UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES

EN-Methods for analyzing energy efficiency and renewable energy technologies

Méthodes d'analyse de l'efficacité énergétique et des technologies des énergies renouvelables

14E222 CR (6 ECTS)
Master universitaire en sciences de l'environnement (MUSE)
Institut des sciences de l'environnement (ISE), Université de Genève

Teachers

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Contents

1 INTRODUCTION

The course offers an understanding of key methods used to analyse energy systems. These methods provide the analytical basis for studying the technical, environmental, and economic performance of technologies, process chains and entire sectors. It offers you hands-on practical experience by applying the methods separately and in combination. It will serve as important basis for your future research in the context of your M.Sc. thesis or any internship as well as future professional activities. The course builds upon knowledge and skills that you should have acquired in the *Tronc Commun* and especially from the course *Physics and technology of energy*. The methods covered are:

- Energy efficiency policy evaluation and Multi-criteria assessment
- Input-Output analysis
- Energy statistics
- Technological learning
- Pinch analysis
- Life cycle assessment (LCA)
- Uncertainty and Monte Carlo method
- Renewable energy balance and Techno-economic analysis
- Energy system optimisation

Lectures and exercises are in English, you may prepare your assignment report in French.

2 ORGANISATION

Each week you will prepare an assignment in teams of two students. For each assignment you will prepare a short report. **Please communicate your name and the name of your partner with whom you form a team to the supervisor. Attendance of all group members to both the lecture and assignment is essential.**

Thursday 08:15 -10:00: Lecture

- Introduction to the concepts and the research method. Instructions are provided for the week's assignment.

Friday 08:15-17:00: Weekly assignment (computer-based exercise)

- Prepare the weekly assignment before starting the assignment.
- **If your presence is not possible on Friday for urgent reasons, please communicate this to the week supervisor to agree to a suitable solution.**
- ***General feedback on the previous week is given at the start of the session on Friday at 08:15.***

Deadline for assignments: the week after the assignment on Wednesday at 17:00

- Submit your file into Moodle with the following name: **Methods_weekX_NameSurname**
- We will accept only one 1 file in Word or pdf format without links to Excel or other programs.
- **If you cannot submit on time**, discuss the reasons with the coordinators **in advance** (not the day of the submission). **If we are not notified in advance, we will deduct 0.5 points from your mark for every day beyond the deadline.**

3 COURSE CONTENTS

Each week covers a different research method.

Method 1: Energy efficiency policy evaluation and Multi-criteria analysis
This lecture and exercise deals with key indicators for tracking energy efficiency at the sectoral and the country level. The success of energy efficiency policies is evaluated by means of key performance indicators. You will conduct cost-benefit analysis of different types and critically discuss the results.

Method 2: Technological learning
The theory of technological learning and the analysis of technological systems by means of learning curves or experience curves allows to describe technological progress and cost degression which may be used for long-term projections.

Method 3: Input-Output analysis
Input/output analysis is an important tool in order to study macro-economic effects. In this assignment the contribution to economic growth (GDP) and employment effects are calculated for a novel technology (power-to-gas plant).

Method 4: Pinch analysis
Very substantial amounts of energy can be saved by heat integration, i.e. reusing waste heat from one process or activity as useful heat for another. The so-called Pinch analysis allows to identify the minimum energy requirements of a complex system which could be an industrial plant or, for example, a combined industrial and residential settlement.

Method 5: Life Cycle Assessment
The aim of this week is to convey the essence of the Life Cycle Assessment (LCA) method and to apply it in order to better understand certain features of the current mix of Swiss electricity generation, of electricity supply with photovoltaic panels (with and without batteries) and of electric vehicles.

Method 6: Energy statistics
A number of statistical approaches are commonly applied to evaluate the perception of users about energy aspects and to quantify interrelations within the energy system.

Method 7: Uncertainty and Monte Carlo Method
The aim of this week is to introduce empirical uncertainty analysis in energy systems using Monte Carlo simulations. The assignment deals with the assessment of the cooling energy demand in Swiss office buildings.

Method 8: Renewable energy balance and techno-economic analysis
The objective of this week is to conduct energy balances and a techno-economic analysis of a renewable energy system, at the example of a photovoltaic (PV) system with and without a battery. In this exercise you will set up the energy balances, model the system in a spreadsheet and evaluate the economics under different boundary conditions.

Method 9: Energy system optimisation
This lecture will make you familiar with tools allowing to pinpoint optimal solutions of a given technology system (e.g., minimisation of costs or emissions). The assignment covers the optimization of system design and electricity market operation.

4 SCHEDULE

Table 1: Course schedule. Different teachers are responsible for each week assignment.

Date	Topic	Lecture	Exercise
1 THU 22.02.2024 (08:15-10:00) & Friday 23.02.2024 (full day)	Energy efficiency policy evaluation and MCA	M. Patel	I. Fouiteh, F. Sasso
2 THU 29.02.2024 (08:15-10:00) & Friday 01.03.2024 (full day)	Technological Learning	M. Patel	I. Fouiteh, F. Sasso
3 THU 07.03.2024 (08:15-10:00) & Friday 08.03.2024 (full day)	Input-Output analysis	T. Guibentif	T. Guibentif, J. Michellod
4 THU 14.03.2024 (08:15-10:00) & Friday 15.03.2024 (full day)	Pinch analysis	M. Babaei	M. Babaei, M. Kolahi, A. Mahmoudan
5 THU 21.03.2024 (08:15-10:00) & Friday 22.03.2024 (full day)	Life Cycle Assessment (LCA)	M. Patel	J. Michellod, P. Boiko
THU 28.03.2024 (08:15-10:00) & Friday 29.03.2024 (full day)	No course (due to Easter Friday)		
Easter holidays 30.03.2024-07.04.2024			
6 THU 11.04.2024 (08:15-10:00) & Friday 12.04.2024 (full day)	Energy statistics	J. Chambers	I. Fouiteh, A. Mahmoudan
7 THU 18.04.2024 (08:15-10:00) & Friday 19.04.2024 (full day	Uncertainty and Montecarlo method	J. Chambers	M. Babaei, M. Kolahi
8 THU 25.04.2024 (08:15-10:00) & Friday 26.04.2024 (full day)	Techno-economic analysis	J. Chambers	J. Michellod A. Syla, A. Nyandwi
9 THU 02.05.2024 (08:15-10:00) & Friday 03.05.2024 (full day)	Energy System Optimisation	J. Chambers	A. Syla, M. Kolahi

5 TEXTBOOKS

David J.C. MacKay: Sustainable Energy Without the Hot Air.
PDF download for free from http://www.withouthotair.com/, 2008

Kornelis Blok, Evert Nieuwlaar: Introduction to Energy Analysis, 3rd Edition 2020/2021
Available as ebook from the UNI-CV library

6 SOFTWARE

Make sure there is at least one laptop with Excel installed in for your team in the Friday session.

- **Microsoft Excel** – make sure you have it installed and know how to use it.
- **OpenLCA** for Life Cycle Assessment, this will be installed during class.
- **Python Jupyter Notebooks and Pyomo** for Uncertainty and Monte Carlo Method, Renewable energy balance and techno-economic analysis, and Energy System Optimisation. You will be given access to Python through an online tool, there is nothing to install.

7 EVALUATION AND GRADING CRITERIA

The course is graded as follows:

1. Average of submitted assignments contributing **75%** to the final grade.
2. Oral exam contributing **25%** to the final grade.

The final grade is the weighted sum of the oral and assignments. The minimum grade to pass is 4.

Evaluation of weekly assignments

Each weekly assignment will be graded. The grade of the reports will not only depend on whether the answer is numerically correct but will also consider the following aspects:

- The student demonstrates good insight in general and into the possibilities the limitations of a technologies and research methods.
- The student demonstrates insight into which parameters and assumptions determine the obtained outcome.
- Conclusions are based on a critical analysis of the methods and data used and the results obtained.

Further aspects you should pay attention to are:

- How to construct a clear, logical and consistent argumentation.
- How you deal with uncertainties.
- How you account for the feedback and comments provided in previous assignments.
- How you present data in tables and charts.
    - *Note: every chart and table must have a caption. Charts and tables with captions should be clearly understandable and should not duplicate results presented elsewhere in the text.*

Oral exam

The oral exam will consist of questions 3-5 questions randomly selected from the topics of the different weeks. The questions are related to key concepts elaborated during the **course lectures** rather than mathematical or programming skills. However, the student may be requested to write a formula and interpret it using a whiteboard.

8 COURSE MATERIAL

- This course guide.
- The assignments along with supplementary material required to perform the assignments which will be handed out each Thursday and will be uploaded on Moodle.
- Handouts of the lectures and additional background material which will also be uploaded on Moodle.

9 GROUP WORK RULES

The report should be prepared by each work group independently. You may discuss with other groups, but you **must not** copy or plagiarise the work of others (other groups, previous years, etc). See the Article 8 MUSE regulations below. Material drawn from other sources must be quoted and cited. Checks for plagiarism may be performed.

Excerpt of Art. 8 ('Fraude et plagiat') of the 'Règlement MUSE 2021'

1. Toute fraude, plagiat, tentative de fraude ou de plagiat correspond à un échec à l'évaluation concernée.

2. En outre, le Collège des professeurs de la Faculté des sciences peut annuler tous les examens subis par l'étudiant lors de la session; l'annulation de la session entraîne l'échec de l'étudiant à cette session.

3. Le Collège des professeurs de la Faculté peut également considérer l'échec à l'évaluation concernée comme définitif.

4a. Le Décanat saisit le Conseil de discipline, après avoir entendu l'étudiant mis en cause et après consultation du Comité,

i. s'il estime qu'il y a lieu d'envisager une procédure disciplinaire;
ii. en tous les cas, lorsque l'échec à l'évaluation concernée est définitif et qu'il entraîne l'élimination de l'étudiant de la faculté.

4b. Pour les autres cas, l'étudiant mis en cause doit être entendu avant toute décision par l'instance facultaire; il a accès à toutes les pièces du dossier.