

Adaptive control strategy for domestic hot water storage tank ENGINEERING supplied by district heating



/nnovation Fund Denmark

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### Background/Motivation

Many DHW tank systems are not running optimal

• The consequence is a high DH return temperature from the service of DHW

• As well as high DH peak loads

This leads to lower efficiency of the DH system because:

• Higher than needed DH return temperature results in distribution heat loss and reduced heat plant efficiency

- This can as well reduce the potential for lowering the DH flow temperature
- High peak load can create supply bottlenecks and thus activation of less favorable heat generation sources



## The application and the control

- DH return temp. limiter:
  - When exceeding the DH return temp. limit **setting**, the charging is reduced
- DH power limiter (incl. M-BUS connected energy meter):
  - When exceeding the DH power limit **setting**, the charging is reduced





Focus application:

DHW preparation by storage tank with internal coil



## Field test buildings:

Kolding 1 Kolding 2 Residential, 31 flats Residential, 47 flats

Data Data

Hillerød 1 Hillerød 2 Residential, 42 flats Residential, 30 flats

Data, control Data, control



TRE FOR Varme



HOFOR 1 HOFOR 2 HOFOR 3

Residential Institutional Residential

(Data), control (Data), control (Data), control





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Cold Water Temperatures



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### Cold Water Temperatures







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### Cold Water Temperatures

25

20



Hillerød 1 DHW

10-20 01-21 04-21 07-21 10-21 01-22 04-22 07-22 10-22 01-23

Day [mm-yy]

25

20

T CW wt [°C]



Kolding 2 DHW

### Energy Consumption for DHW (ex. circ.)



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### Cold Water Temperatures









C≪

Day [mm-yy]

### Energy Consumption for DHW (ex. circ.)











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### On what level to set the DH return temp. limiter or a DH power limiter ?



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12000

[liters] 00001

8000

6000

4000

2000

00:00

 $\nabla$ 

21:00

9

DHW

No

∞

100 [kW] 8

P DH

ø

DHW

<u>с</u>

100 [°C]

×

Temp.

#### A day with and with out **DH power limiter**

 $\nabla$   $\nabla$ 

18:00

20220324 Hillerød 1 DHW ST

of reduced DHW tank temperature 20220302 Hillerød 1 DHW ST 12000 6000 set DHW av: 54.6 T DH ret wt (DHW): 33 °C T CW: 7.9 °C [liters] 5000 T DH Ret ECL P DH MAX: 27 kW T DHW Tank P av DH (DHW). 13 kW - T DHW Tank out 9 P DHW DHW Vol: 3789 Liters P DH DHW 4000 Weekday: Wed 8000 P lim set  $\nabla$ DHW Vol pr. div 0 ø 100 [kW] 3000 6000 Н 2000 4000 ۵  $\nabla$ ø DHW  $\nabla$ 1000 Ο 2000  $\nabla$  $\nabla$ o LV 00:00 03:00 06:00 09:00 12:00 15:00 18:00 21:00 00:00

The control adapts to a duration period

Adaptive control

Day

6000

4000

3000

2000

1000

00:00

Temp. x 100 [°C]

set DHW av: 55

PDH MAX: 39 KW

Weekday: Thu

P av DH (DHW): 13 kW

DHW Vol: 4043 Liters

T DH Ret ECL

T DHW Tank out P DHW

 $\nabla$   $\nabla$ 

09:00

12:00

Day

**Reference** control

15:00

06:00

T DHW Tank

P DH

P lim set

 $\nabla$ 

03:00

 $\nabla$ 

▽ DHW Vol pr. div

5000 - TCW: 8.3 °C

T DH ret wt (DHW): 36.7 °C

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A period - DH return temp. limiter (HOFOR 1)





### A period - DH power limiter (HOFOR 3)







#### 25% reduction of Max. DH power

Hillerød 2 Max. DH Power pr. day 0.5 Max. DH power pr. day average (Ref.): 16.2 kW 0.45 Max. DH power pr. day average (Adapt.): 11.3 kW 0.4 0.35 Ref. control 0.3 Adap. control 0.25 0.2 0.15 0.1 0.05 0 10 15 20 25 30 35 45 50 0 5 40 Max. DH Power pr. day, 30 min average [kW]

#### 30% reduction of Max. DH power



## Results

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Location:	T DH ret red.	<b>Control Method</b>	<b>Building type</b>	Note
	[°C]			
Hillerød 1	~2,5	Adaptive T DH ret. lim	Residential	No aditional equipm.
HOFOR 1	~2,2	Adaptive T DH ret. lim	Residential	No aditional equipm.
HOFOR 2	~1,4	Adaptive T DH ret. lim	Institutional	No aditional equipm.
Hillerød 1	~2,9	Adaptive Power lim	Residential	DHW E-meter
Hillerød 2	~3,4	Adaptive Power lim	Residential	DHW E-meter
HOFOR 3	~5,4	Adaptive Power lim	Residential	DHW E-meter

For DH return temp. limiter, the reduction of the DH return temp. is around 2°C

For DH power limiter the reduction of the DH return temp. is around 4°C







- DH return temperatures are reduced in the range from 1,4 to 5,4°C, depending on control principle and location
  - For DH return temp. limiter, the reduction of the DH return temp. is around 2°C
  - For DH power limiter the reduction of the DH return temp. is around 4°C
- The DH peak power (30 min. average) is reduced by 25% 30% for the given examples, the understanding is that this can be even more in many cases
- A minor reduction of the DHW supply temperature for shorter periods is the consequence of the limiting functions, this anyhow not an unknown when applying the functions
- The developed methods are robust and straight forward to apply. Anyhow for the DH power limiter function an additional energy meter is needed, which is becoming more usual to install for retrofit and new build







# Thank You for your attention

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Part of project:





