



3<sup>RD</sup> INTERNATIONAL CONFERENCE ON  
**SMART ENERGY SYSTEMS AND  
4<sup>TH</sup> GENERATION DISTRICT HEATING**

COPENHAGEN, 12–13 SEPTEMBER 2017



**AALBORG UNIVERSITY**  
DENMARK

# Modelling participation in the Polish Day-Ahead Market (DAM) using a district heating company as a case

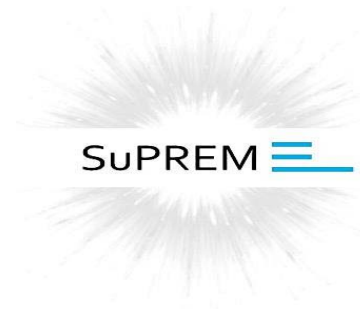
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Institute of Fluid Flow Machinery PAS  
Department of Distributed Energy



COPENHAGEN, 12 SEPTEMBER 2017

# Project SUPREME



**SUPREME** – Twinning for a sustainable, proactive research partnership in distributed Energy systems planning, modeling and management

**UNIVERSITY  
OF TWENTE.**



**AALBORG UNIVERSITY**  
DENMARK



**Centrum Badawcze PAN**  
Konwersja Energii i Źródła Odnawialne  
**KEZO**

**Anders N. Andersen**  
*Department of Development  
and Planning*

*EMD International A/S*



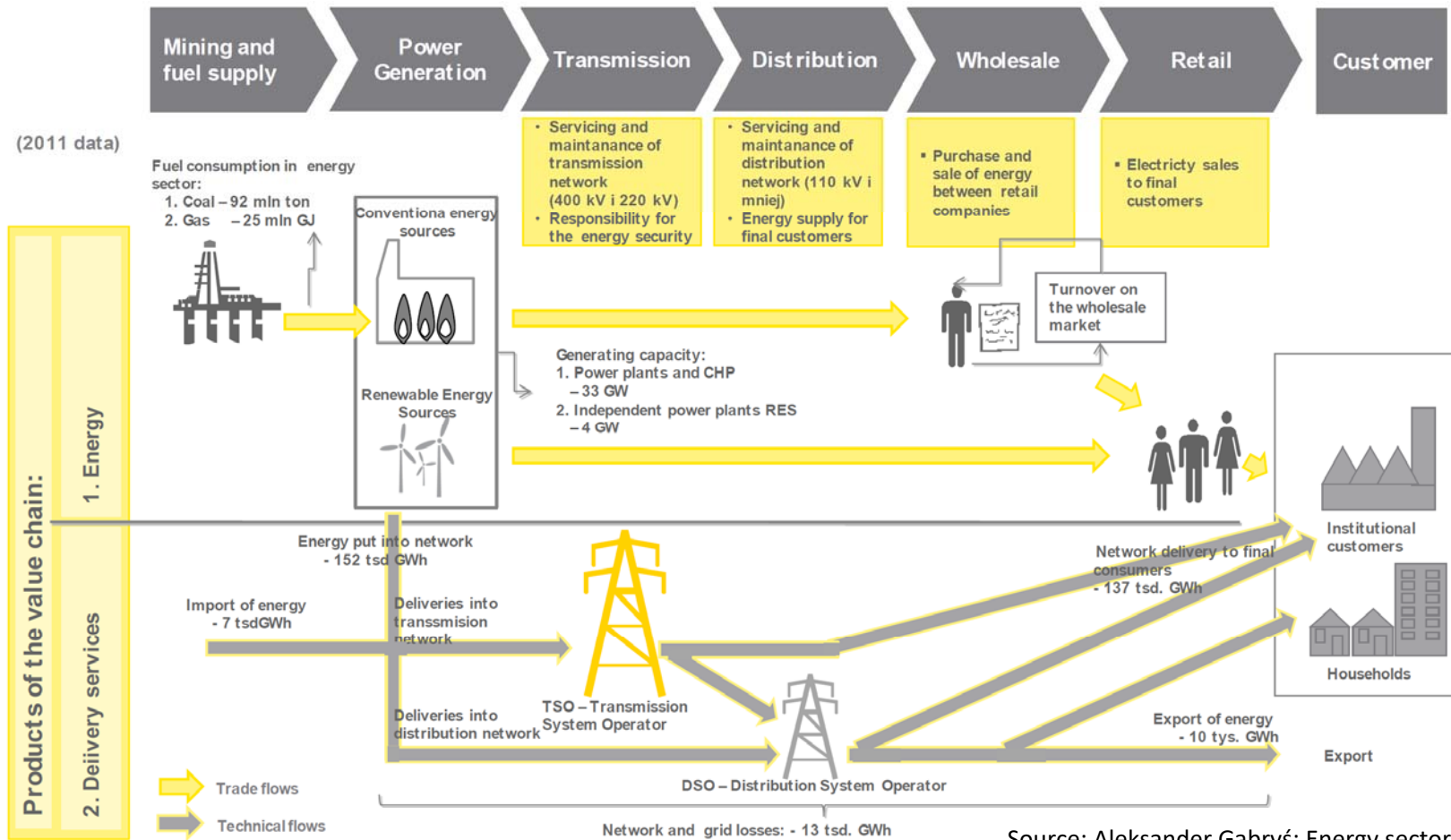
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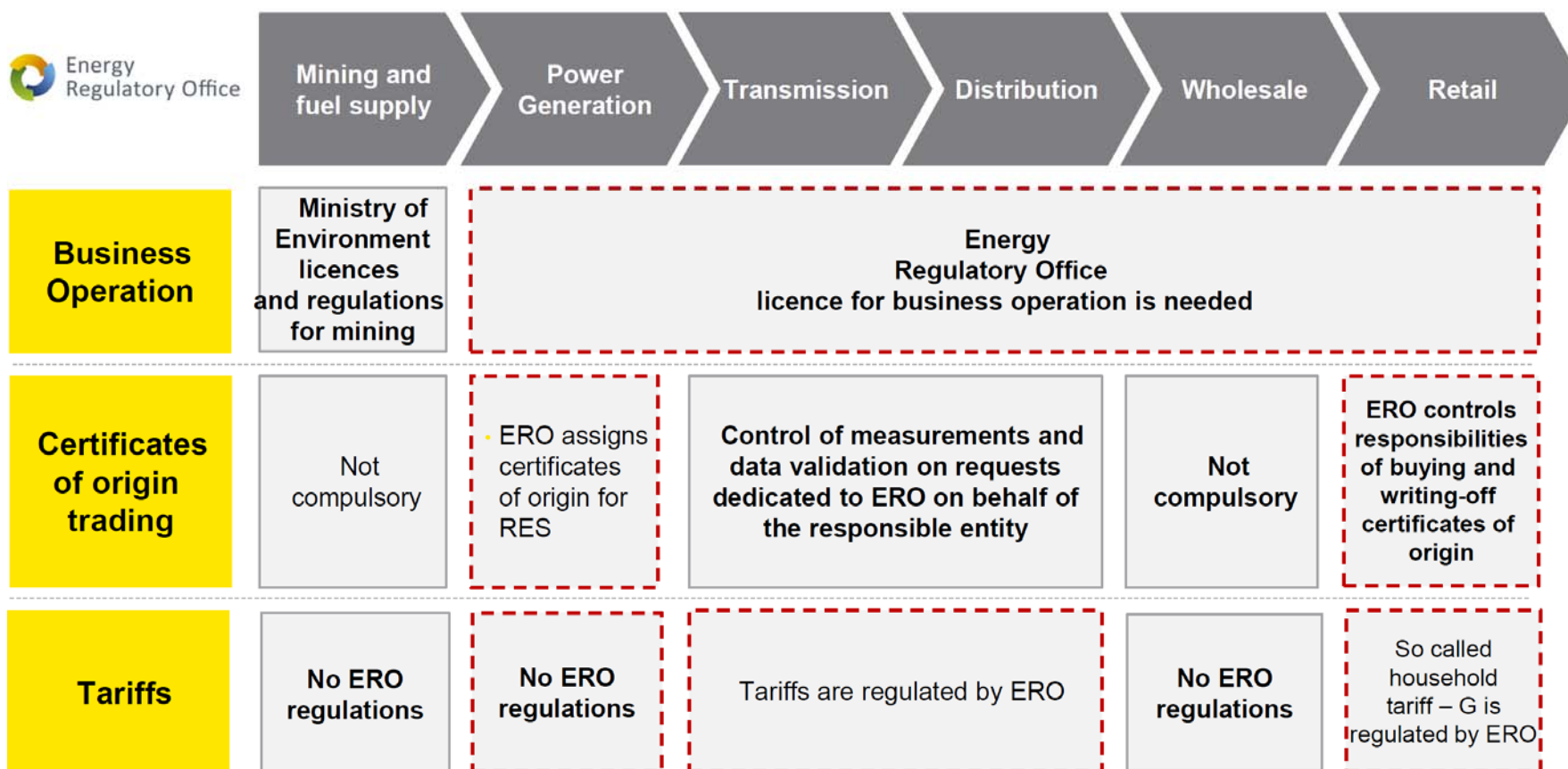
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# Structure of value chain in energy sector in Poland



Source: Aleksander Gabryś: Energy sector in Poland

# Key players in energy sector – business entities



Source: Aleksander Gabryś: Energy sector in Poland

# The National Power System



**PSE** Polskie Sieci Elektroenergetyczne

Map of Polish transmission grid



Source: PSE S.A.



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**PAK S.A.**  
generation  
*ZEL PAK S.A.*  
*El Pątnów II Sp. z o.o.*  
capacity: 2457 MW  
production: 11.2 TWh

**ENEA S.A.**  
generation  
*El. Kozienice S.A.*  
*Ec. Białystok S.A.*  
capacity: 3109 MW  
production: 12.6 TWh

**ENEA S.A.**  
sales: 14.3 TWh

**TAURON Polska Energia S.A.**  
generation  
*TAURON Wytwarzanie S.A.*  
*Ec Tychy S.A.*  
*Ec Nowa Sp. z o.o.*  
capacity: 5574 MW  
production: 24.0 TWh

**TAURON Sprzedaż Sp. z o.o.**  
*Vattenfall Sales Poland Sp. z o.o.*  
sales: 36.6 TWh

Source: Energy Regulatory Office (URE)

2011



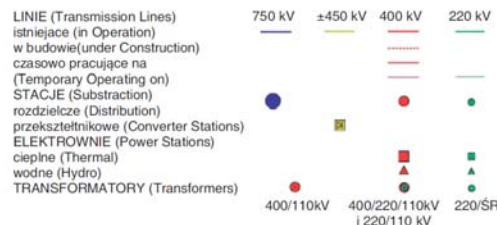
**ENERGA S.A.**  
generation  
*ENERGA (El Ostrołęka)*  
*Ec Elbląg, Ec Kalisz*  
capacity: 1151 MW  
production: 4.7 TWh

**ENERGA – Obrót S.A.**  
Sales: 18.6 TWh

**PGE Polska Grupa Energetyczna S.A.**  
generation  
*Giek S.A. (E.; Bełchatów)*  
*El. Turów, ZEL Dolna Odra, Ec Rzeszów, Ec Lublin-Wrotków, Ec Gorzów, Ec Bydgoszcz, Ec Kielce, En. Zgierz)*  
*PGE EL Opole S.A.*  
capacity: 13,002 MW  
production: 61.7 TWh

**PGE Obrót S.A. (branch offices based in Lublin, Zamość, Warszawa, Białystok, Łódź I and II, Skarżysko-Kamienna)**  
sales: 30.4 TWh

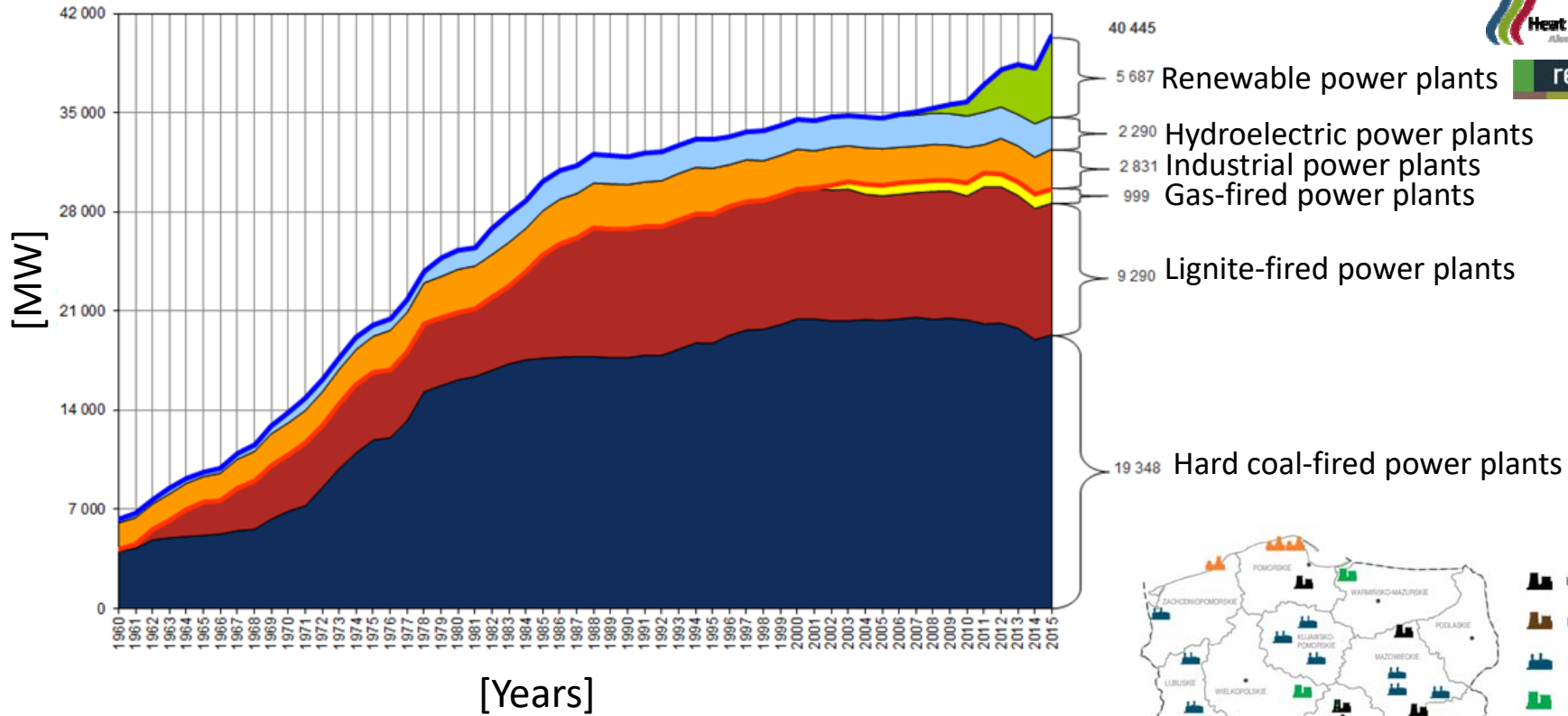
capacity – installed capacity  
production – gross electricity production  
sales – sales to end buyers



Selected consolidated capital groups: territorial range (criterion – area of operation of distribution system operators within groups), group members, business activity



# Energy production in Poland



Electricity generation in Poland by source



# Main Energy policies (national level)



- Act of 10 April The Energy Law
- Act of 20 February 2015 on renewable sources
- Act of 15 April 2011 on Energy efficiency
- National Energy Efficiency Action Plan for Poland 2014 of 20 October 2014
- Act of 29 August 2014 on Energy Performance of Buildings
- Ordinance of Minister of Infrastructure and Development on the methodology for determining the energy performance of a building or part of a building and energy performance certificates
- The national plan aimed at increasing the number of buildings with low energy consumption
- Energy Policy of Poland until 2030 of November 2009





# Energy market in Poland

**Towarowa Giełda Energii SA (TGE)** was established at the end of 1999. In the first six months, from registration of its business operations, it has launched the Day Ahead Market (electricity spot market). In 2003, TGE was the first and so-far only entity to obtain a license to run a commodity exchange market from the Financial Supervision Commission (KNF).

The key areas of TGE operations are:

- **Day Ahead Market (DAM),**
- Intraday Market (IDM),
- Day Ahead Market gas (DAMg),
- Commodity Forward Instruments Market with Physical Delivery (CFIM),
- Commodity Forward Instruments Market with Physical Delivery gas(CFIMg),
- Property Rights Market for Renewable Energy Sources and Co-generation, (PRM)
- CO2 Emission Allowance Market (EAM).



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# Day-Ahead Market



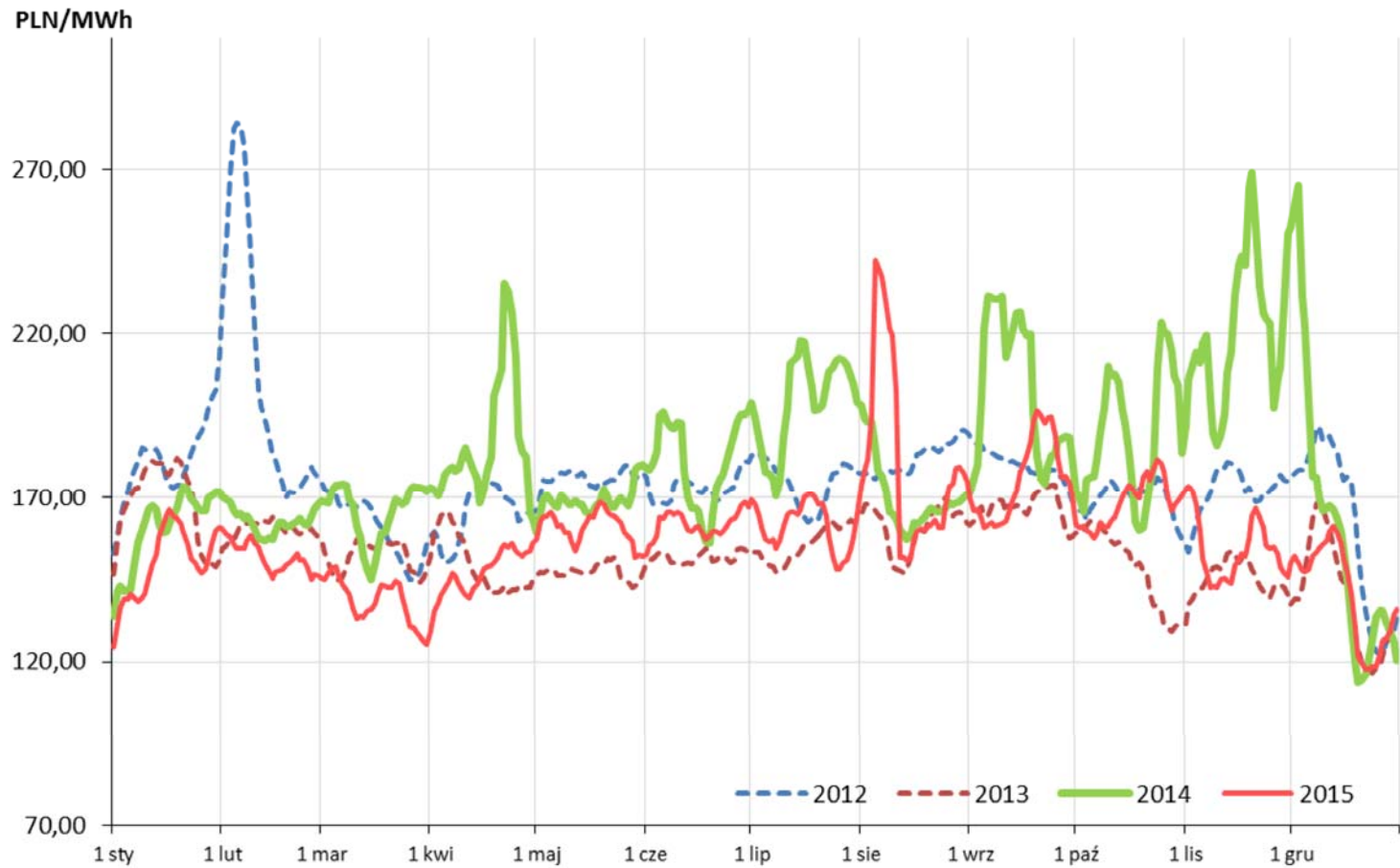
- In 2015, prices decreased by 13% yoy compared to an increase of 17% in 2014. The average hourly price of electricity on the TGE Day-Ahead Market came to 156.95 PLN/MWh in this period (179.93 PLN/MWh in 2014).
- For peak hours (on weekdays, from 8:00 a.m. to and including 10:00 p.m.), the price dynamic was nearly double. The 2015 average equaled 186.63 PLN/MWh, i.e. it declined by 20% compared to the preceding year (in 2014, peak hour prices increased by 31% on an annual basis).
- The volatility of the electricity price across 12 months was much higher than in 2014. The highest decrease (19%) came in Q4 2015 versus the same quarter in 2014. In Q3, the lowest decrease (9%) was observed. In contrast, prices fell by 10% and 12% in Q1 and Q2, respectively, compared to the same quarters in 2014.

The Polish Day Ahead 2016 prices has an average of **160 PLN/MWh (37,69 EUR/MWh)**.

Average prices in Denmark and Germany in 2016 was:

Day Ahead Price, EUR/MWh		
DK-West	DK-East	DE European Power Exchange
26,67	29,40	28,98

Source: [http://osp.energinet.dk/\\_layouts/Markedsdata/framework/integrations/markedsdatatemplate.aspx?language=en](http://osp.energinet.dk/_layouts/Markedsdata/framework/integrations/markedsdatatemplate.aspx?language=en)



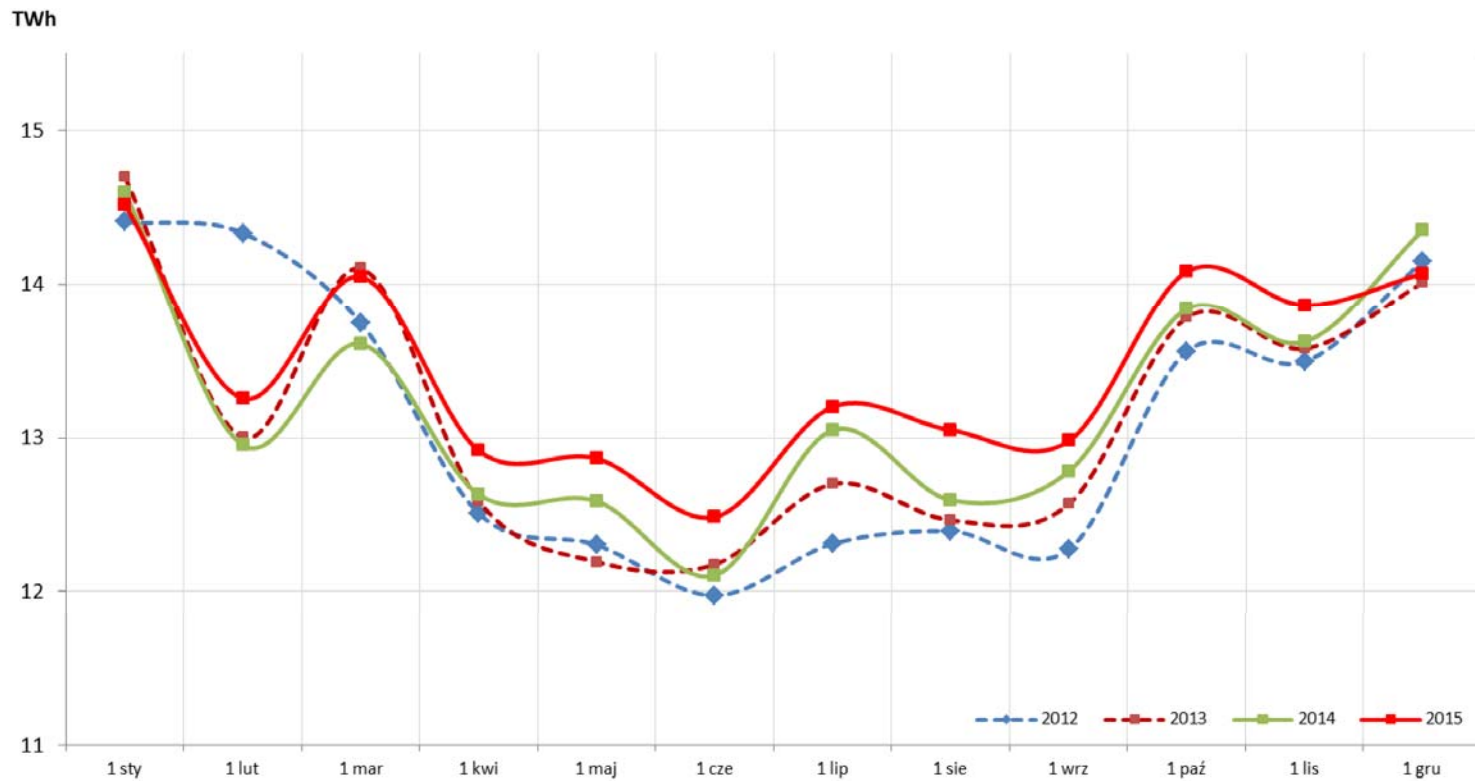
Source: TOE based on TGE data

## Daily Prices on the TGE Day-Ahead Market



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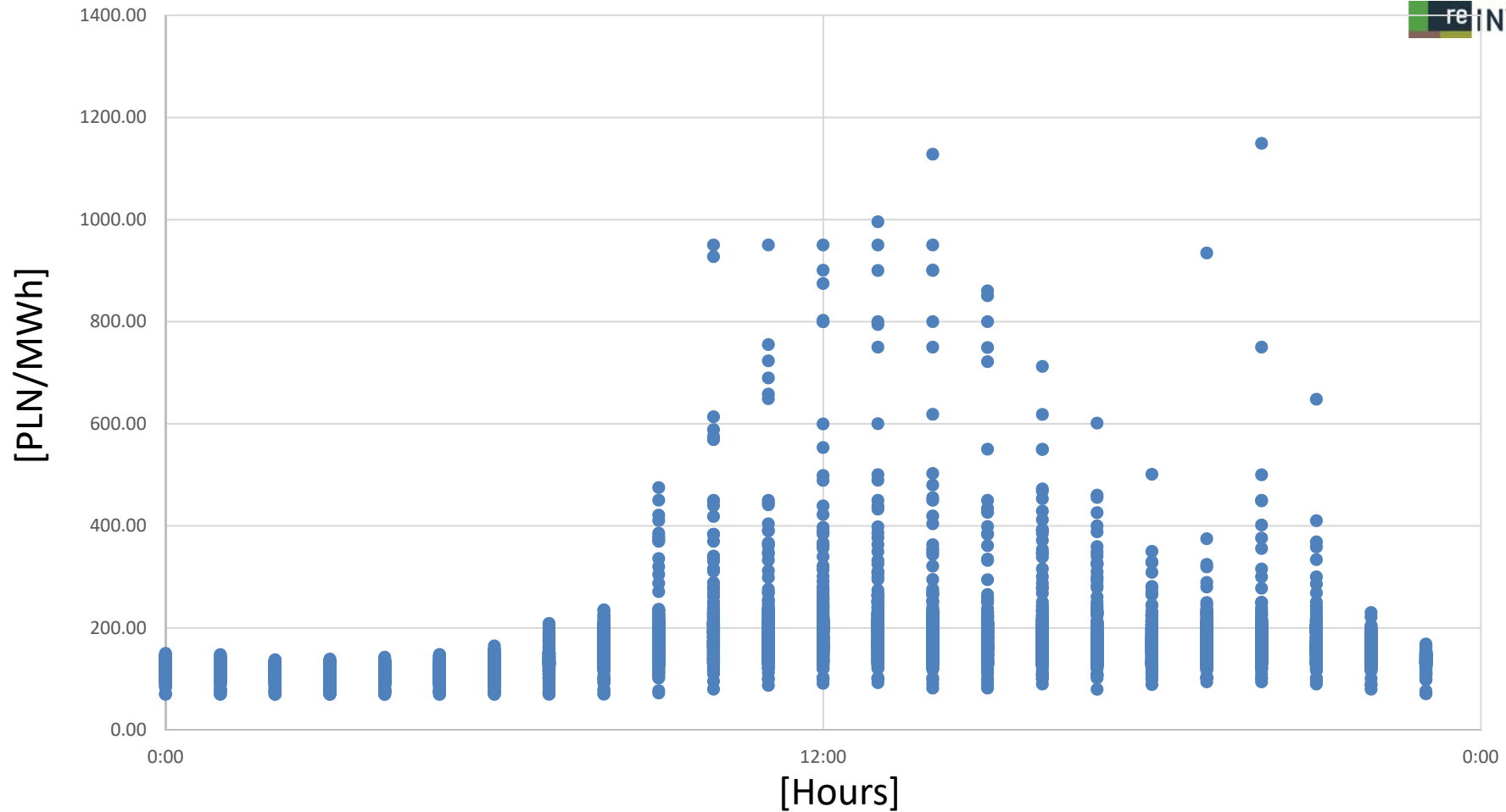
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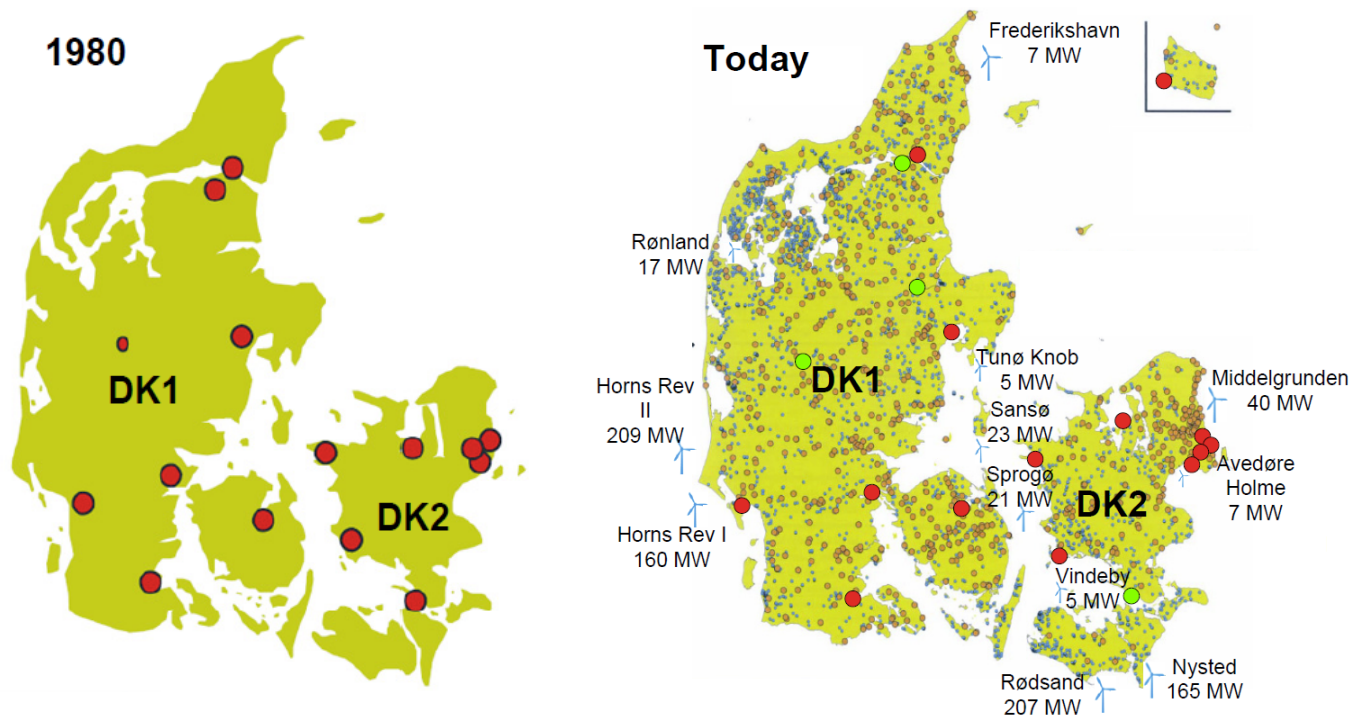
Source: TOE based on PSE data

## Total domestic monthly demand for electricity

# Prices on Day-Ahead Market in 2016



# The new idea of Polish government Clusters of Energy



Source: Aalborg University

In 2016 in Poland worked 428 District Heating companies.



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# PEC Legionowo



As a test case we are using a District Heating company located in Legionowo, central Poland. The company works since 1978 and its main responsibilities are production, transmission and distribution of thermal energy. In addition it also conduct business activity in transactions and distribution of electric energy



3x Electric Power Generation G3516H

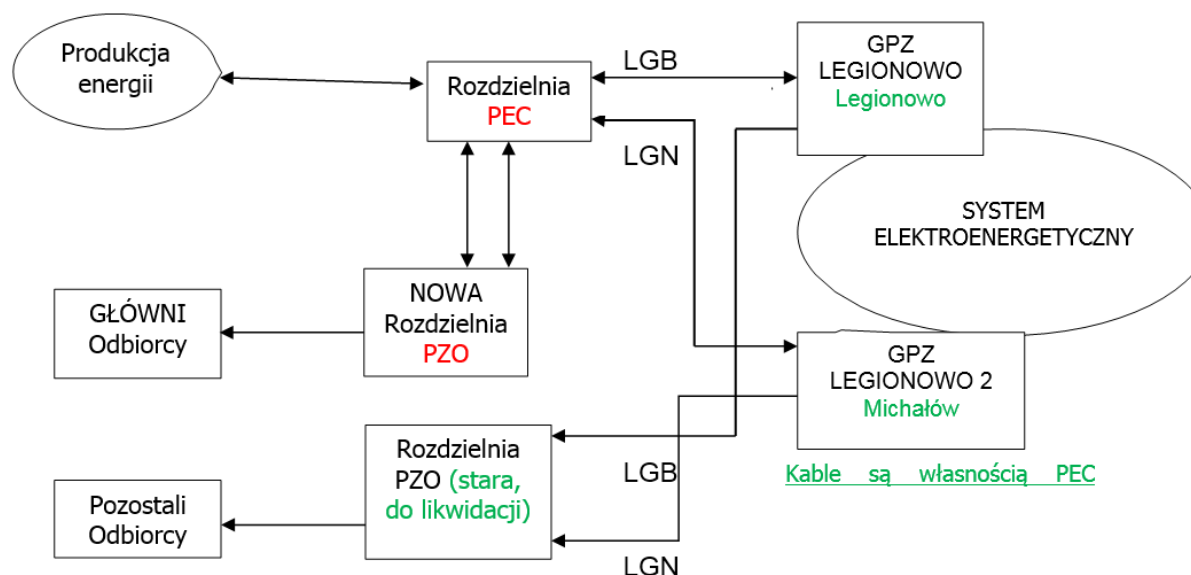




# PEC Legionowo



PEC Legionowo is also local DSO. District Heating company is owner of local electro energetic system (15 kV) taken over from City Legionowo. In PEC Legionowo the average price for 1 MWh of electricity is equal **180PLN (~43EUR)**.



# EnergyPRO analysis



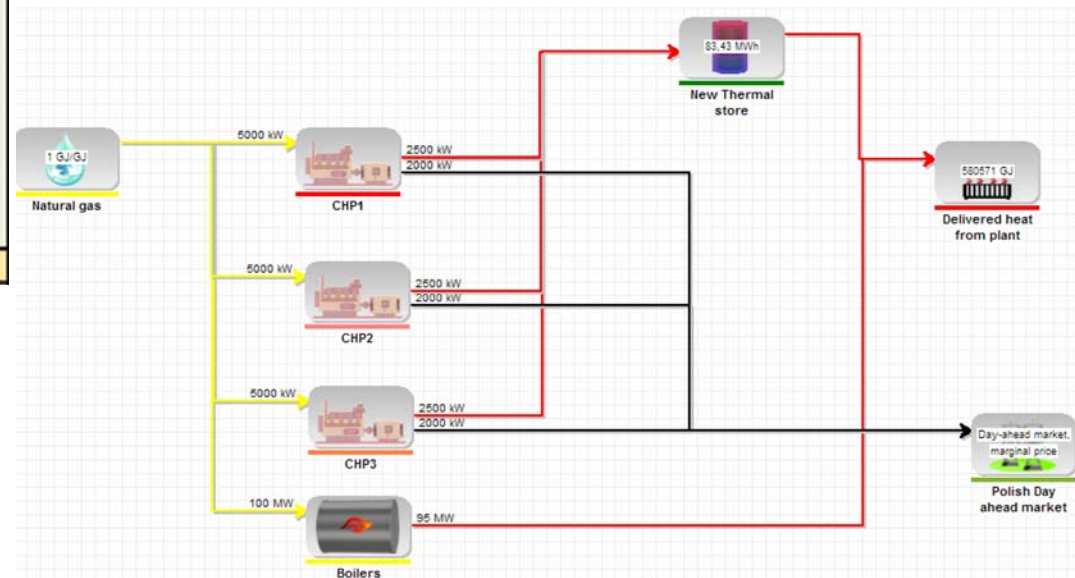
The yearly heat delivered from plant:

2016	Contracted power [total]	Use of endusers [GJ]	Gas fuel used [3 engines, cogeneration] - [m3]
January	87,7881	103.747	-
February	87,7311	70.963	-
March	87,7793	73.504	215310
April	88,0436	44.517	647434
May	88,0436	17.285	950818
June	88,0436	10.832	914906
July	88,0651	10.096	1003787
August	88,1592	10.176	999790
September	87,3232	16.832	943831
October	87,792	58.357	1016122
November	87,8882	74.925	984214
December	87,9243	89.336	882996
<b>TOTAL/AVERAGE</b>	<b>87,881775</b>	<b>580.571</b>	<b>8559208</b>

CHPs described:

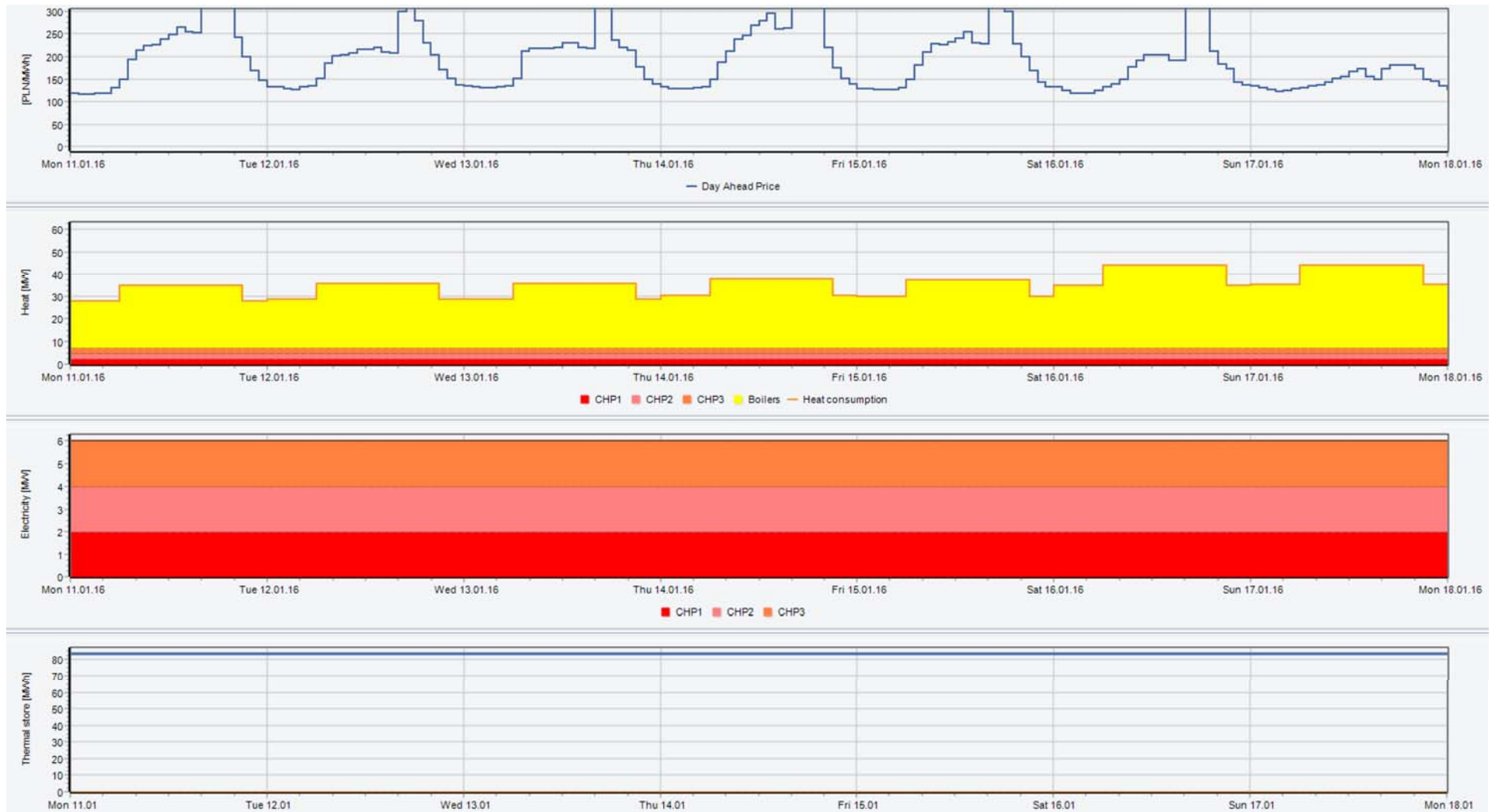
CHP	
Electrical power	2000 kW-el
Electrical efficiency	40%
Fuel input	5000 kW-fuel
Heat efficiency	50%
Heat power	2500 kW-heat

Model of DH in Legionowo

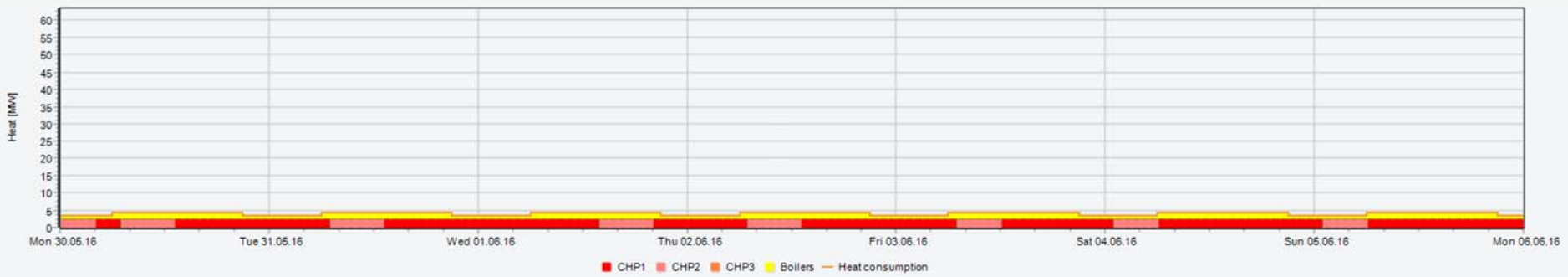


Gas prices: 21 PLN/GJ

Heat prices: 40 PLN/GJ



## CHP and thermal storage (winter)



Only CHP (summer)



## CHP and thermal storage (summer)



# Cash flow



Calculated Period: 01.2016-12.2016  
(All amounts in PLN)

	Total	Total
<b>Revenues</b>		
Sale of electricity	6 651 946	7 535 652
Yellow certificates	5 242 500	5 684 500
Sale of heat	23 803 411	23 803 411
<b>Total Revenues</b>	<b>35 697 857</b>	<b>37 023 563</b>
<b>Operating Expenditures</b>		
Purchase of gas	16 588 408	16 904 973
Maintenance cost of CHP1	338 400	305 960
Maintenance cost of CHP2	262 640	303 280
Maintenance cost of CHP3	237 760	300 280
Maintenance cost of Boilers	217 689	208 849
<b>Total Operating Expenditures</b>	<b>17 644 897</b>	<b>18 023 342</b>
<b>Net Cash from Operation</b>	<b>18 052 960</b>	<b>19 000 221</b>
<b>Cash Account</b>	<b>18 052 960</b>	<b>19 000 221</b>

	Total	Total
	2 829 450	4 656 362
	2 186 250	3 173 500
	4 760 682	4 760 682
	9 776 382	12 590 544
	4 132 550	4 839 629
	197 200	175 320
	123 720	169 000
	28 880	163 440
	20 783	1 038
	4 503 133	5 348 427
	5 273 249	7 242 118
	5 273 249	7 242 118

The case **without thermal storage**  
and **with thermal storage**

**Difference: 947 261,00 PLN (223 410,61 €)**

**5%**

The case where the CHP covers the entire heat demand (**without storage** and **with storage**).

**Difference: 1 968 869,00 PLN (464 355,90 €)**

**27%**

# Conclusions



- The Day-Ahead Market in Poland is an interesting option for District Heating companies with CHP units. In the case of use of heat storage profits increase by 5%.
- Very interesting case is when all the heat demand is covered by CHP units. In the case of use of heat storage profits increase by 27%.
- In the case of PEC Legionowo having its own electricity distribution system, the Day-Ahead Market is not as profitable (average energy price on market is 160PLN/MWh, PEC sells energy for 180PLN/MWh)
- The situation on the Polish energy market could be changed when new players appear under the form of Clusters of Energy.

# Thank you for your attention



**Hanoi (Vietnam)**

## Questions?

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