International Conference on Smart Energy Systems and 4th Generation District Heating
Copenhagen, 25-26 August 2015

Heat Losses in District Heating Systems and Heat Meters

Oliver Martin-Du Pan

AALBORG UNIVERSITY
DENMARK

4DH
4th Generation District Heating
Technologies and Systems

Monitored Heat Losses are High

- Insulation Levels.
- Number of Heat Exchangers between the generated heat and the consumers which has for effect of increasing the flow temperature from the energy centre.
- Single pipe instead of double pipe configuration to supply the heat at two temperature levels: Space heating and the domestic hot water.
- Length of the pipes connecting:
  - Energy centre to substations;
  - Substations to Blocks;
  - Laterals to each Heat Interface Units.
- Oversized pipe diameters. The heat losses increase proportionally to the diameter of the pipes.
- Poor commissioning of every too simple heat interface units at the consumer. These are commissioned with a too high primary flow (~500 l/hr) with effect of reducing its cooling (less than ~2°C) while increasing the return temperature; thus the heat losses.

AALBORG UNIVERSITY
DENMARK

Do Heat Meters undermeter the Heat?

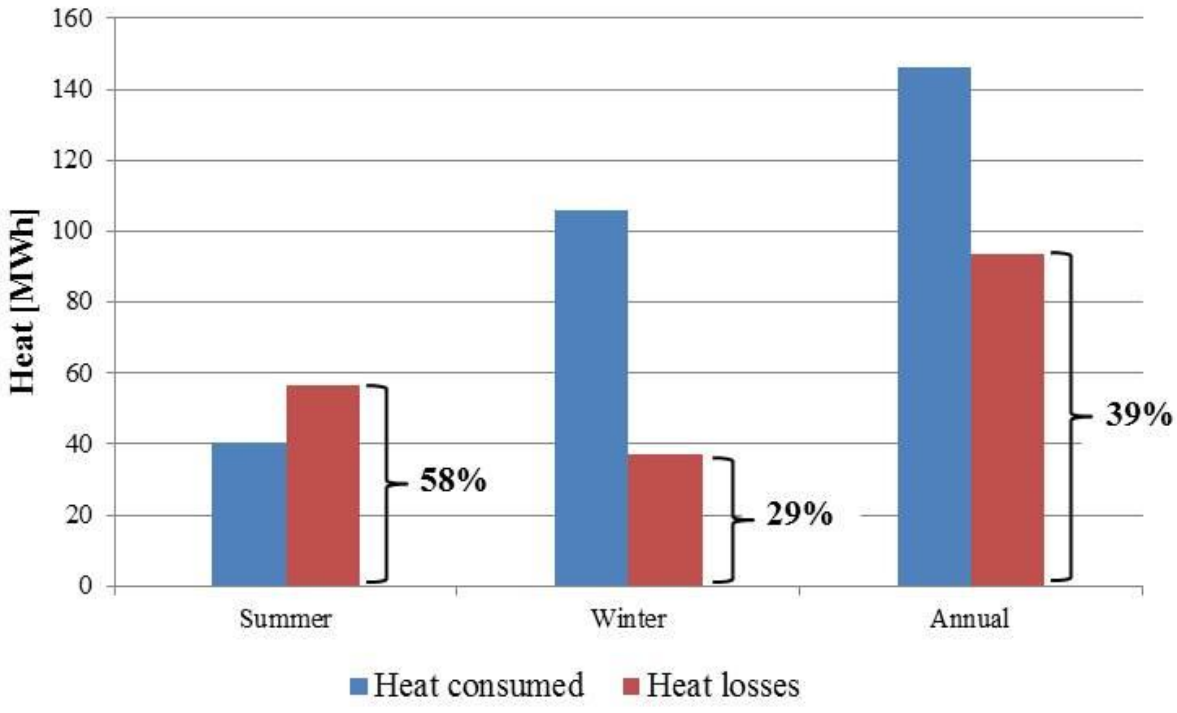
- The maximum ΔT can't be measured, due to:
  - Intermittency of the temperature measurement 4 to 20 seconds
  - The pipes have a thermal capacity that stores heat with effect of reducing peak measurements.
- Metering error on the flow and the ΔT measurement could also occur by the used sensors and their poor installations.
- The starting temperature difference to meter the heat – See spec sheet below:

TEMPERATURE INPUT

			SHARKY
Measuring cycle	T	s	With mains supply: 2 s; with A-cell battery: 16 s; with D-cell battery: 4 s
Starting temperature difference	$\Delta\Theta$	K	0.125
Min. temperature difference	$\Delta\Theta_{min}$	K	3
Max. temperature difference	$\Delta\Theta_{max}$	K	177

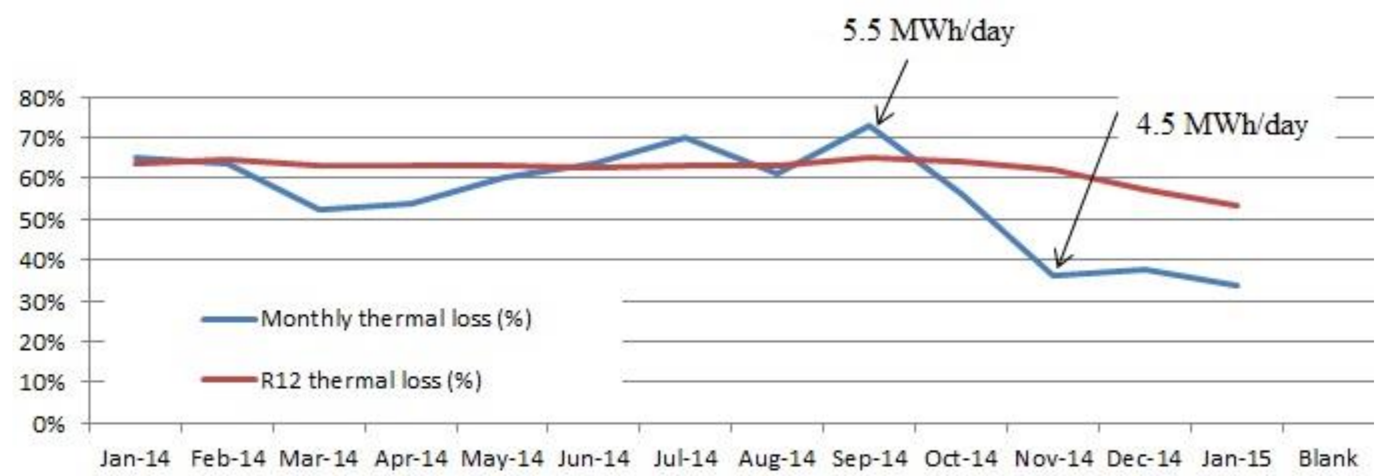
Background

Elmswell DH's heat consumption from 1-4-2009 to 9-4-2010 (the 30-9-2009 was the half way through and switching from summer to winter heating load)



Monitored Heat Losses are High Undergoing Analysis

Heat meters under-meter the heat. This was improved by increasing the cooling of the primary flow through the HIU:



Heat Calculation

- $\dot{E} = \dot{m} * C_P * \Delta T$
  - $\dot{E}: Heat\ - power\ [W]$
  - $\dot{m}: The\ flow\ \left[\frac{kg}{s}\right]$
  - C_P: Specific heat capacity [J/(kg*K)]
  - ΔT: Difference in temperature [K]

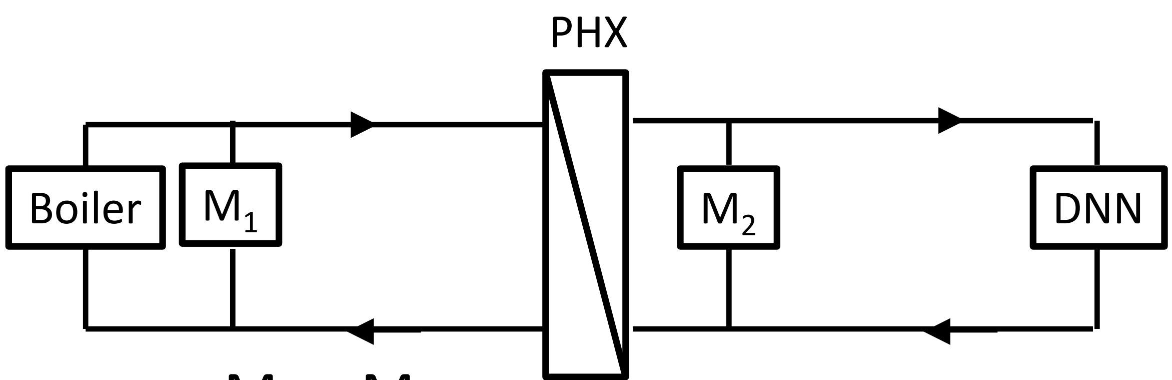
- C_P is a constant but $\dot{m}\ and\ \Delta T$ can continuously vary and are calculated with an error.

Heat Meter – Case Study 1

From December to March:

The boilers heat meter monitored generating: 419 MWh

The energy centre monitored supplying: 322 MWh

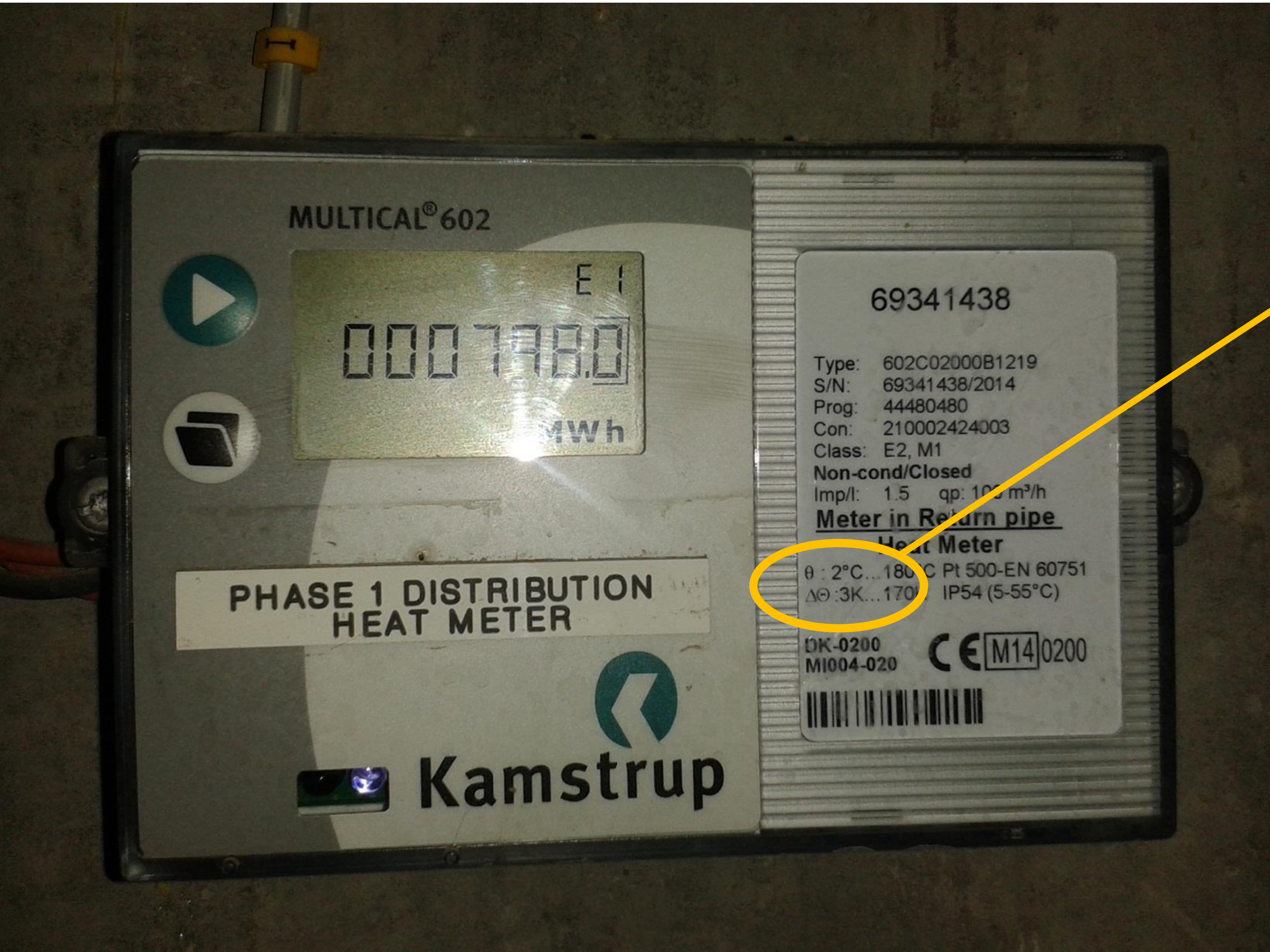


$$M_1 > M_2$$

$$M_2 = \sim 0.7 * M_1$$

Are the heat losses of 30%?

Kamstrup – Multical 602



Tested as suitable by the MID if ΔT > 3 [K]

Measuring Instrument Directive (MID)

4DH
4th Generation District Heating Technologies and Systems

- Directive by the European Union so that the meter can be used across all member states of the EU. However, this certificate is obtained when the heat meter is tested under the following conditions:
  - $\Delta T > 3$ K and temperature ranging from 15 to 130°C
  - On a DN 100 pipe, the flow must range between 0.6 and 120 m^3/hr, or approximately:
    - Reynolds number: ~5,000 to ~1,000,000 [-]
    - Velocity: 0.02 to 4.2 [m/s] for water at ~70°C

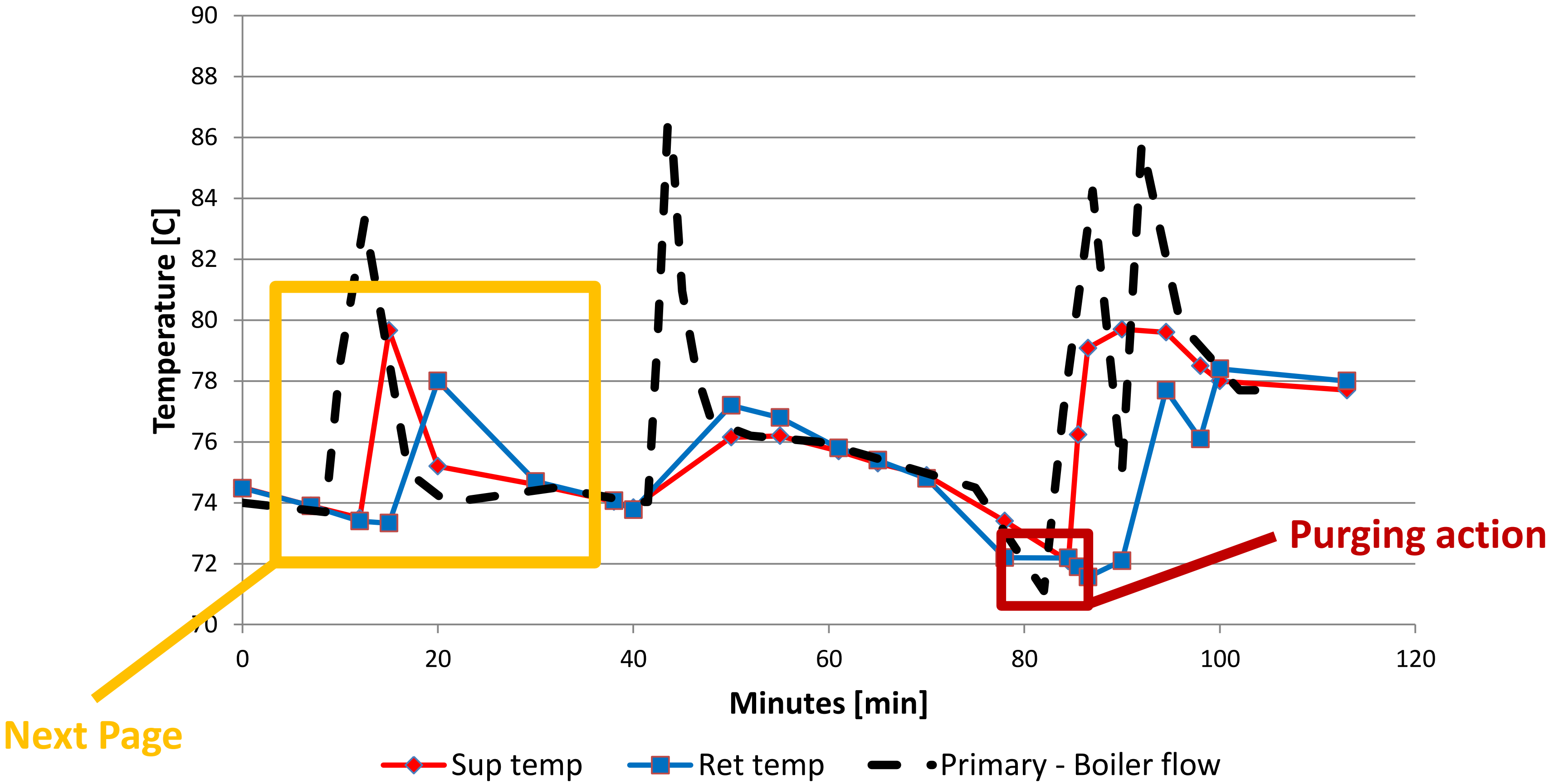
Turbulent Flow with a $\Delta T > 3$ K

Experimental Measurement

$$\dot{m}_{Energy\_centre} = \sim 35\ m^3/hr = \sim 9\ kg/s$$

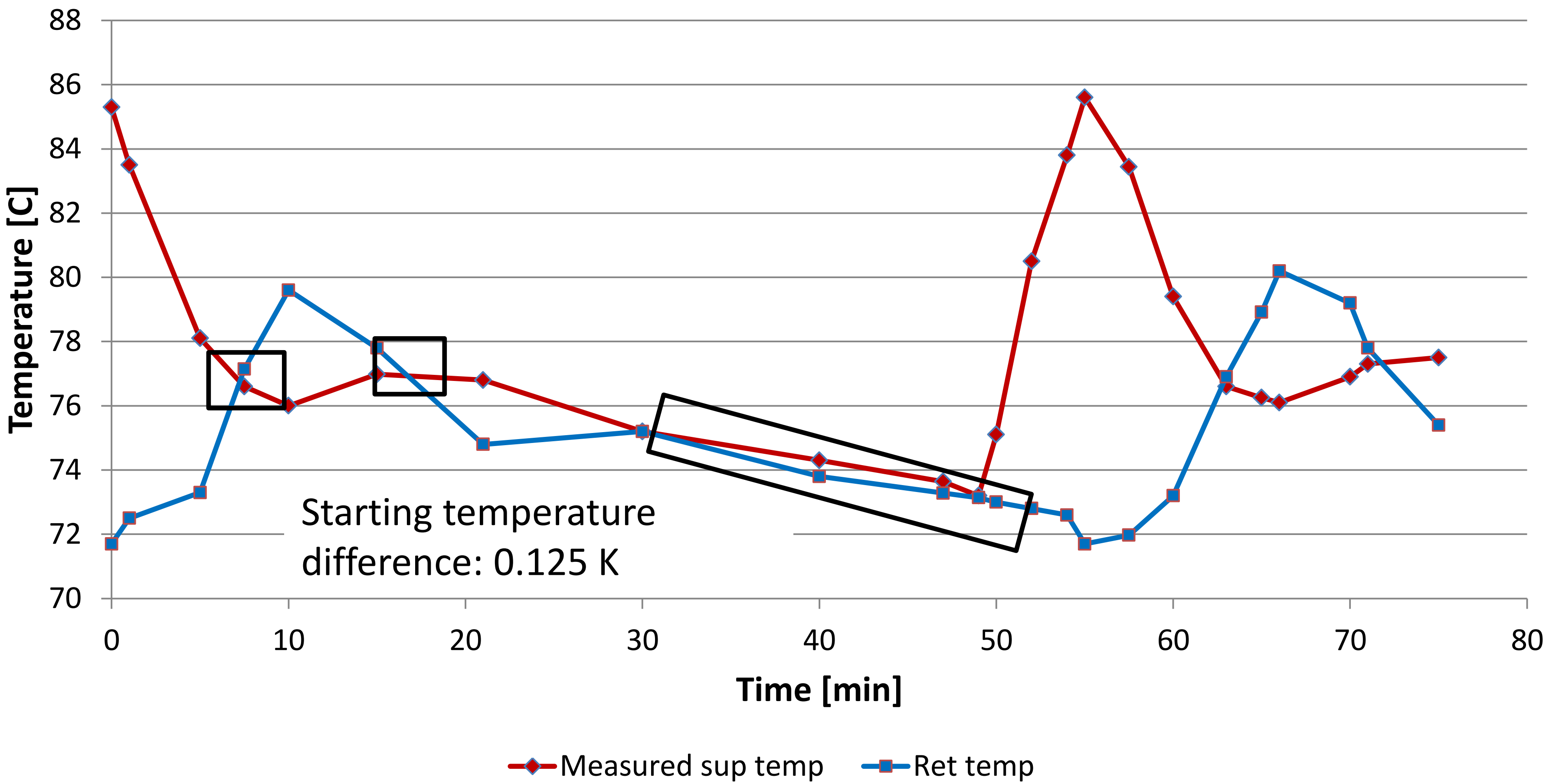
$$\dot{m}_{DHN} = \sim 67\ m^3/hr = \sim 18\ kg/s$$

The boiler generates ~50 kWh per operation with intervals of 30 minutes. Thus, the DHN demand is of ~100 kW thermal.

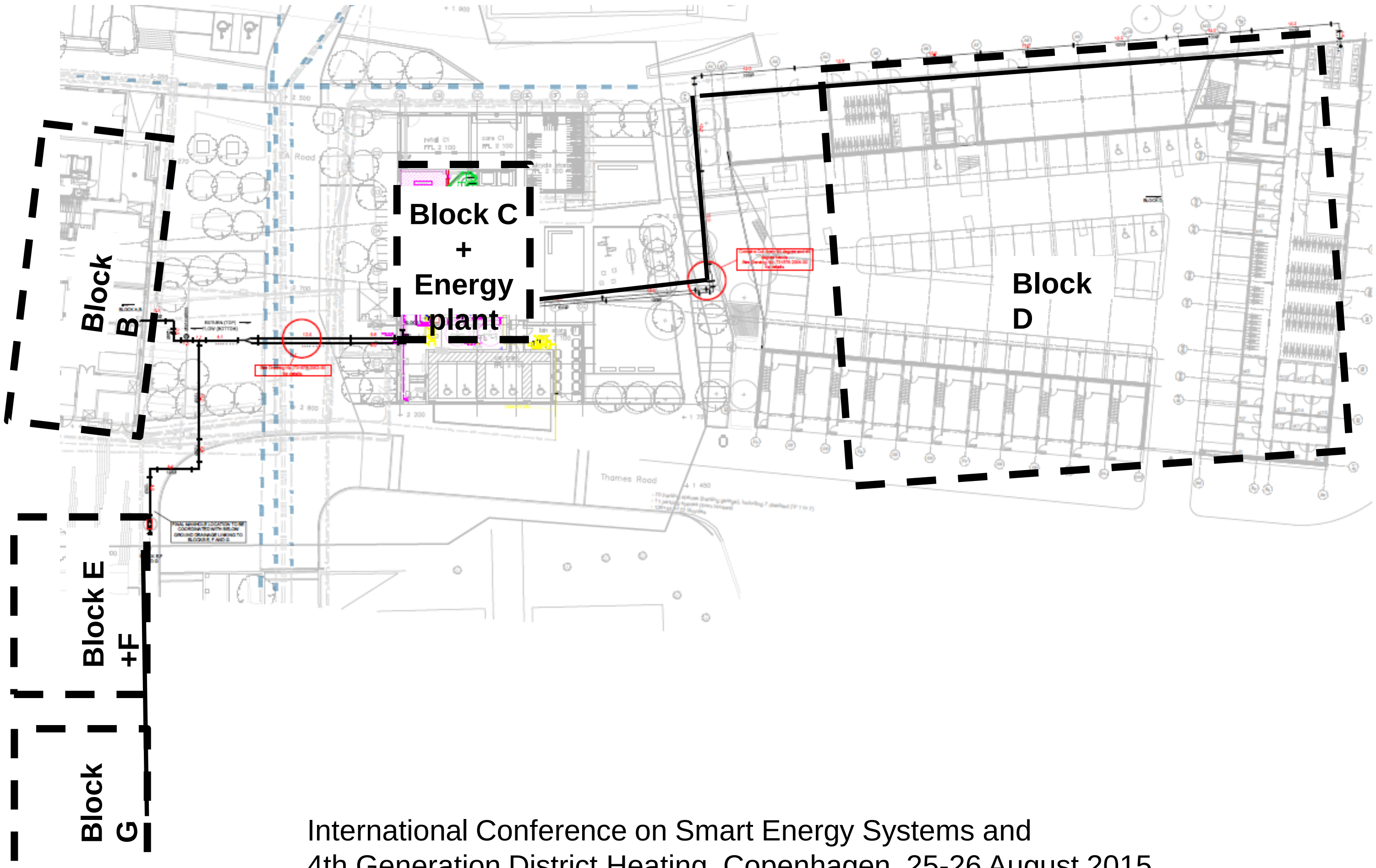


District Heating Network
Bypasses are closed - DHN Flow 35 m^3/hr

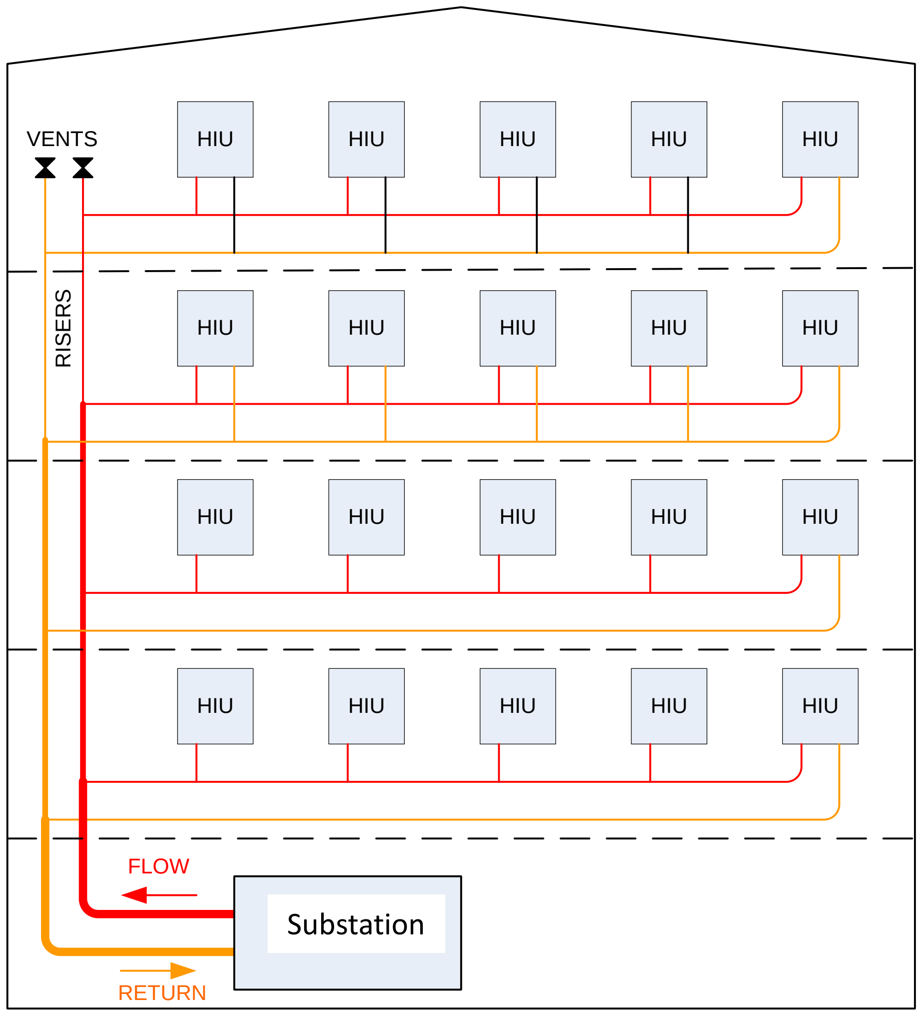
For over 50% of the time a heat meter is susceptible not to meter the heat due to having a potential temperature difference of less that 0.125 K. This corresponds to approximately 10 kW – 10% of the load.



Case Study 2 - London

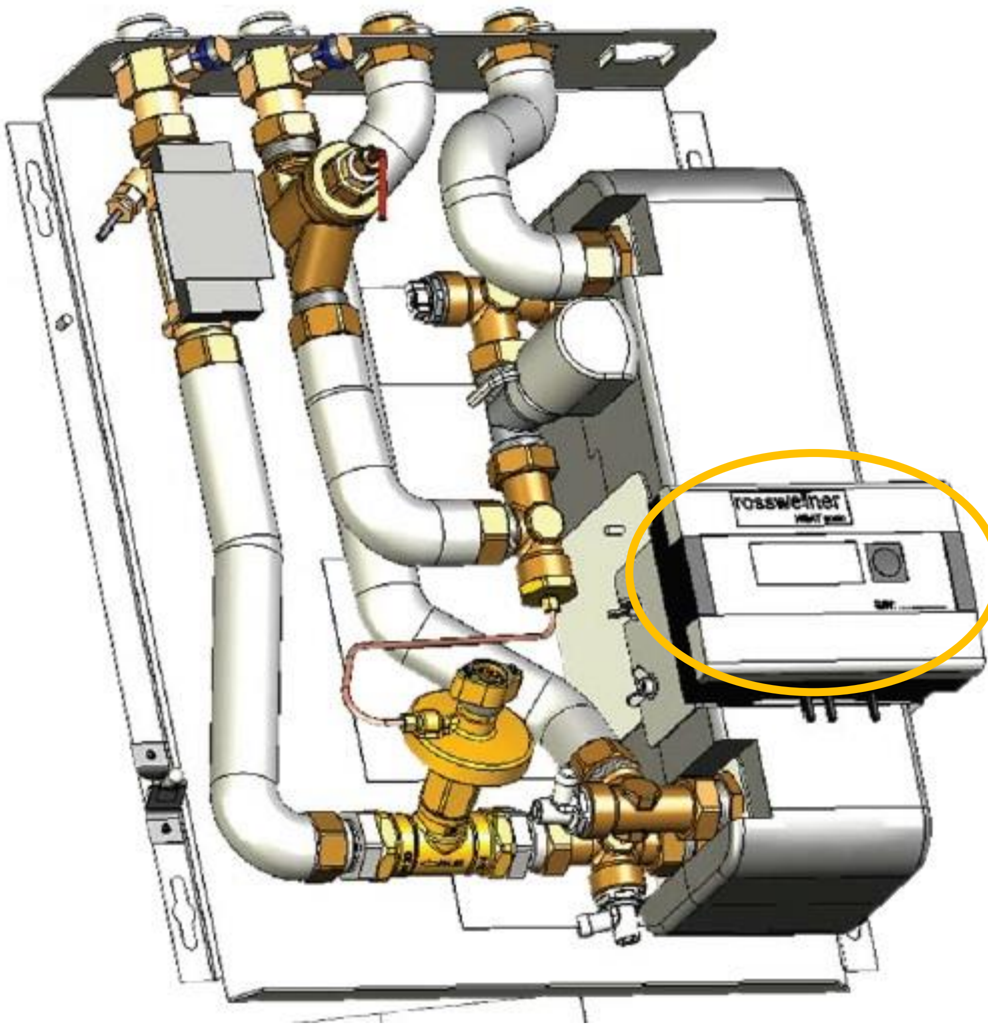


Heat Meter at every HIU



AALBORG UNIVERSITY
DENMARK

587 Consumers with HIU and Cylinder



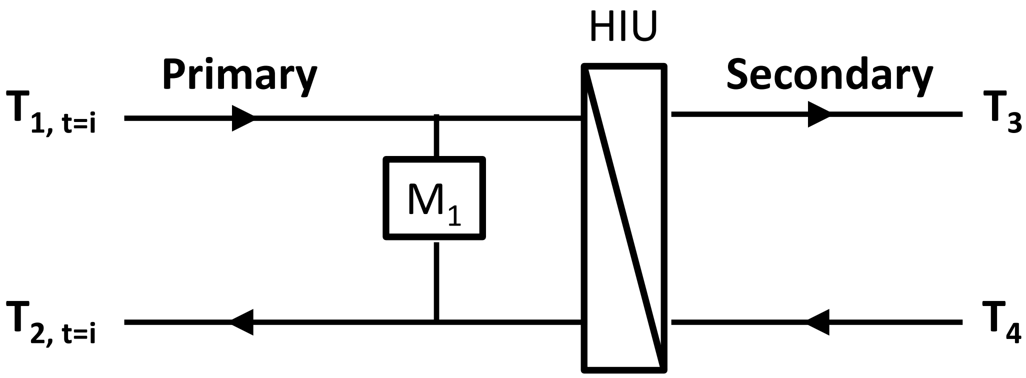
Heat meter

The HIU is also used to heat a cylinder at 60°C, so the secondary return temperature cannot be less than 60°C in no space heating demand condition and cylinder at 60°C.

Temperature measurement

When the primary flow temperature reduces: $T_{1,\,t=i+1} < T_{1,\,t=i}$

The heat consumption is undermetered: $\dot{E} = \dot{m} * C_P * \left(T_{1\,,t=i+1} - T_{2,\,t=i+1}\right)$



However, the heat meter would then overmeter the heat when the flow temperature increases, but it does not always compensate the undermetering because of the starting temperature difference of ~0.125°C.

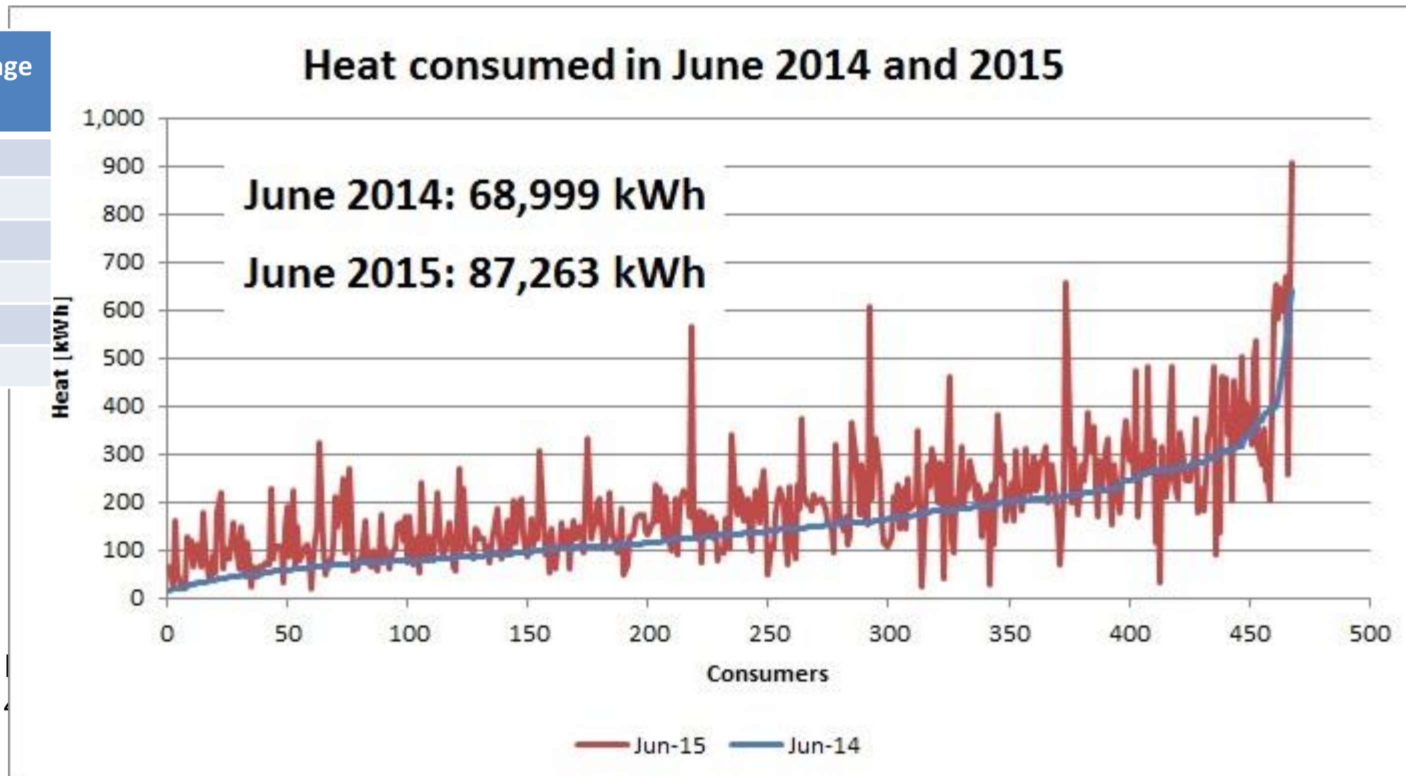
Heat Interface Unit Consumption

a) Filtered the unoccupied flats b) Filtered suspicious heating load variations

	2014						2015					
	Feb	Mar	Apr	May	June (27 days)	July (31 days)	Feb	Mar	Apr	May	June (27 days)	July (31 days)
Sold Heat [MW]	165	138	88	73	69	67	178	153	105	87	87	79.5
Consumers	312	312	312	312	468	445	312	312	312	312	468	445
Daily heat consumed per consumer [kWh/day]	18.9	14.2	9.4	7.5	5.4	4.9	20.4	15.8	11.2	9.0	6.9	5.8

	Difference per consumer [kWh/day]	Percentage [%]
February	1.5	7.9
March	1.6	11.3
April	1.8	19.1
May	1.5	20.0
June	1.5	27.8
July	0.9	18.6

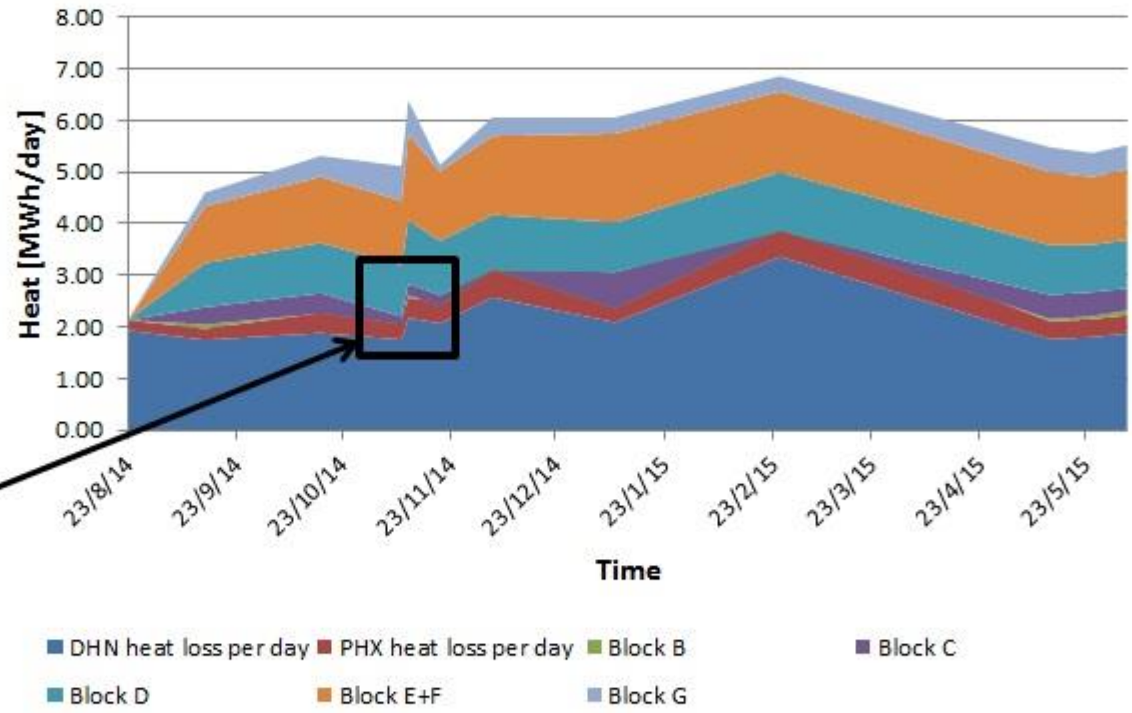
Holiday??



Conclusions

- Heat metering error happens from the energy centre to the consumers.
- Monitored heat losses can be reduced by:
  - Increasing the ΔT; and by
  - Supplying a steady flow temperature.
- Very high metering error happens under high flow rate and low ΔT conditions.
- Heat metering errors can also occur because of:
  - The poor operation of the energy plant and of the DH network;
  - The error by the used temperature and flow sensors

Thank you – oliver_mdp@yahoo.com



Block C undermeters; we have just updated the maximum flow to be communicated from the flow meter to the heat meter calculator from 200 to 400 dm^3/min

Block B Still undermeters, although we had already increased the max flow from 300 to 600 dm^3/min

Although we increased the DH network flow temperature from ~67°C to 80°C and that the DH network was extended, the DH network heat losses (heat losses to the soil) remain at ~2 MWh/day after and before the winter season.