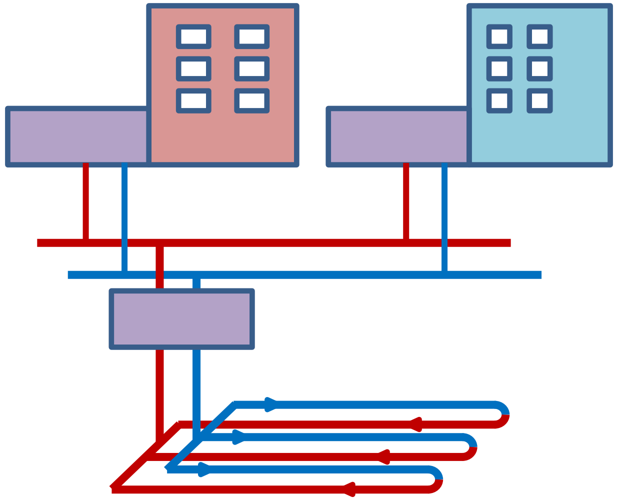
# Bi-directional low temperature district heating and cooling networks



## Techno-economic Assessment and Appraisal

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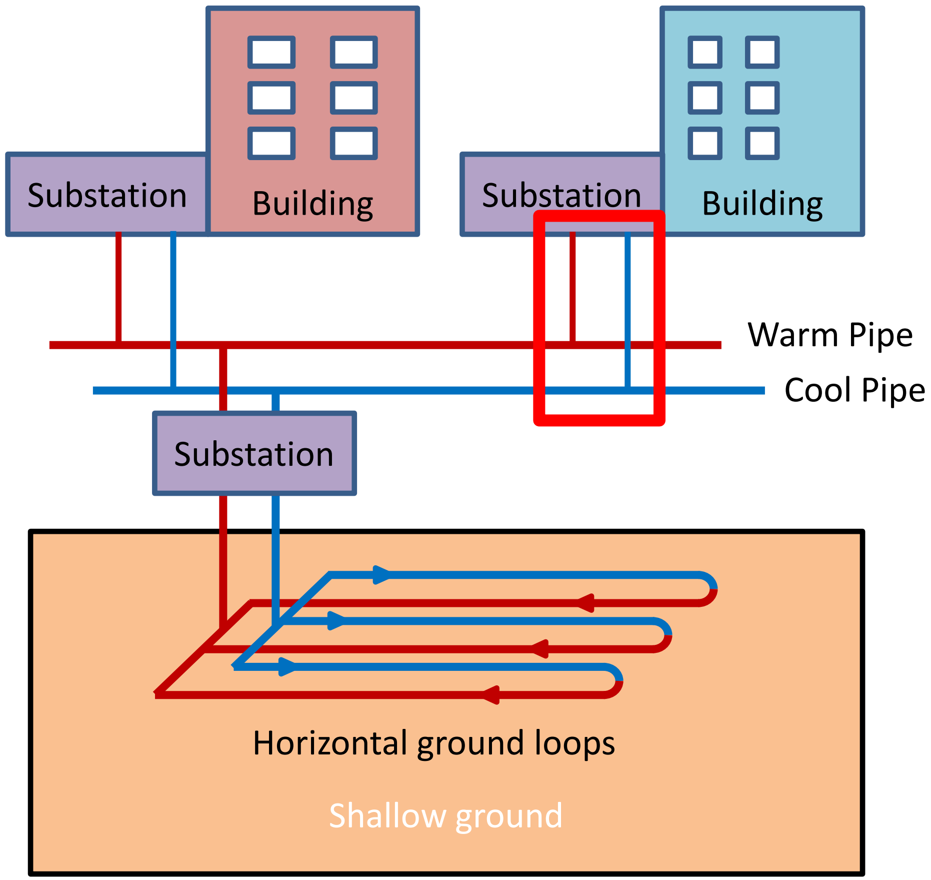
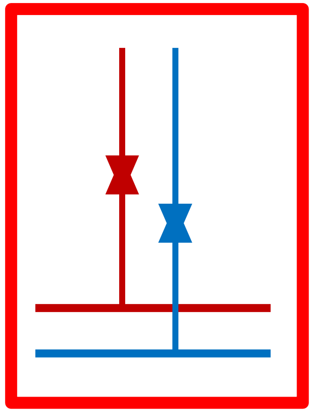
# BLTN Network Overview



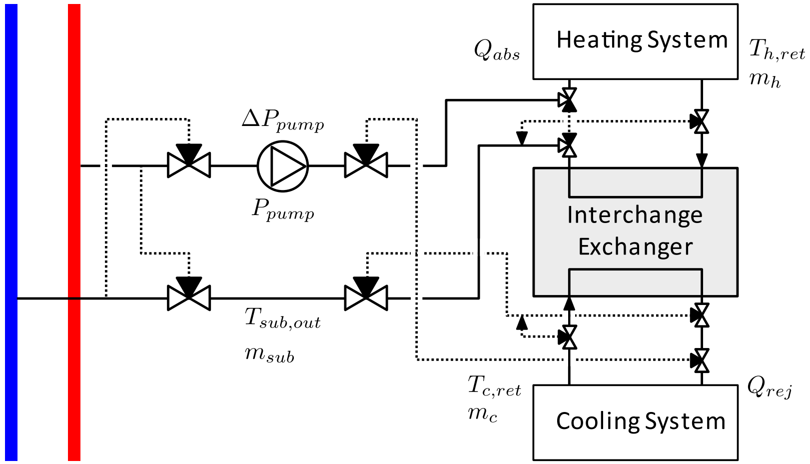

Schematic showing a horizontal ground-source heat pump system



Heat absorbed from network:
Water flow from warm to cool pipe

Heat rejected to network:
Water flow from cool to warm pipe

## Bi-directional mass and energy flows




Schematic showing bi-directional building substation

# Background – Heating and Cooling in the UK

*"…approximately **18%** of homes assigned to **district heat** by 2050 (representing homes of highest heat density)."*

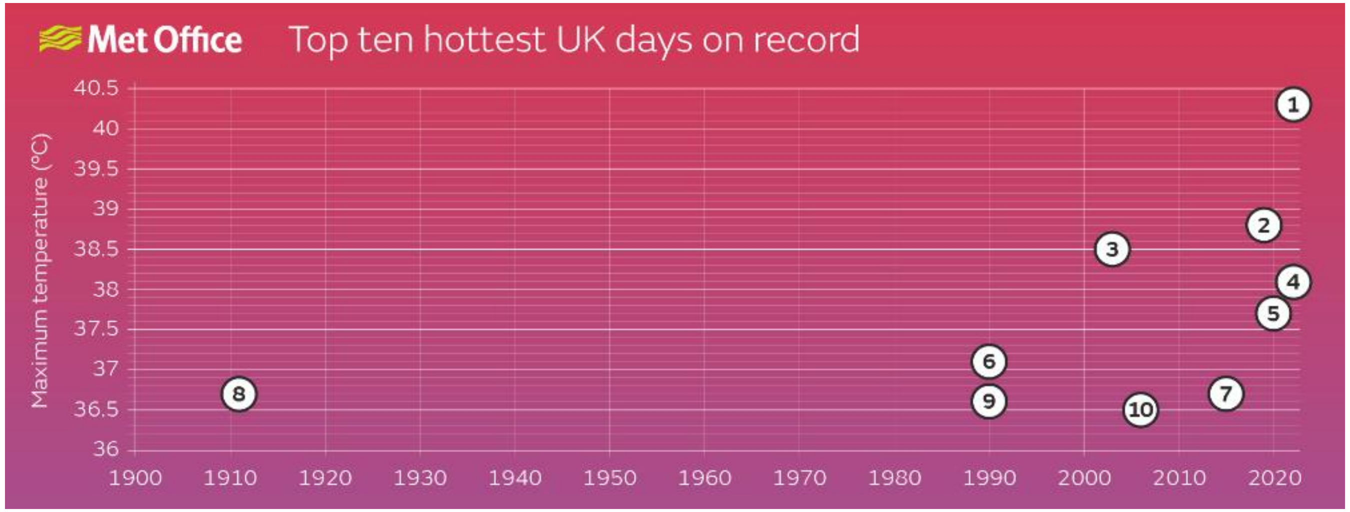
Climate Change Committee's Sixth Carbon Budget, 'Least-Cost' Pathway to Net Zero, 2020

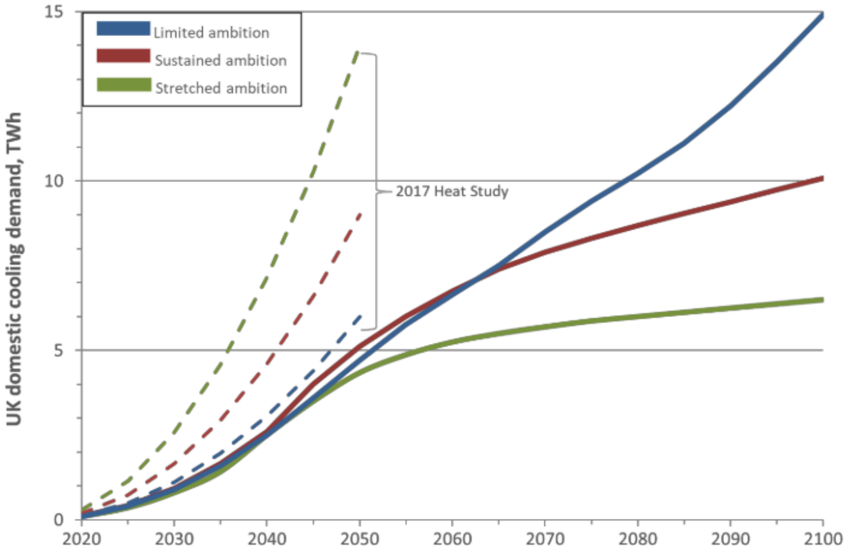
*"…developing the market for low-carbon heat networks will be a **no-regrets** action…"*

UK Government's Heat and Buildings Strategy, 2021

*"…**cooling** technologies are permitted but **not required** within zones."*

UK Government Consultation on Heat Network Zoning, 2021



# Project objectives & Work Packages

- **Technical:** To investigate the optimal design and operation of *Bi-directional Low Temperature Networks* (BLTNs) considering interactions with the electricity system
- **Market:** To study potential schemes for local heat market and P2P trading of heat and electricity
- **Policy:** To understand challenges (i.e. policy, regulatory) involved in the transition from 'status quo' to the proposed BLTN

**Existing system & resources**

WP1: Defining case studies (Cardiff)

WP2: Assessing underground heat sources and storage (Cardiff)

**Transition from existing to zero carbon system**

WP5: Managing implementation and transition to BLTNs (Exeter)

**Zero carbon in 2050**

WP3: Techno-economic appraisal of BLTNs (Cardiff)

WP4: Local heat markets and P2P sharing (Cardiff)

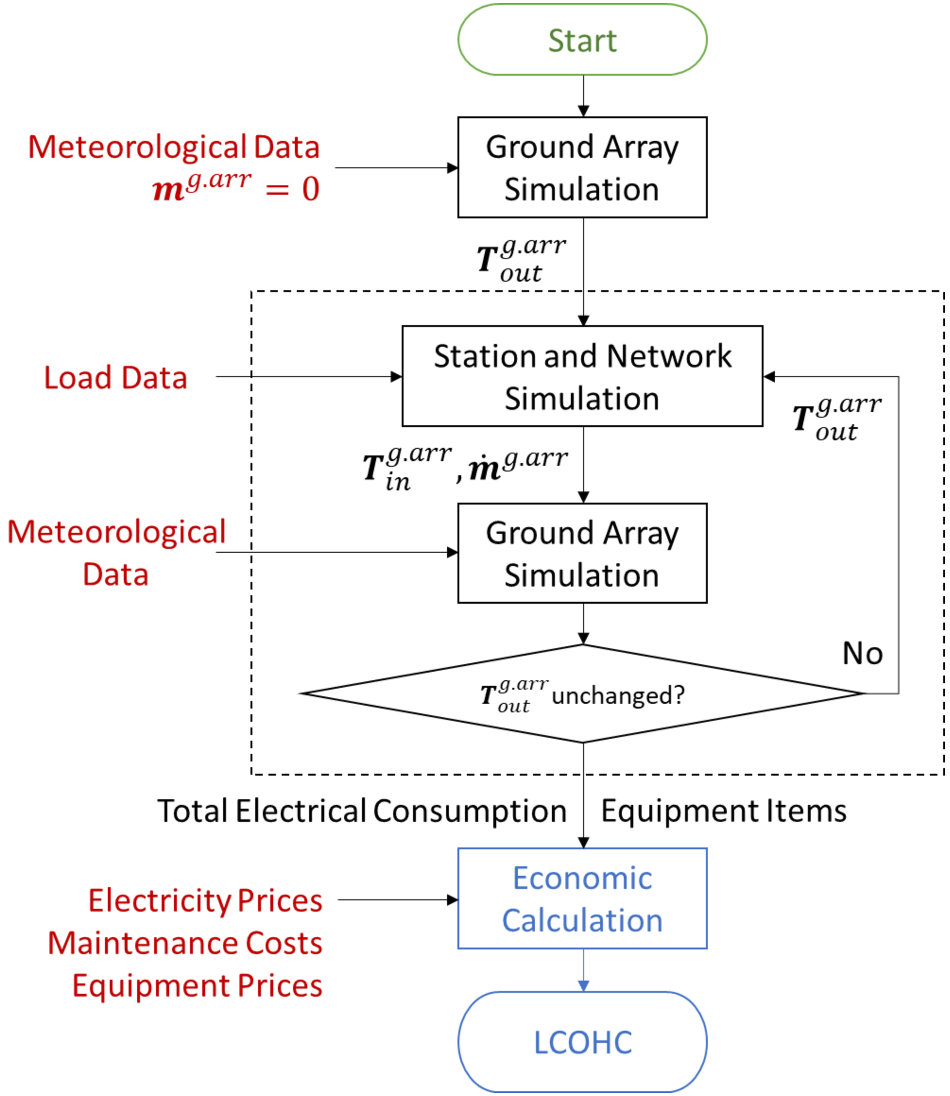
Project partners:

# Techno-economic Assessment of BLTNs

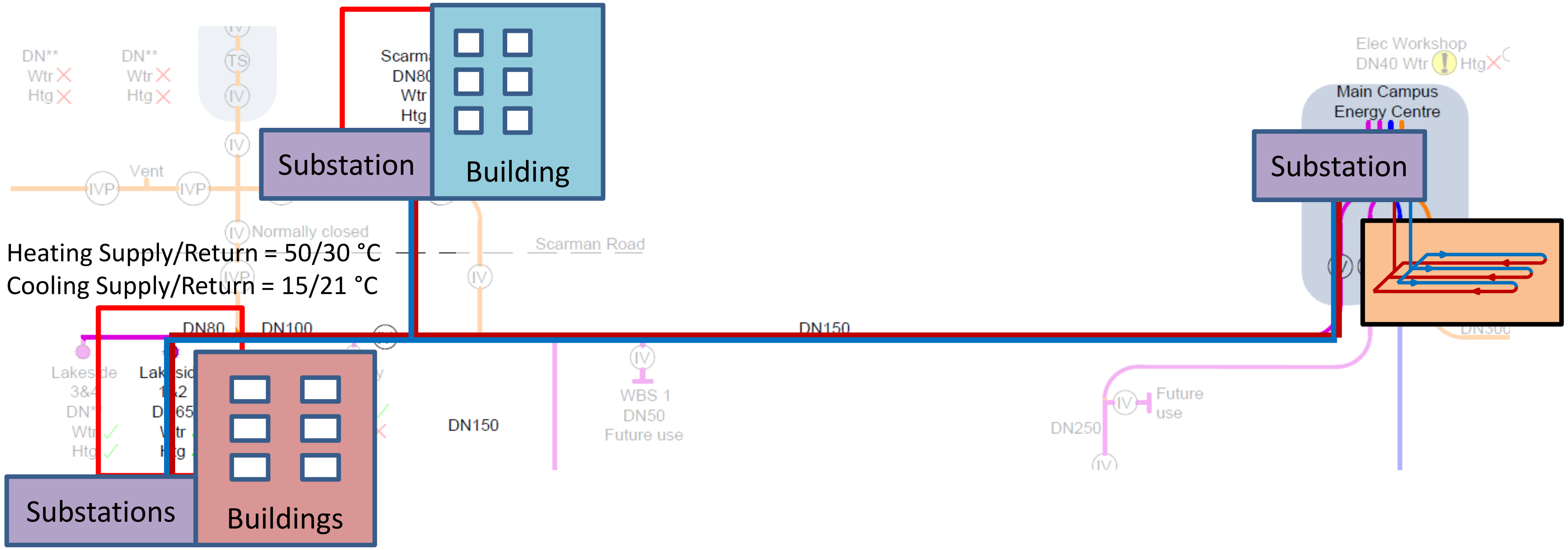
How does the nominal pipe temperature affect the design and the Levelised Cost of Heating and Cooling (LCOHC)?

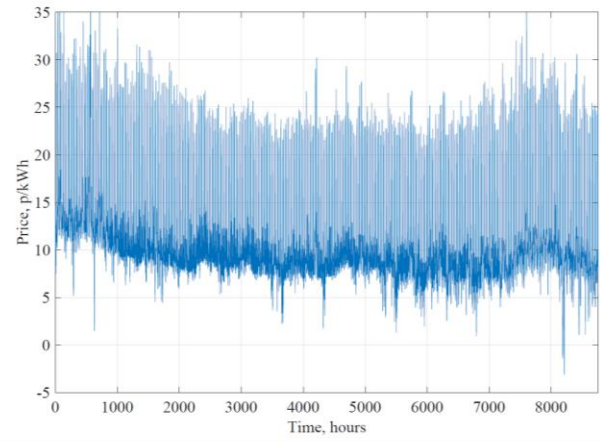
How does the heating to cooling load ratio (HCLR) affect the LCOHC?

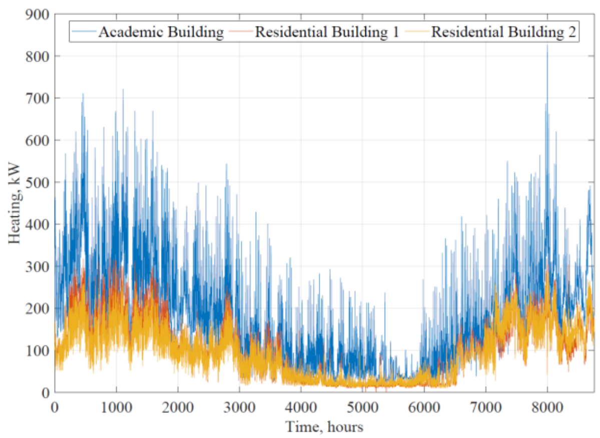
$$LCOHC = \frac{\sum_t^T (C_{cap} + C_{O\&M})/(1+R)^t}{\sum_t^T (E_{load,h} + E_{load,c})/(1+R)^t}$$

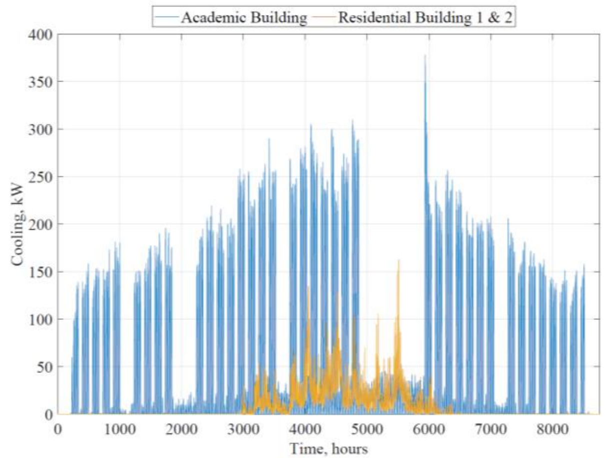


# University Campus Case Study

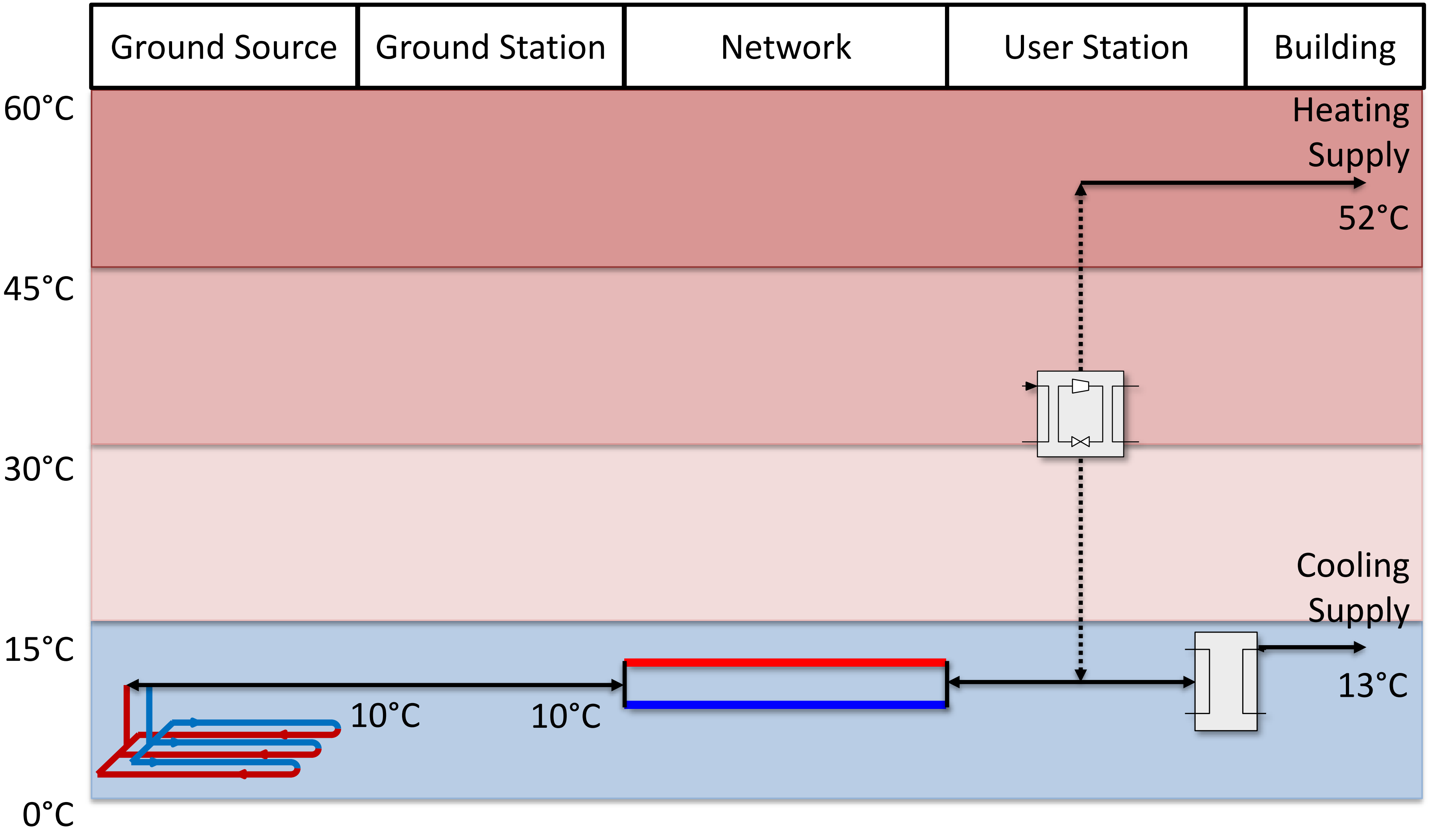


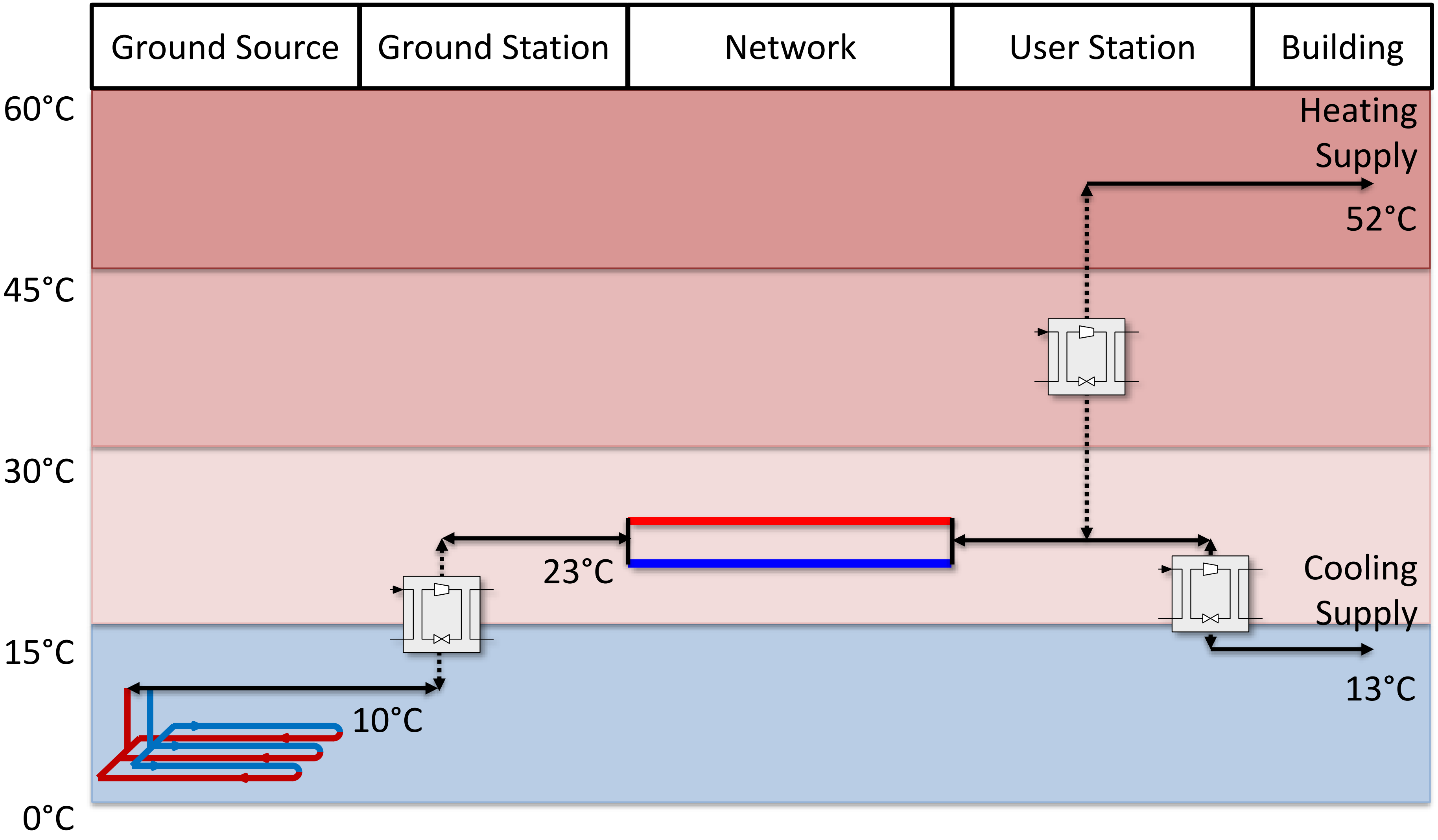



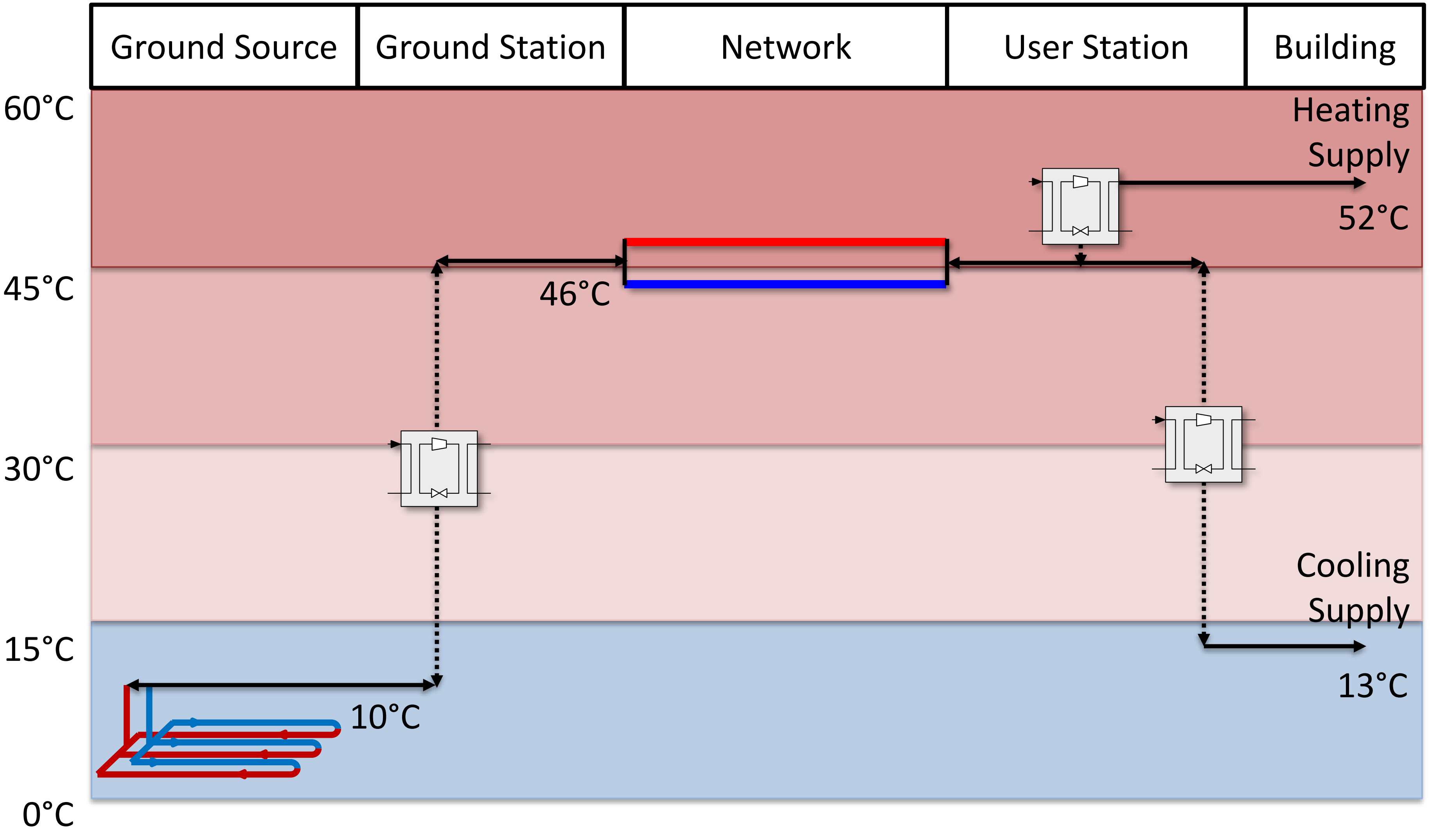
# Configuration Temperatures – *T_Var*



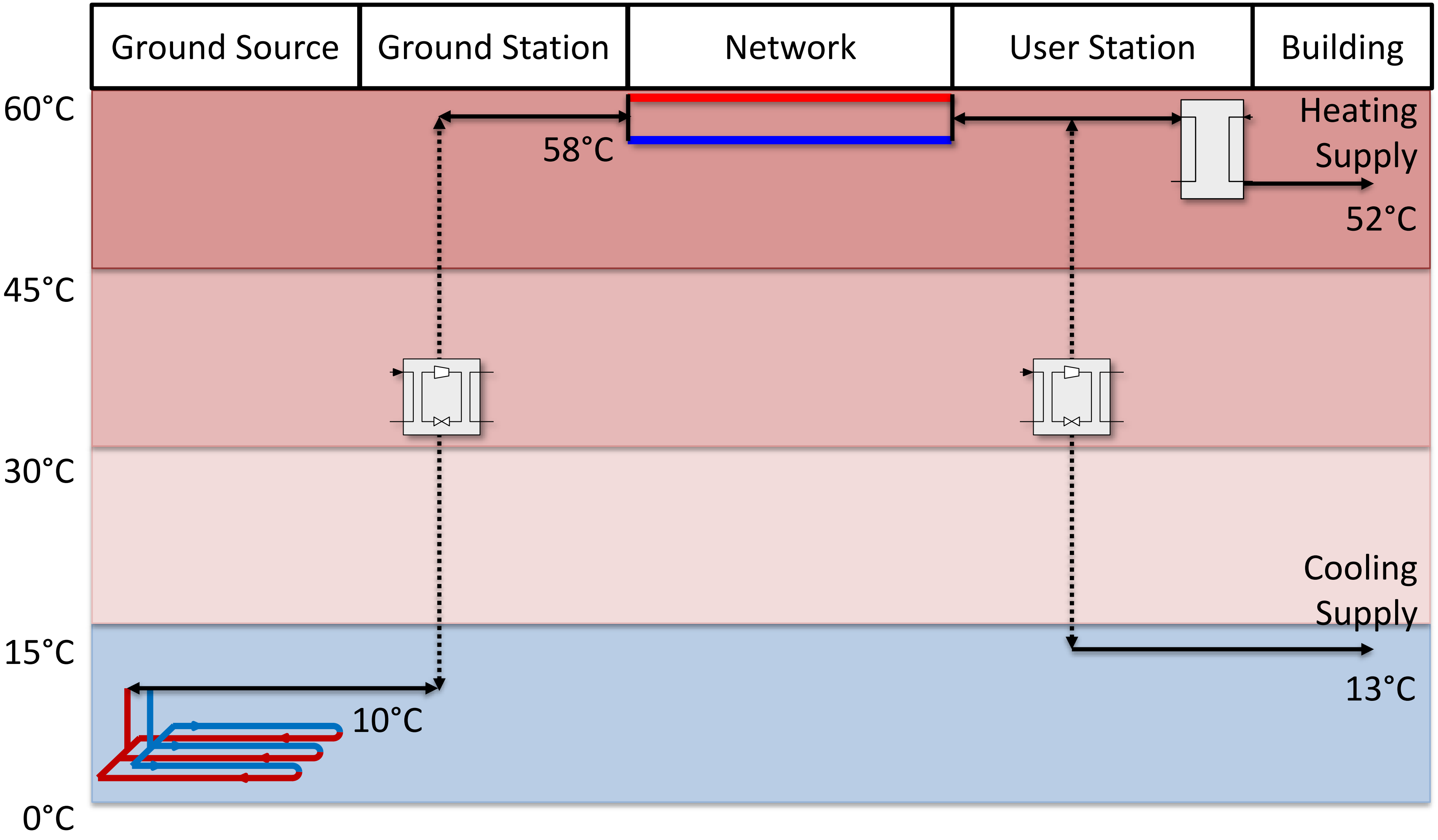
# Configuration Temperatures – *T_23 °C*



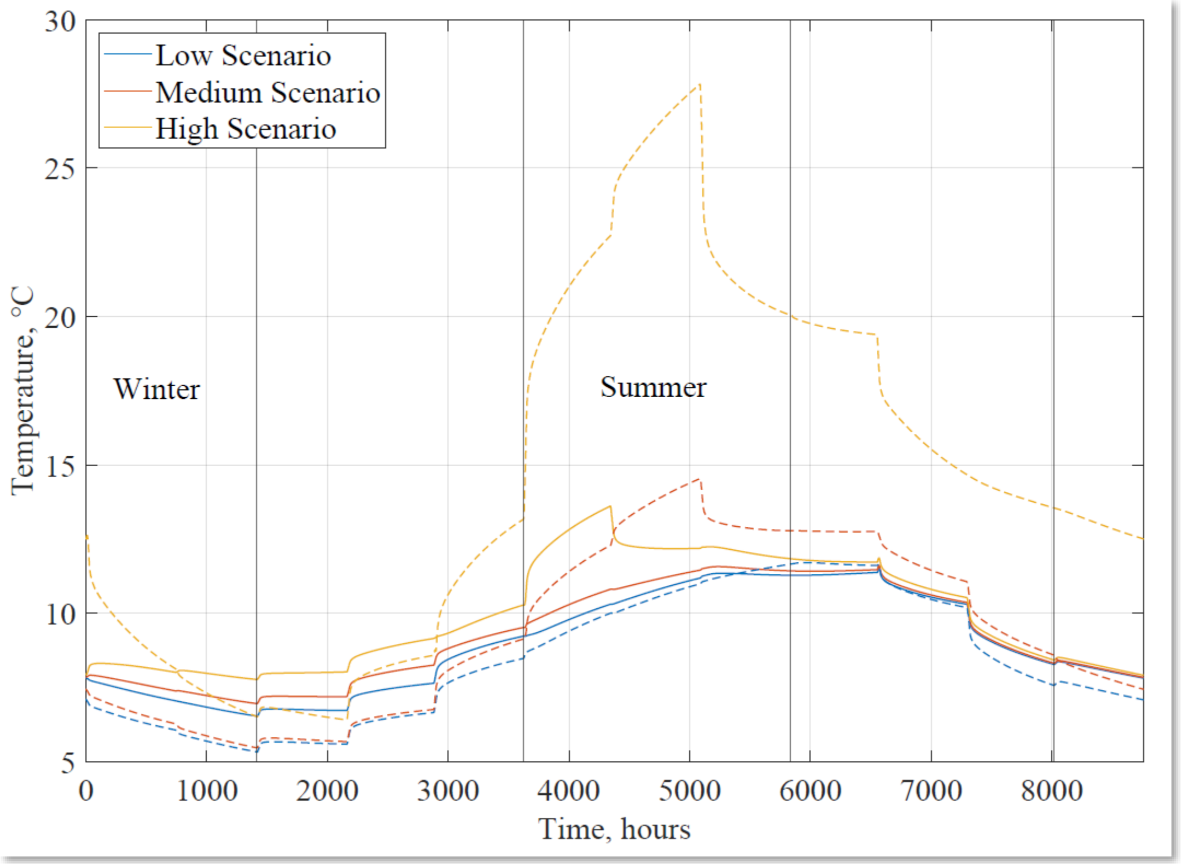
# Configuration Temperatures – *T_46°C*



# Configuration Temperatures – *T_58°C*



# Results –Array Fluid Outlet Temps.




Solid lines – *T_var* (passive cooling in buildings)
Dashed lines – *T_23°C, T_46°C* and *T_58°C* (active cooling in buildings)

Cooling Scenarios:

| | |
|---|---|
| Low | H:C = 6:1 |
| Medium | H:C = 2.4:1 |
| High | H:C = 1:1 |

Ground temperature variation is greatly reduced when passive cooling is used in buildings (max 13.6 °C)

# Results – LCOHC

LCOHC for increasing cooling load (3.5% discount rate, 50-year period):

Legend Key

a = Pipe Capital Cost

b = Circulation Pump Capital Cost

c = Building Heat Pump Capital Cost

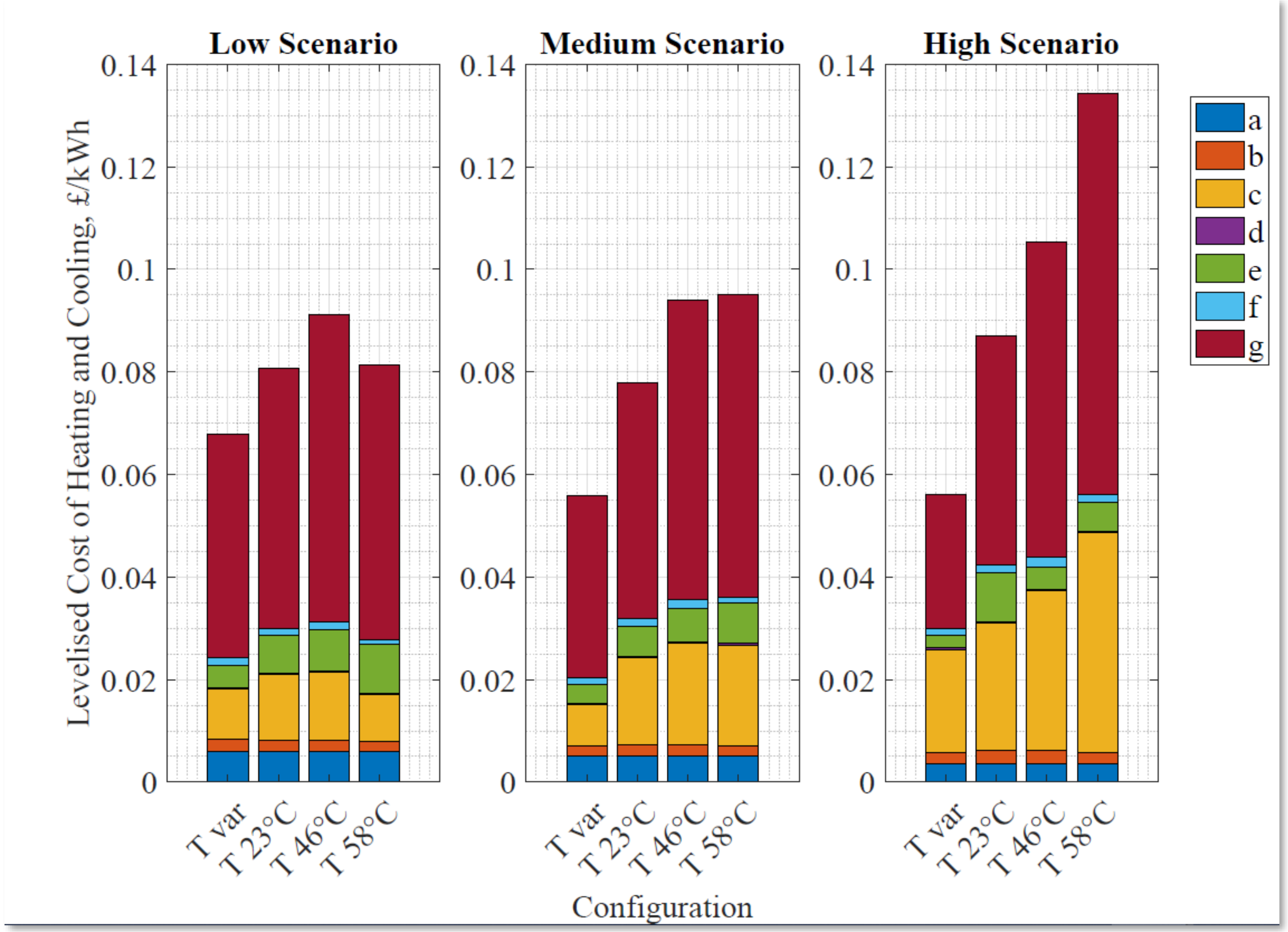
d = Heat Exchangers Capital Cost

e = Ground Source Substation Capital Cost

f = Circulation Pump O&M Cost

g = Heat Pump O&M Cost

T_Var configuration outperforms others even in heat dominated scenarios



# Conclusions

- If even a *small amount* of cooling is present and available heat sources are at ambient temperature, low operating temperatures reduce power consumption.
- Increasing cooling loads on the network can further reduce power consumption per kWh of load served.
- Use of passive heating is not robust against future cooling load increases.
- Site-specific conditions and many causal relationships
- Created tool may be used to quickly assess individual cases

# Other Ongoing Activities

- Quantification of available flexibility from BLTNs to support the electricity grid

- Analysis of peer-to-peer heat and electricity markets utilizing BLTNs

- Min-max regret analysis of BLTN design configurations given multiple uncertain scenarios

# Thank You!

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