This course is primarily open to PhD students from institutions belonging to EcoSD network but also open to other researchers. It is supervised by Pr. Isabelle Blanc, administrator of EcoSD and professor at MINES ParisTech.

ECOSD

EcoSD (Eco-conception de systèmes durables, standing for Eco-design of Sustainable Systems) Network is a French association with the objective of encouraging collaboration between academic and industrial researchers in order to create and spread advanced knowledge in eco-design fields. This initiative aims at helping a global sustainable development process at national and international scales.

ORGANIZERS

This course is partly funded by EcoSD. It is hosted by MINES ParisTech at the site in Sophia Antipolis and co-organized by MINES ParisTech and IFFSTAR. It is validated by the Doctoral School in Engineering Sciences from MINES ParisTech and Arts & Métiers ParisTech.
PRE-REQUISITES
Basics on LCA methodology and practice of an LCA software
Basics in Statistics
English
Familiarization with the programming language R: Please, install the software environment R and related tool R Studio. Next, download the folder “Introduction to R” and execute the file “Tutorial – Introduction to R.R” in R Studio.

OBJECTIVES
Life Cycle Assessment (LCA) is one of the most widespread environmental management tools and can provide relevant information for the debate on the concerns of certain technologies in diverse production sectors. Providing environmental information for policy makers is necessary to answer the questions on major concerns such as resource depletion, global warming or social acceptance.

However, LCA requires the collection of a large amount of data with different levels of reliability. These uncertainties are propagated to LCA results and may affect the interpretation and conclusions of the analysis. Moreover, real systems are affected by inherent variability as a result of geographical, temporal and technological specificities. It is thus important to characterize these variations and their effect on LCA results. Therefore, it is necessary to assess and understand the possible sources of uncertainty and variability and to rank them in order to highlight the priorities to minimize the environmental impacts of the evaluated technologies.

This PhD course is oriented towards a major key issue for LCA, namely understanding and handling uncertainties in LCA. Some of the key issues addressed during the course will be:

- Distinguishing between UNCERTAINTY and VARIABILITY
- Sensitivity analyses: a review of statistical tools
- Spatial variations
- Modeling of uncertainty of impact characterization
- Meta-analysis: meta-models applied to LCA
- Parameterized models and reduced parameterized models applying Global Sensitivity Analysis (GSA) for energy pathways
- Prospective uncertainties

This PhD training alternates theory (11 x 1h30 courses) and practice (7 x 1h30 case study + 8 h personal work). The theoretical fundamentals learned during the lectures will be applied to a case
study on energy pathways. A statistical tool (R Studio) will be used. 4 sessions of 2 h are scheduled for the personal project that will be developed in teams (2–3 people).

**TEACHING STAFF**
- Isabelle BLANC (Professor at MINES ParisTech)
- Lynda AISSANI (Researcher at IRSTEA)
- Paula PEREZ-LOPEZ (Assistant Professor at MINES ParisTech)
- Anne VENTURA (Researcher Institut Français Transports Aménagements Réseaux IFSTTAR)
- Romain BESSEAU (Ph.D. student at MINES ParisTech)

**CONTENT**
1. Introduction to uncertainties/Variability related to LCA
2. Sensitivity analysis: Definition and statistical tools
3. Assessing spatial variability in LCA: why?
4. Assessing spatial variability in LCA: how?
5. Uncertainty Analysis in LCA
6. Global Sensitivity Analysis (GSA) in LCA
7. Understanding sources of uncertainties in impact characterization methods
8. Meta–analysis/Meta–models
9. Parameterized models & reduced parameterized models based on GSA
10. CASE STUDY: Assessing the environmental impacts of energy pathways – Uncertainty and variability

**TEACHING MATERIAL**
All participants will receive:
- The lecture presentations in PDF format;
- A printed document presenting the case study;
- A .zip folder containing the files required to develop the personal project;
- A bibliographic list of major scientific publications in relation to each module

Language: **ENGLISH**

**LOCATION**
MINES ParisTech, Sophia Antipolis, France. The school is located at the technology park of Sophia Antipolis, in the commune of Valbonne.
Access is detailed here:
http://www.oie.mines-paristech.fr/
Accueil/Informations–pratiques/

To get here by bus:
From Nice
- Line 230 Nice < Sophia (Bus stop “Sophie Laffitte”)
From Antibes
REGISTRATION & CONTACT
Pr. Isabelle BLANC
E-mail: isabelle.blanc@mines-paristech.fr
Phone: +33 (0) 4 93 95 75 13

MORE INFORMATION
Please, visit the website of the Centre Observation Impacts, Energie (O.I.E.) to get more information on this training:

USEFUL LINKS
MINES ParisTech: http://www.mines-paristech.fr/
Centre O.I.E.: http://www.oie.mines-paristech.fr/
Institut national de recherche en sciences et technologies pour l’environnement et l’agriculture (IRSTEA): http://www.irstea.fr/
Institut Français Transports Aménagements Réseaux : http://www.ifsttar.fr
EcoSD: http://ecosd.fr/

2018 PARTICIPANTS
Manchester University (GB), Aarhus Université (Denmark), Université de Sheerbrooke (Canada), Technical Universität Braunschwein (Germany), UMEA Université (Sweden), Graduate School Energy & Environment (Thailand), INP Grenoble (France), IFPEN (France), BRGM (France).
## PROGRAM

<table>
<thead>
<tr>
<th>CDE 1</th>
<th>MONDAY</th>
<th>TUESDAY</th>
<th>WEDNESDAY</th>
<th>THURSDAY</th>
<th>FRIDAY</th>
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<tbody>
<tr>
<td>8h30 - 10h00</td>
<td>Introduction to uncertainties / Variability related to LCA &lt;br&gt; Isabelle BLANC – MINES ParisTech</td>
<td>Uncertainty Analysis in LCA &lt;br&gt; Isabelle BLANC – MINES ParisTech</td>
<td>Meta–Analysis / Meta–Models &lt;br&gt; Isabelle BLANC – MINES ParisTech</td>
<td>Case study (EP)</td>
<td>Case study finalization (EP)</td>
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<td>10h30 - 12h00</td>
<td>Sensitivity analysis : Definition and statistical tools &lt;br&gt; Paula PEREZ LOPEZ – MINES ParisTech</td>
<td>Global Sensitivity Analysis (GSA) in LCA &lt;br&gt; Paula PEREZ LOPEZ – MINES ParisTech</td>
<td>Parameterized models &amp; Reduced parameterized models based on GSA &lt;br&gt; Isabelle BLANC – MINES ParisTech</td>
<td>Case study (EP)</td>
<td>Case study finalization (EP)</td>
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<td>13h30 - 15h00</td>
<td>Assessing spatial variability in LCA: why &lt;br&gt; Lynda AISSANI – IRSTEA</td>
<td>Understanding sources of uncertainties in impact characterization methods (1) &lt;br&gt; Anne VENTURA – IFFSTAR</td>
<td>Case study (EP)</td>
<td>Case study (EP)</td>
<td>Presentation of the case study (EP) by groups &amp; Discussion</td>
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<td>15h30 - 17h00</td>
<td>Assessing spatial variability in LCA: how &lt;br&gt; Lynda AISSANI – IRSTEA</td>
<td>Understanding sources of uncertainties in impact characterization methods (2) &lt;br&gt; Anne VENTURA – IFFSTAR</td>
<td>Case study (EP)</td>
<td>Case study (EP)</td>
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