Predictive Modeling of risk factors in slaughterhouses using Low-cost inertial sensors

Thesis Defense

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15 November 2020

Outline

Section 1

Work-Related Muscukuloskeletal Disorders in Slaughterhouses

Motivation

State of the Slaughterhouse Industry (BMUB 2015/16)

1. Labour is a high pertcentage of the costs.
2. Fatigue and bad practices lead to injuries, absenteesim and costs.

Literature Review

State of the Slaughterhouse Industry (BMUB 2015/16)

1. Labour is a high pertcentage of the costs.
2. Fatigue and bad practices lead to injuries, absenteesim and costs.

Section 2

Thesis Hypothesis and Objectives

Section 3

Methodology, Prototype & Experiments

Section 4

Predictive Modeling & Decision Making

Section 5

Conclusions

Section 6

Energy, Infrastructure, City

Motivation

Questions about Germany's Climate Action Plan 2050 (BMUB 2015/16)

1. How can the almost complete transition from fossil fuels to renewable energy sources for electricity generation be accomplished by 2050?

http://www.klimaschutzplan2050.de/en/action-areas/energy-sector/

Motivation

Questions about Germany's Climate Action Plan 2050 (BMUB 2015/16)

1. How can the almost complete transition from fossil fuels to renewable energy sources for electricity generation be accomplished by 2050?
2. How can we build acceptance for a timely grid expansion?

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3. What proportion of fossil fuel burning power stations do we need for a transitional period, and for how long?

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Motivation

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2. How can we build acceptance for a timely grid expansion?
3. What proportion of fossil fuel burning power stations do we need for a transitional period, and for how long?
4. Which role do decentralised energy supply concepts play?

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2. How can we build acceptance for a timely grid expansion?
3. What proportion of fossil fuel burning power stations do we need for a transitional period, and for how long?
4. Which role do decentralised energy supply concepts play?
5. How can the electricity and heating/cooling markets be more closely integrated [...]?

http://www.klimaschutzplan2050.de/en/action-areas/energy-sector/

Perspective

Disciplines for investigating energy topics

Physics	Engineering	Economy	Society
Theoretical feasibility (Natural laws)	Technical feasibility (Technologies)	Economic feasibility (Funding)	Social feasibility (Decision space)

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Techno-economic modelling

How much energy? For how much?

Section 7

Sustainable model use

Optimisation model workflow

Research question

Optimisation model workflow

Research question $\xrightarrow{\textit{informs}}$ Modelling assumptions

Optimisation model workflow

Research question → *informs* → Modelling assumptions

Research question ↓

Data

- Tabular
- Geographic
- Database

Optimisation model workflow

Research question → *informs* → Modelling assumptions

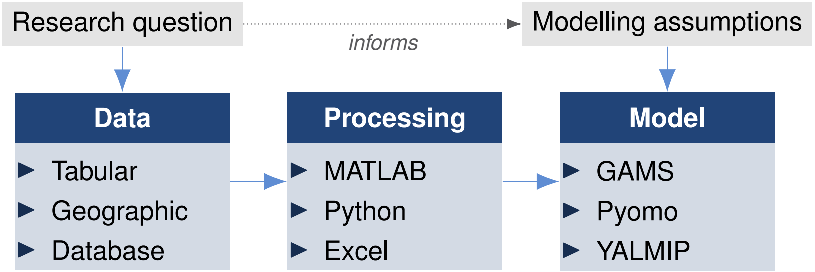
Data

- Tabular
- Geographic
- Database

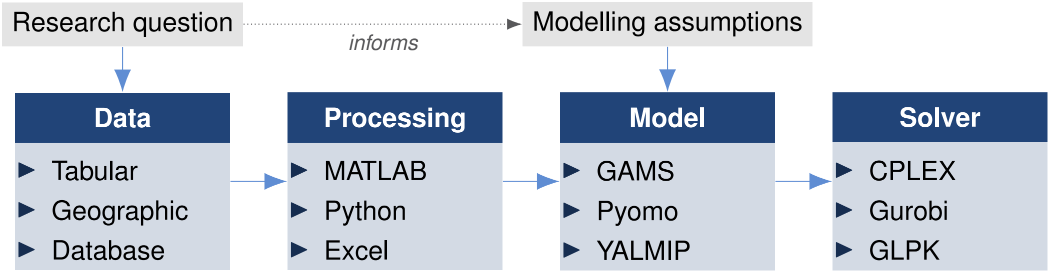
Model

- GAMS
- Pyomo
- YALMIP

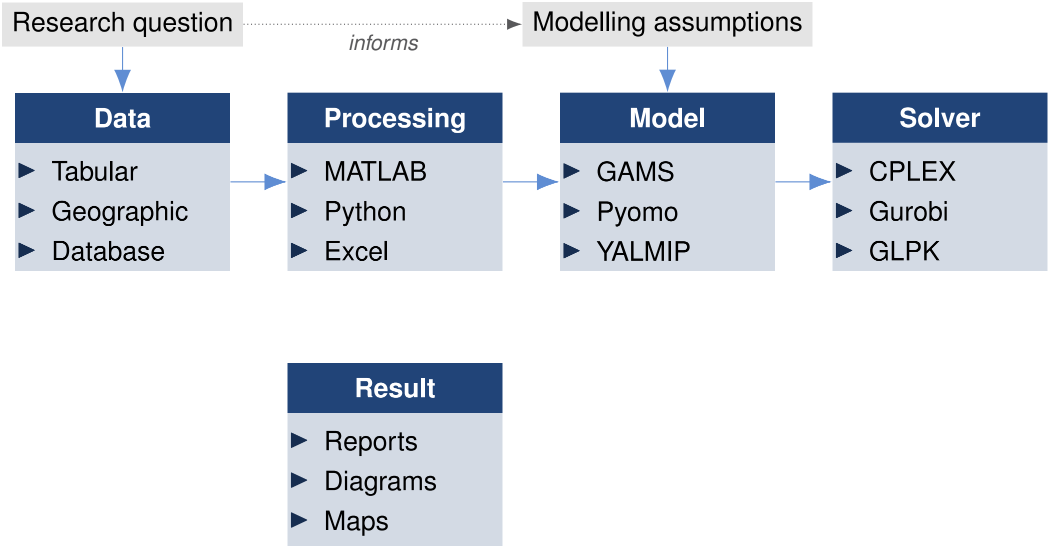
Optimisation model workflow



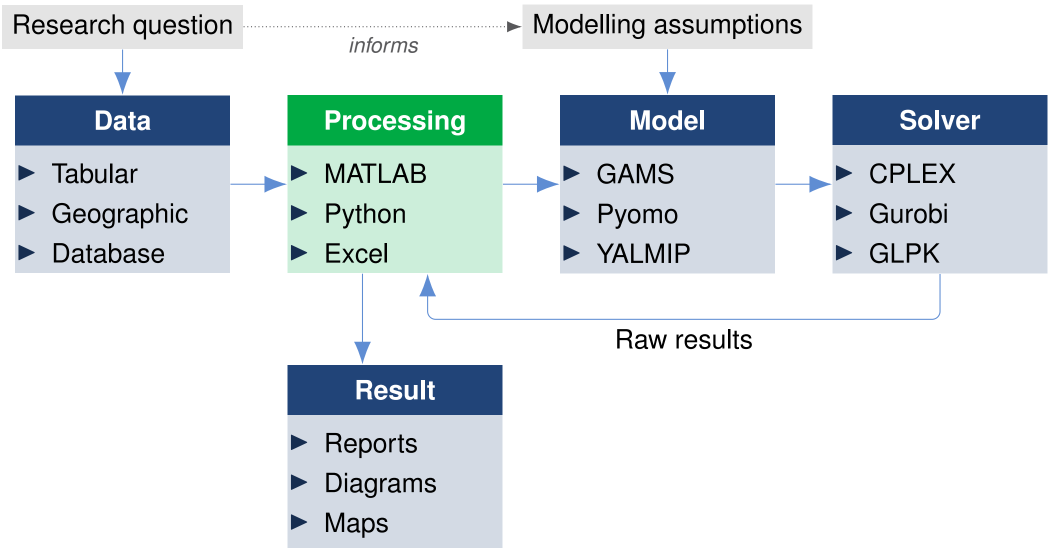
Optimisation model workflow



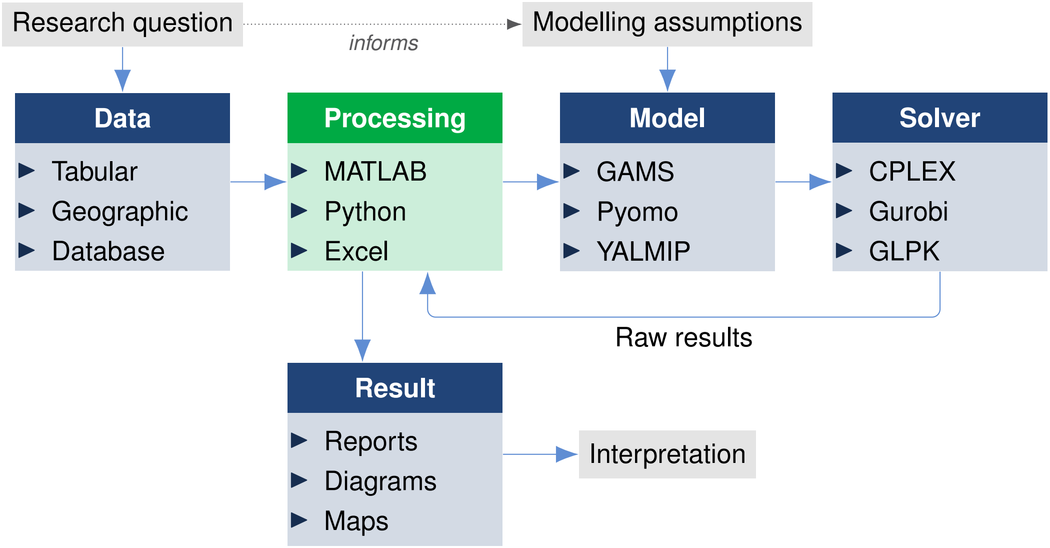
Optimisation model workflow



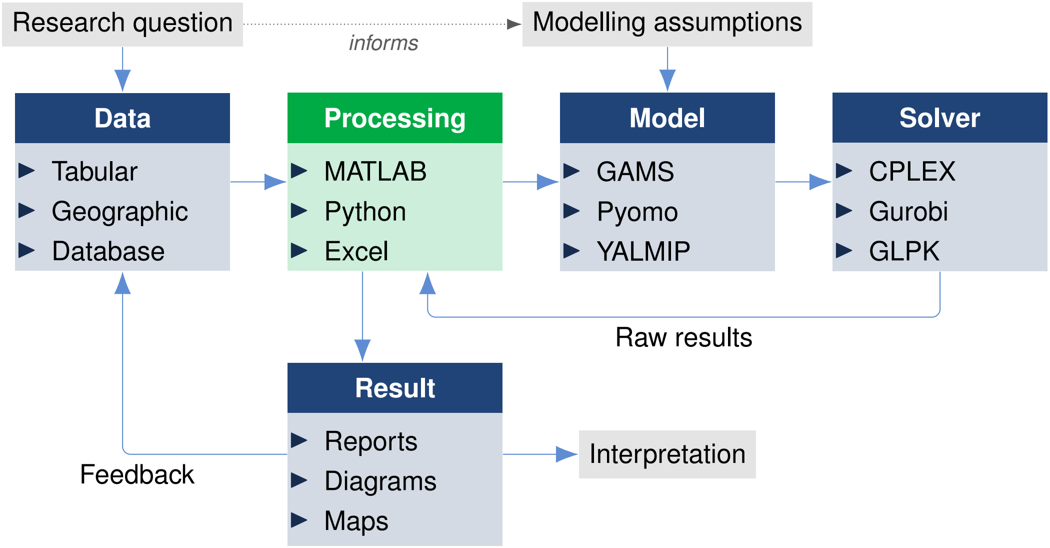
Optimisation model workflow



Optimisation model workflow

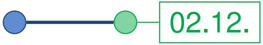


Optimisation model workflow



Distributed version control for scientific work

Distributed version control for scientific work



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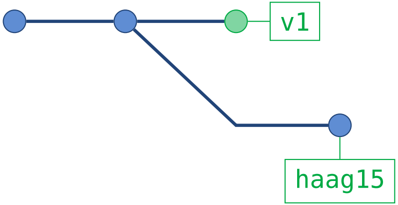

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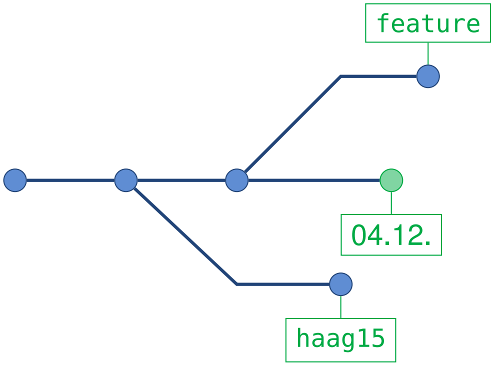

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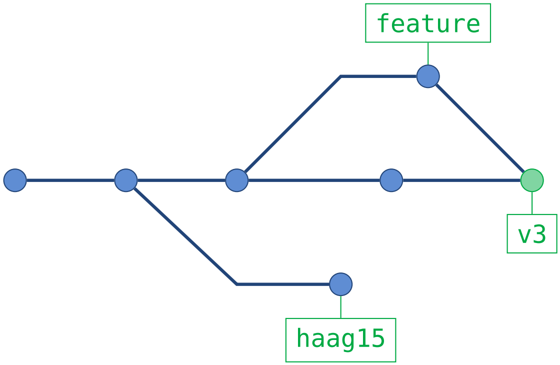

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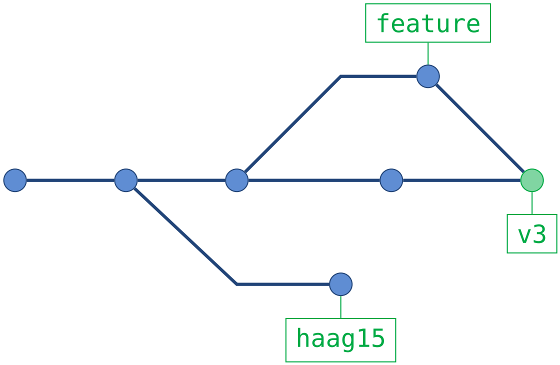
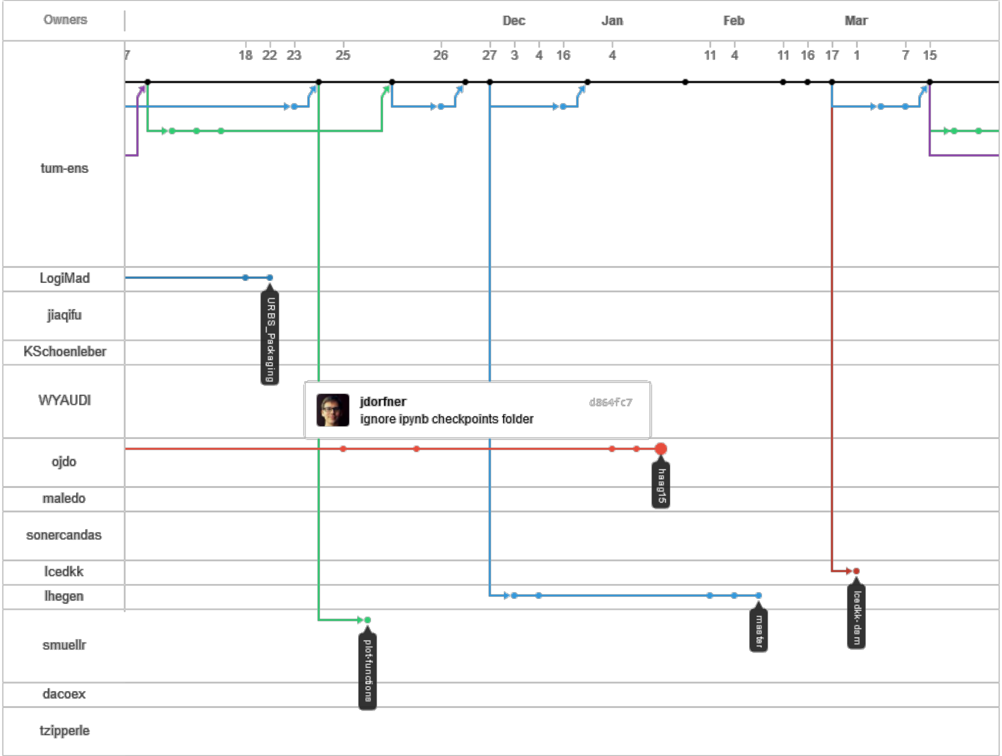


Collaboration

Development

Archival



Owners
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KSchoenleber
WYAUDI
ojdo
maledo
sonercandas
lcedkk
lhegen
smuellr
dacoex
tzipperle
URBS_Packaging
jdorfner
d864fc7
ignore ipynb checkpoints folder
haag15
master
lcedkk-dam
plot-functions

Conclusion

Infrastructure

Engineering

Technical feasibility
(Technologies)

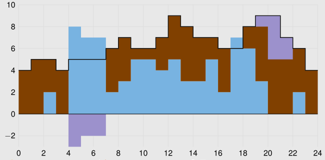
Economy

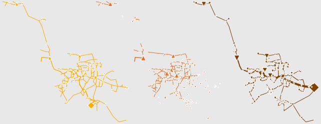
Economic feasibility
(Funding)

Techno-economic modelling

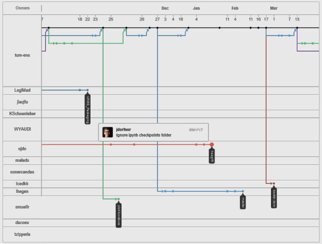
How much energy? For how much?

Modelling





Open Source

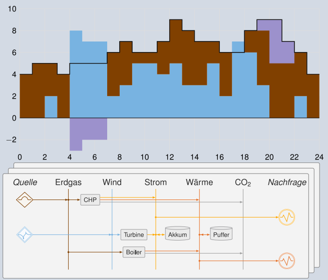


Section 8

Mathematical modelling, optimisation, case study

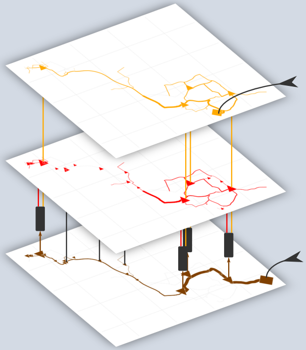
Model overview

urbs



https://github.com/tum-ens/urbs

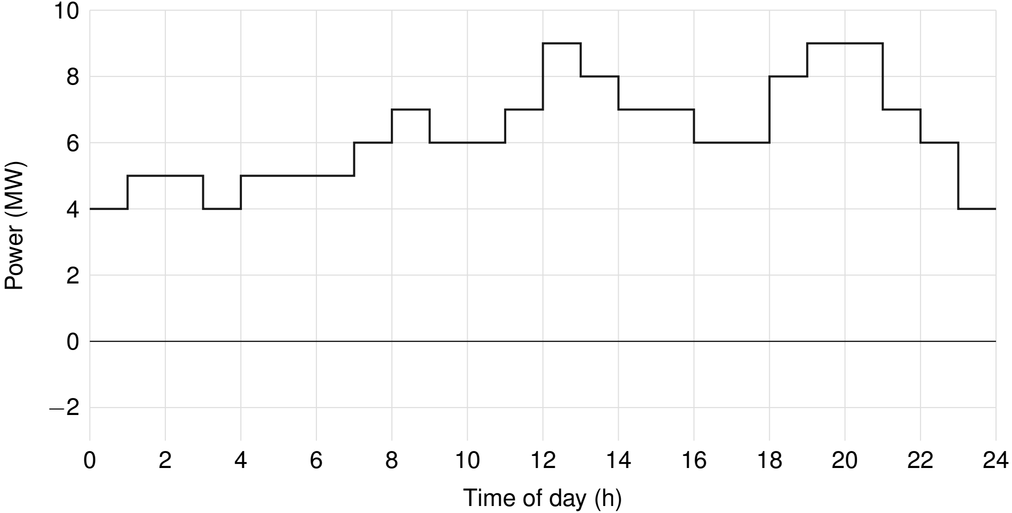
rivus



https://github.com/tum-ens/rivus

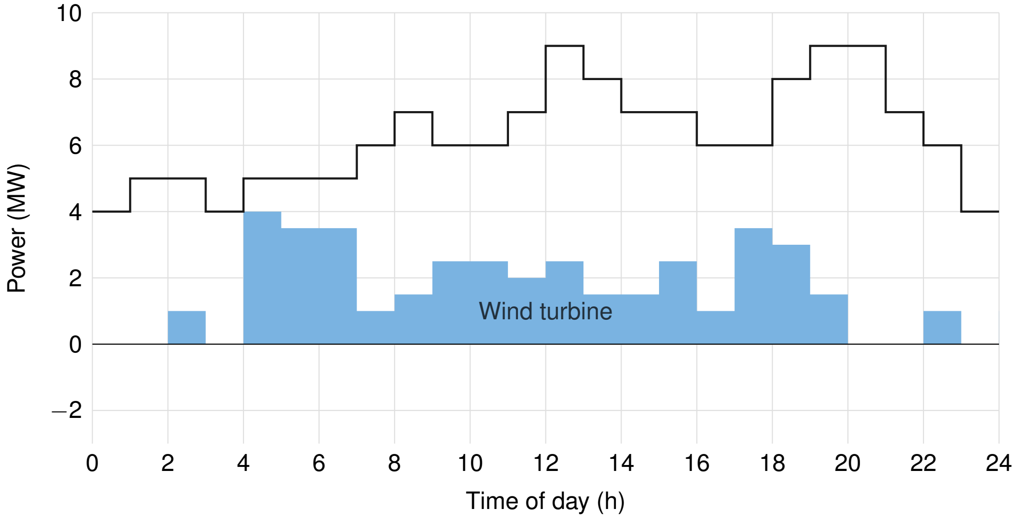
urbs

Principle illustrated



urbs

Principle illustrated



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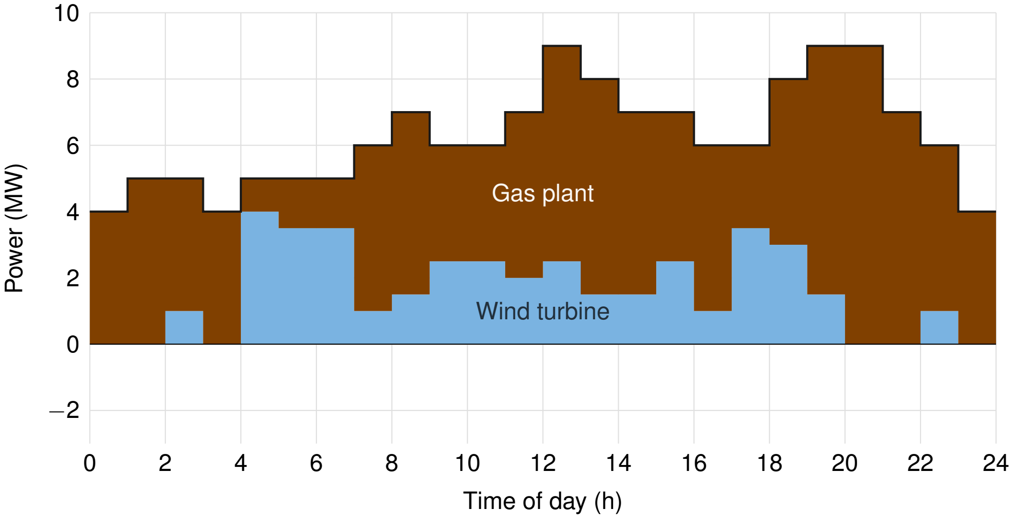

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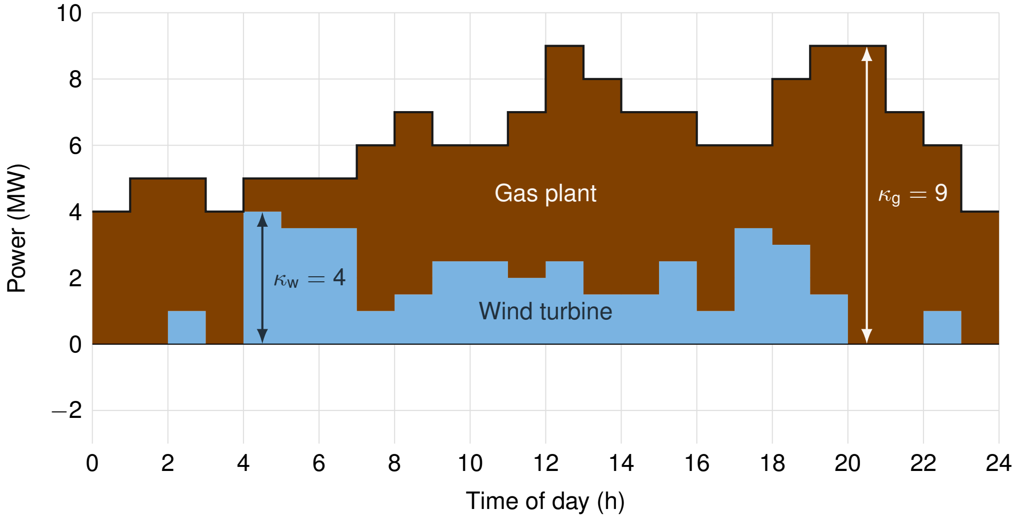

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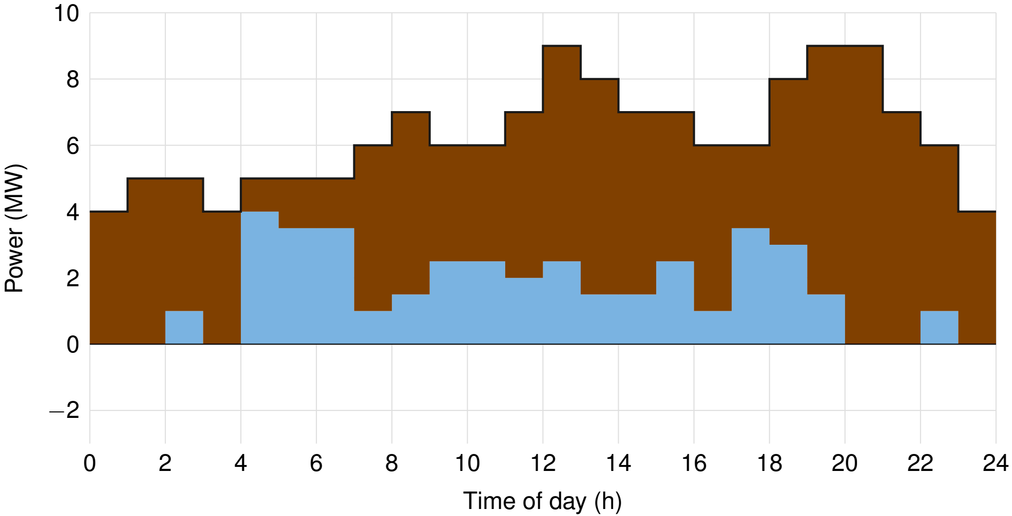

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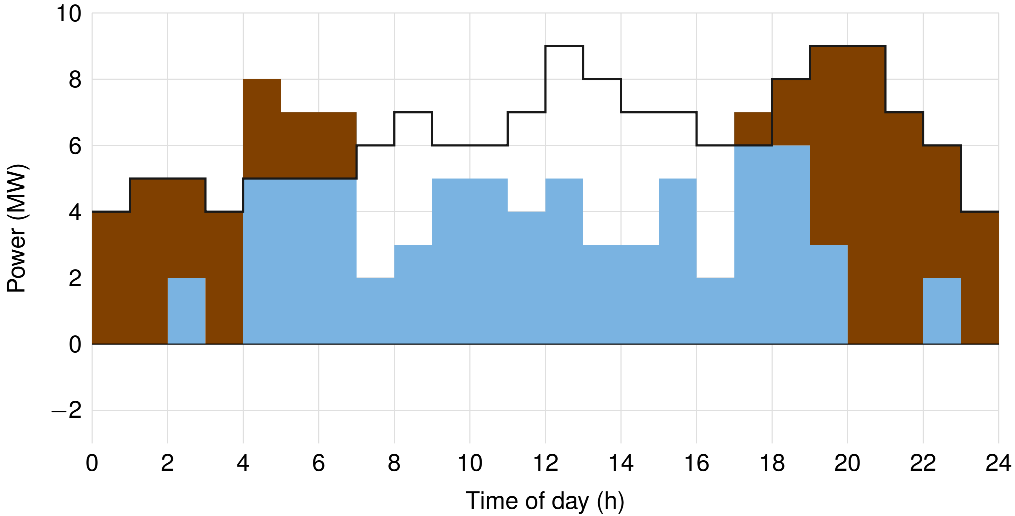

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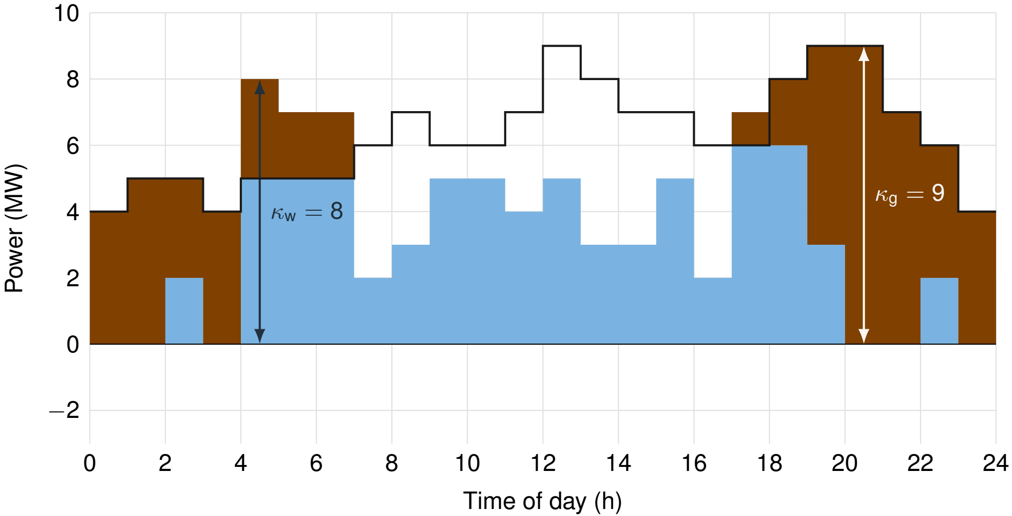
Principle illustrated



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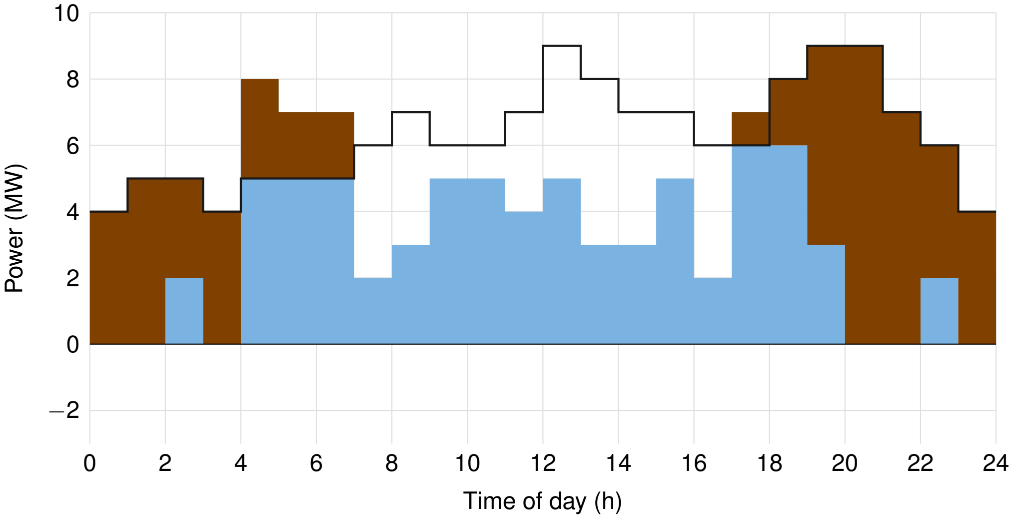

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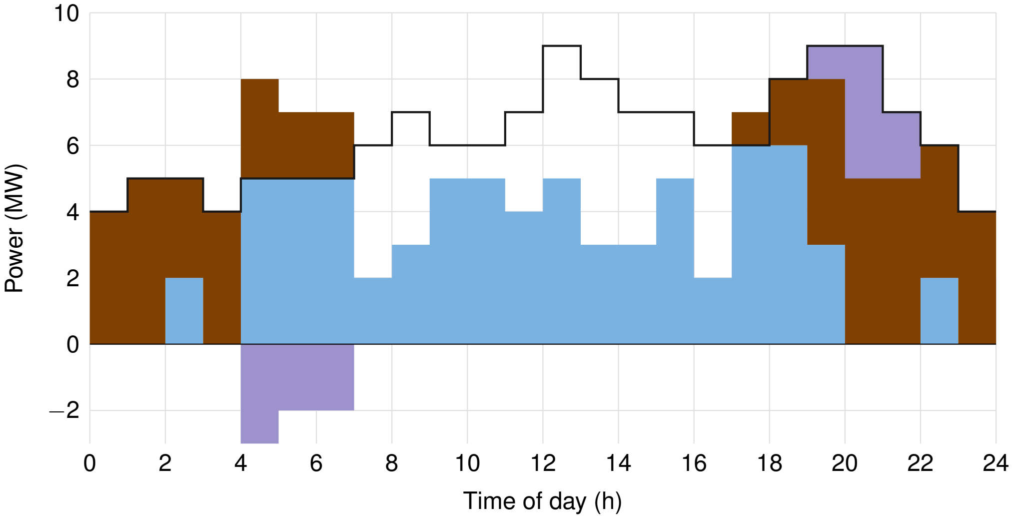

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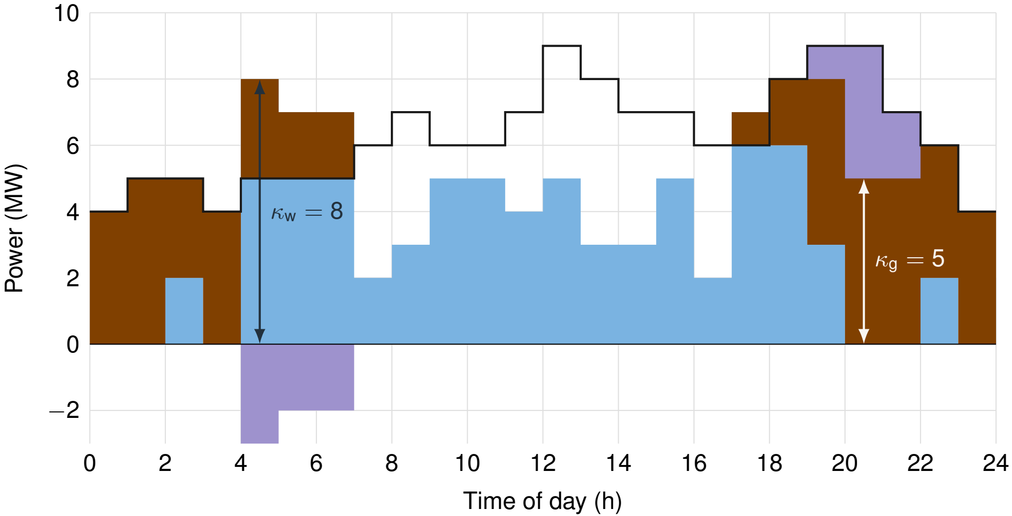

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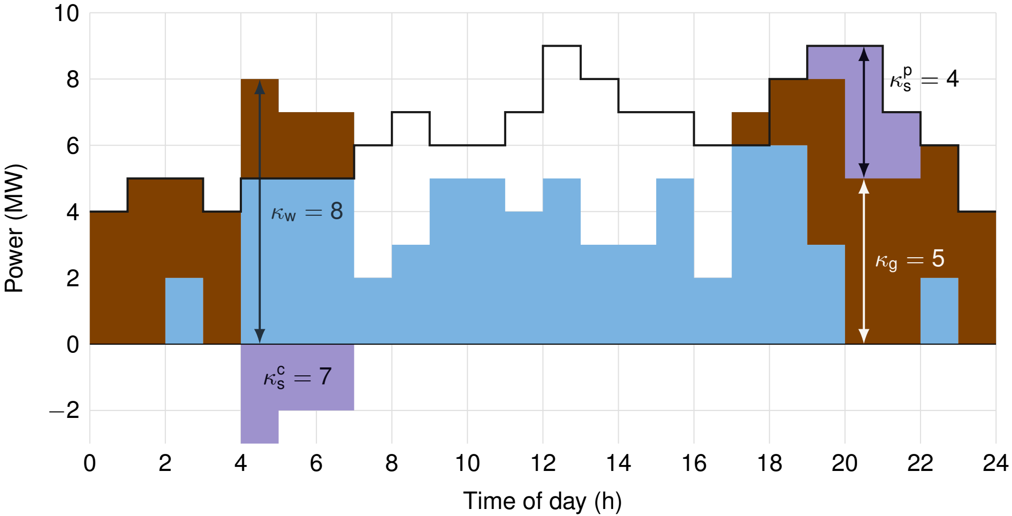

Notation as mathematical optimisation problem

Sets $t \in T, \; p \in P, \; s \in S, \; \ldots$

Parameters d_t

Notation as mathematical optimisation problem

$$\begin{aligned} \text{Sets} \quad & t \in T,\ p \in P,\ s \in S,\ \ldots \\ \text{Parameters} \quad & d_t,\ k_p^{\text{fix}},\ k_s^{\text{fix,c}},\ k_s^{\text{fix,p}} \end{aligned}$$

Notation as mathematical optimisation problem

$$\begin{aligned} \text{Sets} \quad & t \in T,\ p \in P,\ s \in S,\ \dots \\ \text{Parameters} \quad & d_t,\ k_p^{\text{fix}},\ k_s^{\text{fix,c}},\ k_s^{\text{fix,p}},\ k_p^{\text{var}},\ k_s^{\text{var}},\ \dots \end{aligned}$$

Notation as mathematical optimisation problem

Sets	$t \in T,\ p \in P,\ s \in S,\ \ldots$
Parameters	$d_t,\ k_p^{\text{fix}},\ k_s^{\text{fix,c}},\ k_s^{\text{fix,p}},\ k_p^{\text{var}},\ k_s^{\text{var}},\ \ldots$
Variables	$\kappa_p,\ \kappa_s^{\text{c}},\ \kappa_s^{\text{p}}$

Notation as mathematical optimisation problem

$$
\begin{array}{rl}
\text{Sets} & t \in T,\ p \in P,\ s \in S,\ \dots \\
\text{Parameters} & d_t,\ k_p^{\text{fix}},\ k_s^{\text{fix,c}},\ k_s^{\text{fix,p}},\ k_p^{\text{var}},\ k_s^{\text{var}},\ \dots \\
\text{Variables} & \kappa_p,\ \kappa_s^{\text{c}},\ \kappa_s^{\text{p}},\ \epsilon_{pt},\ \epsilon_{st}^{\text{in}},\ \epsilon_{st}^{\text{out}},\ \epsilon_{st}^{\text{con}},\ \dots
\end{array}
$$

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Parameters $d_t,\ k_p^{\text{fix}},\ k_s^{\text{fix,c}},\ k_s^{\text{fix,p}},\ k_p^{\text{var}},\ k_s^{\text{var}},\ \dots$

Variables $\kappa_p,\ \kappa_s^{\text{c}},\ \kappa_s^{\text{p}},\ \epsilon_{pt},\ \epsilon_{st}^{\text{in}},\ \epsilon_{st}^{\text{out}},\ \epsilon_{st}^{\text{con}},\ \dots$

Objective
$$\min \sum_{p \in P} \left(k_p^{\text{fix}} \kappa_p + \sum_{t \in T} k^{\text{var}} \epsilon_{pt} \right) + \sum_{s \in S} \left(k_s^{\text{fix,c}} \kappa_s^{\text{c}} + k_s^{\text{fix,p}} \kappa_s^{\text{p}} + \sum_{t \in T} k_s^{\text{var}} \left(\epsilon_{st}^{\text{in}} + \epsilon_{st}^{\text{out}} \right) \right)$$

Notation as mathematical optimisation problem

$$
\begin{aligned}
\text{Sets} \quad & t \in T,\ p \in P,\ s \in S,\ \ldots \\
\text{Parameters} \quad & d_t,\ k_p^{\text{fix}},\ k_s^{\text{fix,c}},\ k_s^{\text{fix,p}},\ k_p^{\text{var}},\ k_s^{\text{var}},\ \ldots \\
\text{Variables} \quad & \kappa_p,\ \kappa_s^{\text{c}},\ \kappa_s^{\text{p}},\ \epsilon_{pt},\ \epsilon_{st}^{\text{in}},\ \epsilon_{st}^{\text{out}},\ \epsilon_{st}^{\text{con}},\ \ldots \\
\text{Objective} \quad & \min \sum_{p \in P} \left(k_p^{\text{fix}} \kappa_p + \sum_{t \in T} k^{\text{var}} \epsilon_{pt} \right) + \\
& \sum_{s \in S} \left(k_s^{\text{fix,c}} \kappa_s^{\text{c}} + k_s^{\text{fix,p}} \kappa_s^{\text{p}} + \sum_{t \in T} k_s^{\text{var}} \left(\epsilon_{st}^{\text{in}} + \epsilon_{st}^{\text{out}} \right) \right) \\
\text{Constraints} \quad & \text{s.t. } \forall t \in T: \quad \sum_{p \in P} \epsilon_{pt} + \sum_{s \in S} \left(\epsilon_{st}^{\text{out}} - \epsilon_{st}^{\text{in}} \right) = d_t \\
& \ldots
\end{aligned}
$$

Standard form of linear optimisation problems (LP)

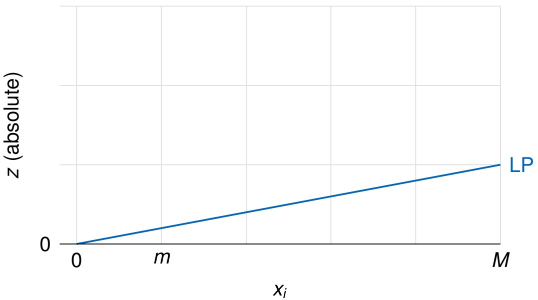
Generic form

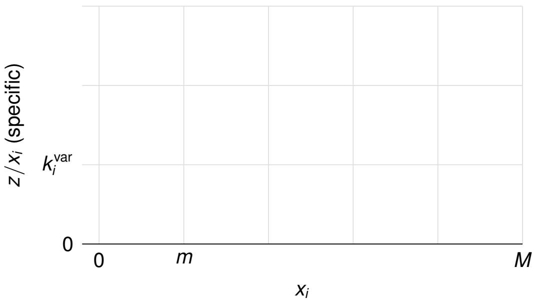
$$\min_{\boldsymbol{x}} z = \boldsymbol{c}^{\mathsf{T}} \boldsymbol{x}$$

$$\text{s.t. } \boldsymbol{A}\boldsymbol{x} \leq \boldsymbol{b}$$

with $\boldsymbol{x} \in \mathbb{R}^n$, $\boldsymbol{A} \in \mathbb{R}^{m \times n}$,
$\boldsymbol{b} \in \mathbb{R}^m$, $\boldsymbol{c} \in \mathbb{R}^n$.

Mixed-integer linear programming (MILP)

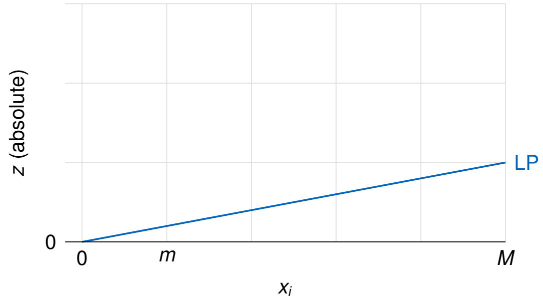


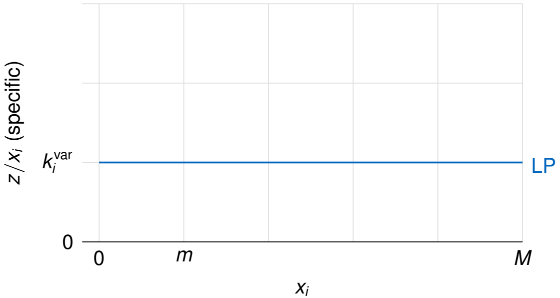


LP $\quad z = k_i^{\text{var}} x_i$

$$x_i \leq M$$

Mixed-integer linear programming (MILP)

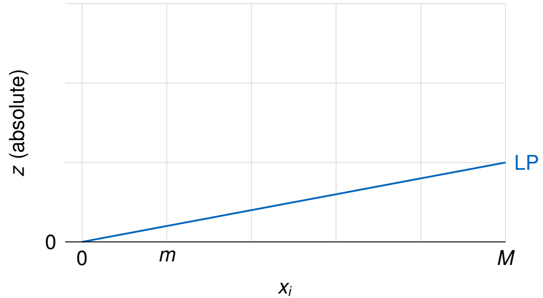


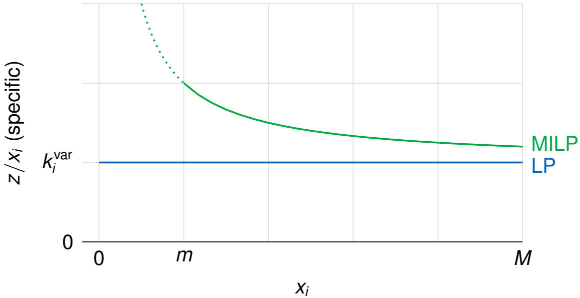


LP $\quad z = k_i^{\text{var}} x_i$
$\quad x_i \leq M$

LP $\quad \dfrac{z}{x_i} = k_i^{\text{var}} \equiv \text{const}$

Mixed-integer linear programming (MILP)





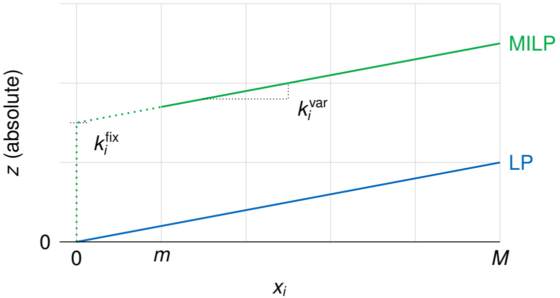
LP $\quad z = k_i^{\text{var}} x_i$

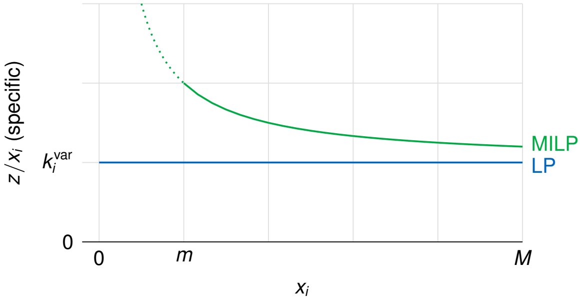
$\quad x_i \leq M$

LP $\quad \dfrac{z}{x_i} = k_i^{\text{var}} \equiv \text{const}$

MILP $\quad \dfrac{z}{x_i} = k_i^{\text{var}} + \dfrac{k_i^{\text{fix}}}{x_i}$

Mixed-integer linear programming (MILP)





LP $\quad z = k_i^{\text{var}} x_i$

$$x_i \leq M$$

MILP $\quad z = k_i^{\text{fix}} y_i + k_i^{\text{var}} x_i$

$$y_i \in \{0, 1\}$$

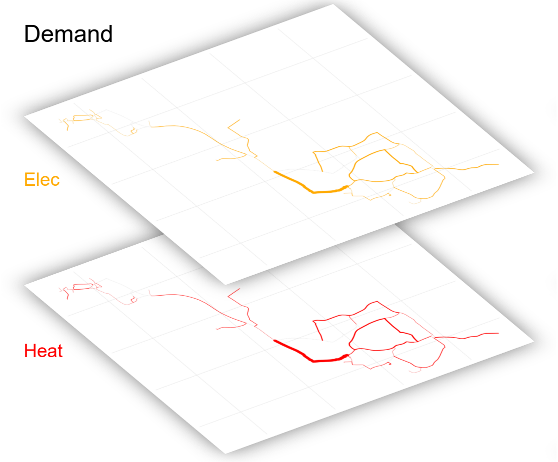
$$m\, y_i \leq x_i \leq M\, y_i$$

LP $\quad \dfrac{z}{x_i} = k_i^{\text{var}} \equiv \text{const}$

MILP $\quad \dfrac{z}{x_i} = k_i^{\text{var}} + \dfrac{k_i^{\text{fix}}}{x_i}$

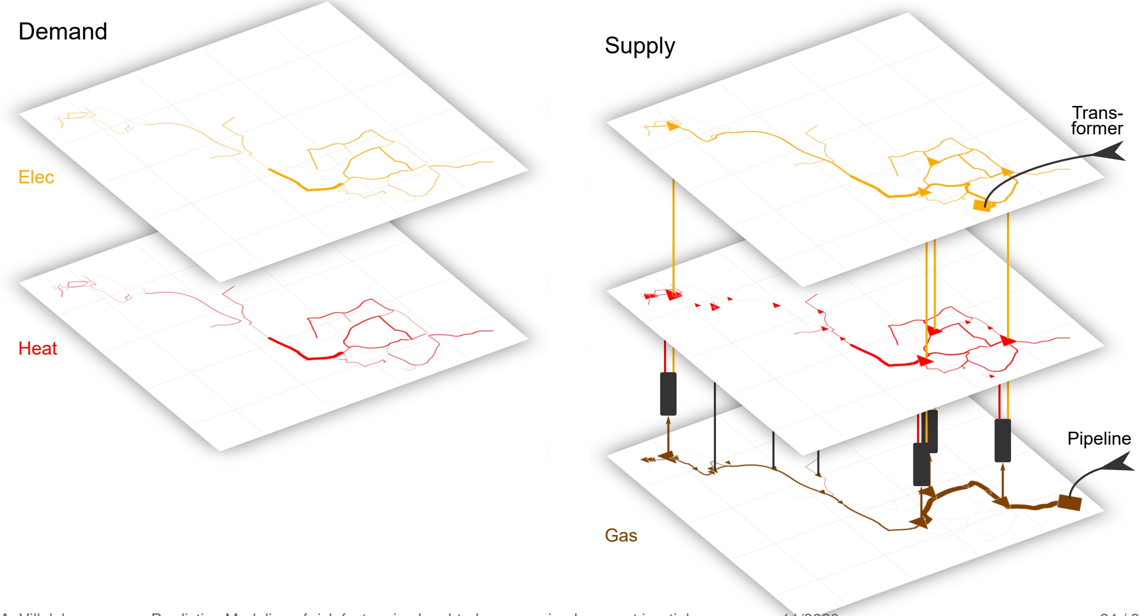
rivus

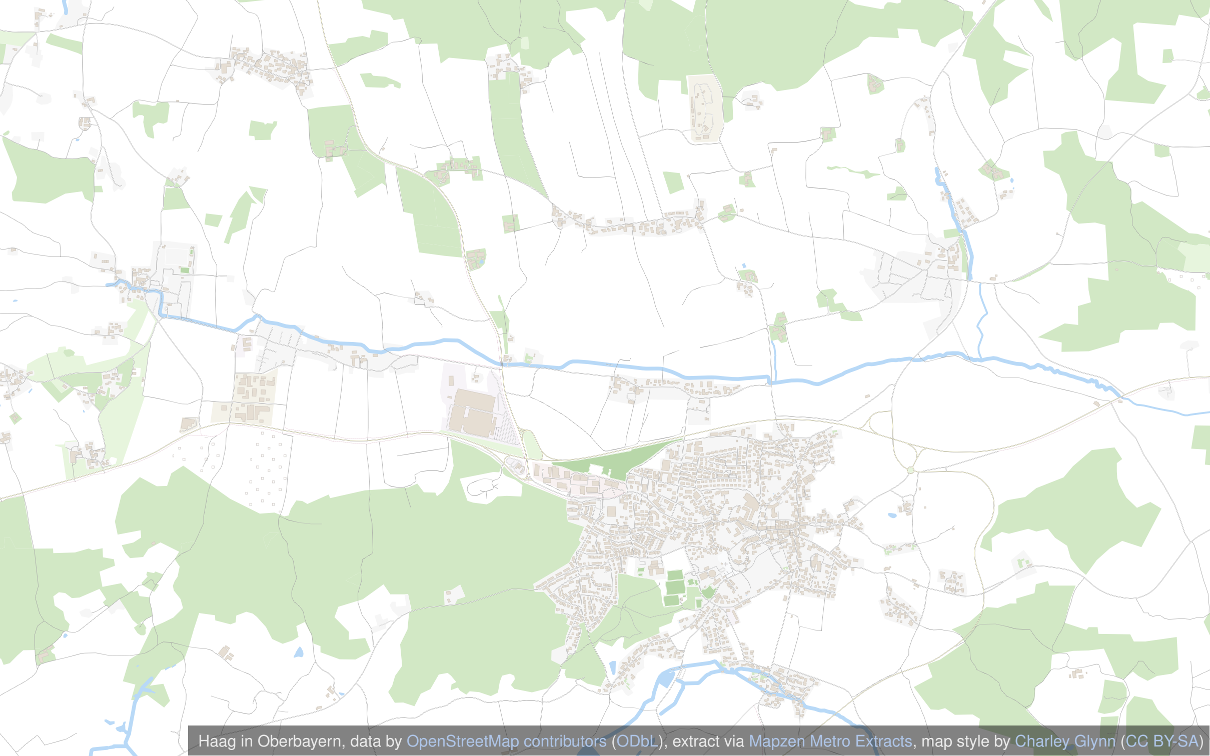
Principle illustrated



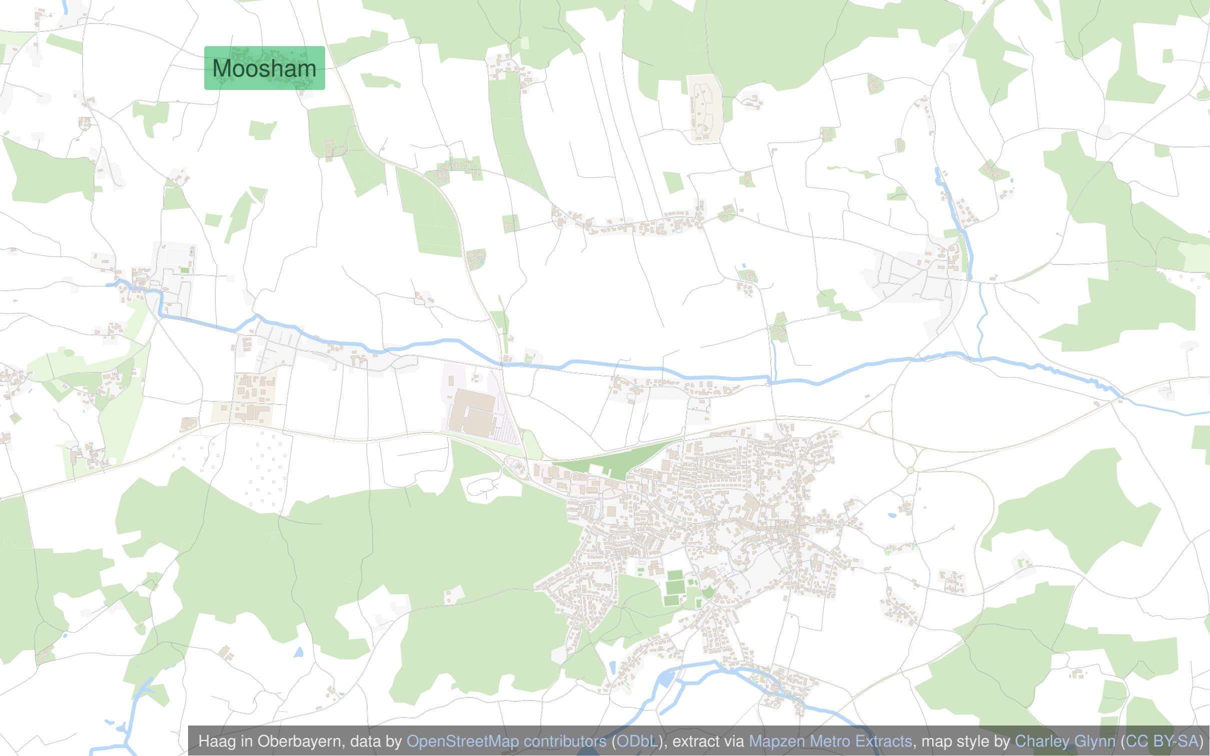
rivus

Principle illustrated

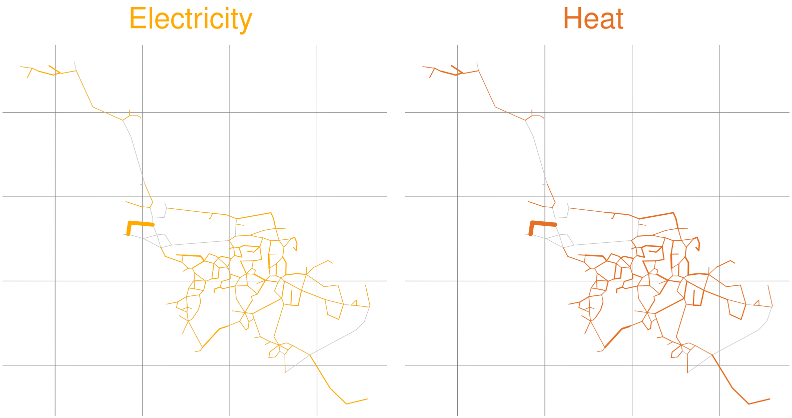




Haag in Oberbayern, data by OpenStreetMap contributors (ODbL), extract via Mapzen Metro Extracts, map style by Charley Glynn (CC BY-SA)


Moosham
Haag in Oberbayern, data by OpenStreetMap contributors (ODbL), extract via Mapzen Metro Extracts, map style by Charley Glynn (CC BY-SA)

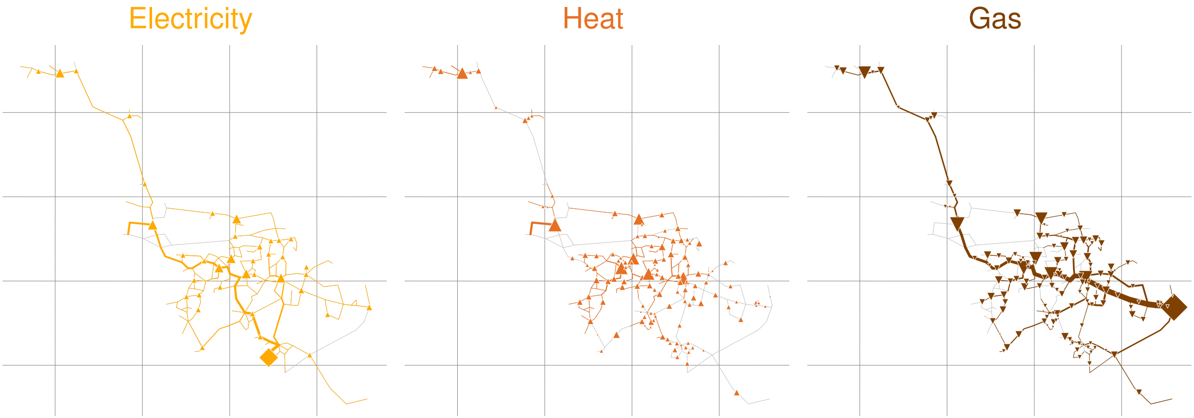
Input data **rivus**



Light industry (Schletter) biggest single consumer

https://github.com/tum-ens/rivus/data/haag15

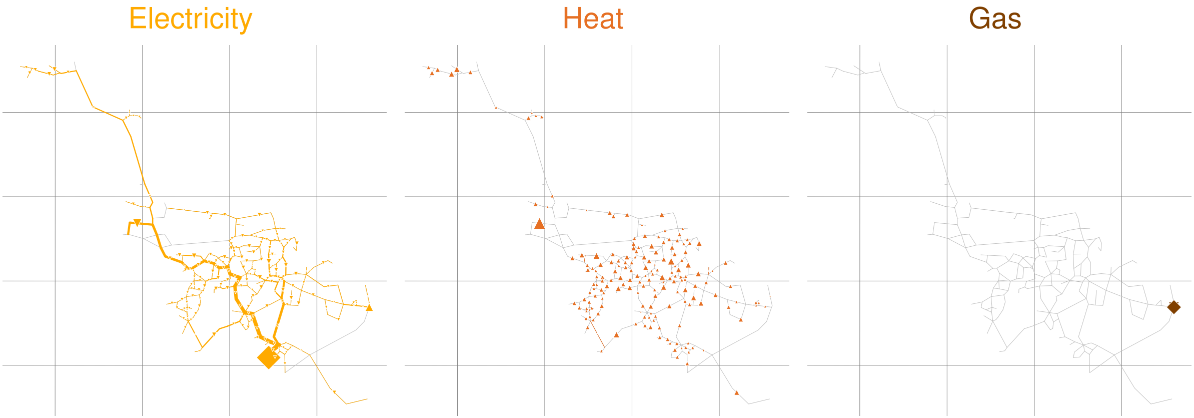
Result **rivus** – Capacities in scenario base



Full networks for electricity and gas, several local heating networks

`https://github.com/tum-ens/rivus/runhg15.py:scenario_no_electric_heating()`

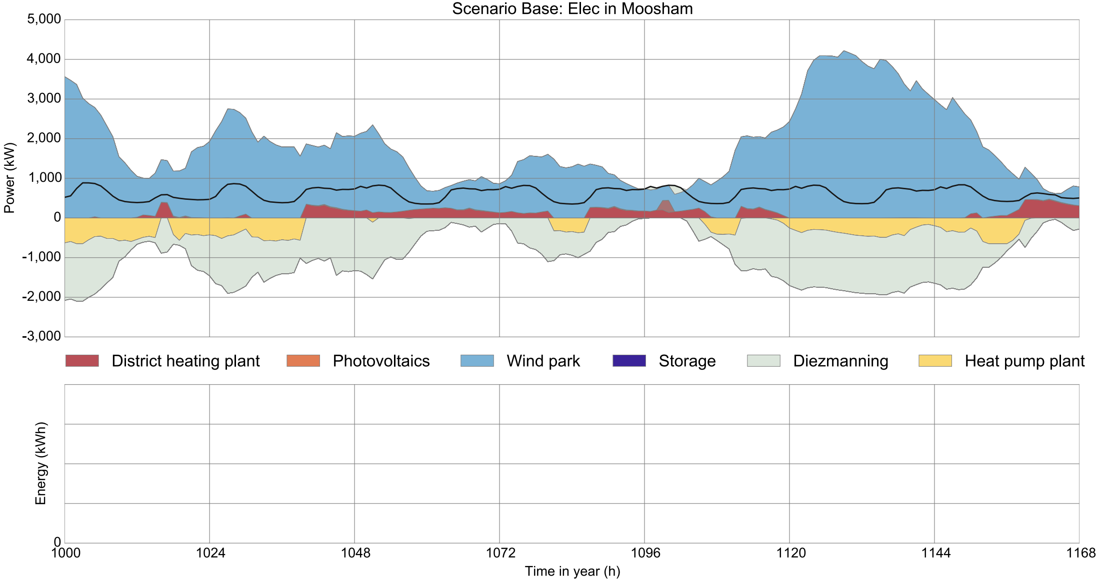
Result **rivus** – Capacities in scenario future



Strong electricity grid, no gas network, only heat pumps

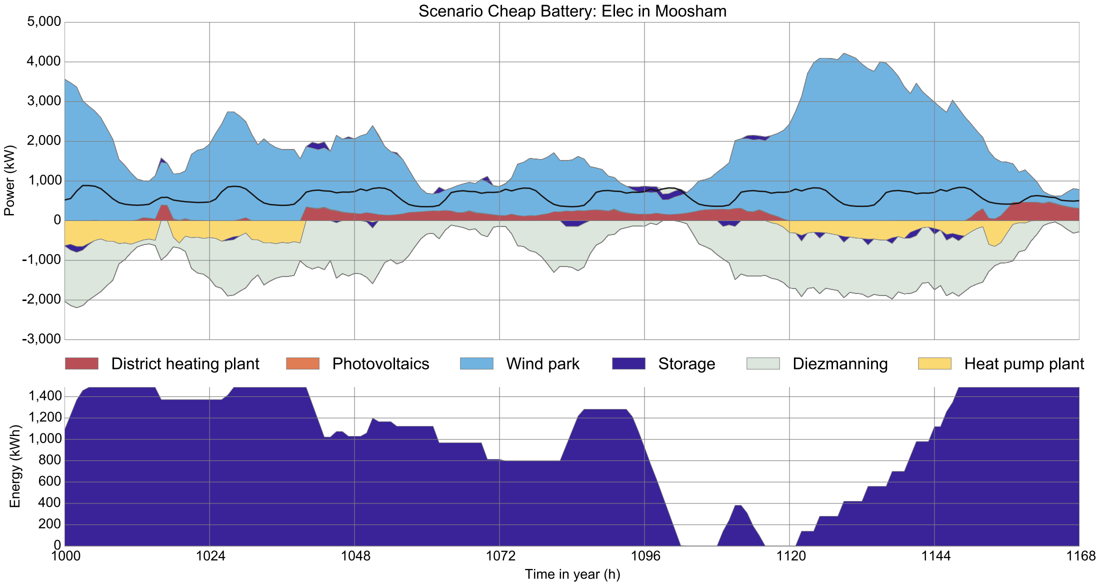
`https://github.com/tum-ens/rivus/runhg15.py:scenario_renovation()`

Result **urbs** – 1 week electricity in scenarios base



https://github.com/ojdo/urbs/tree/haag15/rivhg15.py:scenario_base()

Result **urbs** – 1 week electricity in scenario cheap battery



`https://github.com/ojdo/urbs/tree/haag15/rivhg15.py:scenario_cheap_battery()`