46770 Integrated Energy Grids

Aleksander Grochowicz

# Course description

# 46770 Integrated Energy Grids

Welcome to the first IEG lecture!

1. Introduction of the teaching team
2. Schedule
3. Learning environment and philosophy
4. Practicalities
5. Grading: exam and course project
6. Literature and lecture plan

5 ECTS M.Sc. course.

Runs over 13 weeks/13 sessions (last session: May 6, 2026)

Wednesday 8am – 12pm (4 hours)

Location: DTU Lyngby Campus, Building 358, Room 60A

# Lecturing team

**Marta Victoria**

- Associate Professor
- Course responsible
- Created the course last year
- On maternity leave

**Aleksander Grochowicz**

- Postdoctoral Researcher
- Primary contact person
- Lectures 1-4, 10-13

**Parisa Rahdan**

- Postdoctoral Researcher
- Co-responsible
- Lectures 5-9

# Lecturing team

**Lukas Karkossa**
- PhD student
- Teaching assistant

**Rossella Frugis**
- PhD student
- Teaching assistant

**Carlos Fernández de Heredia Liger**
- MSc student
- Teaching assistant
- IEG Alumni

# Wednesday schedule

| | |
|---|---|
| **8:15 – 9:00** | **Part I of Lecture (Aleks/Parisa)** |
| 9:00 - 9:15 | Break |
| **9:15 - 10:00** | **Part II of Lecture (Aleks/Parisa)** |
| 10:00 - 10:15 | Break |
| **10:15 – 11:00** | **Presentation of assignments in groups** |
| 11:00 -12:00 | Solving of assignments, asking questions, clarifications etc. |

5 ECTS credits correspond to 11 hours of work per week during the 13-week period (DTU rules). You are expected to continue working on studying the theory, solving the problems and course project during the afternoon or some other time!

# Learning environment

- New set-up for this course
- Challenges and benefits of a large group and course
  - Main source of information: DTU Learn
  - Additional resources: https://aleks-g.github.io/integrated-energy-grids/intro.html
- Questions (mostly) after the lecture, please do ask for clarifications and correct mistakes!
- Use the discussion threads in DTU Learn, and please do not send questions via e-mails
  - Other students will probably have similar questions and concerns, and will benefit from the discussions/answers!
- Talk to our teaching assistants during the breaks and after the lectures. (Office hour: Tuesday, 15:00 – 16:00; Room: LY329A-R121)

- Organisational or other questions: algro@dtu.dk or via DTU Learn

# Learning outcomes: Course

By the end of the course, you will be able to:

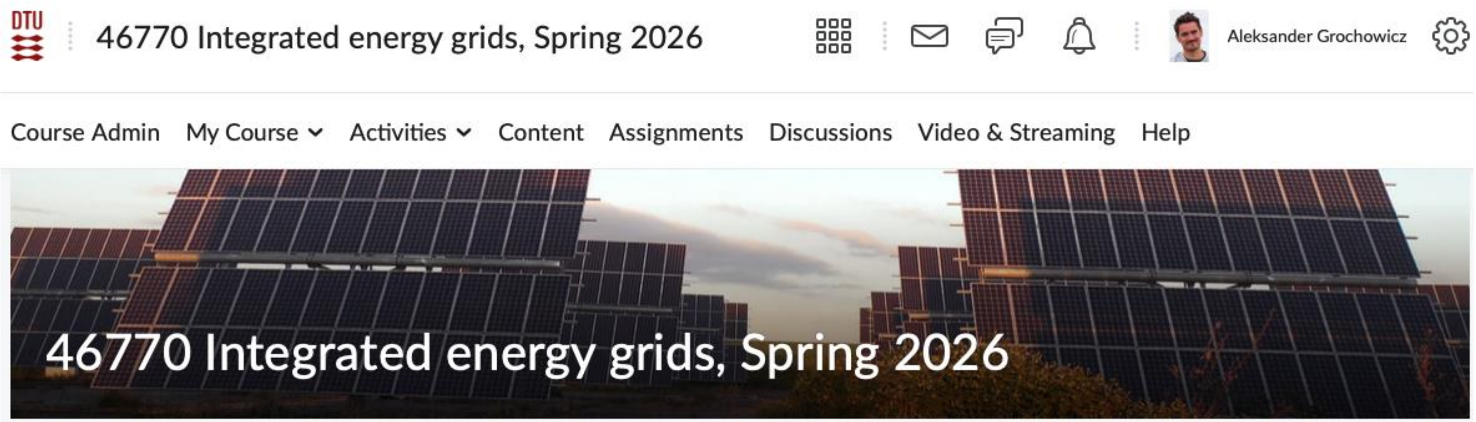
- Describe the structure of multi-carrier energy systems (electricity, heat, natural gas and hydrogen) and components at the interface between them.
- Explain the synergies between the energy sectors and the concepts of sector coupling.
- Describe the optimal energy flow problem for different energy carriers and the approaches to solve it.
- Formulate the optimal power flow problem for transmission and radial distribution systems on a computer.
- Formulate the optimal gas flow problem on a computer.
- Formulate the optimal heat flow problem on a computer.
- Explain the similarities between energy flow problems for different energy carriers, and the multi-energy flow problem.
- Interpret, analyse, and present numerical results.

# Course online platforms

### DTU Learn

Main source for information (lecture slides, problems statements, delivering course project, asking questions etc).

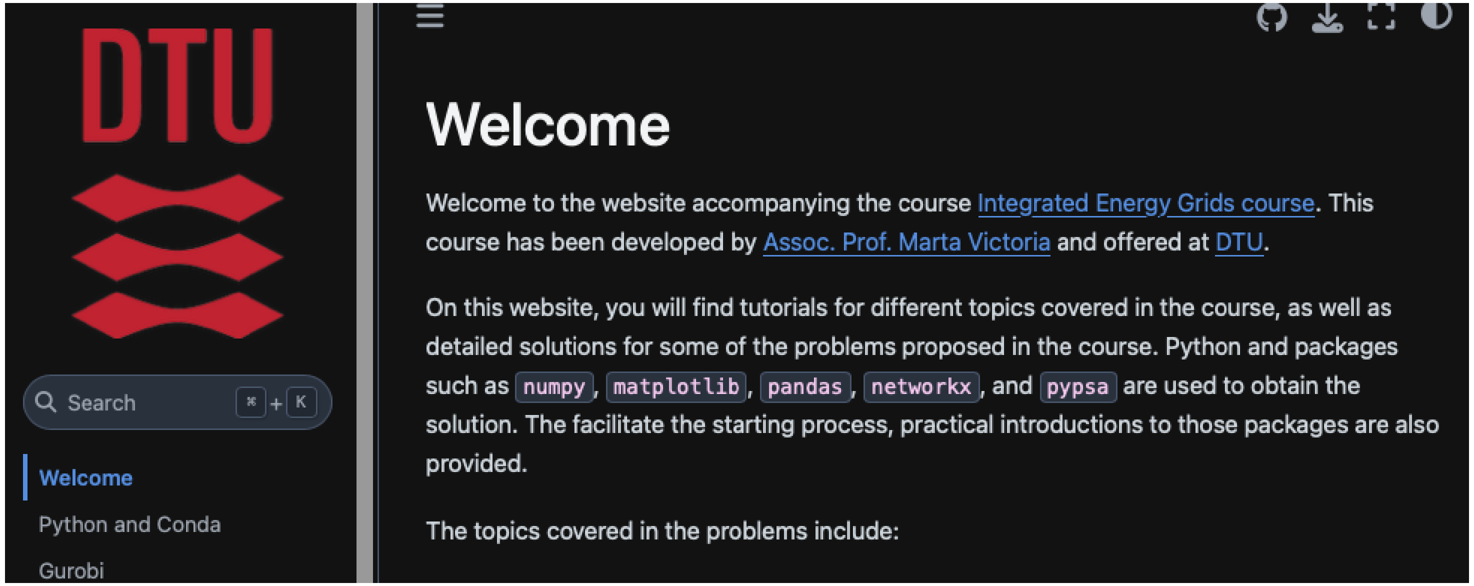
https://learn.inside.dtu.dk/d2l/home/294914




### GitHub Page

Software instructions and problems solutions.

https://aleks-g.github.io/integrated-energy-grids/intro.html



# Preparing to work with the problems

Update the links

We are going to learn and use open modelling software and data science approaches to deal with energy grids including Python, pandas, numpy, matplotlib, networkX, linopy, PyPSA, and Gurobi.

Lectures will focus on relevant theory and problems will be solved using open-source software.

Short introductions to relevant coding knowledge/software are provided in the form of jupyter notebooks:

https://aleks-g.github.io/integrated-energy-grids/intro.html

Start by setting up an environment: https://aleks-g.github.io/integrated-energy-grids/intro-install.html

If you do not have previous experience with Python, just start with the introduction to Python:

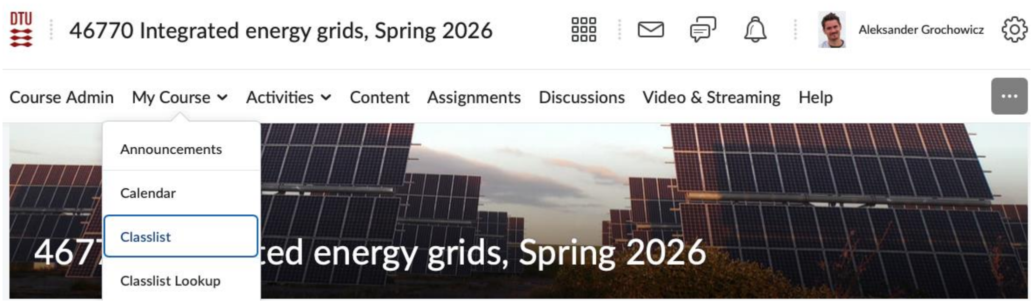
https://aleks-g.github.io/integrated-energy-grids/intro-python.html

# Evaluation and grading

**Written exam** (3 hours, all aids but no internet connection): May 29, 2026. It consists of about 50 multiple-choice questions. It represents 70% of the grade (max. 7 out of 10 points).

**Course project**: Mandatory in order to take the exam, represents 30% of the grade (max. 3 out of 10 points). You create groups of 4 students yourselves; for further questions ask our TAs.

Optional: Up to 0.5 out of 10 points can be gained for presenting the problem your group is assigned to (based on last name, see file “Week0/Groups_for_problems_presentations.pdf”) and completing the multiple choice tests after each lecture.




Finally, conversion of the final grade (out of ten) to the 7-scale Danish grading system

| |
|---|
| [92% - 100%] → Grade 12 (pass) |
| [84% - 92%) → Grade 10 (pass) |
| [68% - 84%) → Grade 7 (pass) |
| [60% - 68%) → Grade 4 (pass) |
| [50% - 60%) → Grade 2 (pass) |
| [20% - 50%) → Grade 0 (fail) |
| [0% - 20%) → Grade -3 (fail) |

# Course project

Goal: Incorporating learnings of the lectures throughout the course.

The course project will be split up in **two parts**:

1. The first half of the course project is **due on March 25**. You will get preliminary feedback by April 7. You may implement the feedback and choose to re-work the first half of the course project.
2. Finally, the **full** course project is **due on May 1**. The grade is decided based on the final submission. You will get feedback by May 14.

The course project is set up step-by-step, and you can work on it incrementally as the course progresses.

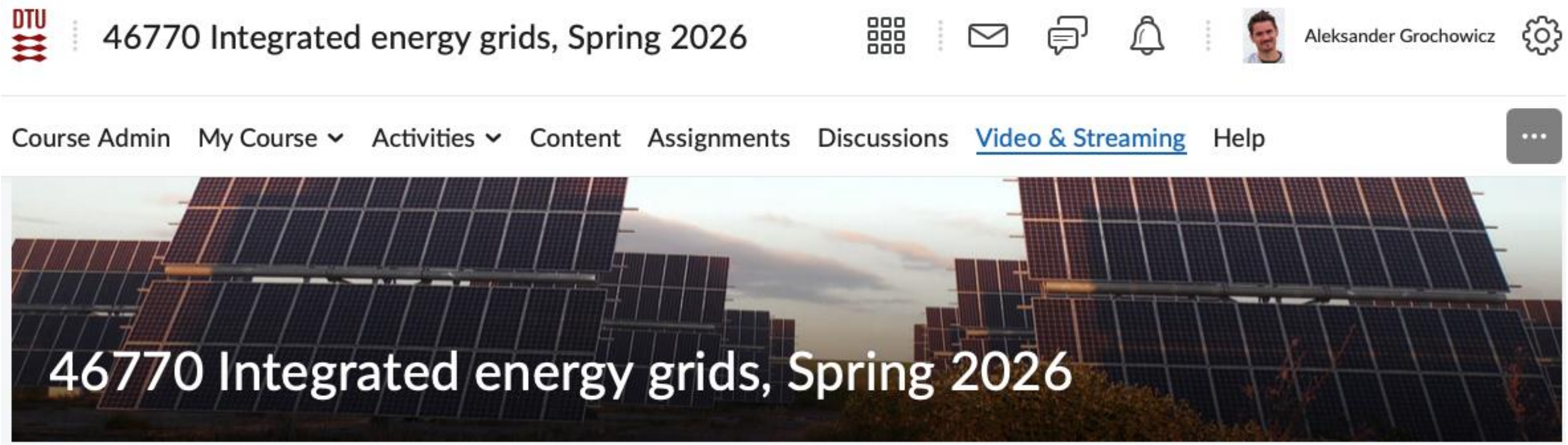
https://aleks-g.github.io/integrated-energy-grids/Problems/IEG_course_project.html

Submit a **short report (max. 10 pages)** in groups of 4 students about your main findings. **Due May 1**.

# Video recordings

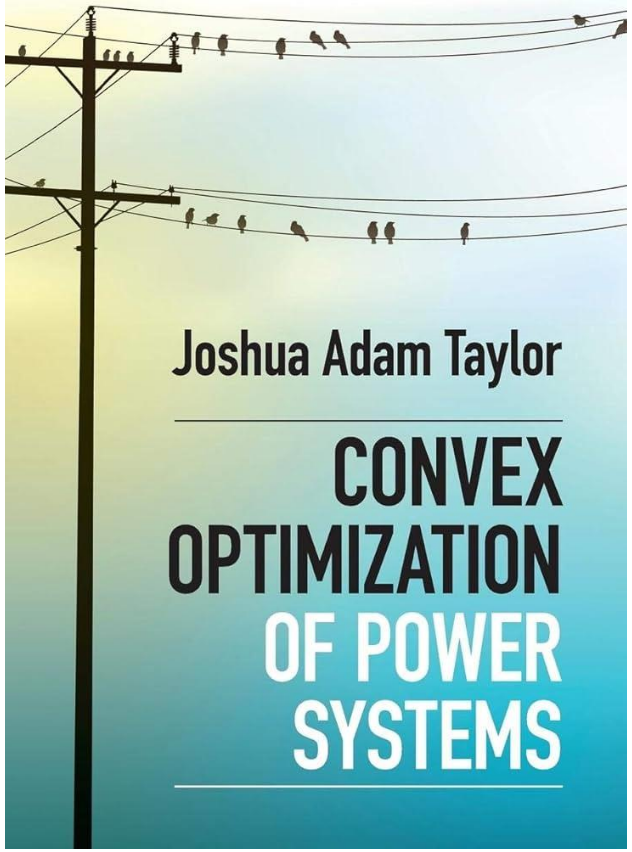
This course is set up for **in-person attendance**, which is strongly encouraged.

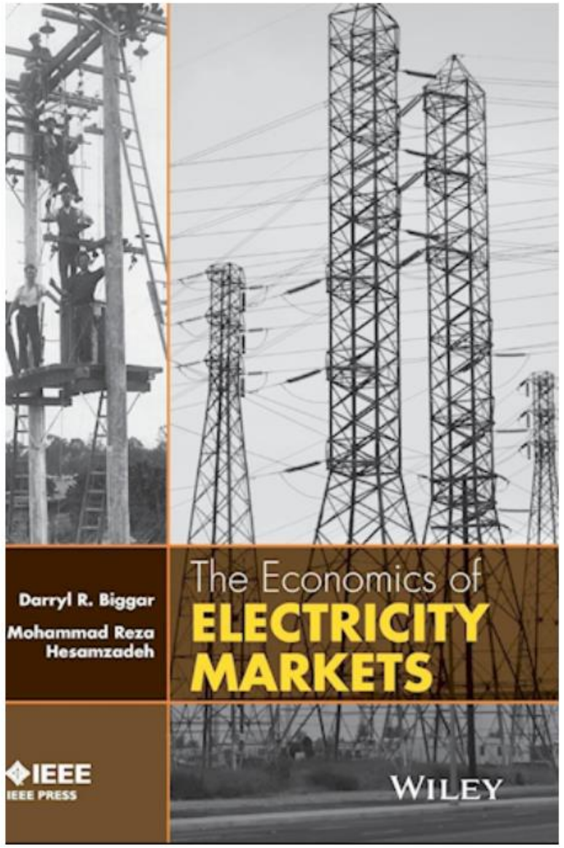
We will try our best to record lectures (in case of illness or repetition), but we think you get more out of being present than hybrid participation.



# Additional materials

There is not a single reference book for this course. The slides should be self-contained, and specific material will be recommended for every lecture. Some of the books used to prepare this course:



# Draft calendar

| Week | Date | Lecture |
|---|---|---|
| 1 | Feb 4 | Course presentation.<br>Balancing renewable generation.<br>Introduction to storage and transmission. |
| 2 | Feb 11 | Review optimisation<br>Dispatch optimisation in one node. |
| 3 | Feb 18 | Capacity and dispatch optimisation in one node.<br>Limiting $CO_2$ emissions. |
| 4 | Feb 25 | Networks |
| 5 | Mar 4 | Linearized optimal power flow |
| 6 | Mar 11 | Optimal power flow |
| 7 | Mar 18 | Gas networks and optimal gas flow |
| 8 | Mar 25 | Deadline for course project (Part 1) |
| | Apr 1 | No lecture (Easter) |
| 9 | Apr 8 | Heat networks and optimal heat flow |
| 10 | April 15 | Capacity and dispatch optimisation in a network |
| 11 | Apr 22 | Multi-carrier energy systems (heating and land transport) |
| 12 | Apr 29 | Multi-carrier energy systems (industry, aviation, shipping);<br>Delivery of course project: May 1 |
| 13 | May 6 | Advanced topics / Current research |

# Types of optimisation problems and course structure

| | One node | Network | | | |
|---|---|---|---|---|---|
| **One time step** | Economic dispatch or One-node dispatch optimisation (Lecture 2) | Power | | Gas flow (Lecture 8) | Heat flow (Lecture 9) |
| | | Linearized AC power flow (Lecture 5) | AC power flow (Lecture 6) | | |
| **Multiple time steps** | Multi-period optimisation<br><br>Joint capacity and dispatch optimisation in one node (Lecture 3) | Joint capacity and dispatch optimisation in a network (Lecture 10) | | | |

# Students’ data collection to fine-tune lectures

Go to vevox.app or scan the QR code

Code: **145-512-358**

Join at:
**vevox.app**

ID:
**145-512-358**

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