

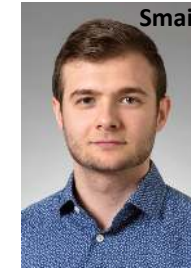
Samspil mellem grøn energi og energieffektivisering af bygninger

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@ Installationskonferencen 2019

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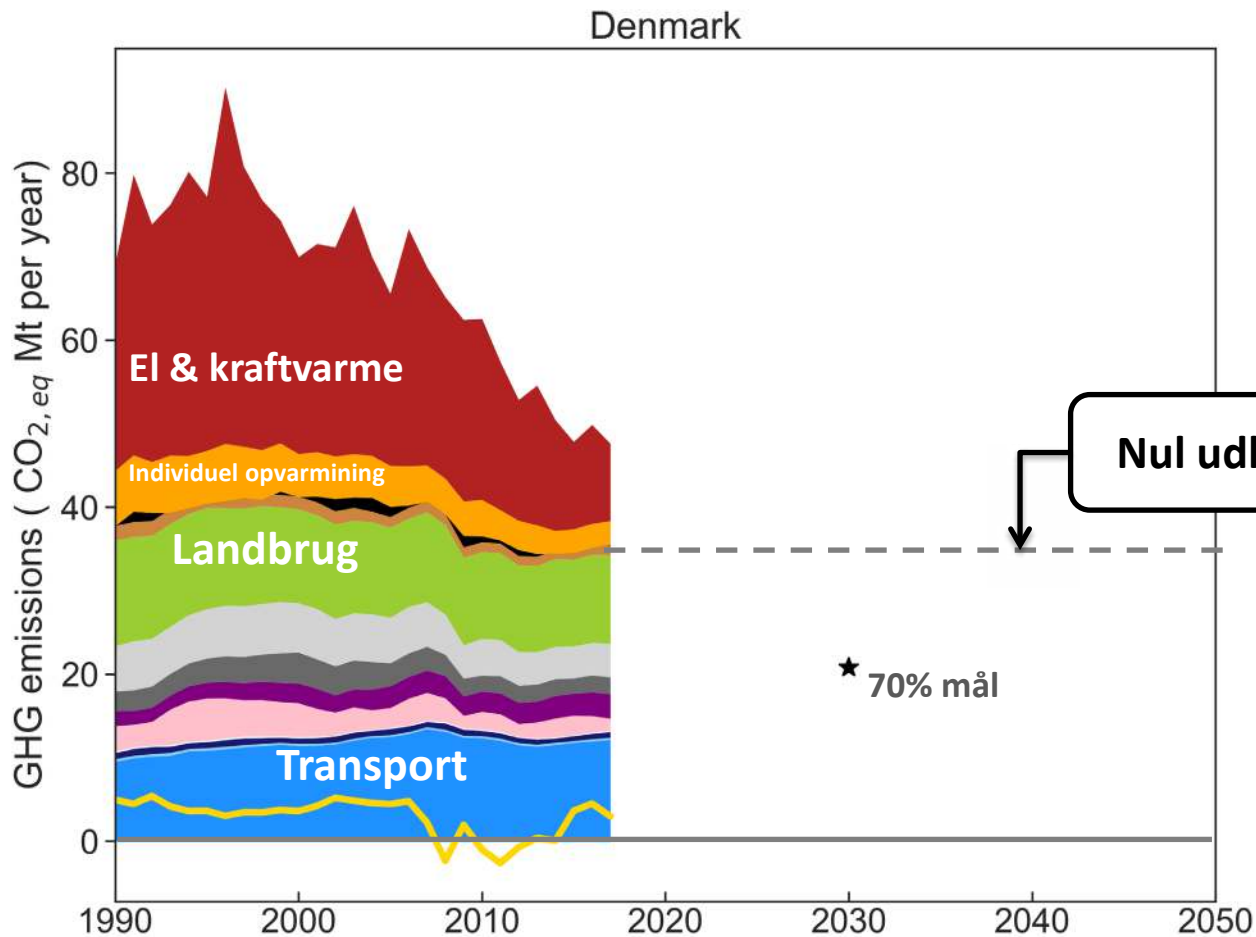


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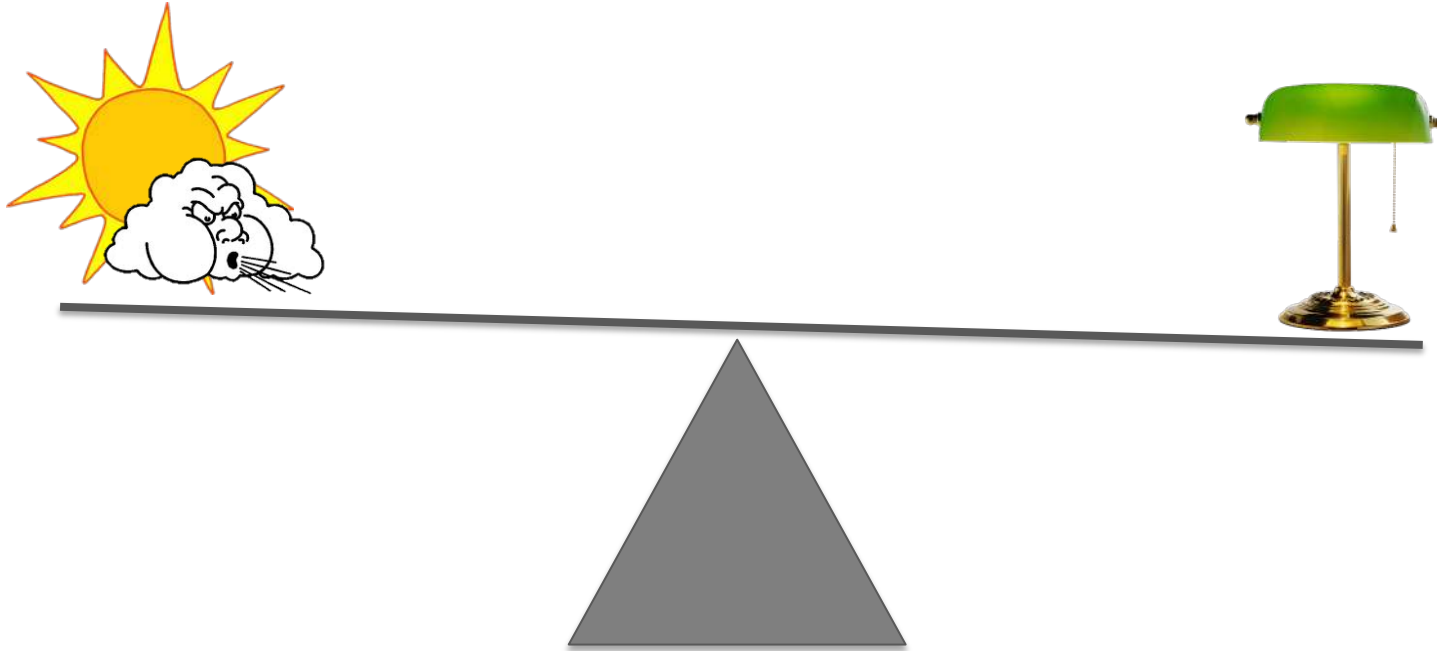


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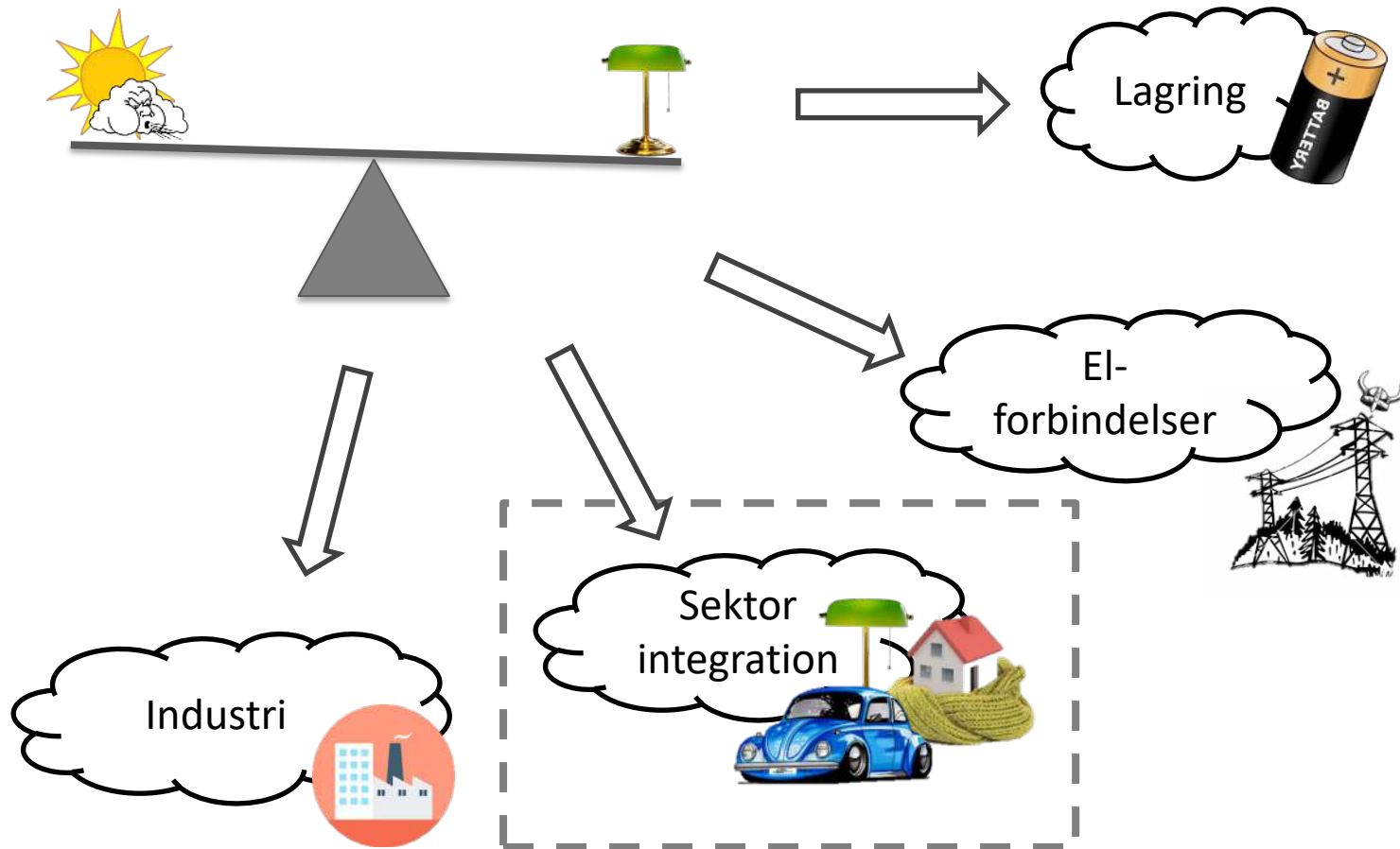
Danske CO₂ udledninger

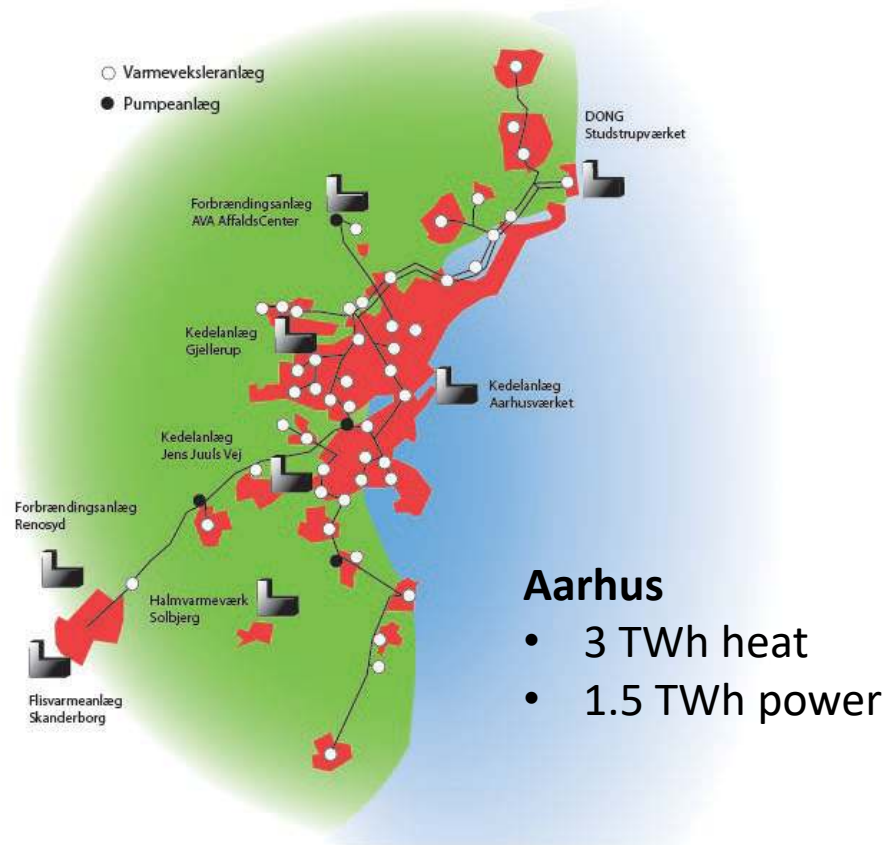


Udfordringen ved grøn energi



Energibalance

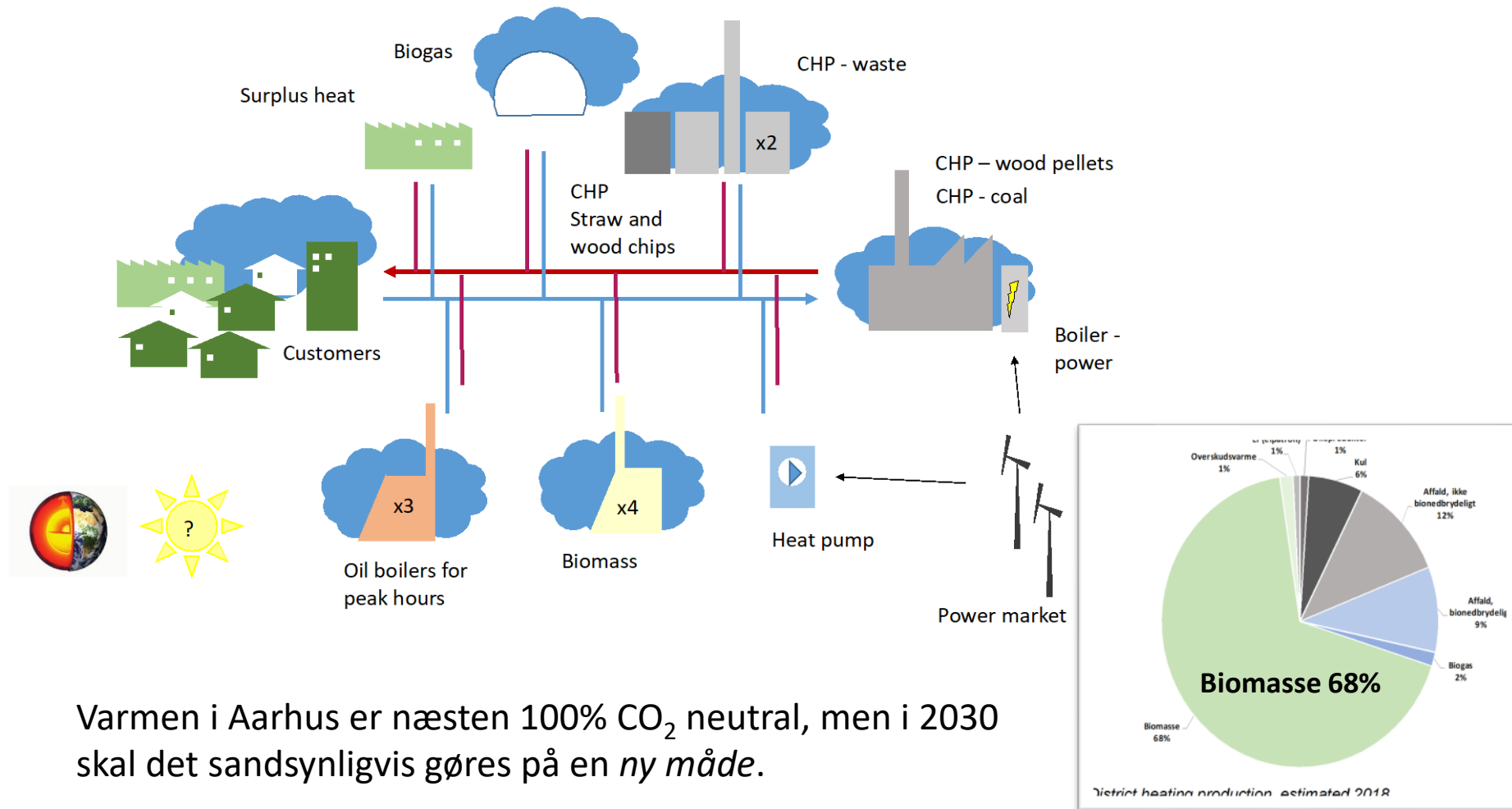




Grøn energi til hele byen

AARHUS VARMEFORSYNING

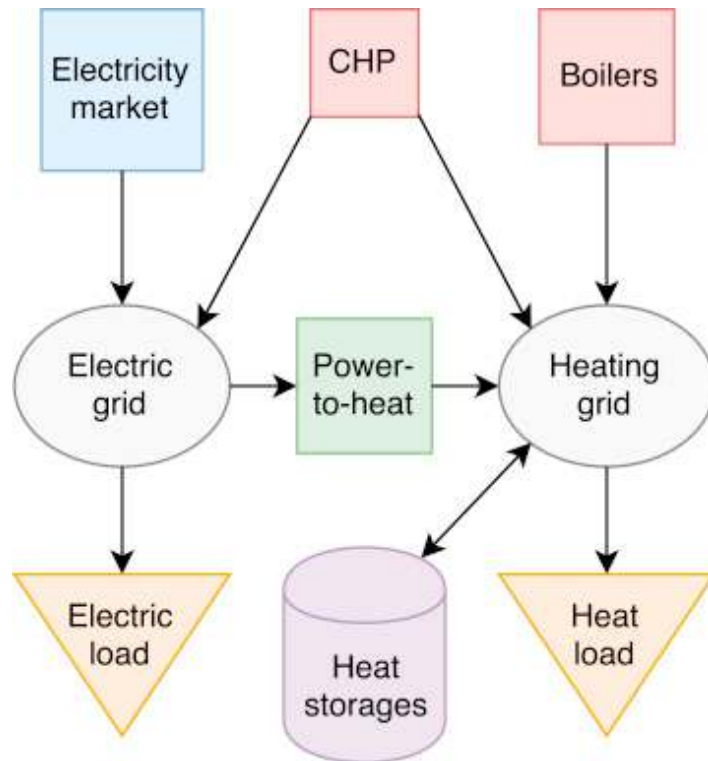
Varmeproduktion i Aarhus



Varmen i Aarhus er næsten 100% CO₂ neutral, men i 2030 skal det sandsynligvis gøres på en *ny måde*.

Produktionsoptimering

Hvad er den billigste løsning?



Investeringsomkostninger

$$\min_{\substack{\bar{P}_u^{\text{el}}, \bar{P}_u^{\text{heat}}, \bar{H}_s, \\ P_{u,t}^{\text{el}}, P_{u,t}^{\text{heat}}}} \left(\sum_{u \in \text{prod. units}} c_u^{\text{el}} \bar{P}_u^{\text{el}} + c_u^{\text{heat}} \bar{P}_u^{\text{heat}} + \sum_{s \in \text{storages}} c_s^{\text{stor}} \bar{H}_s \right)$$

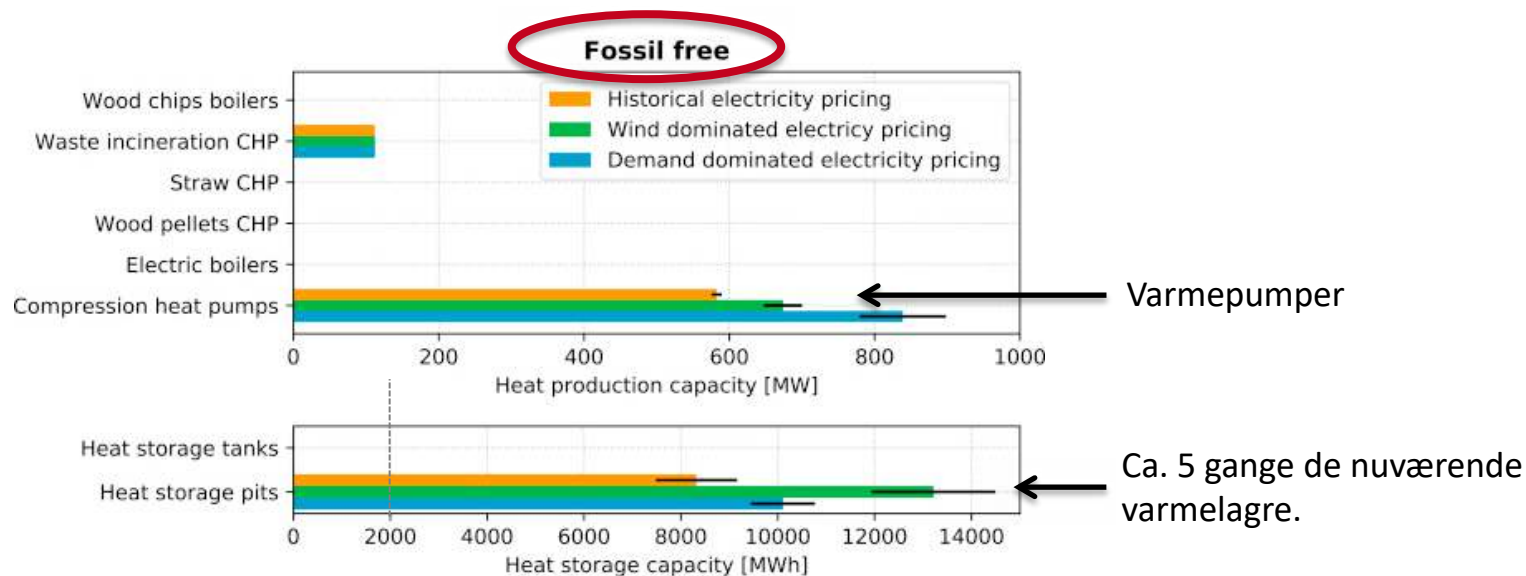
$$+ \sum_{t=1}^N \Delta t \left[\sum_{u \in \text{prod. units}} o_{u,t}^{\text{el}} P_{u,t}^{\text{el}} + o_{u,t}^{\text{heat}} P_{u,t}^{\text{heat}} + \sum_{s \in \text{storages}} o_{s,t}^{\text{disp}} h_{s,t} + o_{s,t}^{\text{upt}} f_{s,t} \right]$$

Driftsomkostninger

Kilde: <https://doi.org/10.1016/j.energy.2018.10.044>

Varmepumper og lagre er klart billigst

(uden afgifter)



Varmeprisen burde kunne holdes på cirka samme niveau som i dag.

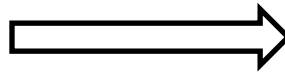
Kilde: <https://doi.org/10.1016/j.energy.2018.10.044>

Lav-temperatur fjernvarme

Lav-temperatur fjernvarme giver bedre muligheder for *billig og effektiv forsyning med grøn energi.*

Eksempel:

Fremløbstemperatur 60 °C -> 50 °C





Grøn energi til hele byen

BYGNINGER I AARHUS

Alle huse er ikke ens

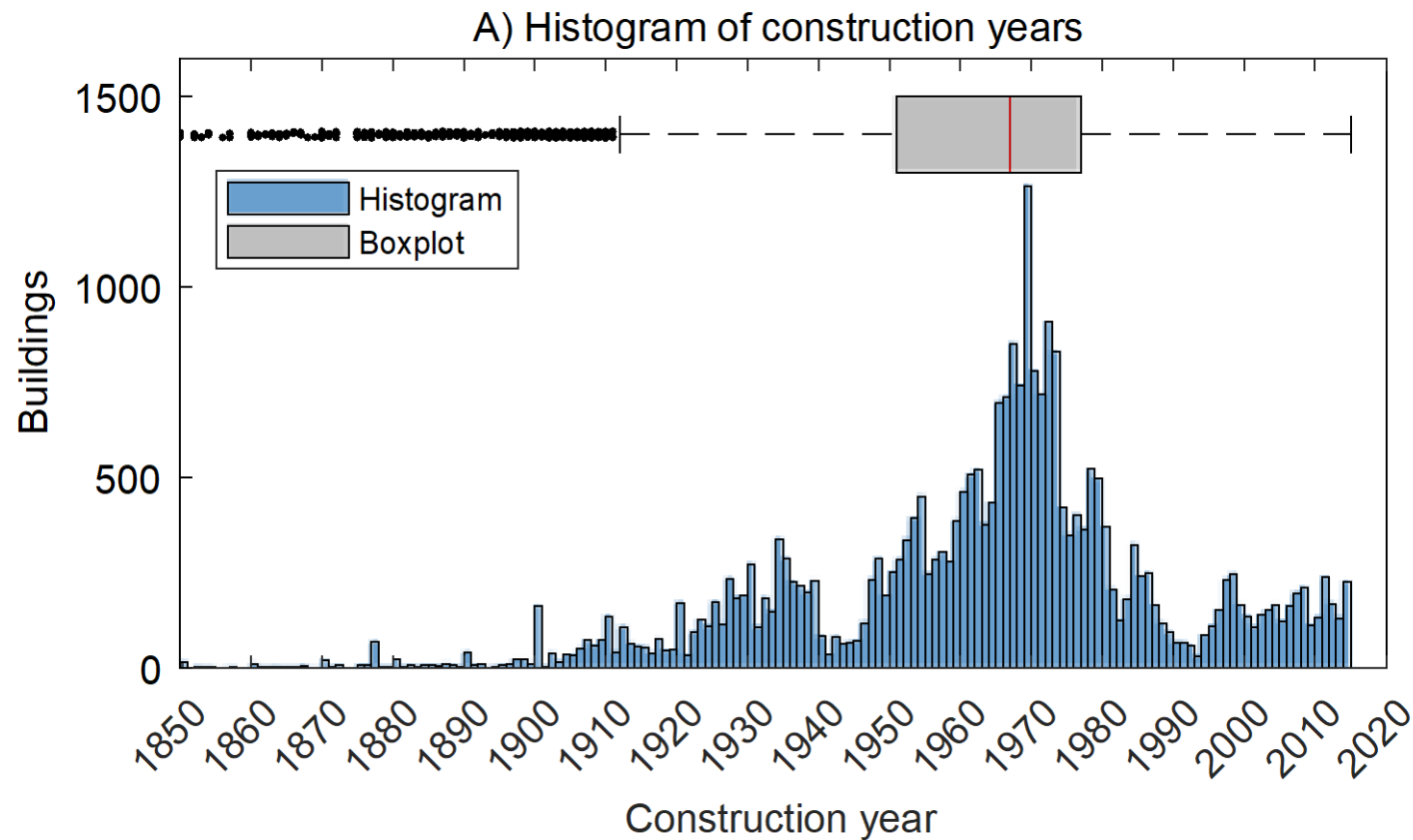
Archetype	Example	Building period	Segmentation argument
Archetype 1		1851-1930	Shift in building tradition
Archetype 2		1931-1950	Cavity walls introduced
Archetype 3		1951-1960	Insulated cavity walls introduced
Archetype 4		1961-1972	First energy requirements (BR61)
Archetype 5		1973-1978	Tightened energy requirements (BR72)
Archetype 6		1979-1998	Tightened energy requirements (BR78)
Archetype 7		1999-2006	Tightened energy requirements (BR98)
Archetype 8		2007-2010	Tightened energy requirements (BR06/ BR08)
Archetype 9		2011-2015	Tightened energy requirements (BR10)

Lavere forbrug per m²



Kilde: M.H. Kristensen, Ph.d. afhandling
(<https://ebooks.au.dk/aul/catalog/book/301>) .

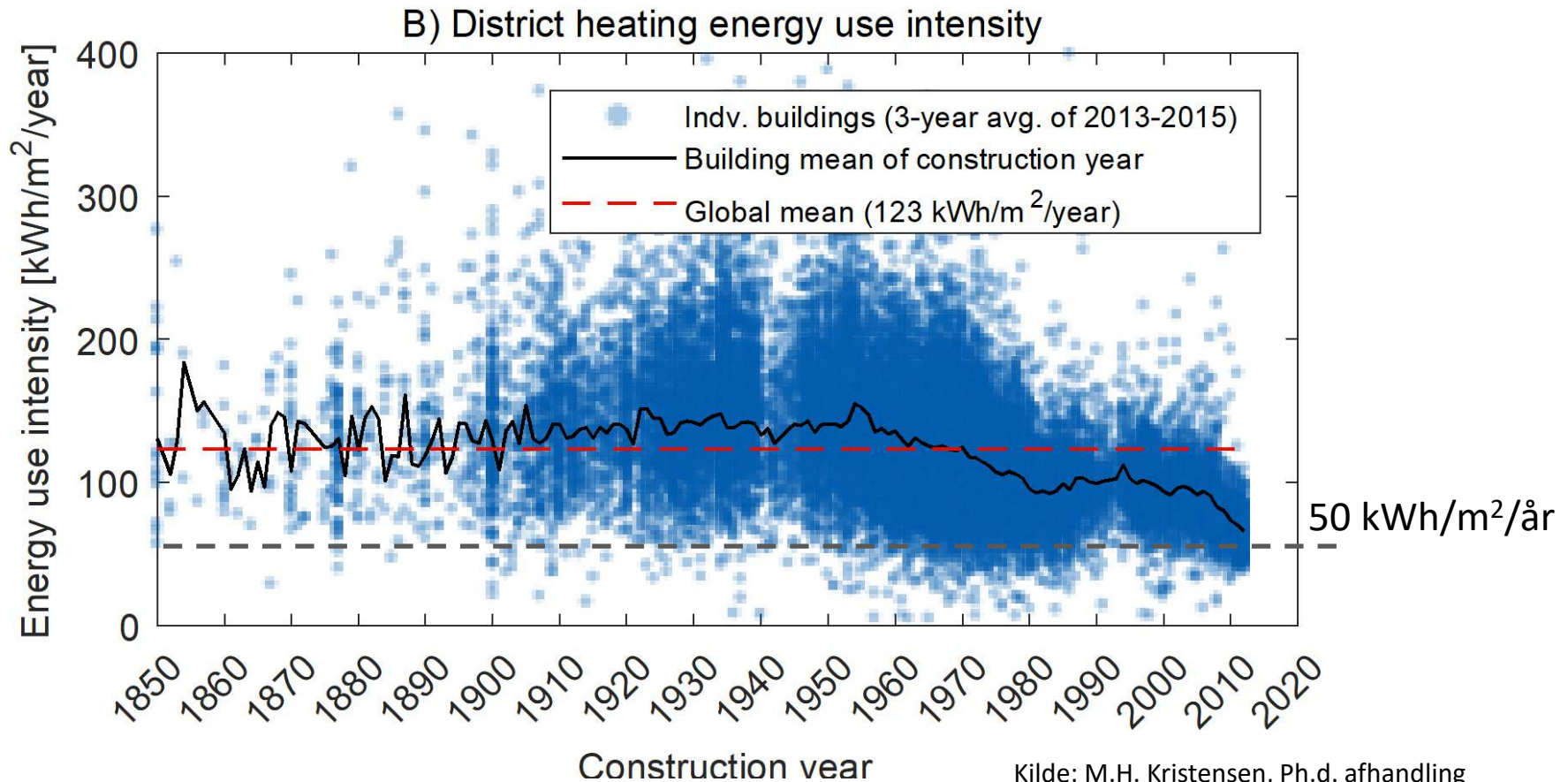
Hvor når blev Aarhus bygget?



Kilde: M.H. Kristensen, Ph.d. afhandling
(<https://ebooks.au.dk/aul/catalog/book/301>) .

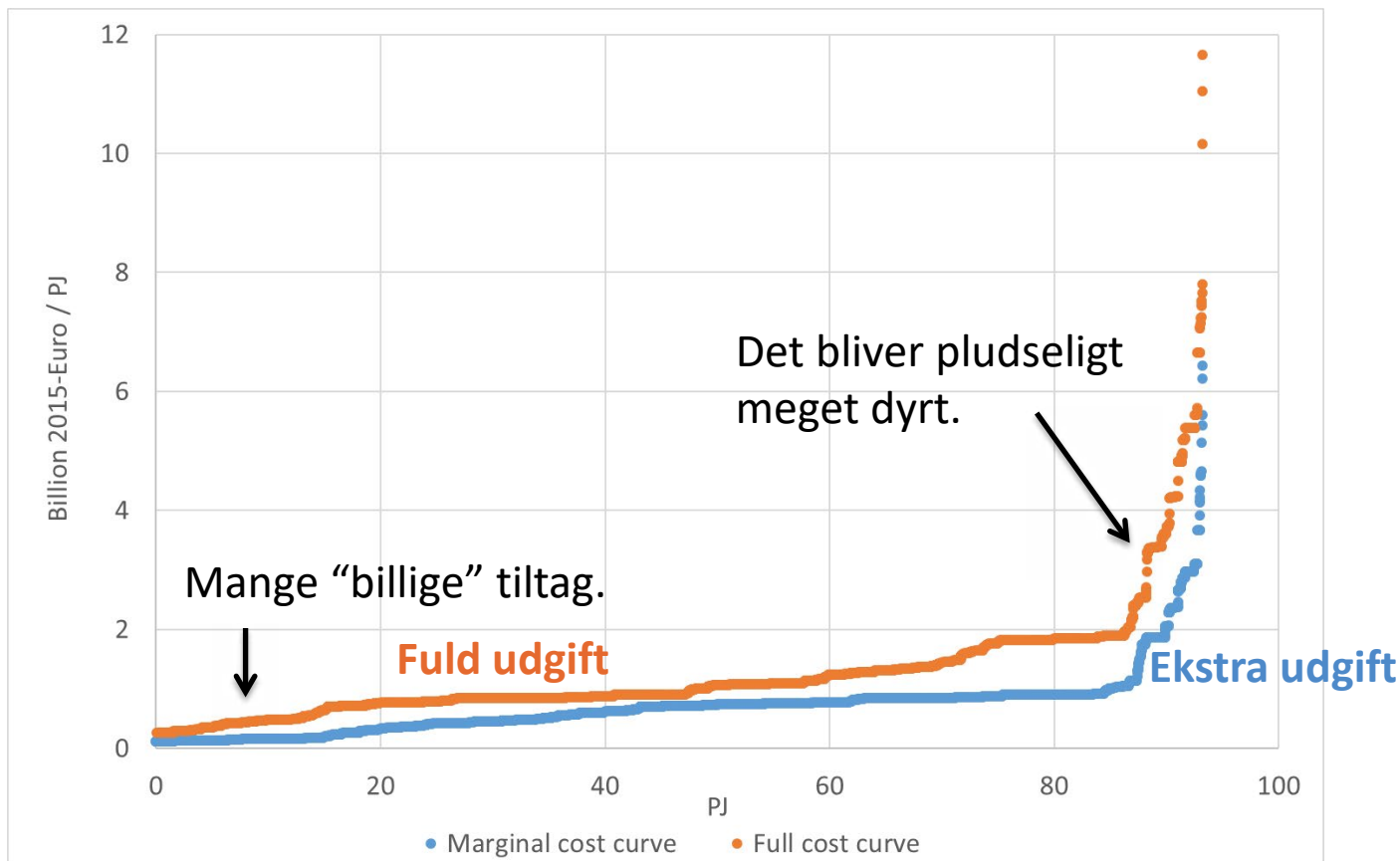
Det faktiske varmeforbrug

Der er meget at spare, hvis de mest energislugende bygninger kan renovres, men hvad koster det?



Kilde: M.H. Kristensen, Ph.d. afhandling
(<https://ebooks.au.dk/aul/catalog/book/301>) .

Energirenoveringspotentiale i Danmark

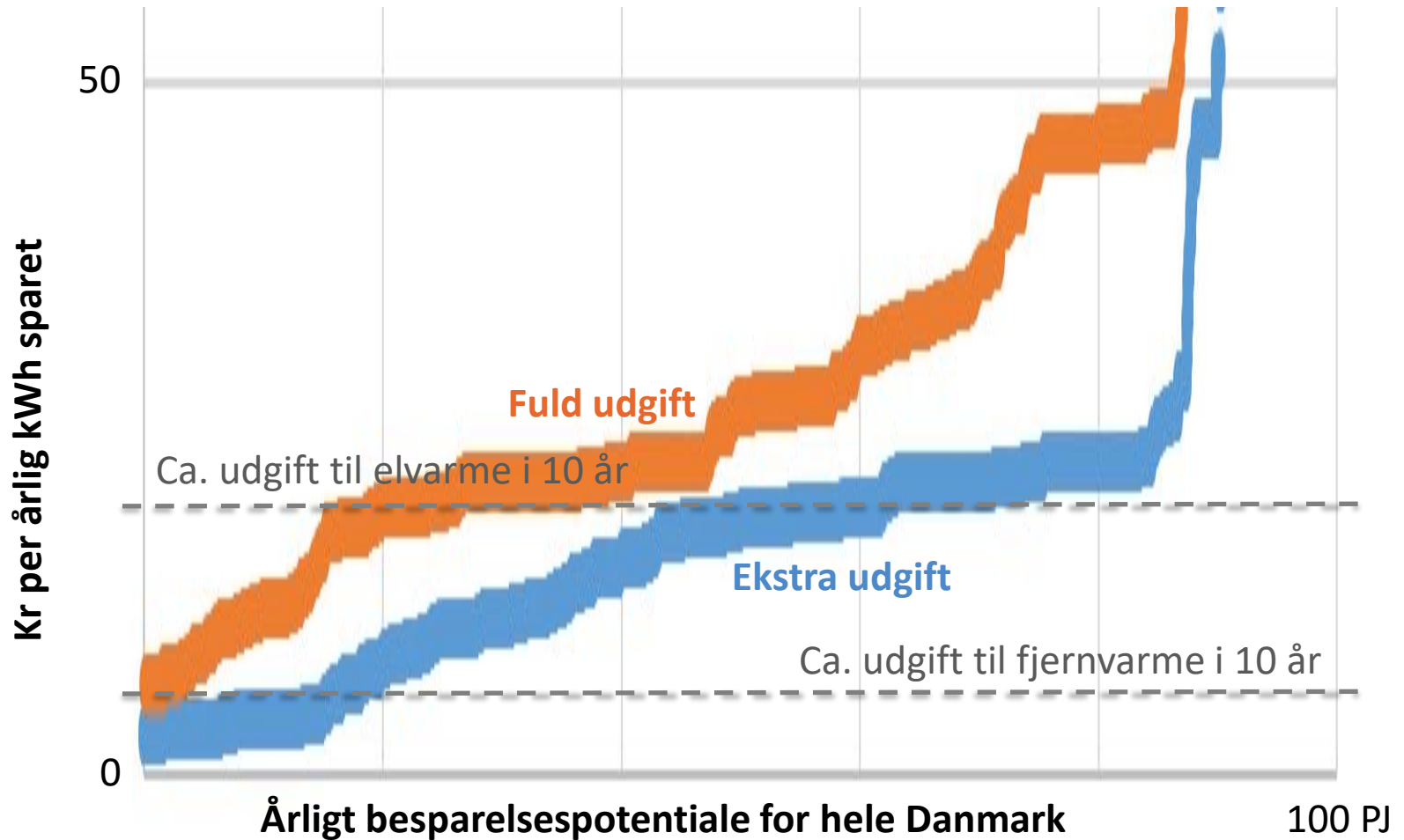


Kilde: ENS og DTU, pre-print

([https://www.researchgate.net/publication/](https://www.researchgate.net/publication/336414009)

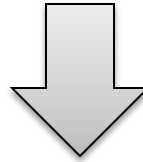
[336414009 Overcoming the hurdle meeting Danish energy saving requirements by targeting household investment behavior](https://www.researchgate.net/publication/336414009)).

Kan det betale sig at renovere?

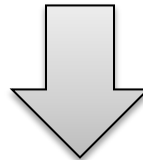


Byfortætning & Energibesparelser

Vi bliver gladere og gladere for at bo det samme sted.



Større fjernvarme rør er dyre og besværlige at grave ned.



Energibesparelser og fleksibel bygninger i midtbyen kan afhjælpe problemet.

Opsamling

- ◆ Varmepumper og andre teknologier, der har fordel af lav-temperatur fjernvarme, er økonomisk og klimamæssigt fordelagtige.
- ◆ Mange energirenoveringer er dyre ift prisen på varme.
- ◆ Lav-temperatur tilpasninger kan i mange tilfælde være lige så vigtige som et lavere energiforbrug.

Financiering:



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