

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

- François Cluzel (assistant professor at CentraleSupélec)
- Romain Farel (PhD, industrial partnership manager at CEA list)
- Andreas Hein (post-doc at CentraleSupélec)
- 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)
- Bernard Yannou (professor at CentraleSupélec)
- Gwenola Yannou-Le Bris (associate professor at AgroParisTech)
- Pierre-Alain Yvars (professor at Supmeca)
- Guest speaker to be announced

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. CONCEPTS & METHODS FOR ECO-DESIGNING COMPLEX SYSTEMS

Pr. Bernard Yannou will make an **overview of concepts** which are addressed by eco-designing complex systems and **suitable methods of design engineering**.

3. DESIGN FOR USER IMPACT

Dr. Yann Leroy and Dr. François Cluzel 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. DESIGN OF ECO-INDUSTRIAL PARKS

Dr. Andreas Hein will introduce the concept of eco-industrial park, which is a set of businesses within a geographic area that share resources in order to increase profitability and reduce environmental impact. **Designing eco-industrial parks requires sophisticated modelling methods, multidisciplinary simulations, and needs to take into account economic, environmental, and social aspects.** Within this module, participants will learn the fundamental concepts of industrial ecology and eco-industrial parks. The participants will apply their knowledge hands-on by designing a by-product exchange relationship in a team exercise.

5. ECO-COMPLEXITY OF AGRIFOOD CHAINS

Dr. Gwenola Yannou-Le Bris will propose an overview of the **complex case of agrifood chains** as a way to introduce the stakes of LCA perimeters. She will highlight the importance of the social aspects approaches in the food value chains cases.

6. 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.

7. ECO-OPTIMISATION OF COMPLEX SYSTEMS

Pr. Pierre-Alain Yvars will propose a half-day module on eco-optimisation 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 architecture generation and pre-sizing early simulations of performances**. The techniques used are set-based design tools and methods.

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-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**.

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. GUEST SPEAKER TO BE ANNOUNCED

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 7 October	Tuesday 8 October	Wednesday 9 Oct.	Thursday 10 Oct.	Friday 11 October
Morning 1	Breakfast	04 - Design of eco-industrial parks	07 - Eco-optimisation of complex systems	09 - Eco-innovation of complex systems	11 - Guest Speaker (tba)
Morning 2	01 - Welcome & introduction,				
	Lunch	Lunch	Lunch	Lunch	Lunch
Afternoon 1	02 - Concepts & methods for eco-designing complex systems	05 - Eco-complexity of agrifood chains	08 - Value networks of complex systems	10 - Circular economy & Circularity indicators	12 - Research workshop
Afternoon 2	03 - Design for user impact	06 - LCA of complex systems			
				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: <http://www.centralesupelec.fr/en/our-campuses>

MORE INFORMATION

Please visit our website to get more information on this training and possible local accommodation: <https://ecodocs2019.sciencesconf.org>

REGISTRATION & CONTACT

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USEFUL LINKS

CentraleSupélec: www.centralesupelec.fr

Laboratoire Genie Industriel: www.lgi.centralesupelec.fr

Supmeca: www.supmeca.fr

AgroParisTech: www.agroparistech.fr

EcoSD: www.ecosd.fr

S-mart: www.s-mart.fr

Université Paris-Saclay: www.universite-paris-saclay.fr

The Design Society: 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.

