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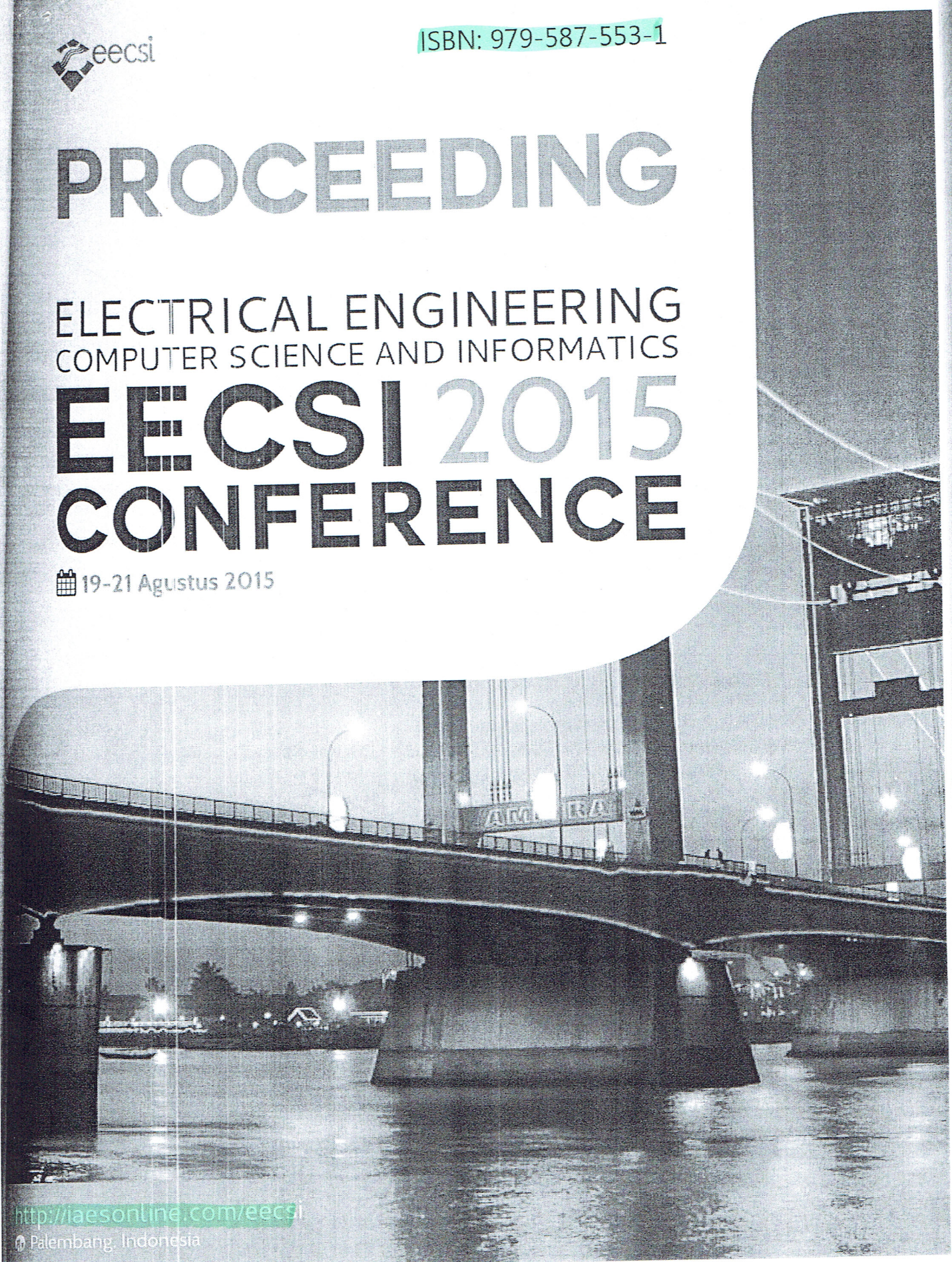
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# PROCEEDING

ELECTRICAL ENGINEERING  
COMPUTER SCIENCE AND INFORMATICS

# EECSI 2015 CONFERENCE

📅 19-21 Agustus 2015



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📍 Palembang, Indonesia



**iaes**  
Institute of Advanced Engineering and Science

**PROCEEDING**  
**The 2<sup>nd</sup> International Conference on**  
**Electrical Engineering, Computer Science and Informatics (EECSI 2015)**

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## Foreword from General Chair EECSI 2015

In the name of Allah, Most Gracious, Most Merciful

Welcome to the 2<sup>nd</sup> International Conference on Electrical Engineering, Computer Science and Informatics (EECSI 2015) in Palembang City, Land of Sriwijaya, Indonesia.

EECSI 2015 provides a forum for researchers, academicians, professionals, and students from various engineering fields and with cross-disciplinary working or interested in the field of Computer Science, Informatics, Signal, Image, Video Processing, Electronics Engineering, Electrical Power Engineering, Instrumentation and Control Engineering, and Telecommunication Engineering.

I would like to express my hearty gratitude to all participants for coming, sharing and presenting your research findings in this conference. There are more than 120 papers submitted to EECSI 2015, however only high quality selected papers are accepted to be presented in this event, so we are also thankful to all the international reviewers and steering committee for their valuable work. I would like to give a compliment to all partners in publications and sponsorships for their valuable supports.

Organizing such an prestigious conference was incredibly challenging and would have been impossible without our outstanding committee, so I would like to extend my sincere appreciation to all committees and volunteers from Universitas Sriwijaya as a host, Universitas Ahmad Dahlan, Universitas Islam Sultan Agung and Universitas Diponegoro for providing me with much needed support, advice, and assistance on all aspects of the conference. We do hope that this event will encourage the collaboration among us in the future.

I wish you all find opportunity to get rewarding technical program, intellectual inspiration, renew friendships and forge innovation, and that everyone enjoys some of what Palembang City has to offer!.

Deris Stiawan.Ph.D  
General Chair EECSI 2015



## Foreword from Rector Universitas Sriwijaya

In the name of Allah, Most Gracious, Most Merciful

The International Conference on Electrical Engineering, Computer Science and Informatics (EECSI 2015) is now held in Palembang, Indonesia and being organized under the collaborative committee effort among Universitas Sriwijaya and Institute Advanced Engineering and Science (IAES) supported by well known universities such as Universitas Ahmad Dahlan, Universitas Islam Sultan Agung, and Universitas Diponegoro.

The goals of the conference are to obtain and extend the knowledge of the recent issues, opinions, bright ideas about the development of a comprehensive green technology constructively from distinguish scholars, researchers, and academics.

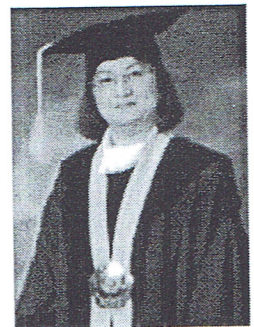
Furthermore, this forum is expected to bring new innovations in technology for a better future, especially in the field of information technology, computers, and electrical en engineerings and also create cooperation between institutions of science at the college level, industries and government.

It is a great pleasure to welcome all the participants of this conference and also several keynote speakers from Wilkes University – United State of America, Universiti Teknologi Malaysia and Bandung Institute of Technology Indonesia.

I do hope that this conference to be a valuable forum for engineers and scientist to share their precious researches and this event will give significant contributions to the development of Electrical Engineering and Computer Science. It is hope that this conference will raise the awareness of scientific community members in bringing better life.

I hope that the conference will be stimulating and memorable for you. So, enjoy your time in Land of Sriwijaya – Palembang.

Prof. Dr. Hj. Badia Perizade, M.B.A.  
Rector  
Universitas Sriwijaya, Palembang – Indonesia



## Foreword from IAES – Indonesia Section

In the name of Allah, Most Gracious, Most Merciful

Welcome to our colleagues from Asia and around the world to attend the 2<sup>nd</sup> International Conference on Electrical Engineering, Computer Science and Informatics (EECSI 2015) in Palembang, Land of Sriwijaya, Indonesia.

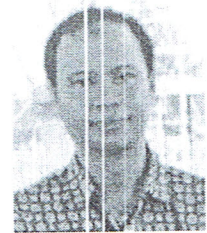
EECSI 2015 is an event in the field of Electronics Engineering, Electrical Power Engineering, Instrumentation and Control Engineering, Telecommunication Engineering, Computer Science, Informatics, Signal, Image, Video Processing, and also other related fields.

I would like to express my sincere gratitude to all participants for coming down to Palembang to share and present your research findings. We are also thankful to all the international reviewers and steering committee for ensuring high quality of all the accepted papers. I would like to give a tribute to all partners in publications and sponsorships for their valuable supports. The conference is believed to be a gate to show great development of our research to the world.

I would like to extend my deep appreciation to all the organizing committee especially from Universitas Sriwijaya as a host, Universitas Ahmad Dahlan, Universitas Islam Sultan Agung and Universitas Diponegoro for working very hard to make this conference as today. We do wish that this kind of collaboration will be improved and developed better in the future

We wish you a happy conference and success in Palembang.

Associate Professor Dr. Mochammad Facta  
IAES – Indonesia Section



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# Generating Electricity using PV/FC Hybrid System

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**Abstract**— A reliable electrical energy supply is a prerequisite for improving the standard economic and quality of life levels in a country. As is the case in many countries, it is uneconomical to connect these villages to the existing grid, the installation of stand-alone electrical power generators has become common practice. As a result, diesel stand-alone power generators see widespread use in these remote locales, which, whilst fit for their intended purpose, unfortunately suffer from several drawbacks, including instability in regards to everyday oil prices and a number of environmental issues. The implementation of a PV/FC hybrid power system could be one potential alternative to help solve these problems. Therefore, this paper presents PV/FC system control strategies. This study is especially important in terms of envisioning the future energy supply needs. By using HOMER the proposed control strategies and suggested components of a PV/FC system would be able to produce a satisfactory outcome.

**Keywords**—photovoltaic; fuel cells; HOMER; hybrid power system; remote area; diesel generator

## I. BACKGROUND

There are many remote villages that are located far away from the utility grid. Connecting such villages to the existing grid is certainly both impractical and inefficient. Therefore, in order to fulfil the electrical energy demand in those particular villages, the installation of standalone generators is a normal practice.

However petroleum costs keep increasing, with the fluctuations in price often being unpredictable. As such, the use of diesel as a fuel source for standalone generators in remote areas can no longer be considered reliable. In addition, since its consumption releases significant pollutants, such as CO<sub>2</sub>, CO, NO<sub>x</sub> and SO<sub>2</sub>, diesel is unfriendly to the environment [1, 2].

As a result, the best option for remote areas would be to install standalone electrical generators, which utilise a renewable energy supply. Under similar conditions, there are some renewable energy sources and technologies that are available for use, which have already been applied, as shown in Error! Reference source not found..

TABLE I. APPLICATIONS OF RENEWABLE ENERGY IN SOME COUNTRIES

Country	Renewable energy applied	Capacity
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Sine Moussa Abdou, Thiès region, Senegal [3]	PV-Wind turbine- Battery-Diesel generator	5.2 kWp PV array, 5 kW wind turbine, 120 kWh battery bank and a 8.5 kVA diesel genset
Kimprana-Mali [3]	PV- Battery- Diesel generator - local grid	72 kWp, PV array, 1185 kWh, 175 kVA diesel genset, 400 V DC, Sunny Mini Central
Conselice, Italy [4]	Palm oil	50 MWel (engines) + 6 MWel (steam turbine)
Angonia, Tete, Mozambique [5]	Hydropower	280 kW
Maguga Dam, Swaziland [6]	Hydropower	19.2 MW

One potential renewable energy source is a hybrid photovoltaic (PV) and fuel cell (FC) system. Regarding the green energy concept, these are both excellent renewable energy sources. PV/FC power plants have been successfully operated in many countries, including Germany, Italy, Finland, Japan, Spain, Saudi Arabia, Switzerland and the USA [7].

Even though many efforts have been made towards simplifying the design of PV/FC systems, so far researchers have been unable to agree on a definitive optimum design process for such a system. There is a real need to explore optimum sizing of component selection, operational control strategies and performance-related issues in this area.

In order to obtain an optimal design, which includes the sizing of components, hourly-based operating states and the operational control strategy, four main components of a PV/FC hybrid power system requires to be examined, namely PV, the electrolyzer, hydrogen storage tanks, fuel cells as well as other accessories. The stored hydrogen and oxygen furnish the fuel cells in a controlled fashion without interruption when the PV system cannot supply sufficient power to the electrolyzer and accessories during off-solar days.

## II. SYSTEM DESCRIPTION

A hybrid-type power generation system consists of a PV module equipped with a controller that is used to attain maximum power-point trackers, a pressurized storage tank for H<sub>2</sub> storage, fuel cells, inverter (DC-AC) and electrolyzer for H<sub>2</sub> production as shown in Figure 1. The whole system can be designed using HOMER as shown in Figure 2. Furthermore,

several component prices for this study will be obtained from previously published papers [8, 9].

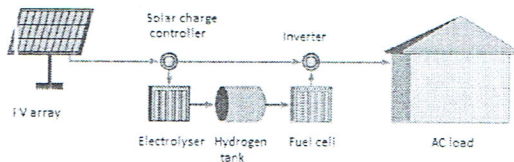


Fig. 1. The configuration of a PV/FC hybrid power generation system.

### III. HOMER SOFTWARE

The Hybrid Optimization Model for Electric Renewable (HOMER) is software that is used to perform comparative economic analysis on distributed generation power systems. The data inputted into the HOMER software will perform an hourly simulation for every possible combination of the components. These inputs are used to rank the systems according to user-specified criteria, such as cost of energy (COE) or capital costs. Furthermore, HOMER simulations can perform 'sensitivity analysis', in which the values of certain parameters, such as cost of fuel cells, are varied in order to determine their impact on the COE [10].

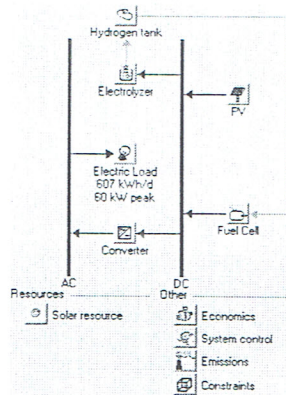


Fig. 2. The configuration of a PV/FC hybrid power generation system in HOMER software

The simulation can be carried out based on a 25-year-long projection period and 6% annual real interest rate. The aim was to ensure the highest levels of reliability in terms of supply security, efficiency of the stand-alone PV/FC system and to properly define the operational strategy needed to maintain the generator, all of which can be summarized as follows:

(a) The first scenario was the PV system supplies the electricity immediately to the load demand. In this scenario the

power of the PV system was equal to the load demand ( $P_{Load}$ ); ( $PV_{supply} = P_{Load}$ ).

(b) The second scenario was if the power of the PV system exceeds the  $P_{Load}$ . In such a situation, the PV system would immediately supply the  $P_{Load}$  as well as distribute the excess power from the PV system to the electrolyzer in order to produce  $H_2$ ; ( $PV_{supply} > P_{Load}$ ).

(c) Another scenario was that the PV system provides less electrical power than the  $P_{Load}$ . In this scenario, the  $P_{Load}$  would be supplied by both the PV system and the FC; ( $PV_{supply} < P_{Load}$ ).

(d) Finally, if solar irradiation is unavailable, electricity might be supplied from the FC to the load demand; ( $PV_{supply} = 0$ ).

Furthermore, experiments were conducted in order to find the optimum values of each decision variable size, with the possible decision variables being (1) PV array, (2) fuel cell generator, (3) converter, (4) electrolyzer and (5) hydrogen storage tank.

### IV. CONCLUSION

A feasibility study regarding the use of PV/FC hybrid power systems for remote locations could be carried out comprehensively by using the HOMER software. Based on the simulation results, the control strategies and the performance of the system components are acceptable for implementing. The PV/FC system operates completely independent from world fossil fuel price fluctuation (which is likely to only increase in the years to come). As an additional benefit, no harmful pollutants such as  $CO_2$ ,  $CO$ ,  $NO_x$  and  $SO_2$  will be released into the environment. Considering varieties in load profiles and meteorological conditions, the proposed method could be safely implemented for the optimization of hybrid PV/FC power systems.

### Acknowledgements

The authors would like to thank the Ministry of Higher Education and Universiti Teknologi Malaysia to conduct the research. Also the Dean, Faculty of Electrical Engineering, Universiti Teknologi Malaysia is acknowledged for the permission to publish the results of the research.

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