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Aplicación de la Norma Cubana 50001/2011 en dos Empresas Procesadora de madera en Guantánamo
Application of the Cuban 50001/2011 Standard in two wood Processing Companies in Guantánamo

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Resumen
Se analizó los aspectos energéticos del aserrío Pueblo Nuevo de Imías y las fábricas de Mueble Imperio I y II de Guantánamo, con el propósito de determinar los principales hitos energéticos de las dos instituciones teniendo en cuenta sus objetos sociales, utilizando como herramienta la Norma Cubana 50001/2011. El método utilizado fue la modelación matemática para estimar los indicadores energéticos y ambientales, que permitió determinar que la electricidad como mayor portador del aserrío consume 1358,3 MWh y las fábricas 193,920 MWh.
Palabras clave: Eficiencia; Energéticos; Indicadores; Portadores.
Summary
The energy aspects of the new village of Imías and the furniture factories Empire I and II of Guantánamo were analyzed, the main problem is to determine the main energy carrier of the two institutions taking into account their social objectives. The purpose of the Research is to determine the main energy milestones using the Cuban Standard 50001/2011 as a tool. The method used was mathematical modeling to estimate energy and environmental indicators. The main result is that the electricity in the largest carrier the sawmill consumes 1,358.3 MWh and the factories 193,920 MWh.
Keywords: Efficiency; Energetic; Indicating; Bearers.

Introduction

Throughout the centuries, man has used the energy contained in fossil fuels to satisfy his vital and subsistence needs, however, its disproportionate use has led to the depletion of these sources and the deterioration of the environment. During the last decades, global warming and the greenhouse effect have shown that the current global energy consumption scheme is not sustainable, i.e., it cannot be maintained indefinitely without threatening its own existence. The current energy transformation models are responsible for the emission of 75% of greenhouse gases, causing their reinforcement and contributing to global warming and the acceleration of climate change, as stated by (Varela, 2018).

In correspondence with this and the prevailing need that the Pueblo Nuevo sawmill in the Imías municipality and the Empire I and II Furniture factories in Guantánamo have, it is appropriate to determine the energy efficiency and environmental indicators of the two industries, the curtailment of the consumption of energy carriers, especially electricity, for which it is necessary to apply the Cuban Standard (NC)- ISO 50001/2011, which allows an organization to follow a systematic approach to achieve continuous improvement of its energy profile, including efficiency, use and consumption.

It also allows the creation of an effective energy policy, which involves establishing the framework for energy planning, reviewing energy performance (analysis of energy consumption, identification of areas of significant consumption and identification of opportunities to improve energy performance) and defining the expected results (energy performance indicators -IDEn-, goals and objectives).

In Cuba, studies are carried out to determine the main energy carriers consumed by industries according to their social purpose and the production they must carry out for society. In this sense, the province of Guantánamo creates multidisciplinary commissions to work in the main industries of the territory and create awareness of the efficient use of energy carriers and be environmentally friendly.

Development

The work was developed in Pueblo Nuevo sawmill, located in the municipality of Imías, 4 km north of the municipal capital, on the road leading to Los Calderos with coordinates N: 161 775 and E: 310 250 belonging to the Imías Agroforestry Company (Dupuy, et al..., 2019), and in the factories of Empire Furniture I and II, one in the southern zone of the municipality of Guantánamo,

(Dupuy, et al., 2020), N: 163 882.99 and E: 669 565.01 and the other 4 km from the road leading to the municipality Manuel Tames N: 169 326.15 and E: 673 939.94.

The sawmill is mainly supplied by the Nipe-Sagua-Baracoa mountain range, with a total forest area of 5146.9 ha. Distributed in the municipalities of Imías and San Antonio del Sur. With a total of 928 ha of natural plantings and 4218.9 ha of artificial plantings, 95% dominated by Mayari Pine (Pinus Cubensis), according to Dupuy, Garrido, Guerra (2019). And the UEB of Empire Furniture I and II, most of the products it receives for its production are exported, mainly wood. In the sawmill, due to the productive process both primary and secondary of wood, it has as energy carrier with higher consumption demand, electricity, which also occurs in the factories of Empire Furniture when processing wood to obtain furniture.

The following is a description of the aspects to be taken into account in the technical instructions:

Study area

The areas of use of energy carriers and their rational use should be clearly defined based on the criteria of a multidisciplinary team that includes not only researchers and specialists, but also workers in the area, in such a way as to allow for the deepest possible knowledge of the field history of the area.

Diagnosis of the current situation of the study area

The characteristics of the areas studied are that they are high consumers of energy carriers, especially electricity, which allows CO2 to be emitted into the atmosphere above what was planned, since when electricity generation is increased to meet the demand of the actual plan, fossil fuels are burned above what was planned. This leads to excessive electricity consumption. To eradicate this situation there must be an improvement in energy efficiency, consumption and ecological indexes.

Studies for the application of NC-ISO 50001/2011

Energetic Carriers	UM	UEB Empire Furniture I y II				Pueblo Nuevo sawmill			Total
		Años			Total	Años			
		2016	2017	2018		2016	2017	2018	
Electricity	MWh	333,4	363,58	661,32	**1358,3**	64,2	64,3	65,4	**193,920**
Diesel	L	17570	27680	42830	**88080**	81900	82700	85100	**249700**
Gasoline	L	3420	3430	4220	**11070**	960	1000	1200	**3660**
Oils and Lubricants	L	1290	620	850	**2760**	920	1400	1700	**4020**

Table 1: consumption behavior of Energy Carriers from 2016-2018.

Liquefied Gas GLP)	Kg	2700	3105	4095	**9900**	-	-	-	-
Lubricating Grease	Kg	-	145	90	**235**	-	-	-	-

Source: Own elaboration, adapted from (Dupuy 2019 and 2020).

In order to carry out the study, the data of wood production in the Sawmill, provided by the production department, were taken into account, as shown in Table 4.

In the case of furniture production in the Empire Furniture factories of the engineering and development department, as shown in Table 5.

The consumption of energy carriers comes from the annual balance sheet of the companies that are recorded in the 5073 model, as shown in Table 1. Table 2, which converts the units of the energy carriers to Tons of Conventional Fuel (TCC), Table 3, was used to achieve that the energy carriers are in a single unit of measurement.

Carrier	**UM**	**Conversion Factor**	**Conversion Factor**
		L/T	**T/TCC**
Regular and Special Diesel (1 liter = 830 g)	L	1178,55	1.0534
Regular Gasoline	L	1367,24	1.3541
Special Gasoline	L	1360,91	1.3576
Lubricating Oils	L	1119,59	1,000
Lubricating Greases	T	---	
Electric Power	MWh	---	0,3502
Regular Liquefied Gas (LPG)	Kg	1360,91	1,35759

Table 2: Conversion of Energy Carriers to Tons of Oil Equivalents

Source: Taken from Despaigne (2013)

Energetic Carriers	**UM**	**UEB Empire Furnitures I y II**				**Pueblo Nuevo sawmill**			**Total**
		Años				**Years**			
		2016	**2017**	**2018**	**Total**	**2016**	**2017**	**2018**	
Electricity	TCC	952,08	1038,26	1888,51	**3878,86**	183.323	183.609	186.80	**553,73**
Diesel	TCC	16,411	25,855	40,007	**82,273**	65.967	66.61	68.546	**201,12**
Gasoline	TCC	1,852	1,852	2,279	**5,983**	0.519	0.540	0.648	**1,707**
Oils and Lubricants	TCC	1,152	0,553	0,759	**2,464**	0.821	1.250	1.518	**3,589**
Liquefied Gas GLP)	TCC	1,266	1,456	1,920	**4,642**	-	-	-	

Lubricating Greases	TCC	-	0,145	0,090	**0,235**	-	-	-	

Table 3: Energy Carrier Conversion at Pueblo Nuevo sawmill and Imperios Furniture UEBs from 2016 to 2018.

Source: Own elaboration, adapted from (Dupuy, 2019 and 2020).

		Years			
Indicators	**UM**	**2016**	**2017**	**2018**	**Total**
Wood in Bolo	(m^3)	22719.9	25276.01	36882	84887
Sawn Timber	(m^3)	3173.8	2771.2	3169.3	9114.3
Firewood for fuel	(m^3)	4116.7	5020.7	4802.6	13940
Vegetable sack	Ton	18519	19420	18645	56584

Table 4: Wood extractions at the Pueblo Nuevo sawmill.

Source: Dupuy, 2019

		Years		
Producción de Muebles	**U/M**	**2016**	**2017**	**2018**
		52067	32898	29942

Table 5: Furniture production in Empire I and II factories from 2016 to 2018.

Source: Dupuy, 2020

Behavior of the NC-ISO 50001/2011 Indicators

After modeling in the Excel program the pareto diagrams, Figure 1 and 2, it was possible to appreciate how the behavior of the energy carriers varied. This program was also used to determine the baselines and target lines of the two sites, to evaluate the electricity consumption against sawn timber in the sawmill, and in the case of the Imperio Furniture factories, it was electricity against furniture production during the time studied. This resulted in the pattern indexes and the real indexes with which the energy efficiency indicators of the sawmill and factories I and II were calculated.

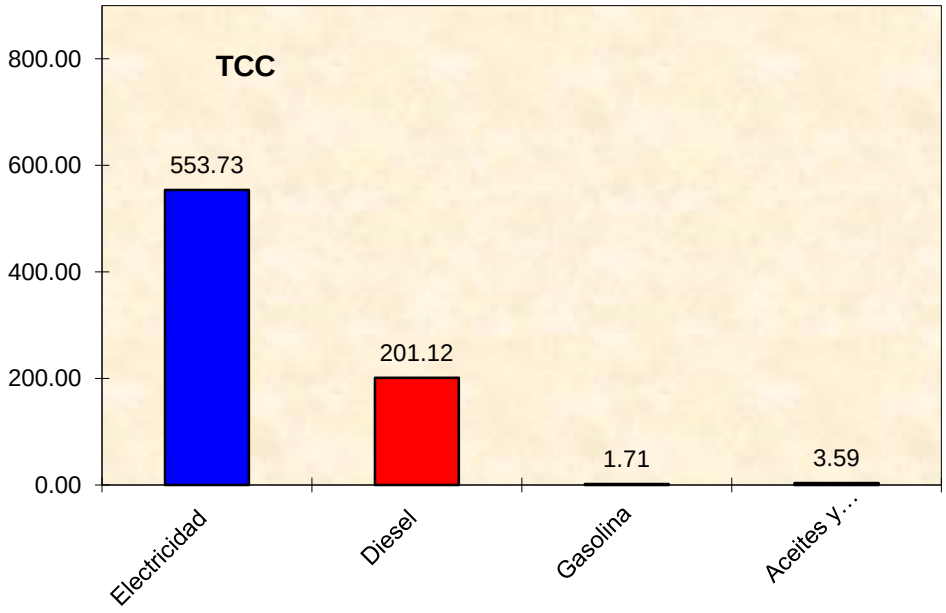

Figure: 1Pueblo Nuevo sawmill pareto diagram

Source: Taken from (Dupuy, 2019).

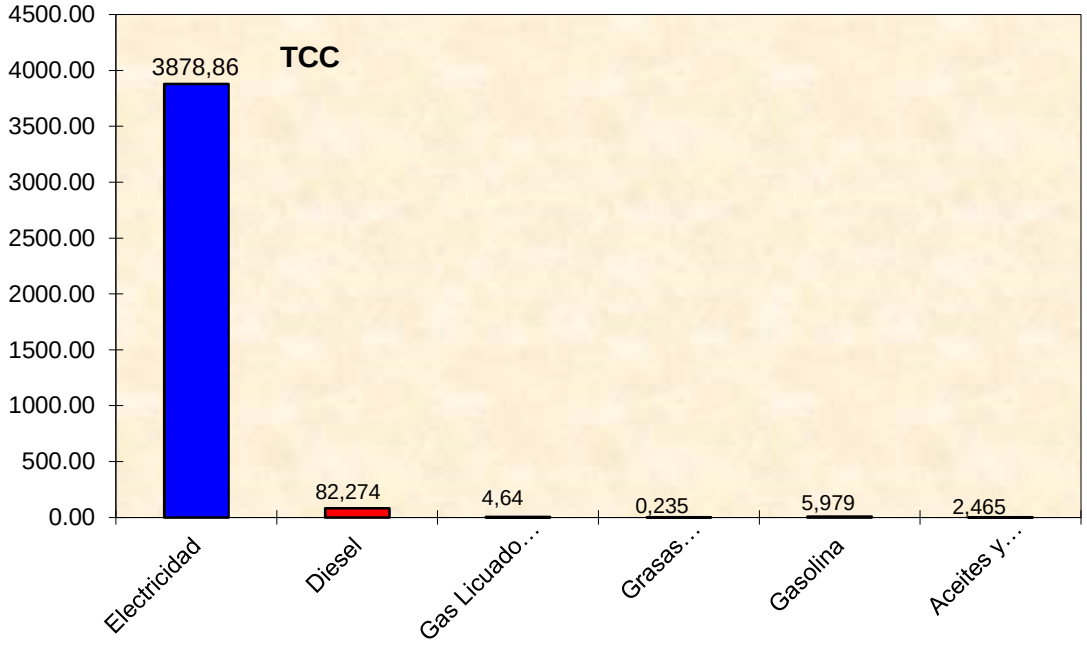

Figure: 2 Diagram and Pareto of Empire Furnitures I and II factories.

Source: Taken from (Dupuy, 2020)

Months	Year 2016		Year 2017		Year 2018	
	Sawn Timber (m^3)	Electricity (MWh)	Sawn Timber (m^3)	Electricity (MWh)	Sawn Timber (m^3)	Electricity (MWh)
January	195,03	3,23	180,2	3,23	196,62	3,61
February	159,01	3,12	230,93	4,12	210,01	5,45
March	289,30	5,78	243,46	5,78	301,30	5,01
April	210,53	4,93	190,3	4,93	215,53	5,78
May	301,4	4,89	245,3	4,99	309,4	4,99
June	320,53	6,78	250,4	6,78	330,53	7,78
July	351,32	7,03	261,31	8,03	371,32	8,21
August	215,13	4,17	191	3,17	215,13	5,17
September	282,03	5,78	210	4,78	283,10	6,78
October	306,10	6,83	270	6,83	265,45	4,50
November	315,2	7,10	280	7,38	231,02	4,30
December	178,22	3,66	227,3	3,28	239,89	3,84
Average	**264.483**	**5.35**	**230.933**	**5.358**	**264.108**	**5.451**

Table: 6 Lumber Consumption vs Electricity.

Source: Taken from (Dupuy, 2019).

Months	Year 2016		Year 2017		Year 2018	
	Furniture Production (UP)	Electricity (MWh)	Furniture Production (UP)	Electricity (MWh)	Furniture Production(UP)	Electricity (MWh)
January	1800	29,7	2376	29,3	3155	38,51
February	2550	28,6	3259	21,2	2087	32,87
March	7306	28,4	2240	25,02	1967	40,29
April	4131	31,2	3514	29,9	4225	60,61
May	3576	31,5	2327	28,02	2433	55,45
June	2295	32,8	2448	34,3	4337	53,66
July	2247	22	1450	34,2	422	64,71
August	4880	28,1	4228	37,51	2435	59,82
September	8136	32,8	2462	36,27	1157	57,68
October	7299	29,7	3460	42,69	1584	56,18
November	3851	38,6	3192	45,17	3322	83,39
December	3996	35,7	1942	38,83	2818	58,15
Average	4339	30,758	2742	33,53	2495	55,11

Table: 7 Furniture Productions vs. Electricity

Source: Dupuy, 2020

These graphs show the simultaneous variation of energy consumption with the production carried out, allowing to quantitatively determining the value of energy not associated with production, identify the average variation pattern of consumption with respect to production and constitute the consumption baseline for a given period of time.

From the establishment of the baseline, the target line can be determined with the lowest consumption data, which are the points below the target line. Given the union of the data, the correlation coefficients of the baseline are good and in the case of the target line are also considered good (Figures 1 and 2) (NC-ISO: 50001/ 2011).

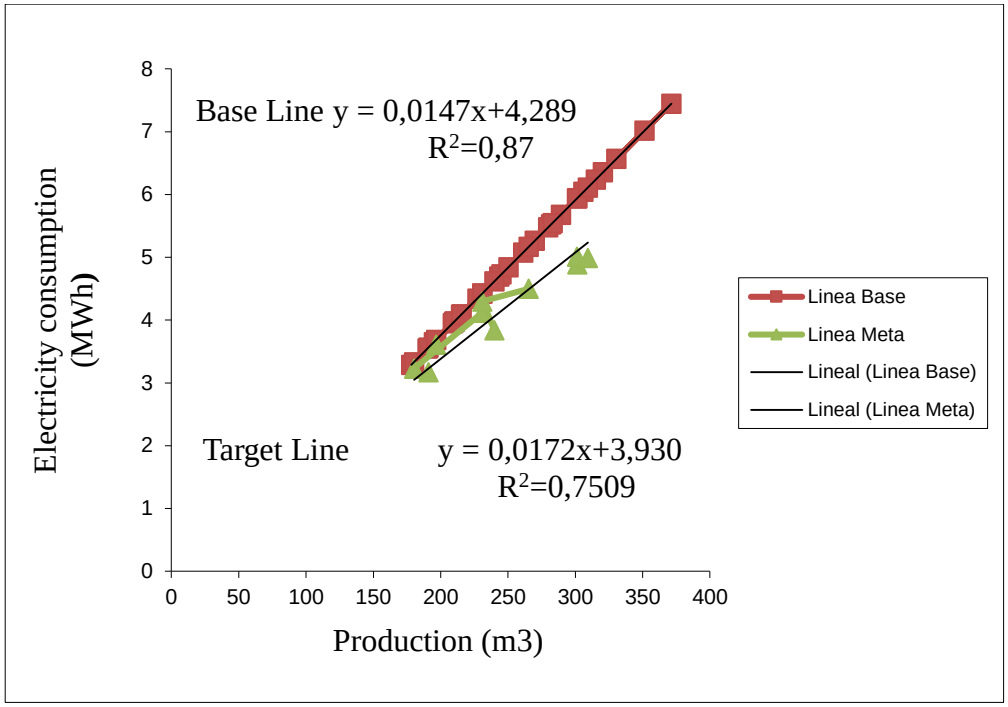

Figure: 3 Baseline (red) and target (green) for electricity consumption vs. production

Source: Taken from (Dupuy, 2019).

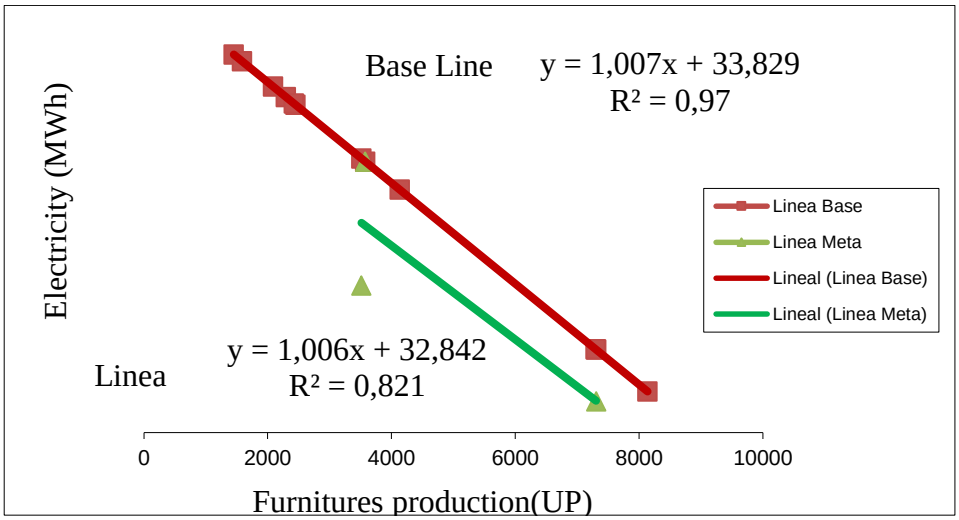

Figure: 4 Baseline (red) and target (green) of electricity consumption vs. production

Source: Taken from (Dupuy, 2020).

Figures 3 and 4 show that there is a linear correspondence of energy carrier consumption of the form:

Y=a+bX (1)

Where:

Y. Electricity consumption, MWh

X. Lumber production, m3 or Furniture Production (UP).

Months	Sawmill Real Consumption Index.(MWh/m^3)			Standard Sawmill consumption index.(MWh/m^3)			Actual consumption index (MWh/UP) Factories I y II			Consumption index Pattern (MWh/UP) Factories I y II		
	Year 2016	Year 2017	Year 2018	Year 2016	Year 2017	Year 2018	Year 2016	Year 2017	Year 2018	Year 2016	Year 2017	Year 2018
Jan.	0,88	0,88	0,877	0,55	0,55	0,55	60,7	80,2	106,51	58,97	77,84	103,36
Feb.	0,46	0,46	0,460	0,46	0,46	0,458	86,0	110	70,46	83,54	106,76	68,37
March	0,66	0,66	0,663	0,64	0,63	0,635	247	75,6	66,40	239,3	73,38	64,44
April	0,65	0,65	0,653	0,64	0,64	0,639	139	119	142,63	135,3	115,12	138,41
May	0,55	0,55	0,549	0,53	0,52	0,525	121	78,5	82,14	117,1	76,23	79,70
June	0,74	0,74	0,737	0,70	0,70	0,703	77,4	82,6	146,41	75,18	80,19	142,08
July	0,73	0,73	0,728	0,69	0,69	0,690	75,8	48,9	14,25	73,61	47,50	13,82
August	0,55	0,55	0,548	0,54	0,53	0,535	165	143	82,20	159,8	138,51	79,77
Sept	0,63	0,62	0,626	0,65	0,64	0,644	275	83,1	39,06	266,5	80,65	37,90
Oct	0,83	0,83	0,828	0,73	0,73	0,728	246	116	53,47	239,1	113,35	51,89
Nov	0,67	0,67	0,669	0,75	0,74	0,743	130	107	112,15	126,1	104,57	108,83
Dec	0,52	0,52	0,518	0,51	0,51	0,512	135	65,5	95,13	130,9	63,62	92,32
Aver.	**0,66**	**0,65**	**0,655**	**0,61**	**0,61**	**0,614**	**147**	**92,5**	**84,23**	**142,1**	**89,81**	**81,74**

Table: 8 Indices of Actual and Pattern electricity consumptions.

Source: Own elaboration, adapted from (Dupuy, 2019 and 2020).

The R-squared of the model is 0.87 for the baseline and 0.75 for the target line for sawmilling, in the case of mills it is 0.97 for the baseline and 0.821 for the target line, which means that there is an appropriate fit between energy carrier consumption and lumber production and furniture making, since these values exceed the threshold of 0.6 (Webster, 2000). This means that the reliability criterion of the data is good, because they are in the threshold between 8.0 - 1 which are very strong.

The actual consumption indices are determined from all the points that make up the baseline and the standard consumption indices are determined from the target line. Table 8 shows the results in MWh/m3 of sawn timber and MWh/UP for the amount of furniture produced.

For the sawmill case, the values indicate that it is possible to reduce the electricity consumption rates from 0.658 MWh/m3 to 0.616 MWh/m3, with a saving of 0.042 MWh/m3 of sawn timber and for the mill case, the values indicate that it is possible to reduce the electricity consumption rates from 107.75 MWh/UP to 104.56 MWh/UP, with a saving of 3.19 MWh/UP of furniture production.

The graphs of electricity consumption indexes against sawn wood (Figure 3) and electricity consumption against processed furniture (Figure 4), in the first case, it is observed that from a value of 264 m3 of sawn wood, the consumption index tends to stabilize, value that is in correspondence with the standard consumption index and in the second case, it is from 3337 furniture produced.

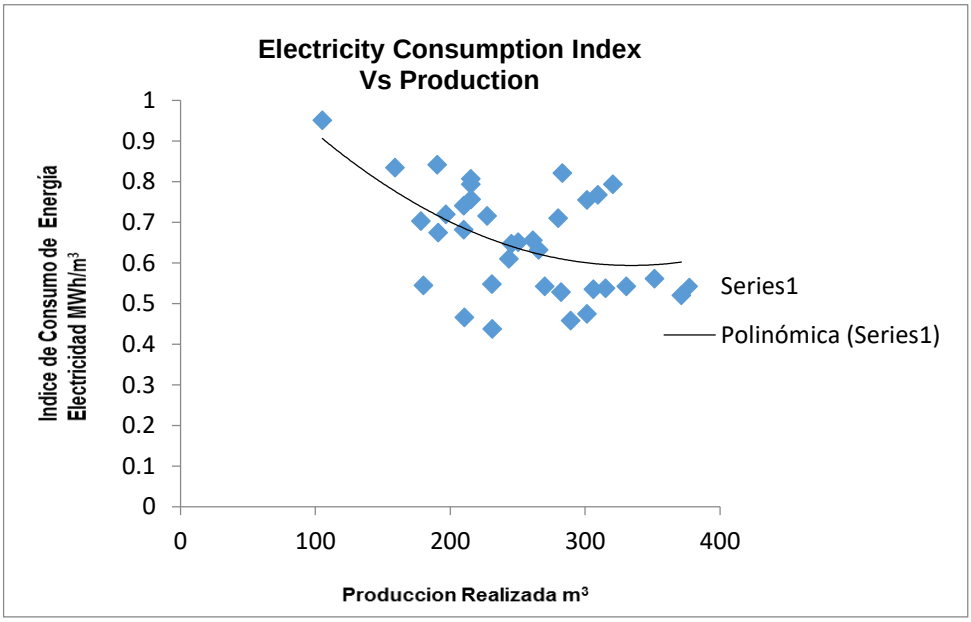

Figure: 5 Pueblo Nuevo sawmill consumption rate graphs.

Source: Dupuy, 2019

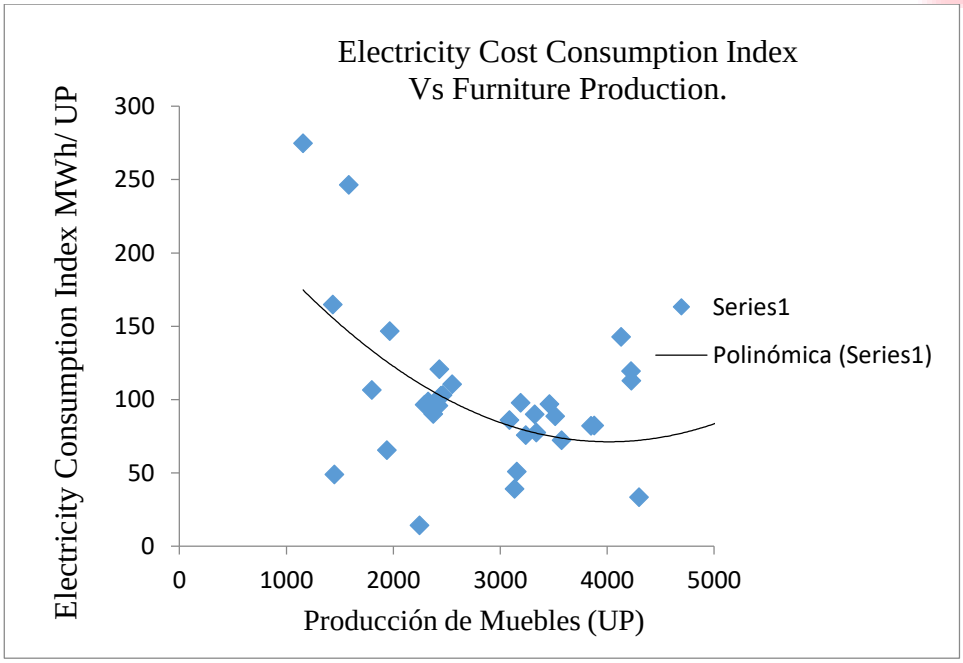

Figure: 4 Graph of the Empire Furnitures factories I and II.

Source: Dupuy, 2020

Energy efficiencies of electric energy use were determined, to evaluate the efficiency of the use of energy carriers of the sawmill and factories, the following indicators were used: energy efficiency index (Ne) (Eq. 1), eco-efficiency (EE 2) and emissions index (IES 3). (Lesme, Oliva, Palacio, 2006).

Ne=IconsPP/IconsRP (2).

Where:

Icons PP. average standard consumption index (MWh/m3).

Icons RP. Average real consumption index (MWh/m3).

The eco-efficiency is the ratio between the energy carrier consumption given by the target line times the emissions it produces and the actual energy carrier consumption times the emissions it produces: (Equation 3)

EE=(Straight M electri Consumption x Emissions)/(Actual electri Consumption x Emissions) (3)

To determine the CO2 emissions given by electricity consumption, the emissions factor reported by the National Electrical Union (UNE of 1127 gCO2/kWh Arrastía, 2010) was taken into account. This index is given by equation 4.

IES= (Total Emissions)/ (Total Production)(4)

Energy efficiency indicators	Electric power sawmill	Electric power I y II
Consumption índex (IC)	0,668 MWh/m^3	0,655 MWh/ UP
Energy efficiency index (Ne)	95%	91%
Ecological efficiency (EE)	91%	91
Emissions rate (IES)	10Ton de CO_2/m^3	12 Ton de CO_2/UP

Table 9. Energy Efficiency Indicators

Source: Own elaboration, adapted from Dupuy, 2019 and Dupuy, 2020.

The consumption indexes behaved similarly, in the case of the energy efficiency index, although they were above 90%, the Sawmill worked with better performance, the ecological efficiencies coincided at the same point of % and the emission indexes, the Sawmill had better performance since by working with better energy efficiency it emits less CO2 to the atmosphere.

Conclusions

The work was carried out in the Pueblo Nuevo sawmill in the municipality of Imías and in the Imperio I and II furniture factories, and showed that the most consumed energy source in the two production centers is electricity. In the case of the sawmill it is 553.73 TCC, and in the furniture factories Imperio the consumption is 3878.86 TCC. In this sense, work should be done to reduce it by adjusting the load and making better use of this energy in production, as it is a fundamental factor for wood processing and furniture manufacturing. This leads to the improvement of the consumption indexes and its decrease and to achieve a better efficiency for this concept in the production of furniture in the two factories. The energy efficiency indexes and the ecological index behaved above 90% and that the NC-ISO 50001/2011, is a fundamental tool to check the behavior of these indicators in the time that the study is carried out.

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