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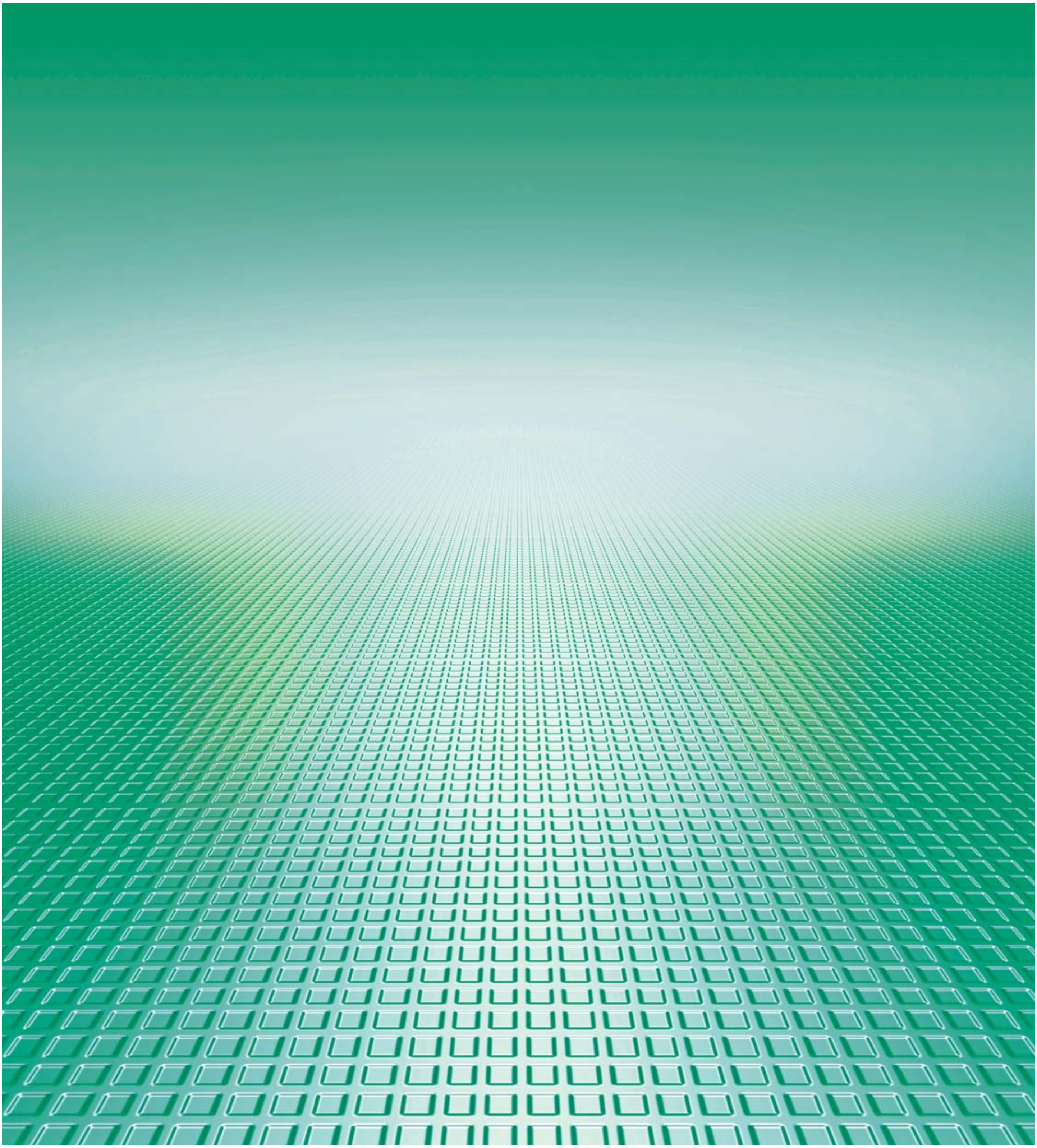
同志社大学リーディング大学院　グローバル・リソース・マネジメント ジャーナル



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Editor's Preface

Yoichi Mine
Chief Editor, GRM Journal
Professor, Graduate School of Global Studies, Doshisha University

This issue is the second of the *Global Resource Management (GRM) Journal*, which was first published in March 2014. Publication of this 2015 issue was delayed due to the need to prepare rules concerning submission of papers and to reconsider the overall structure of the journal from the editorial point of view. I am so happy to be able to release this issue eventually with a selection of quality papers written by GRM students.

The significance of the agenda of global resource management is recognized increasingly in today's international society. In 2015, political chaos in Syria and Iraq along with outbreaks of terrorist attacks in Beirut and Paris, attracted the world's attention. At the same time, widening inequalities around the world in Asia and Africa as well as in so-called developed continues continue to deprive people of opportunities to live better lives they value. The failure of human security has been caused by complex interactions of factors including political and economic inequalities as well as injustice pertaining to culture, religion and ethnicity.

There is no easy solution. However, if one aims to make progress toward sustainable peace and development, the alleviation of inter-group inequalities in terms of natural resources and infrastructure, as addressed by our own program, are expected to play a pivotal role. Today, we should focus more clearly on resource inequalities so that we can make difference in resolving conflict and bringing about coexistence of people with different backgrounds, by means of mobilizing practical knowledge in social sciences, natural sciences, and the humanities.

It is with these thoughts in mind that we undertook the task of editing this latest issue of GRM Journal. After strict and thorough peer-review processes, we selected two papers that were considered to be suitable for publication. Both papers offer fresh knowledge that is in accordance with the mission of global resource management, whose importance and appropriateness continue to rise. Having worked out authors' guidelines, we have started to accept papers online, so we expect to receive more papers on relevant topics from visiting scholars and GRM students in the future.

GRM Organizing International Conferences Symposium

Nazuna Nakao

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I Context

This article describes one of the lectures on global resource management, "GRM Organizing International Conferences Symposium II." In fact, this lecture is programmed for a group of students, each of whom gives his or her ideas to create the theme and works together to organize a conference or workshop. However, I was allowed to complete the entire process alone under the supervision of my professor and the administrative staff. As a result, this article focuses on the procedure for organizing the conference alone and why I chose a topic of "dialogue basis."

II Procedure

This conference is related to my research themes. In the process of conducting several field research projects in two regions that have a common traditional culture, I came to understand that they have not had any opportunities to share their views, despite the fact that they have been curious and recognized each other. When conducting interviews for research in both regions, I always asked people how they recognized each other, and their responses revealed that despite their curiosity and familiarity, they knew little about each other. Therefore, I was motivated to make them feel closer through my commitment.

To stage a successful conference, I decided to propose the ideas to them in person. First, this approach makes it possible to explain the purpose of the conference and my ideas correctly. In considering how to offer them an ideal opportunity, I thought the best way was to have a conference that would enable them to exchange their views instead of discussing them. I wanted to explain the background of holding a dialogue-based conference with non-academic speakers, so there is no intension to conduct stiff and complicated discussions. Second, this approach facilitates the exchange of information by focusing on what they want to ask and what they want to share. Having a frank chat enables me to grasp their true feelings. Therefore, I visited both regions, the former abroad ("Region A"), the latter in Japan ("Region B"). Regarding Region A, while conducting field research in August 2014, I met three people whom I have known for three years and invited them to attend the conference. Regarding Region B, I visited with the GRM program officer and invited them to attend the conference in October 2014. As a result, they both agreed to have a conference on the concept of "dialogue basis" and accepted my offer.

After the formal decision to hold the conference, I proceeded with clerical tasks such as arranging the dates and booking flight tickets. I also mediated between guests and administrative staff to ask them to send out photocopies of their passports and relayed their requests to the staff, for example where they would like to depart from and their preference to not have tight schedules. Both regions changed and reduced the number of conference delegates, but I did not try to persuade them otherwise and left these decisions to them since I wanted to fulfill their requests as much as possible.

The conference was to be held for six hours on a single day in consideration of their schedules. People from Region B, however, expressed concern that the schedule was too long-running, claiming that their inability to speak English and scarce knowledge would make it hard to have a better conference despite the allocation of time. Though the exchange of opinions, which was initially planned to facilitate mutual understandings, could not be fully realized, I suggested that the delegates offer presentations, thinking it would better spur an exchange of views. Fortunately, they agreed to do presentations and gave themes that they had chosen themselves. Then I decided to make a presentation including general knowledge about both regions in advance of the guests' presentations. My presentation focused on the similarities of both regions. To make the conference significant for the seven attendees who are not scholars, I believed this was the best way to facilitate awareness of their mutual impressions and information, rather than exchanging and learning complicated facts.

Three guests from Region A arrived two days before the conference and left Japan two days later. They asked me to spend all of these days with them because they were anxious about their first stay in Japan. I made an effort to be as hospitable to them as possible. I greeted them at the airport, took them to restaurants, planned an itinerary that I thought would interest them, picked up and saw them to their hotel, and saw them off at the station when they left. Four guests from Region B arrived on the day of the conference and left on the following day. They did not have any requests, and I only greeted them at the station.

I was both chairperson and interpreter. Each speaker had 15 to 20 minutes for a presentation as well as a Q&A session with two breaks and 30 minutes for summarizing. The conference room had two sets of computers and monitors, one for presentation and the other for showing pictures or videos. Speakers from Region A made their presentations in English, while speakers from Region B made theirs in Japanese. I translated every slide. They were awkward during the first meeting. I suggested that they exchange souvenirs, and they gradually opened up to each other. After that, we got started with the conference by having lunch. While they had lunch, I delivered some opening remarks. I tried to get them to relax as best I could.

After self-introductions, I made a presentation. All the speakers greatly liked my idea of using pictures, and they laughed upon realizing what they had in common. Through nonverbal tools such as pictures, it was easy to make them aware of their similarities. I believe that the process raised their sense of closeness.

All speakers had a time limit, but I did not keep time strictly, opting instead to respect what they wanted to express. As a result, we did not have any time left over and finished 30 minutes late. Without having time for the Q&A session, speakers actively raised questions and gave voice to their opinions.

III Conclusion

There are two major reasons why I succeeded in having the conference by myself. First, I took the appropriate steps to accommodate the unique situation. Second, I benefited from the close relationship between the two regions. I had to change the main theme because both regions changed and reduced the number of delegates, but it was a valuable experience for me to work to meet their demands.

In conclusion, I could not fully carry out a dialog-based conference as all speakers took much time for their presentations. However, I believe this is the result of their kind consideration not to leave time unused and to keep me from having to conduct the entire process by myself. This is one aspect of the conference that could be improved, but I am thankful for their kindness nonetheless. Besides, it was this relationship that enabled me to have the conference, and all speakers took time to come all the way to Japan to attend. It will be greatly meaningful if I am able to have more a more free and full dialog-based conference next time.

International Student Session (ISET/ISS 2014) in Vietnam

Dates: November 26 to 30, 2014

Venue: HAGL Plaza Hotel, Danang, Vietnam

Yuichiro Hayakawa
Shinichiro Kaikawa
Naoya Narita
Kensaku Matsuda
(Graduate School of Science and Engineering, Doshisha University)

1. ISET/ISS

The ISET/ISS was cooperatively organized by Doshisha University (Japan), the University of Bologna (Italy), and Seoul National University (Korea) under the Triangle Cooperative Agreement between these three universities. The Federal Institute of Technology Lausanne (Switzerland) joined as an ISET organizer from 2011.

ISET/ISS 2014 was held in Danang, Vietnam, from November 26 to 30, 2014. ISET/ISS 2014 provides the opportunity for university students to present their papers at the International Student Session (ISS). There are three sessions:

1. Panel Session on Unified Education: Nine presenters gave presentations.
2. Technical Session: Five papers were presented. The presenters were from Seoul National University, the Federal Center of Technological Education, and the Danang University of Science and Technology.
3. International student session: Thirty-six papers were presented. The presenters were MSc and PhD students from Doshisha University, the Federal University of Minas Gerais, Ecole Polytechnique Montreal, Hanoi University, and Danang University.

Fig.1. Opening ceremony of ISET/ISS 2014

2. Approach to orchestration of ISS 2014

The ISS session was organized and orchestrated by students in the class Global Resource Management (GRM) Organizing International Conferences I. The students organized the following staff:

General Affairs
S. Kaikawa, K. Matsuda, M. Ogino

Subcommittee A
Registration, Flight and Hotel Reservations
Y. Suzuki, S. Imato, S. Kumagai

Subcommittee B
Program, Proceedings
Y. Hayakawa

Subcommittee C
News
R. Kawashima, Y. Ataka, N. Narita,
M. Nakagawa

Subcommittee D
Operation
R. Hashimoto, A. Umeda

Fig. 2. The opening session

1.) General Affairs

In general, we supported the subcommittee members. We made records of the lectures for the meeting and generated a mailing list for ISS Committee members. Finally, we shared information, including the collection of passports, the schedule, location, schedule changes, etc.

2.) Subcommittee A

We made flight and hotel reservations. We discussed travel agencies and then decided that the best travel agency was one that had a local branch office. We staffed the front desk on the day of the ISS.

3.) Subcommittee B

At the beginning, I determined the schedule and session program. Then we collected papers and formed the proceedings.

4.) Subcommittee C

First, we checked the GRM office to see if there were any rental video cameras available. We had discussed the roles we would play on the day of the ISS and considerations when filming. We set up the equipment and rehearsed one day prior to the ISS.

5.) Subcommittee D

We made lists of the necessary equipment and checked the equipment available in the conference facilities in advance. We then prepared and purchased the equipment we lacked. This committee kept track of time on the day of the ISS.

Fig. 3. Checking and preparing the equipment

Fig. 4. Carrying a microphone

Fig. 5. Setting up for filming

Fig. 6. Session chair of the ISS

Fig. 7. Start of the conference

3. Presentations for the ISS

All students in the class submitted their papers to the ISS and made presentations in English. Students in both information engineering and electrical engineering participated in the conference, which made for some nice discussions. This session gave us an opportunity to learn about studying in a foreign country and communicating in a foreign language.

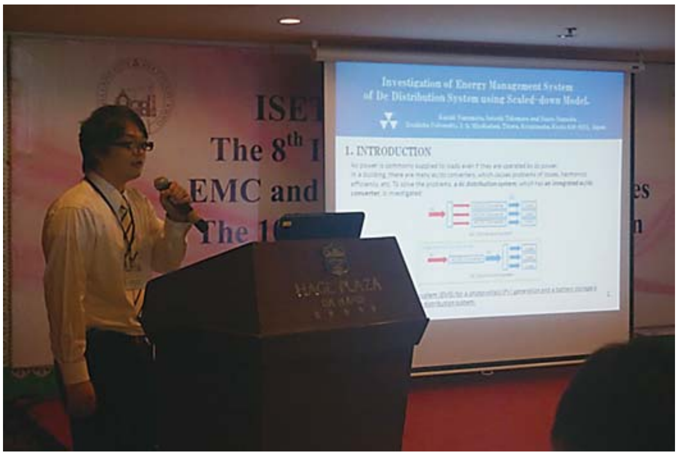


Fig. 8. Participants at the 2014 ISET/ISS

4. ISET Symposium

1.) *Prof. M. Nakata*, Doshisha University

"Asia-Africa Partnership for Sustainable Energy Development"

Our university is trying a GRM (Global Resource Management) program. This program is deeply concerned with developing human resources. This symposium proposes some recommendations to build a mutually beneficial partnership between two continents by the study about effective partnerships between Asia and Africa, particularly in the energy and water sectors.

2.) *Prof. A. Ametani*, Doshisha University
"Unified Education of Natural, Social and Human Sciences in Universities in the World"

Unified education of natural, social and human sciences in universities is a significant subject, and various approaches have been investigated and tested. Approaches to unified education were presented, together with the education system of the GRM.

3.) *Prof. Y.T. Yoon*, Seoul National University
"Frequency Regulation Using a Battery Energy Storage System Considering Response Time of Power Generation in a Power Network"

This study analyzes the effects of discretized control update times for a battery energy storage system (BESS) based on a digital controller. It uses two area models that represent a seven-bus system and two battery storage banks for frequency regulation.

Fig. 9. Prof. M. Nakata

Fig. 10. Prof. A Ametani

Fig. 11. Prof. Y. T. Yoon

4.) *Prof. L. Araujo*, Federal Center of Technological Education
"Lightning Currents Measured by Means of a Remote Device"

This lecture presented the fundamental aspects of a remote device that is able to measure and record waveforms of lightning currents. It is used for reliable devices installed at the base of the instrumented tower of Morro do Cachimbo Station.

5.) *Dr. H. H. Nguyen*, Danang University of Science and Technology
"Comparison of Self-adaptive Evolutionary Algorithms for Multimodal Optimization"

This presentation introduced a self-adaptive evolutionary algorithm for solving complex multimodal problems.

6.) *Mr. H. S. H. Nguyen*, Danang University of Science and Technology
"Control Magnetic Levitation System by Combining PID and Sliding Mode Control"

This presentation studied regulation and tracking control design for a magnetic levitation system (Maglev).

7.) *Ms. H. T. Nguyen*, Danang University of Science and Technology
“Dynamic-Stability Enhancement of a Multi-machine Power Flow Controller (IPFC)”

This presentation studied the dynamic-stability enhancement of a two-area four-generator system connected with a large-scale offshore wind farm (OWF) based on a doubly-fed induction generator (DFIG) using an interline power-flow controller (IPFC).

Fig.12. Prof. L Araujo

Fig. 13. Dr. H. H. Nguyen

Fig. 14. Ms. H. T. Nguyen

5. Concluding Remarks

It was a very pleasant and exciting experience for all the students who participated in and facilitated ISET/ISS 2014 in Danang. We never had this kind of experience before. We hope to organize an international conference or symposium on our own in the future.

Finally, we would like to thank Prof. A. Ametani, who teaches the class Organizing International Conferences and who arranged this opportunity.

(Hayakawa Yuichiro, Kaikawa Shinichiro, Matsuda Kensaku and Naoya Narita, graduate students, Graduate School of Electrical and Electronics Engineering)

ISET/ISS 2014 -Symposium / Danang Program
HAGL Plaza Hotel, Danang, Vietnam, on Thursday, 27 November, 2014, from 8:30 to 20:00

Thursday, November 27
A. Panel Session on Unified Education / Chair: Prof. A. Ametani 8:30-10:30
A-1 Introduction of Danang University of Science and Technology
Prof. L. D. Nguyen, Danang University of Science and Technology
A-2 Asia-Africa Partnership for Sustainable Energy Development
Prof. M. Nakata, Doshisha University
A-3 Panel Presentation
Prof. A. Ametani, Doshisha University / Ecole Polytechnique Montreal
Prof. Y. Baba, Doshisha University
Prof. S. Visacro, Federal University of Minas Gerais
Prof. Y. T. Yoon, Seoul National University
Prof. P. Yutthagowith, King Mongkut's Institute of Technology Ladkrabang
Prof. K. Yamabuki, Wakayama National College of Technology
Ms. I. Lafaia, Ecole Polytechnique Montreal
A-4 Panel Discussions
A-5 Questions and Comments
A-6 Summarizing Remarks
Coffee break 10:30-11:00

B. Technical Session / Chair: Prof. T. Yoon 11:00-12:00
ISET-3 to ISET-7 5 presentation

Lunch 12:00-13:30

C. International Student Session (ISS)
ISS-I Transient Analysis / Chair: I. Lafaia, S. Kaikawa 13:30-14:30
ISS-1 to ISS-10 10 student presentation

ISS-II System Dynamics in Infrastructures / Chair: P. X. Nguyen, M. Nakagawa 14:30-15:30
ISS-11 to ISS-20 10 student presentation

Coffee break 15:30-16:00

SS-III Infrastructure Related Subject 1 / Chair: M. Guimaraes, Y. Hayakawa **16:00-16:30**

ISS-21 to ISS-25 5 student presentation

ISS-IV Infrastructure Related Subject 2 / Chair: R. E. de Souza,K. Matsuda **16:30-17:36**

ISS-26 to ISS-36 11 student presentation

Welcome Banquet **18:00-20:00**

A. Panel Session on Unified Education **8:30-10:30**

ISET-1 Asia-Africa Partnership for Sustainable Energy Development

Prof. M. Nakata, Doshisha University

ISET-2 Unified Education of Natural, Social and Human Sciences in Universities in the World

Prof. A. Ametani, Doshisha University / Ecole Polytechnique Montreal

B. Technical Session **11:00-12:00**

ISET-3 Frequency Regulation Using a Battery Energy Storage System Considering Response Time of Power Generation in a Power Network

Prof. Y. T. Yoon, Seoul National University

ISET-4 Lightning Currents Measured by Means of a Remote Device

Prof. L. Araujo, Federal Center of Technological Education

ISET-5 Comparison of Self-adaptive Evolutionary Algorithms for Multimodal Optimization

Dr. H. H. Nguyen, Danang University of Science and Technology

ISET-6 Control Magnetic Levitation System by Combining PID and Sliding Mode Control

Mr. H. S. H. Nguyen, Danang University of Science and Technology

ISET-7 Dynamic-Stability Enhancement of a Multi-machine Power System connected with a Large-scale Offshore Wind Farm Using a Interlined Power Flow Controller (IPFC)

Ms. H. T. Nguyen, Danang University of Science and Technology

ISS-10 Effects of Residual Flux and Switching Angle on Sympathetic Inrush Current

A. Zaid, MSc, Doshisha University

ISS-II: System Dynamics in Infrastructure 14:30–15:30

ISS-11 Influence of Window Function of Discrete Fourier Transform

K. Takai, MSc, Chubu University

ISS-12 Similarity of Transient Characteristics between a Photovoltaic Panel and a Diode

K. Matsuda, MSc, Doshisha University

ISS-13 EMTP Simulation of Synchronization in SS-PLC Communication for a DC Distribution System

Y. Ataka, MSc, Doshisha University

ISS-14 Influence of Measuring System of Transient Potential Rise of Grounding Electrode

Y. Hayakawa, MSc, Doshisha University, Kyoto, Japan

ISS-15 Estimation Method of Degradation State of Lithium-ion Batteries Using Transient Waveforms

N. Narita, MSc, Doshisha University

ISS-16 Lightning Surge Voltage on a Small Ship due to Nearby Lightning

S. Kaikawa, MSc, Doshisha University

ISS-17 Investigation of Energy Management System of DC Distribution System using a Scaled-down Model

K. Yamamoto, MSc, Doshisha University

ISS-18 An Equivalent Circuit Estimation of a Lithium-ion Battery using a Transient Voltage Waveform by the Linear Least Squares Method

S. Yamada, MSc, Doshisha University

ISS-19 Experimental Study on Internal Impedance of Single and Series-or Parallel-connected Photovoltaic Cells

H. Higo, MSc, Doshisha University

ISS-20 An Equivalent Homogeneous Circuit of Rails in Consideration of Sleeper for Lightning Surge Analysis

Y. Imanishi, MSc, Doshisha University

ISS-III: Infrastructure Related Subjects 1 .... 14:00–14:50

ISS-21 Maximum Acceptable Window Luminance for VDT Work on Window Side and the Limit of Use of Daylight in Offices

M. Kusumoto, MSc, Doshisha University

ISS-22 Experiment to Search for Optimal Preference Illumination and Color Temperature in an Office Using Task Ambient Lighting

R. Hashimoto, MSc, Doshisha University

ISS-23 An Intelligent Lighting System Providing an Individualized lighting Environment with Illuminance- and Color Temperature-linked Control

R. Kawashima, MSc, Doshisha University

ISS-24 Evaluation of an Automatic Class Model Size Optimization Method for Surge Geometric Margin Minimum Classification Error Training

M. Ogino, MSc, Doshisha University

ISS-25 Turning-round Behavior Influenced by Headphone-based Sound Image Localization

S. Kumagai, MSc, Doshisha University

ISS-IV: Infrastructure Ralated Subjects 2 .... 14:50–15:20

ISS-26 Lightning Current Distribution of a Wind Turbine Tower in the Ocean

Y. Ikeda, PhD, Doshisha University

ISS-27 Small Capacitance Measurement using Transient Waveforms and the Nonlinear Least Squares Fitting Method

D. Permata, PhD, Doshisha University

ISS-28 Overview of an Artificial Lightning Research Project

G. M. Saquilayan, PhD, Doshisha University

ISS-29 Selective Coatings on Copper Substrates for Solar Thermal Collectors

B. A. T. Suarez, PhD, Doshisha University

ISS-30 Lightning Measurements at Morro do Cathimbo Station

M. Guimaraes, PhD, Federal University of MinasGerais

ISS-31 A Discussion on the Lightning Rerformance of Transmission Lines: Effects of Lightning Current Representation and Soil Ionization

R. E. Souza, PhD, Federal University of MinasGerais

ISS-32 Boutre-Trans Project: A 225 kV AC Underground Cable Installed in Southeastern France

I. Lafaia, PhD, Ecole Polyechnique Montreal

ISS-33 Model for an Underground Cable Installed in an HDPE Tube

I. Lafaia, PhD, Ecole Polyechnique Montreal

ISS-34 Coupling Effects between Counterpoises in Transmission Line Grounding

P. H. Nyuyen, PhD, Hanoi University of Science and Technology

ISS-35 Transient Stability Analysis of IMPSA Wind Power Plant Integration on the Ninh Thuan Power System

H. M. Duong, MSc, Danan University of Science and Technology

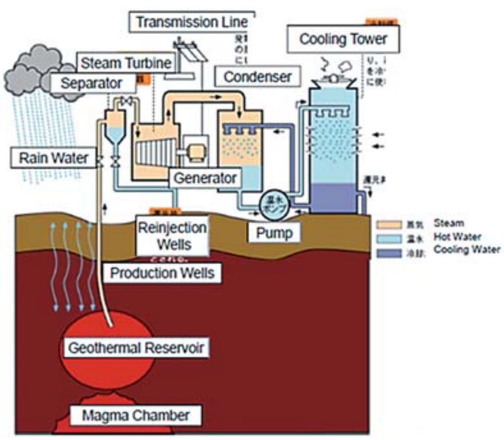
ISS-36 Optimization of Electric Energy in a Three-phase Induction Motor by Balancing of Torque and Flax Dependent Losses

H. T. Nyuyen, PhD, Danan University of Science and Technology

Joint Fieldwork 2014 in Kyushu

Date: September 8 to 11, 2014
Venue: Oita and Fukuoka, Kyushu

Earth's population is expected to increase from 7 billion to 9 billion in 2050 with a quadrupling of the economy. As a result, demand for energy is projected to increase 80%. [1] Thus as future leaders, it is important for us to have awareness of and knowledge about energy issues and energy resources. There are various energy sources including some that are renewable. One of these resources, geothermal energy, utilizes the Earth's heat.



(Mechanism of geothermal energy generation)

ABOUT THE FIELDWORK

GRM Fieldwork I-2 in Oita and Fukuoka centers on an introduction to, and knowledge-building for, geothermal energy, particularly Japanese geothermal energy resources. It is a joint fieldwork combining three Leading Graduate Schools by MEXT: the Advanced Graduate Program in Global Strategy for Green Asia, Kyushu University; the Advanced Doctoral Program in Global Resource Management, Doshisha University; and the TAOYAKA Program for Creating a Flexible, Enduring, Peaceful Society, Hiroshima University. It is a four-day fieldwork program consisting of lectures (indoor and outdoor), site visits (research institute and geothermal plants), student group activities, and student presentations that aims to showcase our learning and analysis of geothermal resource management.

SITE VISITS AND LECTURES

The first two days was a combination of plant visit and lectures around the Oita and Fukuoka area. To kick-start our fieldwork, Professor Hayashida gave an outdoor lecture entitled “What Is Occurring in Central Kyushu” and talked about the topography, geography, and resources of Kyushu.

(Prof. Hayashida giving his “What Is occurring in Central Kyushu” lecture)

Apart from the plant visit, we were also given a chance to visit the Kyoto University Geothermal Research Laboratory to learn about their work and some of their research.

(Lecture at the Kyoto University Geothermal Research Laboratory)

The third day was a day packed with lectures. Other issues regarding geothermal energy were discussed, including a comparison of geothermal resources to other energy resources like nuclear, poverty in Nepal and its geothermal energy, and Africa's situation and its potential for geothermal resources.

(Prof. Mine giving his "The Past, the Present and the Future of Africa: An Introduction" lecture)

Apart from the lectures of our professors we also had guest speakers from outside the academic circle like Dr. Eng. Tagomori, Executive Officer and General Manager of the Geothermal Department of West Japan Engineering Consultants, Inc. He provided basic information on the Japanese power sector, geothermal energy utilization, exploration, risk, measures, and policies. I would say that the highlight of his lecture was the discussion on the two major issues affecting the development of geothermal energy—resource development risk large initial investment risk—and possible measures to reduce the large financial risk.

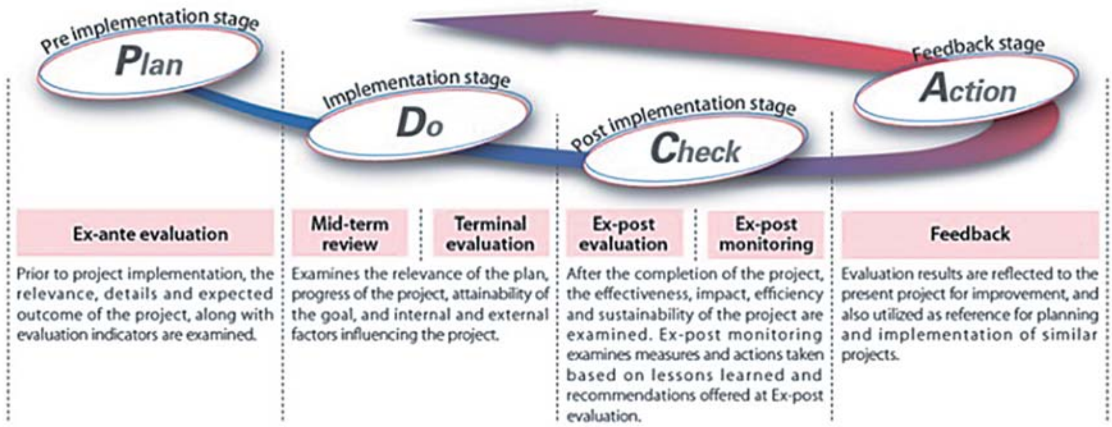
(Dr. Tagomori giving his “Geothermal Power in Practice” lecture)

Dr. Tagomori cited two possible measures for reducing the financial risk of the large initial investment. One was soft loans and the other was ODA soft loans.

ODA soft loans are granted by several institutions, one of which was represented by one of our lecturers: Mr. Kobayakawa, Director, South Asia Division 3, Japan International Cooperation Agency (JICA). Mr. Kobayakawa gave a lecture entitled “Project Formulation and Implementation under Japanese Official Development Assistance.”

(Mr. Kobayakawa giving his “Project Formulation and Implementation under the Japanese Official Development Assistance” lecture)

Mr. Kobayakawa discussed the conceptual basis of JICA assistance and the interventions that it can provide in the form of either technical assistance or financial assistance. One of the main focuses that he discussed with regard to JICA projects was evaluation, in which they use the PDCA (plan-do-check-action) cycle.



(PDCA Cycle)

There was also a discussion about some JICA projects concerning energy production such as the one in Sri Lanka.

STUDENT PRESENTATIONS

From the beginning of the fieldwork, three mixed groups were formed consisting of students from different programs, countries, and majors. These groups were tasked with applying knowledge gained during the fieldwork, summarizing the advantages and disadvantages of constructing geothermal plants in specific countries and areas, and presenting their findings on the last day. Among the selected areas were the Philippines, Kenya, and Indonesia.


(Students preparing for a presentation)

Different perspectives on geothermal energy were raised in the presentations. Our group chose the Philippines, and we made a short case analysis focusing on the community and environmental impacts. In the case of Kenya, social and cultural challenges were tackled and in the case of Indonesia, the focus was on the potential of the country as well as policies and partnerships for promoting and developing Indonesian geothermal energy resources.

(A student presentation)

To wrap up the fieldwork, Prof. Wada gave a synthesis and highlighted the importance of fieldwork.

(Prof. Wada's closing discussion)

In general, it was a very fruitful and balanced event. We as students were able to further understand and learn new things about geothermal energy, not only through the lens of our own fields, but also with an interdisciplinary understanding. We were also augment what we've learned from books with experience by seeing actual geothermal power generation at a plant.

[1] OECD Environmental Outlook to 2050: *The Consequences of Inaction.*

Miriam Caryl Carada
(Doctoral Student, Graduate School of Global Studies)

Energy supply in isolated areas: an outline of the current situation and the potential of hydrogen technologies for distributed power generation

Jorge Lamas
Graduate School of Science and Engineering, Doshisha University
Department of Mechanical Engineering

Abstract

Energy supply in isolated areas is a challenging issue. In many regions, expansion of the main power network is either too expensive or not technically feasible, and thus communities in these areas often have limited access to electricity. Current advances in distributed energy technologies have allowed the implementation of efficient micro-grids using renewable energy sources that generate energy on-site with a substantially lower dependence on fuel imports. Several studies have found that in many cases, renewable energy systems can be more economically favorable than expanding the main power network. However, renewable energies alone cannot always provide a reliable power supply. This paper introduces currently available distributed energy generation and storage technologies, and summarizes recent studies regarding energy supply projects implemented in isolated areas. Several studies converge on the idea that a reliable power supply may be obtained in isolated areas through renewable energies coupled with hydrogen fuel cells, utilizing hydrogen generation as a means for storing surplus electricity generated by the renewable energy systems. Since hydrogen for the fuel cells can be imported through other sources as well, such systems provide isolated areas with a margin for increased energy consumption and economic growth. For this reason, it is essential to explore the available sources of hydrogen and storage methods. Although the current costs for distributed energy generation and storage technologies remain high, future development of technology and increased manufacturing production is expected to lower the costs to highly competitive prices.

Keywords: Sustainable energy, Hydrogen energy, Energy security, Isolated grids, Rural development

I. Introduction

Access to sustainable energy is essential for human development and it has become a priority sector for investments. The International Energy Agency (IEA 2014) estimates that about 1.3 billion people still lack access to electricity, and 2.7 billion people lack alternatives to biomass for cooking. In this paper, the role of energy in human development is illustrated. A stable energy supply for industries, hospitals and schools, can greatly contribute to economic growth, improved health and education. Statistics show a correlation between increasing commercial energy consumption in several countries, with increased average life expectancy, school enrollment ratio, underweight children, and population with access to clean water. Several studies have been conducted regarding the impact of electricity availability in rural areas (Reiche *et al.* 2000, Kanagawa and Nakata 2007; Gómez and Silveira 2010; Van Gevelt 2014). Both in developed and developing countries, electrification of rural areas has been linked to a significant increase in socio-economic levels. Expansion of the main power network (*i.e.*, the power network that interconnects large-scale power generating stations to distribute electricity throughout the nation) allows the rural population to rely more on electric appliances that reduce manual labor and make life more comfortable. Thus, increased electrification is reflected in increased energy consumption per capita.

Developing countries are rapidly increasing their energy consumption but the availability of conventional fuels is putting considerable limitations on access to energy (Lior 2008). Furthermore, oil prices are rapidly increasing as the reservoirs become more difficult to access and require more complex technology. These rising prices will either result in expensive energy infrastructures, or an increased demand for coal and natural gas to supply current thermal power plants. Despite the increasing demand for fossil fuels, their use is being discouraged over concerns of air and water pollution, environmental changes, and global climate change. There is also uncertainty about coal and natural gas reserves, and whether they can meet global energy demands. The coal reserves are estimated to be largest, and are expected to last for 200 years more, at consumption rates of 2006 (Shafiee and Topal 2009). In contrast, oil and natural gas are expected to last for only 40 and 70 years, respectively. These numbers could decrease drastically if global demands increase faster than expected. As reserves decrease, energy security could become vulnerable for countries that rely on fossil fuel imports.

For isolated areas where there is no access to the main power network, the limited availability of fuel has a stronger impact. There are numerous populated areas surrounded by unsuitable terrain that complicates extending the main power network. Archipelago countries, such as Japan, Indonesia and The Philippines, face the problem of extending their power networks over the sea to reach populated islands. Forests and mountainous regions often require terrain conditioning, which can rapidly escalate the costs of extending the power network. Furthermore, plans to extend the power network may be hindered over the presence of national reserves and wildlife sanctuaries, where construction activities are restricted. As a result, extending the main power network to isolated areas sometimes requires vast resources that may not be deemed justifiable. For such areas, energy is often supplied through small- or medium-scale diesel generators, which require low initial investment and are easy to scale up as the electric demands increase. Although this method has been proven effective, it requires a constant supply of fuel, which in many cases results in increased costs and additional consumption of resources related to transport and handling. In Japan for example, the cost of electricity in islands using diesel generators can increase more than double compared to electricity from the power network (FEPC 2014). Furthermore, electrification shows a reduced impact in areas where a constant supply of fuel cannot be guaranteed. If power cuts are frequent, stored reserves of alternative energy sources, such as candles for lighting and firewood for heating, appear to be more useful than their electric counterparts (Davis 1998). Therefore, a different approach to the electrification of isolated areas should be considered.

This paper is divided as follows. Section II presents recent trends and cost analysis for the electrification of isolated and rural areas. Section III gives an introduction to micro-grids and distributed generation resources, followed by a summary of studies on power generation for isolated areas in Section III.A. Energy storage technologies are discussed in Section III.B, and the recent trends on hydrogen fueled micro-grids are presented in Section III.C. Finally, Section IV addresses some of the available sources of hydrogen and storage methods that could support these hydrogen-fueled micro-grids.

II. Power Network Expansion through Distributed Energy Systems

Renewable energies are promising alternatives to fossil fuel based energy systems. The installation of renewable energy systems, in particular wind turbines and solar photovoltaics (PV), has been rapidly increasing during the last decade (IRENA 2014). These technologies, albeit having poor energy density and large output fluctuations, work efficiently as distributed energy resources (Shinji *et al.* 2008; Steimer 2010). Distributed energy systems employ several small-scale (1 kW to 100 MW) power generation and storage systems to generate electricity on-site, reducing transmission losses due to transmission and distribution. In addition to electricity, cogeneration and multi-generation technologies that can simultaneously generate electricity, hot water, heating and cooling, or fuel are also available (cf. Chicco and Mancarella 2009). Although initial costs for distributed generation systems tend to be higher than those for conventional power systems, other factors should also be taken into consideration, such as primary energy consumption, carbon dioxide emissions, fossil fuel independence, and costs to society. Optimization criteria using these factors are being researched to determine whether the impact of implementing distributed systems is significant (Østergaard 2009).

Distributed energy systems using renewable energies, in particular solar, wind and micro-hydro, have the capacity to benefit remote rural areas. There are several agricultural applications for renewable energies, including but not limited to irrigation, greenhouse ventilation, refrigeration, grain threshing and milling, food processing and storage, as well as electricity for radio, television and telecommunications (Weingart and Giovannucci 2004). Energy demand patterns for rural areas are generally different from those for urban and suburban areas; therefore the approach to installing distributed energy systems should be selected accordingly. Areas that previously had no access to electricity may rapidly increase their energy demands after the electric supply has been installed. A study by Pereira *et al.* explains the impacts of the “2003 national rural electrification project” in Brazil (Pereira *et al.* 2010). Energy consumption per capita for households that were not part of the electrification program decreased from 6.91 to 5.00 GJ per year after the program. This decrease was attributed to changes in energy consumption behavior. In contrast, energy consumption for electrified households increased from 5.16 to 6.19 GJ per year after the program. When electricity is supplied to rural areas by expanding the power network, an increase in energy demand may be met without the need to increase the installed capacity. However, if distributed energy systems are implemented instead, it is important to consider future energy demand growths, and allow room for increasing the generation capacity.

Expansion of the main power network is generally the cheapest means of electrification. A study on an isolated island in India assessed the difference in cost of electricity by supplying the island with power from the existing network, and with renewable energies (Karki *et al.* 2008). The study area considered a peak load of 530 kW, where power consumption per capita is 0.46 kWh/day. The study reveals that a PV-biomass stand-alone system would produce the highest cost of electricity for this area, unless policies such as net metering and feed-in tariffs are implemented. However, not all isolated areas respond the same way to distributed energy generation. Szabó *et al.* (2011) used spatial mapping to compare costs between different energy generation technologies in the African continent. In this study, costs of connection to the network, installation of solar PV, and generation by diesel engines, including fuel transport, are calculated for the African continent. The number of people that can be supplied with each system is then estimated, with regard to their ability to pay a certain rate for electricity. The study finds that when people can afford to pay 0.05 Euros (USD 0.06) more per kilowatt-hour of electricity, the amount of people that can be supplied with PV increases dramatically, while for diesel generation it remains the same, and for network connection it actually decreases. These results suggest that in some cases, distributed energy generation systems show lower electricity costs compared to extension of the main power network. Hence, deciding which areas should be connected to the main power network and which should use distributed energy systems, can help optimize the consumption of resources.

III. Micro-grids

When the number of interconnected distributed generation systems starts to increase, it is important to match the aggregated power output with total demand in order to maintain a stable power-system operation. For renewable energies with variable power output (*i.e.*, solar and wind power), energy storage and load balancing techniques are indispensable (Liu and Su 2008). Technologies for energy storage that are already on the market include rechargeable batteries and supercapacitors (electrochemical storage), flywheels (mechanical storage), and superconducting coils (electromagnetic storage). Since power output from solar and wind power systems can be higher than actual power demand or vice-versa, energy storage devices are used to balance the load and store surplus energy for later use. However, energy storage systems have limited capacity and thus can only store and supply a limited amount of energy. Therefore, fuel based systems are often used for backup power generation. Microturbines, diesel and electric generators (thermal systems), and fuel cells (electrochemical systems) are distributed energy generation technologies that transform fuel into useful energy. Tanrioven (2005) shows that the addition of fuel cells or diesel generators to renewable energy systems can increase the reliability of the system as the installed capacity is increased. To interconnect distributed energy generation and storage technologies, and control their operation to ensure a stable power output, the concept of micro-grids has been introduced.

Micro-grids utilize control algorithms to manage each of the interconnected energy devices to stabilize the power output with the actual energy demands. Several algorithms for optimizing the micro-grid's operation and minimizing fuel consumption have already been proposed (Hernandez-Aramburo *et al.* 2005; Obara 2007; Moghaddam *et al.* 2011). These algorithms control the operation (e.g., power output from generators, power consumption from loads, and state of charge in storage devices) of the various components in the micro-grid to provide the optimum use of resources, while minimizing cost and CO_2 emissions. As renewable energy systems and interaction with the main power network became more prominent, micro-grids evolved into smart-grids, which utilize forecast information of weather, and energy supply and demands to schedule the operation of each individual device. In this way, energy storage system can operate more effectively by recharging with anticipation if a power output decrease from the renewable power systems is forecasted.

Cogeneration systems are commonly added to micro-grids and smart-grids as well. Fuel based systems such as microturbines, reciprocating engines, Stirling engines and fuel cells are often used in cogeneration systems because they generate large amounts of waste heat during operation. This generated heat can be utilized as the driving energy input for refrigeration equipment, air conditioning, and hot water production. In this way, efficiency can be increased from 30-45 percent of pure electric generation to over 80 percent for cogeneration systems. A study by Maidment and Prosser (2000) compares the performance of cogeneration systems for cold storage facilities with and without absorption chiller technology. The hourly load considered for the facility was between 320 and 400 kW. Utilizing cogeneration to provide electricity, hot water and ambient heating for a cold storage facility using only conventional vapor compression refrigeration would present a payback period between 7.9 and 10.6 years. In contrast, using waste heat from the cogeneration system in an absorption chiller instead of ambient heating, the system's payback period was expected to decrease to 4.6 years.

From the technologies available for cogeneration systems, fuel cells appear to offer the highest electric efficiency (Onovwiona and Ugursal 2004). The operation principle of fuel cells is through electrolytic recombination of ions, similar to that of conventional batteries. In fuel cells, hydrogen and oxygen are fed into an electrochemical cell, where ions flow through an electrolyte, while electrons are transported through electrodes to produce electricity. The ions and electrons recombine with the molecules on the opposite side of the electrolyte to form H_2O. Compared to turbines and engines, fuel cells operate on an electrochemical process that does not produce NOx and soot emissions that result from combustion (Larminie and Dicks 2003). On the other hand, fuel cell systems require complex fuel flow, pressure and temperature management systems to control the power output. The characteristics of the available fuel cell generation technologies are presented in Table 1. The two main types of fuel cells utilized for residential energy generation are Polymer Electrolyte Membrane Fuel Cells (PEMFC) and Solid Oxide Fuel Cells (SOFC). The electrolyte in PEMFCs is activated at low temperature (65 °C), which allows for fast startups and effective load following operation. However, the material of the electrolyte is very sensitive to impurities and moisture levels in the fuel; therefore auxiliary systems are used to maintain this delicate balance. In SOFCs, the electrolyte is very resilient to impurities and can utilize carbon monoxide as fuel along with hydrogen. This electrolyte however, is activated at high temperature (750 °C) and thus requires preheating stages for the cell stack and the fuel input which consume additional energy, and in addition elongate its startup time. For both types of fuel cells, hydrogen (and CO in the case of SOFCs) is usually obtained by reformation of natural gas. Therefore, both systems also need a gas reforming unit if pure hydrogen cannot be supplied. Through reutilization of exhaust heat, researchers have been able to reduce the energy needed for auxiliary elements in fuel cells, increasing the overall efficiency of the system (Moghaddam 2011). In the same way, fuel cells have shown promising results as part of efficient residential cogeneration systems with decreased emissions of CO_2

(Stambouli and Traversa 2002; Tsay 2003). For fuel cell systems, the main setback has been that the industry is relatively new and development and production costs remain high. Current studies indicate that the viability of residential fuel cell systems are often limited by the equipment costs. One study in Malaysia reports that if replacement and maintenance costs for the fuel cell systems can be lowered to one third, fuel cell cogeneration systems would be able to replace the conventional system of electricity supply through power networks (Mahlia and Chan 2011). Fortunately, as it happens with most technologies, fuel cell production costs are expected to fall dramatically as production volume increases in the following years. An increase in production from 5 to 500 MW per year is expected to reduce costs by a factor of four to eight times (Thijssen 2007).

Table 1. Summary of the cogeneration characteristics of available fuel cell technologies (Onovwiona and Ugursal, 2004).

	Polymer Electrolyte Membrane Fuel Cell	**Phosphoric Acid Fuel Cell**	**Solid Oxide Fuel Cell**	**Molten Carbonate Fuel Cell**
Type of Electrolyte	H^+ ions	H^+ ions	O^{2-} ions	CO_3^{2-} ions
Operating temperature	65-85° C	190-210° C	750-1000° C	650-700° C
Electrical efficiency (HHV)	35%	36%	45%	46%
Cogeneration efficiency (HHV)	72%	75%	70%	70%
Power/heat ratio	0.95	0.92	1.79	1.92

III.A. Isolated Grids

With the advances in distributed power generation technologies, power supply becomes possible without integration to the national power network. This is especially important for isolated areas (as discussed in the introduction), where extension of the main power network is not economically or technologically feasible. In order to design a micro-grid that can supply all energy demands during the year, the capacity of components would most likely tend to increase. Although this is expected to have higher investment costs, a comparison for the long term may favor the use of micro-grids, since the costs would escalate in the same manner if the main power network is to be extended through unfavorable terrain. Energy consumption using the power network would increase as well since higher electric losses exist when long power lines are used. For on-site generation using conventional engines, fuel transportation costs and future oil prices also need to be taken into account. For isolated areas where energy demand and fuel consumption patterns are different from those in urban areas, a corresponding analysis is required.

As previously discussed, provision of a sustainable power supply in isolated areas is a persistent issue. Expansion of the main power network is not always possible, and constant demand for fossil fuels for diesel generators has negative impacts on the environment and the economy. The low availability of oil products in the near future also poses a threat to energy security in isolated areas. With the advances in micro-grids using renewable energies, the viability for isolated micro-grids for remote and rural areas increases. Efficient energy storage systems in these areas play a major role compared to network-connected distributed energy systems. Considering the future potential of these technologies, some countries have begun implementing energy independent power supply systems in remote areas.

Nayar *et al.* (2008) present a study on an isolated micro-grid for three islands in the Republic of Maldives using a 2.5 kWp solar PV system and 24 wind turbines each with a rated capacity of 1.8 kW, where a 30 kW diesel generator is considered for backup power. Using electronics and control technology to schedule the operation of the diesel generator, this system has been operating for over a decade with satisfactory results. In contrast, a study by Himria *et al.* (2008) on a remote area in Algeria analyzed another wind-diesel hybrid system (600 kW wind turbine, and a 500 kW diesel generator), but found that the economic feasibility of the isolated grid was heavily limited by the price of fuel, as well as the wind speeds in the area. Moharil and Kulkarni (2009) analyzed an isolated micro-grid using only a 25 kWp solar PV system in Sagardeep Island, India, a rural community with severe energy shortages. The community at Sagardeep used to obtain electricity from a diesel generator, although a shortage of fuel only allowed for energy production for a few hours a day and only for selected customers. However, the increasing price of oil made it difficult to sustain this system. In response, 17 solar PV panel systems were installed over a period of ten years, together with energy meters to monitor individual electric consumption. This system was deemed successful, as education, working hours, entertainment for human recreation, and residential commodities were all improved thanks to the availability of electricity. Thiam (2010) presents a summary of micro-grids in Senegal. The performance of diesel generators, wind turbines, and solar PV are compared against each other for three remote areas in Senegal with energy demands between 7.77 and 13.05 kW/day. In this case, diesel generators presented the highest levelized electricity cost, over seven times the levelized cost of solar power in the worst case. In this study the impact of fuel transport and distribution costs on energy supply in remote areas can be clearly seen. Although wind power in this case was not as competitive as solar, the results depended greatly on the wind speeds available for the area. Higher wind speeds are expected to increase power generation and thus improve the competitiveness of wind systems. Regardless, both solar and wind power systems were well above the diesel system.

Sen *et al.* (2011) analyzed the possibility of co- and tri-generation in remote areas in India using biomass. Utilizing biomass it is possible to generate electricity, heat for refrigeration or food processing, and distilled water. The main complications with tri-generation is that it has conventionally been used for large-scale industries, where installed capacity is over one megawatt, and scaling it down to lower capacity systems faces technical difficulties. However, successful implementation of these systems is expected to have a positive impact on society by creating microindustries in rural areas and thus increasing economic activity. Kumaravel and Ashok (2012) present an off-grid model for a micro-grid in an isolated area in West India. Several configurations for micro-grids are compared, and the authors conclude that for this area, a 22 kW solar PV/ biomass/hydropower micro-grid can achieve competitive costs and higher performance than the conventional system used in this area: diesel and hydroelectric generators. In order to further minimize the investment costs, design optimization models are under development. Morais *et al.* (2010) present an optimization model to minimize capital costs for a 630 W isolated micro-grid in Budapest. The model is able to schedule the operation of batteries for energy storage and fuel cells for backup power, depending on the availability of wind and solar resources for power generation. A similar model is presented by Kyriakarakos *et al.* (2011) for a small island in the Aegean Sea, in Greece. This model incorporates poly-generation of power, purified water, and fuel for 10 kWh/ day local consumption. A detailed economic analysis is presented as well, including a forecast of future oil prices. The study concludes that such system is feasible with minimal financial risk.

Domenech *et al.* (2014) analyzed the social factors in the implementation of a micro-grid in a remote area in Peru, using renewable energies. This micro-grid was installed over the course of a year, starting with wind power systems, followed by a micro-hydro power plant, a solar PV farm, and finalizing with individual PV systems. This implementation in stages was due to the varied energy demand patterns across the community, and the different power output profiles of each renewable energy source. Rechargeable batteries were installed for energy storage. The community of Alto Peru, where the micro-grid was installed, had diverse reactions to this micro-grid, regarding power reliability and excessive power consumption by certain users. Therefore, the people relied heavily on technicians for repair, maintenance, and installation of power meters for example. The results of this study reveal the differences of implementing micro-grids between isolated areas and areas that have access to the main power network. In isolated areas, local participation plays a key role in the successful implementation as they get to decide where power is needed most and who has the potential to benefit more from the energy supply.

III.B Energy Storage in Isolated Micro-grids

For isolated micro-grids, efficient energy storage is of utmost importance since backup fuel may not be available at all times. Various studies have discussed the available energy storage technologies (Ritchie 2000; Kaldellis and Zafirakis 2007; Beaudin *et al.* 2010; Connolly 2010). Figure 1 shows the most commonly used types of energy storage technologies: Pumped Hydro Storage (PHS), Compressed Air Energy Storage (CAES), capacitors, and rechargeable batteries (lead-acid, Nickel-Cadmium, Sodium-Sulfur, and Lithium-Ion). Other technologies such as flywheel mechanical storage and supercapacitors have been developed but are not yet being used extensively. Each of these technologies has advantages and disadvantages, as well as limitations for their use. PHS and CAES present the largest capacity for energy storage. In PHS, water is pumped to an upper reservoir when electricity is available. The stored water presents a high potential energy based on the difference in height of the lower and higher reservoirs. When this energy is needed back, water returns to the lower reservoir after passing through a turbine that rotates an electric generator. A larger size of the reservoir gives a higher capacity for energy storage. In a similar manner, CAES utilizes underground caverns or empty water and gas reservoirs to store compressed air. Air is compressed when electricity is available, and the energy is extracted through a turbine powered by this compressed air. Although both of these systems have high efficiencies and large storage capacity, construction of energy storage plants depends on the geography of the area. CAES systems may only be built if a suitable reservoir is available, and PHS will need an adequate difference in the height of the terrain. Conservation of the local environment is also an important factor because construction of a PHS reservoir is generally expected to cover a large land area. When these systems are utilized with renewable energies, their power generation patterns are also considered. Solar PV in particular are subject to sudden fluctuations in power output, which can create a discontinuous signal. Although batteries and capacitors may still be recharged with a discontinuous power source, PHS and CAES require a stable power input to operate efficiently, and thus it may not be recommended to combine these technologies with solar PV.

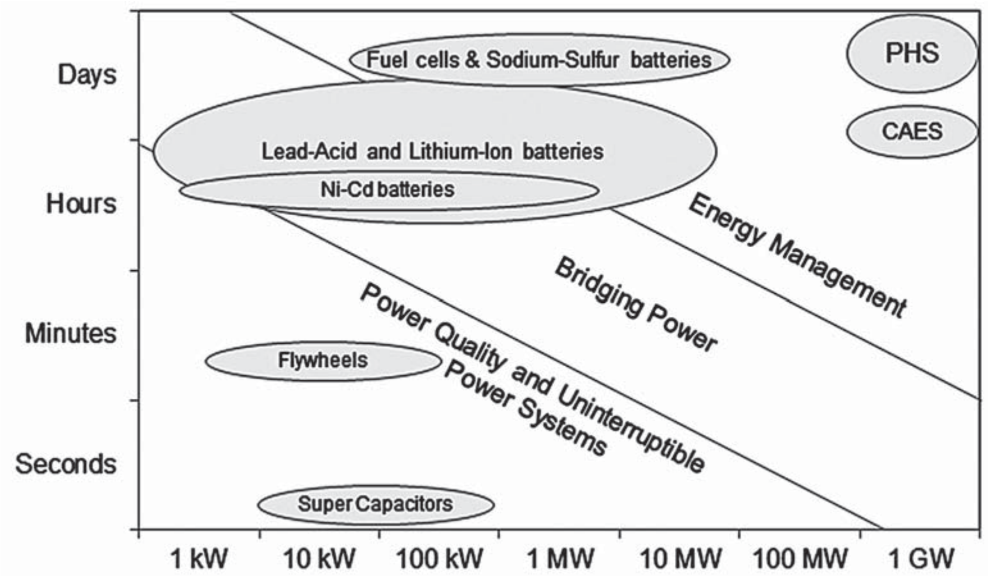


Figure 1. Scale and application of various energy storage technologies. Adapted from Kaldellis and Zafirakis (2007).

Rechargeable batteries present a more versatile option for energy storage thanks to their fast response, high efficiency and easy installation. They are non-intrusive and can be added to any system without significant reconfiguration. Batteries are however limited by their storage capacity and charge/discharge cycles. Furthermore, the lifetime of rechargeable batteries is around five years for lead-acid and Li-ion batteries, and 10 to 15 years for Ni-Cd batteries. In the long term, waste management of depleted batteries may also become a problem, in particular for Ni-Cd batteries since cadmium is a toxic material. Sodium-Sulfur batteries have a longer lifetime and their materials are inexpensive and recyclable; however, they operate at high temperature (270 °C) and thus require additional thermal management and safety regulations.

With the recent development of fuel cell technologies, hydrogen generation has also been considered an attractive alternative for energy storage. Hydrogen can be used as fuel to generate energy, although hydrogen in its pure form is not commonly found in nature. Nevertheless, hydrogen can be generated through water electrolysis, using electricity to separate water into H_2 and O_2 molecules. Energy may be stored in this way and recovered through fuel cells to produce electricity and heat. Hydrogen storage is already being considered as a solution for energy independence in isolated micro-grids using renewable energies, such as solar PV (Paul and Andrews 2008) or wind power (Yu *et al.* 2009). In PV systems, configuring the array so that the voltage output matches the electrolyzer's input can further improve efficiency (Gibson and Kelly 2010). Hydrogen storage in micro-grids using solar energy can serve as support for rechargeable batteries to increase the entire micro-grid's performance. Since power output from solar PV depends highly on weather, energy available during the year will vary between seasons. Therefore, relying on batteries during months with high solar output and using stored hydrogen to generate energy when solar output is low may reduce the micro-grid's total energy consumption (Avril *et al.* 2010). As hydrogen storage is usually implemented together with fuel cells, these micro-grids can also benefit from cogeneration of heat and power. Shabani *et al.* (2010) studied a hydrogen fueled micro-grid for a remote area in Australia, where solar energy is abundant. The results suggest that these systems could be sufficiently competitive to replace diesel generators within 30 years. A study by Brinkhaus *et al.* (2011) analyzes the possibility of off-grid solar PV micro-grids for a typical household area in Europe. Energy storage using batteries and hydrogen is compared, and the hydrogen storage system appears to show higher reliability throughout the year in terms of stable power supply. They conclude that these off-grid systems are technologically viable and are expected to be more financially competitive as costs approach those offered by the main power network.

As many countries continue to expand their energy infrastructure, areas that are now isolated may be able to be connected to the main power network in the future. Therefore it is also worth considering whether the main power network will be compatible with the energy storage and generation systems used in the isolated micro-grid. In this regard, studies by Li *et al.* (2008), Korpas and Greiner (2008), and Gutiérrez-Martín *et al.* (2009) have suggested that electrolytic hydrogen can be helpful for load balancing when connecting micro-grids to the main power network. Load in the main power network may be stabilized by shifting energy variations into the electrolyzer and using fuel cells at peak times to generate electricity on-site for local consumption, improving the power quality of the network. With these considerations, countries where the main power network is still under development could rely on hydrogen fueled micro-grids to supply energy to isolated areas, and benefit from them for load balancing when the main network is expanded.

III.C Isolated Micro-Grids Using Hydrogen Storage

Ntziachristos *et al.* (2005) present a study of an isolated micro-grid in the Greek Aegean Islands. The main power network in Greece interconnects the mainland with the Eptanisa Islands, but connection of the Aegean Islands to the west has yet to be implemented. Peak loads in this region are as low as 40 kW and the cost for electricity production is considered fairly high. Renewable energies started to be introduced in these islands, but problems with load fluctuation of the currently installed network limit the increase in capacity of renewable energies. The study considers the use of electrolyzers for load balancing and generating hydrogen to produce backup power from fuel cells. The analysis incorporates various sizes of a wind turbine system, electrolyzer for production of compressed or liquefied hydrogen, and different types of fuel cells for evaluation. The results of the study show that the proposed system can achieve payback periods between one and two years, with the period decreasing with a higher capacity wind turbine. Although liquefaction of hydrogen shows lower efficiency than compressed hydrogen, the system's payback period does not seem to vary much for either technology, suggesting that the method for hydrogen storage may not have a big impact as long as immediate consumption is favored over long-term storage.

Hydrogen storage should be assessed more assertively in order to improve reliability and minimize energy shortages for isolated micro-grids. Muhammad Ali and Andrews (2006) address the issues of high costs for hydrogen storage in isolated micro-grids, by presenting lower cost storage options and methods for solar-hydrogen systems. A computer simulation for an isolated energy supply system in southern Australia has been carried out to estimate the hydrogen fuel demands during a year. The results suggest that the cost of electricity would likely remain high for hydrogen storage systems without cost constraint, although it may be lowered by finding the optimal amount of hydrogen to store seasonally. On the other hand, the electricity cost becomes highly competitive as the storage cost decreases. In response, the authors analyzed the lowest cost for hydrogen storage options and concluded that metal gas cylinders to store compressed hydrogen allow for seasonal storage of up to seven kilograms of hydrogen at minimum costs for the selected area. There exist other low cost options for hydrogen storage that are still under research, but rapid progress is expected as the demand for hydrogen systems continues to increase. Elamari (2010) applies hydrogen storage to an isolated residential energy system in the Saharan Desert in Libya. In this region, many remote villages are not connected to the main power network, and diesel generators would be too expensive due to fuel transportation and maintenance. In this area, solar energy resources are more abundant and reliable than wind, so Elamari analyzed a solar PV system coupled with a PEMFC and a water electrolyzer, and designed a simulation model and a program for a DC/DC converter controller to maximize the output of the system. No cogeneration is implemented in this system, but generation of hydrogen might supply fuel for cooking or transportation, provided adequate equipment can be implemented.

IV. Hydrogen Infrastructure

The concept of hydrogen infrastructure is relatively new, but it has been receiving increased attention recently. As mentioned in the introduction of this paper, there is increasing concern over the availability of fossil fuels and their capacity to cover increasing global energy demands. Therefore, alternative sources of energy that are compatible with the current infrastructure are constantly under research. Hydrogen appears to be the most promising alternative in this regard, as it can be generated from both fossil fuels and renewable energies. Therefore, an energy infrastructure that utilizes hydrogen could be attractive to both consumers and suppliers in the industry, from residential and industrial energy consumption to the transport sector. Furthermore, a reduction in the combustion of fossil fuels is expected to have a positive impact on environmental degradation and air quality, as well as improving energy security by reducing fuel imports. The United States is already recognizing the importance of starting a hydrogen infrastructure in detailed reports that help as guidelines for assessing hydrogen based energy systems (US DOE 2002; Levene 2004). Other reports support the concept of hydrogen infrastructure as a transition between conventional fossil fuel energy systems and the introduction of renewable energies (Muradov and Veziroğlu 2005; Marbán and Valdes-Solís 2007). These reports present the possible paths for converting the actual energy infrastructure into one compatible with hydrogen technologies. This transition is expected to have positive impacts on energy security, environmental protection and economic growth. Currently, over 98 percent of the global demand for hydrogen is produced through reformation of hydrocarbons (mainly steam reforming of natural gas), and it is mostly consumed only in refineries and ammonia production. As the market for hydrogen fuel expands, natural gas consumption for hydrogen production is expected to increase as well. Therefore, additional sources of hydrogen (e.g., from renewable energies) are to be implemented in order to improve energy security. Midilli and Dincer (2007) utilize the global instability ratio and hydrogen based sustainability ratio, developed by Midilli, to evaluate the benefits of hydrogen energy systems. Their report suggests that an increase in non-fossil fuel hydrogen production is exponentially proportional to increased energy sustainability and lower global energy instability. Additionally, they suggest that a global increase in hydrogen energy utilization could help to improve sustainable development and energy stability values.

For isolated areas with high energy demands that currently rely on diesel powered generators, hydrogen fuel can provide a cleaner and more stable alternative, compared to the installation of large-scale electric storage systems. Isolated areas with high energy demands are those that have an established supply line of fuel, for example, the several islands surrounding the main island in Japan. Japan is not a main producer of oil products, thus the fuel needed to supply the isolated areas needs to be imported from other countries, consuming a high amount of resources and leaving a large carbon footprint in the process. Generating hydrogen in the main island through water electrolysis or reformation of carbohydrates, and using the existing fuel supply lines to transport this fuel, the energy security for these isolated areas could be effectively improved, while reducing carbon emissions due to power generation. However, if isolated areas are to transition into hydrogen based energy supply systems, then additional hydrogen sources that can meet the increased demand need to be explored. Hydrogen generation may be divided into three: non-renewable hydrogen, renewable hydrogen, and hydrogen for energy storage.

Currently, the main source for hydrogen is found in hydrocarbons. Hydrocarbons can be separated into H_2 gas and other carbon components through a number of processes. The source of hydrocarbons for hydrogen production is also varied. Methane found in natural gas is currently the main source of non-renewable hydrogen due to its abundance and for having the highest hydrogen content (two molecules of hydrogen gas per atom of carbon) among other hydrocarbons. An efficient and technologically mature process called catalytic steam reforming uses methane (CH_4) and high temperature steam (H_2O) that react over a nickel catalyst to disassociate it into H_2, CO and CO_2 gases. Although this process presents a source of carbon emissions, the catalytic reforming process does not produce NOx or soot emissions as combustion of hydrocarbons does. The steam reforming process may also be used with ethanol, which has the same hydrogen to carbon ratio as methane. Ethanol is in liquid state at standard temperature and pressure, which makes it more convenient to transport compared to natural gas. Ethanol is considered an effective source of energy for low power applications (100 to 1000 W), but for higher power applications it still lacks the infrastructure and logistics for its use (Palo *et al.* 2007).

In recent years, hydrogen generation through reformation of industrial byproducts has also been receiving attention. Although non-renewable, hydrogen generated from industrial byproducts does not present an additional consumption of resources. Waste products from coke ovens in steelworks plants, mainly coke oven gas and tar, are considered a potential source of hydrogen (Onozaki *et al.* 2006; Bermúdez *et al.* 2010). Coke oven gas has a hydrogen content of 50-60 percent and methane content of nearly 25 percent from which hydrogen may be recovered. A fraction of these waste gases is utilized for other processes in steelworks plants, but often there is excess gas that is not being taken advantage of. If isolated areas adopt hydrogen fuel as a source of energy, then industrial waste gases can be used to reduce fossil fuel imports for hydrogen production. Since these gases are considered waste products, they provide an attractive source of hydrogen with no net CO_2 emissions and lower transportation losses.

Another source of hydrogen with zero net CO_2 emissions is biomass. Biomass may be considered a renewable resource depending on the sustainability of its harvesting practices. Balat and Balat (2009) list the benefits of bio-hydrogen as fostering the economic sector (sustainability, increased rural jobs, reducing fuel imports), encouraging environmental protection (reducing carbon emissions and air pollution), and improving energy security (domestic targets, reducing fossil fuel consumption). Levin and Chahine

(2010) have compiled a report on hydrogen production methods using biomass. Biomass has been used as a source of hydrocarbons for several years now, and as such the conventional method of steam reforming may be applied to produce hydrogen. Bio-oil output from biomass is rated above 75 weight percent, and further reformation into hydrogen has shown yields of 85 percent from the total hydrogen content (Wang *et al.* 1998). Hydrogen generation through autothermal reforming of ethanol is also an efficient process with high product purity. Furthermore, ethanol is soluble in water and thus appears to be a suitable fuel for PEMFCs, as they require a high hydration level in the cell stacks (Deluga *et al.* 2004). Other processes for hydrogen production using gas are available as well. Gasification of biomass can provide high hydrogen output, if the resulting gases can be separated efficiently. Current research is improving the techniques for gas purification, achieving satisfactory results. Hydrogen is also obtained through photolysis or fermentation using algae, bacteria, or other microorganisms. Fountoulakis and Manios (2009) have shown that glycerol addition significantly enhances hydrogen output from anaerobic digestion of municipal solid waste and agro-industrial byproducts. Although these technologies are not yet mature, they appear to have a large output capacity for hydrogen generation.

Supplementary to biomass, hydrogen produced from renewable energy resources may be obtained simultaneously to further decrease the dependence on fossil fuels. Hydrogen from electrolysis can be readily implemented in solar, wind, hydro, and geothermal power systems. For each of these renewable energy sources, a number of additional processes for hydrogen generation are available (Dincer 2012). Solar energy shows the most diverse range of hydrogen production methods, such as thermolysis, thermochemical water splitting, photo-catalysis, bio-photolysis, artificial photosynthesis. The solar thermochemical water splitting process is further explained by Licht (2003). Besides, electrolysis seems to be the most effective and commercially viable for producing hydrogen from renewable resources (Sherif *et al.* 2005; Fuel Cell Today 2013). Recent advances in water electrolysis are increasing the efficiency of the process and reducing costs. A Solid Oxide Electrolyzer Cell proposed by Jensen *et al.* (2007) showed outstanding results in hydrogen production, and is expected to reduce costs by half compared to conventional alkaline electrolyzers as the technology matures. Hydrogen as a means for energy storage is also possible using both non-renewable and renewable energies. Large-scale power stations, including coal, hydro, geothermal and nuclear power, that generate power at maximum capacity regardless of demand can benefit from water electrolysis to store surplus energy in the form of hydrogen. In the same way, renewable energies that depend on weather conditions, such as wind and solar power, may store energy in the form of hydrogen when the power output exceeds demand.

Table 2. Summary of hydrogen storage technologies (HI-Energy, 2014).

	Compressed gas			Liquid hydrogen	Metal hydride	Chemical hydride
Technologies	Steel cylinders (200 bar)	Composite Cylinders (350 bar)	Composite Cylinders (700 bar)	N/A	Hydrides of light metals	Hydrides that react with water to produce hydrogen
Energy density	1 wt%H2	6 wt%H2	5 wt%H2	5 wt%H2	1-2 wt%H2	4 wt%H2
Availability	Commonly used	Standard for onboard vehicle tanks	Target for onboard vehicle tanks	Transport by tanker or in large-scale stationary vessels	Still in development	Still in development
Issues	Lowest cost, but low energy density	Low weight composite materials are a challenge		High cost, difficult to scale size down	High cost, yet low energy density	Regenerating the hydride consumes energy

In addition to hydrogen production, the method for storing hydrogen also needs to be selected with respect to the expected consumption patterns. There are four commercial storage technologies for hydrogen (Table 2): compressed gas, liquid hydrogen, metal hydrides, and chemical hydrides (Zhou 2004; HI-Energy 2014). Compressed gas in 200 bar steel cylinders is the most commonly used method. Higher pressures (350 and 700 bar) can be achieved using composite cylinders, although the selection of suitable composite materials is still an issue regarding tank size. Liquid hydrogen is more often used in large-scale transport using tankers, as hydrogen liquefaction has very low efficiency on a small scale. For long-term storage, metal hydride tanks are a better option. Metal hydrides are still expensive, but present diminished losses and improved safety. Chemical hydride technology is still under development, although it presents high energy density for storage. Regarding consumption, it is recommended to use on-site electrolysis and to avoid mid to long-term storage. If consumption is high (over 20 kg/day), on-site reforming of natural gas may be more suitable than electrolysis, mainly due to the costs and operation of the additional components needed for steam reforming (HI-Energy 2014). With regard to safety, hydrogen storage is not considered any riskier than compressed natural gas storage. The minimum fuel to air ratio at which the mixture first becomes flammable is similar between hydrogen and methane, at approximately 5 percent fuel volume. Furthermore, hydrogen safety standards have been in practice for decades and sufficient knowledge has accumulated to create or improve them, depending on the application (Tchouvelev *et al.* 2006; HI-Energy 2014).

V. Conclusions

Electrification of rural and isolated areas remains a problem. Energy supply is widely related to social development, but many regions in the world still lack a stable energy supply due to financial or technical issues. Diesel generators have been widely used for this purpose despite increasing fuel costs, but recent advances in distributed energy generation technologies promise to bring more economic and sustainable solutions. In particular, small-scale renewable energies such as wind and solar power seem to provide a viable alternative for power generation in certain rural and isolated areas. However, power output from solar and wind is inherently variable and it cannot by itself ensure stability in power supply, thus additional energy generation and storage systems are needed. Several distributed energy technologies can be used to stabilize the output signal of solar and wind power systems. These technologies can be interconnected through micro-grids in order to control their operation to match the energy demands. Technologies that produce exhaust heat such as fuel cells can also be used for cogeneration of power and hot water, increasing their overall efficiency. Several studies have shown that micro-grid systems can achieve competitive costs in isolated areas through the use of distributed energy resources, although former studies still suggest utilizing diesel generators for back-up power. In order to reduce dependence on fossil fuels and increase sustainability in isolated micro-grids, methods of compensating for the fluctuations in power output from renewable energies are needed.

Some studies are paying attention to more effective energy storage systems. Hydrogen generation as means for energy storage is a particularly attractive alternative. Hydrogen can be generated through water electrolysis using electricity from renewable energies, and utilized in fuel cells to provide both heat and power. Although rechargeable batteries present higher efficiencies than hydrogen generation, their capacity is limited and they cannot be recharged until power generation becomes higher than the demand. In contrast, hydrogen fuel can be generated through diverse sources including fossil fuels, biomass and renewable energies, and it can be transported to isolated areas in times of need, ensuring a more reliable energy supply system. Additionally, hydrogen fuel provides isolated micro-grids with the opportunity of growth. While the capacity of rechargeable batteries is usually determined with respect to the estimated power demand, fuel cells can provide energy as long as there is a fuel supply. This allows isolated areas to invest in energy to improve their commercial activities without having to increase the capacity of their energy supply system. If power supply in isolated areas is to be provided through hydrogen fueled micro-grids, an increase in hydrogen gas demand is to be expected. This paper introduces some of the available processes for hydrogen generation and storage that can be used to meet this demand. Although the costs for hydrogen fueled micro-grids are currently high, they are expected to continue to decrease over the next few years, making them competitive with conventional diesel based systems. Furthermore, the benefits in sustainability and energy stability offered by hydrogen based micro-grids make them the most viable option for power supply in isolated areas.

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The Status of the Twa Minority in Rwanda in the Past and the Present: A post-genocide policy challenge

Toshie INUI

Table of Contents

Abstract

After the 1994 Genocide, the government of Rwanda (GoR) prohibited ethnicity-based separate identification of citizens. The ID card no longer shows the ethnic identification of the card holder, and all citizens are called only Rwandese. However, the Twa, an ethnic group that has been marginalized historically in Rwanda, is now called a "Historically Marginalized People/Population" (HMP). Since my first field visit in 2011, I have witnessed social and economic discrimination against the Twa in Rwanda, and confirmed this in various reports published by human rights NGOs as well as UN organizations, despite the fact that the GoR is trying to remove the prejudices, inequalities and discrimination against the Twa. Such discrimination deprives the Twa of the freedom to live in dignity, as well as the freedom from want and fear.

This article presents an analysis of inequalities and differences between the Twa and the rest of the Rwandese from the perspective of horizontal inequalities (HIs), which encompass political, economic, social and cultural-status dimensions. These inequalities are discussed in terms of political participation, income, employment, access to education. This article also discusses policy issues regarding the Twa by examining the transformation of Rwandese society after the 1994 Genocide against the Tutsi. Finally, it concludes that the support from the GoR, although still insufficient, is having some positive effects on the life of the Twa.

Keywords

Rwanda, Twa, minority, livelihoods, HIs (horizontal inequalities),

I. Introduction

It is 53 years since the Republic of Rwanda (Rwanda) achieved independence in 1962. After independence, Rwanda became politically and economically unstable. At present, Rwanda is stable after experiencing the 1994 Genocide and determining that it would never happen again. The 1994 Genocide is usually described as a genocide committed by the majority Hutu against the minority Tutsi and the moderate Hutu. However, another minority group in Rwanda, the Twa, was also targeted during the 1994 Genocide, a subject that is rarely mentioned in academic research. After the genocide, Rwanda launched Vision 2020 in 2000 as well as other policies for economic development. Also, the indication of the name of ethnicity on ID cards was abolished after the genocide. Now, Rwanda is widely regarded as one of the success stories in Africa because Rwanda is trying to rebuild "New" Rwanda through "unity," "work" and "patriotism." But to what extent has Rwanda changed since the 1994 Genocide and do its policies include all citizens?

The Kingdom of Rwanda was formed in 1468 by the succession of the throne of Ruganzu I Bwimba. The kingdom did not expand its dominion for 300 years after formation, but it started to attack regions around the kingdom from around the 18th century and extended its territory. However, the dominion was unstable for a long time until it was colonized by Germany in 1899.[1] The League of Nations approved the mandate for Belgium in 1924. The identification card (ID) system[2], which mentions the name of ethnicity was established during the Belgium mandate. With this system, the three ethnicities in Rwanda, the Tutsi, Hutu and Twa, were clearly divided and Belgium established a system in which the Tutsi were rulers and the Hutu were ruled[3]. This European power brought such ethnic distinctions to the kingdom of Rwanda based on the Hamitic Hypothesis[4]. The sudden death of the king in 1959 triggered mistrust

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1 Takeuchi, Shinichi (Editor), *Ruwanda Shi Nenpyou*, (Chronology of History of Rwanda) "Chousa Kenkyu Houkokusyo Gendai Ahurika no Hunsou wo Rikai Suru Tameni (Research Report Understanding the Current Conflicts in Africa)" Japan External Trade Organization, 1998.

2 *Ibid*,.

3 Takeuchi, Shinichi "Gendai Afurika no Funsou to Kokka (The Post-Colonial Patrimonial State and Conflict in Africa: Understanding the Genocide in Rwanda)" Tokyo: Akashi Shoten, 2009, pp.128-129.

4 The Hamitic Hypothesis was advocated by a British explorer John Hanning Speak. Ham,

between Tutsi elites and Belgium and then Belgium tried to enforce the relations with Hutu elites called PARMEHUTU. Then, in 1959, an ethnic massacre led to about 200,000 refugees fleeing the conflict, which triggered the transformation of the politics from the Tutsi elites' monarchy established by Belgium to a Hutu elites' dominated structure.[5] Three years later, Rwanda became independent on the 1st July 1962. The second generation of refugees from the conflict in 1959 formed anti-government forces (Rwanda Patriotic Front; RPF). The 1994 Genocide occurred on the 6th of April in 1994 with the assassination of President Habyalimana and it terminated on the 18th of July 1994 with the assumption of the RPF. About 500,000 to 800,000 people of the Tutsi, moderate Hutu and Twa were killed during the 1994 Genocide, and instability continued after the ceasefire. Rwanda tried to integrate the people by abolishing the indication of ethnicities from the ID cards[6], and the International Criminal Tribunal for Rwanda (ICRT) and Gacaca courts were established in Rwanda.

There were three ethnicities, the Tutsi, Hutu and Twa, in Rwanda, but the GoR abolished the indication of the name of ethnicities on the ID card after the 1994 Genocide. The GoR has also prohibited the ethnicity-based separate identification of citizens. According to Lewis and Knight, the Twa is "the third and the lowest-status ethnic group, class, 'caste' or echelon of Rwandese society, and are recognized as being one of the 'Pygmy' people of Central Africa. The Twa are Banyarwandans sharing a common language, religions and culture of the Rwandese people as a whole."[7] Actually, the Twa were not only outsiders but also had the perspective of insiders during the 1994 Genocide. The Twa numbered no less than 28,000 and 30% of them were killed during the 1994 Genocide[8]. Interahamwe, which is a group of extremist Hutu, intimidated male

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one of the sons of Noah, appears in the chapter 9 of the Old Testament. After the evacuation from the heavy floods, Ham saw his father, Noah, being drunk and sleeping without clothes. Noah was enraged with Ham who was eventually cursed by Noah. Later, it was claimed that Ham brought civilization to Africa. This is called the Hamitic Hypothsesis. John Hanning Speke, *Journal of the Discovery of the Source of the Nile*, London: J. M. DENT & SONS LTD, 1969, p.201.

5 Takeuchi, Schinichi, "Ruwanda ni Okeru Hutatsu no Hunsou jenosaido wa Ikani Kanou ni Natta Noka (Tow Conflicts in Rwanda How did the genocide happen)", *Syakaikagaku kenkyu (Research of Social Science)* 55(5-6), 2004, p.107.

6 The Government of the United Kingdom of Great Britain Northern Ireland Immigration and Nationality Directorate of the Home Office Country Information and Policy Unit, *Rwanda Assessment,* London, 2001, p.23.

7 Lewis, Jerome & Knight, Judy, *The Twa of Rwanda: Assessment of the Situation and Promotion of Twa Rights in Post-war Rwanda*, Chadlington and Copenhagen: World Rainforest Movement and International Working Group for Indigenous Affairs, 1995, p.21.

8 Lewis, Jerome & Knight, Judy, *op.cit.,* 1995, p.93.

Twa into participating in Interahamwe. However, academic research on the 1994 Genocide does not focus on the conditions of the Twa.

The Twa are described as "Historically Marginalized People/Population (HMP)" in Rwanda today. The name, HMP, reflects their history of discrimination, prejudice and exclusion in Rwanda. All people who have Rwandese nationality are called Rwandese, but the Twa are called HMP as well as Rwandese. The Twa have suffered discrimination and prejudices historically, and have not been able to benefit sufficiently from the policy of the GoR, so they are finding it difficult to make a living. Article 14 of the Constitution mentions compensation for the genocide survivors, but the Twa's welfare is not indemnified in the Constitution. Thus, the Twa are the most vulnerable people in Rwanda today.

This research focuses on Rwanda, which has abolished the indication of the name of ethnicities from ID cards and is attempting to construct a new multi-ethnic nation. Also, it examines the differences and gaps between the Twa and other Rwandese, making use of the notion of Horizontal Inequalities (HI), which includes the perspectives of politics, economics, societies and cultures. The research also examines the current situation of the Twa and how they are treated in Rwanda. The Twa ae a historically forgotten group, but the present GoR is offering them support. There are few studies on the Twa, and this research aims to clarify the current issues confronted by the GoR from the Twa point of view, and to understand how Rwandan society has changed since the 1994 Genocide by focusing on the discriminated people, the Twa.

Section 2 of this article provides an overview of the Twa people. Section 3 focusses on two policies the GOR implemented for poverty reduction and examines the policies of the Kagame Regime since 2003. Section 4 describes the current status of the Twa. Finally, Section 5 analyses the inequalities between the Twa and other Rwandese from the perspectives of politics, economics, society and culture by adopting HIs and clarifies the current policy issues for poverty reduction of the Twa.

* This article does not aim to separate the nations of Rwanda but it aims to elucidate current policy issues relating to the Twa in post-genocide Rwanda. As such, this article does not transgress Article 33 of the Constitution of the Republic of Rwanda.

II. The Historical Status of the Twa

This section presents a historical overview of the Twa in Rwanda and the ethnicities that used to exist formally in Rwanda. There were three ethnic groups in Rwanda, the Tutsi, the Hutu and the Twa. Now they are all called Rwandese. There is much discussion on the origins of the Tutsi and the Hutu. Both the Tutsi and the Hutu have their roots in the Bantu. The Tutsi are usually regarded as the Bantu who not only adopted the food production system of yams but also engaged in cattle breeding[9]. The Hutu are also considered to originate from the Bantu and to have migrated from the frontier between today's Cameroon and Nigeria. The Twa is one of the names for the pygmies who used to be hunter gatherers[10] in central Africa. At the beginning of the 19th century, the language, Kinyarwanda, became the common language of the Tutsi, Hutu and Twa. Then, the Twa started to integrate into society, which was dominated by the Tutsi and Hutu. Originally, the Twa lived in the forest and made their living by hunting and gathering, but the livelihoods of the Twa gradually transformed to pot-making because of the large-scale deforestation in the 19th and the 20th century.[11]

According to the Unrepresented Nations and People Organization (UNPO), the Twa people live in the Great Lakes region, especially around Lake Kivu and Lake Edward[12]. Also, the report by Minority Rights Group International (MRG) says that the Twa are the original inhabitants of the forest in equatorial areas[13]. From these descriptions, the Twa should be regarded as indigenous people in Rwanda. However, the Twa are not admitted as an indigenous people because of Article 33[14] of the Constitution of the Republic of Rwanda. There was no rigid hierarchy between the Tutsi, Hutu and Twa before the colonial period, but such a hierarchy was created especially during the time of Belgian colonial rule. Ethnicities in Rwanda were formed after the establishment of the Kingdom of Rwanda in 1468, and further divided into classes and strengthened during the colonial period so that Europeans could control the Kingdom of Rwanda more easily.

The name Twa is commonly used in Rwanda and Burundi. This means that the same group of pygmies is called by different names in different countries in Africa. They are called Aka or Bambendjelé in the Republic of Congo, Bagyeli, Baka or

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9 Takeuchi, Shinichi, "Gendai Afurika no Funsou to Kokka (The Post-Colonial Patrimonial State and Conflict in Africa: Understanding the Genocide in Rwanda)" Akashi Shoten, 2009, p.85.

10 Lewis, Jerome, *The Batwa Pygmies of the Great Lakes Region*, London: Minority Rights Group International, 2000, p.5.

11 Takeuchi, Shinichi, "Gendai Afurika no Funsou to Kokka (The Post-Colonial Patrimonial State and Conflict in Africa: Understanding the Genocide in Rwanda)" Akashi Shoten, 2009, p.158.

12 UNPO, http://www.unpo.org/members/7861 (accessed on 22/June/2015).

13 Lewis, Jerome, *The Batwa Pygmies of the Great Lakes Region*, London: Minority Rights Group International, 2000, p.3.

14 Article 33; Freedom of thought, opinion, conscience, religion, worship and the public manifestation thereof of guaranteed by the State in accordance with conditions determined by law. Propagation of ethnic, regional, racial or discrimination or any other form of division is punished by law.

Medzanin in Cameroon[15], Twa, Mubuti or Bayanda in the Democratic Republic of Congo, and Bayanda in Uganda[16]. The number of Twa in Rwanda is estimated to be from 28,000 to 33,000[17]. Also, there are from 69,500 to 87,000[18] in the Great Lakes region.

The Twa of Rwanda are not formally called Twa but HMP because of their history of marginalization, discrimination and segregation. For instance, they could not eat and sit with other Rwandese[19]. It is very difficult for them to make a living because they possess little or no land. Mwami (the king of Rwanda) distributed land to some of the Twa in 1961, but most of the Twa had to rent land in exchange for belonging to a group of Hutu and supplying labor and products to them. Rwandese except the Twa possess land that had been kept from their ancestors in accordance with an executive order in 1966, but the Twa could not do so because they lived in the forests at that time. According to research on the possession of land of the Twa community conducted in 1993, 604 out of 4,553 Twa possessed no land, and 3,876 had some land but not enough, while only 73 had enough land[20]. Therefore, the Twa had to maintain their livelihoods by begging, working as farm laborers or making pots. In addition, the land law in 2005 had negative impacts on the Twa. The Twa could not possess land legally because the land law was based on the executive order in 1966. Thus, the Twa could not possess land in that year and there was no land for them to possess in 2005 when the land law came into effect.

In addition to the question of land ownership, the Twa do not have sufficient access to education. Primary education in Rwanda is obligatory and tuition is free. However, the families of students have to bear the costs of text books, uniforms, shoes, bags, lunch and others, which are burdensome for poor households. This situation makes it difficult for the Twa to go to school because they generally do not have enough money. An annual report in 2004 by COPORWA, an NGO supporting the Twa, states that only

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15 African Commission on Human and Peoples' Rights and International Working Group for Indigenous Affairs, *Report of the African Commission's Working Group on Indigenous Populations/ Communities: Research and Information Visit to The Republic of Burundi, March-April 2005*, Banjul and Copenhagen, 2007, p.11.

16 Mugarura, Benon and Ndemeya, Anicet, *The Experience of The Twa Pygmies of The Great Lakes Region*, Genève: International Council on Human Rights Policy, 2001, p.1.

17 Lewis, Jerome, The Twa Pygmies: Rwanda's Ignored People, London: University College London, 2006, p.3.

18 UNPO, http://www.unpo.org/members/7861 (accessed on 1/Dec/2012).

19 Lewis, Jerome, *op.cit.*, 2006, pp.6-7.

20 Lewis, Jerome and Knight, Judy, *The Twa of Rwanda: Assessment of the Situation and Promotion of Twa Rights in Post-war Rwanda*, Chadlington and Copenhagen: World Rainforest Movement and International Working Group for Indigenous Affairs, 1995, p.35.

23.4% of Twa could read and write and only 34% of Twa went to school[21]. The literacy rate of Rwanda in 2000 was 64.9%[22], so this figure is low compared with the rate of the whole country of Rwanda. In addition, it was reported in 1993 that some Twa children were bullied by other children and teachers because they were Twa[23].

Many male Twa were sent to jail after the 1994 Genocide with some of them being arrested based on false accusations, and the ratio of male and female Twa outside prisons was said to have become unbalanced as a result. This affected Twa society. Usually, the Twa make their living by making and selling pots as well as by getting and carrying clay. There were too few male Twa who could work as manual laborers, especially carrying clay, which meant that not enough pots could be made and incomes were reduced.

Although the Twa are experiencing the difficult conditions described above, the situation has started to change recently. Clause 2 of Article 82 of the Constitution of the Republic of Rwanda, which is about the composition of senators, mentions that "eight (8) members appointed by the President of the Republic shall ensure the representation of historically marginalized communities"[24]. Besides, as one of the policies for poverty reduction, the GoR declared the principle of "One Family, One Cow." The GoR give a cow to each poor family under the policy, so five Twa families got a cow each. The policy is aimed at benefiting the Twa, but giving a cow may ultimately change their life style from pot making and/or cultivation. Thus, the GoR may have to revise the policy so that their culture of pot-making is protected and respected.

III. The transformation of Rwanda under the Kagame Regime

This section focusses on two policies for poverty reduction in Rwanda under the control of the Rwanda Patriotic Front (RPF), the Kagame Regime. One is the policy adopted by the Ministry of Finance and Economic Planning (MINECOFIN) in 2002 and the other is one adopted by the Ministry of Local Government (MINALOC) in 2011. Then, after a brief explanation of the history of Rwanda, the section considers how the Twa and other vulnerable people are included in the policy target and how the policies changed from 2002 to 2011.

In 2003, a new Constitution was enacted and a presidential election based on universal suffrage was implemented. The incumbent president, Paul Kagame, won the

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21 COPORWA, *Rapport annuel enquête sur la condition de vie socio-économique des ménages bénéficiares de la Communautés rwandais,* Kigali, 2004, p.14.

22 UNDP, http://hdrstats.undp.org/en/countries/profiles/RWA.html (accessed on 1/ Novembr/ 2012).

23 Lewis, Jerome and Knight, Judy, *op. cit*., 1995, p.46.

24 The Republic of Rwanda, The Constitution of the Republic of Rwanda, Kigali, 2003, Article 82.

election with 95% of the votes[25]. The RPF won the election for the chamber of deputies. The senate is composed of 26 members nominated by each province, Kigali city, a historically marginalized community, the forum of political organizations and universities. In addition, Article 82 of the Constitution prescribes that at least 30% of the senators must be women.

President Kagame has enacted many reforms in Rwanda. He is especially energetic in poverty reduction efforts, and MINECOFIN and MINALOC have taken charge of policies for poverty reduction. The contents of these polices are discussed below.

1. National Poverty Reduction Program: PRSP

In 2002, MINECOFIN launched the Poverty Reduction Strategic Paper (PRSP), focusing on economic development and poverty reduction. The PRSP defines poor people as those who lack certain amounts of land, income, provisions, clothes, medical treatment and education. More specifically, it defines the poor as those whose expenditure is less than 64,000 Rwanda Franc or whose expenditure on provisions is less than 45,000 Rwanda Franc[26]. PRSP maintains that the GoR should try to stabilize the economy by means of gradual inflation, developing the private sector, including the informal sector, and nurturing good relationships with donor countries. [27]

In addition, it includes agriculture, health, education and the economic infrastructure. The agricultural sector focuses on productivity and the development of fertilizers[28]. The health sector should address the increase of quality of medical treatment and its access, the prevention of HIV/AIDS, family planning and deterring population growth[29]. Goals related to the educational sector include an increase of the literacy rate, promotion of girls' education and education about HIV/AIDS in schools[30]. The economic infrastructure should be built up in order to accelerate the development of land, air and railroad transportation, as well as that of energy and communication[31].

In addition to the contents described above, the PRSP emphasizes the necessity of strengthening support for vulnerable groups through cooperation with MINALOC and

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25 Takeuchi, Shinichi, "Kyouken Taisei no Seiritsu to Seidoka Naisengo Ruwanda no Kokka Kensetsu (The Formation of Authoritarian Regime and Institutionalization –Post Conflict National Construction of Rwanda-)", *Afurika report (Africa Repot)* 50, Japan External Trade Organization, 2010, p.18.

26 The Republic of Rwanda, Ministry of Finance and Economic Planning, National Poverty Reduction Program, 2002, pp.40-48.

27 *Ibid.,* pp.40-48.

28 *Ibid*., pp.40-99.

29 *Ibid*., pp.59-62, 68-73.

30 *Ibid*., pp.63-66.

31 *Ibid*., p.74.

NGOs. The vulnerable groups include genocide survivors, children in difficult situations such as orphans and disabled persons. Although some funds are available for them, the Twa are not regarded as a vulnerable group and it is difficult for the Twa to join in community activities[32].

2. National Social Protection Strategy: NSPS

This strategy was drafted by the MINALOC in contrast with PRSP, which can be elaborated with the aid of international organizations such as the World Bank and UN agencies. NSPS defines vulnerable groups as elderly people over 65 years old, widows, patients, orphans, young people, genocide survivors and HMPs (Twa). The GoR emphasizes support for genocide survivors with such measures as the provision of income and employment opportunities for vulnerable groups. The strategy also aims to expand social welfare, increase access to financial services, establish a social security fund for Rwanda for informal sectors and agricultural sectors and so forth. Finally, it stated that the GoR would try to reduce poverty systematically through collaboration among ministries and communities.[33]

As mentioned above, PRSP may be affected by the will of the development partners, which is sometimes no more than their speculations regarding the development of Rwanda. The PRSP document focuses only on the economic aspects such as income and expenditure. It defines genocide survivors, children in difficult situations and disabled persons all together as vulnerable groups. Some sections discuss the Twa, but the Twa are just described as Batwa and there is no deliberation on the historical background of this group. In addition, there is no clear definition of vulnerable groups in the document. For example, what kinds of people will be regarded as genocide survivors, children in difficult situations and disabled persons? Furthermore, each strategy has its own policy goals, but it does not spell out how they will be achieved.

On the other hand, NSPS explains the nature of vulnerable groups explicitly. The document also covers the guarantee of income and employment, support for people living under poverty, and improvement of development efficiency by intensification of cooperation between government and civil society. The target period is the 5 years between 2011 and 2016. The aims and objectives of NSPS are clearer than those of PRSP because the latter was more specific about the vulnerable groups and it would be easy to notice vulnerable persons. Like PRSP, NSPS still lacks a detailed definition of vulnerable groups. But, NSPS has concrete programs for achieving missions and plans with the ministries and communities such as cash grants with requirements for genocide

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32 *Ibid*., pp.93-94.

33 The Republic of Rwanda Ministry of Local Government, National Social Protection Strategy, 2011, pp.34-43

survivors and vulnerable people and investment plans for increasing the incomes of vulnerable people. NSPS also focusses on increased access to financial services by vulnerable people and expanding the social security fund to other areas. These programs and plans tend to focus on economic aspects, but NSPS is more explicit about addressing poverty reduction from all aspects. NSPS was probably drafted chiefly by the GoR because the genocide survivors are emphasized in this policy compared with PRSP.

The Twa were not directly discussed in PRSP, but NSPS mentioned their name as HMP and the support for them. The situation of the Twa seems to be improving even though the policies and support from the GoR for the Twa are insufficient. However, why are the Twa, who had been marginalized and discriminated against now being accommodated in society through policy measures? Foreign aid might have an impact on such a shift as its ratio in the development budget of the country is still very high. The ratio of foreign aid in 2012 in the national revenue of Rwanda was reduced from 85% to 41%[34]. Rwanda will face many difficulties if the aid is further reduced. Therefore, the GoR might utilize the Twa in order to appeal to donor countries to help the plight a small minority from a humanistic point of view. Thus, the GoR, which is controlled by the larger minority group the Tutsi may give support to the Twa as the same minority group in Rwanda to prevent future conflicts based on minority-majority politics. The reasons why the government wishes to support the Twa may be open to speculation, but the increased support for the Twa should be welcomed even though the reasons may be political rather than humanitarian.

IV. The Current Situation of Twa

This section describes the current situation of the Twa through interviews that were conducted in 2012 in cooperation with the NGO, Communauté des Potiers de Rwanda (COPORWA). I conducted interviews at six villages in Nyaruguru district, Southern Province. The discussion in this section is based on the results of the interviews.

In this interview research, I used the focus group method. "A focus group is a special type of group in terms of purpose, size, composition, and procedures. The purpose of a focus group is to listen and gather information. It is a way to better understand how people feel or think about an issue, product, or service. Participants are selected because they have certain characteristics in common that relate to the topic of the focus group."[35] One of the positive points of the focus group method is that it enables

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34 Alex Perry, "Strong Man, Rwanda's Battle-hardened President, Paul Kagame, Is Under Attack by the West. He's Ready for the Fight.", *TIME* (Europe, Middle East and Africa version), 24, September, 2012, p.34.

35 Richard A. Krueger and Mary Anne Casey, *Focus groups: a practical guide for applied researc*h, Thousand Oaks California: Sage Publications, 2000, p.4.

interviewees to speak their mind and say what they think about the topic to interviewers naturally.

The authorities limited the interviews to only two days. One of the most likely reasons why COPORWA agreed on such a limit on the research may be related to the characteristics of Rwandese society. There are not many foreigners in Rwanda especially in rural areas. If foreigners walk around alone or in a group, Rwandese people watch them. Sometimes, they notify the sector or the cell office about the foreigner(s). Then, such public offices will interrogate the foreigner(s) and keep an eye on them. In such conditions, COPORWA would face difficulty in conducting their activities if I were closely watched by public officials.

The questionnaire of the interviews covered the following topics:

1. The numbers of family members and persons in the village
2. Daily meals
3. Way of making a living
4. What they want to change in their life
5. The number of children going to school
6. Discrimination in school
7. (Changes brought by Vision 2020)
8. (What they feel about the name of HMP)

The interviews were conducted in the following places: Village V (8 families and 80 people), Village K (12 families and 30 people), Village RW (12 families and 35 people), Village B (15 families and 40 people), Village R (10 families and 40 people) and Village N (21 families and 42 people). I asked the Twa the above interview questions from 1 to 6. When there was time during the interview, I also asked Questions 7 and 8.

The possession of cow is a symbol of wealth in Rwanda. Goats are also important domestic animals in Rwanda because they can be bred and sold in markets. Some of the Twa were given goats and cows by the GoR as a policy. The Twa are usually thought of as making their living only by pot-making, but usually they combine pottery, agriculture and farming domestic animals such as goats and pigs.

They commonly live in modern houses in the capital city, Kigali, and the central area of the main regions, but they live in houses made of clay in rural areas and in the suburbs of the main regions. Extremely poor people often live in houses made of clay without doors. Most of the Twa people whom I met during the interviews lived in such houses. Therefore, the level of poverty could be measured by the type of houses and the possession of domestic animals. A brief summary of my findings from the field visits follows.

Village V: people in this village made their living only by pottery-making. They make two pots per day, with the price being 100 Rwanda franc per pot, and they sell ten pots per week. The dresses that people wore were dirty and they did not have shoes. The houses were made of clay with roofs but no doors.

Village K: people in this village made their living by agriculture and pottery. They made tiles in addition to pots. They dressed very well and all women wore African costume made of African cloth. Village K also received modest support from the GoR, so their houses had doors even though they were made of clay.

Village RW: people in this village mainly made their living by pottery but also by agriculture. They made 15 pots per week, but they did not reveal the prices and how many pots were sold. Few people wore shoes, but the village was supported by the GoR and the houses had doors, though the walls were made of clay. Some women wore African costumes made of African cloth, which was largely ragged.

Village B: people in this village mainly made their living by pottery but also agriculture, and rearing domestic animals. They did not wear shoes and their clothes were dirty. There were no indications that Village B received support from the GoR, but they said that they could join social activities such as community meetings and Umuganda[36] because of the GoR. They looked happy and appreciated being able to attend social activities with other Rwandese.

Village R: people in this village mainly made their living by agriculture but also pottery. They had more land to cultivate than that of the other five villages. The houses were made of clay and had doors. They were dressed well but not so cleanly.

Village N: people in this village mainly made their living by pottery but also agriculture. They sold their pots for around 150 Rwanda franc per pot, but they did not disclose the sales amount and their total income from the pots. Few of them wore shoes. The women dressed well with African costumes made of African cloth. The village had modest support from the GoR, so the houses were made of concrete and bricks and had doors. One woman, who looked like the leader of this village, had a cellphone.

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36 Umuganda is one of obligatory social activities in Rwanda and held every final Saturday on every month. Those who do not attend it have to pay some amount of penalty. Required activities include cleaning or repairing the public roads.

The interviews with villagers revealed that there were three similarities among villages: the daily meal, what they want to change in their life and what they feel about the name of HMP. They ate potatoes and beans once a day in the evening and they wanted to change their daily meal, and they wanted to change the way they made a living from pottery to agriculture and rearing domestic animals because they made little money from pottery. There was little demand for the old-fashioned looking pots made by the Twa in the market. Furthermore, the consumer goods markets were full of cheap pottery goods from China. On the other hand, some of the Twa said that they wanted to improve the quality of their pots. However, the Twa who mentioned this were not in good economic condition. Perhaps they had identified some needs on the part of some customers who were willing to buy their pots.

Regarding the name HMP, they generally thought that they had to accept the name but did not understand why they were given such a name. The GoR authority is quiet about this terminology, so they cannot do anything about it. However, during the interview some Twa said that the GoR intended to change the name HMP.

There are two differences among villages in terms of their reactions to the questions: the changes in village life occasioned by Vision 2020 and the discrimination in school. Village K, RW and N received visible benefit or positive impacts by the implementation of Vision 2020, and the residents of those villages appreciated the efforts of the GoR. On the other hand, in those villages that did not receive any positive impacts, namely, Village V and B, villagers did not express any particular feelings toward the GoR. At the same time, they did not know what they could do to get jobs because most of them had not received education. Thus, they had little idea about how to increase their income.

There were two types of opinions about discrimination in school. Some said there was discrimination in school, and others did not. Some children did not go to school because they could not concentrate on classes due to hunger. As a result, they dropped out of school. On the other hand, some of the Twa indicated the persistence of discrimination in school. Some Twa children were discriminated against by teachers when they wore nice or new uniforms that had been provided with support from NGOs. They also faced discrimination in their daily lives. For instance, if something went missing in a market when a Twa child visited, the child tended to be suspected of being the thief.

The interview research has revealed that the situations against the Twa are changing little by little. Given that the criteria for obtaining support from the GoR are not clear, it is important for the GoR to treat all villages equally. I felt that some of the Twa had no hope for their future because they could not escape poverty even though they produced as many pots as they could. Most of the Twa received no education, and the lack of educational opportunities makes it difficult for them to get jobs. If the GoR believes that people are the most important asset of the nation, it is important to give them educational opportunities as well as domestic animals and houses.

V. The Current Policy Issues in Rwanda from the Perspective of Horizontal Inequalities (HIs)

This section examines the relationships between the Twa and the rest of the Rwandese from the perspective of horizontal inequalities (HIs) and then explains the current issues that the GoR face with regard to the Twa. HIs are inequalities between culturally-defined groups rather than between individuals. Cultural elements that define group boundaries include ethnicity, gender, nationality, religion, race, and region. The inequalities are analyzed from the perspective of politics, economy, society and culture. "Economic HIs include inequalities in access to and ownership of assets-financial, human, natural resource-based, and social. Social HIs include inequalities in access to a range of services such as education, healthcare, and housing, as well as in educational and health status. Political HIs include inequalities in the distribution of political opportunities and power among groups, including control over the presidency, the cabinet, parliamentary assemblies, the bureaucracy, local and regional governments, the army, and the police. Cultural status HIs include disparities in the recognition and standing of different groups' languages, customs, norms, and practices."[37] In places where HIs are high in all dimensions, violent conflicts triggered by inter-group inequality in terms of cultural-status are more likely. It is important to analyze HIs in Rwanda to meet the countries aim of never repeating genocide and violent conflict.

1. Political HIs

Disparities in representation in parliament is an important part of political HIs. Eight senators are elected by the HMP communities due to Article 82 of the Constitution[38]. Thus, the equitable participation of the Twa in politics is constitutionally guaranteed, but in reality, only one senator was elected by Twa society in 2011[39]. Besides, it is not clear whether this person elected by the Twa community is Tutsi, Hutu or Twa. The person was just elected from the Twa community, so he or she may be

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37 Frances Stewart (Editor), *Horizontal Inequalities and Conflict Understanding Group Violence in Multiethnic Societies*, Basingstoke: Palgrave Macmillan, 2008, p.6.

38 The Republic of Rwanda, The Constitution of the Republic of Rwanda, Kigali, 2003, Article 82.

39 Gay MacDougall, *Report of the Independence Export on Minority Issues*, Genève: High Commissioner for Human Rights, 2011, p.18.

Tutsi, Hutu or Twa who is working for the community.

Filip REYNTJENS, a political scientist and a professor of the University of Antwerp, discusses Tutsitization in Rwanda. He said that "over 80 percent of mayors, most permanent secretaries and university teachers and students, almost the entire army command structure and the intelligence services were Tutsi."[40] Although ethnicity is still a key factor in Rwanda with the Tutsi taking important posts in the regime, political stability has been maintained and there have been no demonstrations against the Kagame Regime even though anti-government groups may be regulated strongly by the GoR. If such situation should occur, the GoR would be required to make more efforts to achieve transparency and accountability in politics. The way of selecting senators from the Twa community should be clearer because it might a part of "Tutsitization" if the selected person is neither Twa or Hutu.

2. Economic HIs

Economic HIs include inequalities in income, employment, assets and others. The GNI per capita of Rwanda in 2011 was 570USD[41], which is about 359,000 Rwanda Franc. On the other hand, a report by COPORWA in 2004 noted that the income of Twa was 40,932 Rwanda Franc[42]. Most Rwandese engage in agriculture, but the main occupation of the Twa is pottery. It is difficult for the Twa to make a living by pottery because demand for pottery is decreasing. A report by COPORWA in 2007 states that 9% of the Twa work in agriculture, 71% in pottery and 20% in others, and 92% of other Rwandese work in agriculture, 2% in pottery and 6% in others[43]. Even though many of the Twa aspire to change their jobs from pottery to other jobs such as agriculture or become payed workers in town, this would be difficult because of the lack of land and education. In addition, Rwandan society is an academic career-based society, so it is difficult for those who do not graduate from university to get highly paid jobs in Rwanda.

Thus, it is difficult for the Twa to get jobs in other sectors and their income is very low compared to that of other Rwandese. The availability of land in Rwanda is limited, so it is difficult to distribute land to the Twa. The GoR should provide educational

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40 Filip Reyntjens, "Rwanda Ten Years On: From Genocide To Dictatorship" *African Affairs*, 103, 2004, p.188.

41 The World Bank, http://data.worldbank.org/indicator/NY.GNP.PCAP.CD/countries/RW-ZF-XM?display=graph (Accessed 25/October/2012).

42 COPORWA(CAURWA), *Rapport annuel enquête sur la condition de vie socio-économique des ménages bénéficiares de la communautés rwandais*, Kigali, 2004, p.34.

43 COPORWA, *Rapport annuel Survey On The Status of The Rights Of Access To Land Along the Historically Marginalized Group Living In Rulindo District*, Kigali, 2007, p.14.

opportunities to adult Twa as well to enable them to find jobs in new economic sectors.

3. Social HIs

This section focuses on access to education and health. The gross and net enrolment ratios of primary schools were respectively 127.3% and 95.9% in 2011 and those of secondary schools were 35.5% and 25.7%[44] in the same year. Tuition at primary school is free in Rwanda. However, all Rwandese have to pay for school supplies such as uniforms and textbooks, and the Twa do not have enough money to bear the costs. A survey conducted in 2004 by COPORWA revealed that no less than 51%[45] of the Twa had never gone to school. Also, the actual ratio of Twa children who went to school in 2004 was only 34%[46]. According to the World Bank, they do not mention the net percentage of the primary school enrolment in 2004 of Rwanda, but the ratio in 2003 was 90%[47], and the gross percentage of 2004 was 132%[48]. In addition to the ratio of access to education, the income of the average Twa household in 2004 was 40,932 Rwanda Franc[49] (about 100 US dollar in 2004). On the other hand, the World Bank mentions that gross nation income per capita in 2005 of Rwanda was 260 US dollar[50]. It is clear that there is a large gap in income between the Twa and the rest of the Rwandese. This is why the Twa cannot afford school.

In addition to education, access to healthcare especially access to health insurance is insufficient for the Twa. The ratio of Rwandese who have health insurance was about 91% in 2010[51]. The cost of health insurance depends on income and ranges between 2,000 and 7,000 Rwanda Franc, so poor people pay 2,000 Rwanda Franc[52], but even this

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44 The Republic of Rwanda Ministry of Education, Rwanda Education Statistics, Kigali, 2012, pp.8.

45 COPORWA, *op.cit*., 2004, p.15.

46 COPORWA, *op.cit*., 2004, p.15.

47 The World Bank, http://data.worldbank.org/indicator/SE.PRM.NENR?order=wbapi_data_value_2004+wbapi_data_value+wbapi_data_value-last&sort=asc&page=2 (Accessed 14/August/2015).

48 The World Bank, http://data.worldbank.org/indicator/SE.PRM.ENRR/countries?order=wbapi_data_value_2004+wbapi_data_value+wbapi_data_value-last&sort=asc&page=2 (Accessed 14/August/2015).

49 COPORWA, *op.cit*., 2004, p.34.

50 The World Bank, http://data.worldbank.org/indicator/NY.GNP.PCAP.CD/countries/RW?display=graph (accessed 27th/June/2015).

51 The government of Rwanda, Ministry of Health, http://moh.gov.rw/english/?page_id=2529 (accessed 1/ November/ 2012).

52 All Africa.com, http://allafrica.com/stories/201101100192.html (accessed 15/December/2012).

is too high for most of the Twa.

There is inequality between the Twa and the rest of the Rwandese, and the amelioration of social HIs depends on the improvement of economic HIs. If the Twa's income were raised, they would be able to go to school and have increased access to healthcare. The GoR offers the educational opportunity of primary school to all Rwandese as compulsory education, but data from the World Bank and COPORWA indicates inequalities between Rwandese and the Twa. Tuition in primary education is free, so more children would be able to go to school if the GoR were to provide school lunch and facilities for free. Thus, the GoR should enact social security for poor people to improve their health and education.

4. Cultural-Status HIs

Twa culture is associated with pottery-making in Rwanda and this is also regarded as part of the culture of Rwanda in general. 71% of Twa work at pottery and only 2% of other Rwandese work at it[53]. The pots are sold from 100 to 150 Rwanda Franc and it is difficult to boost sales of the pots because of insufficient local needs for pots. Thus, it is difficult for Twa to earn enough money to live on from pottery. Therefore, many of them want to change their job from pottery to agriculture. However, it would be difficult to change their way of making a living to agriculture because the access to land is limited in the case of the Twa.

The GoR has launched the policy of "One Family One Cow," based on the cow as a symbol of wealth. Although the GoR has distributed cows to poor families, it did not distribute one cow for every Twa family, so its intention to change the lifestyle of the Twa may be doubtful. However, in the long term, it is expected that the distribution of cows will gradually change the livelihoods of Twa and that the number of potters could decrease.

In Rwanda, there are issues with transparency and accountability with regard to how HIs are dealt with in policy-making. Socio-economic HIs could be addressed by increased access to education and measures for income generation targeting the Twa. The improvement of cultural HIs hinges upon the protection of pottery as part of the national cultures of Rwanda and the promotion of the pottery industry if Twa wish to continue to make their living by pottery. Thus, it is important to tackle the issues comprehensively in multiple fields.

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53 COPORWA, *op.cit.*, 2007, pp.13-14.

Conclusion

This research focused on the experience of Rwanda, which has abolished the indication of ethnic names from ID cards of citizens and tried to construct a new nation. This country could serve as an example of a multi-ethnic African nation. The research also examined differences and gaps between the Twa and other Rwandese through the perspective of horizontal inequalities (HIs), which encompass politics, economy, society and culture.

Since the 1994 Genocide, the RPF has been in office under the banner "Never Again." The GoR decided to ban the formal distinction of ethnic groups: Tutsi, Hutu and Twa, and tried to integrate all of them into the single Rwandese. At the same time, Rwanda has made efforts towards development and poverty reduction. The poverty ratio has decreased and the ratio of the gross nation income (GNI) and gross domestic product (GDP) has gradually risen. Therefore, Rwanda has achieved massive economic and social changes since the 1994 Genocide.

The society of Rwanda may be changing positively little by little as seen by the change in attitude toward the Twa. However, the Twa are still living in extreme poverty. There is a lack of infrastructure such as electricity and water supply, as well as provisions to satisfy basic human needs such as clothes, provisions, houses, medical treatment, and education. The HIs between the Twa and the rest of the Rwandese will be ameliorated with higher and more effective participation of the Twa in national and local politics, income generation, employment creation, and access to education and health. It is also important for Rwandese to show respect to Twa culture, especially, pottery making. The GoR has made some progress on poverty reduction since the 1994 Genocide even though HIs are still very high in Rwanda and there are still bias in light of ethnicities. The policies of the GoR have not equally affected the life of all Rwandese, as the HIs between the Twa and the rest of the Rwandese persist. The policies should match the Twa's needs to improve their own living conditions. Thus, the GoR should provide social security to cover basic human needs of poorer populations, especially those of the Twa. General policy measures such as the introduction of the compulsory educational system may not be sufficient to remove the social and educational inequalities that persist in Rwandan society because various conditions discourage the Twa from going to school. Only when the HIs between the Twa and the rest of the Rwandese have been effectively removed can it be said that Rwanda has truly changed.

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