ME-409 2024/2025

Project

Tuong-Van Nguyen
Planair

Arthur Chuat
IPESE

9th of September 2024

Outline

1. Context and goals
2. Organization
3. Model structure
4. Interface guidelines + live demo

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Project description

https://ipese-lectures.epfl.ch/energy-conversion-2019/project-description.html

Project description

- Context
- Goals
- Organization
- Model structure
- Interface guidelines
- Timeline

How to write a scientific/technical report

- General structure
- Content
- TO DO's and NOT TO DO's

Project description

The *aim* of this project is to investigate the possible energy mixes of Switzerland under the horizon 2050. You are given a model that represents an energy system, which does *not* correspond to the current Swiss energy system. You can expand or restrict the model by progressively adding or removing energy conversion technologies. You may also vary the model parameters: resources costs, carbon content and availability, end-use energy demands, and technologies characteristics. You can then run an optimization to minimize the system costs (economical objective) or impacts (environmental objective), and analyze the results.

Context and goals

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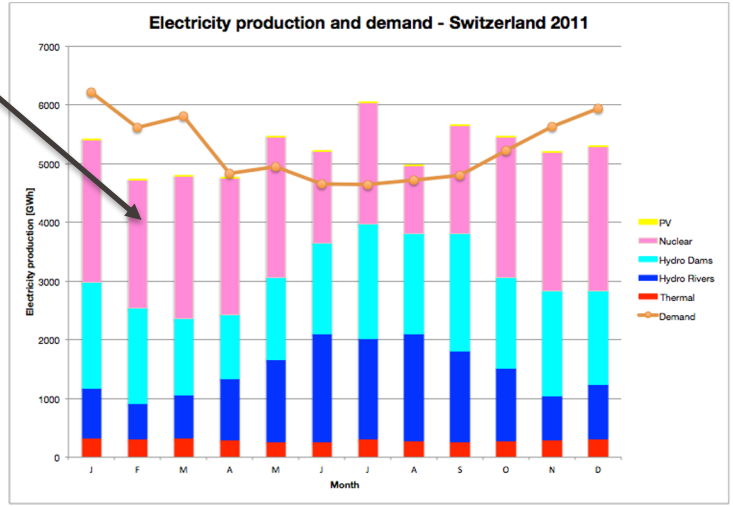
Context

Various countries taking strategic decisions about their energy future

How to fill this gap ?

March 11th, 2011
Fukushima nuclear disaster



2034 : Phase-out of nuclear power plants
(decided by Swiss citizens in 2017)

Sources:
- SFOE, Swiss electricity statistics 2011
- SFOE, Energy strategy 2050 explanatory document

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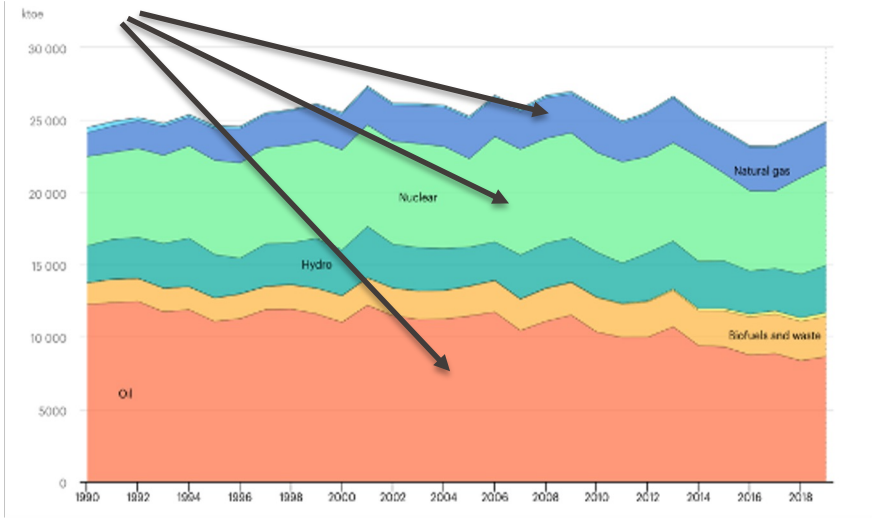
Context

Various countries taking strategic decisions about their energy future

October 2018
IPCC reports on impacts of warming above 1.5°C

How to fill these gaps ?



Primary energy consumption in Switzerland

2050: Reduce net greenhouse gas emissions to zero (net emissions target)

Sources:
- IEA, Switzerland
- SFOE, What is the Energy Strategy 2050?

Goals

You are a consultant of the Swiss government, asked to write a scientific report for their use, to help **support decision-making in national energy policy** at the **2050 horizon**.

Steps :

- Optimize an energy system model, with data relevant to 2023
- Estimate the end-use demands and technologies available in 2050
- Analyze different energy scenarios, compare their pros and their cons
- Propose two specific designs for the Swiss energy system in 2050

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Tasks

1. Status of the Swiss Energy System as of **2022**
   - *Which resources and technologies are currently used?*
2. Swiss energy demands of **2050**
   - *Considering economic development and population growth, how are our energy demands expected to change?*
3. **Baseline scenarios** for the future energy systems
   - Which scenarios for the development of our energy system can be expected, at which costs and impacts?

Tasks

4

Trade-offs between economic costs and environmental impacts

- *How can we respect our 2050 targets at an acceptable cost?*

5

Impact of **energy sobriety and efficiency**

- *Which changes in our behaviours and technologies can help us reaching these targets?*

6

The future is **uncertain**

- Geopolitical changes impact prices and resource availabilities, are the proposed energy systems adequate?

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2. Organization

Organization
General

Groups of 5 students → Please register for the group before the 16.09

Monday 10-11h – Exercise session
- On campus (CO 3)

Monday 11-13h – Lecture
- On campus (CO 3)

Monday 13-14h – Project session
- **On campus (AAC 2 31)**

Organization
Teaching team

Naveen Bhati
PhD student
IPESE

Pullah Bhatnagar
PhD student
IPESE

Arthur Chuat
PhD student
IPESE

Angela Meshkova
MSc student
Energy Science
& Technology

Yann Roubaud
MSc student
Environmental Sciences
& Engineering

Project session
Monday 13h15-14h00
AAC 2 31

Organization
Material

Course website **[VPN needed / access from EPFL]**

- Contains *Project description*

Online platform **[VPN needed / access from EPFL]**

- To run your optimizations

ed : Forum for project related questions

Moodle

- Excel file (*EC_interface.xlsx*)
- Group formation
- Intermediate and final report submissions (+ feedback on a later stage)

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Organization
Deliverables

Group formation → Next Monday 16/09/2024

Intermediate report
- Graded, 25% of project grade
- Maximum limit of 6 pages

→ Intermediate report 18/11/2024

Final report
- Graded, 75% of project grade
- Maximum limit of 12 pages

→ Final report 20/12/2024

Project accounts for 40% of course final grade

40% Project | 60% Written exam

3. Model structure

Model structure

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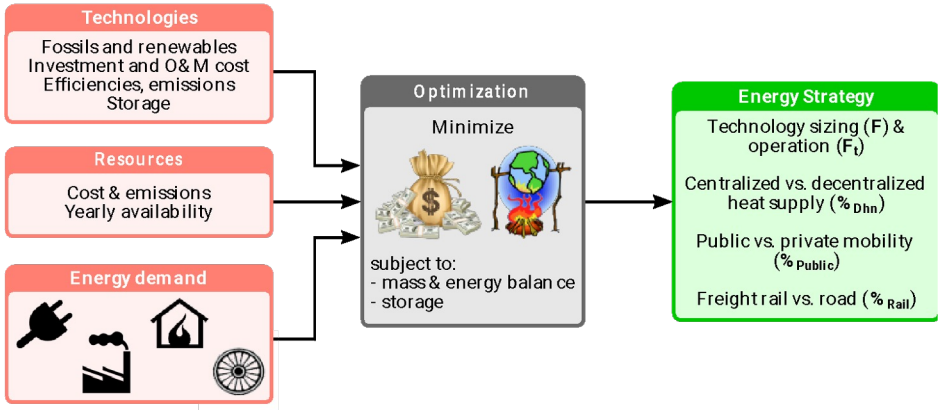
The model is a representation of any national energy system and is constituted by :

- Resources : coal, natural gas, uranium, …
- End-use energy demands : electricity, heating, mobility.
- Energy conversion technologies : coal plant, wind turbine, PV panel, …



Model structure

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The model is defined as a linear optimization problem, which matches the energy demand with the available resources, while minimizing a specified objective function.

Objective function : CAPEX, OPEX, TOTEX, GWP_op, GWP

Constraints :

- Mass balance, energy balance, cyclic conditions (storage)
- Technologies limitations (deployment potential, capacity factor)
- Additional constraints on the defined key performance indicators (KPIs)

Decision variables :

- Installed capacity for each technology
- Operation of each technology (on a monthly basis)
- Shares of : centralized heating (DHN) / public vs private mobility / rail vs road freight

Model structure

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Energy-based model, with a “snapshot” modeling approach : optimization of the system in a target year

Simplified yet complete energy system : electricity, heat and mobility demand

Multi-periods formulation : seasonality of demand and energy storage

Based on the input data and objective function, the optimizer selects the optimal :

- Generation capacity of each technology (wind, solar, nuclear, etc.)
- Storage capacities required
- Operation of each power plant at a time t
- Imports of resources

→ Complete Energy Strategy for 2050

4. Interface guidelines

+ live demo

Interface
Excel sheet

4 tabs defining the input data for the model

- Control: Specify your objective function, constraints
- Resources: Availability, cost, carbon content
- Demand: Electricity, heat and mobility
- Technologies: +50 characterized energy technologies

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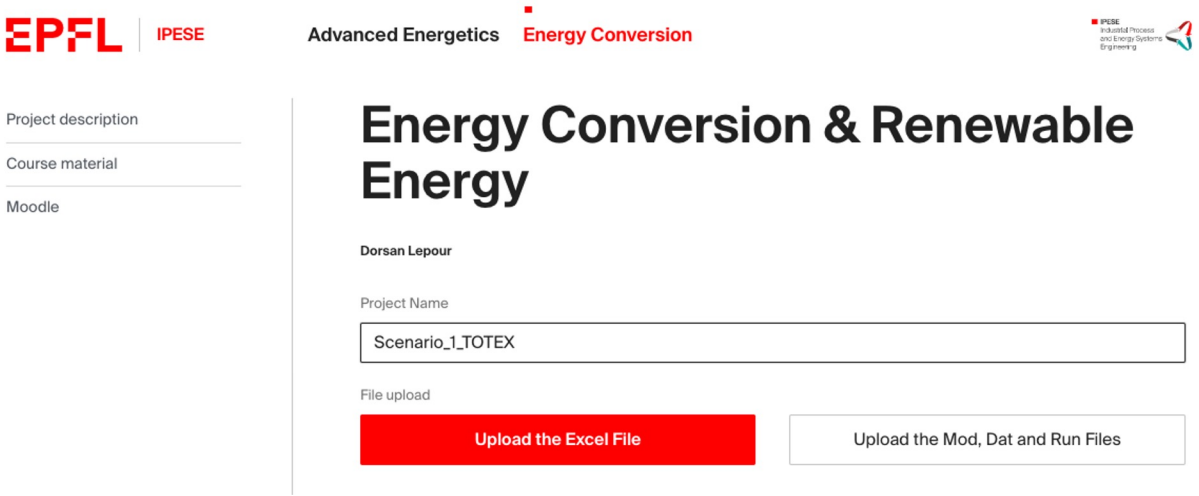
Interface
Platform

https://ipese-lectures.epfl.ch/energy-conversion/project/



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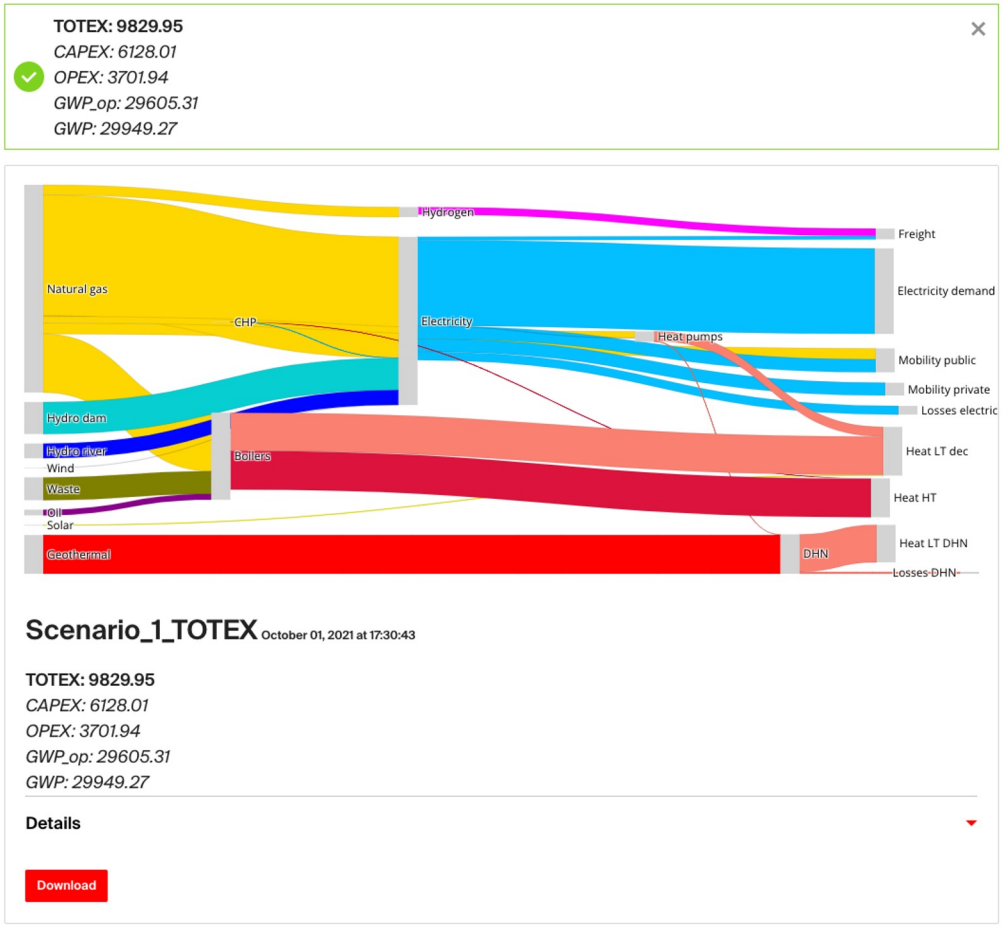
Interface
Platform

KPIs

Sankey diagram

Run name and date

Output data
(10 .csv files)



Project related questions

Questions & communication

Use first and foremost the weekly project session

You may also use the ed forum

- The answer to your question there will benefit everyone

Avoid as much as possible to send emails to the assistants

And finally, get to work ahead of time. You are ~130 students, it will be impossible for us to help you if the 30 groups bombard us at the same time with questions the day before a milestone ! 🤯