Suppression of Fluctuations in Renewable Energy Based on The Game Theoretic Cooperative Control

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FL12-9-1
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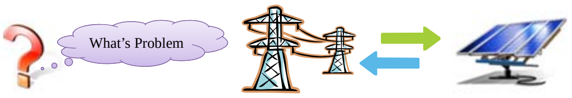
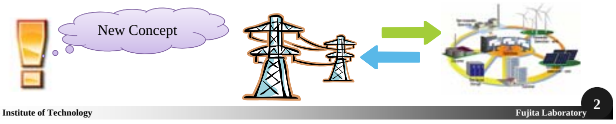
Background

- The increase in decentralized generating plants [2,7]

- Influence by decentralized generating plants [8]

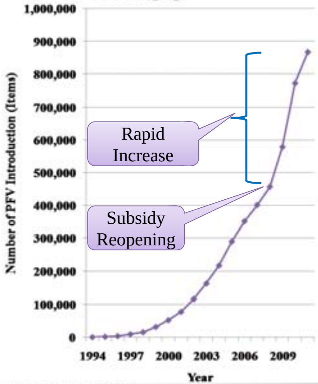


- Microgrids are connected to power system [5,6]

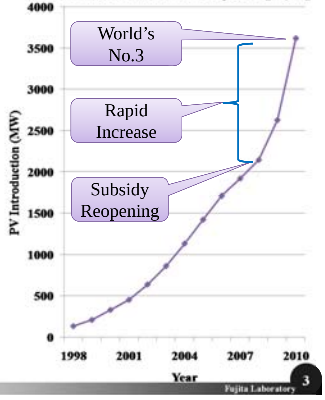


Background: Development of PV [2,7]

Number of PV Introduction for Houses [7]



Quantity of All PV Introduction in Japan [1,2]



Background

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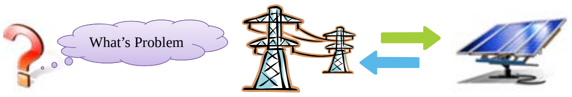
- Influence by decentralized generating plants [8]



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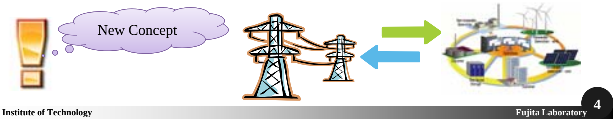


Background: Influence on System [8]

Stable Supply is Impossible by Volatility of PV

- Change Frequency
  - Adjustment of the amount of supply is difficult
  - Parallel off of PVs in an accident
  - Oversupply in time with little demand
- Change Voltage
  - Parallel off of PVs in an accident
  - Oversupply in time with little demand
  - Reverse power flow

<Solution>

- Introduction of Microgrid
- Optimization of Panel's Direction
- Optimization of PV's Allocation

<Others>

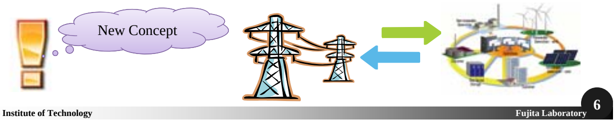
- Introduction Stabilizer
- Improvement PCS
- Introduction Battery
- Extension Transformer

Background

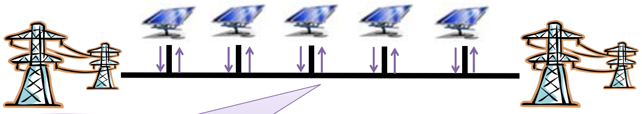
- The increase in decentralized generating plants [2,7]

- Influence by decentralized generating plants [8]

- Microgrids are connected to power system [5,6]

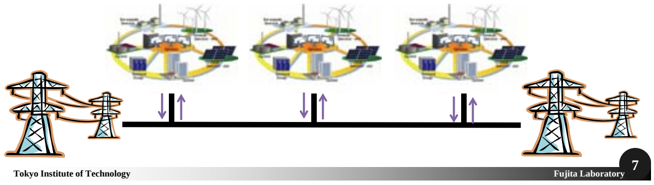


Background: Microgrid[5,6]



The limit of quantity which can be connected with decentralized generating plants (Limit: 10GW, Now: 3.6GW [1])

The volatility of decentralized generating plants is absorbed within Microgrid



Optimization of Panel's Direction (1)

<Situation>

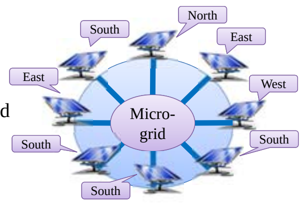
There are many PVs in a microgrid

<Usually>

Almost all panels are installed southward

<Here>

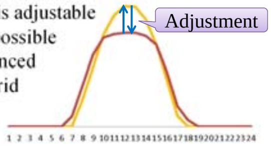
Mix it other then the south direction



<Advantage>

Generated output of the whole microgrid is adjustable

- ➢ Equalization of generated output is possible
- ➢ Demand and supply can also be balanced
- ➢ Suppress the volatility in the microgrid
- ➢ Suppress the volatility of PV



Optimal Allocation of Angles (2)

<Objective>

Suppress the volatility of PV in the relatively low frequency band

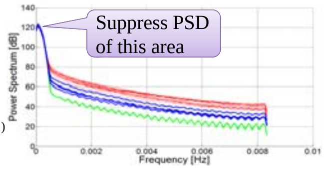
<Evaluation Method>

Power Spectral Density (PSD) [3]

PSD is Small ⇒ Volatility is Small

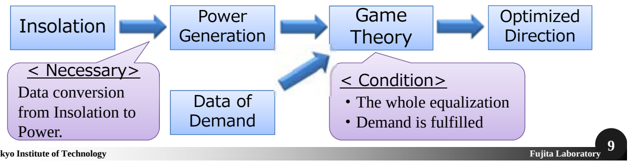
<Tool>

NEDO Database of Insolation (METPV-11)



<Approach>

1. Payoff-based Inhomogeneous Partially Irrational Play (PIPIP) [4]
2. Optimal Simple Experimentation Dynamics (OSED) [4]



Insolation → Power Generation → Game Theory → Optimized Direction

Data of Demand → Game Theory

< Necessary>
Data conversion from Insolation to Power.

< Condition>
- The whole equalization
- Demand is fulfilled

Optimization of PV's Allocation

<Situation>

100 places are chosen from about 700 PV systems in a microgrid

<Objective>

Suppress the volatility of PV efficiently in the relatively low frequency band

<Approach>

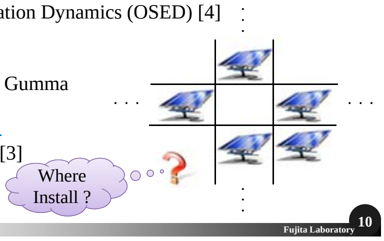
1. Payoff-based Inhomogeneous Partially Irrational Play (PIPIP) [4]
2. Optimal Simple Experimentation Dynamics (OSED) [4]

<Tool>

Observational data of Ota City, Gumma

<Evaluation Method>

Power Spectral Density (PSD) [3]



Future Work

- ➢ **Application of various game theory [4]**
  Examination of game theory other than PIPIP
- ➢ **Infrastructure design using game theory**
  Problem ⇒ Where is a power line installed?
- ➢ **Introduction of fuel cell**
  Problem ⇒ Information of fuel cells always cannot be seen
- ➢ **Introduction of wind power generation**
  Problem ⇒ ・The shortage of data
  ・Restrictions of a setting position are strong
- ➢ **Visualization of the placement and direction**
  Introduction of programming languages

Schedule

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Survey	Power situation Microgrid				About Future Work		
Direc-tion		Problem Establi-shment	Simulation Evaluation Improvement				
Alloc-ation				Problem Establi-shment	Simulation Evaluation Improvement		
Semi-ner	FLS	FLS				FLS	
Future Work						New Approach	

Reference

[1] IEA ,“TRENDS IN PHOTOVOLTAIC APPLICATIONS Survey report of selected IEA countries between 1992 and 2010,” 2011.

[2] 電気事業連合会 ,“FEPC INFOBACE,” 2011.

[3]七原, “大量導入時における太陽光、風力発電の出力変動特性,”オペレーションズリサーチ, Vol. 56, No. 7, pp. 375-380, 2011.

[4] T. Goto, T. Hatanaka and M. Fujita, “Payoff-based Inhomogeneous Partially Irrational Play for Potential Game Theoretic Cooperative Control: Convergence Analysis,” *Proc. of 2012 American Control Conference*, pp. 2380-2387, 2012.

[5] T. Hatanaka, Y. Wasa and M. Fujita, “Game Theoretic Cooperative Energy Network Management for Distributed Microgrids: Variability Reduction of Photovoltaic Generation,” *Proc. of the 2013 American Control Conference*, submitted.

[6] NEDO, “太陽光発電ロードマップ,” 2009.

[7] 資源エネルギー庁, “我が国における再生可能エネルギー,” 2012.

[8] 九州経済産業局, “地域EMS課題調査報告書,” 2011.