



# Energy analysis and refurbishment strategy for Zagreb University buildings: Former Faculty of Technology in Zagreb by Alfred Albini



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## ABSTRACT

In the year 2012 the University of Zagreb started the process of energy audits and energy certification of all university buildings with the intent to improve their energy performance. As a property owner, the University of Zagreb encompasses approximately 130 buildings (465,000 m<sup>2</sup>). The first phase of this research project involves the audit of 23 faculty buildings, which make up 30% of all faculty buildings area belonging to the university. One of the largest buildings, audited in the first phase, is the building of the former Faculty of Technology in Zagreb built from 1958 to 1964 and designed by the esteemed 20th century Croatian architect Alfred Albini. This classic work is the last of Albini's accomplishments and is a protected cultural heritage monument. Today the building belongs to the Faculty of Food Technology and Biotechnology and the Faculty of Mining, Geology and Petroleum Engineering. The paper presents results of the energy audit and energy certification of Albini's modern architecture building and determines the energy balance in contemporary usage. The paper also suggests possible energy efficient improvement measures and profitability calculations.

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## 1. Introduction

The Republic of Croatia's Ordinance on Energy Audits of Construction Works and Energy Certification of Buildings<sup>1</sup> prescribes the introduction of energy audits of buildings which are necessary for determining energy performance and management in buildings with energy and water consumption, measures for energy-efficient improvements and their cost-effectiveness, and energy certification of buildings [1]. The ordinance also prescribes energy certification deadlines, which was for public use buildings with a total useable floor area greater than 1000 m<sup>2</sup> scheduled for 31 December 2012. The deadline for buildings with the total use of floor area more than 500 m<sup>2</sup> was set on 31 December 2013, whereas for building exceeding 250 m<sup>2</sup> is 31 December 2015. Energy performance certificates provide information on the energy features of buildings and facilitate comparative analyses of buildings on the basis of their energy features, efficiency of their energy systems and the quality and features of their exterior walls. An energy performance certificate can be obtained only after a detailed energy audit of the building which also includes gathering the information

necessary for energy efficiency evaluation. A building's energy consumption report contains conclusions, a chapter which lists recommendations and the order in which economically justified measures should be adopted in order to improve energy efficiency and energy performance of the building.

## 2. Refurbishment strategy for Zagreb University buildings

Given the legal requirement of the certification process, the University of Zagreb decided to perform energy audits of its faculty buildings. Altogether 32 faculties are housed in more than 130 buildings whose gross floor area amounts to approximately 412,000 m<sup>2</sup>, which, if the buildings housing Rector's offices are included, reaches approximately 465,000 m<sup>2</sup>.

The project of energy audit and certification of the university's buildings has been headed by a coordination team. The assignment of auditing was, however, entrusted to individual teams from the Faculty of Architecture, Faculty of Civil Engineering, Faculty of Electrical Engineering and Computing and the Faculty of Mechanical Engineering and Naval Architecture. The five teams consisted of one expert from each of the mentioned institutions. The first round of energy audits included the buildings of the eight following faculties: Faculty of Architecture, Faculty of Geodesy and Faculty of Civil Engineering which all share the building at 26 Kačićeva Street (gross floor area ~21,300 m<sup>2</sup>), Faculty of Humanities and

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<sup>1</sup> Ordinance on Energy Audits of Construction Works and Energy Certification of Buildings (Official Gazette 81/12, 29/13, 78/13).



**Fig. 1.** Position of the former Faculty of Technology in Zagreb (red dot) and main city square of Ban Josip Jelačić (green dot). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)

Source: Google Maps (<https://maps.google.com/>).

Social Sciences at 3 Lučićeva Street ( $\sim 23,850 \text{ m}^2$ ), Faculty of Food Technology and Biotechnology and Faculty of Mining, Geology and Petroleum Engineering at 4 and 6 Pierottijeva Street ( $\sim 17,150 \text{ m}^2$ ), Faculty of Electrical Engineering and Computing at 3 Unska Street ( $\sim 43,100 \text{ m}^2$ ), Faculty of Mechanical Engineering and Naval Architecture at 1 and 5 Lučićeva Street ( $\sim 30,570 \text{ m}^2$ ). The buildings of all these faculties make up more than 30% of the total floor area of all Zagreb University's buildings.

The buildings audited in the first phase are either located in the protected historical centre of the City of Zagreb or they are protected as individual immovable cultural properties. The first phase of the project of energy audit and certification began at the end of 2012.

### 3. Former Faculty of Technology in Zagreb

The former Faculty of Technology in Zagreb, and the present Faculty of Food Technology and Biotechnology and the Faculty of Mining, Geology and Petroleum Engineering, comprises two buildings: the building at 4 Pierottijeva Street and the building at 6 Pierottijeva Street that was constructed at a later date (Figs. 1 and 2).

The older building at 4 Pierottijeva Street, which used to house the Society of Engineers and Technicians, was built in 1937 (architects M. Haberle and H. Bauer). Its L-shaped plan comprising  $\sim 1138 \text{ m}^2$  gross floor area is divided into a south and north wing. The building has a ground floor, mezzanine and three storeys housing lecture halls and offices of the Faculty of Mining, Geology and

Petroleum Engineering. All the building's architectural parts show the formal features typical for the period in which it was built: reinforced concrete skeleton and brick infill walls, plaster applied to internal and external walls with openings, multi-ribbed reinforced concrete floors and flat roofs. The southern and western gable walls are attached to the subsequently built structure designed by Alfred Albini.<sup>2</sup>

Albini was a prominent protagonist of Croatian modern architecture who moderately and creatively built on the tradition accepting numerous modernist impulses and integrating them in his personal architectural expression. He took special interest in the issues of urban planning and protection of cultural heritage and expressed his views in newspaper articles and theoretical papers [4].

The building at 6 Pierottijeva Street, also a part of the former Faculty of Technology, was built in 1958–1964 according to the design

<sup>2</sup> Alfred Albini was a Croatian architect (Graz, 1896 – Zagreb, 1978). He studied at Vienna's University of Technology (former Technische Hochschule) in 1919, and graduated from the Polytechnic of Zagreb in 1923. From 1923 to 1962, he worked at the Faculty of Architecture in Zagreb, first as teaching assistant to Viktor Kovačić and later as professor. In the period from 1928 to 1964, Albini designed and completed several residential and commercial buildings: the Žerjavić Foundation House (Zagreb, 1928–1930/1932), the building of the Town Savings Bank (Osijek, 1930), Meixner House (Zagreb, 1933), the Arko House (Zagreb, 1940), the Croatian Cultural Centre in Sušak (Rijeka, 1941), the Residential and Commercial Building in Zadar (1954) and the Faculty of Technology in Zagreb (1964). He was the laureate of the City of Zagreb Award (1962), Viktor Kovačić Award for life achievement (1966) and Vladimir Nazor Award (1968) [2,3].

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