OPTIMISING THE DISTRICT HEATING SYSTEM

IEA DHC Annex TS2 Workshop, October 23, 2018, Nottingham

Ralf-Roman Schmidt

MAIN CHALLENGES FOR DISTRICT HEATING AND COOLING SYSTEMS

- Uncertain price trends for electricity, natural gas and biomass
- Decreasing specific heat demand in existing and new buildings
- Political requirements for decarbonisation

ALTERNATIVE HEAT SOURCES

Such as solar and geothermal energy, ambient heat via heat pumps and waste heat from industries and service sector

- can minimize investment risk (independent on fuel prices)
- guarantee supply security (independence of energy imports)
- Reduce CO_2 emissions

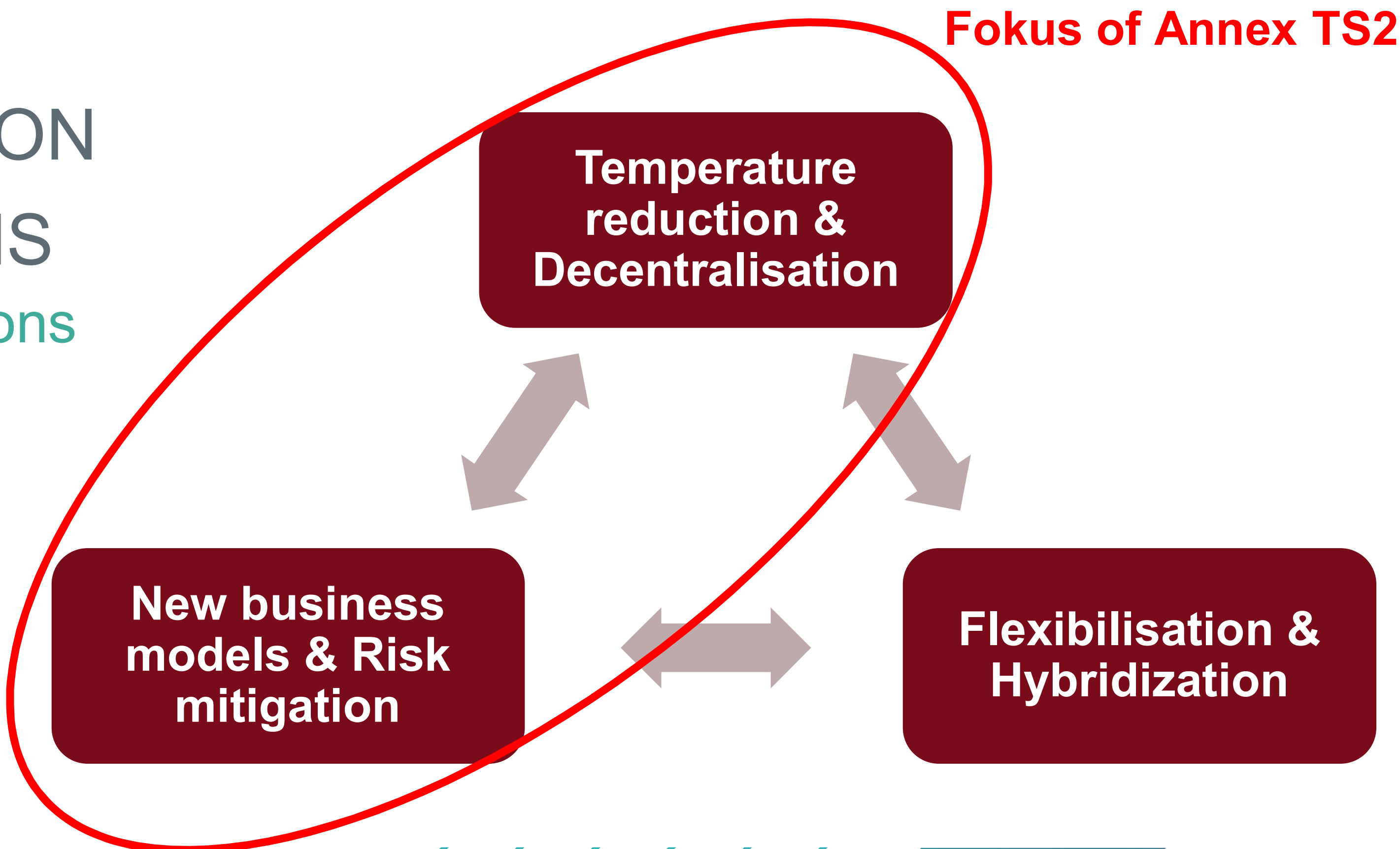
BARRIERS FOR THE INTEGRATION OF ALTERNATIVE HEAT SOURCES

These sources are in general

- fluctuating and/ or non-controllable and/or
- small scale and/ or on a decentral location located and/or
- have their highest potential at low temperature levels

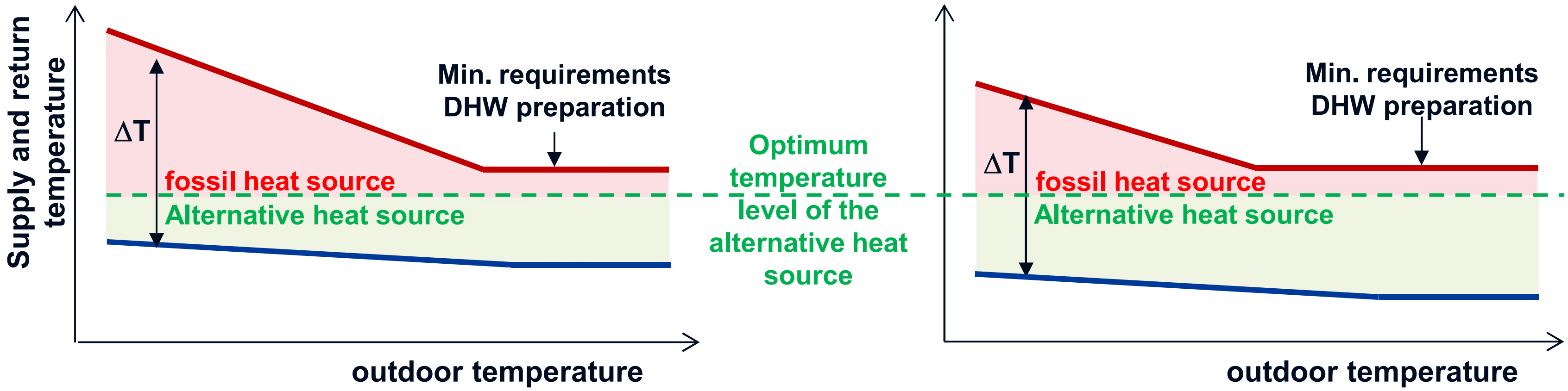
SOLUTION OPTIONS

3 dimensions



TEMPERATURE REDUCTION & DECENTRALISATION

HIGH NETWORK TEMPERATURES IN MANY CITIES



- **Challenges** for lowering the supply temperatures
  - <u>room heating</u>: radiators are often designed for T_{supply} = 50-90° C
  - <u>DHW preparation</u>: T_{supply} > 55-60° C[1] required to avoid Legionella
  - <u>transport capacity</u>: for low $\Delta T = T_{supply} - T_{return}$ pumping cost are high
  - <u>building side installations</u>: reducing T_{return} is cost intensive

DHW = domestic hot water
[1]: depending on national regulations
T_{suppyl} = supply temperature
T_{return} = return temperature

EXAMPLE: REDUCTION OF RETURN TEMPERATURES

National project: **T2LowEx** – transformation of traditional DH networks towards low temperature network via secondary side measures

- **Aim**: Investigation of secondary side potentials and effects of temperature reduction in existing DH networks in Austria
  a) Identification of the <u>reasons for high return temperatures</u> and measures for reducing them
  b) Comprehensive <u>economic evaluation</u> of the effects of lower return temperatures for the network and the customer
  c) Development of incentive based <u>business models</u> and win-win situations for end customers and heat suppliers.

Kategorie	Fehler-quelle	Problem / Auswirkung	Mögliche Maßnahme	Fehlerortung	Aufwand	...
Hausanschlus-sstation	Falsche Lage des Wärme-übertragers	Bei horizontaler Lage Anschlüsse oben: Schmutzpartikel setzen sich ab; Anschlüsse unten: Luft sammelt sich	Plattenwärmetauscher immer senkrecht montieren	Sichtkontrolle	Mittel - Hoch	
	Regelung	Überfahren der primärseitigen Fahrkurve kann instabiles Reglerverhalten in der Hausanschlussstation bewirken	Anpassen der Fahrkurve laut Herstellerangaben und Adaptierung nach durchgeführtem hydraulischem Abgleich	häufiges Takten von Anlagenkomponent en	Niedrig	
Hausanlage	Fehlender hydraulischer Abgleich	Über- bzw. Unterversorgung von Heizflächen; Komforteinbußen "Wohnraumklima"; erhöhte Heiz- und Pumpstromkosten	Hydraulischen Abgleich durchführen	Ungleiche Wärmeverteilunge n in den einzelnen Räumen; störende Betriebsgeräusche an Heizkörpern; "Diskomfort"	Niedrig	
	Nutzer-verhalten	falsches Lüften; verstellen der Heizkörper durch Möbel; falsche Benützung der Heizkörper (ein Heizkörper zum Heizen für die ganze Wohnung); etc.	Stoßlüften statt Fenster dauerhaft gekippt; auf freistehende Heizkörper achten; Nutzen aller Heizkörper in jedem Raum und Verwendung der Thermostatventile	Aufklärungsmaßna hmen und Bewusstseinsbildu ng bei den Nutzern	Niedrig - Mittel	
Trinkwasser-erwärmungsanlage	Anlage / System selbst	niedrige RLT nur möglich, wenn sich das Heizungswasser an der Sekundärseite abkühlen kann	Wassermengen kontrollieren → Einregulieren der Verbraucher; Fühlerpositionen optimieren; drehzahlgeregelte Pumpen	Anlageninspektion / Überprüfen der hydr. Schemata	Niedrig - Hoch	
	Zirkulations-system	Speicherlose Durchflusssysteme liefern in zapffreien Zeit systembedingt RLT über der minimal erforderlichen Zirkulations-RLT von 55 °C	stufenweise / kaskadische TW-Erwärmung; Einsatz von Speicher (Zwischenspeicherung der Restwärme möglich)	Anlageninspektion / Überprüfen der hydr. Schemata	Niedrig - Hoch	
...						

EXAMPLE: REDUCTION OF RETURN TEMPERATURES

EU-project TEMPO

Demonstration of technological innovations towards low(er) network temperatures:

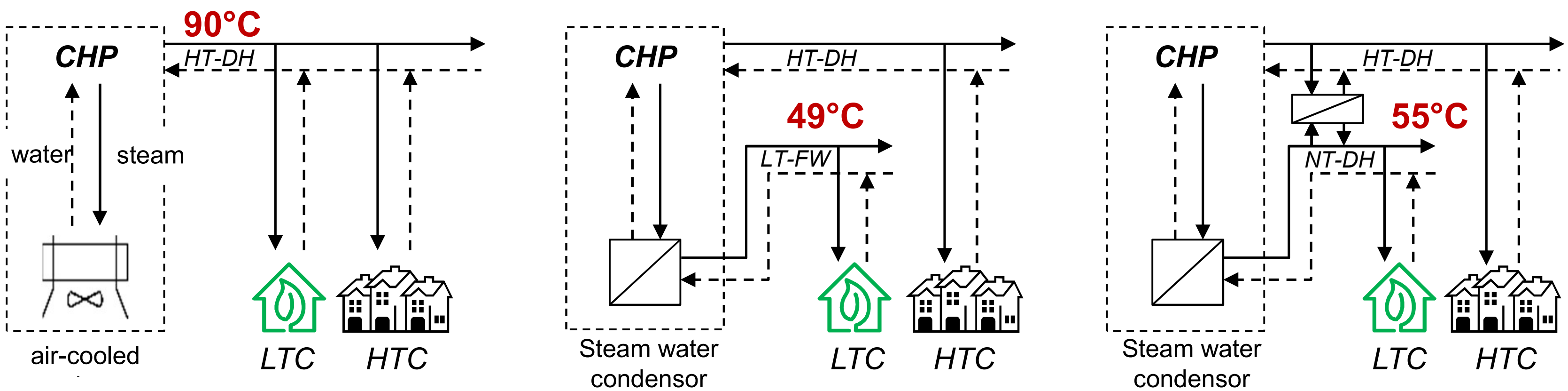
- supervision **ICT platform** for fault detection and diagnosis in substations
- **Visualisation tools** for expert and non-expert users
- Smart DH **network controller**, to balance supply and demand and minimize the return temperature (from STORM project)
- Innovative **pipe system** - eliminating bypasses in substations
- Optimisation of the **building installation** (e.g. poor hydraulic balancing, misbehaving thermostatic radiator valves etc.) by automatic fault detection
- Decentralised **buffers** - cut the power peaks in the network

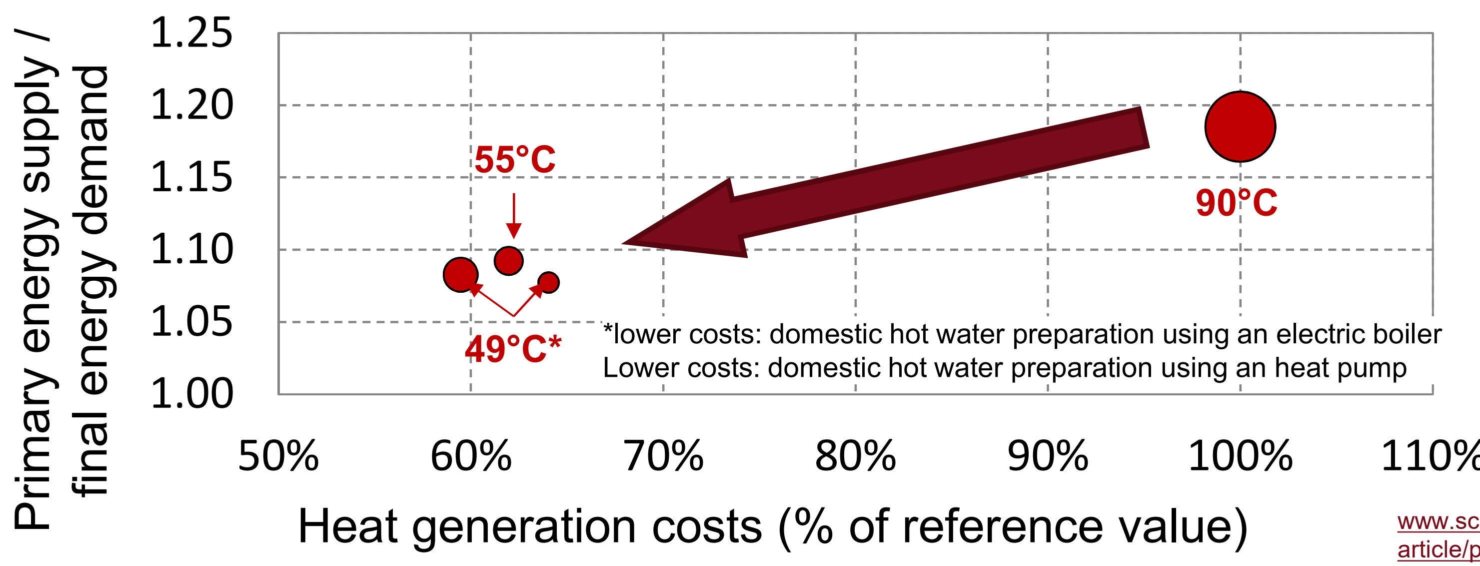
- **Application to 3 demo sides** (existing urban, existing rural, new rural)

More Information: www.tempo-dhc.com

EXAMPLE: LOW TEMPERATURE DISTRICT HEATING

Utilization of condensor waste heat





LTC: low-temperature customer
HTC: high-temperature customer

www.sciencedirect.com/science/article/pii/S036054421501748X

EXAMPLE: WASTE HEAT UTILIZATION FROM A DATA CENTER

powered by klima+ energie fonds

Data center Atos

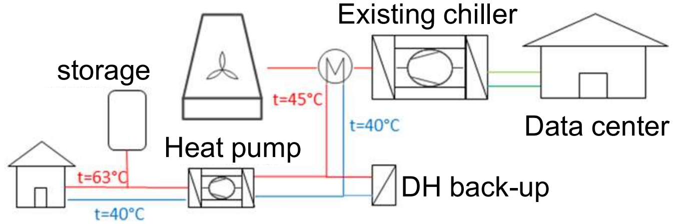
- **Build in 2010, extension in 2012**
- **Cooling demand 5 GWh**

About 250 m distance

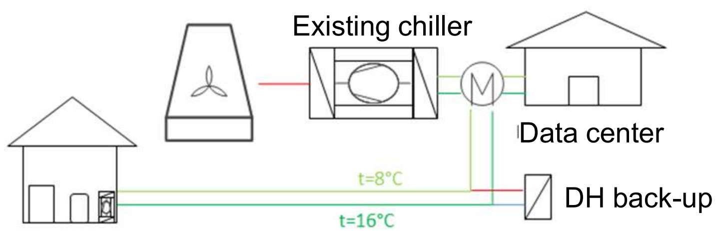
New district SOZIALBAU AG

- **1.100 apartments, date of construction 201**
- **Heat demand 7,3 GWh**

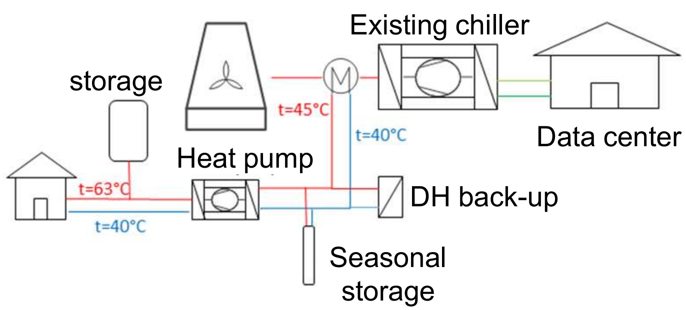
V1 (HP with DH Back-Up)



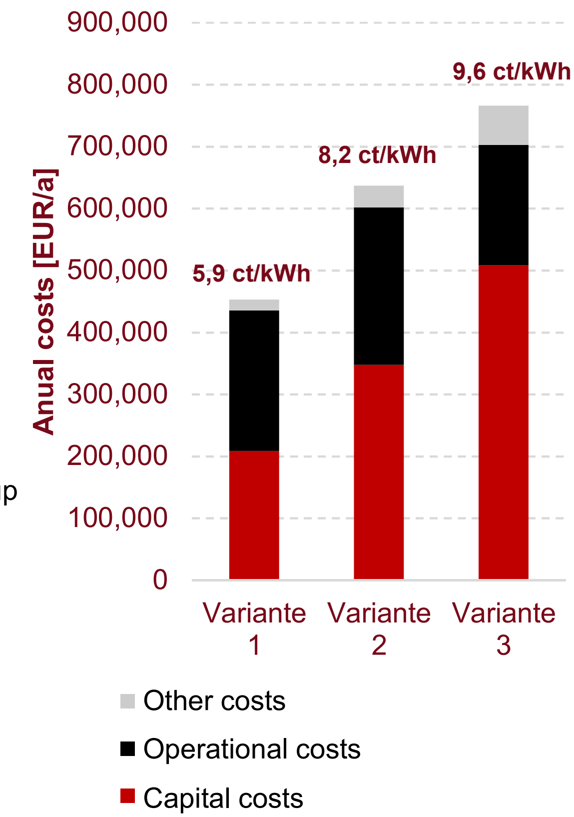
V2 (ultra-low DH network)



V3 (V1 + seasonal storage)



Economic evaluation



EXAMPLE: WASTE HEAT UTILIZATION SEASONAL STORAGE FOR LINZ

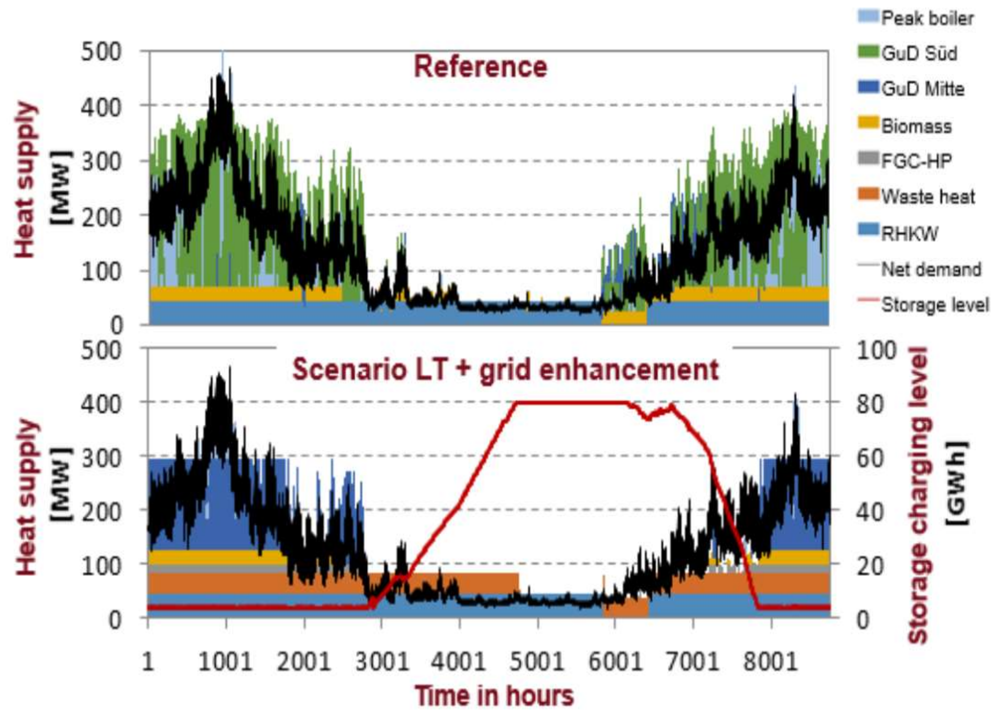
powered by klima+energie fonds

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

ENERGIE INSTITUT

LINZ AG STROM

- large amounts of **waste heat from a steal mill** cannot be used due to the **competition to waste incineration**
- The **integration of a seasonal storage** (2,000,000 m³, 100 mil. €) could lead to a share of about 25% waste heat
- optimized **storage management** (balancing of the CHP plants) allows up to 4.4 full load cycles and a **payback period of 20 years** (best case)



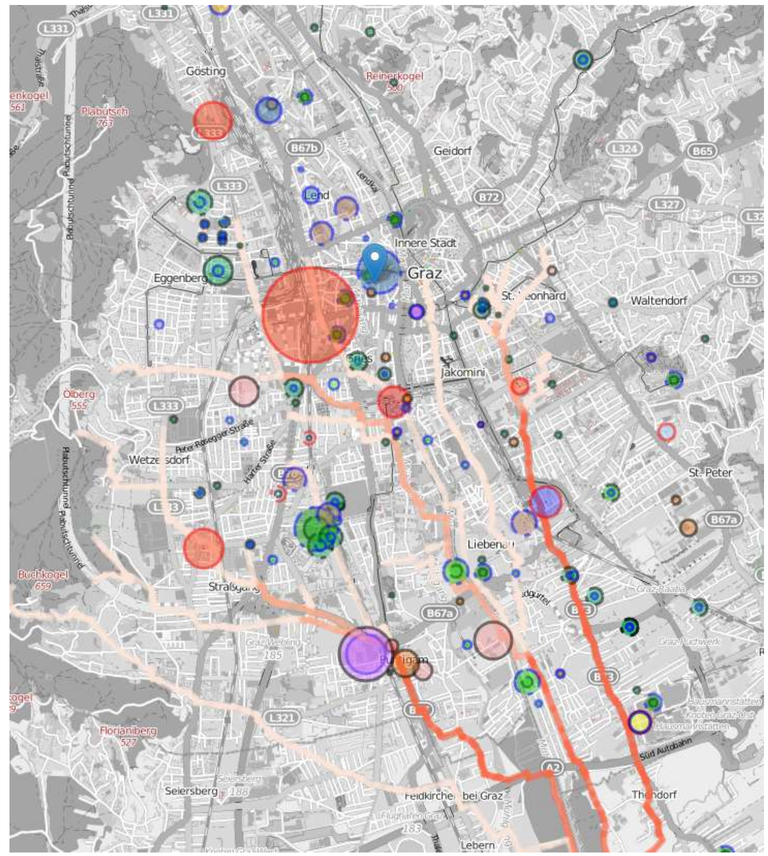
- **However, various uncertainties apply, boosting the investment risks!**
  - especially electricity prices, long term availability of the waste heat and CO2 market conditions

Köfinger, M. et al: "Simulation based evaluation of large scale waste heat utilization", Smart Energy Systems and 4th Generation District Heating, 12-13. September 2017, Copenhagen; http://www.4dh.eu/images/1_20170913_Presentation_-_FDHS_Linz.pdf

EXAMPLE: WASTE HEAT UTILIZATION, IDENTIFICATION OF SOURCES

IEA DHC Annex XII project MEMPHIS

- **Development of a generic methodology**
  - using open data to assess
  - waste heat potential from industry and service sector + sewage water
- **Application and Demonstration**
  - 3 cities (AT, DE, UK)
  - interactive web application
- **Transferability and Impact analysis**
  - Analyzing the transferability of the methodology to other countries
  - Evaluating technical and economic aspects



http://www.2018dedays.org/wp-content/uploads/2018/09/180927-3-Business-Roman-Geyer.pdf

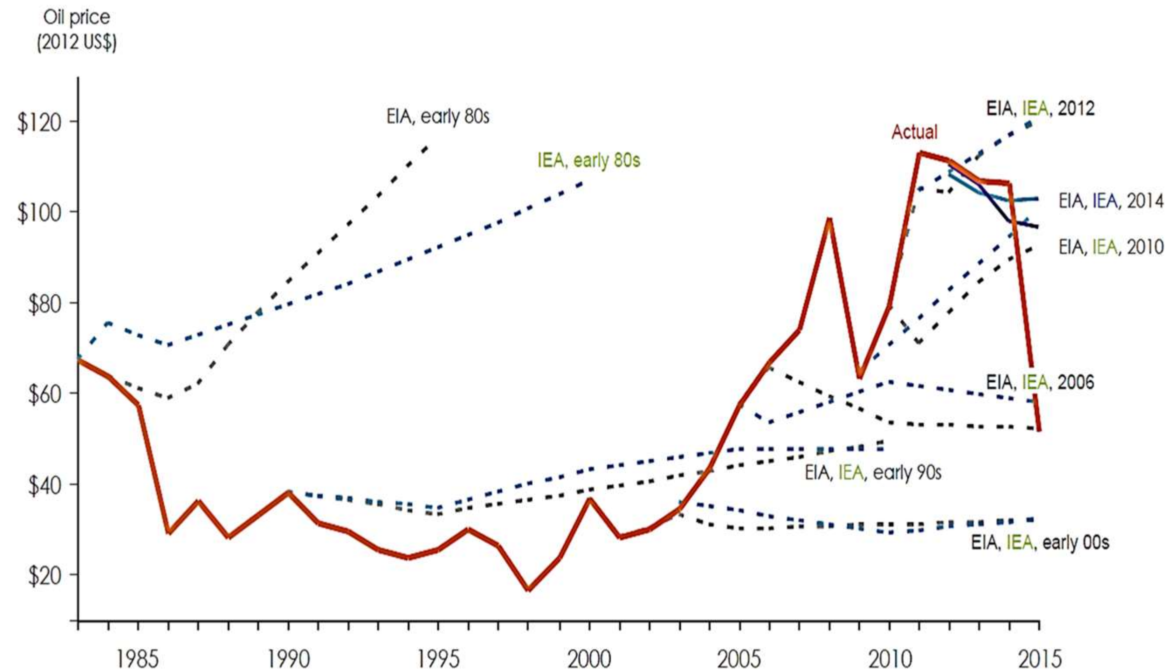
http://blogs.hawk-hhg.de/memphis/

NEW BUSINESS MODELS & RISK MITIGATION

CONSIDERING UNCERTAIN LONG TERM PERSPECTIVS

example: development of the oil prices and IEA/EIA scenarios

- Energ efficiency and decarbonisation
- Legal framework, regulations and subsidies
- Volatility of electricity markets
- Development of the oil and gas price
- Digitalisation and new technologies



Notes: IEA and EIA imported crude oil price forecasts, selected years, baseline scenarios. All figures are in constant 2012 US$/bbl.
IEA: International Energy Agency, EIA: U.S. Energy Information Administration

Sources: IEA, *World Energy Outlook*, 1982, 1993, 2000, 2006, 2010, 2012, 2014
EIA, *Annual Energy Outlook*, 1983, 1993, 2000, 2006, 2010, 2012, 2014

Source: Dieter Helm: THE NEW ENERGY LANDSCAPE – low fossil fuel prices, decarbonisation and new technologies, IET Mountbatten Lecture, 3rd November 2015, University of Oxford,

EXAMPLE: DEVELOPMENT OF HEAT SUPPLY STRATEGIES

- **Motivation**: replacement of the existing lignite chp plants in the district heating network Chemnitz due to their high CO2 emissions and age

- Application of a **decision support methodology** that is
  - Highly transparent and follows a **clear sequential approach**

1. Assessment of **boundary conditions**

a) evaluation criteria, time horizon
b) Status-Quo and scenarios
c) regulations, subsidies, electricity price forecast

2. Development of **technology scenarios**

a) Technology characteristics potential of heat sources
b) heat generation costs
c) heat supply portfolio
d) Sensitivity analyses

3. Decision on the **final concept**

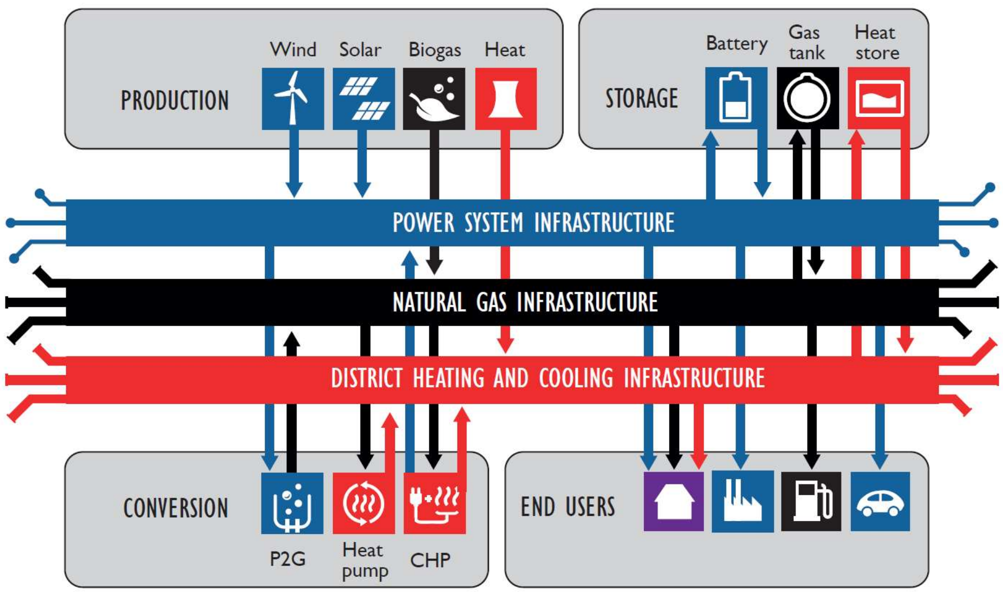
a) variants selection
b) SWOT-Analysis
c) Multi–Criteria evaluation
d) Transition strategy & action plan

http://www.4dh.eu/images/Ralf-Roman_Schmidt_heat_supply_strategies_4DH_conference.pdf

FLEXIBILISATION & HYBRIDIZATION

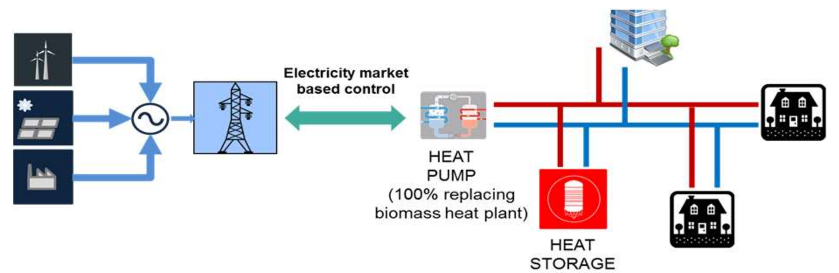
INTEGRATED ENERGY SYSTEMS

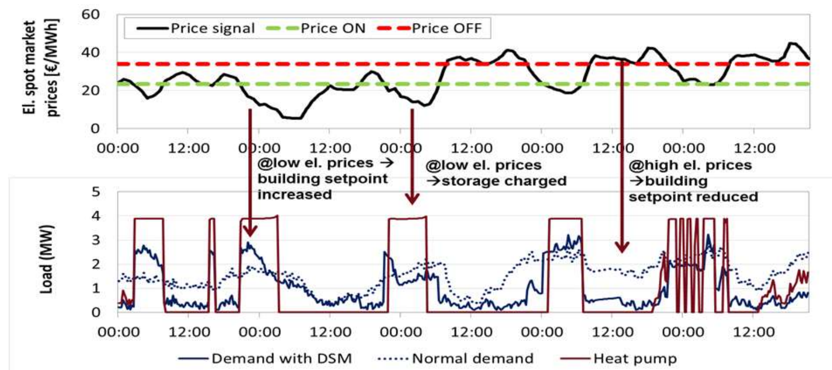
- The integration of the electricity/ gas grids and heating/ cooling networks is considered as one of the **key measures for decarbonizing the energy system** (aka “sector coupling”). This
  - triggers important **synergies**, that couldn’t be realised by optimizing the sectors individually.
  - is connected to several **challenges**, such as an increasing competition between the energy domains and a higher complexity.

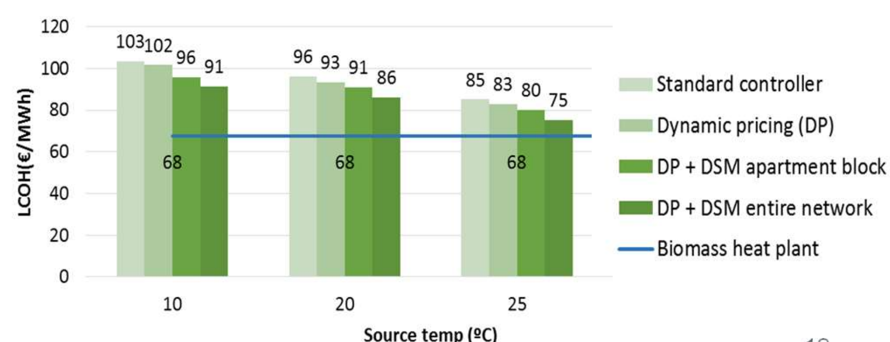


EXAMPLE: HEAT PUMP INTEGRATION, DEMAND SIDE MANAGEMENT AS „ENABLER"

- **Aim:**
  - Evaluation of different control strategies for the integration of heat pumps (>1MW) in district heating networks
- **Method:**
  - Participation at the spot-market
  - Utilization of the DH network flexibility (storage, demand side management)
- **Results**
  - Reduction of the heat generation costs between 9 and 15% (example: rural network)

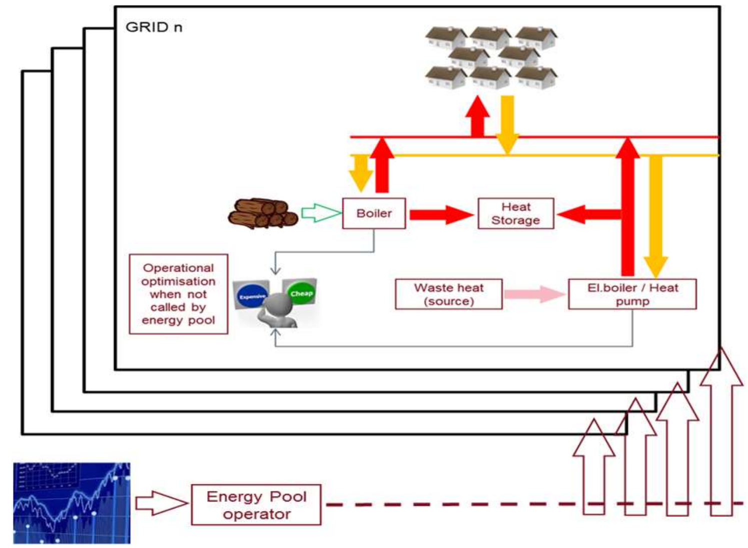




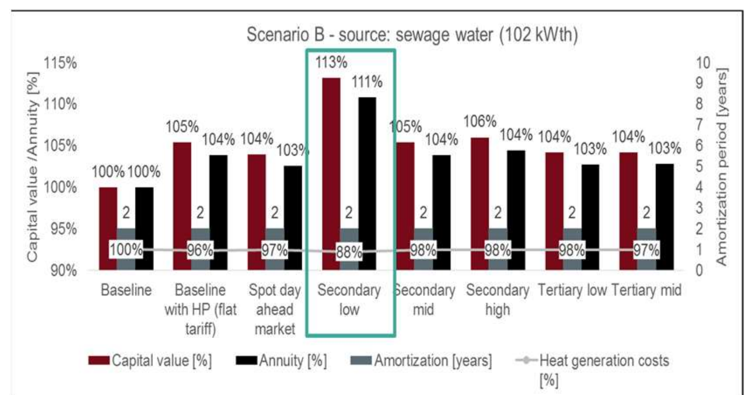


EXAMPLE: HEAT PUMP INTEGRATION POOLING FOR BALANCING MARKETS

- **Aim:** develop innovative business models for heat pump integration in existing old and inefficient district heating networks by exploiting the:
  - Day-ahead SPOT Market
  - Balancing markets (secondary and tertiary balancing energy)



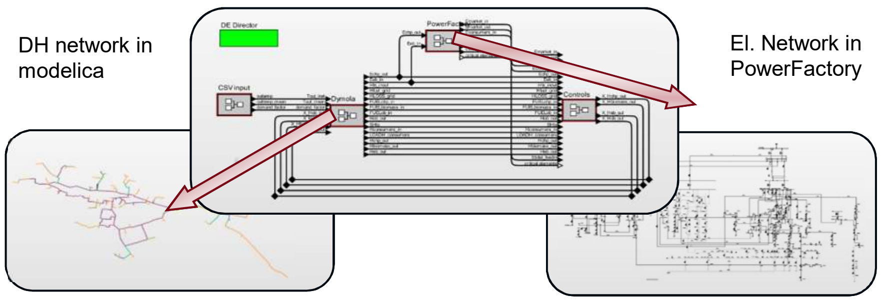
- **Outcome**:
  - Higher network capacity
  - no reinvestment in new biomass boilers
  - Increase of revenues
  - Reduction in heat generation costs
  - Reduction of HP operation costs in comparison to a flat electricity tariff.



http://www.2018dedays.org/wp-content/uploads/2018/09/180927-3-Society-Olatz-Terreros.pdf

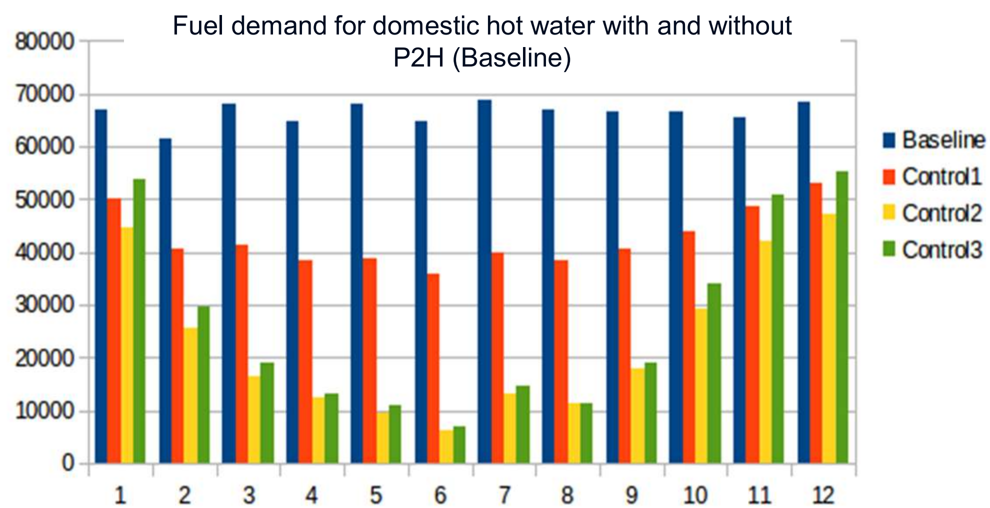
EXAMPLE: OPTIMISING HYBRID ENERGY GRIDS FOR SMART CITIES

- Different Network Control System will be elaborated implementing novel Cooperative Control Strategies, coupling thermal and electrical network



- **method**: Co-Simulation thermal/ electrical networks, using FMI Interface, optimizing in Matlab

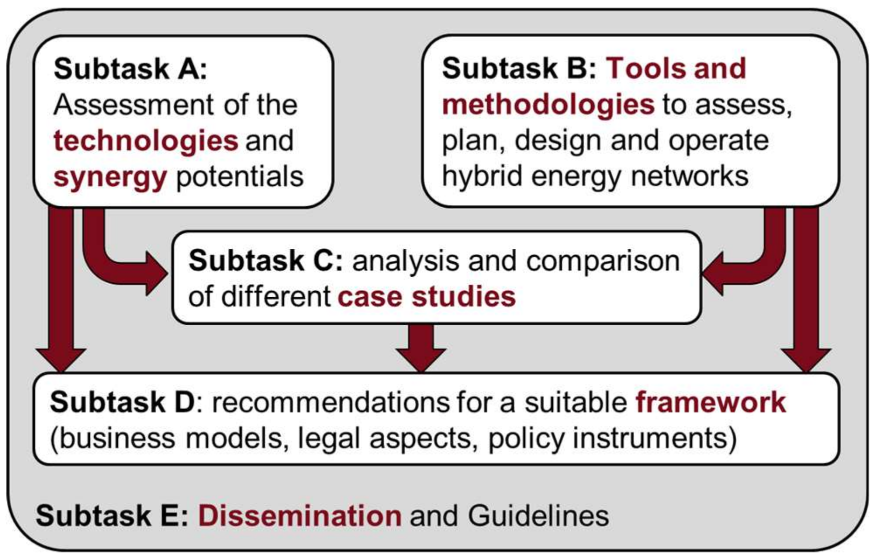
- **Demo-Case:** Ulm (Germany), increasing share of PV results in low-voltage networks problems (power quality, overload, reflux),
- **results**: optimized utilization of electric boilers for domestic hot water supply



http://www.orpheus-project.eu/

OUTLOOK: IEA DHC ANNEX TS3: HYBRID ENERGY NETWORKS

- **Aim**: To promote the opportunities and to overcome the challenges for district heating and cooling networks in an integrated energy system context
- **Results:** guidebook and policy papers as well as different networking activities including industry workshops and special session at conferences
- **participants** can join anytime, resources are contributed in-kind
- **Participating countries**: Austria, Denmark, Germany, Sweden, UK, Korea, France, Belgium
- **working phase:** 2019-2021
- **cooperation** with IEA ISGAN, other cooperation's under development (EBC; ECES …)
- **Operation agent**: Ralf-Roman Schmidt (AIT), with support of Fraunhofer IEE



http://www.iea-dhc.org/the-research/annexes/2017-2020-annex-ts3-draft.html

THANK YOU!

Dr.-Ing. Ralf-Roman Schmidt

AIT Austrian Institute of Technology GmbH
Giefinggasse 6 | 1210 Vienna | Austria
T +43(0) 50550-6695 | M +43(0) 664 235 19 01 | F +43(0) 50550-6679
Ralf-Roman.Schmidt@ait.ac.at | http://www.ait.ac.at