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# Integration of renewable energy sources in district heating and cooling networks

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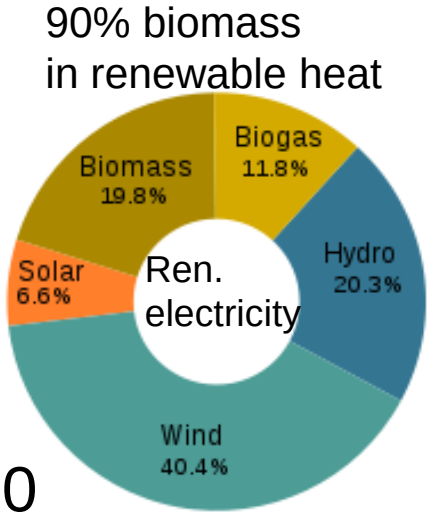
# Current situation urban energy use




- Germany: very ambitious national goals
  - Electricity: 35% until 2020, 80% by 2050
  - Renewable total: 18% by 2020, 60% by 2050
  - Energy efficiency: 50% electricity reduction by 2050
- Measures and instruments:
  - (*National Renewable Energy Action Plan* following EU directive 2009/28/EC)
  - Electricity sector: Renewable Energy Act, Combined Heat and Power Act
  - Heating/cooling sector: Renewable Energies Heat Act, market incentive program and support programs of the KfW, Energy Saving Ordinance
- BUT: No reduction in urban energy demand with low building rehabilitation rates of 1 to 2 % per year, little local renewables

# Overview

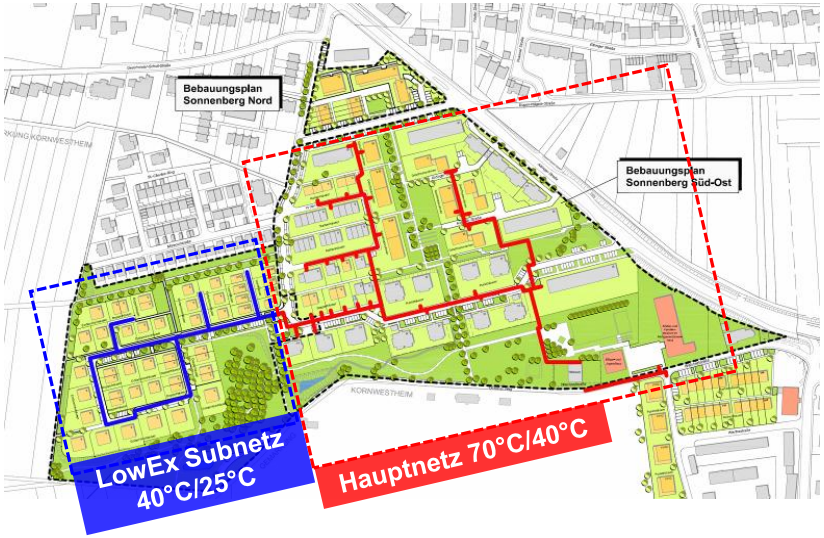
- Problem statement: heat demand decrease / network-based energy supply increase
- Innovative district heating network (network structure, costs, regulation, substations,…)
- Renewables supply to the network (solar heat, biomass, geothermal energy)
- Challenges and proposed solutions
- Simulation tools
- Ludwigsburg demo-project

# Funding program energy efficient cities


80 Townhouses

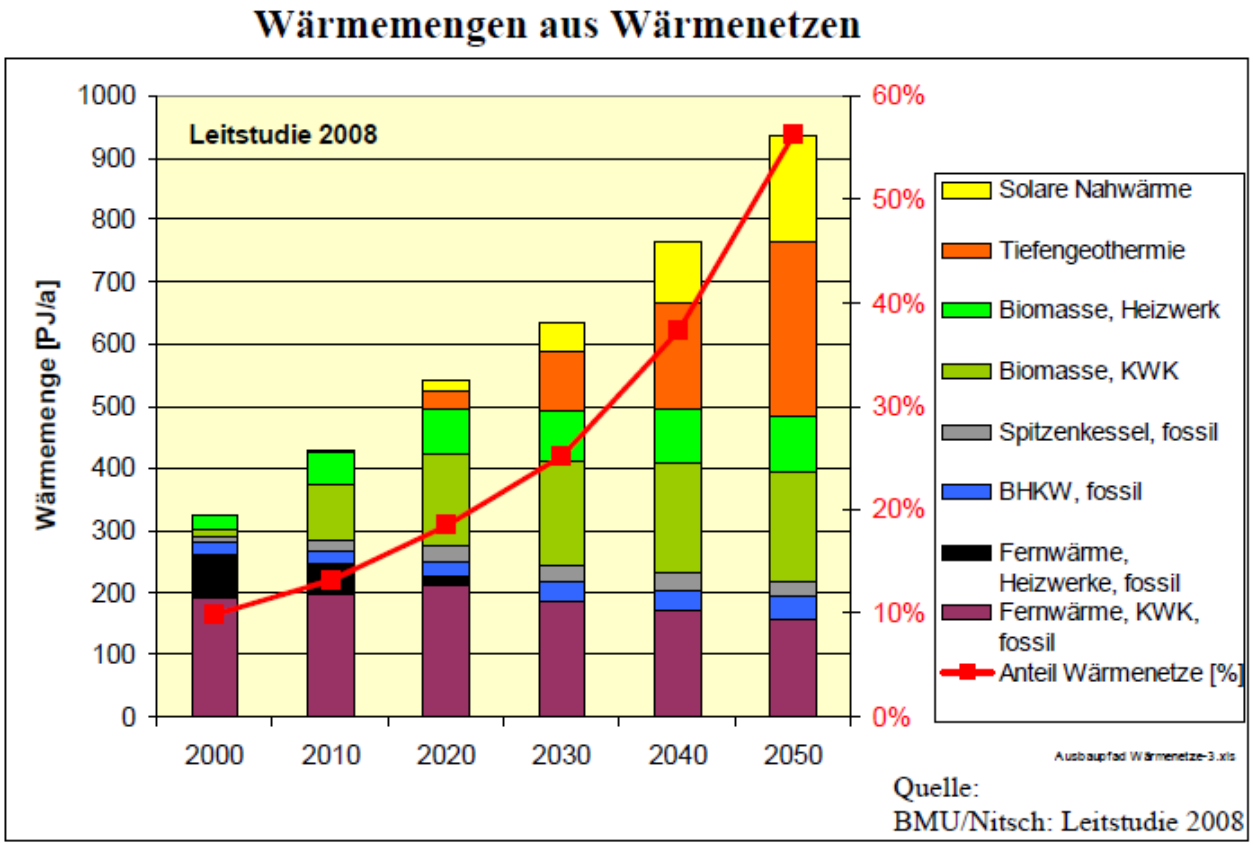
Geschosswohnungsbau

Stadtvillen / Reihenhäuser




- How to supply a modern low heat demand city quarter with district heating systems
- How to integrate renewables (for instance solar heat)

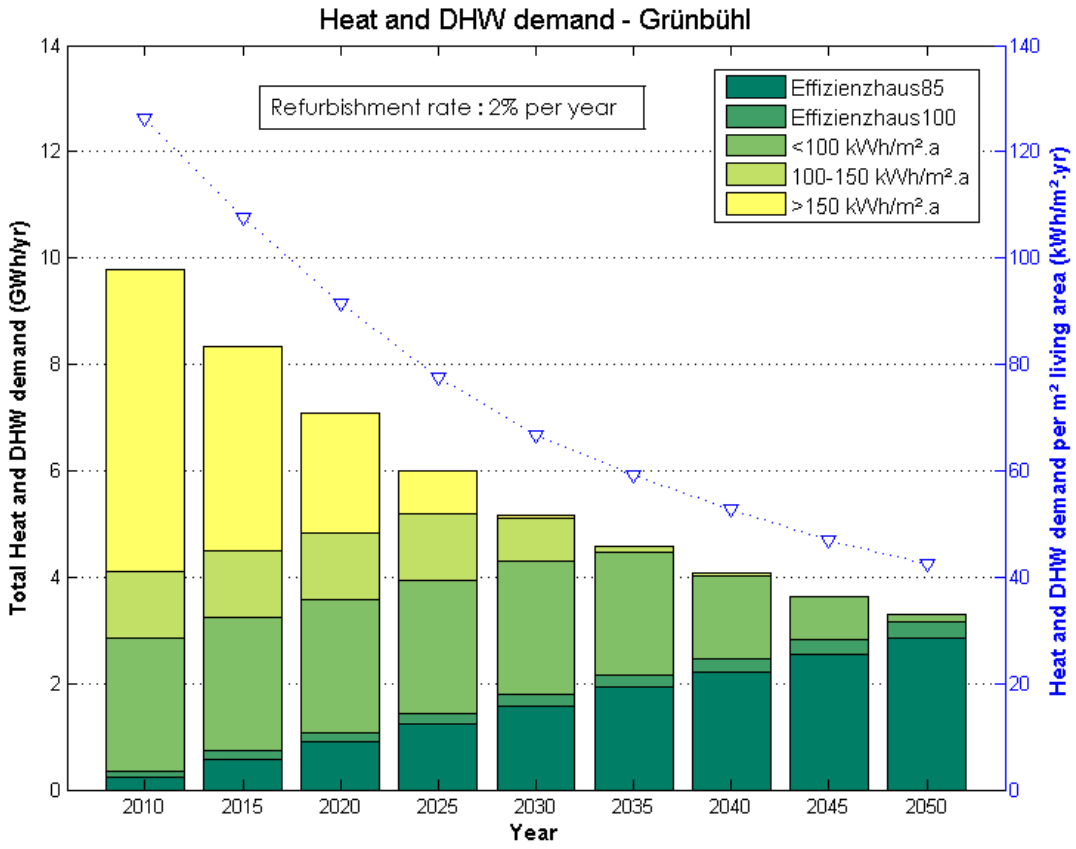
# Increasing contribution of network-based energy supply

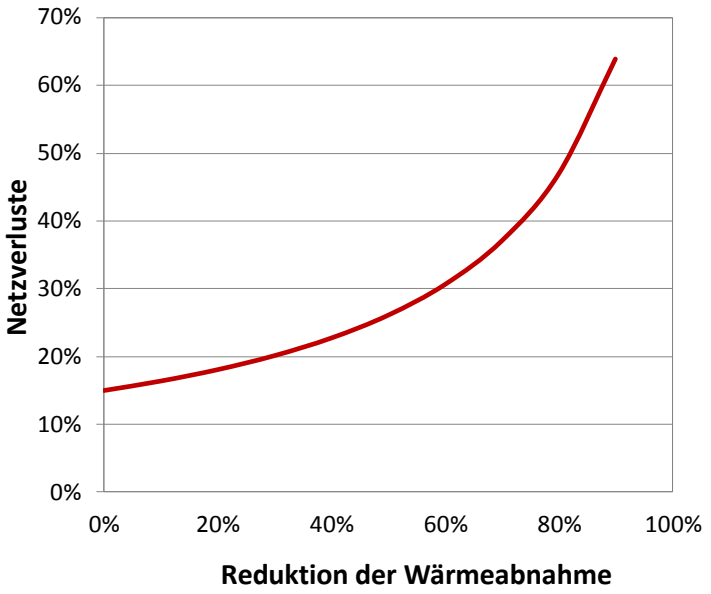



Necessity of a very significant structural change:
2000:
Individual heating systems: 85,7%
District heating systems: 14,3%

2050:
Individual heating systems: 43%
District heating systems: 57%

# Decreasing heat demand, increasing heat losses



# Solution : Innovative piping network

Standard: 2-pipe network

Innovative: Twin-pipe network


→ decrease of the heat losses: 30 – 45 %

→ decrease of the network investment: > 30% (smaller and less deep trenches, easier connections, shorter installation time)

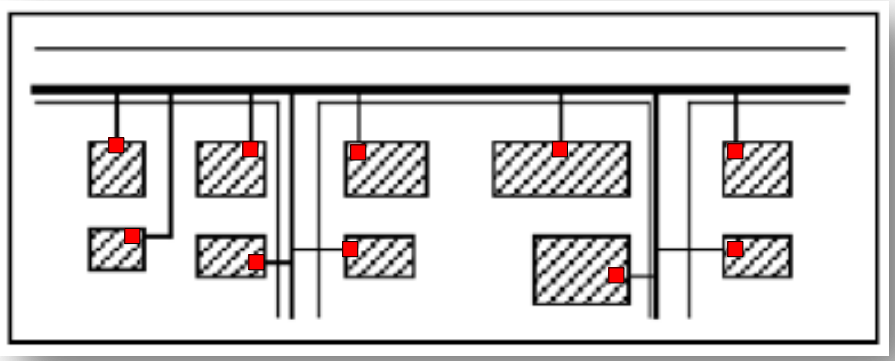
# Decrease of the heat losses

## New filling materials

Quelle: KE KELIT

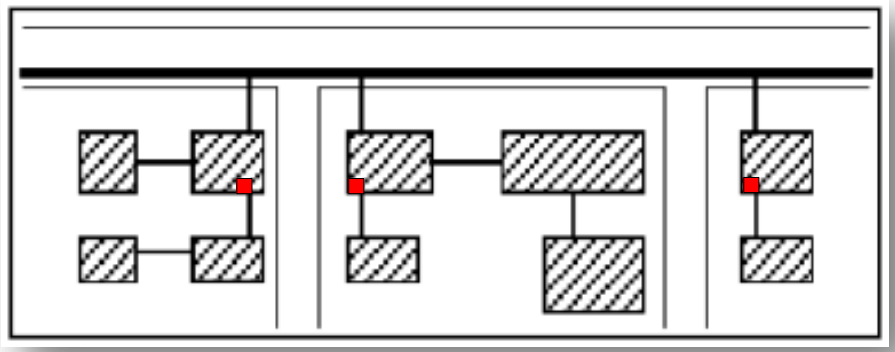
Quelle: FITR

# Solution :
# One substation for several building blocks



Conventional connection: 1 substation for each building
(Substation investment : 6 -10 t€)

- substations



local heating distribution, with header substations linked to the main district heating network.
Operating company required.

Quelle: Fraunhofer UMSICHT

# Solution: new tariff structure

→ Introduction of heating flat rates

Cost savings with cheaper substations (20% - 60% cheaper), lower operation & maintenance costs

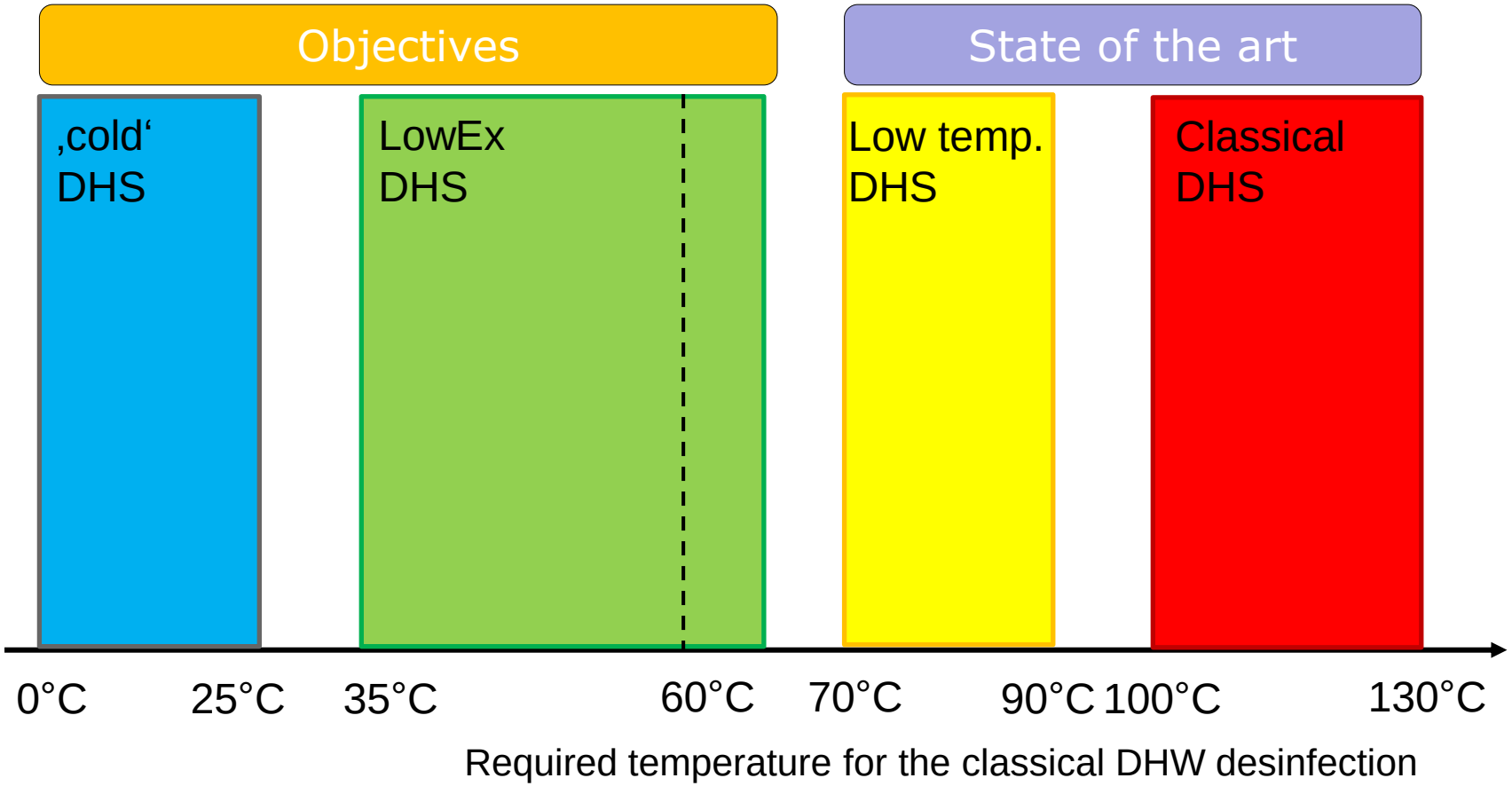
Legal aspects:

New german heating regulation 2009:

Buildings with heat demand < 15 kWh/m² a: no duty for consumption-based heating costs (§ 11 Abs.(1) Nr.1a HeizKV).

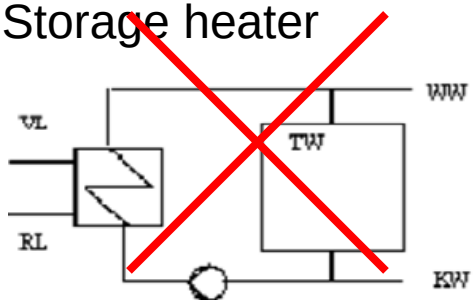
Duty for consumption-based DHW costs still remains
→ Clarification required!

# Solution: Decrease of the network temperature



# Domestic hot water solutions

Storage heater

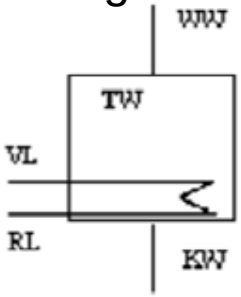



$T_{ww}$

60°C

1- Advantage:
High flow rates possible
Drawbacks:
Increase the return temperatur by charging process
High temperature because of legionella

Storage charging system

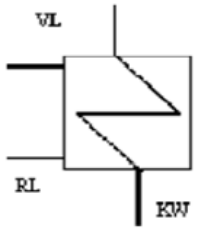



~~60°C~~

45°C

2- Advantage:
Low return temperatures
High flow rates possible
Drawbacks:
Higher heat losses
High temperature because of legionella

Decentral direct flow heaters



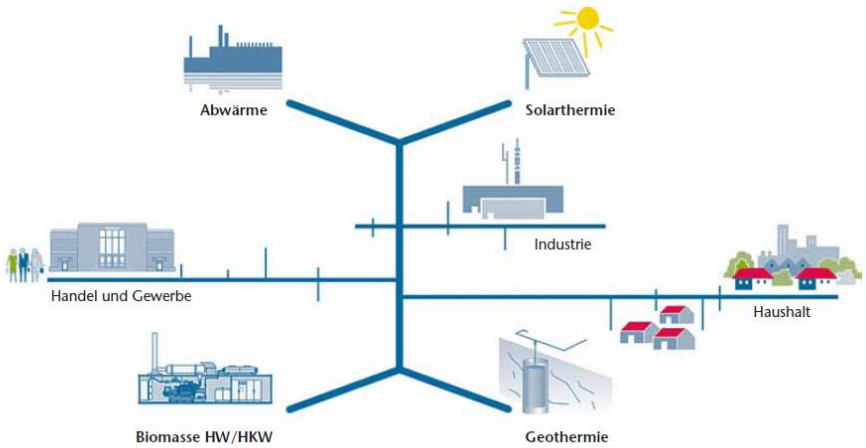

45°C

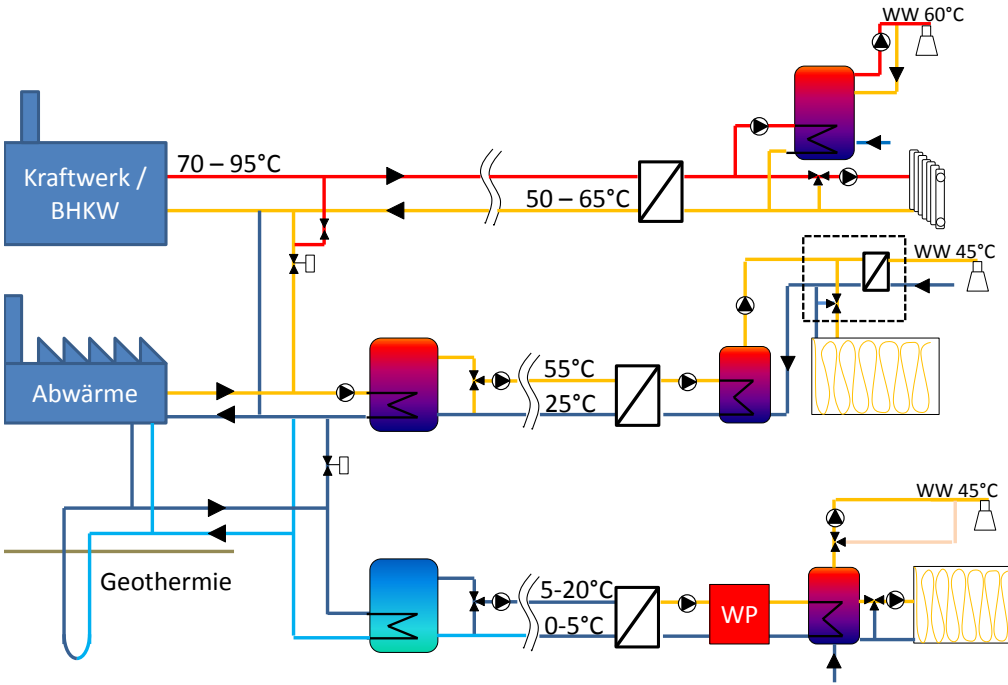
3. Advantage:
Low return temperatures
Low stand-by heat losses
No legionella problem
Drawbacks:
High connected load required

# Legionella prevention in DHW

| Thermal | Electrical | Technical |
|---|---|---|
| DHW heating up to 60°C at least. **Conventional method!**<br><br>drawbacks:<br>- every pipe must be reached<br>- critical with poorly insulated and highly distributed networks<br>- high energy use | Anodic oxidation<br><br>it consists:<br>a) Oxigen radicals<br>→ elimination of viruses and bacteria<br>b) Metastable oxidants (through chlorides in water)<br>→Elimination of the biofilm<br>proven technology;<br>used since 1996 in clinics | Local direct flow heaters<br><br>- Decentralized production of the DHW (40-45°C)<br>- Max. 3 liter water content in the pipes<br>- lower network heat losses |

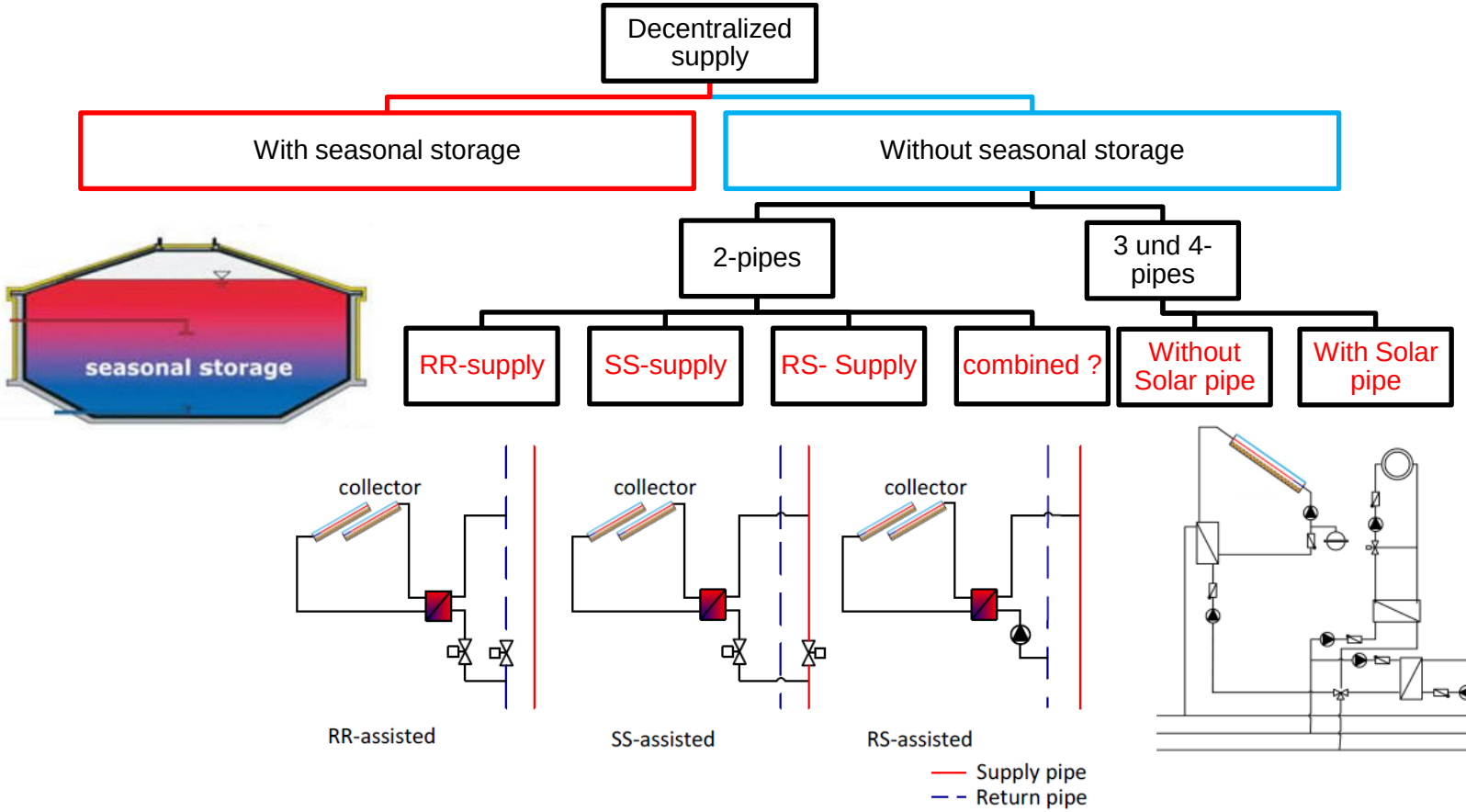
# Renewables supply concept:
## virtual heat plant, adaptive network




Quelle: Fraunhofer UMSICHT

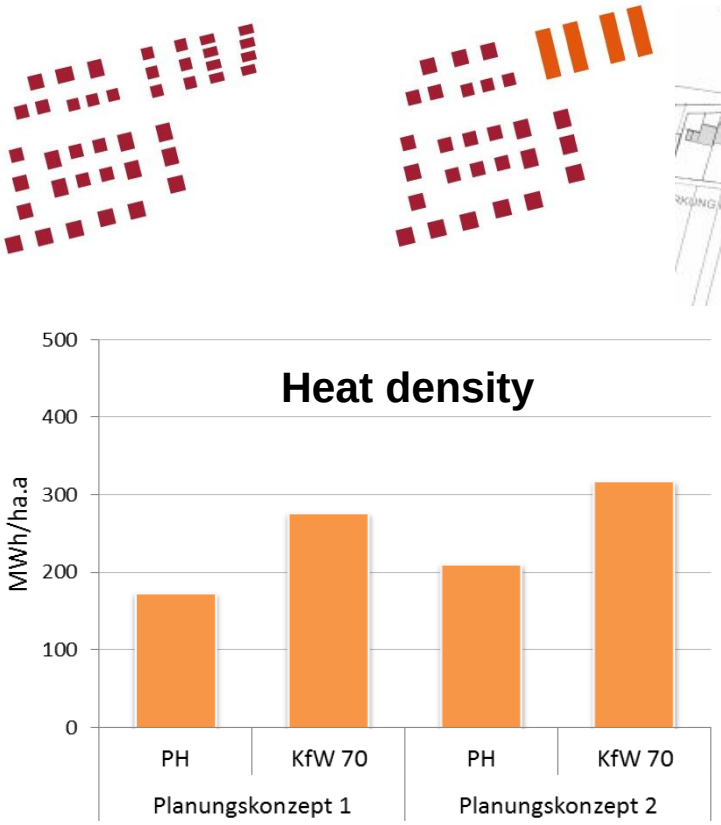
# Renewables supply:
## Case of solar thermal systems

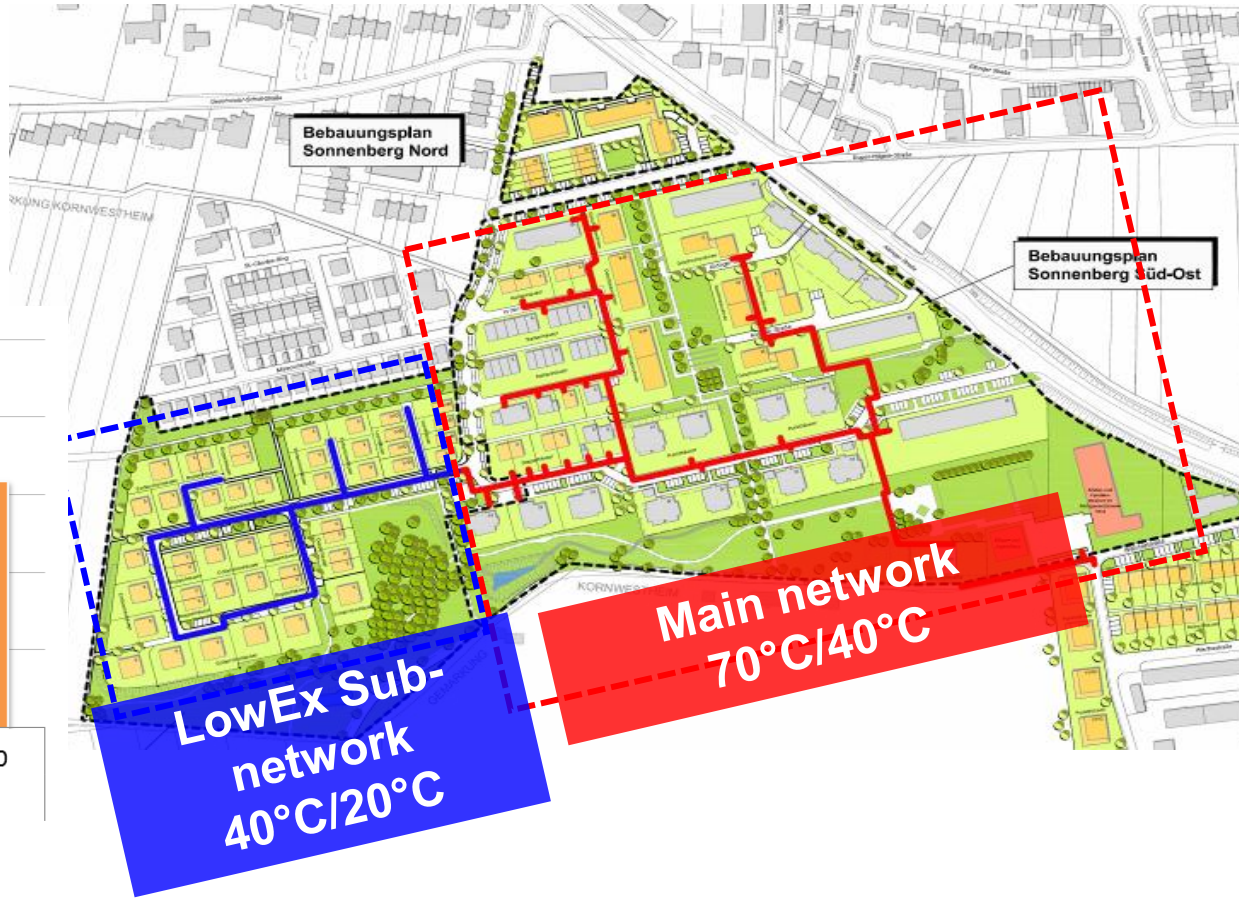




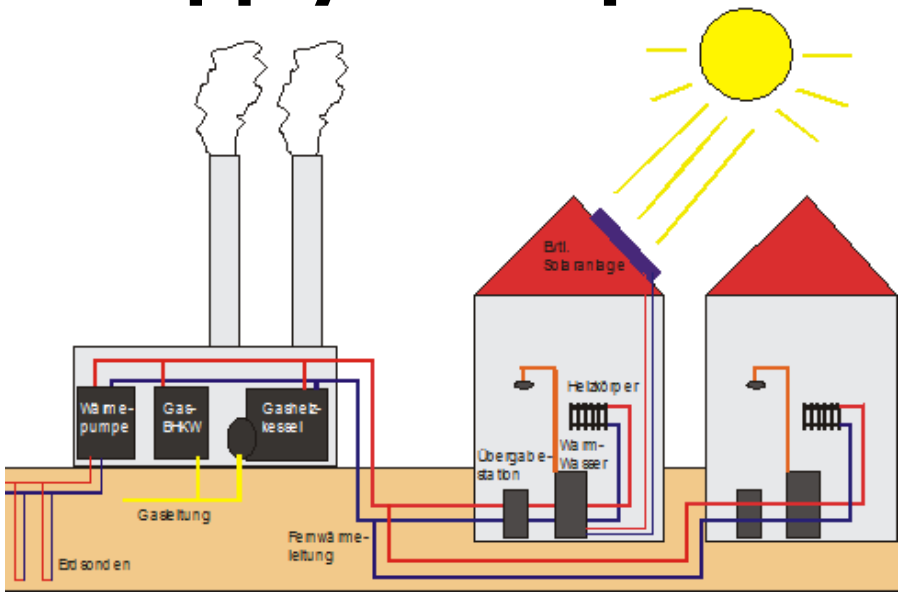

Quelle Abbildung mit Solarvorlauf: TU Graz

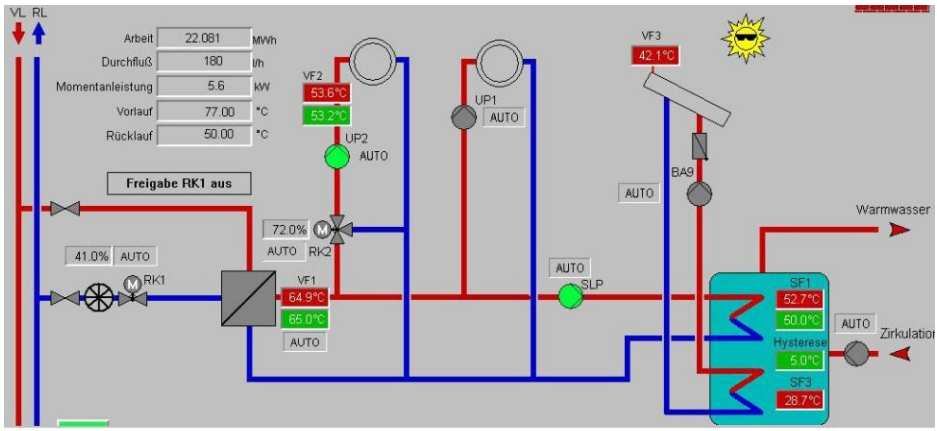
# EnEff Stadt Ludwigsburg: Innovative network



# Supply concept Ludwigsburg




LowEx heating network with:

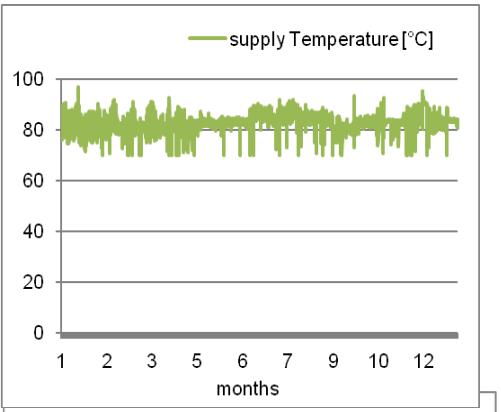
- 200 kW brine-water heat pump with 50 geothermal heat exchangers, CHP engine and gas boilers
- Smart-metering system with data visualization
- central storage management by energy supply company

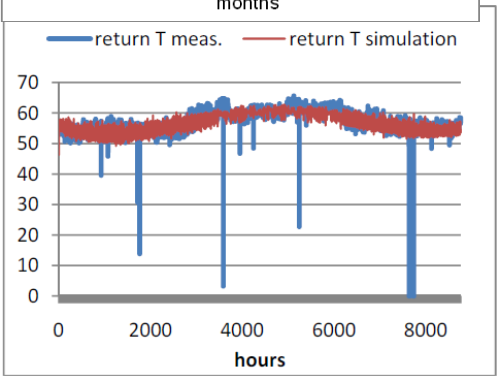
# Heat demand simulation

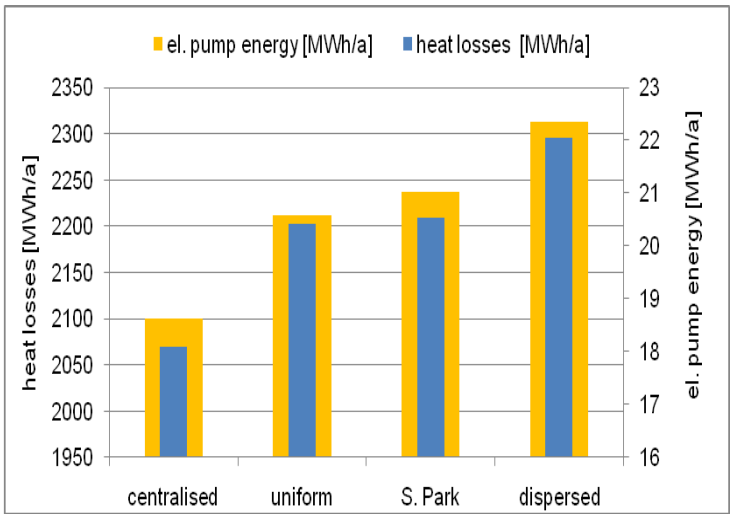
# Network simulation

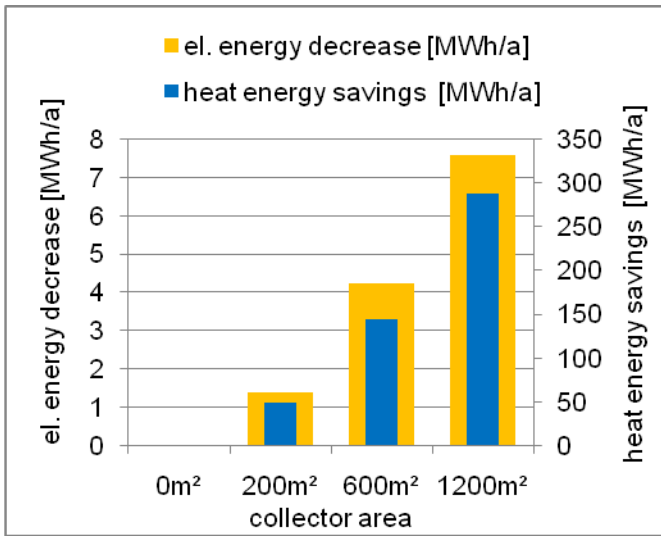
## spHeat

spStructure → spHydro → $\dot{V}$, $\Delta p$ → spThermo → $T$ → spOutput



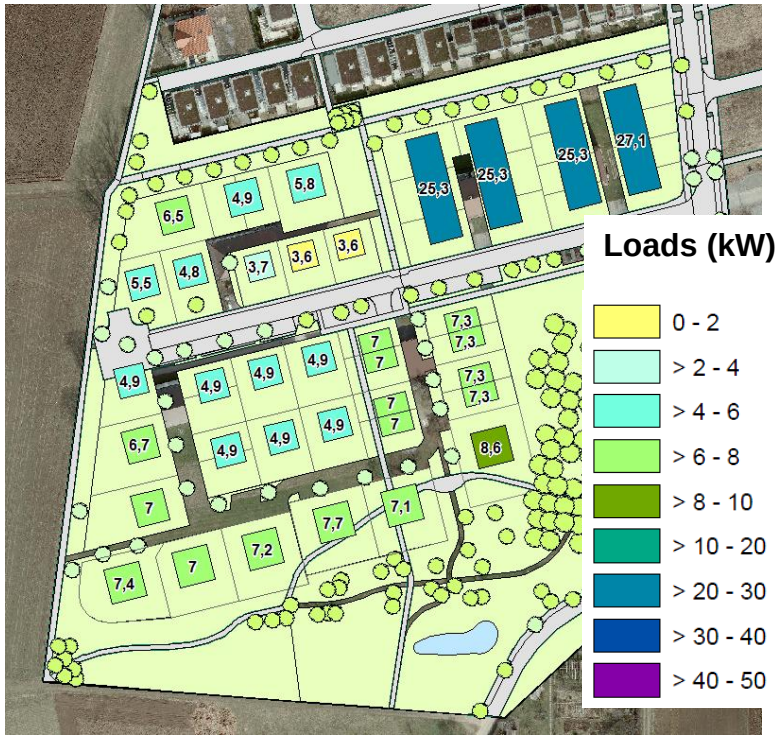



# Consumer Loads – urban concept 2

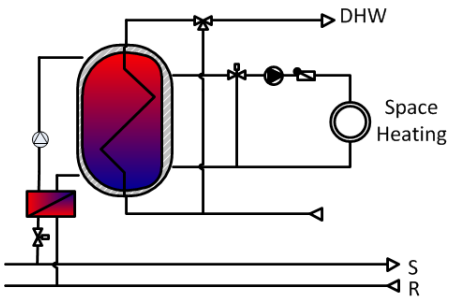
KfW 70 low energy buildings

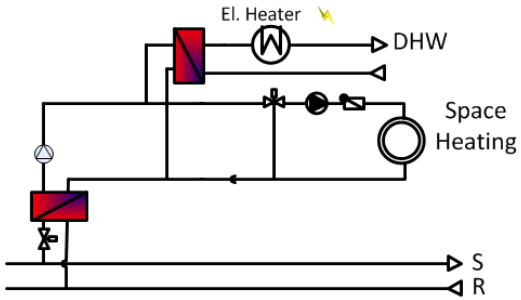

Passiv buildings

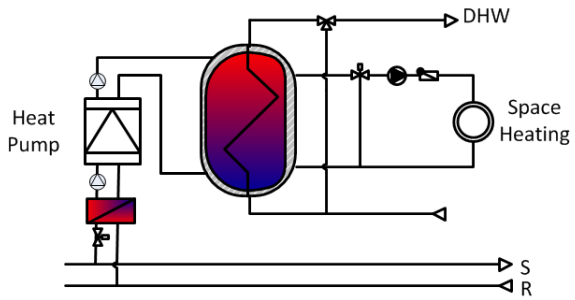


# Network options for the planned district

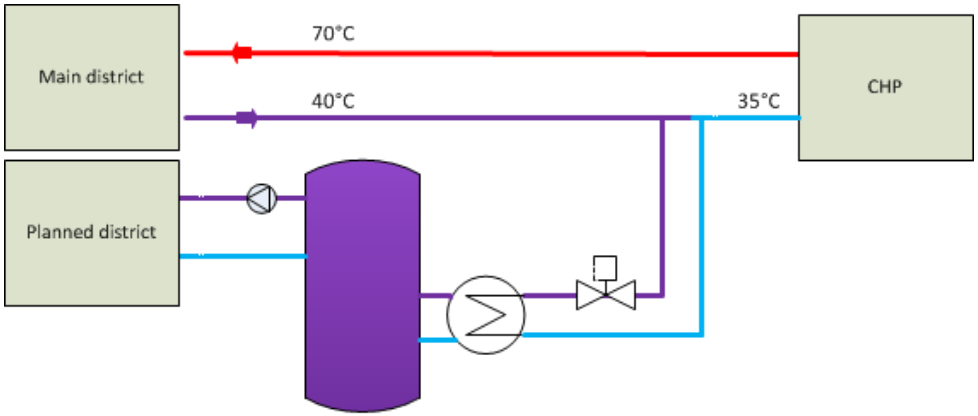
| A: high temperature network | B: medium temperature network | C: low temperature network |
|---|---|---|
| S/R: 70/40°C | S/R: 40/20°C | S/R: 25/5°C |
| substation with hot water storage | Electric heater for DHW | Water/water heat pump with storage |
| DH supply from the supply line of the main network | DH supply from the return line of the main network<br>Lower operational temperature | |



# Low temperature supply (B+C)



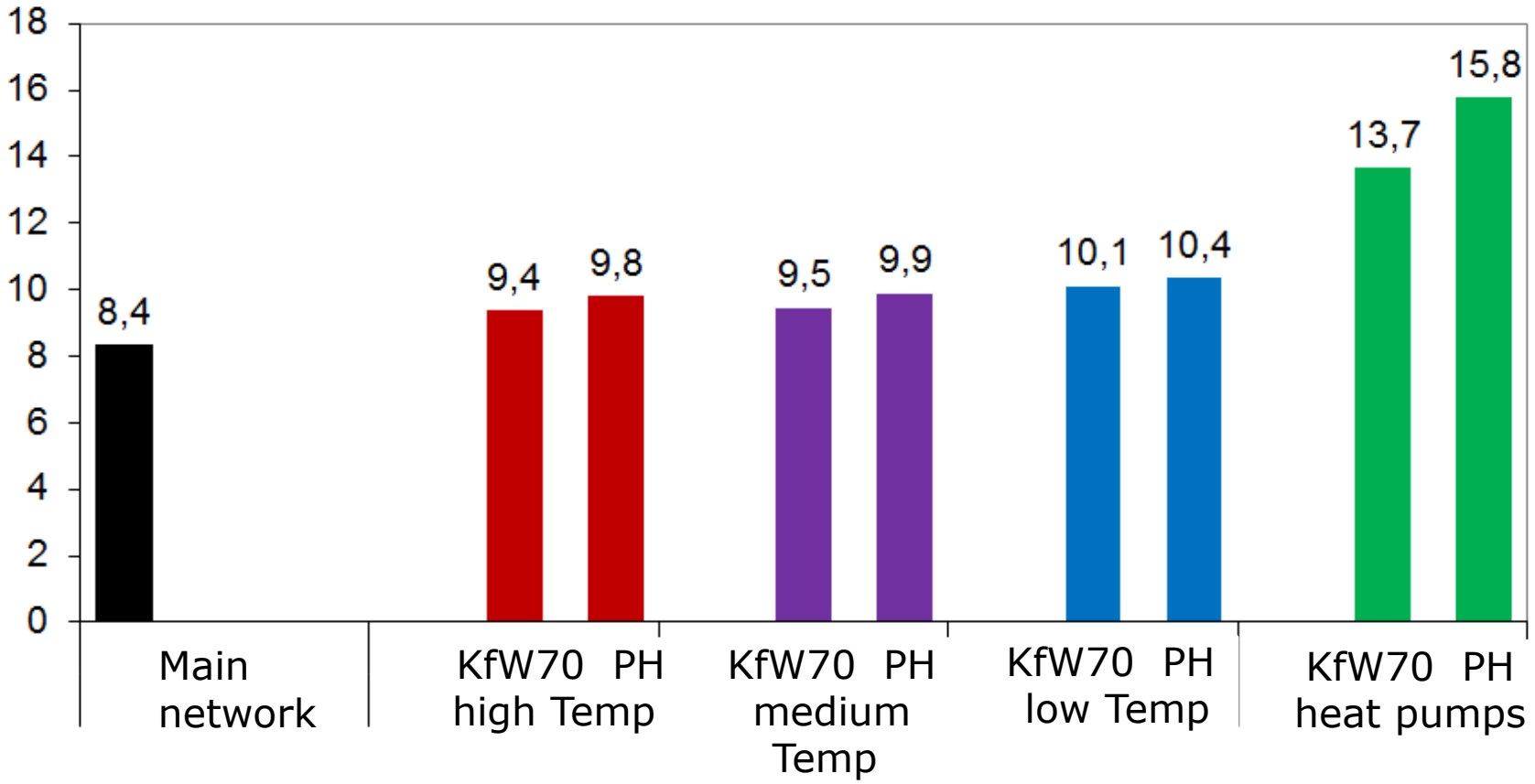

DH supply from the return line of the main network in case B and C

- Integration of renewable energy at lower tempearture and with high efficiency.
- long CHP operation time achieved through additional consumers

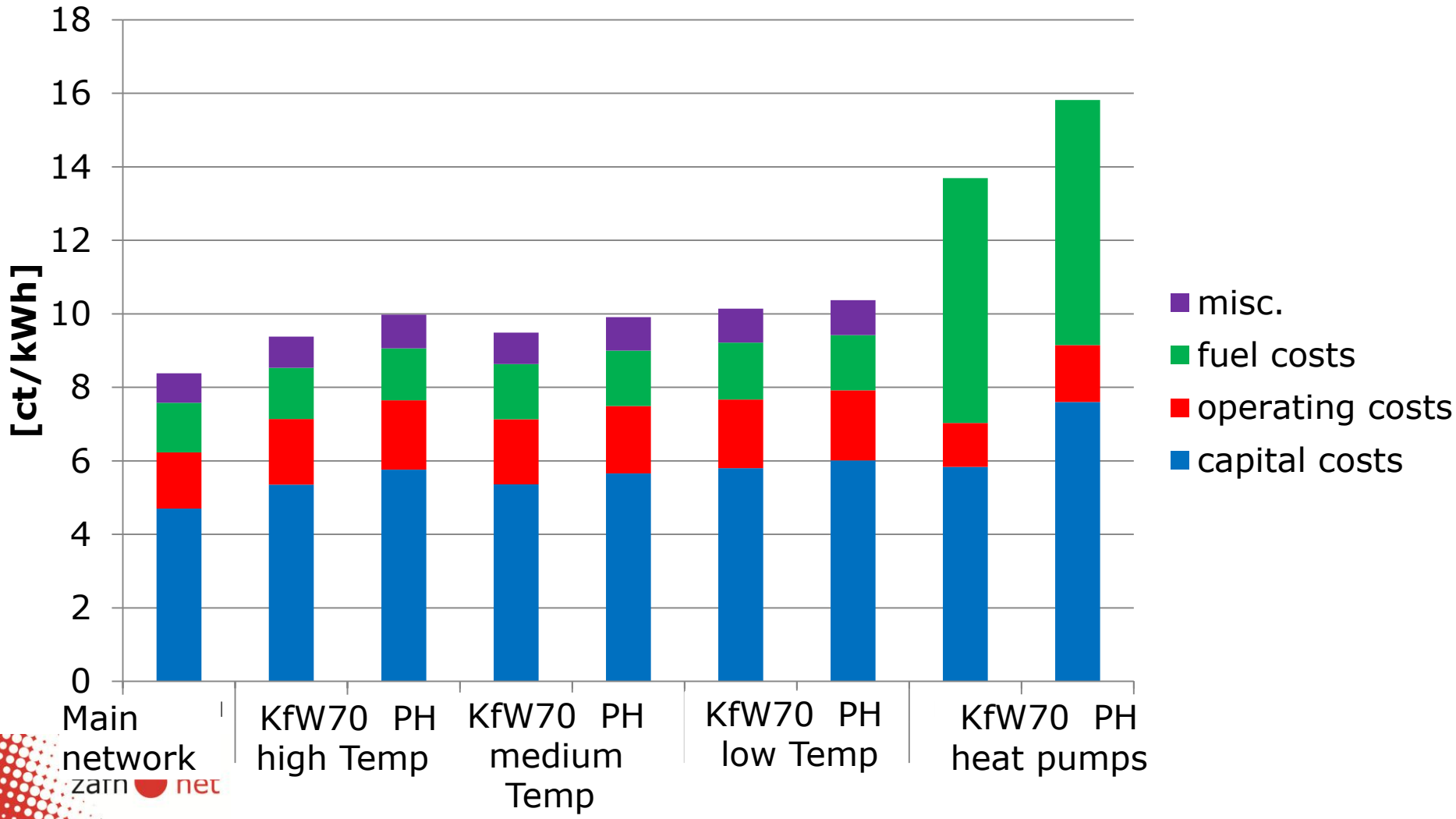
| **Costs of pump station B and C in €** | |
|---|---|
| Pumps | 7 300 |
| Storage tank | 5 000 |
| Heat exchanger | 3 000 |
| Piping | 3 000 |
| Building | 20 000 |

# Economics- heat generation costs

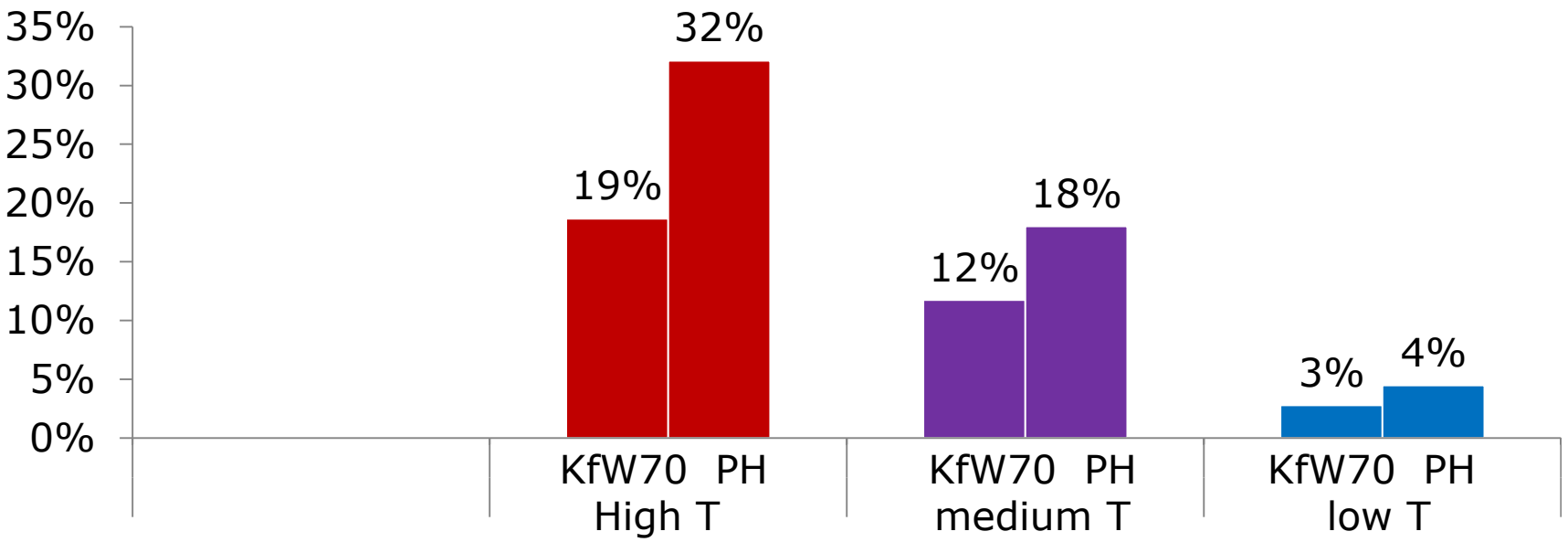
[ct/kWh]



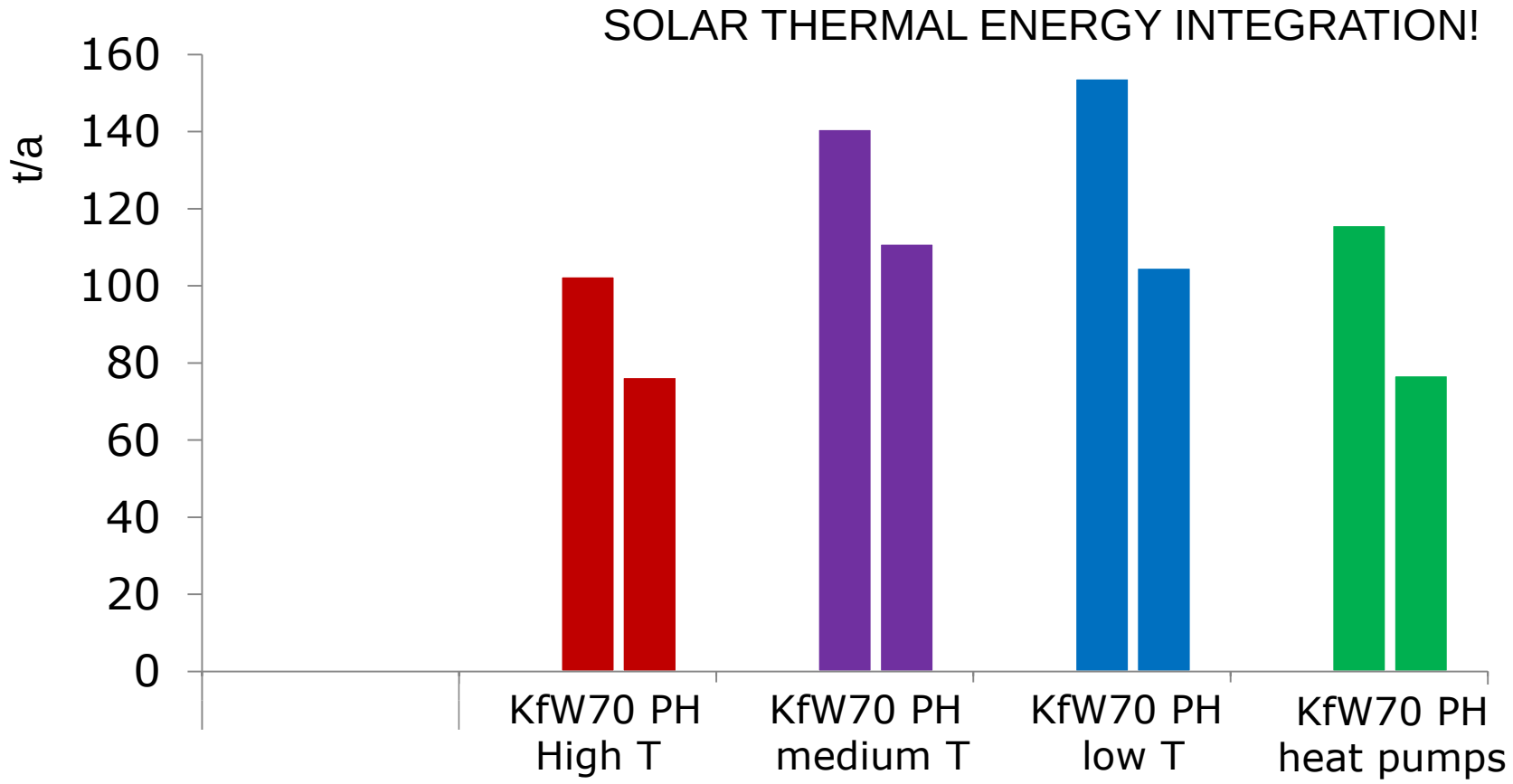
# Economics- heat generation costs



# Annual heat losses



# CO2 emissions



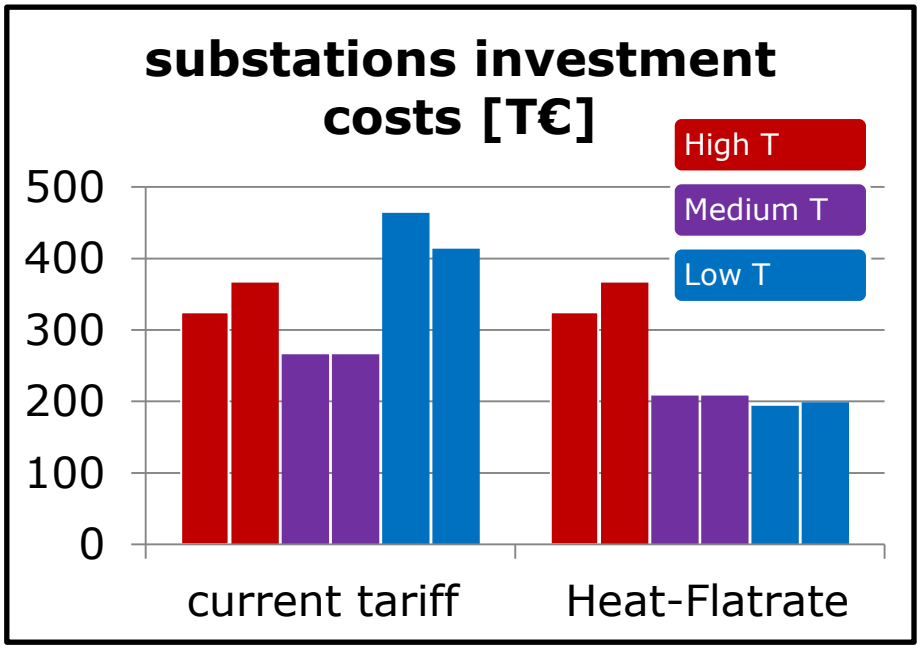
# New tariffs for heat supply

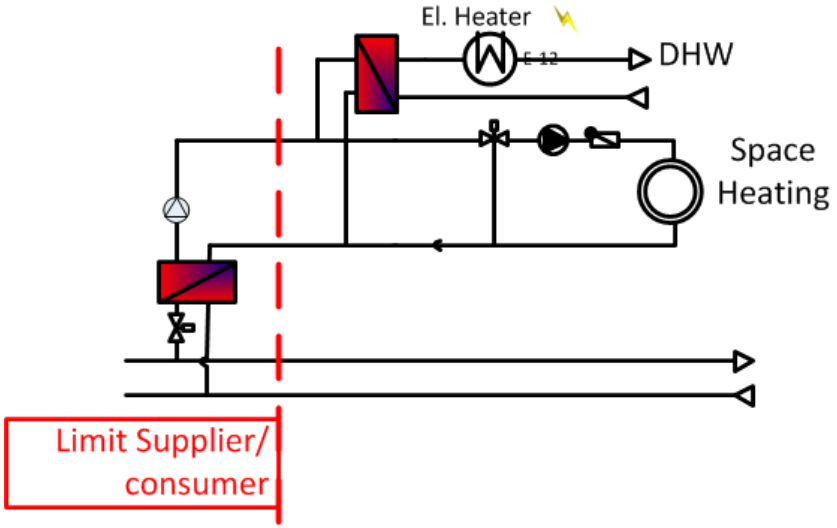
**Conditions of Heat-Flatrate (case B and C)**

Without heat metering

DHW heating done by consumer (lower capital costs for supplier)

Lower operating costs (1% instead of 2%)



# Conclusions

- Virtual heating plants are smart solutions for energy efficient cities
- Network distribution needed for decentral integration of renewables and demand side management
- Higher solar fractions can be achieved in low temperature networks
- New control strategies and (bidirectional) measurement equipment required for distributed heat sources
- Low heat density DH networks need adapted supply solutions with lower heat losses

# Vielen Dank für Ihre Aufmerksamkeit!

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