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# SMART SOLUTIONS AND OPPORTUNITIES FOR DISTRICT HEATING: THE CASE OF BUDAPEST

**András Horkai[1,] *, Balázs Némethi[2] and Attila Talamon[1]**

[1]Szent István University, Ybl Miklós Faculty of Architecture and Civil Engineering
Budapest, Hungary

[2]FŐTÁV Budapest District Heating Works Private Co. Ltd.
Budapest, Hungary

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## ABSTRACT

The smart city, as a phenomenon, primarily focuses on citizens, city services, decision making mechanisms and information technology solutions, with various criteria such as sustainable development, economic efficiency and broad participation. One of its subsystems is the Smart Environment, which among others, aims for decreasing energy consumption and increasing energy efficiency of the built environment: to make energy processes more sustainable (renewable energies, water management), and circular processes utilizing resources.

District heating is one of the most environmentally friendly and modern method of heat supply (with concentrated emission and efficient power supply of renewable energies), which is present in the heat market of Budapest with a share of about 30 %. District heating supplier of the capital city (FŐTÁV) provides to nearly quarter million dwellings.

Present article focuses on the district heat supply in Budapest, the use of resources and renewable energies and demonstrates the investments of the high-efficiency cogeneration facilities according to the EU directive on the heat producer's side. The article also presents public energy saving tenders in district heating in the capital so far: I LOVE PANEL and OKOS-HÁZAK project.

## KEYWORDS

Budapest, district heating, energy saving, smart environment

## CLASSIFICATION

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*Corresponding author, $\eta$: horkai.andras.laszlo@ybl.szie.hu; +36 30 490 3878;
Budapest, Thököly út 74., H-1146, Hungary

## INTRODUCTION

In Hungary, 60 % of the energy consumption of buildings is provided by residential buildings; 35 % provided by public buildings, service and commercial buildings; industry and agriculture are present in low shares (about 5 %) [1].

In 2016, Hungary contained 649 129 dwellings [2], which have been practically unchanged for many years. District heating units account for 14,68 % of the domestic housing stock, representing a considerable proportion [3].

In Hungary, the goals of the National Building Energy Strategy [1] include: increasing energy efficiency and renewable energy utilization in district heating: investment not only for building renewals, but also for energy efficiency interventions, for example: measurement accounting, modernization of substations, renewable energy applications. These activities result in additional energy savings beyond the effects of building renovations, and the strategy plays a key role in consumer awareness, consulting and information exchange [1].

In this article, the authors introduce and analyse the smart solutions and development opportunities that have been realized and planned for the district heating supply from the producer's side and with the involvement of the household consumers in Budapest.

## SMART CITY AND SUBSYSTEMS

The concept of a smart city focuses on services, information technology solutions and decision-making mechanisms along the lines of sustainability, efficiency and broad-based development priorities. This expression is one of the key phenomena of economic innovation and contemporary urban development, the integration of cities and digital technologies [4, 5].

"A smart city is a settlement or a group of settlements, which develops its natural and built environment, digital infrastructure, and the quality and economic efficiency of its locally available services by adopting novel and innovative information-technologies, in a sustainable way, through the increased involvement of its residents" [6].

The Smart City Ranking and the Smart Cities Council index system specify six subsystems in smart cities to measure the development of cities and the impact of smart city projects: smart governance, smart traffic, smart environment, smart economy, smart living conditions, and smart people [6].

From the point of view of district heating supply and building energy, the two most important subsystems are the smart environment and smart people.

Smart environment covers sustainable environmental resource management (renewable energy, water-, and waste-management), measures to improve the air quality, increasing urban resilience and adaptation to climate change, and the energy-efficient development of the built environment [6].

Smart people covers the strengthening of the knowledge economy and a competitive labour force, programs supporting lifelong learning and innovation in education, measures taken to establish a creative and inclusive society such as participatory planning, co-production and co-design processes [6].

In the relationship between these two subsystems, it is important to increase the energy awareness of the consumers (smart people subsystem) to ensure sustainable management of environmental resources and thus to make our environment more energy-efficient (smart environment subsystem).

# DISTRICT HEATING SUPPLY IN BUDAPEST

District heating is an environmentally friendly, modern heat supply method that represents approximatelly 30 % of the capital heat market (this 30 % is owned by Budapest District Heating Works Private Co. Ltd. (Hungarian: FŐTÁV). Over the past decade, high-efficiency cogeneration facilities have been built on the producer's side in accordance with EU directives.

FŐTÁV operates nine separate, hydraulically independent (unconnected) district heating zones and four block-heating [7]. The connection of the systems has been partially completed and partly planned. The relative heat loss of heat transfer and distribution systems – partly due to continuous upgrades – is approx. 10-11 %, which is 1-2 percentage points below the European average. Most of the substations supply a building or section, and accordingly their metering and control functions are connected to the provided area. The least effective points of the district heating system are the insufficient heat insulated buildings with high energy consumption and the outdated secondary systems owned by the consumers. Due to their market-retention and market expansion goals, the district heating provider also plays a role in modernizing them [7].

# SMART SOLUTIONS FROM THE PRODUCER'S SIDE

## NORTH-PEST HEAT COOPERATION AND ENERGETIC USE OF HOUSEHOLDS WASTE

The amount of heat generated by the energy utilization of household waste (0.5 PJ per year) reaches half of the district heating energy demand of Hungarian rural cities (e.g. Nyíregyháza, Székesfehérvár). However, which share now rising to 5% is still rather low, especially with the 3,2-3,3 PJ energy content of the fired household waste generated in the Budapest Waste Recovery Works (HuHa) and considering the energy efficiency of the facility, which is limited to 30 % [7].

The Budapest Waste Recovery Works is the only household waste-fired power plant in Hungary. Its task is to thermally dispose of about 60 % of household solid waste generated in Budapest. In 1976 a decision was made to set up a waste incinerator for a long-term solution of waste disposal with a capacity of 350 000 tons per year [8].

In the case of a major investment in energy utilization of household wastes, reducing natural gas dependence, increasing cost efficiency, increasing security of supply and optimizing the transport of heat and environmental sustainability, FŐTÁV has implemented a district heating connection between two major districts of the capital (North- Pest and Újpalota), thus enabling HuHa's annual capacity increase in heat production to be significantly increased and subsequently even doubled [7].

Because of the modernization, heat energy from the incineration of waste is used to heat water, so annual $CO_2$ emissions will be reduced by nearly 20 000 tonnes [9].

Networks and remote monitoring has a great added value in the operation of the system. FŐTÁV builds models for the simulation system from the performance data gathered in the monitoring system, which will support the enable of the planning of the co-operation.

Future plan is the construction of the (II.) Sewage Sludge and Waste Utilization Works and its connection to the district heating system of Budapest, which is suitable for the utilization of sewage sludge in household waste.

### COMPLETE BUDAPEST HEAT COOPERATION AND ENERGETIC USE OF SEWAGE AND HOUSEHOLDS WASTE

Considering the expected savings, the investment cost and the expected heat turnover, the development of the comprehensive heating co-operation system in Budapest is a more significant development than the North-Western heat cooperation. Within the framework of the project, FŐTÁV intends to gradually develop the strategic connecting pipeline system in the capital. The resulting system will provide a high-utilized base load for the low-cost heat capacities of the heat producers currently operating or will be established in the future in the region (e.g. the new Sewage Sludge and Waste Utilization Works) [7].

The development would involve the joint utilization of household waste and sewage sludge, which would result in approximately 45-50 MW of waste-based combined heat and power generation capacities. Building a strategic pipeline and connecting the currently isolated areas is the criteria of the economical usage of this low-cost, 50 % renewable heat [10].

The creation of this system – like the North-Western heat cooperation and HuHa – reduces fossil energy dependency and contributes to the development of a sustainable environment. Among the goals of the strategic plan, it is important, that the interconnected Budapest system increases the competition of existing and engaging new heat sources, which improves the efficiency of supply. At the same time, the management of a much more complex system will move the operation control to smart network solutions.

### INCLUSION OF FURTHER RENEWALS

In addition to communal waste, renewable energy sources in the district heating supply of the capital can be realistically utilized by combustion of solid biomass (mainly wood chips) and use of thermal water (limited in the deeper layers (2 000 m), so it is available for use in the primary district heating systems). Both power sources are included in the district heating contractor's plans for the medium term [7].

## INVOLVEMENT OF HOUSEHOLD CONSUMERS TO REDUCE ENERGY CONSUMPTION

Given that in Hungary, 60 % of the energy consumption of buildings is provided by residential buildings [1], it is particularly important to address household consumers with information on energy saving and energy efficiency, and to encourage them to use less energy and use renewable energies.

The FŐTÁV has developed several plans to reduce household energy consumption and involve consumers in the process. One such application is the 'Okos-Ház' (*Smart-House* in Hungarian) project and another major development is the 'i love panel' project.

### 'OKOS-HÁZ' (SMART HOUSE) PROJECT

The aim of the tender announced for about 50 million Hungarian Forints, HUF (about 175 000 € at that time rate) in 2012 was to encourage consumer energy efficiency and energy saving. Further motives were promoting renewable electricity generation, since renewable heat production on the user side (eg solar collectors) is not a climate-effective solution, since it triggers the high efficiency cogeneration.

The residents of each building with district heating (condominium, housing co-operative) could apply the project, which was in the service area of FŐTÁV Zrt. and had a valid public utility contract with the service provider. Another condition was that only those buildings could be involved in the competition, in which the modernization of the secondary heating

system had already been completed and the installation of the thermostatic radiator valves had been completed in all the flats of the building. The conditions also included that the building's domestic hot water (DHW) circulation system should be fully built (extend to the riser pipes) and the building should have a lighting system in common areas [11].

Nearly fifty residential communities participated, and the four winner houses were partially modernized, with the total cost of the construction completed by FŐTÁV:

- modernization of the building's domestic hot water system: complete pipeline reconstruction, efficient thermal insulation, installation of the circulation system with thermostatic balancing valves,
- the full design of the "smart metering" system for both heating and DHW systems: installing cost-scaling devices in the heating system, incorporating electronically readable water meters and install a permanent read-out system in the building; retrieving the monthly measurement data to the billing system; publishing measurement data for user(s),
- electricity produced on solar panels can be used in the building-level accounting system, or if solar cells generate a yield that exceeds the current energy demand, it is fed back to the distribution system through a metering point transformed into a bi-directional energy measurement.

According to the primary calculations, upgrades can reduce energy consumption by up to 25 %: in the finished Smart Houses the results show, that 26 to 38% reduction in heat consumption, 6 % to 13 % in water consumption and 10 % in energy consumption were reached [12, 13].

### 'I LOVE PANEL' – THE MOST ECONOMICAL BUILDING

The competition announced by FŐTÁV in 2013 aimed also for promoting energy efficiency, energy saving and increasing renewable energy use among district heat users.

From the point of view of savings, heat, water and electricity consumption are of paramount importance, which are a key element of housing costs. The purpose of the 'I love panel project' was to compare the energy saving practices of buildings with these three factors and to find the most economical building built with industrialized technology [14].

Those buildings in Budapest could apply, which had been built with industrialized technologies; were equipped with district heating (both for the heating of buildings and for the heat source of domestic hot water production, with the latter having a fully developed circulation system); the modernization of the secondary (building) heating system had already been completed in the building; had a lighting system in common areas.

The winning buildings earned 1 kW of solar power with its respective inverters and fittings: the aim is to use solar panels to generate approximately 10 % of electricity consumption of the building in year.

The proposals were evaluated based on the above-mentioned three aspects: district heat, water and electricity consumption. Three evaluation features were identified for the comparison: district heat consumption (measured in GJ/m², kWh/m²); water consumption (measured in m³/m², l/m²) and saving of electricity (%).

Of the 13 entries received for the stringent requirements, the professional jury announced three winners: the energy value of the winners can serve as a guideline for other buildings - what are the goals to be pursued.

## CONCLUSIONS

In Budapest, several major developments have been made in recent years regarding district heating (both on the producer side and with involving consumers), with the aim of efficient

energy management and the use of renewable energies, thus increasing overall environmental sustainability. The presented projects fit well into the smart city development strategy and emphasize the involvement of the household consumers and increase the consumer's energy awareness.

Among the presented projects, the 'Okos-Ház' (Smart House) project is an extensive and highly successful program. The success of the project is well exemplified by the fact that one of the winners in the project got a 2 kW solar panel, and then the community planted additional 15 kW at its own expense, multiplying its performance. Also within the framework of this project, the smart metering network, as well as automated cost distributors and scanners were installed and have been working properly, but the system has not encouraged consumers to make any further changes.

Projects show that there is great potential for consumer upgrades and consumer involvement. However, based on experience, consumers have no need to monitor their own consumption and change it. It is important in the future to stimulate consumers' awareness of energy: there are ways to measure energy consumption and track the results if consumers need it.

A development program does not in itself encourage the consumer community, to participate in such an action: any similar investment – with involvement of household consumers – will be successful if, on the one hand, consumers receive substantial financial support and a strong local endeavour. This is also the case with the projects presented: in communities where there was a local incentive force for investment, serious results could be achieved. However, to maintain serious results, it is necessary to reach these consumers.

The situation with the producer's side investments is different, they usually work as planned. System-level thermal co-operation works well in day-to-day operation, problems can be solved, objectives are met. The development points that further system operations are needed in order to increase the utilization of the given heat sources.

It is important for these developments to continue in the future and to increase the energy efficiency of district heating and to change the environmental awareness of communities together, reducing the burden of the built environment.

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