10th Eco-Energy and Materials Science and Engineering Symposium


On December 5-8, 2012
Sunee grand hotel,
Ubon-ratchathani

Organized by

Co-organized by
PREFACE:
Message from the President of
Rajamangala University of Technology Thanyaburi

Rajamangala University of Technology Thanyaburi (RMUTT), in conjunction with Kyoto University, is pleased to host the 10th Eco-Energy and Materials Science and Engineering Symposium (10th EMSES). This international conference is not only giving an opportunity for Thai and foreign researchers to present and discuss their research works and update their expertise but also to initially stimulate the development of research works on eco-energy and materials science and engineering. Our program consists of six research tasks: (1) Energy Technology, (2) Environmental and Social Impact, (3) Nanotechnology and Materials Science, (4) Energy Economics and Management, (5) New Energy technology and (6) Nuclear Technology.

I would like to take this opportunity to express our sincere gratitude to our two distinguished Plenary Speakers for kindly accepting our invitation. I deeply appreciate the very strong support given by Kyoto University. Thanks to the tireless works of the Organizing Committee, the Technical Program Committee, the invited speakers and paper and poster contributors, and excellent program been assembled to cover a broad spectrum of interesting topic.

We warmly welcome you to the 10th EMSES on December 5-8, 2012, Ubon Ratchathani, Thailand.

Numyoot SONGTHANAPITAK, Ph.D.
President of Rajamangala University of Technology Thanyaburi and Conference Chairman of 10th EMSES 2012
PREFACE:
Message from the Director of
Institute of Advanced Energy, Kyoto University

It is my great pleasure to have the 10th Eco-Energy and Materials
Science and Engineering Symposium (EMSES) with Rajamangala
University of Technology Thanyaburi (RMUTT) under the long-term
collaboration between RMUTT and Kyoto University. The 1st EMSES
was held in 2001 in Thailand and the symposium has been expanded in
its scientific contents as well as the academic network. I believe that the
10th EMSES gives a good opportunity to all participants to exchange
their knowledge and idea to realize eco-friendly energy system in society.
I would like to express my welcome to all participants and sincere thanks
to the 10th EMSES organizing committee and all supporting
organizations to make us having this symposium.
I hope that the symposium will be successful and lead to further progress
in energy science and technology and also in friendships of participants.

Professor Yukio Ogata, Ph.D.
Director of Institute of Advanced Energy, Kyoto
University
PREFACE:
Message from the Former Dean of
Graduate School of Energy Science, Kyoto University
Program Leader,
Global COE “Energy Science in the Age of Global Warming”

I want to express my hearty welcome to all participants of Eco-Energy and Materials Science and Engineering Symposium (10th EMSES). This symposium is aiming the realization of importance of energy and materials technology through the academic, science and technology network among the world communities. The symposium gives an opportunity for researchers to discuss their research works and also to initially stimulate the development of research works on eco-energy and materials science and engineering. Once the cooperation among researchers has been created, the further cooperation work will be developed.

I would like also extend my sincere thanks to all who made the meeting possible, including the 10th EMSES organizers, the SEE forum committee members, and the Japanese Government, JSPS, for their kind support. I am looking forward to seeing you in Ubon Ratchathani, Thailand.

Professor Takeshi YAO, Ph.D.
Former Dean of Graduate School of Energy Science, Kyoto University
and Program Leader, Global COE “Energy Science in the Age of Global Warming”
Message from the Chairperson of 10th EMSES Organizing Committee

Rajamangala University of Technology Thanyaburi (RMUTT), in conjunction with Kyoto University, is pleased to host the 10th Eco-Energy and Materials Science and Engineering Symposium (10thEMSES).

RMUTT has a major mission on encouraging and supporting all areas of research. One of the key reasons is to assist in developing capability in science and technology in order to cope with recent rapid change in this field. We have jointly set up an academic symposium on the 10thEMSES with the perception on the significance of exchanging knowledge and research experiences between researcher in the field of energy, materials technology and environmental science. This symposium is not only giving an opportunity for Thai and foreign researcher to present and discussion their research works and update their expertise but also to initially stimulate the development of research works on eco-energy and materials science and engineering. Once the cooperation among researchers has been created, the closer future cooperation incorporate with joint-research works will be developed. Thus, to support the aforesaid role, the symposium working committee would like to invite you to participate in this academic symposium.

I would like to express our sincere thanks to the organizing committee, participants and contributors for your kind corporation to this symposium. I wish this symposium proceeding will be a useful reference for future scientific research development.

Sommai PIVSA-ART, Ph.D.
Dean of Faculty of Engineering, RMUTT
Director of CoE on Sustainable Energy System (Thai-Japan)
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RMUTT, Thailand

30 x 15C = 33, 30 / 40
### Conference Program of 10th Eco-Energy and Materials Science and Engineering

#### 5th December 2012

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<tr>
<td>01:00-05:00 pm</td>
<td>Registration</td>
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#### 6th December 2012

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<td>09:00-09:40 am</td>
<td>Opening Ceremony at Taptim Siam 4 Hall</td>
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<td></td>
<td>Assoc. Prof. Dr. Numyoot Songthanapitak, President of RMUTT, Thailand and Chairperson of 10th EMSES conference</td>
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<td></td>
<td>Prof. Dr. Kiyoshi Yoshikawa, Vice President of Kyoto University, Japan Co-Chairperson of 10th EMSES conference</td>
</tr>
<tr>
<td>09:45-10:45 am</td>
<td><strong>Keynote Speaker I</strong>: Japan Power Generation Mix and Energy Security after Fukushima Nuclear Accident, presented by Professor Dr. Keiichi N. Ishihara, Graduate School of Energy Science, Kyoto University, Japan</td>
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<tr>
<td>10:45-11:00 am</td>
<td>Coffee break</td>
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<td>11:00-12:00 am</td>
<td><strong>Keynote Speaker II</strong>: Vertical Motions in Greater Bangkok Area after the 2004 Sumatra-Andaman Earthquake from GPS Observations and Its Prediction based on the Geophysical Modelling, presented by Professor Dr. Chaiermchon Satirapod, Chulalongkorn University, Thailand</td>
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<td>12:00-01:30 am</td>
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#### Room 1: Pathumwan

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<tr>
<th>Paper ID</th>
<th>Chair</th>
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<td>IN03,ET04,ET10, ET12,ET13,ET17</td>
<td>Prof. Dr. Padungsak Ratthanacho</td>
<td>Dr. Wirachai Roynarin</td>
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<tr>
<td>IN0,NM35,NM54, NM61,NM72</td>
<td>Assoc. Prof. Dr. Wisanu Pecharapa</td>
<td>Dr. Sorapong Pavasupree</td>
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<tr>
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<td>Assoc. Prof. Dr. Vijit Kinnares</td>
<td>Dr. Boonyang Plangklang</td>
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<tr>
<td>IN17,NM31,NM32, NM34,NM60</td>
<td>Prof. Dr. Narongrit SombatSompon</td>
<td>Dr. Supakij Suttiuengwong</td>
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<td>Assoc. Prof. Dr. Seiichi Kawahara</td>
<td>Asst. Prof. Dr. Warunee Annyawriyaman</td>
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<td>IN15,NT13,NT14, NT15,NT16,NT18,NT19</td>
<td>Prof. Dr. Hideaki Ohgaki</td>
<td>Dr. Nithiwatthi Choosakul</td>
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<td>Prof. Dr. DaeHee Park</td>
<td>Asst. Prof. Dr. Jakree Srinonchart</td>
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<td>Coffee break</td>
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<td>03:15-04:45 pm</td>
<td>Energy Technology 2</td>
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<td>Nano&amp;Materials Technology 2</td>
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<td>05:00-06:30 pm</td>
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</tr>
<tr>
<td>Co-Chair</td>
<td>Dr. Sorapong Pavasupree and Dr. Sumonman Niamlang</td>
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# Conference Program of 10th Eco-Energy and Materials Science and Engineering

**7th December 2012**

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<td>Assoc. Prof. Dr. Thawatch Kerdchuen</td>
<td>Dr. Seichi Aiba</td>
<td>Prof. Dr. Takeshi Yao</td>
<td>Asst. Prof. Dr. Somchai Hiranvarodom</td>
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<td>Co-Chair</td>
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<td>Dr. Leong Yew Wei</td>
<td>Dr. Supaporn Tomson</td>
<td>Dr. Nathabhat Phankong</td>
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<tr>
<td>Chair</td>
<td>Dr. Arthit Sode-Yome</td>
<td>Assoc. Prof. Dr. Kawee Srikulkit</td>
<td>Prof. Dr. Jun Li</td>
<td>Prof. Dr. Hiroyuki Hamada</td>
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<tr>
<td>Co-Chair</td>
<td>Asst.Prof.Dr. Boonrit Prasartkeaw</td>
<td>Assoc. Prof. Dr. Yuji Aso</td>
<td>Dr.Sarocha Charoenvai</td>
<td>Dr. Narongchai O-Charoen</td>
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<td><strong>Lunch break</strong></td>
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<td>Environmental &amp; Social Impact 1</td>
<td>Energy Economic &amp; Management 1</td>
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<tr>
<td>Chair</td>
<td>Prof. Dr. Chul-Su Kim</td>
<td>Prof. Dr. Yuichi Anada</td>
<td>Prof. Dr. Keiichii N. Ishihara</td>
<td>Assoc. Prof. Dr. Natha Kuptasheen</td>
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<tr>
<td>Co-Chair</td>
<td>Dr. Winai Chanpeng</td>
<td>Assist. Prof. Dr. Kazushi Yamada</td>
<td>Asst. Prof. Dr. Sommai Pavsa-art</td>
<td>Dr. Boonyang Plangklang</td>
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<td><strong>Time</strong></td>
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**Excursion**
Optimal Distributed Generation Placement and Sizing for Power Loss Reduction Using Particle Swarm Optimization

W. Phuangpornpitak and K. Bhumkittipich
Power and Energy System Research Centre, Department of Electrical Engineering, Faculty of Engineering,
Rajamangala University of Technology Thanyaburi, Klong 6, Thanyaburi, Pathumthani 12110
E-mail: au_wrcpppt@hotmail.com

Abstract — This paper presents a new methodology using Particle Swarm Optimization (PSO) for the placement of Distributed Generation (DG) in the radial distribution systems to reduce the power loss. Single DG placement is used to find the optimal DG location and its size which corresponding to the maximum loss reduction. The proposed method is tested on the 26-bus radial distribution system which modified from the Provincial Electricity Authority (PEA) distribution system. The total power is 8.49 MW and 5.97 MVAR and the power loss is 11.68 kW and 26.08 kVAR. The load flow analysis on distribution use forward-backward sweep methodology. The simulation results show that PSO can obtain maximum loss reductions.

Keywords — Distribution Generator, Particle Swarm Optimization, Radial Distributed System

1. INTRODUCTION

PV distributed generation systems can make a positive contribution to the sustainability in developing countries that have access to electricity grid. Thailand is a tropical country and has plenty of sunshine[1]. Therefore, the country has abundant of solar resource to generate electricity. Integration of solar photovoltaic system with grid connection would assist in supplementing the continually increasing of electricity need in Thailand. Greater use of PV distributed generation systems can also increase reliability of the electricity grid. Many problems exist arising from the operation of PV distributed generators jointly with the grid. Particularly, optimal placement and sizing of such system need to be optimized for improving voltage support in distribution networks. Therefore, it is necessary to take into account optimal allocation and sizing of DG grid connected in distribution systems during the design stage.

With the increase of distributed generation systems that are happening nowadays, the application of particle swarm technique which is the useful tool for system design and sizing for an actual feeder are presented in this study. The methodology applies the Particle Swarm Optimization (PSO) in order to minimize the system loss. Minimum system losses are obtained subject to power constraint, voltage constraint and current limit.

The organization of this paper is as follows. Section 2 addresses the problem formulation. The PSO algorithm is represented in Section 3. A PSO computation procedure on for the OPDG problem is given in Section 4. Simulation result on the test systems are illustrated in Section 5. Then, the conclusion is given in Section 6.

2. PROBLEM FORMULATION

The real power loss reduction in a distribution system is required for efficient power system operation. The loss in the system can be calculated by equation (1) given the system operating condition [2].

\[ P_L = \sum_{i=1}^{n} \sum_{j=1}^{n} A_{ij} (P_{ij} + Q_{ij}) + B_j (Q_{ij} - P_{ij}) \]

(1)

where,

\[ A_{ij} = \frac{R_j \cos(\delta_i - \delta_j)}{V_i V_j} \]

\[ B_j = \frac{R_j \sin(\delta_i - \delta_j)}{V_i V_j} \]

where, \( P_i \) and \( Q_i \) are net real and reactive power injection in bus 'i' respectively, \( R_0 \) is the line resistance between bus 'i' and 'j', \( V_i \) and \( \delta_i \) are the voltage and angle at bus 'i' respectively.
The objective of the placement technique is to minimize the total real power loss. Mathematically, the objective function can be written as:

\[ \text{Minimize } P_L = \sum_{k=1}^{N_s} Loss_k \]  

Subject to power balance constraints

\[ \sum_{k=1}^{N_s} P_{DGk} - \sum_{k=1}^{N_s} P_{DN} = P_L \]  

Voltage constraints:

\[ |p_i|_{\text{min}} \leq |p_i| \leq |p_i|_{\text{max}} \]  

Current limits:

\[ |I_i| \leq |I_i|_{\text{max}} \]  

where \( Loss_k \) is distribution loss at section \( k \), \( N_s \) is total number of sections, \( P_L \) is the real power loss in the system, \( P_{DGk} \) is the real power generation DG at bus \( i \) and \( P_{DN} \) is the power demand at bus \( i \).

3. PARTICLE SWARM OPTIMIZATION

PSO is an optimization technique based on the movement and intelligence of swarms. PSO applies the concept of social interaction to problem solving. It was developed in 1995 by James Kennedy (social-psychologist) and Russell Eberhart (electrical engineer) [3]. Particle swarm is the system model or social structure of basic creature which make a group to have some purpose such as food searching. It is an important part to take the most of population in a group that has the same activity. The group of creatures has this relative behavior, for example, bee swarm, fish school and bird flock.

PSO consists of a group (swarm) of individuals (particles) moving in the search space looking for the best solution. Each particle is represented by a vector \( s \) of length \( n \) indicating the position and has a velocity vector \( v \) used to update the current position which adjusts its flying according to its own flying experience as well as the flying experience of other particles. Each particle keeps track of its coordinates in the solution space which are associated with the best solution (fitness) that has achieved so far by that particle. This value is called personal best, \( p_{best} \). Another best value that is tracked by the PSO is the best value obtained so far by any particle in the neighborhood of that particle. This value is called \( g_{best} \).

The basic concept of PSO lies in accelerating each particle toward its \( p_{best} \) and the \( g_{best} \) locations, with a random weighted acceleration at each time step as shown in Fig. 2. Each particle tries to modify its position using the following information with the flowchart of PSO algorithm as depicted in Fig. 3:

- the current positions,
- the current velocities,
- the distance between the current position and the \( p_{best} \),
- the distance between the current position and the \( g_{best} \).

The modification of the particle’s position can be mathematically modeled by using equations (6) and (7):

\[ v_i^{k+1} = w v_i^{k} + c_1 r_1 (p_{best} - s_i^k) + c_2 r_2 (g_{best} - s_i^k) \]  

\[ s_i^{k+1} = s_i^k + v_i^{k+1} \]  

where,

\( c_1, c_2 \): The weighting factor,
\( r_1, r_2 \): The random numbers between 0 and 1,
\( w \): The weighting function,
\( v_i^k \): The current velocity of particle \( i \) at iteration \( k \),
\( v_i^{k+1} \): The modified velocity of particle \( i \),
\( s_i^k \): The current position of particle \( i \) at iteration \( k \),
\( s_i^{k+1} \): The modified position of particle \( i \),
\( p_{best} \): The personal best of particle \( i \),
\( g_{best} \): The global best of the group.

AllRashidi M.R. and El-Hawary M.E. [5] have noted the advantages of PSO technique over other optimization techniques as follows:

- It is easy to implement and program with basic mathematical and logic operations,
- It can handle objective functions with stochastic nature, like in the case of representing one of optimization variables as random, and
- It does not require the good initial solution to start its iteration process.
However, the drawbacks of PSO technique still exist as follows [5]:
- More parameters tuning is required, and
- Programming skills are required to develop and modify the competing algorithm to suit different optimization problems.

![Fig. 2. Concept of modification of a searching point by PSO](image)

**Fig. 2. Concept of modification of a searching point by PSO**

4. SIMULATION PROCEDURE

The flowchart of the proposed algorithm is illustrated in Fig. 4 [6]. The PSO-based approach for solving the optimal placement of distributed generation problem to minimize the loss takes the following steps:

**Step 1:** Input line and bus data, and bus voltage limits.

**Step 2:** Calculate the loss using distribution load flow based on backward-forward sweep.

**Step 3:** Randomly generates an initial population (array) of particles with random positions and velocities on dimensions in the solution space. Set the iteration counter \( k = 0 \).

**Step 4:** For each particle if the bus voltage is within the limits, calculate the total loss using equation (1). Otherwise, that particle is infeasible.

**Step 5:** For each particle, compare its objective value with the *individual best*. If the objective value is lower than \( P_{best} \), set this value as the current \( P_{best} \), and record the corresponding particle position.

**Step 6:** Choose the particle associated with the minimum *individual best* \( P_{best} \) of all particles, and set the value of this \( P_{best} \) as the current *overall best* \( G_{best} \).

**Step 7:** Update the velocity and position of particle using equations (6) and (7) respectively.

**Step 8:** If the iteration number reaches the maximum limit, go to Step 9. Otherwise, set iteration index \( k = k + 1 \), and go back to Step 4.

**Step 9:** Print out the optimal solution to the target problem. The best position includes the optimal locations and size of DG, and the corresponding fitness value representing the minimum power loss.

The PSO algorithm is able to reach a good solution by finite steps of evolution steps performed on a finite set of possible solutions. The objective function for the optimization is the power loss reduction as shown in equation (1). The PSO algorithm sets in the core of this optimization problem. This routine is programmed by MATLAB software.

![Fig. 4. PSO-OPDG computational procedure](image)

5. SIMULATION RESULTS

The microgrid distribution system (22 kV) is used as a test system. A system was selected from one part of the PEA central station distribution network. The single line diagram of the network is illustrated in Fig. 5. The 26-bus system has 25 sections with the total load of 8.49 MW and 5.28 MVAR. The original total real and reactive power losses of the system are 11.68 kW (0.14%) and 26.08 kVAR (0.49%), respectively. The base MVA is 10 MVA and the base kV is 12.66 kV. For PSO parameters, population size=100, Maximum generation \((k_{max})=50\). Following analysis is performed with the test system and results are presented accordingly.
Fig. 5. A 26-bus radial distribution system

The proposed methodology was run on a 26 bus test system. The impact of installing DG in the case study network with optimal allocation and sizing is presented in Table 1. The decrease in total power loss depends on the location and size of DG.

<table>
<thead>
<tr>
<th>Bus Number</th>
<th>DG size (MW)</th>
<th>Ploss kW</th>
<th>Qloss kVar</th>
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<tr>
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<td>23.6760</td>
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<tr>
<td>3</td>
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<td>18.2691</td>
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<td>5</td>
<td>7.9300</td>
<td>5.0661</td>
<td>11.3894</td>
</tr>
<tr>
<td>6</td>
<td>7.5522</td>
<td>5.3662</td>
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</table>

Fig. 6 shows the suitable DG size of a 26-bus test system and Fig. 7 shows the power loss of a 26-bus test system. The minimum power loss occurs in bus 14 (4.56 kW and 10.20 kVAR). The proposed method can reduce loss by 61% of its original loss.

Fig. 7. Power loss of a 26-bus test system

Fig. 8 shows the voltage level comparison for the 26-bus system with and without installation of DG system. In order to have a clear comparison, bus voltages in the base case and also after installation of DG units are illustrated in Fig. 8. The outcomes represent that installation of DG units considerably improves the voltage profile. Note that installation of DG units give better average voltage levels (0.9985 per unit) compared with the original system (0.9977 per unit). In the system without DG units, the lowest voltage level is 0.9967 per unit. After the PV units are installed, the voltage level are improved (0.9977 per unit).

Fig. 8. Voltage level comparison on the 26-bus system
6. CONCLUSION

In this paper, a particle swarm optimization for optimal placement of DG is efficiently minimizing the total real power loss satisfying transmission line limits and constraints. The methodology is fast and accurate in determining the sizes and locations. The methodology is tested on a 26 bus systems. By installing DG at all potential locations, the total power loss of the system has been reduced drastically and the voltage profile of the system is also improved.

REFERENCES


