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ScienceDirect

Energy Procedia 156 (2019) 149–153

Energy Procedia

www.elsevier.com/locate/procedia

2018 5th International Conference on Power and Energy Systems Engineering, CPESE 2018, 19–21 September 2018, Nagoya, Japan

The Energy Related Water Footprint Accounting of A Public Organization: The Case of A Public University in Thailand

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Abstract

Energy is the one of the most important driven forces of the organization activities. The energy consumption in the organization depends on two modes of utilization, fuel used for transportation and electricity generation. Since there is a significant relation between energy and environment, the impact of the energy production on the environment is the crucial agenda the organization should be accounted for. The greenhouse gas is not only the main concern regarding the energy production but also the water consumption because the fuel or electricity production require a large amount of water. This has the direct impact on the water security so people in the organization should have the responsibility for the water usage contributed to the energy production. As a result, the ecological indication, water footprint, was utilized to quantify the amount of water used for the production of fuel and electricity used in the organization. The analysis was conducted between January to April 2018 which is the second semester of the 2017 academic year. The amount of fuel and electricity used in this period was collected and the water footprint was calculated. The results show that the gasoline use has contributed to the highest amount of water consumption.

Keywords: Diesel, Electricity, Energy, Gasoline, Organization, Water Footprint.

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10.1016/j.egypro.2018.11.120

1. Introduction

The freshwater shortage is in the spotlight of the public for a long time and the problem is also recognized by the public. However, there is no clear picture of the quantity the society itself has contributed to the water usage. As a result, the indication of water consumption is introduced in order to measure the amount of water used by the people. The concept of water footprint was introduced by A.Y. Hoekstra in 2002 and it is the cornerstone of the approach to increase the water saving awareness among the people. The water footprint calculation is also extended to not only the life cycle analysis of a product but also the amount of water used in the organization. Since there is a relation between the energy and the water consumption and the proportion of energy in the organization is high, it is important to determine the amount of water used to produce the energy used in the organization.

2. Literature Review

Mekonnen and Hoekstra [1] determined the water footprint of the hydroelectric generation. This research was also extended by Mekonnen, Gerbens-Leenes and Arjen Y. Hoekstra [2] to assess the water footprint of the electricity generated from different sources, coal, natural gas, oil, uranium, biomass as well as electricity from wind, solar and geothermal energy and hydropower. The in-depth analysis of energy footprint in Thailand was conducted by Okadera, Chontanawat and Gheewala [3] since the energy production needs a lot of water, especially, at the cooling process. The life cycle assessment of natural gas power plants in Thailand was assessed by Phumpradab, Gheewala and Sagisaka [4] and the resource consumption from electricity production per functional unit in thermal power plant was also computed. On the other hand, the water footprint of the gasoline and diesel production was assessed by Bras et al. [4] as a part of the quantification of the life cycle water consumption of a car.

3. Problem Background

The study was performed at the Valaya Alongkorn Rajabhat University, a public and multidisciplinary University located in Prathumthani province, Thailand. The University offers both undergraduate and graduate programs as well as the basic education. The demonstration school of the University has students ranged from early year to high school level. According to the University activities, there is a high demand of the electricity since the University itself is run from Monday through Sunday. There are forty buildings in the main campus area whose satellite map is shown in Fig. 1.

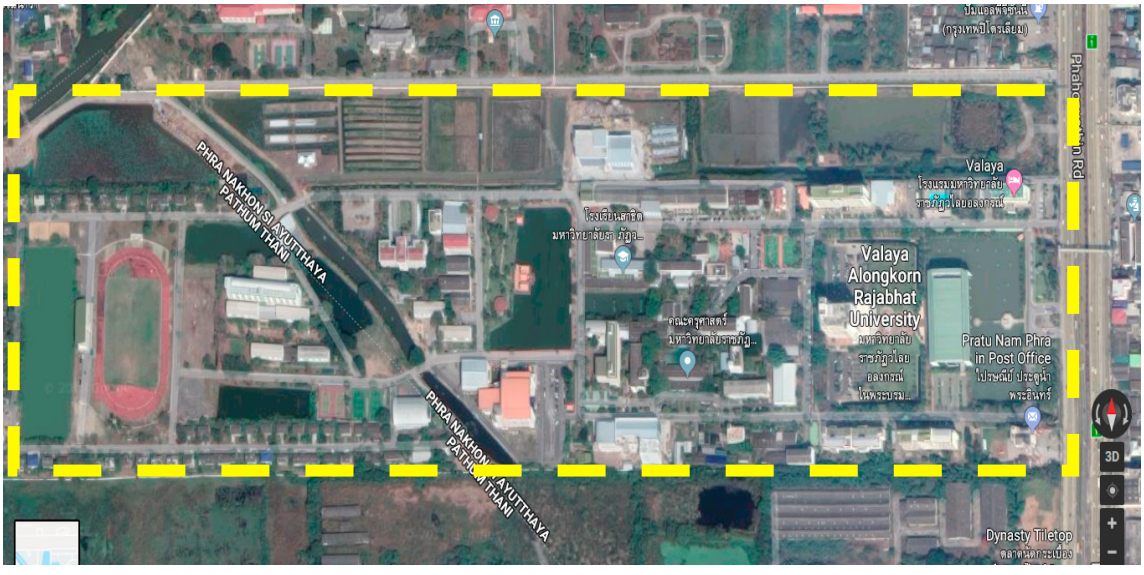

Fig. 1. Satellite Map of the University.

The main source of electrical equipment usage is the air-conditioning system since air-conditioning units were installed in every room and building as shown in Fig. 2.

Fig. 2. Air-conditioning system.

4. Results

The meter readings of electricity use in each building from January to April 2018 are illustrated in Table 1 and the unit of electricity is kWh. Due to Table 1, the highest use of electricity is in the building of the laboratories of agricultural faculty.

Table 1. Electricity use (listed by buildings).

Buildings	Electricity Use (kWh)			
	Jan	Feb	Mar	Apr
Office of Learning Promotion and Provision Academic Services	13,381	18,382	17,201	17,152
Language and Computer Center	12,488	16,887	16,889	19,128
Demonstration School 1	17,840	16,640	14,640	16,800
Demonstration School 2	232	255	92	56
Demonstration School 3	28,013	35,737	17,993	15,932
Food Center	7,000	9,400	7,840	7,960
Green House	956	295	520	411
Plant Genetics Preservation	416	375	317	488
Student Affairs Division	240	880	960	1,120
Faculty of Science and Technology (Office and lecture hall/rooms)	7,600	7,600	4,240	47,000
Faculty of Science and Technology (Home economics Dept.)	900	1,410	1,650	2,640
Science Education Center	12,367	16,120	14,621	16,589
Faculty of Humanities and Social Science (Office and lecture hall/rooms)	7,200	10,560	9,920	11,520
Faculty of Humanities and Social Science (Student government office)	5,560	9,640	9,640	5,720
Faculty of Industrial Technology (Office and lecture hall/rooms)	13,480	22,791	27,638	0
Faculty of Agriculture Technology (Office and lecture rooms)	2,320	2,320	2,400	2,640
Faculty of Agriculture Technology (Laboratories)	23,440	21,520	179,520	36,800
Faculty of Education 1	4,680	4,080	8,940	1,500
Faculty of Education 2	1,680	4,720	3,840	4,720
Faculty of Management Science (Mass Communication Dept)	480	3,040	2,000	2,160
Faculty of Management Science (Office and lecture hall 1)	13,300	17,500	16,600	19,200
Faculty of Management Science 3 (Office and lecture hall 2)	5,500	9,300	8,600	10,900

According to Phumpradab, Gheewala and Sagisaka [4], the per unit value of water consumption required to generate the electricity in Thailand is 0.26 liter/MWh. Therefore, the total amount of water consumed due to the electricity production is computed in Table 2. The total electricity use from January to April 2018 is 1,015,022 kWh which needs the water of 263.9057 liters to generate.

Table 2. Electricity use and its water footprint.

Building	kWh	Liter
Office of Learning Promotion and Provision Academic Services	66,116	17.19016
Language and Computer Center	65,392	17.00192
Demonstration School 1	65,920	17.1392
Demonstration School 2	635	0.1651
Demonstration School 3	97,675	25.3955
Green House	32,200	8.372
Plant Genetics Preservation	2,182	0.56732
Student Affairs Division	1,596	0.41496
Faculty of Science and Technology (Office and lecture hall/rooms)	3,200	0.832
Faculty of Science and Technology (Home economics lecture rooms/laboratory)	66,440	17.2744
Faculty of Humanities and Social Science (Office and lecture hall/rooms)	6,600	1.716
Faculty of Humanities and Social Science (Student government office)	59,697	15.52122
Faculty of Industrial Technology	39,200	10.192
Faculty of Agriculture Technology (Office and lecture rooms)	30,560	7.9456
Faculty of Agriculture Technology (Laboratories)	63,909	16.61634
Faculty of Education 1	9,680	2.5168
Faculty of Education 2	261,280	67.9328
Faculty of Management Science 1	19,200	4.992
Faculty of Management Science 2	14,960	3.8896
Faculty of Management Science 3	7,680	1.9968
Total	1,015,022	263.9057

Another main use of the energy is the fuel consumption of the transportation due to the official uses of vehicles. The University's fleet consists of nine vans, two pickup trucks, one light truck and two coaches. The list of vehicles are shown in Table 3 and some of car fleets are depicted in Fig 3. Since there are two types of fuels used, gasoline and diesel, the water footprint calculation is differentiated into two cases. Due to Table 4, the total amount of fuel consumption is 80,840 liters (gasoline = 24,307 liters and diesel = 2,640 liters) which require the water of 16,039,612 and 1,515,240 liters consecutively.

Fig. 3. Car fleet.

Table 3. Types of vehicles and its use.

Vehicle	Type	Vehicle	Type
Van#1	75% loading, normal terrain	Van#8	75% loading, normal terrain
Van#2	75% loading, normal terrain	Van#9	75% loading, normal terrain
Van#3	75% loading, normal terrain	Pickup truck#1	75% loading, normal terrain
Van#4	75% loading, normal terrain	Pickup truck#2	75% loading, normal terrain
Van#5	75% loading, normal terrain	Light truck	75% loading, normal terrain
Van#6	75% loading, normal terrain	Coach#1	100% loading, normal terrain
Van#7	75% loading, normal terrain	Coach#2	100% loading, normal terrain

Table 4. Consumed fuel and its water footprint.

Fuel	Density (kg/liter)	Fuel used (liter)	Fuel used (kg)	(Liter/kg)	Water footprint (Liter)
Gasoline	0.77	24307	18716	857	16,039,612
Diesel	0.832	2640	2196	690	1,515,240
					17,554,852

Obviously, the amount of water used for transportation fuel is significantly higher than the amount used for the electricity. When two types of fuel are compared, gasoline is the primary source of fuel used for transportation in the University. The water footprint accounted to the gasoline use is 16,039,612 liters while those of diesel is only 1,515,240 liters. The pie chart in Fig. 4 shows the amount of water consumption contributed to different sources.

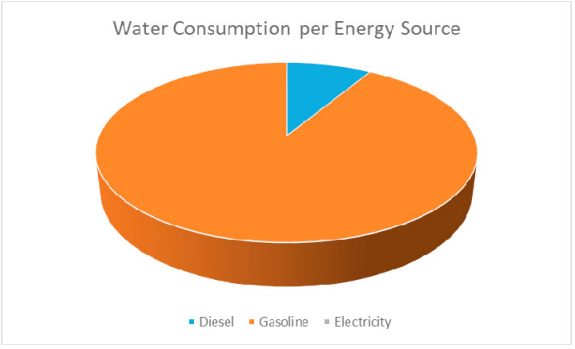

Fig. 4. Pie chart illustrating the water consumption.

5. Conclusions

The types of energy for use in the organization is differentiated into two cases, fossil fuel for the transportation and the electricity. There is the ecological impact from the production of energy and it also includes the water as the required resource for the extraction. The electricity use in each building was read and recorded while the total amount of fuel, gasoline and diesel, were also recorded. The results shows that the production process of gasoline has contributed to the highest amount of water consumption. Therefore, the most effective way to reduce the indirect water consumption is to decrease the amount of diesel used in the vehicles.

References

[1] Mekonnen MM, Hoekstra AY. The blue water footprint of electricity from hydropower. Hydrol Earth Syst Sci; 2012; 16: 179-187.
[2] Mekonnen MM, Gerbens-Leenes PW, Hoekstra AY. The consumptive water footprint of electricity and heat: a global assessment. Environ Sci: Water Res Technol; 2015; 1:285-297.
[3] Okadera T, Chontanawat J, Gheewala SH. Water footprint for energy production and supply in Thailand. Energy; 2017; 77: 49-56.
[4] Phumpradab K, Gheewala SH, Sagisaka M. Life cycle assessment of natural gas power plants in Thailand. Int J Life Cycle Assess; 2009; 14: 354–363.
[5] Bras B, Tejada F, Yen J, Zullo J, Guldberg T. Quantifying the Life Cycle Water Consumption of a Passenger Vehicle. SAE International; 2012.