25th CEE Symposium
"Power demand and supply analysis and Integration Study"

Trend and Requirement of an Integration Study
-From the 23rd CEE Symposium-

October 19th, 2016

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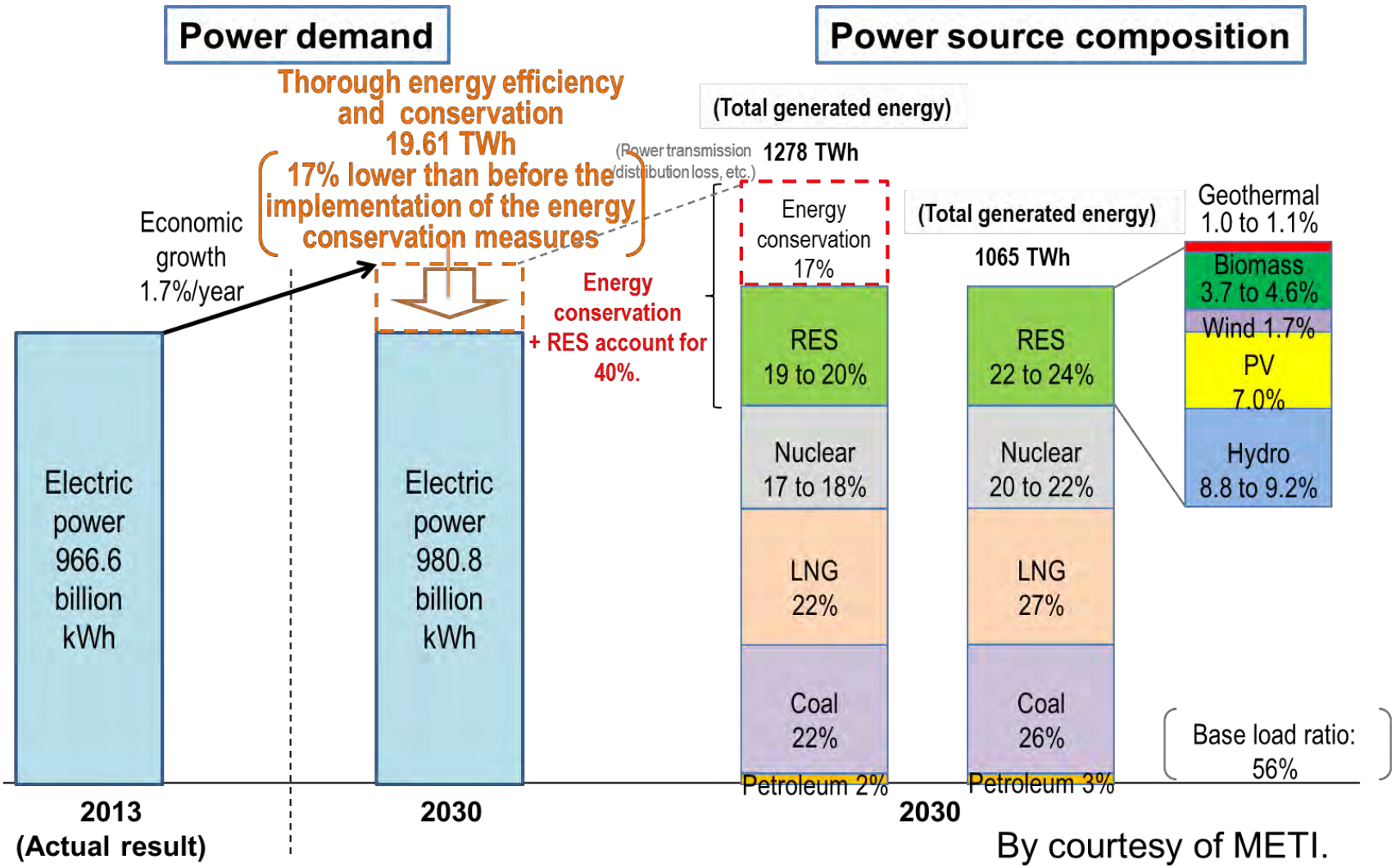
Agenda-本日の内容

1. Latest Energy Situation in Japan and a future analysis

2. Power Demand and supply analysis

3. Integration Study

Electricity balance of the long-term supply demand outlook
日本の長期エネルギー需給見通し（電力）.



Electricity balance of the long-term supply demand outlook.

Progress of RE deployment under FIT program
FITプログラムのもとでの再エネの導入の進展

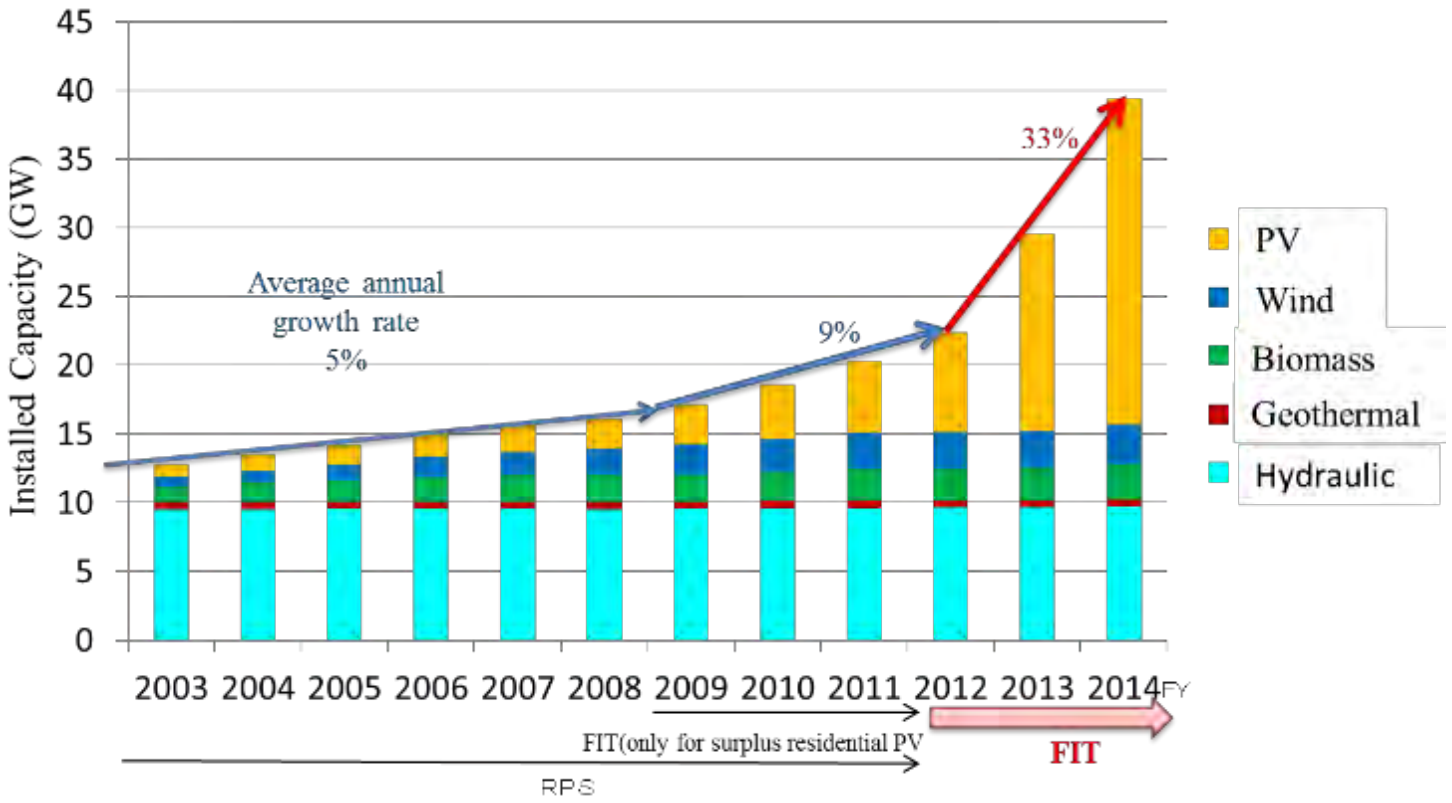


Fig. 2 Installed capacity of renewable generation (by courtesy of METI)

Actual demand and supply balance in Kyushu-area
九州における需給状況

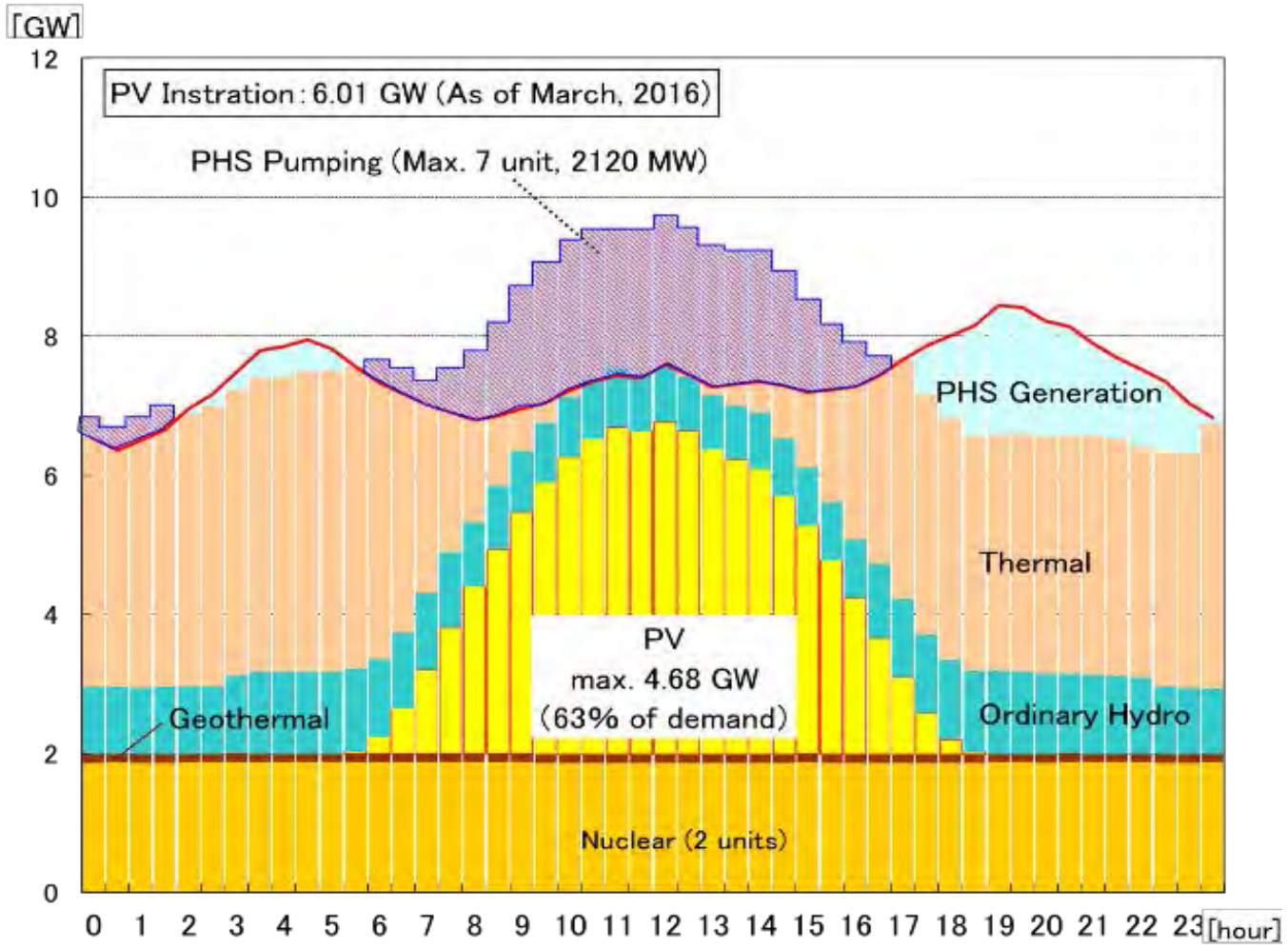


Fig. 8 Demand and supply balance of the Kyushu area on May 4th, 2016 (modified from material of Kyushu EPCO)

PV carrying capacities in FY2014
2014年度に検討されたPVの接続可能量

	Hokkaido	Tohoku	Hokuriku	Chugoku	Shikoku	Kyushu	Okinawa
Wind Carrying C.(a) (10MW)	56 ※1	200 ※1	45 ※1	100	60 ※1	100	2.5
PV Carrying Cap. (b) (10MW)	117	552	70	558	219	817	35.6
(a)+(b)	173	752	115	658	279	917	38.1
W+PV 2σ Output (10 MW)	105.6	547	62	463	171.5	622	28.8
W+PV Max. Output (10 MW)	106.7	549	64	490	190.3	629	30.1
Min. Demand during daytime: (c)※2 (10 MW)	308.4 (May2 6th 12:00)	791 (May12nd 13:00)	252 (May 12nd 13:00)	554 (May 12nd 13:00)	264.5 (May 12nd 12:00)	788 (May 12nd 13:00)	68.0 (April 7th 14:00)
(a) / (c) (%)	18.2%	25.3%	17.9%	18.1%	22.7%	12.7%	3.7%
(b) / (c) (%)	37.9%	69.8%	27.8%	100.7%	82.8%	103.7%	52.4%
Demand and supply analysis using historical 8760 hour data of PV, wind and demand (2013)							
RES Curtailment (10 MWh/annum.) (Curtailment Ratio (%)	4,943 (2.9%)	52,102 (4.6%)	4,400 (3.3%)	11,236 (1.3%)	16,400 (4.5%)	46,446 (4.2%)	-

Prepared from a material of New Energy Sub-committee (2014.12)

PV carrying capacities studied in the Working Group in FY2014

Results from a integration study
Integration studyの結果

- Assumption: PV 103 GW, Wind 32 GW
- The RE curtailment is reduced from around 10% to around 7% by the implementation of the balancing cap. Exchange.

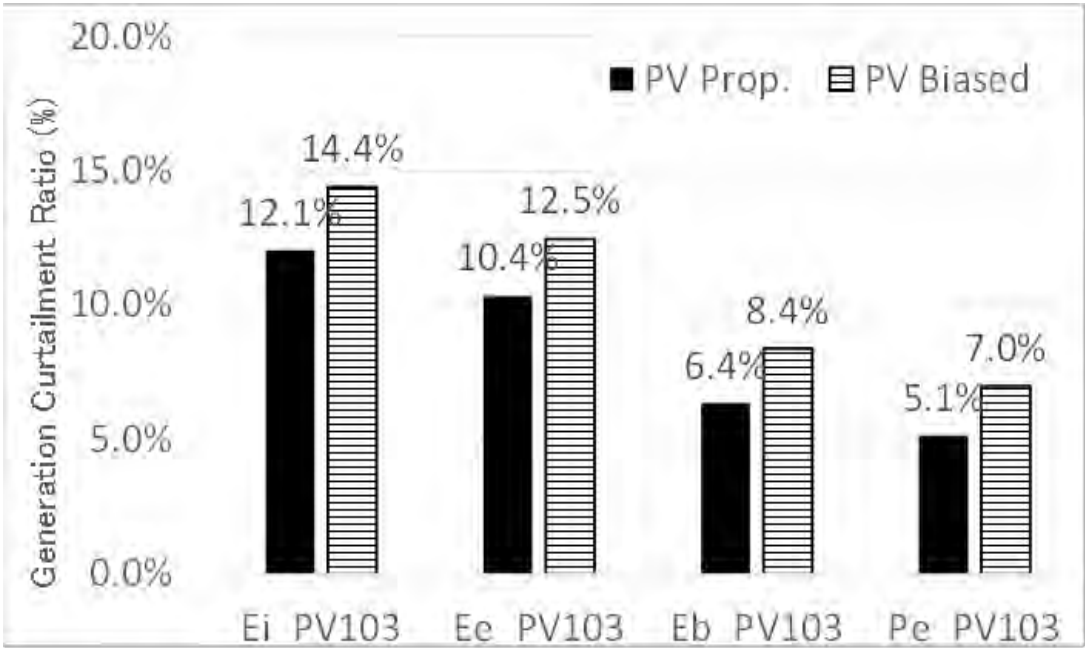


Fig. 9 Annual PV and wind generation curtailments by production simulation of 10 balancing areas with interconnections in 2030. (Ei: Isolated or no interconnection, Ee: energy exchange, Eb: Balancing capacity exchange, Pe: RE priority dispatch with energy exchange)

K. Ogimoto, K. Ohbayashi, K. Asano: Progress and future of Japan's PV deployment, Solar Integration Workshop (2016, TBP)

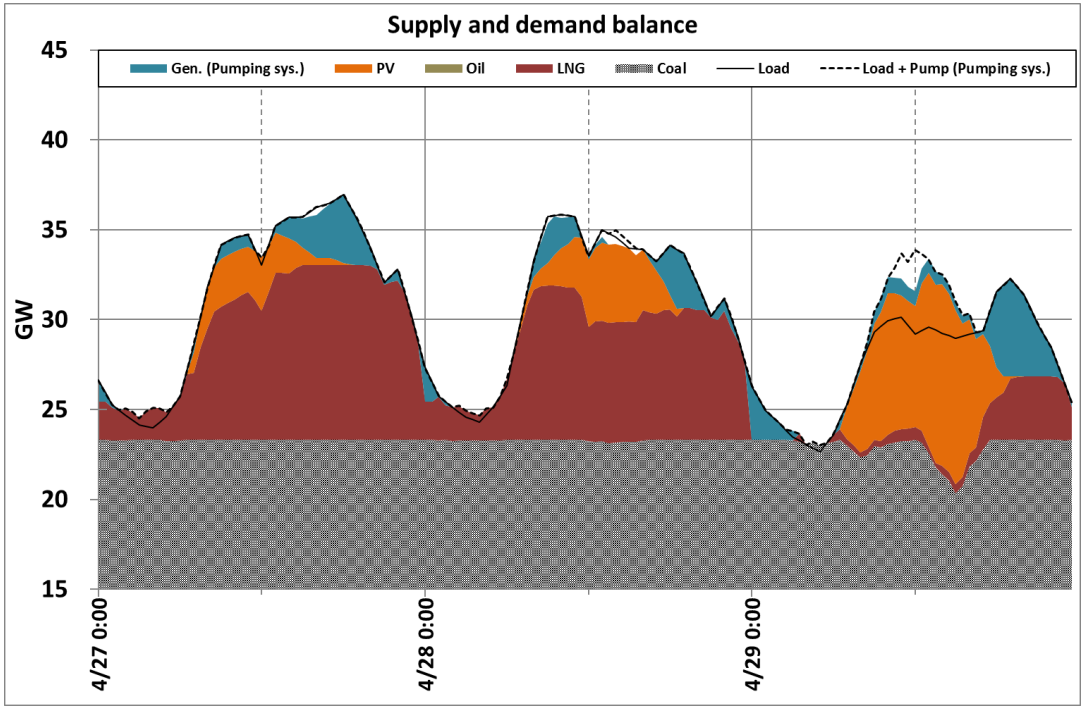
Gaps and future possibilities
前提の相違と将来の可能性

- Transition from priority dispatch to economic dispatch
- Effective operation of conventional and variable-speed pumped storage plants and their expansion, if possible
- Balanced deployment distribution of generations including variable renewable such as PV and wind
- Maximum utilization of interconnection capacity by enhanced operation and expansion as required
- Enhancement of flexibility of conventional thermal power plants
- Introduction of innovative flexibility resources including demand response and battery storage for various types of system services
- Enhancement of PV and wind generation forecast technology
- Enhancement of power system operation which optimize the utilization of all resources.
- Electrification of fossil-fuel energy demand for direct CO2 reduction and indirect reduction through the better use of variable renewable.

K. Ogimoto, K. Ohbayashi, K. Asano: Progress and future of Japan's PV deployment, Solar Integration Workshop (2016, TBP)

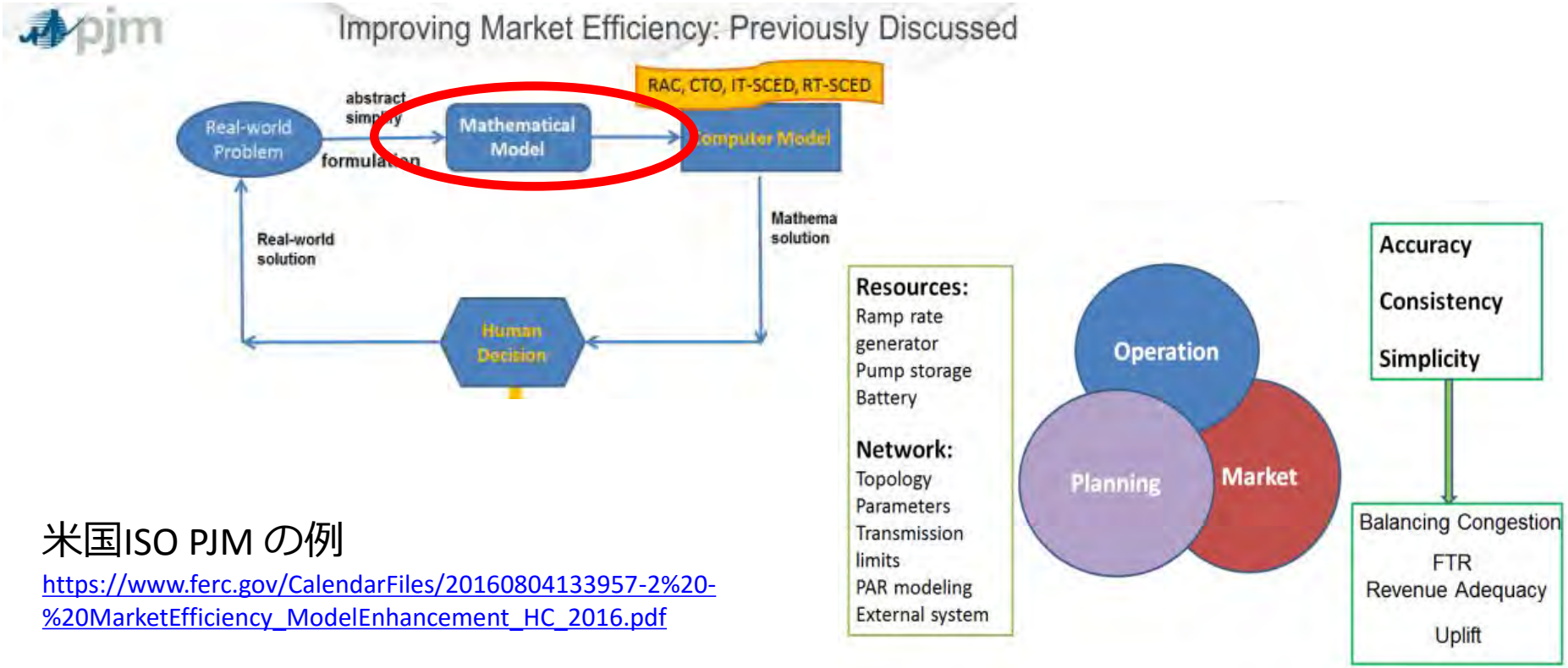
Unit commitment and simulation
起動停止計画とシミュレーション

- Production simulation by UC+simulation is a core tool of power demand supply analysis of a power system with increased variability and uncertainty due to vRES penetration.
  起動停止計画+シミュレーションは、出力が変動する再生化のエネルギー発電の導入が進み変動性と不確実性が増加する電力システムにおいて、需給解析の基本ツールである。



Demand and supply analysis for Everyday Operation
電力需給解析を活用した「毎日の運用」

ISOs/RTOs. use UC and other kinds of software to verify the market results in terms of technical adequacy and execute re-dispatch if necessary.
米国ISO/RTOでは、ゲートクローズ後、技術的な妥当性を確かめ必要な需給運用の修正を行うのにUCなどが用いられる。



米国ISO PJM の例
https://www.ferc.gov/CalendarFiles/20160804133957-2%20-%20MarketEfficiency_ModelEnhancement_HC_2016.pdf

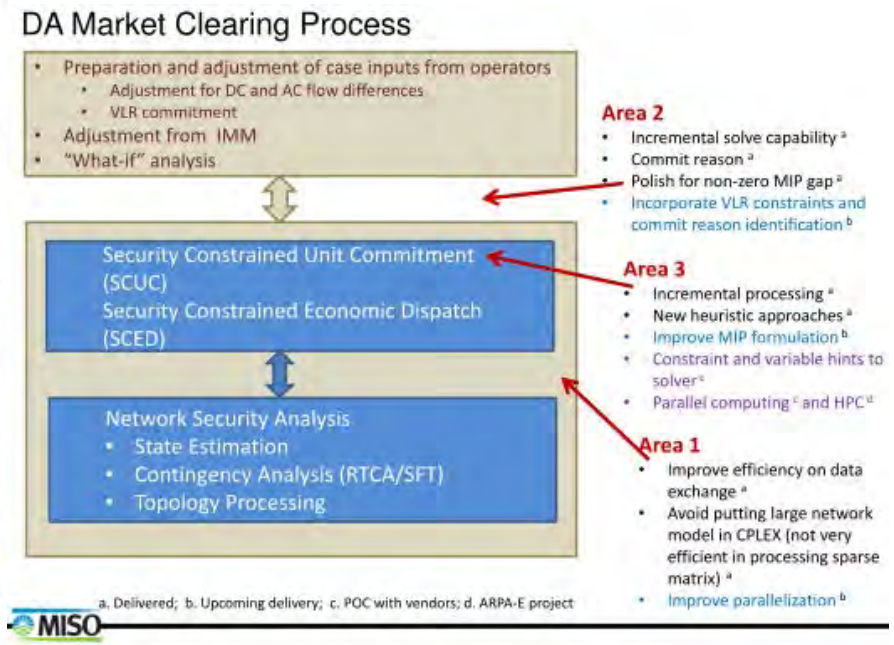
Daily operation planning using supply and demand analysis
電力需給解析を活用した「毎日の運用」の例

In FERC's project "Increasing Efficiency through Improved Software", the Commission is identifying opportunities to enhance operational efficiency in jurisdictional markets by encouraging public utilities, particularly RTOs and ISOs, to consider the deployment of new modeling software for their market operations.

米国FERCによるISO/RTOの運用ソフトウェアの継続的改善のためのプロジェクト

故なき見かけ衡平負担ではなく原因者負担を追求するPJMの「一般負担」低減への取り組み

https://www.ferc.gov/CalendarFiles/20160804133957-2%20-%20MarketEfficiency_ModelEnhancement_HC_2016.pdf



システム運用・市場運営の鍵はプロセスの透明な定義とPDCAを活かした継続的改善（MISO)

https://www.ferc.gov/CalendarFiles/20160804133957-3%20-%20MISO%20FERC_M1_Chen_062016.pdf

Objectives of power demand and supply analysis
電力需給解析の目的

- Indices指標：Economy, Security, Environment, Process efficiency
  経済性、安定供給、環境性、業務効率

- Objectives：運用計画、設備計画の評価・立案
  - Off-line operation/asset planning ⇒⇒⇒Integration study
    オフラインの将来に向けた運用計画・評価/設備計画
  - On-line operation/demand supply control
    オンラインの毎日の運用計画・需給制御

  andに加えて、

  - Tools for many stakeholders including governments, private companies, people to consider and communicate about operation and asset planning of power and energy
    多くのステークホルダーがエネルギー・電力の運用と設備形成を考え意志疎通するツール
  - Tools for manufacturers and service providers to recognize values to design their products
    メーカー、サービスプロバイダーが価値を認識し、商品設計を行うためのツール

Issues of operation/asset planning of a power system
電力システム運用計画・設備計画の課題

- Emerging issues and conditions 新しい要素：
  - Variability and uncertainty of variable RES
    PV・風力の出力の変動性と不確定性
  - Requirement for flexibilities in various time domain
    様々な時間領域での柔軟性の必要性
  - Observability, predictability and controllability of distributed resources such as vRES, cogeneration, DR, and storage
    再エネ、コジェネ、DR、貯蔵等の状態把握性、予測性と制御性
  - Interaction between transmission and distribution system with numerous resources
    無数の資源を持つ配電網と送電網の相互関係など
  - Process improvements and redesign of power market under emerging issues including difficulties of operation and transition of values
    運用性、価値の変化などのもとでの電力市場の再設計

Directions of demand and supply analysis
電力需給解析モデルの方向性

- Emerging Requirements 需給モデルの新たな要件
  - Variability, uncertaingy and flexibility of various time domain
    様々な時間領域の変動性と不確実性、調整力の取扱い
  - Involvement of innovative technologies including distributed resource and aggregation
    小規模分散資源、アグリゲーションを含む新たな技術の取り扱い
  - Interconnection, tramsmission/distribution network
    連系線、送配電網
  - Interaction with market process: DA, ID, GC, realtime, settlement
    市場との連動：前々日、前日、当日、GC後、リアルタイム、評価
- Analysis Model需給解析モデル
  - Unit commitment+Simulation/SCUC/SCED/
  - LP線形計画法/MIPS混合整数計画法/Probabilistic-Rbust
  - Stability of Synchronization, frequency, power flow
    周波数・潮流・安定度など過渡解析

Integration studies using power demand and supply analysis
電力需給解析によるIntegration studyの例

■ Integration studies surveyed in IEA PVPS Task 14 Subtask 3

Study Name	Study Area	Date of issue	UC	PV forecast	Flexibility Resources other than conventional thermal
Dena Ancillary Service Study 2030	Germany	July 2014	YES	(not in focus)	ex. Frequency Control: Pump Storage, Batteries, RES, DR
Stromspeicher in der Energiewende (in German)	Germany	Sep. 2014	YES	(not in focus)	Storage (different types), DR, CHP, Interconnection, RES
The European Power System in 2030: Flexibility Challenges and Integration Benefits	Europe, Focus on PLEF	June 2015	YES	(not in focus)	Interconnection, RES, Stored Hydro
Real Time Generation Mapping of Distributed PV for Network Planning and Operations	Australia	November 2015	YES	YES (Partly)	Situational awareness
E-Highway 2050	Europe	Dec. 2015	YES	YES	Interconnection, HVDC, Phase shifters, pumped hydro
GARPUR	Europe	Dec. 2013 - April 2016	YES (Partly)	YES	Interconnection, HVDC, Phase shifters
Umbrella	Europe	April 2012 - Feb. 2016	NO	YES	Interconnection, HVDC, Phase shifters
iTesla	Tool/?	April 2012 - Jan. 2015	NO	YES	Interconnection, HVDC, Phase shifters
Optimate	Europe	June 2010 - March 2013	NO	YES	Interconnection
Day ahead' prognose and 'Online' prognose	Denmark	---	YES	YES	---
SCS Energiemodell	Switzerland	May 2013	YES	YES	PV output suppression, hydro power (pumped storage), batteries, interconnection
Western Wind and Solar Integration Study	US Western Int.	May 2010	YES	YES	Interconnection, Storage, DR
Western Wind and Solar Integration Study II	US Western Int.	Sep. 2013	YES	YES	Interconnection
Western Wind and Solar Integration Study III	US Western Int.	Dec. 2014	YES	YES	Interconnection
Western Wind and Solar Integration Study IIIa: Low Levels of Synchronous	US Western Int.	Nov. 2015	YES	YES	Interconnection
Low Carbon Grid Study: Analysis of a 50% Emission Reduction in California	US (California)	January 2016	YES	YES	Interconnection, Storage
Overgeneration from Solar Energy in California: A Field Guide to the Duck Chart	US (California)	Nov. 2015	YES	NO	Storage, DR
The value of day-ahead solar power forecasting improvement	US	Jan. 2016	YES	YES	Interconnection, Storage, DR, Faster ramping plants
The Eastern Renewable Generation Integration Study: Flexibility and High Penetrations of Wind and Solar - IEEE PES GM 2015	US Eesten Interconnection	July 2015	YES	YES	Interconnection, Storage
METI Agency for Natural Resources and Energy, Transmission System Hosting Capacity Working Group (in Japanese)	Japan	Oct. 2014 - Nov. 2015	YES	NO	Interconnection, PV output control, Batteries
Report of Policies and Countermeasures after 2013, Chapter 10 Energy Supply Working Group (in Japanese)	Japan	July 2012	YES	NO	Interconnection, PV output control, Batteries, DR

Ogimoto et al. “Survey and case studies of transmission level PV integration assessments utilizing generation forecasts and innovative flexibility resources”, Wind Integration Workshop (2016, TBP)

Integration study case studies
Integration studyの事例

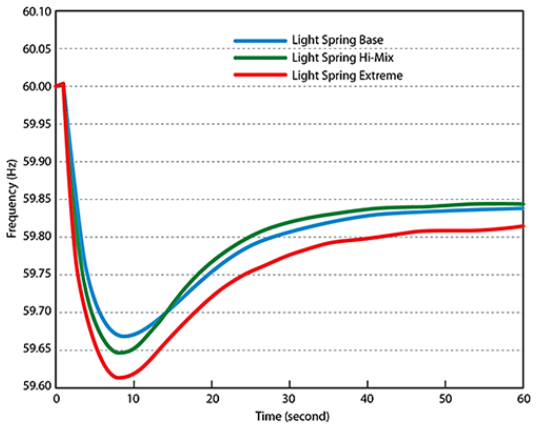


Fig. 3 WWSISF: frequency response to loss of two Palo Verde units under light spring system conditions.

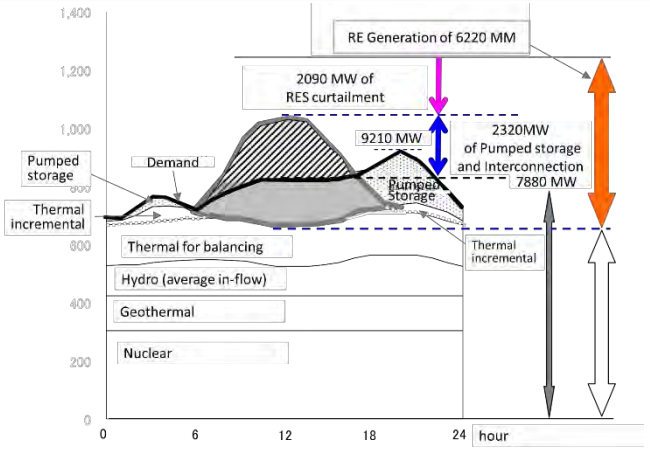


Fig. 5 METI: Image of 24 hour demand and supply balance in Kyushu on a day of maximum RES generation.

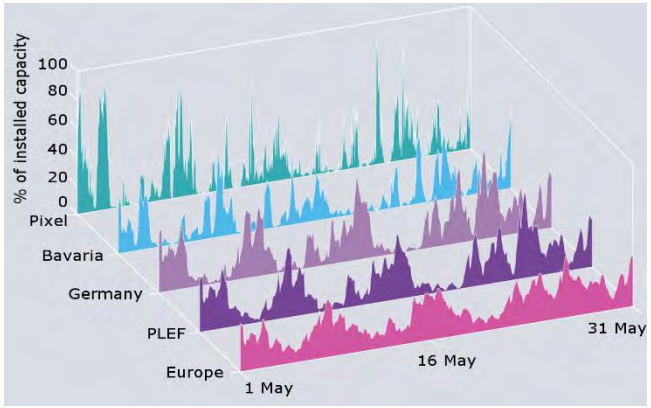


Fig. 4 Fraunhofer: Wind power generation time series (onshore) for May 2030 at different levels of aggregation.

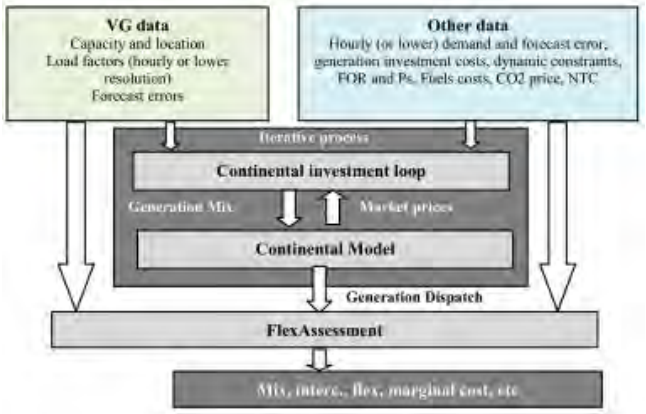


Figure 6 EdF R&D: Structure of the whole system approach for the simulation of the European electricity system.

Ogimoto et al. “Survey and case studies of transmission level PV integration assessments utilizing generation forecasts and innovative flexibility resources”, Wind Integration Workshop (2016, TBP)

Trend of integration studies
Integration Studyの動向

- Began with integration of renewable generation
  再生可能エネルギーの統合で始まった
- Included enhanced and innovative technologies and processes for better integration
  RE統合を改善するために、技術、プロセスオプションを含むようになった。
- Expanded to the integration of innovative technologies, enhanced operational process, themselves
  革新技術やプロセス改善の導入検討に発展した。
- Expanded to different aspects of impacts of frequency, transient stability, and gas-electric integration
  周波数安定性、過渡安定度、ガスとの統合など、多様な影響の分析に発展。
- Technical and economical evaluation of value, cost and price formation
  価値, コストの技術的、経済的評価、価格形成

Guidance Principles for Clean Power Plan Modeling
FERC: Federal Energy Regulatory Commission

"While the CPP assigns no direct role to the Commission, it is possible that the Commission may be called upon, through the EPA-DOE-FERC Coordination Document or for other reasons, to address concerns about reliability as the CPP is implemented. In that case, the use of appropriate modeling tools and techniques will be helpful to the Commission in carrying out its responsibilities for reliability. "

This white paper identifies four guiding principles that may assist transmission planning entities 基本原則:

(1) transparency and stakeholder engagement; 透明性
(2) study methodology and interactions between studies; 検討手法と検討間の連携
(3) study inputs, sensitivities and probabilistic analysis; and 入力データ、ケース検討
(4) tools and techniques. ツールと手法

There are a number of different types of studies that could be useful to effectively assess the impacts of the CPP and associated compliance plans 多種の検討:

(1) resource adequacy, 供給力のアデカシー評価
(2) production cost, 起動停止計画＋シミュレーションによるコスト、信頼度解析
(3) integrated gas-electric systems simulations, 天然ガスと電力の連系した解析
(4) powerflow and transient stability analysis, and 潮流解析、過渡安定度解析
(5) frequency response. 周波数応答解析

160120 FERC, Staff White Paper on Guidance Principles for Clean Power Plan Modeling

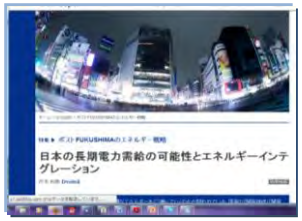
Requirements for integration studies
Integration Studyの必要条件

- Reliable data of facility and operation
  信頼できる設備、運用データ
- For production simulation UC+simulation is the core.
  UC+simulationによるProduction simulationがベース
- Appropriate models of existing and innovative technologies
  既存技術、将来技術のモデル
- Combination of methodologies for different aspects
  多面的な解析のための手法の組み合わせ

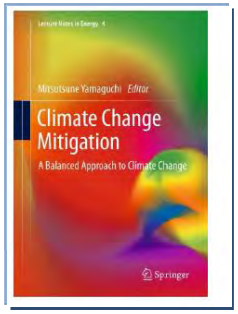
  ⇒Frequency analysis, transient analysis, and Gas-Electric integration
- Appropriate models of system and market operation
  運用/市場プロセスモデル
- With vRES, at lease one year production analysis
  出力の変動する再生可能エネルギーを含む場合は最低1年のproduction解析
- Probabilistic/robust analysis　確率的/ロバスト解析

Thank you

Ogimoto Laboratory, Institute of Industrial Science,
the University of Tokyo
http://www.ogimotolab.iis.u-tokyo.ac.jp/

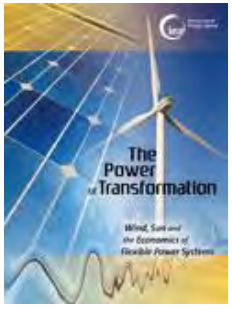


In nippon.com Your Doorway to Japan, related contents are available in English and Japanese.
http://nippon.com/en/in-depth/a00302/



The description of “1. Impact of Scenario Selection” is available in this book which is just published July, 2012.

“The integration of variable renewable generation and the evolution of power system” is published in the Magazine of Atomic Energy Society of Japan.(Jan., Feb. and May in 2015)
http://www.aesj.or.jp/atomos/tachiyomi/mihon.html



With NEDO, translated IEA ”The Power of Transformation” into Japanese.
http://www.nedo.go.jp/library/denryoku_henkaku.html

IEA PVPS Task 14 Report ” Power System Operation and Augmentation Planning with PV Integration” has been published
http://www.iea-pvps.org/index.php?id=322