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#SESAAU2019

SMART OPERATION OF ULTDH BOOSTER SUBSTATION FOR MULTIFAMILY BUILDING

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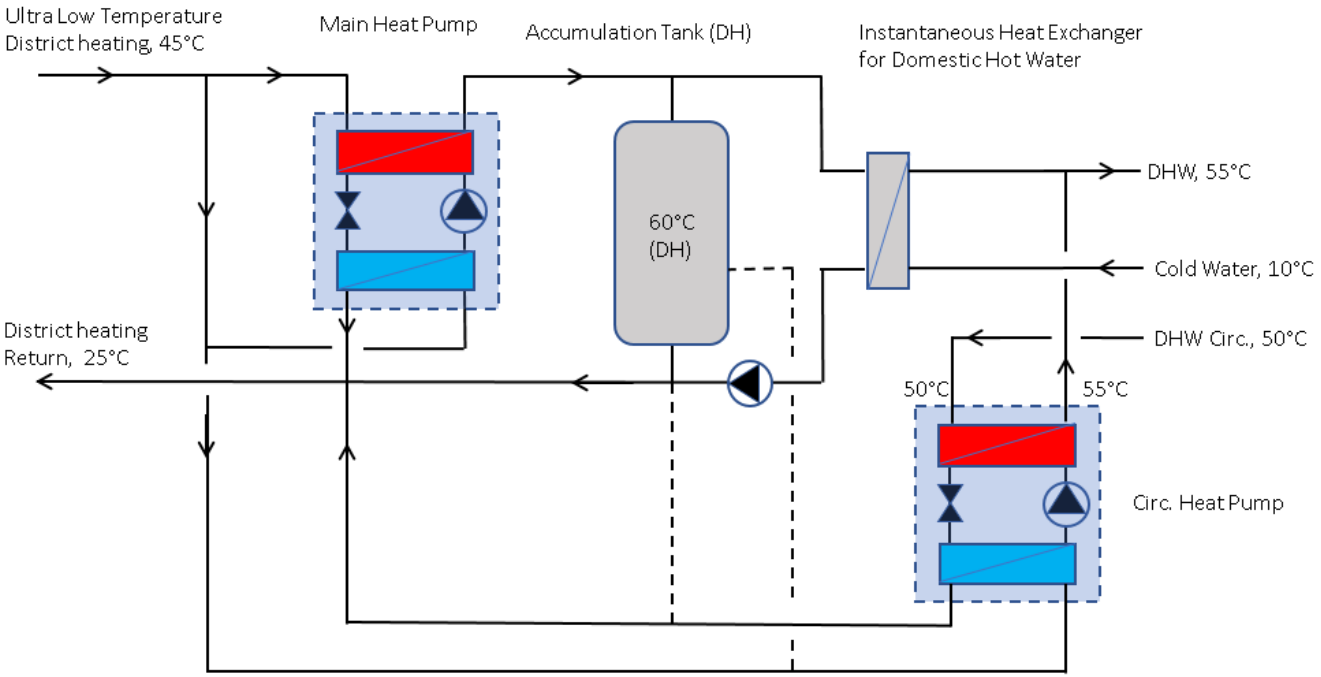
Danfoss A/S - Heating Segment Application Centre

Part of project:
www.energylabnordhavn.dk

Funded by:

Powered by

The Basic Concept ULTDH Heat Booster Substation:



Flexibility 1:
Time of DH tank charge
-DH and Elec. load shift

Flexibility 2:
MHP evaporation temp.
-DH and Elec. fuel shift
-DH return temp.
(Condensing temp.)

Flexibility 3:
Source for Circ. HP
-DH return temp.

IN FOCUS:
Flexibility 1

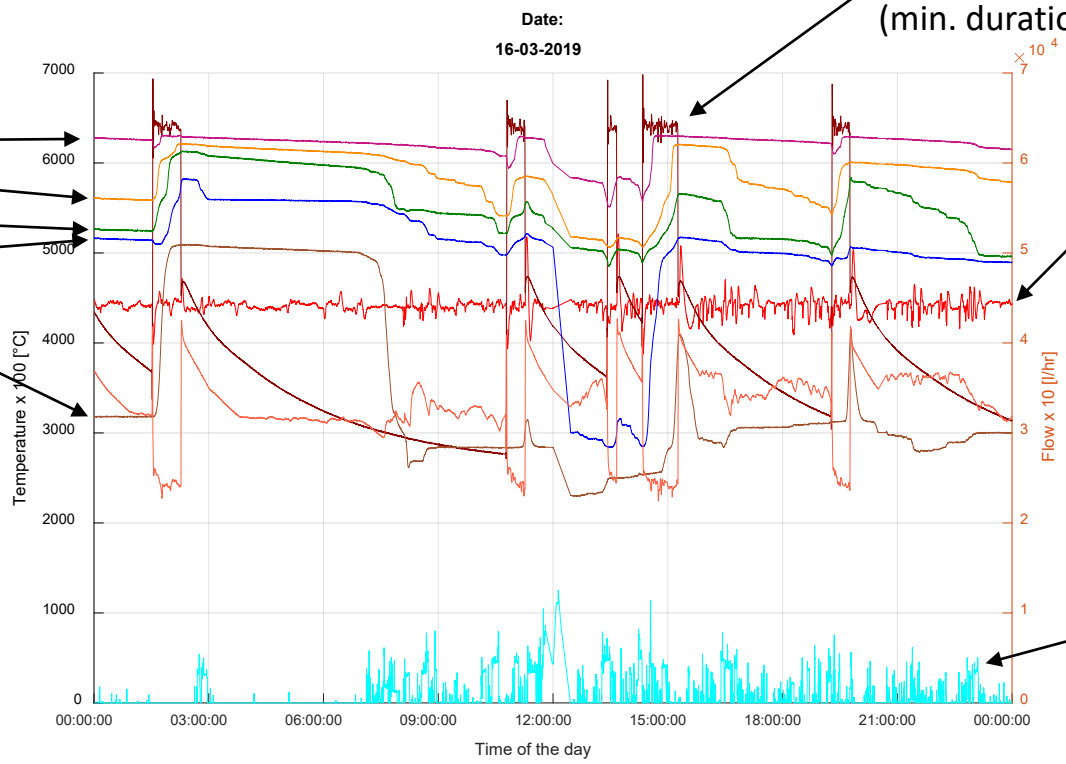
Field Location and Installation:

HBS Charging profile:

5 charging periods
Triggered by energy costs
(min. duration 15 min.)

DH TANK
1.500 L

T tank top #1
T tank #2
T tank #3
T tank #4
T tank #5

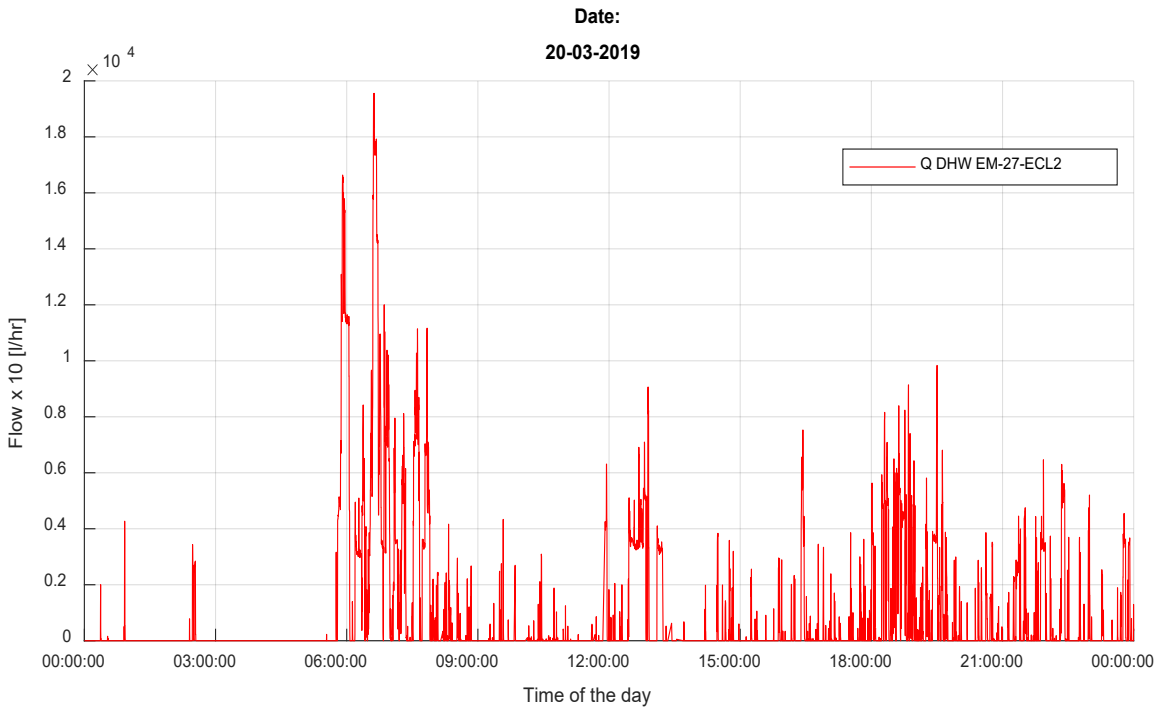


T DH flow

DHW tapping flow

Tank temperatures gives the available usable volume for producing DHW

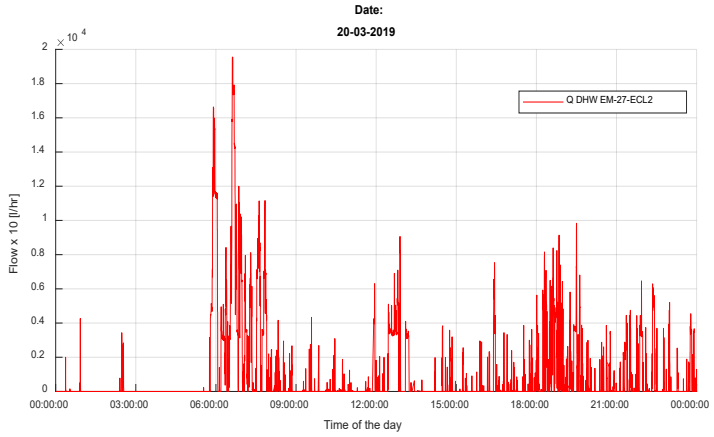
DHW demand patterns over the day



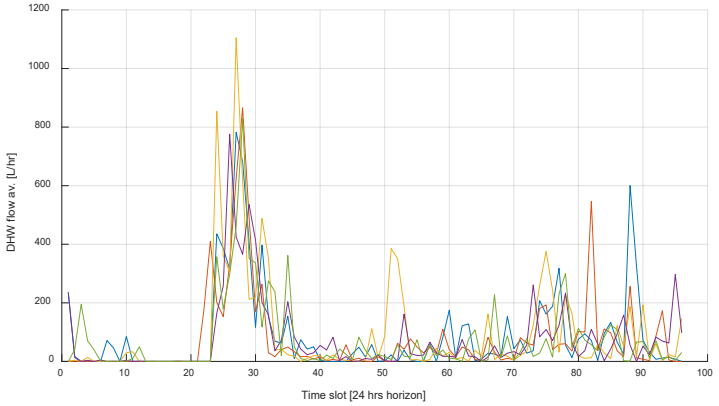
A Wednesday
Sample time 10 sec !
(8.640 data/day)

How to forecast tomorrow ?
Or maybe the next coming Wednesday ?
What about seasonal variations ?

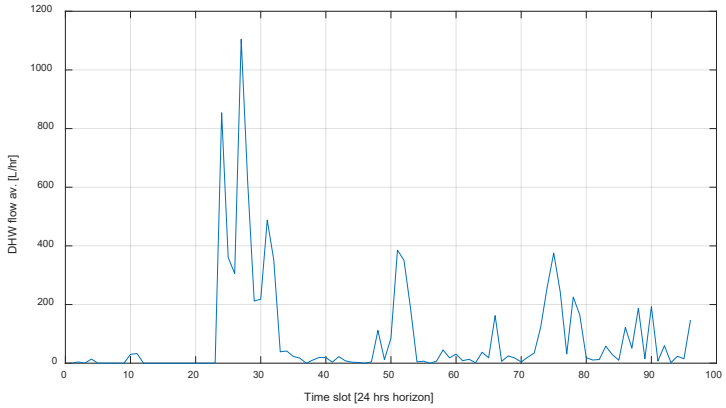
DHW demand patterns over the day



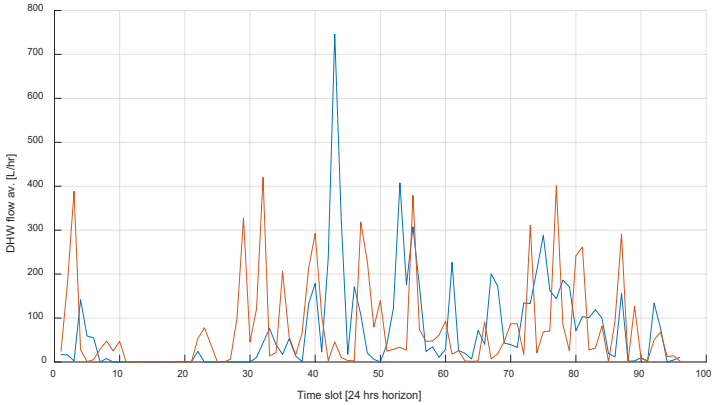
A Wednesday
2.200 Liters DHW produced
Sample time 10 sec !
(8.640 data/day)



Aggregated data
Monday - Friday



Aggregated data
into 96 slots (15 min)



Aggregated data
Saturday - Sunday

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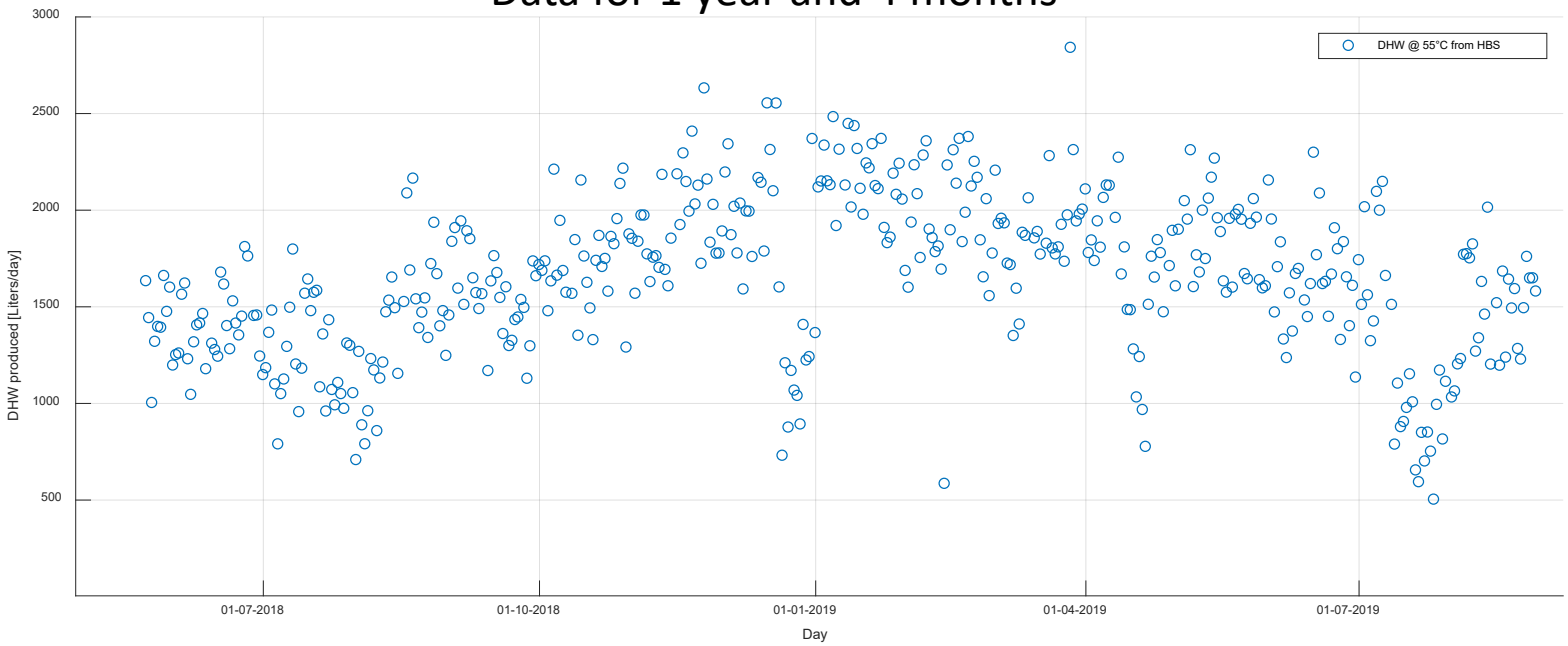
DHW tapping volume pr. Day

(55°C produced by HBS)

Data for 1 year and 4 months

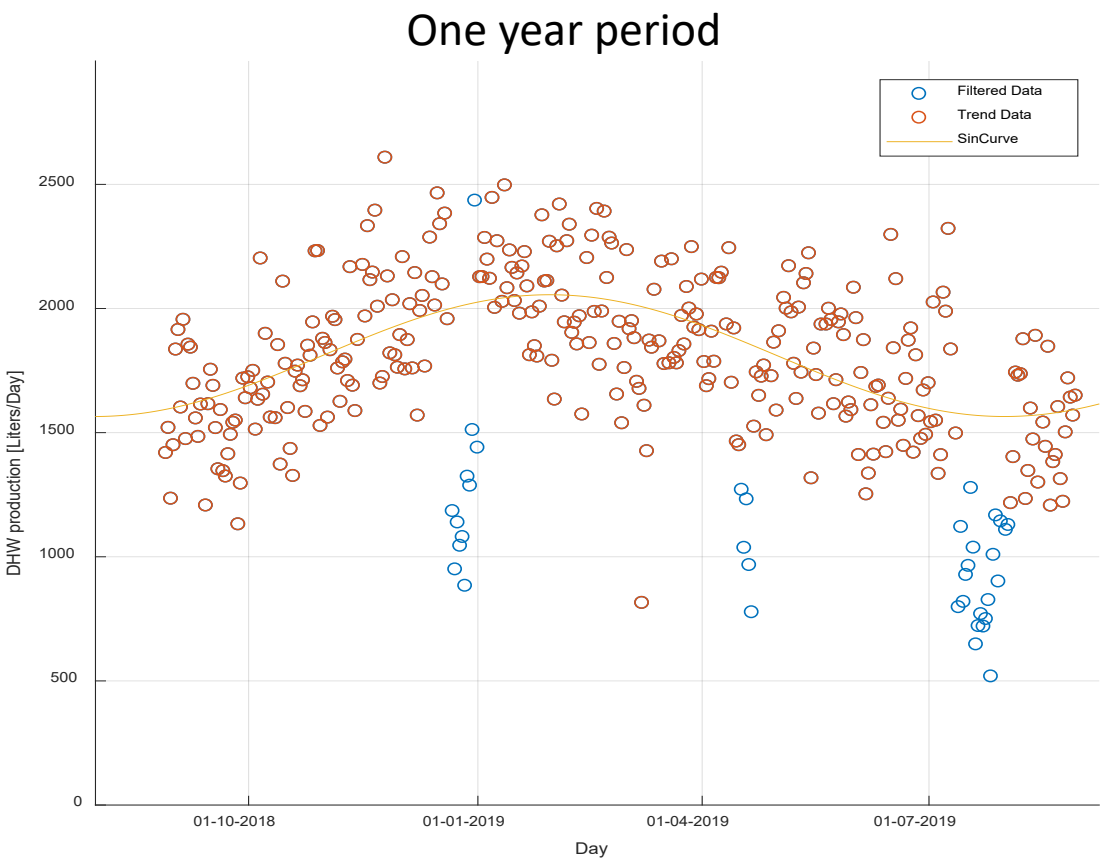


Seasonal variation of DHW consumption !
> Ambient temperature !
> Cold water temperature, due to mixing at tap/shower !
> Alternative places to use DHW, e.g. vacation !

→ Seasonal trend good to know !

DHW tapping volume pr. Day

(55°C produced by HBS)



Trendline (SinCurve)

DHW Volume average: 1.800 liters/day
Trend curve amplitude: 250 Liters
Variation up to +/-500 liters/day

Principle of forecasting:

Distinguish between the 7 days of the week

- Monday learns from Mondays, Tuesday learns from Tuesdays,…..
- Seasonal trend is learned from data of all days

Lets use a Wednesday as example, 3 Wednesdays in a row: W1,W2 and W3

How to forecast W3 based on W1 and W2:

WF = 0,10 (ForeCast is factored by 0,90 and ActualData by 0,10)

Passed W1: W2_FC = W1_AD

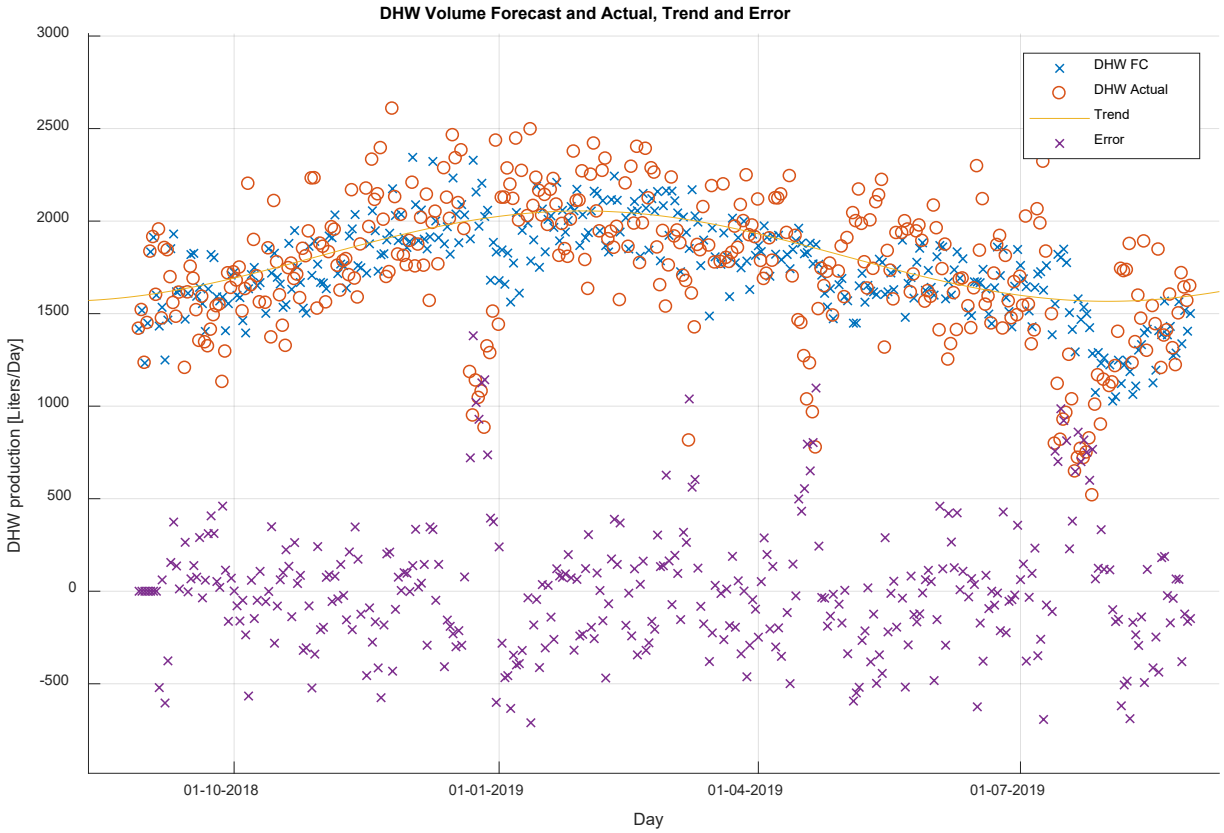
Passed W2: W3_FC = W2_FC*(1-WF) + W2_AD*WF

Passed W3: W4_FC = W3_FC*(1-WF) + W3_AD*WF

…

Day forecast is divided into 15 minutes intervals, to cover the variation or profile over the day
Forecast is first normalized by compensating for yearly variation
Normalized forecast is calculated
Then de-compensated by adding the yearly variation to the normalized forecast

DHW Actual, Forecast and Error pr. day



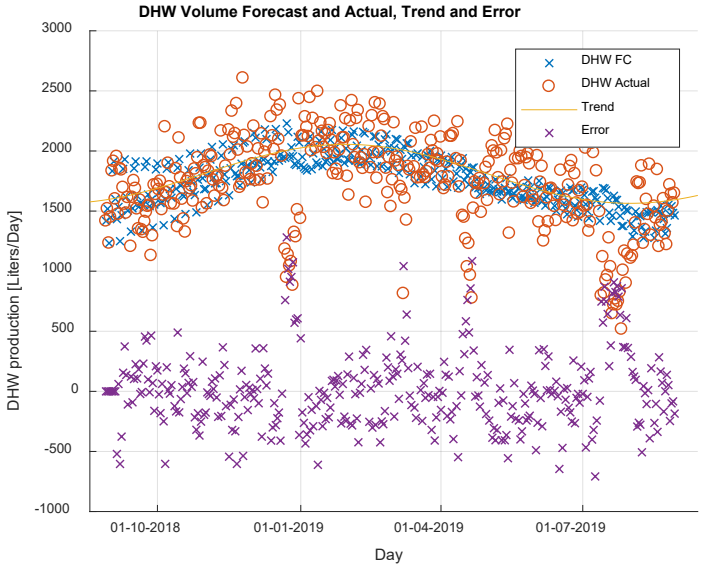
WF=0,25

Error is in average around 0 (seasonal compensation)

First order filtration can be seen (Les variation around Trend for FC compared to AC)

Some outliers due to data issues filtered away (<500 Liters/day)

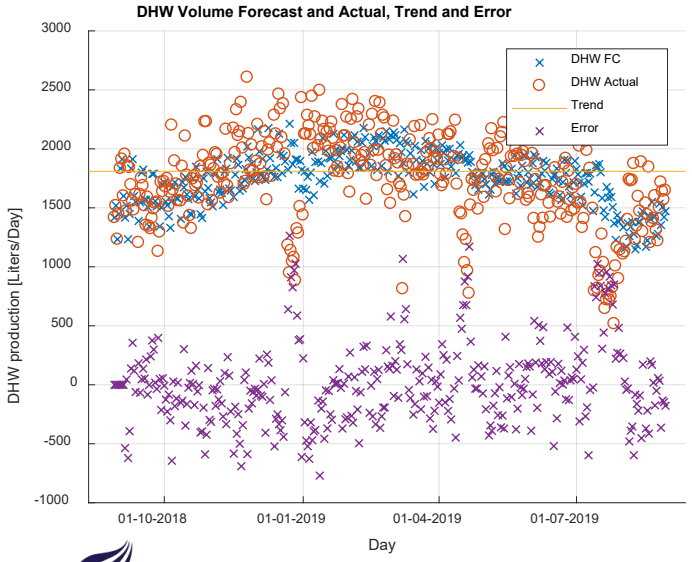
Christmas holiday, Easter holiday and summer holiday is ”noise” or should be handled better !



WF=0,10

Seasonal Comp.

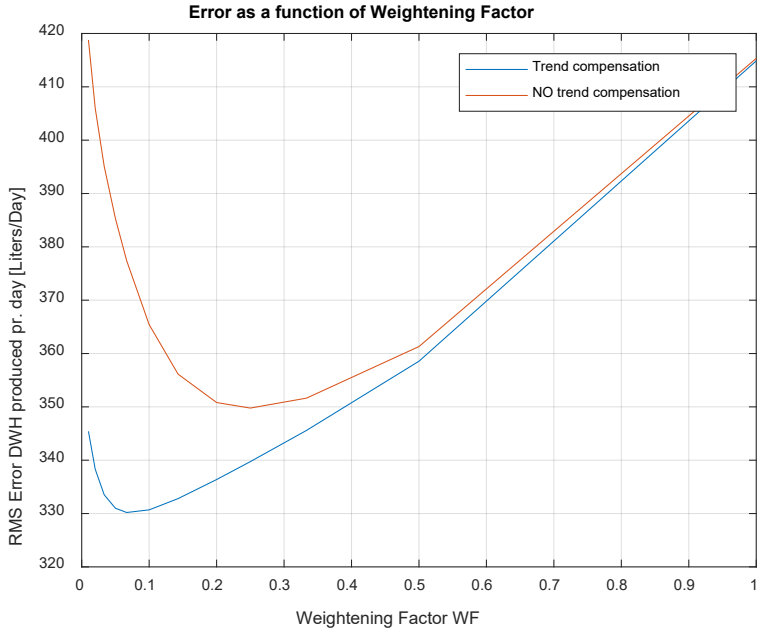
(SineCurve)



WF=0,25

NO Seasonal Comp.

(Straight line)



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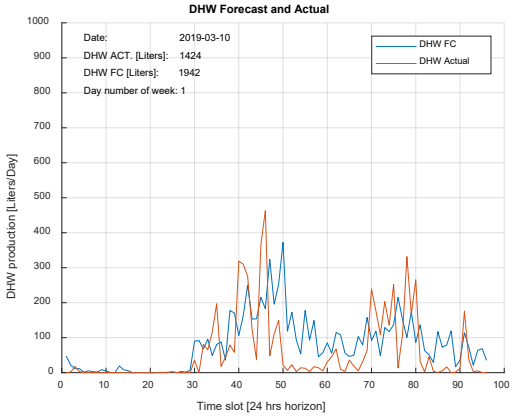
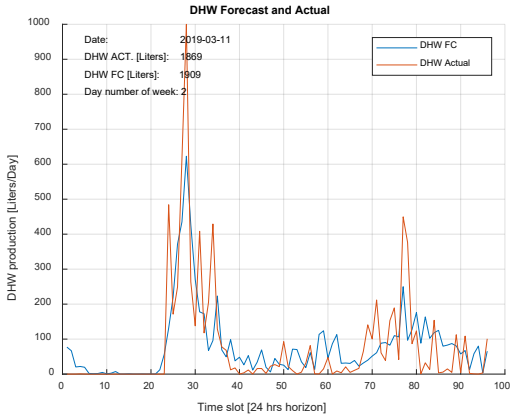
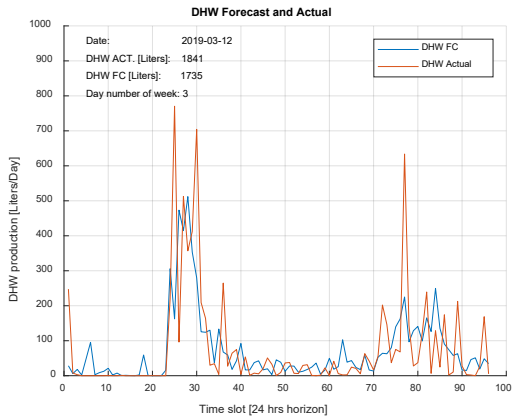
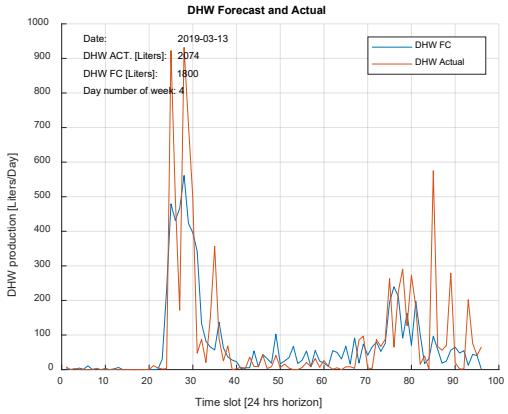
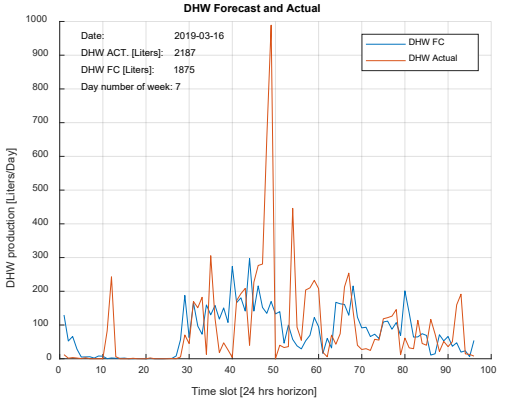
DHW Actual, Forecast pr. Day examples

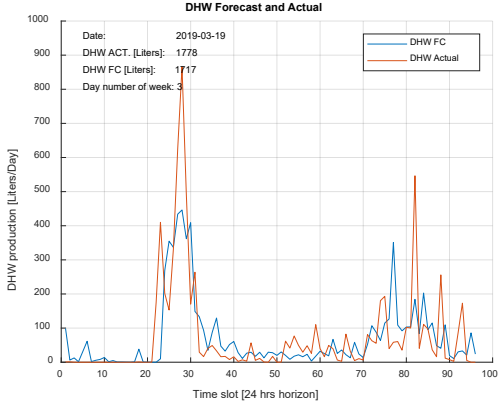






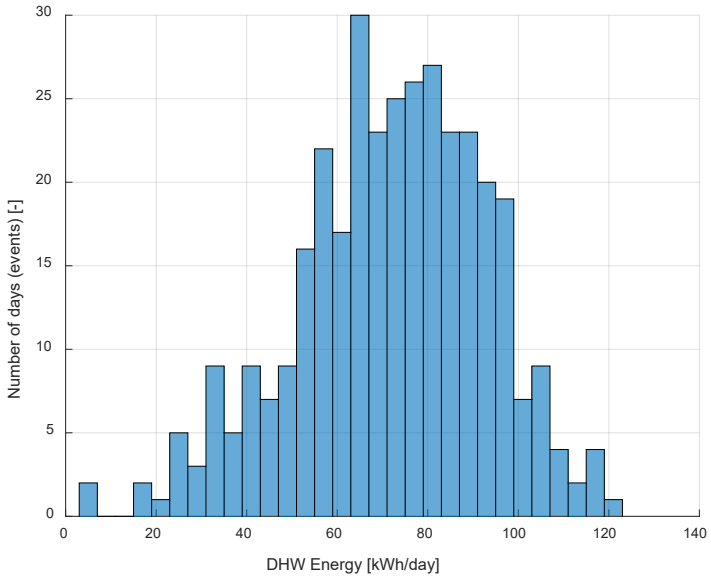




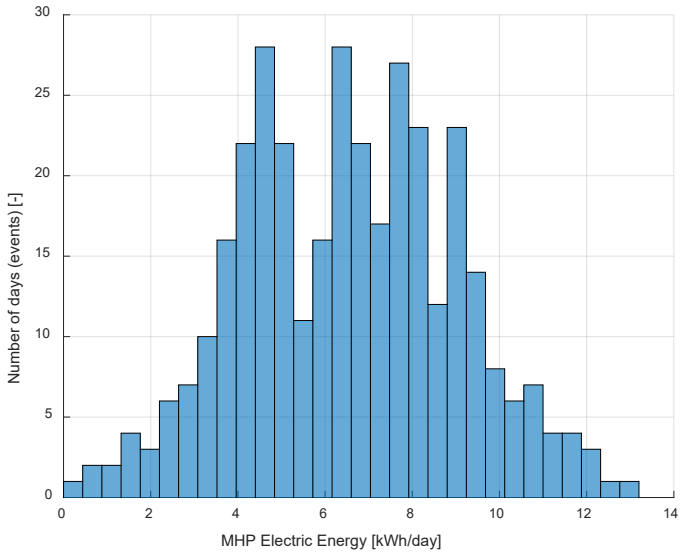


Day No 1 = Sunday, Day No 2 = Monday, Day No 3 = Tuesday and so on…

How big is the flexibility in terms of energy



DHW 72 kWh/Day average



Elec. Flexibility 6,5 kWh/Day average

DH flexibility 72 – 6,5 = 65,5 kWh/Day average

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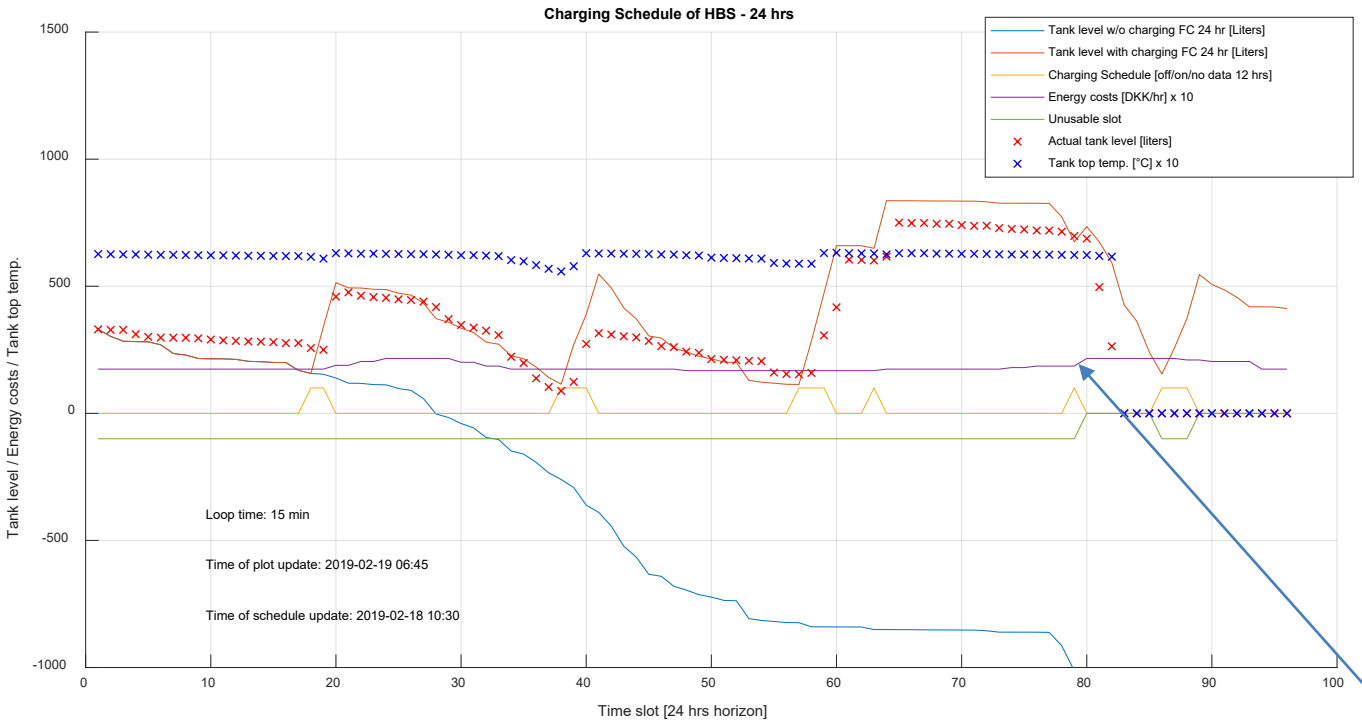
24 Hr forecast of HBS operation schedule



Charge criteria's:

At the lowest energy costs

As late as possible

Within tank charging level constrains (100-1000 liters) usable volume

Usable volume at end 500 Liters

NordPool Elec. Costs
Simulated Marginal DH Costs

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Conclusions

We have realized a Prognosis based scheduling of the HBS, optimizing for lowest energy costs in relation to when to charge the DH tank.

The applied principles are simple but works, they can be improved, e.g. by:
- Use other methods like clustering, pattern recognition
- When forecast is detected "bad" during the day, take action mediately (do not wait until next week)

We will look more into Flexibility 2 and 3 (MHP operation and Source for Circulation HP)
The daily **average** DHW **load shift** potential is 72 kWh/day for a 22 flat building

- Hereof is electricity 6,5 kWh/day and DH 65,5 kWh/day in average
- Regarding capacity flexibility, this is 3 kW electric and 30 kW DH realized for e.g. a period of 1 hr. and 5 min. before the morning DHW peak and before the evening DHW peak in average over the year.
- Over the year this varies by +/-50% due to DHW seasonal variation

On a yearly basis its at least on the same level as the load shift potential for the heating system !

The implemented automatic scheduling of the HBS operation with the related flexibility is running successfully as a part of the EnergyLabNordhavn project !

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Thank You for the Attention…

And check out www.energylabnordhavn.dk

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