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I-PAN

INNOVATIVE POPLAR LOW DENSITY STRUCTURAL PANEL

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D2.5 – Certifications on emissions and processes

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Document information

Abstract

The deliverable D.2.5 comes as part of the project activities within WP2 (Technical requirements), whose objectives were the analysis of the state-of-the-art wood made panels as well as the technologies used for their production, while the output has been a clear definition of the technologies requirements of the new production line.

In particular, in Task 2.4 (Life Cycle Analysis, Leader CTECH) a LCA analysis has been performed to assess the environmental impacts associated with the production and distribution of the innovative OSB, compared with traditional panels, resulted in the evaluation of the I-PAN process carbon footprint (deliverable D.2.6).

The present deliverable intends to describe the environmental benefits achieved thanks to I-PAN innovation by the companies involved in the project, according to ISO 14001:2004 and ISO 14004:2004 and in line with the Eco-Management and Audit Scheme (EMAS) guidelines.

Keywords

Poplar, wood, OSB, environment, LCA, carbon footprint, GWP, EMAS, sustainability

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LIST OF ABBREVIATIONS AND DEFINITIONS

CARB	California Air Resources Board
EAP	Environment Action Programme
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
EU	European Union
EW	Engineered Wood
GHG	Greenhouse Gas
GWP	Global Warming Potential
ICPC	International Cooperation Partner Country
LCA	Life Cycle Assessment
LSB	Lightweight Strand Board
MDF	Medium Density Fibreboard
NSRF	National Strategic Reference Framework
OSB	Oriented Strand Board
PEFC	Programme for the Endorsement of Forest Certification

INTRODUCTION

This deliverable is part of the activities of CIAOTECH regarding the assessment of the environmental impacts of the I-PAN project, performed in WP2 (Technical requirements), task 2.4 (Life Cycle Analysis).

The main inputs are the results of the LCA study performed by CIAOTECH and described in the deliverable D2.6, in which the environmental benefits of the innovations introduced by I-PAN are assessed and evaluated according to ISO 14040 and ISO 14044.

The objective is to contribute to the environmental certification of the companies involved in the project according to the 7th Environment Action Programme (EAP) and the Eco-Management and Audit Scheme (EMAS) guidelines.

In particular, all the virtuous behaviors established by the project partners and inspired by the positive environmental outcomes of I-PAN will be taken into account and described.

1 THE 7TH EAP AND EMAS

The **environmental protection** is an issue of fundamental importance, and represents a priority in the agenda of European Commission.

The **Directorate-General for Environment** is the European Commission department responsible for EU policy on the environment. It aims to protect, preserve and improve the environment for present and future generations, proposing and implementing policies that ensure a high level of environmental protection and preserve the quality of life of EU citizens (http://ec.europa.eu/dgs/environment/index_en.htm).

To reach these challenging objectives, the European Union has put in place a broad range of environmental legislation to reduce air, water and soil pollution. Through the implementation of the **7th Environment Action Programme (EAP)**, which will be the guiding European environment policy until 2020, the EU intends to continue on the path of strengthening the defence of the environment, ensuring people's health and economic benefits for Europe: "*In 2050, we live well, within the planet's ecological limits. Our prosperity and healthy environment stem from an innovative, circular economy where nothing is wasted and where natural resources are managed sustainably, and biodiversity is protected, valued and restored in ways that enhance our society's resilience. Our low-carbon growth has long been decoupled from resource use, setting the pace for a safe and sustainable global society.*" (7th Environment Action programme).

Figure 1 - 7th Environment Action Programme logo

Among other actions, a number of environmental policy instruments, ranging from mandatory rules to voluntary tools, intend to ensure that European industry works towards a high level of environmental protection, minimise its environmental footprint and increase its sustainability.

To guide industries towards resource efficiency improvements, eco-innovation and participation in the transition to a circular economy, the European Commission has developed the EU **Eco-Management and Audit Scheme (EMAS)**. EMAS is a management instrument developed by the European Commission for companies and other organisations to evaluate, report, and improve their environmental performance: it is open to every type of organisation eager to improve its environmental performance and communicate its environmental achievements to stakeholders and society in general, it spans all economic and service sectors and is applicable worldwide.

EMAS' distinctive key elements are performance, credibility and transparency (http://ec.europa.eu/environment/emas/about/summary_en.htm):

PERFORMANCE: EMAS is a voluntary environmental management instrument based on a harmonised scheme throughout the EU. Its objective is to improve the environmental performance of organisations by having them commit to both evaluating and reducing their environmental impact, and continuously improving their environmental performance.

CREDIBILITY: The external and independent nature of the EMAS registration process ensures the credibility and reliability of the scheme. This includes both the actions taken by an organisation to continuously improve its environmental performance, and the organisation's disclosure of information to the public through the environmental statement.

TRANSPARENCY: Providing publicly available information on an organisation's environmental performance is an important aspect of the scheme's objective. It is achieved externally through the environmental statement and within the organisation through the active involvement of employees in the implementation of the scheme. The EMAS logo, which can be displayed on (inter alia) letterheads, adverts for products, activities, and services, is an attractive visual tool which demonstrates an organisation's commitment to improve its environmental performance and indicates the reliability of the information provided.

The **EMAS registration** assures that a company has conducted an environmental review considering all environmental aspects of the organisation's activities, products and services; adopted an environmental policy containing commitment both to comply with all relevant environmental legislation and to achieve continuous improvements in environmental performance; and developed an environmental programme that contains information on specific environmental objectives and targets, to be used as a tool to help the organisation in its everyday work when planning and implementing the improvements.

Moreover, the certified companies must have established an effective environmental management system (EMS), aimed at achieving the organisation's environmental policy and at improving the environmental performance continually; carried out an environmental audit, assessing the management system in place and conformity with the organisation's policy and programme as well as compliance with relevant environmental regulatory requirements; and provided an environmental statement of their environmental performance which lays down the results achieved against the environmental objectives and the future steps to be undertaken in order to continuously improve the organisation's environmental performance.

The certification procedure ends when an accredited environmental verifier approves the environmental review, the EMS, the audit procedure and the environmental statement. The validated statement needs to be sent to the EMAS Competent Body for registration and made publicly available, then the certified organisation can use the EMAS logo.

Figure 2 - EMAS logo

2 THE I-PAN PROJECT: PROCESS AND EMISSIONS

In this paragraph the environmental benefits of the I-PAN project are described in terms of process innovation and reduction of CO2eq emissions.

It is important to underline that even the management of the I-PAN project itself has been led by the consortium members paying attention to limit the direct emissions of CO2 (derived for example from the burning of fossil fuels including domestic energy consumption and especially transportation) reducing the actions that might increase the project's carbon footprint.

Considering in fact that business travels are usually large generator of carbon emissions, videoconferencing among project partners has been chosen instead of physical meetings where possible, limiting the number of meetings and related travels. Whenever possible the most environmentally adequate transport mode has been selected: car sharing or public transport have been used rather than cars.

At least, project brochures and leaflets were printed in limited quantities.

2.1 I-PAN INNOVATIVE PROCESS

I-PAN project objective was to provide novel and highly environmental friendly solutions in the field of the engineered wood (EW) based boards.

The most important heavy EW in the market is the **Oriented Strands Board (OSB)** that in the last decades, replaced plywood in many sectors connected with the structural panel market becoming basically the reference panel worldwide. Whenever lightness does not represent a critical advantage, OSB panels represent the material of choice, with well-regarded properties. In fact OSB is employed in a variety of industrial sectors, ranging from the building sector, to maritime industry and the recreational sector, since it is: easily engineered in terms of size, thickness, strand orientation and with relatively large choice of adhesives; uniform and flawless; stable and durable; and water-resistant; versatile; with desirable structural properties; and less costly than traditional plywood.

Within the market of traditional wood-based panels, **lightweight boards** represent a doable alternative to heavy EWs, when lightness is highly desirable. The application of light boards though is not just restricted to furnishings and interiors as this type of wooden board is successfully employed in the building industry, marine and caravan construction and many others.

The concept of the **I-PAN project** was to boost the utilization of traditional wood-based panels by engineering their properties to match lightweight applications requirements, reducing the manufacturing cost along the overall process and allowing a highly sustainable approach at the same time, through the reduction of raw material process input, the use of re-cycled material, the minimization of wastes and energy consumption and the reduction of pollutant compounds emissions.

The I-PAN project aimed in fact at designing a breakthrough wood-made lightweight panel, adopting recycled poplar wood coming from the upper part of the tree that is commonly underused. To this purpose, a novel manufacturing process was designed and innovation to existing resins was defined in order to require less energy during the drying and pressing process, minimizing VOC emission and reducing the overall cost of production.

Figure 3 - Traditional OSB

The I-**PAN project specific objective** was to develop and demonstrate the environmental benefits brought by its advanced solutions by:

(i) reducing the pressure on forests derived raw materials use, thanks to the maximization of use of selected poplar plantations allowing 7-8 years poplar growth cycle.

(ii) reducing the quantity of wood as an input of the overall process, thanks to the use of 30% made of recycled poplar wood for the development of an innovative EW based technology for Lightweight Strand Board (LSB) production, recyclable at the end of the product lifecycle.

(iii) reducing the wastes and consumptions along the overall manufacturing process, starting from an optimal use of raw material (poplar wood) to the several steps needed for wood treatment (e.g. lower energy for fast drying and blending processes) an final product release.

(iv) reducing the quantity and presence of hazardous and volatile chemicals by developing a new formaldehyde-based resin suitable for the necessary bonding recycled wood.

(v) reducing the carbon footprint by innovating the production process and decreasing the number of felled trees.

To achieve the expected impacts, the following **innovations** has been developed in respect with traditional production process:

1) The production of strands (thin wood slices representing the main stratified components of wood made panels) through an innovative drying, handling and metering system;

2) The employment of a novel resin to be innovated by a lower room-temperature polymerization;

3) The innovation on the Mat (raw board) Forming the process of blending and pressing wood strands together in order to produce a thick and solid layer for final panel composition.

Finally, I-PAN pushed the limits of the engineered wood sector towards a more circular economy, and realized the OSB using up to 30% recycled wood derived from the upper parts of the poplars, usually discarded.

Figure 4 - Poplar plantation

2.2 I-PAN CO_{2EQ} EMISSIONS

The environmental benefits obtained through the I-PAN innovation have been widely assessed in the **Life cycle assessment (LCA)** study described in deliverable D.2.6. In the present paragraph, the main outcomes of the I-PAN project in terms of CO2eq emissions as determined by the LCA are provided, as better described in the D.2.6.

The LCA is a technique to assess the environmental aspects and potential impacts associated with a product, process or service through all stages of its life cycle. The life cycle embraces all the activities from raw material extraction and production, through manufacturing, packaging and distribution, use, as well as final disposal or recycling. Energy, material and water resources are used in creating, packaging, transporting and using a product whilst the associated process generates emissions to air, land and water, causing strong environmental impacts. The leading standards used for performing LCA are ISO 14040 and 14044 where ISO 14040 outlines general principles and framework and ISO 14044 provides requirements and guidelines.

The two scenarios addressed in the comparative LCA study performed have been:

- **Standard OSB production process - KLINE 2005** *(D. Earl Kline - Gate-to-Gate Life-Cycle Inventory of Oriented Strand Board production - Brooks Forest Products Center - Virginia Tech - 2005)*;
- **I-PAN production process**.

In Figure 5 and Figure 6 the two process cycles are defined in term of system boundaries and life cycle stages; the functional unit, to which the final results in terms of GWP refer, is **1m3 wood-based panel**.

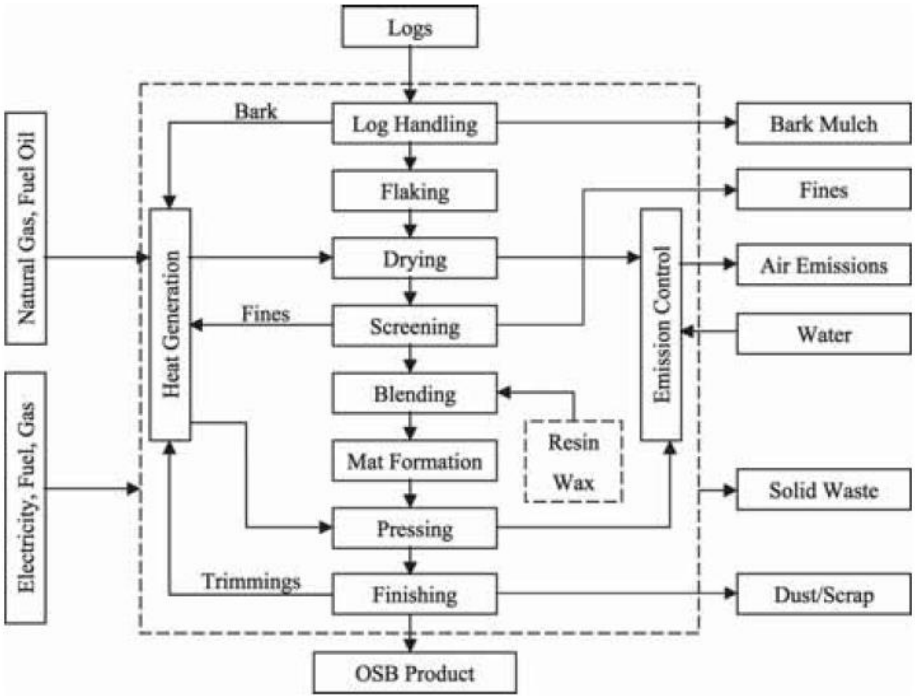

Figure 5 - Life cycle of conventional OSB panel

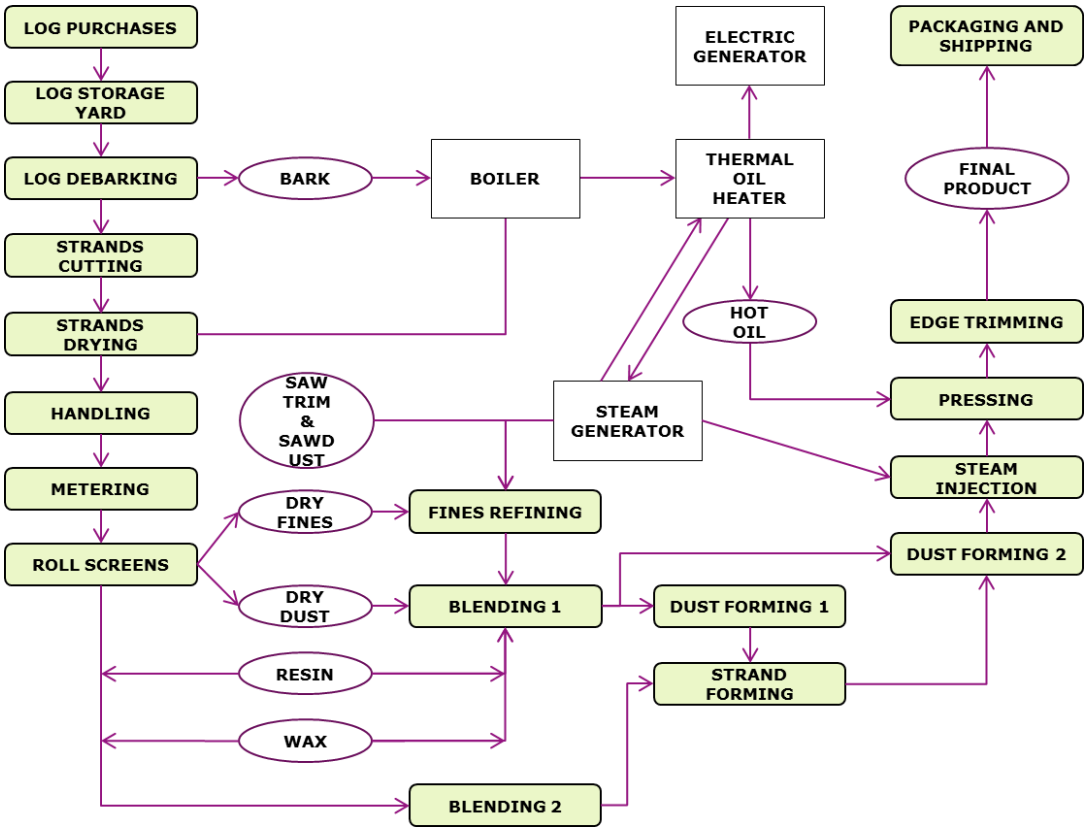

Figure 6 - Life cycle of I-PAN OSB panel

The analysis has been performed using the LCA software package **CCaLC Tool** (Carbon Calculation over the Life Cycle of Industrial Activities, University of Manchester), and the results are reported in the following figures.

STANDARD PROCESS

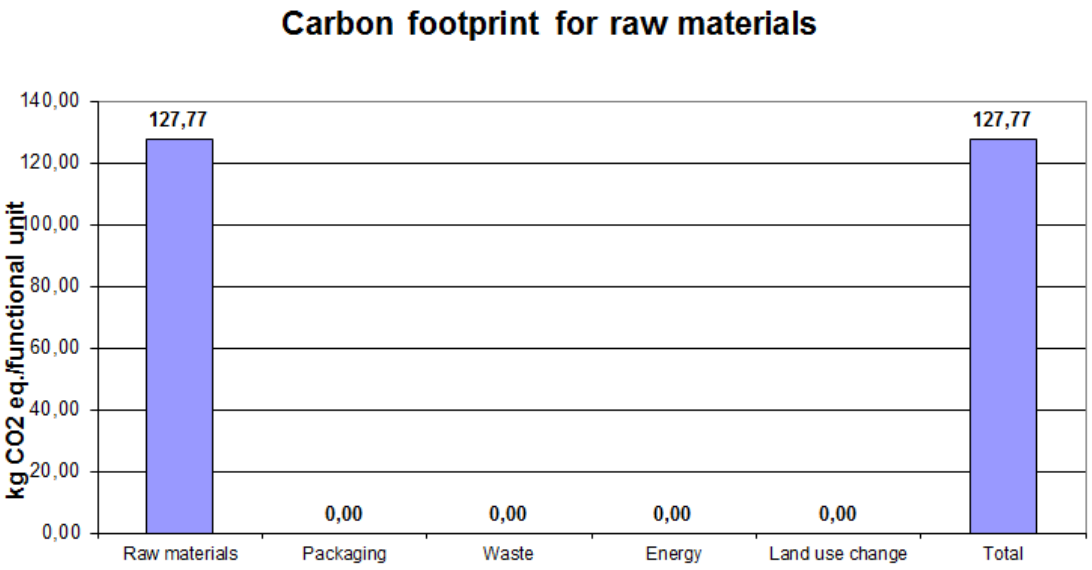

Figure 7 – Standard process: Raw materials carbon footprint

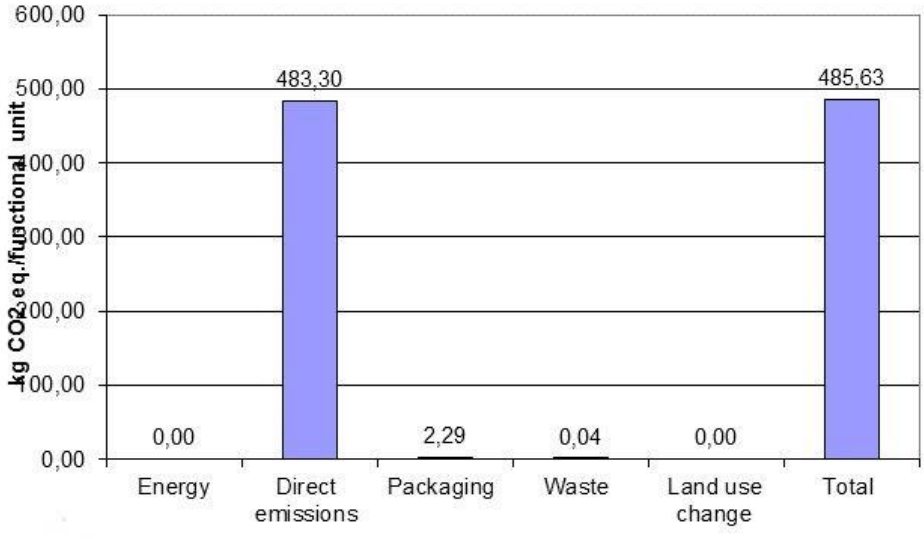

Figure 8 – Standard process: Production carbon footprint

The total carbon footprint related to the production of 1 m^3 of OSB, including the contribution due to the raw materials (Figure 7) and production processes (Figure 8) is equal to **614.12 kg CO2eq**, as shown in Figure 9.

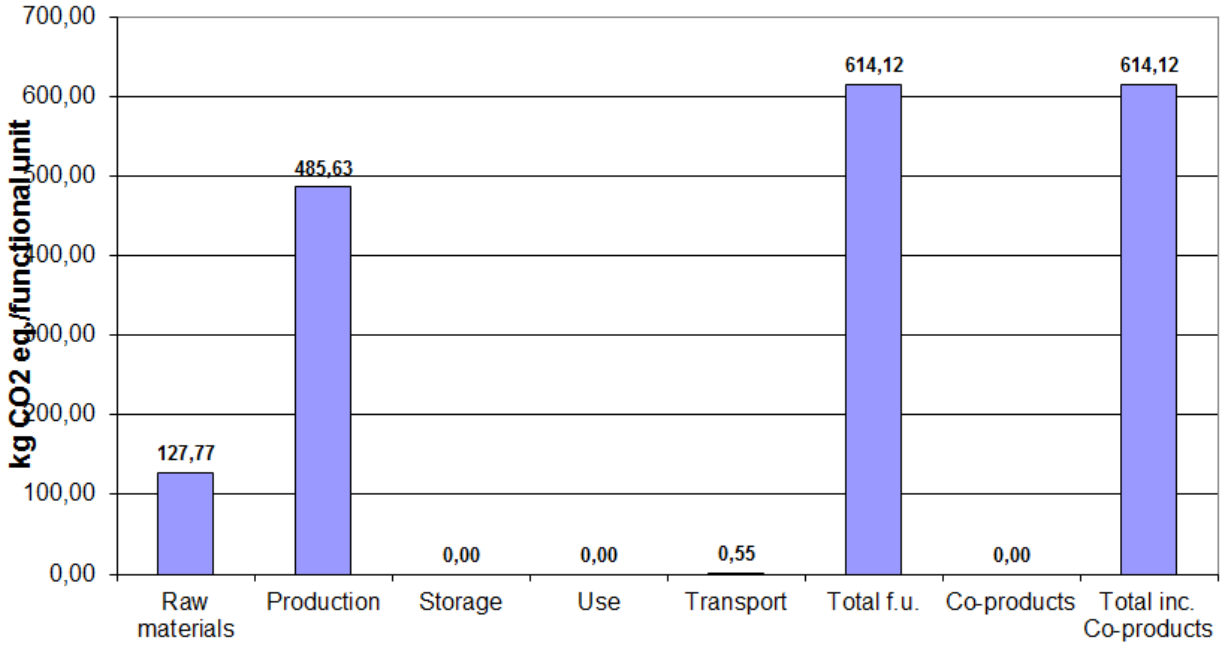

Figure 9 –Standard process - Total carbon footprint

I-PAN PROCESS

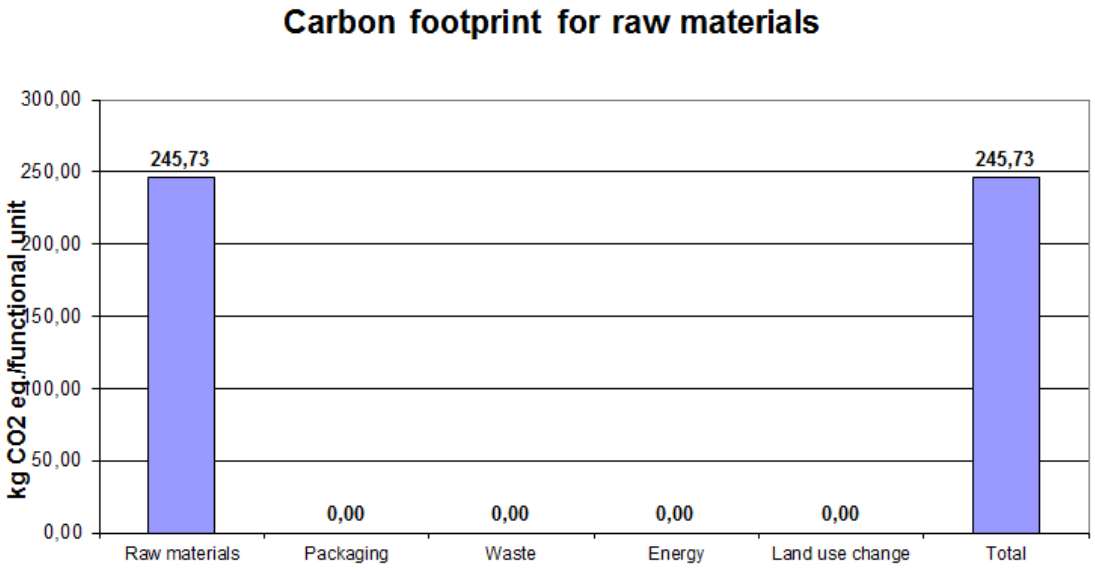

Figure 10 – I-PAN process: Raw materials carbon footprint

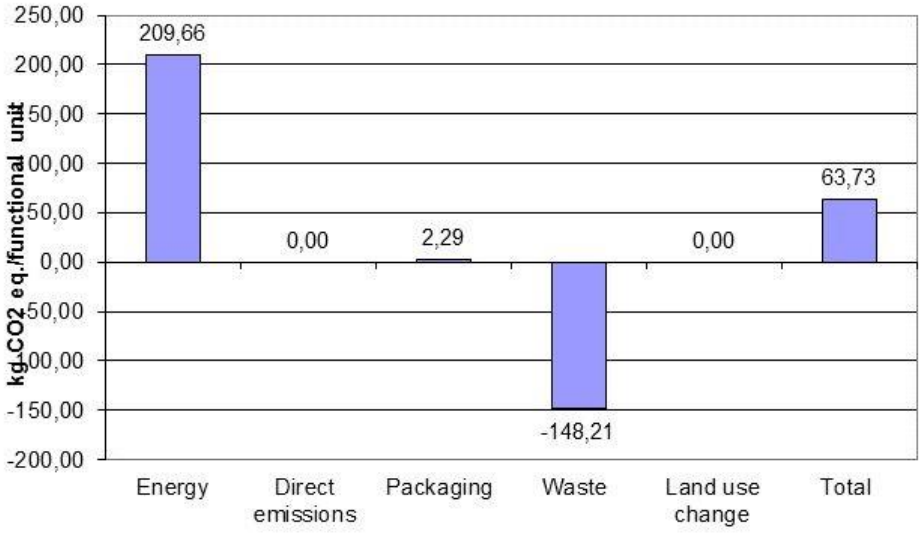

Figure 11 – I-PAN process: Production carbon footprint

The **total carbon footprint** related to the production of **1 m^3 of I-PAN OSB**, including the contribution due to the raw materials (Figure 10) and production processes (Figure 11), is equal to **310.02 kg CO2eq**, as shown in figure 12.

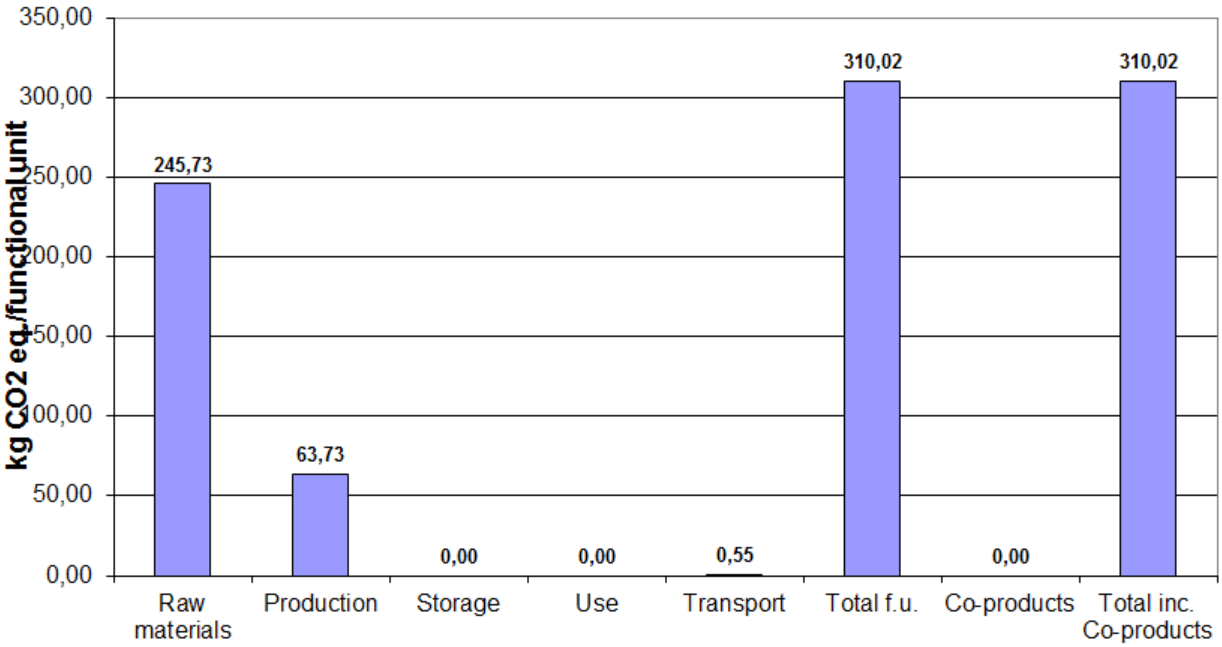

Figure 12 – I-PAN process - Total carbon footprint

CONCLUSIONS

The Greenhouse Gas (GHG) emissions associated with the innovative I-PAN process are considerably lower than standard processes: Figure 13 shows the comparison between the GWP of the two processes (I-PAN and standard): the reduction of CO2eq emissions is equal to about 50%.

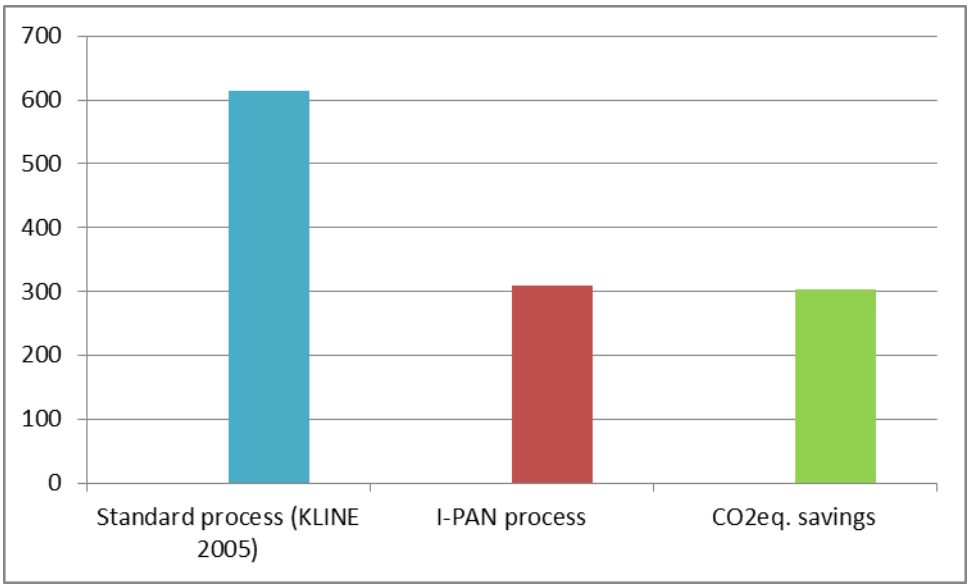

Figure 13 - GWP, comparison between I-PAN and standard processes

TRANSPORT

Further benefits are related to the **final weight of I-PAN panels**, which is considerably lower than the weight of standard OSBs. In fact, the density of I-PAN OSB is equal to 450 kg/m^3, while traditional panel density is equal to about 650 kg/m^3 *(D. Earl Kline - Gate-to-Gate Life-Cycle Inventory of Oriented Strand Board production - Brooks Forest Products Center - Virginia Tech - 2005)*.

The panel lightness has a significant impact in terms of GWP associated with the transport phase. The calculation of the **GWP related to the phase of transport** of the panels from the production site to the distribution centres has been done assuming an average distance, estimated by the project partners, equal to 500km.

Moreover, according to a literature survey (*L. Ridge, EUCAR - Automotive LCA Guidelines - Phase 2. Total Life Cycle Conference and Exposition, Graz, Austria, December 1–3; Society of Automotive Engineers, 1998)* the reduction of carbon dioxide emission per each km when 1 kg is saved on board with respect to baseline scenario has been considered equal to 1.083×10^{-4} $kgCO2_{eq}/(Km \cdot kg)$.

The results of the analysis in terms of CO2eq emissions saved are shown in Table 1.

	quantity	*u.m.*
CO2eq emissions avoided per kg of OSB saved	1,08E-04	kgCO2eq/(km·kg)
Difference in weight between standard and I-PAN OSB	200,00	kg
CO2eq emissions avoided per km for each functional unit	2,17E-02	kgCO2eq/km
Average trip	500,00	km
CO2eq emissions avoided per functional unit	1,08E+01	kgCO2eq/functional unit
Number of functional units produced every year by I-PAN	110250,00	m3
CO2eq emissions avoided by I-PAN per year	**1,19E+06**	**kgCO2eq/year**

Table 1 – I-PAN process – CO2eq. saved during transport phase

The CO2eq saved during the transport of 1 m^3 of I-PAN OSB compared to the transport of 1 m^3 of standard OSB is equal to **1.08 kg**. Considering the **entire annual production** of OSB at project partners premises (110,250 m^3), it can be estimated about **1,190,000 kg CO2eq cut**.

3 PROJECT PARTNERS' ENVIRONMENTAL PERFORMANCES

The reduction of CO2 emissions described in the previous section is in line with the objective of the European Union to meet its targets for cutting greenhouse gas emissions under the Kyoto Protocol and for 2020: the EU has made a unilateral commitment to reduce overall greenhouse gas emissions from its 28 Member States by 20% compared to 1990 levels. The 20% reduction commitment is one of the headline targets of the Europe 2020 strategy for smart, sustainable and inclusive growth.

The involvement in I-PAN activities has allowed the project partners to start or continue a **path towards the environmental sustainability** of their processes and activities, in line with EMAS certification principles. The project has in fact implied significant environmental benefits for all the 8 project partners, 4 SMEs (CTECH, STELA, IDP, CHI), 2 large industrial partners specialised in the two key area of I-PAN project namely, technologies for manufacturing wood-made panels (IMAL) and production of poplar made panels (IBL), a Research Centre (ECSC) and a University (UMIL).

In particular, **for the industrial manufacturing partners (IMAL, IBL, STELA, CHI) the environmental achievements have been directly related with the innovative process/products developed within the project activities**. However, the environmental focus of the project pushed all the partners towards greener behaviour in all their usual activities. Here following the environmental related performances and further precautions as derived from the "learnt lessons" thanks to the I-PAN project experiences, are provided referred to the 4 industrial manufacturing industries.

3.1 IMAL

IMAL, the project coordinator, is a world leader in technology for the production of wood-based products through investments in specific technical areas of research and is flexible towards customer demand and market requirements. It also has several international patents. The company is often involved in national and international research projects, acting as R&D and innovation initiator.

The company specialises in a range of high-tech instruments and equipment for glue blending and quality monitoring, as well as the supply of complete part new/part reconditioned plants, accompanied by full guarantee. Various products of IMAL's range have also been TUV certified through the prestigious Munich Institute in Germany, as well as being certified ISO 9001 Vision 2000.

During the project IMAL has been involved in the definition of technical requirements and specifications of the innovative developed technologies. Being a company that operates in the construction of plants for the production of wood-based panels and constantly involved in the research and innovation of green technologies able to reduce the use of resources and improve the production performance, IMAL has had a central role:

- in the experimental phase of resins;

- in the development of the technologies to be employed in the feed log and in the blades and rotors apparatus;

- in the drying system research related activities, as experts on strands production process;

- in the innovation of the blending technologies;

- in the definition of the technological layout;

- in the integration for the pre-industrial demonstration.

The participation in the I-PAN project has contributed to the development in IMAL of a series of green activities, as described hereinafter.

3.1.1 R&D ACTIVITIES

The R & D activities have always been important in IMAL and have played a key role within the I-PAN project.

IMAL R&D department, in the specially dedicated R&D facility and run by a team of highly-qualified engineers with great inventive capacity, is constantly at work to design innovations for both existing and future projects, aimed at improving performance, reducing running costs, reducing maintenance with the application of special materials, optimising plant layout with a view to obtaining maximum yield at minimum cost and optimising production processes.

The engineers of the company's R&D division also collaborate in close conjunction with several Italian University Research laboratories, and the encouragement of this kind of collaboration, along with their annual investment policy, enable the company to retain its reputation as an avant-garde manufacturer in this industrial sector.

3.1.2 COMPANY'S GREEN DIVISION

"GREEN DIVISION" is a new department born in 2012 (starting year of the I-PAN project) and specifically created for the production and the development of technologies dedicated to the environmental sector, based on high qualified human resources and manufacturing technologies in the service of a sector with wide action possibilities, created in answer to the various requests received by the world of recycling and urban and industrial waste treatment.

Figure 14 - From company's GREEN DIVISION website

The internationally acknowledged thirty years leadership has allowed the company to address also the waste treatment sector with very qualified answers. Energy recovery and recycling of secondary raw materials are the domains in which the GREEN DIVISION can provide the best technological innovations and performances in line with the sector directives (also in extra-EU Countries).

In addition to the know-how consolidated into the energetic exploitation of the biomass for energy production (for thermal or biological processes), there are specific competences concerning high quality production of RDF (Refuse Derived Fuel) also for specific uses (cement production factories, thermal power stations, grate furnaces or fluidized bed furnaces).

Recycling is widely confirmed by the consolidated technologies and by the new patents that the company has produced for the selection and the next industrial re-use of the recyclable materials ("oven-ready" glass, plastic and metals) and for the production of compost for agronomic uses: high-end products that are manufactured basing on internationally organized experience and production structure.

3.1.3 GREEN SOLUTIONS

WOOD RECYCLING - Produce high quality panels from recycled wood

Up until the mid-1980s, panel manufacturers had an abundance of wood at their disposal for their process requirements.

At present, in North and Central Europe, North America, Brazil and elsewhere, despite reforestation policies and an increase in the number of trees, the cost for obtaining these resources in addition to related environmental issues, have forced many companies to seek alternative options. And the only real and proven option is urban waste wood. In fact, most urban forests are attractively priced and in some areas can be collected free of charge.

Figure 15 - Wood recycling

As a result of the great expertise acquired in chip cleaning, the company produces from 1982 integrated recycling systems for urban wood waste and, with over 270 plants that recycle any variety of urban forest worldwide, is widely acknowledged as the world leader in this field.

With the application of this special technology, it is not only possible to recycle wood for wood-based panels but for other products in the industry as well such as pallet blocks.

These activities have been undertaken by IMAL well before I-PAN, but are perfectly in line with the objectives of the project, which uses for the production of OSB panels about 30% of recycled wood: the results of the project will further boost the company's activities in the wood recycling field.

INSULATION BOARD - Technology which looks to the future

Figure 16 - Insulation boards

A newly launched and innovative product of the company's range is the Insulation board production line, a **new insulating product realised starting from 2013 and destined to replace rock wool and polystyrene for thermal and acoustic insulation purposes** in domestic and industrial applications as well as in the production of furniture and doors.

These modern production lines are supplied starting from the equipment in the wood preparation area, through to the refiner, dryer, the essential glue dosing and blending process, the forming station, press and packaging process until the end product is ready for shipping.

ENERGY FROM BIOMASS - Energy from renewables

With its long experience in wood handling and preparation, the company has also begun over the last decade to supply equipment to the biomass energy industry:

- wood chips handling and energy plants;
- waste wood cleaning, handling and energy plants;
- wood refining and screening for co-firing systems;
- seasonal biomass handling and energy plants;
- electrical energy generated from biomass, by means of an ORC turbine.

The interest of the company in the field of energy from biomass is confirmed by the use in I-PAN of wood wastes as fuel in the biomass boilers, which allow on one side the production of thermal energy to be used in the ovens during the processes of drying and on the other side the production of electricity.

3.2 IBL

Starting in the mid-1950s, IBL began expanding in the wood-panel industry; in just a few years, the Panel Division endowed itself with a sound organisation and today counts three companies in Italy with production facilities and offices in various European countries. In the 1960s, it was joined by the Packaging Division, which has gradually turned into the current Logistics Division, able to manage an integrated logistics system that today organises services for major Italian and foreign companies including Fiat and General Electric. Out of the Packaging Division in fact, two companies saw the light - Argol and Villanova. Villanova deals with logistics in the automotive industry, while Argol organises services for the mechanical engineering industry.

IBL cut **poplar trees**, machine the timber and transform every part into panels, from the simplest sawn to rotary-cut veneer up to multiply and semi-finished products. IBL have heavily invested in technology and as a result IBL is the best supplier of the furniture industry. Currently, the poplar cultivation assets cover almost 50% of its needs. IBL is also focused on the environment: **99% of the timber used comes from special cultivated areas, where the trees are always replanted**. The so-called noble woods are used to a very small extent for facing. IBL is based in Monferrato (Coniolo (AL), Italy and it has three other units in Hungary, Romania, and it has more than 554 employees.

The I-PAN project has contributed to the introduction of important innovations in the production of wood panels, with particular reference to the use of poplar wood and of glues with low formaldehyde content, as described below.

3.2.1 ENVIRONMENT - POPLAR

Figure 17 - Poplars

Wild poplar woods have always existed but it is the concept of **"short rotation tree"** (fast growing trees cultivation) to have raised, over the last 30 years, the interest in the whole world on poplar. It is indeed in Casale Monferrato that the Research Centre for plantation trees has created the "**I-214 Clone**", the most cultivated poplar variety worldwide for industrial purposes. Poplar cultivation is the most advanced form of tree cultivation in the world. The use of the most innovative cultivation techniques aimed at make the most of its natural strong points granting constant quality and the respect of the **most severe environmental standards**.

Poplar wood shows a series of features which make it suitable to be transformed into plywood and blockboard panels as:

- Light weight: poplar plywood has a specific weight of 450 kg/m3 +/- 10%.

- Light and plain colour: unlike other wood species, poplar logs allow to obtain wide white and plain sheets.

- Versatility: poplar has an excellent ratio between specific weight and mechanical features; despite of its light weight, the modulus of elasticity and the screw strength make of poplar a suitable wood to be used in the furniture sector (its first end use) as well as structural component as an alternative to other material where the CE2+ certification is also available.

- Ease of work: despite its high resistance, poplar is a mild wood, it is therefore easy to work and reduces tools consumption.

Figure 18 - Poplar measurement for industrial use

However, the most interesting characteristic that makes poplar wood suitable for industrial purposes is its **environmental friendly** nature:

- Like all fast growing species, poplar has an excellent capacity to purify air. The faster and the bigger the tree grows, the faster and the higher it releases oxygen and holds carbon dioxide. A growing poplar absorbs 70-140 litres/hour from the atmosphere and releases the same quantity of oxygen. What is more the carbon dioxide contained in a grown tree remains stored in the logs and afterwards in the panels obtained from them (Carbon Sink).

- Poplar can purify water, as it absorbs polluted water from the soil and releases it purified into the atmosphere holding the harmful toxins into the wood or into the leaves. Once they join the soil again they are already decayed or they are already combined with other organic components thus highly reducing the pollution of the aquifer.

- Poplar works as a retaining element for soil erosion and desertification, it improves biodiversity and conserves the environment.

- Poplar is a renewable source and can be used to replace material with a high carbon dioxide content.

- Poplar trees come from cultivations managed through strict environmental standards, they are not cut down from virgin forests.

- Poplar cultivations are located next to the production sites, therefore exhaust emissions caused by transport are consequently strongly reduced.

- Poplar wastes are an excellent biofuel, therefore the tree is used in its whole (no production waste).

Figure 19 - Poplar logs

IBL uses poplar wood coming from cultivations for the realization of its products and belongs to the **International Association Pro-Populus** (http://www.pro-populus.eu/en). Born in 2008, the Association is unique in its genre as for the first time ever it gathers poplar manufactures, promoters as well as industrial users in their various sectors (panel production, packaging and energy). The association aims first of all to raise poplar to the role of strategic raw material, since it presents unique features making it the ideal means to support many transversal policy areas within the European Union, such as raw material availability, climate change mitigation, renewable energy use, and development of territories, in line the "EU 2020" strategy in terms of sustainable development and environmental protection.

The I-PAN project confirmed the company's choice to use poplar wood as green product for the realization of the innovative OSB panels.

3.2.2 HEALTH – FORMALDEHYDE EMISSIONS

Formaldehyde emissions have been recognised having harmful consequences on human health: within the EU, formaldehyde is currently classified as a Category 2-R45 substance ("May cause cancer", **Regulation No 605/2014 of 5 June 2014**), while in the U.S. the current classification by EPA is that of a "probable human carcinogen" (EPA's group B1, http://www3.epa.gov/airtoxics/hlthef/formalde.html).

However, formaldehyde is widely used in the wood industry in the form of phenol-formaldehyde (PF), melamine-formaldehyde (MF), melamine-urea-formaldehyde (MUF) and urea-formaldehyde (UF) resins.

The I-PAN project has paid special attention to the formaldehyde content of the OSB panels, in line with the more stringent regulation mentioned above and contributing to the achievement of the following certifications:

EUROPE: CLASS E1

The release of formaldehyde has been determined using the perforator method according to EN 120: as specified in EN 13986 (Wood-based panels for use in construction – Characteristics, evaluation of conformity and marking), the panels of Class E1 have a release ≤6.5mg/100g.

USA: CARB CERTIFICATION

Obtained in 2014, during the development of project activities, the certification has been issued by the California Air Resources Board, also known as CARB or ARB, the "clean air agency" in the government of California. Established in 1967, CARB is a department within the cabinet-level California Environmental Protection Agency. The stated goals of CARB include attaining and maintaining healthy air quality; protecting the public from exposure to toxic air contaminants; and providing innovative approaches for complying with air pollution rules and regulations.

IBL S.P.A.

S.P. 31 bis - Regione Cavallino, 8
I - 15030 - Coniolo (AL)

PRODUCT CERTIFICATE
FOR CARB n° 011 03/14

By order of California Air Resources Board, according to the Executive Order W-14-016, relating to ARB approval of Third Party Certifiers under California Code of Regulation, having

- verified the accuracy of emission test procedures and facilities for Factory Production Control of manufacturer and evaluated them;
- monitored the manufacturer quality assurance programs;
- verified the correlation of the FPC with the secondary test method;
- provided independent audits and inspections as an ARB approval TPC according to the supervision contract 31379-31392-2014, third quarter of 2014
- verified the provisions concerning IOS-MAT-0003, last revision

we hereby certify that the product

Plywood, urea-formaldehyde (UF), unfaced
technical class: CARB Phase 2
thickness range : 3 mm ≤ 19 mm
product name: Plywood

produced by the above mentioned company has met the requirements of the
CARB Final Regulation Order, Airborne Toxic Control Measure §93120,
CATAS QUALITY AWARD - General Rules rev. 4 dated 26.05.2014 and
CATAS QUALITY AWARD - Technical Rules FORMALDEHYDE CARB rev. 2 dated 26.05.2014
concerning the compliance with the emission standards of

PHASE 2 (P2)
for HARDWOOD PLYWOOD (HWPW-VC)
according to Table 1 in FRO ATCM §93120.2 (a)

This evaluation is based on the monitoring and the test reports number:
from 183413/1 to 183413/6, dated October 30th, 2014

October 30th, 2012	November 24th, 2014	April 24th, 2015
FIRST ISSUE	CURRENT ISSUE	VALID UNTIL

CATAS S.p.A.
Iscr. Reg. Imprese Udine
nr.iscr. C.F. 01818850305
Reg. Impr. UD 20663
P.IVA 01818850305
C.Soc. 1.003.650,00 Euro i.v.
Sede: Via Antica 24/3
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ATT_FORCARB, rev. 02 dated 24.11.2014

CATAS www.catas.com

Figure 20 - IBL – CARB certification

3.2.3 CERTIFICATIONS

Besides the above mentioned certificates regarding formaldehyde content, IBL has gained other environmental certifications proving the limited environmental impacts of its products and processes.

IBL HAS CONFORMED IN 2013 TO THE EUROPEAN REGULATION 995/2010

During the course of project activities, IBL has conformed to the Regulation (EU) No 995/2010 (http://ec.europa.eu/environment/forests/timber_regulation.htm) of the European Parliament and of the Council of 20 October 2010, laying down the obligations of operators who place timber and timber products on the market and also known as the (Illegal) Timber Regulation, which counters the trade in illegally harvested timber and timber products through three key obligations:

A) It prohibits the placing on the EU market for the first time of illegally harvested timber and products derived from such timber;

B) It requires EU traders who place timber products on the EU market for the first time to exercise 'due diligence';

Once on the market, the timber and timber products may be sold on and/or transformed before they reach the final consumer. To facilitate the traceability of timber products economic operators in this part of the supply chain have an obligation to

C) Keep records of their suppliers and customers.

IBL

DICHIARAZIONE DI CONFORMITA'
REGOLAMENTO EUROPEO 995/2010

In base al Regolamento Europeo 995/2010, IBL SpA ai sensi del Regolamento Europeo 995, adotta in qualità di operatore un sistema di dovuta diligenza come richiesto all'articolo 4.

Per comodità, indichiamo di seguito gli obblighi degli operatori:

1. È proibita la commercializzazione di legno o prodotti da esso derivati di provenienza illegale.
2. Gli operatori esercitano la dovuta diligenza nel commercializzare legno o prodotti da esso derivati. A tal fine utilizzano un insieme di procedure e misure, "sistema di dovuta diligenza", di cui all'articolo 6.
3. Ciascun operatore mantiene e valuta periodicamente il sistema di dovuta diligenza che utilizza, salvo il caso in cui ricorra ad un sistema di dovuta diligenza messo a punto da un organismo di controllo di cui all'articolo 8. I sistemi di supervisione esistenti ai sensi della legislazione nazionale e qualsiasi meccanismo volontario di catena di custodia rispondenti ai requisiti del presente regolamento possono fungere da base per il sistema di dovuta diligenza.

Coniolo, li 17.07.2013

IBL SpA
Massimo Bonzano

Figure 21 - IBL – Conformity to Regulation 995/2010

POPLAR PLYWOOD AND BLOCKBOARDS FROM IBL ARE CERTIFIED PEFC™.

The Programme for the Endorsement of Forest Certification (PEFC - http://www.pefc.org/) is an international non-profit, non-governmental organization dedicated to promoting Sustainable Forest Management (SFM) through independent third-party certification.

PEFC works throughout the entire forest supply chain to promote good practice in the forest and to ensure that timber and non-timber forest products are produced with respect for the highest ecological, social and ethical standards. Thanks to its eco-label, customers and consumers are able to identify products from sustainably managed forests.

Today, PEFC includes 40 national members among its membership, which is also open to international stakeholders such as civil society organizations, businesses, government entities and intergovernmental bodies.

IBL owns the PEFC certification since many years. However, the attention of IBL for the environment of forests has been confirmed in the I-PAN project, through the use of both poplar wood coming from managed forests and recycled wood.

3.3 STELA

Stela Laxhuber GmbH is an internationally active SME in the field of drying technology. STELA already installed more than 3 500 drying plants are used in the most various product divisions and branches: agricultural products, food, sawdust, wood chips, bark, green waste, sewage sludge, sunflower seed, straw; pellet industry, pulp and paper industry, wood gasification, biomass to liquid, chipboard industry.

STELA has been chosen by the project coordinator because of its profile of highly innovative SME in the area of drying system technology, with particular reference to the related environmental aspects.

Besides I-PAN, the attention of STELA towards the sustainability of its processes and products is demonstrated by the following projects, developed in parallel with I-PAN in the field of drying technologies.

LOW TEMPERATURE BELT DRYER

STELA has had a defining impact on the development of this technology and today is market leader with more than 150 low-temperature belt dryers in operation worldwide. Belt dryers are used in a wide range of industrial branches and product divisions: pellet industry; wood products industry; pulp and paper industry; sawmills; biomass power plants.

One of the greatest benefits of the belt dryer is its use of **low-temperature heat sources**, which are frequently available as waste heat. Belt dryers use lowest temperatures from 30°C and multi-stage heating circuits. Usual heating medias are for example: hot water from cogeneration (CHP, ORC), hot water from flue gas condensation, low-pressure steam and thermo-oil.

Figure 22 - Stela's low temperature belt dryer

The main features of the dryer lines related to **environmental benefits** are:

- Guaranteed low dust emission values in accordance with the German Pollution Control Act (BImSchG/TA-Luft);

- Multi-Vent system with multiple directly coupled, low-noise radial fans for continuous air distribution with minimal pressure loss and noise emissions;

- Low thermal and electrical consumption values by optimally synchronized components;
- Insulated dryer body;
- Product turning device for an uniform final moisture and energy-saving ventilation of the product.

The main environmental achievements are:

- Reduction of exhaust air;
- Reduction of emissions;
- Reduction of specific thermal consumption.

AGRODRY®-PLANT WITH STELA BITURBO TECHNOLOGY

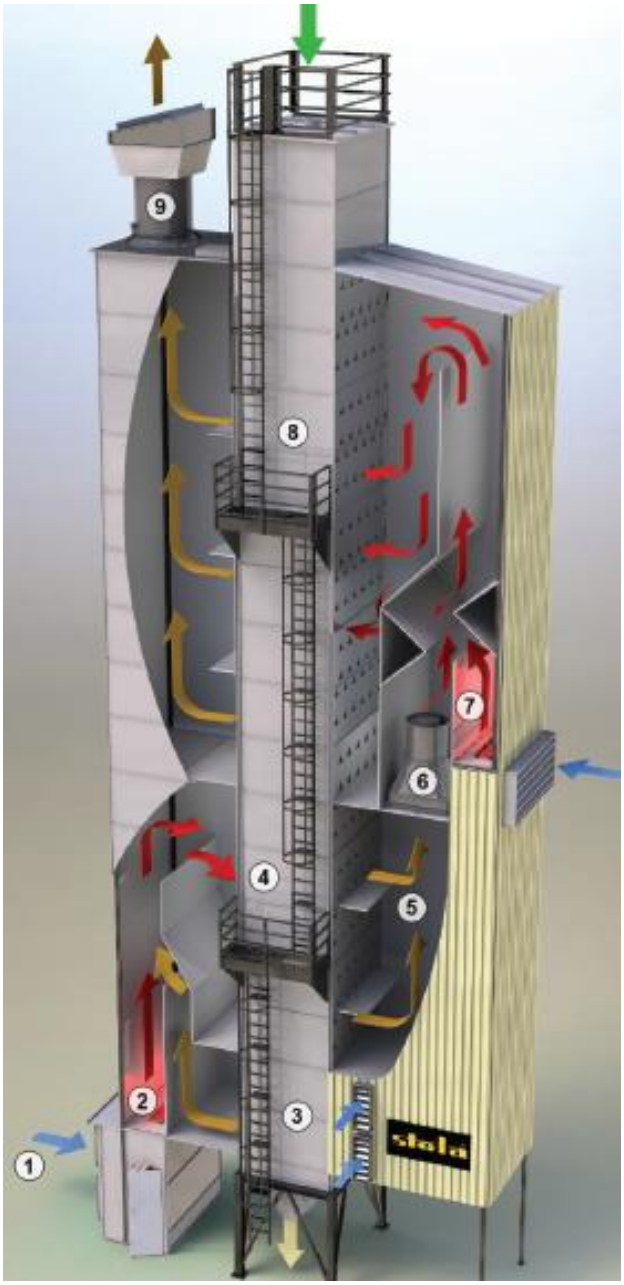

Figure 23 - AgroDry®-plant with STELA Biturbo Technology

The innovative air duct system of the STELA Biturbo technology **reduces the required hot air volume by up to 40 %** and thus **lowers the specific energy consumption by up to 15 %** compared with conventional drying plants with active heat recovery.

The fresh air (1) is aspirated in the lower area of the drying plant, heated up by a gas line burner (2) and led into the lower drying section, the product area (4), together with preheated air from the cooling zone (3). The hot air temperature can be adjusted completely independent from the upper temperature zone. The higher tempered exhaust air (5) from this zone is collected and led into the upper zone of the drying plant by means of an intermediate fan (6). The hot air of the upper drying zone is generated by mixing with preheated supply air (7). This drying air is at first led through the upper wet product zone (8), before it is emitted outside again as exhaust air by an exhaust air fan (9).

Advantages compared with conventional drying plants with active heat recovery:

- Lower thermal consumption (reduction by up to 15 %);

- Reduced air volume;

- Improved product quality by alternating ventilation;

- Lower dust formation due to exhaust air filtering in the wet product zone;

- Lower electric consumption values.

3.4 CHIMAR

CHIMAR is a Greek SME developer and provider of industrial technology for producing adhesive resins and chemical additives applied in the manufacture of wood panels. CHIMAR develops and provides technology in its field for more than 35 years. It serves resin and panel industries worldwide (in America, Africa, Europe, Asia and Oceania), thus being in the position to provide product technology satisfying the most stringent and demanding regulations.

Furthermore, it has a long R&D expertise by undertaking and implementing R&D projects in collaboration with established research and industrial organisations of the field, creating knowledge networks with the expertise and infrastructure that are needed to develop new products and technologies.

CHIMAR is also a pioneer in the field of **reduction of the formaldehyde emission** from wood panels (formaldehyde has been classified by the recent European regulation No 605/2014 of 5 June 2014 as "Carc. Cat. 2; R45 - May cause cancer"). Following a process of continuously experimenting at laboratory, pilot and industrial scale, CHIMAR has developed effective resin systems for low emission particleboard, MDF and plywood.

The I-PAN project has further contributed to the development of CHIMAR's process of "green" innovation, promoted by the company through the participation in many others European and national projects in fields strictly related to those developed within I-PAN and in which CHIMAR has been involved in recent years, some of them being still ongoing.

3.4.1 EUROPEAN R&D PROJECTS

H2020-637020-MOBILE FLIP

Mobile and Flexible Industrial Processing of Biomass aiming at developing and demonstrating mobile processes for the treatment of underexploited agro- and forest based biomass resources into products and intermediates. *(http://www.mobileflip.eu/project.htm).*

The project, started in January 2015, aims at developing and demonstrating mobile processes for the **treatment of underexploited agro- and forest based biomass resources into products and intermediates**.

The processes is evaluated in terms of raw material flexibility, as the biomass resources are typically scattered and seasonal. Process concepts have been designed around the key technologies pelletizing, torrefaction, slow pyrolysis, hydrothermal pretreatment and carbonisation. The products vary depending on the process concept, being typically fuels as such or for co-combustion (pellets, torrefied pellets, biocoals), biochars for soil remediation, biodegradable pesticides for agricultural or forestry use or chemicals for wood panel industry and sugars and hydrolysable cellulose as intermediate for the sugar platform. During the project a life-cycle analysis and a wide sustainability evaluation (economic, environmental and social assessment) will be carried out for the process concepts in order to clarify their potential for flexible raw material valorisation.

The participation in the MOBLIE FLIP project confirms the attention of CHIMAR towards the theme of protection of the environmental resources.

LIFE13 ENV/IT/000996-GREENJOIST

Production of recycled high quality joists from wood waste. *(http://www.greenjoistproject.eu/it/)*

LIFE+ GREENJOIST, started in July 2014, aims at demonstrating the value and feasibility of an eco-innovative recycling process, able to **reuse and valorize wood waste to produce green, high quality and cost-effective joists** to be used in different sectors such as manufacturing, transportation, logistics and construction. This will contribute to the consolidation of sustainable eco-innovative businesses in the EU woodworking industry, contributing to the achievement of EU 2020 goals of Resource Efficiency, avoiding dangerous impacts on human health and the environment. With a potential to substantially cut the currently landfilled wood waste, amounting to 15 Mln tons per year, the LIFE+ GREENJOIST project has set out a well-structured plan with the following key objectives:

Figure 24 - GreenJoist project: wood waste and joists

1) Showcase an innovative process for the production of high-quality, cost-effective joists from recycled wood waste through the realization of a pilot plant at pre-industrial, non-commercial scale demonstrating the feasibility and effectiveness of this novel recycling process.

2) Foster a sustainable society and economy where waste, which is both harmful and costly, is used as a valuable resource and manufacturing is committed to the environment.

3) Increase awareness of eco-innovative solutions in both the general public, policy makers and woodworking industry, focusing on the environmental and economic advantages as well as on their technical feasibility.

4) Avoid the use of virgin wood in the construction of new joists and pallets, saving trees while cutting the generated CO2 emissions for the transportation and processing.

5) Promoting the shift from using potentially harmful chemicals to natural components in the woodworking industry.

As in the I-PAN project, the objective is to valorise the renewable resource "wood", using recycled wood to reduce pressure on the environment.

FP7-613588-MIRACLES

Development of a multi-product integrated biorefinery for high-value specialties from algae for application in food, aquafeeds and non-food products. *(http://miraclesproject.eu/).*

MIRACLES, started in November 2013, is an industry-driven R&D and innovation project aimed at developing integrated, multiple-product biorefinery technologies for the production of specialties from microalgae for application in food, aquaculture and non-food products.

Microalgae are a promising feedstock for the sustainable supply of commodities and specialties for food and non-food products. Despite this potential, implementation to date is limited, mainly due to unfavourable economics. Major bottlenecks are the lack of available biomass at acceptable costs and the absence of appropriate biorefinery technologies. The 4-year MIRACLES project aims to overcome these hurdles with the development of an **integrated, multiple-product biorefinery** for valuable specialties from algae for application in food, aquafeeds and non-food products.

The focus is on the **development and integration of mild cell disruption and environmentally-friendly extraction and fractionation processes**, including functionality testing and product formulation based on established industrial algal strains. The project will also develop new technologies for optimizing and monitoring valuable products in the algal biomass during cultivation. An innovative photobioreactor and an improved harvesting technology, combined with medium recycle technologies, will enable substantial cost reduction in algal biomass production.

The project has a multidisciplinary approach. To achieve the ambitious objectives of the MIRACLES project a consortium of partners with complementary expertise in all phases of the value chain has been formed, consisting of twenty-six partners from six EU countries, the associated country Norway, and International Cooperation Partner Country (ICPC) Chile, and including 11 prominent research organizations. Strong industrial leadership is guaranteed through the participation of 12 SMEs and 3 end users.

The project concerns issues slightly different than those of I-PAN, but in line with its environmental objectives.

FP7-605236-ECOPRESSWOOD

Focusing on the development of formaldehyde-free adhesive resins for wood based panels using as raw materials residues from biodiesel production, to be cost competitive and environmentally friendly. *(http://www.ecopresswood.eu/)*

Figure 25 - ECO-PRESSWOOD project

Pressed wood panels are composed of chopped or cut wood that are glued together using adhesives. Most of these resins are petroleum based products containing a hazardous chemical: **formaldehyde**. The acceptable levels of formaldehyde in wood pressed products have been reduced over the past decades due to increased public awareness on its effects on health and the consequent consumer demand for non-hazardous products.

The current situation in Europe is that the Committee for Risk Assessment of the European Chemical Agency has recommended reclassifying formaldehyde from category 2, "probably carcinogenic to humans" to category 1B "substance which is presumed to have carcinogenic potential for humans". This reclassification is expected by 2015 and it will surely have an impact on EU standards with regards to formaldehyde emissions from wood panels. In turn, this will affect the competitiveness of European woodworkers who will be forced to **reduce, or even eliminate, the use of formaldehyde resins** in wood panels.

The **development of efficient renewable resins** to substitute petroleum formaldehyde based adhesives is one of the biggest challenges for the Wood Industry. To do so, the ECO-PRESSWOOD project, started on the 1 March 2014, aims to develop "formaldehyde free" wood based panels that combine bio-based chemistry, nanotechnology and process engineering.

To be **cost competitive and environmentally friendly**, this new resin will be produced from residues of biodiesel production. The performance of the bio-panels will be increased by ceramic nanoparticles that will provide extra reinforcement. Moreover manufacturing processes will be researched to integrate both developments.

The R&D activities aiming at obtaining free formaldehyde glues to be used in the construction of wood panels, already started in this FP7 project, are then continued in the I-PAN project, allowing the realization of panels with a very low content of formaldehyde in line with the most stringent regulations.

3.4.2 GREEK NATIONAL R&D PROJECTS

09SYN-81-715-BIOREF

Development of biorefinery for the valorization of biodiesel production residues to produce biodegradable polymers & high added–value products.

The main objective of BIOREF research project, ended in August 2014, was to ensure viability of **sustainable development** through the development of **bio-refineries that convert renewable raw materials** through integrated physical, (thermo)chemical and biological processes into the same or new products that are currently derived through (petro)chemical processing.

BIOREF was co-funded by the National Strategic Reference Framework (NSRF) Programme, the European Regional Development Fund and the participating organisations. The focus was on the development of a novel bio-refinery that utilises residual streams from a first generation sunflower biodiesel production industrial plant for the production of biodegradable plastics with potential application in food packaging, value-added food additives and biomaterials.

The role of CHIMAR within this project, which developed in parallel with I-PAN, was the development of novel bio-based adhesive systems using sunflower cake protein, such adhesive system finding application in the production of wood-based panels, the same final products of the I-PAN project.

12CHN322-FIBRACOM

Development of new lightweight and nanotechnology enhanced bio-composites from kenaf, hemp and jute. *(http://fibracom.physics.auth.gr/)*

This project, started in April 2013, is supported by the Greek National Competitiveness and Entrepreneurship Programme (National Strategic Reference Framework 2007-2013) and the European Regional Development Fund under the Project: New Lightweight and Nanotechnology Enhanced Bio-composites from Lignocellulosic Materials.

FIBRACOM aims at the development of new lightweight, nanotechnology enhanced bio-composites for multiple applications. The composites will exhibit innovative properties, namely it will be water repellent and oleo-phobic along with superior strength compared to their counterparts already available in the market. The ultimate target is the development of lower price and higher performance novel composite materials **utilizing renewable sources**.

Two types of resins will be used, i.e., phenolic (phenol-formaldehyde) and epoxy resins, as the polymeric substrate. These thermoset polymers will be reinforced with cellulosic (nano)fibers for potential use in automotive interior substrates, construction and infrastructures, window pillars, package tray or trunk liner, and particleboards with wide application in furniture and interior constructions. The lignocellulosic (nano)additives will originate from kenaf, hemp and Juta, while the polymers will be synthesized from monomers derived from renewable resources (e.g. soy and Cashew nut shell liquid or triglycerides). **The resulting composites and respective end products will be completely biodegradable materials and thus friendly to the environment**.

Figure 26 - FIBRACOM project

The project is based on the collaboration of several partners with complementary expertise. The Chinese partners (IBFC-CAAS) will provide lignocellulosic fibers and shieves as well as seeds of high quality whose cultivation will be tested for first time in Europe (Greece) from the Greek partner CRES, which will provide also kenaf fibers. The Greek University (AUTH team) will work on the production of cellulosic nano-sized fibers/particles by applying advanced physicochemical methods and will study the fabrication of (nano)composites using these nanofibers. The Dalian University will work with the Greek University (AUTH) on the development of novel nanocomposites and on the harmonization of the testing procedures. Chimar S.A. will produce particleboards from shieves and thermosetting resins enhanced with (nano)additives, while AUTH will also prepare (nano)composites based on epoxy bio-resins.

As in I-PAN, the project focuses on the issues of environment protection, use of renewable resources and sustainability.

11SYN-8-944-FORECO

Development of bioenergy and recycled wood products from forest residues & wood by-products.

The project originates from the same environmental considerations made in I-PAN in reference to the use of wood resources and allows CHIMAR to continue with the activities started in I-PAN.

In fact, nowadays considerable amounts of forest residues and wood industry waste are produced but remains unexploited, posing a threat to the environment and depriving the pool of resources of valuable renewable material. FORECO project aimed to conceive, investigate, analyze and demonstrate a comprehensive and ready to put in place system for the **exploitation of forest residues and wood industry waste either as a source of energy or as a recyclable material**, complying with/aiming to fulfill the sustainability objectives of the **Green economy**. This Greek national project involved a network of collaborating partners (University, Research Institution, Environmental Technology Company, Wood and Cement Industries, Wood Product Manufacturers, Resin & Wood Panel Technology Provider, Local Municipality). Particular emphasis was placed on dissemination activities, networking with local communities, forest associations, forest owners, wood manufacturers and other interested stakeholders.

The project (October 2013 – June 2015) was co-funded by the National Strategic Reference Framework (NSRF) Programme, the European Regional Development Fund and the participating enterprises. In this project CHIMAR work was focused on the development of new products resulting from recycled wood. Environmentally friendly composites were produced from low quality wood residues stemming from forests and wood industry waste, thus replacing quality wood either partially or totally.

3.4.3 CHORUS CLEAN ENERGY CLUSTER

CHIMAR is a member of the **CHORUS Clean Energy Cluster** (http://www.chorustcluster.org/), the Greek cluster which brings together companies and research entities in order to establish an arsenal of **renewable and zero/low carbon footprint technologies, transformable into innovative, integrated products and solutions for the global Clean Energy and Green Mobility markets**.

Exploiting the available natural resources, the existing regional industrial specialization, the human, technical and scientific resources in the region, CHORUS Clean Energy Cluster puts in sight:

- Solar fuels and fuels with zero/low CO2 footprint
- Energy from waste (urban, agricultural)
- Hybrid systems for the production/storage of energy
- Low CO2 footprint industrial processes
- Smart systems for vehicles' emissions control
- Recharging stations for electric vehicles
- Sustainable and green transportation systems
- "Smart" ports and "gates", specialized logistics hubs

The CHORUS brings together enterprises and research laboratories located primarily in the Region of Central Macedonia in Greece. It builds on the work ethic of the region's workforce, a pool of knowledge and labour that has been known throughout Greece for excellence and innovation in the Clean Energy/Green Mobility area. Encompassing the advantages of the Region's geography, its access routes (the Egnatia highway, the Port of Thessaloniki, the Makedonia Airport and the Railway connections) the natural resources (sun, fossil fuels) and existing industrial specialisations (refineries, steel industry,

ceramics, construction, waste processing, information and automation, etc) that can provide diverse opportunities in the cluster's thematic area.

CHORUS targets are companies / organizations with a range of technology products and solutions that are relevant for the development of **clean energy, including low carbon energy, renewable energy and energy efficiency**; that are heavy energy users and could use clean energy technologies and solutions with other products and services that are relevant for the development of innovative integrated clean energy solutions, such as logistics, information technologies, etc.; that can provide services in the areas of networking, knowledge transfer, business incubation and financing.

CHORUS Cluster fosters an environment that provides unique opportunities for cooperation, creativity and innovation. Its members can better source new knowledge and pursue innovation opportunities through stronger links with companies, research organizations, service providers and other innovation stakeholders that have strong track record of excellence in the cluster's thematic; and take advantage of economies of scale and shared resources.

The participation of CHIMAR in the I-PAN project has coincided with company's entry as member in the CHORUS cluster: CHIMAR has in fact applied for the CHORUS cluster proposal in September 2012,at the beginning of the I-PAN project, and the participation of CHIMAR in CHORUS officially started in October 2013, during the course of project activities.

4 CONCLUSIONS

The I-PAN project will allow to achieve significant environmental benefits, as evidenced by the LCA study performed in the deliverable D2.6, where benefits are expressed in terms of GWP as kg of CO2eq saved by the new process / product compared to the traditional processes / products.

In addition to the results closely related to the innovations introduced by the project, I-PAN has enabled partners to face the issues of environmental protection promoted by the 7th Environment Action Programme, in line with the Eco-Management and Audit Scheme (EMAS) guidelines.

However, as evidenced by this deliverable, the project is part of a broader process of attention to the environmental issues undertaken by the I-PAN partners and witnessed by the numerous initiatives, activities, projects, products and in general green solutions adopted by partners in the various areas related to their activities and encouraged by their participation in the I-PAN project.