# Evaluation of the influence of the primary energy factor of hydropower systems


**R. Tamašauskas**
*JSC „Planuotojai", Kaunas, Lithuania*
**J. Šadauskienė**
*Faculty of Civil Engineering and Architecture, Kaunas University of Technology, Kaunas, Lithuania*
**M. Šadauskaitė**
*Kaunas University of Technology Gymnasium, Kaunas, Lithuania*


## Introduction

Recently, the EU construction sector focuses on sustainable energy use and production [1]. Taking into account the different climatic conditions and building traditions in EU countries, Member States commit themselves to develop national targets, increasing the number of buildings of this type, defining primary energy demand.

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 $f_{P,nren}$. The part of the 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].

Hydropower is being challenged: water availability has different temporal and spatial fluctuations in different locations; water availability fluctuations indirectly and directly affect the different electricity generating technologies [4,5].

The analyzed literature did not give sufficient information about calculation of value of non-renewable factor. Therefore the aim of this article is to calculate value of non-renewable factors for hydropower plants in Lithuania.

## 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 by analyzing the reports of electricity transmission system operators in Lithuania.

The largest hydroelectric power plant in the territory of Lithuania is located near the river Nemunas, where it is installed 100.8 MW power. In Lithuania, except for the Nemunas and Neris rivers, it is possible to build only small hydroelectric power plants with a capacity of less than 10 MW (Fig. 1.). The contribution of small hydropower is about 1-1.5 %. The reason is their low capacity, which is mostly limited by the relatively low heights of the river falls and the large areas of the formed pond. A similar percentage of electricity from total electricity generation is accounted for by EU small hydroelectric plants - 1.6%

The value of $f_{P,nren}$ of hydropower plants was calculated using the methodology described in EN 15603 [1].The $f_P$, tot was calculated from Equation 1:

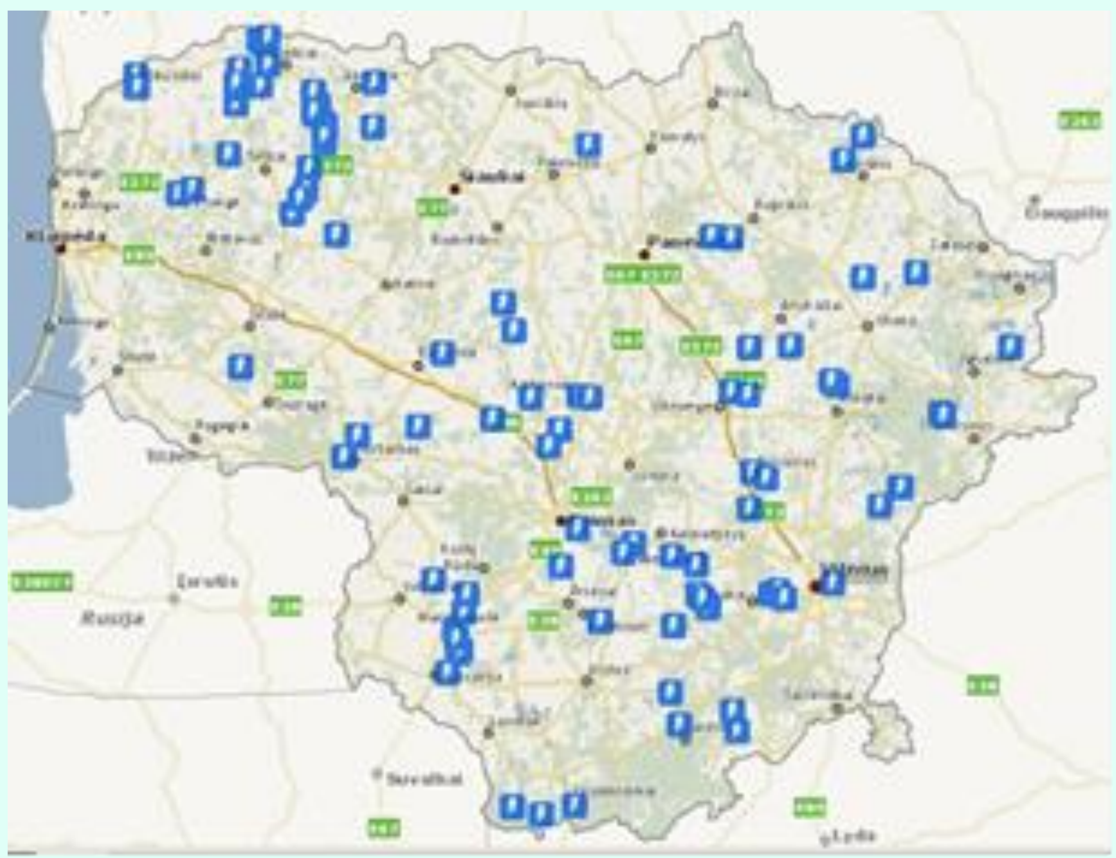

**Fig. 1.** The map of the small Lithuanian hydroelectric power plant.

$$f_{P,tot} = f_{P,nren} + f_{P,ren} \qquad (1)$$

where:

$f_{P,tot}$ - the total primary energy factor, kW·h;
$f_{P,nren}$ - the non-renewable primary energy factor, kW·h;
$f_{P,ren}$ - the renewable primary energy factor, kW·h.

Accordingly, the renewable primary energy factor $f_{P,ren}$ is equal 1. The value of the $f_{P,nren}$ produced by hydropower turbines is given by the formula (Equation 2):

$$f_{P,nren} = \frac{E_{a,nren}}{E_{ren}}; \qquad (2)$$

where:

$E_{a,nren}$ - the amount of additionally consumed non-renewable energy (from the electrical grid) regarding the produced electricity of the hydropower plants, designed to supply into the building, kWh/year;
$E_{ren}$ - the amount of electrical energy, which is produced in hydropower plants and supplied into the building, kWh/year.

## Results and discussion

The calculated values of the $f_{P,nren}$ factors of the analyzed hydropower plants are presented in Fig 2. Calculation results show that the average annual value of $f_{P,nern}$ ranges from 0.005 to 0.078. 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.

The values of the $f_{P,nern}$ of the hydropower plants determined in this work were used to revise the methodology of assessment of energy performance of buildings in the Lithuanian Technical Regulation STR 2.01.09:2012. The mentioned standard provide the value of non-renewable primary energy factor $f_{P,nern}$ was 0.500. However, the $f_{P,nern}$ value set in this work is 0.059. The difference makes up 9 times. On the basis of these studies, the method of assessing the energy performance of buildings due to non-renewable primary energy factor when energy is produced from hydroelectric power plants are used was adjusted.

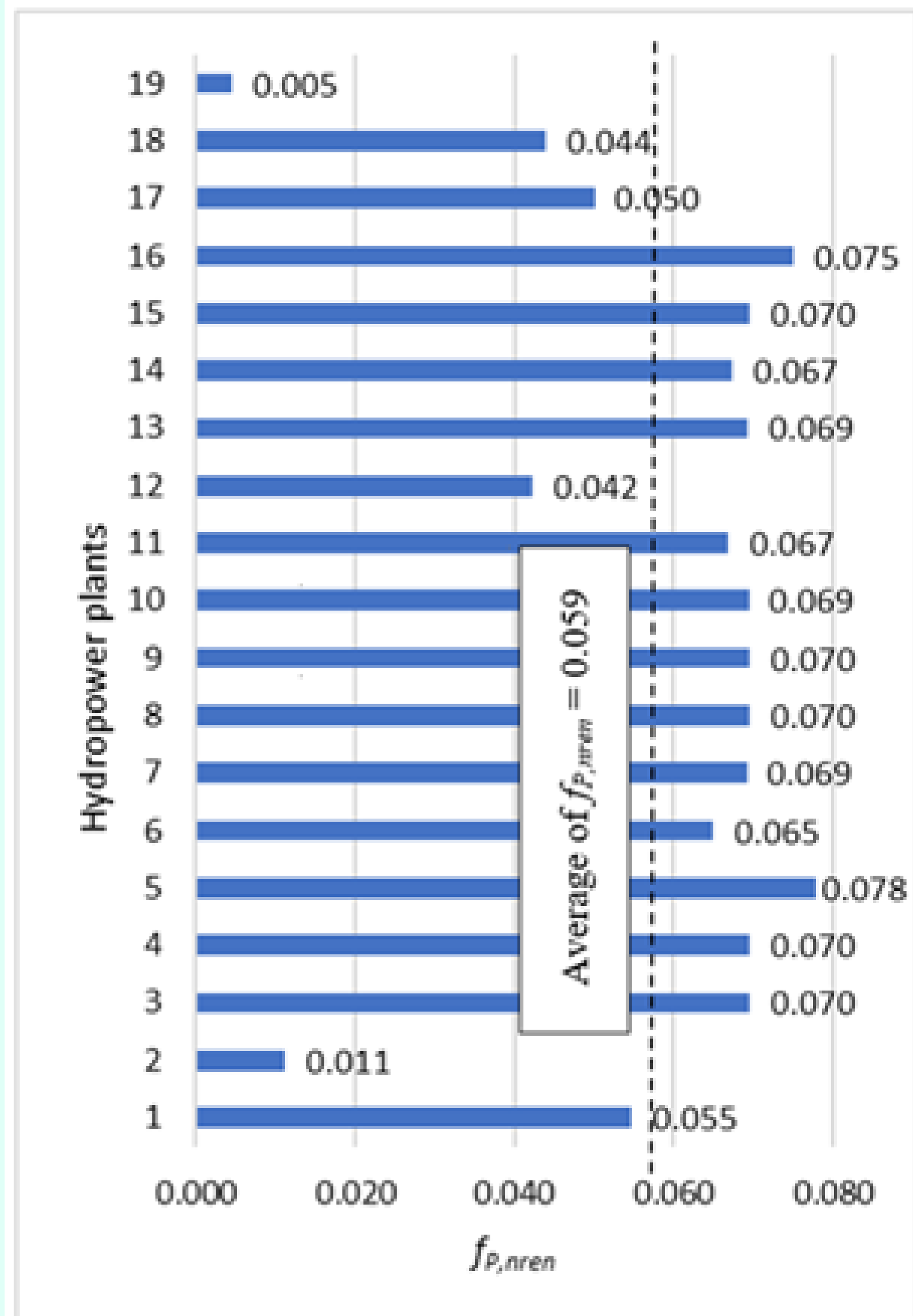


**Fig. 2.** Average annual values of $f_{P,nren}$ of hydropower plants in Lithuania.

## Conclusions

The main conclusions drawn from all these work are:

– This is a detailed study of the hydropower systems 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 systems are used.

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

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

## References


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