IDEA CAMPUSENERGY2017

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Low Temperature Thermal Networks: Domestic Hot Water Production

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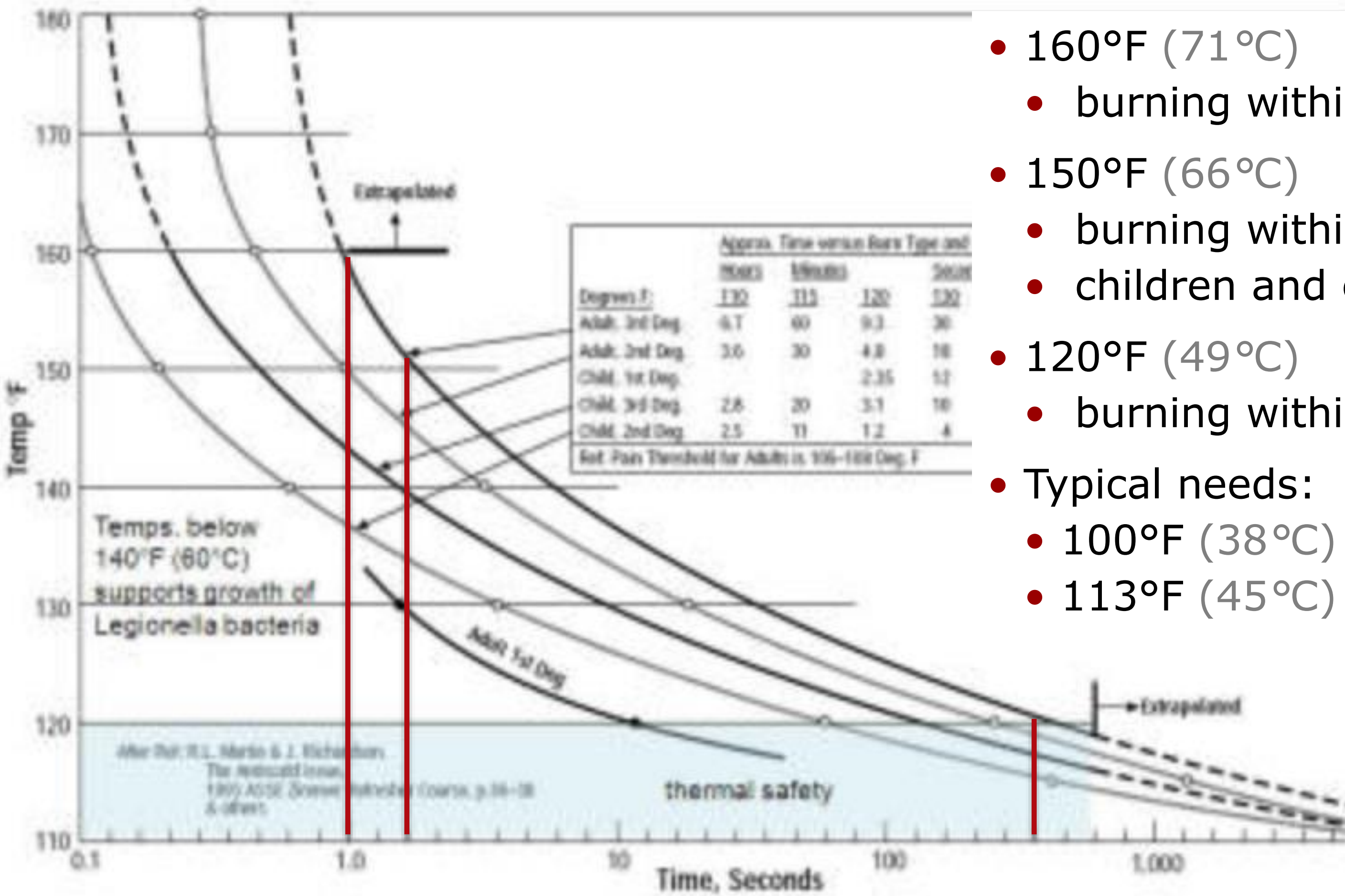
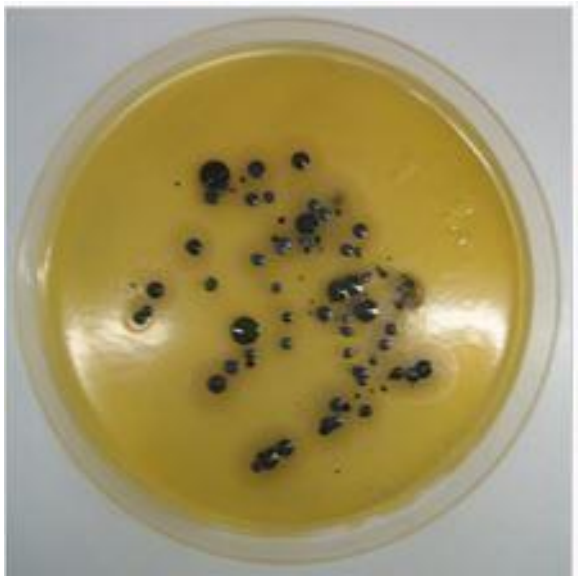
DHW temperature: Comfort/Use/Safety



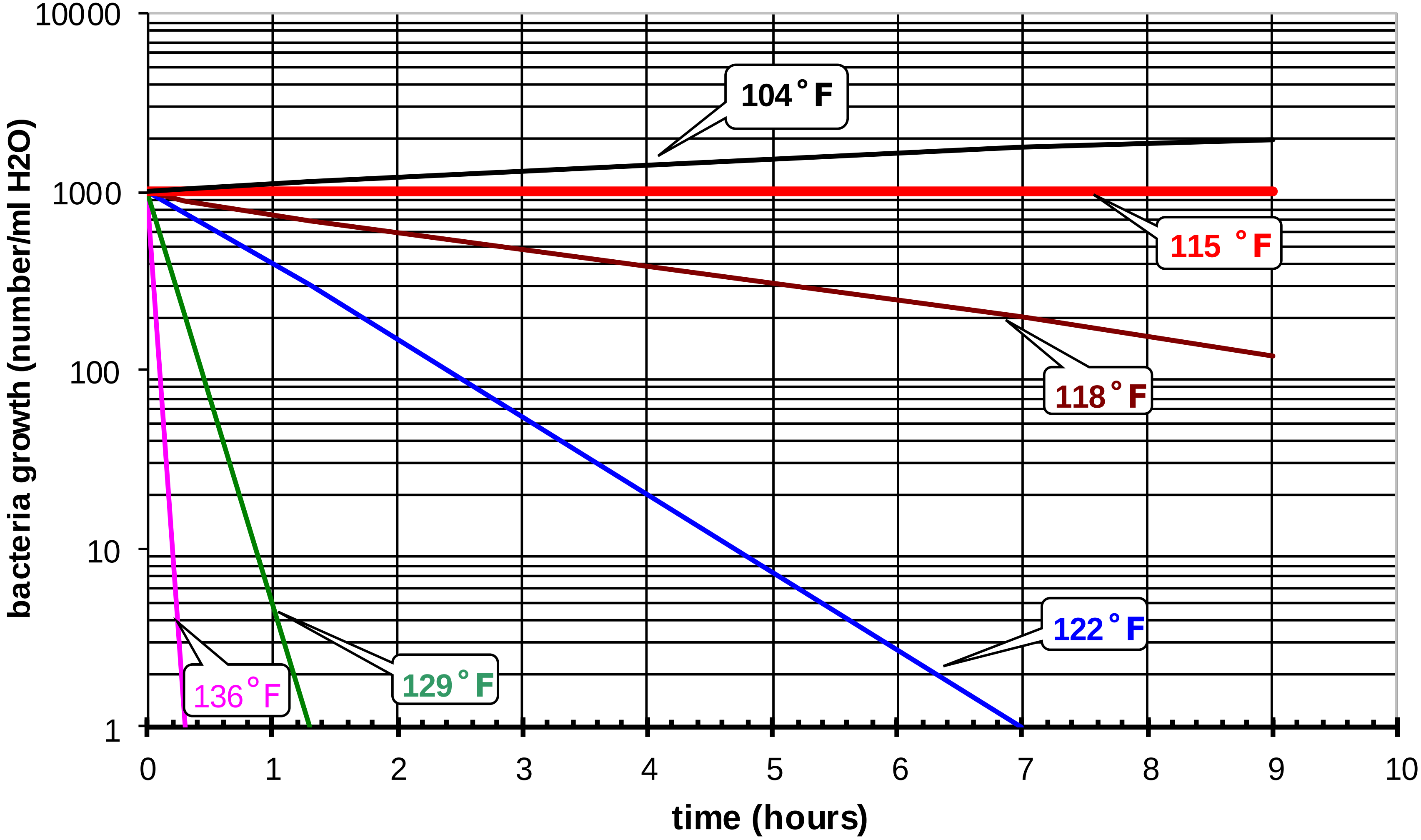
- 160°F (71°C)
  - burning within 1 second
- 150°F (66°C)
  - burning within 3 seconds
  - children and elderly react too slow
- 120°F (49°C)
  - burning within 10 minutes
- Typical needs:
  - 100°F (38°C) showers
  - 113°F (45°C) hand washing dishes

DHW temperature: Legionella bacteria



- Legionella Growth
- 77°F (25°C) starts growing
- 131°F (55°C) stops growing
- 97°F (36°C) is ideal
- 6 to 8 Hr. regeneration at 97°F (36°C)
- Thrives in stagnant water
- Dead pipe ends
- Large storage cylinders
- Pasteurization time depends on temperature

DHW temperature: Legionella growth



DHW standards: flow and temperature

- Standards are available:
- North America
  - Regional, state, and local plumbing codes
  - ANSI/ASHRAE/IES 90.1: *Energy Standard for Buildings Except Low-Rise Residential Buildings*
  - ASHRAE Guideline 12: *Minimizing the risk of Legionellosis Associated with Building Water Systems*
- Danish DS439:2009 standard
- Swedish technical regulations F:101
- German DIN4708

DHW standards: Storage vessel size

- Euroheat & Power have technical guidelines:

- Storage Volume > 106 gal (400L)
- DHW temperature predefined to 140°F (60C) according DIN4708
- Boil the cylinder 1 time per 24h to kill bacteria

- Storage Volume < 106 gal (400L)
- DHW temperature predefined to 140°F (60C) according DIN4708
- no boiling requirement

- Storage Volume < 3.2 quart (3L)
- DHW temperature not predefined according DIN4747
- 113°F (45°C) is possible

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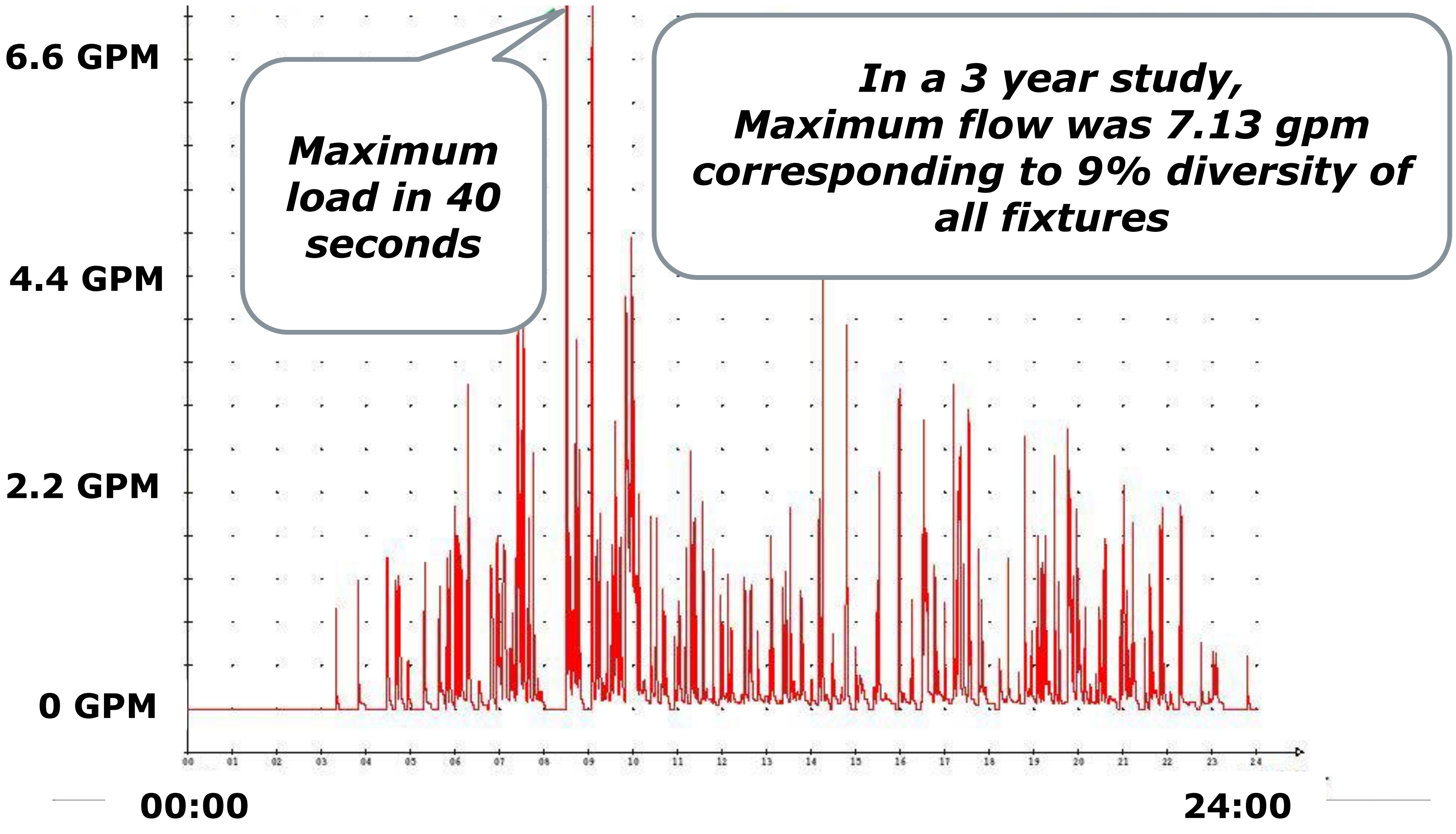
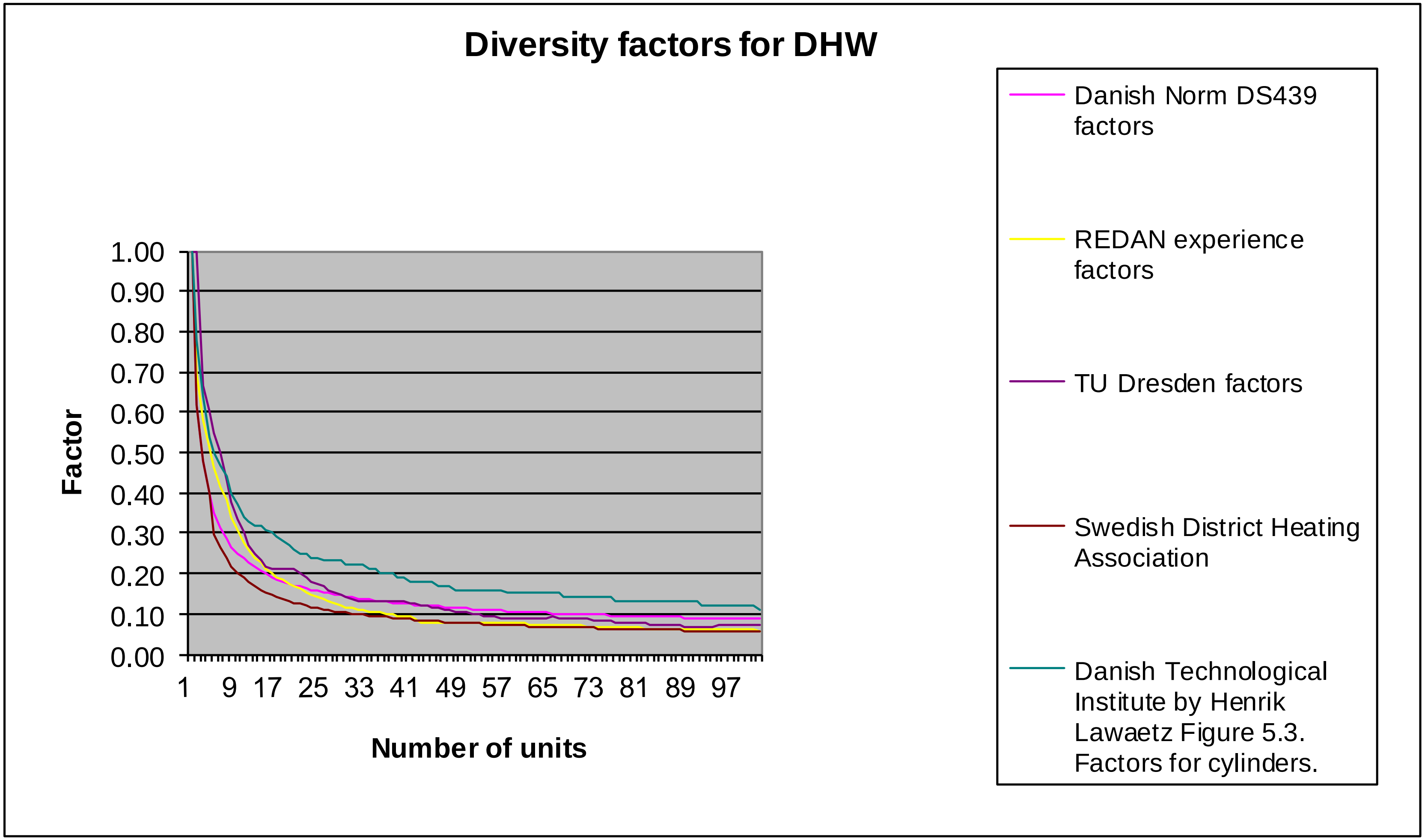
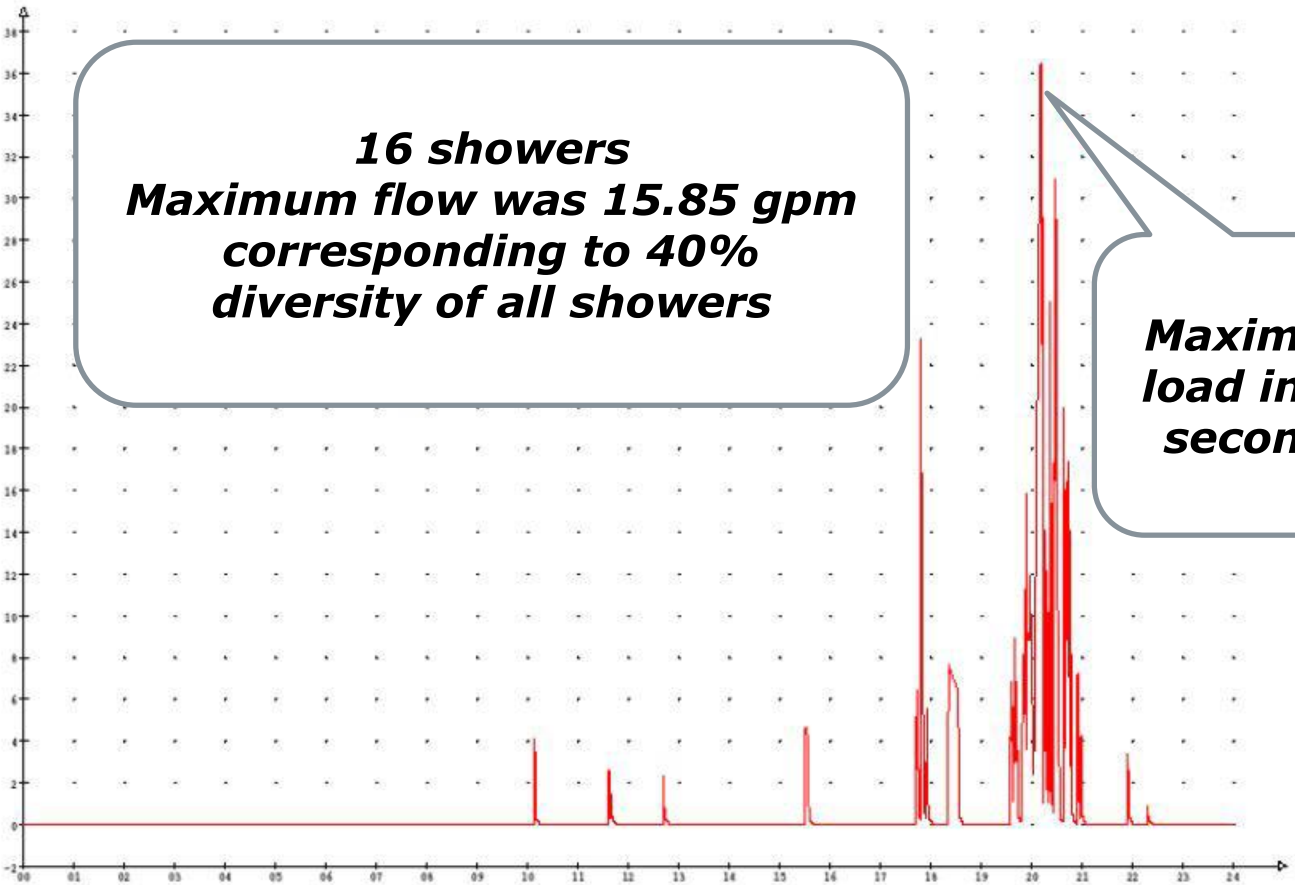
Measurements from 33 unit apartment building



Diversity factors for "standard" apartments from various European norms



Measurements from a sports facility



16 showers
Maximum flow was 15.85 gpm corresponding to 40% diversity of all showers

Maximum load in 50 seconds

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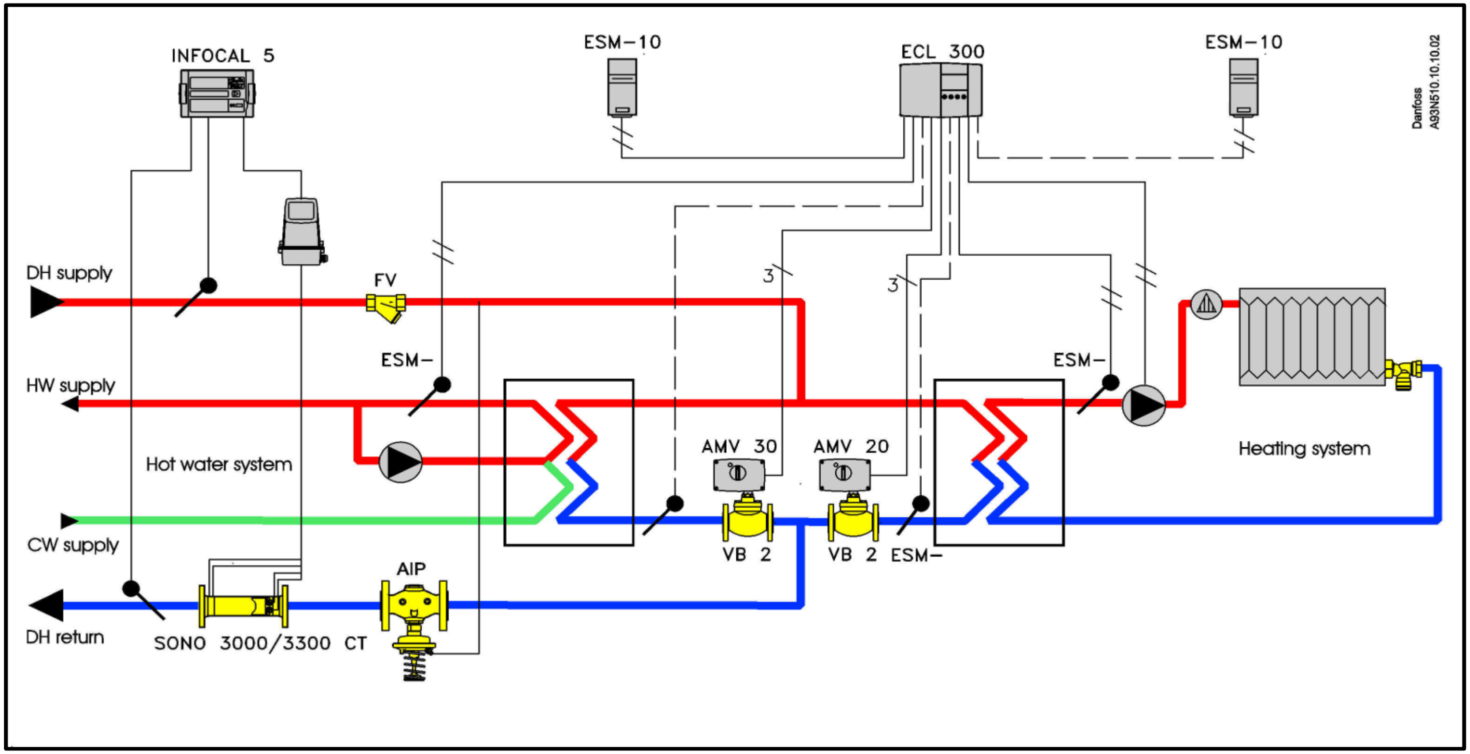
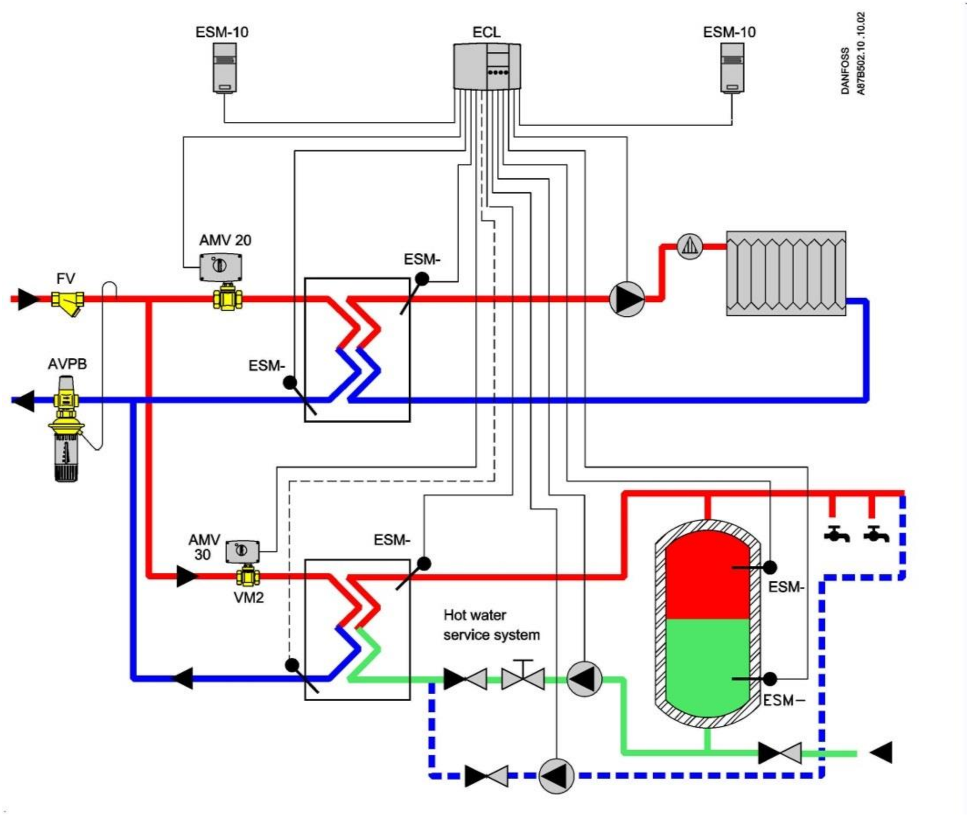
Indirect Heating and Instantaneously produced domestic hot water



Indirect Heating and DHW charging system



Comparison between DHW applications

Instantaneous DHW application

- Benefits:
  - Unlimited amount of DHW water
  - Minimum risk of Legionella
  - Lower costs
  - Low return temperatures and heat losses
  - Lower flow temperatures possible
  - Minimized space demand
  - Less maintenance
- Limitations
  - Higher flow rates on the DH side

Storage charging cylinder

- Benefits
  - Lower connecting load
- Limitations
  - Higher heat losses
  - Higher DH return temperatures
  - Higher costs
  - Not suitable for low temperature systems, as high cylinder temperatures are needed to eliminate risk of Legionella
  - Maximum space demand
  - More maintenance

Hamburg HafenCity

- Europe's largest re-development project
- 50,000 residents by 2020.
- 380 Acre mixed residential development is setting green standards
- CHP is used to heat buildings in HafenCity – 90% of the primary energy is utilized.
- Compared to a conventional fossil fuels:
  - 3.7 million €/yr. in fuel savings
  - 14,000 tons/yr. of CO_2 emission avoided
- +125 Substations connected to the district heating network
- 80 include central DHW systems

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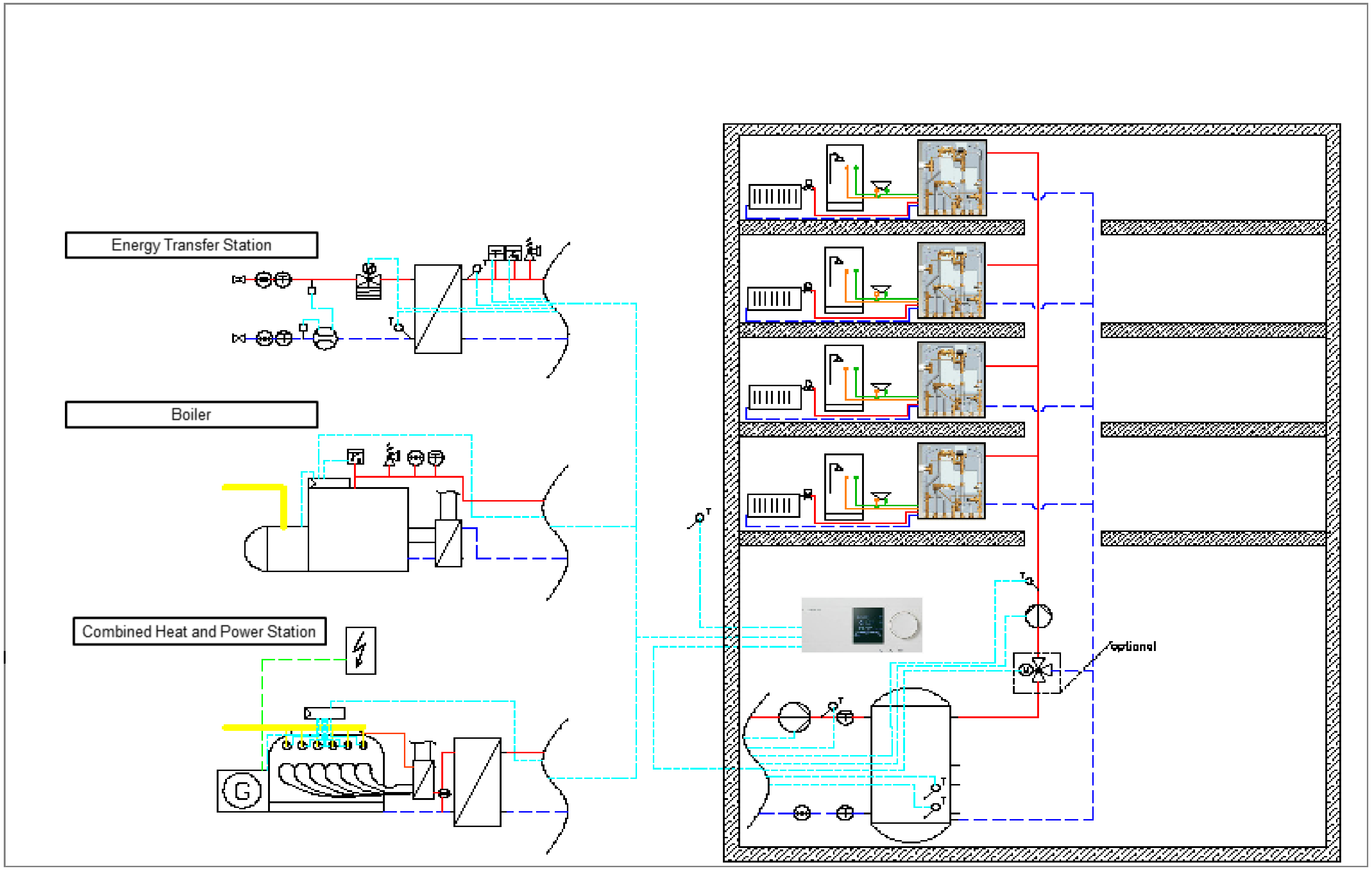
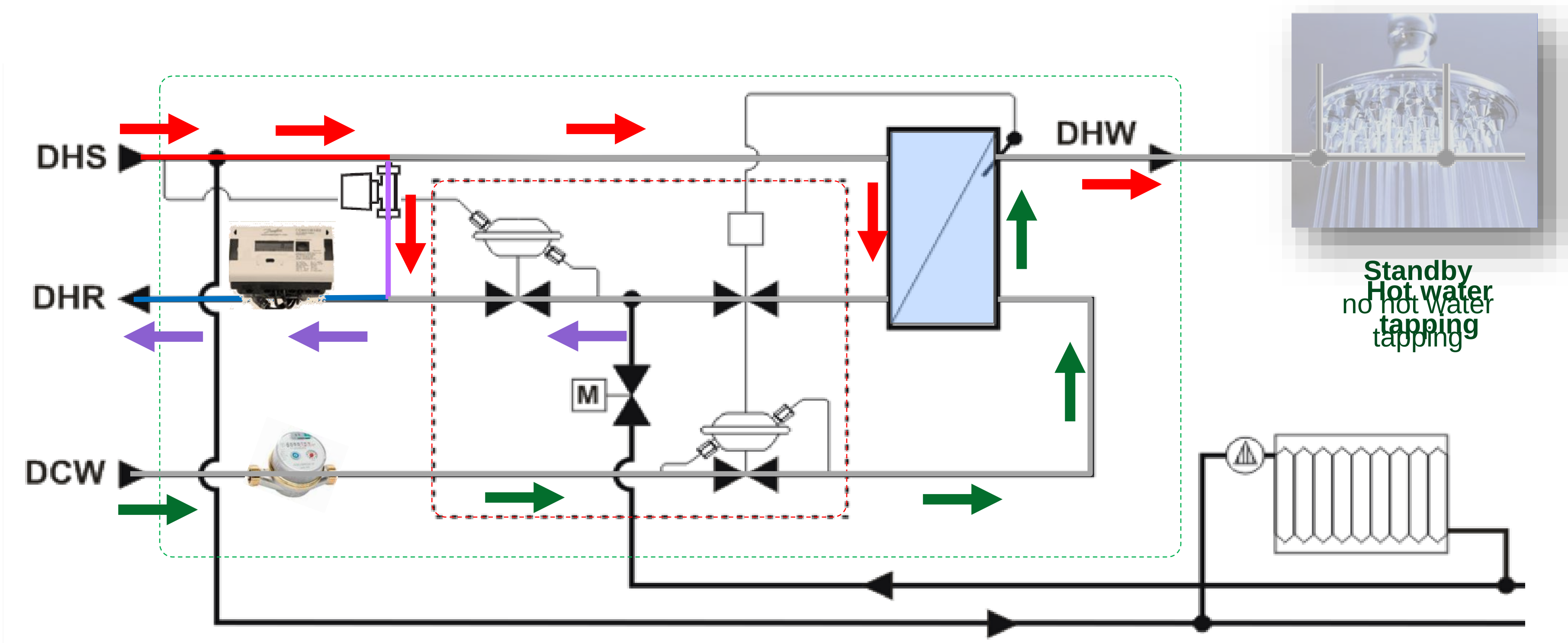
Decentralized DHW-production: unit stations



Control Principles in unit substations

Scenario



Standby
Hot water tapping
no hot water tapping

Highbury football stadium, London

Facts on Installed Danfoss substations:

Pressure Level: PN10
Differential pressure: 0,7bar
Design temperatures for heating: 70/26C-35/25C
Design temperatures for DHW: 70/28C-60/10C

4 sizes of substations:
- Akva Lux VX (5 kW heating and 42 kW DHW)
- Akva Lux VX (5 kW heating and 53 kW DHW)
- Akva Lux VX (5 kW heating and 60 kW DHW)
- Termix VVX Compact 20 (15 kW heating and 100 kW DHW)

- Re-development into 719 residential apartments
- 4 Grandstands converted into studio, one, two and three bedroom apartments with 7-storey glass-fronts.
- Each apartment is equipped with a prefabricated substation from Danfoss and connected to a central gas fired boiler.
- The substations provide space heating and domestic hot water with built in metering for accurate billing and fault detection.
- Supports London Climate Change Agency goals to reduce CO_2 emissions and remove 25% of electricity grid production.
- Central Plant solutions were the most supportive of these goals

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Industrialized Solutions for all applications










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Temperature considerations/constrains

- In Denmark Building Codes prescribes 70/40C as DH design temperatures in new networks. Lower is OK.
- On the same time pilot- and research projects on low temperature systems with 55C/50C and even 40C flow temperatures are ongoing
- As lower temperature level as more surplus heat – and renewable sources like solar and heatpumps can be utilized optimally
- Solar collector feed-in temperature in Austria is 60/35-29/54C
- Usage of a condensing boiler requires max 57C return temperature to stay within condensation area
- DHW has by cylinders to be heated to 60C, which requires minimum 65C primary
- Decentralized(<3L) instantanous water heater can produce 45C by minimum 50C primary
- In case the district heating must be utilized for absorption chillers the flowtemperature from source should minimum be about 95C to get 80% efficiency(see example)
- CHP and solar requires storage to achieve best efficiency

Comfort criterias on DHW temperatures by VDI6003

Table 1. Comfort criteria for washbasins

Usable temperature ϑ_{ww}= 40 °C *)		Performance level		
Comfort criteria	**Abbreviation/unit**	**I**	**II**	**III**
a) Time interval during serial usage	t_{ww} in min	max. 5	0	0
b) Possibility of simultaneous use of two or more draw-off points		no	yes	yes
c) Maximum temperature deviation during usage	in K	±5	±4	±2
d) Minimum draw-off rate	$\dot{V}$ in ℓ/min	3	5	6
e) Minimum draw-off level	V_B in ℓ	4	25	50
f) Maximum time to reach the usable temperature under consideration of c) and d)	t_g in s	60 **)	18	10

*) see VDI 2067 Part 22
**) based on the 3 litre regulation of worksheet DVGW W 553

Table 2. Comfort criteria for showers

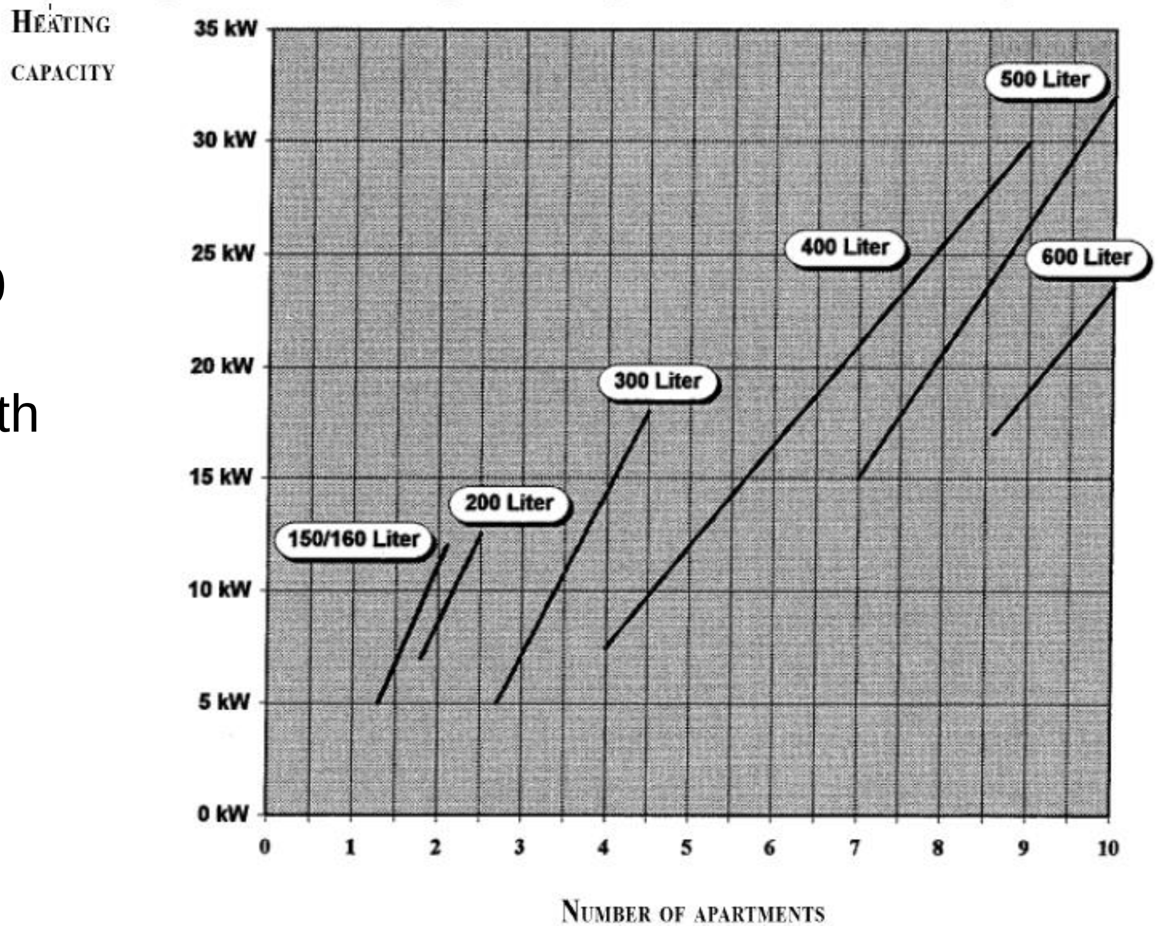
Usable temperature ϑ_{ww}= 42 °C *)		Performance level		
Comfort criteria	**Abbreviation/unit**	**I**	**II**	**III**
a) Time interval during serial usage	t_{ww} in min	max. 8	max. 5	0
b) Possibility of simultaneous use of two or more draw-off points		no	yes	yes
c) Maximum temperature deviation during usage	in K	±5	±4	±2
d) Minimum draw-off rate	$\dot{V}$ in ℓ/min	7	9	9
e) Minimum draw-off level	V_B in ℓ	28	60	120
f) Maximum time to reach the usable temperature under consideration of c) and d)	t_g in s	~26 **)	10	7

*) see VDI 2067 Part 22
**) based on the 3 litre regulation of worksheet DVGW W 553

Example of sizing of a DHW cylinder with internal coil for appartments from Euroheat & Power.

- DHW temperature 60 °C;
- Cold water temperature 10 °C;
- standard apartments.

Example with 10 appartments:
600L cylinder with 24kW coil.



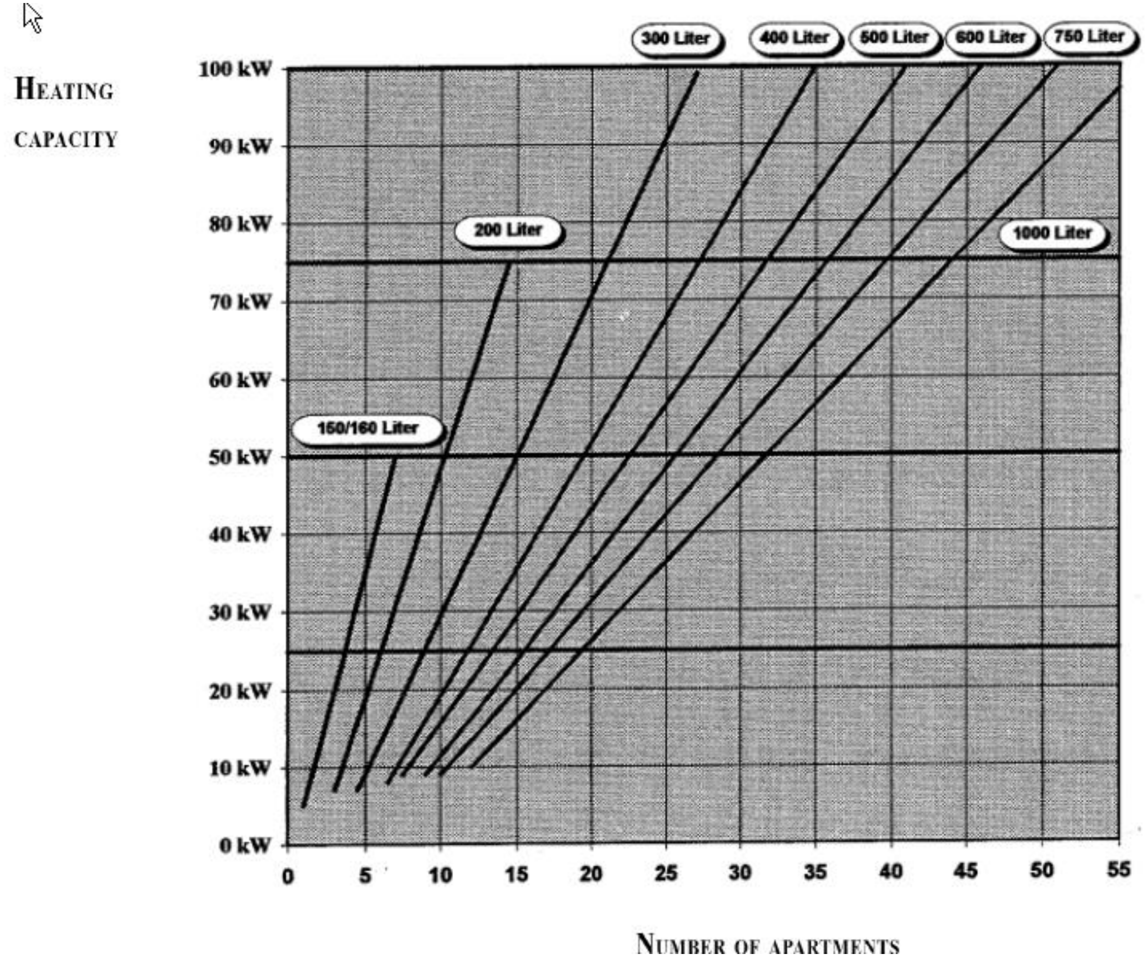
GUIDELINES
FOR DISTRICT HEATING SUBSTATIONS

EUROHEAT & POWER

Example of sizing of a DHW charging system for appartments from Euroheat & Power.

- DHW temperature 60 °C;
- Cold water temperature 10 °C;
- standard apartments.

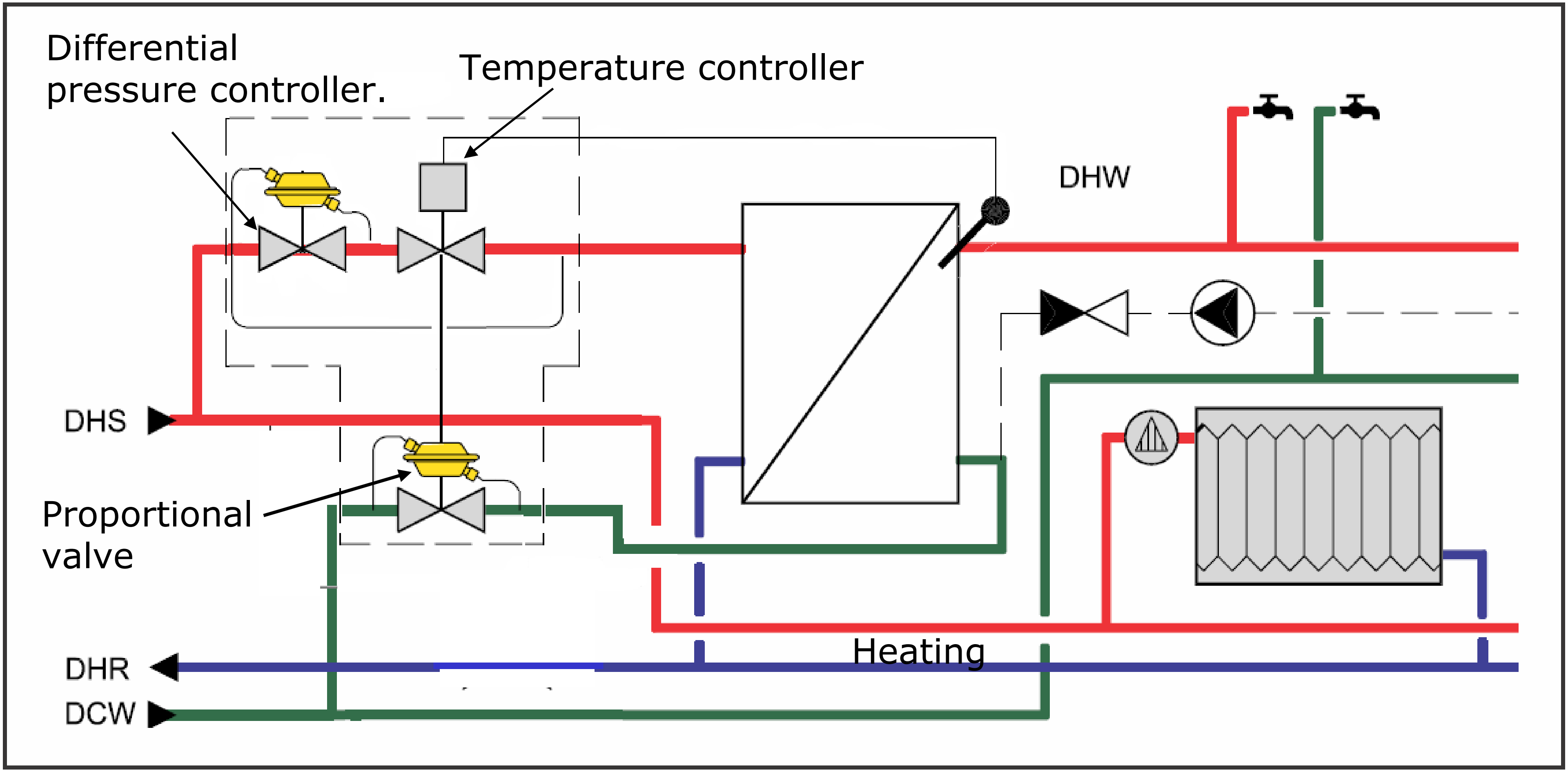
Example with 10 appartments:
500L cylinder with 16kW in external heatexchanger.

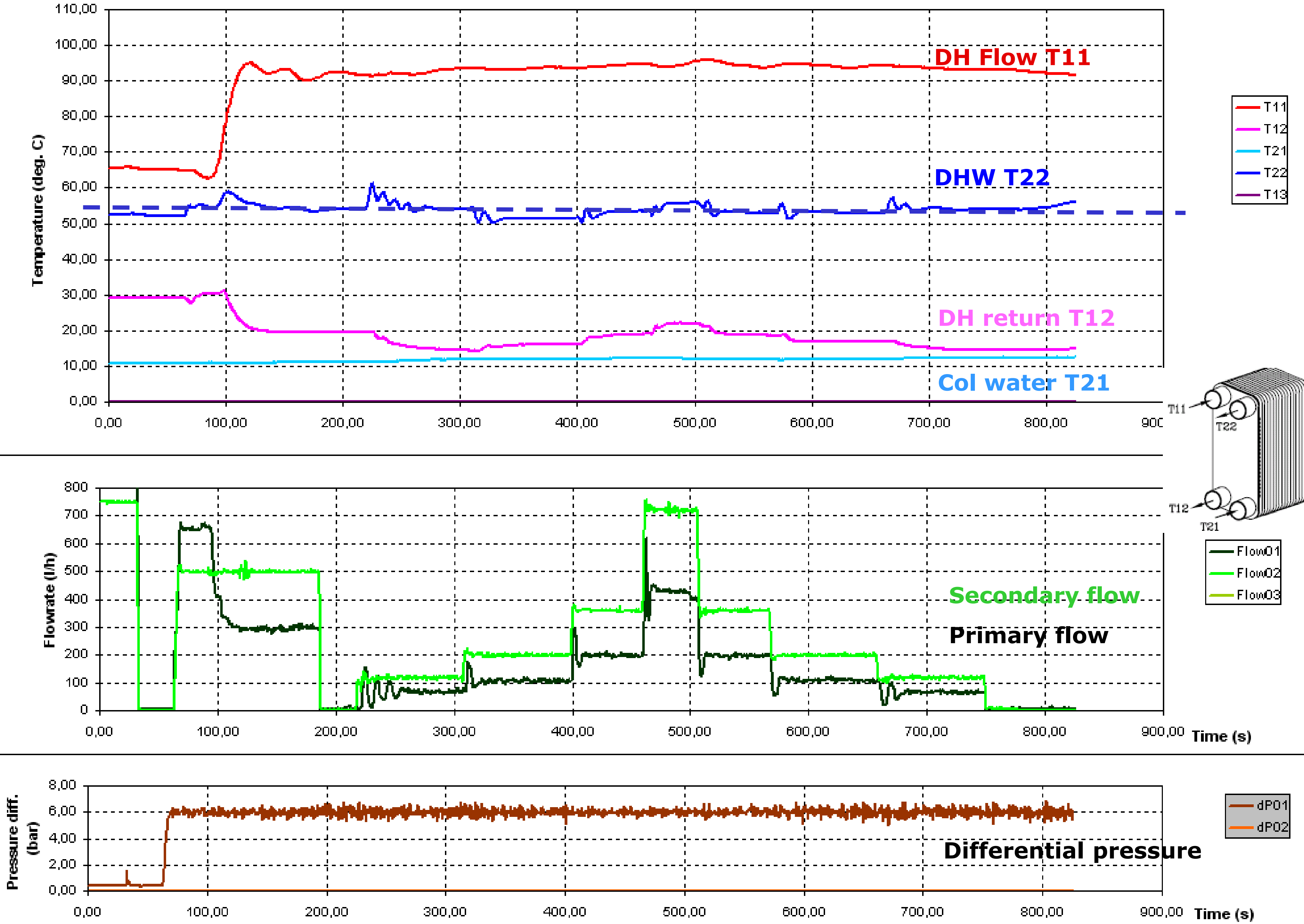


GUIDELINES
FOR DISTRICT HEATING SUBSTATIONS

EUROHEAT & POWER

Application.

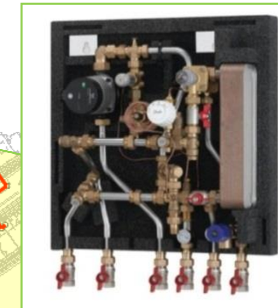



110,00
100,00
90,00
80,00
70,00
60,00
50,00
40,00
30,00
20,00
10,00
0,00
Temperature (deg. C)
0,00
100,00
200,00
300,00
400,00
500,00
600,00
700,00
800,00
900
DH Flow T11
DHW T22
DH return T12
Col water T21
T11
T12
T21
T22
T13
T11
T22
T12
T21
800
700
600
500
400
300
200
100
0
Flowrate (l/h)
Secondary flow
Primary flow
Flow01
Flow02
Flow03
0,00
100,00
200,00
300,00
400,00
500,00
600,00
700,00
800,00
900,00
Time (s)
8,00
6,00
4,00
2,00
0,00
Pressure diff. (bar)
Differential pressure
dP01
dP02
0,00
100,00
200,00
300,00
400,00
500,00
600,00
700,00
800,00
900,00
Time (s)

DH by low-temperature system tests in practise – 50/25C

Lystrup (DK)

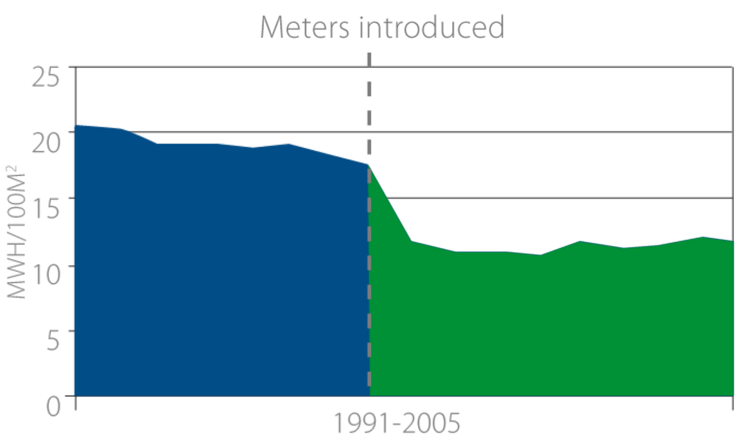
- A project supported by the Danish government
- 40 low-energy class I 2015 single-family houses – 41kW/m2
- Higher district heating water speed, higher pressure drop – smaller dimensions
- Testing of two types of low-temp. substations
  - DH-storage: low kW-load
  - and instantanous DHW with efficient hex
- Only 17% heat loss from low temp DH network vs. 41% for traditional 80/40°C
- Additional pumping energy is only 4% due to small dimensions
- Good cost-efficiency overall
- No complaints from end-customers
- Instantaneous house substation with lower total heat loss & lower purchase price was marginally best



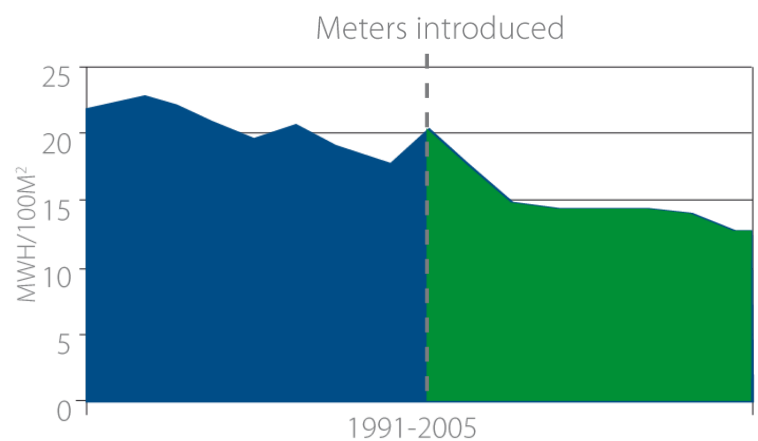
Inner diameter 14 mm rs. 16mm!

Energy savings: DanFlat leads to lower energy consumption

- With DanFlat, tenants are in full control of their energy use.
  - This reduces energy consumption considerably.
- Studies from Denmark show that individual metering can reduce energy consumption by at least 30%.



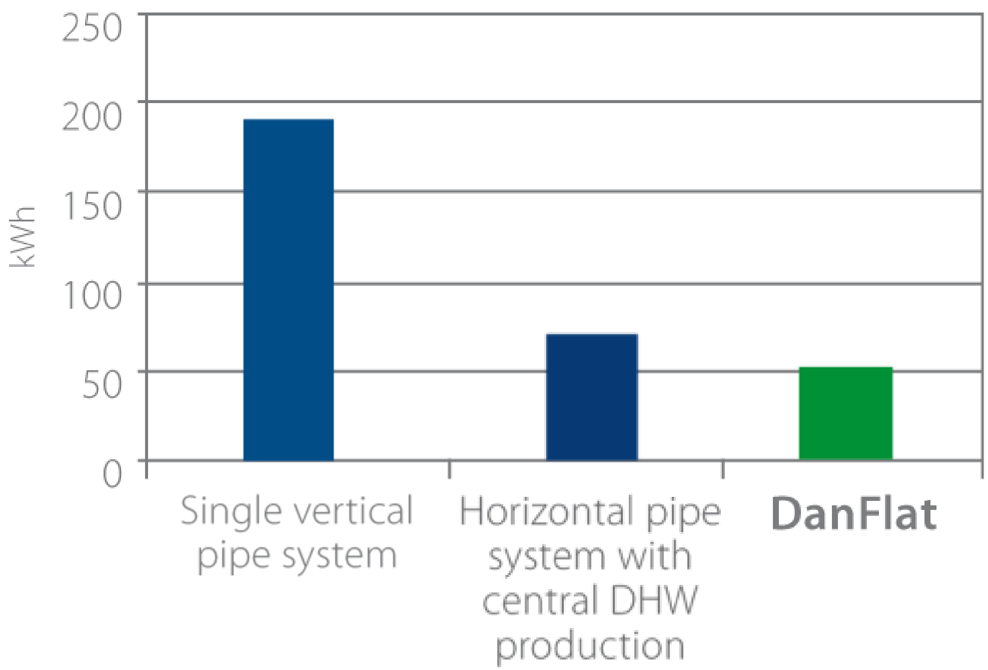
Housing association “Hyldespjældet”
Individual metering since 01.1998



Housing association “Morbærhaven”,
Individual metering since 01.2000

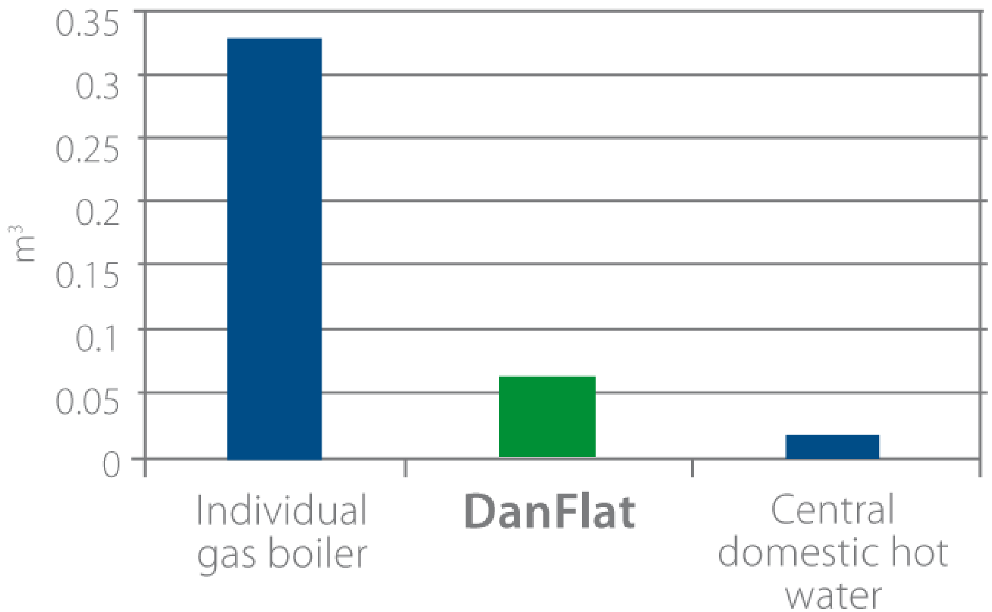
Energy savings: Reduced heat loss

- Comparative studies of three distribution systems documents significant advantages of the DanFlat solution
- Heat loss from pipes reduced by more than 40% compared to central DHW horizontal pipe system
- Heat loss from pipes reduced by more than 80% compared to single vertical pipe system



Space consumption: Comparison with traditional systems

- DanFlat systems provide substantial reductions in space consumption
- Space requirements up to 80% less than with individual gas-fuelled boilers
- DanFlat systems take up slightly more space than systems with central domestic hot water production. In return, they free up considerable
space in basement areas.



Individual gas boiler: 0.32.
Boiler (0.15 m3) + chimney (0.17 m3)
DanFlat: 0.062. Flat station (0.062 m3)
Central domestic hot water: 0.02.
Water meter (0.01 m3) + heat meter (0.01 m3)

* Storage tank in basement will take up significantly more space than in a DanFlat solution

Low total costs

Case study, Munich, Germany:
New building cost effectiveness analysis

50 apartments – new building			Variant 1 Electrical DHW boiler in apartment Central heating	Variant 2 Central DHW Central heating	Variant 3 Decentralized DHW Central heating + buffer storage
1.	**Investment and capital costs**				
1.1	Investment costs	€	67.334,00	85.505,00	72.291,00
1.2	Capital-dependent costs	€ / a	4.865,83	7.062,68	6.277,80
	Relation to Variant 1	%	100,00	145,18	129,02
2.	**Consumption related costs**	€			
2.1	Heat loss	€ / a	3.012,81	2.168,03	745,42
2.2	Energy costs Circulation pumps	€ / a	253,99	177,18	164,03
	Total	€ / a	3.266,80	2.345,21	909,45
	Relation to Variant 1	%	100,00	71,79	27,84
3.	**Operation related costs**	€			
3.1	Maintenance	€ / a	1.080,00	1.170,00	1.170,00
	Total	€ / a	1.080,00	1.170,00	1.170,00
	Relation to Variant 1	%	100,00	108,33	108,33
4.	**Annual costs**	€ / a	9.212,62	10.577,89	8.357,25
	Relation to Variant 1	%	100,00	114,82	90,72

Source: Quelle Kulle & Hofstetter, Stadtwerke Munchen