Institute of Sanitary Engineering & Waste Management

Leibniz Universität Hannover

Dealing with uncertainty in the conceptual design of industrial water reuse networks

WaReIp
Water Reuse in Industrial Parks

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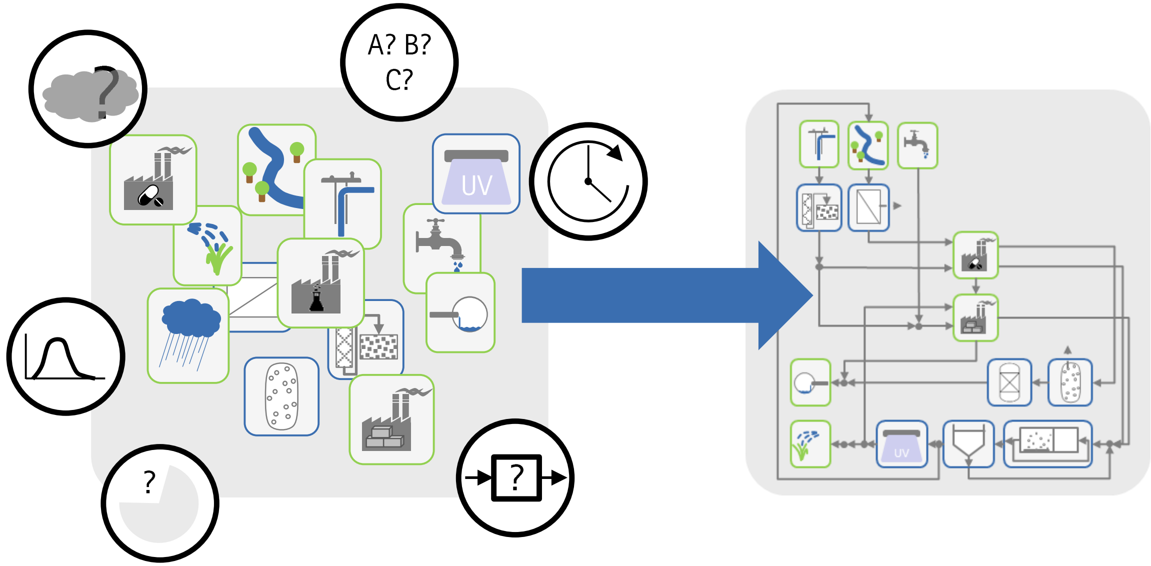
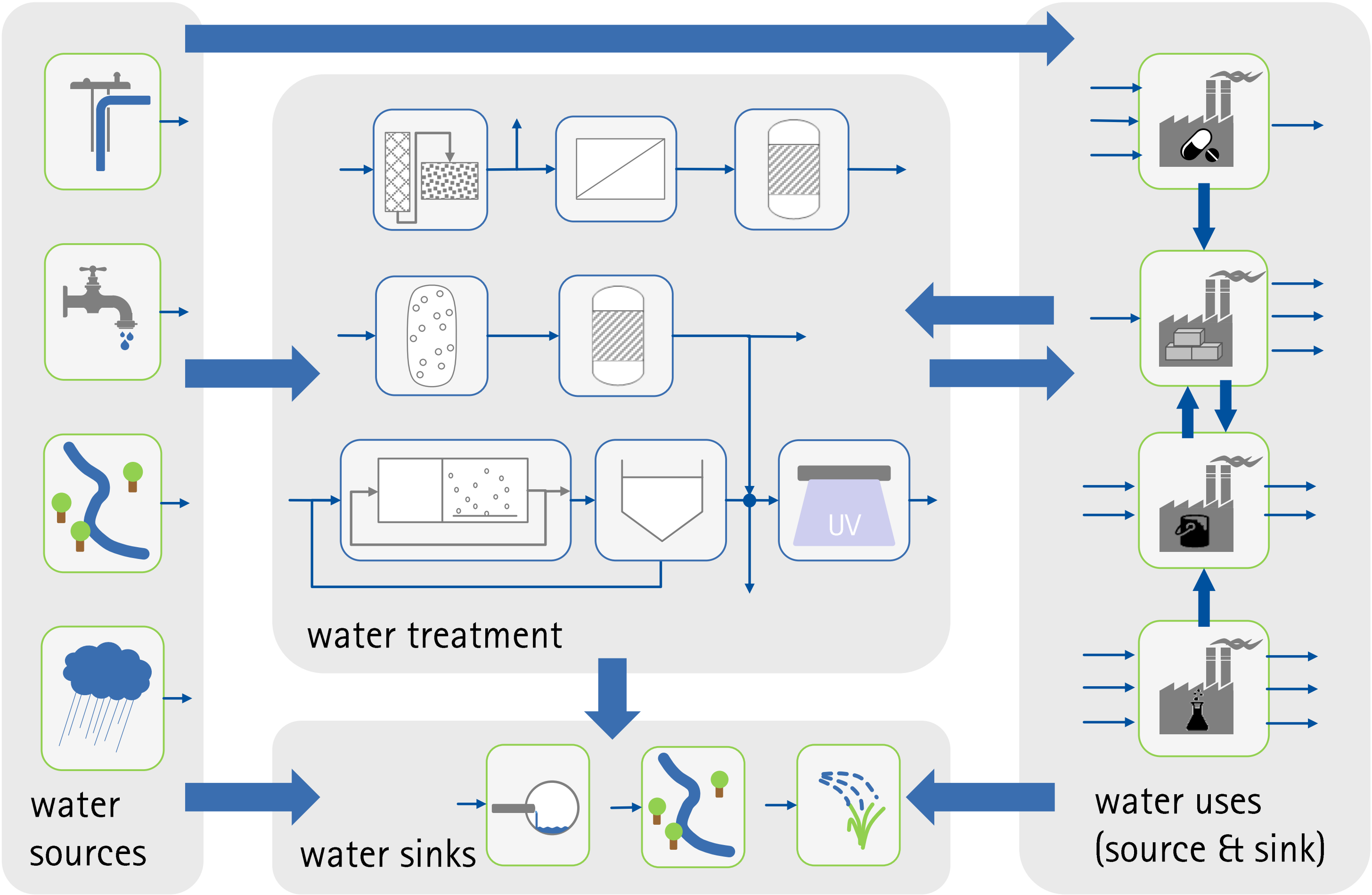


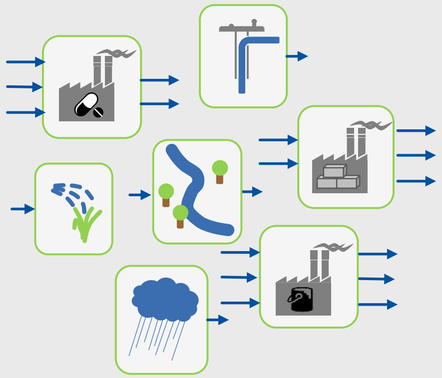
Dagmar Pohl, Maike Beier, Stephan Köster

Water Reuse in Industrial Parks

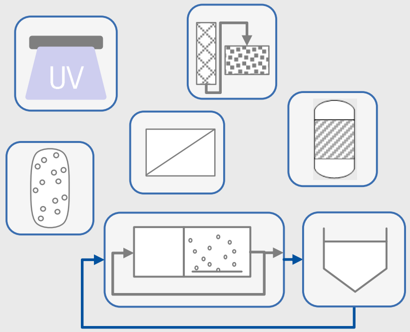


... complex design challenge!

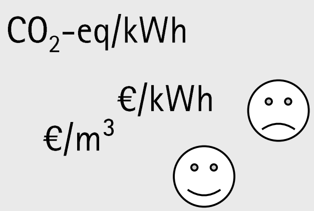
Data Basis for Conceptual Design



sources and sinks



treatment processes



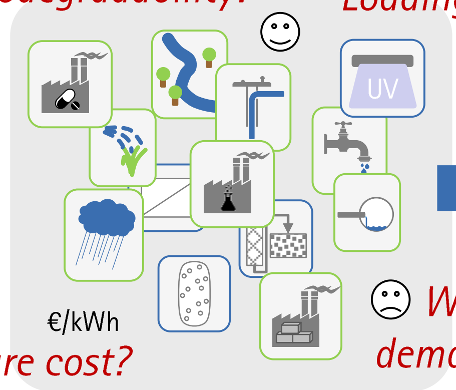
assessment factors,
goals & preferences

- capacity/demand/ discharge
- discharge quality/quality requirements

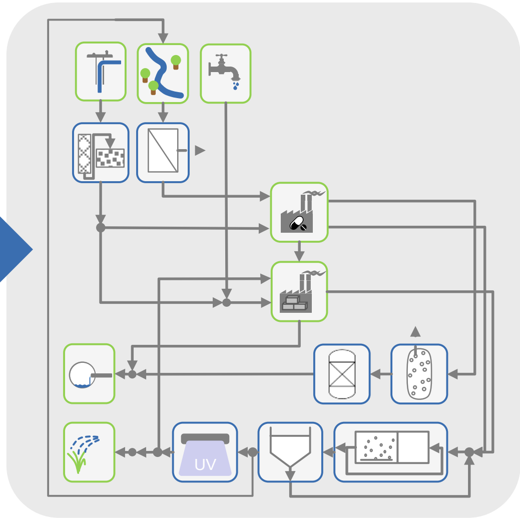
- range of applicability
- treatment efficiency
- dimensioning & design parameters

- economic, environmental, social aspects
- stakeholder preferences

Technical Design Methods



- Experience
- Heuristic rules
- Graphical methods
- Mathematical optimisation



In early design phases, many parameters are uncertain or unknown!

Types of Uncertainty and Variability

Optimisation

A? B? C? — decision/design uncertainty

Data collection

? — incomplete knowledge

? — model uncertainty

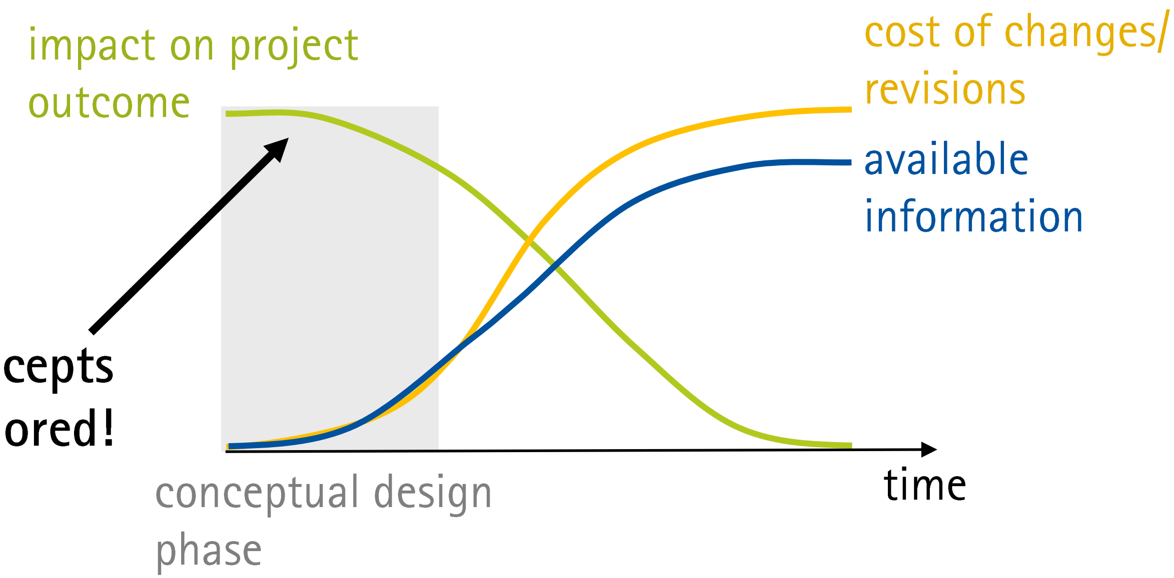
Robust & flexible design

irreducible variability

the future

„unknown unkowns“

Conceptual Design



Lots of concepts should be explored!

Impossible to thoroughly mitigate uncertainty for all alternatives!

→ How to deal with this?

Uncertainty Analysis in Conceptual Design

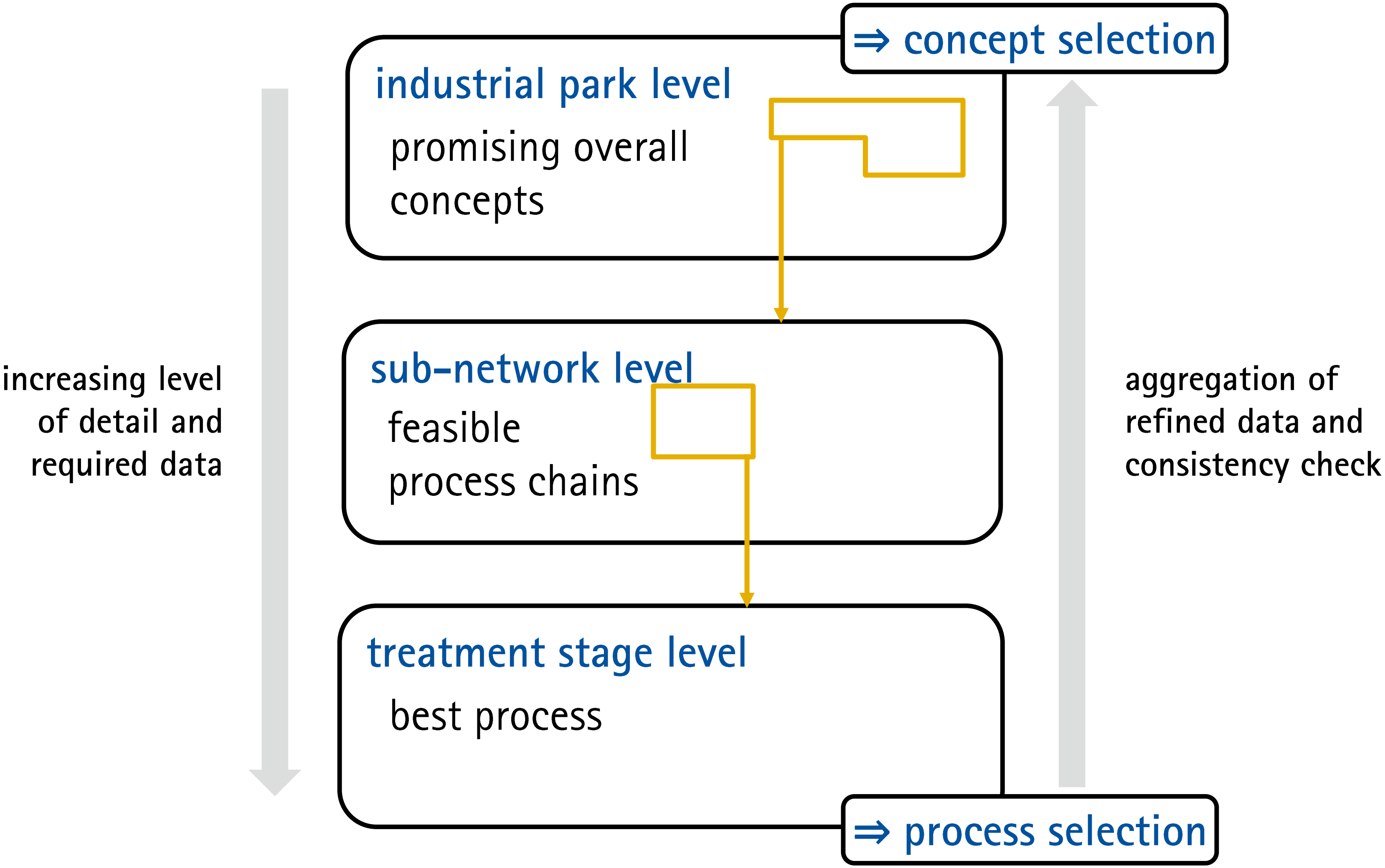
Objectives

- develop designs that:
  - meet requirements **reliably**
  - perform well (technically, economically, ecologically, socially ...)
    → alternatives need to be **sufficiently different for decision-making**
- **avoid unpleasant surprises** during the design & planning process (causing revisions)

However ...

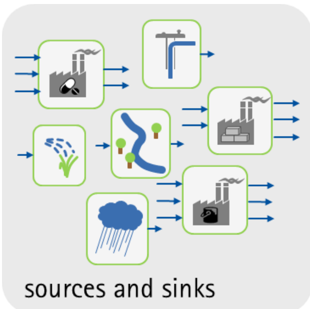
- expected values & uncertainty estimates are context-dependent
  e.g. process performance depends on application and treatment goals
- getting data and uncertainty estimates is often tedious
  → discard "bad" designs early on

Hierarchical Approach to Design under Uncertainty



Step 1: Find promising overall concepts

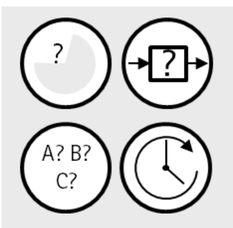
industrial park level



required data:

- capacity/demand/discharge of water sources & sinks
- water quality/ quality requirements

averages and characteristic fluctuations



define:

- mutually exclusive scenarios
- crucial loadcases (within each scenario)

develop designs for overall network, roughly estimating network performance

Step 1: Find promising overall concepts

industrial park level

check each design alternative for all scenarios

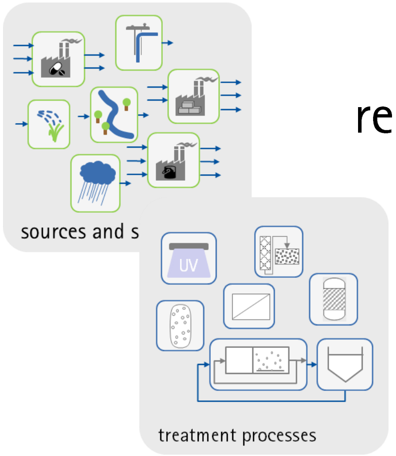
→ if a design does not work for a scenario:
note required adaptions and responsible source of uncertainty and/or discard the design

output step 1:

- robust alternative overall concepts
- sources of uncertainty that influence network design and/or feasibility

Step 2: Design feasible process chains

sub-network level



required data:

- ✓ previously defined scenarios & load cases
- removal efficiencies, recovery & applicability of treatment steps

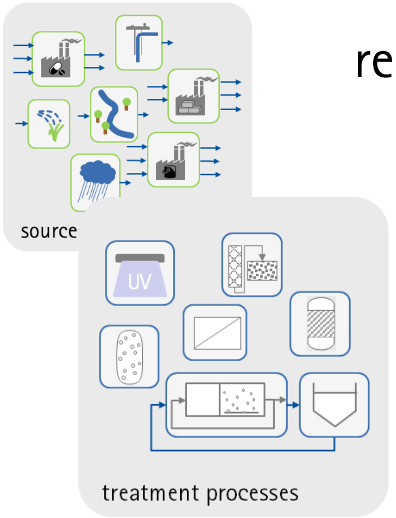
develop process chains and check feasibility for all scenarios (meeting quality requirements & demand, applicability)

output step 2:

- reliable process chains for sub-networks with estimates of water qualities & quantities
- (combinations of) required/acceptable/critical treatment efficiency ranges & influent conditions to satisfy water demands

Step 3: Choose the best process

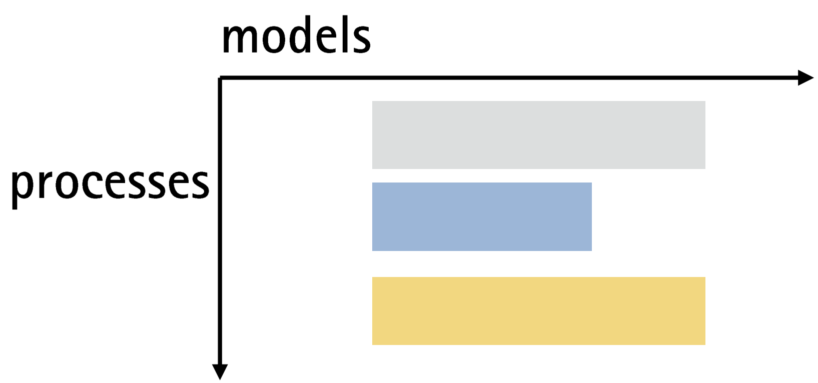
treatment stage level



required data:

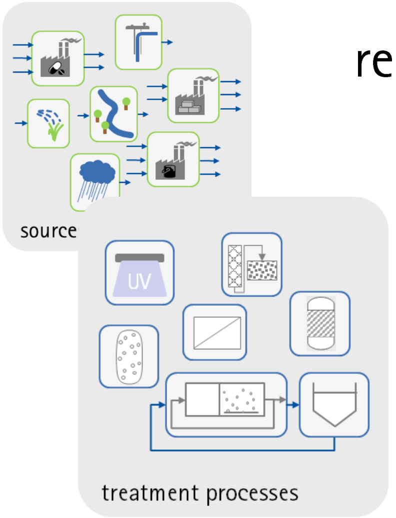
- ✓ previously defined scenarios & load cases
- ✓ removal efficiencies, recovery & applicability of treatment steps
- performance-related process characteristics
  (e.g. specific energy & auxiliaries demand, dimensioning …)

compare performance indicators of different processes (if possible) using various models for each process



Step 3: Choose the best process

treatment stage level



required data:

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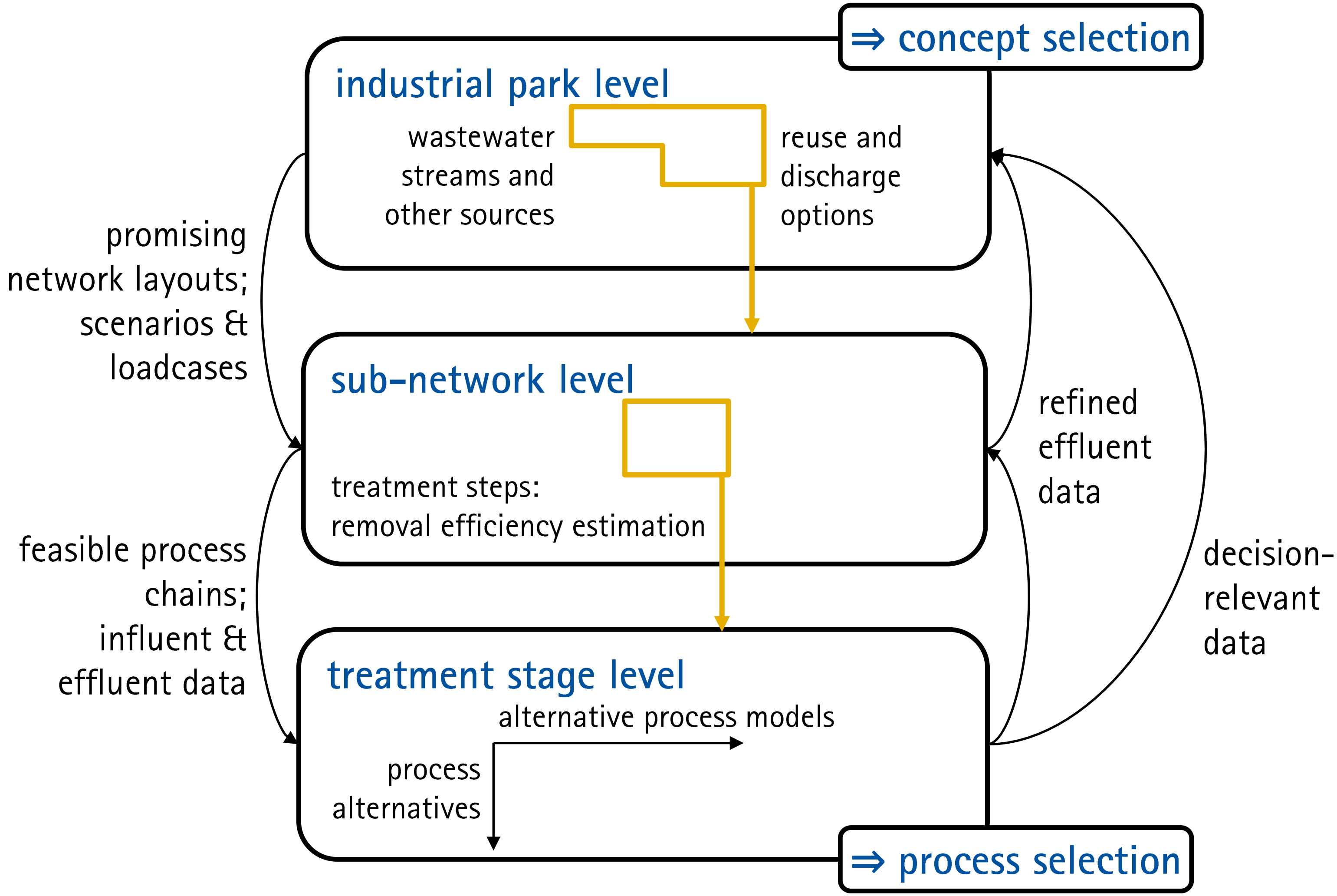
  (e.g. specific energy & auxiliaries demand, dimensioning …)

compare performance indicators of different processes (if possible) using various models for each process

output step 3:

- estimates for decision-relevant figures & refined effluent data
- uncertainty that influences process choice
  → potential benefits of uncertainty mitigation
  → risk trade-offs

Hierarchical Approach Summary



Conclusions

- different types of uncertainty can be discerned
  → targeted mitigation / management strategies

- considering uncertainty helps to:
  - prioritize data acquisition
  - reveal risks
  - point out potentials for optimisation
  - increase transparency

⇒ create robust, reliable, flexible solutions & increase acceptance

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