LIFE-C: PROMOTING LIFE CYCLE THINKING IN HIGHER EDUCATION

Lidia Lombardi[1], Gabriella Arcese[2], Grazia Chiara Elmo[2], Barbara Mendecka[1], Szymon Sobek[3], Krzysztof Pikoń[4], Aleksandra Kuzior[5], Konstantinos Moustakas[6], Maria Kyriazi[6], Mika Horttanainen[7], Kaisa Grönman[7], Mariam Abdulkareem[7], Musharof Khan[7], Aleksandra Woszczek[7]

[1] Università degli Studi Niccolò Cusano: Dipartimento di Ingegneria, Via Don Carlo Gnocchi, n. 3, 00166, Roma, Italia
[2] Università degli Studi Niccolò Cusano: Dipartimento di Scienze Economiche, Psicologiche e della Comunicazione, Via Don Carlo Gnocchi, n. 3, 00166, Roma, Italia
[3] Silesian University of Technology. Department of Heating, Ventilation and Dust Removal Technology, ul. Stanisława Konarskiego 20, pok. B-9, 44-100 Gliwice, Poland
[4] Department of Technologies and Installations for Waste Management, Silesian University of Technology, Konarskiego 18, Gliwice, 44-100, Poland
[5] Department of Applied Social Sciences, Silesian University of Technology, ul. Roosevelta 26-28, 41-800 Zabrze, Poland
[6] National Technical University of Athens. School of Chemical Engineering. Unit of Environmental Science & Technology. 9 Heroon Polytechniou Street Zographou. Campus 15780, Athens, Greece
[7] Lappeenranta-Lahti University of Technology. Department of Sustainability Science. Yliopistonkatu 34. 53850 Lappeenranta, Finland

ABSTRACT: Life cycle thinking is the way of thinking of the consequences in term of environmental, economic and social effects of a product, process or activity throughout its entire life cycle, which includes extraction and processing of raw resources, manufacturing, transportation and distribution, use, re-use, maintenance, recycling, and final disposal. The LIFE-C Project has the objective of raising Life Cycle Thinking awareness of Higher Education students, developing a specific class on Life Cycle Assessment, Social Life Cycle Assessment and Life Cycle Costing, based on innovative teaching methodologies. The three modules will be public and freely available for anyone on the web.

Keywords: life cycle assessment, life cycle costing, social life cycle assessment, life cycle sustainability, teaching

1. INTRODUCTION

Life cycle thinking is the way of thinking of the consequences in term of environmental, economic and social effects of a product, process or activity throughout its entire life cycle, which includes extraction and processing of raw resources, manufacturing, transportation and distribution, use, re-use, maintenance, recycling, and final disposal. The applied methodology to evaluate those consequences is the life cycle sustainability assessment (LCSA), which refers to the three pillars: environment, social and economics. LCSA helps in clarifying the trade-offs between the three sustainability pillars, life cycle stages and impacts, by providing a more comprehensive picture of the positive and negative impacts along the life cycle, supporting decision-making processes towards more sustainable products and processes in a holistic approach.

The environmental aspects are evaluated by the Life Cycle Assessment (LCA), which refers about several environmental impact categories– in a multi-criteria approach - according to three areas of protection: the ecosystem, the human health, and resources. With such a wide view, LCA is able to catch the possible burden shift from one phase of the life cycle to another, or from one impact category to another, when analyzing a product system.

LCA has been applied to several sectors, among which waste management sector collected a large number of theoretical studies and applications to real world, as the support to waste management planning. LCA applications in waste management date back to the late 1990s, with an explicit mentioning of LCA by the Waste Framework Directive (Directive 2008/98/EC) (Sala et al., 2021).

LCA has still a fundamental role in helping the development of waste management system supporting decision (Christensen et al., 2020), and in particular it has a fundamental role in the support to technology development.

Indeed, when developing a new process or technology, meaning characterized by a low Technology Readiness Level (TRL), it is necessary to be aware of the environmental impacts of such a new process, especially in comparison to the existing ones, for the interest of several stakeholders (for instance potential investors, companies, authorities or decision makers). This can be done by applying LCA to the technologies under development, basing the inventory data on theory or lab- or pilot-scale systems or even when the technology is operated as first demonstration, with the aim of understanding possible improvements for the industrial scale replication.

LCA methodology is defined by ISO 14040:2006 standards and is made up of four phases: goal and scope definition; inventory analysis, impact assessment and interpretation.

Similarly, Life Cycle Costing (LCC) and Social Life Cycle Assessment (S-LCA) are able to catch the economic and social aspects, respectively, while considering the whole life cycle.

LCC refers to product, process, or activity over its entire life cycle, aggregating all costs that are directly related to the studied system from resource extraction over the supply chain to use and disposal. It may also take into account external relevant costs and benefits anticipated to be privatized (for example, if it is expected in the future that a new tax on CO_2 will be enforced or a subsidy granted for engaging unskilled people within the next two years, etc..,). Different viewpoints of the life cycle actors - supplier, manufacturer, user or consumer – might be considered, and the conventional cost benefit analysis can be isolated, incorporating only private costs and benefits, to calculate the conventional economic indicators. There is not any international standard or any internationally acknowledged methodology to carry out LCC, up to now.

SLCA focuses on the real and potential social aspects of a product, process, or activity throughout its life cycle stages, taking into account various social factors such as human rights, labor conditions, health and safety, community well-being, and the overall social equity of the involved processes.

S-LCA makes use of generic and site-specific data, can be quantitative, semi-quantitative or qualitative, and complements the environmental LCA and the LCC. Presently, ISO standards devoted to S-LCA are not available yet (ISO/FDIS 14075 is under development and planned for the end of 2024). Although S-LCA follows the ISO 14040 framework, some aspects differ, are more common or are amplified at each phase of the study. The UNEP Guidelines for Social Life Cycle Assessment of Products and Organizations (UNEP, 2020) proposes a methodology to develop life cycle inventories, based on identifying social and socioeconomic impacts on six main stakeholder categories: (i) workers/employees; (ii) local community; (iii) society (at national and global levels); (iv) consumers; (v) value chain actors and (vi) children. The stakeholder categories provide a comprehensive basis for the articulation of the subcategories. For each category, several sub-categories are identified which are classified according to stakeholders as well as impacts. The inventory is elaborated for indicators (e.g. number of jobs created) linked to impact categories (e.g. local employment) which are related to the five main stakeholder groups.

The UNEP Guidelines neither propose impact assessment methods and models nor interpretation

approaches. Inventory results should be judged based on national requirements and ethical concerns carefully.

The application of LCA, and more in general of LCSA, at an early stage of technology development is even more current and relevant when looking at the demand of innovative processes and technologies able to provide answers to the challenge of circular economy. Indeed, more and more complex processes are being proposed for the recovery of materials – and fuels – from waste streams: their development must be accompanied by a deep care about their environmental impacts, especially in comparison with the current ones, and LCSA is the tool able to support such a development process, with the aim of reaching a sustainable circular economy.

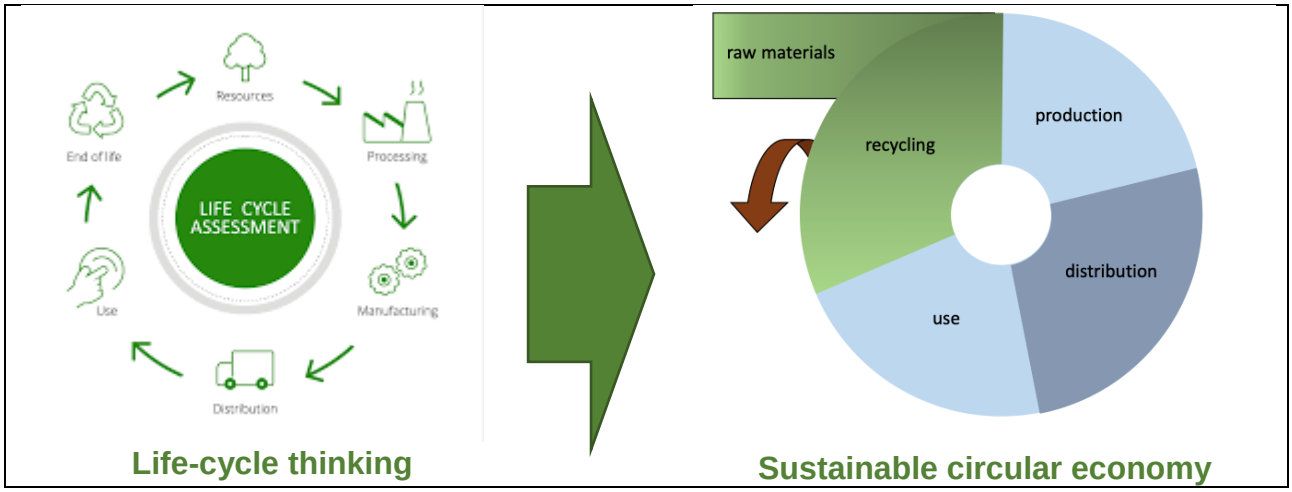

Figure 1. Life-cycle thinking supporting the development of sustainable circular economy.

LCA and more in general Life Cycle Thinking (LCT) need to be taught and widespread especially among the higher education students in order to fully introduce this way of thinking of the environmental consequences of choices in all activity sectors.

2. THE LIFE-C PROJECT

Life-C project[1] aims to prepare students and professionals across all activity sectors, to become true agents of change, by providing them with knowledge and tools to address their future choices and decisions minimizing environmental impacts, in their respective professional fields. The general objective of the project is to minimize the environmental, economic, and social impact of the products and activities on future economies and industries.

The project will develop a specific class on LCT, addressing all three dimensions of sustainability – environmental, economic, and social – based on innovative teaching methodologies.

The project is coordinated by the Silesian University of Technology (SUT), in Poland. The partners of the projects are Niccolò Cusano University (Unicusano), in Italy, Lappeenranta-Lahti University of Technology (LUT), in Finland, National Technical University of Athens (NTUA), in Greece.

The partners proposed to contribute to reaching the main objective by raising LCT awareness, providing an e-learning LCA course, available on a devoted e-learning platform, for international students of engineering and economic faculties, infusing the required technical and scientific knowledge for

[1] Erasmus + Programme 2021-2027. Key Action 2: Cooperation partnerships in higher education. GRANT AGREEMENT n° 2022-1-PL01-KA220-HED-000085853. https://life-c.eu/

understanding the sustainability of production processes and technologies with an LCT approach.

The LIFE-C Project started in September 2022 and will end in August 2025. So, at the time of writing, it is more or less at halfway. The project is structured in five work packages (WP):

- WP1: Project management, quality assurance and evaluation;
- WP2: Defining the needs and state-of-the-art of the LCA teaching sector, to provide the solutions and answers for recognized educational gaps; this WP has already been completed;
- WP3: Preparing a complete set of teaching materials and educational/coaching methodologies for students and teachers to implement and deliver the Life-C course in their Universities; this WP is under development;
- WP4: Delivery of the Life-C course for the interested students, collecting the evaluation and recognizing acquired ECTS; this WP will start next June and will last till almost the end of the project;
- WP5: Dissemination and exploitation – promoting the Life Cycle Thinking in higher education and building the social media presence of the Life-C project during conferences, newsletters, profiles, and webinars throughout the project duration.

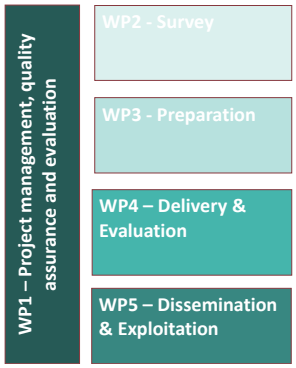

Figure 2. LIFE-C structure.

The course is organized in three modules, dedicated to a basic introduction to LCT and LCA (Module 1), solving current challenges from the field of LCA for the modern industry (Module 2), and social aspects of the LCA (S-LCA) (Module 3).

After completing the Module 1: “Introduction to the life cycle thinking and assessment” the students are provided with:

- a basic understanding of the LCT and LCA;
- skills to apply a general LCA approach to different scenarios;
- knowledge to analyse the results of the LCA in terms of the environmental impacts of products and services;
- understanding the usefulness of LCA
- ability to critically evaluate the results of LCA; develop recommendations for improving the sustainability of products and services.

After completing Module 2: “Application of life cycle assessment” students will be able to:

- understand the usefulness of LCA in real cases;
- apply the LCA to products and services;
- analyse the full results of the LCA;
- critically evaluate the results of LCA, develop recommendations for improving the sustainability of products and services, and identify opportunities for reducing an environmental load of analysed processes;
- create LCA of products and services.

After completing Module 3: “Social life cycle assessment and costing” students will:

- gain a basic understanding of the of S-LCA and LCC. Develop an understanding of how S-LCA and LCC can be used in private/public context;
- be able to apply S-LCA and LCC to different real-world scenarios of products and services life cycles;
- Students will be able to analyse the results of S-LCA and LCC of products and services;
- Critically evaluate the results of S-LCA and LCC; develop recommendations for improving the sustainability of products and services.

At the time of writing, the pilot phase of the project just started. In the first half of July the Summer School on Module 1, devoted to PhD students, has been open and will go through the next two months till the end of September. The Winter School (November-December 2024) will be devoted to Module 2 and 3, for PhD students. At the same time the new classes in each partner university will start with the new academic year for bachelor and master students.

After the pilot phase, and eventual revisions, the LIFE-C course will be public and freely available for anyone on the web.

3. CONCLUSIONS

The LIFE-C Project has the objective of raising life cycle thinking awareness of higher education students, especially those belonging to engineering and economic faculties. These students will be the professionals of tomorrow working in the companies in the near future. Providing them with solid basis about how to evaluate the environmental impact in the perspective of life cycle, will help them to be able to analyse and improve environmental performances of any product, service, or activity. Within the project, the partners are developing a specific class on life cycle assessment, social life cycle assessment and life cycle costing, based on innovative teaching methodologies, that will be introduced in several curricula where life cycle thinking is presently absent. Eventually, the three modules will be public and freely available for anyone on the web. Co-funded by the European Union. Views and opinions expressed are however those of the author or authors only and do not necessarily reflect those of the European Union or the Foundation for the Development of the Education System. Neither the European Union nor the entity providing the grant can be held responsible for them.

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