PROCEEDING

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9TH ISIEM

9th INTERNATIONAL SEMINAR ON INDUSTRIAL ENGINEERING & MANAGEMENT

ISIEM

"COLLABORATIVE INNOVATION TOWARDS BORDERLESS INDUSTRIAL AND ECONOMIC SYSTEM"

GRAND INNA MUARA
HOTEL CONVENTION & EXHIBITION
PADANG, WEST SUMATERA, INDONESIA
TUESDAY-THURSDAY, SEPTEMBER 20-22, 2016

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BKSTI BADAN KERJASAMA PENYELENGGARA PENDIDIKAN TINGGI TEKNIK INDUSTRI INDONESIA
PERSATUAN INSINYUR INDONESIA TEKNIK INDUSTRI

ISSN : 1978-774X

PROCEEDING

9th ISIEM

The 9th International Seminar on Industrial Engineering and Management

Grand Inna Muara Hotel Convention & Exhibition Padang,
West Sumatera, Indonesia, September 20 – 22, 2016

Organized by :

Industrial Engineering Department of

•Trisakti University• Al Azhar Indonesia University•
• Esa Unggul University•Telkom University•
•Tarumanagara University •Pasundan University •
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PREFACE

Dear Presenters and Delegates,

On behalf of the Organizing Committee, I am honored to welcome you to the 9th International Seminar on Industrial Engineering and Management (ISIEM). This seminar is organized by the Industrial Engineering Department from eight Universities, namely Trisakti University, Telkom University, Tarumanagara University, Atma Jaya Catholic University of Indonesia, Al Azhar Indonesia University, Esa Unggul University, Pasundan University, and Bung Hatta University.

The theme **"Collaborative Innovation Towards Borderless Industrial and Economic System"** which in accordance with the current economic era, we hope that through the exchange of ideas, experiences and recent progress in Industrial Engineering and Management from academicians, engineers, professionals and practitioners from Universities, research institutions, government agencies and industries be able to help us to deal with future challenges.

We hope that our presenter and delegates will gain many shared ideas and great experiences from this conference and also acquire additional insights from our honorable speakers, **Gursel Ilipinar, PhD** from ESADE Business School – Barcelona, **Profesor Emeritus Dato' Ir. Dr. Zainai Bin Mohamed** from UTM Razak School of Engineering and Advance Technology – Malaysia, **Milko-Pierre Papazoff** from Vice President of French External Trade Counsellor (Malaysian Chapter).

The success of this seminar is due to the hard efforts of many people who we gratefully acknowledge. Special thank to all reviewers, speakers, and presenters, also highly appreciate to the committee for mutual effort and invaluable contribution.

Finally, we hope you will enjoy this conference and the natural beauty of Padang city – Indonesia and see you in the next ISIEM.

Best wishes,

Chair of the 9th ISIEM 2016

Dr. Wisnu Sakti Dewobroto, M.Sc

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18. Ayu Bidiawati J.R, S.T.,M.T.	(Bung Hatta University)

KEYNOTE SPEECH

#1
Prof. Emeritus Dato' Ir. Dr. Zainai Bin Mohamed
UTM Razak School of Engineering and Advanced Technology
UTM International Campus

#2
Gursel Ilipinar, PhD
Innovation Management Expert
ESADE Business School - Barcelona

#3
Milko-Pierre Papazoff
VP of French External Trade Counsellor (Malaysian Chapter)

AGENDA

September 20, 2016

18:00 - 18:30	Registration
18:30 - 19:30	Dinner
19:30 - 19:40	Padang Dance by Bung Hatta University
19:40 - 19:45	Welcoming Speech from Head of Committee ISIEM 9th
19:45 - 20:00	Opening Ceremony by Bung Hatta University Rector
20:00 - 21:00	Keynote Speech # 1 **Prof. Emeritus Dato' Ir. Dr. Zainai Bin Mohamed** **(UTM Razak School of Engineering and Advanced Technology,** **UTM International Campus – Malaysia)** **Moderator:** Dr. Adianto, M.Sc.
21:00 - 21:15	Photo Session with all participants

September 21, 2016

6:30 - 8:00	Breakfast and Registration
8:00 - 9:00	Keynote Speech # 2 **Gursel Ilipinar, PhD** **(Innovation Management Expert** **ESADE Business School – Barcelona)** **Moderator:** Ir. Wahyukaton, M.T.
9:00 - 10:00	Keynote Speech # 3 **Milko-Pierre Papazoff** **VP of French External Trade Counsellor (Malaysian Chapter)** **Moderator:** Dr. Ir. Syarif Hidayat, M.Eng.Sc, M.M.
10:00 - 10:30	Question and Answer
10:30 - 11:15	Coffee and Tea Break
11:15 - 12:35	Parallel session #1
12:35 - 13:30	Lunch break
13:30 - 16:30	Parallel session #2
15:00 - 15:15	Coffee and Tea Break
18:30 - 20:00	Dinner

September 22, 2016

08:00	- 09:30	Parallel session #3
09:30	- 17:00	City Tour

PARALLEL SESSION

SEPTEMBER 21, 2016 SESSION 1 ROOM 1
Moderator : Dr. Lamto Widodo, S.T., M.T.

Time	Paper	Code	Paper Code
11.15-11.25	**MAINTENANCE PERFORMANCE MEASUREMENT TRANSJAKARTA BUS AT PERUM DAMRI SBU BUSWAY CORRIDOR I & VIII USING MAINTENANCE SCORECARD** Didien Suhardini, Iveline Anne Marie, Amal Witonohadi, Auliandi Fahriditya Putra Jurusan Teknik Industri, Fakultas Teknologi Industri, Universitas Trisakti, Jakarta, Indonesia	IM	110
11.25-11.35	**IDENTIFICATION OF SUPPLY CHAIN PERFORMANCE INDICATORS AND STRATEGIC OBJECTIVES USING THE BALANCED SCORECARD** Dwi Kurniawan, Adela Anggun Pertiwi, Lisye Fitria Industrial Engineering Department, Institut Teknologi Nasional, Bandung, Indonesia	SCM	26
11.35-11.45	**IMPROVEMENT TO QUALITY OF TELECOMMUNICATION SERVICE BY MINIMIZE FAILURE OF SIMKARI APPLICATION DEVICE (A CASE STUDY IN PT DATALINK SOLUTION)** M. Hudori Department of Logistic Management, Citra Widya Edukasi Polytechnic of Palm Oil, Bekasi, Indonesia	QM	79
11.45-11.55	**POSITIONING ANALYSIS FOR HIGHER EDUCATION BASED ON PERCEPTUAL MAPPING USING MULTIDIMENSIONAL SCALING** Hafizh Suharja, Yati Rohayati, Rio Aurachman School of Industrial and System Engineering, Telkom University, Bandung, Indonesia	IM	16
11.55-12.05	**IMPROVING THE SERVICE QUALITY OF DISTANCE EDUCATION USING INTEGRATION SERVICE QUALITY FOR HIGHER EDUCATION AND KANO** Istianah Nedia, Yati Rohayati, Maria Dellarosawati Idawicasakti School of Industrial and System Engineering, Telkom University, Bandung, Indonesia	QM	40
12.05-12.15	**DESIGN OF STANDARD OPERATING PROCEDURE (SOP) OF DESIGN AND DEVELOPMENT OF PRODUCT ACCORDING TO ISO 9001:2015 CLAUSE 8.3 BASED ON RISK BASED THINKING BY BUSINESS PROCESS IMPROVEMENT METHOD AT CV. XYZ** Rindy Aprilina Gita Prastyanti[1], Sri Widaningrum, Heriyono Lalu Faculty of Industrial Engineering, Telkom University, Bandung, Indonesia	QM	52
12.15-12.25	**DESIGN OF NONCONFORMITY AND CORRECTIVE ACTION STANDARD OPERATING PROCEDURE BASED ON INTEGRATED REQUIREMENTS FROM ISO 9001 AND ISO 14001** Rahmah Fadhilah, Sri Widaningrum, Heriyono Lalu Industrial Engineering Department, Telkom University of Engineering, Bandung Indonesia	QM	53

SEPTEMBER 21, 2016 SESSION 1 ROOM 1
Moderator : Dr. Lamto Widodo, S.T., M.T.

Time	Paper	Code	Paper Code
12.25-12.35	**DESIGN AND ANALYSIS PHYSICAL AND LOGICAL SECURITY USING TIA-942 AND ISO/IEC 27000 SERIES IN DATA CENTER OF PDII-LIPI** Mukhlis Anugrah Pratama, Mochammad Teguh Kurniawan, Information System Major, Industrial Engineering Faculty, Telkom University, Bandung, Indonesia	DSS	68

SEPTEMBER 21, 2016 SESSION 1 ROOM 2
Moderator : Dr. Ir. Syarif Hidayat, M.Eng.Sc, M.M.

Time	Paper	Code	Paper Code
11.15-11.25	**INCREASING PRODUCTIVITY WITH OBJECTIVE MATRIX METHOD CASE STUDY ON BUILDING MAINTENANCE MANAGEMENT PIO PT. XXX** R Bagus Yosan, Muhammad Kholil, Winny Soraya Industrial Engineering, Mercubuana University, Jakarta, Indonesia	IM	42
11.25-11.35	**LEAN PROJECT MANAGEMENT TO MINIMIZE WASTE, CASE STUDY : INDARUNGVI PROJECT, PT SEMEN PADANG** Nilda Tri Putri, Sarvina Department of Industrial Engineering, Faculty of Engineering, Andalas University, Padang, Indonesia	QM	38
11.35-11.45	**APPLICATION OF LEAN MANUFACTURING IN THE PRODUCTION OF SPUN PILE USING WASTE ASSESMENT MODEL AND VALUE STREAM ANALYSIS** Syarif Hidayat, Siti Nurlina Industrial Engineering Department, Faculty of Science and Technology, University Al Azhar Indonesia, Jakarta, Indonesia	PS	11
11.45-11.55	**THE IMPLEMENTATION OF CORPORATE SOCIAL RESPONSIBILITY OF STARBUCKS COMPANY** Charly Hongdiyanto Ciputra University, Indonesia	IM	72
11.55-12.05	**A MODIFIED ECONOMIC PRODUCTION QUANTITY (EPQ) WITH SYNCHRONIZING DISCRETE AND CONTINUOUS DEMAND UNDER FINITE HORIZON PERIOD AND LIMITED CAPACITY OF STORAGE** Jonrinaldi, Henmaidi, Nurike Oktavia Department of Industrial Engineering, Andalas University, Padang, Indonesia Master Program of Industrial Engineering, Andalas University, Padang, Indonesia	PS	44
12.05-12.15	**APPLICATION OF VALUE STREAM MAPPING IN THE NVOCC FCL SERVICE PROCESS TO MINIMIZE DELAY IN SUBMISSION OF THE DOCUMENT (A CASE STUDY IN PT YUSEN LOGISTICS INDONESIA)** M. Hudori, Nismah Panjaitan Department of Logistic Management, Citra Widya Edukasi Polytechnic of Palm Oil, Bekasi, Indonesia Department of Industrial Engineering, Sumatera Utara University, Medan, Indonesia	QM	76
12.15-12.25	**WAREHOUSE LAYOUT DESIGN USING SHARED STORAGE METHOD** Alan Dwi Wibowo, Rahmat Nurcahyo, Cut Khairunnisa Department of Agro-Industrial Technology,Universitas Lambung Mangkurat, Indonesia Departemen of Industrial Engineering, Universitas Indonesia,	PS	22

SEPTEMBER 21, 2016 SESSION 1 ROOM 2
Moderator : Dr. Ir. Syarif Hidayat, M.Eng.Sc, M.M.

Time	Paper	Code	Paper Code
	Indonesia		
12.25-12.35	**CABLE CLAMP PRODUCTION CAPACITY PLANNING USING ROUGH CUT CAPACITY PLANNING (RCCP) METHOD (A CASE STUDY IN PT FAJAR CAHAYA CEMERLANG)** M. Hudori Department of Logistic Management, Citra Widya Edukasi Polytechnic of Palm Oil, Bekasi, Indonesia	PS	80

SEPTEMBER 21, 2016 SESSION 1 ROOM 3
Moderator : Dr. Ir. Yogi Yogaswara, M.T.

Time	Paper	Code	Paper Code
11.15-11.25	**DEVELOPMENT OF ONLINE KNOWLEDGE MANAGEMENT CYCLE INDICATORS USING SECI APPROACH: CASE STUDY IN AN ENERGY COMPANY** Aldio Fikri Siddik, Amelia Kurniawati, Umar Yunan Kurnia Septo Hediyanto Industrial Engineering Department, Telkom University, Bandung, Indonesia Information System Department, Telkom University, Bandung, Indonesia	DSS	51
11.25-11.35	**MANAGEMENT INFORMATION SYSTEM FOR ORDER FULFILLMENT: A CASE STUDY** Johanes Fernandes Andry, Halim Agung, Yana Erlyana Faculty Technology and Design, Bunda Mulia University, Jakarta, Indonesia	DSS	3
11.35-11.45	**Risk Factor Analysis of Liquified Natural Gas (LNG) Supply Process Chain in Indonesia** Rahmat Nurcahyo, Farid Akbar, Yadrifil Kampus UI Depok Indonesia	SCM	14
11.45-11.55	**ENHANCING PENDULUM NUSANTARA MODEL IN INDONESIAN MARITIME LOGISTICS NETWORK** Komarudin, Muhammad Reza, Armand Omar Moeis System Engineering, Modeling and Simulation (SEMS) Laboratory, Department of Industrial Engineering, Universitas Indonesia	OR	49
11.55-12.05	**PURCHASING CONSORTIUM SYSTEM USING COMMON REPLENISHMENT EPOCH (CRE) MODEL BY DESIGNING MOBILE INFORMATION SYSTEM FOR SMALL and MEDIUM ENTERPRISES (SMEs)** Yudha Prasetyawan, Imam Baihaqi, Shinta Dewi Industrial Engineering Department, Sepuluh Nopember Institut of Technology, Surabaya, Indonesia Business and Management Department, Sepuluh Nopember Institut of Technology, Surabaya, Indonesia Agroindustrial Technology Department, Universitas Internasional Semen Indonesia, Indonesia	DSS	10
12.05-12.15	**DESIGN E-COMMERCE ANGON BASED ON MARKETPLACE TO INCREASE REVENUE FOR LIVESTOCK'S ACTORS (SELLING MODULE)** Atika Elysia, Irfan Darmawan, Muhammad Azani Hasibuan Department of Industrial Engineering, Telkom University, Bandung, Indonesia	IM	65

SEPTEMBER 21, 2016 SESSION 1 ROOM 3
Moderator : Dr. Ir. Yogi Yogaswara, M.T.

Time	Paper	Code	Paper Code
12.15-12.25	**CONTROL SYSTEMS DESIGN FOR AUTO JUDGEMENT CHECK MACHINE IN ROTOR ASSEMBLY LINE USING PROGRAMMABLE LOGIC CONTROLLER** Syahril Ardi, Moh Faiza Abu Rizal Production and Process Manufacture, Polytechnic Manufacture Astra, Jakarta, Indonesia	PS	31
12.25-12.35	**OPERATIONAL RISK IDENTIFICATION IN ADMINISTRATION SERVICES OF HIGHER EDUCATION** Robby Anzil Firdaus, Rahmat Nurcahyo, Anafi Yuan Septiari, Supriadi Industrial Engineering Departement, Universitas Indonesia, Indonesia	IM	17

SEPTEMBER 21, 2016 SESSION 2 ROOM 1
Moderator : Niken Parwati, S.T., M.M.

Time	Paper	Code	Paper Code
13.30-13.40	**SHELVES RE-DESIGN TO CONSIDER ASPECTS OF ERGONOMICS IN KOPETRI MINI MARKET, KARAWANG** Dene Herwanto, Sukanta University of Singaperbangsa Karawang, Karawang, Indonesia	6	ER
13.40-13.50	**COGNITIVE ERGONOMIC ANALYSIS OF PROFESSIONALS IN INDUSTRIAL DESIGNER APPAREL (Case Study: Designer at PT. Kurnia ASTASURYA)** Erwin M Pribadi, Ari Robiana Rijalah Industrial Engineering Department, Universitas Pasundan, Bandung, Indonesia	13	ER
13.50-14.00	**DESIGN CONCEPT OF WASHING GALLON USING DESIGN METHOD RATIONAL** Antonio Bennarivo Nainggolan, Mira Rahayu, Teddy Syafrizal Industrial Engineering Department, Telkom University, Bandung, Indonesia	56	ER
14.00-14.10	**DESIGNING ERGONOMIC CONVEYANCE TOOLS FOR SULFUR MINERS IN THE IJEN CRATER** Anny Maryani, Dyah Santhi Dewi, Elsa Camelia Harmadi, Pamungkas Dwi Admaja Industrial Engineering Department, ITS Surabaya, Indonesia	61	ER
14.10-14.20	**AUTOMATIC POLARIZING FILTER SYSTEM FOR WELDING MASK** Muhammad Ridwan Andi Purnomo, Riadho Clara Shinta, Rizqi Ramadhani, Ahmad Rizal Yassaruddin, Muhammad Iqbal Sabit Department of Industrial Engineering Universitas Islam Indonesia	47	ER
14.20-14.30	**DESIGN GALLON WASHING TOOLS USING ERGONOMIC FUNCTION DEPLOYMENT METHOD** Bintang Sri Perdana, Mira Rahayu, Teddy Syafrizal Industrial Engineering Department, Telkom University, Bandung, Indonesia	57	ER
14.30-14.40	**ERGONOMIC ANALYSIS FOR THE ARMOURED PERSONNEL CARRIER DRIVER** Halim Mahfudh, Lilik Zulaihah, Reda Rizal Department of Industrial Engineering, Universitas Pembangunan Nasional Veteran Jakarta	91	ER

SEPTEMBER 21, 2016 SESSION 2 ROOM 1
Moderator : Niken Parwati, S.T., M.M.

Time	Paper	Code	Paper Code
14.40-14.50	**APPLICATION OF ANALYTICAL HIERARCHY PROCESS TO CHOOSE CRITERIA FOR MOBILE PHONES** Dessi Mufti, Yesmizarti Muchtiar, Iswanto Industrial Engineering Department, Universitas Bung Hatta, Padang, West Sumatera, Indonesia	83	IM
14.50-15.00	**DESIGNING A PERSONAL SURVIVAL KIT IN FLOOD DISASTERS THROUGH PARTICIPATORY DESIGN APPROACH** Grace Novelia, Johanna Renny Octavia Industrial Engineering Department, Parahyangan Catholic University, Bandung, Indonesia	89	ER
15.00-15.10	**DESIGN IMPROVEMENT FOR POTATOES CULTERY TOOLS "POTTY" USING PRODUCT ARCHITECTURE ANALYSIS** Rahmat Ramadhani Bayu, Dicha Keci Barakin, Rendra Gilang Yuniarto, Muhammad Iqbal Industrial Engineering, Telkom University, Bandung, Indonesia	30	ER
15.10-15.20	**STUDY OF SHAFT POSITION IN GAS TURBINE JOURNAL BEARING** Rizky Arman, Iman Satria Mechanical engineering Dept, Faculty of Industrial Technolgy, Bung Hatta University, Padang, Indonesia	105	PS
15.20-15.30	**APPLICATION METHODS P-C-P TO IMPROVE QUEUE SERVICE QUALITY IN SUPERMARKET CASHIER AT THE PEAK DEMAND CONDITION** Yesmizarti Muchtiar, Muhibbullah Azfa Manik, Emil Endrivon Department of Industrial Engineering, Bung Hatta University, Padang, Indonesia	78	QM
15.30-15.40	**DESIGN E-COMMERCE ANGON BASED ON MARKETPLACE TO INCREASE PURCHASING EFFICIENCY FOR LIVESTOCK'S ACTOR (PURCHASE MODULE)** Pratiwi Galuh Putri, Irfan Darmawan, Muhammad Azani Departemen of Industrial Engineering Telkom University, Bandung, Indonesia	67	IM
15.40-15.50	**DEVELOPING INFORMATION SYSTEM OF LIBRARY ON E-SCHOOL QR-CODE BASED IN 13 NATIONAL HIGH SCHOOL USING EXTREME PROGRAMMING METHODOLOGY** Timbul Prawira Gultom, Nia Ambarsari, Muhammad Azani H. Department of Industrial Engineering, Telkom University, Bandung, Indonesia	71	DSS
15.50-16.00	**USING EDUQUAL AND KANO'S MODEL TO IMPROVE THE SERVICE QUALITY OF TRAINING AND CERTIFICATION PROGRAM** Iftitah Pratomo, Yati Rohayati, Sari Wulandari School of Industrial and System Engineering, Telkom University, Bandung Indonesia	23	IM
16.00-16.10	**DEVELOPMENT DETAIL DESIGN GALLON WASHER USING DESIGN FOR ASSEMBLY (DFA)** Mohamad Walid Anshar Ichsan Shahib, Mira Rahayu, Teddy Sjafrizal Industrial Engineering Department, Telkom University, Bandung, Indonesia	55	ER

SEPTEMBER 21, 2016 SESSION 2 ROOM 1
Moderator : Niken Parwati, S.T., M.M.

Time	Paper	Code	Paper Code
16.10-16.20	**MAKING A PLYWOOD BOAT CATAMARANS MODEL FOR HANDLING OF FLOOD EMERGENCY IN AREAS OF DURI KEPA** Indra Gunara Rochyat, Asnawati, Wahyu Albin Tabrani Product Design Department – Design & Creative Industry Faculty, Esa Unggul University, Jakarta, Indonesia	102	ER
16.20-16.30	**STUDY OF LIFT MARKET THROUGH GAP ANALYSIS** Niken Parwati, Nurhanisa Maysa, Aprilia Tri Purwandari Department of Industrial Engineering, Faculty of Science and Technology, Universitas Al Azhar Indonesia	93	IM

SEPTEMBER 21, 2016 SESSION 2 ROOM 2
Moderator : Inna Kholidasari, S.T., M.T., Ph.D.

Time	Paper	Code	Paper Code
13.30-13.40	**MAXIMUM PROFIT CALCULATION BASED ON THE QUANTITY OF DEMAND VEGATABLES WITH THE SINGLE ORDER QUANTITY METHOD** Annura Minar Gayatri, Nunung Nurhasanah, Ahmad Juang Pratama Industrial Engineering, Faculty of Science and Technology, Univerisity of Al Azhar Indonesia, Jakarta, Indonesia	84	PS
13.40-13.50	**DETERMINING THE INVENTORY POLICY FOR V-BELT USING PROBABILISTIC METHOD** Sukanta, Dene Herwanto University Singaperbangsa of Karawang, Indonesia	7	PS
13.50-14.00	**SYSTEM DYNAMICS BASED BALANCED SCORECARD TO SUPPORT DECISION MAKING IN STRATEGY OF PERFORMANCE IMPROVEMENT (A CASE STUDY IN THE UNIVERSITY)** Linda Theresia, Yenny Widianty, Dawi Karomati Baroroh Department of Industrial Engineering, Institut Teknologi Indonesia, Serpong, Indonesia Industrial Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia	8	DSS
14.00-14.10	**DRUG INVENTORY POLICY PROPOSAL USING PROBABILISTIC METHODS TO INCREASE THE SERVICE LEVEL** Sabila Syafitri Pambudi, Dida Diah Damayanti, Budi Santosa Chulasoh Departemen of Industrial Engineering, Telkom University, Bandung, Indonesia	74	PS
14.10-14.20	**AN AUTOMATED GUIDED VEHICLE SIMULATION THROUGH ROBOTINO TO HELP LEARNING COURSE INDUSTRIAL AUTOMATION** Tatang Mulyana, Haris Rachmat, Prasetia Pramudita Yuliarso Laboratory of Production Manufacturing and Automation, Faculty of Industrial Engineering, Telkom University, Bandung, Indonesia	33	PS
14.20-14.30	**THE IMPLEMENTATION OF ANALYTIC HIERARCHY PROCESS ON THE SELECTION OF SUPPLIER IN START-UP BUSINESS: A CASE STUDY** Ahmad Setyo Irawan, Liliani International Business Management, Universitas Ciputra, Surabaya, Indonesia	27	SCM

SEPTEMBER 21, 2016 SESSION 2 ROOM 2
Moderator : Inna Kholidasari, S.T., M.T., Ph.D.

Time	Paper	Code	Paper Code
14.30-14.40	**OPTIMAL PREVENTIVE MAINTENANCE OF TWO-PHASE MAINTENANCE POLICY FOR LEASED PRODUCT** Hennie Husniah, Andi Cakravastia, Bermawi P. Iskandar Department of Industrial Engineering, Langlangbuana University, Bandung, Indonesia Department of Industrial Engineering, Bandung Institute of Technology, Bandung, Indonesia	28	PS
14.40-14.50	**A SIMPLE MATHEMATICAL MODEL OF TECHNOLOGICAL TRANSFER WITH TWO COMPETING FOLLOWERS (A PRELIMINARY RESULT)** Hennie Husniah, Asep K. Supriatna Department of Industrial Engineering, Langlangbuana University, Bandung, Indonesia Department of Mathematics, Padjadjaran University, Bandung, Indonesia	29	OR
14.50-15.00	**INCREASING PRODUCTIVITY OF PT. XYZ THROUGH THE UTILIZATION OF STANDARD TIME AND THE TWO HANDED PROCESS FOR PANEL BOX PRODUCTION** Arnolt Kristian Pakpahan; Didien Suhardini; Arum Tri Astuti Organizational and Business Development Laboratorium, Industrial Engineering, Faculty of Industrial Engineering, Trisakti University	100	IM
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STRUCTURAL MODEL FOR SUSTAINABLE CAMPUS ASSESSMENT: A CASE OF ANDALAS UNIVERSITY

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ABSTRACT

Universities can generate a significant impacts to environment through their activities and operations. Thus, sustainability should be implemented in achieving a sustainable campus. Evaluating the implementation of sustainable campus become a need to achieve a higher performance. This paper develops a structural model for sustainable campus assessment conducted to a case of Andalas University. It begins with identification of KPIs of sustainable campus assessment through literature study. Interpretive Structural modeling (ISM) method is applied to determine the interrelationships amongst the categories of KPIs. The results indicated setting and infrastructure, energy and climate change, waste, and water as the basic categories, while transportation and education appears to be the leading categories. The structural model can aid the universities in achieving a higher performance of sustainable campus.

Key words: assessment, structural model, sustainable campus.

1. INTRODUCTION

In recent years, sustainable campus has became a critical issue among universities around the world. Campus sustainability is an increasingly issue of global concern for university policy makers and planners as a result of the realization of the impacts the activities and operations of universities have on the environment (Alshuwaikhat and Abubakar, 2008). University can generate a significant impact to environment due to the high usage of energy, extensive transportation, massive waste, high consumption of materials, and extensive development of buildings and facilities (Gunawan et al., 2012). Therefore, sustainability concept needs to be implemented in the development of an university.

A sustainable university can be defined as a higher educational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfill its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyle (Velazquez et al., 2006). According to the definition, sustainable campus must address the integration all the triple bottom line of sustainability consist of environmental, economic, and social.

Campus has many activities and complex operations which potentially generate the significant environmental impacts. Thus, sustainability should be applied to all aspects of a university, from the classrooms, offices, and laboratories, housing, transportation and other services, as well as to the entire campus (Alshuwaikhat and Abubakar, 2008). Therefore, assessing the sustainable campus has become a necessity to evaluate the implementation of sustainability in a university.

In this research, attemp is made to develop a structural model of sustainable campus assessment. The study is conducted to a case of Andalas University located in Padang, Indonesia. It begins with identification of initial Key Performance Indicators (KPIs) for sustainable campus assessment through literature review. Then, the KPIs validated to experts from the university. Finally, the interrelationships amongst the categories of KPIs is analyzed using the Interpretive Structural Modeling (ISM) methodology.

2. THEORETICAL BACKGROUND

2.1. Description of Study Area

This study is focused on the main campus of Andalas University, a leading university in Indonesia established in 1956. The campus is located in Limau Manis, Padang, West Sumatra. It built in a landmass of 502 ha and 255 m above the sea. Currently, Andalas University has a total of 15 faculties and more than 25,000 students. For the teaching activity, it supported by 1,385 lecturers. In 2014, Andalas University has accredited by National Accreditation Board for Higher Education with a rank of A (excellent).

Andalas University has made various efforts to achieve a sustainable campus. At the beginning of the campus development in 1980, it has allocated about 160 ha for the Biology Education and Research Forest. The forest is used to conduct various activities of biology education and research on diversity and ecology of plants, animals and their mirobes.

In 2004, it increased about 15 ha allocated to arboretum and 7 ha for dill garden. With those efforts, in 2015 Andalas University has successfully getting an fourth ranking among Indonesian universities in the UI Greenmetric World University Ranking. It is a world university ranking for universities to assess and compare campus sustainability efforts (www.greenmetric.ui.ac.id). The UI Greenmetric World University Ranking is the first attempt to make a global ranking of universities' sustainable behavior (Grinsted, 2011).

2.2. Interpretive Structural Modeling (ISM) Methodology

Interpretive Structural Modeling (ISM) is proposed by Warfield in 1973 as computer assisted methodology (Agarwal et al., 2007). ISM is an interactive learning process that enables the decision makers to develop a map of the complex relationships among many elements involved in a complex problem (Kannan et al., 2009). ISM methodology helps in building an interaction map to identify the interrelationships among system variables. It provides a better understanding of a system structure and draws up a useful guideline in generating a graphical representation of the structure (Chen and Wu, 2010).

ISM is interpretive as the judgment of the experts decides whether and how the system variables are related. It is structural as on the basis of relationship and overall structure is extracted from the complex set of system variables. The first step of ISM is to identify the variables relevant to the problem. A structural self interaction matrix (SSIM) is then developed based on a pair-wise comparison of variables. SSIM is then converted into a reachability matrix. Noted that the reachability matrix is under Boolean operations. Its transitivity is then checked. The transitivity is a basic assumption of ISM methodology, which stated that if variable-A related to variable-B and variable-B related to variable-C, then variable-A necessarily related to variable-C (Kannan et al., 2009).

3. RESEARCH METHOD

The methodology has two main stages. First, identify the key performance indicators (KPIs) for sustainable campus assessment through literature review. The KPIs were then validated to a case of university. Second, determine the interrelationships of KPIs using Interpretive Structural Modeling (ISM) method.

3.1. Identification of Key Performance Indicators

This study starts with development of key performance indicators (KPIs) for sustainable campus assessment. The related literatures were then extensively reviewed to identify the KPIs. It mostly adopted from the UI Greenmetric World University Ranking (Guidelines of UI GreenMetric World University Ranking, 2014). In addition, the KPIs were also taken from the Alshuwaikhat and Abubakar's campus sustainability framework (Alshuwaikhat and Abubakar, 2008), sustainable UKM programme's framework (Fadzil et al., 2012), University of Nottingham's campus sustainability indicators (Sustainability Report of University Nottingham, 2013), and University of

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Connecticut's campus sustainability indicators (Campus Sustainability Design Guidelines of University of Connecticut, 2004). As a result, the initial KPIs of sustainable campus assessment consist of six categories divided into a total of 35 indicators were identified. The initial KPIs were then validated by conducting interviews to five members of green campus team of Andalas University. The experts suggested that all categories and indicators of the initial KPIs are highly important in assessing the sustainable campus. Thus, proposed as the KPIs for sustainable campus assessment (Amrina and Imansuri, 2015) as shown in Table 1.

Table 1. KPIs of Sustainable Campus Assessment

Categories	Indicators
1. Setting and Infrastructure	1. Open space area/total area 2. Open space area/total people 3. Area on campus covered in forested vegetation 4. Area on campus covered in planted vegetation 5. Non-retentive surfaces/total area 6. Sustainability budget/total university budget
2. Energy and Climate Change	7. Energy efficient appliances usage 8. Renewable energy usage policy 9. Total electricity use/total people 10. Energy conservation program 11. Green Building 12. Climate change adaptation and mitigation program 13. Greenhouse gas emission reduction policy 14. Smooking area policy on campus 15. Sustainable food program on campus
3. Waste	16. Recycling program for university waste 17. Toxic waste recycling 18. Organic waste teatment (garbage) 19. Inorganic waste teatment (rubbish) 20. Sewerage disposal 21. Policy to reduce the use of paper and plastic on campus
4. Water	22. Water conservation program 23. Piped water
5. Transportation	24. Total cars entering/total people 25. Total bicycles/total people 26. Transportation policy on limiting vehicles on campus 27. Transportation policy on limiting parking space 28. Campus buses 29. Bicycle and pedestrian policy
6. Education	30. Sustainability courses / total courses 31. Sustainability research funding/total research funding 32. Sustainability publications 33. Sustainability events 34. Sustainability organizations (student) 35. Sustainability website

3.2. Developing Network Model

A network model of sustainable campus assessment then developed based on the proposed KPIs. Interpretive Structural Modeling (ISM) method was applied in the developing of the model. A questionnaire was then designed and sent to a total of 30 experts consist of Dean, Vice Dean, Head of Department and Green Campus Committe of Andalas University. They were selected based on their knowledge and experience in achieving sustainable campus. Those experts were consulted in identifying the relationships amongst the categories of KPIs. The results are used to develop a structural model of the sustainable campus assessment. Details are given in the following section.

4. DEVELOPMENT OF NETWORK MODEL OF SUSTAINABLE CAMPUS ASSESSMENT

The following steps show the development of a structural model of the six categories of KPIs for sustainable campus assessment.

4.1. Structural Self-Interaction Matrix (SSIM)

A total of 30 experts were consulted to determine the relationships amongst the categories of KPIs of sustainable campus assessment. Answer to the questions from the experts were averaged. The results indicated 10 direct relationships amongst the categories of KPIs. The SSIM is shown in Table 2.

Table 2. Structural Self-Interaction Matrix

Categories	1	2	3	4	5	6
1	-	X	O	V	A	O
2		-	X	X	A	A
3			-	O	O	O
4				-	O	O
5					-	O
6						-

Four symbols are used to denote the direction of relationship between the categories (i and j):

- V for the relation from i to j
- A for the relation from j to i
- X for both directions, relations from i to j and j to i.
- O if the relation between the categories does not appear valid.

4.2. Initial Reachability Matrix

The SSIM is then transformed into the Initial Reachability Matrix by substituting the symbols of V, A, X, and O into a binary matrix of 1 and 0, where 1 means there is relationship between the categories and otherwise, 0 means there is no relationship between the categories. The substituting process is as per the following rules:

1) If (i, j) entry in the SSIM is V, then (i, j) entry in the reachability matrix is 1 and (j, i) entry is 0.
2) If (i, j) entry in the SSIM is A, then (i, j) entry in the reachability matrix is 0 and (j, i) entry is 1.
3) If (i, j) entry in the SSIM is X, then entry for both (i, j) and (j, i) is 1.
4) If (i, j) entry in the SSIM is O, then entry for both (i, j) and (j, i) is 0.

The Initial Reachability Matrix of the categories of KPIs for sustainable campus assessment is obtained by the rules above and the result is presented in Table 3.

Table 3. Initial Reachability Matrix

Categories	1	2	3	4	5	6
1	1	1	0	1	0	0
2	1	1	1	1	0	0
3	0	1	1	0	0	0
4	0	1	0	1	0	0
5	1	1	0	0	1	0
6	0	1	0	0	0	1

4.3. Final Reachability Matrix (SSIM)

The Final Reachability Matrix is developed from the Initial Reachability Matrix by incorporating the transitivities amongst the categories of the KPIs of sustainable campus assessment using the following equation:

$$M = M^k = M^{k+1}, k > 1 \qquad (1)$$

where *k* denotes the powers and *M* is the reachability matrix. It is noted that the reachability matrix under the Boolean operations. The transitivities are a basic assumption of ISM methodology which stated that if variable-A related to variable-B and variable-B related to variable-C, then variable-A necessarily related to variable-C (Kannan et al., 2009). The Final Reachability Matrix of the categories of KPIs of sustainable campus assessment is shown in Table 4.

Table 4. Final Reachability Matrix

Categories	1	2	3	4	5	6	Driving power
1	1	1	1	1	0	0	4
2	1	1	1	1	0	0	4
3	1	1	1	1	0	0	4
4	1	1	1	1	0	0	4
5	1	1	1	1	1	0	5
6	1	1	1	1	0	1	5
Dependence power	6	6	6	6	1	1	

The driving power and dependence power for each category are also presented in the table. The driving power is the total number of categories (including category itself) which it may relate, while the dependence power is the total number of categories which may relate to it.

It can be seen that two categories of transportation and education have the highest driving power with a value of 5. On the other hand, these two categories are not affected by any other indicators, indicated by the zero value of dependence power. In term of dependence power, four categories of setting and infrastructure, energy and climate change, waste, and water are determined as the most dependent categories. Those categories have affected by any other categories. In addition, it can also be concluded those four categories have strong interrelationships amongst them, indicated by the their value of driving power and dependence power.

4.4. Level Partitions

Based on the Final Reachability Matrix, it can be obtained the reachability set and antecedent set (Warfield, 1974) for each category. The reachability set consists of the category itself and the other categories, to which it may relate. The antecedent set consists of the category itself and the other categories, which may relate to it. Then, the intersection of reachability sets and antecedent sets is derived for all categories. The categories for which have the same reachability sets and the intersection sets are put into the first-level categories in the ISM structure. Those categories are then discarded from the other remaining categories in the level determination. Next, the reachability sets and antecedent sets are determined for the remaining categories. The iteration is continued until the level of all categories of KPIs for sustainable campus assessment obtained as presented in Table 5.

Table 5. Level Partition

Categories	Reachability set	Antecedent set	Intersection set	Level
1	1,2,3,4	1,2,3,4,5,6	1,2,3,4	I
2	1,2,3,4	1,2,3,4,5,6	1,2,3,4	I
3	1,2,3,4	1,2,3,4,5,6	1,2,3,4	I
4	1,2,3,4	1,2,3,4,5,6	1,2,3,4	I
5	1,2,3,4,5	5	5	II
6	1,2,3,4,6	6	6	II

From the table, it can be seen that the categories of KPIs of sustainable campus assessment consist of two levels. In the first level, identified four categories of setting and infrastructure, energy and climate change, waste, and water. Two categories of transportation and education are determined to be placed in second level. The identified levels of the categories aid in building the structural model of Interpretive Structural Modeling (Kannan et al., 2009).

4.5. Micmac Analysis

The categories of KPIs of sustainable campus assessment are then classified based on their driving power and dependence power using MICMAC analysis. The MICMAC analysis is used to analyze the driving power and the dependence power of the categories (Mandal and Desmukh, 1994). The categories are classified into four clusters named autonomous, dependent, linkage, and driver as depicted in Figure 1.

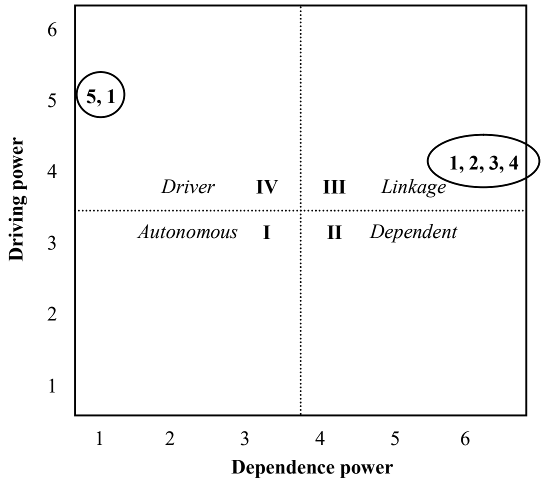

Figure 1. Micmac Diagram

From the diagram, it can be seen that there is no autonomous and dependent category (in the first and second quadrant). This clearly indicated there is no independent category of the KPIs of sustainable campus assessment due to has no affected by any other categories. It can be concluded that all categories are having an interrelationship and influencing the sustainable campus assessment. Similarly, it also indicated no dependent category of the KPIs of sustainable campus assessment.

Four categories of setting and infrastructure, energy and climate change, waste, and water identified in the third quadrant as the linkage categories. These categories are regarded as unstable categories. The categories have a high driving prower as well as a high dependence power. Any changes on these four categories will have an affect on the other categories and also provide a feedback effect on them. The universities should pay more attention to these categories.

In fourth quadrant, two categories of transportation and education are identified as the most driver categories. Those categories are driving all other categories but not driven by any other categories. Any action on these categories will have a significant effect on the other categories. Thus, the universities should manage these categories in a stable condition due to their influences to other categories.

4.6. Structural Model

Finally, a structural model of categories of the KPIs of sustainable campus assessment is then developed based on the Final Reachability Matrix. The transitivities of the categories are removed from the matrix. The categories of the KPIs are organized into two levels as depicted in Figure 2.

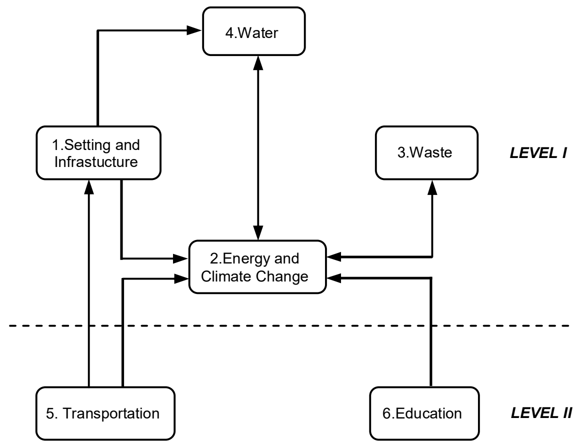

Figure 2. Structural Model

Based on the structural model of categories of the KPIs, four categories of setting and infrastructure, energy and climate change, waste, and water are regarded as the basic categories in assessing sustainable campus. Of those categories, energy and climate change has influenced by any other categories. This issue has become a global problem in any campus in the world. An effort to generate an alternative energy source need to be campaigned. For that purpose, the faculty member can support by conducted research on renewable energy. In term of climate change, universities need to design an appropriate strategy to tackle the related problems.

Transportation and education appear to be the leading categories in achieving sustainable campus. It might due to transportation being related closest to environmental impact. The transportation used around the campus are very extensive, thus need pay more attention to reduce the impact. Education as a main function of a campus plays an important role in achieving a higher performance of sustainable campus. Universities have responsibility in sustainable development to promote the sustainability culture to its students, staff, and community (Gunawan et al., 2012).

5. CONCLUSIONS

University can generate a significant environmental impacts due to the high usage of energy, extensive transportation, massive waste, high consumption of materials, and extensive development of buildings and facilities. Thus, it is essential to assess the implementation of sustainable campus. This paper has developed a structural model of categories of Key Performance Indicators (KPIs) for sustainable campus assessment. The KPIs are identified and derived from the literature and then validated to a case of Andalas University. As a result, six categories divided into a total of 35 indicators are proposed as the KPIs of sustainable campus assessment.

A structural model of categories of the KPIs is then developed using Interpretive Structural Model (ISM) methodology. The categories of KPIs are structured into two levels. The structural model establishes the interrelationships amongst the categories of KPIs. The interdependencies amongst the categories of KPIs are also given by micmac diagram. The structural model provides a better understanding of the interrelationship amongst the categories of KPIs. The model can aid the universities with a more realistic representation of interrelationships amongst the categories of KPIs for sustainable campus assessment. Future work will further incorporate the structural model into Analytical Network Process (ANP) methodology to the development of sustainable campus assessment tool.

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