Energy Planning for Resilient Communities

Advanced hot water systems

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Washington, 12/06/2017

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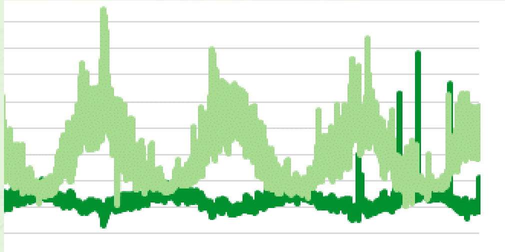
Studies

- Research projects, feasibility studies
- Thermohydraulic simulation and design



Piping systems

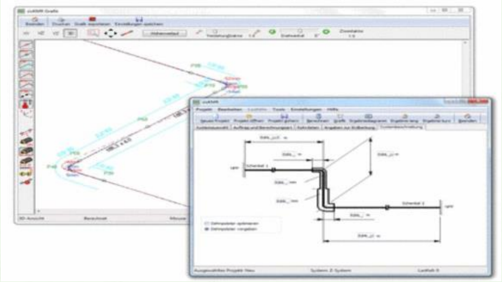
- A & E
- Construction supervision

Generation plants

- Planning and design

Software development

- i.a. sisKMR, POLIS



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Agenda

1. Motivation and objectives for energy system transformation
2. Transformation and optimization potential in district heating
3. Exemplary (research) projects of GEF
   - BMWi: DYNEEF
   - BMWi: NENIA
   - CHEMNITZ
   - BMWi: DUISBURG-WEDAU
4. Conclusion

Motivation and objectives for energy system transformation

- Transformation and optimization of energy systems mainly influenced by triangle of main objectives (or requirements) in energy economy:
  1. Ecological footprint*
  2. Preservation of energy security (energy resilience**)
  3. Preservation of economic efficiency

*Main pillars of decarbonization:

Increase of share of renewable energies

Reduction of primary energy consumption

Increase of (building, technical) efficiency

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**Criteria for demarcation:

Energy security
(especially for mission-critical facilities)

Reliability

- Quality and technical maturity of components
- Adequacy of maintenance and service
- …

Availability

- Degree of diversification of energy resources
- Degree of energy autarchy on building/district level
- Topology of „energy distributing structures"
- …

Adaptivity

- Back-up and storage capacities
- Ramp-up times
- Flexibility on demand side
- …

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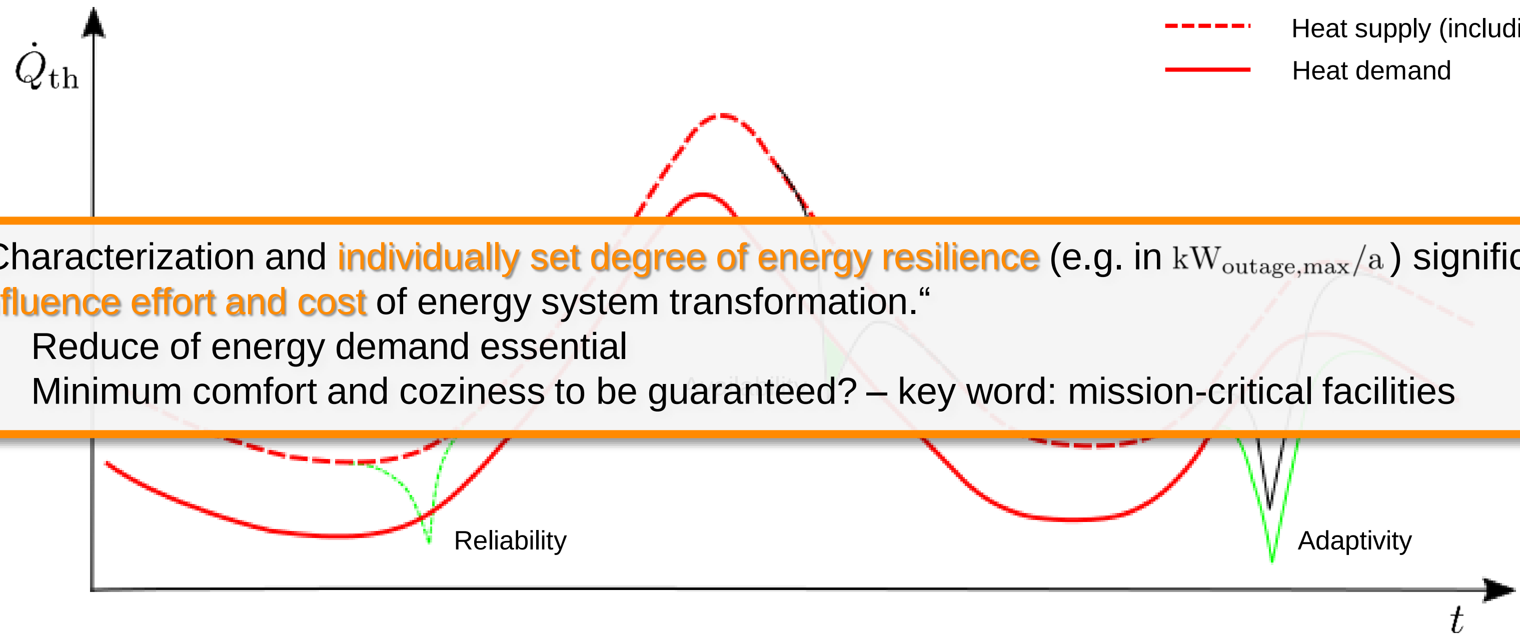

„Characterization and individually set degree of energy resilience (e.g. in $\mathrm{kW_{outage,max}/a}$) significantly influence effort and cost of energy system transformation."

- Reduce of energy demand essential
- Minimum comfort and coziness to be guaranteed? – key word: mission-critical facilities

Motivation and objectives for energy system transformation

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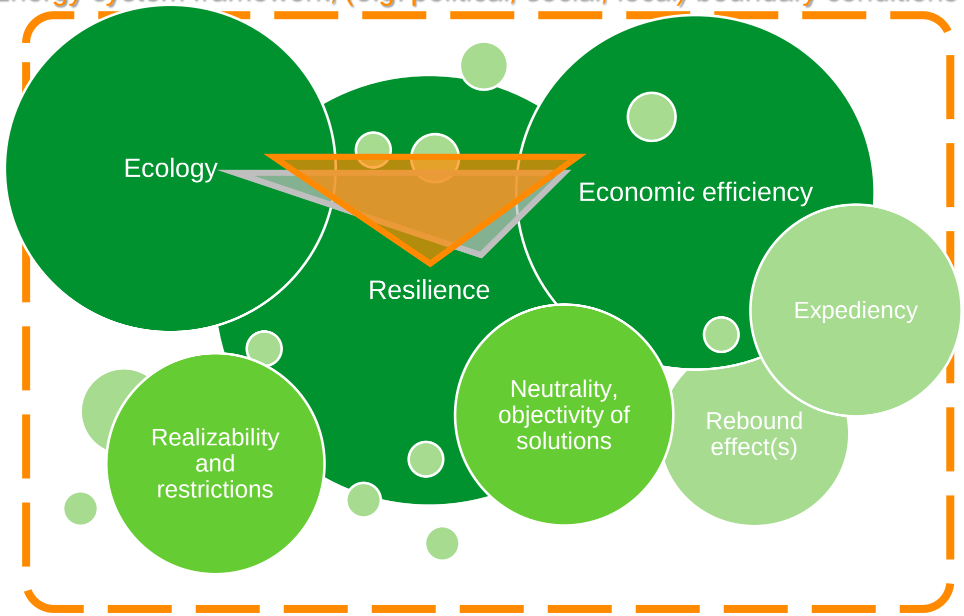
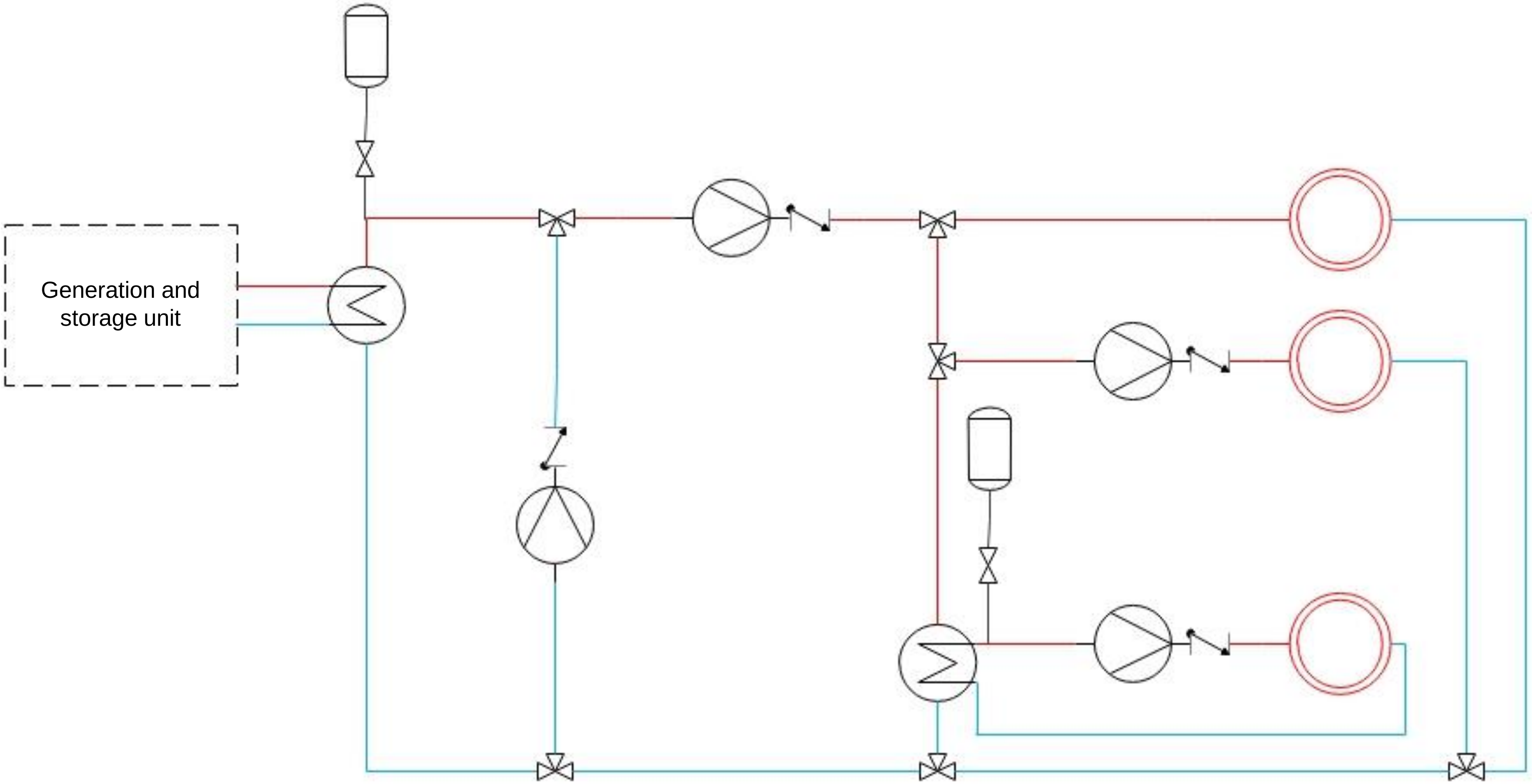


„System transformation towards 4th generation should focus on **reduction of ecological footprint** while **preserving energy security** (energy resilience) at moderate costs.“
„Economic sustainability of new system concepts will evolve in the long-term.“
- Increasing relevance in market, economy of scale
- Disruptive business models
- Adjusted boundary conditions

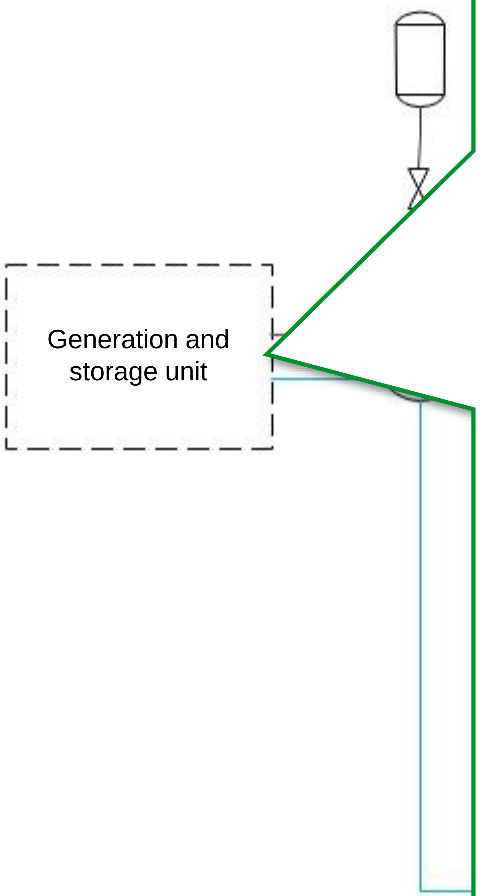
Transformation and optimization potential in district heating

Simplified DH-system and components:



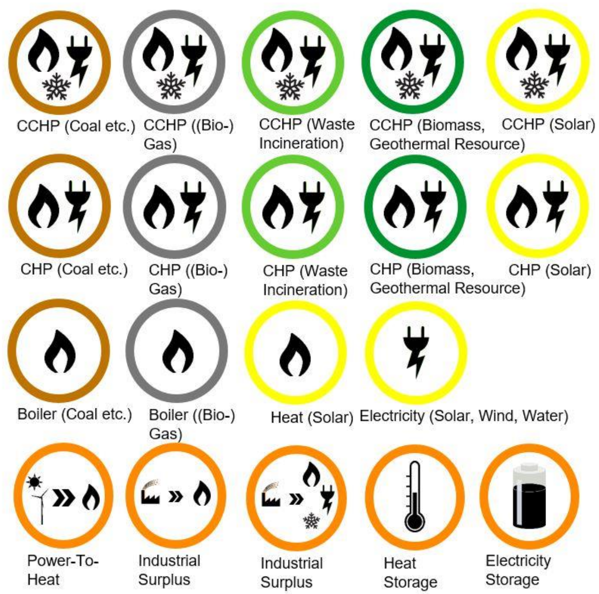
Transformation and optimization potential in district heating

Simplified DH-system and components: Generation and storage



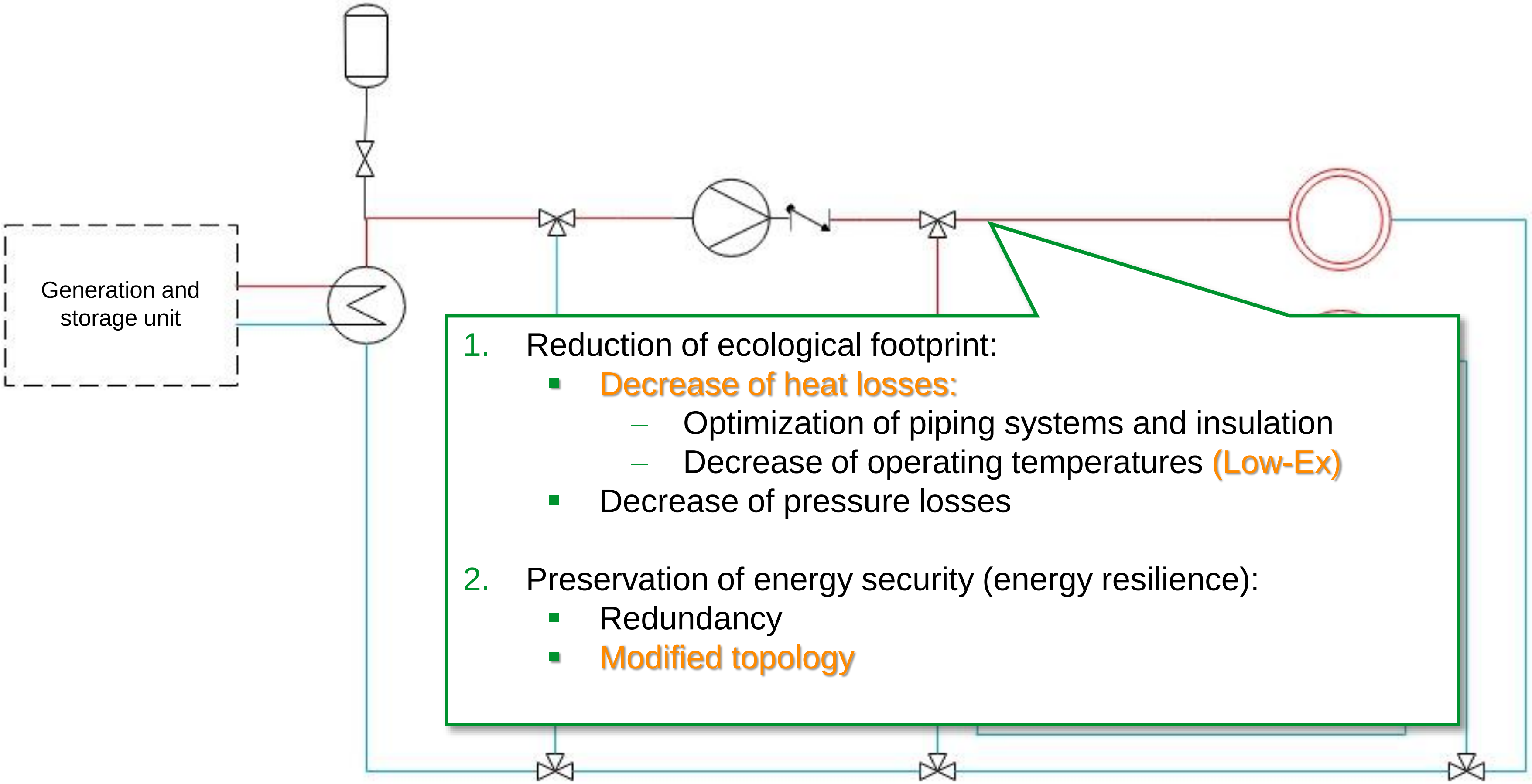
1. Reduction of ecological footprint:
   - Decarbonisation
   - Increase of efficiency (min. primary energy consumption)

2. Preservation of energy security (energy resilience):
   - Diversification
   - Flexibilisation and increase of storage capacities
   - Disaggregation
   - Sector coupling (PtH, PtG...)



Transformation and optimization potential in district heating

Simplified DH-system and components: Piping system

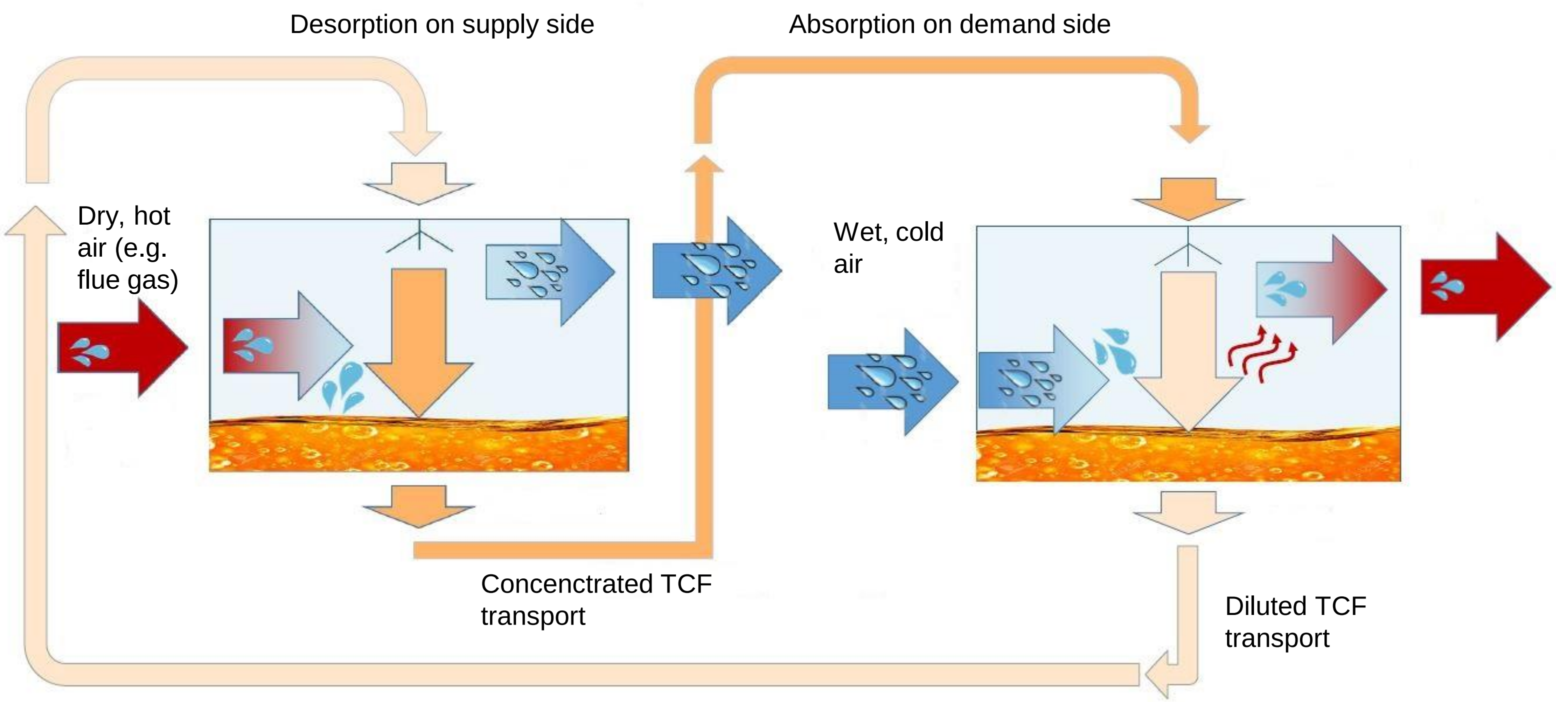


1. Reduction of ecological footprint:
   - Decrease of heat losses:
     - Optimization of piping systems and insulation
     - Decrease of operating temperatures (Low-Ex)
   - Decrease of pressure losses

2. Preservation of energy security (energy resilience):
   - Redundancy
   - Modified topology

Transformation and optimization potential in district heating

Simplified DH-system and components: Decrease of heat losses – a (theoretical) alternative to thermally insulated and/or Low-Ex-systems

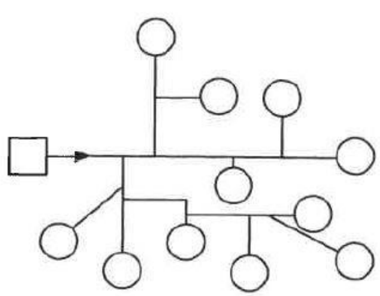


EU H2020-project H-DISNET: Schematic process scheme of open absorption process with thermochemical fluid (TCF, e.g. $MgCl_2$-H_2O)

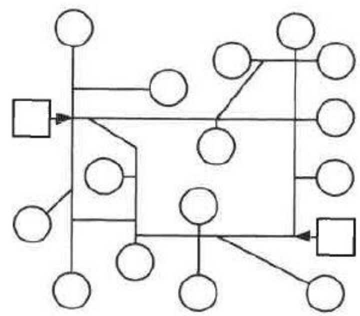
Graphic taken and adapted from http://www.flexynets.eu/en/Media

Transformation and optimization potential in district heating

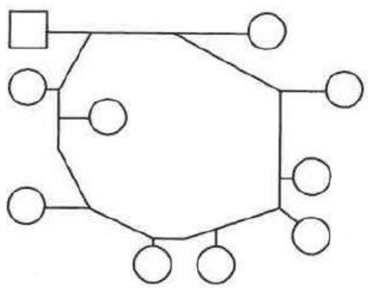
Simplified DH-system and components: Increase of energy resilience by modified topology



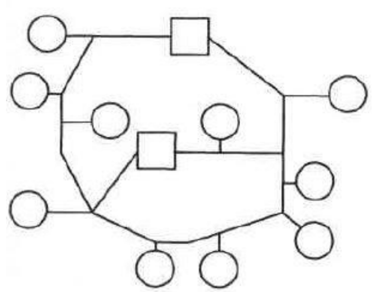
Line or radial network
(historically grown)



Meshed radial network
(historically grown)

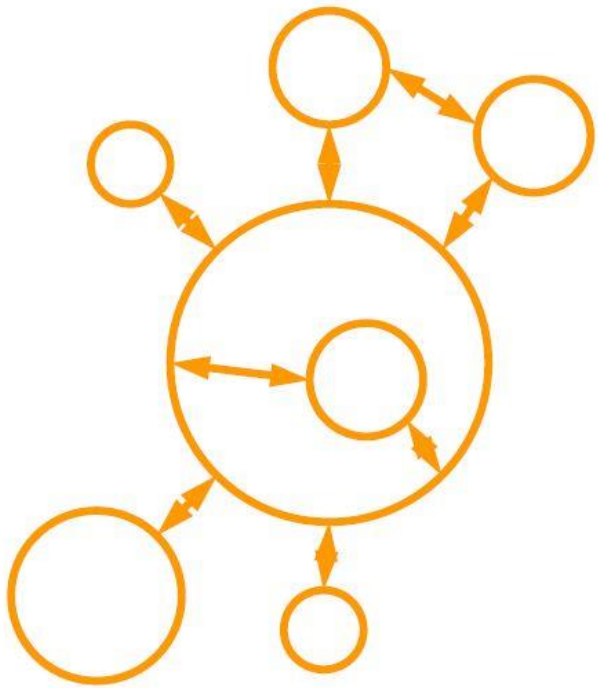


Ring network



Meshed ring network

Graphics taken from Rötsch, Dietmar: *Zuverlässigkeit von Rohrleitungssystemen: Fernwärme und Wasser*; Springer-Verlag 1999

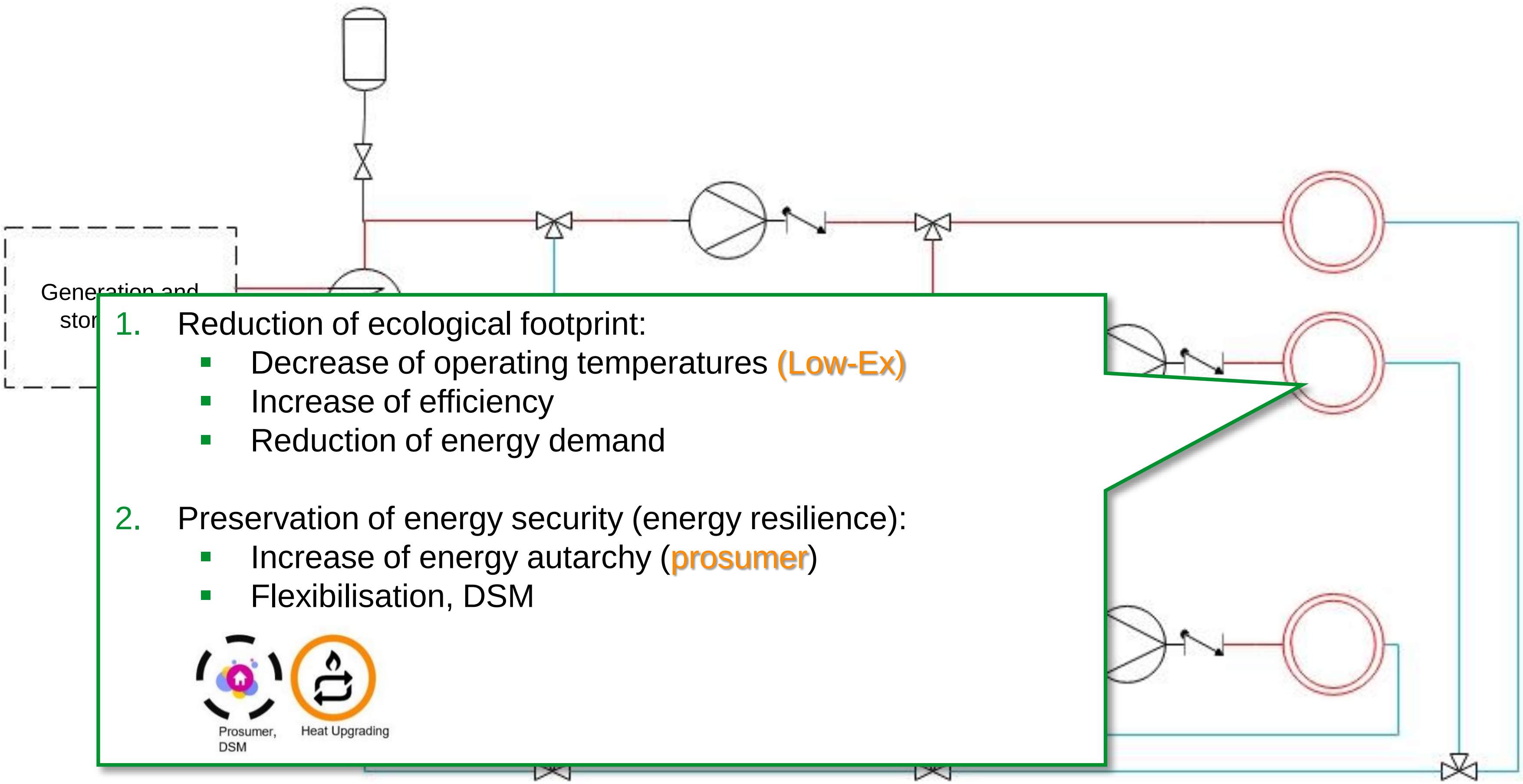


EU H2020-project Flexynets: One-pipe ring system for Low-Ex-networks (15-20 °C)

Graphic taken from http://www.flexynets.eu/en/Media

Transformation and optimization potential in district heating

Simplified DH-system and components: Demand side

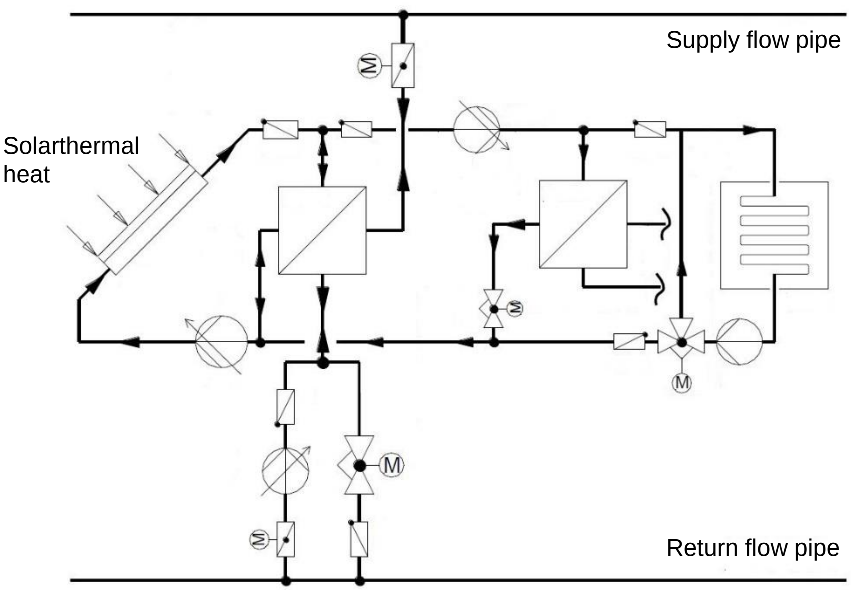


1. Reduction of ecological footprint:
   - Decrease of operating temperatures (Low-Ex)
   - Increase of efficiency
   - Reduction of energy demand

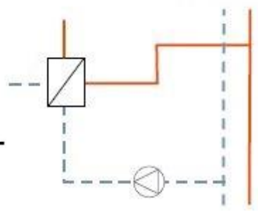
2. Preservation of energy security (energy resilience):
   - Increase of energy autarchy (prosumer)
   - Flexibilisation, DSM

Transformation and optimization potential in district heating

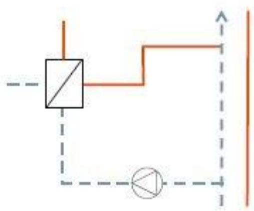
Simplified DH-system and components: Integration of prosumers



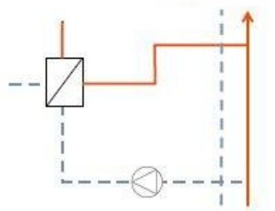
BMWi-project DEZENTRAL: Bi-directional substation with decentralized feed-in (lab-scale)



Decentral feed-in (between supply and return flow)



Decentral feed-in (return flow)



Decentral feed-in (supply flow)

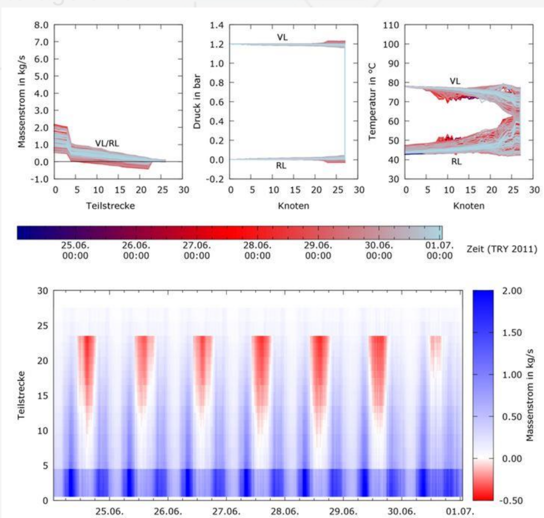
Graphics taken and adapted from Schäfer et al.: *DEZENTRAL – Dezentrale Einspeisung in Nah- und Fernwärmesysteme unter besonderer Berücksichtigung der Solarthermie*, final report of Solites, 2015 and https://projektinfos.energiewendebauen.de/projekt/dezentrale-einspeisung-solarer-waerme-in-nah-und-fernwaermenetze/

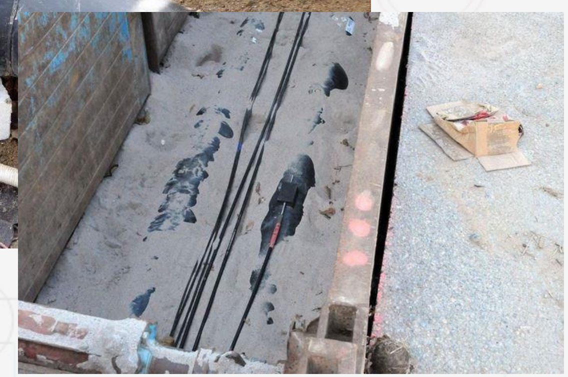
Transformation and optimization potential in district heating

Simplified DH-system and components:

For transition from lab- to pilot- and large-scale implementation of advanced (heat) supply systems further research effort required:

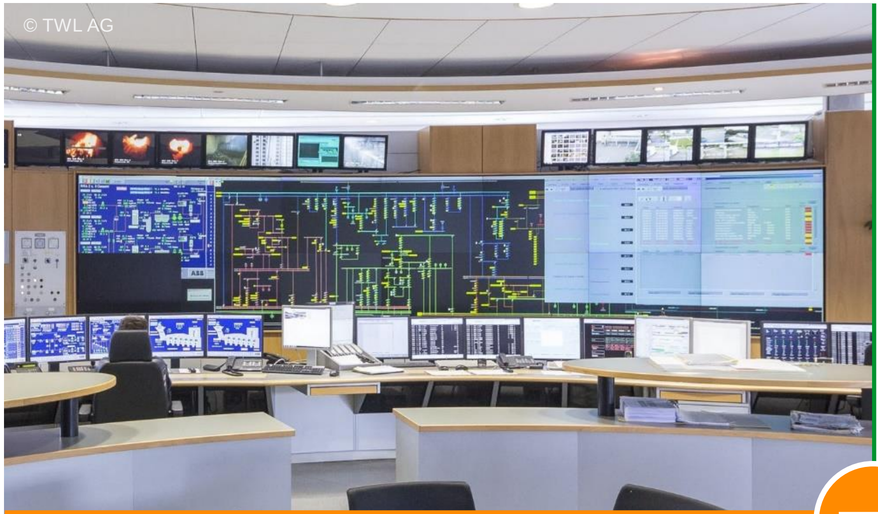
- EMSR: increasing number of degrees of freedom, high complexity due to sector coupling
- Quality of optimization and high-resolution forecasting models
- Prevention of local exceeding of operating limits in dynamic mode (temperature, pressure)
- Long-term reliability and robustness of new components
- …





Graphics taken from https://projektinfos.energiewendebauen.de/projekt/erneuerbare-waerme-optimal-in-fernwaermenetze-einspeisen/ and https://projektinfos.energiewendebauen.de/projekt/zustandsbewertung-von-waermenetzen-bei-volatiler-fahrweise/

Exemplary (research) projects of GEF
BMWi: DYNEEF

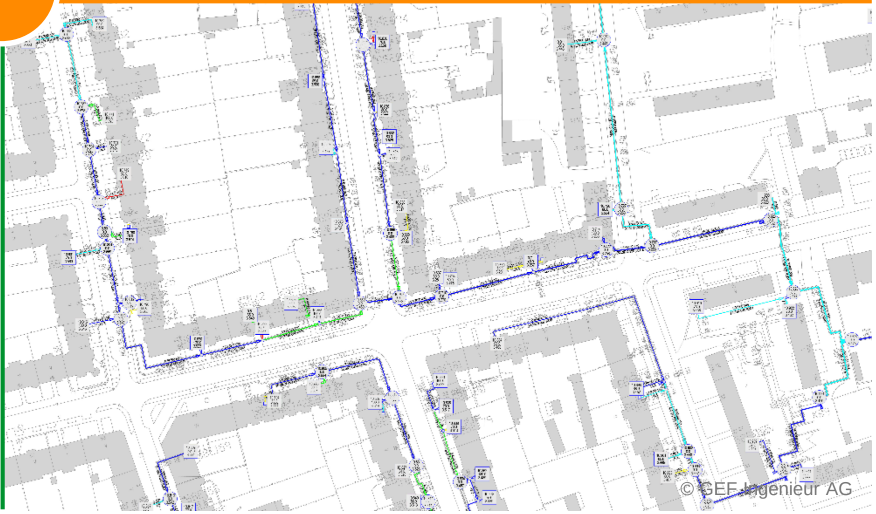


CHP simulation for operational optimization

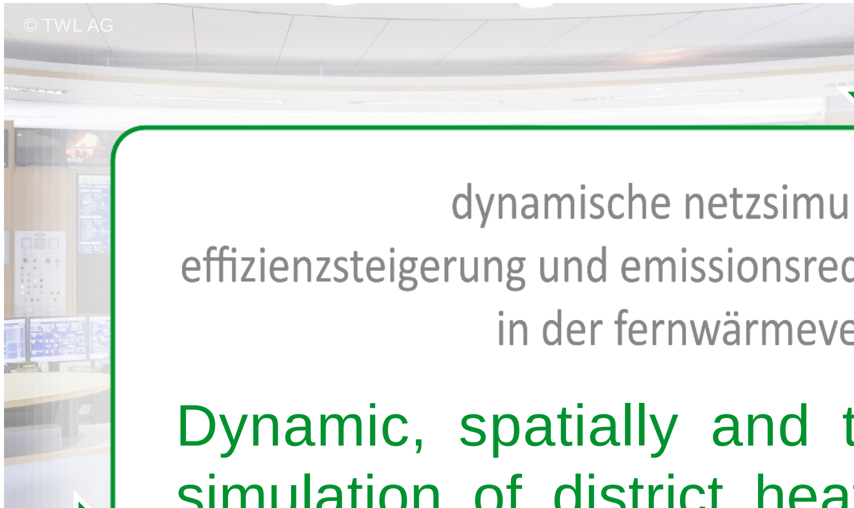
- District heating grid modelled as punctiform heat sink
- No referencing in space
- Dynamic

Thermohydraulic simulation of district heating grid

- Heat generation plants modelled as punctiform heat sources
- High spatial resolution
- Usually steady-state (isolated examination of most relevant load cases)



Exemplary (research) projects of GEF
BMWi: DYNEEF



CHP simulation for operational optimization

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  examination of most relevant load cases)

dynamische netzsimulation zur effizienzsteigerung und emissionsreduzierung in der fernwärmeversorgung

dyneef

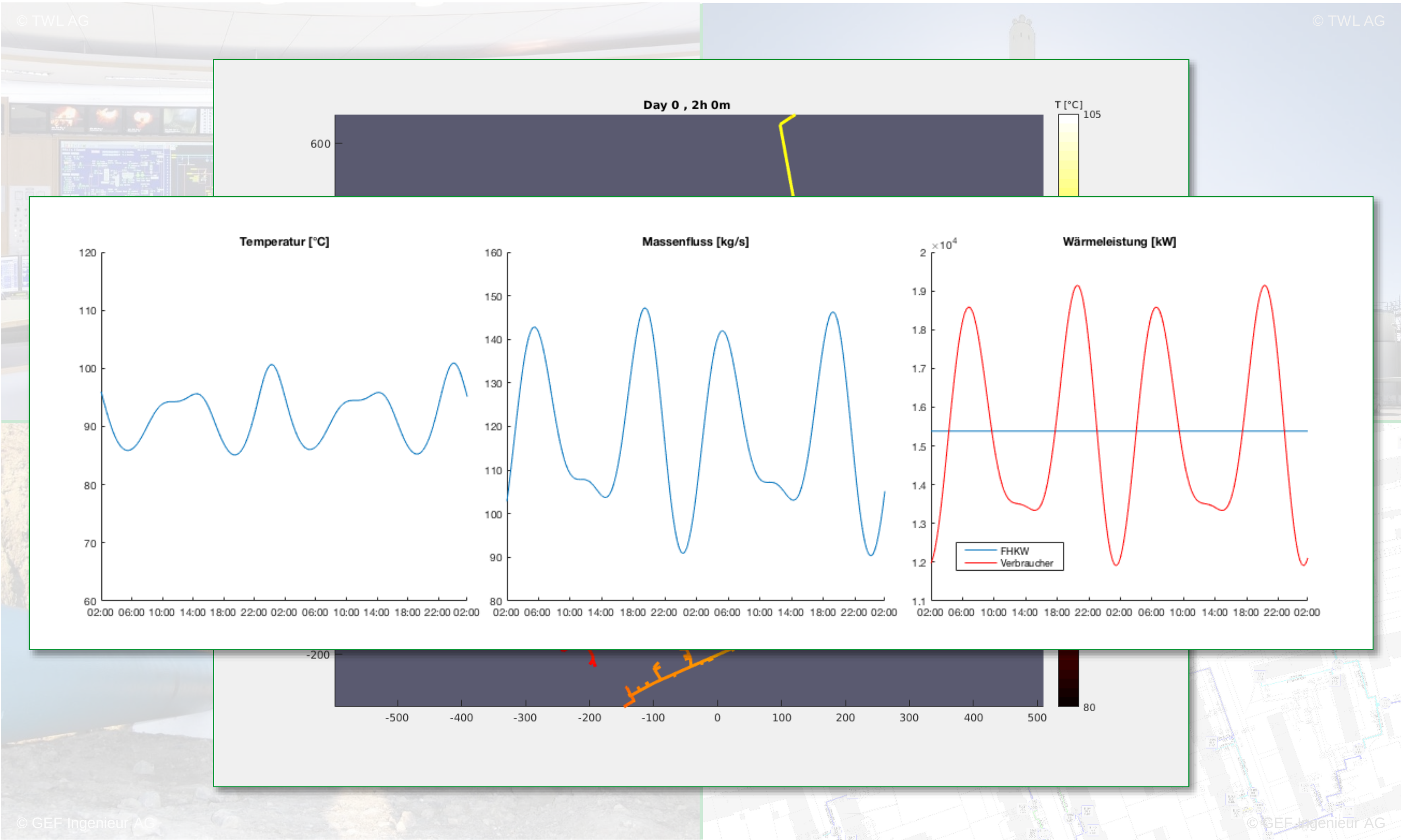
Dynamic, spatially and temporally highly resolved simulation of district heating grids for flexibilisation and efficiency increase of generation plant operation

Duration 11/2015 – 10/2018

GEF Ingenieur AG | Fraunhofer ITWM | TWL Meine Energiequelle.

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

Exemplary (research) projects of GEF
BMWi: DYNEEF



Exemplary (research) projects of GEF
BMWi: NENIA

- Transformation of existing district heating grids requires bundling and integration of (transitional) resources and technologies:
  - Waste incineration
  - Industrial surplus energy (waste heat)
- Regulatory, financial, organisational, technical... barriers require innovative and holistic solutions

Graphic taken from https://projektinfos.energiewendebauen.de/projekt/potenziale-industrieller-abwaerme-in-waermenetzen-ermitteln/

Exemplary (research) projects of GEF
BMWi: NENIA

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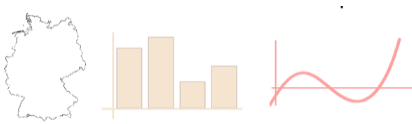
Waste heat potential: Declaration of emissions (11th BImSchV), E-PRTR (CO_2) et al.

GIS-Model

GEMOD: Heat demand model of German building stock (status quo and scenarios)

Techno-economic classification

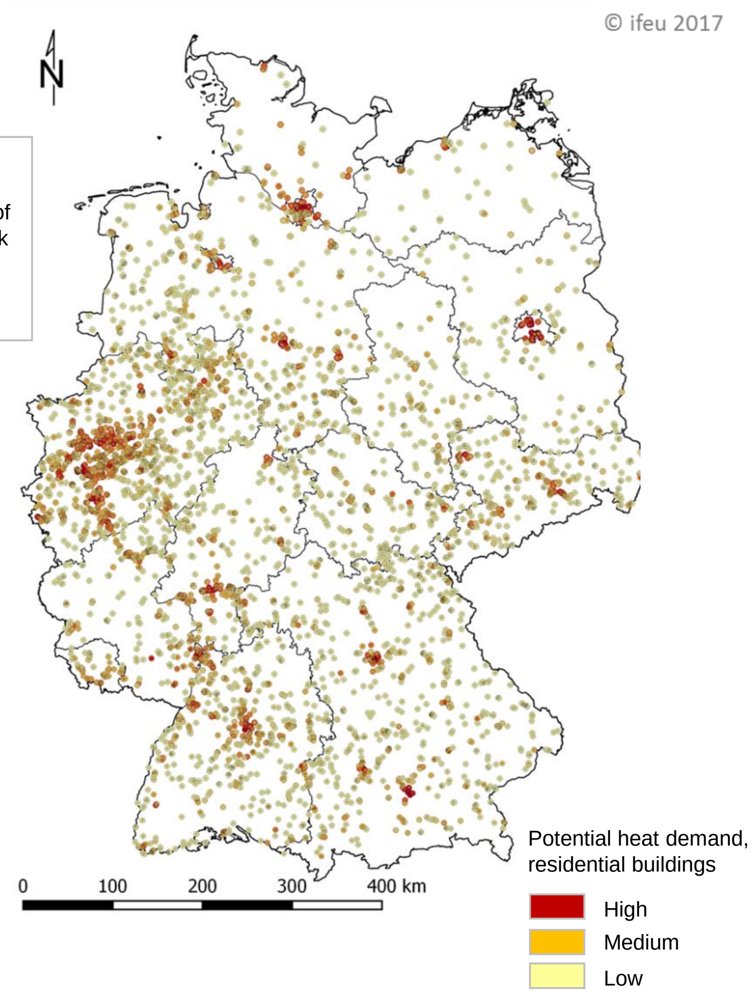


Calibration

Case studies

Recommendations of action

Exploitation strategy
Evaluation of public accessibility to GIS-tool



Exemplary (research) projects of GEF
CHEMNITZ

Project phases (03/2016 – 08/2017):

Boundary conditions

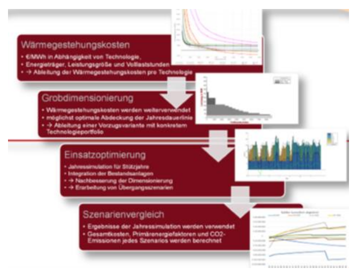
Price forecasts

(Local) initiatives and political framework

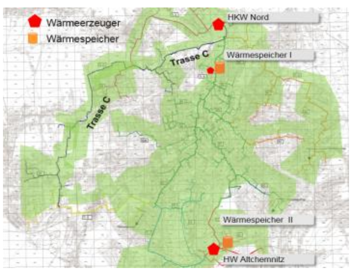
Heat demand Chemnitz

Conceptual phase

Derivation of future supply system



Iterations



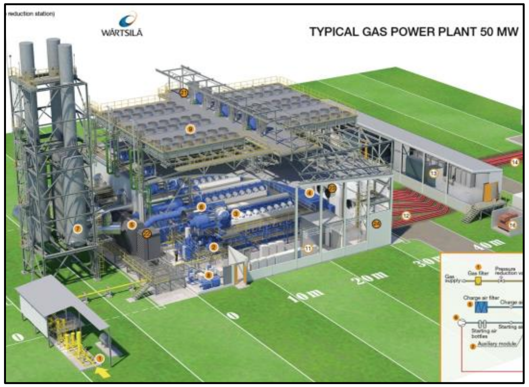
Optimization of district heating grid

Transformation strategy

Choice of best solution, implementation plan

Exemplary (research) projects of GEF
CHEMNITZ

- Stepwise implementation until 2030:
  - Renewable base load (biomass-CHP)
  - Medium load with gas-CHP
  - Peak load with gas boiler
  - Additionally, waste incineration, biogas and solar thermal energy can be considered
- Advantages:
  - Modular system, phased implementation – best response capacity for changing political and technological boundary conditions
  - High-efficient technologies, increasing share of renewables
  - Hydraulic optimization and increased efficiency in district heating grid possible



High energy security, sustainable reduction of CO_2-emissions and energy prices in line with market requirements

Exemplary (research) projects of GEF
BMWi: DUISBURG-WEDAU

- New residential district (ca. 60 ha, 2.500 units) with attached university campus
  - One of the biggest urban development projects in Germany
  - Nucleus of transformation for district heating in Duisburg
- GEF will participate in a study examining Low-Ex district heating (starting in 2018)
  - Power-to-heat, fuel cells, combination of CHP and heat pumps, waste heat
  - Bi-directional substations
  - Synergies by coordinated and efficient planning of piping systems
    - Predefined positioning/alignment (media-specific)
    - Stepped trenches, well-defined corridors (media-specific)
  - Enriched by consistent mobility concept

Conclusion

- District heating systems represent a key technology for transformation of energy systems towards 4th generation:
  - Reliable and well-established system components
  - Highly diversifiable and flexible heat supply allows effective and efficient decarbonisation
  - Immanent load balancing and storage capacity
  - Facilitates sector coupling and integration of transitional energy resources
- Broad range and variety of research projects and approaches underline potential of district heating systems
- Challenges:
  - Operating parameters in dynamic mode with bi-directional load flow
  - EMSR, system optimization
  - Overall system costs vs. return expectations