Deliverable 5.3: Report on the workshop on thermo-chemical networks at EHP Conference 2017

Philipp Geyer - 31/May/2017

Overall aim of the workshop

Aim of Workshop 1 according to the grant agreement: “Integrate components in applications on source and demand side and disseminate technology. Invitees: Researchers working on thermo-chemical processes, energy engineers for heating and cooling systems, heat recovery buildings as well as industry and industrial drying.”

Due to the opportunity to carry out the workshop as a side event at the EHP Conference 2017, the scope of the workshop has slightly been extended and included the whole network integration, its planning and its economics in discussion with the district heating planners, energy providers and communities as they are present at the conference.

This project has received funding from the European Union‘s Horizon 2020 research and innovation programme under grant agreement 695780.

Program

13:30 – 14:30	**Opportunities for 5th Generation district heating and cooling networks**
	Session chair: Tony Roskilly
13:30 – 13:40	**Keynote speaker: Wolfram Sparber**
	Chairman of the management board of Alperia and head of Institute for Renewable Energy at EURAC Research
13:40 - 14:00	**Group discussion & feedback**
14:00 – 14:10	**Technology pitch: Philipp Geyer**
	Coordinator of the EU H2020 project H-DisNet and Professor of Architectural Engineering at KU Leuven
14:10 - 14:30	**Group discussion & feedback**

Coffee break

15:00 – 16:00	**A thermo-chemical urban game I: Identifying potentials and drafting networks**
	Session Chair: Philipp Geyer
15:00 – 15:20	Introduction to thermo-chemical technology and to the cases
15:20 – 15:55	**Game I: Potentials, stakeholders, actions, network design and operation**
	Case Bolzano by Alessandro Mazzocato, Alperia
	Case Hasselt by Jan Dreesen, City of Hasselt
	Case Newcastle, by Mohammad Royapoor, University of Newcastle
15:55 – 16:00	Wrap-up Session I at tables

Coffee break

16:30 – 17:30	**A thermo-chemical urban game II: Entering business**
	Session Chair: Philipp Geyer
16:30 – 16:40	Introduction to thermo-chemical technology and summary from Session I at tables
16:40 – 17:10	**Game II: Economic benefits, business models and value propositions**
	Case Bolzano by Alessandro Mazzocato, Alperia
	Case Hasselt by Jan Dreesen, City of Hasselt
	Case Newcastle, by Mohammad Royapoor, University of Newcastle
17:10 – 17:30	Conclusions Session

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Session 1: Opportunities for 5th Generation district heating and cooling networks

Aim and method

The aim of the first session of the workshop was to set the scene for 5th Generation district heating and cooling networks. A keynote speech from Wolfram Sparber set out examples of future systems as well as for the upgrade of existing systems and future build solutions.

Interactive session A involving all attendees was then commenced. In this session, each table involving up to eight individuals addressed specific questions related to the topics. The objective was to discuss the challenges of existing and next-generation district energy systems. The different perspectives of stakeholders involved in the realization and operation of such systems served to identify what would be required to bring them forward to the market.

Next a presentation of the H-DisNet project and its outcomes aimed to align the existing project as a potential solution. In the following interactive session B, attendees were asked to engage in a second interactive session which sort to get them thinking about its opportunities and challenges from their perspective. Opportunities and challenges for thermo-chemical technology have been identified in this discussion.

Results of interactive session A: Next generation thermal district networks

What are the perceived benefits of a future district network?

- Household waste heat can be accessed: Small sources of excess heat can be utilized by innovative low/no-temperature networks.
- Less distribution losses in the system: Low-temperature networks and innovative technologies reduce heat losses
- Heat can be delivered at competitive cost: Novel technologies allow the lower the price for heat/cold from the network.
- Lower or negative carbon emissions: Forming heat cascades and exploiting heat sources much better reduces carbon emissions.
- Combine with microgrid systems and reduction of size of energy centers: Utilization of infrastructure in networks allows the reduction of peaks and a better exploitation of infrastructure.
- Reduced physical size of pipes, integrated heating and cooling pipes: Innovative pipe and network designs allow compact construction.
- Improved utilization of renewables: Lower temperatures and decentralized networks integrate renewables far better.

What opportunities/challenges exist for exploiting industrial residual heat sources?

Opportunities:

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- Reduction of primary energy for internal consumption
- New markets for selling energy to external users

Challenges:

- Investment costs and end user price specially in countries with low energy price (Switzerland, Croatia)
- For SME to expensive

What are the existing barriers to the deployment of new solutions for district heating/cooling networks?

- Lack of knowledge
- Data on performance of existing and future systems
- Consumer protection (price/monopolies)
- Regulation/legal framework missing
- Investment support (e.g. subsidies)
- Strong local governance
- Control of network/prosumer/suppliers
- Perception of dangers of power plants (e.g. waste biomass to energy)
- No space for equipment
- Efficient technologies in dual direction
- Low heat load/density
- Distributed production undermining the business model
- Existing structure of networks
- Old buildings/industry need high temperatures
- Cheap alternatives

Which solutions will unlock the next generation of district heating/cooling?

- Low temperature networks/heat pump as subnet at about 5 to 40 °C
- Multiple source systems
- Heat sources at lower temperature can be integrated
- Solutions are site/situation specific
- Storage can improve flexibility
- System has to be based on (conventional) backup
- Role of customer to operate storage
- Sale of comfort (not kWh)

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Results of interactive session 2: Thermo-chemical networks

What opportunities/challenges exist for exploiting industrial residual heat sources?

Opportunities for H-DisNet:

- H-DisNet gives the opportunities for small/medium scale industries or infrastructures/services to exploit the **residual heat** at low temperature which is normally released to the atmosphere. As example subways and supermarkets have been mentioned. The advantage is that they are already in an urban context, close to potential users so that means the investment cost can be easily amortized
- **Storage** for long and medium period without thermal losses, opportunity to recovery "seasonal heat"
- **New service**: control of the air quality, 2-phase cooling
- Higher **energy density**, which means smaller diameters and reuse of existing pipes (pipe-in-pipe installations)
- Large potential given moist air is present, e.g. in drying, high efficiency in commercial dryers
- Large potential in the support of cooling in hot humid areas
- Control of clean air supply and demand side
- Reduction of XXX rate (energy saving)
- Usage of plastic, reduction of the **cost** of the network, low cost energy, low cost storage
- **Drying** of wood/biomass by return flow heat

Challenges for H-DisNet:

- **Investment costs** (not known at the moment): lower investment cost for the piping system but need of additional components like absorber and desorber for each user; that means also more space required in the buildings for their installation in comparison to heat exchangers of standard DHC networks
- Avoiding **corrosion** with highly corrosive TCF, material selection at decent prices compatible for corrosion, erosion and accelerated aging, proper material selection is required
- Due to the increase in price for useful space, a challenge is the **space** reduction for the network components, possibility to have a central absorber for a small neighborhood/district. A similar challenge exists for low temperature DCH, where heat pumps are necessary
- The participants at one round table did not see an opportunity for **large industries** which already recovery heat at higher temperatures. The cost of a new infrastructure for low temperature heat recovery by thermo-chemical fluid would be too high in comparison to the benefits (the major benefits come from heat recovery at high temperature);

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- **Complexity** of the system was seen as barrier for the application of the system. Measures to break down complexity and explain the technology to a non-technical audience was seen as key.
- The need for **humid air** was seen as limiting challenge.
- **Pollution** and emission to/from the TCF has to be examined
- Only **one type of TCF** per network
- **Leakage/Security** (chemical aspect) in the system
- **Temperatures** are low

Session 2+3: A thermo-chemical urban game

Aim

The aim of the urban game was first to develop technological application scenarios for the technology to compose the components to form a network for specific urban cases. This included the following subobjectives:

- Identify sources and sinks/supply and demand
- Connect these nodes with stakeholders and with actions (thermo-chemical technological components, other technology, building retrofit etc.)
- Define the layout and technology of the network (transport mode, approx. network layout, etc.)
- Get information on typical operation modes (approx. operation scheme) and storage requirement

Second the aim of the event was the support of the dissemination of the technology:

- Disseminate awareness on potentials and benefit of technology (loss-free transport, storage, multiple services)
- Make participants familiar with economic benefit and value propositions
  - Learn about their acceptance/interest in them
  - Identify drivers and barriers for implementation
- Check interest in specific business models
- Find potential demonstrator/pilot locations/partners and strengthen the contact to them

Method

To achieve the aims mentioned above, first an introduction to thermo-chemical technology was given.

Second cards/stickers served to allow the participants to assign components of the technology as well as stakeholders to the local conditions of three cases described below. They placed the cards and discussed about the potentials, components, actions and stakeholders in the first session with the following cards:

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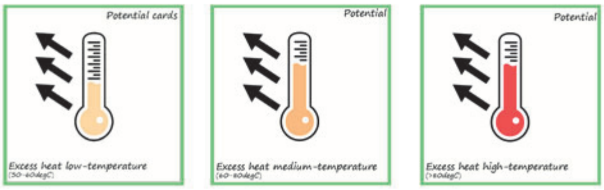
Potential cards

Where is demand that is suitable for thermo-chemical technology?

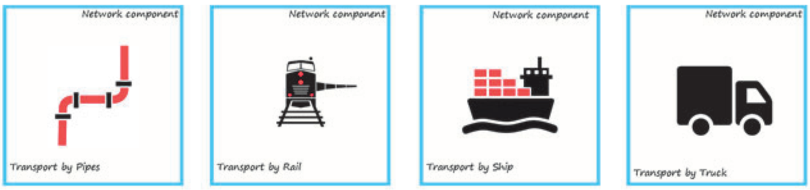
Where is unused excess heat?



12

Network components symbols

How is the network configured?



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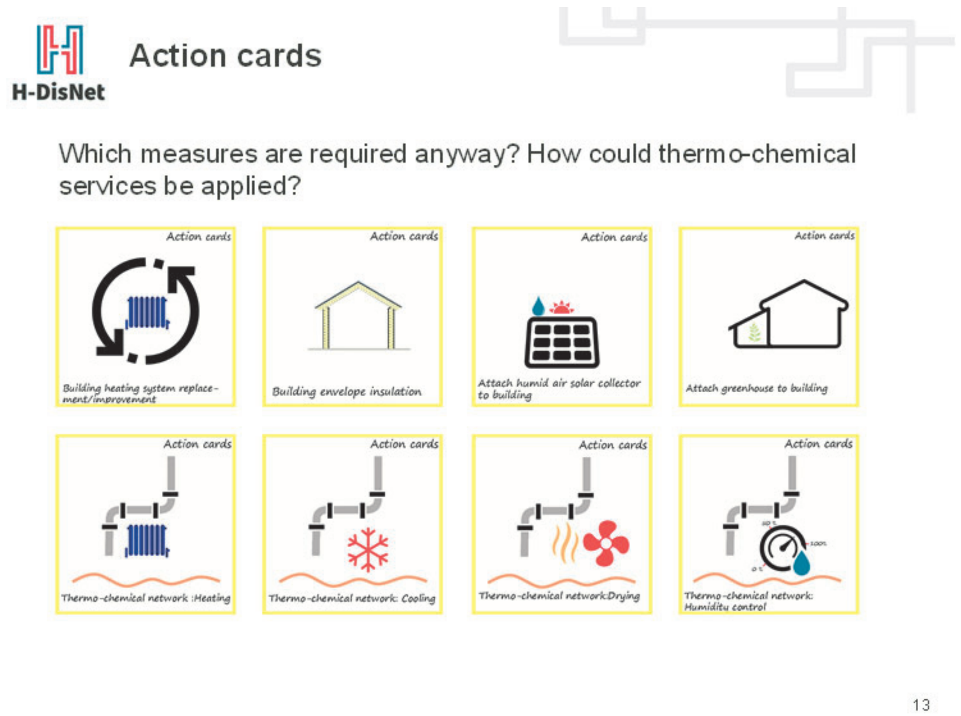
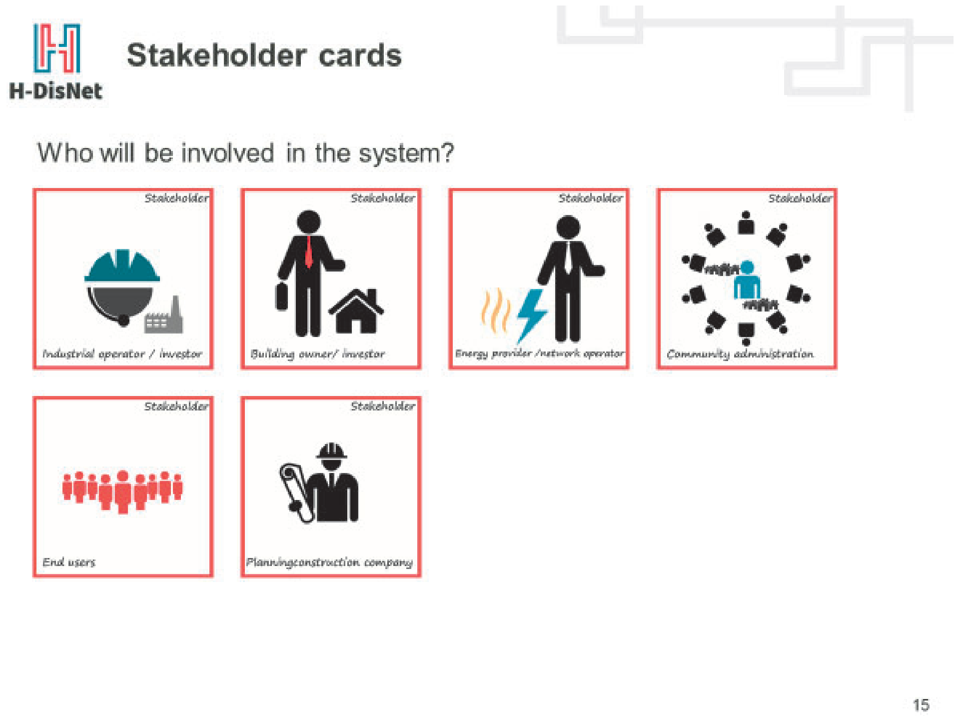
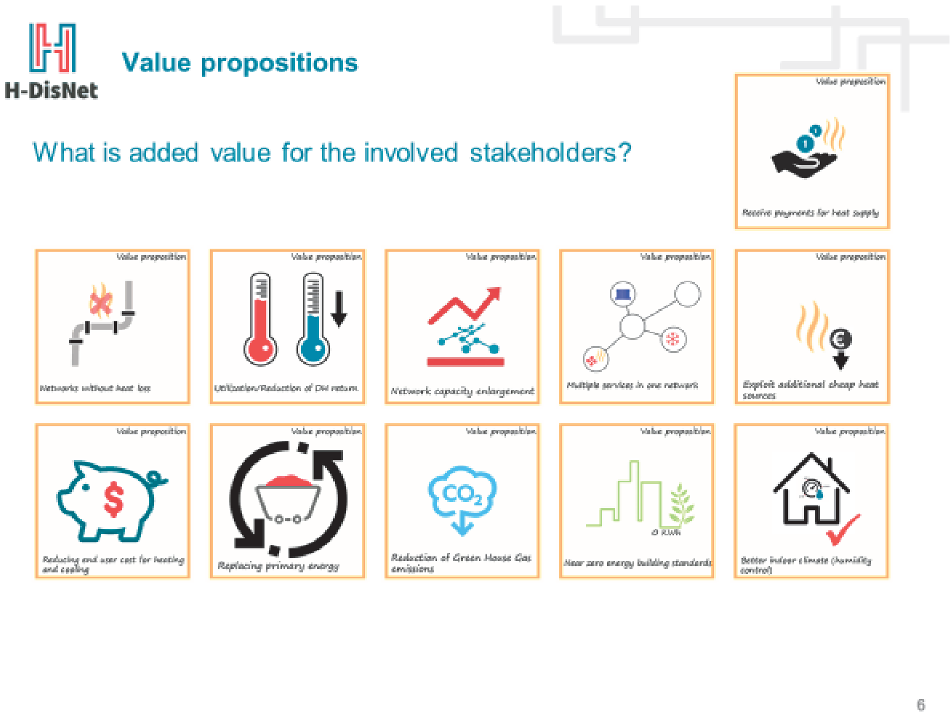
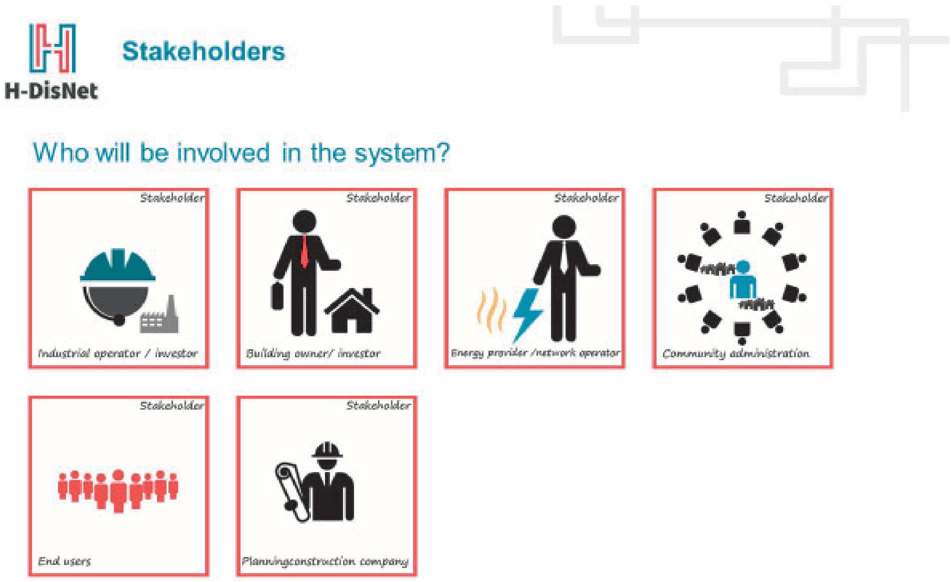




In the second session, which add the economic dimension to the discussion, the participants used the following cards:





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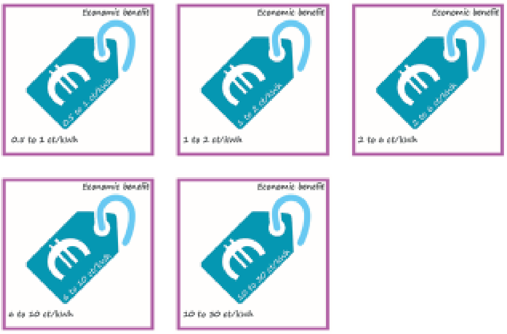
Pricing of services

What is the pricing level?

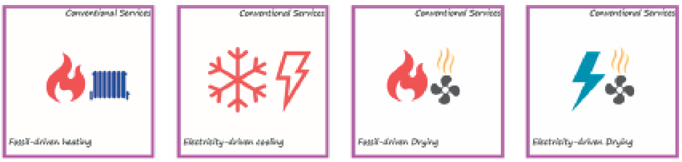


Market segments

To which market segment do they belong?

Conventional services

With which services is the thermo-chemical technology competing?



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Case Bolzano with results

Introduction/characteristics

- A small city in Italy in the alps already with an innovative district heating system
- Extension of the network with integration of thermo-chemical technology as topic
- Heat mainly from waste treatment station and CHP units of power supplier (Alperia), in future from industry (steel, aluminium processing)

Results for Bolzano

Integration of Thermochemical Networks discussed:

Centralised distribution from Waste processing plant could guarantee the use of real residual heat from heat network return pipe. Reduced temperature could improve the electric efficiency of steam turbine. Would not have the same benefit if placed at the CHP unit (no increased electric efficiency) or at decentralised places near TCF consumers (with mixed heat from different sources).

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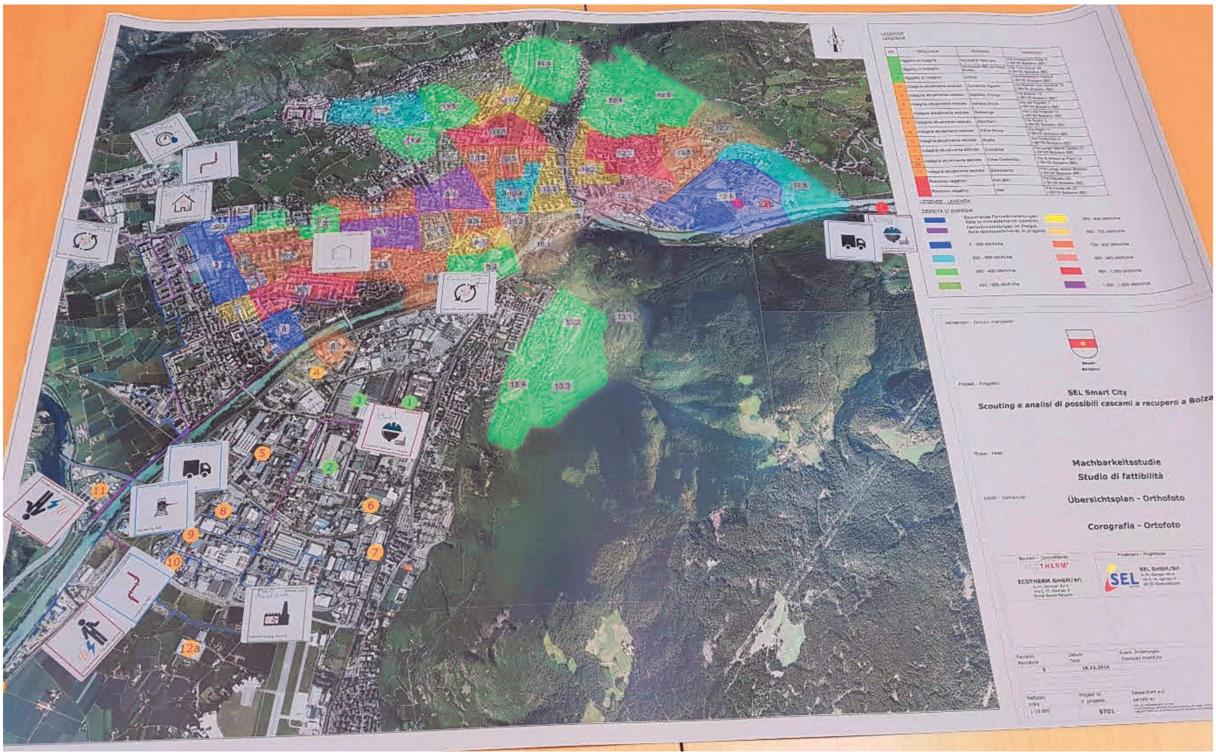

Clustered TCF consumers:

- Identified in the western perimeter of the city with (1) hospital (heat recovery, cooling, humidity supply in winter), (2) greenhouse area (latent heat recovery in winter, cooling and higher state of enclosure for improved CO2 supply during winter) and (3) new residential area (potentially planed for TCF assisted heating and cooling).
- Cluster could be connected to the waste treatment plant via pipeline (sufficient total quantity to justify 3,5 km of transport infrastructure)

Singular TCF consumer:

- Municipal swimming pool south of the centre (connected to local heat network, potential decentral TCF regeneration)
- Food drying, food processing industry in the south of the city (~ 1 km distance to waste processing unit)

Strategy for the refurbishment of the city centre:

- TCF Network pipes along with new heat network extensions, creation of subnetworks with lowered temperature in the thermal network and desiccant supply to refurbished buildings for support of heating and cooling

Decentralised sources of residual heat:

- Example of dairy industry at the eastern perimeter of the city. Cannot be connected with TCF Network.

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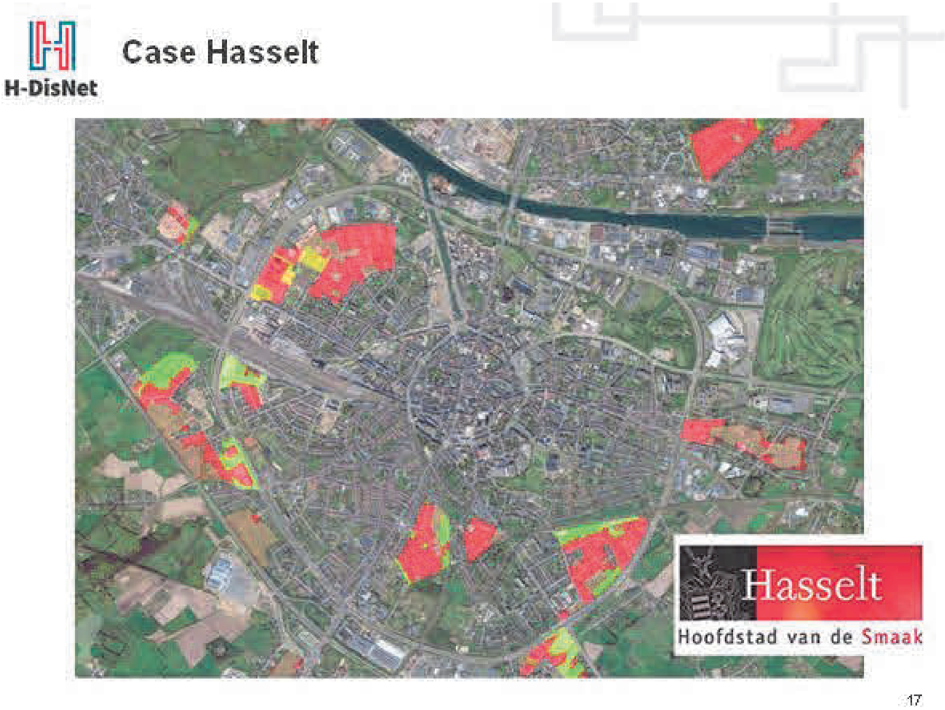
- Could potentially host new industries with needs for drying (Industrial laundry, cooling stock houses etc.)

Case Hasselt with results

Introduction

Hasselt in Belgium is a small city with about 100,000 inhabitants in Flanders. It has no district network and residential buildings form the major part of the building stock and thus the application potential for the thermo-chemical technology. Furthermore, there is much excess heat available not in the city but within reasonable distance to the city in Genk, Olen and Antwerp.



Results for Hasselt

- An existing residential area called De Willeman that consists of typical detached one-family homes that are in a bad condition in terms of energy. The city administration is interested in improving this area. Driving stakeholder in that case is the city administration. A barrier is that the administration needs to approach each building owner separately. Furthermore, insulation of the building envelope is required, which is cost intensive. The location that is a few kilometres distant to the centrum makes the application of thermo-chemical technology with cheap plastic pipes and efficient long-distance transport very beneficial.
- In Wolske, a new high-quality residential apartment area is under development. The area is planned to be built in low-energy technology. This enables the integration of thermo-chemical

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heating and heat recovery technology. As driving stakeholders in the process, the city administration, the building investor and the energy provider Infrax. The opportunity of the technology to offer cooling and humidity control at a decent price was seen beneficial for high-value buildings.

- Excess heat is in Hasselt only available at limited amount. However, the Prinz Albert channel passes Hasselt very close, which makes by means of thermo-chemical technology excess heat potential from Genk (about 14 km away), Olen (about 50 km away, site of the partner Aurubis) and Antwerp (about 80 km away) available.
- Ship transport has been identified as interesting option not only because supply and demand are located closely at the channel but also as it avoids the necessity to build a pipeline. This allow to exploit industrial excess heat with only very low dependency of investments on specific industry in the network. The situation that a pipe network is built, industry changes and excess heat is not available making the respective pipe investments useless is not given in case of ship transport.

In conclusion, a network focusing on the prospected high-value buildings in Wolske and exploiting the sources at the channel was seen as very beneficial.

Case Newcastle with results

A collection of 5 tower blocks in the North East of England were assessed for TCN treatment as an alternative method of retrofitting these 1960s buildings. Three of the towers are supplied with gas and electricity and are heated with gas central heating (type 1). The other two are supplied with electricity alone and are heated by night storage electric heaters (type 2). Each tower is 15 storeys high and houses 30 one- and 60 two-bedroom apartments (90 in total). Previously a detailed energy and environmental sensor deployment, fabric thermal audit and direct resident engagement were conducted and detailed energy requirements of these towers were available that assisted the project team in drawing adequate conclusions outlined in the next section.

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Results for the Newcastle case

- All towers have the potential to be treated with TCN.
- A district TC network was proposed for type 1 towers that are 1.9 km of walking distance away from a 2 km deep geothermal borehole (on Newcastle science central site) that supplies heat at 80°C (Fig. 19). There is also a 10MW CHP engine on the same site. The geothermal array is yet untapped and the CHP engine is intended to supply heat to the science central site. These constant streams of heat can be captured and directed to a central energy centre adjacent to the three type 1 towers and a centralised plant can be deployed to
  - Use centralised fans and heat exchange facilities in the energy centre to recover the heat from strong TC solution and deliver warm air through ductwork to all apartments
  - Use a centralised pumping station within the energy centre that would pump strong solution to all apartments whereby a heat exchange facility in each apartment would recover the heat from strong solution and heat the apartment.

It was concluded that the second option would be best from practicality and east of operation.

- For type 2 towers (that are a 3km walking distance from Science Central) it is again possible to extend a TC network which supplies type 1 towers to reach type two towers too (see fig 19).
- A similar energy centre could be constructed with piped distribution networks to all 180 apartments on type 2 towers.

It was also concluded that the drying properties of TC heating solution benefited all 5 towers in two ways:

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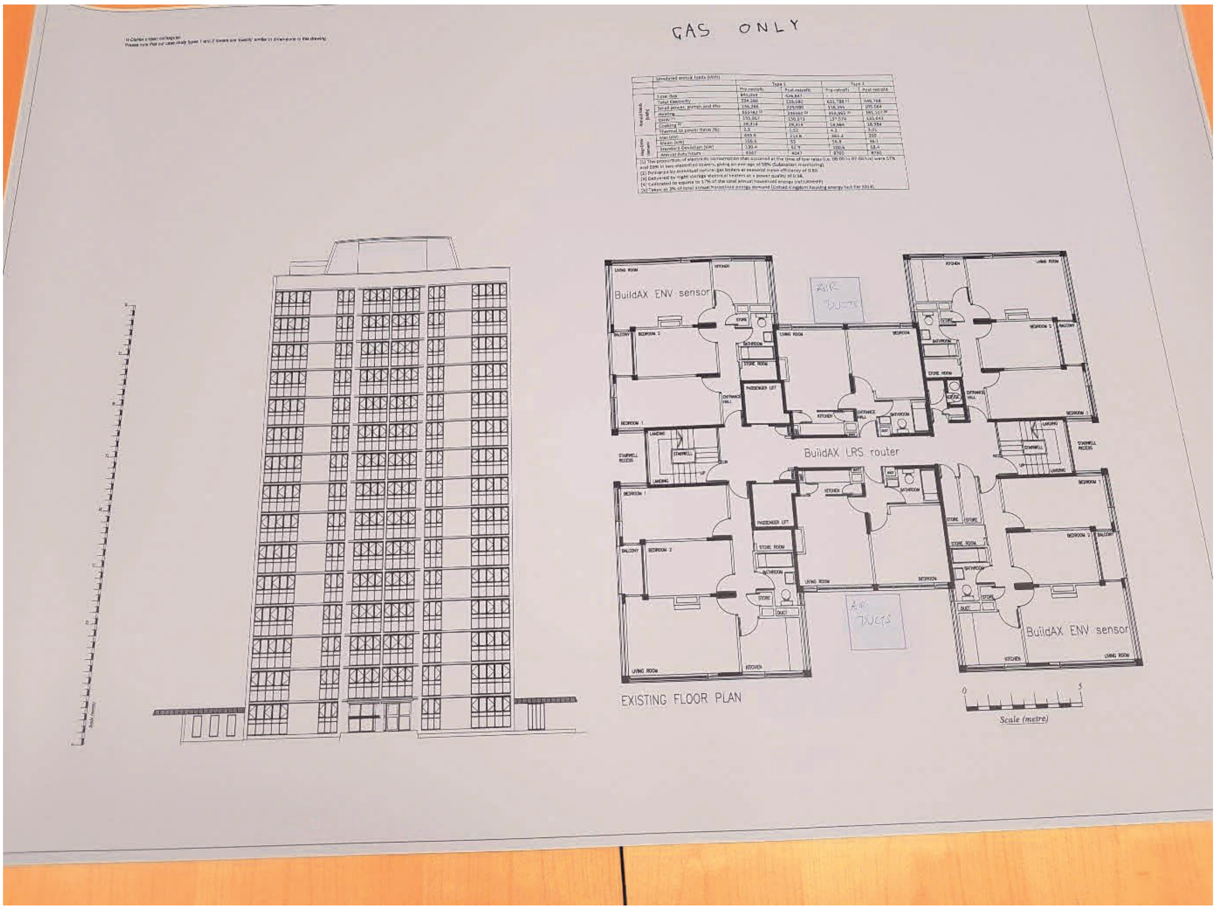
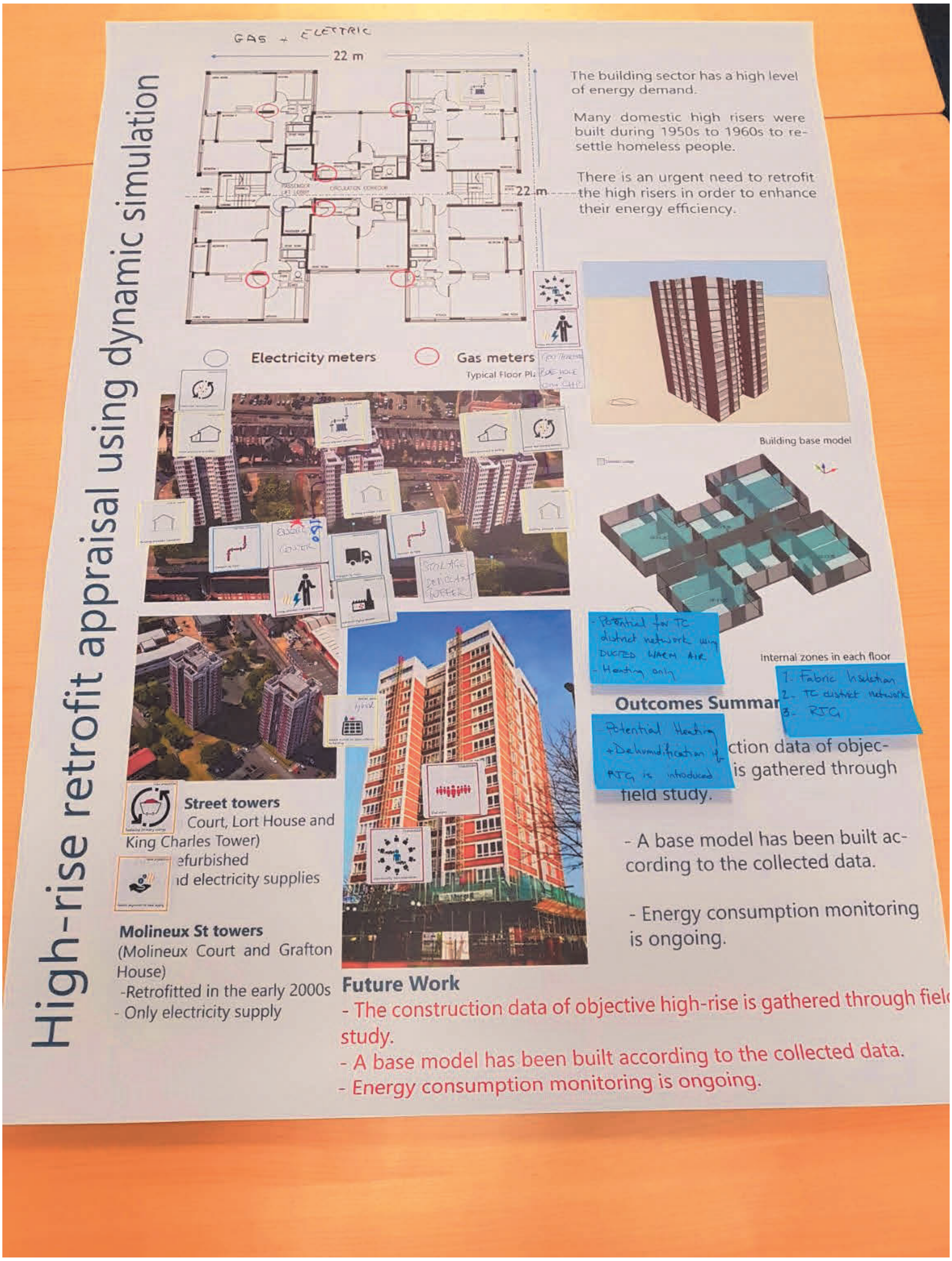
- Most apartments suffer from a degree of damp problems and this would be mitigated by the dry and warm air generated by the TC solution.
- Previously talks were held between the tower owners and research teams at Newcastle University on the possibility of integrating a rooftop greenhouse into each tower to act as a social space, also to encourage people to grow some of their own food and support individuals with socio-economic and medical problems. The TCN could also aid to improve the indoor environmental condition of a rooftop greenhouse by helping to heat and dehumidify its climate.





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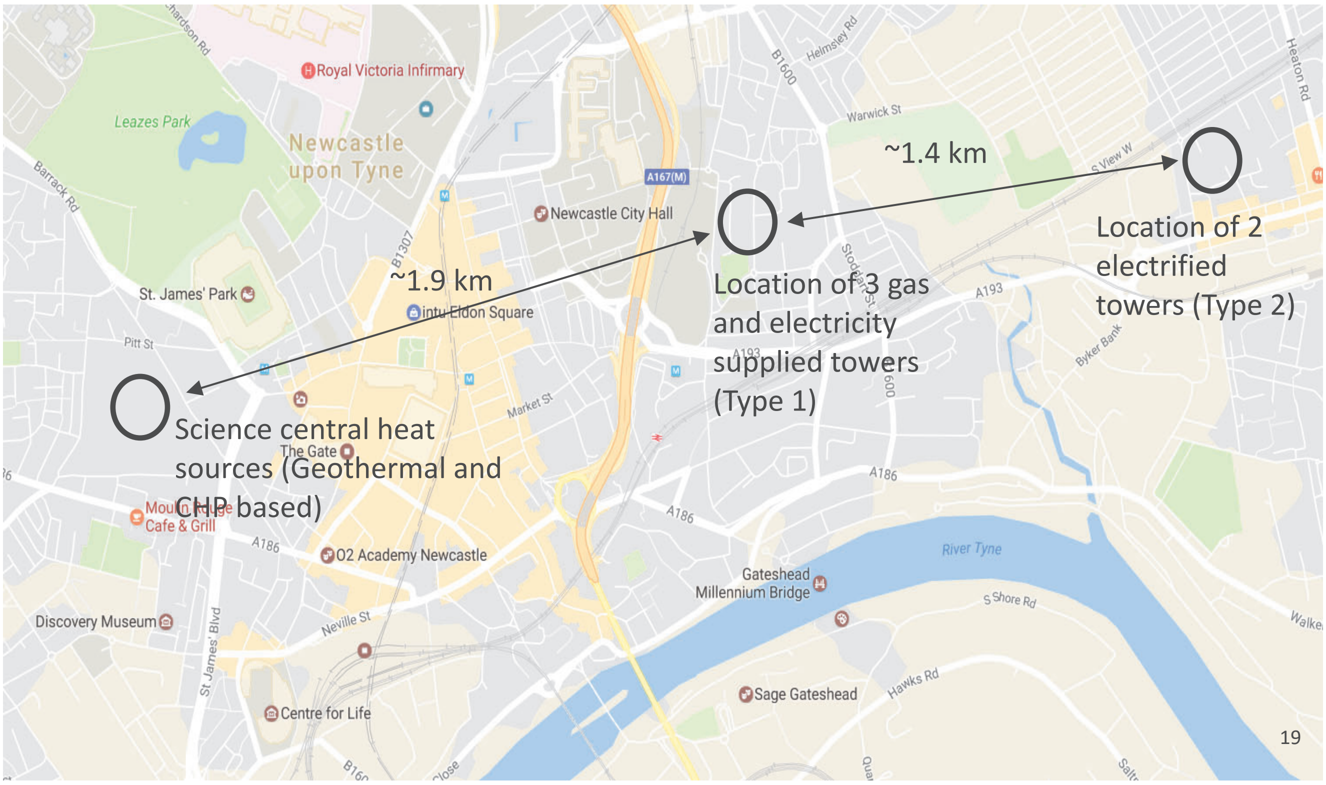

Conclusions

The workshop identified high potential for the thermo-chemical technology in the discussion of the 5th generation district networks in specific applications complementing conventional thermal technology. For instance, drying, humidity control but also specific applications of heating and cooling show this potential. This potential could be qualitatively validated in the case discussion in the second part by means of the urban cases and their specific conditions.

Furthermore, barriers that need to be tackled in further development of the technology have been identified. For both, heat supply in future networks with lowered temperature and especially within cooling networks, the low temperature difference in the network has been discussed as a main barrier for application that needs thorough consideration in further development. In this situation, the potential of combined thermal/thermo-chemical networks shows the highest potential, as the TCF part of the supply will be given at remaining heat density and by this may provide a large share of the total network energy capacity.

Furthermore, the complexity of the system needs to be tackled on a technology level as well as actions to provide people with indispensable understanding of the technology. Beside further explanation, the demonstrators will play a crucial role to further promote the technology. Industry with high share of

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low temperature residual heat will need to invest in demonstrators for further promotion of the technology. This will show how to valorise the potential of thermo-chemical technology and to provide it to prospective customers.

In summary, the technology has the potential to play a complementing role in conjunction with thermal district energy technology. A further examination and demonstration of specific beneficial applications is the key to exploit the technology for reduction of primary energy demand and end user costs.

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