European Bank
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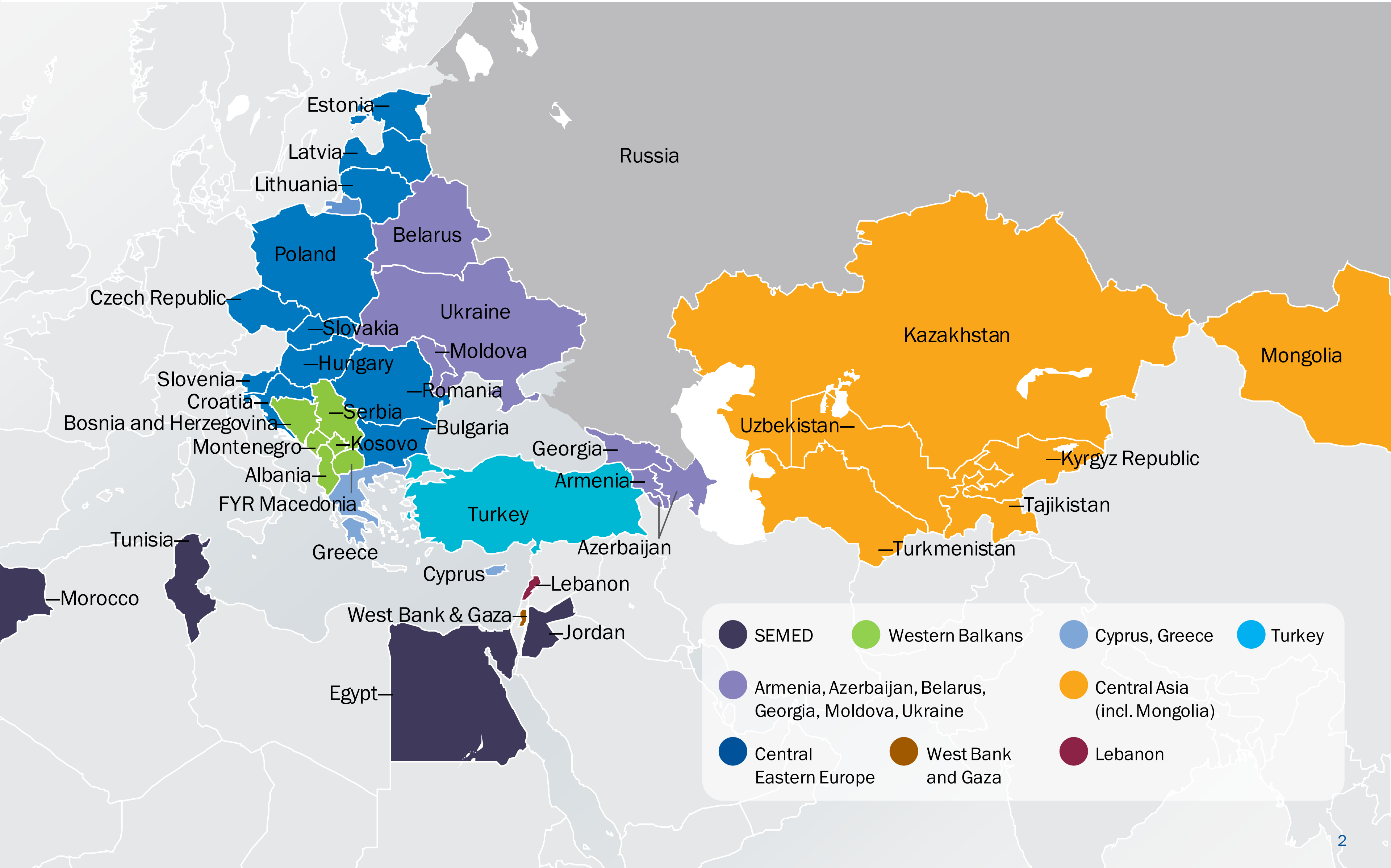
From Jordan to Mongolia – EBRD District Energy Experience

Renewable energy in DE systems

December 2019

Where we invest
Increasing footprint



Objectives for the Sector

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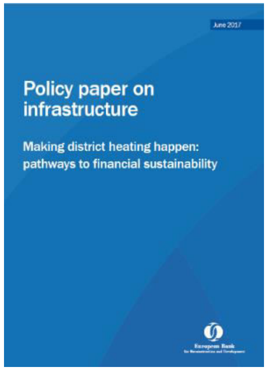
- Increase energy efficiency and reduce environmental impacts
- Improved service levels
- Increased commercialisation, consumer control and consumption based billing

EBRD provides financing and works with operators and policymakers to improve the operational, environmental and financial performance of the DE sector.



Ulaanbaatar District Heating Project

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Ulaanbaatar District Heating Project

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Challenges

- Coldest capital city in the world - as low as -40° C
- ~1.5 million residents
- Rapid urbanisation
- Large informal housing districts without utilities - “ger” areas
- Ger residents heat and cook by burning coal, wood or waste in stoves and simple boilers
- Extreme levels of air pollution in winter
- Urgent need for additional DH transmission capacity

District heating is a lifeline for the city

Ulaanbaatar District Heating Project

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DH in Ulaanbaatar

- Peak heating load of ~1960 Gcal/h (~2280 MWth)
- ~700,000 residents are supplied with DH
- Crucial for life in the city
- DH displaces inefficient, polluting local boilers

The Project and next steps

- US$ 15 million programme for extension and enhancement of transmission networks
- US$ 12 million programme focused on distribution and demand side
- CO2 reduction of ~190,000 tonnes per year
- Future-proof solution which allows for introduction of lower carbon sources

Abdali District Heating & Cooling

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Major commercial, leisure and residential redevelopment in Central Amman based on green building technologies

Challenge

- Scare water availability for a large cooling plant
- Electrical supply constraints in a growing city

Cooling Capacity	31,000 TR (110 MW)
Chilled Water Supply Temperature	4.4 ºC
Thermal Energy Storage Tank	80,000 m^3
Heating Capacity	101 MW

Abdali Plant Overview

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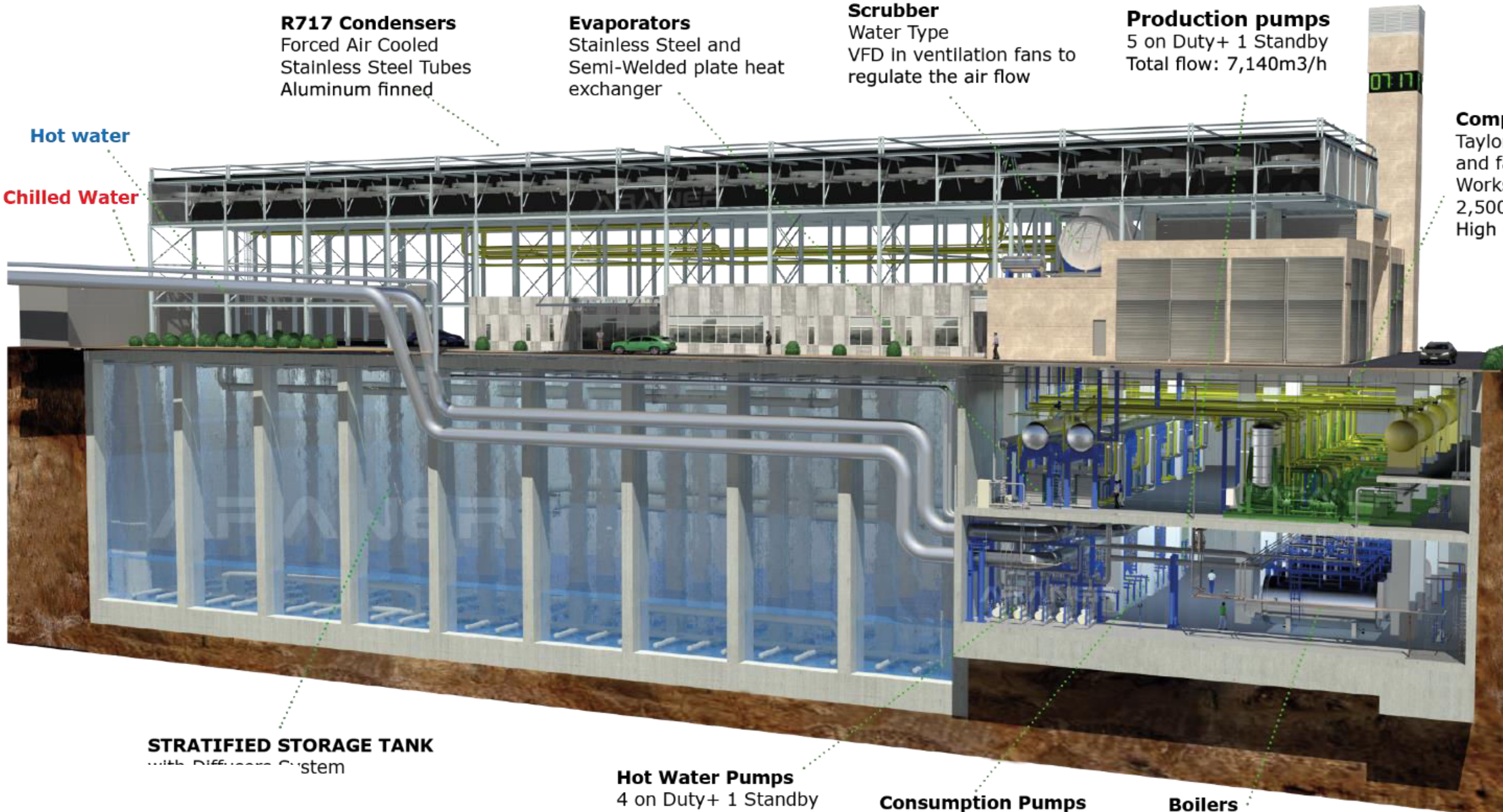

Project Details

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EBRD financing

- Loan of ~EUR 27 million (EUR 42 million EPC contract)

Project Benefits

- CO_2 savings of ~15,000 tonnes per year
- ~40% energy savings
- Significantly reduced peak electrical demand
- Minimal water consumption
- Natural refrigerant (Ammonia)
- Lower cost heating and cooling

Banja Luka District Heating

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EBRD Finance	€ 8.35 million
GHG Reduced	45,750 tonnes of CO_2 eq / yr

Supporting the City of Banja Luka for the purchase of an equity stake in a new district heating Company 'Eko Toplane'.

- New 49 MW biomass boiler plant replacing heavy fuel oil based capacity
- Green City Action Plan preparation
- City adopted a new tariff structure

Drone Based Thermal Imaging

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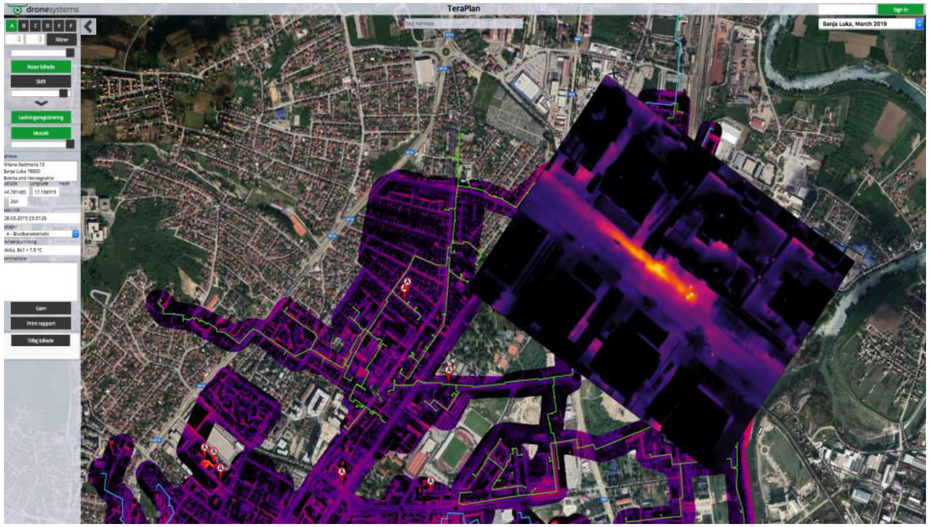
- 2nd project under development focused on network modernisation and smart control
- EBRD and Eko Toplane launched a drone based thermal survey
- Flew drones fitted with high-res infrared cameras over the DH network
- Data is mapped on an interactive web-based platform
- Plan the project network investments and optimise current operation



Questions

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

Prof. Dejan Ivezic

Conference
Renewable energy sources
in district heating and cooling systems

50. MEĐUNARODNI KONGRES I IZLOŽBA O KGH
50th INTERNATIONAL HVAC&R CONGRESS AND EXHIBITION
Belgrade, Sava Center
December 4–6, 2019

References

- 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.

Content

1. Development strategy of the Belgrade district heating system
2. Short term action plan of infrastructural development until 2030
3. Long term action plan of infrastructural development for 2030-2040 period
4. Summary tables

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 CO_2 emission for approximately 500.000 t and reduction of emissions of particles, SOx, NOx and other pollutants.

Construction of CHP facilities

- CHP in HP Voždovac, 10 $MW_{el.}$ 10 MW_{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

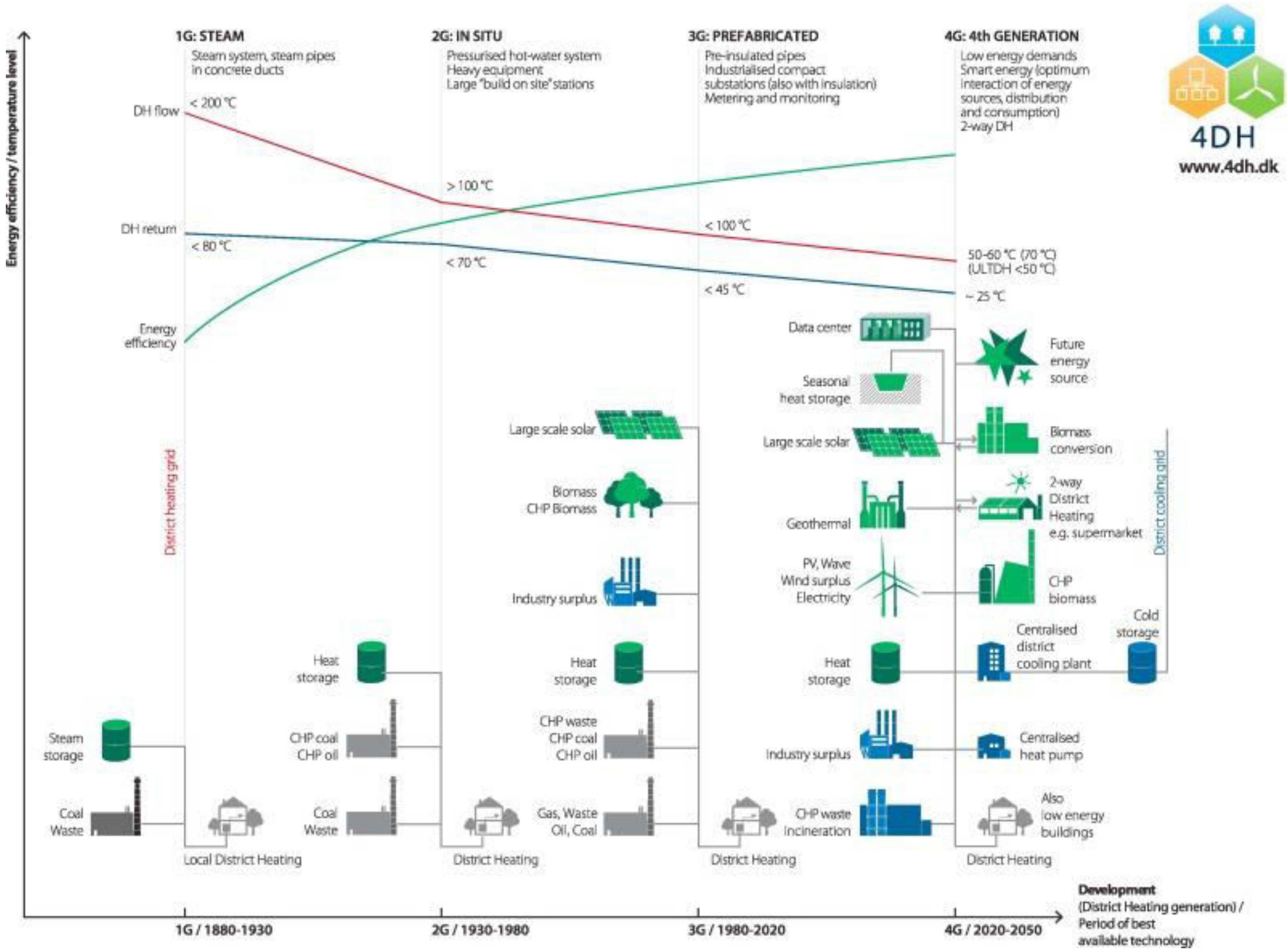
- Interconnection of Novi Beograd (NB) and Zemun (ZE) networks; shutting down HP Zemun
- Interconnection of Novi Beograd, Dunav and Konjarnik networks (plans for networks expansion are taken into consideration, integration of over 80 MW_{th} of new consumers)
- Interconnection of Novi Beograd, Dunav 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 all. 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

- Annual solar radiation amounts 1300 kWh/m^2
- 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

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

Thank you!

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Renewable Energy Sources in District Heating and Cooling Systems

50th International HVAC&R congress and exhibition

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

UN environment

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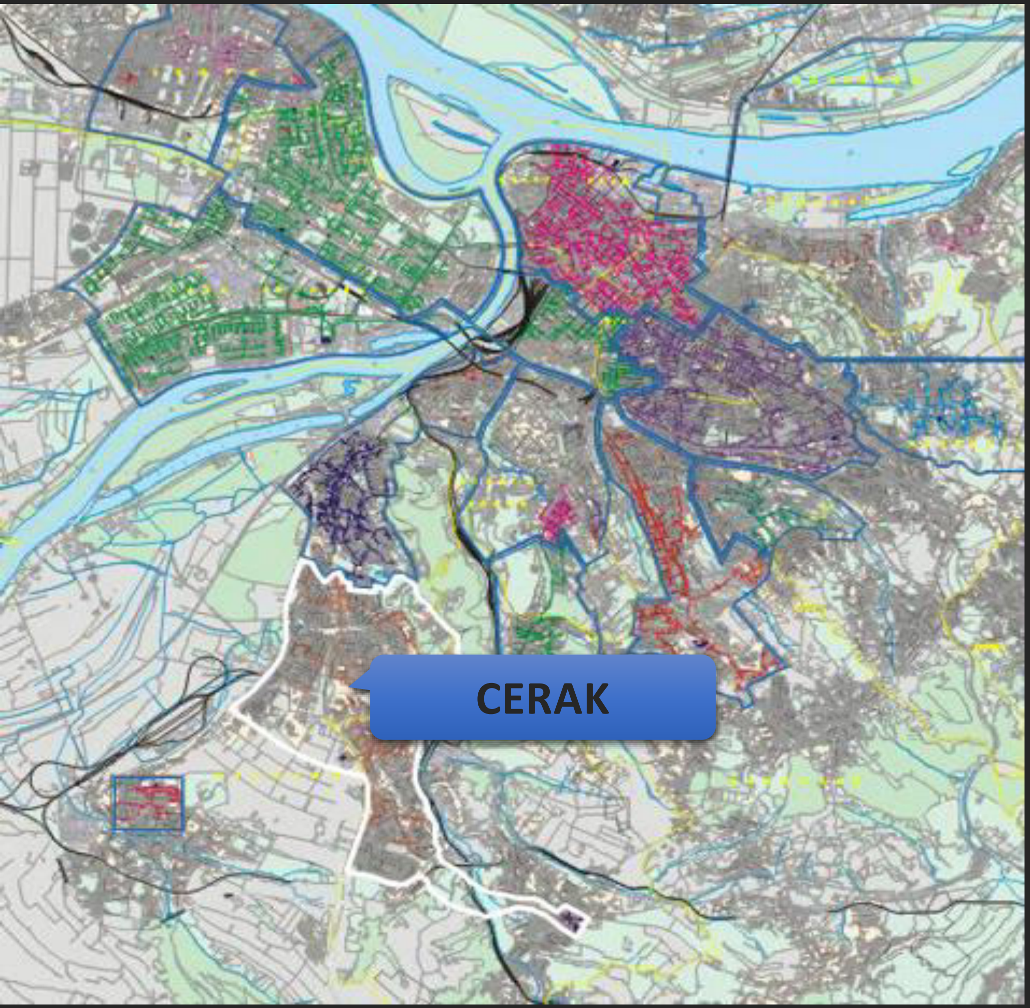
STRUCTURE (%) OF RENEWABLE ENERGY POTENTIAL IN SERBIA

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**;

SOLAR THERMAL POTENTIAL IN BELGRADE DISTRICT HEATING SYSTEMS

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

SOLAR THERMAL POTENTIAL IN BELGRADE DISTRICT HEATING SYSTEMS

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 m^2);
- Cerak heat plant has a **site** of about **76,000 m^2**;

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SOLAR THERMAL POTENTIAL IN BELGRADE DISTRICT HEATING SYSTEMS

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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**

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SOLAR THERMAL POTENTIAL IN BELGRADE DISTRICT HEATING SYSTEMS

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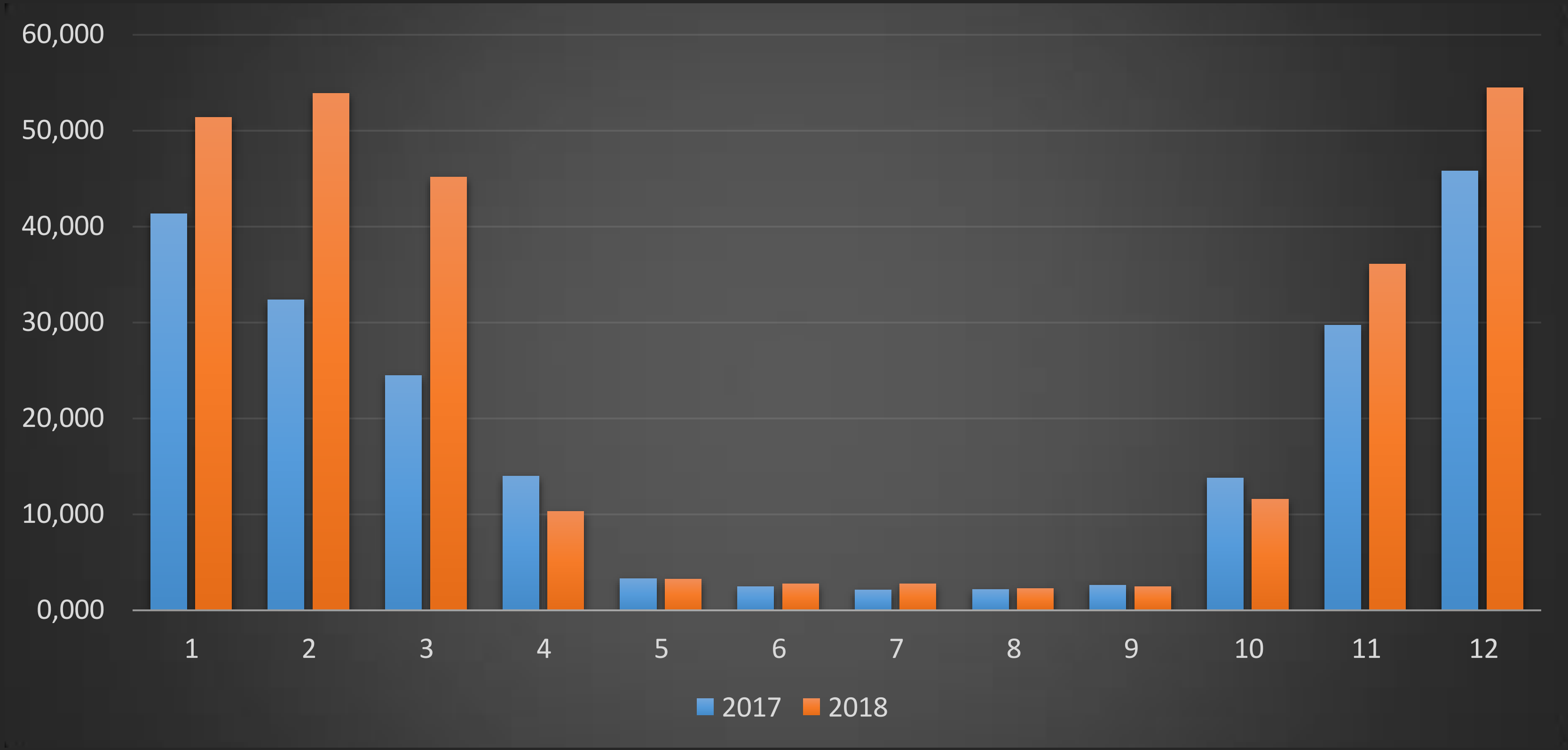
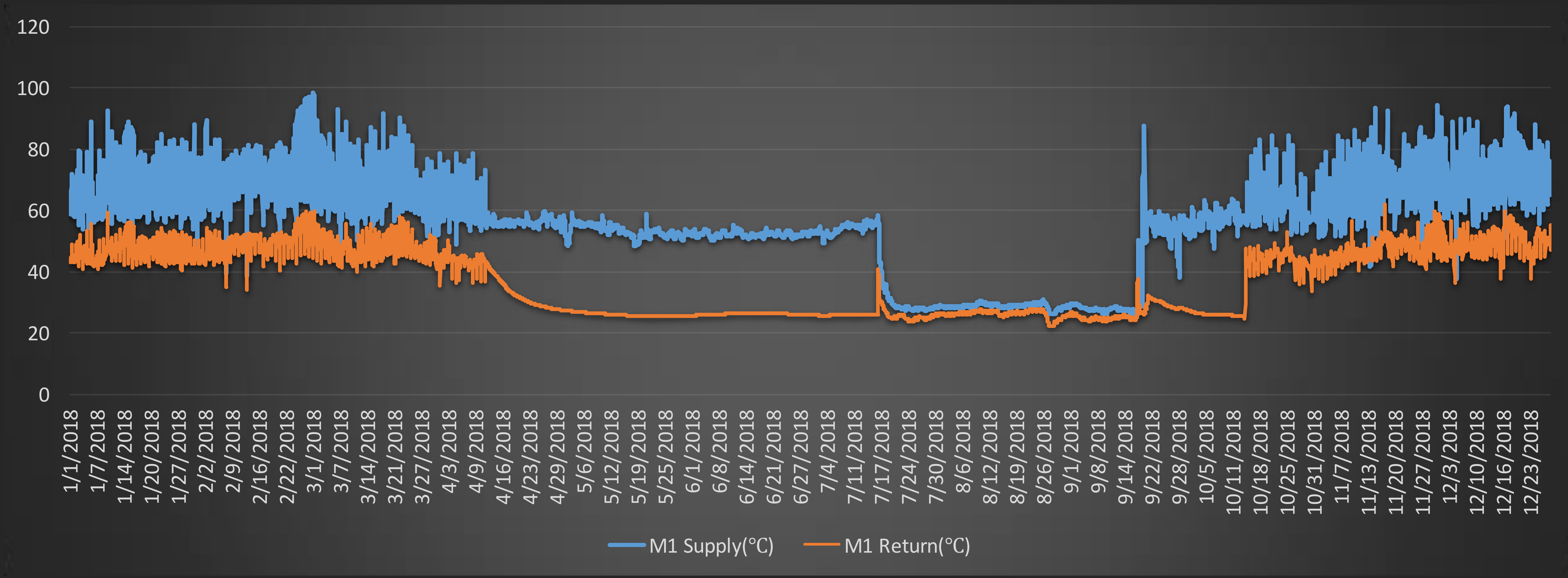
HEAT ENERGY DEMAND IN CERAK



SOLAR THERMAL POTENTIAL IN BELGRADE DISTRICT HEATING SYSTEMS

DISTRICT HEATING NETWORK SUPPLY AND RETURN TEMPERATURES IN CERAK

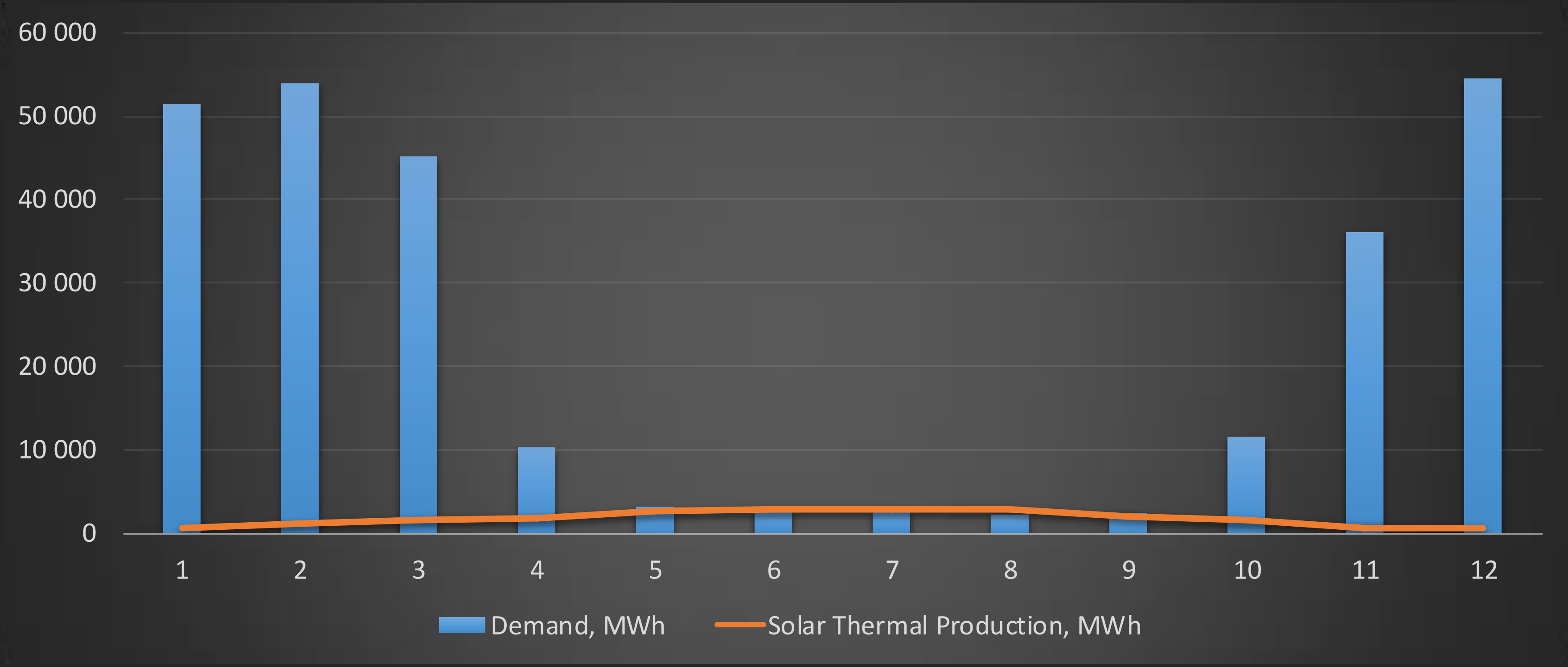


HEAT DEMAND AND SOLAR HEAT PRODUCTION PER SOLAR THERMAL COLLECTOR AREA

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 m²**	**35,000 m²**
Solar collector length	5.97 m	5.97 m
Row distance	4 m	4 m
Ground area	23.88 m²	23.88 m²
Required land area	18,000 m²	62,000 m²

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 m^2** 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).

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SOLAR THERMAL POTENTIAL IN BELGRADE DISTRICT HEATING SYSTEMS

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Thank You

Dr. Romanas Savickas

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