



# Project - Energy supply system of EPFL Campus

Lecture ME 454

Modeling and Optimization of Energy Systems

Prof. F. Maréchal

Alessio Santecchia, Ermanno Lo Cascio,  
Jordan Holweger, Julia Granacher, Luise  
Middelhauve, Rafael Amorim Leandro de  
Castro Amoedo, Xiang Li

February 2020

# General Overview

EPFL	12 Groups	ME 454	5-6 Students per Group	2-3 Presentations per Group	7 Teaching Assistants
IPESE	20min Oral exam	1 Final Report per Group	2 Students per Presentation	10 Days before Exam Due Date Report	2 Rooms

- Grading Method
  - Oral Exam -- *20 Minutes*
  - Group Project -- *Presentation & Report*
- Group Project
  - Groups of 5- 6 Students
  - 5 Presentations during Class – *2-3 per Group*
  - Final Report -- *Due Date 10 Days before Exam*
- Project Presentations
  - **Not Graded**
  - 2 -3 slides -- *5 min + 10 min Discussion*
  - 2 Students for each Presentation
  - **Random** selection of Groups each Session
  - Upload slides on moodle -- *before Session*

# Timeline

Week	Theory	Project	Deliverable
1	Course introduction	-	
2	Equations and Solving Methods	Part 1 - Building Demand	
3	-	Part 1 - Building Demand	
4	MILP problem statement	Part 2 – Integration Utilities	Students Presentation 1
5	Thermo-economic analysis	Part 2 – Integration Utilities	
6	Optimization approaches	Part 2 – Integration Utilities	
7	Solving optimization problems	Part 3 –NLP Heat Recovery	Students Presentation 2
8	Thermodynamic properties for process flowsheet models	Part 3 –NLP Heat Recovery	
9	EASTER BREAK		
10	Process unit, flowsheets & resolution sequence	Part 4 –Flow Sheeting	
11	Data Reconciliation	Part 4 –Flow Sheeting	
12	Heuristic methods & Multi Objective Optimisation	Part 5 - Scenarios	Students Presentation 3&4
13	-	Part 5 - Scenarios	
14	-	Part 5 - Scenarios	
15	Recap/ Questions	-	Students Presentation 5



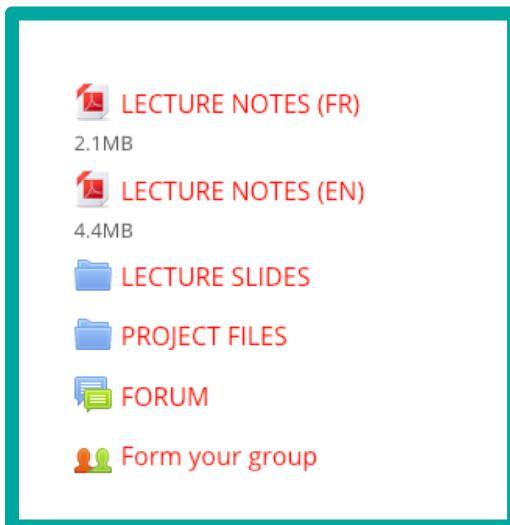
# Important Platforms

overleaf, moodle & mattermost

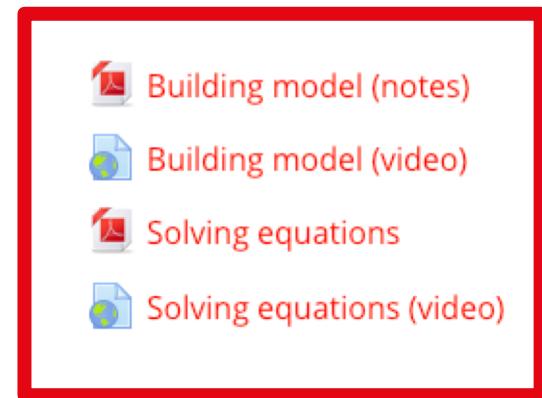
Moodle contains all **material & files** necessary for the course & project.

- Website

Main documents and folders:



Weekly notes and videos:



! Check before each class, updates may occur

# Mattermost

Direct communication with assistants and your group members via chat.



Docs

Features

Apps &amp; Integrations

Blog

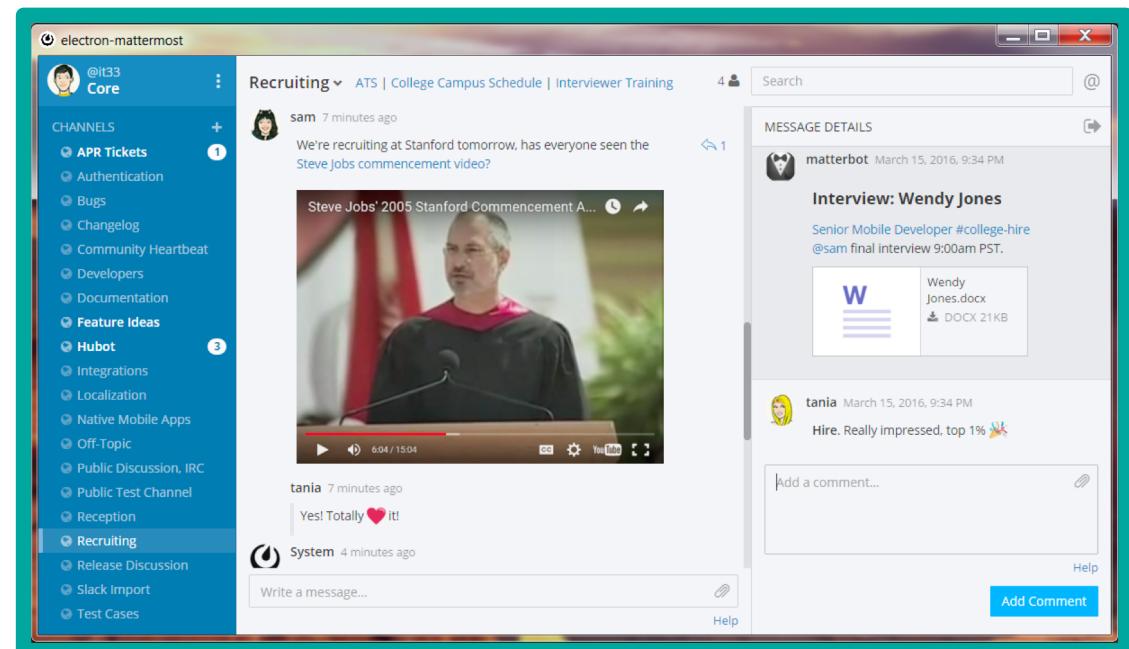
Contribute

Enterprise

Download



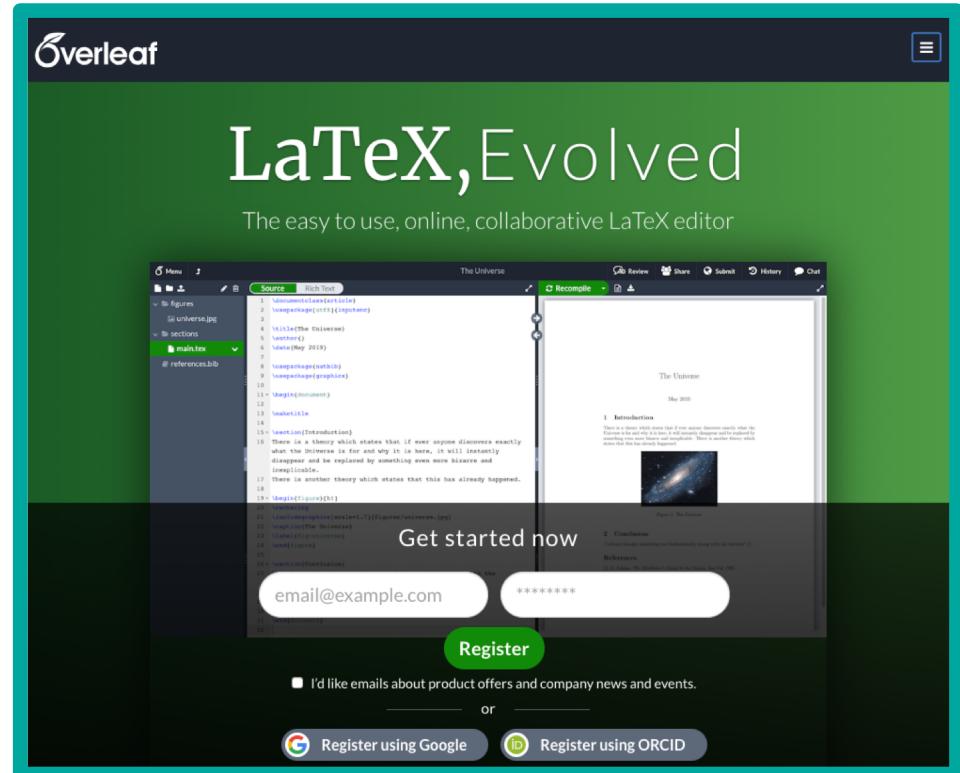
- **Sign up in a group on moodle**
- **Accept the invitation to our server (email)**
- **Install the software from the Website**



# Overleaf

Collaborative LaTeX editor to write reports together

- **Sign up with epfl email**
- **Create new project**
- **Share with your group**



[Website](#)

Collaborative LaTeX editor to write reports together

## Templates

Filters: All / Templates / Examples / Articles

Start your projects with quality LaTeX templates for journals, CVs, resumes, papers, presentations, assignments, letters, project reports, and more. Search or browse below.

Search... Search

### Popular Tags



Academic Journal  
Bibliography

## Documentation

Documentation Home  
[Learn LaTeX in 30 minutes](#)

### Overleaf guides

- [Creating a document in Overleaf](#)
- [Uploading a project](#)
- [Copying a project](#)
- [Creating a project from a template](#)
- [Including images in Overleaf](#)
- [Exporting your work from Overleaf](#)
- [Working offline in Overleaf](#)
- [Using Track Changes in Overleaf](#)
- [Using bibliographies in Overleaf](#)

Welcome to the Overleaf knowledge base. A complete list of topics is provided on the left hand-side, but here is a selection of useful articles:

### New to LaTeX?

Start with our [Learn LaTeX in 30 minutes](#) guide.

For more specific introductions, have a look at:

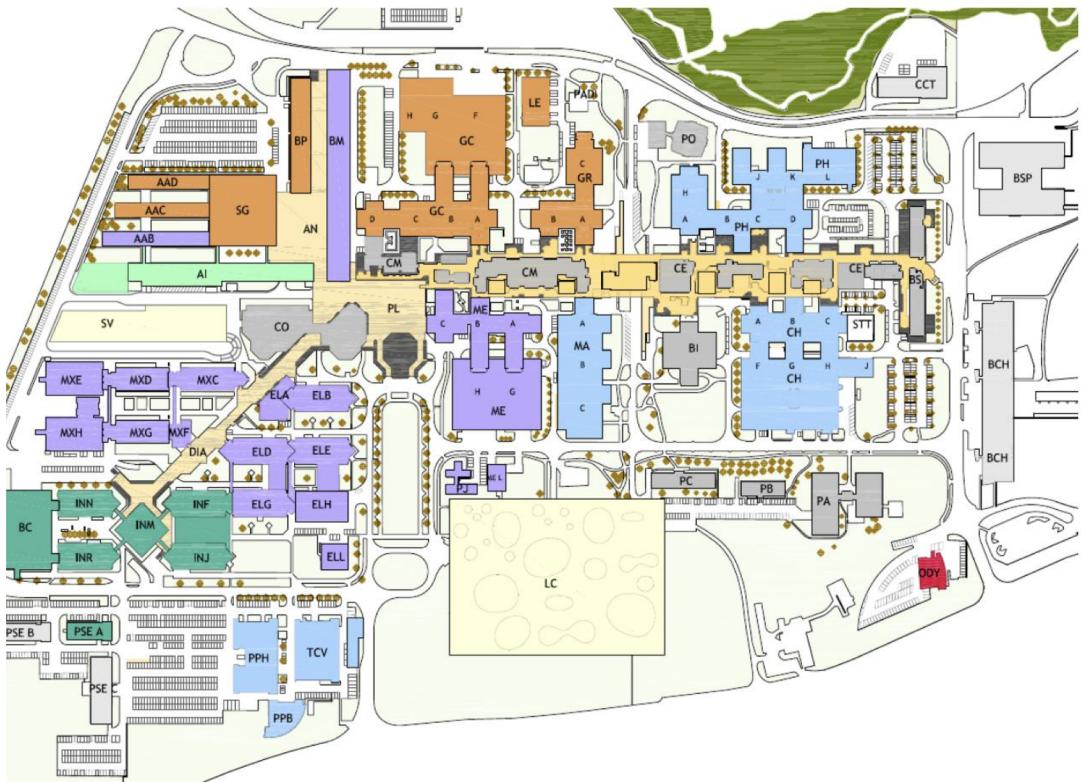
- [Create your first document in LaTeX](#)
- [Paragraphs and new lines](#)
- [Bold, italics and underlining](#)
- [Lists](#)
- [Mathematics](#)

Templates

Documentation

# Project Overview

- The **energy system** of EPFL supplies heating, cooling and electricity.
- The **heating system** is about to reach the end of its lifetime.
- The management board is searching for **replacement** of the existing system.



# Project Overview

Matlab

Building demand &  
Typical Periods  
*Presentation 1: Week 4*

AMPL

Utility models  
*Presentation 2: Week 7*

AMPL

MILP Scenario Evaluation  
Week 15  
&  
Final report  
(10 days before exam)

AMPL

NLP Heat Recovery  
Options  
*Presentation 3 : Week 12*

VALI

Data reconciliation  
*Presentation 4: Week 12*

# Project Overview

## How do we start?

Matlab

Building demand &  
Typical Periods  
*Presentation 1: Week 4*

AMPL

Utility models  
*Presentation 2: Week 7*

AMPL

MILP Scenario Evaluation  
Week 15  
&  
Final report  
(10 days before exam)

AMPL

NLP Heat Recovery  
Options  
*Presentation 3 : Week 12*

VALI

Data reconciliation  
*Presentation 4: Week 12*

# What is our Goal?

# Project Overview

- The **energy system** of EPFL supplies heating, cooling and electricity.
- The **heating system** is about to reach the end of its lifetime.
- The management board is searching for **replacement** of the existing system.

What is our Goal?



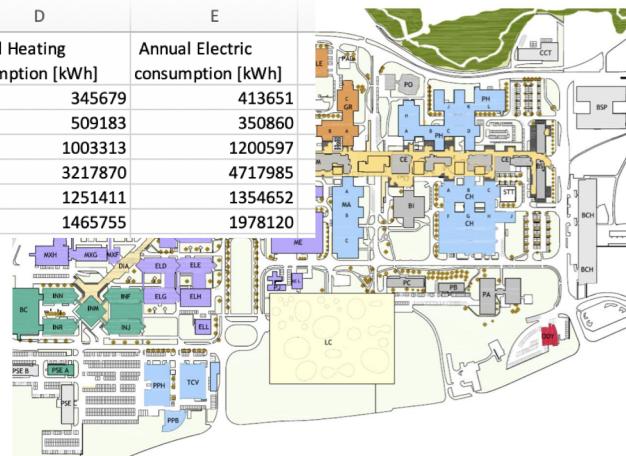
# What do we have?

# Available Data

- Building Data

P1\_buildingdata.csv

	A	B	C	D	E
1	Building	Construction	Heated ground surface [m <sup>2</sup> ]	Annual Heating consumption [kWh]	Annual Electric consumption [kWh]
2	BI	1	4496	345679	413651
3	BS	1	10267	509183	350860
4	CE	1	16655	1003313	1200597
5	CH	1	28986	3217870	4717985
6	CM	1	18663	1251411	1354652
7	GC	1	26586	1465755	1978120



- Weather Data

P1\_weatherdata.csv

	A	B
1	T amb [°C]	Irr [W/m <sup>2</sup> ]
2	9.1	0
3	9.3	0
4	9.1	0
5	9	0
6	8.8	0
7	8.7	0
8	8.7	0
9	8.6	0
10	8.7	2
11	9.4	41
12	10.1	76
13	10.7	104

- 2 “prepared” Matlab files

Buildings.m & All\_Buildings.m

- Project Description

Project\_description.pdf

# What is missing?

# Available Data

- Building Data

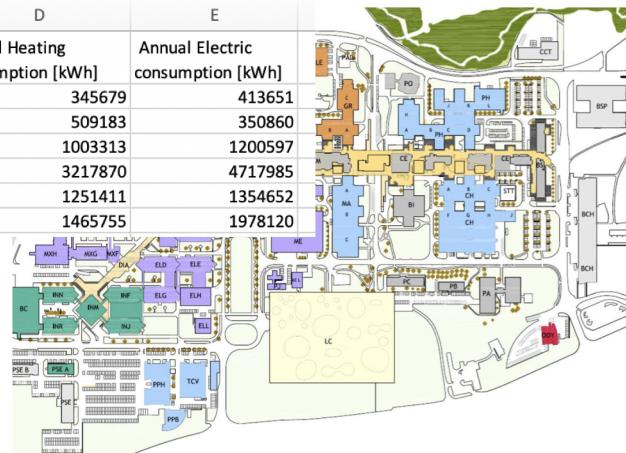
P1\_buildingdata.csv

	A	B	C	D	E
1	Building	Construction	Heated ground surface [m <sup>2</sup> ]	Annual Heating consumption [kWh]	Annual Electric consumption [kWh]
2	BI	1	4496	345679	413651
3	BS	1	10267	509183	350860
4	CE	1	16655	1003313	1200597
5	CH	1	28986	3217870	4717985
6	CM	1	18663	1251411	1354652
7	GC	1	26586	1465755	1978120

- Weather Data

P1\_weatherdata.csv

	A	B
1	T amb [°C]	Irr [W/m <sup>2</sup> ]
2	9.1	0
3	9.3	0
4	9.1	0
5	9	0
6	8.8	0
7	8.7	0
8	8.7	0
9	8.6	0
10	8.7	2
11	9.4	41
12	10.1	76
13	10.7	104



Demand profiles?

Identification of typical heat and electricity demand per building

Identification of typical heat and electricity demand per building

Task 1: Estimation of heat gains

Task 2: Calculation of building envelope properties

Task 3: Calculation of the hourly demand

Task 4: Clustering of typical days

# Outline Part 1

Identification of typical heat and electricity demand per building

Task 1: Estimation of heat gains

Task 2: Calculation of building envelope properties

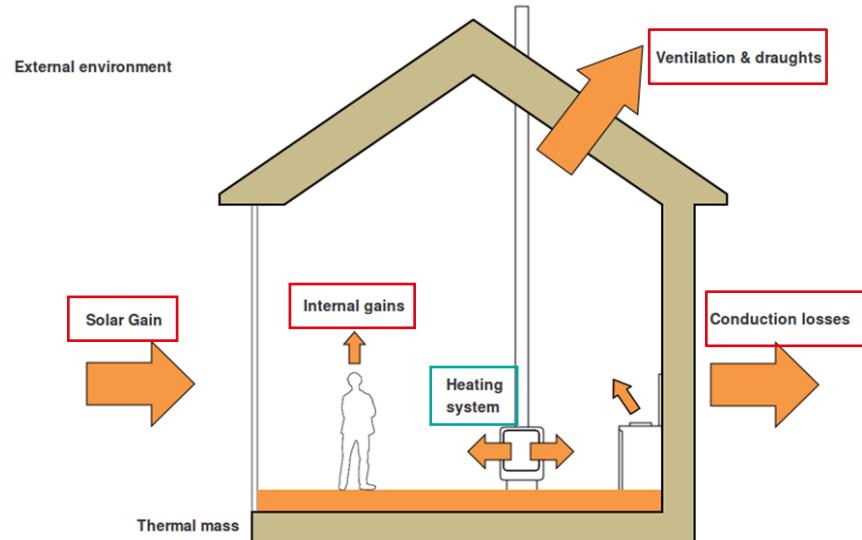
Task 3: Calculation of the hourly demand

Task 4: Clustering of typical days

# Estimation of Heat Gains

$$\dot{Q}_{th}(t) = A_{th} \left\{ k_{th} (T_{int} - T_{ext}(t)) - k_{sun} i(t) - \dot{q}_{pl}(t) \right\} - f_{el} \dot{Q}_{el}(t)$$

Conduction & Ventilation      Solar gain      Internal gains



# Estimation of Heat Gains

$$\dot{Q}_{th}(t) = A_{th} \left\{ k_{th} (T_{int} - T_{ext}(t)) - k_{sun} i(t) - \dot{q}_{pl}(t) \right\} - f_{el} \dot{Q}_{el}(t)$$

Conduction & Ventilation      Solar gain      Internal gains

P1\_buildingdata.csv      P1\_weatherdata.csv      P1\_internaldata.csv

# Estimation of Heat Gains

$$\dot{Q}_{th}(t) = A_{th} \left\{ k_{th} (T_{int} - T_{ext}(t)) - k_{sun} i(t) - \dot{q}_{pl}(t) \right\} - f_{el} \dot{Q}_{el}(t)$$

Conduction & Ventilation      Solar gain      Internal gains

21 °C

- P1\_buildingdata.csv
- Project description:  
Figure 1.1 & Table 1.2

80%

- P1\_buildingdata.csv
- Unified Distribution
- Mo – Fr; 7AM – 9PM

# Estimation of Heat Gains

$$\dot{Q}_{th}(t) = \underbrace{A_{th} \{ k_{th} (T_{int} - T_{ext}(t)) \}}_{\text{Conduction & Ventilation}} - k_{sun} i(t) - \underbrace{\dot{q}_{pl}(t)}_{\text{Solar gain}} - f_{el} \dot{Q}_{el}(t) - \underbrace{\dot{q}_{el}(t)}_{\text{Internal gains}}$$

? Unknown ?

→ Task 2 of part 1

# Outline Part 1

Identification of typical heat and electricity demand per building

Task 1: Estimation of heat gains

Task 2: Calculation of building envelope properties

Task 3: Calculation of the hourly demand

Task 4: Clustering of typical days

- ✓ Form a Group (moodle)
- ✓ Set up Tools (Matlab, Mattermost, Overleaf)
- ✓ Download Project files - **Project description**
- ✓ Get started with Part 1 Task 1
- ✓ Look forward to next Wednesday ☺

# Questions?