icsbe 2014
Third international Conference on Sustainable Built Environment
Faculty of Civil Engineering and Planning Islamic University of Indonesia

ISTEcS
International Seminar on Tropical Eco Settlements
The Research Institute for Human Settlement Ministry of Public Works, Indonesia

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CONFERENCE PROCEEDINGS

3rd International Conference on Sustainable Built Environment (ICSBE)
"Resilience and Risk Reduction Towards Well Being Society"

4th International Seminar on Tropical Eco-Settlements (ISTEcS)
"Bringing Coastal Cities Into The Future: Challenges, Adaptation, and Mitigation"

Editors:
Mochamad Teguh - Islamic University of Indonesia, Indonesia
Anita Firmanti - Ministry of Public Works, Indonesia
Thomas Boving - University of Rhode Island, USA
Akihisha Kitamori - Kyoto University, Japan
Thanongsak Imjai - Rajamangala University of Technology, Thailand

Inna Garuda Hotel
Yogyakarta, October 21-22, 2014

CONFERENCE PROCEEDINGS

The 3rd International Conference on Sustainable Built Environment (ICSBE)

RESILIENCE AND RISK REDUCTION TOWARDS WELL-BEING SOCIETY

In collaboration with:

The 4th International Seminar on Tropical Eco-Settlements (ISTEcS)

BRINGING COASTAL CITIES INTO THE FUTURE: CHALLENGES, ADAPTATION, AND MITIGATION

Inna Garuda Hotel, Yogyakarta, Indonesia
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Agency of R&D Ministry of Public Work, Indonesia

International University Partners:

University of Rhode Island

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Welcome Speech

The Chairman of Organizing Committee

Assalamu'alaikum warrahmatullahi wabarakatuh,

The honorable;

- Rector of UII, Ir. Harsoyo, M.Sc., Ph.D.,
- Director General of Spatial Planning, Ministry of Public Works, Indonesia, Dr. M. Basoeki Hadimoeljono,
- Director General of Agency for Research and Development, Ministry of Public Works, Indonesia, Ir. Waskito Pandu, MSc.,
- The Head of Research Institute for Human Settlement, Ministry of Public Works Indonesia, Prof. Dr. Ir. Anita Firmanti, MT.,
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- Conference's Partners: University of Hawai'i at Manoa – USA, Univesity of Rhode Island – USA, Fatih Sultan Mehmet University – Turkey, Disaster Research Center Gadjah Mada University – Indonesia, Kyoto University – Japan, Rajamangala University of Technology – Thailand,
- Keynote speakers: Prof Thomas Boving, Ph.D., Prof. Farhad Atash, Ph.D., Prof. Mochamad Teguh, Ph.D., Dr. Dadang Rukmana, Prof. Dr. Ir. Anita Firmanti, MT., Prof. Aris Marfa'i, Thanongsak Imjai, Ph.D.
- Participants of the 3rd ICSBE 2014 and the 4th ISTEcS.
- Distinguished Guest, ladies and gentlemen,

Welcome to Yogyakarta!

The International Conference on Sustainable Built Environment (ICSBE) was first launched in 2010 with the theme "Enhancing Disaster Prevention and Mitigation". The second conference was launched in 2012 with the theme "Livable Cities in the Fast-Growing Countries". This year, the third ICSBE 2014 presents the theme "Resilience and Risk Reduction Towards Well-Being Society", which is a fine match with the position of Yogyakarta as the one of resilient cities in Indonesia due to its prone disaster location. A resilient city is able to survive a traumatic blow to its physical infrastructure, its economy, or its social fabric.

A resilient city bends but does not break; it absorbs impacts without shattering. Even if the bridges and roads are ruined and the buildings toppled, the resilient city's core institutions survive; its social fabric holds; and in time, its economy rebounds. Resilience can be difficult or even impossible to gauge a city's true rebound capacity until an actual disaster is at hand. A city"s degree of resilience can also change over time; the same kind of event can yield very different outcomes depending on prevailing socioeconomic conditions. The conference aims to better understand how resilient is perceived in the societies. What problems need to be tackled in the planning and design of the built environment in order to achieve such resilient? The conference presents five sub themes comprising urban/rural environments and settlements, building and constructions, infrastructures, policies and management, and coastal cities.

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The Organizing Committee received 140 abstracts coming from 9 different countries and covering in 5 specified sub-topics. The scientific committee members blindly reviewed to all submitted abstracts and have provided technical comments to the author/s with regard to ensure that the submitted full paper is qualified. After reviewing process to overall submitted papers, the scientific committee has decided to receive 69 papers only and the authors were invited to present his/her paper in the conference. It should be noted that papers not presented in the conference session are excluded in the conference proceedings. Finally, there are 54 presented papers included in the conference proceedings covering the sub-topics as follows:

1. Urban/rural Environments and Settlements: 16 papers
2. Building and Constructions: 19 papers
3. Infrastructures: 8 papers
4. Policies and Management: 6 papers
5. Coastal Cities: 5 papers

This program will not take place without the generous support from our partners. Therefore, I would like to extend my gratitude to Bank Mandiri, Bank Syariah Mandiri, Bank Muamalat for co-sponsoring this event.

My gratitude also goes to our international invited speakers: Prof. Thomas Boving, Ph.D. and Prof. Farhad Atash, Ph.D. – University of Rhode Island (URI), USA, Prof. Mochamad Teguh, Ph.D. – Universitas Islam Indonesia (UII), Prof. Aris Marfa'i – Gadjah Mada University, Prof. Dr. Ir. Anita Firmanti, MT. – Ministry of Public Works (PUSKIM), Indonesia, Dr. Dadang Rukmana – Director of Urban Planning and Development, Directorate General of Spatial Planning and Development, Ministry of Public Works. Thanongsak Imjai, Ph.D. – Rajamangala University of Technology, Thailand. Finally, I must thank all members of the organizing committee for making this event possible.

Wassalamu'alaikum warrahmatullahi wabarakatuh

Yogyakarta, October 21, 2014

ICSBE General Chair of Organizing Committee

Suparwoko, Ph.D.

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Welcome Speech

Director of Research Institute for Human Settlements

4th. International Seminar on Tropical Eco-Settlements

"Bringing Coastal Cities into the Future: Challenges, Adaptation, and Mitigation"

It is a great pleasure to welcome you at the 4th. International Seminar on Tropical Eco-settlements (ISTEcS), which is held in the beautiful city, Yogyakarta. To our overseas participants, let me welcome you once again to our country, Indonesia.

The ISTEcS is a bi-annual event since 2006 with the only exception of 2008, hosted by Research Institute for Human Settlements (RIHS) Ministry of Public Works Indonesia. As previous seminars in the series that each had emphasis on specific issues related to tropical settlements, this year's ISTEcS will also focus on the sustainability challenges of coastal cities in tropical zones arising from sea level rise, climate change, and land subsidence. These phenomena have become a global concern as they could put populations of these cities at greater risk of flooding and other climatic disasters. Adaptation and mitigation are thus two fundamental terms within this context.

Efforts must be taken to bring coastal cities to the future. We believe all adaptative and mitigating measures require every stakeholder to hold hand together in collaboration. With this seminar, we therefore seek to establish a forum for government officials, researchers, academicians, industry practitioners, non-governmental and multinational organization staff members to share their views and experiences on managing sustainable coastal cities. No less important is an opportunity to build collaborative partnerships with experts of different scientific areas and country of origins.

The 2014's ISTEcS is also special in the way that this event is organized in collaboration with the 3rd. International Conference on Sustainable Built Environment (ICSBE), hosted by Islamic University of Indonesia (UII), following a previous cooperative agreement signed not long ago between UII and RIHS. Such a collaboration, rather than rivaling one another, would have benefited both institutions as well as prospective participants. Not only could we share our resources for mutual goal, we could also take advantage on enhanced networks for our future works.

Our secretariats have received about 60 technical papers covering different aspects of urban/rural settlements, including coastal cities as a special issue of the joint seminars. To ensure the quality of papers to be published in the conference proceedings, all accepted papers have undergone a blind review process by our scientific committee members and professionally been edited in accordance with the given template. These papers will be presented in parallel sessions for two consecutive days.

We sincerely hope that these joint seminars will prove beneficial and valuable for you, all the seminar participants. Besides attending the seminars, you may also find time to visit many local attractions of Yogyakarta.

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Finally, as the RIHS Director, I wish you productive discussions during paper presentations and a very pleasant stay in Yogyakarta.

Yogyakarta, October 21, 2014

Director of Research Institute for Human Settlements

Prof. Dr. Ir. Anita Firmanti, MT.

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Welcome Speech

The Dean, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia

Assalamu'alaikum warrahmatullahi wabarakatuh

The honorable:

- Rector of UII, Ir. Harsoyo, M.Sc., Ph.D.,
- Director General of Spatial Planning, Ministry of Public Works, Indonesia, Dr. M. Basoeki Hadimoeljono,
- Director General of Agency for Research and Development, Ministry of Public Works, Indonesia, Ir. Waskito Pandu, MSc.,
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- Participants of the 3rd ICSBE 2014 and the 4th ISTEcS.
- Distinguished Guest, ladies and gentlemen,

First of all, praise is to Allah, the Cherisher and Sustainer of the world, for His blessing for all of us. He who has provided us a chance so that we could be here to share knowledge, ideas, solutions and experiences in the Third International Conference on Sustainable Built Environment (ICSBE) 2014. To the academic, our colleagues from the overseas universities, guests, participants, students and so on, please accept our gratitude, warm welcome and appreciation.

In the last decade, there were several disasters occurred in Indonesia. Yogyakarta, as one of big cities in Indonesia, had been facing two great disasters in 2006 and 2010. The first disaster was an enormous M 5,9 earthquake, the victims was very devastating, more than 5.700 deaths and 37.000 injuries. The total financial losses was USD 3,1 billions. The second disaster was Merapi Volcano Eruption, which killed hundreds of people in 2010. These disasters have given us extra experiences how to protect our communities and the environment.

Resilience and risk reduction has been a really important part in order to overcome the disasters in future, and then societies have the key role to play that. The disasters were causing many casualties, injuries, and financial losses because the societies do not know the proper action. Many parties take involve in activities of resilience and risk reduction, they teach the resilience and risk reduction to societies living in the prone disaster areas. A city with a robust, diversified economy, for example, will rebound much more quickly than a city with a narrowly specialized or weak economy. Planning, too, can dramatically bolster a city‟s resilience. Well-rehearsed evacuation and emergency management plans can enable a city to endure a crisis with minimal loss of life. Cities that invest in hazard mitigation planning and action can also reduce their vulnerability.

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The Third International Conference on Sustainable Built Environment (ICSBE) 2014 takes issues in this urgent agenda of "resilience and risk reduction towards well-being society". The conference takes role as the media to share wisdom and experiences, and develop knowledge as well as skill and recent technologies on applied built environment sciences and technologies. This conference conducted with participants from different background study is expected to have integrated solution of resilience and risk reduction towards well-being society. We will discuss five sub themes comprising urban/rural environments and settlements, building and constructions, infrastructures, policies and management, and coastal cities.

Let me deeply state a special appreciation to the Research Institute for Human Settlement, Ministry of Public Works (PUSKIM) who has fully support this conference so that joint host of this conference between FCEP UII and PUSKIM is well managed. It is a great pleasure to acknowledge the invited speakers; Prof. Thomas Boving, Ph.D. and Prof. Farhad Atash, Ph.D. – University of Rhode Island (URI), USA, Prof. Mochamad Teguh, Ph.D. – Universitas Islam Indonesia (UII), Prof. Aris Marfa'i – Gadjah Mada University, Prof. Dr. Ir. Anita Firmanti, MT. – Ministry of Public Works (PUSKIM), Indonesia, Dr. Dadang Rukmana – Director of Urban Planning and Development, Directorate General of Spatial Planning and Development, Ministry of Public Works, Thanongsak Imjai, Ph.D. – Rajamangala University of Technology, Thailand. I also would like to extend my special thanks and high appreciation to our sponsors: Bank Mandiri, Bank Syariah Mandiri, Bank Muamalat for their generous support to take place this conference. Our appreciation is also for all participants who have actively written excellent research papers.

Finally, my special thanks go to Rector of UII, all the steering and organizing committees for making this conference possible. It is desired to have a sustainable conference to be held continually in future times, as we are challenged by daily minor and major disasters to make a well-being society.

Wassalamu'alaikum warrahmatullahi wabarakatuh

Yogyakarta, October 21, 2014

Faculty of Civil Engineering and Planning (FCEP)

Universitas Islam Indonesia

The Dean

Dr.-Ing. Widodo Brontowiyono.

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Welcome Speech

The Rector of Islamic University of Indonesia

Assalamu'alaikum Warahmatulahi Wabarakatuh

- The Honorable, Dean of Faculty of Civil Engineering and Planning Universitas Islam Indonesia, Dr.Ing. Widodo Brontowiyono,
- Director General of Spatial Planning, Ministry of Public Works, Indonesia, Dr. M. Basoeki Hadimoeljono,
- Director General of Agency for Research and Development, Ministry of Public Works, Indonesia, Ir. Waskito Pandu, MSc.,
- The Head of Research Institute for Human Settlement, Ministry of Public Works Indonesia, Prof. Dr. Ir. Anita Firmanti, MT.,
- Respectable all of the keynote speakers and participants,

Distinguished guests, ladies, and gentlemen,

On this special occasion, let us offer our praise and gratitude to Allah SWT for it is with His mercy and grace that we are able to attend the 3rd International Conference on Sustainable Built Environment (ICSBE) today.

On behalf of the university, we are honored and very pleased to have your visit today especially to the keynote speakers and all participants. It is also a pleasure for me to extend everyone a warm welcome to Universitas Islam Indonesia (UII), the oldest national university in the country.

Distinguished speakers, ladies, and gentlemen,

We are also honored to inform you that this program is jointly hosted by Faculty of Civil Engineering and Planning, UII and The Research Institute for Human Settlements, Agency of Research and Development Ministry of Public Work, Republic of Indonesia (PUSLITBANGKIM KEMEN PU RI). We hope that this activity will establish closer ties and cooperation between the two institutions in the future.

This 3rd International Conference on Sustainable Built Environment (ICSBE) is conducted under the topic 'Resilience and Risk Reduction towards Well-Being Society' in association with the 4th International Seminar on Tropical Eco-Settlement (ISTEcS) under the theme 'Bringing Coastal Cities into the Future: Challenges, Adaptation and Mitigation.

Distinguished guests, ladies, and gentlemen,

We are fully aware that the population growth in the last centuries grows rapidly. A growing population leads to several environmental issues as well as social problems. This means that a better setting of the settlement is very important to make a city become livable. Inspired by that notion, this conference in one hand is aimed to better understand how livability is perceived in the fast-growing cities.

In the other hand, this conference will provide the opportunity to government officials, researchers, academicians, industry practitioners, non-governmental and multinational organization staffs and other stakeholders to share their views and experiences to build

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international collaborative networks on managing sustainable coastal cities. Some important issues that will be presented on this seminar are about how to handle all the problem of the urban/rural environment, how to assess the risk of building and construction, infrastructure, politics management, and coastal cities. All that issues are intended to build a well-being society with a good reduction of risk and reliance.

Distinguished speakers, ladies, and gentlemen,

To conclude, once again I extend everyone my warm welcome to this conference. I hope that this conference will inspire us to enhance our awareness to explore any possibilities in building resilient society. Also, I look forward to fruitful discussions and hope we can be inspired by the best practices we will hear from our distinguished speakers.

I thank you.

Wassalamu'alaikum Warahmatullahi Wabarakatuh.

Yogyakarta, October 21, 2014

Rector

Dr. Ir. Harsoyo, M.Sc.

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ENERGY CONSUMPTION AND THERMAL COMFORT FAVORED BY THE OCCUPANTS IN THE AIR CONDITIONED HOUSE

SUGINI[1], Jaka NUGRAHA[2]

ABSTRACT: This paper is part of a research report sponsored by the Indonesia Higher Education titled PMVtapsem Model of Thermal Comfort Saving Energy in Air Conditioned Building. Phase previous studies have found the best PMVtapsem thermal comfort models. From the test results it can be concluded that the model PMVtapsem models are models that can explain the concept of the relationship of thermal comfort hierarchical veriabel appropriately. However, for the determination of comfortable thermal range in order to thermally comfortable standard setting, it turns out the model PMVtap Sugini 2007 more precision and more simple than the models PMVtapsem. The next research phase will include the following steps: (1) Looking for a model of the relationship between the energy consumption of air conditioned homes with thermal comfort settings favored by the occupants; (2) Test the comfortable range of thermal based thermal index PMVtap Sugini 2007 experimentally in controlled air conditioned room; (3) Connect a comfortable thermal range of the result of step (2) with a model of the relationship of energy consumption in homes air conditioned in step (1). Observation in the air conditioned house is the method being used in this research. The variable observed are the thermal comfort indicated by the Air Conditioned option and energy consumption variable indicated by the raising of electricity account as the result of AC usage per unit AC loads. The population in this research are the air conditioned house with its occupants. The data collection involve 234 family. The second is to determine the setting of thermal comfort in the air conditioned room and the relation between the energy consumption and thermal comfort setting in air conditioned room to figure out the increasing energy consumption due to the favorite thermal comfort option. The conclution of this research shows that the relation between the comfort thermal (AC setting) with the energy consumption could be shown in the pattern y= 0.342 + 0.00432 x and y = 1.44 – 0.0291 x. Thermal comfort range perceived comfortable by 80% of occupants between PMV-0,75 up to 1,7 or PMVtap-1,29 up to PMVtap 1,21 and 23º ET up to 30,5 º ET in AC setting with the temperature 25 and fan 1 and 5 up to 30 and fan 1. The increasing of energy consumption on the thermal comfort option of 0,45 % per one unit workloads (per day per PK) for 25 degree Celcius temperature setting with the low fan. 0,882 % per unit workloads for 25 degree Celcius temperature setting with the maximum fan and 0,47% per unit workloads with 30 degree celcius temperature with low fan. By ignoring the fan setting, thus with the 25 degree celcius fan setting will increase the energy consumption for 2,3% per unit workload.

KEYWORDS : Sustainability, thermal comfort, energy consumption, air-conditioned house

1. INTRODUCTION

1.1. BACKGROUND OF THE PROBLEM

Global warming happening nowadays have a strong relation with the number of world energy consumption. The whole world energy consumption was used 45,36% for the building. Out of the highest energy used for the building operational was used for the artificial air in the air conditioned room (Wigginton dkk, 2006). Thus, this research was directed to the operational of artificial air energy efficient using air conditioned is urgent and important.

The development of index model of the energy efficient thermal comfort become very urgent and fundamental to be done. By this research, the standart range of comfort thermal could

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be composed by considering the physical-physiological and psychological aspect, also the aspect of energy efficient will be the correction of the existing standart thermal quality. In the end, the corrective standar of comfort thermal will reduce the air-condition (AC) workload in a air-conditioned room. The regression of one AC for 600 watt by one hour in a day will save the operational expenses for the Rp 130.000.000,00 energy a year and reduce the pollutan gas production CO2 by 160 kg/ year. This saving would be multiplied with the number of AC operated in Indonesia. Next, the thermal comfort standart based on this energy efficient thermal index PMVtapsem will be the basic of the development of design direction.

Sugini, 2007 based on the index model of PMVtap already construct the thermal comfort range. This range will be decreased mathematically. By mathematic calculation, Sugini assumed the resulted range will have the chance to reduce the thermal energy workload in air-conditioned room. The question is how the reality in the real operational level? Comfort thermal for the air-conditioned room measured by several index. SNI put the thermal comfort standart on ET while ISO put the standart on PMV index thermal. Those standart developed by SUgini 2007 into the PMVtap and expanded its development on 2013-2014 by Sugini and Jaka Nugraha on research funded by higher education directorate using Fundamental Scheme research. This paper were part of those research

The attainment of the comfort thermal air-conditioned room done by the occupants by the option of AC setting on the temperature and fan. While the energy consumption due to the AC usage could be seen on the amount of electricity account bill.

1.2. THE FORMULATION OF THE PROBLEM

- How is the relation pattern between the thermal comfort setting air-conditioned house with the increasing of energy consumption?
- How was the range of favourite comfort thermal in the air-conditioned house?

1.3. THE PURPOSE OF THE RESEARCH

- To figure out the relation pattern between the thermal comfort setting air-conditioned house with the increasing of energy consumption
- To find out the favourite comfort thermal range in a air-conditioned house
- To find out the energy consumption due to the favourite AC setting

2. THEORITICAL FRAMEWORK

2.1. STATE OF ART THERMAL RESEARCH THE RANGE OF THERMAL COMFORT AND ENERGY EFFICIENCY

Study about the range of comfort thermal has been done inside and outsine Indonesia. Based on Sugini's research (Sugini, 2007) can be concluded that based on the equation of PMVtap Sugini and the regression relationship between PMW with ta and ET* for the scope of case on the air conditioned room group could be known that every increasing 0,1 degree PMW would impact the increasing temperature for 0,56 Celcius Degree. This meant that by principle the standart of thermal comfort in air conditioned room could be increase by 2,968 degree celcius.

If this theory being implemented in a practical level, especially in a air-conditied building, it will give a significant impact. According to Oseland (1994) every one degree regression on AC usage it will reduce at least 10% energy consumption of the artificial operational air in the building, save 5 % or household energy consumption and 3% save the office operational

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expenses. Thus the increasing air temperature for 2,968 degree celcius will save 29,68 energy consumption on operational building artificial air. The next question arise, by using the analysis SEM model is it possible to produce the thermal index model PMVtapsem which have more chance to formulate the range of the energy-efficient comfort thermal? This research was trying to answer that question.

Muhammad Nur Fajri Alfata Fanny Kusumawati, 2011, compare two of the Triharsokaryono research on 1998 and 2011. In 18 years range on the same object and group sample shows the similarity that comfort thermal based on thermal index PMV and PPD was not suitable with the range of thermal comfort by the occupants. Respondent could receive the higher comfort thermal range. The conclution of those research shows that there are still enormous opportunity to develop better standart seen from the demands of the occupants nor the energy conservation. The next question that should be answered are (1) how high the range of thermal comfort range which is acceptable so it can give significant impact on the decreasing energy need for the air control; (2) If the index PMV and PDD can not be used to predict the range of comfort thermal, what is the suitable index thermal for the Indonesian condition? These two question can be answered by this research.

Sujatmiko Wahyu, 2010 found out that based on perception of the occupant condition thermal comfort of the observation area below the neutral poin. This research shows the same indication that during this time the building operation with the setting of comfort thermal setting has not suitable with the potention of the occupant ability to adapt with the comfort thermal room. Thus, the real search of the comfort thermal range suitable with the ability of human psyschological to adapt and the pursuit the better index thermal will be an important thing to do. So this research is significant to be done because it will give significant effect.

In the previous year, this research already produce the index model of thermal comfort PMVtapsem (Sugini, Jaka Nugraha, 2013). However, for the interest of the thermal comfort range prediction, prove that Sugini's model, 2007 more appropriate compare with those PMVtapsem

3. DESIGN AND RESEARCH METHOD

3.1. POPULATION AND SAMPLE

The Purpose of this research require building unit could technically controlled. The unit which technically observed with the relative variable could be controlled by the limitation of the research is the air-conditioned house.

The observation step on energy consumption done by transversal way by increasing the number of respondent into 240 family. Questionner being distributed were 350. The searching of the range favourite thermal were done by the experiment method of controlled room with 15 conditioning involving 30 respondents. From this stage, 450 unit data were being processed.

4. RESEARCH FINDING

4.1. THE CONTROLLED RANGE OF THERMAL COMFORT IN AIR-CONDITIONED ROOM

Based on this research, the description of the sample are as follows; out of 450 data, only 399 up to 400 data could be analysed with the setting of the combination of experiment room which has the range of comfort thermal based on ET index with mean 28.045º ET by the range 21.100 º ET and 33.000 º ET. Based on PMV index room have the thermal comfort

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level by mean of 0,917 or inclined to warm with the value range between PMV -1,9600 dan PMV 2,1400. Based on the index PMVtap for the air-conditioned room formula by the thermal comfort 0,3755 or nearly warm with the scope of values between -2,4900 and 1,6100. However, based on the respondents perception, thus the combination of experimental room have the thermal comfort -0.1654 or rather cool.

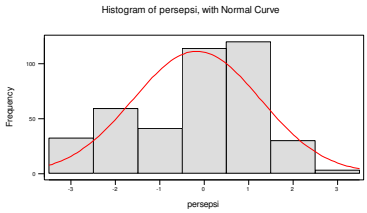

Figure 1. Room Thermal Comfort Profile based on Occupants Perception

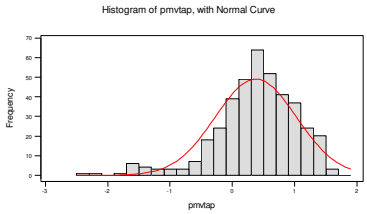

Figure 2. Room Thermal Comfort Profile based on thermal index PMVtap

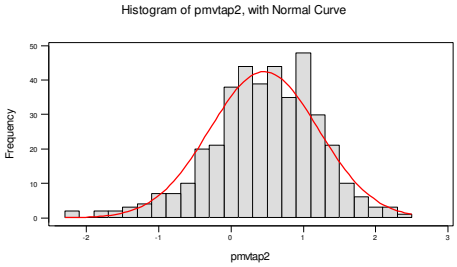

Figure 3. Room Thermal Comfort Profile based on thermal index PMVtap2

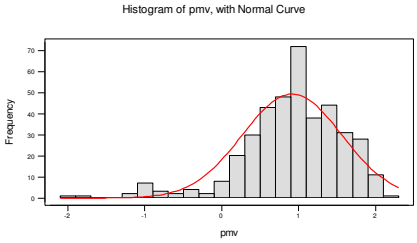

Figure 4. Room Thermal Comfort Profile based on thermal index PMV

The following table 1 explains setting and respondent percentage distribution on the perception of -3 (cold), -2 (cool), -1 (pretty cool), 0 (netral), 1 (pretty warm), 2 (warm), 3 (hot). If the perception tolerance considered to accept the thermal condition is between pretty cool (-1) and pretty warm (1), so the result of measurement result analysis shows that thermal comfort range that can be accepted by 80% room occupants is as showed on the following table:

Table 1. Setting and occupant percentage that can accept the thermal comfort

Setting	Perception							sum	%
	-3	-2	-1	0	1	2	3		recieve
AC25fan1	1	2	2	10	13	2	0	30	25
	3,333333	6,666667	6,666667	33,33333	43,33333	6,666667	0	100	83,33333
AC25fan5	0	1	2	11	12	4	0	30	25
	0	3,333333	6,666667	36,66667	40	13,33333	0	100	83,33333
AC30fan1	0	0	1	5	19	4	1	30	25
	0	0	3,333333	16,66667	63,33333	13,33333	3,333333	100	83,33333

From the table above, it can be known that experiment setting favored by 80% respondents are setting AC25fan1, AC25fan5 and C30fan1.

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Based on probability analysis, lower limit and upper limit of thermal comfort range can be formulated based on ET, PMV, PMVtap. Based on analysis, it can be inferred that thermal comfort range which is perceived comfortable by 80% room occupants is from PMV-0,75 to 1,7 or PMVtap-1,29 to PMVtap 1,21 on air-conditioner setting of 25 temperature degree and fan 1 and 5 until 30 temperature degree and fan 1.

4.2. THE SEARCH OF ENERGY CONSUMPTION OF AIR-CONDITIONERITIONED HOUSE TO DETERMINE ENERGY SAVING THERMAL COMFORT RANGE

4.2.1. The Implementation of Data Networking, Processing and Formulation of Relationship Model of Energy Consumption and Life Style of Air-conditioneritioned Thermal

As explained on the research method, energy consumption observation is conducted with transverse observation. From the data networking that was designed for 350 respondents, based on the data inputted, there were 234 people/house involved as respondents. Based on the data, filtering was done and finally central tendency could be obtained from sample characteristic.

The data above is the result of remuneration from raw data enclosed. From the raw data of air-conditioneritioned thermal life style signed by air-conditioner setting variable as independent variable (X1), while the dependent variable (Y2) is energy consumption variable. To get equivalent value, energy consumption variable is obtained by dividing the increase of electrical expense caused by the usage of air-conditioner with the workload. Burden is obtained by multiplying air-conditioner operation time variable (hour/month) and AC Capacity (PK).

The analysis of relationship model searching is done by using Regression Analysis. From the data, based on analysis, relationship pattern between thermal life style attitudes measured based on AC setting and energy consumption.

4.2.2. Sample Description

Based on sample average, the tendency can be described as following:

- *Air-conditioneritioned Thermal Life Style*

Thermal Life Style viewed from the usage of air-conditioner can be explained as following. Air-conditioner setting of overall respondent average i 21,59ºC. However, house air-conditioner setting outside Yogyakarta Spesial District, which is 23,25 ºC, tends to be higher than in Yogyakarta, which is 21,4ºC. Fan setting tends to be chosen by house occupants is *medium 76,36%.* The duration of air-conditioner average usage in one day is 8,66 hours, while the frequency of air-conditioner usage per month is 26,25 days. Therefore, the air-conditioner average workload is 233,54 hours/month. Air-conditioner capacity dominantly used on air-conditioner with 1 PK capacity is 59,49 %, while the one with 0,5 PK capacity is 34,8% and another is 6,32%. From three reason backgrounds (comfort, savings, both comfort and savings) to choose, the result shows 44% because of comfort, 48,9% because of both comfort and savings and 7,1% because of savings.

- *The Increase of Energy Consumption*

The increase of energy consumption shown by % increase of electricity expense caused by air-conditioner usage on the house research sample is 80,16%%. In detail, the increase as shown on the following table 4 and figure 3:

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The increase actually relates to temperature setting, fan setting, capacity and workload. In detail, it can be seen on the table 5, table 6, and figure 4 and 5. Therefore, to calculate the search for relationship between the increase of energy consumption and air-conditioner setting, the measures are equalized by using the increase parameter per workload unit. Workload unit itself is multiplication between the air-conditioner capacity and the duration of air-conditioner usage (hour/month).

4.2.3. The Model of Relationship between Energy Consumption and Air-conditioneritioned Thermal Life Style

The Model of Relationship is sought by analyzing linear regression. In this case, % of increase per workload unit is Y2 dependent variable and air-conditioner setting is independent variable. Air-conditioner setting in this case is measured using temperature parameter, fan and its multiplication (x1).

1. The Model of Regression between Y2 and air-conditioner setting (x1)

   From two models, linear and quadratic (enclosed), based on R value, the best one is following model on regression equation 1 as following illustration on figure 6.

   $$y = 0.342 + 0.00432\ x \qquad (1)$$

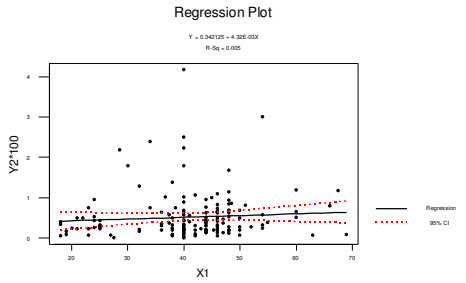

Figure 5. The Model of Regression between the increase percentage of energy consumption measured by using the increase of electricity expense and air-conditioner setting (the multiplication between temperature setting and fan setting)

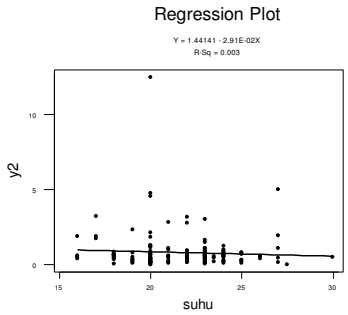

Figure 6. The Model of Regression between the increase of energy consumption and temperature setting

2. The Model of Regression between Y2 and temperature setting

   The detailed model on regression equation 2 as illustrated on figure 7.

   Regression Equation 2

   $$y = 1.44 - 0.0291\ x \qquad (2)$$

4.3. THERMAL COMFORT RANGE AND ENERGY CONSUMPTION

Based on analysis and discussion on 4.3 and 4.5, it can be simulated the calculation of energy consumption consequence seen from regression forumula 1 and 2, also setting range, as following.

Table 2. Setting and the increase of energy consumption

Setting	Temperature	Fan	Fan Temperature	Increase of Energy Consumtion	
				Regresion 1 (temperature x fan)	Regresion 2 (temperature)
				y = 0.342 + 0.00432x	y = 1.44 – 0.0291x
AC25fan1	25	1	25	0,45	2,1675
			0	0,342	1,44
AC25fan5	25	5	125	0,882	2,1675
			0	0,342	1,44
AC30fan1	30	1	30	0,4716	2,313

From the table above, it can be explained that air-conditioner setting of 25ºC with low fan will increase the energy consumption 0,45% per one unit of workload (per day per air-conditioner per PK). Air-conditioner setting of 25 ºC with high fan increases the energy 0,882% per workload unit. Air-conditioner setting of 30 ºC with low fan increases the energy 0,47% per workload unit. If seen from temperature setting by ignoring fan setting, fan setting of 25 ºC will increase the energy consumption 2,2% per workload unit and fan setting of 30 ºC increases the energy consumption 2,3% per workload unit.

5. CONCLUSION

Based on the research, it can be concluded that:

1. Thermal Comfort Range perceived comfortable by 80% room occupants is from PMV-0,75 to 1,7 or PMVtap-1,29 to PMVtap 1,21 and 23º ET to 30,5 º ET on air-conditioner setting of 25 and fan 1 and 5 to 30 and fan 1.
2. Relationship pattern between thermal comfort and energy consumption can be described as model of y = 0.342 + 0.00432 x1 and y = 1.44 - 0.0291 x. In which y is the increase percentage of energy consumption for each air-conditioner, each PK and hour/month usage and x1 is temperature setting and fan, x2 is temperature setting.
3. The increase of energy consumption on the thermal comfort setting of 25ºC with low fan is 0,45% per one unit of workload (per day per air-conditioner per PK). 0,882% per workload unit on the setting of 25ºC with maximal fan setting and 0,47% per workload unit on the setting of 30ºC with low fan. If ignoring fan setting, fan setting of 25 ºC will increase the energy consumption 2,2% per workload unit and setting of 30 ºC will increase the energy consumption 2,3% per workload unit

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