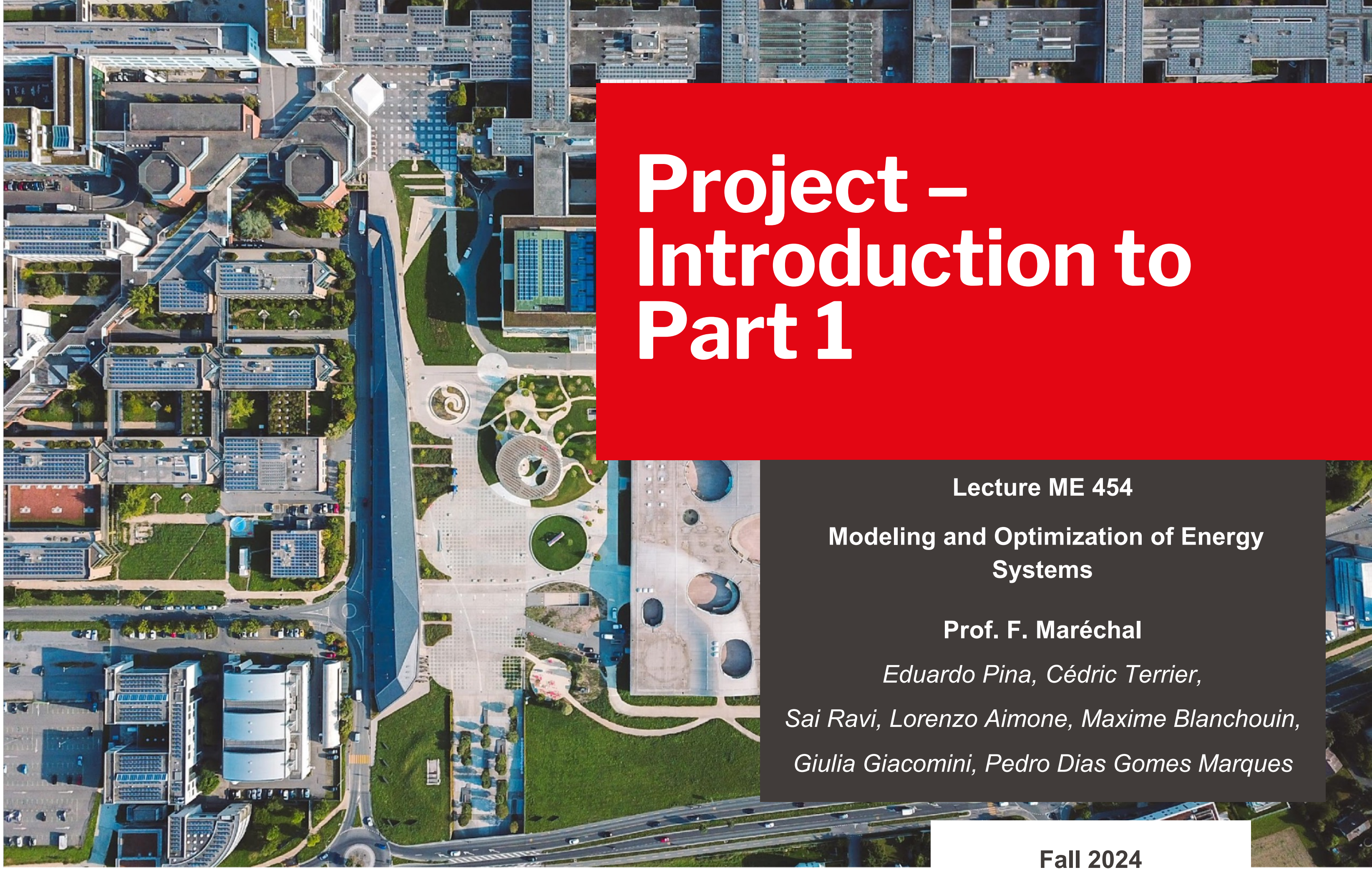

Project – Introduction to Part 1

Lecture ME 454

Modeling and Optimization of Energy Systems

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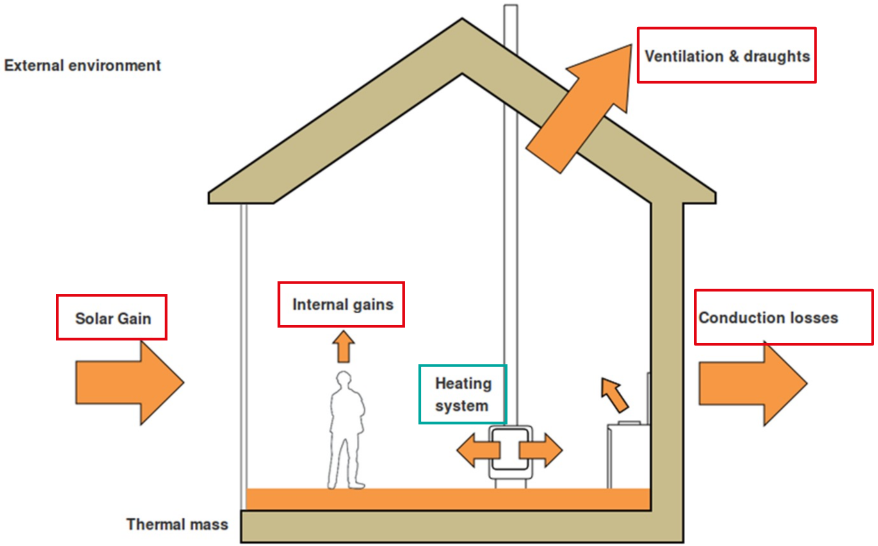
Hourly heating demand

Conduction & Ventilation — Solar gain — Internal gains

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



Outline Part 1

Identification of typical heat and electricity demand per building

Task 1: Estimation of internal heat gains

Task 2: Calculation of building envelope properties

Task 3: Calculation of the hourly demand

Task 4: Analysis on impact of renovation

Task 5: Clustering of typical days

Outline Part 1

Identification of typical heat and electricity demand per building

- Task 1: Estimation of internal heat gains
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Data processing

Conduction & Ventilation

Solar gain

Internal gains

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

Buildings.csv

Table 1.1: EPFL Buildings

Building	Construction period[a]	Heated surface A_{th} [m^2]	Annual heat demand Q_{th} [kWh]	Annual electricity demand Q_{el} [kWh]
BC	2	17480	418,491	1,603,596
CO	2	11901	477,008	943,653
BP	2	10442	457,861	691,031
BS	2	10267	509,183	350,860
TCV	2	6095	318,209	2,067,675
IN	2	24073	1,260,041	1,889,430
GC	1	26586	1,465,755	1,978,120
CE	1	16655	1,003,313	1,200,598
ODY	2	4092	253,199	81,410
MA	1	14018	889,271	5,531,370
GR	1	9997	649,081	813,804
ME	2	17151	1,126,830	3,118,001
CM	1	18663	1,251,411	1,354,652
AA + SG	2	18389	1,306,603	1,231,934
BI	1	4496	345,679	413,651
EL	2	22127	1,728,630	1,447,090
PO	2	692	64,607	94,326
CRPP	2	10831	928,960	1,608,750
MX	2	25868	2,600,901	2,832,408
BM	2	19697	2,121,607	2,411,721
CH + STT	1	28,986	3,217,870	4,717,985
DIA	2	847	105,136	-
PH	1	23581	3,036,870	4,433,829
AI	2	17674	2,768,898	3,898,106

[a] Construction period 1 corresponds to medium temperature demand (65 °C) while period 2 is for low temperature demand (50 °C)

Weather.csv

	A	B
1	T amb [∞C]	Irr [W/m2]
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

Assumptions

Conduction & Ventilation

Solar gain

Internal gains

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

- We'll use some initial values for this for now. Say Kth = 4 and Ksun is 0.05
- In the next step you'll calculate it using NR

21 °C

- Buildings.csv
- Project description: Figure 1.1 & Table 1.2

80%

- Buildings.csv
- Uniform Distribution
- Mo – Fr; 7AM – 9PM

Computed from occupancy profiles and opening days

Hourly Profiles

- Buildings are functioning only between 7 AM and 9 PM, between Mondays and Fridays (Saturdays and Sundays, they are not in use)
- Build the profile of the building operation with this for a week and then from there a year
- Gains from electric appliances are only during these operational hours
- Occupancy profiles of buildings is needed for heat gains and each building has a share of classroom area, self-service restaurant area and an office area
- This profile of the days are used to construct occupancy profiles of weeks and subsequently the whole year like before

How to calculate heat gains from people ?

Example

$$Q_{7,8,office} = 0.2 * 5 \frac{W}{m^2}$$

$$Q_{7,8,canteen} = 0 * 35 \frac{W}{m^2}$$

$$Q_{7,8,classroom} = 0.4 * 23.3 \frac{W}{m^2}$$

$$Q_{7,8,building} = 0.3 * Q_{7,8,office} + 0.05 * Q_{7,8,restaurant} + 0.35 * Q_{7,8,classroom}$$

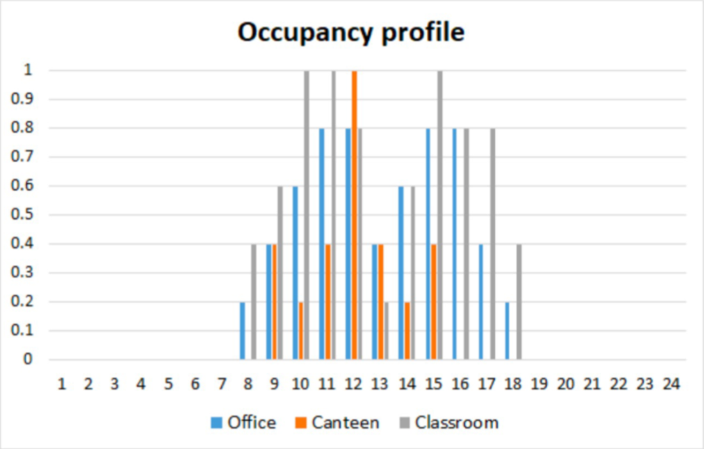

Table 2: Standard occupancy profile

Usage	Heat gain (W/m^2)	Share A_{type}/A_{th}
Office	5	0.3
Self-service Restaurant	35	0.05
Classroom	23.3	0.35
Others	0	0.3

Hourly profile for each building

Conduction & Ventilation — Solar gain — Internal gains

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

Plugging in all the data we processed into the above equation, we will have hourly profiles for each building.

But now, we have to identify the conditions in which the heating system is actually turned on and use only these data.

Conditions for heating

- What is the minimum external temperature at which you should consider heating? Should there be some tolerance here?
- Should we heat when the buildings are closed?
- Should we consider cooling needs? (For simplicity and the sake of this project, we can assume there are no cooling needs)

Translate the answer to these questions into logical statements that will allow you to identify the real heating load

Other aspects:

One zoom meeting per week with your TA is possible (rendez-vous needed, elaborate your questions in detail and send it to your TA 2 days before the meeting using the Mattermost group)

Your TODOs

Form a Group (in moodle) : to be finished before next week

Set up Tools (Mattermost, Virtual machine, Quarto) and test if they work well

Download Project files from moodle - **Project description.pdf**

Get started with Part 1 Task 1 – **Project materials on gitlab and Quarto Tutorial on moodle**

If you are fast, start reading about Task 1.2 where you will use Newton-Raphson to find the values of k_{th} and k_{sun}. More information on that task will come next week.