid urban waste collection	platform that provides predictive information about how full a specific	Reducing fuel consumption, CO2 emissions and noise	instalation cost and monthly fee; depends onnumber of sensors and trucks	N	Y	multiple
	SACROPS	We use hyperspectral images and machine learning, combined with	Reducing water consumption and use of	monthly fee; depends on plot size	N	Y	production
	IDAB-IIoT	hardware platform for easily connecting machines or industrial	N/A	Around 3000€ including sensors	Y	Y	multiple
	New technologies based on blockchain to manage the identity, reliability and traceability of transactions of goods	benefits of blockchain technology applied to supply chain	N/A	consultancy cost and monthly fee; depends on activity	N	Y	trade/exchange
	Foodintegrity	NIRS can record spectra for solid and liquid samples with no pretreatment,	reduction in use of reagents for sample preparation	approx. 80.000 Euro	N	Y	multiple
	ViewMass	Being able to obtain information about biomass or bioproducts in	Vehicle monitoring in real time can enable controlled	LiDAR sensor: 5000€ Multispectral camera: 3000€	N	Y	transport
	Olivacoin	The Olivacoin platform is helping olive tree growers and oil producers	N/A	N/A	TRL 7-9	Y	trade/exchange
	Smart Brain	platform devoted to collect data from multiple sources, analyse it, and	helps to reduce carbon footprint of the industry as	free	TRL 7	Y	production
PAN-EUROPEAN BASIC	Satellite positioning	Monitoring the origin and track of a biomass supply.	May be used for proving the biomass provenience, and	N/A	Y	Y	transport
	RFID	Product or person identification and tracking or access restrictions. Fast	May be used for proving the biomass provenience, and	Tags: ~0.10€, Readers: x00€...>2000€, depending on frequency (LF, HF,	Y	Y	transport
	QR code	Product or service identification. Fast and easy information sharing. Free.	Can be used to: - assure the provenience	free alternatives available	Y	Y	multiple
	NIRS	It can be used to assess various properties of materials or objects. NIR	May lead to more efficient biomass use, reduced	N/A	Y	Y	multiple
	Bluetooth	short-range wireless technology for fixed and mobile devices to transmit	N/A	N/A	Y	Y	other
	WiFi	used to provide wireless access to the internet via dedicated access points	N/A	N/A	Y	Y	other
	LoRa	LoRa and LoRaWAN permit inexpensive, long-range connectivity	N/A	N/A	Y	Y	other

Table 2: Assessment of Regional and Pan-European Technologies cont.

	Sigfox	In agriculture: remote access to real-time information about rainfall,	N/A	N/A	Y	Y	multiple
	3G / 4G LTE / 5G	Cellular mobile communications system providing broadband data	N/A	Depends on technology, implementation, and service providers.	Y	Y	other
	Blockchain	used to record transactions across many computers so that any involved;	N/A	N/A	Y	Y	trade/exchange
	ALS - Airborne Laser Scanning	Can be used to optimized use of fertilizers or harvesting.	N/A	N/A	Y	Y	production
PAN-EUROPEAN COMPLEX	HYDRA100 Scout	provides critical insight into data from deep below the surface	Water savings, pollution reduction.	ask for a quote	Y	Y	production
	HAYTECH	Possibility to remotely (online) check the state of you haystack, assuring its	Maximize the quality, value and efficient usage of	650,00 € - HAYTECH10 set	Y	Y	multiple
	Quanturi monitoring systems	wireless temperature monitoring system for composting or for storage	Maximize the quality, value and efficient usage of	ask for a quote	Y	Y	storage
	Greenhouse Technology	greenhouse cooling, climate control, moisture removal and heat reuse. As a	Energy and fresh water savings, increased crop yield	ask for a quote	Y	Y	production
	GrainSense	Helps making confident decisions based on actual data regarding	N/A	N/A	Y	Y	multiple
	CarbonToSoil	mobile application with mission to reverse climate change by putting	Helps reverse the climate changes by supporting	free app (subsidy in Finland)	prototype	Y	production
	Hyperspectral imaging	On site and online measurements, instant results, sending samples to	Improved production, waste reduction, improved quality	10 - 10 000 euro depending on the application requirements and production	Y	Y	multiple
	MEMS based spectral sensors	On site and online measurements, instant results, sending samples to	Improved production, waste reduction, improved quality	10 - 10 000 euro depending on the application requirements and production	Y	Y	multiple
	SensLog	web-based sensor data management system	N/A	free	N	Y	multiple
	Scienergie	IT solutions for management and production optimization in wood	N/A	N/A	Y	N	multiple
	Wuudis	inventory monitoring and managing biomass delivery chains in real time,	N/A	N/A	Y	Y	multiple
	MooV	MooV identifies the optimal value chain configuration for any given	MooV can be used to minimize the CO2 emissions	depends on the case	Y	N	chain integration/optimisation
	FHPDAT	Efficient data exchange between stakeholders for better planning and	N/A	free	Y	N	chain integration/optimisation
	WinforstPro	Tailor-made forestry software, wood management, logistics connection,	N/A	N/A	Y	Y	chain integration/optimisation
	felixFORST	software for supervision and evaluation of timber tradings. Based	N/A	N/A	Y	N	chain integration/optimisation
	felixERNTE	ongoing, digital feedback and mapping of timber harvesting and	N/A	N/A	Y	N	chain integration/optimisation
	felixSÄGE	Software for management and optimization of sawmill operations.	N/A	N/A	Y	N	chain integration/optimisation
	felixFRACHT	It enables the scheduling of several deliveries from loading to takeover in	N/A	N/A	Y	N	other
	felixENERGIE	automatically generates the entire order documentation along the	N/A	N/A	Y	N	other
	felixTIMBETER	user-friendly tool for measuring timber. Photograph the wood with	N/A	N/A	Y	N	multiple
	Signumat	Timber marking and tracking system based on numbering, barcode or RFID	N/A	N/A	Y	Y	production
	GeoMail	Software solution for logistics and accounting for the wood and forest	N/A	N/A	Y	Y	chain integration/optimisation
	Energy wood characteristic data calculation	easy-to-use calculation tool enables quick conversion between standard	N/A	free	N	N	trade/exchange

Table 3: Assessment of Regional and Pan-European Technologies cont.

	ChipCost	Calculation tool for the productivity of chippers and estimation of	N/A	free	N	Y	trade/exchange
	Winlog	Software for log sorting optimization that offers an all-encompassing	N/A	N/A	Y	Y	multiple
	Interopt	Bucking optimization software for logs by dimension, quality or highest	N/A	N/A	Y	Y	multiple
	Variosort	Variosort Lumber Sorter supervises the fully automated sorting and	N/A	N/A	Y	Y	production
	Goldeneye Plus Hardwood Grader	The software reliably grades hardwood lumber based on	N/A	N/A	Y	Y	multiple
	Maxicut	It considers geometry, quality and resale value of final products as well as	N/A	N/A	Y	Y	processing
	Virtual Cut	produce logs virtually with their possible cutting patterns when they	N/A	N/A	Y	Y	processing
	Mill Manager	software suite for mill wide control and reporting, displaying real-time	N/A	N/A	Y	Y	production
	Smart Mill	illumination, network, 3D imaging, and optimization for the Sawmill 4.0	N/A	N/A	Y	Y	production
	WinGIS	Agriculture: farmers or group of farmers or entire countries are	Helps in monitoring / assessing the influence of a	N/A	Y	Y	chain integration/optimisation
	Holz V6	Business management software tool for wood traders and sawmills	N/A	N/A	Y	N	trade/exchange
	SIMPLE - Saw Integrated Micro Printer for Log Ends	Product identification. Can help to minimize losses.	Can be used to: - assure the provenience	Hardware costs: not avaialble. Marking costs: <0.002€ per item.	N	Y	multiple
	Precision wine	costs reduction; disease risk reduction; increase potential of	Reduces needs for: irrigation, water, fertilizers, pesticides	free demo	TRL 7-9	Y	production
	Connected ag-weather station	Visualize both current and provisional forecast data for rainfall, humidity,	Possibly reduced use of fertilizers and pesticides.	ask for a quote	Y	Y	production
	MPH Calculator	Calculation and conversion tool for industrial and energy wood. Enables	May help to reduce waste	free	TRL 7-9	N	trade/exchange
	Inspectorul Pădurii, IWood Tracking, Wood Tracking	Tracking of wood transportation based on car registration number	May help fighting illegal wood harvesting.	free	N	N	transport
PAN-EUROPEAN ONLINE PLATFORMS/ DATABASES	Scottish Bioresource Mapping Tool	Knowledge of available biomass with its type and geographic breakdown	Efficient utilisation of biomass	free	Y	N	other
	Holzauktionen	Online trading platform for wood run by Austrian Federal Forests	N/A	free	Y	N	trade/exchange
	Cerco/Offro	Online trading platform for selling round wood and other wood	N/A	free	Y	N	trade/exchange
	Eschlböck Woodchip Exchange	Online trading platform for wood chips.	N/A	free	Y	Y	trade/exchange
	Giełda biomasy	Complete source of information on biomass availability, and	Promoting the usage of biomass as well as other	free	Y	N	other
	Big DATABIO Platform	The main goal of the DataBio project is to show the benefits of Big Data	N/A	N/A	N	Y	other
	Ositrade	online marketplace for professional users	N/A	N/A	Y	N	trade/exchange
	Copernicus	European Union's Earth Observation Programme, looking at our planet and	Monitoring the climate changes, providing data and	free	Y	Y	other
	VITO Earth Observation	Distribution portal for satellite image and airborne spectroscopy image	N/A	free	Y	Y	production
	BorzaLesa	Wood trading portal. Online platform selling and purchasing of logs, sawn	N/A	N/A	Y	N	trade/exchange
	e-drewno	to enable customers to take part in a wood sale auction in a forest district	PGL Lasy Państwowe is a state owned company taking	free	Y	N	trade/exchange

Table 4: Assessment of Regional and Pan-European Technologies cont.

	Agri MarketPlace	marketplace between farmers and end users (industry/retail,) created to raise	N/A	N/A	Y	Y	trade/exchange
	EUROSTAT	The EUROSTAT is a broad and reliable source of data providing insights on	N/A	free	Y	Y	other
	BALTPOOL Biomass Exchange	on-line trading venue operating according to the set rules and	N/A	N/A	Y	N	trade/exchange
	Online catalogue of forestry companies and wood fuel producers	Online catalogue of forestry companies and wood fuel producers	N/A	free	TRL 7	Y	trade/exchange

4.2. Classification of Technology using Multi-Criteria Decision Analysis

In order to assess the potential of each technology the criteria were each assigned the following weighting:

- Benefit (efficiency) – 3
- Environmental impact (sustainability) - 3
- Cost factor – 2
- Technology currently in use – 3
- (Potentially) available in the MDR – 2

The colour assessment described in section 4.1 was also given the following weighting:

- Green (high rating) – 5
- Amber (medium rating) – 3
- Red (low rating) - 1

Through weighted average calculations for all technologies this allowed for the assessment of the technology potential within the biotechnology sector. Each technology was then colour coded green, yellow or red based on the outcome:

- Green: high potential – weighted average between 4-5
- Yellow: some/moderate potential – weighted average between 3-4
- Red: limited potential – weighted average 0-3

The results of this analysis are shown in Table 5, Table 6 and Table 7 below.

Table 5: Technology potential analysis using weighted averages

	Benefits (efficiency)	Environmental impact (sustainability)	Cost factor	In use?	(Potentially) available in one the MDRs?	sumproduct	below fraction line	weighted average
Rapid Biomass Analysis	5	3	3	5	5	55	13	4.23
"Life cycle assessment of biomass-to-energy systems in Ireland	5	5	3	1	5	49	13	3.77
Brash to bioproducts (MarEI)	5	5	3	3	5	55	13	4.23
Modelling Performance Characteristics of Biomass Haulage in	5	5	3	1	5	49	13	3.77
"Managing the moisture content of wood biomass for the optimisation	5	5	3	1	5	49	13	3.77
Bio-SNG	5	5	3	1	5	49	13	3.77
GENCOMM	5	5	3	1	5	49	13	3.77
Freshbox	5	5	3	3	5	55	13	4.23
Olivia	5	5	5	3	5	59	13	4.54
Smart system for prediction and routes optimization in solid	5	5	3	1	5	49	13	3.77
SACROPS	5	5	3	1	5	49	13	3.77
IDAB-IIoT	3	1	1	5	5	39	13	3.00
New technologies based on blockchain to manage the identity, reliability	3	1	3	1	5	31	13	2.38
Foodintegrity	5	3	1	1	5	39	13	3.00
ViewMass	5	5	1	1	5	45	13	3.46
Olivacoin	5	1	3	3	5	43	13	3.31
Smart Brain	5	5	5	3	5	59	13	4.54
Satellite positioning	3	3	3	5	5	49	13	3.77
RFID	3	3	3	5	5	49	13	3.77
QR code	3	3	5	5	5	53	13	4.08
NIRS	5	5	3	5	5	61	13	4.69
Bluetooth	3	1	3	5	5	43	13	3.31
WiFi	3	1	3	5	5	43	13	3.31
LoRa	5	1	3	5	5	49	13	3.77
Sigfox	5	1	3	5	5	49	13	3.77
3G / 4G LTE / 5G	3	1	3	5	5	43	13	3.31
Blockchain	3	1	3	5	5	43	13	3.31
ALS - Airborne Laser Scanning	5	1	3	5	5	49	13	3.77
HYDRA100 Scout	5	5	ask for a quote	5	5	55	13	4.23
HAYTECH	5	5	3	5	5	61	13	4.69

Table 6: Technology potential analysis using weighted averages cont.

Quanturi monitoring systems	5	5	ask for a quote	5	5	55	13	4.23
Greenhouse Technology	5	5	ask for a quote	5	5	55	13	4.23
GrainSense	5	1	3	5	5	49	13	3.77
CarbonToSoil	5	5	5	3	5	59	13	4.54
Hyperspectral imaging	5	5	3	5	5	61	13	4.69
MEMS based spectral sensors	5	5	3	5	5	61	13	4.69
SensLog	5	1	5	1	5	41	13	3.15
Scienergie	5	1	3	5	1	41	13	3.15
Wuudis	5	1	3	5	5	49	13	3.77
MooV	5	5	3	5	1	53	13	4.08
FHPDAT	5	1	5	5	1	45	13	3.46
WinforstPro	5	1	3	5	5	49	13	3.77
felixFORST	5	1	3	5	1	41	13	3.15
felixERNTE	5	1	3	5	1	41	13	3.15
felixSÄGE	5	1	3	5	1	41	13	3.15
felixFRACHT	5	1	3	5	1	41	13	3.15
felixENERGIE	5	1	3	5	1	41	13	3.15
felixTIMBETER	5	1	3	5	1	41	13	3.15
Signumat	5	1	3	5	5	49	13	3.77
GeoMail	5	1	3	5	5	49	13	3.77
Energy wood characteristic data calculation	3	1	5	1	1	27	13	2.08
ChipCost	5	1	5	1	5	41	13	3.15
Winlog	5	1	3	5	5	49	13	3.77
Interopt	5	1	3	5	5	49	13	3.77
Variosort	5	1	3	5	5	49	13	3.77
Goldeneye Plus Hardwood Grader	5	1	3	5	5	49	13	3.77
Maxicut	5	1	3	5	5	49	13	3.77
Virtual Cut	5	1	3	5	5	49	13	3.77
Mill Manager	5	1	3	5	5	49	13	3.77
Smart Mill	5	1	3	5	5	49	13	3.77
WinGIS	5	5	3	5	5	61	13	4.69
Holz V6	3	1	3	5	1	35	13	2.69
SIMPLE - Saw Integrated Micro Printer for Log Ends	5	3	5	1	5	47	13	3.62
Precision wine	5	5	5	3	5	59	13	4.54

Table 7: Technology potential analysis using weighted averages cont.

Connected ag-weather station	5	5	3	5	5	61	13	4.69
MPH Calculator	3	3	5	3	1	39	13	3.00
Inspectorul Pădurii, IWood Tracking, Wood Tracking	5	3	5	1	1	39	13	3.00
Scottish Bioresource Mapping Tool	5	3	5	5	1	51	13	3.92
Holzauktionen	5	1	5	5	1	45	13	3.46
Cerco/Offro	5	1	5	5	1	45	13	3.46
Eschlböck Woodchip Exchange	5	1	5	5	5	53	13	4.08
Giełda biomasy	5	3	5	5	1	51	13	3.92
Big DATABIO Platform	3	1	3	1	5	31	13	2.38
Ositrade	5	1	3	5	1	41	13	3.15
Copernicus	5	5	5	5	5	65	13	5.00
VITO Earth Observation	5	1	5	5	5	53	13	4.08
BorzaLesa	5	1	3	5	1	41	13	3.15
e-drewno	3	3	5	5	1	45	13	3.46
Agri MarketPlace	5	1	3	5	5	49	13	3.77
EUROSTAT	5	1	5	5	5	53	13	4.08
BALTPOOL Biomass Exchange	5	1	3	5	1	41	13	3.15
Online catalogue of forestry companies and wood fuel producers	5	1	5	3	5	47	13	3.62

4.3. Identifying Potential Technology Solutions for Each Stage of the Supply Chain

The results of the assessment of the technology analysis and the technology potential were combined to highlight the technologies with the highest potential for each stage in the supply chain, Table 8, Table 9 and Table 10.

The table was then analysed in combination with the six identified value chains of interest for each region: lignocellulose, manure and horticulture for the Irish region and olive and olive oil waste, vegetable waste and algae for the Andalusian region. Table 11-13 highlight the technology potentials for the three Irish regions value chains and Table 14-16 shows the potential technologies of interest for the value chains from the Andalusian region. Only those technologies that were considered moderate to high potential (yellow and green) were mapped onto the different value chains.

Table 8: Analysis of technology potential per supply chain function

Technology	Supply chain stage	Potential
Rapid Biomass Analysis	multiple	
"Life cycle assessment of biomass-to-energy systems in Ireland modelled	chain integration/optimisation	
Brash to bioproducts (MarEI)	chain integration/optimisation	
Modelling Performance Characteristics of Biomass Haulage in Ireland for	transport	
"Managing the moisture content of wood biomass for the optimisation	chain integration/optimisation	
Bio-SNG	other	
GENCOMM	storage	
Freshbox	transport	
Olivia	multiple	
Smart system for prediction and routes optimization in solid urban waste collection	multiple	
SACROPS	production	
IDAB-IIoT	multiple	
New technologies based on blockchain to manage the identity, reliability and traceability of transactions of goods	trade/exchange	
Foodintegrity	multiple	
ViewMass	transport	
Olivacoin	trade/exchange	
Smart Brain	production	
Satellite positioning	transport	
RFID	transport	
QR code	multiple	
NIRS	multiple	
Bluetooth	other	
WiFi	other	
LoRa	other	
Sigfox	multiple	
3G / 4G LTE / 5G	other	

Table 9: Analysis of technology potential per supply chain function cont.

Goldeneye Plus Hardwood Grader	multiple	
Maxicut	processing	
Virtual Cut	processing	
Mill Manager	production	
Smart Mill	production	
WinGIS	chain integration/optimisation	
Holz V6	trade/exchange	
SIMPLE - Saw Integrated Micro Printer for Log Ends	multiple	
Precision wine	production	
Connected ag-weather station	production	
MPH Calculator	trade/exchange	
Inspectorul Pădurii, IWood Tracking, Wood Tracking	transport	
Scottish Bioresource Mapping Tool	other	
Holzauktionen	trade/exchange	
Cerco/Offro	trade/exchange	
Eschlböck Woodchip Exchange	trade/exchange	
Giełda biomasy	other	
Big DATABIO Platform	other	
Ositrade	trade/exchange	
Copernicus	other	
VITO Earth Observation	production	
BorzaLesa	trade/exchange	
e-drewno	trade/exchange	
Agri MarketPlace	trade/exchange	
EUROSTAT	other	
BALTPOOL Biomass Exchange	trade/exchange	
Online catalogue of forestry companies and wood fuel producers	trade/exchange	

Table 10: Analysis of technology potential per supply chain function cont.

Blockchain	trade/exchange	
ALS - Airborne Laser Scanning	production	
HYDRA100 Scout	production	
HAYTECH	multiple	
Quanturi monitoring systems	storage	
Greenhouse Technology	production	
GrainSense	multiple	
CarbonToSoil	production	
Hyperspectral imaging	multiple	
MEMS based spectral sensors	multiple	
SensLog	multiple	
Scienergie	multiple	
Wuudis	multiple	
MooV	chain integration/optimisation	
FHPDAT	chain integration/optimisation	
WinforstPro	chain integration/optimisation	
felixFORST	chain integration/optimisation	
felixERNTE	chain integration/optimisation	
felixSÄGE	chain integration/optimisation	
felixFRACHT	other	
felixENERGIE	other	
felixTIMBETER	multiple	
Signumat	production	
GeoMail	chain integration/optimisation	
Energy wood characteristic data calculation	trade/exchange	
ChipCost	trade/exchange	
Winlog	multiple	
Interopt	multiple	
Variosort	production	

Table 11: Mapping of technologies onto Lignocellulose value chain

Value chain	Simplified Supply chain / Material	General Barriers	Production	Storage	Biomass trading	Transport (logistics)	Processing (conversion)	Distribution	Chain integration
Lignocellulose	Straw	**High cost low confidence and trust in techbology Doubts in the extent of farmer engagement**							
	challenge/need		Decision making based on moisture content Application of NIRS to assess changes in composition ArcView-GIS in all areas	Data analysis to support decision making Supply optimisation Application of NIRS to assess changes in composition ArcView-GIS in all areas		Data analysis to support decision making Supply optimisation Measuring or modelling "real" cost Application of NIRS models to assess changes in composition ArcView-GIS in all areas	Data analytics adding value Data analysis to support decision making Supply optimisation Measuring quality Matching to requirements of the end user Application of NIRS models to assess changes in composition ArcView-GIS in all areas		
	solution (technology) - regional					Modelling Performance Characteristics of Biomass Haulage in Ireland for Bioenergy Markets with GPS, GIS and Fuel Diagnostic Tools.			
	solution (technology) - European		**Smart Brain**	QR Code	QR Code	**Smart system for prediction and routes optimization in solid urban waste collection**	**NIRS**	**Wuudis**	**MooV**
			NIRS	**NIRS**	**Wuudis**	**Satalite positioning**	**Wuudis**		**WinGIS**
			Sigfox	**HAYTECH**	Bioresource mapping tool	RFID			
			ALS - Airborne Laser Scanning	**Wuudis**	**Giełda biomasy**	QR Code		QR Code	
			Connected ag-weather station	Quanturi monitoring systems	**BALTPOOL Biomass Exchange**	**Wuudis**			
			CarbonToSoil			ViewMass			

Table 12 (continued): Mapping of technologies onto Lignocellulose value chain

	Forestry	**Cost/finance scale of operation skillset required for technologies**							
	challenge/need		Decision making based on moisture content ArcView-GIS in all areas	Data analysis to support decision making Supply optimisation ArcView-GIS in all areas		Data analysis to support decision making Supply optimisation Measuring or modelling "real" cost Application of NIRS models to assess changes in composition ArcView-GIS in all areas	Data analytics adding value Data analysis to support decision making Supply optimisation Measuring quality Matching to requirements of the end user Application of NIRS models to assess changes in composition ArcView-GIS in all areas		
Lignocellulose	solution (technology) - regional		**Rapid Biomass Analysis**			Modelling Performance Characteristics of Biomass Haulage in Ireland for Bioenergy Markets with GPS, GIS and Fuel Diagnostic Tools.			**Brash to bioproducts (MarEI)**
									"Managing the moisture content of wood biomass for the optimisation of Ireland's transport supply strategy to bioenergy markets and competing industries"

Table 13 (continued): Mapping of technologies onto Lignocellulose value chain

	solution (technology) - European		Smart Brain	QR Code	BALTPOOL Biomass Exchange	ViewMass	NIRS	QR Code	MooV
			NIRS	NIRS	Holzauktionen	Satalite positioning	Scienergie	Scienergie	FHPDAT
			Scienergie	Scienergie	QR Code	RFID	Maxicut	Wuudis	WinforstPro
				Wuudis	Scienergie	Smart system for prediction and routes optimization in solid urban waste collection	Virtual Cut	felixENERGIE	felixFORST
				SIMPLE - Saw Integrated Micro Printer for Log Ends	Wuudis	Scienergie	Mill Manager		felixERNTE
					felixTIMBETER	Wuudis	SIMPLE - Saw Integrated Micro Printer for Log Ends		felixSÄGE
					Signumat	felixFRACHT			GeoMail
					Chipcost	Inspectorul Pădurii, IWood Tracking, Wood Tracking			WinGIS
					Winlog	QR Code			
					Interopt				
					Variosort				
					Bioresource mapping tool				
					Cerco/Offro				
					Eschlböck Woodchip Exchange				
					Giełda biomasy				
					MPH Calculator				

Table 14: Mapping of technologies onto Manure value chain

Value chain	Simplified Supply chain / Material	General Barriers	Production	Storage	Biomass trading	Transport (logistics)	Processing (conversion)	Distribution	Chain integration
Manure	**Pig/Dairy cattle manure**								
	challenge/need								
	solution (technology) - regional					Modelling Performance Characteristics of Biomass Haulage in Ireland for Bioenergy Markets with GPS, GIS and Fuel Diagnostic Tools.			
	solution (technology) - European		**Smart Brain**	Quanturi monitoring systems		ViewMass	**NIRS**	QR Code	**MooV**
			NIRS	QR Code	QR Code	**Satalite positioning**		**Wuudis**	
				NIRS	**Wuudis**	**Smart system for prediction and routes optimization in solid urban waste collection**			
				Wuudis	Bioresource mapping tool	**Wuudis**			
				Quanturi monitoring systems	**BALTPOOL Biomass Exchange**	RFID			
	Chicken manure								
	challenge/need								
	solution (technology) - regional					Modelling Performance Characteristics of Biomass Haulage in Ireland for Bioenergy Markets with GPS, GIS and Fuel Diagnostic Tools.			
	solution (technology) - European		**Smart Brain**	Quanturi monitoring systems		ViewMass	**NIRS**	QR Code	**MooV**
			NIRS	QR Code	QR Code	**Satalite positioning**		**Wuudis**	
				NIRS	**Wuudis**	**Smart system for prediction and routes optimization in solid urban waste collection**			
				Quanturi monitoring systems	Bioresource mapping tool	QR Code			
					Giełda biomasy	**Wuudis**			
				Wuudis	**BALTPOOL Biomass Exchange**	RFID			

Table 15: Mapping of technologies onto Horticulture value chain

Value chain	Simplified Supply chain / Material	General Barriers	Production	Storage	Biomass trading	Transport (logistics)	Processing (conversion)	Distribution	Chain integration
Horticulture	**Spent mushroom compost**								
	challenge/need			Data analysis to support decision making Supply optimisation Application of NIRS to assess changes in composition ArcView-GIS in all areas					
	solution (technology) - regional					Modelling Performance Characteristics of Biomass Haulage in Ireland for Bioenergy Markets with GPS, GIS and Fuel Diagnostic Tools.			
	solution (technology) - European		**Smart Brain**	**Quanturi monitoring systems**	QR Code	ViewMass		QR Code	**MooV**
				QR Code	**Wuudis**	**Satalite positioning**		**Wuudis**	
				Wuudis	Bioresource mapping tool	**Smart system for prediction and routes optimization in solid urban waste collection**			
					Giełda biomasy	QR Code			
					BALTPOOL Biomass Exchange	**Wuudis**			
						RFID			
	Mushroom offcuts (stems)								
	challenge/need		Decision making based on moisture content ArcView-GIS in all areas	Data analysis to support decision making Supply optimisation Application of NIRS to assess changes in composition ArcView-GIS in all areas					

Table 16 (Continued): Mapping of technologies onto Horticulture value chain

						Modelling Performance Characteristics of Biomass Haulage in Ireland for Bioenergy Markets with GPS, GIS and Fuel Diagnostic Tools.			
	solution (technology) - regional					Freshbox			
	solution (technology) - European		**Smart Brain**	**Quanturi monitoring systems**	QR Code	ViewMass	**NIRS**	QR Code	**MooV**
			NIRS	QR Code	**Wuudis**	**Satalite positioning**		**Wuudis**	**WinGIS**
			Sigfox	**NIRS**	Bioresource mapping tool	**Smart system for prediction and routes optimization in solid urban waste collection**			
			ALS - Airborne Laser Scanning	**Wuudis**	**Giełda biomasy**	QR Code			
			Connected ag-weather station		**BALTPOOL Biomass Exchange**	**Wuudis**			
			CarbonToSoil			RFID			

Table 17: Mapping of technologies onto Olive value chain

Value chain	Simplified Supply chain / Material	General Barriers	Production	Storage	Biomass trading	Transport (logistics)	Processing (conversion)	Distribution	Chain integration
		High cost low confidence and trust in techbology Doubts in the extent of farmer engagement							
Olive	**Leaves**								
	challenge/need								
	solution (technology) - regional		**Olivia**		**Olivacoin**	**Smart system for prediction and routes optimization in solid urban waste collection**			
			Smart Brain			**ViewMass**			
	solution (technology) - European		**NIRS**	**NIRS**	**Wuudis**	RFID	**NIRS**	QR Code	**MooV**
			Sigfox	**Wuudis**	Bioresource mapping tool	QR Code	**Wuudis**	**Wuudis**	**WinGIS**
			CarbonToSoil		**Giełda biomasy**	**Wuudis**			
			Connected ag-weather station		**BALTPOOL Biomass Exchange**				
			ALS - Airborne Laser Scanning	QR Code	QR Code	**Satalite positioning**			

Table 18: Mapping of technologies onto Vegetable waste value chain

Value chain	Simplified Supply chain / Material	General Barriers	Production	Storage	Biomass trading	Transport (logistics)	Processing (conversion)	Distribution	Chain integration
Horticulture		High cost low confidence and trust in techbology Doubts in the extent of farmer engagement							
	Melon								
	challenge/need								
	solution (technology) - regional		**SACROPS**			**Smart system for prediction and routes optimization in solid urban waste collection**			
			Smart Brain			**ViewMass**			
	solution (technology) - European		**NIRS**	QR Code	QR Code	**Satalite positioning**	**NIRS**	QR Code	**MooV**
			Sigfox	**NIRS**	**Wuudis**	RFID	**Wuudis**	**Wuudis**	**WinGIS**
			ALS - Airborne Laser Scanning	**Wuudis**	Bioresource mapping tool	QR Code			
			CarbonToSoil		**Giełda biomasy**	**Wuudis**			
			Precision wine		**BALTPOOL Biomass Exchange**				
			Connected ag-weather station						
			Greenhouse Technology			Freshbox			

Table 19: Mapping of technologies onto Algae value chain

Value chain	Simplified Supply chain / Material	General Barriers	Production	Storage	Biomass trading	Transport (logistics)	Processing (conversion)	Distribution	Chain integration
Algae	**Algae Piscis: Nannochloropsis gaditana PREMIUM**								
	challenge/need								
	solution (technology) - regional		**Smart Brain**			**Smart system for prediction and routes optimization in solid urban waste collection**			
						ViewMass			
	solution (technology) - European		**NIRS**	QR Code	QR Code	RFID	**NIRS**	QR Code	**MooV**
			ALS - Airborne Laser Scanning	**NIRS**	**Wuudis**	QR Code	**Wuudis**	**Wuudis**	**WinGIS**
					Bioresource mapping tool	**Wuudis**			
					BALTPOOL Biomass Exchange				
				Wuudis	**Giełda biomasy**	**Satalite positioning**			

5. General Challenges in Biomass Supply Chains

There are several key challenges to secure economically feasible and sustainable biomass supply chains for biorefinery operations. Three aspects that will play a major role in the viability of the value chain is the ability to secure sufficient amount of the targeted feedstock, overcome distribution and logistical challenges and variation in the quality of the feedstock. If the value chains output is aimed at commodity products or products that is not considered to be high value products, larger scale is often required to provide an attractive business case and thus requiring larger amounts of feedstock. From an economical and environmental perspective there is typically an acceptable radius around the biorefinery from where biomass can be sourced (e.g. 50 miles or 80 km) and to secure sufficient amounts the biorefinery may have to be flexible enough to handle multiple or mixed feedstocks of various quality (e.g. different kinds of straw, wood or algae). The challenge becomes even more complex when further variation is introduced by seasonable variability or field to field variability that may require the biorefinery process to adapt operational conditions to maintain a stable production. Another aspect that influences both the transportation cost and stability of the biomass is the moisture content, where a low moisture content is desirable to achieve highest storage stability and lowest environmental impact and cost from transportation. The moisture content is especially impactful when developing concepts based on marine or green biomass or when considering diluted co-products and by-products from the food and drink industry. Efficient technologies to dewater and dry the feedstock is essential to overcome this challenge.

The analysis of the specific materials that were mapped and modelled in D1.2 highlight some specific challenges. On Ireland, even though there is a clear clustering of materials (mainly manure) in Cork there is a wide distribution of this feedstock across all the counties on Ireland. Depending on biorefining concepts that will be developed with this feedstock in mind, there may logistical and supply chain challenges that can be addressed and optimised by applying the suitable ICT/IoT and Industry 4.0 technology solutions. In Andalusia, even if the materials arising are fairly well concentrated to specific provinces there may because of the chosen feedstocks and potential biorefining concepts be challenges around freshness unless stabilisation technologies are applied (e.g. drying). Lean and optimised supply chains in combinations with technology solutions for monitoring the quality of the feedstocks could be advantageous.

6. Assessment of ICT, IoT, Industry 4.0 Technologies in the Irish Region

6.1 Analysis

6.1.1 Straw

Table 11 show that the technologies applicable to straw based lignocellulose in the Irish region and for this feedstock a few general barriers was identified. These were high cost, low confidence and trust in the technologies and doubts regarding the extent of farmer engagement. The specific needs across the simplified supply chain for this feedstock focuses on the need for more data to support the decision making and optimising the supply. Regarding feedstock production this specifically mention moisture content analysis. The matrix also clearly shows the desire to measure changes to the composition of the material during the production, storage, transport and processing by Near-Infrared Spectroscopy (NIRS). The technologies available and applicable to the straw supply chain are predominantly pan-European. Technologies with high potential was identified for all aspects of the chain except for the logistics and distribution where only moderately potential solutions were identified. The lack of high potential application for the logistics and distribution highlights a technology gap where further development is needed to lay the foundation for further environmental and economical optimisation of the supply chain. The high potential technologies matched with the straw supply chain are listed and described below.

Smart Brain - Platform devoted to collect data from multiple sources, analyse it, and provide information in order to assist in the decision making of different players involved.

NIRS - It can be used to assess various properties of materials or objects. NIR is widely applied in agriculture for determining the quality of forages, grains, and grain products, oilseeds, coffee, tea, spices, fruits, vegetables, sugarcane, beverages, fats, and oils, dairy products, eggs, meat, and other agricultural products.

Connected ag-weather station - Visualize both current and provisional forecast data for rainfall, humidity, temperature, and wind speed; sensors and software for real-time monitoring via web or mobile app; ultra-precise data helps to make farming decisions concerning pesticides, seeding, irrigation, as well as to save time spent in your fields; simplified crop monitoring, year-after-year analysis

CarbonToSoil - mobile application with mission to reverse climate change by putting carbon back to the soil through regenerative agriculture approaches. Via application anyone can convert a plot of land from a Finnish or global (in the near future) farm, and monitor weather data and see how the crops are growing through images. Users can

also follow the soil conversion progress from lab analysis and in the future also from soil sensor data.

HAYTECH - Possibility to remotely (online) check the state of your haystack, assuring its quality is preserved and diminishing the risk of a spontaneous fire burst.

Bioresource Mapping Tool - Knowledge of available biomass with its type and geographic breakdown

Giełda biomasy - Complete source of information on biomass availability, and technologies, services and stakeholders in renewable energy market.

MooV - Identifies the optimal value chain configuration for any given feedstock while keeping track of the quality changes of the feedstock in space and time. This enables the evaluation of the benefits and bottlenecks in the value chain from supply over logistics to demand

WinGIS – Chain integration including maps, logistics and environment risk assessment that can be applied to for example agriculture and forestry.

The implementation of the technologies mentioned above has the potential of increasing the amount of information for improved decision making around parameters such as precision farming, availability, quantity, quality, optimised supply management, processing and integration as well as environmental considerations and risk management.

6.1.2 Forestry

Continued analysis of Table 11 show that the general barriers for this feedstock is relating to cost and financing limitation as well as scale operation and the skillset required to use these technologies.

Similar to the situation for straw the specific needs across the simplified supply chain for forestry focuses on the need for more data to support the decision making and optimising the supply. In relation to production there is a specific need regarding moisture content analysis and there is also a need to analyse the compositional changes during processing by Near-Infrared Spectroscopy (NIRS).

Among the technologies available and applicable to the forestry supply chain there are two relating to the production and the chain integration that are available on a regional level (listed below) whereas the remaining high level technology solutions are available on a European level.

Rapid Biomass Analysis - Rapid analysis method for the determination of lignocellulosic properties of biomass samples.

Brash to bioproducts (MarEI) - Integrated process model-GIS-LCA to determine optimum supply chain for bioproducts derived from forestry residues in Ireland. Multi-criteria decision analysis is used to optimize biorefinery siting. Mobilising currently unutilised waste product

On a European level, high potential technologies were identified for all aspects of the supply chain except for logistics and distribution where only moderately potential solutions were identified. Compared to the straw supply chain no new high potential technologies were linked to forestry. The technologies identified were Smart Brain, NIRS, Bioresource Mapping Tool, Giełda biomasy, MooV and WinGIS.

Similar to the straw the lack of high potential applications for the logistics and distribution highlights a technology gap where more development is needed specifically address the needs for this feedstock.

The implementation of the technologies mentioned above has the potential of increasing the amount of information for improved decision making around parameters such as availability, quantity, quality, optimised supply management, processing and integration as well as environmental considerations and risk management.

6.1.3 Pig/Dairy cattle Manure and Chicken Manure

Analysis of Table 12 show that no general barriers or specific needs for these feedstocks were identified in the survey that formed the basis for the D1.3 report.

As with the previous two supply chains high potential technologies were not identified for the transport and distribution aspects of the chain. In this case all the high potential solutions are pan European and can besides chain integration provide improved data for decision making in terms of composition and moisture analysis as well information on availability and location. The relevant technologies for this supply chain are Smart Brain, NIRS, Bioresource Mapping Tool, Giełda biomasy and MooV.

6.1.4 Spent mushroom compost Mushroom off cuts

Continued analysis of Table 13 show that no general barriers were identified for the two mushroom materials streams. The specific needs for the storage of these feedstocks were found to be focused on data analysis to support decision making, supply optimisation as well as measurements on composition and moisture content (production of mushroom off cuts).

For the spent mushroom compost only three parts of the supply chain were linked to technologies of high potential and all can be found on a European level. These were

Production (Smart Brain), Biomass trading (Bioresource mapping tool, and Giełda biomasy) and Chain Integration (MooV).

In terms of high potential technologies available for the supply chain of Mushroom off cuts, this is the best covered feedstock from the Irish region. What makes a significant different here is the Freshbox technology (described below), available on a regional level, that can be used during transportation. The other technologies that can be linked to this chain are Smart Brain, NIRS, Connected ag-weather station, CarbonToSoil, Bioresource mapping tool, Giełda biomasy, MooV and WinGIS.

Freshbox - The Integrated Sensor Kit was developed to monitor key physical properties inside a transportation container during a logistics phase.

7. Assessment of ICT/IoT/Industry 4.0 technologies in the Andalusian region

7.1 Analysis

7.1.1 Olive leaves

The general barriers identified for this material (Table 14) was regarding increased cost, low confidence in the technology and doubts that the sector will engage with the opportunity to adopt new technology. No particular needs and challenges was identified in the survey around this material category. However, a number of both regional and pan European high potential technologies has been linked in the analysis to the different aspects of the supply chain. As was highlighted for the Irish supply chains, there is a lack of high potential solutions for transportation and distribution.

On a regional level two solutions called Olivia (described below) and Smart brain were linked to the production stage.

Olivia - A tool that help the farmer to: 1, optimize the irrigation and fertilization throughout the campaign; 2, integrated predictive pest control system; Market predictive at regional level

On a pan European level the following technologies were linked to the supply chain and has been described above: NIRS, Connected ag-weather station, CarbonToSoil, Bioresource mapping tool, Giełda biomasy, MooV and WinGIS.

Implementation of these technologies offer the opportunity for better chain integration, precision farming and provide improved data for decision making in terms of composition and moisture analysis as well information on availability and location.

7.1.2 Melon

The general barriers identified for this material (Table 15) was the same as for Olives, namely increased cost, low confidence in the technology and doubts that the sector will engage with the opportunity to adopt new technology. Also here no particular needs and challenges was identified in the survey around this material category. However, both regional and pan European high potential technologies has been linked in the analysis to the different aspects of the supply chain.

On a regional level Smart brain were linked to the production stage.

On a pan European level the following technologies were linked to the supply chain and has been described above: NIRS, Connected ag-weather station, Precision wine , CarbonToSoil, Bioresource mapping tool, Freshbox, Giełda biomasy, MooV and WinGIS. One previously undescribed technology was linked to the production aspect of melons. This technology is called Precision wine and is described below. The previously

described Freshbox technology was also linked here which can improve the monitoring of freshness during transportation.

Precision wine - costs reduction; disease risk reduction; increase potential of grapes; notifications and alerts sent via email/sms; data collected through agro-meteorological ground stations and ESA (European Space Agency) and NASA satellite

Implementation of these technologies offer the opportunity for better chain integration, precision farming, transportation freshness and provide improved data for decision making in terms of composition and moisture analysis as well as information on availability and location.

7.1.3 Algae - Piscis Nannochloropsis gaditana

With regards to Algae (Table 16), no general barriers or particular needs and challenges was identified in the survey around this material category. No high potential technology solution was found for the transportation and distribution aspects of the supply chain.

Smart Brain (regional), NIRS, Bioresource mapping tool, Giełda biomasy, MooV and WinGIS was linked to this supply chain and implementation of these technologies offer the opportunity for better chain integration and improved data for decision making in terms of composition and moisture analysis as well as information on availability and location.

8. Conclusions

The Bioresource modelling of the Irish and Andalusian regions identified clear clustering effects of the available materials for biorefining in the two regions. The analysis above identifies and links the high potential technologies that can be applied to the supply chain of these materials for both the current uses and future innovative value chains.

There are a few specific opportunities to address product integrity during transportation with the Freshbox technology. However, besides that, very few high potential technologies were identified for the transportation and distribution part of the supply chain. Therefore, technologies that are applicable to these two aspects should be the focus of future ICT/IoT developments. The high potential solutions from a pan-European level clearly outnumbered the regional solutions and covered well the remaining aspects of the supply chain and will if implemented bring valuable data for improved decision making and control of process and quality as well as the possibility to optimise the supply of material to each step in the supply chain of a future biorefinery. Generally, more data for decision making around supply, processing and quality will improve the cost effectiveness and sustainability of any concept. However, biorefining from olives and horticulture specifically will benefit from a well-managed supply chain due to the lower stability of the material streams from these sources.

The solutions that were assessed in task 1.1 and 1.2 were mainly focused on COMPLEX technologies as these are more specific and has the potential to bring more innovation to the biomass industry. BASIC technologies (wifi etc.) useful but due to their universality, not as important as more complex technologies for the purpose of this project.

Some of the general barriers identified was regarding increased cost, low confidence in the technology and doubts that the sector will engage with the opportunity to adopt new technology. Others were related to scale operation and the skillset required to use these technologies