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Biomass for Swiss Energy Future
Swiss Competence Center for Energy Research

IPESE Industrial Process and Energy Systems Engineering
EPFL École Polytechnique Fédérale de Lausanne

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Conceptual Design of Commercial Swiss Biomass Supply Chains

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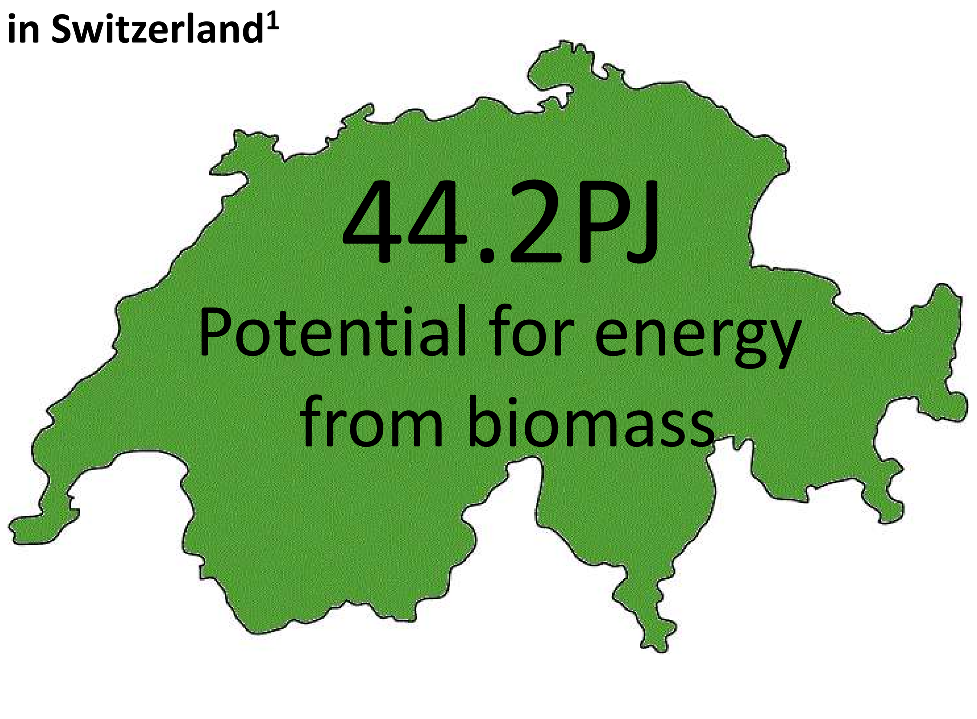
MOTIVATION

Utilize the existing biomass energy potential in Switzerland[1]

- Forest wood
- Wood residues
- Wood from landscape maintenance
- Waste wood
- Agricultural crop residues
- Animal manure
- Organic household waste
- Green household waste
- Commercial & industrial organic waste
- Sewage sludge

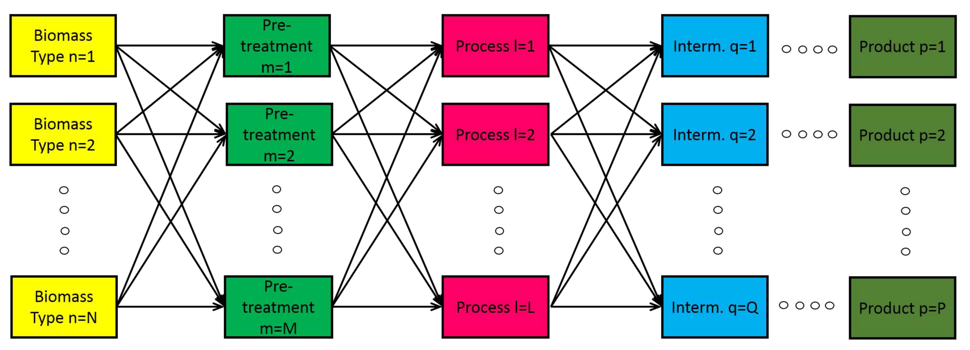


SCOPE

- Design of commercial biomass supply chains, making the link between the biomass resources, the conversion technologies and the energy services.
- Integration of process design with the supply chain, highlighting the benefits and revealing the synergies between the two.
- Development of a decision support tool for the optimal biomass resource allocation.
- Bridge the current design methodologies and set the transition from process design to national level design while considering the economies of scale.
- Deliver comprehensive computer tools where competing options can be compared with a holistic and system integration perspective.

DESIGN APPROACH

Process Design Level



Robust design of biomass conversion pathways on given spatial location, feedstock and demands using a process superstructure approach

Design on process level to ensure efficient and cost optimal operation (MILP optimization)

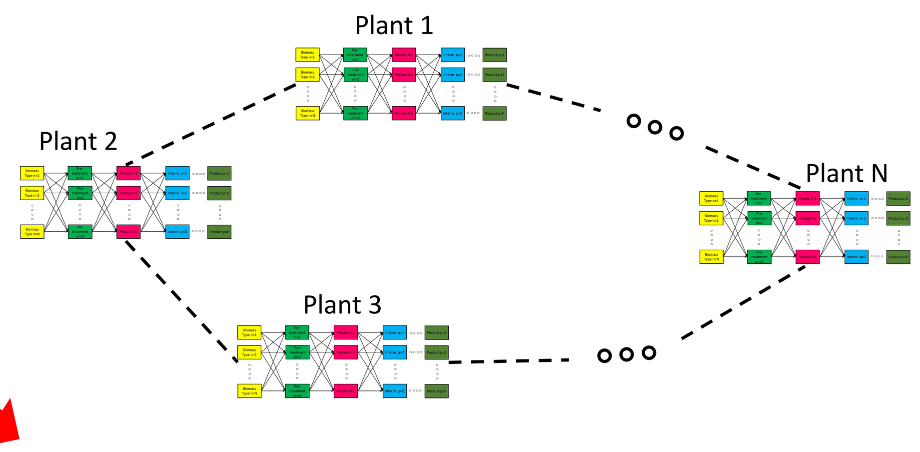
Biomass conversion to fuels, heat and power

Large number of combinations (conventional technologies, renewables, hybrid etc.)

National Level

Design of the supply chain at national level considering ***a multi-objective design optimization approach*** coupled with considerations on :

- resource availability and potential
- process integration/intensification
- social and economic impacts
- national market conditions

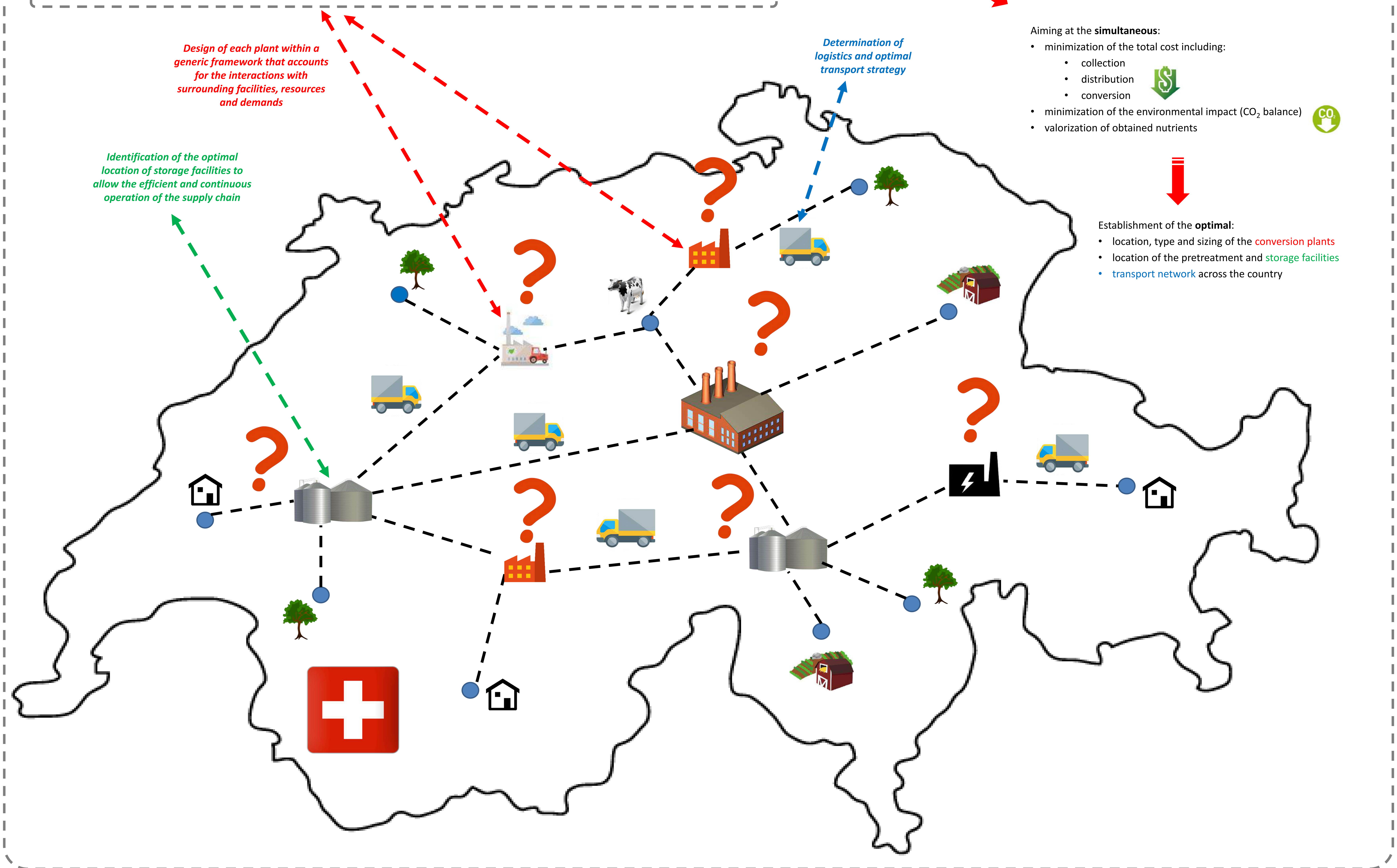


Aiming at the **simultaneous**:

- minimization of the total cost including:
  - collection
  - distribution
  - conversion
- minimization of the environmental impact (CO_2 balance)
- valorization of obtained nutrients

Establishment of the **optimal**:

- location, type and sizing of the conversion plants
- location of the pretreatment and storage facilities
- transport network across the country



KEY QUESTIONS

What is the optimal plant size?

Use of reference sized plants based on **design** and **market** considerations

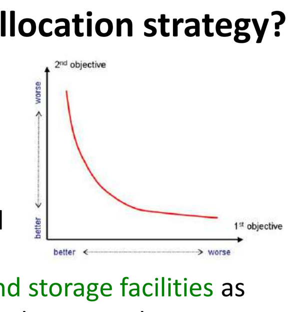
S_1 S_2 ... S_{NS}

The total number of plants is:

$\sum_{s=1}^{NS} N_s$ where N_s is the number of plants of size $s \exists [1,..,NS]$

What is the optimal allocation strategy?

Use of **multi-objective optimization** guided by ***environmental, social and market considerations*** to determine the optimal spatial locations of the processing plants, pre-treatment units and storage facilities as well as the transportation links between them



What are the synergies between the processes in the supply chain and what is the optimal way to exploit them?

Employment of **process integration techniques** to exploit potential interactions between neighboring facilities

$\dot{Q}, \dot{m}, \dot{P}$

Exchange of heat, mass and power between plants and storage sites

How to best store the electricity produced throughout the chain?

Use of **advanced Power-to-Gas processes** for excess electricity storage through chemical media

Design and development of the *optimal storage and utilization* strategy

ACKNOWLEDGEMENTS

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REFERENCES

1. O. Thees, V. Burg, M. Erni, G., Bowman, R. Lemm, Biomass potenziale der Schweiz für die energetisce Nutzung, WSL Berichte, Heft 57, 2017.