The Work on 4GDH within IEA District Heating & Cooling programme and DHC+ Technology Platform

Robin Wiltshire
BRE
Building Futures Group
3 October 2012

IEA-DHC initiatives

Introducing two current cost-shared IEA-DHC projects

- ‘Towards 4th Generation District Heating (4GDH): Experiences with and Potential of Low Temperature District Heating Case studies’
- ‘Economic and Design Optimisation in Integrating Renewable Energy and Waste Heat with District Energy Systems’

And one new task-sharing initiative

- ‘Smart DHC Networks in Low Temperature Energy Systems’

DHC+ Technology Platform initiatives

The Next DHC Generation, 9-10 October 2012. Topics include:

- Smart Cities
- Future thermal demands
- Integration of electrical and thermal networks
- Solar DH
- Smart comfort
- Smart Cooling
- ‘Economic and Design Optimisation in Integrating Renewable Energy and Waste Heat with District Energy Systems’

Applications being co-ordinated to EU Smart Cities Call

District heating development

– Heat carriers and operational temperatures used in DH have evolved

- **1GDH**
  - Steam
- **2GDH**
  - Pressurized Water
  - (tf ≈ 120 °C - tr ≈ 70 °C)
- **3GDH**
  - Pressurized Water
  - (tf ≈ 90 °C - tr ≈ 40 °C)
- **4GDH**
  - Pressurized Water
  - (tf ≈ 55-50 °C - tr ≈ 30-25 °C)

3G District Heating

– 3G (Conventional) District Heating already offers benefits from demand aggregation and use of residual heat

– Currently Low Exergy Demand is met by High Exergy Sources.

  – Heat required: ≈20˚ C
  – Heat supplied: ≈90˚ C

– It would be more efficient if low quality demand could be met with low quality supply

Low temperature district heating

- 4GDH reduces difference between quality of the supply and demand
  - Heat required: ≈20° C
  - Heat supplied: ≈50° C
- Expands range of usable sources
  - Low grade process heat (e.g. 50-70° C)
  - Renewable energy sources can be directly used
  - Energy conversion efficiency (e.g. solar collectors)
  - System reliability
- Reduces cost of distribution
  - Plastic pipes
  - Heat losses
  - Thermal stresses

Low temperature district heating: Future scenario

- DH business case needs adequate demand density kWh/(m year)
- Reduction of heat demand from energy efficient buildings
  - Cost of DH heat reduces as density of demand increases
  - Cost of DH heat may be not competitive for single building solutions in low density areas
- Reduction of heat losses to gain competitive advantage
  - Low temperature
  - Twin pipes & triple pipes (not commercially available as yet)
  - Small diameter pipes

Low temperature district heating: Future scenario

- Smart Thermal Grids
  - Multiple sources (renewable, residual heat from industry)
  - Virtually any building can be a source or storage of low grade heat
  - Bi-directional energy flows
  - Controls to integrate infrastructure, storage, multiple demand and multiple supply
- Integration with Smart Electric Grids
  - Enhances reliability and stability of power grids

Towards 4th Generation District Heating (4GDH): Experiences with and Potential of Low Temperature District Heating

– Focus is on very low temperature (supply 50° – 55 ° C) systems

– Goal is to bring experience, knowledge and solutions for 4GDH to a level where they are ready for much wider implementation

– Assemble information and analyse lessons from early exemplar schemes, which are mostly high efficiency new-build

– Determine what the practicality is for extending to lowering the supply temperature of existing ‘conventional’ district heating systems?

– Extends locally available useful sources of **residual and renewable heat**.

Economic and Design Optimisation in Integrating Renewable Energy and Waste Heat with District Energy Systems

- Increase awareness and knowledge about integration of renewable and waste heat in district energy systems.
- Framework for evaluating renewable and waste heat options, including integration of multiple sources.
- Identify key design issues: interface between energy source and network, influence of supply and return temperatures.
- Recommendations for improving software systems to optimise use of renewable energy and waste heat in district energy systems.

Economic and Design Optimisation in Integrating Renewable Energy and Waste Heat with District Energy Systems – some issues (1)

- CCGT with available waste heat not utilized in nearby DH system.
- Industrial waste heat source that has no adjacent district energy system
- Return temperature too high to enable condensing waste heat recovery from boiler flue gas or the operation of heat pumps.
- Renewable or waste heat source at too low temperature to meet supply water temperature requirements for a portion of the time.
- Waste heat source is intermittent and/or very large relative to the heat load in the surrounding area, especially in the summer.
- Condensing heat recovery creates emissions issues when integrated with the combustion of renewable solid fuels with high moisture content.

Economic and Design Optimisation in Integrating Renewable Energy and Waste Heat with District Energy Systems – some issues (2)

- Renewable wind power curtailed when that excess power could instead be consumed in a district energy network instead.
- Integration of renewable and waste heat sources complicates system dispatch and operation.
- Capacity of available renewable or waste heat source is not sufficient to serve peak load requirements of the DH network.
- No readily available supply of renewable fuel that can be purchased for the district energy network on long term contract at a fair price.
- The renewable or waste heat source is at the fringe of a district energy network where network doesn't have the capacity to receive it all.

Task-share in planning: Low Temperature District Heating for Future Energy Systems

- Will amplify the work of the existing 4GDH project
- Fundamental link between **low temperature systems**, **integration of renewables**, thermal storage, heat demands of future buildings…
- … all of which together imply the need for research areas on Methods & Planning Tools; DHC Technologies; Communities and Interfaces
- IEA-DHC is still planning this initiative, so if you are interested in joining please contact me or dietrich.schmidt@ibf.fraunhofer.de

Low temperature, renewables based exemplar DH systems

– Well-documented examples include the scheme at Lystrup that is connected to the **existing district heating** system

– Pilot schemes also include **solar thermal** scheme at Okotoks (Canada)

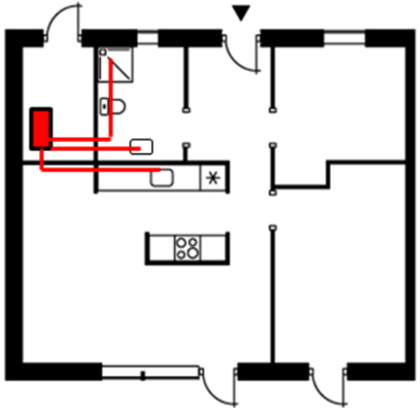
– and the ‘zero carbon’ development at Greenwatt Way in Slough (UK) using **biomass, heat pumps** and **solar thermal**

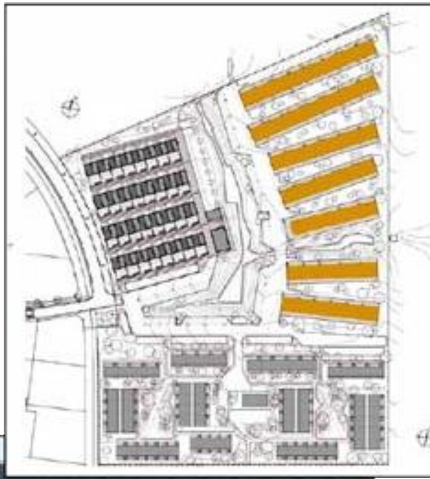
– However, there also examples where low temperature systems have been chosen historically due to a particular source supply temperature, eg Kysehir - **geothermal** and Heerlen - **minewater**

– Existing schemes, often over-engineered, may also benefit financially from reducing supply temperatures

LTDH Experiences: Lystrup, Denmark

- Monitored throughout 2011
- 40 terraced single family houses
- Combination of radiators (55° C-25° C) and under-floor heating
- DHW layout minimises volume of stored water and allows for separate pipes for each fixture

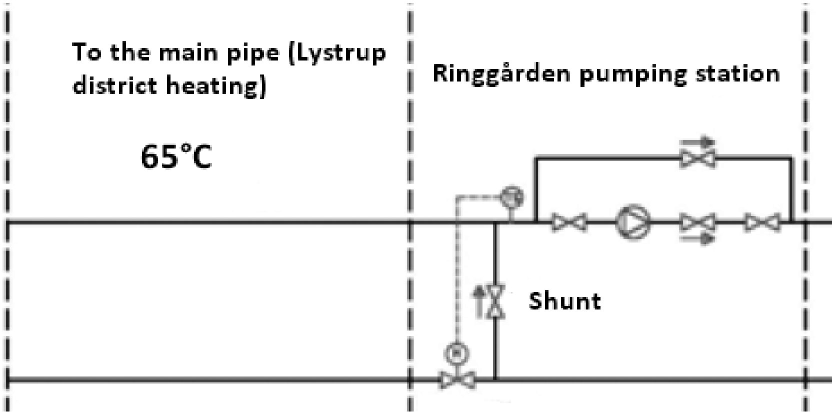




LTDH Experiences: Lystrup, Denmark

– Scheme is integrated with the municipal medium temperature DH

– Low temperature is achieved by means of mixing shunt which lower water temperature from 65˚ C to 55˚ C



LTDH Experiences: Lystrup, Denmark

- Heat losses reduction of 75% to conventional 80/40°C Danish DH achieved with low temperature and design optimisation
- Space heating consumption higher than expected: average internal temperature 2°C above design internal temperature
- Customers satisfied with performance of SH and DHW
- It is important to guarantee proper functioning of substations. Return temperatures have been at some times higher than expected in response to substation malfunctions
- Small pipe lengths reduce water stored volumes for Legionella issues

Kirsehir, Turkey, Case Study

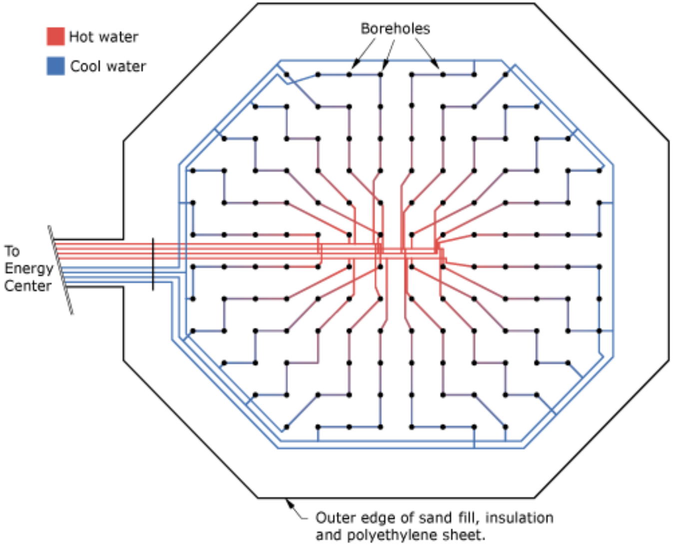
- Availability of geothermal heat at 57 °C was the driver for this low temperature system (back-up boilers can increase this to 61 °C)
- It was estimated that this would be sufficient to satisfy the heating requirements of existing housing since the radiators were sufficiently over-dimensioned. Design temperature -12 °C same as Denmark
- In operation since 1994 without customer complaint
- Relatively high return temperature of about 40 °C – but hardly matters due to geothermal source
- Investments in geothermal systems in Turkey have 5-8 year payback

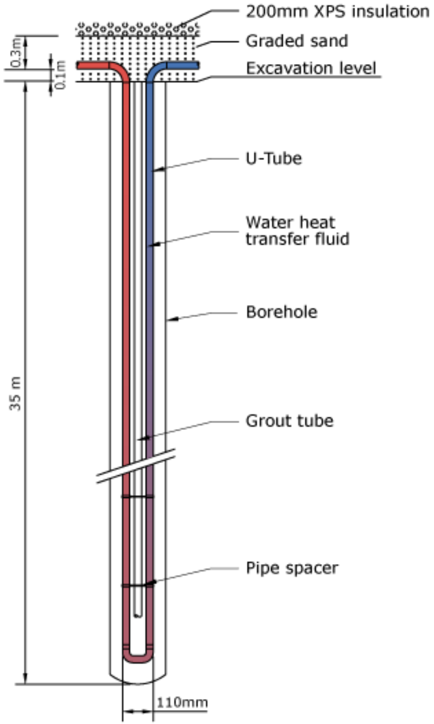
LTDH Experiences: Kırşehir, Turkey

- Kırşehir DH supply heat and DHW to 1800 pre-existing buildings
- Heat from nearby geothermal wells at 57°C (at relatively low depth) and two oil fired backup boilers
- Geothermal and distribution lines interface with plate heat exchanger
- Fibreglass-reinforced polyester and pre-insulated steel single pipes in distribution line

LTDH Experiences: Okotoks, Canada

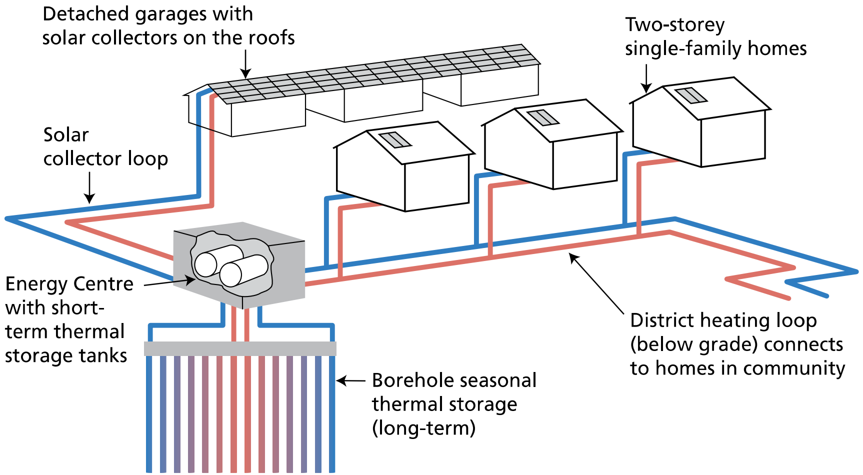
- 52 detached energy efficient homes
- 90% of space heating demand is met by Solar Thermal
- All air space heating with LTDH at 55° C flow and 32° C return
- Short term and seasonal storage used





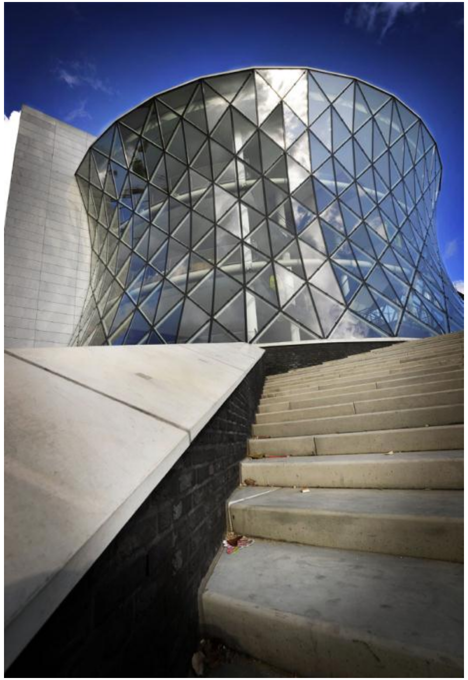
LTDH Experiences: Okotoks, Canada

– Solar thermal district heating project
– 52 detached energy efficient homes
– 90% of space heating demand is met by solar thermal
– Space heating with air-handling unit designed fed via DH network
– Solar thermal DHW provided by buildings installation



Heerlen Minewater DHC System

- low temperature district heating and high temperature district cooling
- principal source is water from disused mines then heat pumps
- 28° C from hot wells
- 18° C from cold wells
- common return re-injected at 24° C



Chalvey Case Study

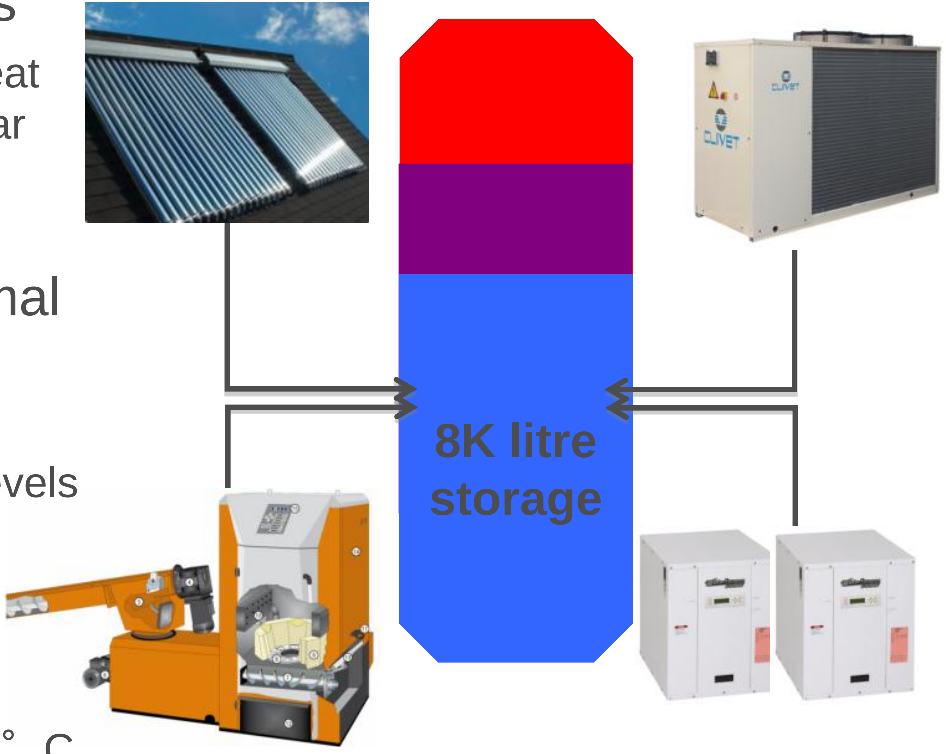
- Chalvey Zero Carbon Homes DH system is an experimental development that aims to demonstrate that Zero Carbon can be achieved with district heating
- supplied by biomass pellet boiler, ground source heat pump, air source heat pump, with some solar thermal
- Comprises 10 homes built to very high level of energy efficiency
- Operating supply temperature of 50 ° – 55 ° C
- Lowering the return temperature crucial to plant efficiency, minimising pipe sizing and pumping energy.

LTDH Experiences: Chalvey, UK

- Demonstration project aimed to study energy usage in zero carbon houses
- 8 Code 6 single family houses & 2 flats
- Single Radiator per house operating at 55° C integrated with MVHR system
- DHW delivered at 43° C at the tap

LTDH Experiences: Chalvey, UK

– Heat from standalone renewables
  – Ground Source Heat Pumps (Main Heat Source), Air Source Heat Pumps, Solar Thermal Panels, Biomass boiler
  – Integration via 8K litre thermal store
– Complex control strategy of thermal storage
  – Running mostly on GSHP
  – Solar Thermal to boost temperature levels of stratified storage
– Challenges in achieving low temperature return
  – Average return temperature about 35° C



Chalvey Case Study

Chalvey Case Study

– Headline result so far is simple: it works! There are no apparent difficulties with 50 ° – 55 ° C supply for new-build

– Thermal store means plant can run when its most advantageous: solar thermal when its sunny, air source heat pump in the afternoon when the ambient temperature is highest

– The principal issue is achieving a low return temperature so as to achieve efficient performance of plant and thermal store.

And….

- Other examples of low temperature networks? Please let me know!
- IEA-DHC will be shortly be discussing topics for our next Three-year programme. Ideas welcome!

For more about the IEA-DHC programme, contact:

Robin Wiltshire (Chair, IEA-DHC) wiltshirer@bre.co.uk

Andrej Jentsch, AGFW (Operating Agent, IEA-DHC) IEA-DHC@agfw.de