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# An Optimum Technique for Renewable Power Generations Integration to Power System using Repeated Power Flow Technique Considering Voltage Stability Limit

Chaisit Wannoi [a,]*, Anurak Khumdee [a], Narumon Wannoi [b], Chai / Chow Chompoo-inwai [a]

[a]*Electrical Engineering Department, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, 10520, Thailand*
[b]*Electrical Technology Department, Faculty of Agriculture Technology, Phetchabun Rajabhat University, Phetchabun, 67000, Thailand*

**Abstract**

This paper presents an optimum location definition and technique for a better placement location of renewable power generations in a wide area power system using repeated power flow technique considering voltage stability limit. In this study, for a better understanding, the author have implemented the newly proposed idea on Thailand's power system especially focusing on renewable generation support plan from the government policy under the current Power Development Plan (PDP 2015). The study results have compared between: 1) installation the renewable generation at the newly recommendation area and 2) installation the renewable generation facilities throughout into distribution system in the Northeastern area of Thailand. The study results focus on impaction to voltage stability when system has load demand increasing and generation capacity decreasing. This study, a Modified-Thailand's power system during peak load in 2013 was used as a system base case with generation capacity around 27,400 MW and load demand around 26,810 MW while system losses 590 MW. The results found that the newly proposed technique can define optimum location for install renewables generation in wide area to enhance system security in term of voltage stability impaction. This technique may also carry to define the installation of other equipment as FACTS devices or define generation dispatch for Automatic Generation Control system (AGC) for power system stability enhancement.


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*Keywords:* Optimum Location; Renewable Power Generation; Wide Area; Repeated Power Flow; Voltage Stability Limit

* Corresponding author. Tel.: +6-691-839-6689
*E-mail address:* cwannoi@gmail.com.


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## 1. Introduction

Typically, the area definition and technique for a proper installation of new power generation in a wide area of power system is very difficult to define base on optimum and highly usefulness to power system stability [1]. Then, this study have present a technique to define optimum area to promote area or zone for a proper placement of any new generation facilities integration into power system using continuation repeated power flow calculation. It is found that the optimum location for installation is critical voltage area when load demand in area has increased or generation capacity in area has decreased which the critical voltage areas have considered with voltage stability limit. This study used Thailand's power system in 2013 during peak load[2,3,4] for system base case which the system has control voltage at 0.95-1.05 p.u. under violation limit setting is 0.9-1.1 p.u. and %loading of transmission less than 100%. Thailand's power system have explanation plan to install new renewable power generation follow the current power development plan[5,6]. This study focus on define the optimum location for install renewable generation in the Northeastern of Thailand power system or area2 used POWERWOLD simulation program. Typically, power system may become unstable if generation capacities in area are decrease or load demands in area are increase or some intermittent renewable resources were integrated into power system[7]. Then, this newly proposed technique has used these issues to create the case studies and solved by repeated power flow calculation to define optimum location for installation renewable generation considering voltage stability limit.

## 2. Key concepts related to voltage stability limit

According to[8], the Voltage stability problems in power system have occurred in heavily stressed or congestion system which this problem leading to voltage collapse and it make system stability decrease. Same situation can be happened in Thailand system under the renewable generation mixed environment. One can represent the voltage collapse with the VR-PR curve at bus voltage when the total active power at bus has increased as show in Fig. 1.

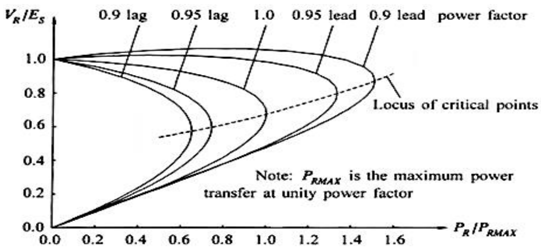


Fig. 1. The $V_R$-$P_R$ curve at bus voltage[8].

## 3. Newly proposed repeat power flow technique

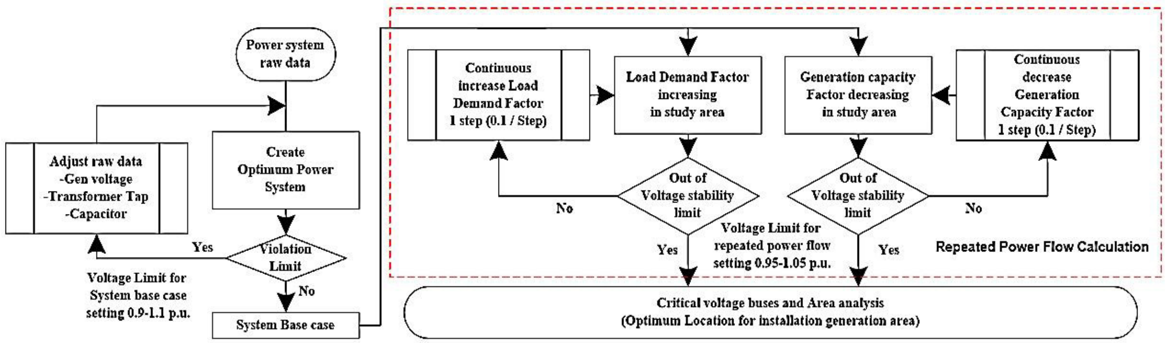


Fig. 2. An Optimum location for Install new generation definition (newly proposed).

Figure 2 has shown flowchart for newly proposed optimum location technique repeated power flow calculation. This newly proposed method has a major different from the traditional repeated power flow method with continuation repeated power flow calculation under two condition which consist the continuous load factor increasing and generation factor decreasing method. This flowchart have start with create the optimum power flow by control limit of voltage is 0.95-1.05 p.u. and %loading of transmission line <100%. After that select power system area for study and start to find critical voltage buses in case load demand in area increasing by step size for increasing is 0.1 until system unstable under generation capacity not change. In case of generation capacity in area decreasing by step size for decreasing is -0.1 until system unstable under load demand not change. Then, The study results to find the critical voltage buses will select voltage buses less than voltage violation limit which these critical voltage buses (CVB) are optimum area for install new power generation for voltage stability enhancement.

## 4. Study results

The results have compared between two cases study: the case of loads demand increasing and the case of generation capacity decreasing in area which the results in case system base case as shown in Fig. 3,4 by focus on main buses in area (71 buses at 115kV and 230kV). A study results from two case studies found 6 buses (LE, SU, SKA, BR, PKC,NR2) in system have voltage lower than the violation limit control. Then, these 6 buses are recommendation areas to install the new renewable generation.

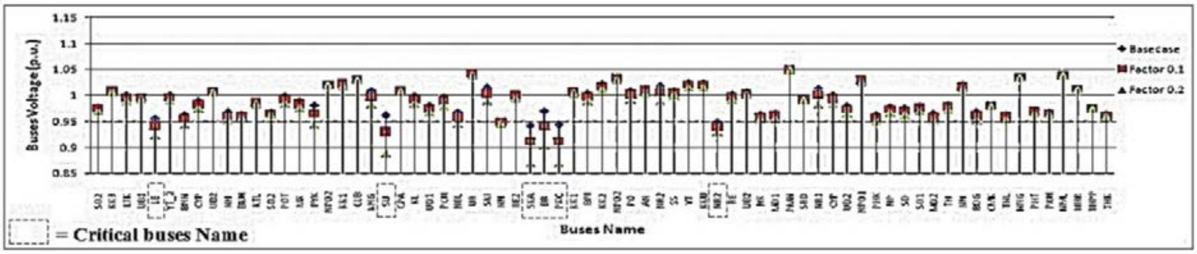


Fig. 3. The voltage profile in case of loads demand increasing until system unstable.

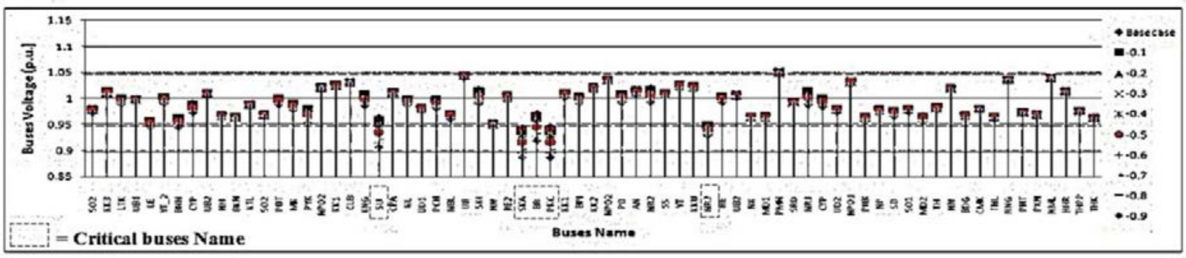


Fig. 4. The voltage profile in case of generation capacity decreasing until system unstable.

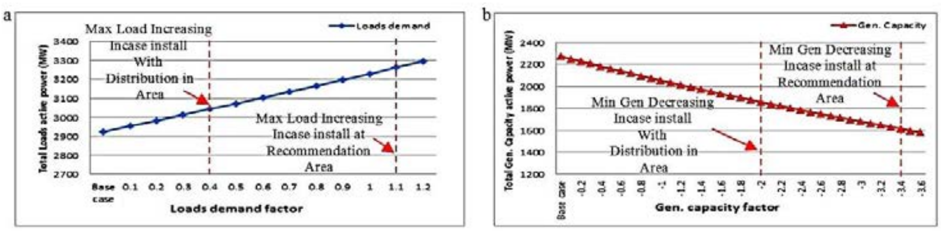


Fig. 5. (a) The Comparison of Maximum loads increasing; (b) The Comparison of Minimum generation capacity decreasing

The Figure 5 have shown the comparison results of the difference location installation of the renewable generation which consist the installation at recommendation areas and installation with distribution at 52 buses at 115kV as same as total capacity (200MW). The study results found installation generation at recommendation areas can support loads increasing more than installation with distribution which the results can show in Fig. 6,7.

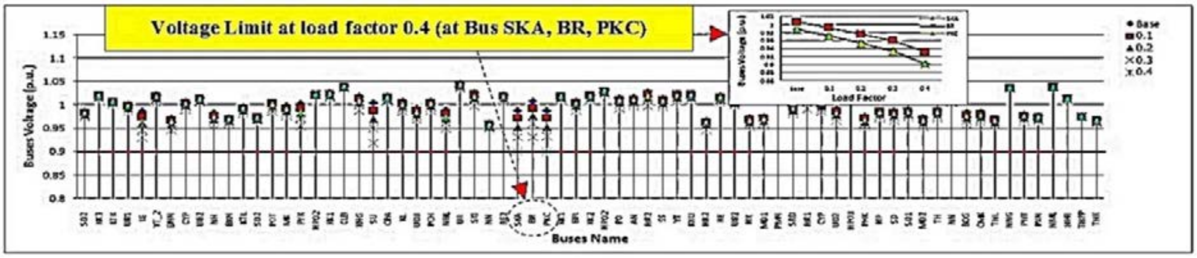


Fig. 6. The voltage profile in case of load increasing after installed the renewable generation with distribution in area2.

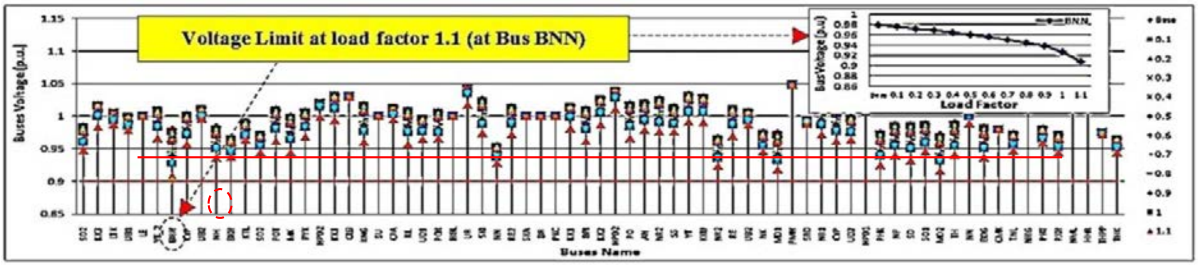


Fig. 7. The voltage profile in case of load increasing after installed the renewable generation at recommendation areas.

## 5. Conclusions

The study results show that installation of the renewable power generation facilities at recommendation areas using a newly proposed technique will have a better benefit. It made the power system has highly flexibility and can withstand to the conditions of loads demand increasing and generation capacity decreasing significantly. In addition, this technique can promote areas for installation new power generation for improving and increase the system voltage stability. Moreover, this technique can also apply to the installation of other equipment such as FACTS devices or define to the generation primary responds and setting generation dispatch for Automatic Generation Control (AGC) for power system enhancement.

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