

Market optimization of Danish distributed CHP-plants across more electricity markets

Presented by Anders N. Andersen, EMD.DK, at the CITIESworkshop at DTU about Modeling and Optimization of Heat and Power Systems, 12th of January 2015



Danish distributed CHP-plants are typically equipped with big capacities on the CHP's and with big capacities on the heat pumps/electrical boilers and equipped with big energy stores (thermal and biogas stores).





This allows flexible productions and that the distributed CHPplants may participate across more electricity markets. The distributed CHP plants are thus helping to reduce the societal costs of balancing the electricity system.





The plants typically consider participation in the Primary reserve market (Frequency containment reserves), the Regulating power market (Replacement reserves) and the day ahead spot market. In Denmark these three markets are all organized as Marginal Price markets (not as PayAsBidmarkets).





In this presentation is shown online examples of how these plants participate in these three electricity markets and presented simulations of optimized bidding strategies.





Scenario 2 at 11 a.m. on the 19th of June. The dotted black line indicates the time.









www.emd.dk/el



































The method used by energyPRO to calculate the activation bidding prices in the Tertiary Reserve Market (Regulating power market): A CHP unit is offered to be activated in the Regulating power market, for the lost earning in spot market.

Examples of the calculations is shown in the next slides.



Example of calculating upward activation bidding price.



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Example of calculating downward activation bidding price.

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Example of calculating upward activation bidding price.

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Three different scenarios have been defined using the simulation approach described:

- 1. Ringkøbing CHP only purchases and sells electricity on Elspot with the forecasts of market prices, heat demand and solar heating.
- 2. As scenario 1, but it also participates on the regulating power market.
- 3. As scenario 2, but the forecasts are equal to the actual values (perfect forecast).





Simulated heat production for the period from 1^{st} of June to 31^{st} of August 2013

Production unit	Scenario 1	Scenario 2	Scenario 3
	MWh _{th}	MWh _{th}	MWh _{th}
NG Engine	3,811	4,779	5,109
NG Boilers	2,571	1,336	969
Electric boiler	60	528	504
Solar collectors	7,042	7,042	7,042
Heat rejection	0	116	0
Final storage content	178	263	320
Heat demand	13,306	13,306	13,304





Production unit	Fuel costs	Taxes incl. CO_2	O&M and	Electricity	NHPC
		quota cost	start costs	trading	
	<i>1,000 EU</i> R	<i>1,000 EU</i> R	<i>1,000 EU</i> R	<i>1,000 EU</i> R	<i>1,000 EU</i> R
NG Engine	241.5	114.4	30.1	-232.8	153.2
NG Boilers	79.1	93.1	0.7	-	172.9
Electric boiler	1.8	2.1	-	0.2	4.1
Final storage	-4.9	-2.4	-0.6	3.2	-4.7
Total	317.6	207.2	30.2	-229.5	325.5

Table 4. NHPC of scenario 1.





Production unit	Fuel costs	Taxes incl. CO_2	O&M and	Electricity	NHPC
		quota cost	start costs	trading	
	<i>1,000 EU</i> R	<i>1,000 EU</i> R	<i>1,000 EU</i> R	<i>1,000 EU</i> R	<i>1,000 EU</i> R
NG Engine	303.1	143.4	40.8	-292.6	194.7
NG Boilers	41.1	48.4	0.4	-	89.9
Electric boiler	15.8	18.3	-	-4.2	29.9
Final storage	-7.2	-3.6	-1.0	5.4	-6.6
Total	352.8	206.6	40.2	-291.5	308.1

Table 5. NHPC of scenario 2.





Production unit	Fuel costs	Taxes incl. CO_2	O&M and	Electricity	NHPC
		quota cost	start costs	trading	
	<i>1,000 EU</i> R	<i>1,000 EU</i> R	<i>1,000 EU</i> R	<i>1,000 EU</i> R	<i>1,000 EU</i> R
NG Engine	324.1	153.3	42.4	-315.7	204.1
NG Boilers	29.9	35.1	0.3	-	65.2
Electric boiler	15.1	17.5	-	-3.4	29.2
Final storage	-8.6	-4.2	-1.2	6.7	-7.3
Total	360.5	201.7	41.4	-312.5	291.2

Table 6. NHPC of scenario 3.























Thank you for your attention !





http://www.store-project.eu/



http://www.store-project.eu/



We have in a research project made live test of the economic benefit for a 21 MW wind farm of offering themselves downward regulation to the TSO



http://emd.dk/el/





Modeling in energyPRO Ringkøbing CHP-plant.





25 20 Elspotpris Varme (MW) - Opreguleringspris 15 Nedreguleringspris - Positiv Primærreserve - Negativ Primærreserve 10 - Varmeforbrug Solfanger 5 Gasmotor 0 Gasturbine 15 21 18 00 El-kedel Gas-kedler - Energiindhold, lagertank



Denne side hostes og vedligeholdes af EMD International A/S

500 400

300

200

100

-100

-200

-300

-400

0

Min

Pris (DKK/MWh)

The first step for energyPRO is to calculate the expected earning in the spot market, without won upward availabilities.



Ugens beregnede variable nettoproduktionsomkostninger for varme: 94.164 kr

Next step is to assume a won availability (yellow engine) and calculate the loss of earning in the spot market.



Ugens beregnede variable nettoproduktionsomkostninger for varme: 94.839 kr