Smart municipal energy grid within electricity market

ŠABAC 21.IX 2017

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Publication!

Energy

Available online 27 July 2017

In Press, Corrected Proof

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Received 10 November 2016, Revised 2 June 2017, Accepted 30 June 2017, Available online 27 July 2017.

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https://doi.org/10.1016/j.energy.2017.06.177

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Highlights

- A smart municipal energy grid has been modeled in HOMER.
- The national electricity grid has been modeled with real time prices.
- Smart municipal grids could utilize excess electricity as their heat source.
- The hours of operation should be obtained with respect to hourly simulations.
- Smart municipal energy grids reduce energy costs below the assumed market price.

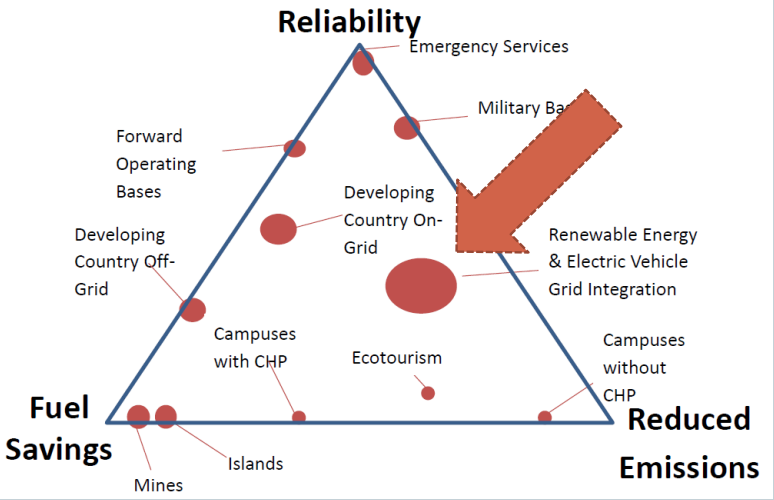
Smart municipal energy grids

Benefits	Challenges
• Locally available flexibility options • Intermittency friendly system - heat/cool demand. • Synergy effect between agriculture and electricity from renewable energy	• Trading electricity on the spot market • Multiple generators economic dispatch. • Economics highly dependable on utilization factors.

Method

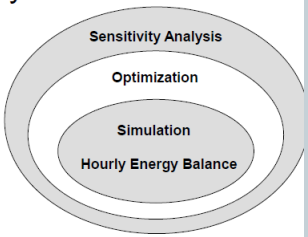
"We spent a lot of money developing our own model, but threw it away because everyone kept asking for our HOMER results."

Bruce Levy, CEO, TDX Power



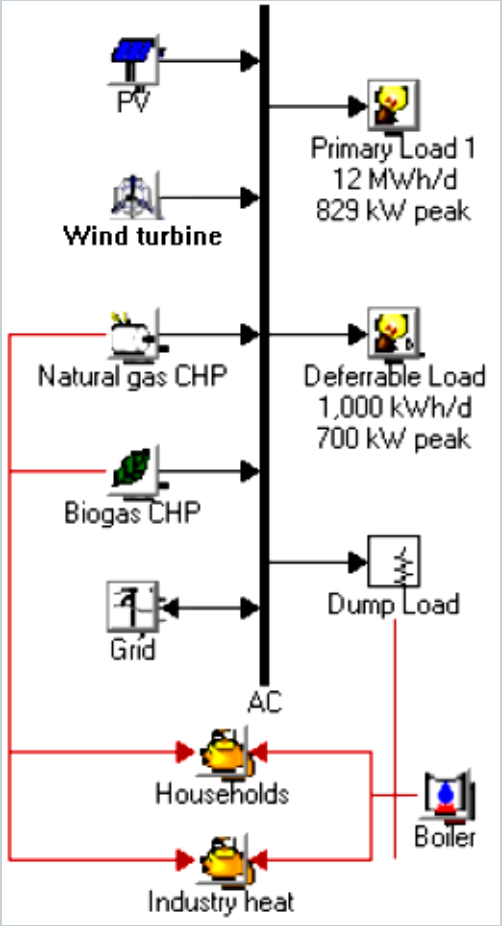
HOMER Analysis Layers

- Hourly Energy Balance
- Chronological Simulation
  - Loads & resources vary continuously
- Optimization
  - Find the least cost solution
- Sensitivity Analysis
  - The data is never "good enough".
  - What if….?



source: Economic Optimization of Microgrid Design: Understanding the Implications of Diverse Architectures Dr. Peter Lilienthal peter@homerenergy.com San Diego, November 20, 2013

Smart municipal energy grid configuration



- PV,
- Wind turbine,
- Natural gas CHP generator,
- Biogas CHP generator,
- Thermal load:
  - Households,
  - Industry,
- Electricity load:
  - Primary,
  - Deferrable.

Assumption: Solar and wind resource inputs

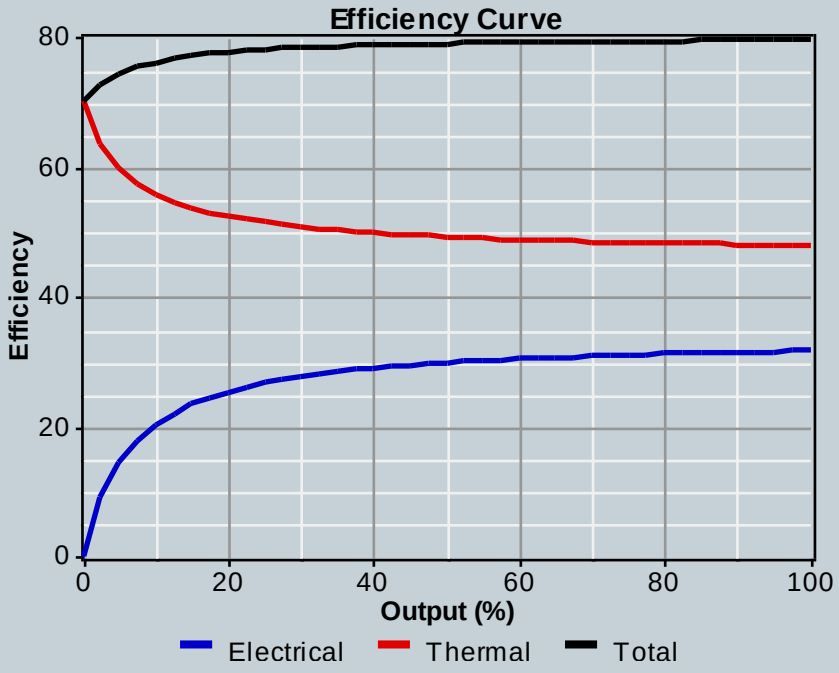
Month	Clearness Index	Daily Radiation ($kWh/m^2/d$)	Wind Speed (m/s)
January	0.410	1.310	5.319
February	0.482	2.240	2.890
March	0.473	3.220	3.209
April	0.466	4.250	2.998
May	0.487	5.280	3.041
June	0.492	5.700	2.141
July	0.515	5.770	3.123
August	0.525	5.120	3.492
September	0.498	3.780	2.539
October	0.463	2.440	3.992
November	0.393	1.380	5.841
December	0.375	1.040	4.590

Assumption: Natural gas and biogas CHP costs

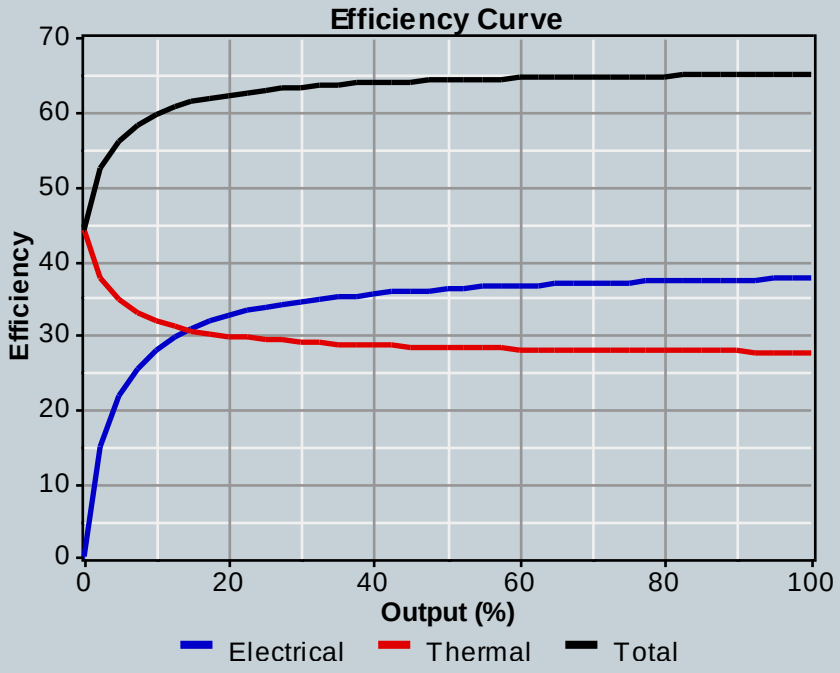
	Natural gas			Biogas		
Size (kW)	Capital (€)	Replacement (€)	O&M (€/hr)	Capital (€)	Replacement (€)	O&M (€/hr)
75	81,337	81,337	0.01	661,652	661,652	0.035
150	138,654	138,654	0.01	1,039,684	1,039,684	0.035
250	205,421	205,421	0.01	1,450,597	1,450,597	0.035
500	350,177	350,177	0.01	2,279,388	2,279,388	0.025
1,000	596,939	596,939	0.01	3,581,705	3,581,705	0.025
2,000	1,017,589	1,017,589	0.006	5,628,095	5,628,095	0.025
3,000	1,390,191	1,390,191	0.006	7,331,163	7,331,163	0.013
5,000	2,059,621	2,059,621	0.006	10,228,649	10,228,649	0.013

Assumption: CHP efficiency curve

Natural gas



Biogas



HOMER optimization space

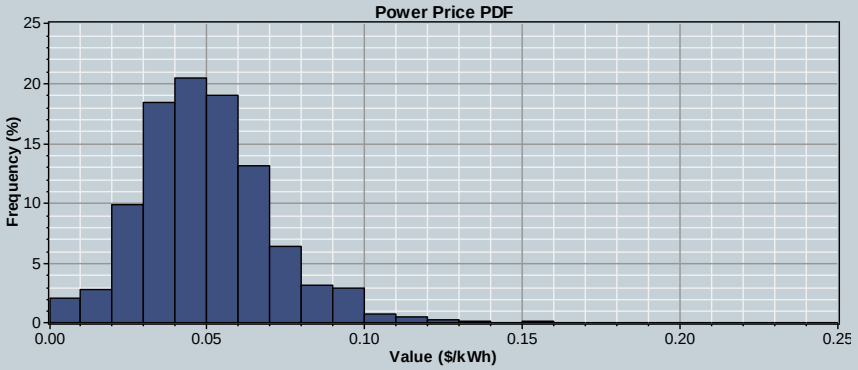
Search space

	PV Array (kW)	S3.7 (Quantity)	NGCHP (kW)	BGCHP (kW)	Grid (kW)
1	-	-	-	-	1,000
2	250	10	75	75	
3	500	25	150	150	
4			250	250	
5			500	500	
6			1,000	1,000	
7			1,500	1,500	

Sensitivity space

	Biomass (€/t)	Natural gas (€/Nm3)
1	-10	0.1
2	-5	0.2
3	0	0.3
4	5	0.4
5	10	0.5

Power density function of the national electricity grid hourly price

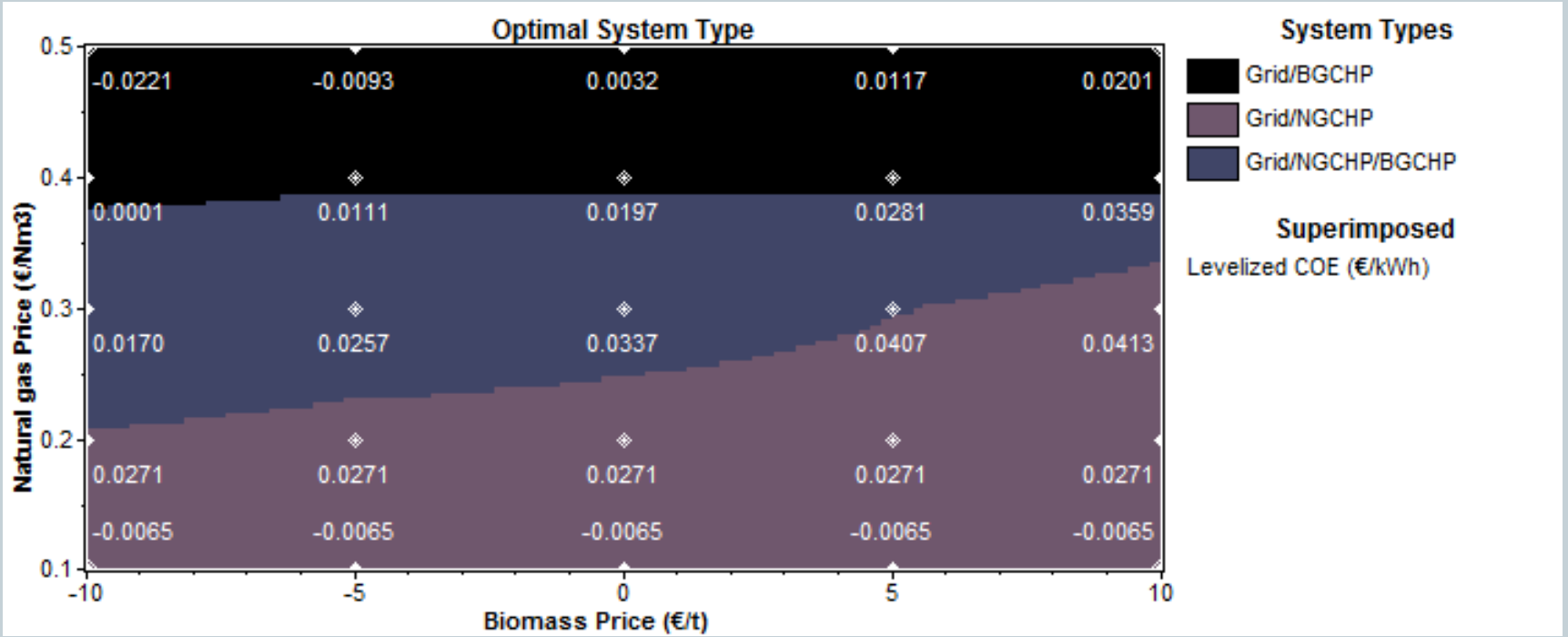


Power density function of the national electricity grid hourly price

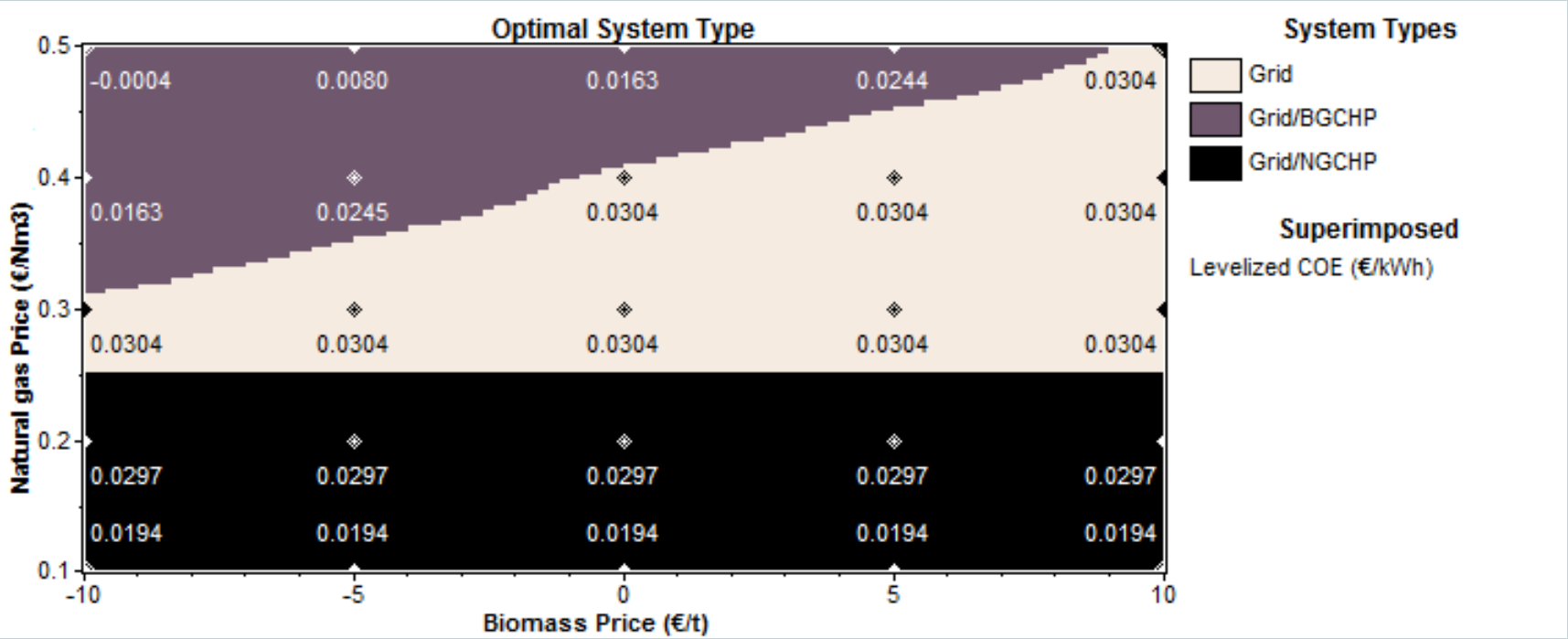
Area/ Type	Catle	Pigs	Sheep	Poultry	Σ Feedstock [t/d]
Macva state district	80,283	400,391	161,878	1,060,996	3,591
City of Sabac	26,837	116,881	36,233	289,520	1,117

Available feedstock for biogas production from manure in the Macva state district and City of Sabac

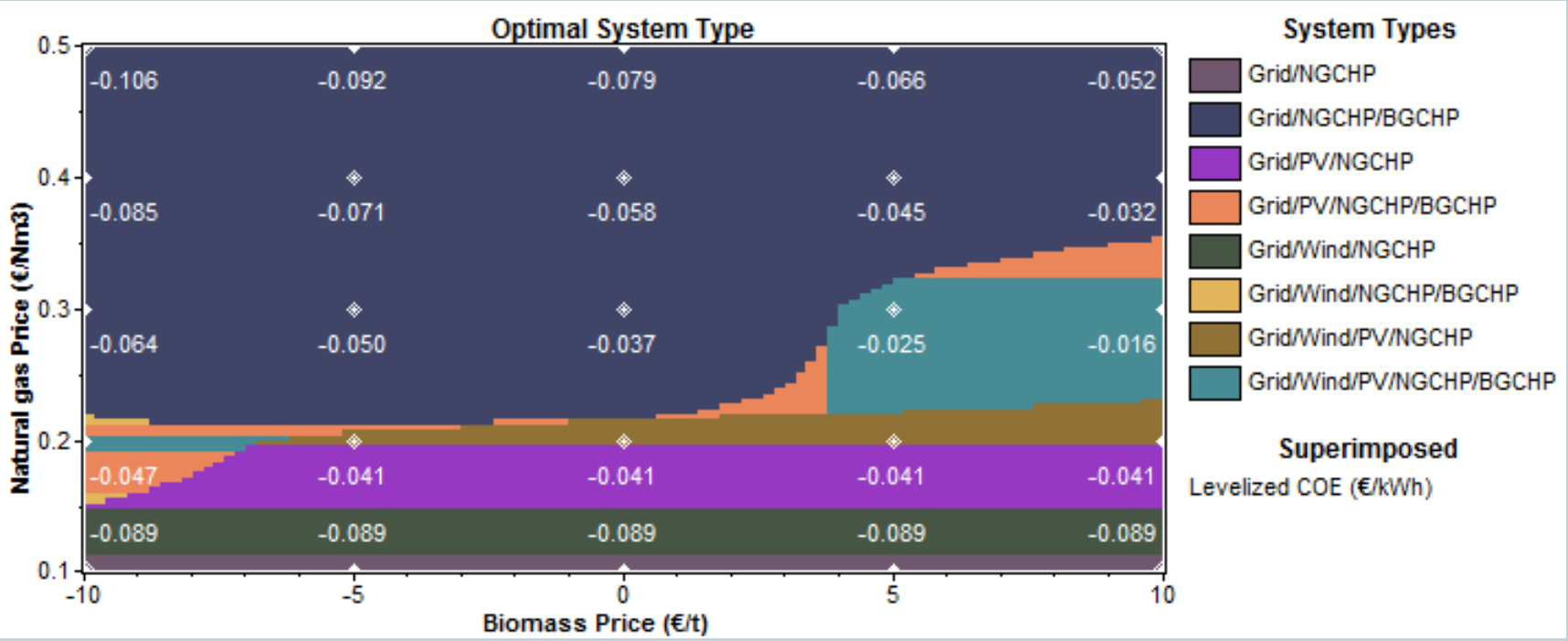
Optimal system structure for national electricity grid average price of 5c€/kWh.



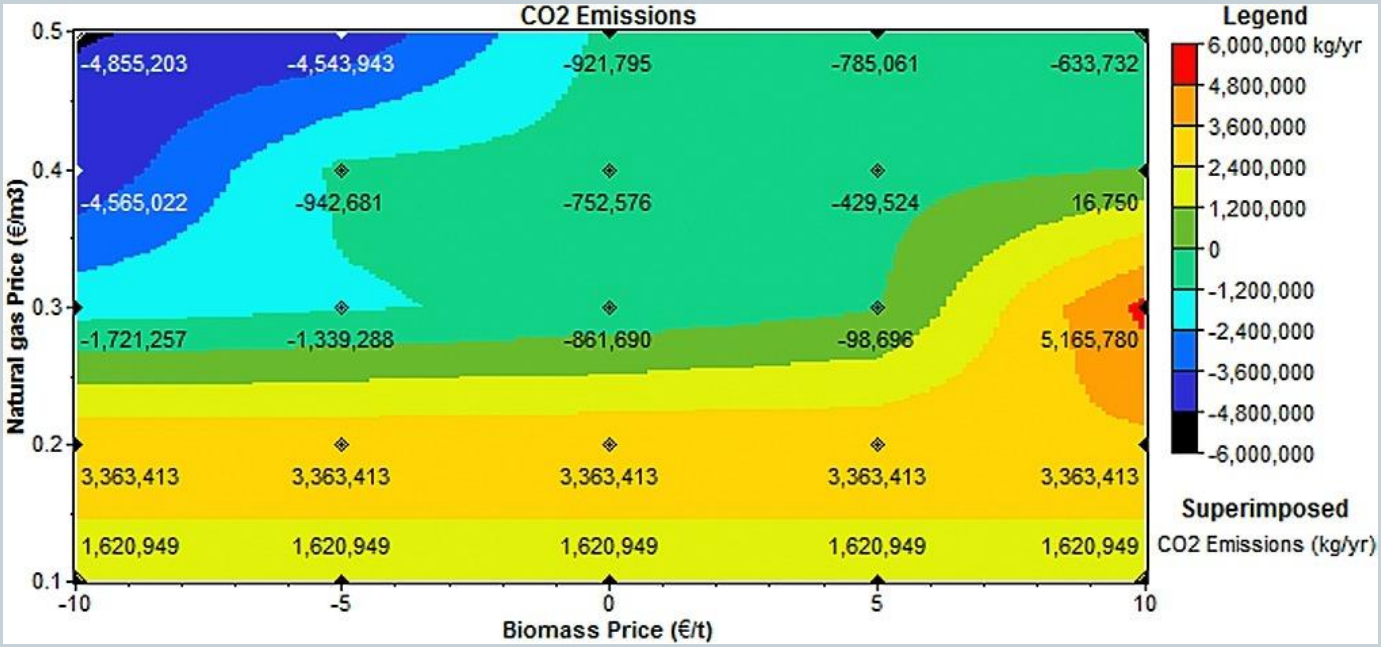
Optimal system structure for national electricity grid average price of 3c€/kWh.



Optimal system structure for national electricity grid average price of 10c€/kWh.



Environmental benefits



Economic comparison with base configuration 5c€/kWhel

System characteristics	Base	S1	S2	S3	S4	S5
Biomass [€/t]		-10	-5	0	5	10
Natural gas [€/Nm3]				0.3		
NGCHP [kW]	-	500	500	500	500	1,000
BGCHP [kW]	-	1,000	1,000	1,000	1,000	-
Grid [kW]	1,000	1,000	1,000	1,000	1,000	1,000
Initial cost [€]	-	3,931,882	3,931,882	3,931,882	3,931,882	596,939
Total cost [€]	11,592,836	9,133,686	9,763,992	10,350,609	10,861,921	10,902,640
Present worth [€]		2,459,154	1,828,847	1,242,229	730,917	690,197
Annual worth [€/year]		159,971	118,969	80,809	47,547	44,898
Return on investment [%]		10.40%	9.41%	8.45%	7.56%	13.9%
Internal rate of return [%]		11.10%	9.58%	8.15%	6.87%	15.3%
Simple payback [years]		5.16	5.62	6.19	7.04	5.63
Discounted payback [years]		6.13	6.77	7.6	8.9	6.78
Hours NGCHP	-	2,410	2,410	2,410	2,410	4,327
Hours BGCHP	-	7,849	7,484	7,031	6,331	-

Conclusions

In this paper it has been shown that smart municipal grids could decrease levelized costs of energy in the municipal grid below national electricity grid average price based on their flexibility.

The payback periods of the smart municipal grids may be decreased with a properly designed economic support energy policy.

The environmental benefits of smart municipal grids are substantial, due to high equivalent emission from the national electricity grid

Hours of operation of CHP plant are dependable on many system design factors and may not be assumed exogenous, and kept at constant level in the techno-economic feasibility study during the investment decision.

The authors are acknowledging the support from the "CoolHeating" Horizon 2020 project from European Commission grant nr. 691679.

Thank you for your attention!

Хвала на пажњи!

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691679.
The sole responsibility for the content of this report lies with the authors. It does not necessarily reflect the opinion of the European Union nor of the Innovation and Networks Executive Agency (INEA). Neither the INEA nor the European Commission are responsible for any use that may be made of the information contained therein.

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