EAUC CONFERENCE
DISTRICT HEATING AND LOW CARBON HEAT TECHNOLOGY OVERVIEW

DR JAMES DICKINSON

BUROHAPPOLD ENGINEERING

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AGENDA

- Drivers and Context
- District heating – History and Future
- Technology Overview
- District Heating and Existing Buildings
- Off site Connection Considerations

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Drivers and Context

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DRIVERS AND CONSIDERATION FOR HIGHER EDUCATION
ENERGY, UTILITIES AND DECARBONISATION

1. Operational

- Energy security – resilience (2N+1, etc.)
- Aging infrastructure and plant
- IPPC/ CHPQA
- Reliability
- Comfort

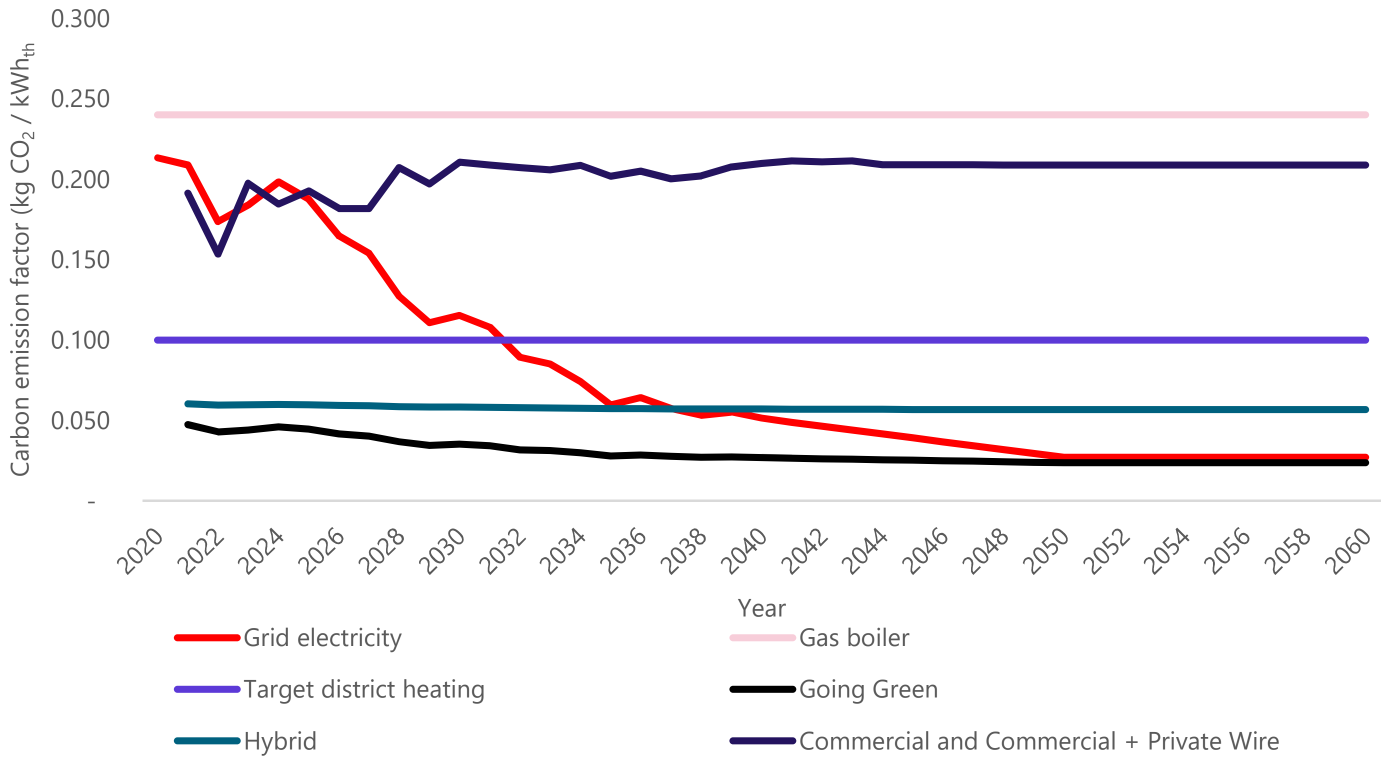
2. Cost Impact

- Reducing operational costs
- Impact of energy price volatility
- Reducing future reinforcement costs (new buildings/ expansion)

3. University Profile/ Perception

- Reducing carbon (gas versus electricity and decarbonisation of grid)
- Carbon Management Plans
- Increasing university placing in league tables
- Increasing research impact and credibility
- Showcasing new technology – creating a test bed and living laboratory

CARBON REDUCTION PROJECTIONS



- Aggressive introduction of nuclear
- Declining gas CHP impact
- Assumes no greening of gas networks – biogas and hydrogen
- Seasonal/ diurnal variability
- Electric heat?

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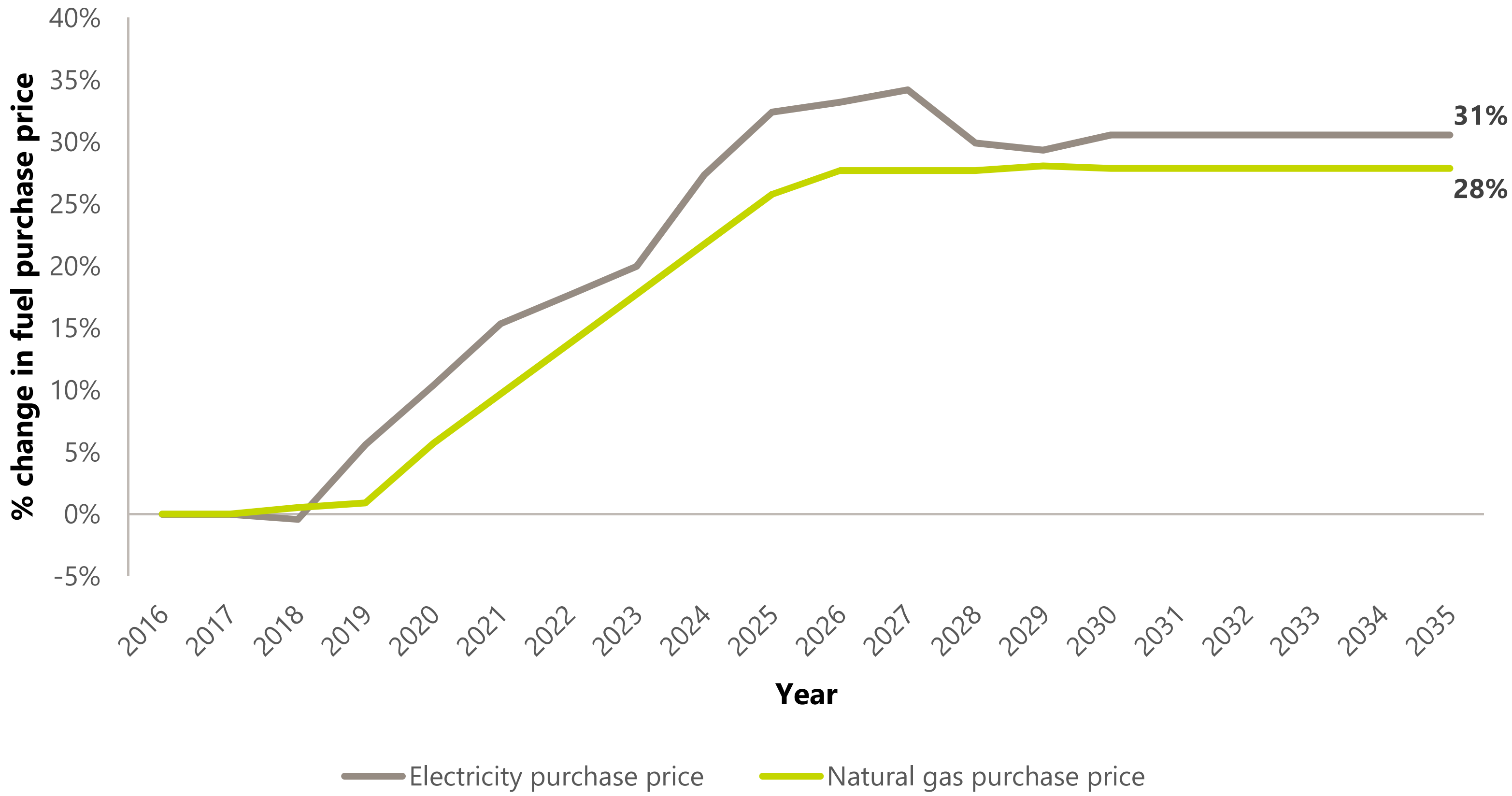
ENERGY PRICE PROJECTIONS



- Conservative energy prices?
- Sensitivity to shocks?
- Seasonal/ diurnal variability

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District Heating

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DEVELOPMENT OF DISTRICT HEATING

- Historical reduction in flow and return temperatures
  - Lower heat loss, pump power
  - Lower maintenance
  - Greater technology range
- 4th generation district heating (4GDH) – soon be considered best practice
- 5GDH now being considered to reduce flow to 40-50°C
- 6GDH Ambient loops - ~20°C (separate plant in buildings)

1GDH
- Steam

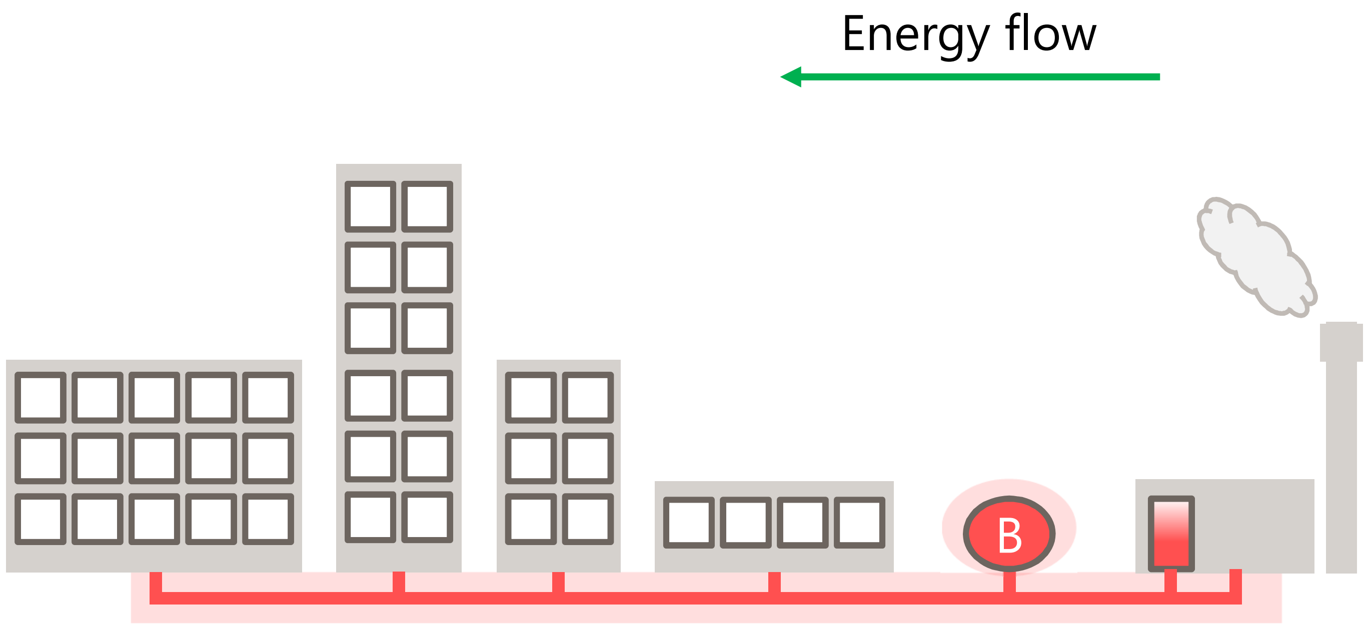
2GDH
- Pressurized Water
- (flow ≈ 120°C <-> return ≈ 70°C)

3GDH
- Pressurized Water
- (flow ≈ 90°C <-> return ≈ 60°C)

4GDH
- Pressurized Water
- (flow <70°C <-> return ≈ 40-35°C)

3G DHN SYSTEM

- Centralised energy centre
- Mature Gas CHP and boiler plant most common heat sources, efficiently achieve flow temperatures of ≈ 90°C
- Biomass can be used to reduce carbon factor for heat
- High temperature heat pumps could be used during mid and high season



4G DHN SYSTEM

- With a flow temperature of 70°C or below:
  - Significantly improved integration of heat pumps, solar, industrial heat
  - Reduced network losses
  - Reduced pipeline thermal stresses, less network maintenance and longer lifetime

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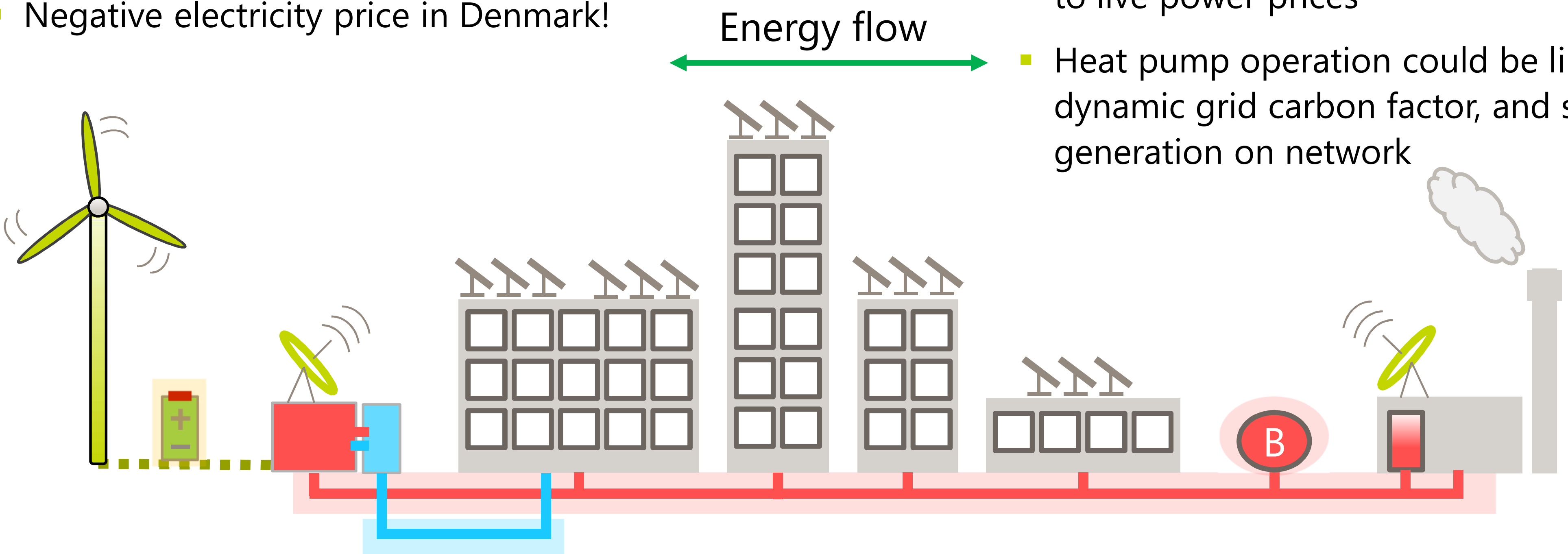
4G DHN AS PART OF A SMART ENERGY SYSTEM

- Reduction in grid export/ curtailment of electricity from renewables
- Negative electricity price in Denmark!

- Increased contribution from heat pumps improves the network's ability to respond to live power prices
- Heat pump operation could be linked to dynamic grid carbon factor, and self generation on network



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Technology Overview

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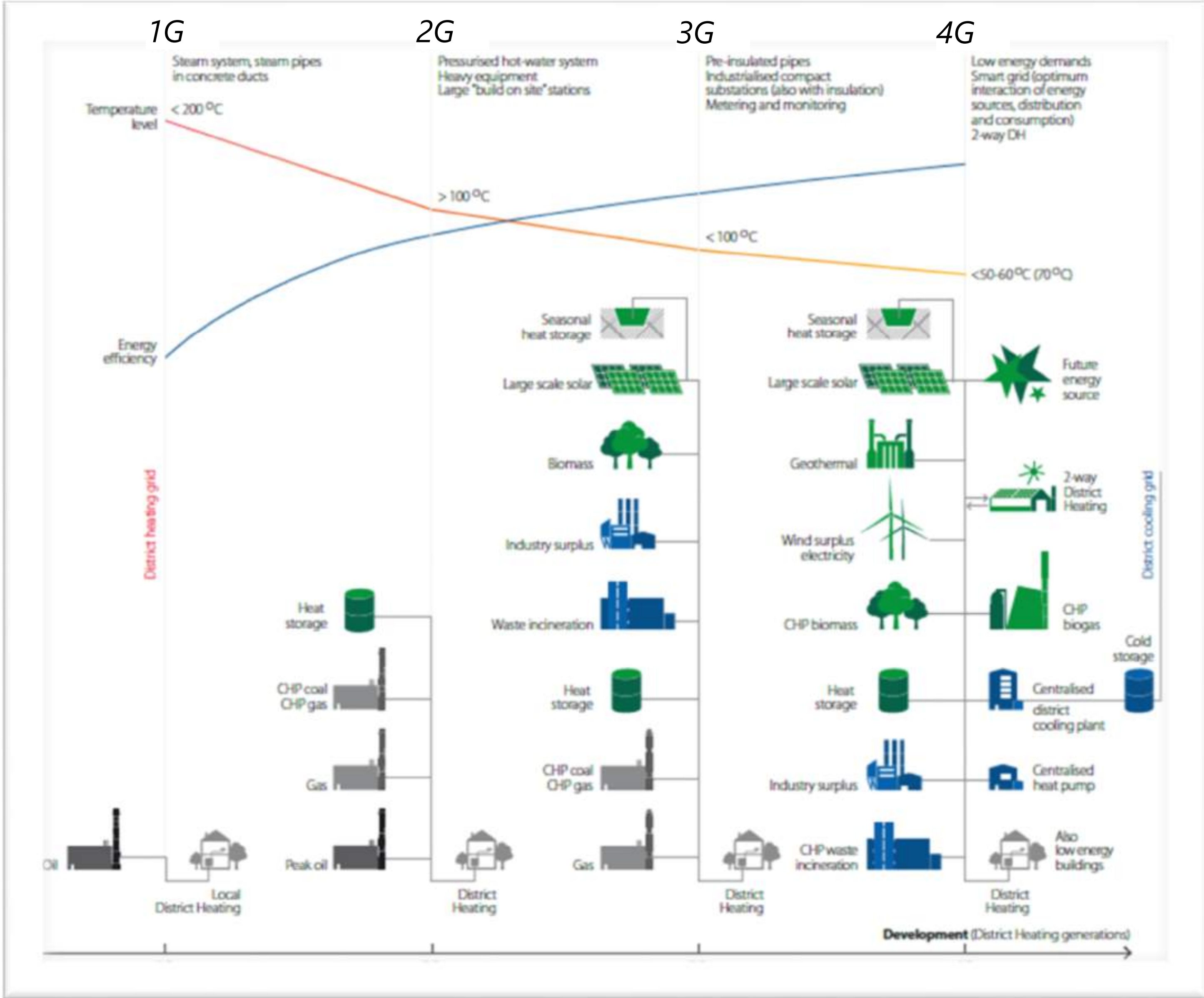
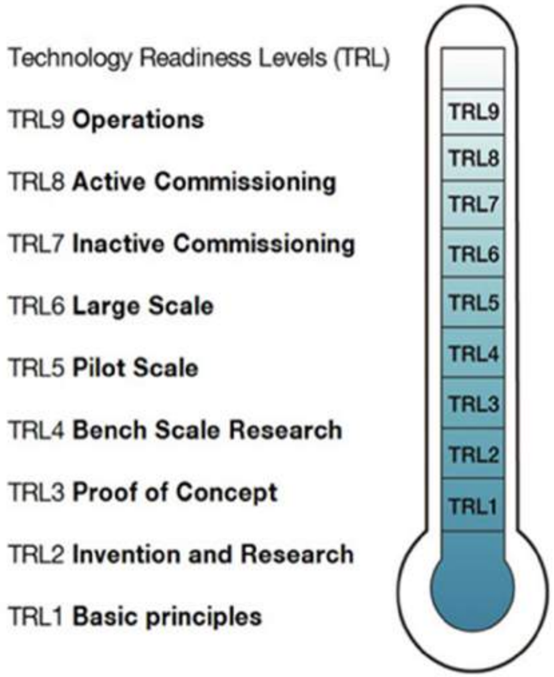
ALIGNING TECHNOLOGY TO DISTRICT HEATING SYSTEMS



- 4G networks are *"inclusive"*
- 3G networks are *"exclusive"*
- District heating is *"technology agnostic"* but buildings are not!

HOW DO YOU RANK THE MARKET READINESS FOR TECHNOLOGY?



TRL1-3: emerging concepts with mostly desktop analysis and small demonstrator units for "proof of concept" research

- Not recommended for near term consideration

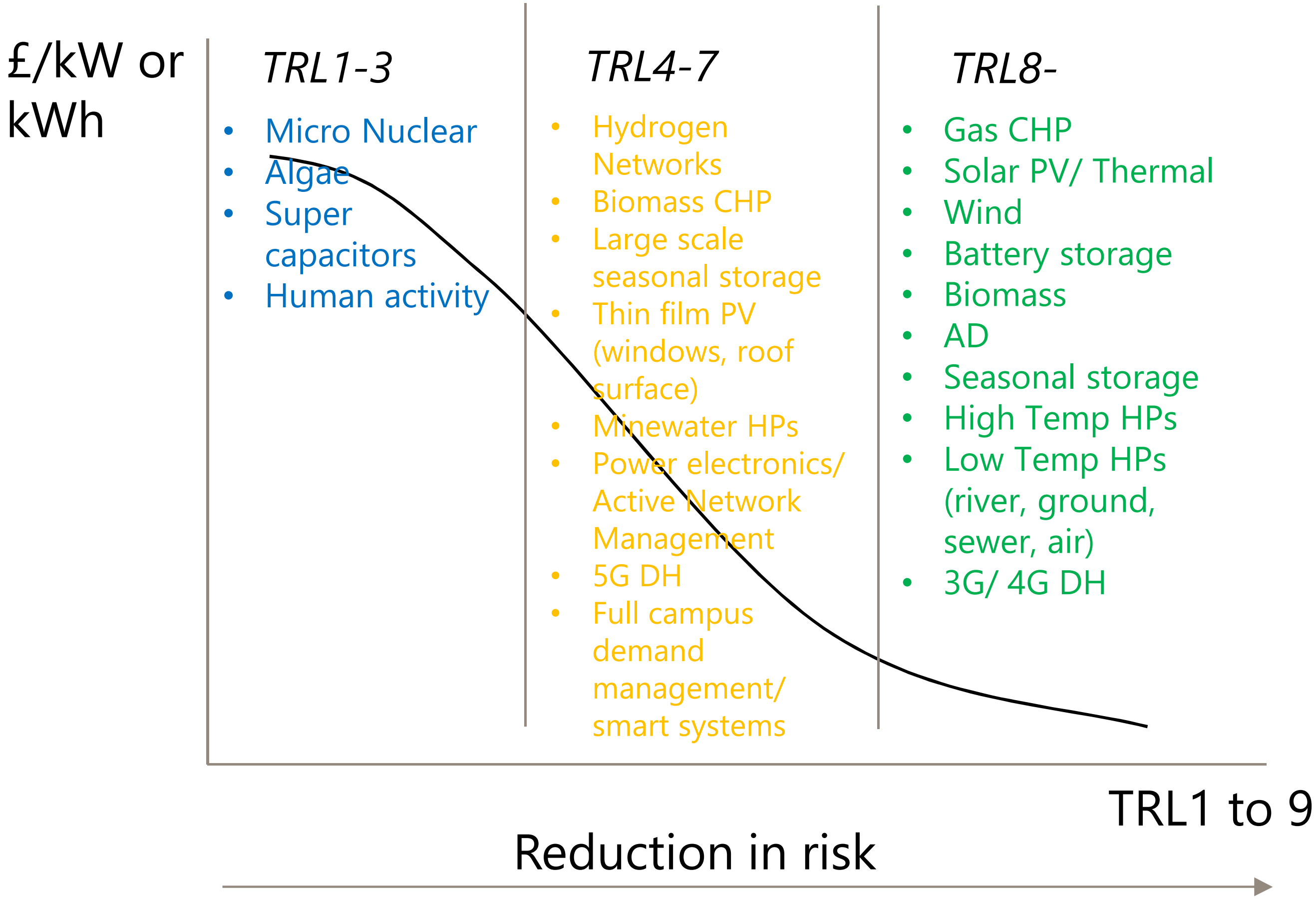
TRL4-7: full scale technology testing to refine the design and test performance and reliability in a near to real-life system

- Recommended if supplier/ manufacturer helps fund system and sufficient back up supply is provided

TRL8 and onwards: technology/ approach near ready for market and beginning to be mass produced by manufacturers at a lower cost with acceptable levels of performance to ensure higher reliability, efficiency and operational costs

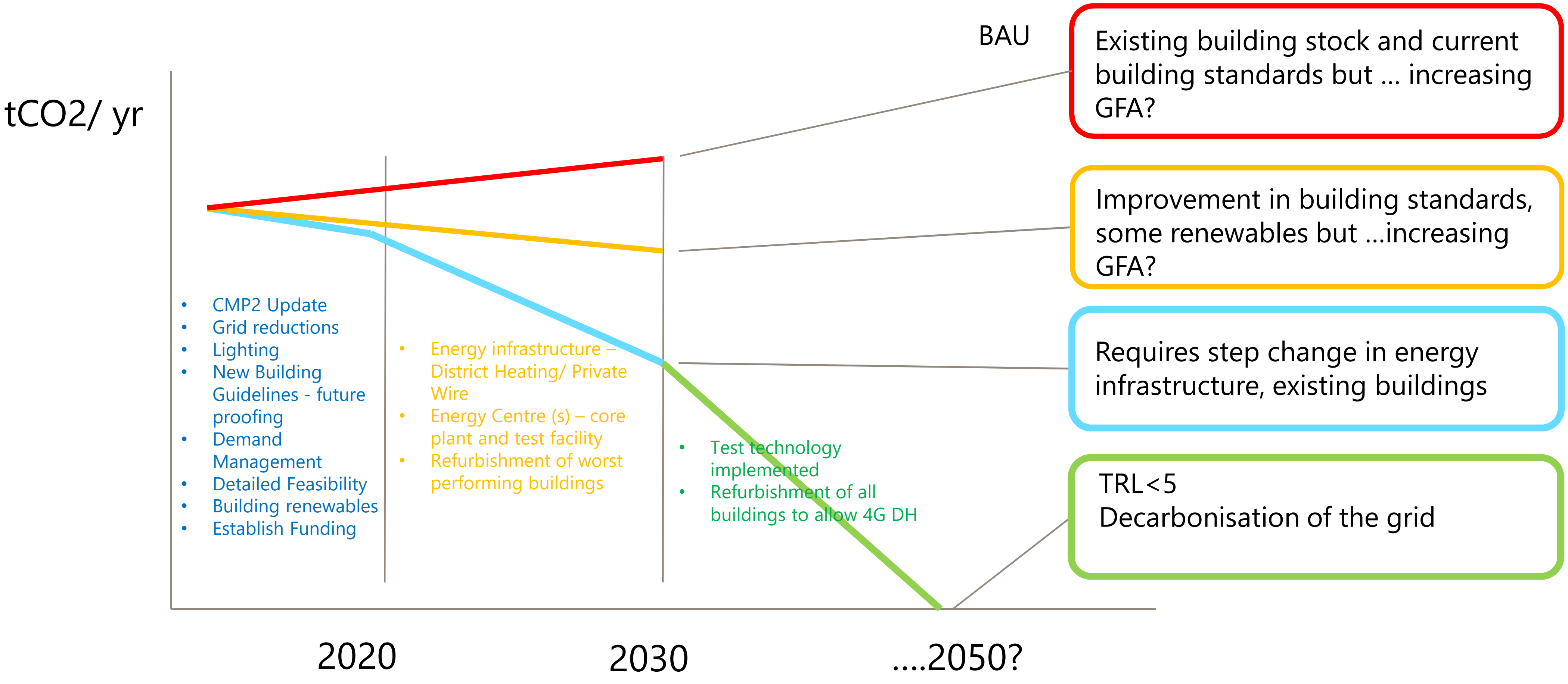
- Recommended if context is right, e.g. techno-economics, owner model, demand/ supply function, supplier support, scale of deployment

TECHNOLOGY COST AND RISK



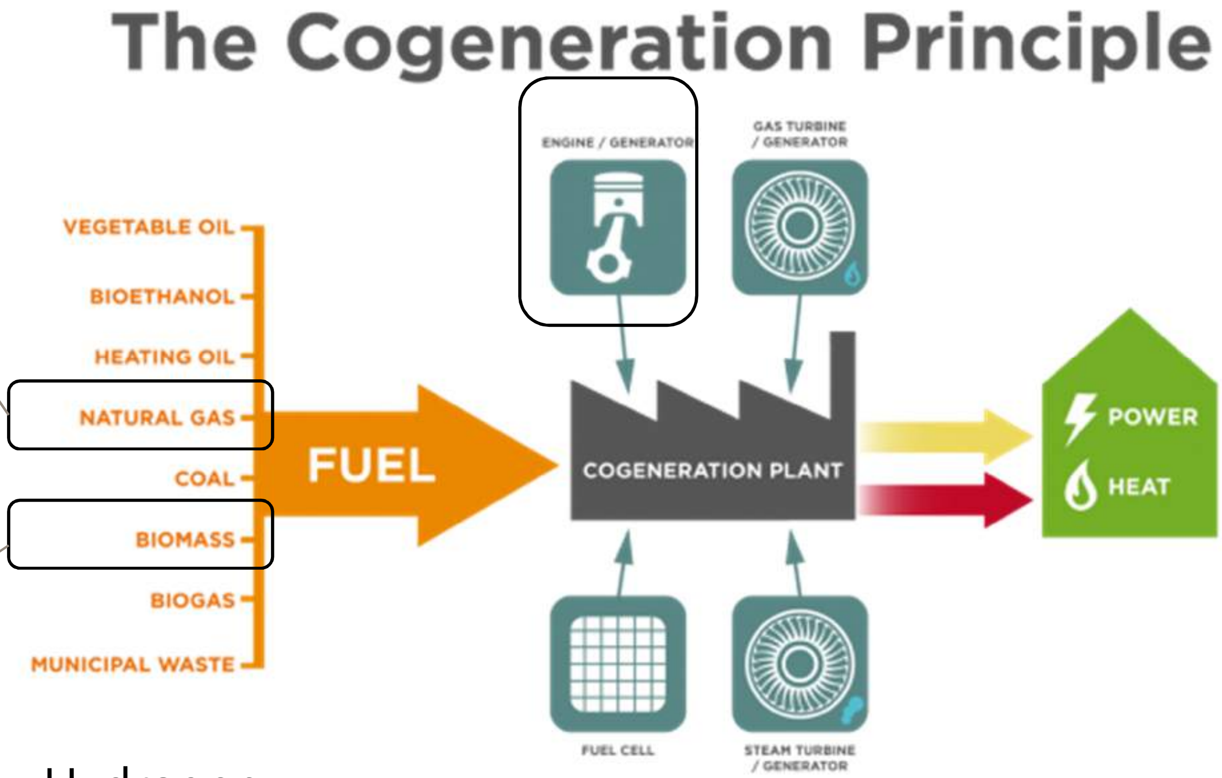
- Technology classification dependent on context and size
- Some technologies potentially TRL8 - e.g. Hydrogen FC, Biomass CHP in the right context

ENERGY TRANSITIONS – TIMING



CHP – GAS AND BIOMASS

Tried and tested



Hydrogen...

Reliability, cost issues

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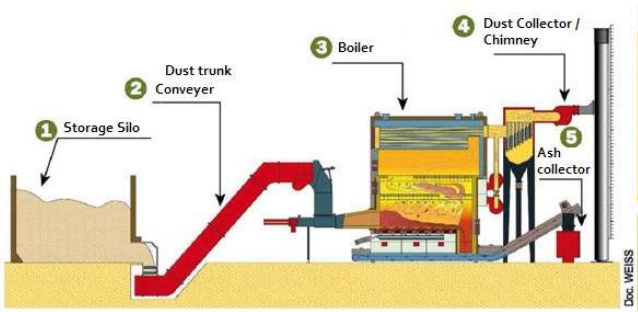
BIOMASS – SPLITS OPINION



- Considerations:
  - Chip or pellet
  - Moisture content
  - O&M
  - Long term pricing
  - Supply Chain
  - Air quality in urban environment
  - Vehicle deliveries
- Mature fuel supply chain in Scotland
- Standardised technology – Heat
- Variability – Heat and Power

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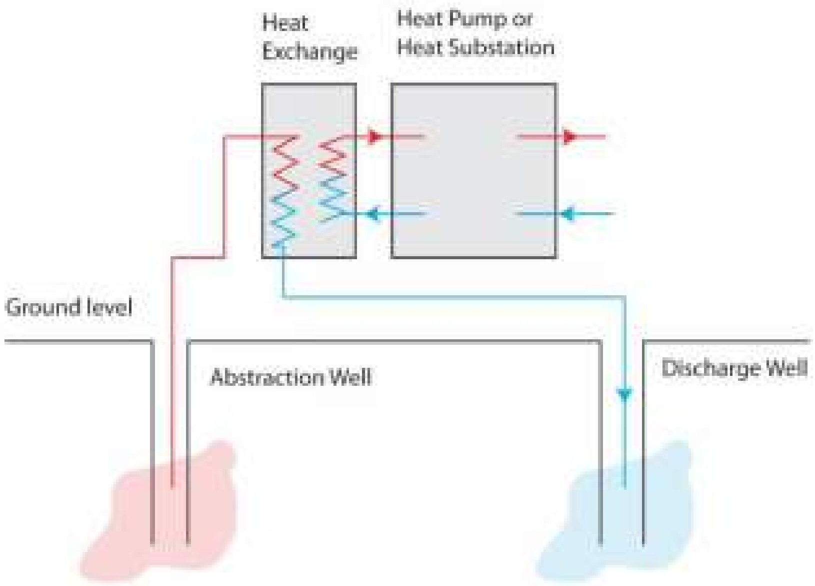
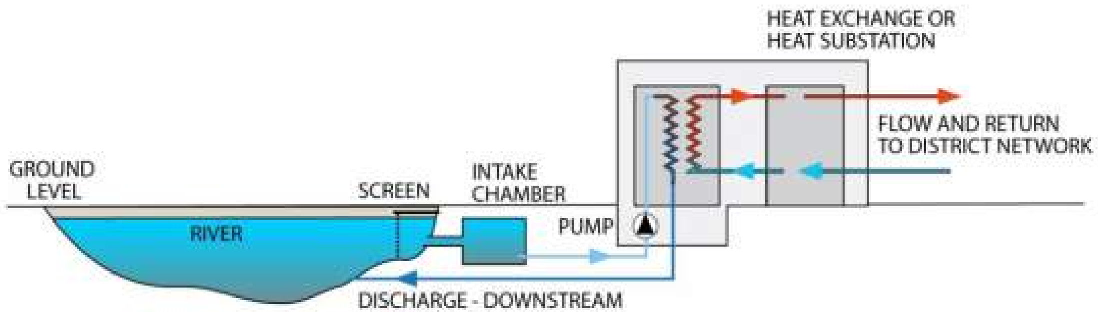
HEAT PUMP VARIATIONS (1)

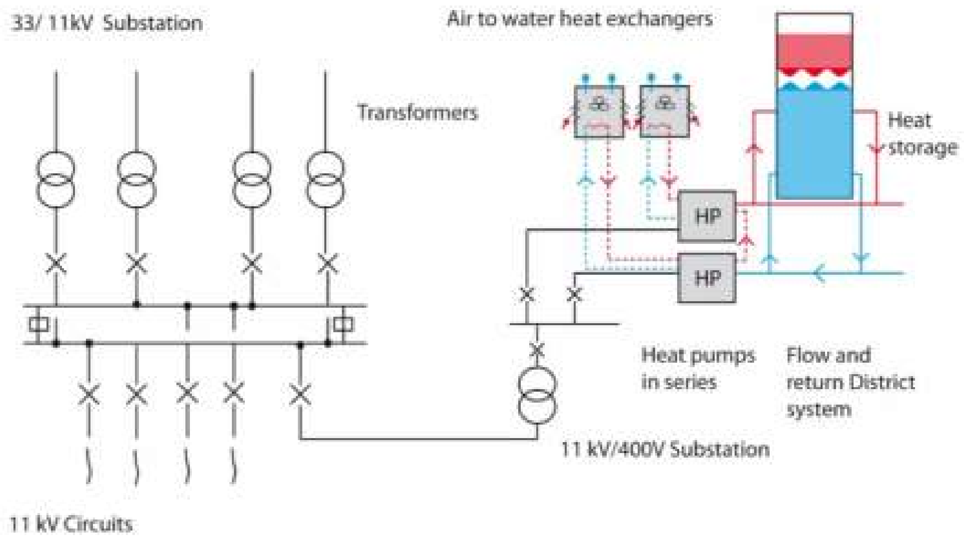


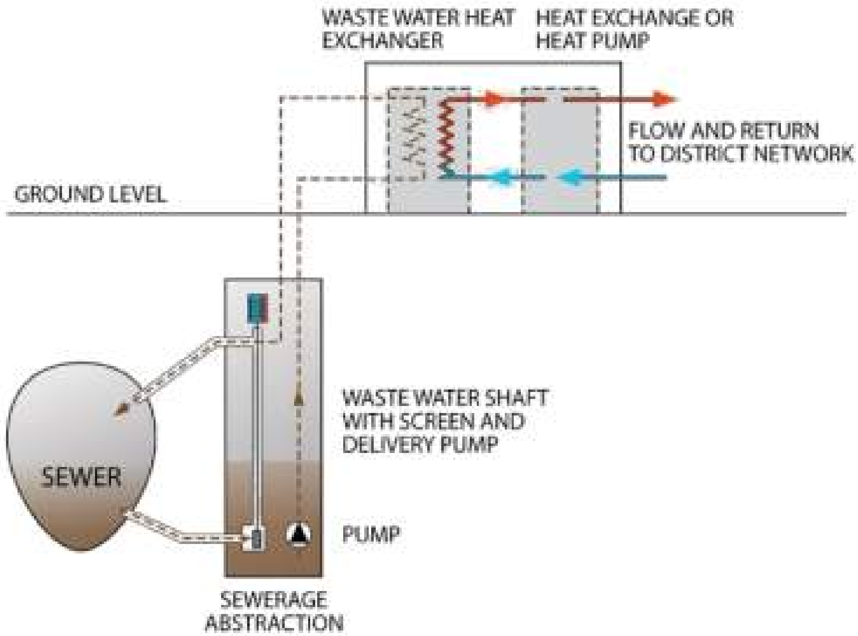


Closed/ Open Loop:
Active storage

Surface Water:
e.g. river, lake, canal, sea

HEAT PUMP VARIATIONS (2)





Substation Heat

Sewer Heat

Others;
air, minewater, heat recovery, waste heat from industry

District Heating and Existing Buildings

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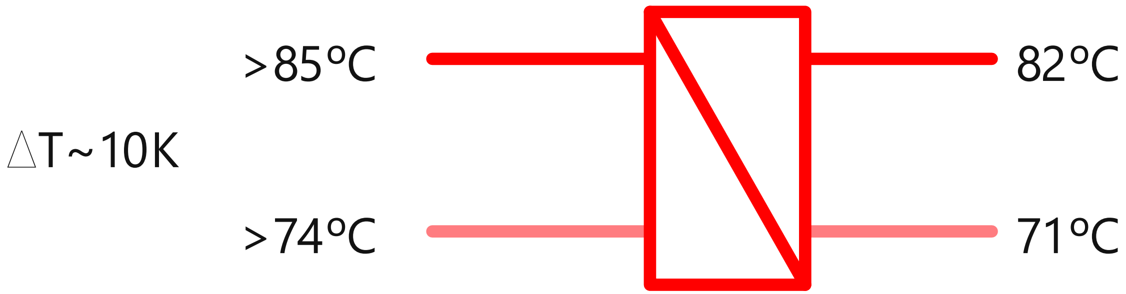
EXISTING BUILDINGS

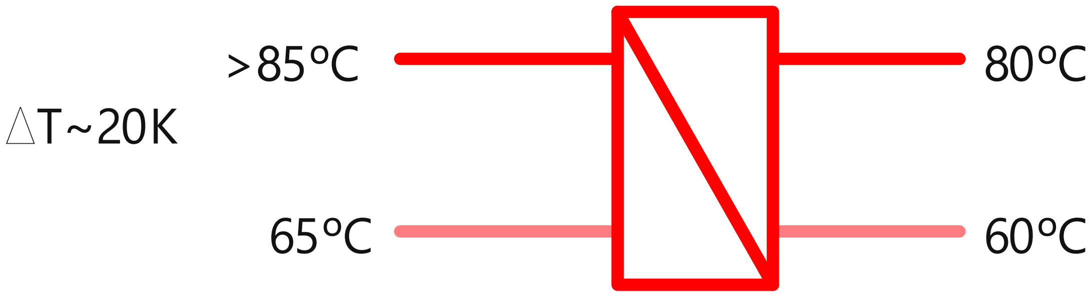


2-pipe/ single pipe, 2 Port

Not optimised for district heating:

- high flow temperatures
- poor plant efficiency, CHP operation
- poor dT – large flow rate and heat losses

CURRENT BUILDING DESIGN

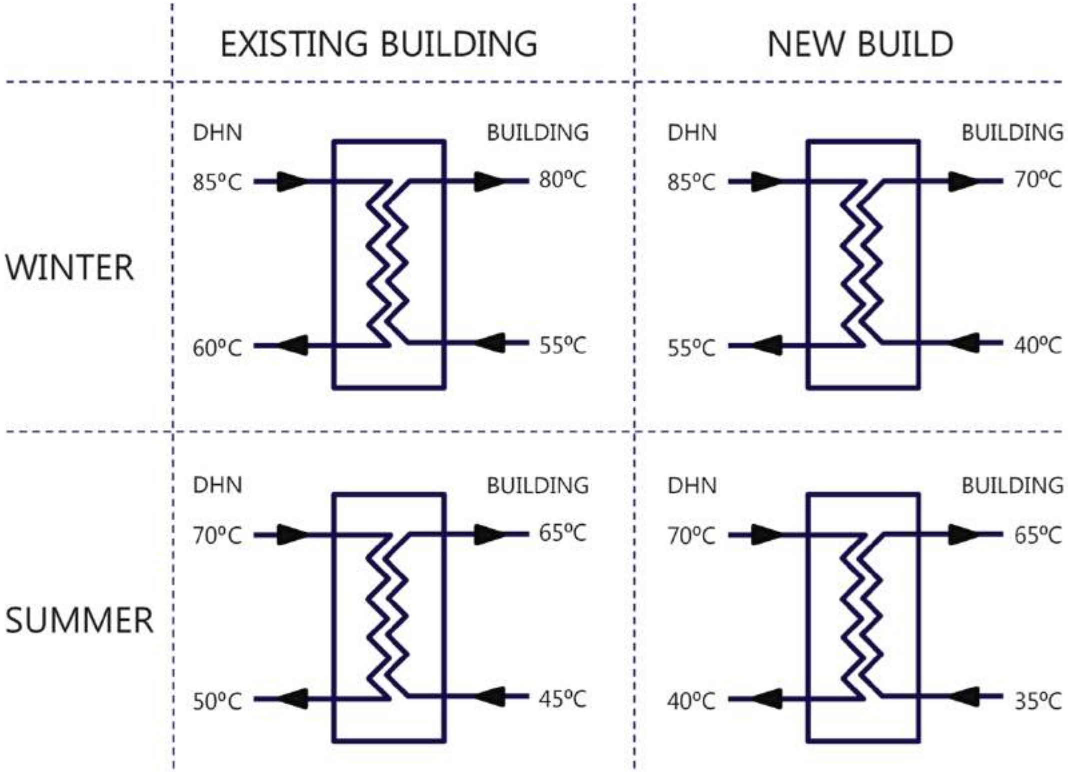


Blend of Space Heating and DHW (calorifiers)

2-pipe, 3 port, VSD

Not optimised for district heating:
- high flow temperatures
- limited dT – still large flow rates and heat losses

EXISTING AND NEW BUILDING



To reduce flow temperature all year round:

- Refurbishment of secondary side systems
  - Oversized radiators/ AHUs
  - Direct DHW
- Improved passive design, e.g.:
  - glazing (double/ secondary)
  - insulation (cladding, internal)

MODELLING CONVERSION OF EXISTING BUILDINGS
GLA STUDY – WITH STRATHCLYDE UNIVERSITY/ UCL

Table 9-1 Modelling results illustrating percentage of annual heat demand met at different heating supply temperatures.

Typology			Percentage of annual heat demand met				
			Baseline	70 °C	60 °C	50 °C	40 °C
Electric heating conversion	nd-2	Small office - Low eff - Heat pump	100%	98.8%	97.2%	89.9%	61.0%
	nd-5	Large Office - Low eff - Heat pump	100%	98.8%	97.2%	89.9%	61.0%
	nd-3	Small retail - Low eff - Heat pump	100%	98.8%	96.9%	86.7%	50.7%
	nd-9	Small office - Med eff - VRF	100%	98.8%	97.1%	89.7%	62.6%
	nd-13	Large Office - Med eff - VRF	100%	98.8%	97.1%	89.7%	62.6%
	nd-10	Small retail - Med eff - VRF	100%	98.8%	96.9%	86.7%	50.7%
	nd-6	Large retail - Low eff - VRF	100%	98.8%	96.3%	86.4%	53.4%
	d-2	House - Low eff - Panel heaters	100%	99.8%	98.2%	89.3%	59.7%
	d-8	House - Med eff - Panel heaters	100%	99.9%	99.0%	92.0%	66.6%
	d-14	House - High eff - Panel heaters	100%	99.8%	99.6%	96.7%	81.4%
	d-4	Low rise flat - Low eff - Panel heaters	100%	99.8%	98.7%	90.4%	59.6%
	d-10	Low rise flat - Med eff - Panel heaters	100%	99.8%	99.8%	92.3%	70.1%
	d-16	Low rise flat - High eff - Panel heaters	100%	99.9%	99.8%	98.8%	92.6%
	d-6	High rise flat - Low eff - Panel heaters	100%	99.8%	98.3%	89.4%	64.2%
	d-12	High rise flat - Med eff - Panel heaters	100%	99.8%	99.2%	93.7%	74.0%
	d-18	High rise flat - High eff - Panel heaters	100%	99.9%	99.7%	98.2%	89.7%
Gas heating conversion	nd-7	Small office - Med eff - Gas boilers	100%	98.8%	97.2%	89.9%	61.0%
	nd-1	Small office - Low eff - Gas boilers	100%	99.2%	97.8%	89.8%	60.0%
	nd-14	Large Office - High eff - Gas boilers	100%	99.0%	97.3%	89.9%	62.8%
	nd-11	Large Office - Med eff - Gas boilers	100%	99.0%	97.3%	89.9%	62.8%
	nd-4	Large Office - Low eff - Gas boilers	100%	99.2%	97.8%	89.8%	60.0%
	nd-8	Small retail - Med eff - Gas boilers	100%	98.8%	96.9%	86.7%	50.7%
	nd-12	Large retail - Med eff - Gas boilers	100%	99.6%	97.4%	88.7%	59.1%
	d-1	House - Low eff - Gas boilers	100%	99.8%	98.2%	89.3%	59.7%
	d-7	House - Med eff - Gas boilers	100%	99.9%	99.0%	92.0%	66.6%
	d-13	House - High eff - Gas boilers	100%	99.8%	99.6%	96.7%	81.4%
	d-3	Low rise flat - Low eff - Gas boilers	100%	99.8%	98.7%	90.4%	59.6%
	d-9	Low rise flat - Med eff - Gas boilers	100%	99.8%	99.8%	92.3%	70.1%
	d-15	Low rise flat - High eff - Gas boilers	100%	99.9%	99.8%	98.8%	92.6%
	d-5	High rise flat - Low eff - Gas boilers	100%	99.8%	98.3%	89.4%	64.2%
	d-11	High rise flat - Med eff - Gas boilers	100%	99.8%	99.2%	93.7%	74.0%
	d-17	High rise flat - High eff - Gas boilers	100%	99.9%	99.7%	98.2%	89.7%

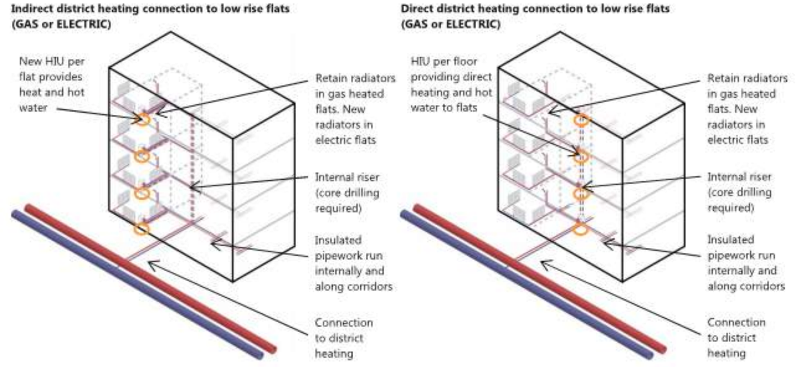


Figure 5-13 District heating connection strategy with indirect (left) and direct (right) connection into low rise purpose built flats

Table 9-6 Modelling results illustrating proportion of annual heat demand met after energy efficiency retrofit in low efficiency house model.

Low efficiency house	Percentage of annual heat demand	
	Baseline	40 flow
Baseline (no retrofit measures)	100%	59.70%
Half air infiltration	100%	68.70%
U-values to Part L1B	100%	86.40%
U-values to Part L1B + half infiltration	100%	95.90%
Passivhaus U-values	100%	94.60%
Passivhaus U-values + half infiltration	100%	99.80%

Table 9-4 Calculation in radiator size increase to meet 100% of the load in the low efficiency house typology living room.

Heating supply temperature	°C	82	70	60	50	40
Living room load (inc. 10% allowance)	W	1,166	1,166	1,166	1,166	1,166
Equivalent output needed	W	1,064	1,700	2,514	4,454	14,616
Number of radiators	-	2	2	2	3	6
Radiator output	W	654	872	1,268	1,550	2,490
Radiator width	mm	900	1,200	900	1,100	1,400
Radiator height	mm	450	450	450	450	600
Radiator depth to wall	mm	80	80	135	135	135
Radiator unit cost excluding labour	£	£23.23	£23.23	£38.14	£44.75	£68.61
Total cost excluding piping & labour	£	£46.46	£46.46	£76.28	£134.25	£411.66

PATHWAY TO LOW TEMPERATURE HEAT NETWORKS

Flow temp

85 °C

- Direct supply to existing buildings
- New buildings at 70/40 to assist return temperatures

70 °C

Replace existing building secondary systems to run at 70/40 e.g.:

- Isolate low loss headers
- Variable speed pumps
- Two port control / Thermostatic radiator valves (TRVs)
- Domestic hot water (DHW) plate to replace DHW cylinders

55 °C

Buildings at 55/25 through:

- Improved building Insulation – reduce rate of heat loss
- Instantaneous DHW
- Low temperature heat emitters

Off Site Heat Sales

OFF SITE ENERGY SALES

Benefits:

- Increase run hours and efficiency of plant and asset – mixed use development
- Increase revenue for university – heat and power sales
- Improve commercial viability
- Community link

Challenges:

- University becoming an energy supplier – not core business?
- Could be Local Authority scheme?
  - University becoming JV partner; or
  - Customer with long term heat (and power) purchase agreement
- Could be private sector scheme?
  - University offer long term heat and power load for competitive energy pricing
  - Lack of control over plant choice and future decarbonisation

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Summary

KEY POINTS

- **Need to decarbonise heat –** move away from fossil fuels
- **Decarbonisation of grid –** good for electric heat
- **District Heating –** step change in building systems:
    - *Existing buildings* **–** reduce heat loss, optimise secondary side system for DH
    - *New buildings* – future proof for future energy systems, e.g. DH
- **Build 3G now with 4G in mind** to allow transition to lower temperatures and higher dT in the future:
    - Use gas CHP initially (?) – DH network is for long term, plant is for short-medium term
- **Flexible supply -** important to avoid technology lock-in, no-regret
- **Research** – increase impact and profile
- **Major projects –** required to make significant carbon reductions

Q&A

james.dickinson@burohappold.com

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