

# Evaluation of the Influence of the Primary Energy Factor of Hydropower Plants in the Methodology for Assessing the Energy Performance of Buildings <sup>†</sup>

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**Abstract:** There is currently no common or standardized procedure for certification of the energy performance of buildings, as each EU Member State takes into account the specificities of its own construction sector when implementing the provisions of Directive 2010/31/EU. This usually depends on two features: the purpose of the building and the climate. Therefore, the purpose of this paper is to evaluate the influence of the hydropower primary energy factor on assessing the energy performance of buildings. For this purpose, non-renewable primary energy factor values were analyzed regarding actual energy production and consumption data from 19 Lithuanian hydroelectric plants. The results of the studies show that the average value of the non-renewable primary energy factor of hydropower plants is 0.059.

**Keywords:** primary energy; renewable energy; hydropower; energy efficiency

## 1. Introduction

Recently, the EU construction sector focuses on sustainable energy use and production. The EU has adopted a new climate and energy framework, which includes delivering a minimum of 27% of the share of renewable energy consumption by 2030 [1]. Taking into account the different climate conditions and building traditions in EU countries, Member States commit themselves to developing national targets, increasing the number of buildings of this type, and defining the primary energy demand that is needed for heating, cooling, ventilation and hot water preparation and the usage of renewable energy sources in new buildings.

One of the parameters of renewable energy sources is the primary energy factor [2,3]. The primary energy factor  $f_{p,tot}$  is a sum of renewable energy factor  $f_{p,ren}$  and non-renewable factor  $f_{p,nren}$ . Renewable energy must account for a major proportion of the energy consumed in a building. Accordingly, the renewable primary energy factor  $f_{p,ren}$  is equal to 1 according to EN 15603 167 [2]. Meanwhile, the portion of energy from a non-renewable energy source is not known clearly because the  $f_{p,nren}$  depends on the additional energy consumed in the conversion device, which normally uses additional non-renewable energy, such as electrical energy generated from a common grid [3].

This is a very important part of the evaluation of primary energy from hydropower plants. As an ancient technology, hydropower is being challenged by climate change and other environmental

concerns [4]. Water availability has different temporal and spatial fluctuations in different locations, and water availability fluctuations indirectly and directly affect the different electricity-generating technologies [5].

The analyzed literature did not give sufficient information about the calculation of value of non-renewable factors. Only with sufficiently accurate data on hydropower renewable ( $f_{P,ren}$ ) and non-renewable ( $f_{P,nren}$ ) primary factors can the amount of renewable and non-renewable primary energy consumed in a building be objectively calculated.

Therefore, the aim of this article is to calculate the value of non-renewable factors for hydropower plants in Lithuania.

## 2. Methods

Data for the investigation (for the period 2007–2014) were collected from 19 hydropower plants operating in Lithuania, with the total capacity (107.3 MW) accounting for 79.2% of the total hydropower capacity in Lithuania. The data were collected by interviewing hydropower plants owners/operators and analyzing the reports of electricity transmission system operators in Lithuania. The main characteristics of the investigated hydropower plants was the total installed power capacity, produced electrical energy and consumed electrical energy.

The value of the primary non-renewable energy factor  $f_{P,nren}$  of hydropower plants was calculated using the methodology described in EN 15603 [2], where an energy calculation framework specifying how to define the various energy flows and how to establish the energy boundaries in the building is included.

## 3. Results and Discussion

The calculated values of the  $f_{P,nren}$  factors of the analyzed hydropower plants are presented in Figure 1.

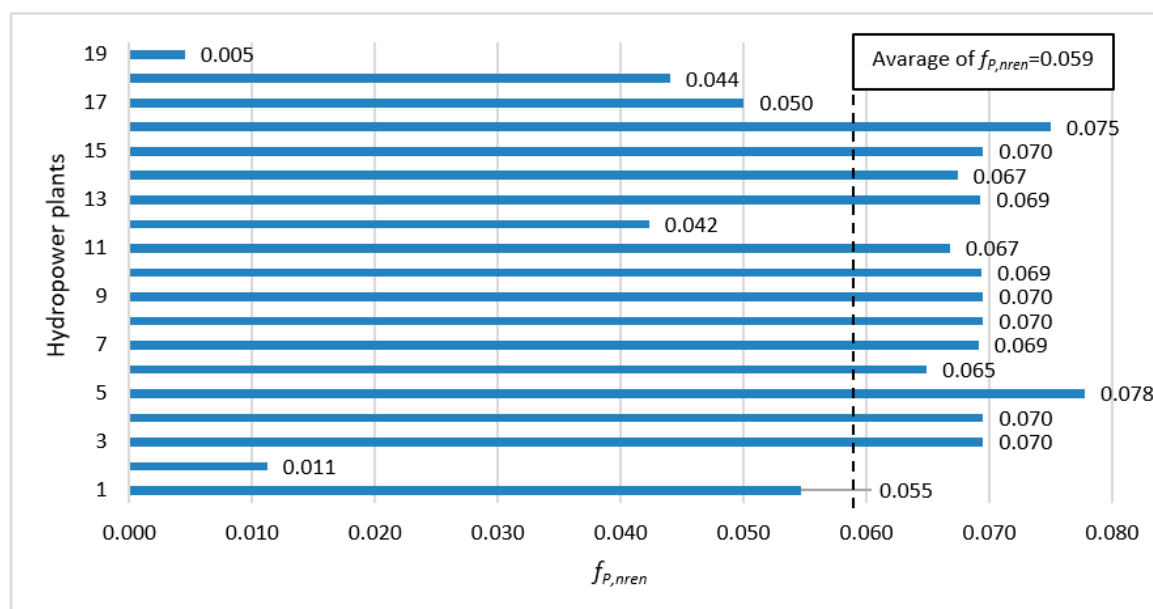


Figure 1. Average annual values of  $f_{P,nren}$  of hydropower plants in Lithuania.

The calculation results show that the average annual range of the value of  $f_{P,nren}$  is 0.073. The lowest value was 0.005 and the highest value was 0.078. The  $f_{P,nren}$  value of hydropower plants operated in Lithuania is 0.059.

Analyzing produced and consumed distribution of electricity quantities by months, it was found that there is a direct relationship between these parameters. The average annual amount of energy used by hydroelectric power plants for own use (for maintenance of a hydropower plant) is up to

1.24% of the total amount of electricity produced. The amount of electricity consumed is not constant, and varies dynamically with the time of year, usually during the warm season less than the cold. Correspondingly, the average can be 1.60% in winter and 1.06% in summer.

The primary energy factor values of the hydropower plants  $f_{p,nerm}$  determined in this work were used to revise the methodology of the assessment of the energy performance of buildings in the Lithuanian Technical Regulation STR 2.01.09:2012. The mentioned standard of the value of non-renewable primary energy factor  $f_{p,nerm}$  was 0.500. However, the  $f_{p,nerm}$  value set in this work is 0.059. The value differs by almost nine times. On the basis of these studies, the method of assessing the energy performance of buildings due to non-renewable primary energy factors when energy is produced from hydroelectric power plants was adjusted.

#### 4. Conclusions

This is a detailed study of the hydropower plants of Lithuania and can be set as a template for similar studies to be carried out elsewhere. This study provides guidelines for the determination of the non-renewable primary energy factor, when energy is produced from hydroelectric power plants.

The results of the research will help to evaluate the energy efficiency of buildings in Lithuania more precisely.

These findings can serve as an indication for other countries. They show that it is relevant to address and quantify renewable and non-renewable energy.

**Author Contributions:** All authors contributed equally to this work. All authors designed the calculations, discussed the results and implications, and commented on the manuscript at all stages. R.T. calculated various primary factor values of non-renewable energy of hydropower plants of different capacity and interviewed hydropower plants owners/operators. M.Š. analyzed the literature data. J.Š. wrote the paper. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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