Green University Resource Planning on Cloud Computing

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***Abstract*—This research is a research and development. It aims to develop Green University Resource Planning on cloud computing. The research is divided into two phases which are 1) document analysis related to Green University indicators, and 2) survey assessment to input data into the Green University Resource Planning System. The research samples are nine experts who are executives and have experience at green universities selected by purposive sampling. The research tool is the survey assessment to input data into the Green University Resource Planning System, which analyses data by considering the mean and standard deviation. According to the document analysis related to Green University Indicators, the research results showed that the categories based on the criteria of UI GreenMetric World University Ranking 2016 suggested that each university has different indicators in relevance to the context, geography, budget, location, internationality, and the survey assessment to input data into the Green University Resource Planning System. The experts found that the overall appropriateness of the survey was rated at the highest level ($\overline{X}$ = 4.55, S.D. = 0.69).**

***Index Terms*—University resource planning, enterprise resource planning, green university, cloud computing.**

I. Introduction

'Green University' refers to a higher education institution, in which a part of the university, or the university as a whole, encourages, manages, and participates in mitigating environmental, economic, social, and health problems arising from resource utilization as much as possible. At the present time, higher education institutions, both in Thailand and elsewhere, have increasingly acknowledged the importance of sustainable and environment-friendly development. Due to the increasing awareness and interest in such development, the author has conceptualized the idea of Green University Resource Planning in higher education institutions based on the idea of Enterprise Resource Planning. The construction of a data structure for higher education helps to save resources and reduce operational processes, as well as effectively deal with problems associated with data processing. As a result, resource allocation processes and related operations are reduced, while management and support services can respond to the teachers' and students' demands more productively. Universities, as is the case with other organizations, are currently being confronted with numerous problems such as resource coordination, budgetary control, personnel in charge of resource allocation, communications, and inter-departmental integration. Hence, University Resource Planning begins with the reconstruction of the university's identity. This will lead to a further shift from traditional administration to more effective inter-departmental integration within the university. This is designed to resolve internal problems, integrating information, and improving the overall quality and productivity of the administration that represents the characteristics of each university [1].

The integration of data in terms of the Enterprise Resource Planning System consists of the following sub-modules: Financial, Distribution, Human Resources, and Manufacturing/Production, as are used in business operations, in order to effectively improve operations [2]. University Resource Planning is composed of a variety of modules related to the specific functions of each university including Finance, Human Resources, and Student Project and Activity Management. Moreover, University Resource Planning also involves the use of enormous interactive databases that contain the information about students, personnel, buildings, documents, and financial transactions [3], [4]. In addition, this also includes information about administration, university correspondence, libraries, academic schedules, curriculum, on-campus and off-campus activities, and finance [2]. In the field of research, the higher education system has been modernized; some educational institutions have now become research universities in order to increase their competitiveness on the global stage [5], [6].

In Thailand, the idea of green university development has been extensively used and developed by many higher education institutions. There are 19 universities in Thailand that are qualified to pass the assessment of UI GreenMetric World University Ranking 2016. Chulalongkorn University was ranked the number one green university in Thailand, and the 30th worldwide, followed by Suranaree University of Technology (the 52nd worldwide), Kasetsart University (the 54th worldwide), Mahasarakham University (the 61st worldwide) and Mahidol University (the 71st worldwide), respectively [7], [8]

The ranking criteria used by the UI GreenMetric World University Ranking 2016 [9] are a global standard, indicating a university's efforts in terms of environment-friendly management and sustainable development as they comply with the university's policy. The criteria comprise six aspects set up by Universitas Indonesia in 2011. [10] stated that UI GreenMetric World University Ranking is a framework for each university to inspect its operations in terms of green university development and sustainable development based on the university's policy. Based on the documentary research into green university policy, the criteria can be divided into 10 categories as follows: 1) Waste 2) Resources 3) Ambient/Indoor Air 4) Research 5) Energy 6) Landscaping 7) Transportation by Bus 8) Achieving

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Corporate Social Responsibility 9) Complying with Regulations, and 10) Infrastructure [11].

Based on the aforementioned background, the researcher presents the idea of Green University Resource Planning (GURP) for higher education institutions to become a green university by developing themselves in agreement with the sustainable development and environment-friendly approach, and to develop the Green University Resource Planning System that is practical, measurable, predictable, and supportive to future decision-making.

II. Purpose of the Research

To propose green university resource planning on cloud computing.

III. Methodology

This research is a research and development project which is divided into two phases as follows:

Phase 1 Document analysis based on Green University Indicators using UI GreenMetric World University Ranking 2016 criteria, a global criteria standard which represents a university's efforts in terms of environment-friendly management and sustainable development as it complies with the university's policy. The author used these criteria as parts of university resource planning for higher education institutions. The criteria comprise six aspects as described below.

1) Setting and Infrastructure: focus on the location, size, and number of green areas within the university.
2) Energy and Climate Change: focus on the efficiency of energy utilization, alternative energy policies, green buildings, and greenhouse gases and electricity usage mitigation policies.
3) Waste: focus on waste management and recycling activities, and paper and plastic usage reduction policies.
4) Water: focus on water conservation and water usage reduction.
5) Transportation: focus on motor vehicle reduction policies, for example, bus and bicycle policy, pedestrian policy, and environment-friendly public transportation policy.
6) Education: focus on courses related to the environment and sustainability, research funds, number of publications, and environment and sustainable development-related websites.

Phase 2 the procedures embedded in the survey assessment to input data into Green University Resource Planning System are identified below:

1) During the first phase, information gained from the Green University Indicators derived from document analysis was used in the survey assessment to input data into the Green University Resource Planning System that was modified according to the context, geography, budget, location and internationality.
2) Proposing the survey assessment to input data into the Green University Resource Planning System to nine experts selected by using purposive sampling for their assessment.
3) Analysing the assessment results according to the assessment criteria by evaluating the mean ($\overline{X}$) and standard deviation (S.D.). The assessment used a 5-level rating scale based on the Likert scale.

IV. Results

The research results are divided into two parts.

Part 1 Document analysis based on Green University Indicators can be summarized as follows:

1) According to the analysis of the indicators with regard to Setting and Infrastructure, each university accepted the indicators as shown in Table I.

Table I, shows the setting and infrastructure indicators from the UI GreenMetric involving green environment, increased space for green environment, environmental control, and sustainable development. The 50% or more accepted indicators resulting from the references will be used in the survey assessment to input data into the Green University Resource Planning System in the future.

2) According to the analysis of the indicators under the Energy and Climate Change heading, each university accepted the indicators as shown in Table II.

Table II, illustrates the energy and climate change management indicators from the UI GreenMetric in terms of using energy-saving electronic devices effectively, enforcing alternative energy policies instead of using electricity, green building for energy conservation, and adapting the university to greenhouse gas emission mitigation. The 50% or more accepted indicators resulting from the references will be used in the survey assessment to input data into the Green University Resource Planning System in the future.

3) According to the analysis of the indicators under the heading of Waste, each university accepted the indicators as shown in Table III.

Table III, presents the waste management indicators from the UI GreenMetric involving waste treatment and recycling, sewerage, and paper and plastic usage reduction policies in a university. The 50% or more accepted indicators resulting from the references will be used in the survey assessment to input data into the Green University Resource Planning System in the future.

4) According to the analysis of the indicators with regard to Water, each university accepted the indicators as shown in Table IV

Table IV, shows the water management indicators from the UI GreenMetric involving water conservation and decreased water usage. The 50% or more accepted indicators resulting from the references will be used in the survey assessment to input data into the Green University Resource Planning System in the future.

5) According to the analysis of the indicators under the Transportation heading, each university accepted the indicators as shown in Table V

Table V, illustrates the transportation indicators from the UI GreenMetric involving the transportation policy for reducing the number of vehicles in a university campus; for example, using campus buses and bicycles, walking, and

using environment-friendly public transportation. The 50% or more accepted indicators resulting from the references will be used in the survey assessment to input data into the Green University Resource Planning System in the future.

6) According to the analysis of the indicators under the Education heading, each university accepted the indicators as shown in Table VI.

TABLE I: SETTING AND INFRASTRUCTURE

Categories and Indicators	Universiti Kebangsaan Malaysia (2015) [12]	University of Oslo (2010) [13]	University of Chicago (2015) [14]	University of Potsdam (2014)[15]	New York University (2006) [16]	Greening Universities Toolkit (2013)[17]	Suan Sunandha Rajabhat University (2014)[18]	Mahidol University (2014) [19]	University of Technology Thonburi (2014) [120]	Thammasat University (2014)[21]	Kasetsart University (2014) [22]
Setting and Infrastructure											
Location							✓	✓		✓	✓
Type of Educational Institution							✓			✓	
Total Size of Campus (square metres)			✓	✓			✓		✓	✓	✓
Number of Faculty and Staff							✓	✓		✓	✓
Total Building Areas (square metres)			✓			✓	✓		✓		✓
Current Number of Students							✓			✓	✓
Total Forest Areas (square metres)				✓	✓		✓	✓	✓	✓	✓
Total Gardening Areas and Fields (square metres)				✓	✓	✓	✓	✓		✓	✓
Total Green Areas (square metres)				✓	✓		✓		✓		
Budget for Environmental Conservation (baht)				✓			✓	✓		✓	✓

TABLE II: SETTING AND INFRASTRUCTURE

Categories and Indicators	Universiti Kebangsaan Malaysia (2015) [12]	University of Oslo (2010) [13]	University of Chicago (2015) [14]	University of Potsdam (2014)[15]	New York University (2006) [16]	Greening Universities Toolkit (2013)[17]	Suan Sunandha Rajabhat University (2014)[18]	Mahidol University (2014) [19]	University of Technology Thonburi (2014) [120]	Thammasat University (2014)[21]	Kasetsart University (2014) [22]
Energy and Climate Change											
Utilization of Energy-Saving Electronic Devices	✓	✓					✓	✓	✓	✓	✓
Alternative Energy Policies		✓	✓	✓	✓		✓	✓	✓	✓	✓
Amount of Energy Usage (kilowatt/hour per year)			✓	✓	✓	✓	✓	✓	✓	✓	✓
Energy Conservation Projects	✓	✓	✓				✓	✓	✓	✓	✓
Green Building Components		✓					✓	✓	✓	✓	✓
Global Warming Mitigation Projects							✓	✓	✓	✓	✓
Greenhouse Gases Mitigation Projects	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓

TABLE III: WASTE

Categories and Indicators	Universiti Kebangsaan Malaysia (2015) [12]	University of Oslo (2010) [13]	University of Chicago (2015) [14]	University of Potsdam (2014)[15]	New York University (2006) [16]	Greening Universities Toolkit (2013)[17]	Suan Sunandha Rajabhat University (2014)[18]	Mahidol University (2014) [19]	University of Technology Thonburi (2014) [120]	Thammasat University (2014)[21]	Kasetsart University (2014) [22]
Waste											
Recycling Projects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Toxic Waste Recycling		✓	✓	✓	✓		✓	✓	✓	✓	✓
Organic Waste Disposal	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Non-organic Waste Disposal	✓	✓	✓		✓		✓	✓	✓	✓	✓
Wastewater Treatment		✓	✓		✓		✓	✓		✓	✓
Paper and Plastic Reduction Policies	✓	✓	✓		✓		✓	✓	✓	✓	✓

Table VI, presents the education indicators from the UI GreenMetric involving the number of courses related to environment and permanence, research funds, the number of academic publications, and the websites about environment and sustainable development. The 50% or more accepted indicators resulting from the references will be used in the survey assessment to input data into the Green University Resource Planning System in the future.

Therefore, according to the document analysis results based on the Green University Indicators summarized from the indicator analysis into six parts and based on the criteria of the UI GreenMetric World University Ranking 2016, each indicator was differentiated by the context, geography, budget, location and internationality. The 50% or more accepted indicators resulting from the references will be used in the survey assessment to input data into the Green

University Resource Planning System in the future [23]-[25].

Part 2 the survey assessment to input data into the Green University Resource Planning System by the experts can be summarized as Table VII.

TABLE IV: WATER

Categories and Indicators	Universiti Kebangsaan Malaysia (2015) [12]	University of Oslo (2010) [13]	University of Chicago (2015) [14]	University of Potsdam (2014)[15]	New York University (2006) [16]	Greening Universities Toolkit (2013)[17]	Suan Sunandha Rajabhat University (2014)[18]	Mahidol University (2014) [19]	King Mongkut's University of Technology Thonburi (2014) [120]	Thammasat University (2014)[21]	Kasetsart University (2014) [22]
Water											
Water Conservation Projects	✓	✓					✓	✓	✓	✓	✓
The Percentage of Water Usage	✓		✓	✓	✓	✓		✓			

TABLE V: TRANSPORTATION

Categories and Indicators	Universiti Kebangsaan Malaysia (2015) [12]	University of Oslo (2010) [13]	University of Chicago (2015) [14]	University of Potsdam (2014)[15]	New York University (2006) [16]	Greening Universities Toolkit (2013)[17]	Suan Sunandha Rajabhat University (2014)[18]	Mahidol University (2014) [19]	King Mongkut's University of Technology Thonburi (2014) [120]	Thammasat University (2014)[21]	Kasetsart University (2014) [22]
Transportation											
Number of Vehicles on Campus			✓				✓	✓		✓	✓
Average Number of Cars on Campus per Day			✓				✓	✓		✓	✓
Average Number of Bicycles on Campus per Day			✓				✓	✓		✓	✓
Cars and Motorcycles Reduction Policy on Campus		✓	✓				✓	✓	✓	✓	✓
Parking Restriction and Reduction Policies		✓	✓				✓	✓	✓	✓	✓
Campus Buses		✓	✓		✓		✓	✓	✓	✓	✓
Pedestrians and Bicycles Facilitation Policies		✓	✓		✓		✓	✓	✓	✓	✓

TABLE VI: EDUCATION

Categories and Indicators	Universiti Kebangsaan Malaysia (2015) [12]	University of Oslo (2010) [13]	University of Chicago (2015) [14]	University of Potsdam (2014)[15]	New York University (2006) [16]	Greening Universities Toolkit (2013)[17]	Suan Sunandha Rajabhat University (2014)[18]	Mahidol University (2014) [19]	King Mongkut's University of Technology Thonburi (2014) [120]	Thammasat University (2014)[21]	Kasetsart University (2014) [22]
Education											
Total Number of Environment-related Courses and Disciplines					✓		✓	✓	✓	✓	✓
Total Number of All Courses and Disciplines							✓	✓		✓	✓
Total Number of Environment-related Research Funds		✓					✓	✓	✓	✓	✓
Total Number of Research Funds		✓					✓	✓		✓	✓
Total Number of Environment-related Publications			✓				✓	✓	✓	✓	✓
Total Number of Publications							✓	✓		✓	✓
Total Number of Environment-related Student Organizations		✓					✓	✓	✓	✓	✓
Total Number of Environment-related Informative Websites		✓	✓				✓	✓	✓	✓	✓

TABLE VII: THE SURVEY ASSESSMENT RESULTS TO INPUT DATA INTO THE GREEN UNIVERSITY RESOURCE PLANNING SYSTEM

Assessment Criteria	$\overline{X}$	*S.D.*	Results
Setting and Infrastructure			
Total Size of Campus (square metres)	4.56	0.68	Highest
Total Building Area (square metres)	4.44	0.68	High
Total Forest Areas (square metres)	4.44	0.68	High
Total Gardening Areas and Fields (square metres)	4.56	0.68	Highest
Total Absorbed Water Areas (square metres)	4.44	0.68	High
Current Number of Professors, Staff and Students (person/academic year)	4.56	0.68	Highest
Budget for Environmental Conservation (total budget of university)	4.56	0.96	Highest
Total	**4.51**	**0.72**	**Highest**
Energy and Climate Change			
Utilization of Energy-Saving Electronic Devices	4.78	0.63	Highest
Alternative Energy Policies	4.78	0.63	Highest
Amount of Energy Usage (kilowatt/hour per year)	4.67	0.67	Highest
Energy Conservation Projects	4.78	0.63	Highest
Green Building Components	4.67	0.47	Highest
Greenhouse Gas Mitigation Projects	4.78	0.63	Highest
Total	**4.74**	**0.61**	**Highest**
Waste			
Recycling Projects	4.89	0.31	Highest
Toxic Waste Recycling	4.56	0.96	Highest
Organic Waste Disposal	4.78	0.63	Highest
Inorganic Waste Disposal	4.67	0.67	Highest
Wastewater Treatment	4.78	0.63	Highest
Paper and Plastic Reduction Policies	4.89	0.31	Highest
Total	**4.76**	**0.58**	**Highest**
Water			
Water Conservation Project	4.78	0.42	Highest
The Percentage of Water Usage (cubic meter/academic year)	4.78	0.63	Highest
Total	**4.78**	**0.52**	**Highest**
Transportation			
Number of Vehicles on Campus	4.22	0.79	High
Amount of Gasoline Usage of a Vehicle (litre/academic year)	4.56	0.50	Highest
Number of Cars on Campus Per Capita (car/person)	4.44	0.68	High
Campus Buses (a bus for travelling inside college or university both of free or having a service charge)	4.56	0.68	Highest
Limited Vehicle Usage on Campus Policies	4.33	0.82	High
Parking Restriction and Reduction Policies	4.33	0.82	High
Promoting Bicycle Usage Instead of Cars on Campus Policies	4.56	0.68	Highest
Pedestrians and Bicycle Facilitation Policies	4.56	0.68	Highest
Total	**4.44**	**0.71**	**High**
Education			
Total Number of All Courses and Disciplines (per academic year)	4.22	0.92	High
Total Number of Environment-related Courses and Disciplines (per total amount of courses and disciplines which are opened)	4.56	0.50	Highest
Total Number of Research Funds (per academic year)	4.00	0.94	High
Total Number of Environment-related Research Funds (per total research budget)	4.44	0.68	High
Total Number of Environment-related Publications Per Academic Year	4.44	0.96	High
Total Number of Publications Per Academic Year	4.56	0.68	Highest
Total Number of Environment-related Student Organizations	4.33	0.82	High
Total Number of Environment-related Informative Websites	4.33	0.82	High
Total	**4.36**	**0.79**	**High**

As shown in Table VII, the results of the survey assessment to input data into the Green University Resource Planning System by the experts indicates the overall appropriateness of the survey was rated at the highest level ($\overline{X}$ =4.55, S.D. =0.69). Moreover, the survey can be summarized as follows: 1) Setting and Infrastructure criteria: the appropriateness of the survey was rated at the highest level ($\overline{X}$ =4.51, S.D. =0.72). 2) Energy and Climate Change criteria: the appropriateness of the survey was rated at the highest level ($\overline{X}$ =4.74, S.D. =0.61). 3) Waste criteria: the appropriateness of the survey was rated at the highest level ($\overline{X}$ =4.76, S.D. =0.58). 4) Water criteria: the appropriateness of the survey was rated at the highest level ($\overline{X}$ =4.78, S.D. =0.52). 5) Transportation criteria: the appropriateness of the survey was rated at a high level ($\overline{X}$ =4.44, S.D. =0.71). 6) Education criteria: the appropriateness of the survey was rated at a high level ($\overline{X}$ =4.36, S.D. =0.79).

V. Discussion

The results of the research on the idea of Green University Resource Planning on cloud computing, analysing the indicators in the criteria of the UI GreenMetric World University Ranking 2016, were assessed into six areas consisting of 1) setting and infrastructure, 2) energy and climate change, 3) waste, 4) water, 5) transportation, and 6) education. The 50% or more accepted indicators resulting from the references will be used in the survey assessment to input data into the Green University Resource Planning System. Therefore, the researcher used the data derived from synthesizing to support the input of data into the Green University Resource Planning System specifically related to the university operations [2], [26], [27]. This was differentiated by the context, geography, budget, location and internationality observed in the university environment to develop the organization sustainably and in an environment-friendly way [28]-[30].

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