



Flex4RES

Flexible Nordic Energy Systems



ELECTRIC BOILERS IN DISTRICT HEATING SYSTEMS

A comparative study of the Scandinavian market conditions

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Nordic Energy Research



Agenda

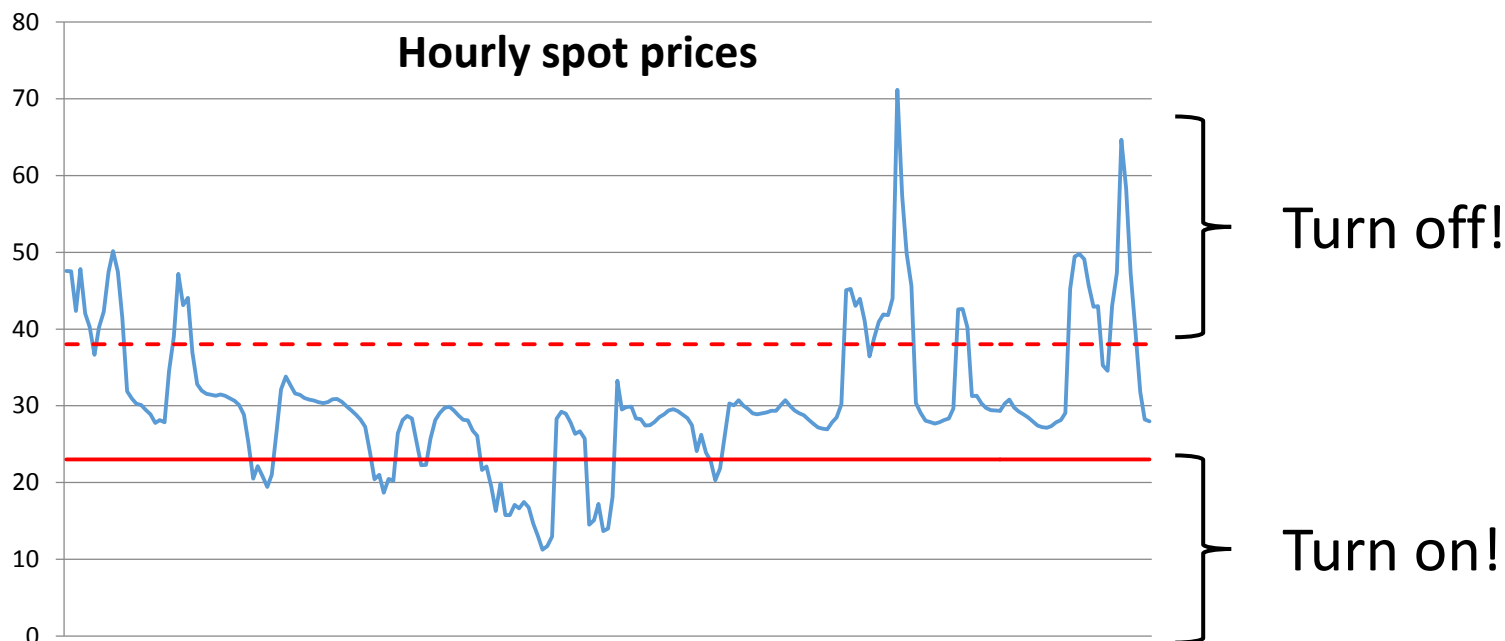
- Introduction
 - Flexibility and electric boilers in Scandinavia
 - District heating technologies
- Marginal cost of operation
 - Electric boilers
 - Competitive technologies
- Comparing marginal cost within each country
- Hours of operation
- Summing-up



Introduction

Electric boilers and flexibility

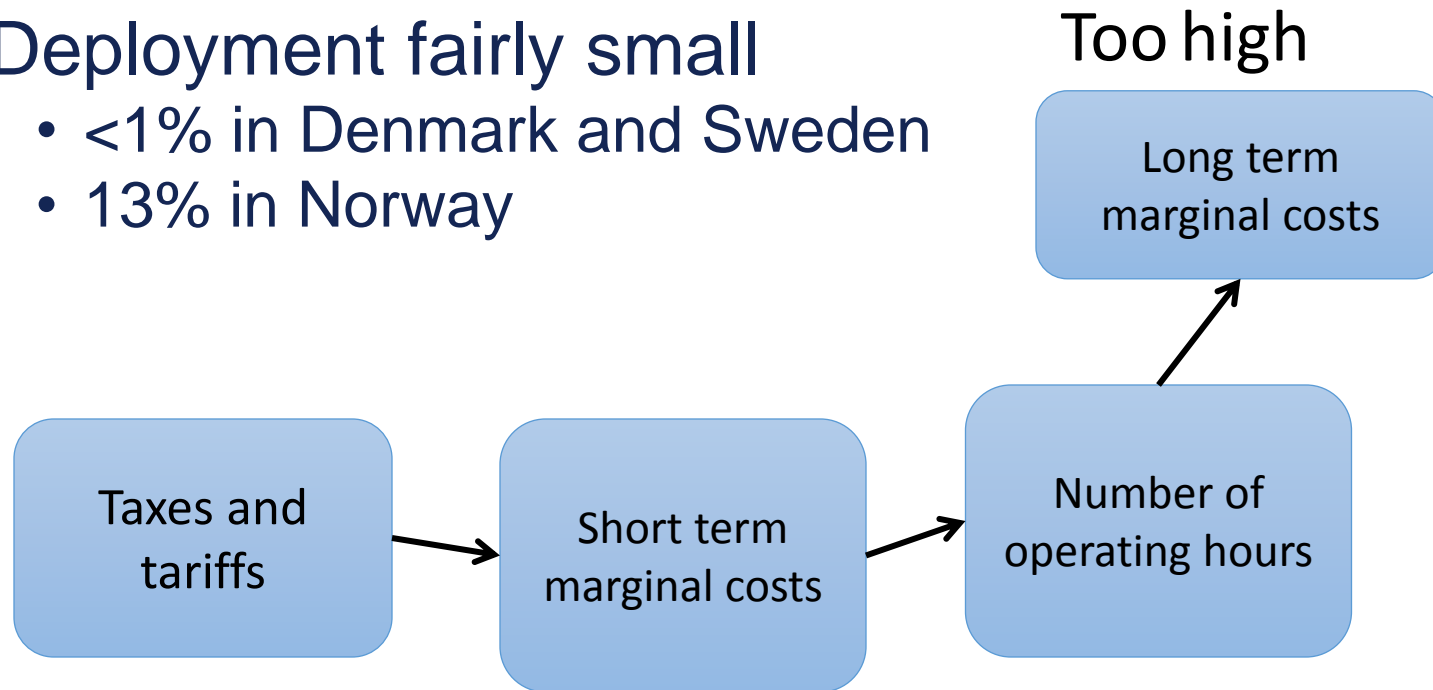
- Integration of VRE – local and/or regional solution?
- Electric boilers as flexibility resource



Introduction

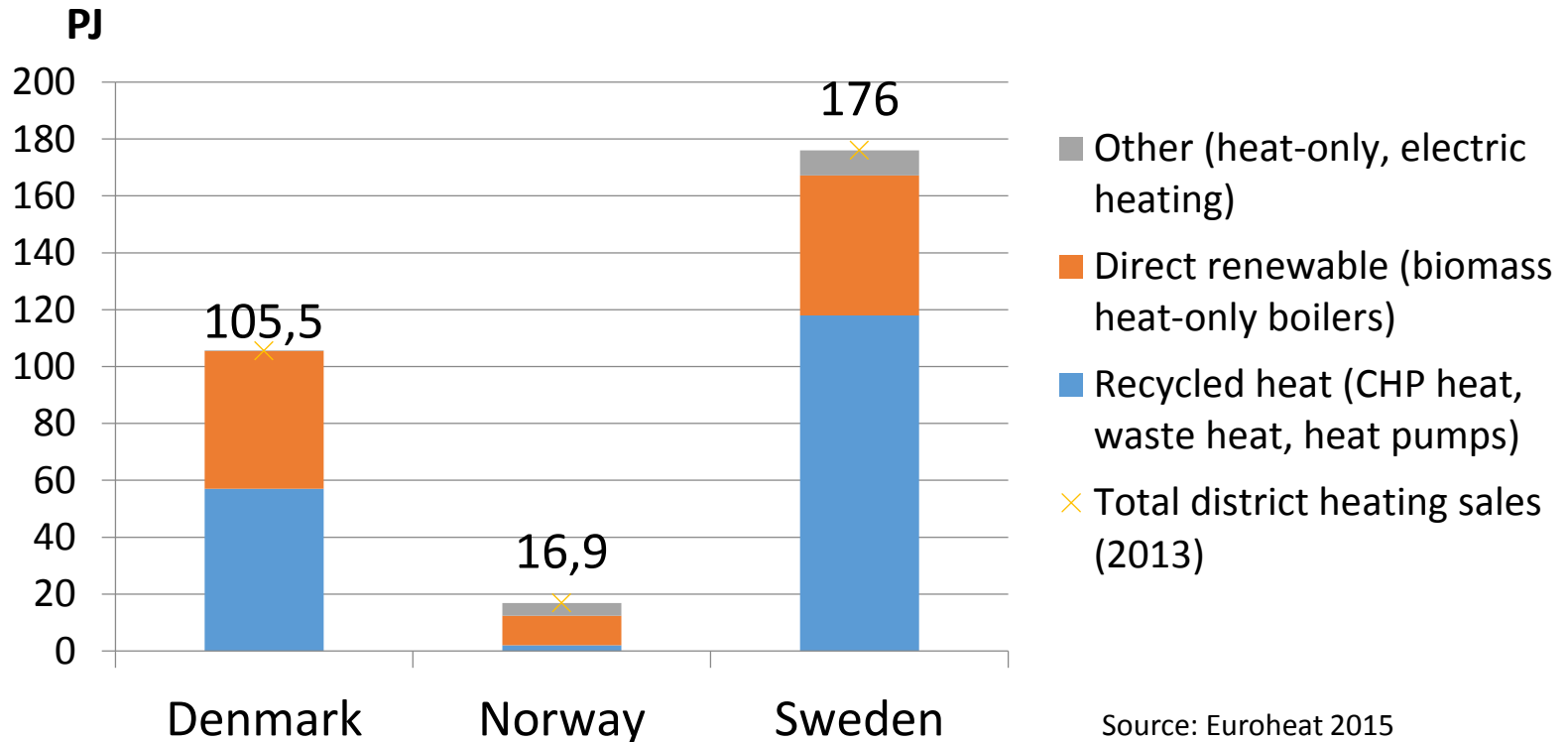
Electric boilers in Scandinavia

- Deployment fairly small
 - <1% in Denmark and Sweden
 - 13% in Norway



This study compares the short term marginal costs of operation, including taxes and tariffs, in the in Denmark, Norway and Sweden, and identifies the number of feasible operating hours given the current electricity market prices.

District heating technologies 1/2



- Current technology and fuel mix in DH-system differs between the three countries.

District heating technologies 2/2



Technologies used for cost calculation are standard plants taken from the Danish Energy Agency's technology catalogue

	Electric boiler	Biomass CHP	Biomass HO	Natural gas CHP	Natural gas HO
Type	Electric boiler, 10 kV	Wood chip fired medium steam turbine	Wood chip fired district heating boiler	Gas turbine, combined cycle (back-pressure)	Gas fired district heating boiler
Capacity (MW heat)	1 - 25	20 - 100	1 - 12	10 - 100	0.5 - 10
Total efficiency	99%	93%	108%	82%	97%
• Heat efficiency		29%		41%	
• Electric efficiency		64%		41%	
Nominal investment (EUR/MW heat)	0.06-0.09	1.2	0.5-1.1	1.1-1.6	0.07-0.13



Marginal cost of operation Electric boilers

EUR/MWh heat	Denmark	Norway	Sweden
Electricity tax	28.42	0.54	31.73
Electricity certificates	0	1.45	2.35
Grid costs	22.65	10.33	4.33
Maintenance	0.5	0.5	0.5
In total, excluding electricity purchase	51.58	12.82	38.91

- Differences in electricity tax
- Differences the variable part of the grid cost
- Cost of electricity purchase should be added to 'total'.



Marginal cost of operation CHP

EUR/MWh heat, excluding electricity sales	Denmark	Norway	Sweden
Biomass	31.42	33.75	27.32
(Emission taxes)	(1.63)	(1.08)	(0.03)
(Electricity support and cost)	(-8.93)	(-7.35)	(-7.37)
Natural gas	96.90		83.15
(Fuel tax)	(22.81)		(3.34)
(CO2 tax and quotas)	(7.55)		(4.02)
(Other emission taxes)	(1.49)		(0.29)

- To obtain final marginal cost, deduct sales of electricity.
- Not much difference in overall cost for biomass CHP – no tax for biomass based fuels.
- Differences in natural gas CHP heat costs mainly due to fuel taxes.



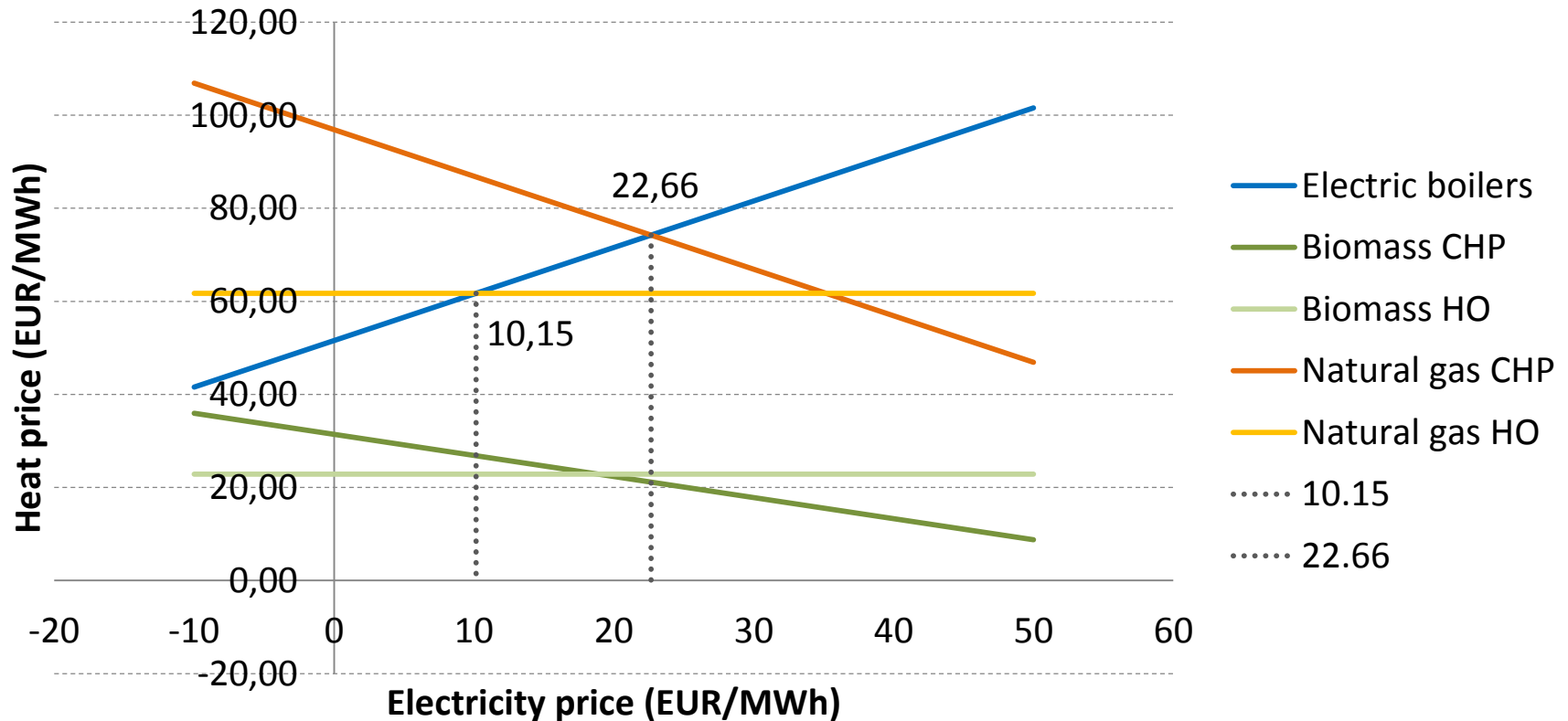
Marginal cost of operation Heat-only

EUR/MWh heat	Denmark	Norway	Sweden
Biomass (Emission taxes)	22.86 (0.97)	23.31 (0.64)	19.49 (0.02)
Natural gas (Fuel tax)	61.73 (28.22)		68.51 (11.80)
(CO2 tax and quotas)	(6.07)		(21.00)
(Other emission taxes)	(0.17)		(0.02)

- Not much difference in overall cost of biomass based HO – no tax for biomass based fuels
- Not much difference in overall cost of natural gas based HO, however, in DK fuel tax, while in SE CO2-tax.



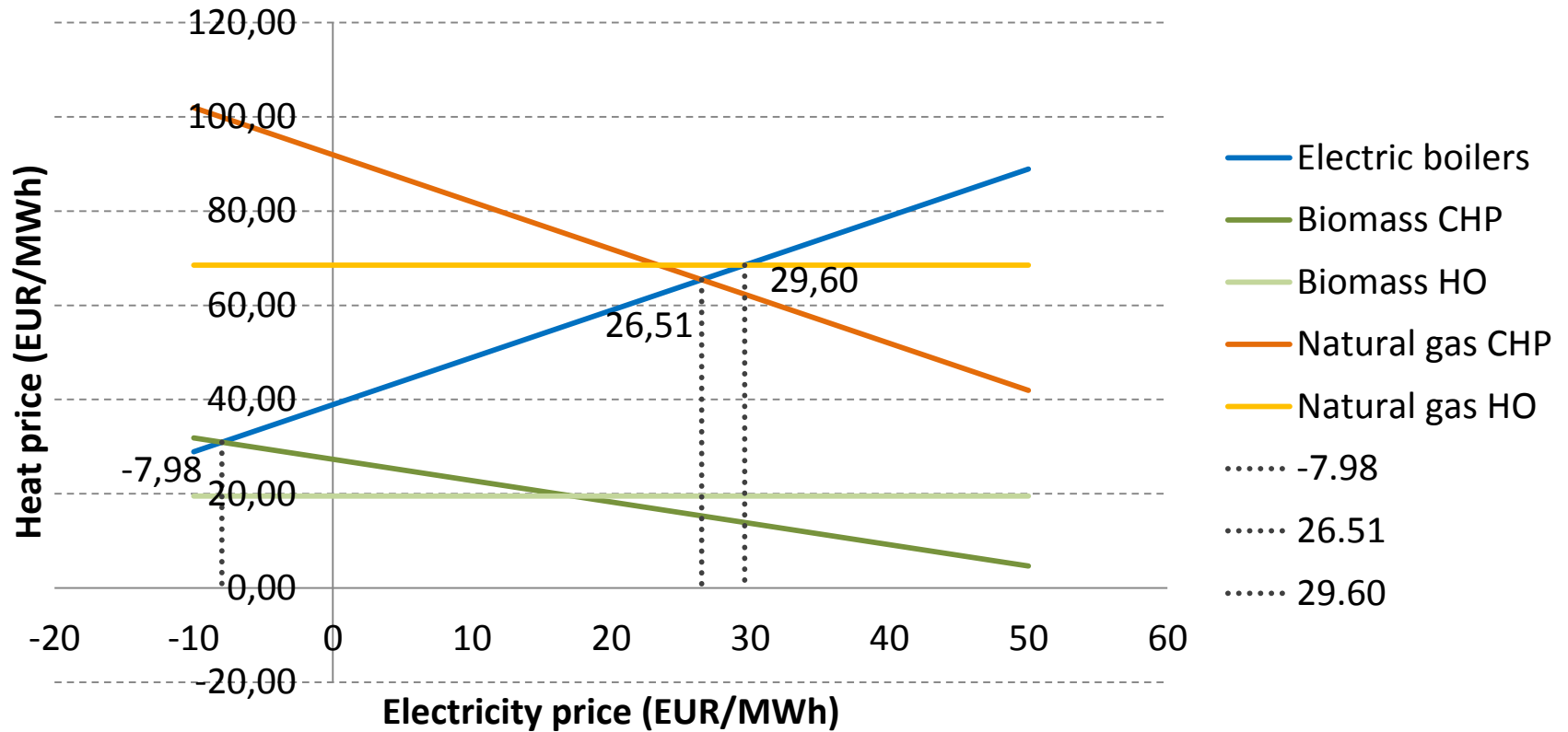
Comparing marginal cost Denmark



- Biomass is always cheaper than electric boilers.
- Natural gas HO cheaper than CHP



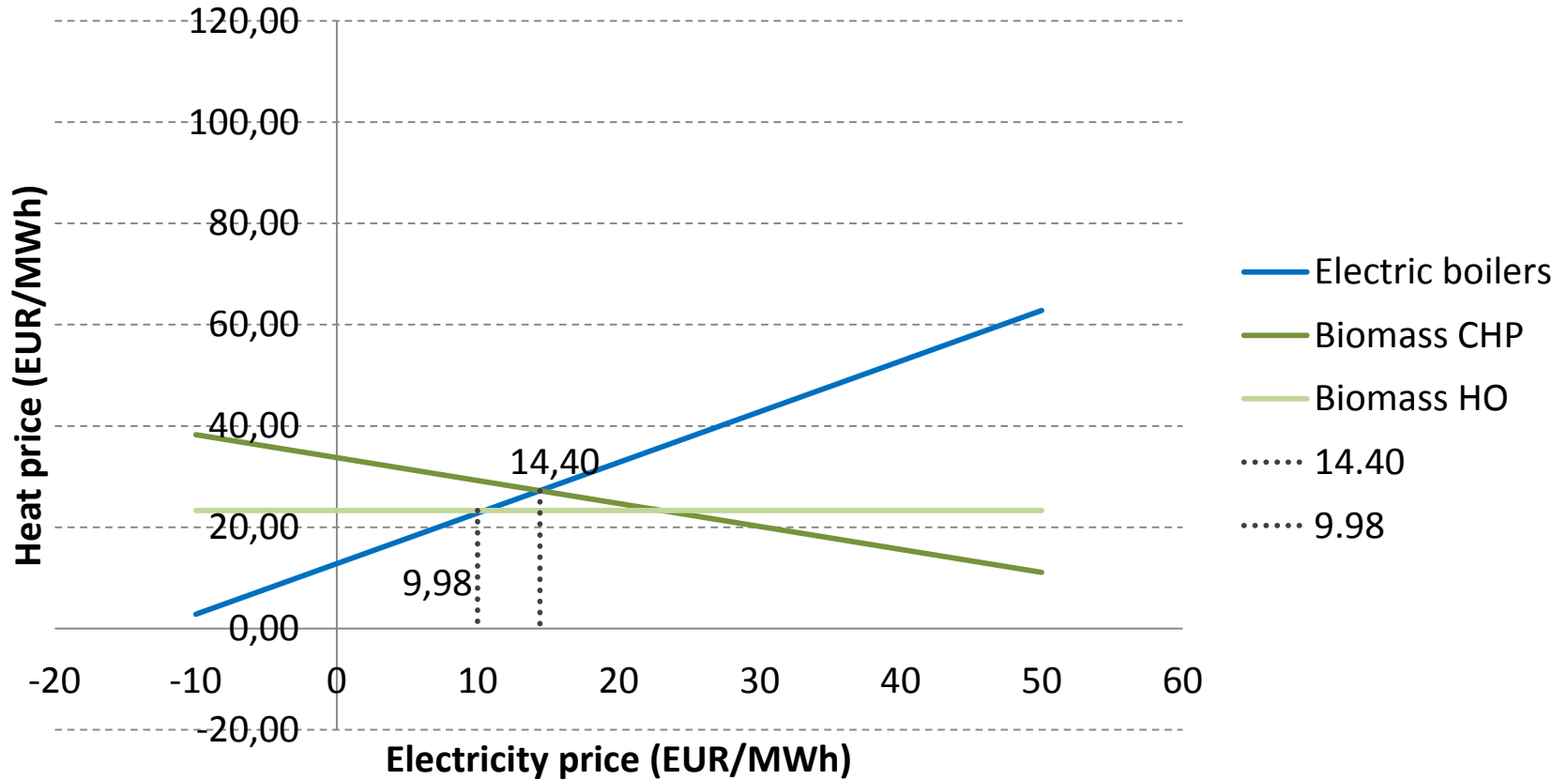
Comparing marginal cost Sweden



- Electric boilers have lower marginal costs than biomass HO and CHP for low power prices
- Electric boilers have lower marginal costs than natural gas CHP and HO for most power prices



Comparing marginal cost Norway



- Electric boilers have lower marginal costs than biomass HO and CHP only for low power prices

Electric boilers' operating hours Spot market



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Elspot, 2014-2015	Biomass CHP	Biomass HO	Natural gas CHP	Natural gas HO
Denmark	0.1%	0.0%	26.2%	6.9%
Norway	13.8%	7.0%	-	-
Sweden	0.0%	0.0%	46.6%	62.7%

Percentage of hours in which the electric boiler has lower marginal cost of operation than the respective technology.

Calculated on the basis of 2014 and 2015, and as an average over each country's bidding areas.



Summing-up

- Current taxation level on electricity consumption of electric boilers varies greatly across the Scandinavian countries and influences the possible utilization of electric boilers in the DH systems.
- Differences in taxation are reflected in lower marginal cost of operation in Norway and Sweden than in Denmark – however, taxes and tariffs for competitive technologies are also different.
- Biomass installations have lower marginal costs than electric boilers in Denmark and Sweden – but not always in Norway.
- Electric boilers for peak load or for flexibility?
- How many hours are needed for flexibility?
- Additional considerations for long term marginal cost: instalment cost, fixed costs and fixed subsidies



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