Technology Collaboration Programme
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IEA DHC

INTERNATIONAL ENERGY AGENCY
TECHNOLOGY COLLABORATION PROGRAMME ON
**DISTRICT HEATING AND COOLING**


**SUMMARY FOR NON-TECHNICAL AUDIENCES**

# FAST DHC - FEASIBILITY ASSESSMENT TOOL FOR DISTRICT HEATING AND COOLING

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# CONTENT



# 1 BACKGROUND INFORMATION

The FAST DHC (Feasibility Assessment Tool for District Heating and Cooling) project was carried out under the framework of the International Energy Agency Technology Collaboration Programme on District Heating and Cooling (IEA DHC). FAST DHC was an international research collaboration between London South Bank University (LSBU), the Austrian Institute of Technology (AIT), Aalborg University (AAU), and Danfoss Climate Solutions (DCS). The project ran from February 2024 to July 2025 and consisted of 5 work packages led by the partner institutions. Figure 1 illustrates the project structure, its work packages (WPs) and their interdependencies, as well as the main tasks within each WP.

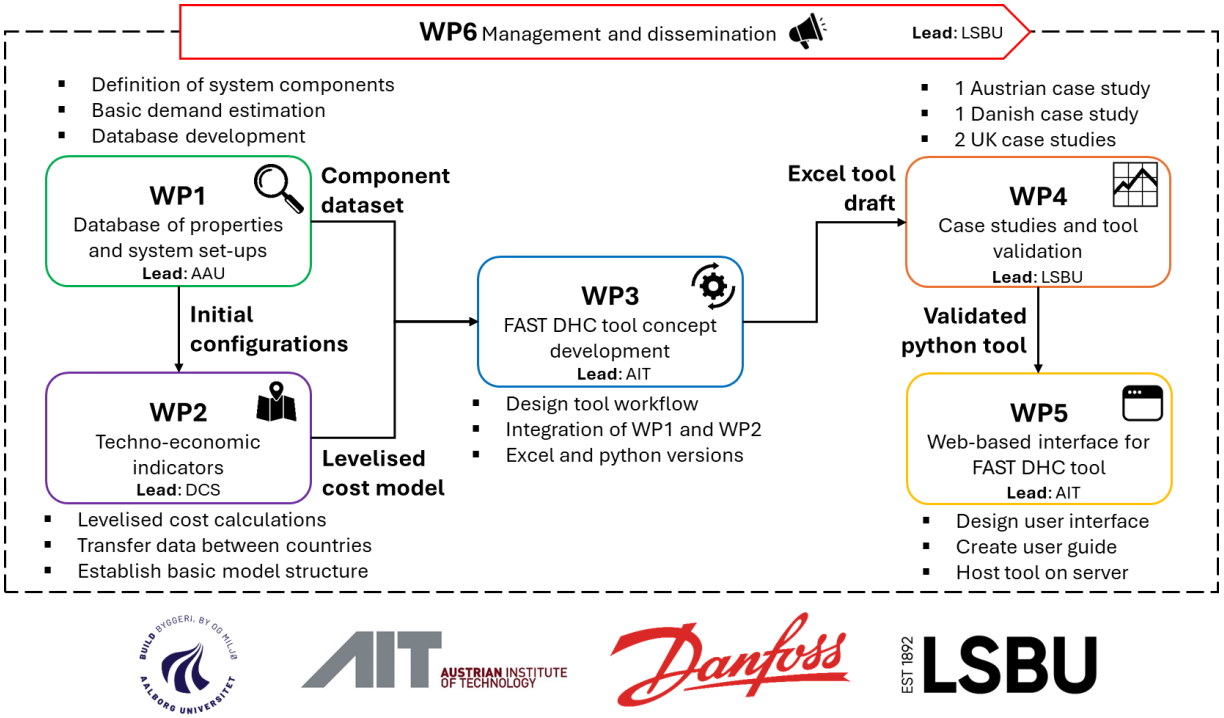


*Figure 1: The structure of the FAST DHC project, highlighting its WPs and partners.*

# 2 INTRODUCTION

The transformation of district heating (DH) systems has been conceptualised as the transition from the 1st to the 4th generation DH networks (4GDH). Recently, hybrid solutions of DH and individual solutions – called thermal source networks (TSNs) – have been introduced as a subclass in 4GDH [1]. Due to their ability to also provide cooling, they are often classified under the wider term of district heating and cooling (DHC).

In TSNs, the novelty is the integration of consumer-side heat pumps (HPs), which in effect transforms the purpose of a distribution network (DN), from supplying heat or cold at directly useful temperatures, to serving as a collective heat source and sink for the connected individual HPs. As these HPs supply buildings with a temperature according to the service requirements, the DN operating temperatures are flexible.

The differences between conventional 4GDH and TSN configurations, particularly the transition from large-scale central H&C generators to building-level HPs, have led to a fundamental debate within the international DHC community over the role and applicability of TSNs, particularly as the previously used term “5th generation” might lead to the perception that TSNs are a progression from the 4GDH, which is not necessarily the case [2]. This was demonstrated in [3], where for a single-source system without cooling, 4GDH was shown to be economically superior to a TSN configuration. On the other hand, TSNs could be a viable alternative in mild climates with heating and cooling demands of similar magnitudes, particularly where traditional DH networks are not present [4]. Furthermore, it is important to consider that DHC is not necessarily the most economical solution, as the high investment costs associated with DNs might not be justified in locations with low heating and cooling demand densities, where standalone HPs might be the cost-effective solution.

The ongoing debate over the merits and challenges of traditional 4GDH systems and TSNs was the main motivation for the FAST DHC project. There is uncertainty over the role and applicability of TSNs, and in which cases they can outperform a 4GDH network or individual H&C systems, in terms of system efficiency, costs and environmental footprint. Typically, the selection of a certain DHC typology demands a case-by-case detailed assessment to identify the best system design, and there is no “one-size-fits-all” solution. This is a data-intensive process that typically involves the use of commercial tools, which require information that might not be available in early planning stages (e.g. hourly demand data). In some cases, existing feasibility tools fail to consider all system properties (e.g. cooling or individual H&C solutions), thus being unable to provide a fair comparison between 4GDH and TSN systems.

Conversely, the FAST DHC project is aimed at supporting early-stage decision making with a freely available web-based tool for the techno-economic performance evaluation of 4GDH and TSNs, and their comparison to individual H&C solutions. The tool can give users an indication

as to which H&C system represents the best potential investment under the assumed boundary conditions, being particularly useful for end-users with limited resources or expertise to perform more detailed analyses. This includes municipalities and consultants conducting first-phase assessments, where hourly data is not yet available. Therefore, the novelty of FAST DHC lies in the way that it can provide a pre-feasibility comparison with very little input from users, enabling them to focus their next evaluation steps towards the most promising solutions, thus saving time and money.

# 3 TOOL METHODOLOGY

## 3.1 TOOL OVERVIEW

The FAST DHC tool is a techno-economic decision support tool consisting of a structured Graphical User Interface (GUI) backed by Python scripts and lookup datasets. It operates on a modular architecture across four sequential input-output modules, as shown in Figure 2.

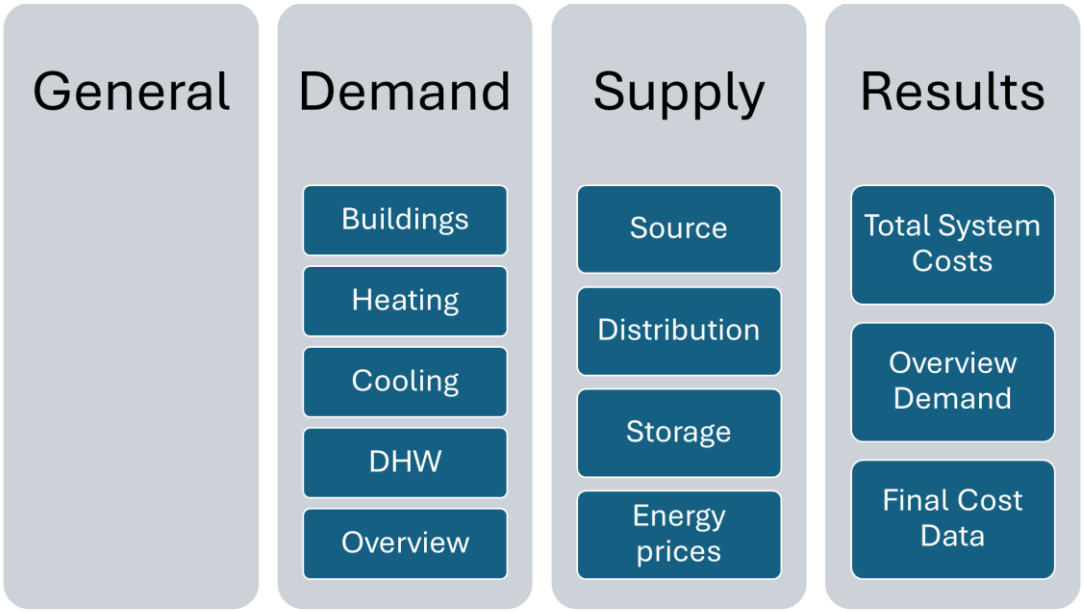


*Figure 2: Overview of the user modules (i.e. tabs) in the FAST DHC web tool.*

The tool relies on a seasonal resolution (winter, spring, summer, autumn/fall) rather than hourly profiles, balancing practicality with technical accuracy suitable for early-stage studies. The functionalities, inputs and outputs of each of the tabs from Figure 2 are described below:

**General Information:** Project context definition (e.g. country, full load hours, discount factor);

**Demands:** Definition of thermal demand profiles across three building types: single-family homes (SFH), apartment buildings (APP), and non-residential buildings (NRB), as well as heating system parameters (underfloor or radiator based);

**Supply Technologies:** Configuration of generation technologies (e.g. HPs, boilers, waste heat), distribution parameters (e.g. heat losses) and storage components (diurnal or seasonal).

**Tool Outputs and Results:** Visualisation of calculated metrics, including total annualised and levelised costs with breakdown of component-specific costs.

## 3.2 SYSTEM CONFIGURATIONS

The FAST DHC tool can evaluate the techno-economic performance of three principal H&C configurations, namely conventional centralised 4GDH, TSNs and individual solutions. Their characteristics and modelling approaches are described in Table 1. The results module can be used to visualise calculated outputs and enables side-by-side comparison.

*Table 1: Description of system configurations/typologies in the FAST DHC tool.*

| Configuration | Space Heating Supply | Cooling Supply | Hot Water Supply | Network Temps |
|---|---|---|---|---|
| 4th Generation District Heating (4GDH) | Central, via network | Individual HPs | Central, via network | 65°C/30°C |
| Thermal Source Network (TSN) | Decentralised networked HPs | Networked or individual HPs | Decentralised networked HPs | 15°C/5°C |
| Individual H&C systems | Individual HPs | Individual HPs | Individual HPs | N/A |

## 3.3 DEMAND CALCULATIONS

Thermal demands are estimated based on default values for average floor area ($m^2$) for different types of buildings, their specific thermal loads ($kW/m^2$), and full load hours per season. These values can be edited and are used to calculate space heating (SH), domestic hot water (DHW) and space cooling (SC) loads, as follows:

**Space Heating:** Peak thermal load uses a simultaneity factor to account for the fact that not all connected buildings require their full heat load simultaneously. This factor decreases as the number of connections increases, converging to about 0.65 in large mixed-use areas.

**Domestic Hot Water:** DHW demand is assumed to have no significant seasonal variation. Peak DHW load is calculated using a probabilistic flow rate formula defined in European guidelines [5], which considers the number of households and aggregated/maximum flow

rates, ensuring realistic sizing that accounts for simultaneity effects. DHW storage to alleviate instantaneous heating capacity can be included as per user selection.

**Space Cooling:** Calculations are based on typical full-load hours and average cooling loads per building type and age for each country. As space cooling is provided at the building level, simultaneity factors are not applied.

## 3.4 COMPONENT SIZING

### 3.4.1 HEAT GENERATION TECHNOLOGIES

Heat source capacities are derived from the seasonal demand profiles. Users specify the share of energy covered by base load generators (e.g. heat pumps or waste heat) versus peak load generators (electric, biomass or gas boilers). The sizing principles for different heat generation technologies are provided in Table 2.

*Table 2: Sizing logic for heat generation technologies in the FAST DHC tool.*

| Component | Sizing Principle | Key Inputs/Assumptions |
|---|---|---|
| Central heat pump | Sized based on maximum seasonal demand, and a safety factor of 1.5. | Seasonal COP values calculated based on source and distribution temperatures. |
| Back-up air-source heat pump (central) | Automatically allocated to cover unmet demand if the user-defined source capacity is insufficient. | Sized using the same safety factor (1.5) and ambient air as the heat source. |
| Central boiler | Sized based on the uncovered peak load based on user selection. | Efficiencies vary for electric (99%), gas (90%) and biomass (85%) boilers. |
| Decentral or individual heat pumps | Sized per building based on peak SH, SC and DHW loads. | Accounts for DHW storage effects and COPs based on network/air temperatures. |

### 3.4.2 DISTRIBUTION NETWORK

Network length calculation is critical for infrastructure cost (CAPEX) in DHC systems. FAST DHC uses an empirical model based on building density indicators, specifically the Plot Ratio (ratio of total heated floor area to total land area). The total network trench length is estimated using the effective width method, linking the land area to the specific pipe length per hectare,

which is calculated using a logistic fit derived from Danish GIS data for DH networks, ensuring that the calculation reflects realistic saturation in dense urban areas versus sparse regions.

Network CAPEX is derived by combining the calculated length with cost curves which depend on the maximum thermal network load. Network operational expenditure (OPEX) is scaled according to the total annual thermal energy delivered.

### 3.4.3 THERMAL STORAGE

The tool supports two types of thermal storage:

**Seasonal Storage:** Used to store excess heat from cooling (rejected from non-residential buildings) for winter heating use. For 4GDH, conventional hot water tanks are modelled. For TSNs, Borehole Thermal Energy Storage (BTES) is considered, with capacity based on typical assumptions for geothermal systems scaled by volume (depth and area).

**Diurnal Storage:** Short-term buffer storage used to optimise electricity costs for the central heat pump by shifting consumption to hours with lower day-ahead electricity prices (peak shifting). This flexibility is based on precomputed cost savings derived from historical Austrian electricity price data and optimisation tools (IESopt [6]).

## 3.5 ECONOMIC MODEL AND DATABASE OF COMPONENTS

The FAST DHC tool utilises the levelised cost concept to provide a long-term, comparable metric (EUR/MWh) for district and individual H&C solutions, factoring in future reinvestments of components with different technical lifetimes. This involves gathering information from a database of 13 technological components typical to both DHC and individual H&C technologies. This database includes information on lifetime, capacity/size as well as CAPEX and OPEX for 13 different technologies, obtained mainly from the technology catalogues from the Danish Energy Agency [7]. Additionally, the tool also provides indicative data on heat recovery costs for 14 heat sources based on a research project commissioned by the UK Government [8]. Where applicable, costs are scaled using power functions derived from empirical catalogue data to account for various unit sizes.

For levelised cost calculations, CAPEX is converted into annual values using the annuity method based on a discount rate (default 5%) and component lifetime. Costs are normalised across countries using Purchasing Power Parities (PPPs) and adjusted for inflation to ensure comparable national price levels. OPEX includes energy as well as operation and maintenance (O&M) costs. These are calculated based on system performance (e.g. COP or efficiency) and country-specific pricing. Electricity tariffs are differentiated as follows:

**Household (HH) tariffs** are applied to decentralised (building-level) heat pumps.

**Non-household (NHH) tariffs** are applied to central heat pumps. The tool allows for detailed tiered tariff structures (bands) and includes distribution charges that vary by consumption level.

# 4 CASE STUDIES AND VALIDATION

A critical part of the FAST DHC project involved testing the tool with case studies related to the different system configurations described in Table 1. Four case studies that consist of feasibility assessments carried out with other software tools, such as IESopt [6] and energyPRO [9], were replicated with FAST DHC for validation purposes, and these are described in Table 3.

*Table 3: Description of case studies replicated with the FAST DHC tool.*

| Case Study | Typology | Location | Generation Capacity and Main Heat Source | Key Features |
|---|---|---|---|---|
| 1 | 4GDH | Bristol, UK | 750 kW heat pump, supermarket waste heat | Small, urban, only heating |
| 2 | 4GDH | London, UK | 26 MW heat pump, wastewater heat | Large, urban, only heating |
| 3 | TSN | Vienna, AT | 1 MW of heat pumps, ground-source | Small, urban, heating & cooling |
| 4 | TSN | Midtjylland, DK | 429 kW of heat pumps, geothermal collectors | Small, rural, only heating |

A comparison of case study results for key parameters is provided in Table 4. Overall, demand estimations were closely aligned across all case studies, which indicate the methodology used for that purpose was reasonable. There is just one validation point for cooling demands (case study 3), and the tool should be further tested in different countries and contexts to validate its cooling demand estimations. However, FAST DHC has a highly flexible approach to demand calculations, as all relevant inputs are editable by the user.

In terms of component sizing, heat pump capacities are in good agreement for 3 out of 4 case studies, with a significant discrepancy being observed for case study 3, involving a TSN. This issue is due to the non-optimised allocation method for calculating HP capacities at a building level in the FAST DHC tool, which calculates separate DHW and SH capacities and defines the maximum value as the final heat pump capacity at the building level. The methodology used for estimating network length proved to be reasonably accurate for the first 3 case studies, but a significant deviation was observed for case study 4. As the latter was the only case study for a rural environment, our conclusion is that the methodology used for estimating

network length is less accurate in rural settings. Large variations were also observed in thermal storage sizing. However, as accurate thermal storage sizing would require detailed assessments on an hourly basis, the discrepancy in results was deemed reasonable.

*Table 4: Comparison of percentual differences in case study and FAST DHC results.*

| Item | Case Study 1 (4GDH) | Case Study 2 (4GDH) | Case Study 3 (TSN) | Case Study 4 (TSN) |
|---|---|---|---|---|
| Heating demand | -3% | N/A | -1% | +3% |
| Cooling demand | N/A | N/A | -1% | N/A |
| Total heat pump capacity | -15% | -15% | +155% | +3% |
| Network length | 0% | -9% | +13% | -47% |
| Thermal storage size | -9% | +52% | -68% | N/A |
| Annualised CAPEX | -14% | +5% | -6% | +50% |
| Annual OPEX | +31% | -1% | -39% | +33% |
| Annualised costs | +15% | +1% | -30% | +40% |
| Levelised costs of energy | +19% | +1% | -10% | +36% |

The analysis of estimated annualised costs shows good agreement (<15%) for the 4GDH case studies (1, 2), whereas TSN case studies (3, 4) had a higher disparity in results (<40%). CAPEX estimates had a close match for the urban case studies (1, 2 and 3), while case study 4, located in a rural setting, was largely impacted by the difference in length and costs for the distribution network. OPEX values also varied significantly across most case studies. The TSN case studies obtained a significant variation in electricity costs, which was linked to the lower granularity of price data in FAST DHC and different efficiency (COP) assumptions. Additionally, high discrepancies were observed for O&M estimates for all case studies, which is expected as these were mostly estimated using fixed rule-of-thumb values (e.g. 1% of total CAPEX).

Finally, a comparison of levelised cost estimations indicates that the FAST DHC tool was able to reproduce results from urban case studies within a ±20% difference. The rural case study 4 had a larger deviation in levelised costs (+36%) and further work is needed to test the tool against other rural DH projects. This discrepancy is illustrated in Figure 3, which compares the results for case studies 2 (urban) and 4 (rural). Other limitations that might need to be addressed in future versions include HP sizing at building level, network length and storage calculations, as well as testing with other case studies involving larger cooling demands.

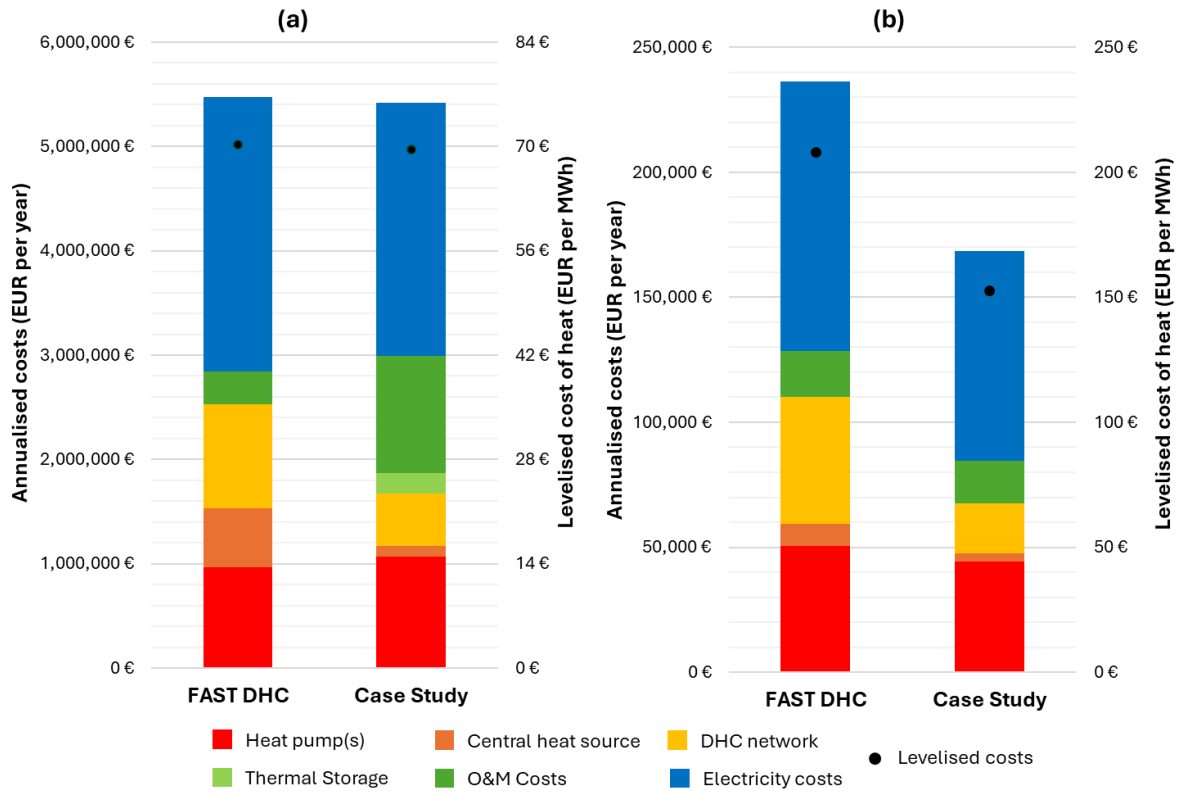


*Figure 3: Comparison of estimated annualised costs per component and levelised costs for Case Studies 2 (a) and 4 (b).*

# 5 TYPOLOGY COMPARISON

With the purpose of illustrating the functionalities of the FAST DHC tool, case study data were also used to evaluate how annualised and levelised cost estimates compare across different system typologies (4GDH, TSN and individual) for the same boundary conditions. This exercise was aimed at indicating to users how the FAST DHC tool should be applied, and also at evaluating how different parameters can be determinant when comparing the economic competitiveness of low-temperature DHC networks and individual H&C solutions.

Case study 1 was replicated for all system typologies available in the FAST DHC tool, and the results of this comparison are shown in Figure 4**Error! Reference source not found.**. As it can be observed, the tool predicts similar levelised costs for a conventional 4GDH network (€150 per MWh) and individual solutions (€148 per MWh), whereas a TSN would lead to higher levelised costs (€170 per MWh) under case study 1 conditions. The price parity between 4GDH and individual systems can be explained by the assumption that individual technologies would operate bivalently, i.e. building-level air-source heat pumps are assumed capable of providing both heating and cooling. This assumption is not considered for residential buildings connected to TSNs, as these are unlikely to have the required infrastructure for central cooling provision, which explains the higher cost estimates achieved for TSNs.

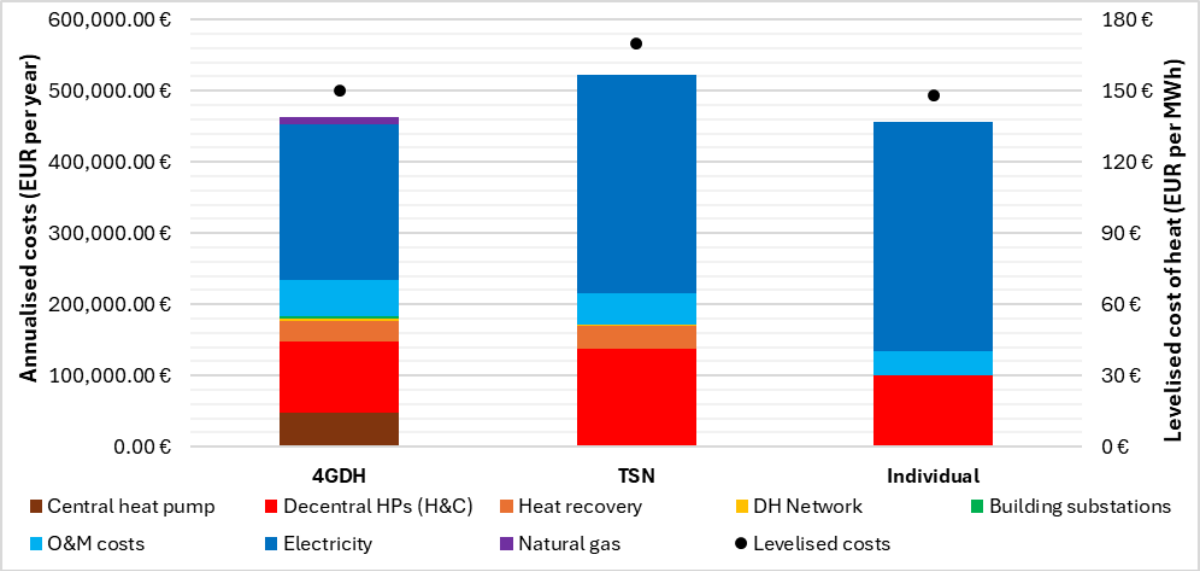


*Figure 4: Annualised and levelised costs for different typologies in case study 1.*

Sensitivity analyses were also carried out to test how different assumptions may impact results. If separate individual systems were required for heating and cooling, the levelised costs for the individual set-up would increase significantly to €167 per MWh. On the other hand, if TSNs could deliver both H&C, their levelised costs would reduce to €146 per MWh, making them the cheapest option amongst the three analysed typologies. Another key assumption that is determinant to the comparison is the temperature of the main heat source. If the heat source for case study 1 was changed from supermarkets to data centres, the levelised costs of the 4GDH configuration would reduce by 15% to €128 per MWh, whereas TSNs would not be impacted considerably. These results are illustrated in Figure 5.

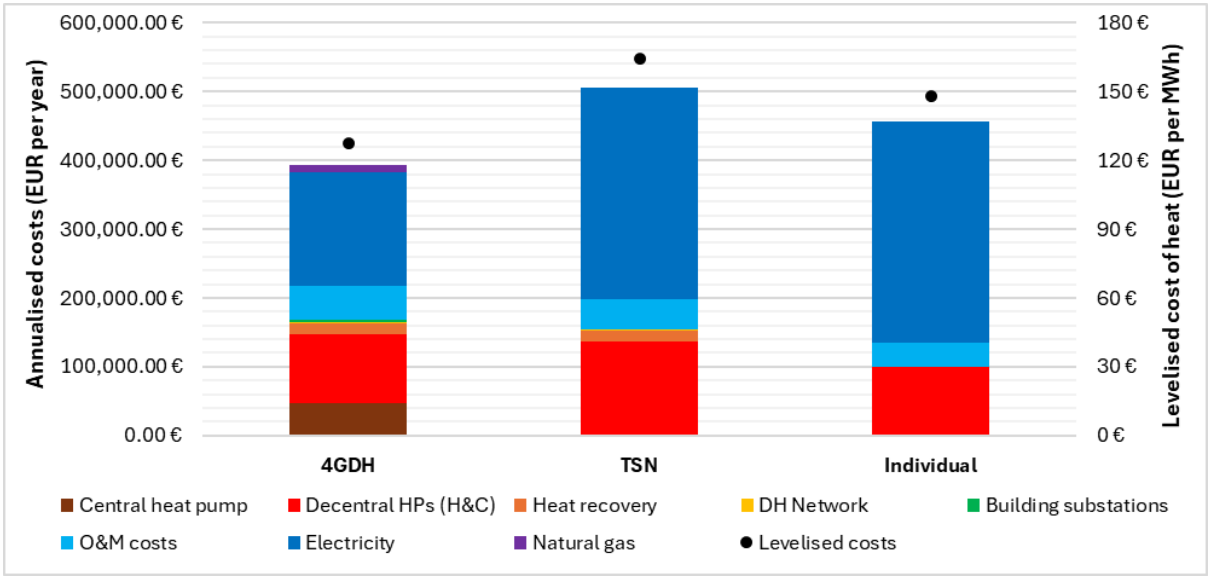


*Figure 5: Typology comparison where the primary heat source is changed from a supermarket to a data centre.*

# 6 CONCLUSIONS

The FAST DHC project developed an easy-to-use, pre-feasibility modelling tool intended to evaluate the annual and levelised costs of low-temperature DHC systems: specifically conventional 4GDH and TSNs, as well as their individual heat pump-based counterfactual. This effort was motivated by the need for a simple comparison tool for early-stage decision-making, especially given the complex debate within the DHC community regarding the technical advantages and applications of centralised 4GDH versus the emerging TSN concept.

The FAST DHC tool provides a transparent, consistent, and practical framework for evaluating these DHC solutions under diverse urban climatic and infrastructure conditions. It enables rapid early-stage assessment of the three distinct configurations, allowing users to define scenarios and configure technologies using default cost data derived from validated datasets. This modular interface supports scenario comparison without demanding detailed hourly data or specialised simulation expertise.

Four case studies were replicated to validate and test the tool's functionalities, demonstrating its effectiveness, particularly for urban applications and 4GDH systems, where it reproduced annualised cost calculations with an acceptable accuracy. Overall, levelised cost estimates for urban case studies were within ±20%. However, some challenges and limitations were observed, particularly relating to TSN modelling. The rural TSN case study obtained the largest difference in levelised costs (+36%), and further work is required to test the tool against other rural DHC projects. Other limitations that should be addressed in a future version of FAST DHC include more refined heat pump sizing at building level, testing with alternative network and storage sizing calculations, as well as case studies involving larger cooling demands. Lastly, expanding the FAST DHC tool to other countries of interest, in Europe and elsewhere, would further strengthen the position of the tool as the "go-to" pre-feasibility indicator for other DHC markets with considerable growth potential.

Overall, the FAST DHC project was able to deliver a simple yet robust and reliable tool for the comparison of centralised 4GDH, TSN and individual H&C systems, being particularly effective for cities. The FAST DHC tool supports informed decision-making by making the trade-offs between infrastructure cost, energy use and system design transparent and reproducible. In doing so, FAST DHC can bridge the gap between strategic planning and technical feasibility analysis, thus supporting cities in understanding the best solution for decarbonising their thermal energy supply.

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