# Dynamic pricing in district heating systems and the impact of heat storage


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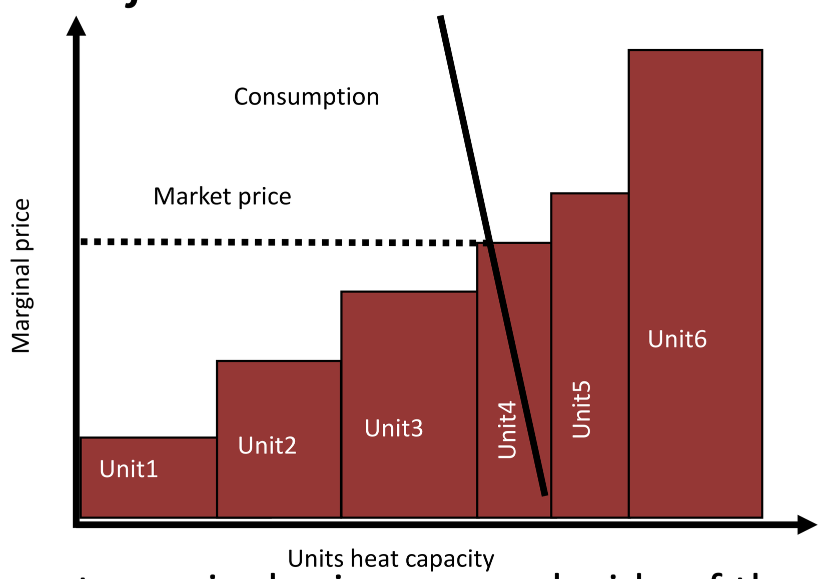
## Introduction

Using dynamic pricing is well known in the power sector. The focus of this poster is the impact of using **hourly marginal pricing in district heating systems** in stead of the heat tariffs currently in use.

***Definition of marginal heat price: The extra total cost associated with a marginal increase of heat demand.***

Marginal heat price depends on:

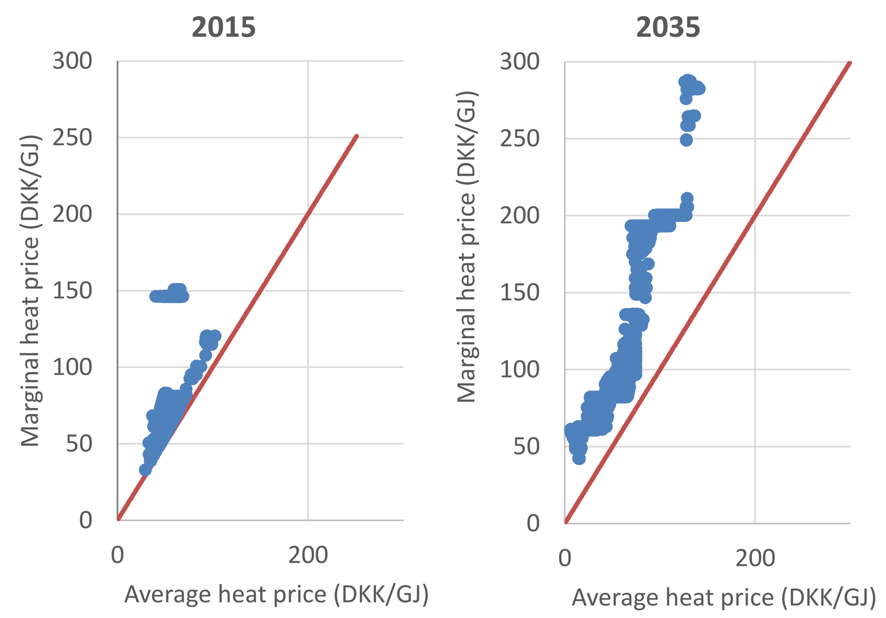
- **Heat demand**, which changes the level of production in the merit-order curve.
- **Electricity price**, which influences the revenue the production units.




- **Congestion**, which ensures different marginal prices on each side of the congested line.
- **Grid losses and fuel prices.**

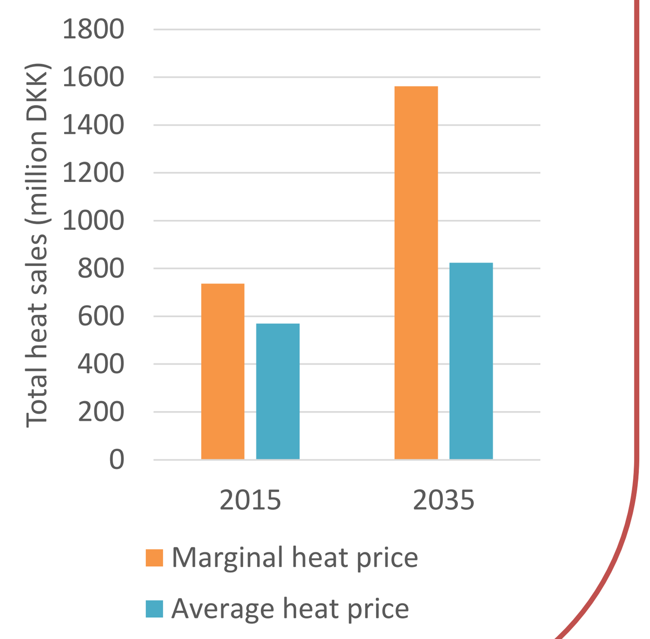
**Impact of heat storage** on the marginal heat price is a major focus point in this poster.

## Results: Marginal pricing vs average pricing

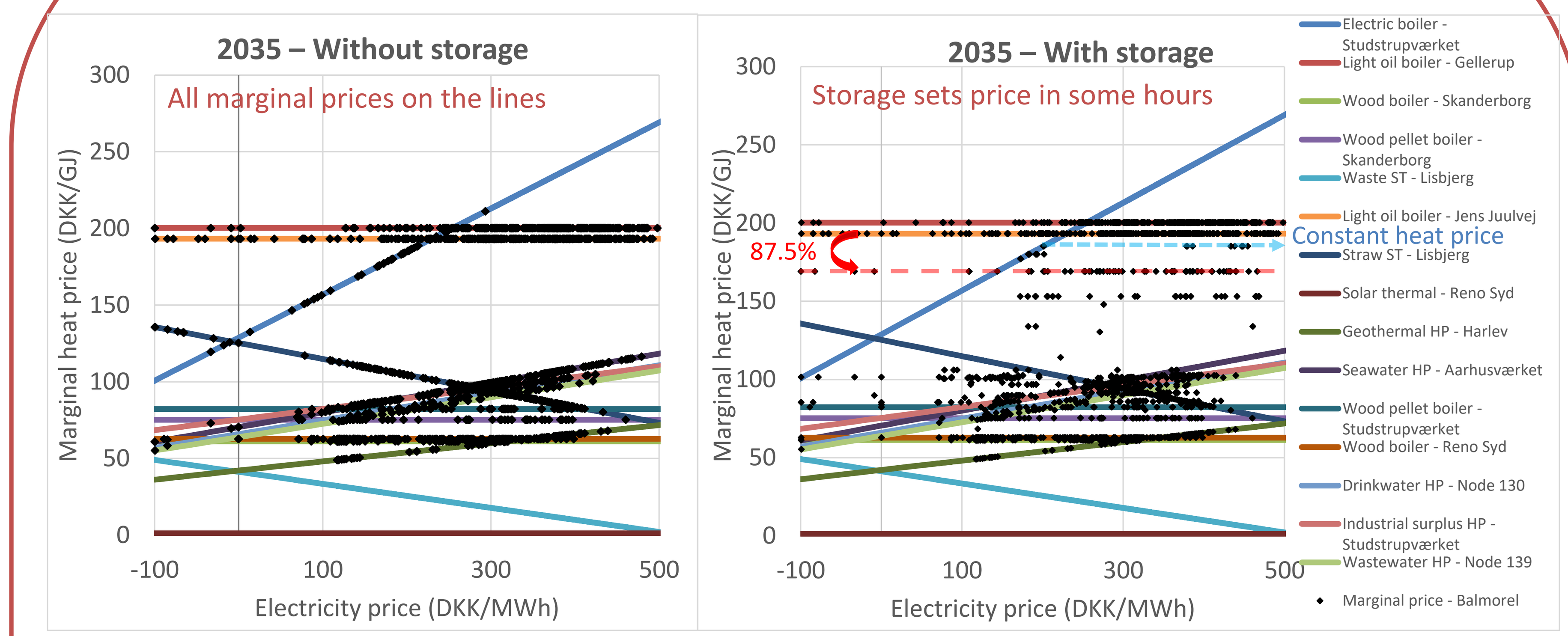



As the marginal heat price uses the marginal cost of the most expensive supplier, it's **always higher** than the average short-term heat costs. The variation of the marginal price is larger (in the order of 50% to 100% larger) than that of the average price.

Using marginal pricing reflects the **true hourly marginal cost**. The total revenue for the heat producers when using marginal prices is larger than the total variable costs. This **surplus** could be used to finance (part of) the fixed costs. The difference is bigger in 2035 than in 2015. It is still possible to keep the non-profit obligation.



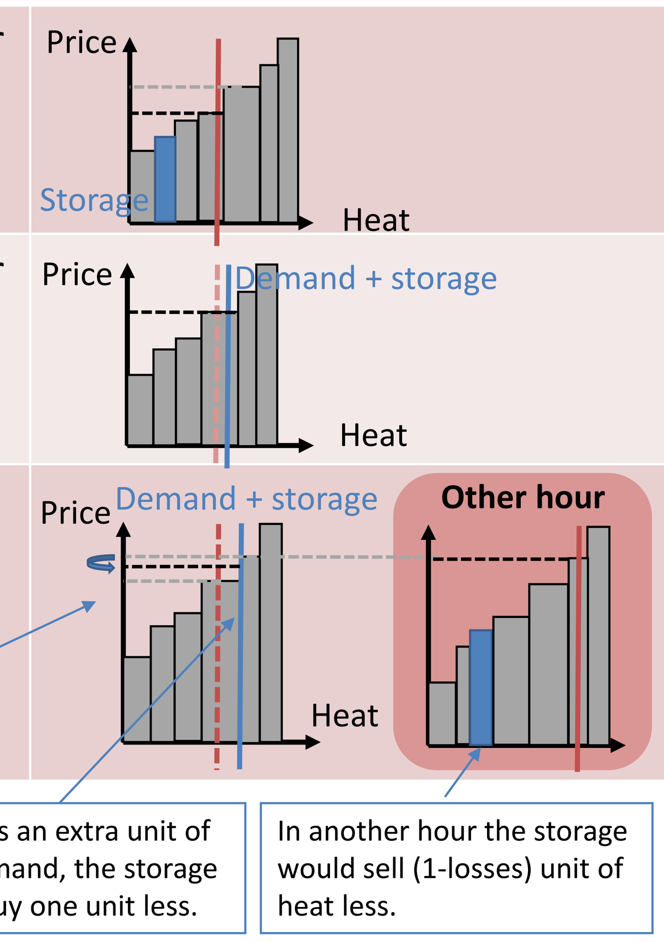

## Results: Impact of heat storage on heat prices




When comparing the results with storage to those without storage, several of the marginal prices now lay apart from the marginal cost lines. In all the hours where the realised marginal prices (black dots) are not on a supplier line, **one of the storages is setting the price**.

This happens when the Heat storage is the marginal unit (scenario 3 in the table).

| | Storage is | Price is set by | Illustration |
|---|---|---|---|
| 1 | Selling | Heat supplier with highest marginal costs | |
| 2 | Buying | Heat supplier with highest marginal costs | |
| 3 | Buying until marginal heat plant produces at full capacity | Heat storage (dot's off the cost lines) | |

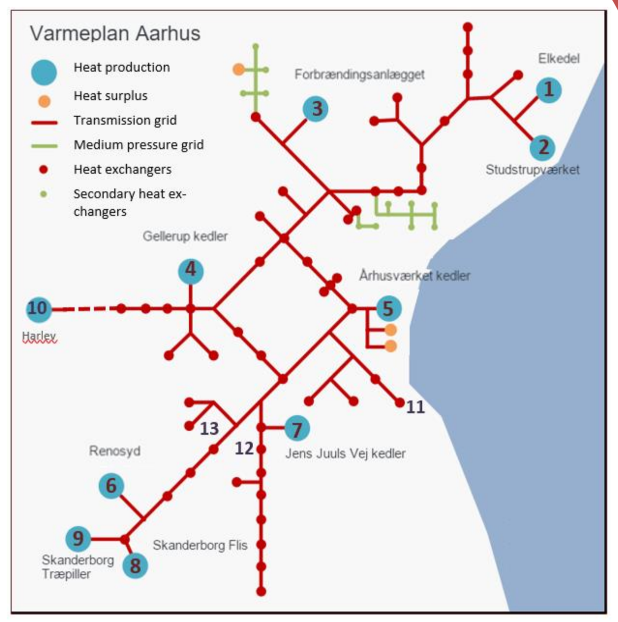



When the storage has bought all heat from the marginal heat plant, for one extra unit of heat demand, the storage would buy one unit less heat at that hour. This would mean that in another hour, the storage would sell (1-losses) units less. The heat price is then (1-losses) x heat price in the other hour. Two kinds of new prices appear:

- **Constant heat prices** where the storage transfers prices from hours where the marginal plant is a CHP/el-boiler/heat pump, **independent of the power price**.
- Heat prices that are introduced by **storages losses**

## Modelling

The **Aarhus district heating system** is modelled in the least-cost optimization model **Balmorel** for the years 2015 and 2035.

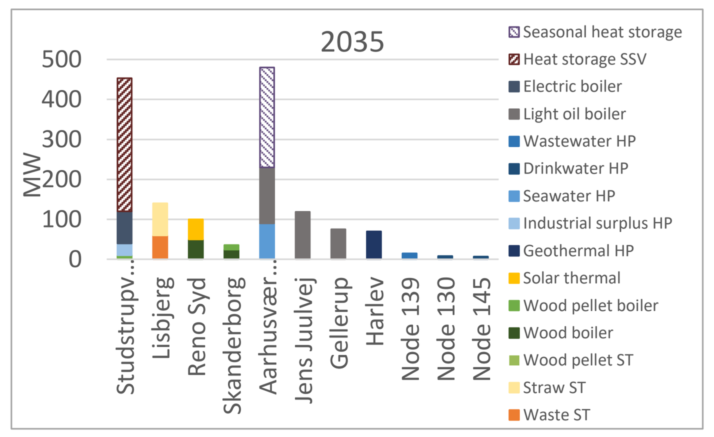



**Heat demand**

The annual heat demand is assumed to be **2.86 TWh** in both years. The total demand is distributed over 47 interlinked demand nodes.

**Heat production**

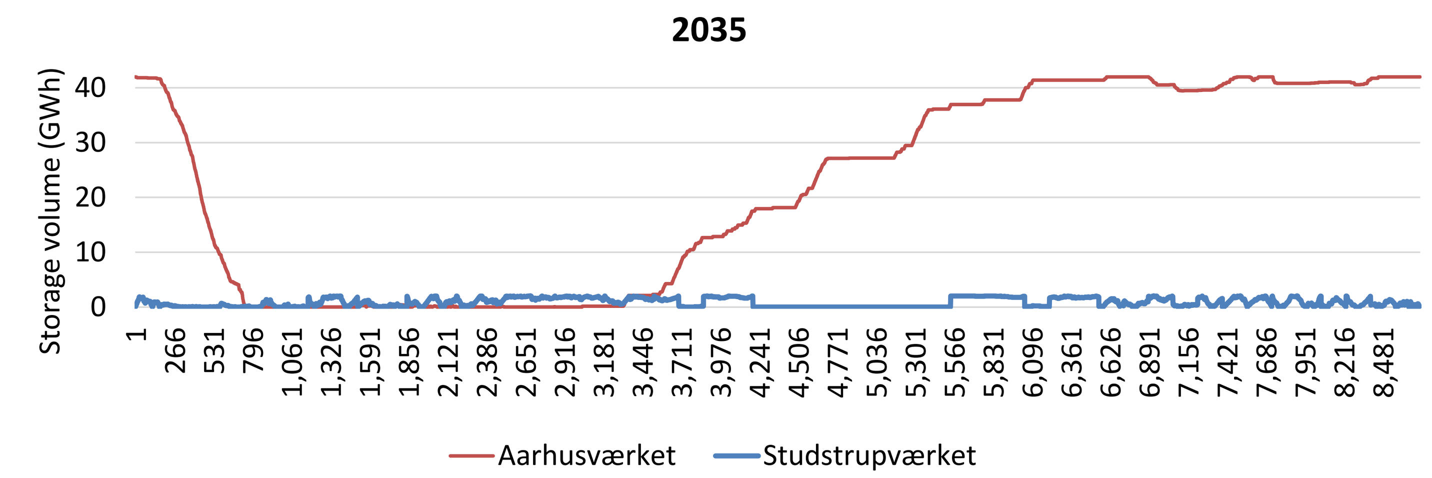
In **2015**, **existing units** are modelled, where the units in **2035** represent a **possible future** for the Aarhus district heating sector, and technologies such as solar thermal heat and heat pumps are introduced in the mix.

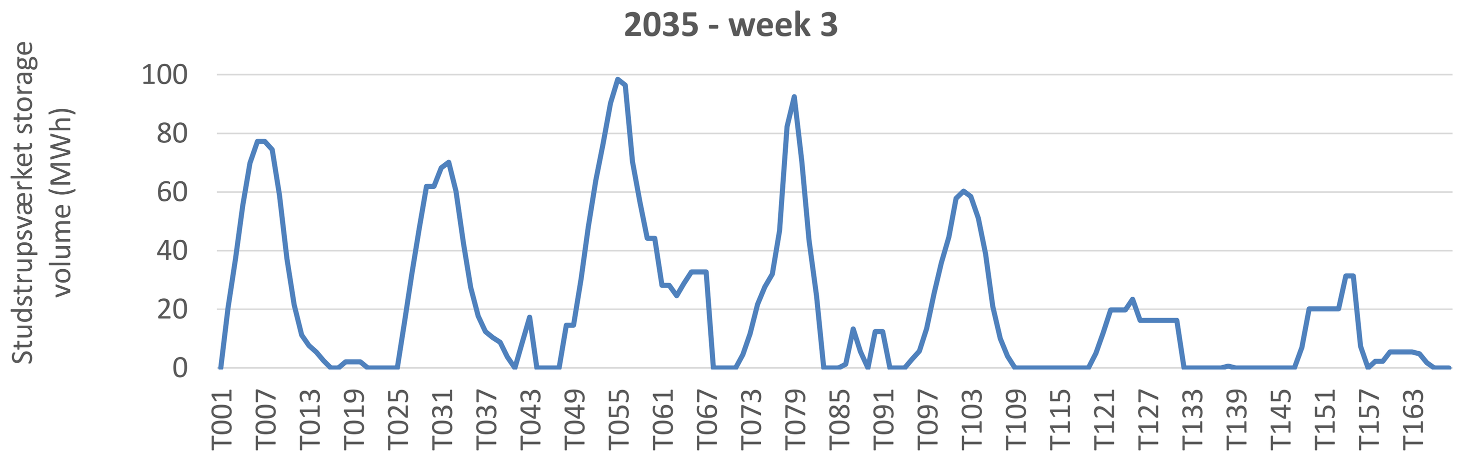



**Heat storages**

1. The heat storage in **Studstrupværket** (SSV) exists in 2015 and is a short-term storage which optimises circularly per week. It has no losses. Storage volume: 2 GWh – Storage (un)load capacity: 333 MW
2. The storage that's is added in 2035 in **Aarhusværket** is a larger seasonal storage and can optimise over an entire year. It has a 12.5% loss. Storage volume: 42 GWh – Storage (un)load capacity: 250 MW

## Results: Use of heat storages




Where the storage in **Studstrupværket** is used as a **daily storage** to balance daily variations in the demand and heat prices, the storage in **Aarhusværket** is used as a **seasonal storage**. The storage buys during the summer when heat demand is low (and solar heating production is high) and sells heat in the winter hours where the heat prices are highest. Due to the storage losses, the storage is not used much for balancing the (smaller) short-term price variations.

## Discussion

**Fixed prices** for heat delivered to district heating systems **do not reflect the actual value of the heat**. Using hourly marginal prices would give the **correct incentive** to new heat suppliers coming to the district heating market, such as industrial surplus heat, or independent heat generators with e.g. solar heat plants or heat pumps. Dynamic pricing would be **technology neutral and economically efficient**.

Heat storages have a large impact on marginal heat prices. **Both seasonal and daily storages** can be used in a district heating system such as in Aarhus.

Next steps would be to look at **practical implementation** of dynamic heat prices in a district heating system such as Aarhus.