
Carbon footprint assessment from Electricity in Ubon Ratchathani Zoo in Ubon Ratchathani province, Thailand

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Abstract The carbon footprint assessment from Electricity in Ubon Ratchathani Zoo in 2020 was shown to be the highest carbon footprint at 312.10 tonnes of carbon dioxide equivalent accounted for 36.24 percent, followed by the year 2022, accounting for 33.56 percent, and the year 2021 accounting for 30.20 percent. The total carbon footprint was 861.23 tons of carbon dioxide equivalent. Attitudes towards the economical use of electrical energy of Ubon Ratchathani Zoo, it was found that the attitude towards electricity consumption of personnel staff had an attitude towards economical use of electricity at the level of strongly agree with an average of 4.58. It was found that participants agreed that saving electricity was the duty of all staff with an average of 4.81.

Keywords: Carbon footprint, Electrical energy usage behavior, Greenhouse gas, Climate change, CO₂ emission

Introduction

At present, climate change due to greenhouse gas emissions is causing wide-range impacts. This is caused by the accumulation of greenhouse gases in the atmosphere, resulting in severe climate changes. The resolution requires global cooperation and Thailand has pledged to the United Nations Framework Convention on Climate and the Kyoto Protocol. The starting point was the implementation of the National Strategy on Climate Change Management, B.E. 2551-2555 (2008-2012) (Office of Natural Resources and Environmental Policy and Planning).

Ubon Ratchathani Zoo, under the Zoological Park Organisation of Thailand (ZPOT), has taken part in the development of greenhouse gas

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management projects and activities as a part of the collaboration between ZPOT and the Thailand Greenhouse Gas Management Organisation (TGO) to initiate operations on carbon footprint calculation following TGO's guidelines on Carbon Footprint for Organisation (CFO) based on CFO data use (Ministry of Natural Resources and Environment, 2021). This is an essential tool that shows data on greenhouse gas emissions and removals as a result of an organisation's activities, which are used for calculating the amount of greenhouse gases in the CO₂ equivalent format. Organisations then use results to reduce their energy use and carbon emissions (Thailand Greenhouse Gas Management Organisation, 2022).

The research aimed to assess the carbon footprint as a result of electricity consumption within Ubon Ratchathani Zoo offices, giving information about the organisation's greenhouse gases emissions, employees' electricity consumption behaviours and suitable approaches for reducing emissions. It will also serve to provide fundamental data for future research.

Materials and methods

The population was 115 employees of Ubon Ratchanthani Zoo.

The sample group was the population of Ubon Ratchathani Zoo's employees which calculated using Yamane (1973) as follows:

$$n = \frac{N}{1 + Ne^2}$$

Given that

n = the sample size,

N = the population size and

e = a margin of error (designated at 0.05).

$$n = \frac{115}{1 + (115)(0.05)^2}$$

$$n = 89$$

The calculation sample size was 89. Simple random sampling was collected.

The data were collected in limited time frame with only 62.

Create and find quality of methods

A questionnaire was used to collect the data. The researchers were investigated relevant studies and adapted the question items to suit the

organisation's context. The questionnaire was divided into three sections, as follows:

Part 1 was five items asking about the respondent's personal information including gender, age, participation in electricity-saving training, affiliation and job tenure, scale.

Part 2 was 10 items asking about attitudes towards electricity consumption using an interval Likert. Criteria for interpretation of attitude scores towards electricity consumption were used as follows:

5.00 – 4.21	=	Strongly agree,
4.20– 3.41	=	Agree
3.40 – 2.61	=	Not sure
2.60 – 1.81	=	Disagree
1.80 – 1.00	=	Strongly disagree

Part 3 was 17 items asking about electricity consumption behaviours and contribution to electrical energy saving using an interval Likert scale as

5.00 – 4.21	=	Regularly
4.20 – 3.41	=	Often
3.40 – 2.61	=	Sometimes
2.60 – 1.81	=	Seldom
1.80 – 1.00	=	Never

The process of creating and testing the research tool was done as follows:

- the employee's attitudes and behaviours regarding electricity consumption, the outline of the questionnaire titled 'Ubon Ratchathani Zoo Employees' Attitudes and Behaviours Regarding Electricity Consumption and the Content validity was measured by item-objective congruence index (IOC) to assess the methodology, congruence, and correlation of the item groups in terms of the content and objectives. Experts' opinions for each item were calculated the IOC. The calculated IOC must be higher than 0.6 and the assessment yielded the value of 0.73, meaning that the questionnaire was capable of measuring what was set by the objectives, and it was applicable for use.

Data were collected retrospectively from three years prior (from 1 January 2020 - 31 December 2020) using the following methods. The secondary data were the amount of electricity consumption within the organisation by the Zoo's Development Division.

The primary data were obtained using the questionnaire from a sample size of 85. The respondents were answered the questionnaire by themselves and then the researchers collected the forms and verified the accuracy. Data were analysed and calculated carbon footprint from internal electricity consumption. The calculation of greenhouse gas emissions and removals are followed the IPCC

Guidelines for National Greenhouse Gas Inventories' guidance on estimation and coefficient correlation (2006). The formula was used as follows:

$$\text{CO}_2 \text{ Emission} = \text{Activity data} \times \text{Emission factor}$$

$$\text{Greenhouse Gas Emissions} = \text{Electricity consumption (kWh)} \times \text{GHG Emission or Absorption Factor (0.5610KgCO}_2\text{e)}$$

Results

Calculation of carbon footprint from internal electricity consumption

The Development Division supplied the data on internal electricity consumption, for which Zoo was financially responsible from January 2020 to December 2022. The data was then used in the calculation of carbon footprint by month over three years, as shown in Table 1. Carbon footprint from electricity consumption is peaked in 2020 at 312,095.52 kilograms of CO₂e (or 312.10 tonnes of CO₂e), followed by 2022 at 289,084.76 kilograms of CO₂e (289.08 tonnes of CO₂e) and 2021 at 260,125.60 kilograms of CO₂e (260.13 tonnes of CO₂e).

Table 1. Electricity consumption within Ubon Ratchathani Zoo

Month	Electricity consumption (kWh) from 2020 - 2022		
	2020	2021	2022
Jan.	47,824.00	37,808.00	38,523.00
Feb.	49,424.00	34,592.00	35,710.00
Mar.	53,872.00	48,000.00	45,211.00
Apr.	44,768.00	42,584.00	38,822.00
May	43,456.00	36,688.00	41,346.00
Jun.	48,120.00	40,856.00	47,253.00
July	48,760.00	39,707.00	47,544.00
Aug.	51,720.00	41,323.00	46,361.00
Sept.	41,128.00	38,133.00	46,472.00
Oct.	41,456.00	38,262.00	47,300.60
Nov.	42,008.00	30,796.00	40,721.00
Dec.	43,784.00	34,933.00	40,039.00
Total	556,320.00	463,682.00	515,302.60

$$\begin{aligned} \text{Greenhouse Gas Emissions 2020} &= 556,320.00 \text{ (kWh)} \times 0.5610 \text{ KgCO}_2\text{e} \\ &= 312,095.52 \text{ KgCO}_2\text{e} \end{aligned}$$

$$\begin{aligned} \text{Greenhouse Gas Emissions 2021} &= 463,682.00 \text{ (kWh)} \times 0.5610 \text{ KgCO}_2\text{e} \\ &= 260,125.60 \text{ KgCO}_2\text{e} \end{aligned}$$

$$\begin{aligned} \text{Greenhouse Gas Emissions 2021} &= 515,302.60 \text{ (kWh)} \times 0.5610 \text{ KgCO}_2\text{e} \\ &= 289,084.76 \text{ KgCO}_2\text{e} \end{aligned}$$

Table 2. Amounts of carbon Footprint form 2020-2022

Month	Amount of carbon footprint from 2020 - 2022					
	2020		2021		2022	
	kgCO ₂ e	tonCO ₂ e	kgCO ₂ e	tonCO ₂ e	kgCO ₂ e	tonCO ₂ e
Jan.	26,829.26	26.83	21,210.29	21.21	21,611.40	21.61
Feb.	27,726.86	27.73	19,406.11	19.41	20,033.31	20.03
Mar.	30,222.19	30.22	26,928.00	26.93	25,363.37	25.36
Apr.	25,114.85	25.11	23,889.62	23.89	21,779.14	21.78
May	24,378.82	24.38	20,581.97	20.58	23,195.11	23.20
Jun.	26,995.32	27.00	22,920.22	22.92	26,508.93	26.51
July	27,354.36	27.35	22,275.63	22.28	26,672.18	26.67
Aug.	29,014.92	29.01	23,182.20	23.18	26,008.52	26.01
Sept.	23,072.81	23.07	21,392.61	21.39	26,070.79	26.07
Oct.	23,256.82	23.26	21,464.98	21.46	26,535.64	26.54
Nov.	23,566.49	23.57	17,276.56	17.28	22,844.48	22.84
Dec.	24,562.82	24.56	19,597.41	19.60	22,461.88	22.46
Total	312,095.52	312.10	260,125.60	260.13	289,084.76	289.08

Attitudes towards electricity consumption

The respondents strongly agreed with energy saving with an average of 4.58, and in detail, the item asking whether the respondents agreed that energy saving was every staff member's responsibility was rated the highest at 4.81, while the item about the staff's energy-saving mindset was in the 'Agree' range with an average of 3.81, which was the lowest across all items.

Table 3. Means and standard deviations regarding attitudes towards electricity consumption' (n=62)

Attitudes towards electricity consumption	Mean \bar{x}	Standard deviation (S.D.)	Degree of agreement
1. Do you agree with the use of energy-saving appliances to reduce the organisation's electricity costs?	4.69	0.49	Strongly agree
2. Ubon Ratchathani Zoo has high electricity consumption and therefore, should set up energy-saving measures.	4.62	0.52	Strongly agree
3. Do you agree that staff have an energy-saving mindset for collective goods?	3.87	1.07	agree
4. Do you agree that saving electricity is every staff member's responsibility?	4.81	0.43	Strongly agree
5. Do you agree that the amount of energy consumption varies according to season?	4.50	0.62	Strongly agree
6. Would you agree if Ubon Ratchathani Zoo organised an electricity-saving campaign?	4.73	0.48	Strongly agree
7. You feel anxious when forgetting to turn off electrical devices.	4.55	0.71	Strongly agree
8. Saving electricity would contribute to the country's energy-saving effort.	4.73	0.51	Strongly agree
9. . You feel satisfied for contributing by reducing unnecessary electricity consumption.	4.71	0.52	Strongly agree
10. Electricity shortage is a major global concern.	4.65	0.51	Strongly agree
Overall	4.58	0.39	Strongly agree

Electricity consumption behaviours and participation in energy-saving activities

The regular energy-saving behaviours and contributions to energy saving was averaged of 4.26. In detail, leaving windows open on when the weather was not muggy was rated the highest at 4.69, while putting hot or warm food in the refrigerator was an infrequent behaviour, rated at 2.36.

Table 4. Means and standard deviations regarding the frequency of the respondents' (n = 62) energy-saving behaviours

Electricity consumption behaviours and participation in energy-saving activities	Mean \bar{x}	Standard Deviation (S.D.)	Behavioral level
1. When leaving a room, you will make sure that all electrical devices are switched off and plugs.	4.63	0.63	Regularly
2. You put hot or warm food into the refrigerator right away.	2.39	1.41	Sometimes
3. You advise others on ways to save energy.	3.66	1.03	Often
4. If a lightbulb is not working or damaged, you will inform responsible parties instantly to get it replaced.	4.47	0.88	Regularly
5. If the bulb is damaged You will be prompted to change the bulb immediately.	4.44	0.76	Regularly
6. You switch off the photocopier when it has not been in use for 30 minutes.	3.98	1.05	Often
7. When noticing that doors or windows are open, you will shut them right away to reduce the air conditioner's workload.	4.66	0.57	Regularly
8. You open the blinds while working to get natural light.	4.47	0.74	Regularly
9. You open the windows on days that are not muggy.	4.69	0.53	Regularly
10. You turn on electrical fans instead of air conditioning.	4.36	0.79	Regularly
11. You switch off electrical devices when they are not in use by others.	4.42	0.78	Regularly
12. Your laptop has been set up to go into sleep mode when not in use for over 30 minutes.	4.11	1.09	Often
13. You switch off the air-conditioner at least 30 minutes in advance.	4.27	0.87	Regularly
14. Before switching on the air conditioner, you open doors and windows to release the hot air.	4.35	0.88	Regularly
15. You set the air conditioner at 25 C° to save energy at work.	4.55	0.69	Regularly
16. You switch on the air conditioner when more than one person is present in the area.	4.34	0.80	Regularly
17. When someone leaves the lights on, you will turn it off.	4.56	0.61	Regularly
Overall	4.26	0.45	Regularly

Discussion

The retrospective data collected from 2020-2022 revealed that the first year of the period had the highest amount of electricity consumption. It declined in the subsequent year before rising again in 2022. The data was then used in the calculation of carbon footprint by month over three years. Carbon footprint from electricity consumption is peaked in 2020 at 312,095.52 kilograms of CO₂e (or 312.10 tonnes of CO₂e), followed by 2022 at 289,084.76 kilograms of CO₂e (289.08 tonnes of CO₂e) and 2021 at 260,125.60 kilograms of CO₂e (260.13 tonnes of CO₂e). Ubon Ratchathani Zoo's carbon footprint is not consistent with the findings by Kingparn *et al.* (2013) that conducted a three-year retrospective assessment of carbon footprint from 2009-2011. Their study found that carbon footprint due to electricity consumption had been increasing annually. Their study found that carbon footprint due to electricity consumption had been increasing annually. Also, the fact that electricity consumption resulted in large carbon footprint, consistent with Sikhiva *et al.* (2020), proved that electricity consumption is a significant source of carbon footprint, emitting large amounts of carbon. Kulsuwan (2019) finding that the total carbon footprint at 1,784.32-ton CO₂/Capital, with an average of 1.64-ton CO₂ /Capital/person. The consideration by sex of study found that sex with highest amount of carbon dioxide equivalent emissions was female which averaged 1,896-ton CO₂/Capital. By age range of study found that age range with highest amount of carbon dioxide equivalent emissions was 31–45-year 892-ton CO₂/Capital, making it possible to use for planning for managing to reduce greenhouse gas emissions in the future in accordance with the research of Usuparat and Phuengrasamee (2014). found that the total carbon footprint of 34,355 tons of carbon dioxide equivalent enabled the organization to use as a database for analyzing the use of resources and pollution emissions to the environment and use for planning and managing to reduce greenhouse gas emissions in the future. , consistent with Matsongkram (2020) studied the subject Carbon footprint and water footprint assessment From the use of electricity by activities within the building related to teaching and learning. It was found that the carbon footprint from using electrical energy is 356.60 tons of carbon dioxide equivalent per year. This is compared to using forest land to store carbon dioxide in the amount of 375.36 rai.

In terms of attitudes and behaviours, the Zoo's employees were highly favourable attitudes towards energy saving with an average of 4.58. Also, participation in energy-saving activities were regular (at 4.26), which corresponds to Srijarudej (2020) studied that Sricharudet (2020) Study of general electricity problems of students in student dormitories. Khon Kaen University It was found that electricity was generally used in general operations. Small drive

and continuous electricity consumption simultaneously to view electrical data collection reviews. Students gave summary opinions to create awareness among students. Make a note of electrical appliances, quantity, calculated units of use, technology and Prachabutr (2011) studied about electrical energy usage behavior of students in student dormitories Khon Kaen University found that attitudes towards economical use of electrical energy in Poonphin Building At the level of complete agreement and behavior in using electricity and participation in the economical use of electricity in the Poonphin Building at a moderate level.

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