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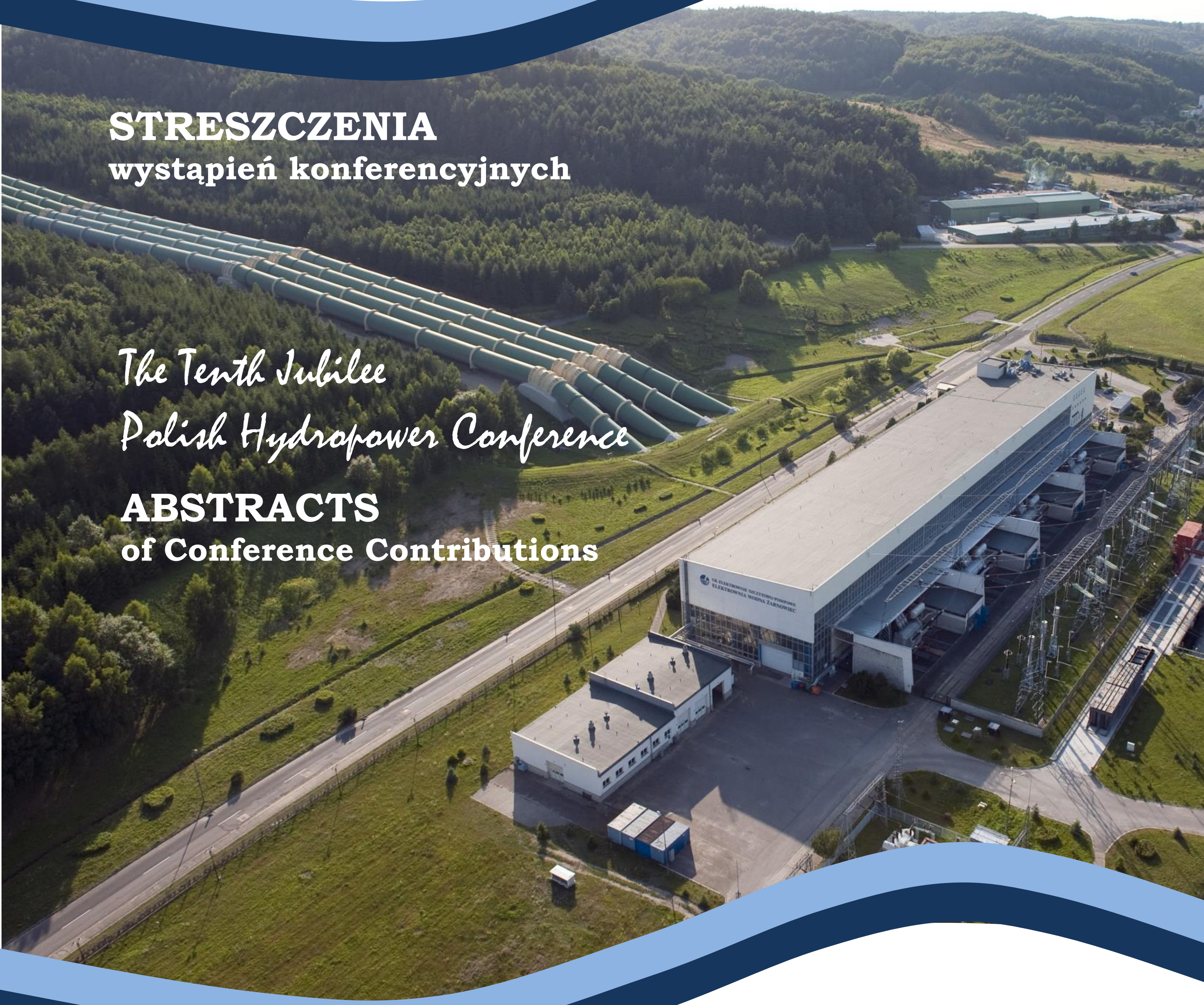

STRESZCZENIA
wystąpień konferencyjnych

The Tenth Jubilee
Polish Hydropower Conference

ABSTRACTS
of Conference Contributions

POLITECHNIKA GDAŃSKA

Towarzystwo Elektrowni Wodnych

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In-conduit hydropower in municipal water networks of lowland areas. A case study in Lithuania

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Introduction

Urban water management is known to be very energy-intensive. Therefore, engineers and researchers worldwide are looking for ways to recover energy residing in water networks supplying drinking water or collecting sewage water and their treatment plants. However, hidden or in-conduit hydro schemes, which lead to energy recovery in existing infrastructures thanks to hydropower installations, are rare cases that may perfectly respect renewable energy and environmental legislation. In this sense, many studies have been conducted worldwide, particularly regarding the energy recovery in municipal water distribution systems [2,3,4], and this area of research is not exhaustive. For example, the EU Horizon Europe Framework Programme has recently launched a call "Development of hydropower equipment for hidden hydropower", dealing with sustainable hydropower production in non-hydropower hydraulic systems with the low head that may also involve prosumer solutions. For example, gravity-fed municipality water networks or excessive pressure installations (e. g., pressure reducing valves -PRV or break pressure tanks - BPT) certainly fall in this area of research.
This study under consideration is meant to answer two main questions:

- Where is the potential stemming from a water infrastructure?
- How (technically) can energy be recovered by a small turbine or an unconventional small hydropower plant?

To answer these questions, the overall objectives must be highlighted:

- Identify potential sites for non-traditional hydropower installations.
- Review the main steps for the development of a pilot project.
- Provide typical recommendations for installing SHP plants into water infrastructure.
- Summarise good practices of these technologies based on cases studies.

Materials and Methodology

The study area is urban water networks with potential macro hydro sites in Lithuania. These potential sites with preliminary key characteristics, including those already under operation, are freely available on the Web-based Atlas of Micro-hydro Inventory in Urban Water Networks [5].

Due to the country's topographic conditions – a pure lowland, flat land, only sewage (wastewater) networks with the free gravitational flow can be attractive for the water energy. As a result, drinking water distribution systems are artificially pressurised and cannot be used for energy recovery. However, a few potential sites with excessive pressure were identified as suitable for installing micro-hydro turbines in these systems.

The municipal water networks of the two largest cities - the capital Vilnius and Kaunas were studied along with a dozen smaller towns. Some 22 potential sites with their main characteristics were identified upstream or downstream wastewater treatment plants (WWTP). The layouts of water networks systems, their engineering drawings, spatial information (GIS data) available with Water companies were analysed. Preliminary power capacities of the potential sites are relatively low - below 100 kW (two of them below 10 kW). A big challenge for these sites was to evaluate available water resources for power generation at individual sites. Data loggers to account for the pattern of available flow during 24 hrs were put into operation. In contrast, the head assessment did not represent any difficulty.

To carry out feasibility studies of the potential sites, two software were tested: RETScreen Expert [6] and "In-Conduit Hydropower Project Screening Tool for Water Supply and Wastewater Treatment Facilities" [1]. The latter could not be used due to imperial units in the software, despite evident applicability to this field. In contrast, the RETScreen computer package is designed for conventional hydro projects but can be easily adapted for in-conduit hydro schemes. The submerged hydro turbines (Kaplan) were proposed for ultra-low head schemes (up to 5m and more). For the larger heads – conventional pump as turbine, a cost-effective solution is to be applicable. The quality of flowing water, especially in sewage systems, was considered in selecting turbines.

This paper presents the interim results of the ongoing EU LIFE NEXUS project performed by the consortium consisting of Spain, Poland and Lithuania. The project explores the potential for micro-hydropower energy recovery along the urban water cycle in selected European cities [5].

Results

Lithuania is lowland, and its large cities are located on the great rivers valleys - the Nemunas and the Neris. Therefore, in the search for suitable sites for hydropower plants, it was found that the most significant potential lies in sewage networks, where sewage collectors descend into deep river valleys.

In water supply networks, the potential location for the installation of SHPs is in pressure-reducing valves (PRV), where they can perform a normal pressure reducing function and generate electricity.

There were two options for installing a hydro turbine in sewage networks: upstream and downstream of the sewage treatment plant. In the first case, a flow of untreated wastewater flows through the turbine, which adversely affects the turbine's operation. The second case, where the turbine is behind WWTP, is much more acceptable because the treated wastewater flows through the turbine, which does not cause the turbine's problems. According to the location of the turbine, the potential sites for the wastewater treatment plant were distributed as follows: 15 sites were upstream of WWTP and 6 downstream of WWTPs,

Six priority sites were selected for which pre-feasibility studies were prepared. Turbines were selected for these sites; the key parameters were determined (Table 1).

Feasibility studies of priority objects have shown that in gravitational sewage networks, it is necessary to assess whether the above pipelines are suitable for installing SHP. In upstream cases, gratings or screens must be installed in front of the SHP to collect large impurities to protect the turbine impeller from mechanical damage. Establishing the hydro turbine in the "by pass" layout in one wastewater collector line is reasonable.

In summary, there are untapped reserves in urban water networks, the development of which can make a significant contribution to renewable energy. We hope that the ongoing project and its publicity will encourage manufacturers to produce turbines as modules adapted for urban water networks. A single element could very easily be installed in a pipeline to extract electricity.

Table1 Characteristics of hydropower plants in urban water networks

Name	Type of operation	Equipment	Installed power, kW	Head, m	Design flow, m^3/s	Diameter, mm
Kaunas (Jonavos str.)	Upstream	Pump as turbine	80.0	35.0	0.3	1000
Kaunas (Raudondvario)	Upstream	Pump as turbine	37.0	27.4	0.18	800
Kaunas (Pypliai)	Downstream	Kaplan	36.6	4.0	1.2	2000
Vilnius (WWTP)	Downstream	Kaplan	32.1	2.85	1.5	2000
Alytus (Baksiai)	Downstream	Pump as turbine	16.5	15.0	0.11	1000
Vilnius (Vingis)	Drinking water network	Pump as turbine	50.4	61.1	0.11	400

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