Document Title	IMAGINE Final Publishable summary
Issue date	16.6.2014

Eco-Design for Airframe

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Title	"Integrated Approach to Manage Glass Fiber Aircraft Insulation Waste"
Starting date	1.9.2012
End date	30.4.2014
Project Period	2nd (12-20 months)
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Approval	Topic Manager:	Date and Signature
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Final publishable summary report

Grant Agreement number: 323395

Project acronym: IMAGINE

Project title: Integrated Approach to Manage Glass Fiber Aircraft Insulation Waste

Funding Scheme: SP1-JTI-CS-2012-01-ECO

Date of latest version of Annex I against which the assessment will be made: 12.09.2012

Periodic report: 1st ☐ 2nd ☒ 3rd ☐ 4th ☐

Period covered: **from** 01/09/2012 **to** 30/04/2014

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[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement.

[2] The home page of the website should contain the generic European flag and the FP7 logo which are available in electronic format at the Europa website (logo of the European flag: http://europa.eu/abc/symbols/emblem/index_en.htm logo of the 7th FP: http://ec.europa.eu/research/fp7/index_en.cfm?pg=logos). The area of activity of the project should also be mentioned.

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Declaration by the scientific representative of the project coordinator

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;
- The project (tick as appropriate) [3]:

  ☒ has fully achieved its objectives and technical goals for the period;

  ☐ has achieved most of its objectives and technical goals for the period with relatively minor deviations. Some delay in proper useable material acquisition

  ☐ has failed to achieve critical objectives and/or is not at all on schedule.

- The public website, if applicable

  ☒ is up to date

  ☐ is not up to date

- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 3.4) and if applicable with the certificate on financial statement.
- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 3.2.3 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of scientific representative of the Coordinator: Constantina-Dia Andreouli .....

Date: 16/06/ 2014

For most of the projects, the signature of this declaration could be done directly via the IT reporting tool through an adapted IT mechanism and in that case, no signed paper form needs to be sent

[3] If either of these boxes below is ticked, the report should reflect these and any remedial actions taken.

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3.1 Publishable summary (1-20 months period)

Summary description Concept of project context and objectives

Insulation material is applied in aircraft (a/c) structures mainly for thermal insulation. The goal of topic JTI-CS-2012-1-ECO-01-045 is to identify and test the recycling options of the a/c insulation system, including description of the proposed recycling process and production of recycling samples.

The main parts of the a/c insulation material are:

- glass wool (resin coated fibers) and
- polymeric foils/bags, reinforced with long fibers.

Among the various insulation materials of the European market, inorganic fibrous materials (in particular glass-fiber insulation or glass-wool) are those most frequently used covering almost 60% of the market. However, despite the large volumes of glass fiber insulation materials used in buildings, aircrafts, etc., the majority of relevant waste, whether from manufacturing, installation or end-of-life, is currently being land filled.

The concept of the present project lies in the full recovery of glass-fiber aircraft (a/c) insulation materials and the recycling of their constituents into new, competitive materials for building applications. This objective is of high importance as today there are only limited recycling options for such insulation materials and environmental, economic and technological benefits are expected from the establishment of the proposed recycling routes.

These goals were implemented in the following steps:

- Following the acquisition and characterization of the end-of life a/c insulation materials, their individual constituents were recovered and characterized to assess their processability using different recycling routes.
- Both primary and secondary recycling of a/c insulation materials were examined.

Primary recycling covers: a) recycling of the polymeric materials into new samples, b) recycling of the recovered glass fibers for the development of polymer and cement/concrete composites.

Secondary recycling covers thermal treatment of fibers in order to generate a) new insulation materials in a closed-loop recycling scheme and b) clay bricks for building applications.

The project envisages utilization of the end of life a/c insulation materials for the development of the following products for the construction sector:

- *New insulation materials, incorporating recycled glass wool fibers.*
- *Cement/concrete composites and clay bricks, incorporating the recovered glass wool fibers.*
- *Polymer composites incorporating the polymeric bags.*

The current project objective is a particular challenge for the development of new materials as there are only limited recycling options for such insulation material and most of the works up to date use alkali resistant glass fibers, waste glass and waste plastics for construction materials and not recycled glass wool fibers.

Nowadays, thousands tons of glass fibers are deposited to landfills every year and together with end of life glass wool waste, result into millions of euros losses of potential product, because of the inability of scrap or waste product to be recycled.

For the new insulation materials, production in an industrial scale is attempted while for the other products the work includes development of test specimens and characterization. For these materials companies from the construction sector will be invited to express their interest for further exploitation of the developed technologies.

Description of work and main achievements

During the course of the project, the consortium, with the topic manager assistance and supervision, worked closely together and organized work in three technical work packages (WPs: 2,3,4).
Within the project, deliveries of two batches of end-of-life aircraft insulation materials were realised after dismantling of two aircrafts and full characterisation carried out for both materials. However, further processing, with separation of the polymeric bags from glass wool and shredding, was carried out only for the first delivery of a/c insulation material since the characterization results of

both insulation materials, showed that they could be potentially hazardous for health. Therefore, as their production date was before 1995 they were considered carcinogenic and the consortium decided to continue the experimentations with commercial insulation materials exhibiting similar characteristics to the insulation material currently used in aircrafts and from the old insulation material to use only the polymeric bags for recycling.

The polymeric bags were separated from the insulation material and further processed by shredding and densification in order to produce polymeric pellets ready to be used used for the production of the various new products. Furthermore, within WP2, two commercial insulation materials with recent production date (2013), where purchased and after their characterizations, they were shredded and used for the production of the various new products in the next WPs.

In WP3 which addresses primary recycling of materials, the recovered glass fibers derived after shredding and cutting and the polymeric bags were utilised for the development of cement/concrete composites and polymeric composites.
Various formulations of concrete samples incorporating different ratios of glass wool, as an aggregate partial replacement, were developed and specimens of lightweight concrete, cladding panels and paving blocks were produced.

The lightweight concrete samples produced with incorporation up to 17% w/w of chopped glass fibers, as replacement of sand, exhibit very good mechanical properties.

As alkali-silica Reactivity (ASR) between glass and the alkaline environment of the concrete mixtures is an undesirable phenomenon which can cause serious deterioration of the concrete properties, a local natural super pozzolan was used at appropriate proportions in order to minimize Alkali-Silica-Reactivity (ASR) and to promoting pozzolanic reactivity and also a special test method, which is used for testing potential Alkali-Silica Reactivity of Aggregates, was used for glass fibers. The study showed that glass fibers, in the percentages used for the production of the current cementitious products, are considered innocuous.

The cladding panels produced with incorporation of 3-10% w/w of chopped GF as replacement of sand exhibit similar mechanical and physical properties compared to the blank ones. The cladding

panels, produced with incorporation of pellets from recycled polymeric bags as substitution for sand, exhibit improved mechanical properties for percentages up to 17% w/w.

The chopped glass fibers were also incorporated in the production of paving blocks. The test samples produced at lab scale using a conventional pressing machine although exhibited good characteristics, they did not fulfill the requirements set by relevant standards due to the absence of vibration during the shaping production process. In case a special pressing machine that incorporates vibration and compaction is available, paving blocks with satisfactory characteristics can also be produced.

Therefore, the recycled polymeric bags and the glass wool can effectively be used up to a certain percentage for the production of cladding panels and lightweight concrete with good mechanical and physical properties implying that such products can easily reach a competitive market.

The recycled polymeric bags and the shredded glass fibers were also used for the development of polymeric matrix composites by the injection molding process. According to the results of the present study, production of polymer products can be an effective way for primary recycling of end-of-life glass fibers as the new developed products provide an environmental friendly profile in combination with adequate properties.

The WP4 addresses secondary recycling routes for the development of new products, involving thermal treatment of glass fibers. The shredded glass fibers were incorporated in a clay matrix and test samples of clay bricks sintered at various temperatures were produced, exhibiting similar properties with the reference samples in terms of mechanical properties and porosity but using a lower sintering temperature.

Besides, the glass fibers derived after shredding were also used for the production of new insulation glass wool material and new materials were produced.

This new insulation material has an improved environmental profile and a smaller CO2 footprint as it uses: a) recycled a/c glass wool fibers and b) recycled polyester fibers (from PET bottles) and c) bio-component fibers. The results of this study have shown that recycled a/c glass wool fibers can be effectively used for the development of new insulation materials exhibiting satisfactory

properties compared to existing commercial products while having an enhanced environmental profile, which also which implies that they can easily reach a competitive market..

In the fifth WP, exploitation and dissemination of project results have been carried out including participation in scientific conference, project web site, and technology transfer through Enterprise Europe Network.

Expected final results and their potential impact and use

Despite the large volumes of glass fiber insulation materials used in aircrafts and buildings, the majority of relevant waste, whether from manufacturing, installation or end-of-life is currently being landfilled. Considering the economic and environmental costs of landfilling or burning, the need to adopt no-waste technology and to encourage reuse and recycling routes of glass fiber insulation materials becomes obvious. Increasing the rate of recovery and reuse of such waste material will assist in the protection of human health and the environment contributing also to the conservation of energy and natural resources.

Of course in order to support the recycling and reuse of these materials it is important to assure that the production of the new developed materials would be economically feasible with products that combine high-quality characteristics, reduced cost and are environmentally friendly.

In this context and in line with the concept of the topic addressed, the present project aims to establish and implement alternative recycling processes in order to exploit materials recovered from glass-fiber a/c insulation in building applications. It was proved that this approach not only help protecting the environment and public health but also offer new “greener” products to the construction sector.

There are many ecological, economic and engineering benefits of utilizing recycled materials in the construction sector. Ecological or environmental benefits include the diversion of non-recycled waste from landfills for useful applications and the reduction in the consumption of non-renewable natural resources. The economic benefits are obviously best realized when the cost of the new developed material is less or comparable to market products of comparable performance.

This cost must consider the source of the alternative material, its transportation, processing, and should consider savings through diversion, such as tipping fees and landfill management costs.

The results of the work carried out in the current project and the produced: a) new insulation glass wool materials, b) the clay bricks, c) the cementitious materials and d) the polymeric composite materials, hold the promise of real industrial exploitation.

a) Regarding the insulation materials the study showed that a/c glass wool fibers and PET recycled fibers can be effectively combined for the development of new insulation material and this product will be exploited through the industrial partner.

b) Regarding clay bricks, the study showed that glass fibers can be effectively incorporated in the clay matrix. The most important is that the addition of recycled glass fibers in clay bricks allows the sintering in a much lower temperature resulting in a significant energy cost reduction, without deterioration of their properties. The evaluation according to European standards of the small clay bricks produced in a pilot scale showed that they exhibit satisfactory properties compared to the commercial products and can easily reach a competitive market.

c) Regarding the cementitious composite materials incorporating recycled a/c insulation glass wool or recycled polymeric bags up to a certain percentage, it was proved that cladding panels and lightweight concrete samples produced in lab scale exhibit good mechanical and physical properties implying that such products can easily reach a competitive market while paving blocks with satisfactory characteristics can also be produced provided that a special pressing machine that incorporates vibration and compaction is used,

d) Regarding the polymeric composite materials, according to the results of the present project, production of polymer products can be an effective way for primary recycling of end-of-life glass fibers as the new developed products provide an environmental friendly profile in combination with adequate properties.

The insulation glass wool products were demonstrated in an industrial scale and this product will be exploited through the industrial partner. The clay bricks, the cementitious and the polymeric composite materials were produced in a lab or a pilot scale from the industrial Research and Technology center and as the company is acting as the national certification body with owned labs

for quality control and building materials certification, has already started contacts with various companies from the construction sector in order to further exploit the results industrially.

The IMAGINE project website is: http://www.imagine-cleansky.eu

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