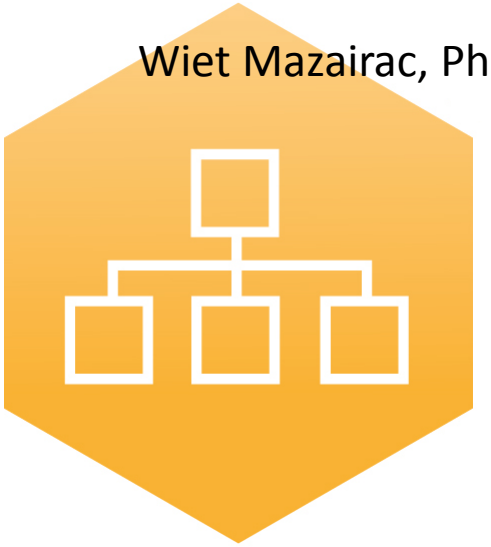
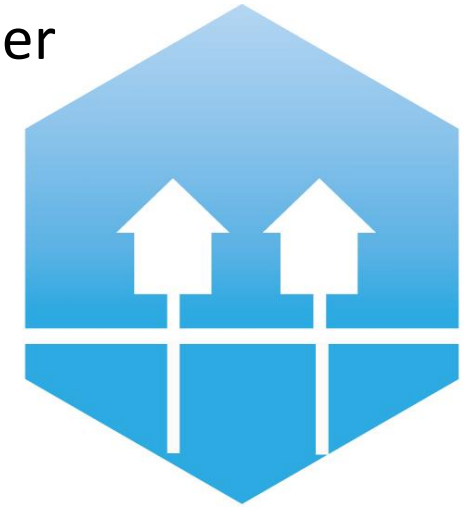
2nd International Conference on Smart Energy Systems and 4th Generation District Heating
Aalborg, 27-28 September 2016

Optimization of the Transition towards a Sustainable Integrated Multi-Carrier Energy Network

Wiet Mazairac, Ph.D. Candidate





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Ph.D. Research Project

- Ph.D. Research Project
  - Optimization of energy networks
  - Integrated optimization of multi-carrier energy networks
  - Subject to technical and economic uncertainty

Fossil vs. Renewable

Global warming

Demand growth

Reserve depletion

Central

Clean

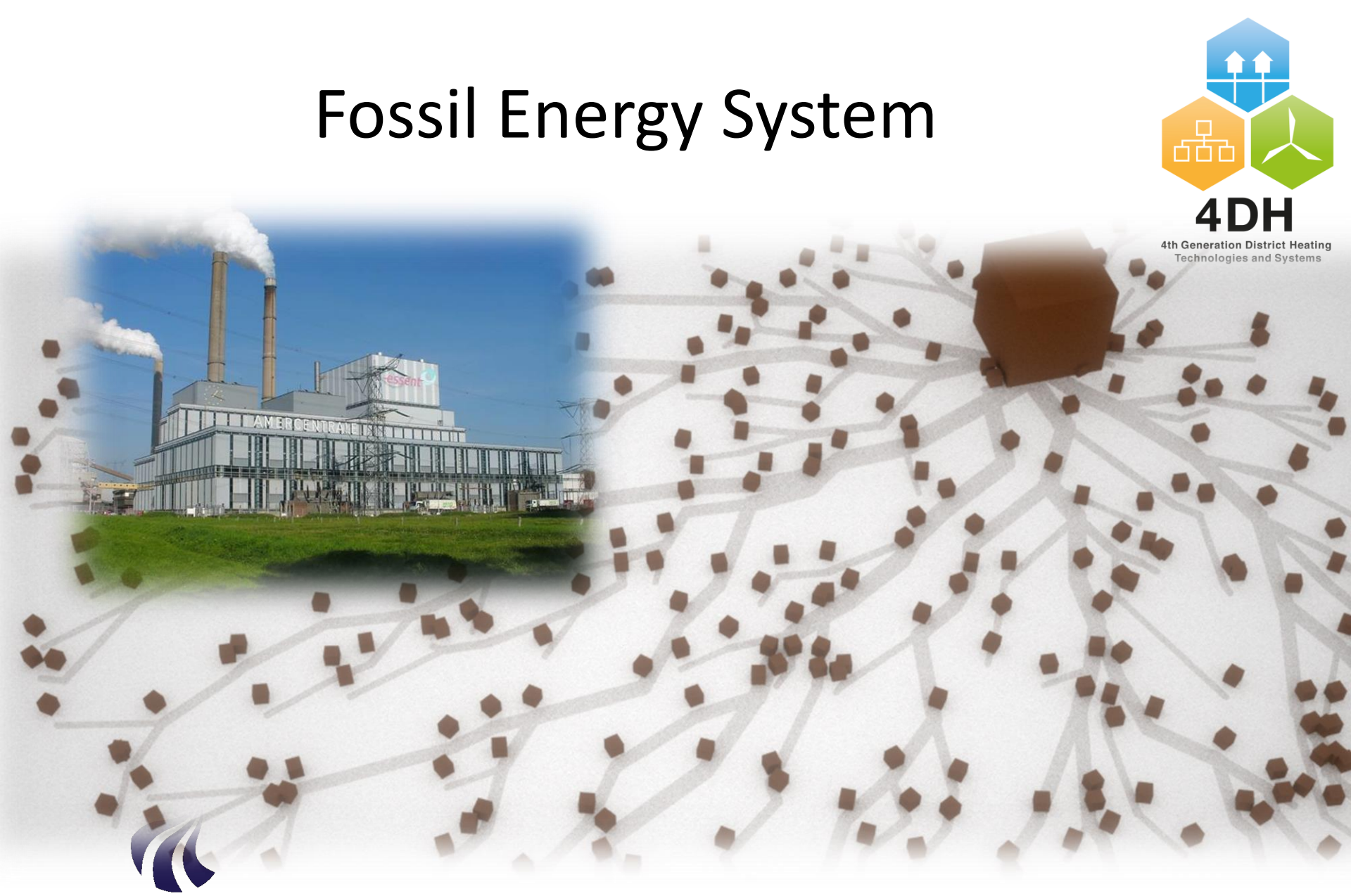
Inexhaustible

Local

Renewable Energy System

Renewable Energy System

Fossil Energy System



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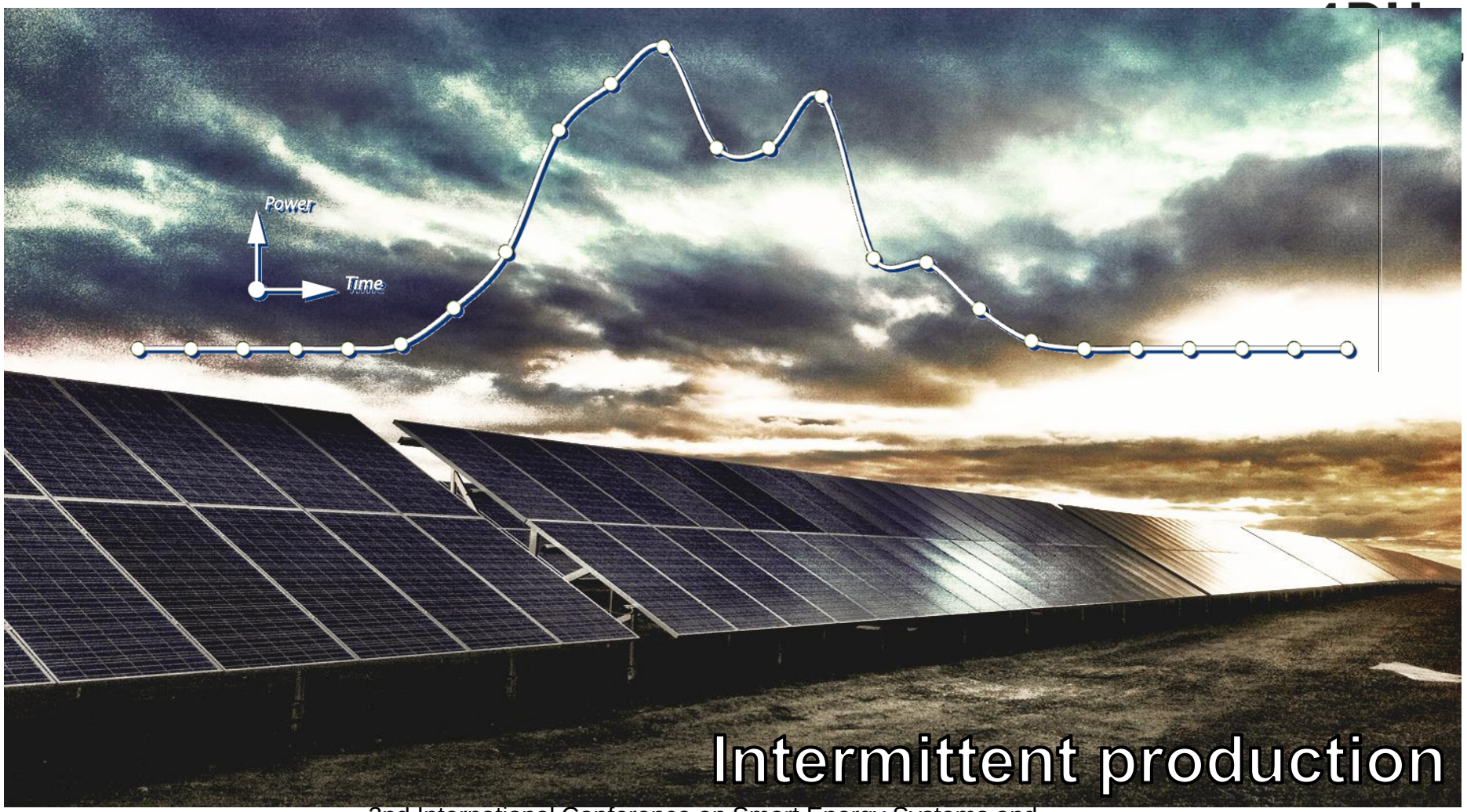
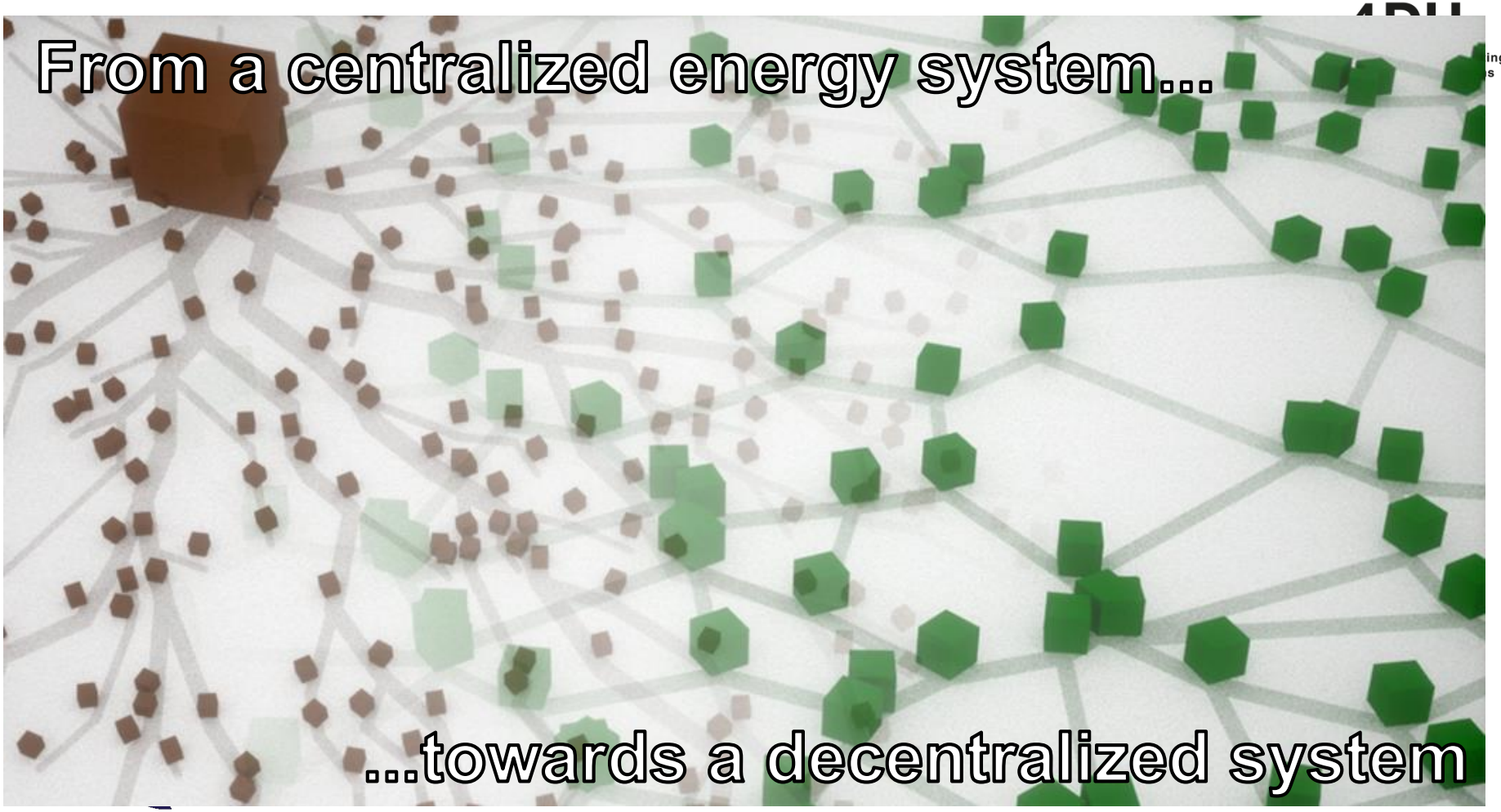
Renewable Energy System

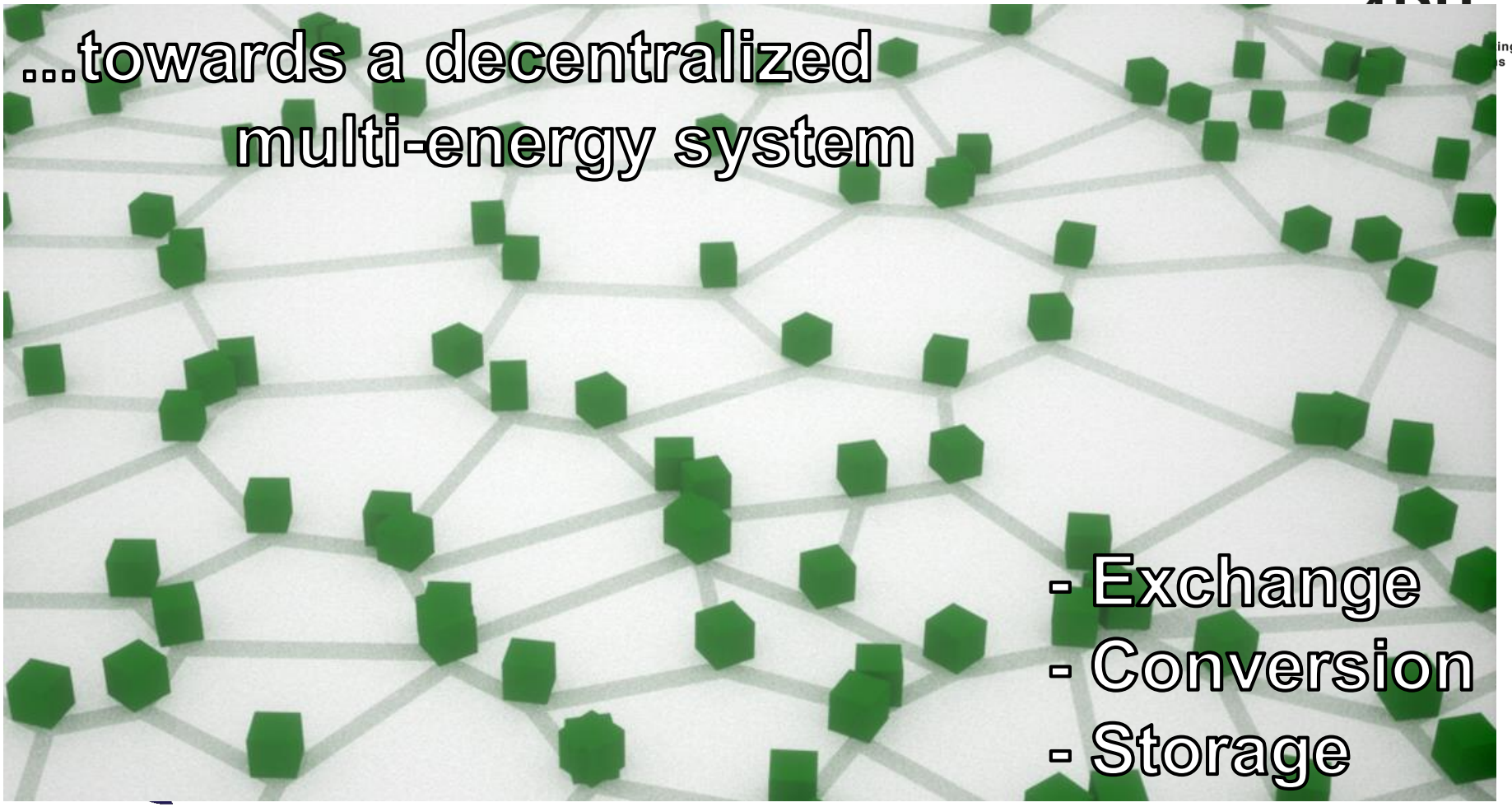


Fossil Energy System

Energy System Reformation

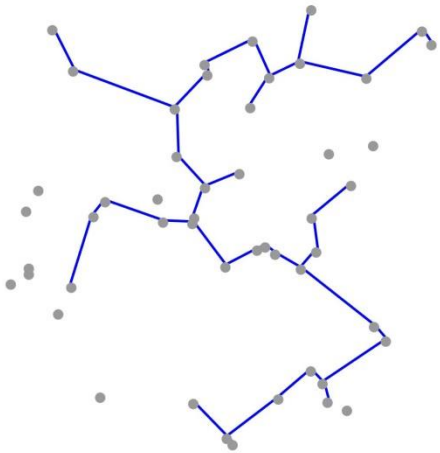


Decentralized Multi-Energy System

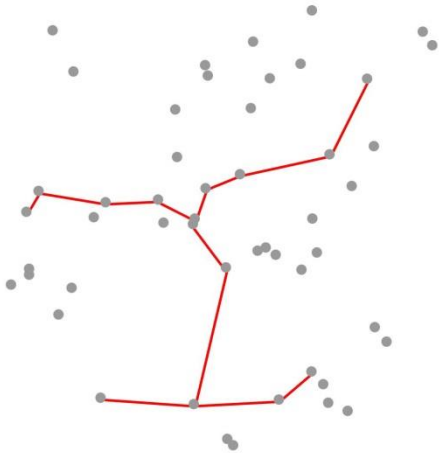


Network Reformation

- From non-integrated to integrated optimization



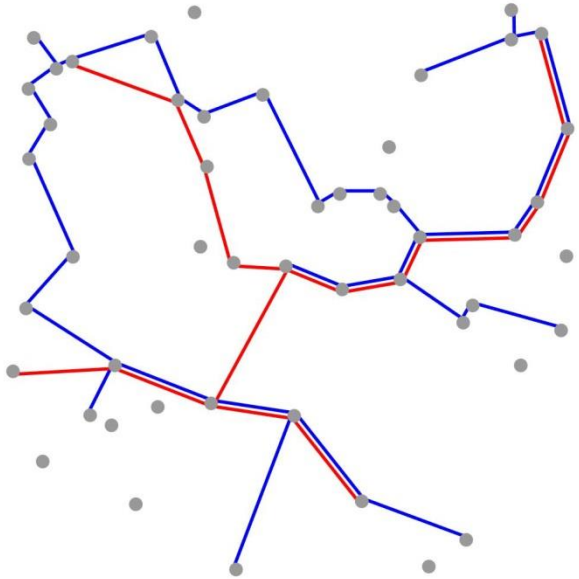
Electric Power Network



District Heating Network

Network Reformation

- From non-integrated to integrated optimization



Multi-carrier network

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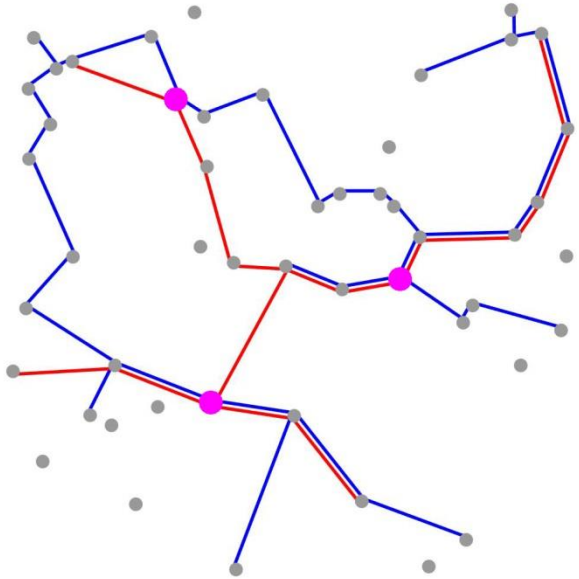
Network Reformation

- From non-integrated to integrated optimization
- Conversion



● Conversion unit

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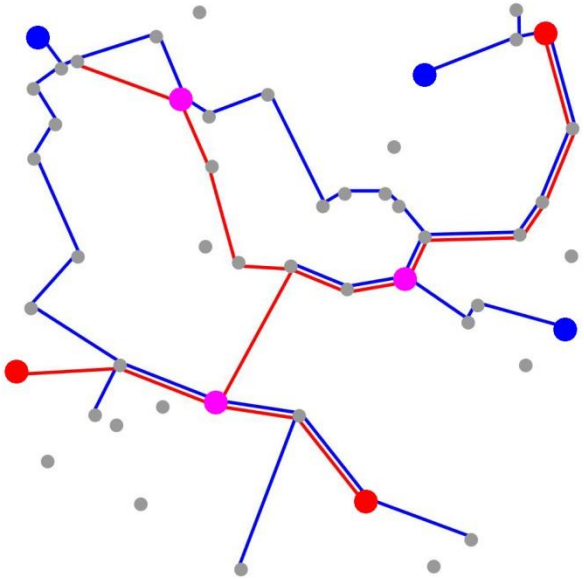
Network Reformation

- From non-integrated to integrated optimization
- Conversion
- Storage



- Conversion unit
- Electric storage unit
- Heat storage unit

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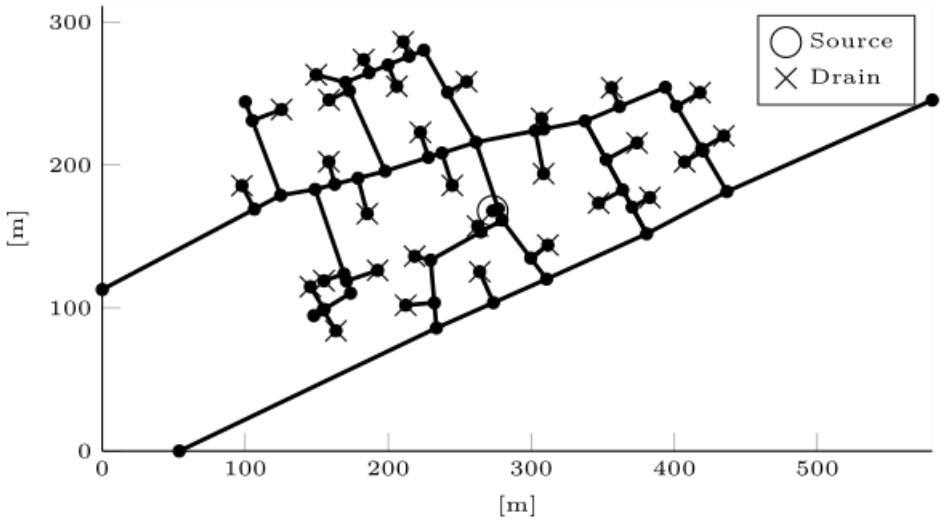
Questions…

- Location and capacity of systems and lines?
- Uncertainties: technical failures, energy availibility, economic future?
- How to get there?

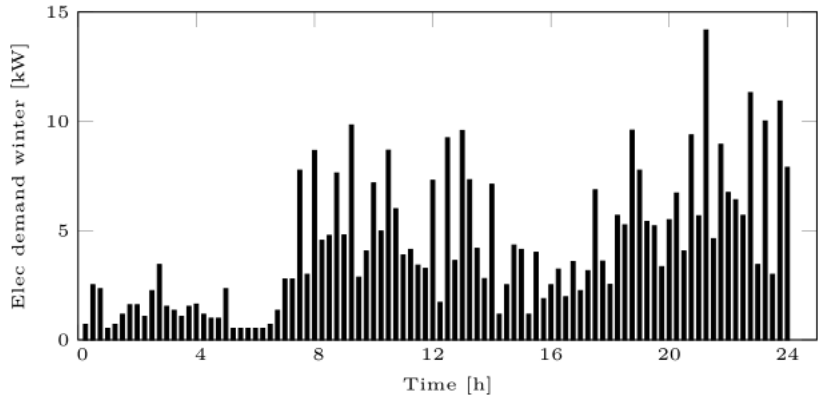
Location and Capacity

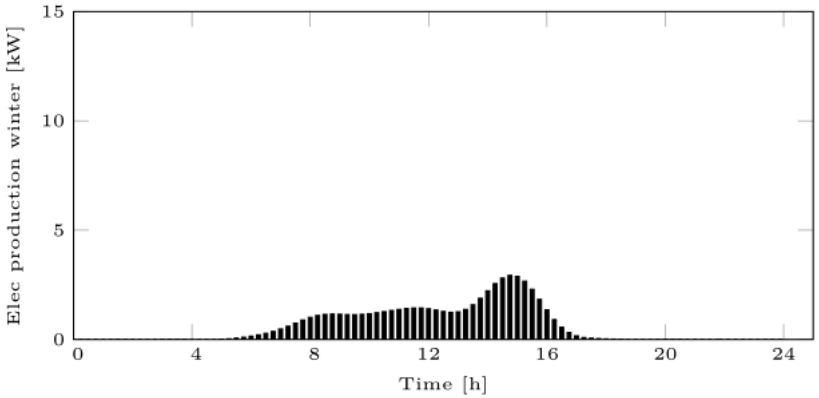
- **<u>Location and capacity of systems and lines?</u>**
- Uncertainties: technical failures, energy availibility, economic future?
- How to get there?

Location and Capacity: Example



Location and Capacity: Example





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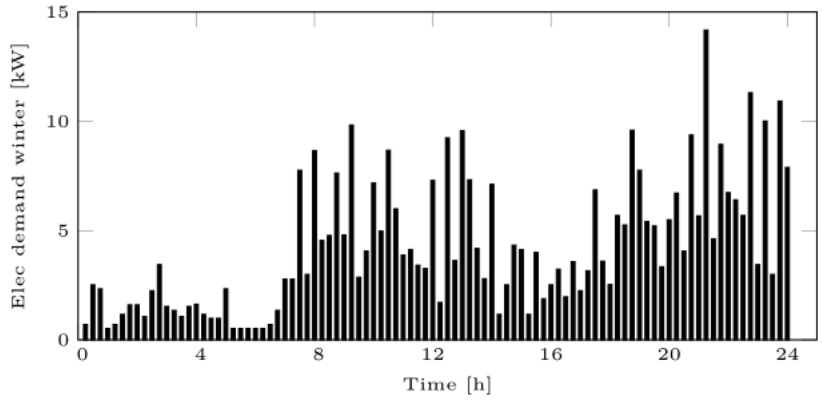
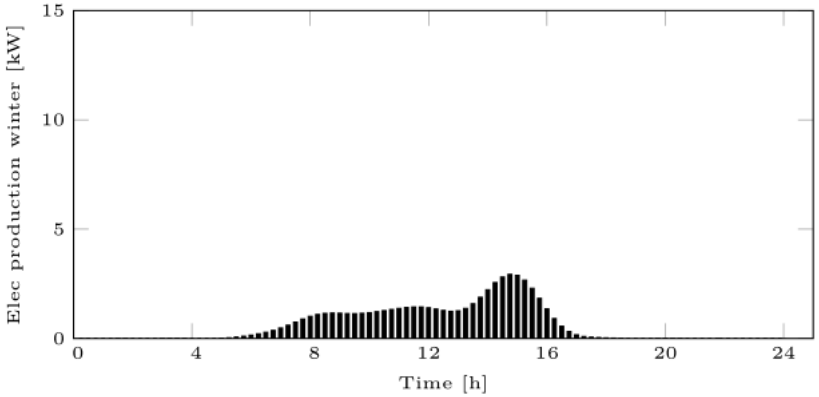
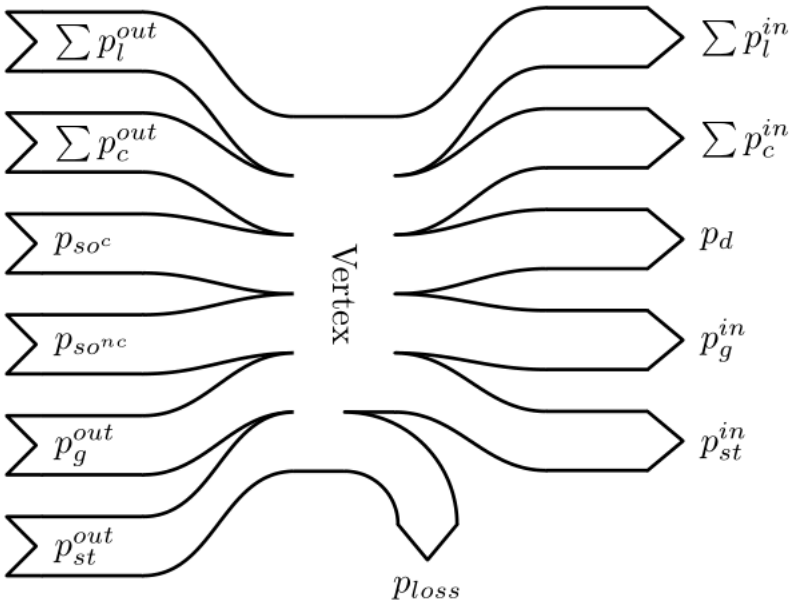
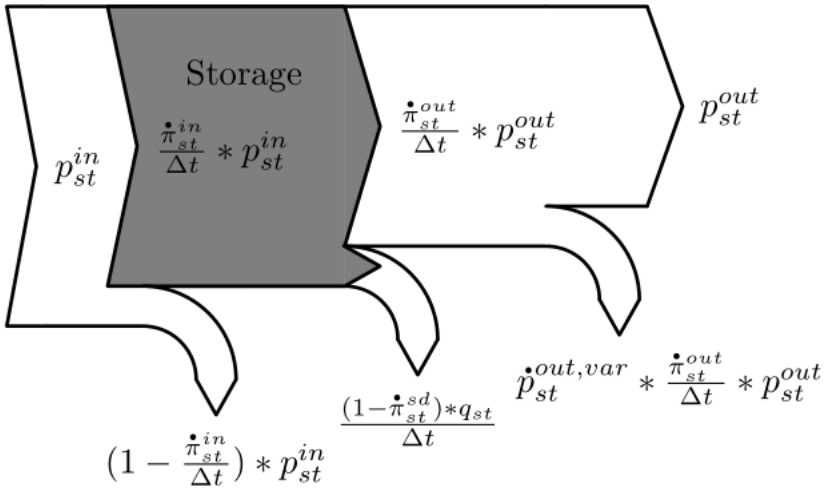
Location and Capacity: Example









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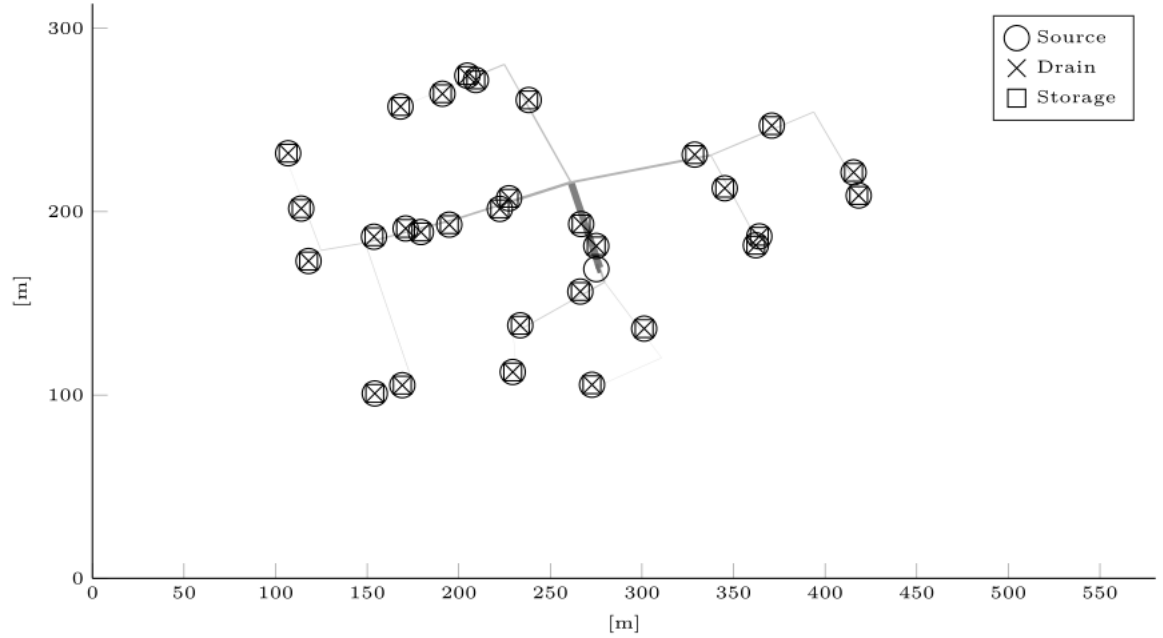
Location and Capacity: Example



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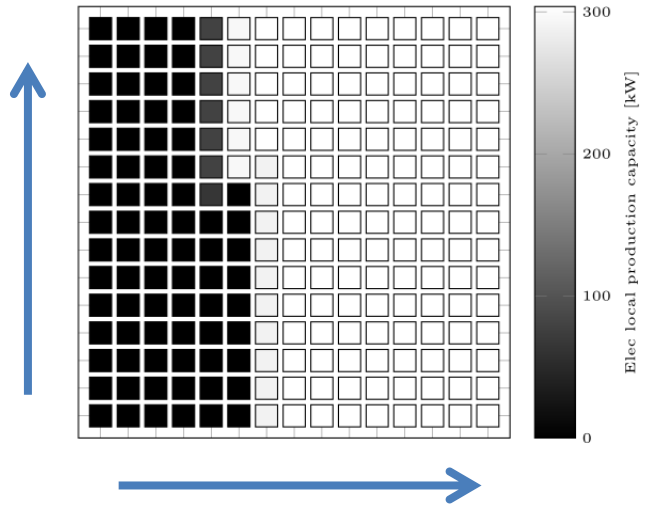
Location and Capacity: Example

Heat costs



PV

Elec. costs

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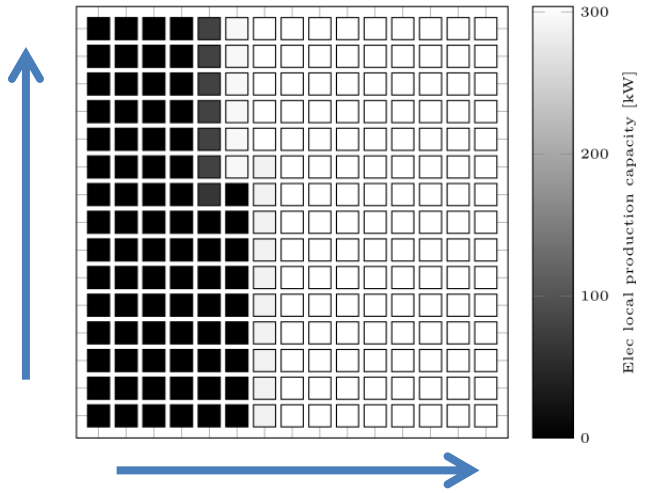
Location and capacity: Example

Heat costs

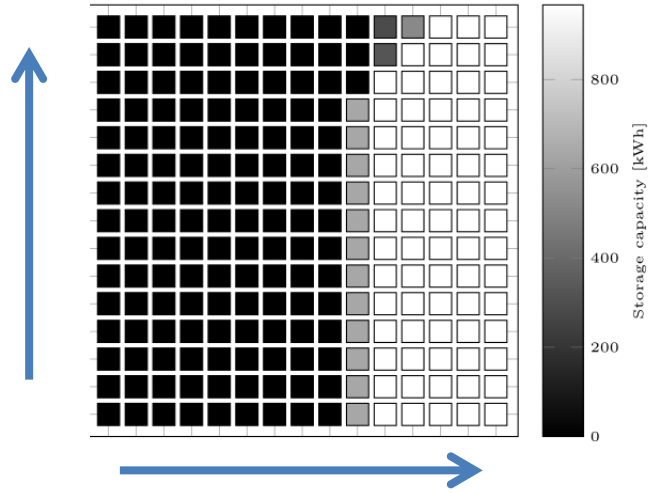


Elec. costs

PV

Battery

Heat costs



Elec. costs

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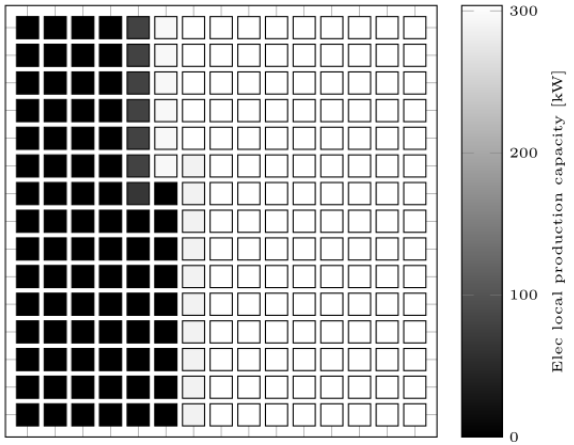
Location and Capacity: Example

Heat costs

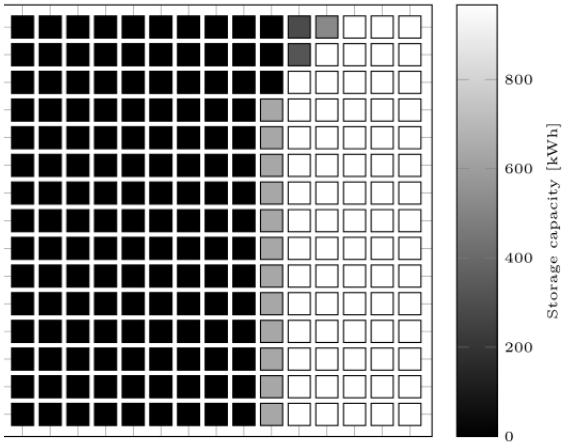


PV

Elec. costs

Heat costs

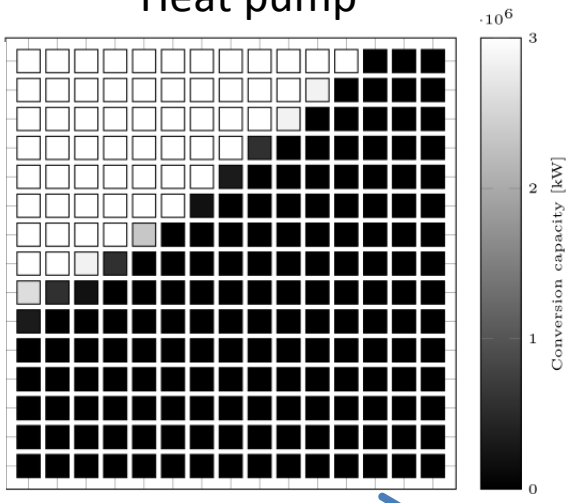
Battery



Elec. costs

Heat pump

Heat costs



Elec. costs

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Questions…

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- **Uncertainties: technical failures, energy availibility, economic future?**
- How to get there?

Questions…

- Location and capacity of systems and lines?
- Uncertainties: **technical failures**, energy availibility, economic future?
- How to get there?

Uncertainty

Stochastic Programming

- Scenarios

Robust Optimization

- Scenarios

Uncertainty

Stochastic Programming

- Scenarios
- Probability
- (The chance it fails once within 10 years is 5%)

Robust Optimization

- Scenarios
- Bounds
- (It will fail)

Uncertainty

Stochastic Programming

- Scenarios
- Probability
- (The chance it fails once within 10 years is 5%)
- Optimize expected value

Robust Optimization

- Scenarios
- Bounds
- (It will fail)
- Optimize worst case

Uncertainty

Stochastic Programming

- Scenarios
- Probability
- (The chance it fails once within 10 years is 5%)
- Optimize expected value
- Historic data
- Redundancy vs. Damage

Uncertainty

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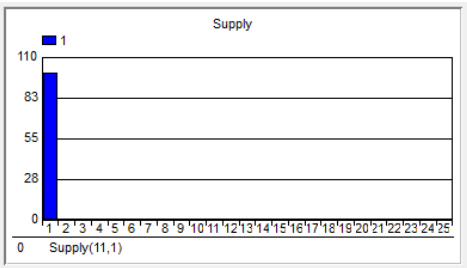

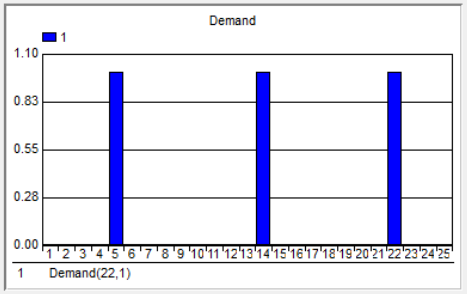

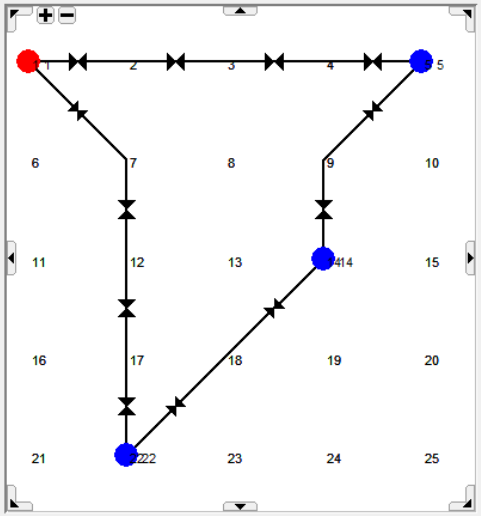

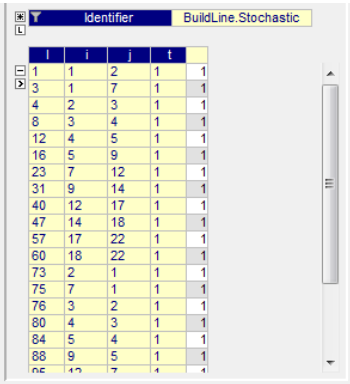

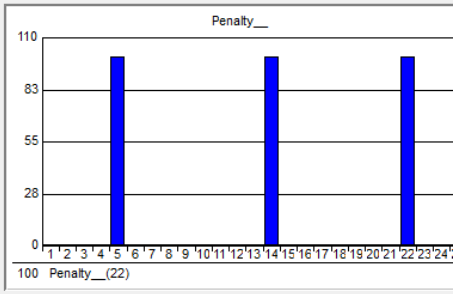

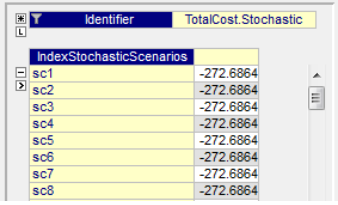

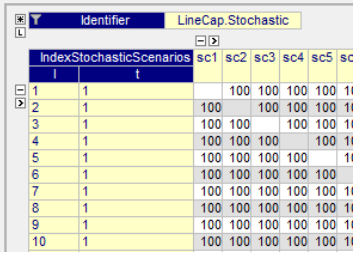

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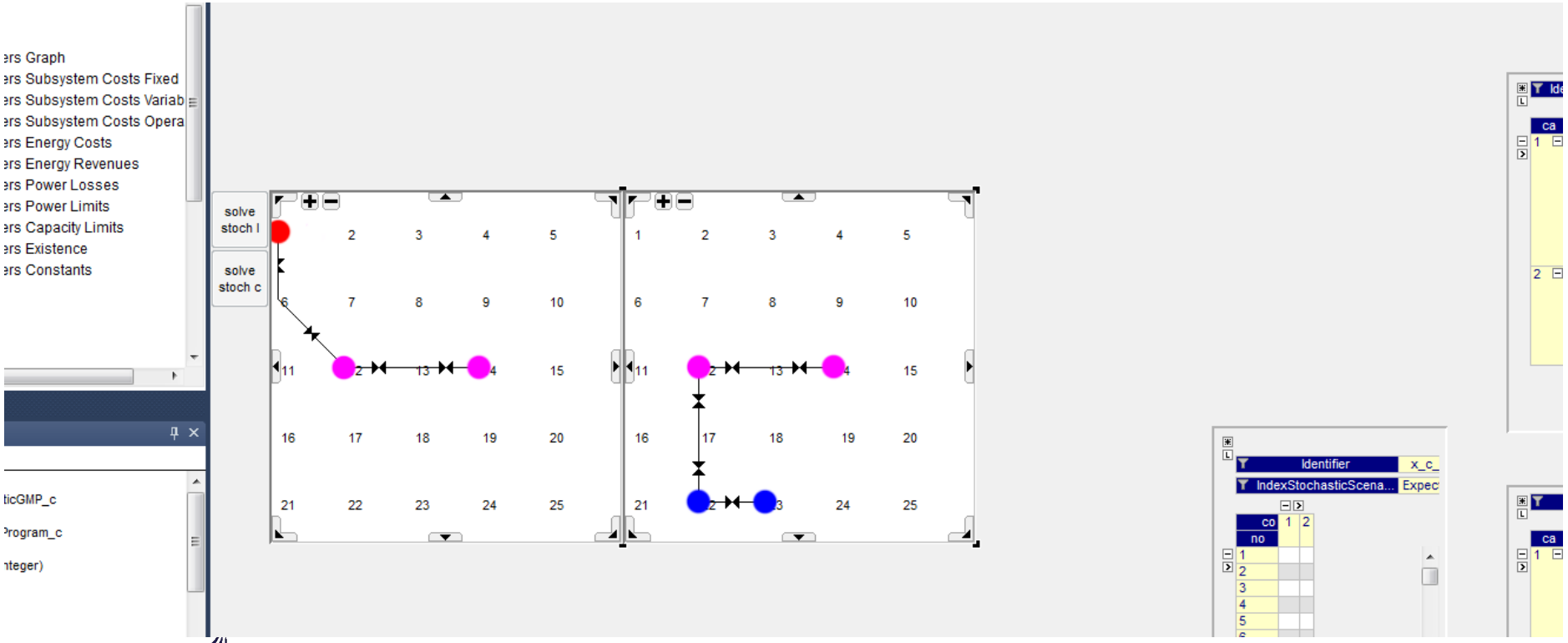
Uncertainty



Questions…

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- **How to get there?**

How to get there?

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Basic Model

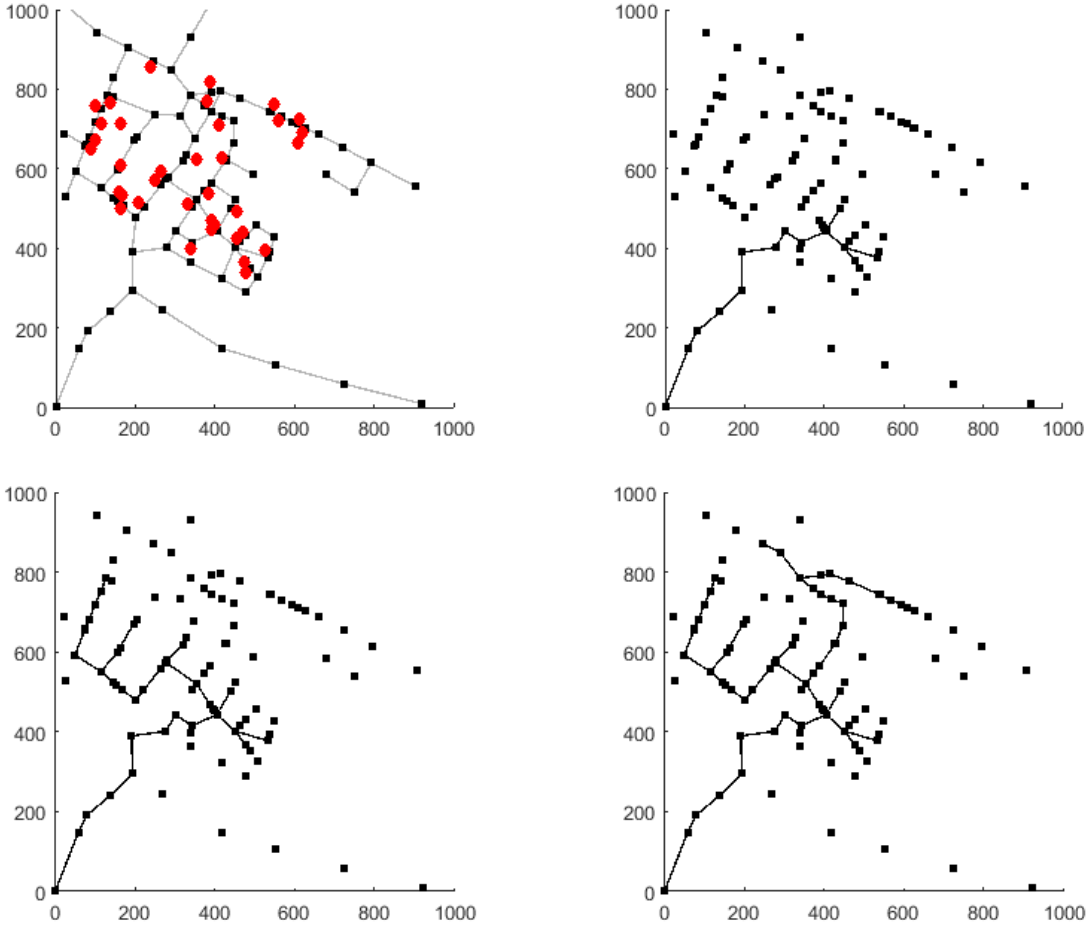
- Existing infrastructure
- Extension planning

Extended Model

- Existing infrastructure
- Extension planning

- Remaining lifetime
- Decommission planning

How to get there?



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Conclusions

Future planning and uncertainty

Clear goals and a road to achieve those goals

Stochastic programming

Increased solution space