Eunice EUROPEAN UNIVERSITY

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EUROPEAN UNIVERSITY FOR CUSTOMISED EDUCATION

STUDY GUIDE

OPTIMAL OPERATION AND SIZING OF ENERGY SYSTEMS

Organised by

University of Mons (UMONS)

1. IDENTIFYING DATA.	
· **Course Name.**	*Optimal Operation and Sizing of Energy Systems, UI-M1-IRENER-202-M*
· **Coordinating University.**	*UMONS*
· **Partner Universities Involved.**	*NA*
· **Course Field(s).**	*Engineering*
· **Related Study Programme.**	*Integrated Energy Systems, IES*
· **ISCED Code.**	*ISCED 7*
· **SDG.**	*7, 11, 13*
· **Study Level.**	*Master Level (first year of Master in Engineering typically)*

· **Number of ECTS credits allocated.**	*4*
· **Mode of Delivery.**	*online live*
· **Language of Instruction.**	*English*
· **Course Dates.**	*Start: 5th Feb 2024, End: 24th May 2024. Exam in June 2024.* *2 to 4 hours of course per week, + labs*
· **Precise Schedule of the Lectures.**	*- Thursday, 08 February: from 08h15 to 10h15* *- Wednesday, 14 February: from 13h30 to 15h30* *- Thursday, 15 February: from 08h15 to 10h15* *- Tuesday, 20 February: from 15h45 to 17h45* *- Wednesday, 21 February: from 13h30 to 15h30* *- Thursday, 22 February: from 08h15 to 10h15* *- Tuesday, 27 February: from 13h30 to 17h30* *- Wednesday, 28 February: from 13h30 to 15h30* *- Thursday, 29 February: from 08h15 to 10h15* *- Tuesday, 05 March: from 13h30 to 17h30* *- Wednesday, 06 March: from 13h30 to 15h30* *- Thursday, 07 March: from 08h15 to 10h15* *- Tuesday, 12 March: from 13h30 to 17h30* *- Thursday, 14 March: from 08h15 to 10h15* *- Thursday, 28 March: from 08h15 to 10h15* *- Thursday, 18 April: from 08h15 to 10h15* *- Thursday, 25 April: from 08h30 to 11h30*

	- *Thursday, 02 May: from 08h30 to 11h30* - *Thursday, 16 May: from 08h30 to 11h30*
· **Key Words.**	*Exact optimization, meta-heuristics, energy systems*
· **Catchy Phrase.**	*What this course is not:* - *a purely mathematical course which insists only on proofs, lemmas, theorems, etc* *What this course is:* - *A 'jackknife' with a sufficiently large panel of optimization techniques and models to face real-world situations in the energy sector.* - *An engineering course which focuses on physical and geometrical intuition (maths will still be present, even if not the main focus of the course).*

· **Prerequisites and co-requisites.**	*Prior skills required:* - *Mathematics for Engineers (linear algebra, mathematical analysis in n-dimensions)* - *Thermodynamics (for the mini-project only)* *Course is fully given in English.*
· **Number of EUNICE students that can attend the Course.**	*2 per EUNICE partner max*
· **Course inscription procedure(s).**	*registration through the EUNICE Website*

2. CONTACT DETAILS.	
· **Department.**	*Service de Génie Electrique (Zacharie De Grève), Service de Thermique et Combustion (Ward De Paepe), Service de Mathématique et Recherche opérationnelle (Daniel Tuyttens)*
· **Name of Lecturer.**	*Exact Optimization for Energy Systems: Zacharie De Grève* *Meta-Heuristics for Energy Systems: Ward De Paepe, Daniel Tuyttens*
· **E-mail.**	*Zacharie.degreve@umons.ac.be*
· **Other Lecturers.**	*See above*

3. COURSE CONTENT.
- *Exact Optimization for Energy Systems:* o *Course: Introduction to Optimization (definitions, classification of optimization problems, examples in the energy sector), Linear Programming Problems*

(definitions and examples in the energy sector, the simplex algorithm, duality, sensitivity analysis, complementary slackness), Mixed Integer Linear Programming Problems (definitions and examples in the energy sector, linearization using binary variables, branch-and-bound algorithm), Non Linear Programming Problems (definitions and examples in the energy sector, unconstrained optimization, constrained optimization – with equality and inequality constraints, Lagrangian stationarity, Karush-Kuhn-Tucker optimality conditions)

- *Labs: the Economic Dispatch Problem with DC network constraints (Linear Programming Problem), the Unit Commitment problem (Mixed Integer Programming Problem), Energy scheduling with non-linear equality constraints (convex relaxations and approximations)*

- *Meta-Heuristics for Energy Systems:*
  - *Course:*
    - *General concepts for Meta-Heuristics. Single-solution based Meta-Heuristics, population-based Meta-Heuristics, hybrid Meta-Heuristics, extensions and perspectives.*
    - *Introduction to energy system modelling (process scheme of the system, identification, and characterization of its elements (variables, characteristic equations, parameters), solution of the equations.*
  - *Project: Modelling, validation and optimization (using literature and commercial software/in-house code) of typical energetic processes.*

4. LEARNING OUTCOMES.

- *Acquire a broad and extensive knowledge of optimization techniques, required in modern energy optimization problems.*
- *Select the most appropriate optimization model and optimizer when confronted to a given optimization problem, identify the best values of the optimizer parameters for a given use-case.*
- *Translate a problem from its text version to a mathematical formulation.*
- *Identify the possible barriers when confronted to real-life problems, and propose relevant simplifications.*
- *Model, validate and optimize energy systems.*
- *Use and/or develop energy systems simulation tools to characterize, analyse and optimise the system performances.*

5. OBJECTIVES.

See Learning Outcomes

6. COURSE ORGANISATION.

UNITS

1.	*Exact Optimization for Energy Systems*
2.	*Meta-heuristics for Energy Systems*
3.	*[Indicate the name of the units and topics of the course]*
4.	*[Indicate the name of the units and topics of the course]*

LEARNING RESOURCES AND TOOLS.

Course slides and notes

PLANNED LEARNING ACTIVITIES AND TEACHING METHODS.

Exact Optimization for Energy Systems: course and lab sessions on dedicated software/using in-house code
Meta-heuristics for Energy Systems: course and mini-project on dedicated software/using in-house code

7. ASSESSMENT METHODS, CRITERIA AND PERIOD.

Exam during the session in June
Marked report for lab sessions/mini-project, during the semester

OBSERVATIONS.

8. BIBLIOGRAPHY AND TEACHING MATERIALS.

TBC