



Industrial Production Processes for Nanoreinforced Composite Structures

Life Cycle Assessment



This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under the Grant agreement no 608746.



What is the purpose of this project?

The main objective of the INCOM project is to develop techno-economical production methods for manufacturing of lightweight structures based on advanced sustainable materials for use in vehicles, aeronautical applications and sporting goods. Special attention is dedicated to upscaling of production processes and pilot scale trials.

Can you explain this in other words?

Lightweight and resistant **composite sandwich structures** are developed and manufactured for different applications. These structures are reinforced with **nanofibrillated cellulose** (NFC), a **nanoscale material** derived from cellulose found in biomass and biowaste.

Glossary

Sandwich composites materials: a sandwich structure is a fabricated material that consists of two thin, stiff facing sheets joined to either side of a low density core material. They have high mass specific stiffness and strength and the peculiarity of being lightweight. (source: Best Practice Guide for Sandwich Structures in Marine Applications www.transportresearch.info)

Nanomaterials: materials with at least one external dimension in the size range from approximately 1-100 nanometers (source: web.stanford.edu).

Nanofibrillated cellulose (NFC): nanoscale cellulose composed by long and semi-flexible fibrils obtained by topdown disintegration of wood or other plant materials (source: Lee et al. 2014, Comp. Sci. Technol, 105 1527).

Life Cycle Assessment (LCA): a methodology to assess the potential environmental impacts of a product, process or service along its entire life cycle, from cradle to grave, through the extraction of raw materials, production, transport, use until disposal. LCA has been standardized in ISO 14040-14044.

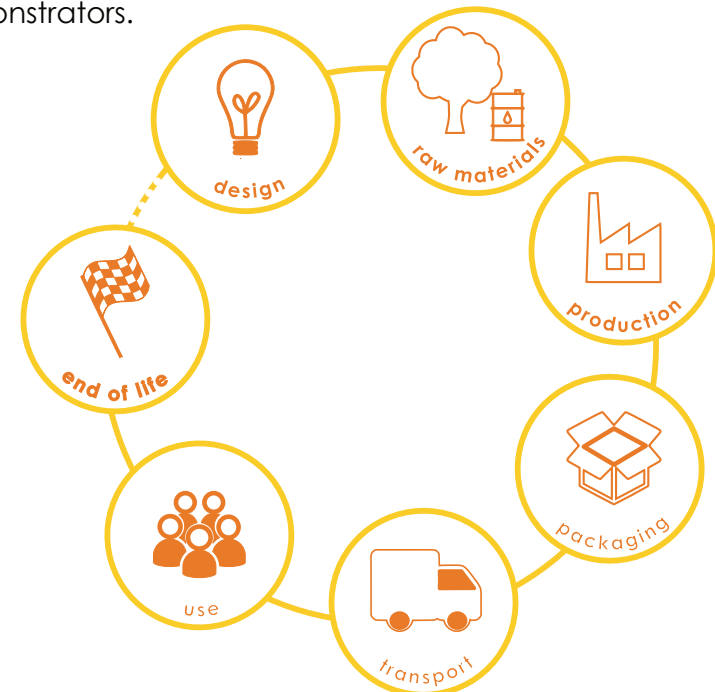
What is Life Cycle Assessment?

Life Cycle Assessment (LCA) is a well known analytical tool to evaluate the environmental impacts of a product, process or service along its entire life cycle.

When performing an LCA study, a lot of data are collected during the inventory, which are aggregated into indicators during the impact assessment.

LCA has widespread applications in product development and ecodesign, policy making, ecolabelling and green procurement.

Within the INCOM project, LCA has been used to assess the environmental impacts associated with the novel technologies developed during the project. LCA studies have been performed as the project evolved to provide ongoing ecodesign feedback both for the technologies and the demonstrators.



NFC production from carrot residues

a. original process



b. process after LCA-based ecodesign feedback

How have LCA and LCC been used to improve the NFC production?

During the INCOM project the production of nanocellulose from carrot bioresidues has been evaluated with LCA and LCC, from lab scale to pilot scale, in order to provide ecodesign feedback during each stage of development.

- **Steps of the original process for the NFC production:** washing, alkali-treatment, bleaching, washing and Masuko grinding, as shown on page 4.
- **Environmental hotspots identified with LCA:** chemicals and electricity consumption.
- **Ecodesign improvement:** LTU redesigned the production process omitting the pre-treatment step, as shown on page 5.

After the initial LCA that identified the environmental hotspots, a comparative LCA/LCC has been done in order to check the eco-efficiency of the new process. The functional unit is defined as 1 kg of NFC water dispersion (2%), corresponding to a dry weight of 20 g NFC. The results of the combined LCA/LCC are very promising:

- **LCA:** the environmental burden has been reduced by a factor of 4 due to a higher NFC yield and reduced consumption of chemicals, energy and water.
- **Carbon Footprint** has been reduced from 234 g CO₂ eq. to 58,6 g CO₂ eq.
- **LCC:** life-cycle costs went down by a factor of 2, from 0,90 euro to 0,42 euro.
- **Eco-efficiency:** the new process shows a clear win/win situation, in terms of both costs and environmental impacts.

What is Life Cycle Costing?

Life Cycle Costing (LCC) is an economic assessment of all costs related to a product or service over its entire life cycle, from materials, transport, production until use and disposal. In the INCOM project, LCC is performed in parallel with LCA, applying the same functional unit and system boundaries. Monetization of environmental impacts is omitted, in order to avoid double counting with LCA results. Combining LCA and LCC has enabled to evaluate the eco-efficiency of each technology and demonstrator.

Which demonstrators have been assessed with LCA and LCC?

LCA and LCC assessment has been performed for the following demonstrators and, when possible, a comparison has been made with a baseline product:

- The prototype of a bulkhead, aiming at the application of nano-fibrillated cellulose and honeycomb materials to the automotive sector.
- Ski poles demonstrator, to evaluate the potential of nano-fibrillated cellulose epoxy resin in the sporting sector.
- The prototype of an aircraft interior part, a doghouse, to test nano-fibrillated cellulose and honeycomb materials for aeronautical applications.

