KeepWarm

Renewing district heating

Improving the performance of District Heating Systems in Central and Eastern Europe

Goran Krajačić

5th International Conference on Smart Energy Systems

Copenhagen, 10th of September 2019

This project is funded by the EU's Horizon 2020 research and innovation programme under grant agreement N°784966, and lasts from April 2018 to September 2020.

This project receives co-funding from the German Federal Ministry of Economic Cooperation and Development.

KeepWarm
Renewing district heating

KeepWarm - 11 partners from 8 countries

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

ICLEI Local Governments for Sustainability

ASSOCIATION FOR DISTRICT HEATING of the Czech Republic

Landwirtschaftskammer Steiermark

KSSENA

Jožef Stefan Institute, Ljubljana, Slovenia
Energy Efficiency Centre

REGIONALNA ENERGETSKA AGENCIJA
NORTH-WEST CROATIA
SJEVEROZAPADNE HRVATSKE
REGIONAL ENERGY AGENCY

FSB University of Zagreb
Faculty of Mechanical Engineering and Naval Architecture

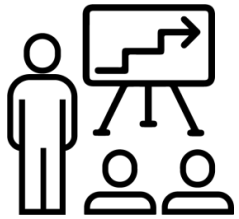
ZREA
ZEMGALES REGIONĀLĀ ENERĢĒTIKAS AĢENTŪRA

KT-ENERGY

VINČA
INSTITUTE OF NUCLEAR SCIENCES
University of Belgrade
NATIONAL INSTITUTE OF THE REPUBLIC OF SERBIA

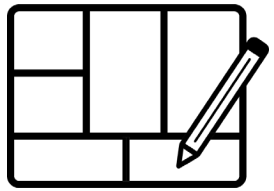
What can we do for them?

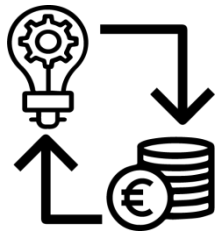
To overcome barriers to district heating deployment in CEE, KeepWarm works in a multi-stage approach to conduct the following activities:



Increase the capacity of specialists working in DHS companies by offering training workshops

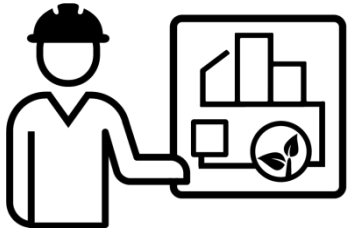
Support them with the development of viable business plans



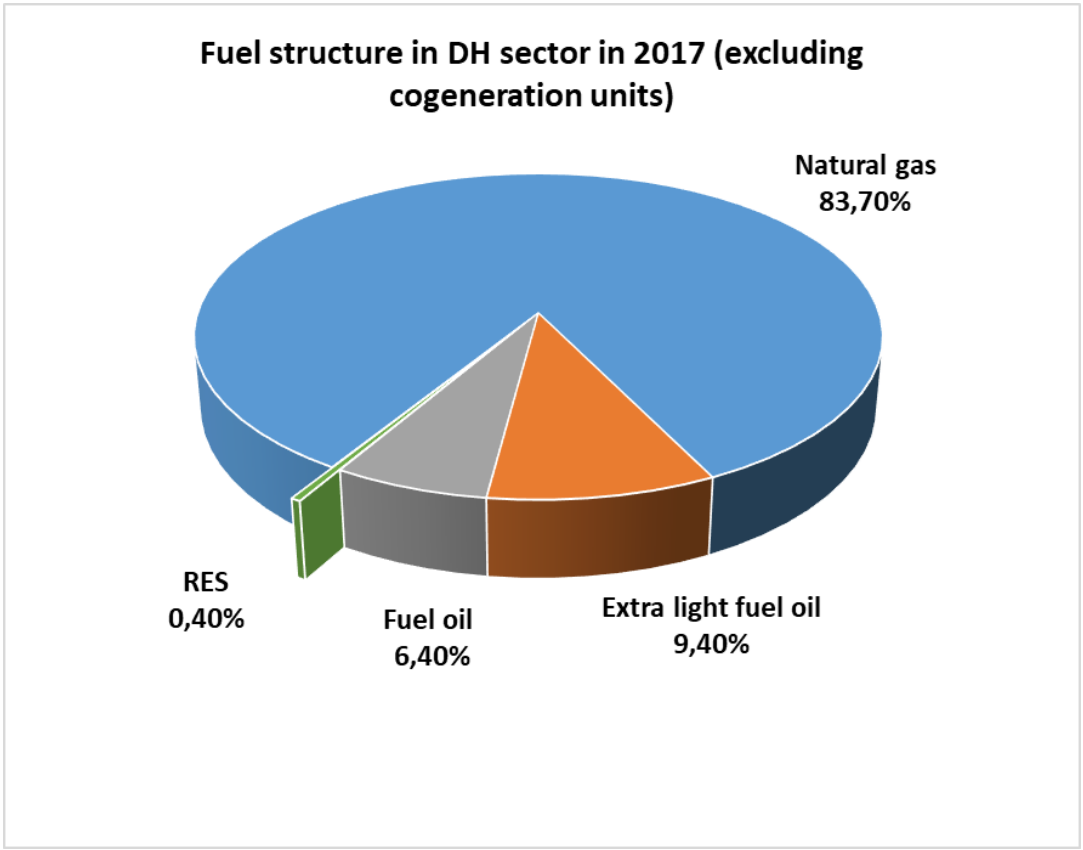


Advise them on how to mobilise funding for bankable pilot projects

Exhibit replicable DHS demo cases



Facilitate the multi-level integration of DHS retrofits into key strategies and plans



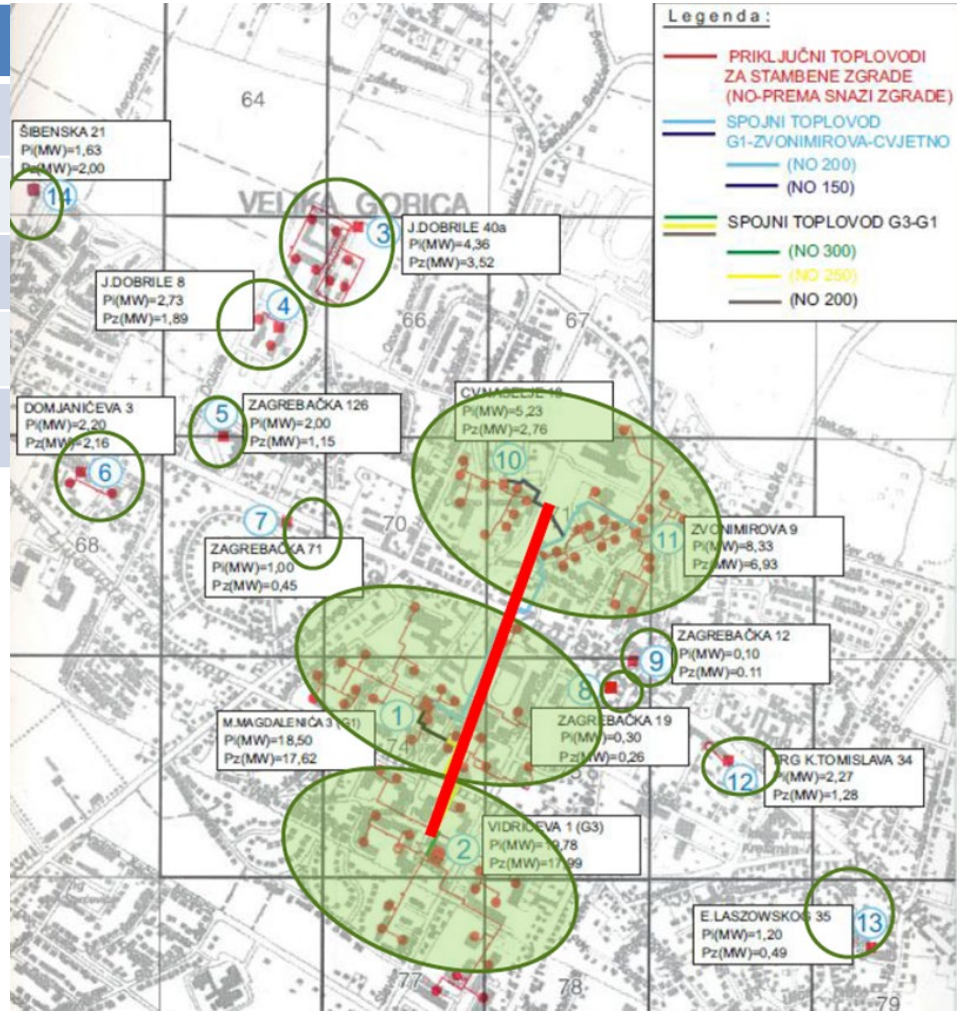
RES in DH in Croatia

- Biomass cogeneration
  - 3 MWe, 10 MW_{th} (Osijek, Sisak)
  - 1 MWe, 4,5 MW_{th} (Glina)
  - …
- Biomass boiler
  - 1 MW_{th} (Pokupsko)
- Solar thermal
  - 400 m^2; 260,8 kW_{th} (Vukovar)
- Geothermal?
  - Krapinske toplice, Topusko, Varaždinske toplice
- Heat pumps?

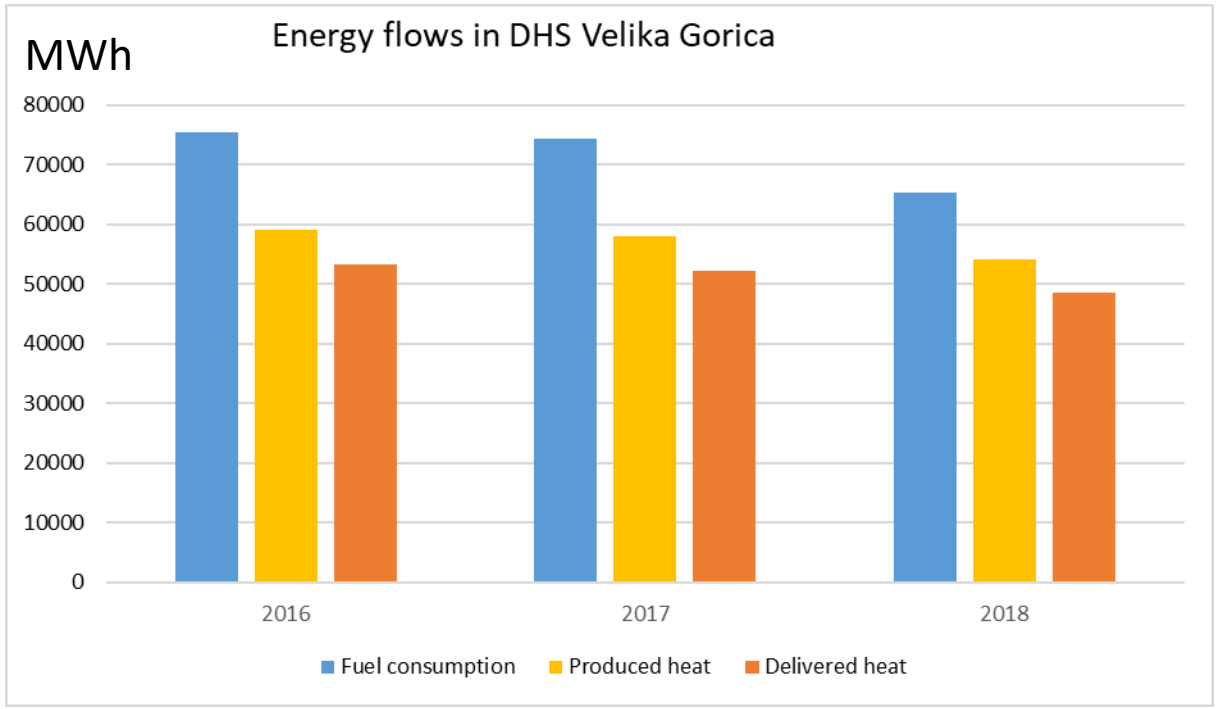
- Cogeneration: HEP, https://www.hep.hr/na-gradilistima-bioelektrana-u-tijeku-su-zavrsni-montazni-radovi/3115
- Solar thermal: Tehnostan, https://www.tehnostan-vukovar.hr/novosti/solarna-kotlovnica-pustena-u-rad/
- Acquae: Krapinske toplice, https://www.krapinsketoplice.com/vodeni-park-aquae-vivae-krapinske-toplice/
- Heat pump: Friotherm, https://www.friotherm.com/applications/district-heating-heat-pumps/

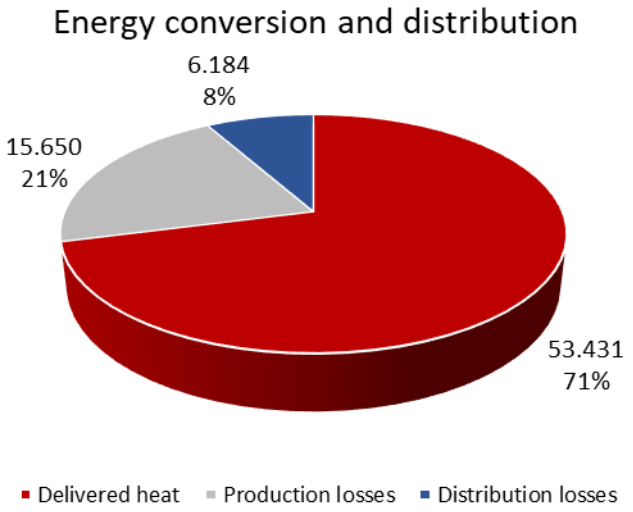
District heating system in Velika Gorica

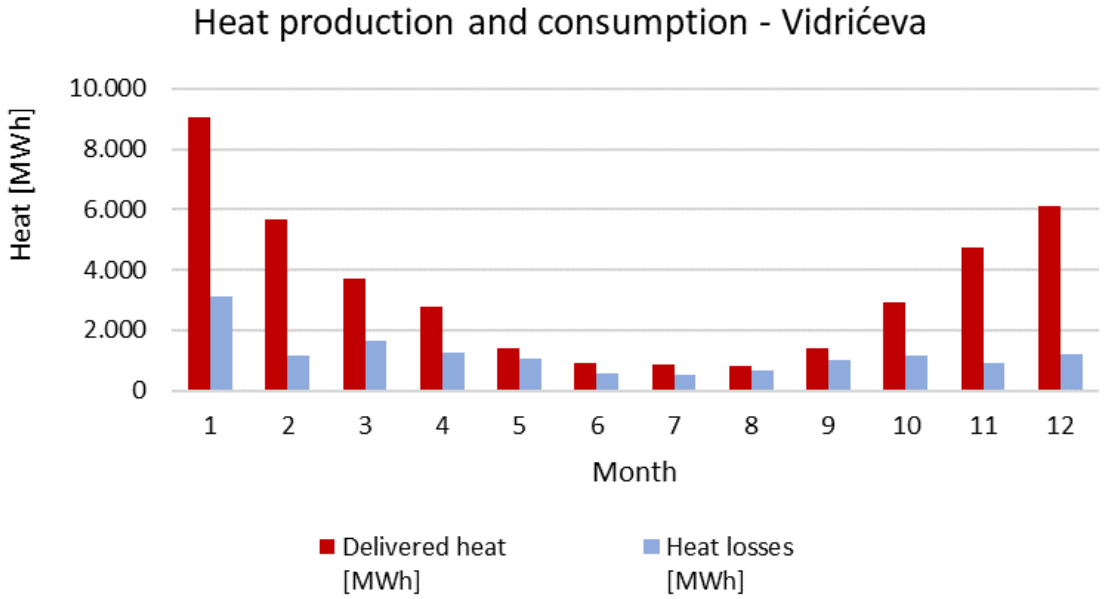
SYSTEM PARAMETER	VALUE
CONTRACTED POWER	46,56 MW (installed 59 MW)
HEATED AREA	338.379,91 m^2
NUMBER OF HEATING SUBSTATIONS	120
PIPELINE LENGHT	10.671m
PERCENTAGE OF PREINSULATED PIPES	70%



Inputs

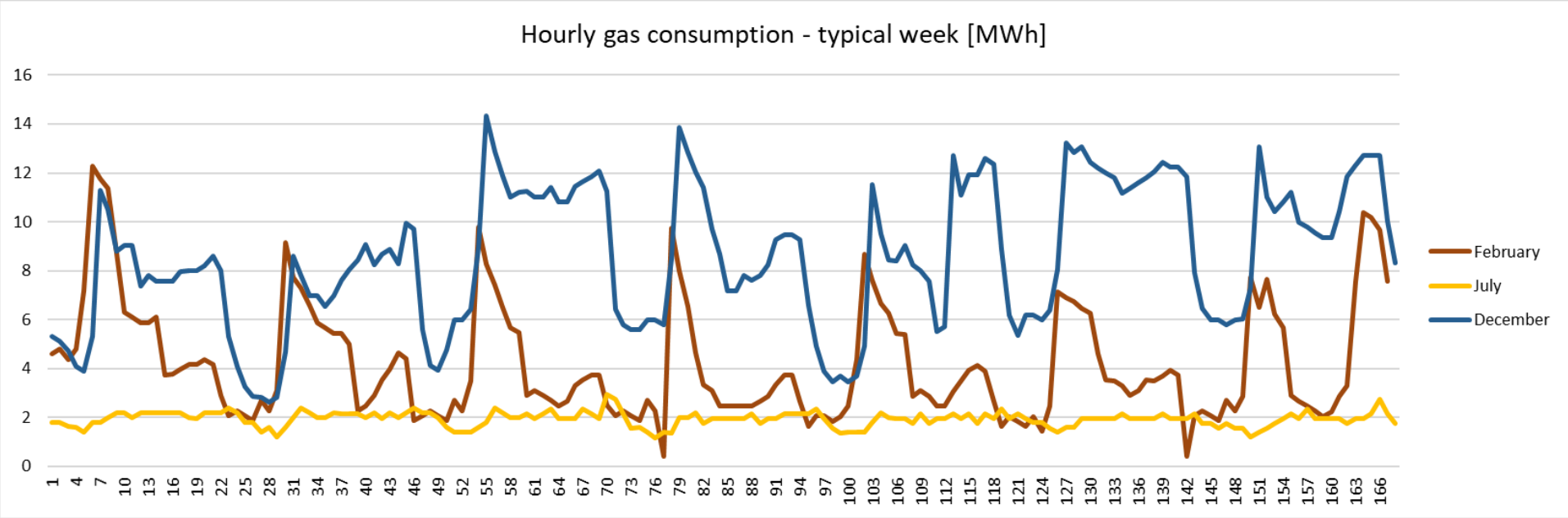

Energy flows in DHS Velika Gorica
MWh
80000
70000
60000
50000
40000
30000
20000
10000
0
2016
2017
2018
Fuel consumption
Produced heat
Delivered heat

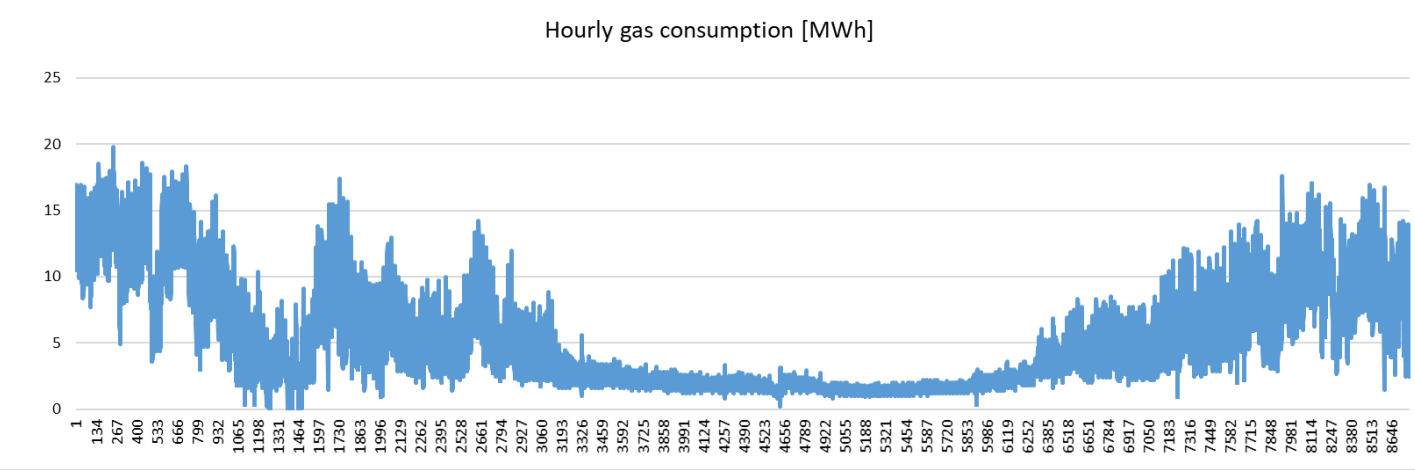

Energy conversion and distribution
6.184
8%
15.650
21%
53.431
71%
Delivered heat
Production losses
Distribution losses


Heat production and consumption - Vidrićeva
Heat [MWh]
10.000
8.000
6.000
4.000
2.000
0
1
2
3
4
5
6
7
8
9
10
11
12
Month
Delivered heat [MWh]
Heat losses [MWh]

KeepWarm
Renewing district heating

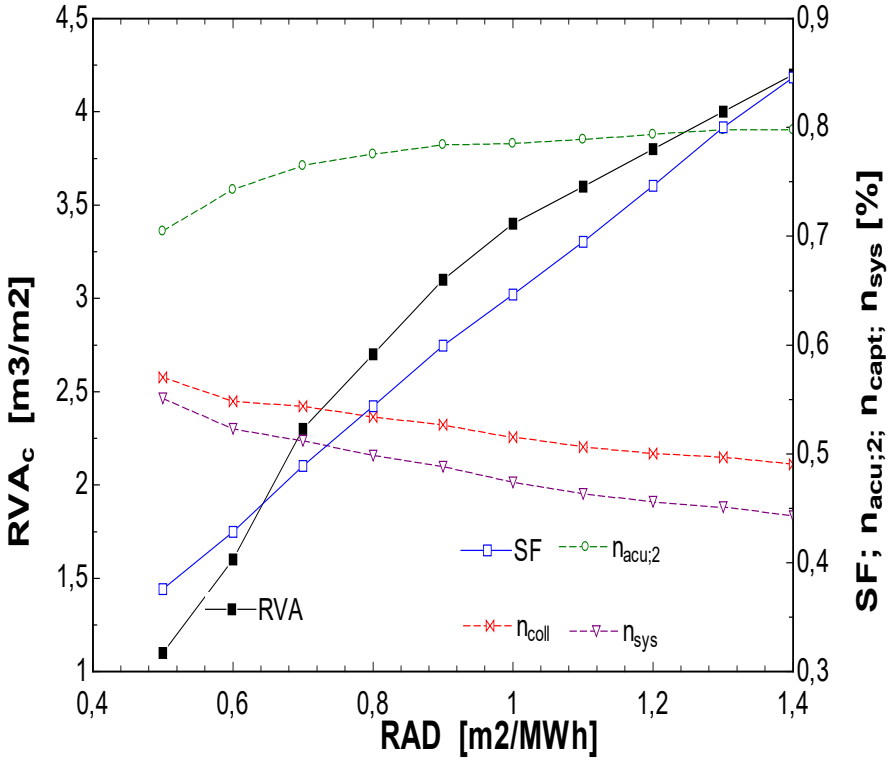
Gas consumption





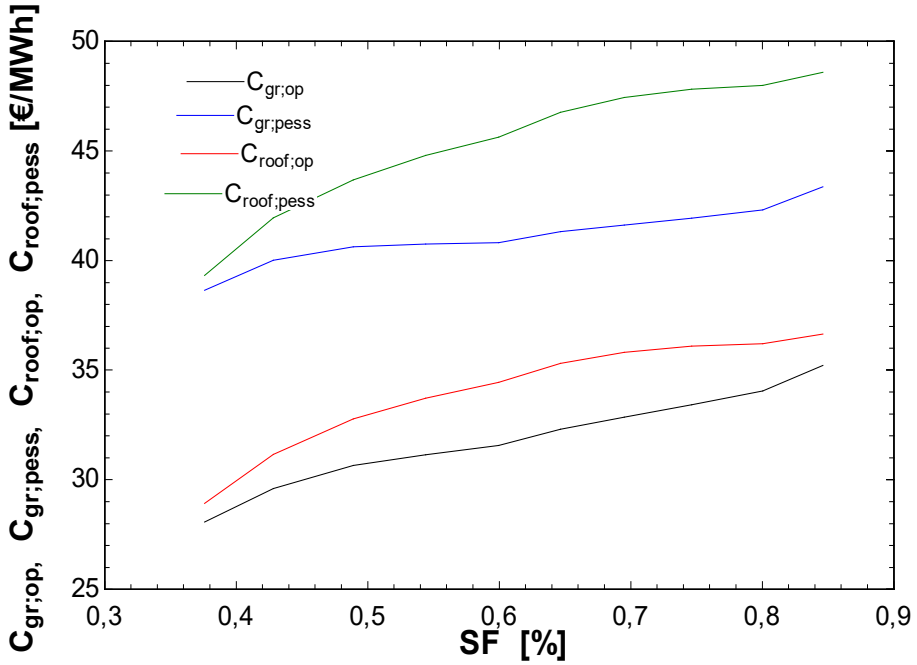
Seasonal storage - Velika Gorica

Felipe Andreu Javier, Schneider Daniel Rolph, Krajačić Goran: ***Evaluation of integration of solar energy into the district heating system of the city of Velika Gorica***, Thermal Science 2016 Volume 20, Issue 4, Pages: 1049-1060
https://doi.org/10.2298/TSCI151106106A

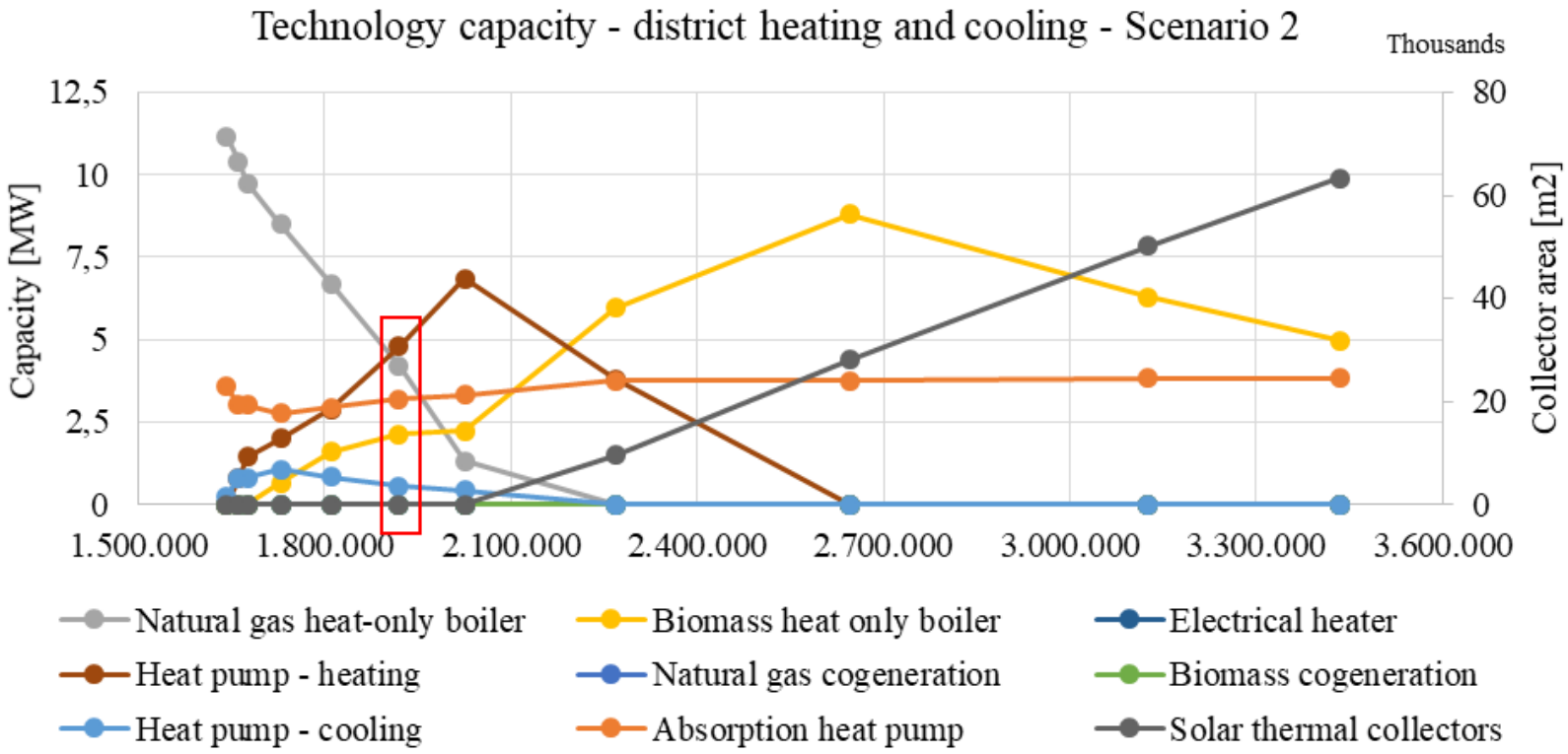


Critical volume criteria

- do not reject any heat produced
- reach the maximum usage of the accumulation



DHC – integration V. Gorica



Energy 169 (2019) 319–328

Contents lists available at ScienceDirect

Energy

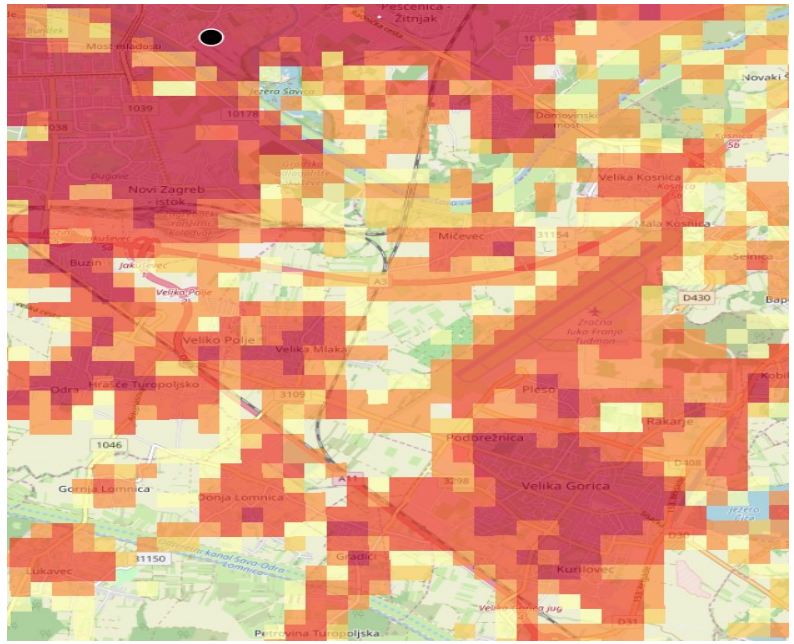
journal homepage: www.elsevier.com/locate/energy

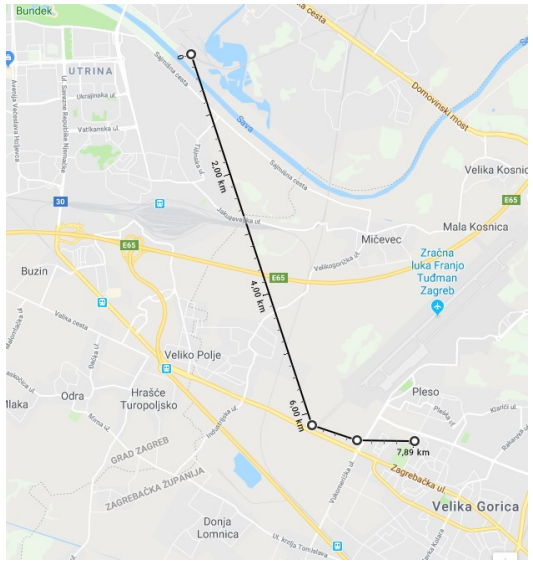
Multi-objective optimization of district heating and cooling systems for a one-year time horizon

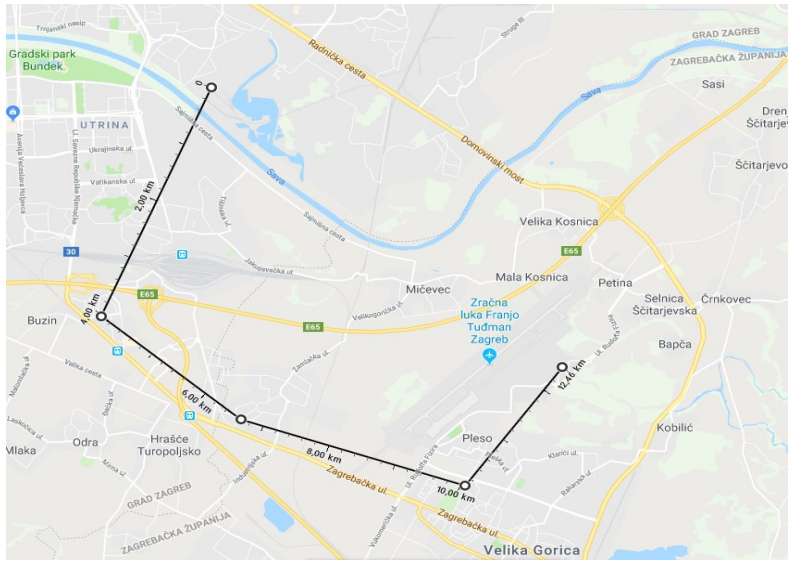
Hrvoje Dorotić*, Tomislav Pukšec, Neven Duić

University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Department of Energy, Power Engineering and Environment, Ivana Lučića 5, 10002 Zagreb, Croatia

DH expansion?



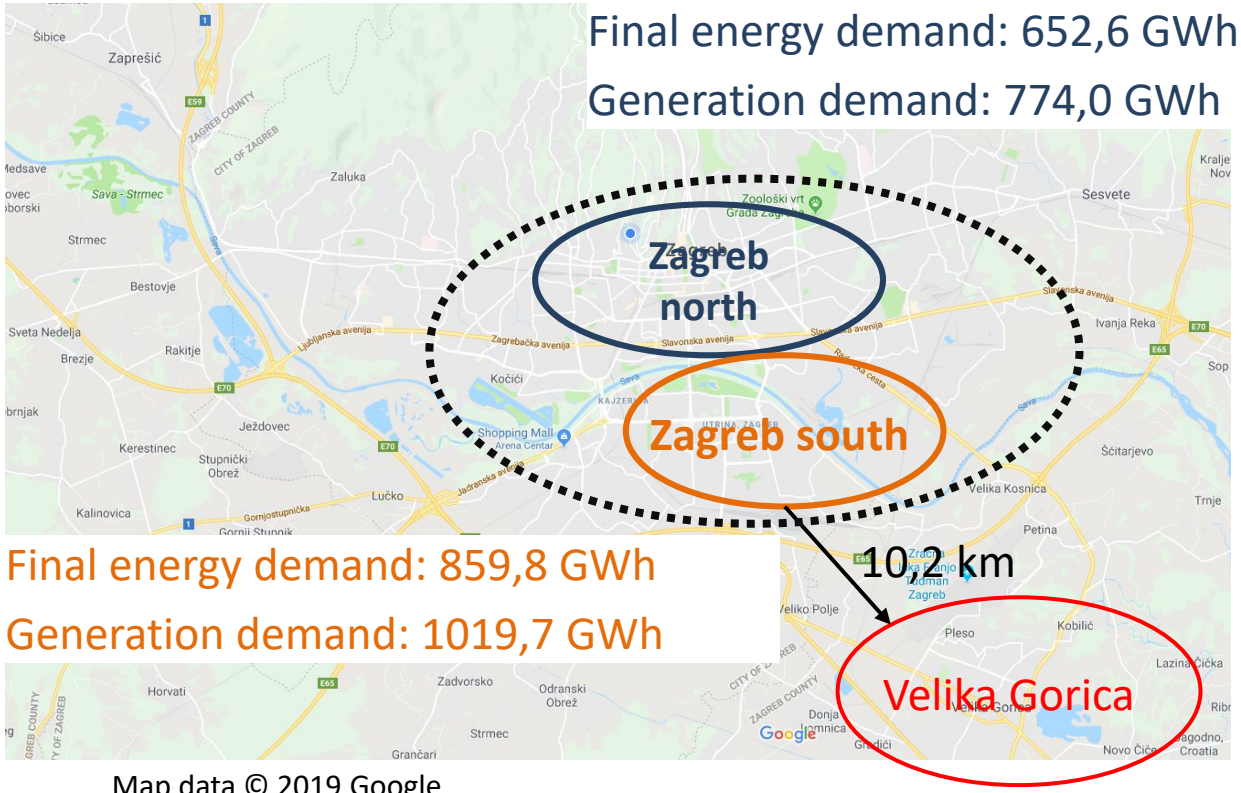




District	Heat Demand [MWh]
Buzin	22 500
Veliko Polje – Velika Mlaka	32 900
Velika Gorica	158 350
International airport Zagreb	47 900

Project	Scenarij 1	Scenarij 2 - vrelovod	Scenarij 2 - OEI
Investment I_0	11.685.090,00 €	18.539.400,00 €	75.700.000,00 €
O&M	1.168.509,00 €	1.853.940,00 €	2.385.000,00 €
Fuel cost	-	-	825.000,00 €
Production	158.350 MWh	171.650 MWh	90.000 MWh
LCOE	13,30 €/MWh	19,47 €/MWh	103,5 €/MWh
LCOE total		48,37 €/MWh	

Interconnecting DH grids of Zagreb and Velika Gorica



In Cooperation with CITIES project and DTU Compute

Case study assumptions

- Connection piping price assumptions from: *Frederiksen, Werner: District Heating and Cooling* – adjusted for inflation and currency exchange

  - Piping cost:

	Start – up cost (M€)	Additional cost per capacity (M€/MW)
Velika Gorica	3,87	0,35

- Perfect foresight
- DH distribution losses modelled exogenously
- Transmission pipe loss: 5%
- Technology costs from: *Technology datasheet for energy plants* by Energinet and DEA
- CO2 price: 22€ / ton
- Electricity distribution and transmission fees: 40 €/MWh_{ele} (in total)

In Cooperation with CITIES project and DTU Compute

Case study – investment options

- 1) Thermal energy storage
- 2) Electric boiler and/or heat pump
- 3) Connection pipe:
  - Zagreb south to Velika Gorica

In Cooperation with CITIES project and DTU Compute

	Investment cost (EUR/ MW_{heat})	Annualized investment cost (EUR/(MW year))	Fixed cost (EUR/(MW year))	Variable cost (EUR/MWh)	Total efficiency	Lifetime (years)	Discount rate
Electric boiler	75,000	7,079	1,100	0.8	98%	20	7%
Heat pump	700,000	60,067	2,000	2	400% (COP)*	25	7%
Thermal storage (per MWh)	3,000	225	8.6	0.1	98%	40	7%

Results techno-economic assessment

- Optimal investment portfolio: 972 MWh thermal storage and 20.75 MW pipe capacity (peak final energy demand: 23.48 MW)

	Storage	Connection pipe
Investment cost (€)	2,916,000	11,127,275
Annuity (€ / year)	218,727	834,647
Total O&M (€ / year)	8,359	66,017
Total yearly costs (€/year)	1,127,750	

	€/MWh of heat sold
Capital price to recover investment	20.5
Calculated 'room' for DH heat price*	18.7

- * *compared to the best available alternative (gas and individual heat pump)*

In Cooperation with CITIES project and DTU Compute

Results

In Cooperation with CITIES project and DTU Compute

Overall savings after the interconnection!

But highly sensitive to electricity and gas prices

	Zagreb south and north (base case)	Zagreb and Velika Gorica
Total system costs (M€)	4,37	3,29
Difference (€)	0	-1.09

- Cropex day ahead weighted average price for 2017: 53.81 €/MWh (source: Cropex)
- DK1 and DK2 on Nordpool day ahead: 30.08 and 31.97 €/MWh (source: Nordpool)
- Gas price in 2017: 26 €/MWh for non-household consumers in Croatia (source: Eurostat)

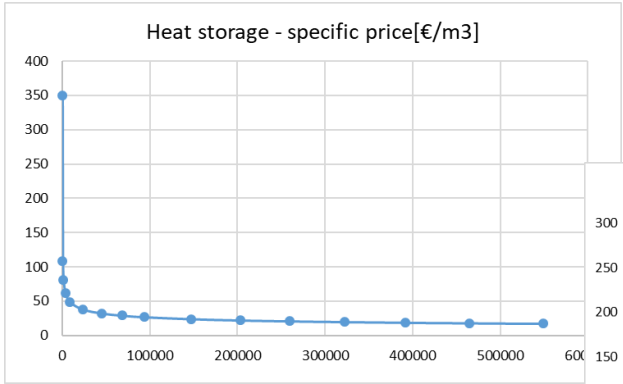
Connected DH systems:	All heat supplied via interconnection System costs (M€/year)	Optimal portfolio (M€/year)	Difference
Velika Gorica and Zagreb	3,93	3,29	-16.3 %

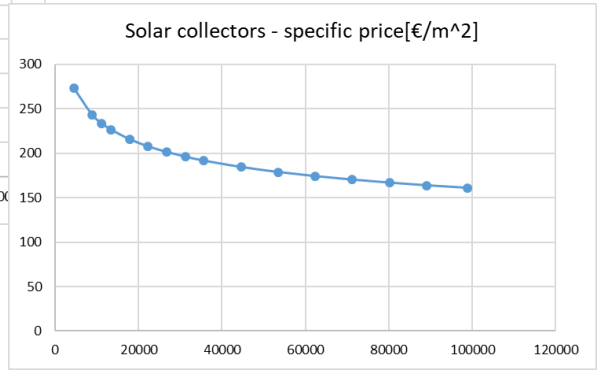
!! Socio-economic costs sensitive to electricity prices > income from electricity sales – around 117 M€

Solar DH in V. Gorica asumptions

- Storage loss: 10%
- Equipment costs (pipelines, pumps, valves, etc.) =10% of the investment cost
- Other costs (design, regulation system, etc.) = 12% of the investment costs
- Discount rate: 5%
- Lifetime: collector field – 25 years

  storage – 50 years



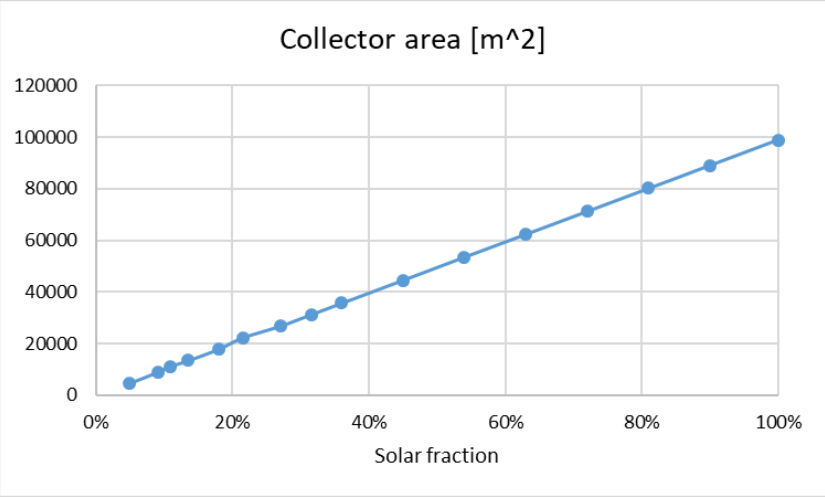


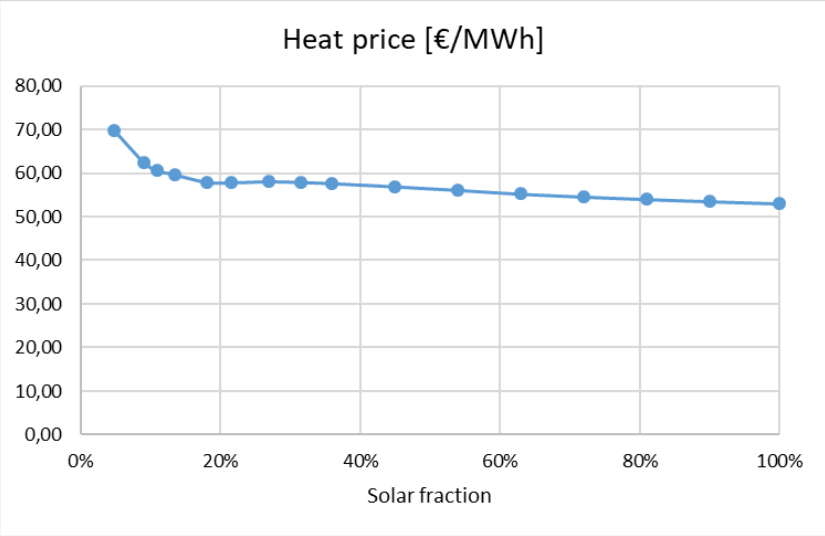
KeepWarm
Renewing district heating

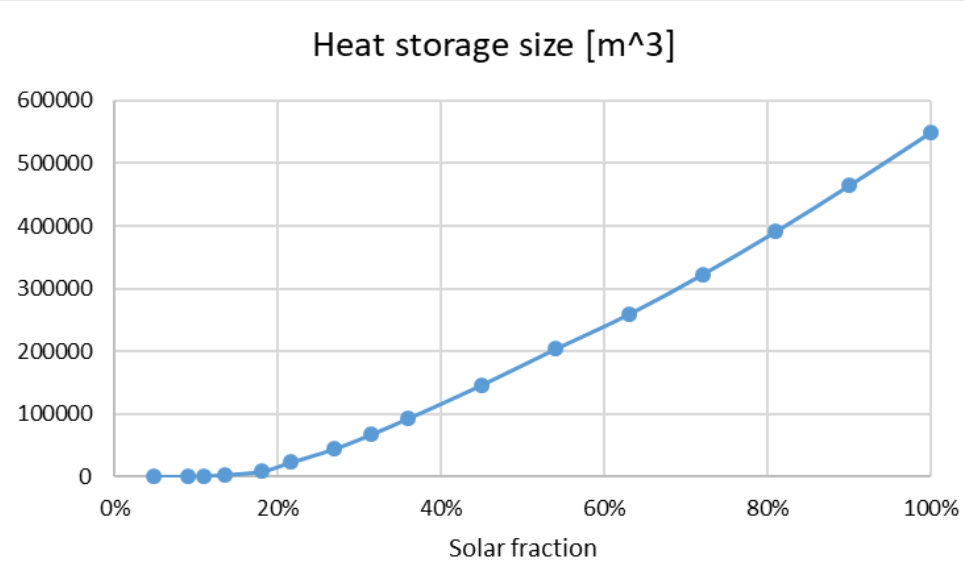
Method

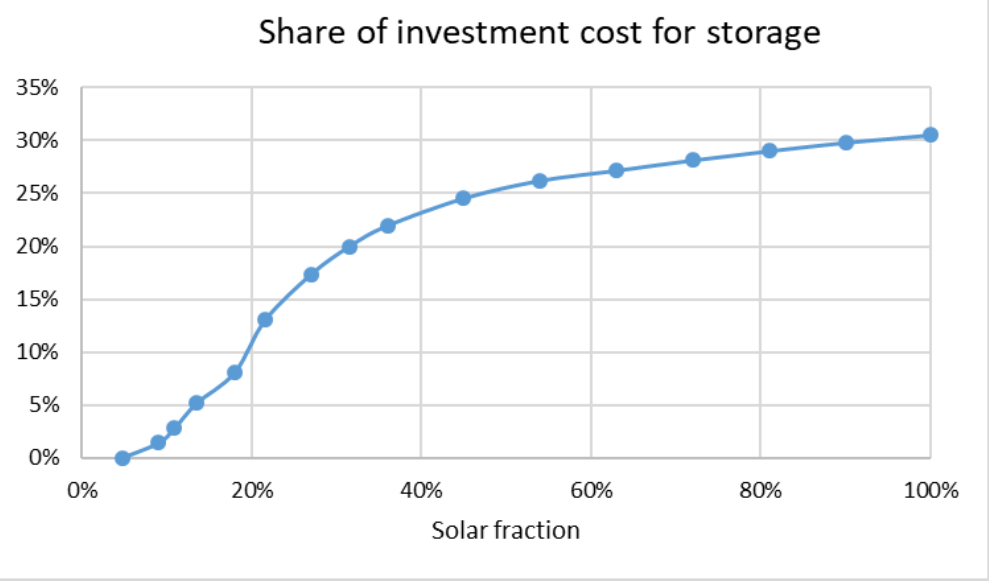
- Isentropic model for the calculation of collector output
- EnergyPLAN model
- Storage capacity – based on 100% solar heat utilization
- Heat price – modified calculation based on Guadalfajara et all:A simple method to calculate Central Solar Heating Plants with Seasonal Storage, 2013

KeepWarm
Renewing district heating









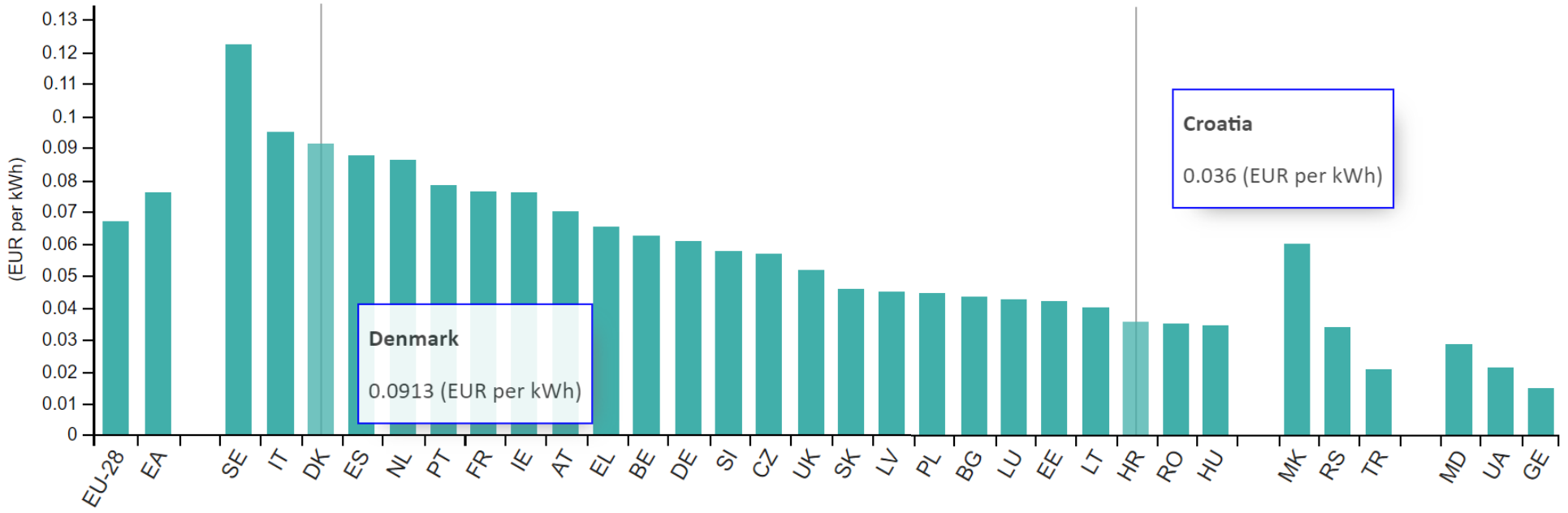
Conclusions for Solar DH – work in progress

- around 15% of heat demand can be covered via solar collectors using only small buffer storage (SF 15% = 190 MWh storage)
- heat prices range between 53€ and 69€ per MWh

KeepWarm
Renewing district heating

Compete with n. gas heating

Gas prices (including taxes) for household consumers, second half 2018



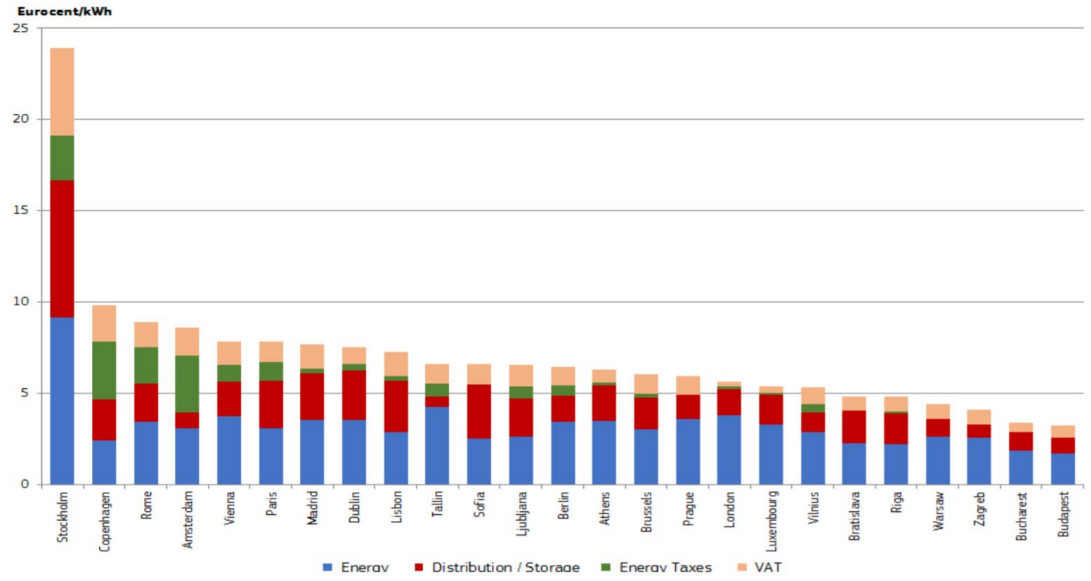
Source: Eurostat (online data codes: nrg_pc_202)

eurostat

KeepWarm
Renewing district heating

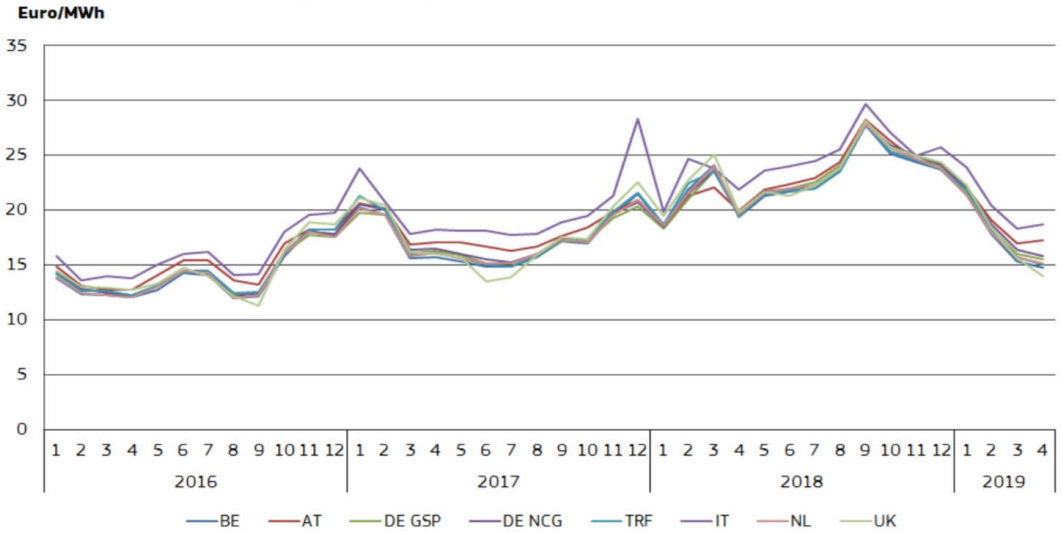
Support DH through policy?

N. Gas price composition



Source: VaasaETT

Wholesale day-ahead gas prices on gus hubs in the EU



Source: S&P Global Platts

KeepWarm

Renewing district heating

Thank you!

goran.krajacic@fsb.hr

For more information,
visit KeepWarm website
www.KeepWarmEurope.eu
or contact the project coordinator
stefanie.schaedlich@giz.de
or follow us on Twitter:
@KeepWarm_EU

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FSB University of Zagreb Faculty of Mechanical Engineering and Naval Architecture

lk Landwirtschaftskammer Steiermark

REGIONALNA ENERGETSKA AGENCIJA NORTH-WEST CROATIA SJEVEROZAPADNE HRVATSKE REGIONAL ENERGY AGENCY

Jožef Stefan Institute, Ljubljana, Slovenia Energy Efficiency Centre

ICLEI Local Governments for Sustainability

ASSOCIATION FOR DISTRICT HEATING of the Czech Republic

ZREA

KSSENA

KT-ENERGY

VINČA INSTITUTE OF NUCLEAR SCIENCES University of Belgrade NATIONAL INSTITUTE OF THE REPUBLIC OF SERBIA

This project is funded by the EU's Horizon 2020 research and innovation programme under grant agreement N°784966, and lasts from April 2018 – September 2020.

This project receives co-funding from the German Federal Ministry of Economic Cooperation and Development.

немачка сарадња DEUTSCHE ZUSAMMENARBEIT