

City of Belgrade: District Energy Action Plan for Next 20 Years

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Conference
Renewable energy sources
in district heating and cooling systems

References



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- PUC “Beogradske elektrane”, Development strategy for period from 2015 to 2025, with projections until 2035., 2016.
- City of Belgrade, Air Quality Plan for agglomeration Belgrade, 2016.
- City of Belgrade, Climate Change Adaptation Action Plan and Vulnerability Assessment, 2015.
- City of Belgrade, Development Strategy and Action Plan, 2017.
- EU, Heating and Cooling Strategy, 2016.



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Short term action plan of infrastructural development until 2030

- Construction of waste-to-energy CHP facility at the Vinča waste management center
- Construction of heat pipeline from TPP “Nikola Tesla A” (TENT-A) to HP Novi Beograd,
- Shutting down of selected heat sources,
- Construction of CHP facilities,
- Network interconnection,
- Systematic replacement of heat pipelines

Project
Description
Conditions for realization
State of realization
Expected effects
Financing

Waste-to-energy CHP facility at the Vinča waste management treatment and disposal center

- CHP regime: 20,6 MW_{el.} and 56,5 MW_{th.}
- Connection to HP Konjarnik (DN 600, about 9 km)
- Priority for produced heat (base load source) during the whole heating season
- PPP 25 year, 300 million euro
- Heat transport system, 20 million euro, PUC „Beogradske elektrane“
- 2022, system in operation

Heat pipeline TPP “Nikola Tesla A” (TENT-A) - HP Novi Beograd

- 600 MW_{th.} in HP Novi Beograd (power losses app. 150 MW), 29 km, DN1000
- Priority for produced heat (base load source) during the whole heating season
- In the preparatory phase of realization (an annex to the agreement on the construction has been signed with the contractor, the Power Construction Corporation of China, negotiations about the credit for the financing of the project)
- 193,5 million euro, 3 years for realization
- Increasing security of supply
- Analysis of influences of possible introduction of EU Emission Trading Scheme

Shutting down of selected heat sources

- Continue the shutting down of several heat sources, primarily ones operating on heat oil or coal, as well as the ones with pollution levels above ELV, or those that require large investment in maintenance of technical-technological level.
- Heat plants Banovo brdo (TENT A) and Zemun are in plan to be shut down by 2022
- More than 1,200 boiler stations were closed in last decades (23 heat sources or 70.16 MW_{th} after 2015). In addition, Secretariat for Environmental Protection financed shutting down of several individual boilers in schools, kindergartens, public institutions, etc.
- Achieved effects: annual reduction of CO₂ emission for approximately 500.000 t and reduction of emissions of particles, SO_x, NO_x and other pollutants.

Construction of CHP facilities

- CHP in HP Voždovac, $10 \text{ MW}_{\text{el}}$, $10 \text{ MW}_{\text{th}}$, natural gas, 2020
- Priority for produced heat (base load source) during the whole heating season - SHW
- Similar CHP facilities within other HP (Cerak, Dunav, Novi Beograd) should be examined, primarily those that provide SHW.
- Energy efficiency over 85%; possibility to obtain the status of privileged producer

Network interconnection

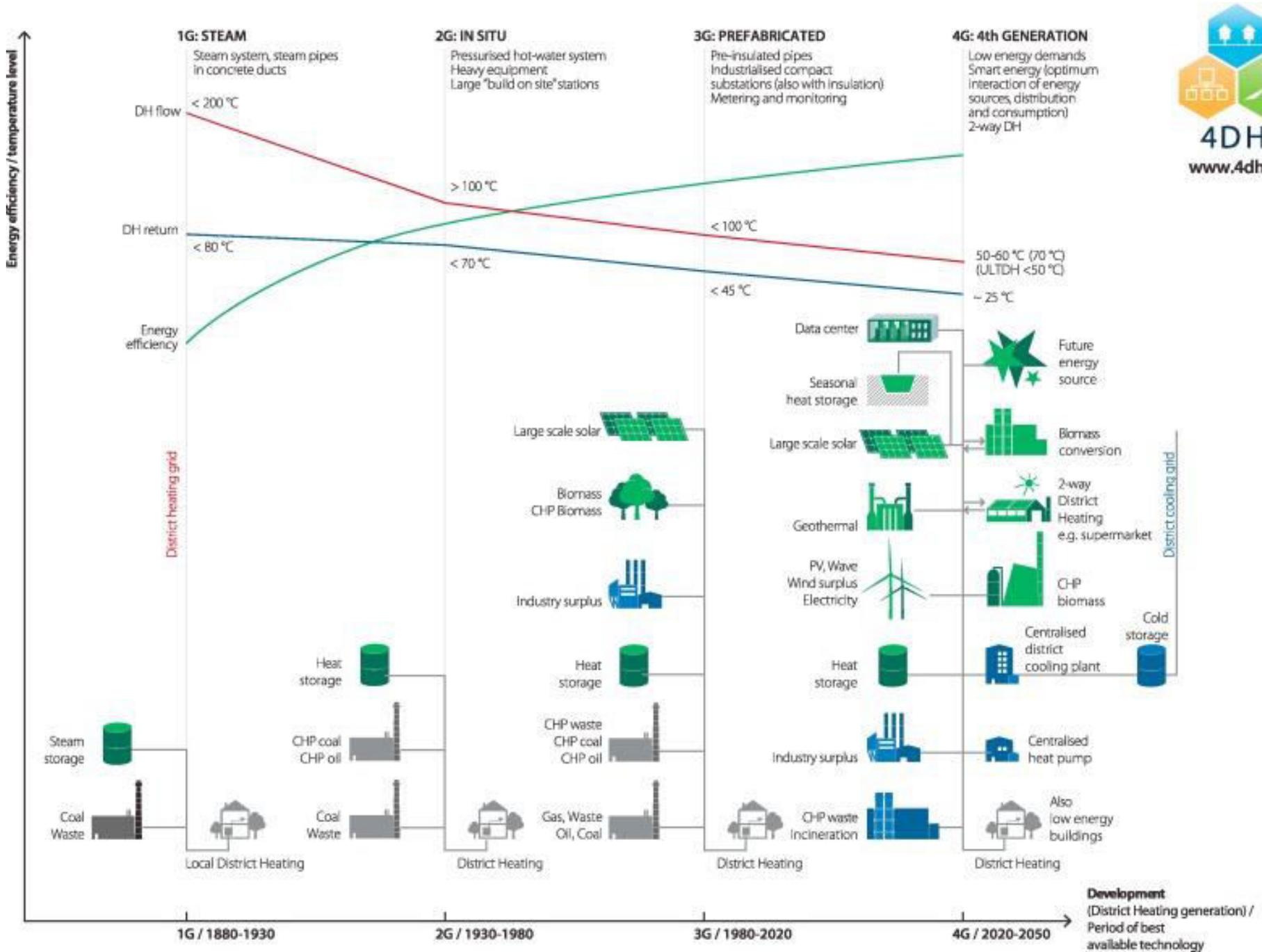
- Interconnection of Novi Beograd (NB) and Zemun (ZE) networks; shutting down HP Zemun
- Interconnection of Novi Beograd, Dunav and Konjarnik networks (plans for networks expansion are taken into consideration, integration of over 80 MW_{th} of new consumers)
- Interconnection of Novi Beograd, Dunav and Konjarnik is closely connected to project of construction of heat pipeline TPP “Nikola Tesla A” (TENT-A) - HP Novi Beograd
- Positive effects to security of supply, economy of operation, local environment
- Prefeasibility study on interconnection within the District Heating System of the City of Belgrade

Systematic replacement of heat pipelines

- “Program for rehabilitation of distribution system of PUC Beogradske elektrane” covers the period from 2017 to 2021
- Replacement of at least 30 km of pipeline route per year
- Selected priority sectors are Cerak and Novi Beograd
- 10-12 million euro per year; In accordance with the signed Contract, the City of Belgrade should use funds from the network usage fee for maintenance and investments
- The goal is to reduce energy losses by 20% by 2025 in comparison to 2015

Long term action plan of infrastructural development for 2030-2040 period

- Transformation to 4th generation district heating system



Lund et al. The status of 4th generation district heating: Research and results, Energy, 164, 2018, 147-159.

Long term action plan of infrastructural development for 2030-2040 period

- Improvement of consumers characteristics - reduction of specific heat load
- Utilization of solar energy
- Utilization of geothermal energy
- Utilization of treated water from wastewater treatment facilities
- Expanding of network and building of new heat sources

Utilization of solar energy



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- Annual solar radiation amounts 1300 kWh/m²
- Low average return temperature (which is in the range of 43 to 45°C, depending on the heating area) and low outflow temperature (which practically does not exceed 95°C) indicate the possibility for integration of solar thermal systems.
- Initial locations: Cerak, Batajnica and Novi Beograd.
- Identification of appropriate locations and evaluation of land availability for solar thermal collectors, with the respect to the vicinity of the network; Feasibility study and optimization of the size of facilities



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Utilization of geothermal energy

- The estimated total energy potential of underground waters at Belgrade urban core is 1.200 MW. The accumulated heat power at less-populated surrounding territories is around 1.100 MW. The total available power at the Belgrade metropolitan area is estimated to 2.300 MW.
- The temperature of the underground waters in depths up to 300 m does not exceed 30°C.
- Defined potential hydro-geothermal energy areas are, as follows: Novi Beograd, left bank of Danube, Zemun and Bežanijska kosa, central areas of Belgrade hillside (from Kalemegdan and across Tasmajdan and Slavija to Dedinje), Vinča, Leštane i Boleč.
- The risks and capital costs are concentrated in the early phases of geothermal heating projects realization. Therefore, the availability and the quality of geothermal energy sources can be proved only after finishing of initial drilling.

Heat pumps with treated water from wastewater treatment facilities as heat source

- The available potential of this energy source is about 380 kWh per capita per year (by using heat pumps for baseload)
- The development strategy of PUC "Beogradski vodovod i kanalizacija" envisaged 14 wastewater treatment facilities in Belgrade metropolitan area, which are all potential and accessible sources of continual heat during the entire year, which would enable an efficient operation of heat pumps.
- Selection of appropriate locations for heat pumps (vicinity and density of consumption); Feasibility study

About RES utilization

- Feasibility of renewable energy sources for heat production can be achieved if facilities operate continuously, during the whole heating season and cover baseload
- The more favorable case is to use those facilities to produce sanitary hot water. This means their operation during the whole year.
- Therefore, projects for RES utilization should be considered, not separately, but together with all other planned projects.

Introduction of district cooling

- The size and concentration of consumption
- Using locally available energy sources (waste heat from industry or other processes, cold water from rivers and aquifers, etc.) that otherwise would not be used
- The new product at the energy market and highly efficient alternative to traditional solutions based on split systems.
- Envisioned building of new settlements at Ada Huja and Makiš, areas appropriate for heat pump applications opens an opportunity for consideration of district cooling in the early stages of design

Expanding of network and construction of new heat sources

- Ada Huja, population 40.000, 2 million m²
 - M3 TO Dunav
 - HP Ada Huja i CHP
- Makiško polje, population 31.000, 4 million m²
 - Optimal for development of low temperature, centralized system for heat distribution, based on RES use
- SHW supply



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Thank you!

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SOLAR THERMAL POTENTIAL IN THE DISTRICT HEATING SYSTEM OF BELGRADE CITY

Dr. ROMANAS SAVICKAS



DISTRICT ENERGY IN CITIES

A GLOBAL INITIATIVE TO UNLOCK THE POTENTIAL OF ENERGY EFFICIENCY AND RENEWABLE ENERGY





STRUCTURE (%) OF RENEWABLE ENERGY POTENTIAL IN SERBIA

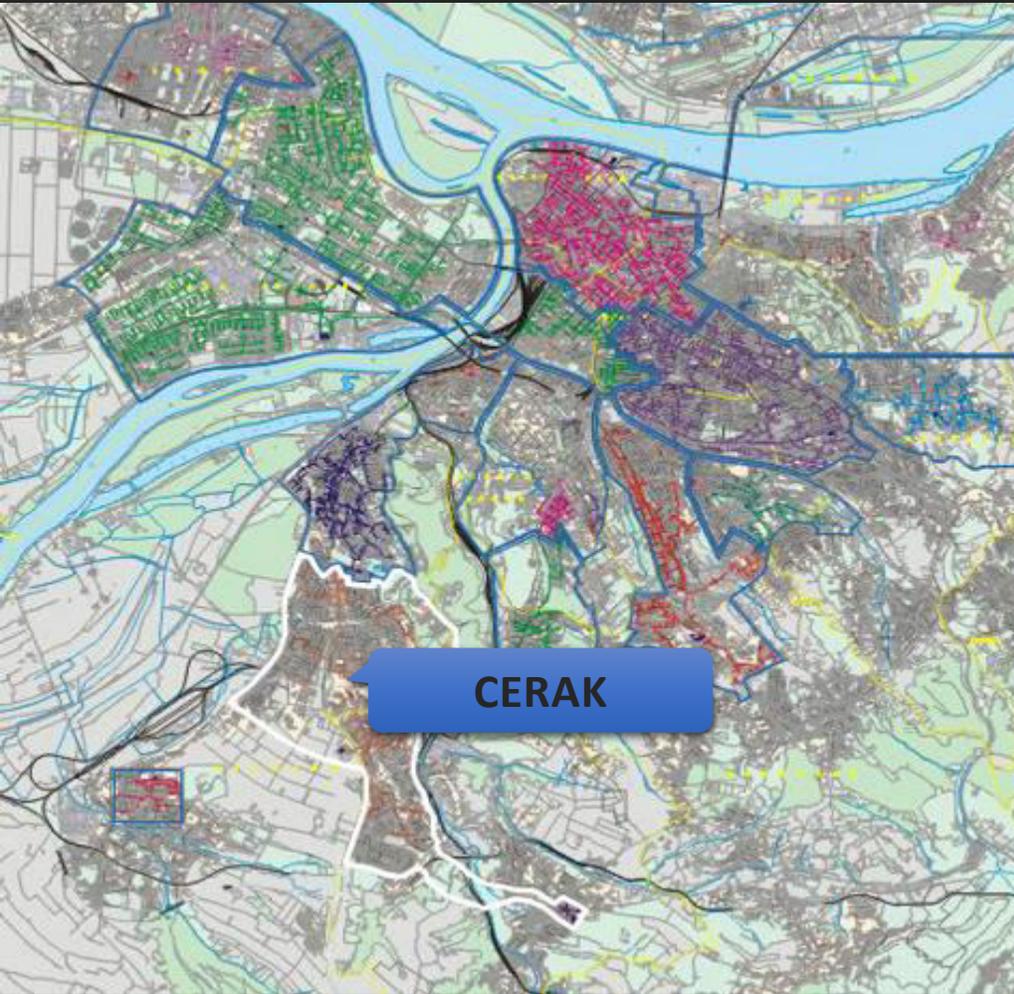
Type of RES	Potential
Biomass	63%
Solar	14%
Wind	4.5%
Geothermal	4.5%
Hydro	14%





ASSESSMENT OF SOLAR THERMAL IN CERAK, BELGRADE

- **Cerak** is located in Belgrade's municipality of Čukarica;
- The population of more than **40,000 residents**;





CLIMATE DATA FOR BELGRADE

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C	4.6	7.0	12.4	18.0	23.5	26.2	28.6	28.7	23.9	18.4	11.2	5.8	17.4
Daily mean °C	1.4	3.1	7.6	12.9	18.1	21.0	23.0	22.7	18.0	12.9	7.1	2.7	12.5
Average low °C	-1.1	-0.1	3.7	8.3	13.0	15.8	17.5	17.6	13.5	9.0	4.2	0.2	8.5
Average snowy days	10	7	4	1	0	0	0	0	0	0	3	8	33
Mean monthly sunshine hours	72.2	101.7	153.2	188.1	242.2	260.9	290.8	274.0	204.3	163.1	97.0	64.5	2,111.9





CERAK POWER PLANT

- **Cerak** power plant has been in operation **since 1985**;
- The **capacity** of **245 MW** (2x58 MW + 116 MW gas water boilers, 2x6.5 MW oil steam boilers);
- Due to a new connections there is a potential to **increase a future capacity**;
- Heat is supplied to **~27,000 apartments** (1,500,000 m²);
- Cerak heat plant has a **site** of about **76,000 m²**;





CERAK POWER PLANT

- **110 km** District Heating **Network** pipeline (Dn700/Dn600);
- Cerak heat plant has a **site** of about **75,900 m²**;





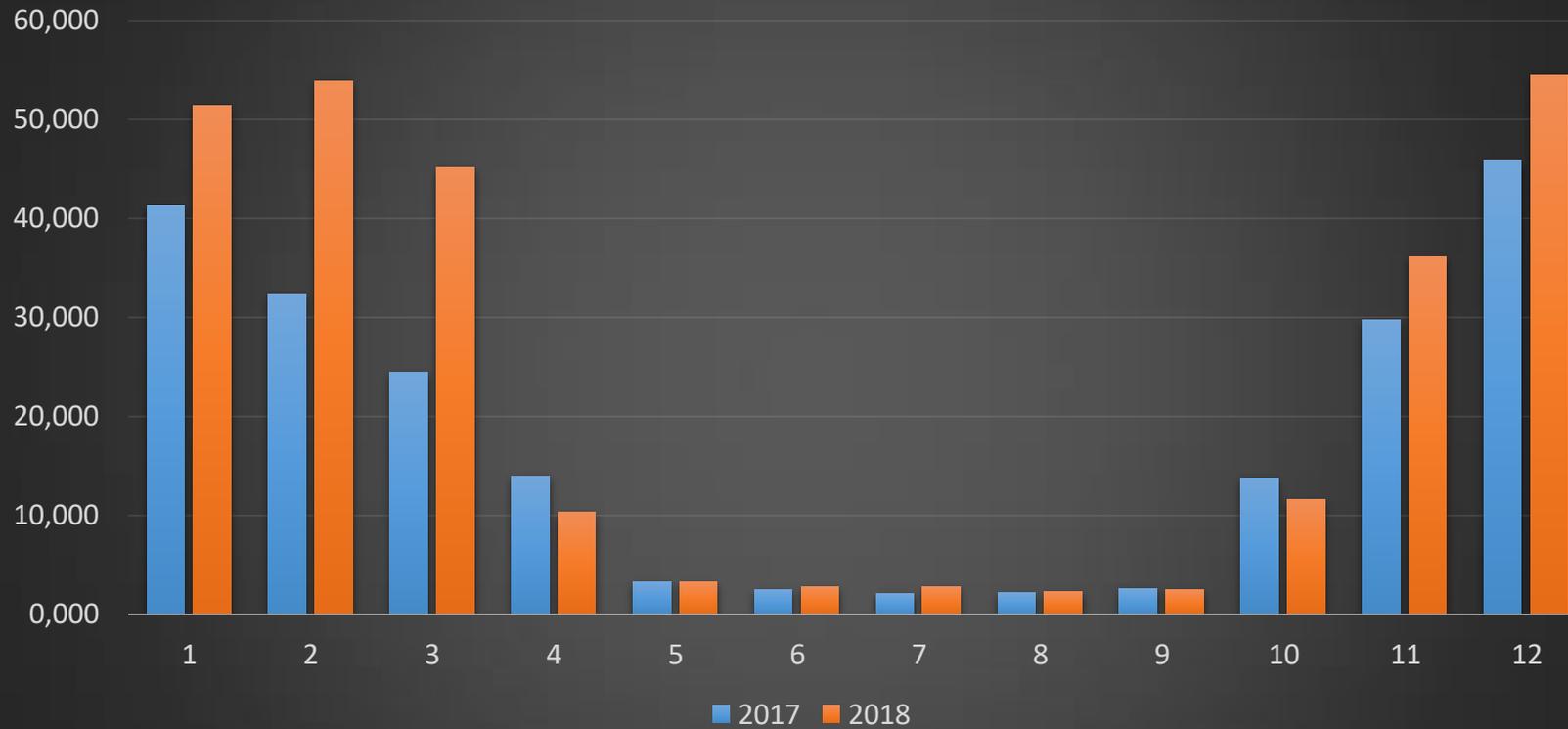
HEAT ENERGY DEMAND IN CERAK

Date	Heat demand, MWh 2017	Heat demand, MWh 2018	Average heat demand, MWh 2017-2018	Share from total heat demand in 2017-2018, %
Jan	41,265	51,327	46,296	19.0
Feb	32,281	53,845	43,063	17.6
Mar	24,380	45,078	34,729	14.2
Apr	13,865	10,213	12,039	4.9
May	3,188	3,116	3,152	1.3
Jun	2,369	2,630	2,499	1.0
Jul	1,992	2,659	2,325	1.0
Aug	2,042	2,147	2,094	0.9
Sep	2,488	2,337	2,412	1.0
Oct	13,663	11,470	12,566	5.1
Nov	29,620	36,018	32,819	13.4
Dec	45,724	54,437	50,080	20.5
Total	212,877	275,283	244,080	100.0





HEAT ENERGY DEMAND IN CERAK

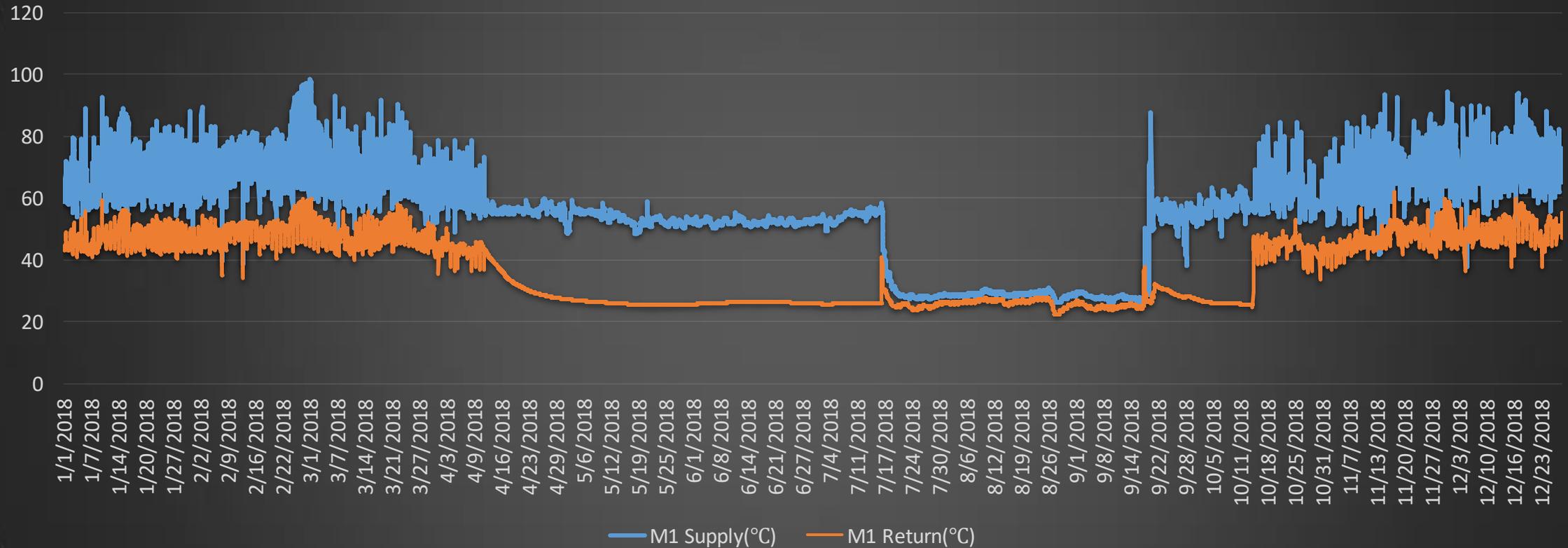




SOLAR THERMAL POTENTIAL IN BELGRADE DISTRICT HEATING SYSTEMS



DISTRICT HEATING NETWORK SUPPLY AND RETURN TEMPERATURES IN CERAK





HEAT DEMAND AND SOLAR HEAT PRODUCTION PER SOLAR THERMAL COLLECTOR AREA

Date	Heat demand 2018, MWh	Heat product, KWh/m2	Heat product, MWh			
			10,000 m2	31,800 m2	35,000 m2	39,700 m2
Jan	51'327	16	163	518	570	647
Feb	53'846	31	312	992	1'092	1'239
Mar	45'079	45	447	1'420	1'563	1'773
Apr	10'214	51	506	1'609	1'771	2'008
May	3'117	72	719	2'286	2'516	2'853
Jun	2'631	79	786	2'500	2'752	3'121
Jul	2'659	81	805	2'559	2'816	3'194
Aug	2'148	78	780	2'481	2'731	3'098
Sep	2'338	57	574	1'825	2'009	2'279
Oct	11'470	41	411	1'308	1'439	1'633
Nov	36'019	23	229	728	802	909
Dec	54'438	16	155	492	542	614
Total	275'283	589	5'886	18'718	20'602	23'368

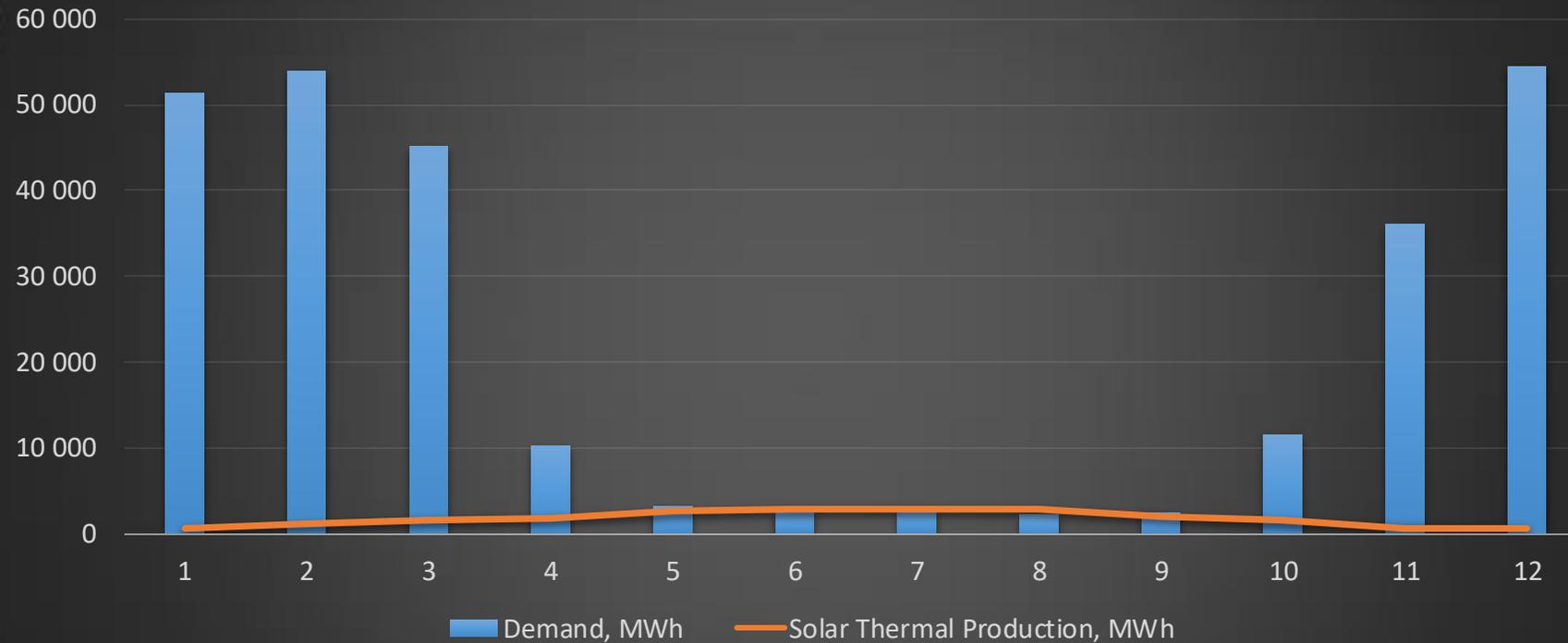




SOLAR THERMAL POTENTIAL IN BELGRADE DISTRICT HEATING SYSTEMS



HEAT DEMAND AND SOLAR HEAT PRODUCTION PER SOLAR THERMAL 35.000 m² COLLECTOR AREA





SOLAR THERMAL PANELS INSTALLATION

- The required **site area** for installation of **10,000 m²** of solar thermal collector panels is about **18,000 m²**,
- The solar thermal collector area of **35,000 m²** requires about **62,000 m²** of site area.

Total solar collector area	10,000 m ²	35,000 m ²
Solar collector length	5.97 m	5.97 m
Row distance	4 m	4 m
Ground area	23.88 m ²	23.88 m ²
Required land area	18,000 m ²	62,000 m ²





LAND AVAILABILITY IN CERAK POWER PLANT

- The **site area** of the **Cerak** heat plant is about **82,000 m²**;
- The area of the **main facilities** including boilers, oil tanks and management/control building is about **44,000 m²**;
- The remaining site area can be estimated to be about **38,000 m²**.
- This area is enough for **10,000 m²** of solar thermal collector panels installation (land of **18,000 m²**), but for **35,000 m²** solar collectors area (land of **62,000 m²**) requires additional area outside power plant.





FINANCIAL ANALYSIS OF SOLAR THERMAL INSTALLATION IN CERAK POWER PLANT

- For the installation of the **10,000 m²** solar thermal collectors is necessary **2,5 mln. Eur CAPEX**. (without thermal storage, land and transmission line).
- **OPEX** makes **14,500 Eur** per year;
- **IRR** makes **8,5 %**;
- **Payback 10 years** (3% interest).





Thank You

Dr. Romanas Savickas

