



## PREREQUISITES

A basic knowledge of eco-design and Life Cycle Assessment is needed.

## OBJECTIVES

Eco-designing products and services is already a hard and often ill-defined task since it involves both lifecycle modelling and multi-criteria decision analysis. But eco-designing complex systems is still harder for many reasons. **This doctoral workshop aims at both defining the industrial and scientific issues of eco-designing complex systems** – products, services, plants, socio-technical systems – and presenting practical solutions for modelling, simulating, optimising and making decisions on the best solutions in the design stage.

Our understanding of a complex industrial system is:

- A large-scale system (high number of subsystems and components, mass and resources);
- With a hardly predictable life cycle (lifetime, upgrades, maintenance, end-of-life...);
- Whose subsystems may have different life cycles and lifetimes;
- In close interaction with its environment (super system, geographic site...);
- Supervised by human decisions and management.

Some examples of such complex systems, which are taken all along the doctoral workshop, are:

- Eco-design of an electrical substation of an aluminium plant (9,000 tonnes of metal and concrete lasting 30 to 40 years, costing 80 million Euros, with few idea on how to recycle it);
- Eco-design of food packaging providing the multiple usage conditions and recycling facilities of countries;
- Eco-design of a value chain for recycling automotive glazing;
- Eco-design of a food value chain;
- Eco-optimisation of a navy shuttle;
- Eco-design of automotive systems through circularity measurements;
- Design of eco-industrial parks.

The complex systems are dealt through several perspectives:

- Life-Cycle Assessment;
- User behaviour modelling;
- Technico-economic value networks;
- Design and performance optimisation;
- Eco-ideation and eco-innovation;
- Industrial ecology and circular economy.

**This doctoral training alternates theory and practice.** More than half of the time is spend on case studies, where participants are asked to apply proposed methodologies and tools, and research workshops, where they are asked to speak about their research issues.

## TEACHING STAFF

- Ghada Bouillass (post-doc at CentraleSupélec)
- François Cluzel (assistant professor at CentraleSupélec)
- Romain Farel (PhD, Data Intelligence Program Manager at Groupe Doctegestio)
- Yann Leroy (assistant professor at CentraleSupélec)
- Michael Saidani (post-doc at University of Illinois at Urbana-Champaign/CentraleSupélec)
- Benjamin Tyl (PhD, research engineer at Apesa)
- Flore Vallet (assistant professor at IRT SystemX/CentraleSupélec)
- Gwenola Yannou-Le Bris (associate professor at UMR SayFood INRAE - AgroParisTech)
- Pierre-Alain Yvars (professor at ISAE-Supmeca)

## CONTENT (program subject to minor changes)

### 1. INTRODUCTION

This first module will introduce **complexity in eco-design** and a brief presentation of participants' issues. Participants are asked to prepare 2 slides on the "complex system" issues they consider to have.

### 2. ECO-INNOVATION FOR A SUSTAINABLE TRANSITION OF AGRI-FOOD SYSTEMS

The transition towards greater **sustainability of food chains** introduces many questions about **sustainability assessment metrics** that can and must be mobilized at **different territorial scales** to enable the analysis of these socio-technical systems. The diversity of the evaluation axes considered is another specificity of the sustainability analysis for these complex systems. Dr. Gwenola Yannou-Le Bris will illustrate this issue and discuss the co-innovation approaches (including value chain actors and stakeholders) that can be deployed in order to propose spaces for exploring new eco-innovation solutions.

### 3. DESIGN FOR USER IMPACT

Dr. Yann Leroy and Dr. Flore Vallet will focus on issues dealing with **user behaviour modelling** and its impact in eco-design, notably through the example of modelling user behaviour in energy systems.

#### 4. LIFE CYCLE ASSESSMENT OF COMPLEX SYSTEMS

Dr. Yann Leroy and Dr. François Cluzel will make a focus on Life Cycle Assessment (LCA) for complex systems. The challenges are here to define a **relevant study perimeter** (e.g. functional unit) and to deal with **data and life cycle uncertainties**. The art of defining probabilized life cycle scenarios is discussed. A short case study will illustrate these issues.

#### 5. SUSTAINABILITY ASSESSMENT FOR THE DESIGN OF COMPLEX SYSTEMS

Dr. Ghada Bouillass will introduce the methodological background of sustainability assessment at different levels and the challenges that raise within its implementation to complex systems. This lecture will allow participants to acquire knowledge on the on-going methodological advances in the field of **Life Cycle Sustainability Assessment (LCSA) and Social Life Cycle Assessment (S-LCA)** as well as how these methods can be used for designing more sustainable product systems. A workshop is to be conducted to explore through a case study the approaches and to highlight their strengths and limitations.

#### 6. VALUE ANALYSIS OF COMPLEX SYSTEMS

Dr. François Cluzel will position LCA of complex systems in a more global approach of **value analysis to defined functions and performances of a system** by jointly considering the economic and the environmental dimensions. The module is consist in a workshop based on a case study to test and apply approaches from the literature.

#### 7. ECO-INNOVATION OF COMPLEX SYSTEMS

Dr. Flore Vallet, Dr. Benjamin Tyl and Dr. François Cluzel will propose a survey on **eco-innovation methods and tools**. They will highlight the current state of research in this area. Participants will then reflect upon eco-innovation thanks to eco-innovation cases. A focus will be made on the **generation of eco-innovative ideas with eco-ideation stimulation mechanisms**.

#### 8. VALUE NETWORKS OF COMPLEX SYSTEMS

Dr. Romain Farel will make a lecture on value networks of complex systems. The objective of this workshop is to give the participant a **step by step method for designing value chain** from scratch for multi-stakeholder industrial systems.

#### 9. ECO-SYNTHESES OF COMPLEX SYSTEMS

Pr. Pierre-Alain Yvars will propose a half-day module on eco-synthesis of complex systems. The purpose is to show how **to take into account early and various types of requirements in the design process** of complex systems to allow early **system architecture generation** and **pre-sizing early admissible solutions**. The DEPS modeling language will be used for modeling Eco Design Problems. The techniques used for solving are set-based design tools and methods.

#### 10. CIRCULAR ECONOMY AND CIRCULARITY INDICATORS

Dr. Michael Saidani will introduce the challenges of **assessing circularity performance at different systemic levels**. A newly developed taxonomy of circularity indicators and its associated query tool will be presented and experienced. Through the workshop, several tools aiming at measuring the circularity of materials/products/systems will be applied on a real world industrial case study. **Participants will question the strengths, complementary and weaknesses of each approach**.

#### 11. LIFE CYCLE ASSESSMENT AND MACHINE LEARNING TOOLS TO DESIGN FOR PRODUCT SUSTAINABILITY

In this newly developed session, Dr Michael Saidani will explore **how LCA and ML can be combined to further drive product sustainable design**. The approach is illustrated through an hands-on case study on an Amazon Climate Pledge Friendly product and its conventional counterpart. OpenLCA is used for the comparative LCA part, and Jupyter Notebook for the NLP part. Perspectives on how AI can support LCA are also discussed, e.g. to address data deficiencies, scenarios exploration, or impact estimation.

#### 12. RESEARCH WORKSHOP

The participants will be asked to **re-analyze their research issues on complex systems** to the light of the summer school and the bibliographical material provided. Participants will also be asked to propose **research leads and a clear roadmap** which are discussed by the group and teachers.

	Monday 11 Oct.	Tuesday 12 Oct.	Wednesday 13 Oct.	Thursday 14 Oct.	Friday 15 Oct.
Morning 1	Breakfast	04 – LCA of complex systems	07 - Eco-innovation of complex systems	09 - Eco-synthesis of complex systems	11 - Life cycle assessment and machine learning tools to design for product sustainability
Morning 2	01 - Welcome & introduction,	06 - Value Analysis of complex systems			
	Lunch	Lunch	Lunch	Lunch	Lunch
Afternoon 1	02 -Eco-innovation for a sustainable transition of agri-food	05 – Sustainability assessment for the design of complex systems	08- Value networks of complex systems	10 - Circular economy & Circularity indicators	12 - Research workshop
Afternoon 2	03 - Design for user impact				
				Social Event	

## TEACHING MATERIAL

All participants will receive:

- The lecture presentations in PDF format;
- A bibliographical list of major scientific publications in relation to each module;
- A synthesis booklet of abstracts including contributions of all participants.

**Language: English.**

## ORGANISATION

Number of participants: **20 participants** maximum from EcoSD network, S-mart network, the Design Society and Université Paris-Saclay.

The training is **free of charge** for these participants.

A few places may be available for young researchers or professionals outside of the partners' networks (1.000€ per participant; please contact us for more details).

Meals and accommodation are the responsibility of participants.

A social event is organized on Wednesday evening in a restaurant (offered by EcoSD and S-mart).

Location: Laboratoire Genie Industriel, Centrale-Supélec, Université Paris-Saclay, Gif-sur-Yvette, France. The school is located 30 km to the south of Paris. Access is detailed here: <https://www.centralesupelec.fr/en/one-school-three-campuses>

## MORE INFORMATION

Please visit our website to get more information on this training and possible local accommodation: <https://ecodocs.sciencesconf.org>

## REGISTRATION & CONTACT

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## USEFUL LINKS

CentraleSupélec: [www.centralesupelec.fr](http://www.centralesupelec.fr)

Laboratoire Genie Industriel: [www.lgi.centralesupelec.fr](http://www.lgi.centralesupelec.fr)

ISAE-Supméca: <https://www.isae-supmeca.fr>

AgroParisTech: [www.agroparitech.fr](http://www.agroparitech.fr)

EcoSD: [www.ecosd.fr](http://www.ecosd.fr)

S-mart: [www.s-mart.fr](http://www.s-mart.fr)

Université Paris-Saclay: [www.universite-paris-saclay.fr](http://www.universite-paris-saclay.fr)

The Design Society: [www.designsociety.org](http://www.designsociety.org)

## THEY PARTICIPATED LAST YEARS

**Academia:** Imperial College London (UK), Aalborg University (Denmark), University of Zagreb (Croatia), Shiv Nadar University (India), Aalto University (Finland), DTU (Denmark), Sapienza University of Rome (Italy), University of Lausanne (Switzerland), Ecole Polytechnique, Université de Technologie de Troyes, Arts & Métiers ParisTech, Université Bordeaux 1, Université de Nantes, AgroParisTech, ESTIA, Université Paris 8, Université Paris-Sud, IRSTEA, ENS Paris-Saclay, Grenoble INP, Telecom SudParis, CentraleSupélec.

**Industry:** APESA, Thales, DGA, Orange Business Services, Groupe PSA, RTE, ONERA, CEA/INES, SC ErgoMedical.

