PLATON –

Planning Process and Tool for Step-by-Step Conversion of the Conventional or Mixed Bus Fleet to a 100% Electric Bus Fleet

Project term: January 1, 2018 – June 30, 2020

Procedure ECPro

Choosing calculated value for assessing operation properties of vehicles

Description and user's manual

Head of research: Validimir Algin, JIME-NASB

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Joint Institute of Mechanical Engineering of
National Academy of Sciences of Belarus (JIME-NASB)

Funding organization of WP leader:

National Academy of Sciences of Belarus,

Independence Ave. 66, 220072, Republic of Belarus, Minsk

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1 Introduction

Procedure ECPro is designed to help the user in choosing the calculated (design, rated) value on a probabilistic representation of possible cases for an object operation under various factors.

Procedure ECPro realizes an approach to assessing energy consumption by electric buses, based on a probabilistic representation of space for numerous cases caused by the inevitable variation of operating factors on a given bus route [2].

The main idea of probabilistic approach that is realized in ECPro procedure is as follows. Any particular solution (for example, determining energy consumption of an electric bus for individual case/route or set of routes) is not base for decision making. It is necessary to consider numerous possible situations and on this basis to justify the calculated (rated) case.

This procedure may be applied to different objects and situations. In context of Platon project, ECPro is used to select the calculated energy consumption of the buses. Factors that lead to changes in energy consumption are: passenger load, temperature, driving style, road conditions, etc.

It is assumed, firstly, that the user has data that corresponds to the average value or the modal (most likely) value of energy consumption for the conditions under consideration.

Secondly, the user must evaluate the degree of possible data scattering, and what probability distribution is suitable for his case: narrow (weak) scattering or wide (strong) data scattering. The ECPro procedure implements two characteristic cases. The first case is described by the distribution of LN03 with a coefficient of variation of 0.11, and the second is described by the distribution of LN03 with a coefficient of variation of 0.2. Both distributions LN05 and LN03 are lognormal.

The LN03 is designed for cases when several factors are known and taken into account (season, snow appearance, action of HVAC) and at the same time other factors vary (driving style, passenger load, road congestion).

The LN05 is designed for cases with wide variation all factors (all seasons and operation conditions): driving style, passenger load, action of HVAC and others auxiliaries, snowfall, route congestion.

The third key problem is the choice of the probability with which the user wants to determine the calculated (rated) value of energy consumption, taking into account the possible excess in real operation of the average or modal value obtained by him. It is recommended to take the probability F_C for the calculated value within F_C = 0.8 ... 0.9, which corresponds to the actual practice of decision-making in reliability theory and other areas of engineering.

Having made decisions on these issues, the user receives a reasonable value of energy consumption E_C, which corresponds to the probability of F_C.

The ECPro procedure is implemented in the Excel file: ECPro.xlsx.

2 System requirements of the ECPro

To realize the procedure ECPro, the personal computer with OS Windows and Excel application is used.

3 Objective of the ECPro

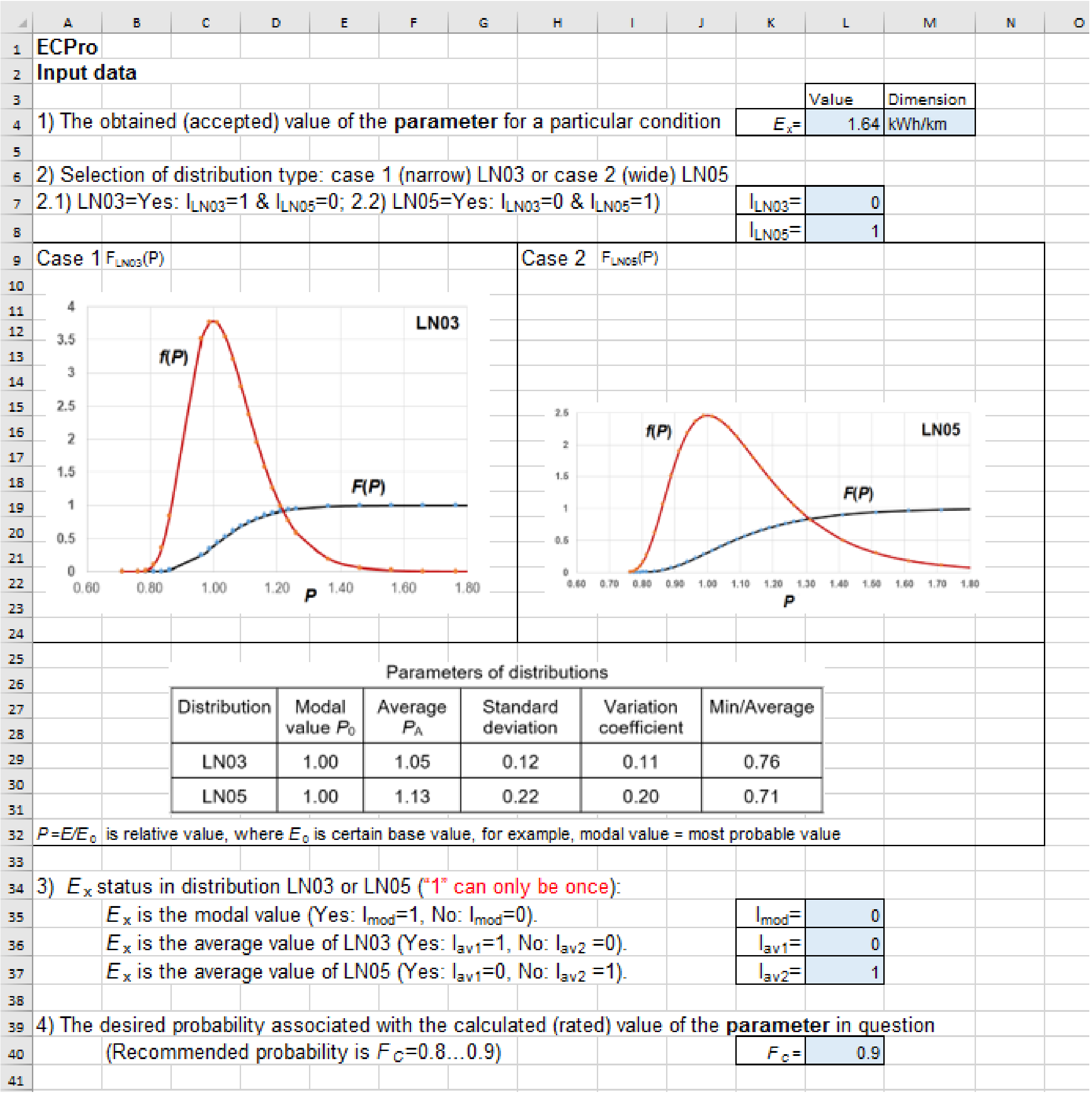
Objective of ECPro is to help the user to responsibly select the calculated value of energy consumption, based on probabilistic distribution of energy consumption for various situation and given that the calculated value refers to the probability accepted by the user.

As result, the user receives the calculated value of bus energy consumption E_C that relates to the accepted probability F_C.

4 Input data for the ECPro

Procedure ECPro is implemented in Excel.

Input data are presented in Figure 1. The user should fill in the value E_x. He may indicate any dimension of this quantity. The calculated energy consumption E_c will be displayed with the specified dimension.



ECPro

Input data

1) The obtained (accepted) value of the **parameter** for a particular condition

	Value	Dimension
E_x=	1.64	kWh/km

2) Selection of distribution type: case 1 (narrow) LN03 or case 2 (wide) LN05

2.1) LN03=Yes: I_{LN03}=1 & I_{LN05}=0; 2.2) LN05=Yes: I_{LN03}=0 & I_{LN05}=1)

I_{LN03}=	0
I_{LN05}=	1

Case 1 $F_{LN03}(P)$

Case 2 $F_{LN05}(P)$

Parameters of distributions

Distribution	Modal value P_0	Average P_A	Standard deviation	Variation coefficient	Min/Average
LN03	1.00	1.05	0.12	0.11	0.76
LN05	1.00	1.13	0.22	0.20	0.71

$P=E/E_0$ is relative value, where E_0 is certain base value, for example, modal value = most probable value

3) E_x status in distribution LN03 or LN05 ("1" can only be once):

E_x is the modal value (Yes: I_{mod}=1, No: I_{mod}=0).

E_x is the average value of LN03 (Yes: I_{av1}=1, No: I_{av2} =0).

E_x is the average value of LN05 (Yes: I_{av1}=0, No: I_{av2} =1).

I_{mod}=	0
I_{av1}=	0
I_{av2}=	1

4) The desired probability associated with the calculated (rated) value of the **parameter** in question

(Recommended probability is F_C=0.8…0.9)

F_C=	0.9

Figure 1 Input data for ECPro

5 The core of the ECPro

The Excel file for realization of ECPro contains the auxiliary data to describe the distributions LN03 and LNO5 by digital data (see Fig. 2).

Auxiliary data: Tables describing distributions

Table 1	Case 1											
$F_{LN03}(P)$	0.021	0.248	0.340	0.434	**0.525**	**0.610**	**0.685**	**0.749**	**0.803**	**0.847**	**0.882**	**0.910**
P	0.86	0.96	0.99	1.01	1.04	1.06	1.09	1.11	1.14	1.16	1.19	1.21
Table 2	Case 2											
$F_{LN05}(P)$	0.280	0.342	0.402	0.460	**0.515**	**0.566**	**0.614**	**0.657**	**0.695**	**0.730**	**0.762**	**0.789**
P	0.99	1.01	1.04	1.06	1.09	1.11	1.14	1.16	1.19	1.21	1.24	1.26

Figure 2 Data to describe the distributions

During the calculation, the user generates Table 3 in an open Excel file based on the data from Table 1 or 2. As an intermediate result, the calculated value of energy consumption in relative (dimensionless) form is determined (see Figure 3).

51										
52	**Calculation**									
53										
54	**1) Form Table 3 of values F1(P1) and F2(P2) closest to selected probability for the selected case**									
55	Example:	F_C= 0.8		Case 1		Table 3				
56	F1=	**0.749**	F2=	**0.803**		F1=	**0.836**	F2=	**0.901**	
57	P1=	1.11	P2=	1.14		P1=	1.31	P2=	1.41	
58										
59	**2) Read the relative calculated value**						P_C=	1.41		
60										

Figure 3 Forming Table 3 and determination of calculated energy consumption in relative unit

6 The outputs of the ECPro

The results are presented in final Table that is depicted in Figure 4.

60								
61	**Results**							
62	I_{LN03}= 0		I_{LN05}= 1		E_x= 1.64		For F_C= 0.9	
63	Parameters		Relative values		Absolute values		Dimension	
64	Modal value		P_0=	1.00	E_0=	1.45	kWh/km	
65	Average value		P_A=	1.13	E_A=	1.64	kWh/km	
66	Accepted (given) value		P_x=	1.13	E_x=	1.64	kWh/km	
67	**Calculated value**		P_C=	**1.41**	E_C=	**2.04**	kWh/km	
68								

Figure 4 Final table containing input and main results including the calculated energy consumption E_C

References

1. Algin V. (2019) *Calculated Modes for Assessing Operation Properties and Dependability of Vehicles*. In: Uhl T. (eds) Advances in Mechanism and Machine Science. IFToMM WC 2019. Mechanisms and Machine Science, vol 73. Springer, Cham, pp. 3749-3758, doi: 10.1007/978-3-030-20131-9_370