

Grid integration of wind and solar energy in Japan and Germany: 'Top-down' grid operation and 'Bottom-up and flexible' grid operation

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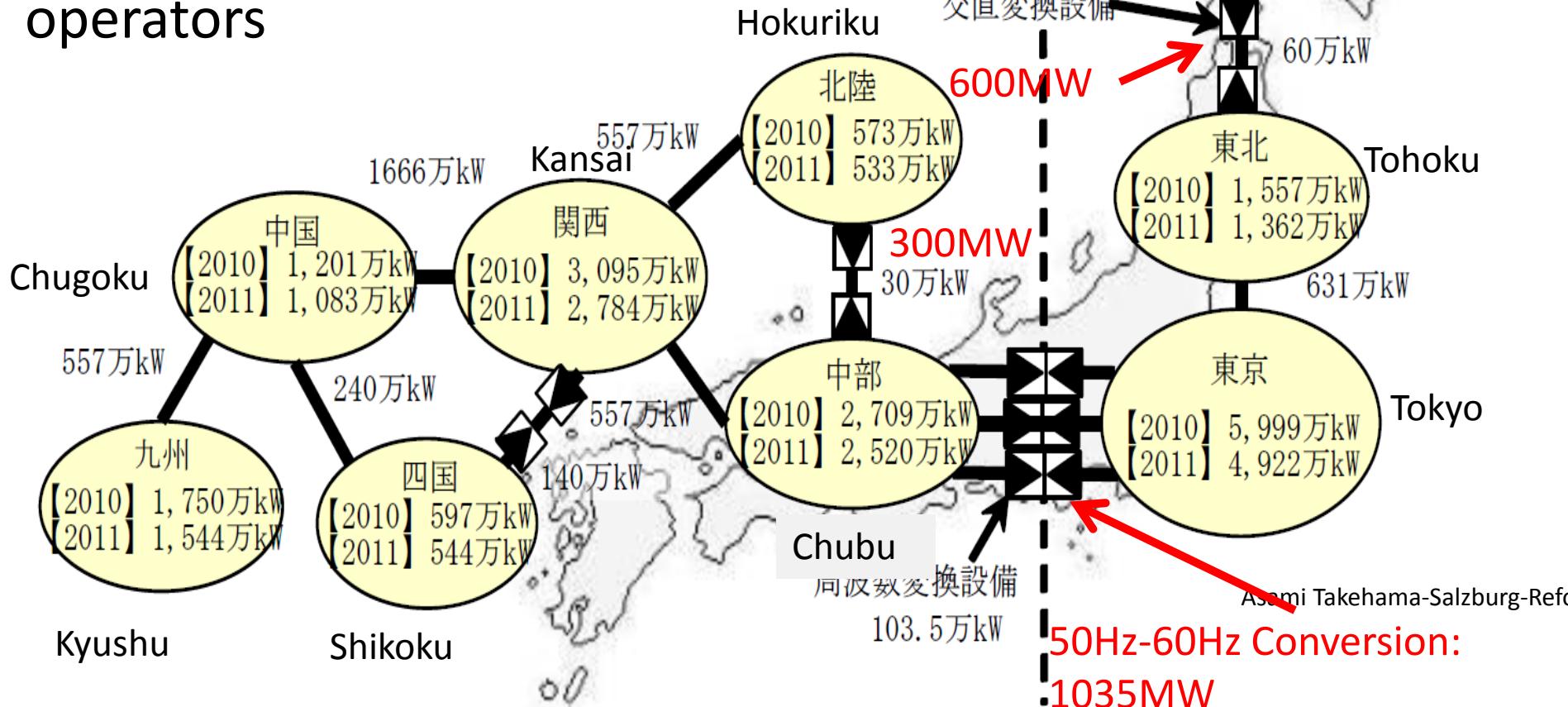
4th Sep 2014

19th REFORM Group Meeting, Salzburg
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Japan's Vertical Integrated Entities

Nine power giants own the grid.

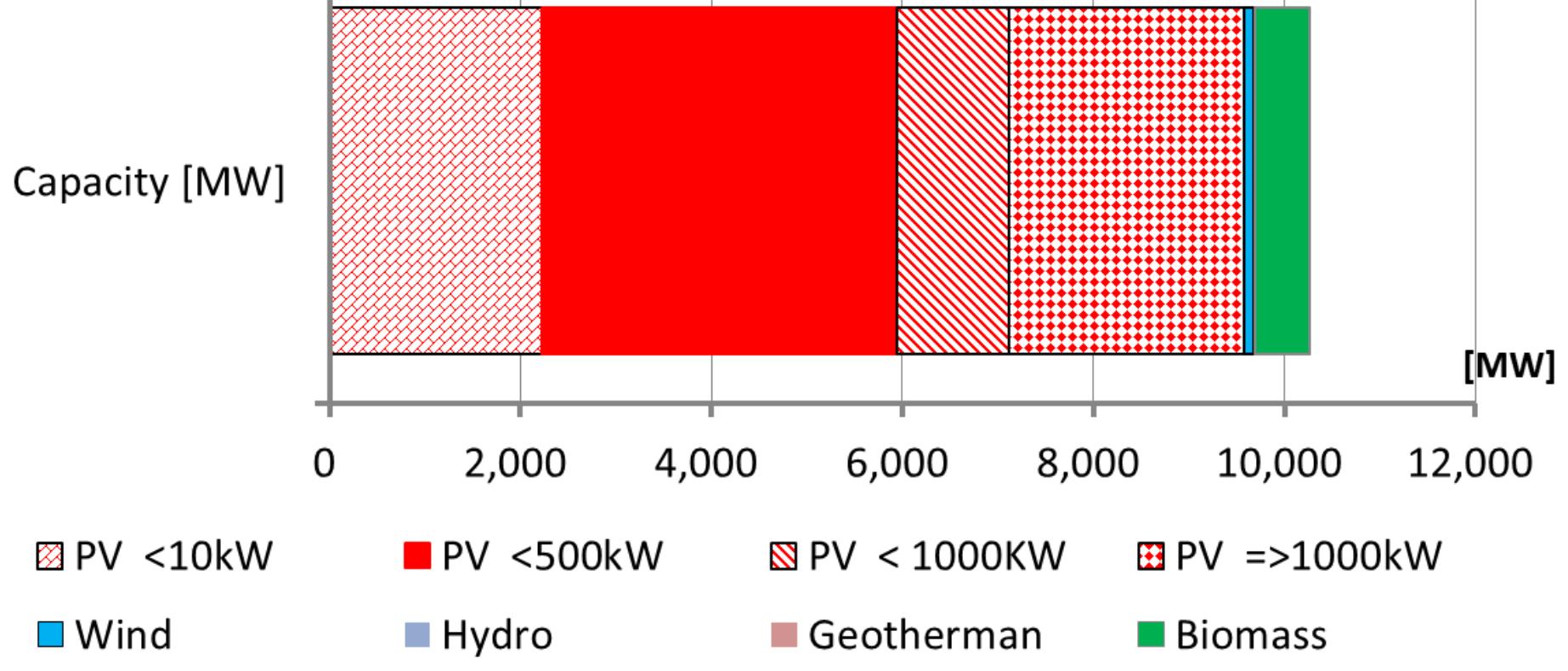
=Nine TSOs Transmission system operators



万kW = 10MW. Nine circles show each major power company's control zone. Figures in each circle show maximum electricity demand in each control zone. Figures between circles : Capacity of main transmission lines between control zones.

Source: Power System Reform Committee, Ministry of Economy Trade and Industry. 「地域間連系線等の強化に関するマスター・プラン研究会中間報告書」、電力システム改革専門委員会, p.5.

Renewable energy capacity installed in Japan Since FIT scheme (from July 2012 to April 2014)



- Since Japan's FIT started (July2012) , 98% of new installations in the PV sector.
- PV capacity <500kW accounts for 50%.
- Capacity <500 kW is easy to get grid access .

Japan's FIT scheme (1)

Very little Priority for renewable energy

- Grid access for renewable energy is obliged.
- No obligation of grid expansion:

Grid operators (power companies) are not obliged grid expansions for renewable energy.

- Renewable energy operators are required to pay **the costs for grid expansion/enhancement**, if necessary.
- No definitions on Priority Feed-in and Priority purchase for renewable energy, under the Japan's FIT.
- Feeding and purchase is obliged, but not the first, and the maximum amount feeding.

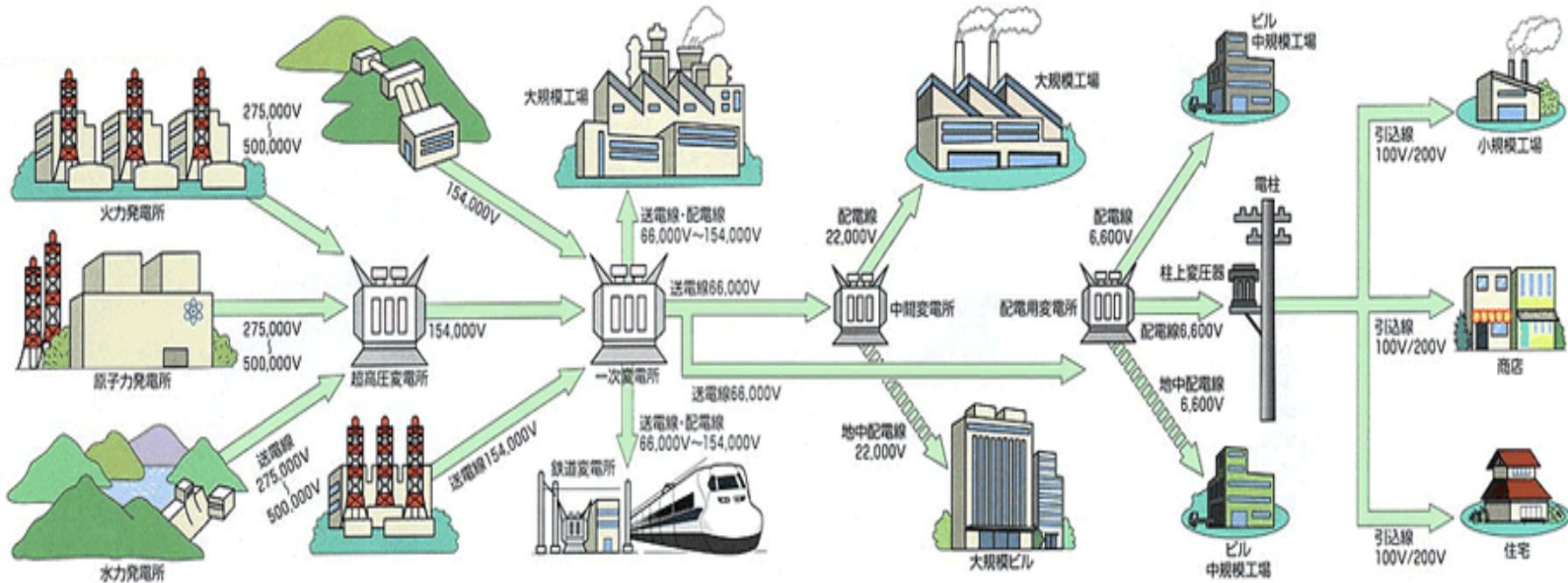
Japan's FIT scheme (2)

Feed-in management

- The Enforcement regulations for the law of renewable electricity procurement by power utility companies
- Section 6 (3)-イ—1,
- At a time of oversupply of renewable electricity in Each Control Zone
- First, conventional power (owned by utility companies) must be curtailed.
- **Nuclear energy is the EXCEPTION for the curtailment.**
- **Secondly, renewable energy is curtailed.**

Voltage levels for grid integration of renewable energy sources in Japan

- Examples at Tohoku Power Co. Inc.
500kV, 275kV, 154kV, 66kV, 33kV (22kV), 6.6kV,
- Hokkaido Power Co. inc,
275kV, 187kV, 110kV, 100kV, 66kV,
33kV, 22kV, 6.6kV
- **PV integrated to 6.6kV - 66kV levels mainly**
- **Wind energy integrated to 66kV and higher voltage.**
- The 66 kV (middle-high) voltage grid **must be expanded promptly** and properly for Renewable energy feed-in.
- The middle/middle-high voltage distribution grid are **not promptly expanded**,
- because **power companies are not obliged to do so.**



Grid integration of power plants and voltage levels (A case of TEPCO, Tokyo Power Co.)

500kV—275kV: Nuclear , Fossil Power (large), Hydro (large)

154kV: Fossil power, Hydro

66kV : Wind, PV (large)

22kV, 6.6kV : PV

0.1/0.2kV: PV (residential)

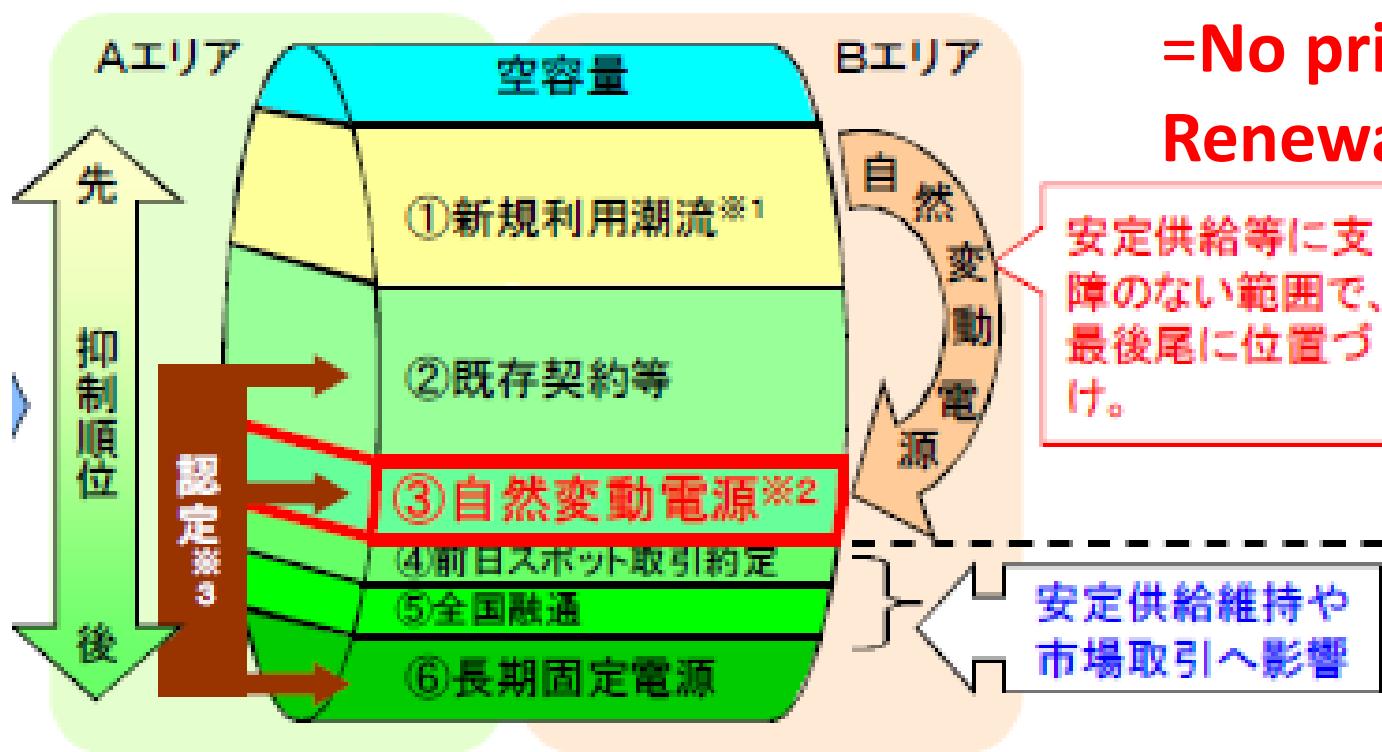
Source) TEPCO, http://www.tepco.co.jp/ir/kojin/images/setsubiindex_zoom01.gif

Feed-in Management Order at Inter-Zone Tie Lines (Curtailment Order)

- 1) Newly contracted flow
- 2) Existing contracted flow
- 3) Variable renewable (Wind, Solar)
- 4) Flow for day-ahead spot trade
- 5) Inter-zone exchange for grid balancing
- 6) Long-term /Fixed plants

(Nuclear, Large Fossils =Long-term investment/ cost payback)

Nuclear and large fossils are protected.
Existing contracted flow is protected.



=No priority feed-in for Renewables

Source) Agency for national resources and energy, the document concerning the discussions for priority feed-in, 2011

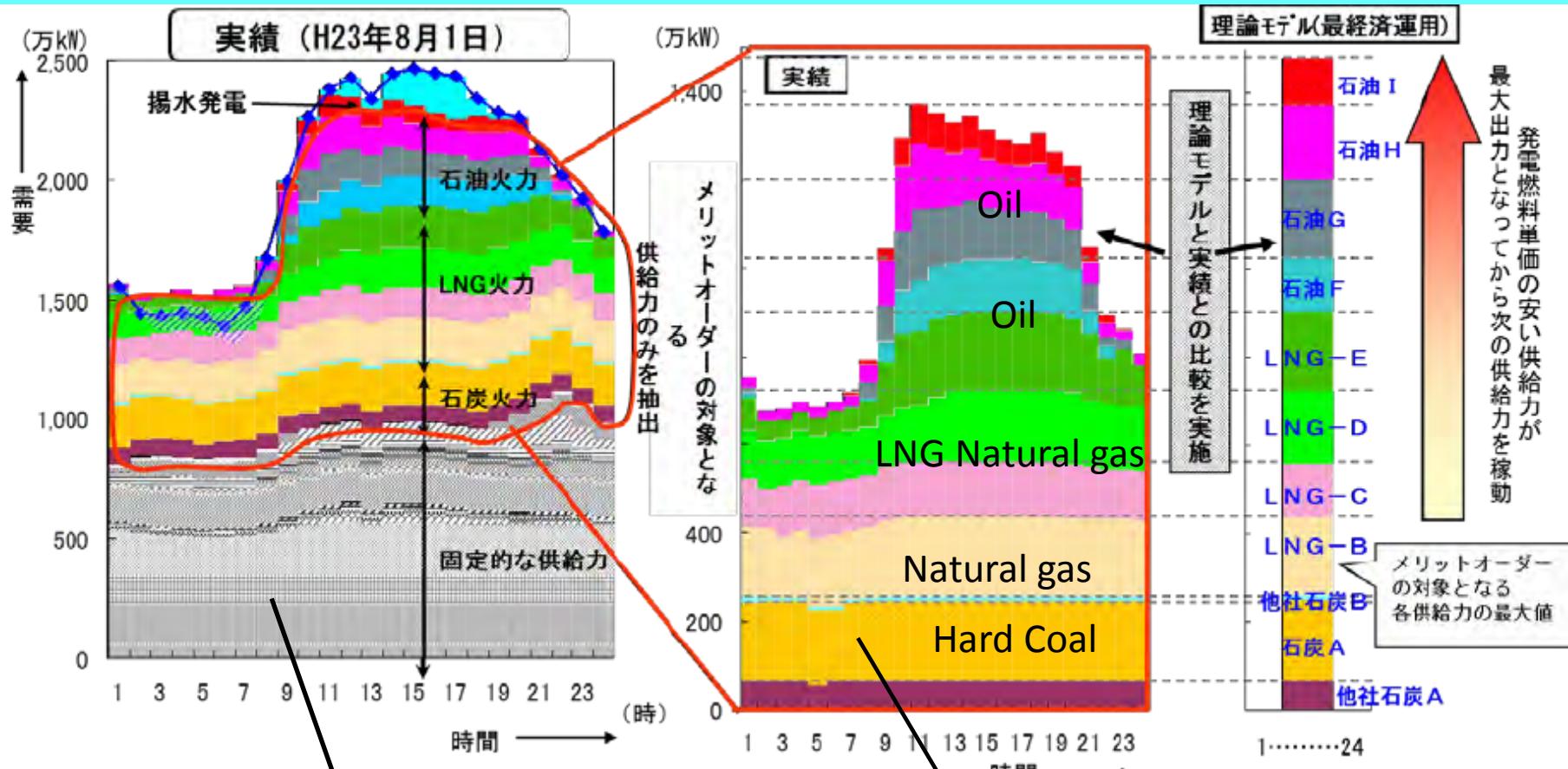
Capacity Limit for Wind Integration set by power companies

Power Company (Control Zone Region)	Total Capacity for Generation (MW) [A]	Cumulative Capacity of Grid Connected Wind Energy 2013 (MW) [B] *1	Capacity Limit For Wind Energy Grid Connection 2013 (MW) [C] *1	Share of the Capacity Limit in Generation Capacity (%) [C/A]	V P [I]
Hokkaido (North Island)	7,420	289	560	7.5%	
Tohoku (North Eastern)	16,550	542	2,000	12%	
Tokyo	64,490	371	No limit is set	Non	
Hokuriku	7,960	146	450	6%	
Chubu (Nagoya region)	32,630	224	No limit is set	Non	
Kansai (Osaka, Kyoto, Kobe region)	34,320	78	No limit is set	Non	
Chugoku	11,990	299	1,000	8%	
Shikoku (Shikoku Island)	6,670	166	450	7%	
Kyusyu (Kyushu Island)	20,030	361	1,000	5%	
Total in Japan	202,060	2,476	5,460		

Source: *1) This limit of grid connection is set by respective power company. Data is based on Federation of Electric Power Companies of Japan in March 2013.

March 2014

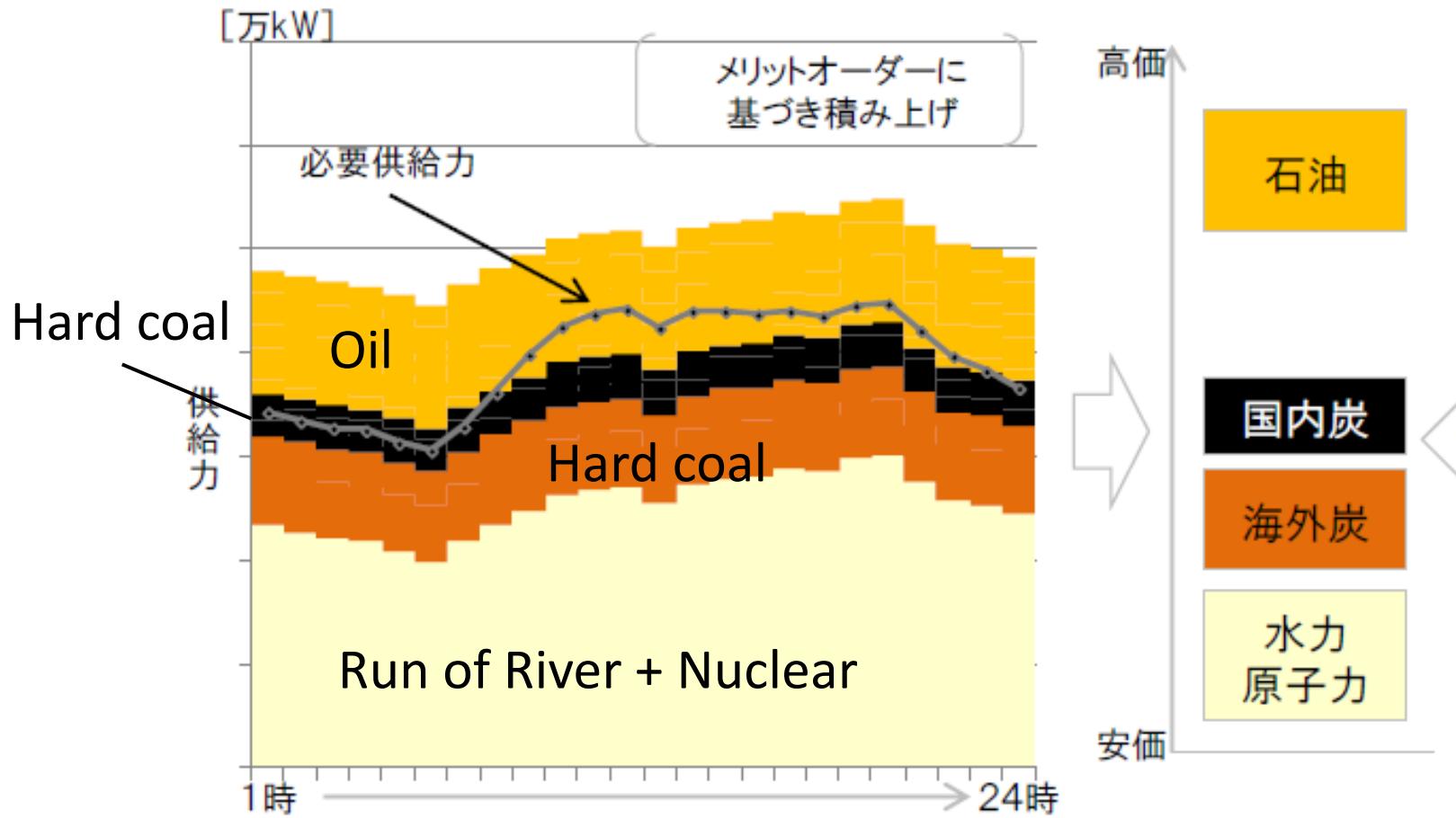
Some examples of Merit Order List in Japanese Power Companies, (Kansai Power Co., 1st Aug 2011)



Grey: Fixed Output (Must Run)
=Nuclear, Run of river hydro)

Fossils fuels

Source) Kansai Electric Power Co. (2013), the Document for the
committee of electricity rate increase



Example in Aug, 2014 (a)需給バランスの想定
(平成26年8月平日のイメージ)

(b)限界費用
(燃料種別毎のイメー

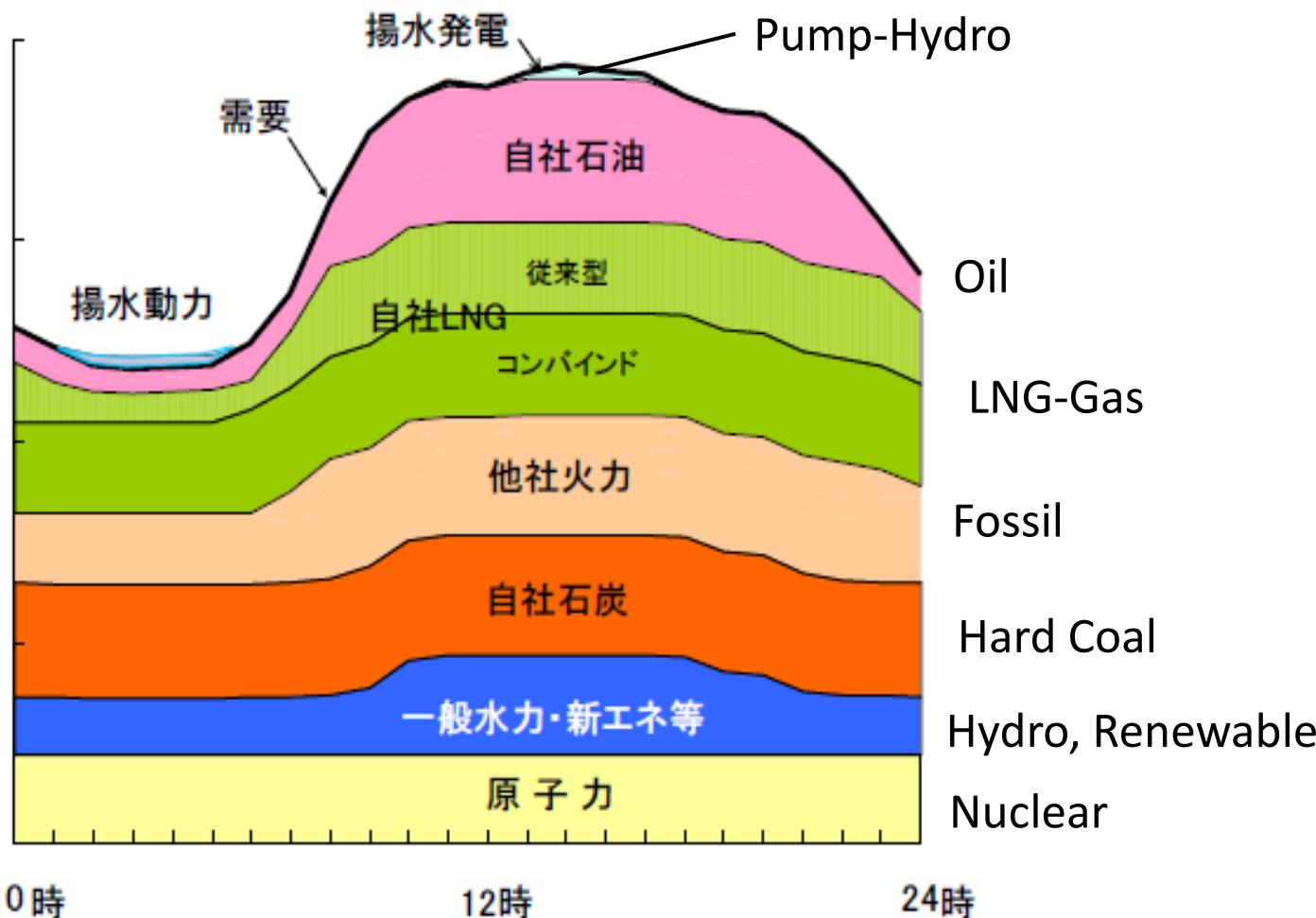
Hokkaido Power has **NO gas power plants.**

The Hokkaido zone has large potential of wind energy.

Hokkaido Power **sets its limit for wind energy integration (<= 560MW).**

Source) Hokkaido Power Co.,(2013), the document for the investigation committee for electricity rate increase (on 6th June 2013).

1日の需給運用のイメージ（H25年8月）



Example of merit order at Kyushu Power Co., Aug 2013

Source) Kyushu Electric Power Company (2012), the Document for the investigation committee of electricity rate increase.

Japan's Grid Operation

- Nuclear has a priority feed-in.
- Long-Term/Fixed plants= Nuclear and large fossils have advantages in feeding.
- These are connected to 500kV/275kV grid.
- Wind and large PV are integrated at 66kV and 6.6kV grid (middle/middle high).
- The middle/middle high voltage grid is not promptly expanded because of no obligation of grid expansion.
- No guarantee of priority feed-in for renewable electricity
- Large capacity of Nuclear/ Coal supply baseload.
- Very limited use of inter-zone tie lines
- Top-Down, Less Flexible grid operation in Japan

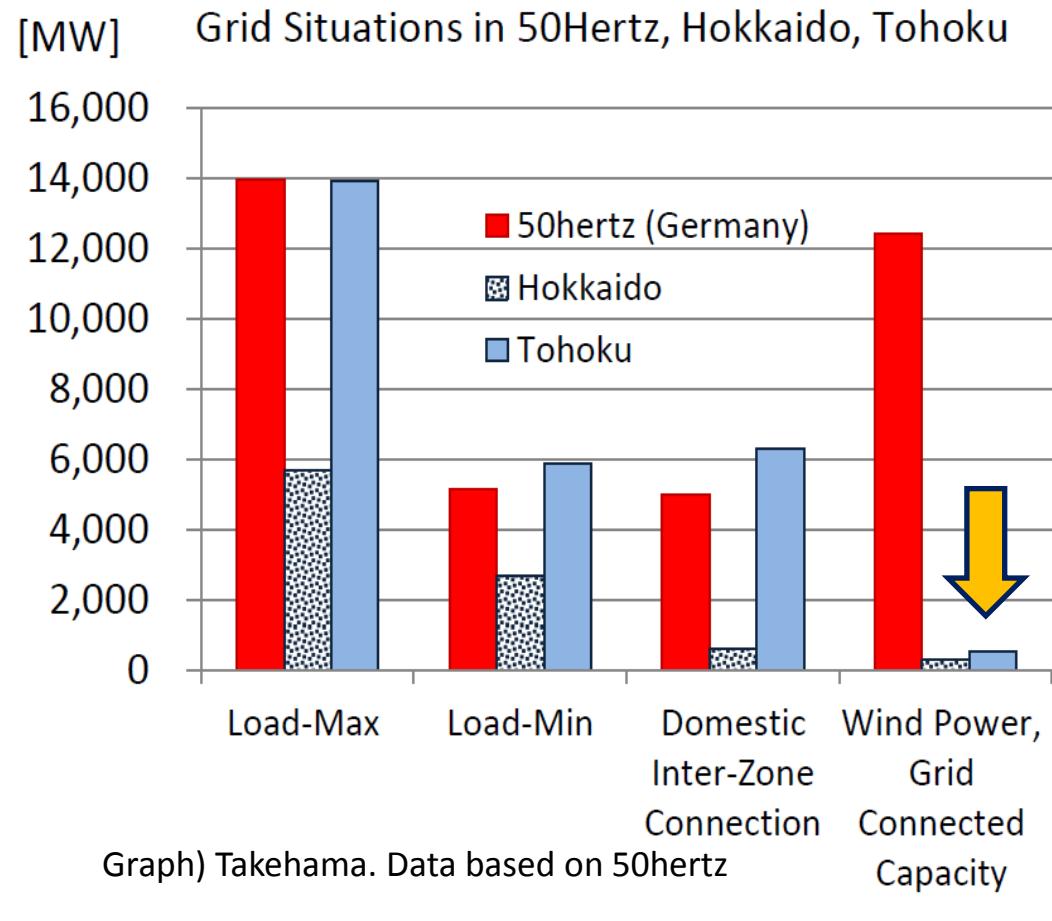
Hokkaido, Tohoku(JPN) have similarities to 50Hertz (DE).
 High potentials of wind energy, Limited capacity of tie lines.
Hokkaido and Tohoku set a limit for wind power integration

Comparison of Grid Stuations in 50hertz (Germany), Hokkaido and Tohoku Zones (Japan)

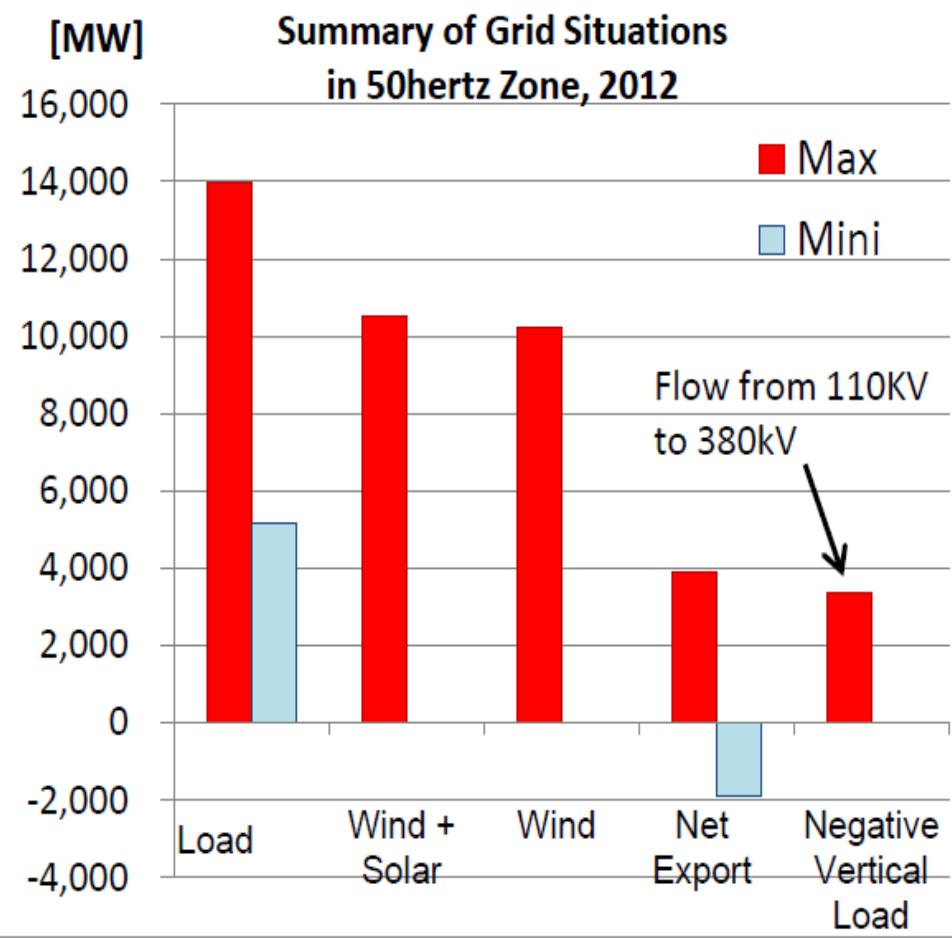
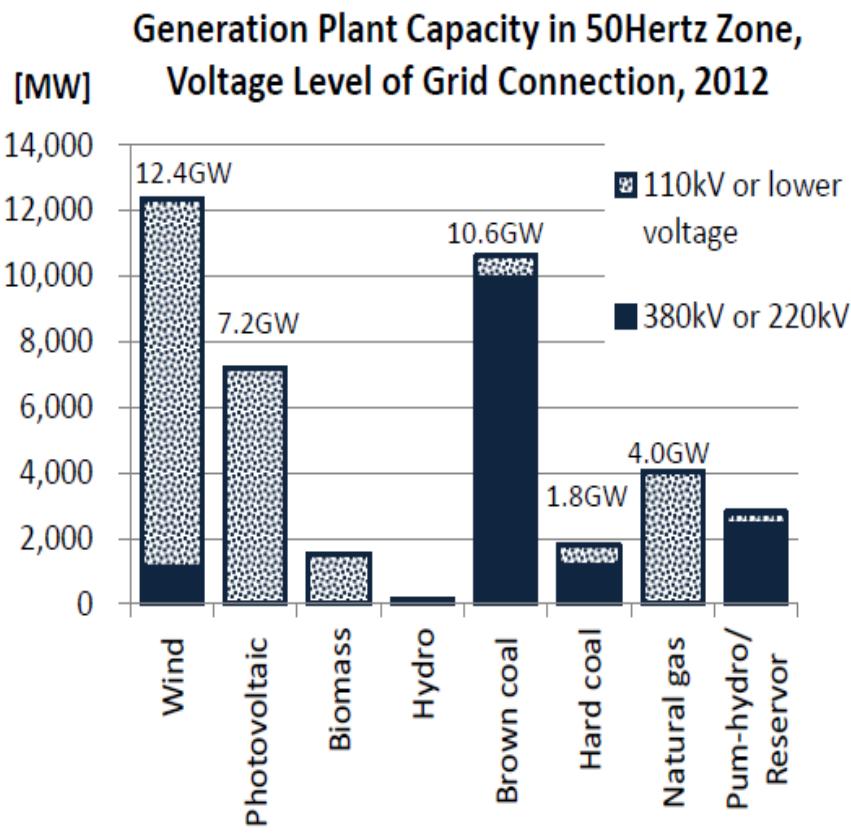
	Load-Max [MW]	Load-Min [MW]	Domestic Tie Line Transmission [MW]	Wind Energy Installed [MW]	Allocation Limit for Wind Power Grid Integration [MW]
50Hertz GmbH (DE)	13,963 *1)	5,164 *1)	5,000 TenneT-50Hertz *2)	12,420 *1)	
Hokkaido (JPN)	5,684 2 Feb. 2012 *5)	2,701 2 Sep. 2013 *5)	600 Hokkaido-Tohoku *3)	289 *4)	560
Tohoku (JPN)	13,720 2013 *6)	6,750 2013 *6)	12,620 Tohoku-Tokyo *3)	542 *4)	2,000

Source) 1) 50hertz, Kennzahlen. 2012. 2) Inter-zone connection with Tennet TSO in a stable condition (based on an interview from 50hertz GmbH. 3) Ministry of Economy Industry and Trade, 2013. 4) Federation of Electric Power Companies of Japan (June 2013). 5) Hokkaido Power Company, Load Data (hourly). 6) Tohoku Power Company, Load data.

- 50Hertz Zone in Germany
- Grid situation
- Wind/Solar integration
- Grid operation



Comparison of grid situations in 50hertz, Hokkaido and Tohoku Zone
50hertz zone has almost same scale of load in Tohoku.
Similarities to Hokkaido with high wind resources, low load, weak grid.
Integrated wind power in Hokkaido and Tohoku is very low.
Japan: Transmission grid has not been unbundled yet from generation businesses.

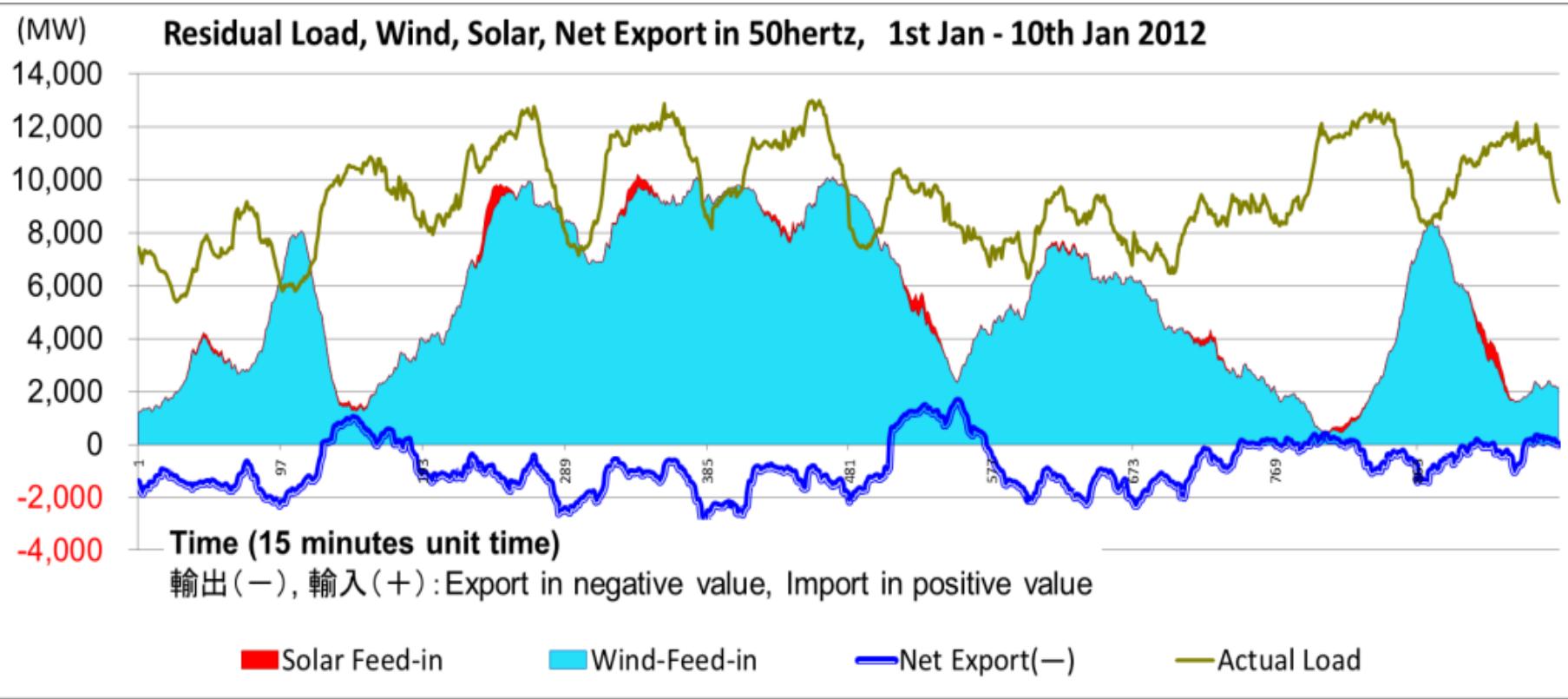


90% of Wind and 99% of PV
is connected to DSO grid
(110kV or lower) in 50Hertz
zone

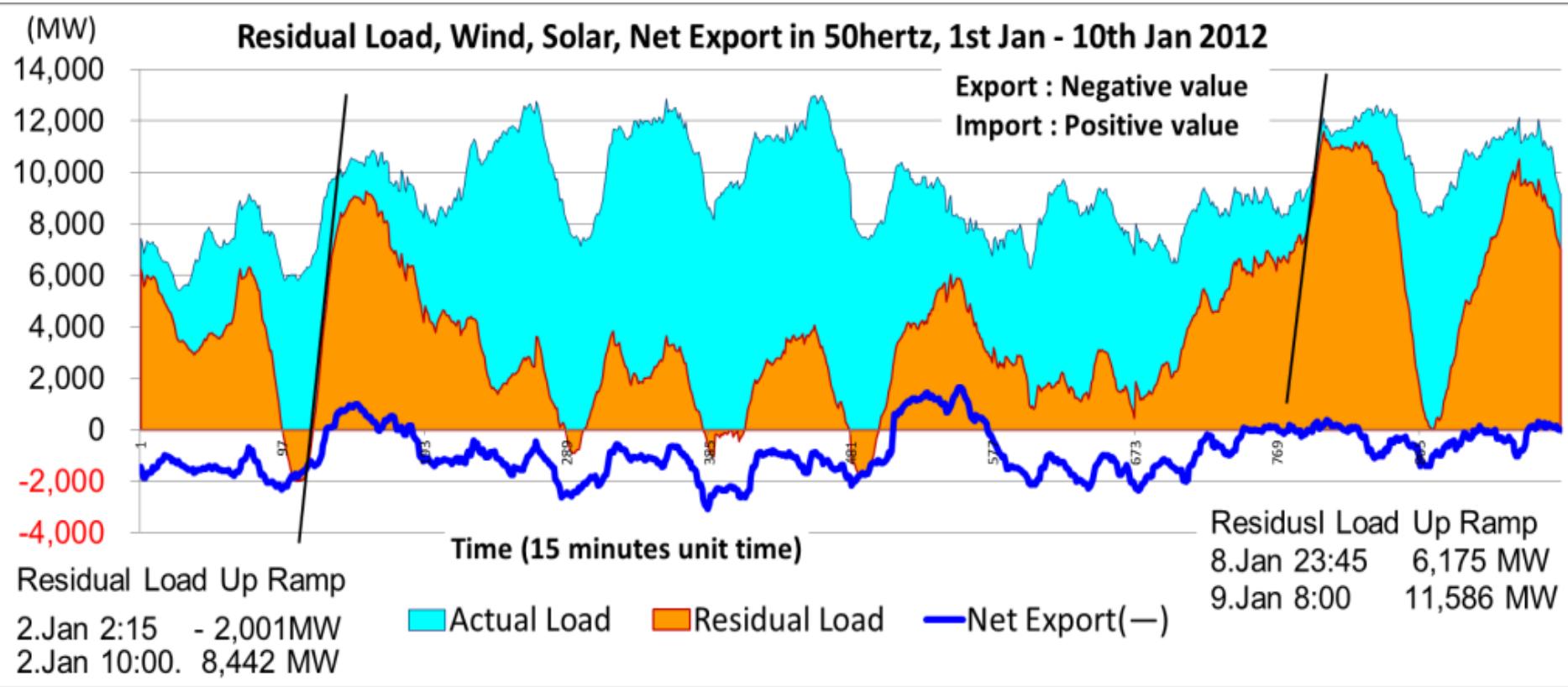
Source) 50hertz (2013), "50hertz
Almanach" and Kennzahlen

Max Load: 14GW
Wind+ PV feed-in: 10.5GW
in 50Hertz Zone

Graph) Takehama. Data based on 50Hertz.



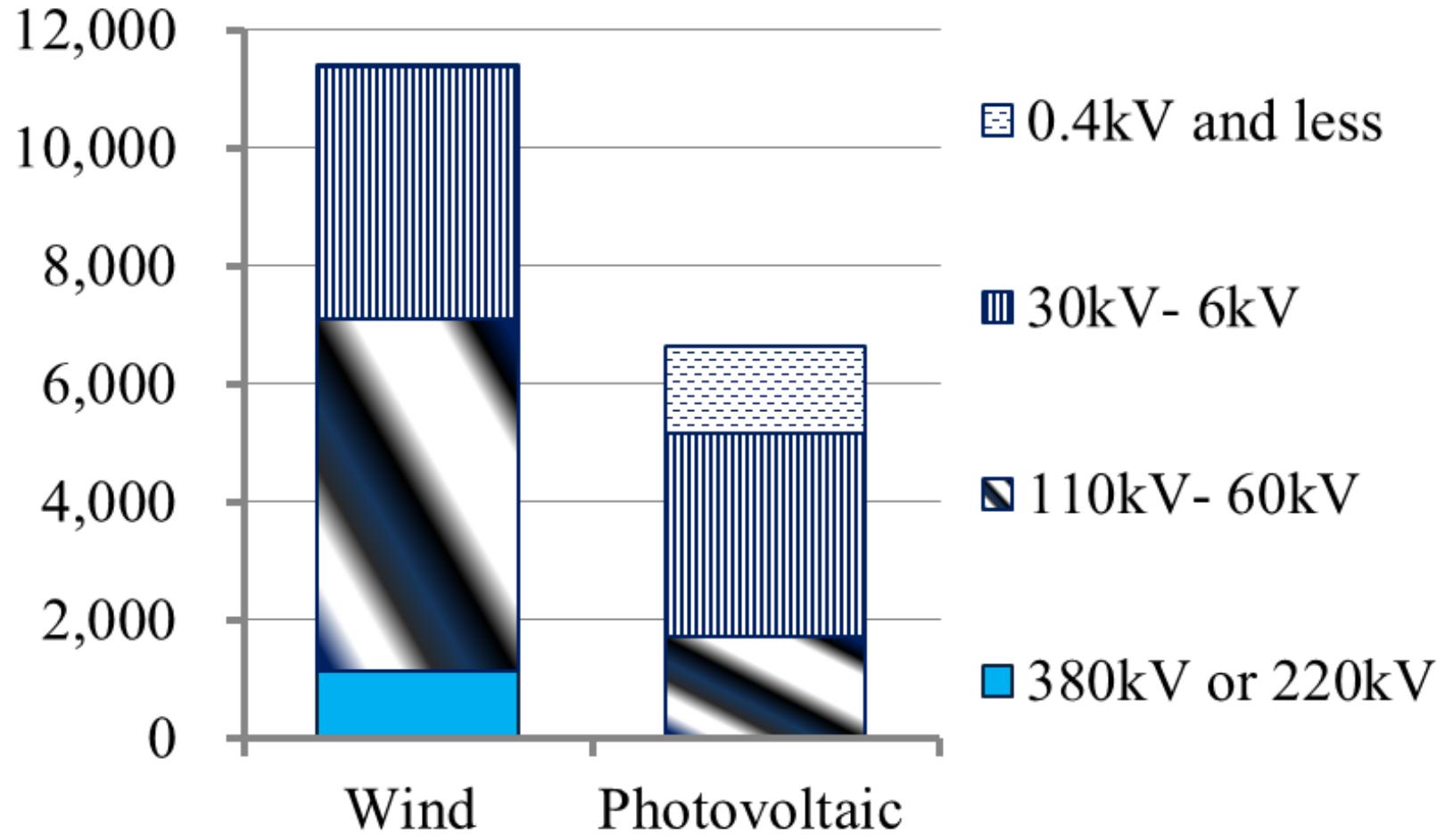
In high wind situations
1st Jan – 10th Jan 2012. 50Hertz



Residual load = Load – (Wind + Solar) :

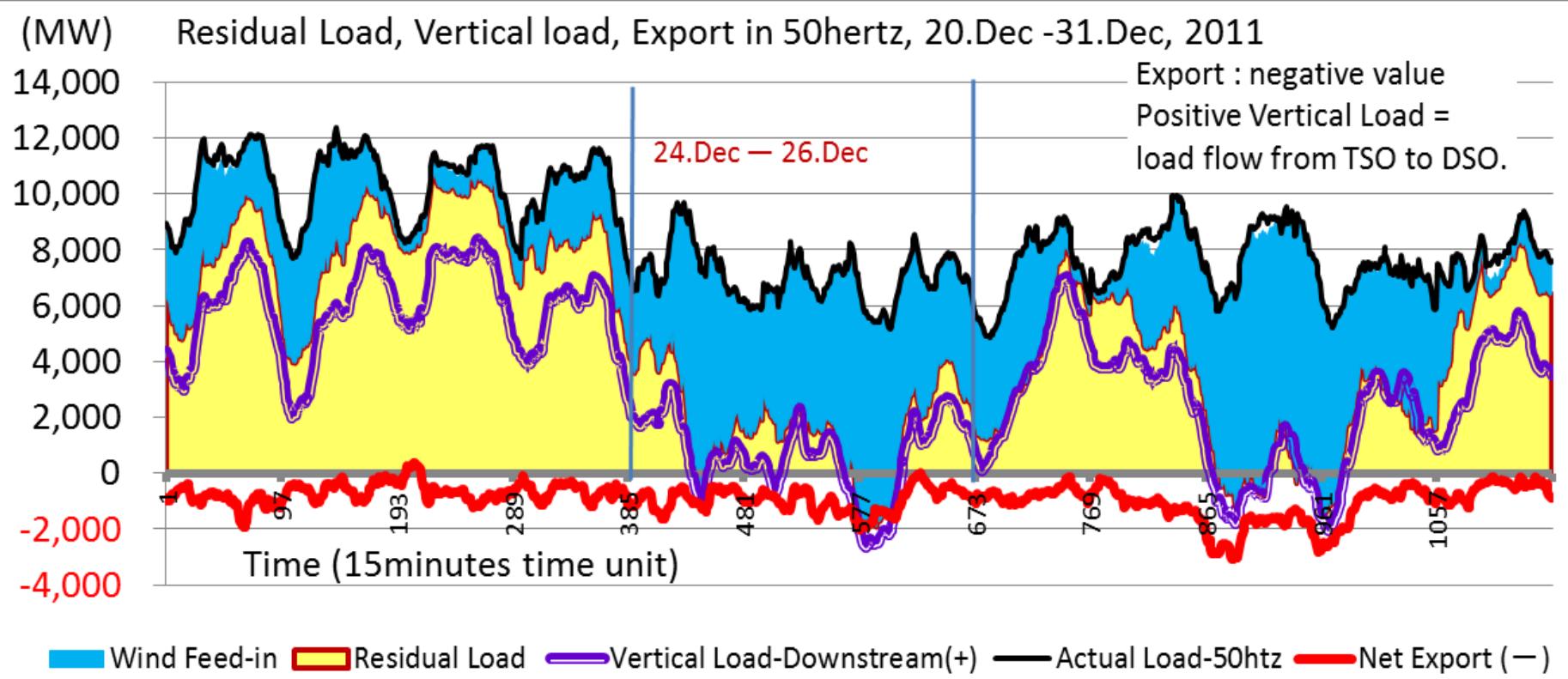
[MW]

Wind and PV energy by voltage level, 50hertz 2012



90% of Wind and 99% of Solar PV connected to 110 KV and lower levels.
(50Hertz, 2012)

The medium/medium high voltage grid is expanded by DSOs properly,
Voltage stabilizing equipment, reactive power compensation
equipment, both-direction protection system must be installed properly.

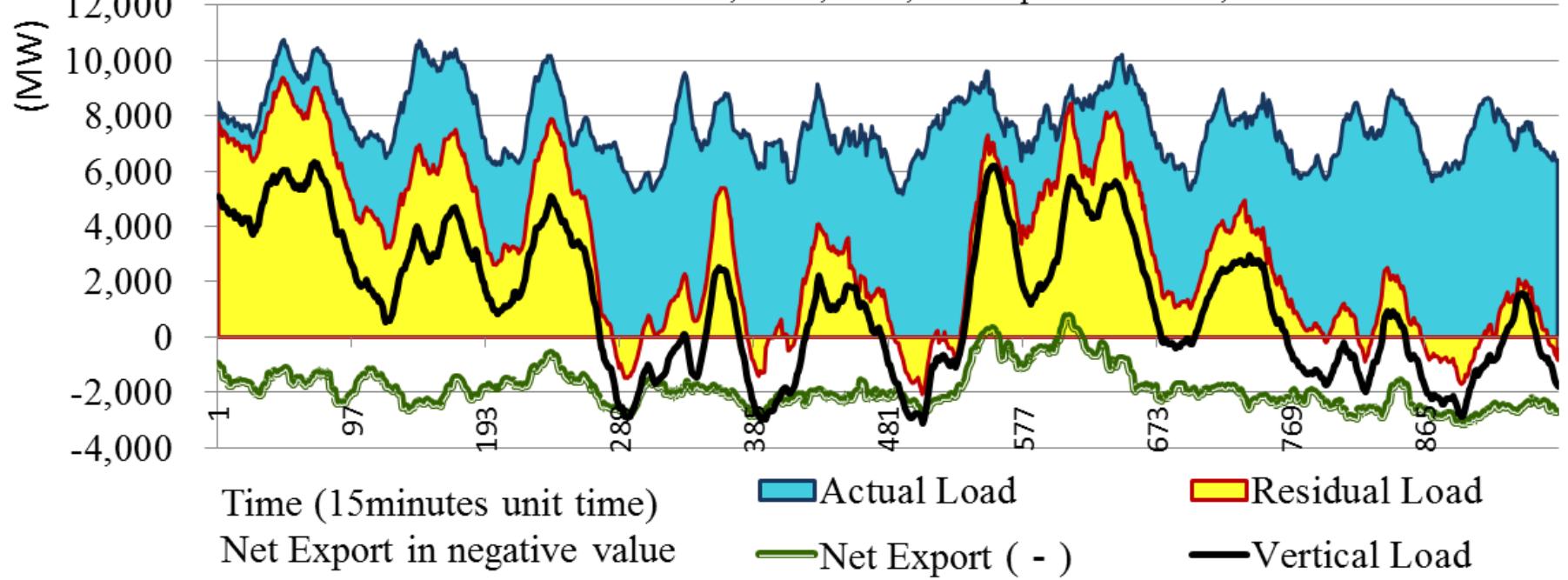


In high wind/low load situations, residual Load in negative, vertical load in negative.

Renewables at low/ middle-high voltage grid is oversupplied in a DSO grid. It is transferred to upper voltage grid.

RES electricity is transferred from 110kV >> 380kV with voltage increase.

Residual Load, Wind, Solar, Net Export in 50hertz, 22. Dec. --31. Dec. 2012



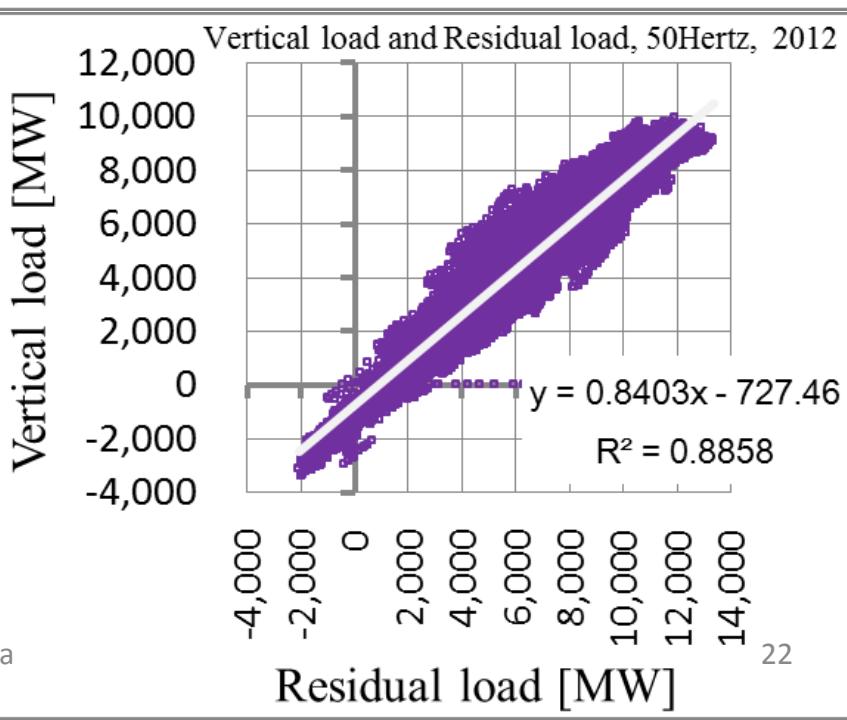
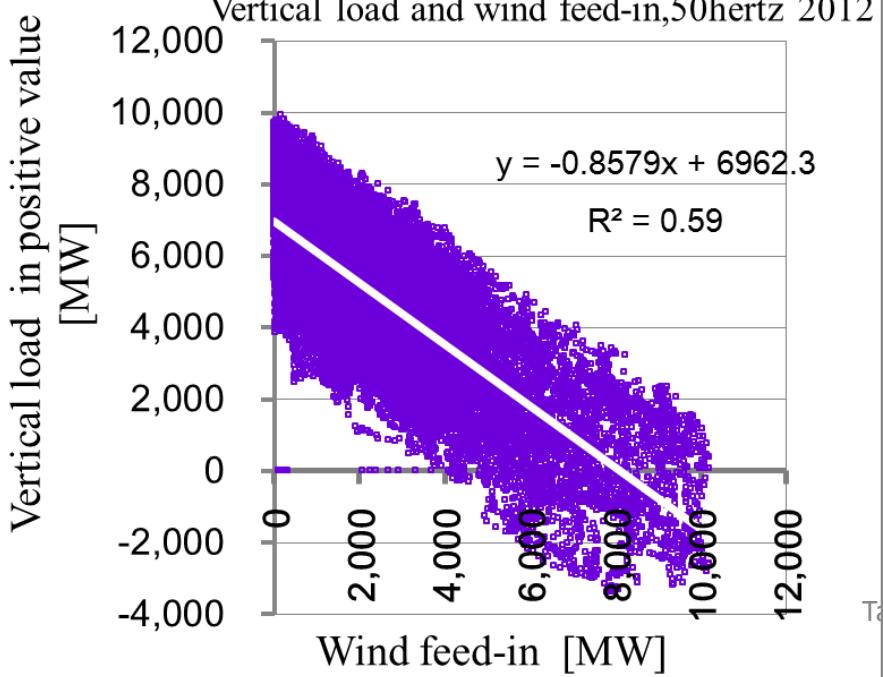
Time (15minutes unit time)
Net Export in negative value

Actual Load

Residual Load

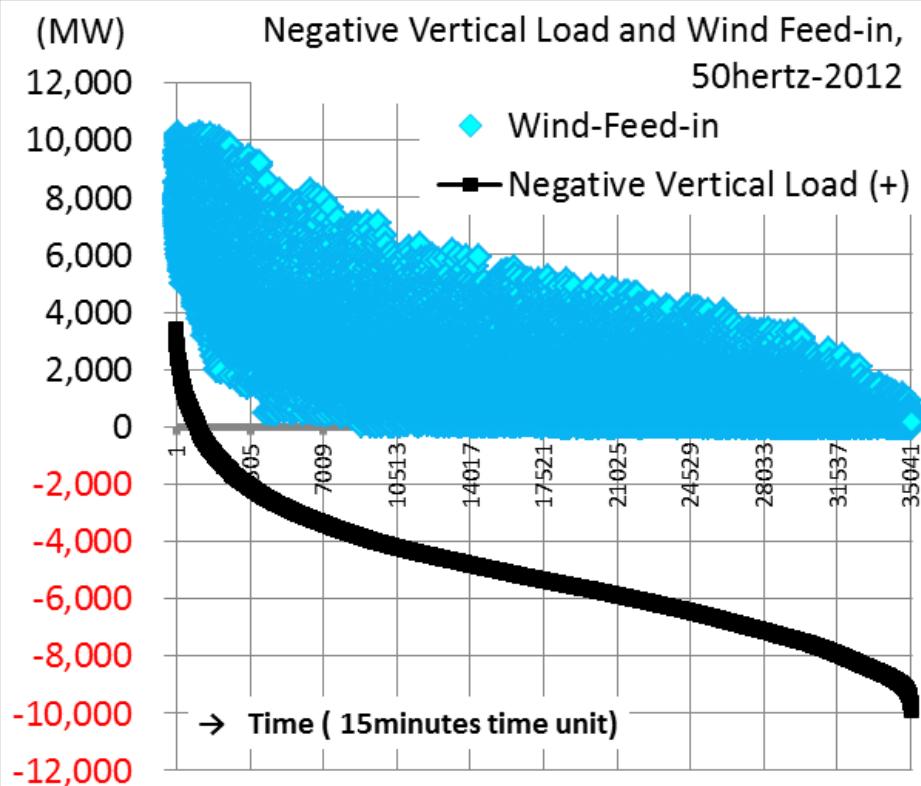
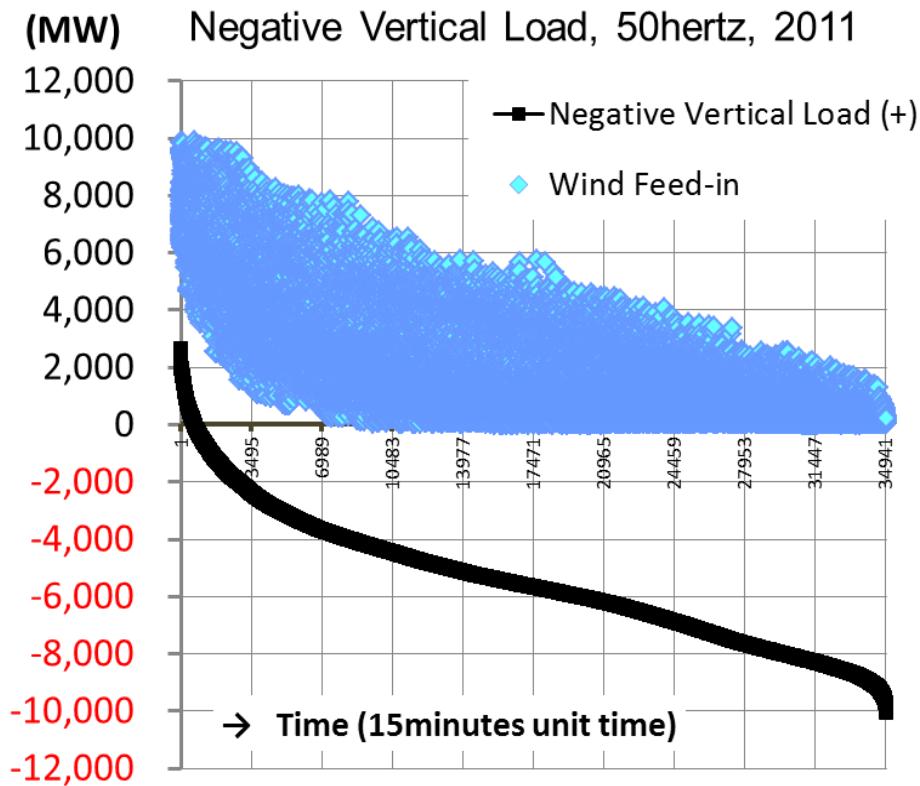
Net Export (-)

Vertical Load

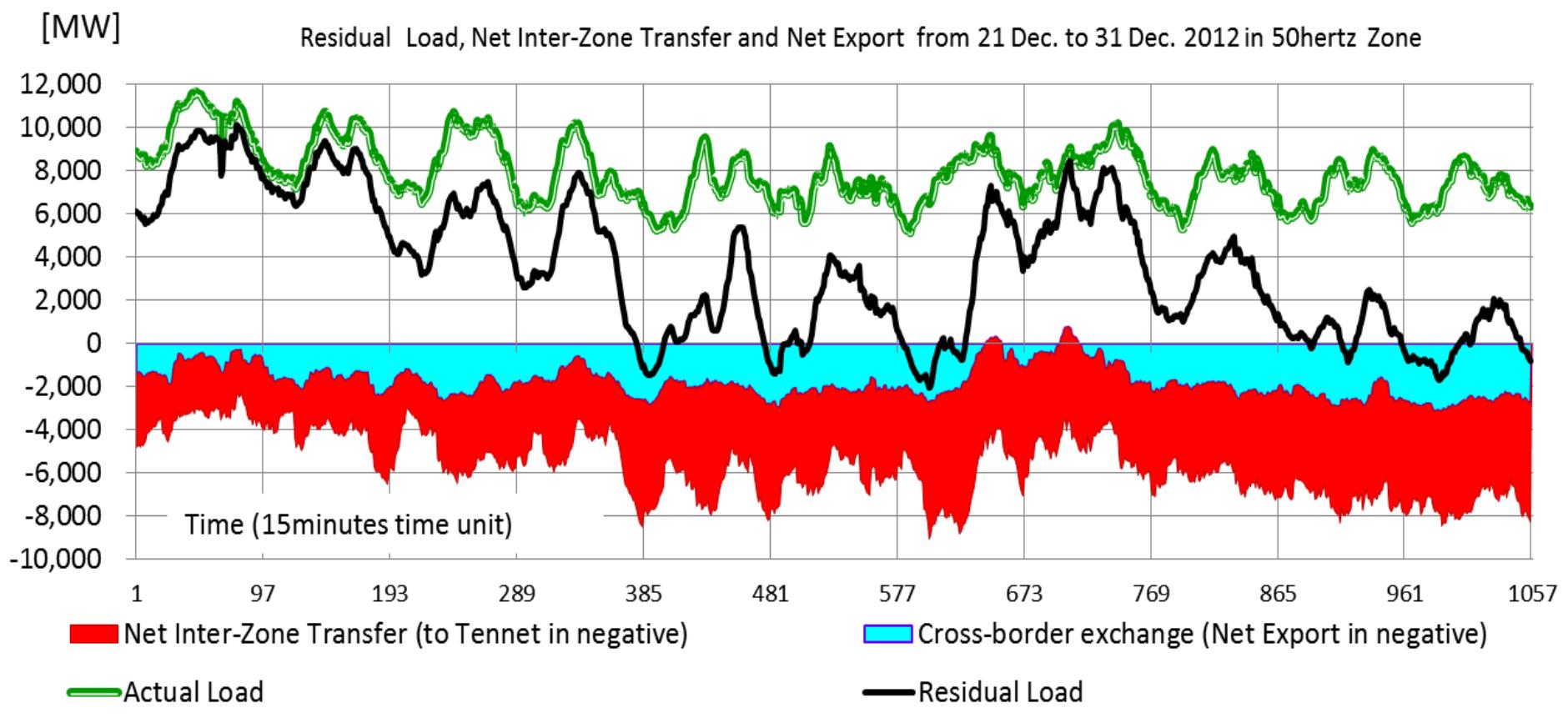


Takehama

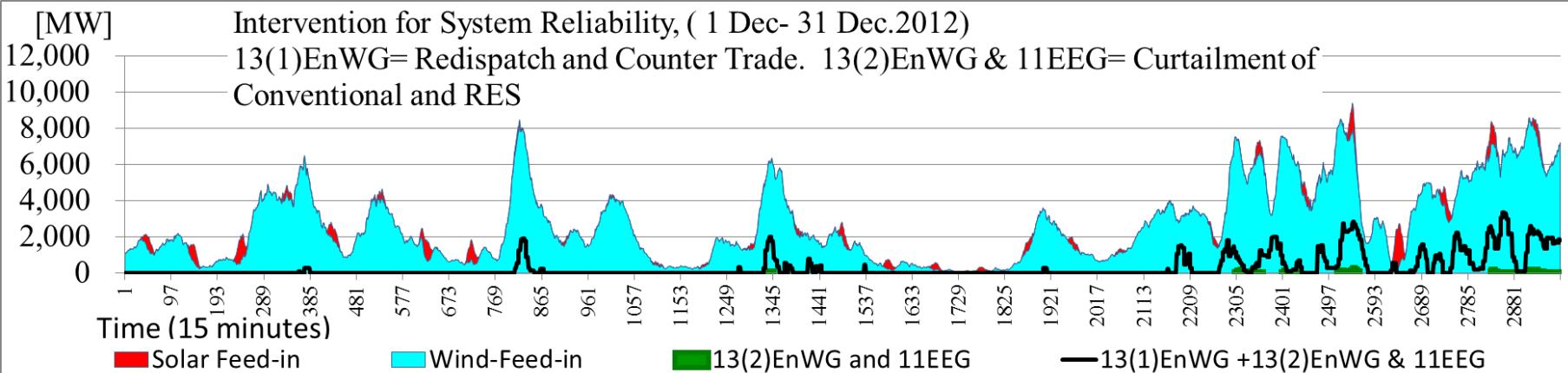
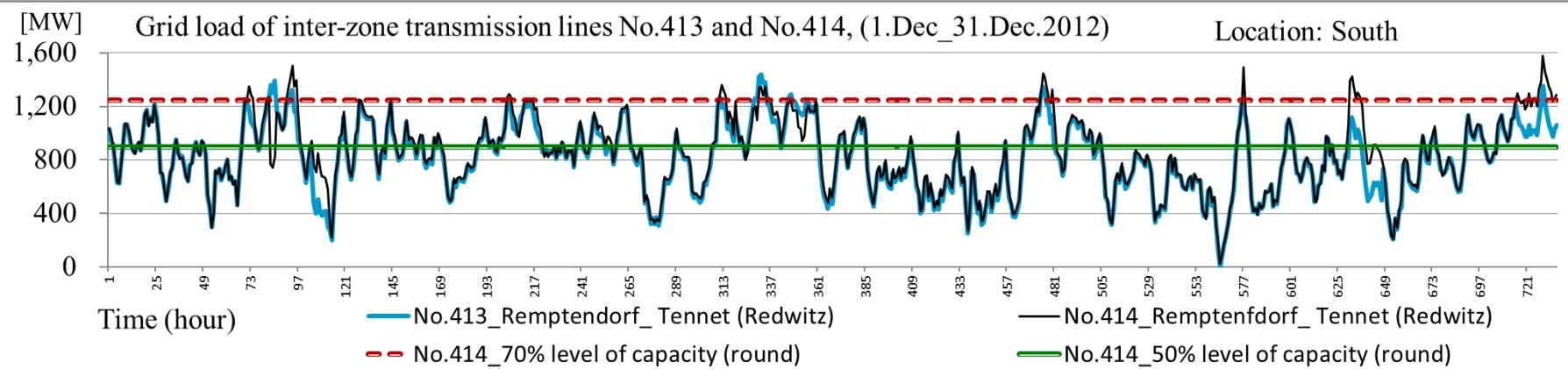
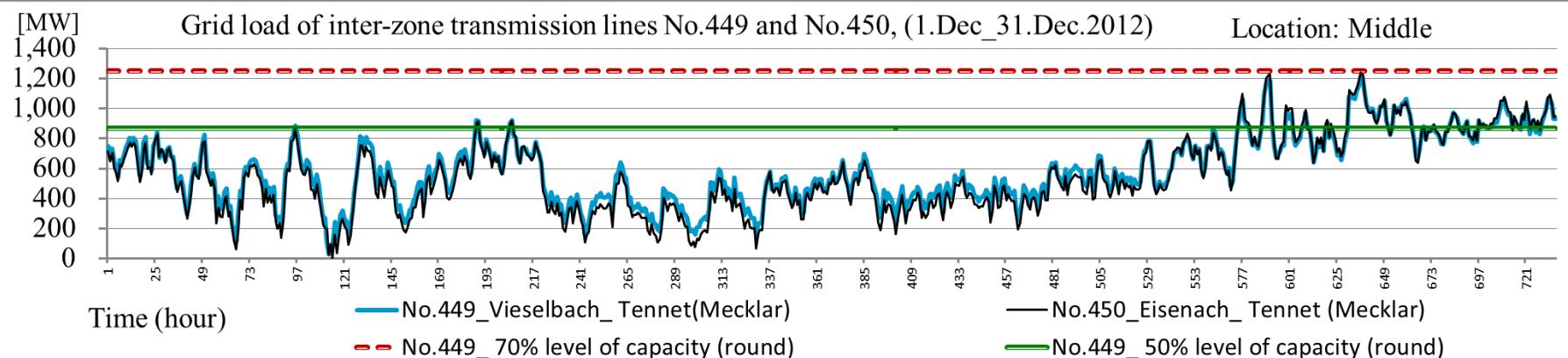
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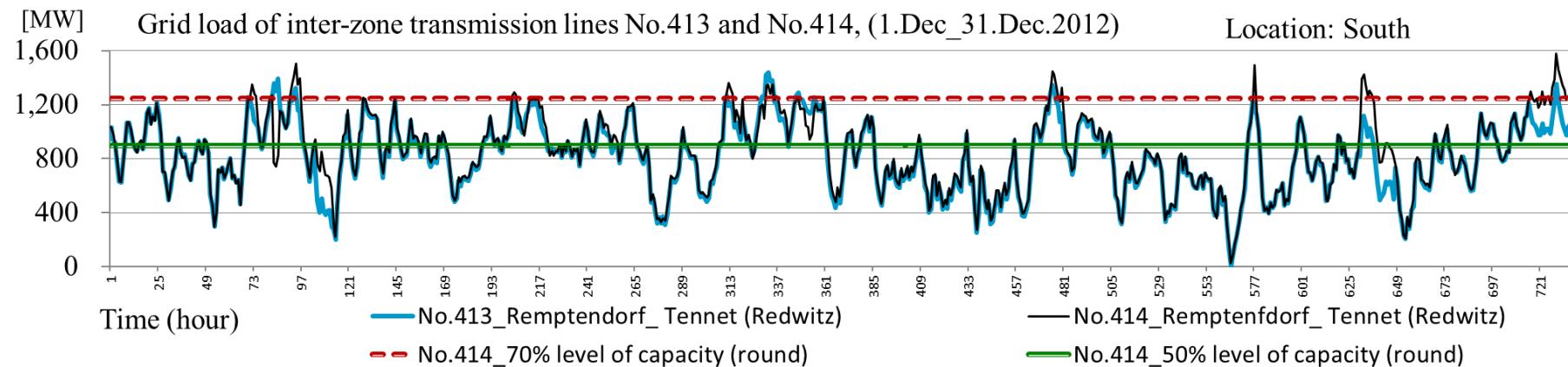
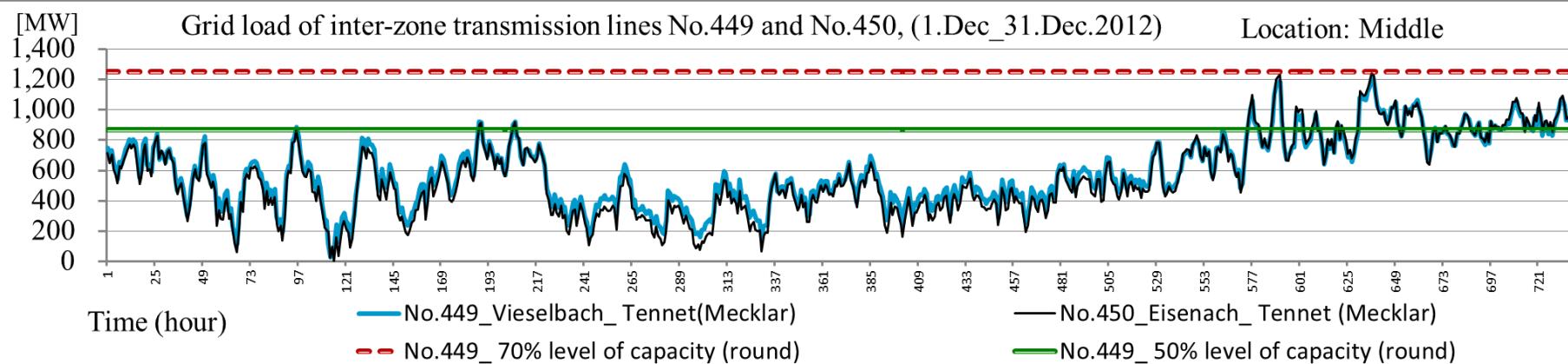
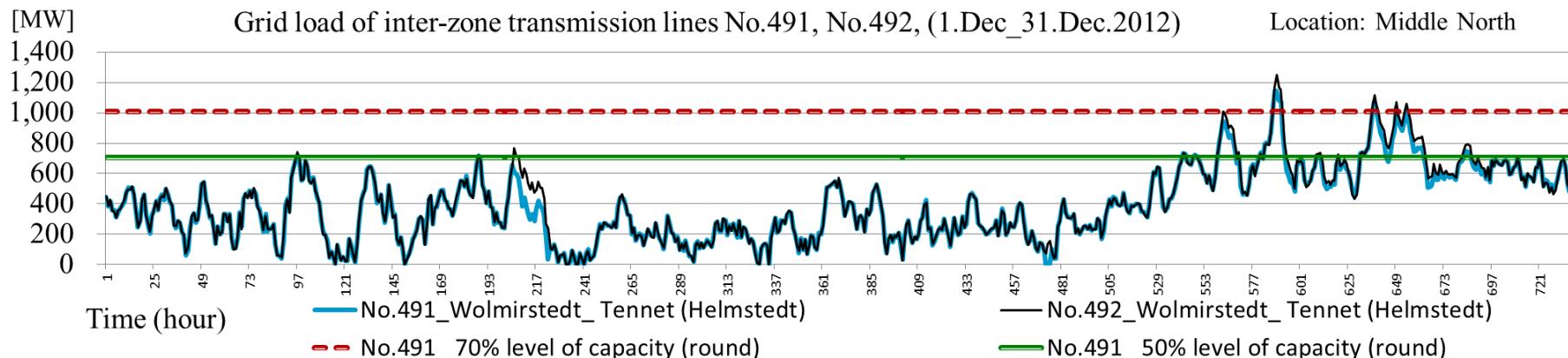
In a time of strong wind, oversupplied wind electricity is fed-in from 110kV to 380KV grid, with voltage increase. Then, transferred to TenneT zone and international export. Negative vertical load is increasing but only in high wind situations. 2011 and 2012, 50hertz



In a time of high wind feed-in,
 Residual load is low. Large amount of electricity is transferred
 to TenneT zone through tie-lines. A substantial amount is
 transferred to international grid.
 (21. Dec- 31. Dec, 2012, 50Hertz zone)



Load flow in tie lines between 50Hertz -Tenet zones. Hourly data, Dec 2012 in 50Hertz. Capacity usage of tie-lines of 50Herzt – Tennet are around 50% to 70%. 25



50Hertz とTenet 区域との地域間連系線の送電負荷(1時間値), 2012年12月の一か月
Tenet 区域との3つの主要連系線の負荷(3系統, 6回線)

Feed-in management under EEG 2012

- 13(1) EnWG
- 1) Grid related measures: Redispatch etc.,
- 2) Market related measures: Reductions in conventional power plants with contracted agreements
- 13(2)EnWG
- Non renewable energy is curtailed, first.
- Renewable energy is curtailed secondly,
- with except for technically required minimum feed-in from certain plants in order to keep grid reliability and stability.
- Detailed data of feed-in management must be disclosed (under EEG)

Feed-in management under 13(1) and 13(2) EnWG

Priority feed-in by EEG minimizes curtailment of renewable energy.

(2012, 50hertz zone)

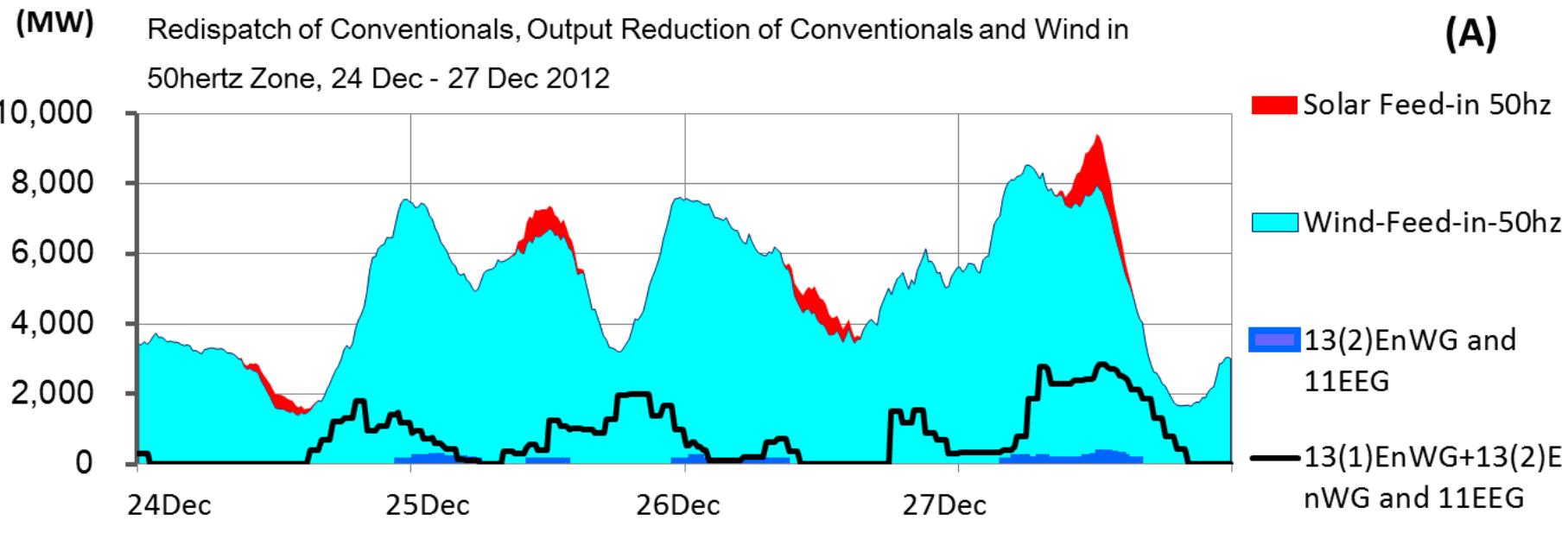
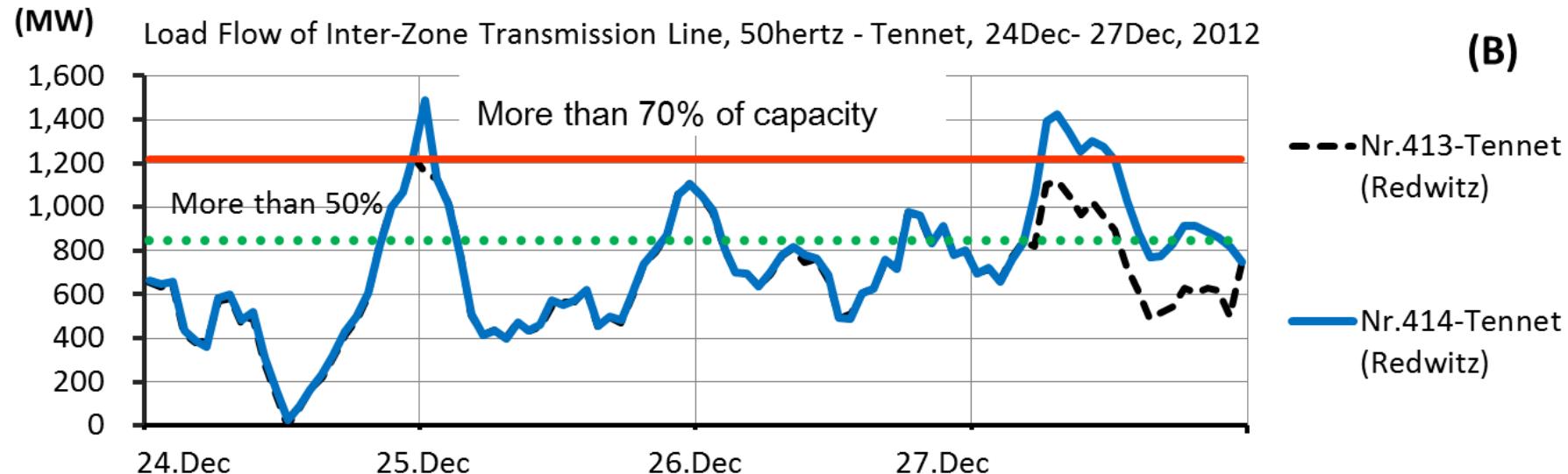
	Total amount [MWh]	Share in wind feed-in [%]	Share in generation in 50hertz [%]	Day [day]	Hour [hour]	Max [MW]
Wind feed-in	18,511,758	100%	—	365	8,775	10,208
13(1)EnWG (Redispatch and counter trade of conventional plants) [A]	2,824,454	15.3%	2.6%	262	2,481	5,111
13(2)EnWG conjoined with 11EEG (Curtailments of conventional plants and renewable plants) [B]	119,846	0.6%	—	77	630	4,925
Total interventions (13(1)EnWG, 13(2)EnWG-11EEG) [A+B]	2,944,300	15.9%	—	—	—	—

Source) Takehama. These are calculated from the data of 50hertz's Maßnahmen nach §13.1EnWG, §13.2EnWG. Total generation in the 50hertz zone in 2012 was 108,070 [GWh].

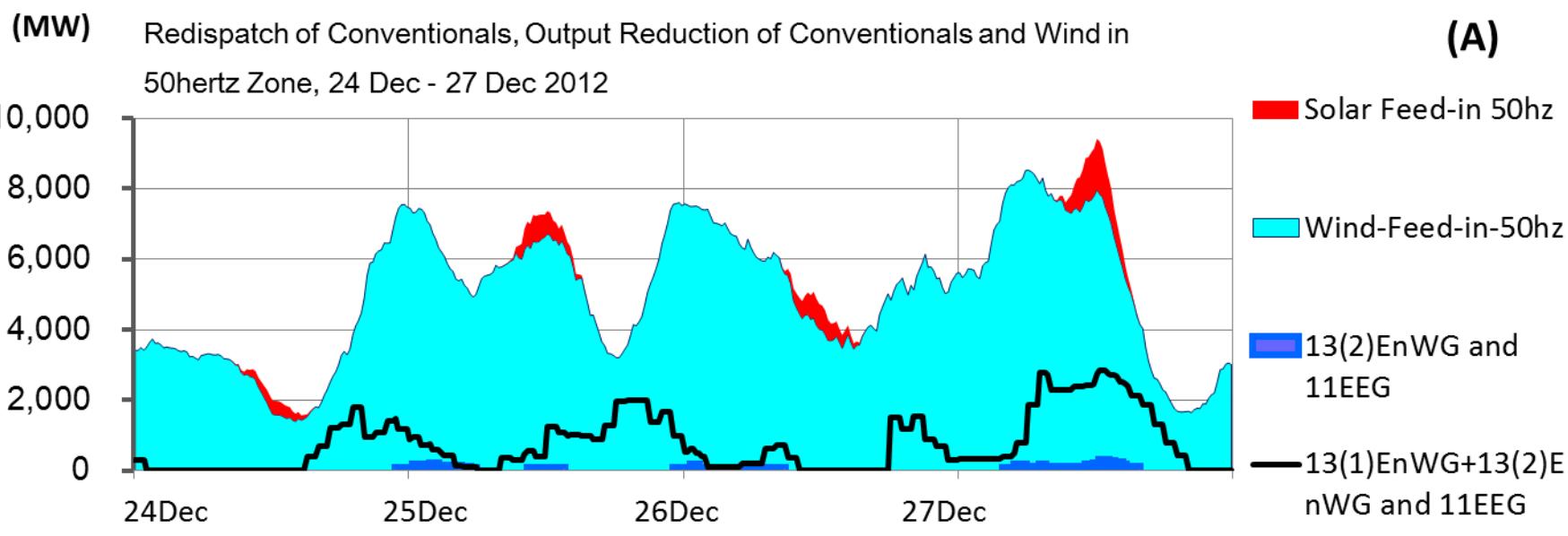
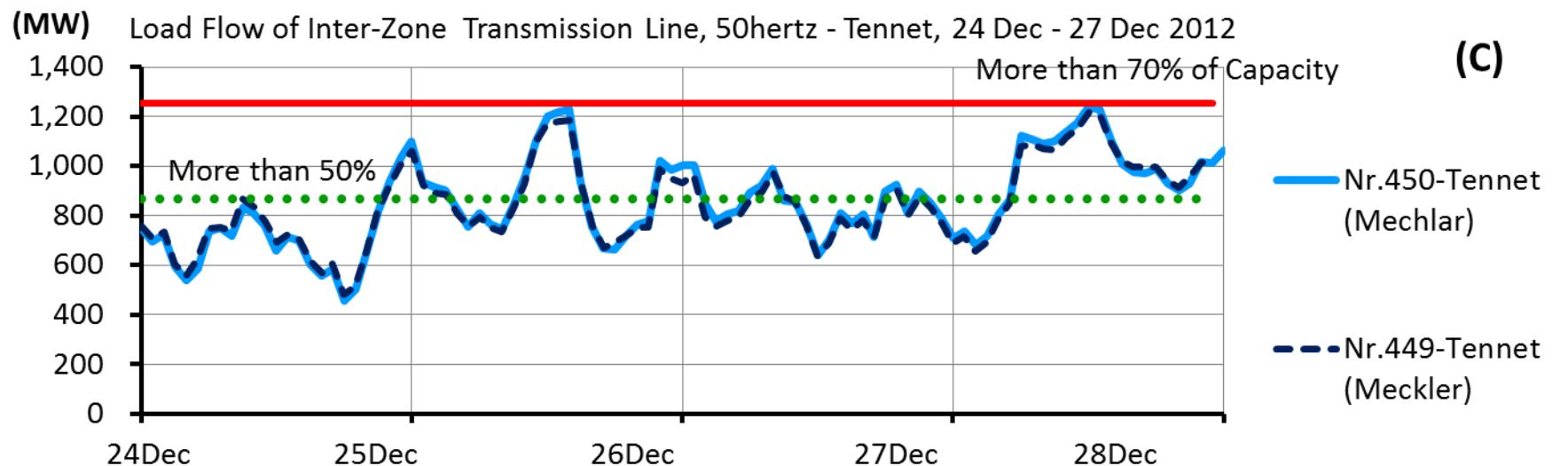
Germany's grid operation (50Hertz Zone)

- Renewables are given a priority under the EEG
- Priority feed-in/ purchase with maximum amount.
- Grid operators are obliged to expand the grid. (EEG, section 9) .
- DSO grid expansion is important.
- Bottom-up, flexible operation with feeding from renewable energy (from middle/middle high voltage grid to higher voltage grid)
- Around 50% to 70% of grid capacity usage in inter-zone tie lines, in a time of high wind situation.
- Large amount of electricity is transferred to TenneT zone.

- EEG 2012, section 9
- <Upon the request of those interested in feeding in electricity, grid system operators shall immediately optimise, strengthen and expand their grid systems in accordance with the best available technology in order to guarantee the purchase, transmission and distribution of the electricity generated from renewable energy sources.>
- <This entitlement also exists as against grid system operators to whose grid system the installation is not directly connected, provided it is an upstream grid system with a maximum voltage of 110 kilovolts and this is necessary in order to guarantee the purchase, transmission and distribution of the electricity.>

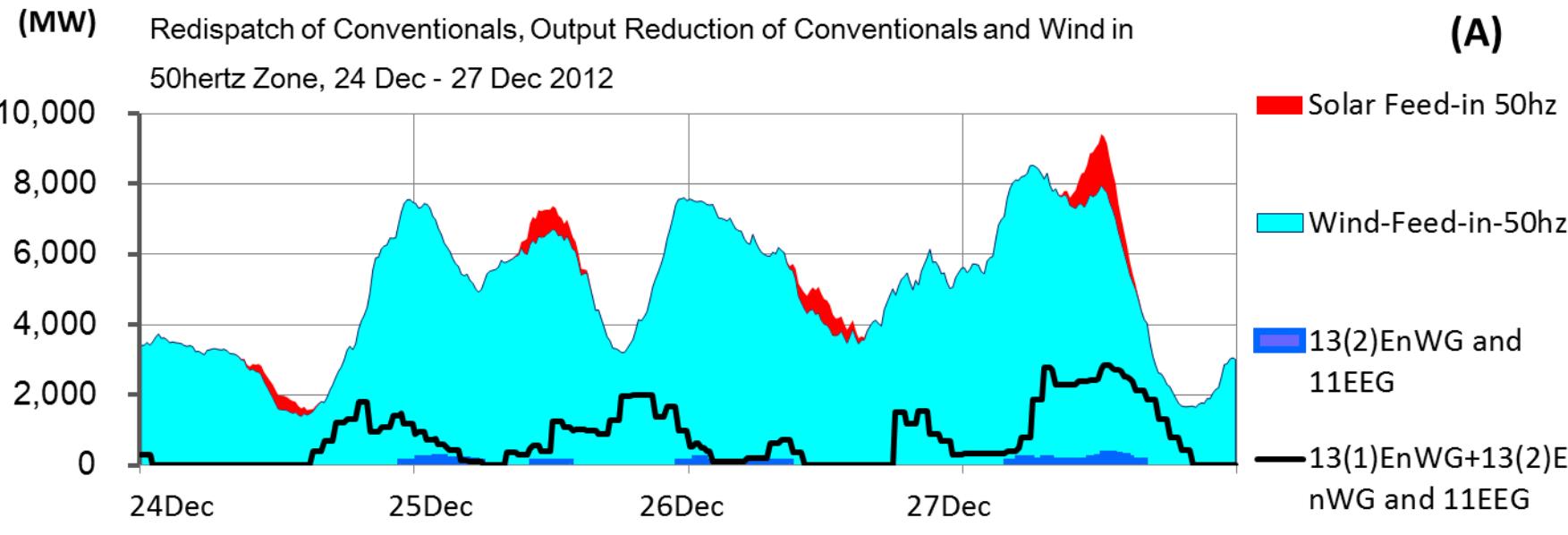
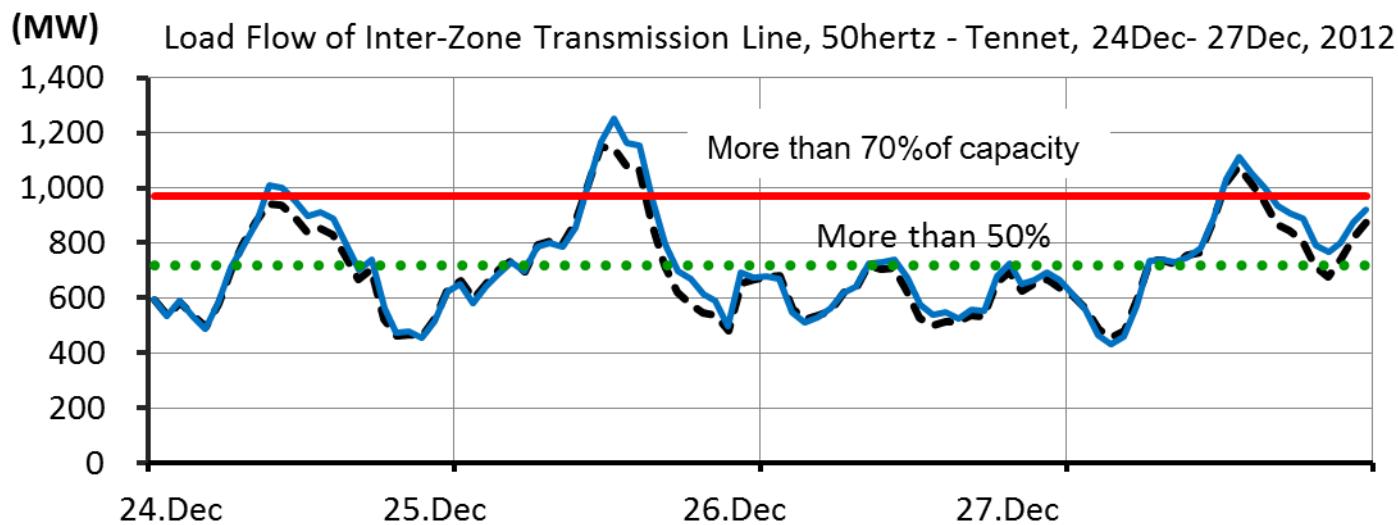


火力Redispatch(送電先変更)と風力出力抑制実施時における、Tennet管内への地域間連系線の負荷. 2012年クリスマス, 1時間値[MW]. ルート1 (No.413とNo.414)
出所)竹濱作成。50Hertz社のKennzahlen風力・太陽光給電データ、Netzbelastung in der Regelzoneの送電線各1回線のロード1時間値より、筆者算出。<http://www.50hertz.com/netzkarte/?wcmLocale=en>。



火力Redispatch(送電先変更)と風力出力抑制実施時における、Tennet管内への連系線負荷、2012年クリスマス、1時間値「MW」。ルート2(No.449, No.450)

出所)竹濱作成。50Hertz社のKennzahlen風力・太陽光給電データ、Netzbelastung in der Regelzoneの送電線各1回線のロード1時間値より、筆者算出。<http://www.50hertz.com/netzkarte/?wcmLocale=en>。



火力Redispatch(送電先変更)と風力出力抑制実施時における、Tennetへの地域間連系線のロード。2012年クリスマス。1時間値。 ルート3(ライン491、492)

出所)竹濱作成。50Hertz社のKennzahlen風力・太陽光給電データ、Netzbelastung in der Regelzoneの送電線各1回線のロード1時間値より、筆者算出。<http://www.50hertz.com/netzkarte/?wcmLocale=en>

- Thank you

Generation capacity in the 50Hertz zone in 2012

	50Hertz control zone			Germany
	Total capacity [MW]	380kV or 220kV [MW]	110kV or lower [MW]	Total capacity [MW]
Wind	12,420	1,110	11,260	31,315
Photovoltaic	7,220	4	7,216	32,643
Biomass	1,530	22	1,508	7,179
Hydro	160	4	156	4,401
Renewable	21,410	1,190	20,220	75,546
Lignite	10,608	9,948	660	21,249
Hard coal	1,820	1,153	667	25,476
Natural gas	4,038	-	4,038	26,975
Pump-up hydro	2,808	2,430	378	9,240
Nuclear	0	0	0	12,068
Conventional	21,513	13,787	7,726	102,941

Source) 50hertz (2013), "50hertz Almanach". Wind and Photovoltaik capacity is based on BMU(2013), Erneuerbare Energien 2012 Daten. Biomass, hydro is based on BMU (2012), Zeitreihen zur Entwicklung der erneuerbaren Energien in Deutschland 2011. Conventional plants in Germany is based on data from: Bundesnetzagentur, Kraftwerksliste Bundesnetzagentur (bundesweit; alle Netz- und

380kV・220kV : TSOs, 110kV : DSOs

90 % of wind and 99% of PV is integrated to 110kV grid or lower.

Lignite : Must run capacity (Technical required minimum)

Hard coal is asked curtailment.

- Top Down and Bottom Up Grid Operation
- Ja-Ger. Comparison
- Grid expansion obligation
- Integration of Large Scale Wind Energy in 50Hertz Zone, Germany,
- Priority for Nuclear and ‘Long-Term fixed’ capacity
- Japan’s FIT, Access obligation
- But No Priority feed-in
- Considerations given to RES when its curtailment
- Some advantage
- Recent Japan’s RES installation
- Voltage levels for RES integration in Ger. JPN
- K
- Japan’s situation

Generation Capacity in the end of 2012

	Total Capacity [MW]	% of [A/B]	of which, Nuclear [MW]	%	of which, Renewable Energy [MW]		
					Wind	Solar PV	Geothermal
General Power Companies 一般電気事業者	Hokkaido 北海道	7,548	3%	2,070	4%	0	1
	Tohoku 東北	17,766	8%	3,274	7%	0	4
	Tokyo 東京	65,269	28%	14,496	31%	1	30
	Chubu 中部	33,437	14%	3,617	8%	22	9
	Hokuriku 北陸	8,061	3%	1,746	4%	5	4
	Kansai 関西	34,950	15%	9,768	21%	0	10
	Chugoku 中国	11,989	5%	1,280	3%	0	3
	Shikoku 四国	6,963	3%	2,022	4%	a	2
	Kyushu 九州	20,637	9%	5,258	11%	3	3
	Okinawa 沖縄	2,183	1%	0	0%	a	0
	Total of General Power Companies [A]	208,804	90%	43,531	94%	32	65
	Total Generation Capacity in Japan [B]						462
Wholesale Power Companies 卸電気事業者	J-Power 電源開発	16,983	7%	0		0	0
	Japan Atomic Power Company 日本原子力発電	2,617	1%	2,617	6%	0	0
	Total of Wholesale Power Companies	19,600	8%	2,617	6%	0	0
	Total Generation Capacity in Japan [B]						15
Tokutei Power Companies 特定電気事業者		280	0%	0		0	0
Tokutei-Kibo Power Companies 特定規模電気事業者		2,120	1%	0		53	0
Total Generation Capacity in Japan [B]		230,804	100%	46,148	100%	85	65
(of which, the share of nuclear power in the total nuclear power in Japan)		100%		20%			

Notes: Japan Atomic Power Company and some of independent power suppliers (Wholesale, Tokutei, Tokutei-Kibo) are subsidiary companies of General Power Companies. Source: Ministry of Economy, Trade and Industry. Power Generation statistics

Comparison of Grid Situations in 50hertz, Hokkaido, Tohoku Zones

	Load-Peak [MW]	Load-Min [MW]	Domestic Inter- Zone Connection [MW]	Wind Power, Grid Connec Capacity [MW] 風力連系
50hertz	13,963 (2012) *1)	5,164 (2012)*1)	5,000 (around) 国内連系 (with Tennet) *2)	12,420 *1)
Hokkaido	5,684 (2 Feb. 2012) *6)	2,701 (2 Sep. 2013) *6)	600 (2009) *3)	289 *4)
Tohoku	13,910 (Mar, 2004) *3)	5,863 (Mar, 2004) *3)	6,310 (2012) *5)	542 *4)

*1) 50hertz, Kennzahlen

*2) Hearing from 50hertz GmbH, in a stable condition

*3) Data by Junji Kondoh, National Institute of Advanced Industrial Science and Technology (AIST)

*4) Federation of Electric Power Companies of Japan, June 2013

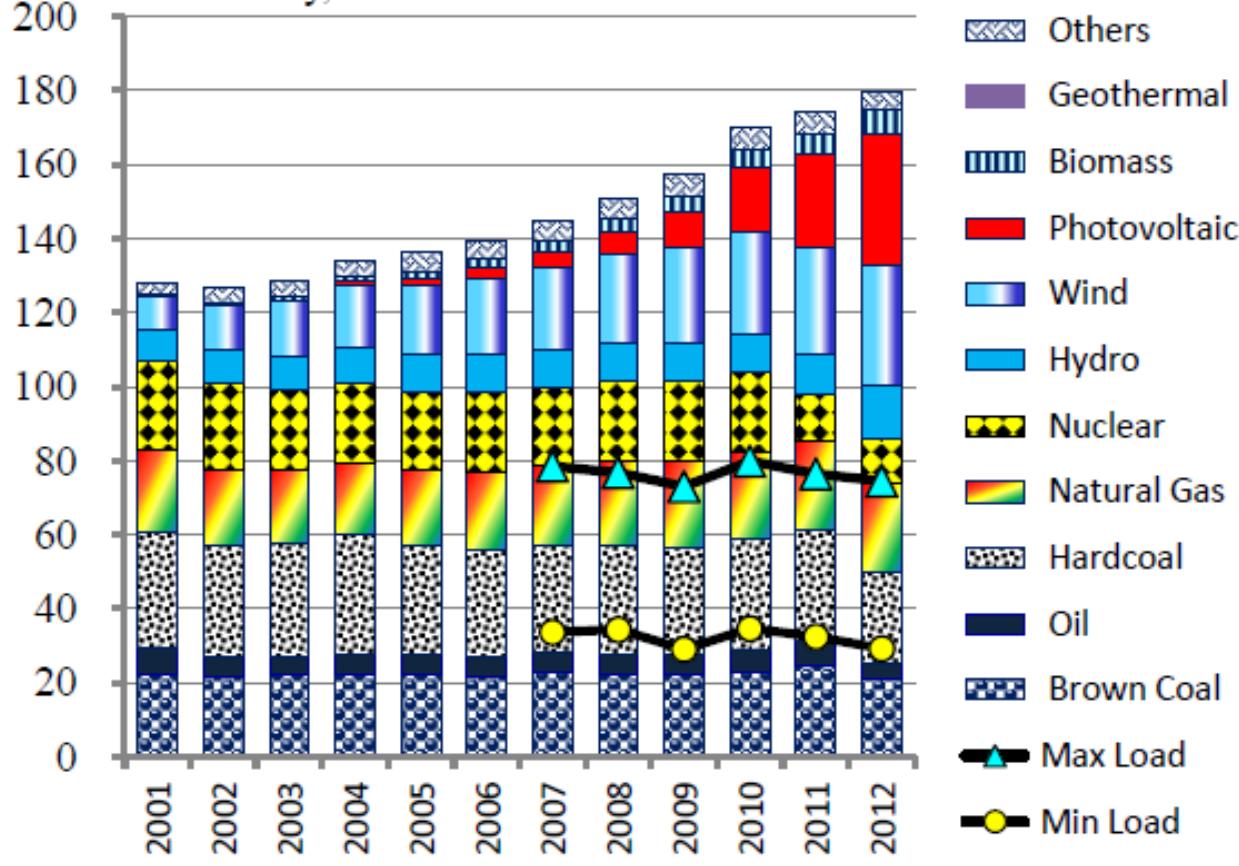
*5) Committee for power system reform by Ministry of Economy, Trade and Industry, 2012

*6) Hokkaido Power Company, Load Data (hourly)

Contents

- Comparison of grid integration of wind/solar and grid situations in Japan and Germany
- Hokkaido, Tohoku in Japan
- 50Hertz in Germany
- Grid data from 50Hertz zone in 15mnute feed-in data
- **Voltage levels of wind/solar integration**
- **wind feed-in, solar feed-in,**
- **Residual load**
- **Electricity transferred from 110kV to 380kV
(negative vertical load)**

[GW] Generation Capacity, Max Load and Min Load in Germany, 2012



Graph) Takehama.
Data: BMWi,
Bundesnetzagentur

ドイツ全域の再エネ設備、発電設備容量

Cumulative Capacity of Wind, PV, conventional plants in Germany 2013

Wind: 33.7GW, PV: 35.7GW

Max Load: 74GW, Min Load: 29GW (in 2012)

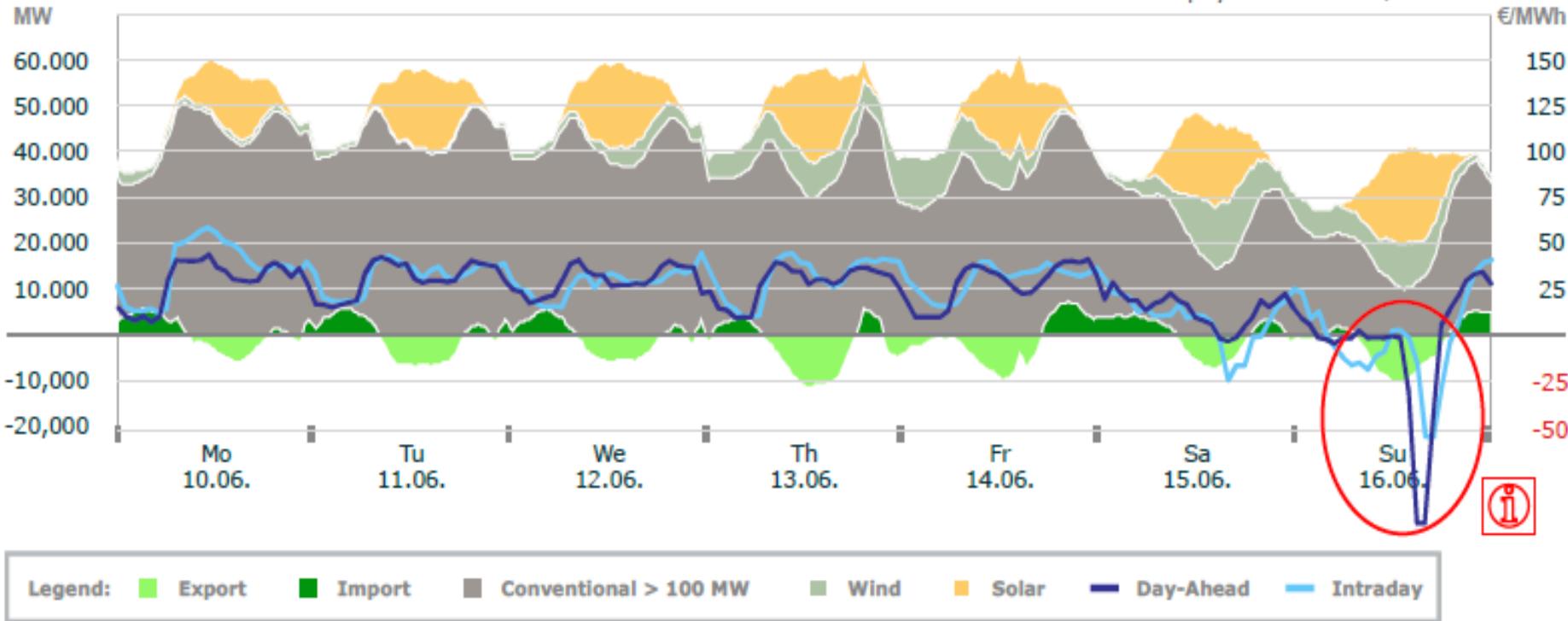
Data) BSW-Solar, BWE

Electricity Production and Spot-Prices: CW 24 2013



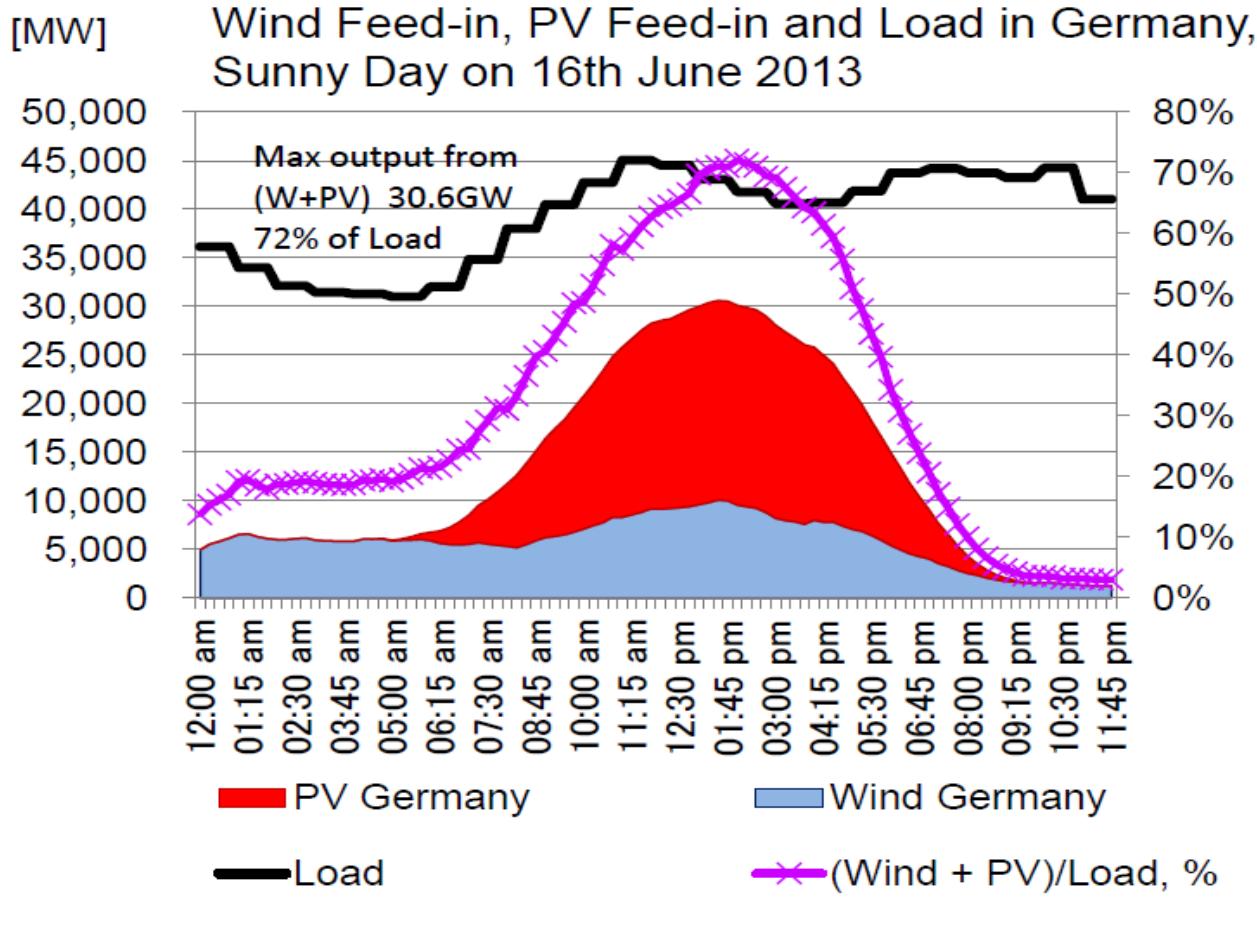
Electricity Production and Export in Germany, 10th - 16th June 2013

displayed week: CW 24; 2013



€ / MWh	Period Mean	Period Min	Period Max	Trading / GWh
Day-Ahead	23.28	- 100.00	45.00	4 783
Intraday	26.95	- 53.50	59.50	288

Source) Johannes Mayer, Electricity Spot-Prices and Production Data in Germany 2013, Fraunhofer ISE.



Load, Wind and PV Output on 16th June 2013 in Germany

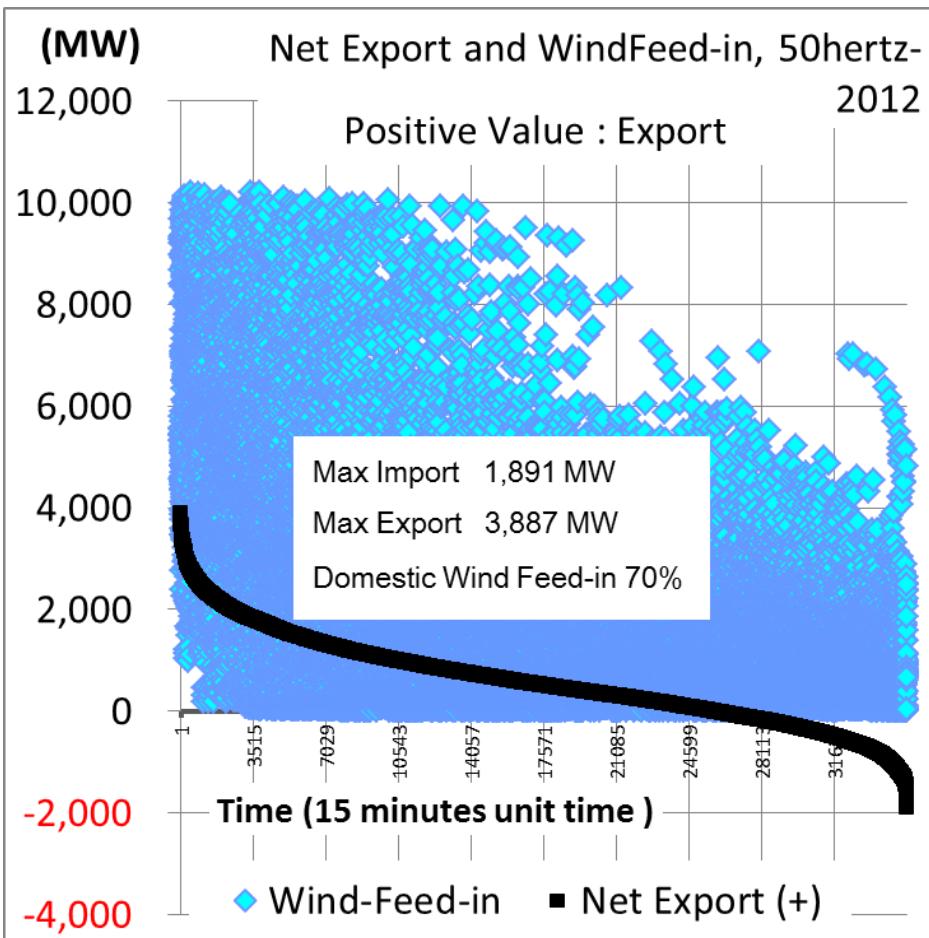
(Wind + PV) max feed-in : 31 GW

(Wind +PV) per Load, max share : 72%

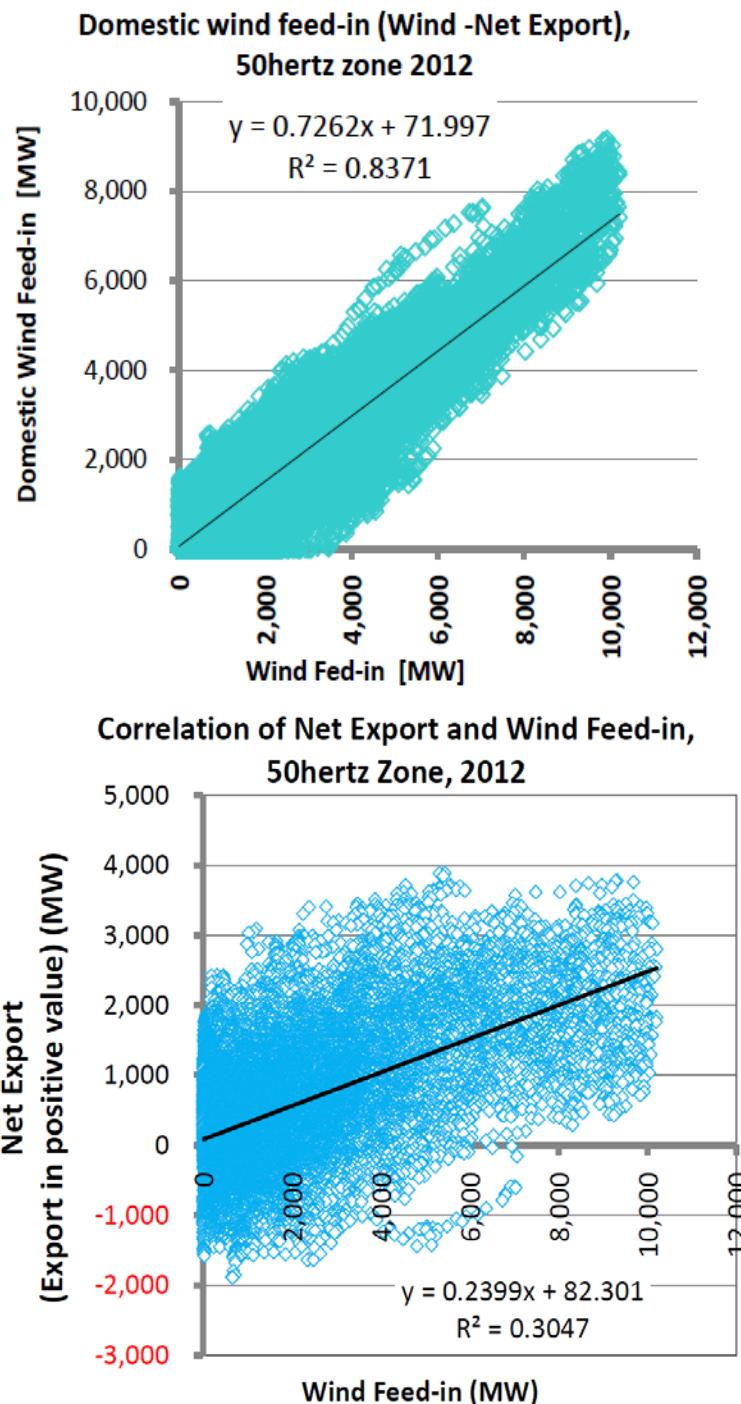
Max Wind feed-in : 10GW

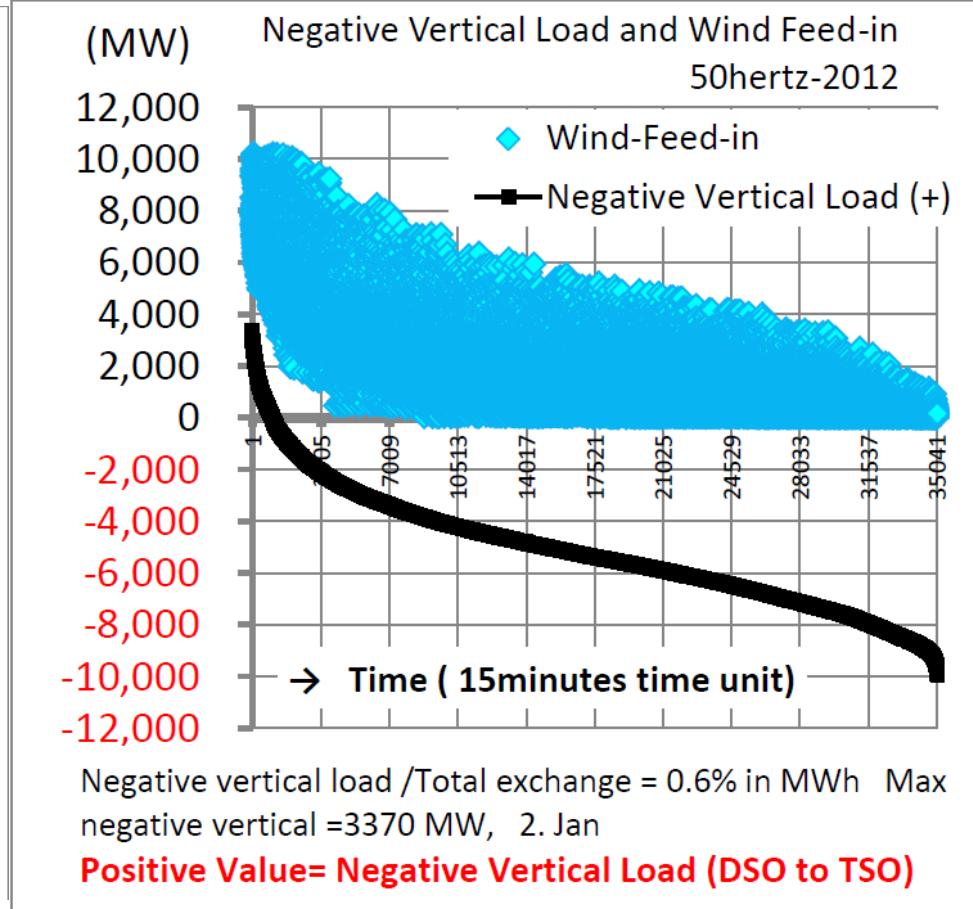
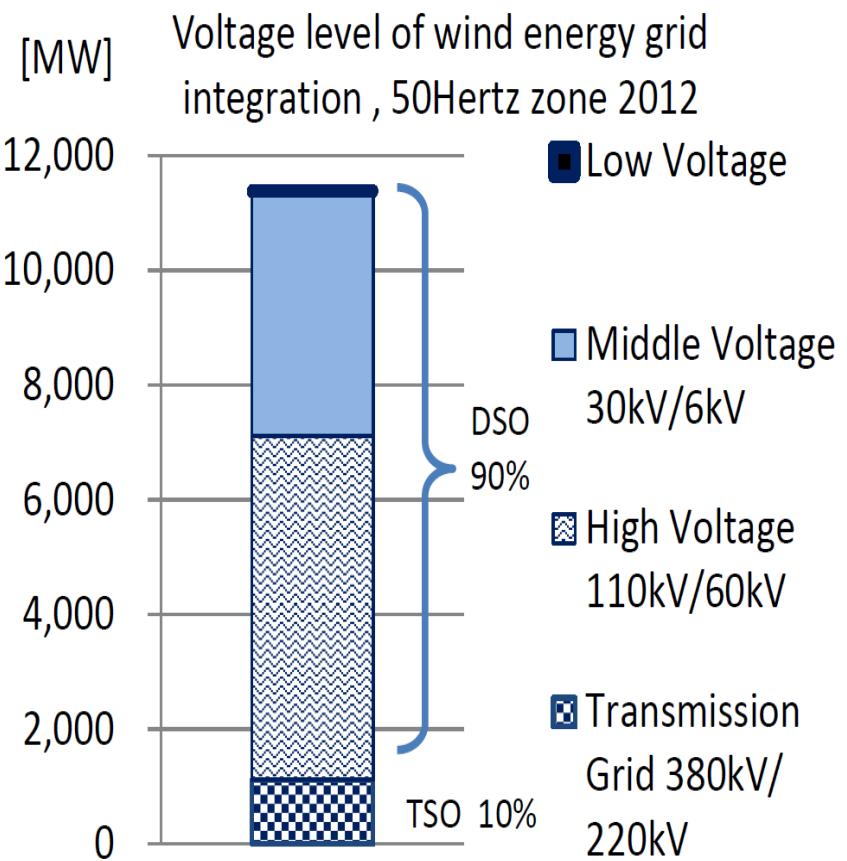
Max PV feed-in : 20.5GW

Graph) Takehama. Data: Entso-E, EEX Transparency



Wind feed-in and Export dependence in 50hertz
70% of wind power was absorbed in domestic grid. Export was 30% of wind feed-in (15 minutes value [MW]). High wind feed-in increases export. Max Export: 3,887MW.
Wind power 5,440MW Source) Takehama, based on data by 50Hertz, Kennzahlen





90% of wind power plants are connected to DSO grid (30kV-110kV). In a time of high wind feed-in, vertical load decreased. Excess wind electricity was transferred from DSO to TSO grid. Negative vertical load occurs (260hours =0.6% /year 2012. Max Negative vertical load 3.3GW). Flexible grid operations are important. 90%の風力設備は110kV以下の配電網連系. 配電系統から送電系統へ逆垂直ロード。柔軟な系統運用が重要

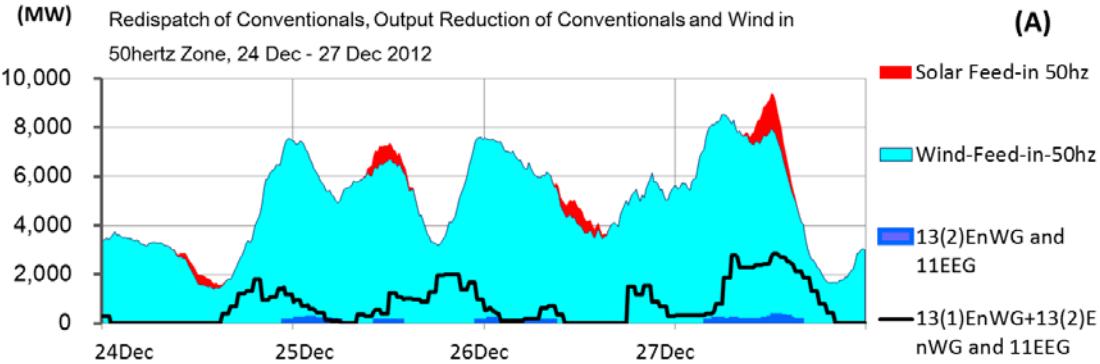
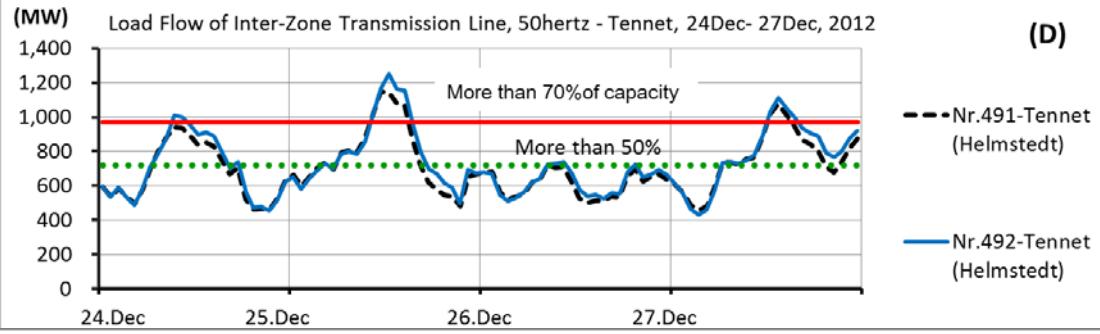
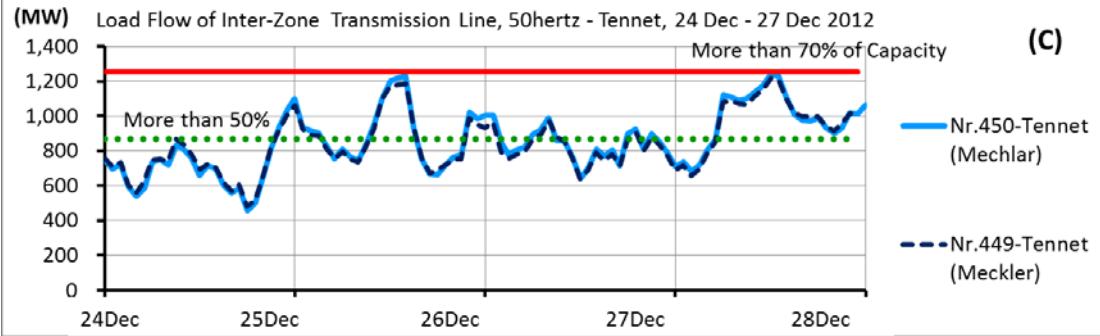
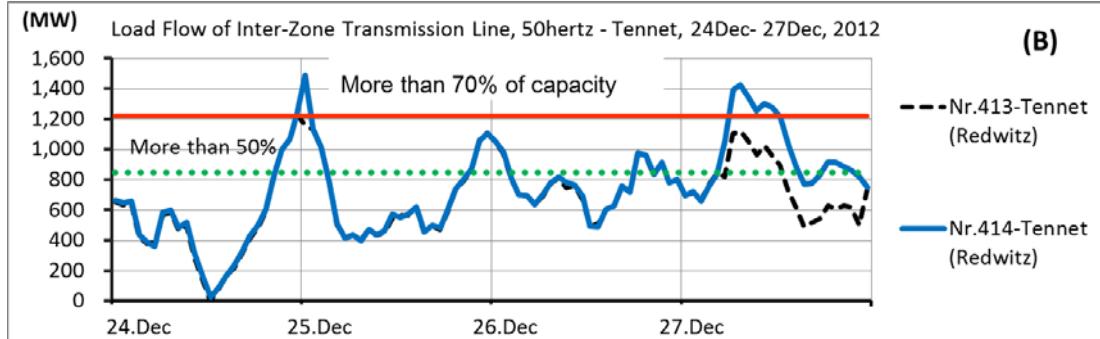
Graph: Takehama. Data from 50hertz's grid data Kennzahlen in 2012, EEG-Anlagenstammdaten

Domestic transfer : Grid Load of Inter-Zone Transmission in a time of Re- dispatch and Output Reductions with high wind feed-in

(Christmas holidays in 2012)
出力抑制時の地域間連系線の送
電口一ド

Grid load from 50herzt to
Tennet reached 70% of
transmission capacity.
TenneT向け連系線ロードは送電容量
の70%に達す

←Re-dispatch and output reductions
based on regulation (section13
EnWG) for system security reason.
By hourly data, by transmission line
(Graph: Takehama. Data by 50hertz, Load flow)



Wind forecast accuracy, based on 50Hertz day-ahead forecast

50hertz区域の風力出力予測の誤差, 公開データから推定

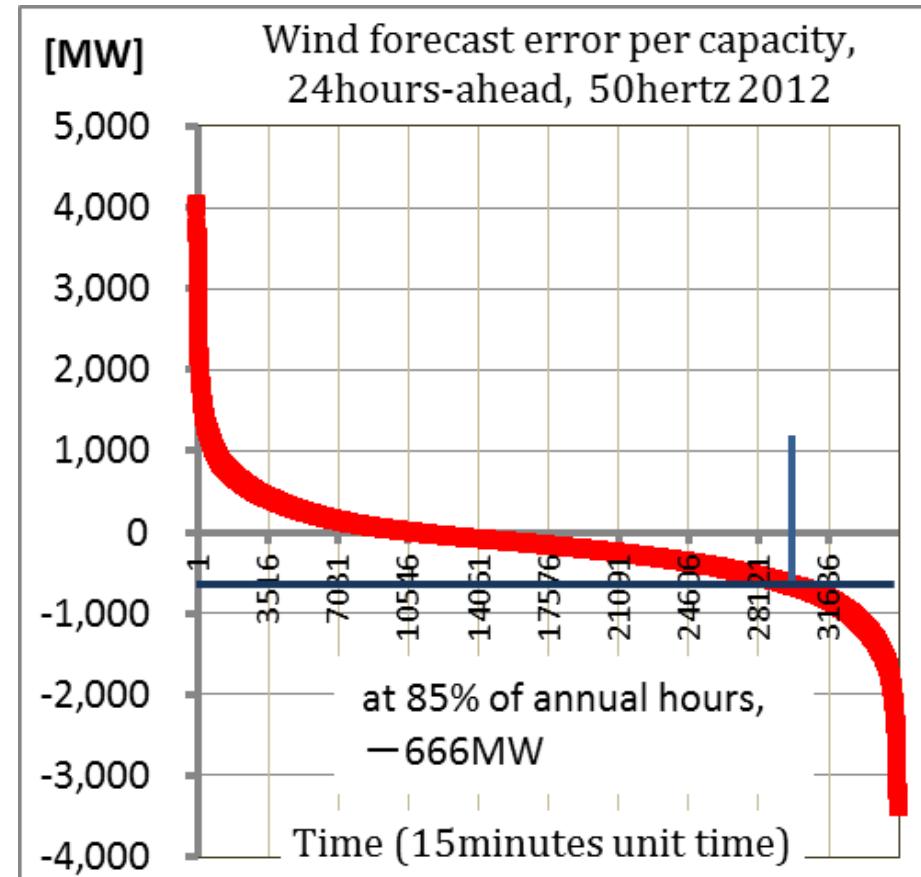
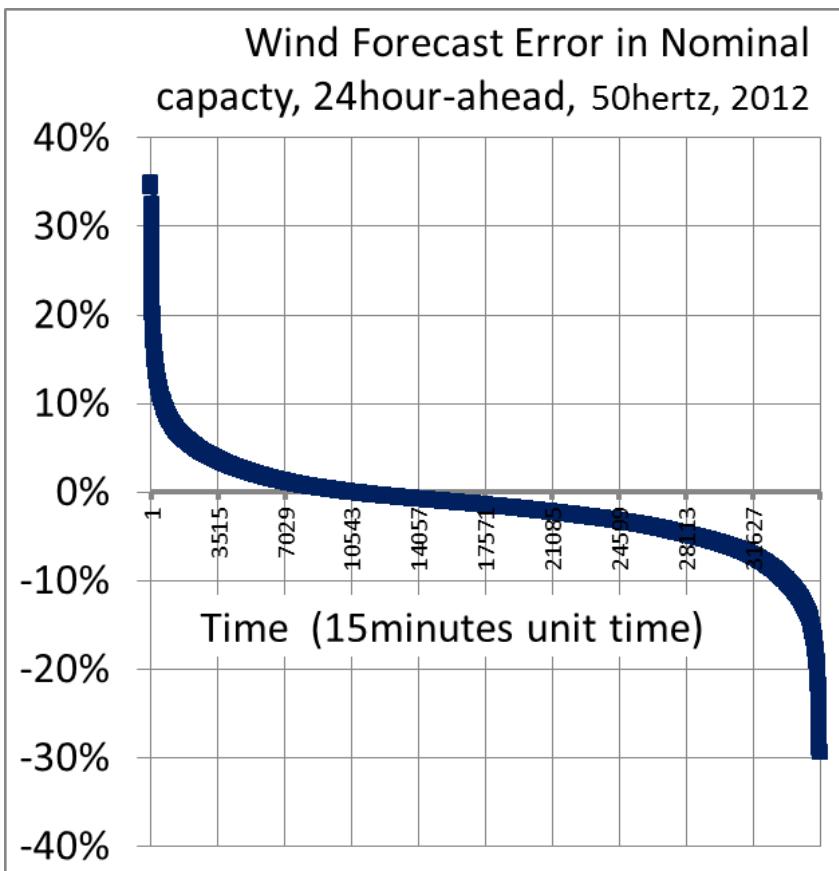
Error at 85% of annual hours: -666MW

Root mean square (RMS) error : 5% per nominal capacity

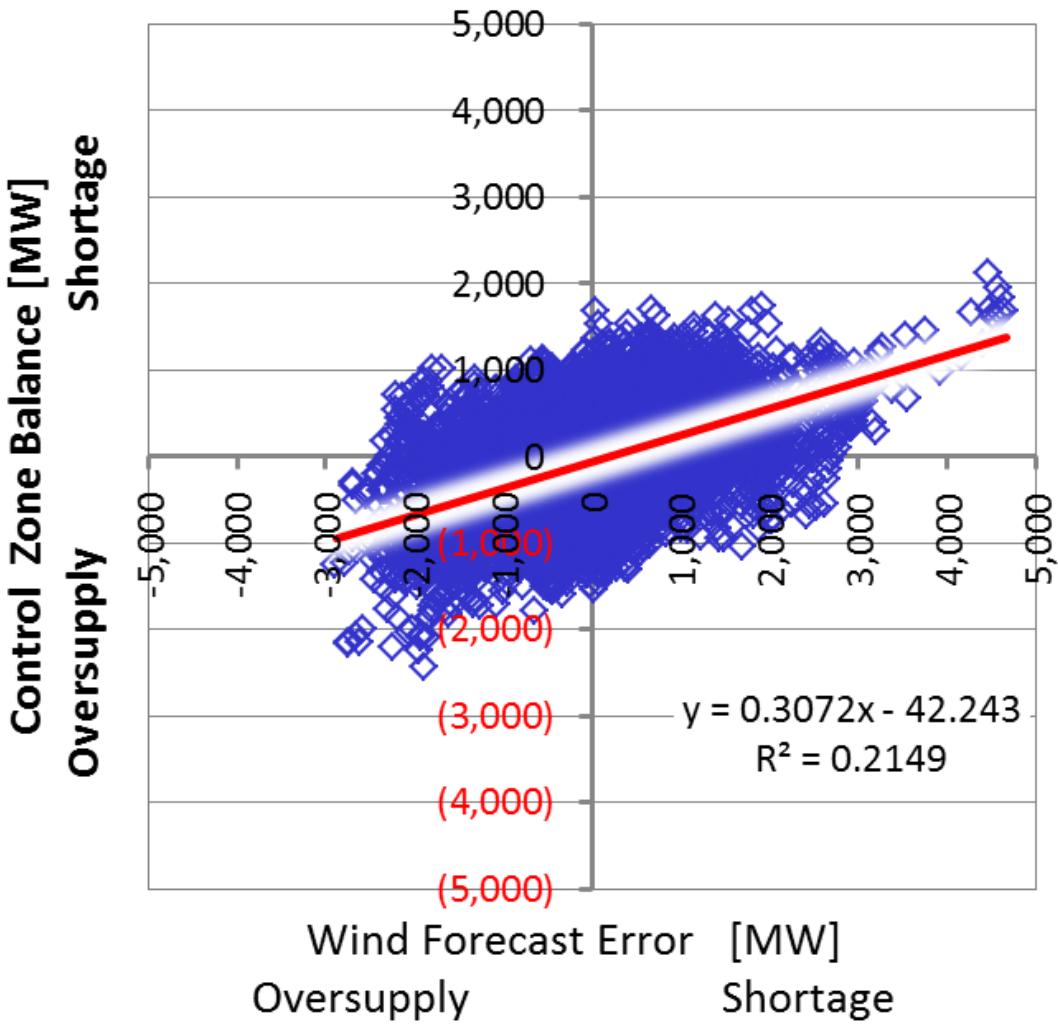
Large error than 10% of nominal capacity : 603 hours (7% in a year)

Max error : 35% (oversupply)

Min error : -30% (shortage)



Wind Forecast Error and Control Zone Balance in 50Hertz 2013



Control area balance is the sum of all variations between
<the scheduled supply- demand>,
and <actual demand-actual feed-in>. Balancing energy=wind forecast error + solar forecast error + load forecast error+ conventional power supply error

Amount of balancing energy used in 50hertz zone is generally smaller than wind error (at day-ahead forecast). This is because wind forecast at day-ahead is revised continuously till real time.

(+) : shortage

(-) : oversupply

Graph) Takehama, Data by 50hertz,
Windenergie Prognosewerte,
Regelzonensaldo

送電区域需給バランス(実需要に対する予定供給力の過不足

=実需給と予定需給の過不足=Balancing energyにより補てんされる。

送電区域全体の需給インバランスは、風力予測誤差よりも小さい)

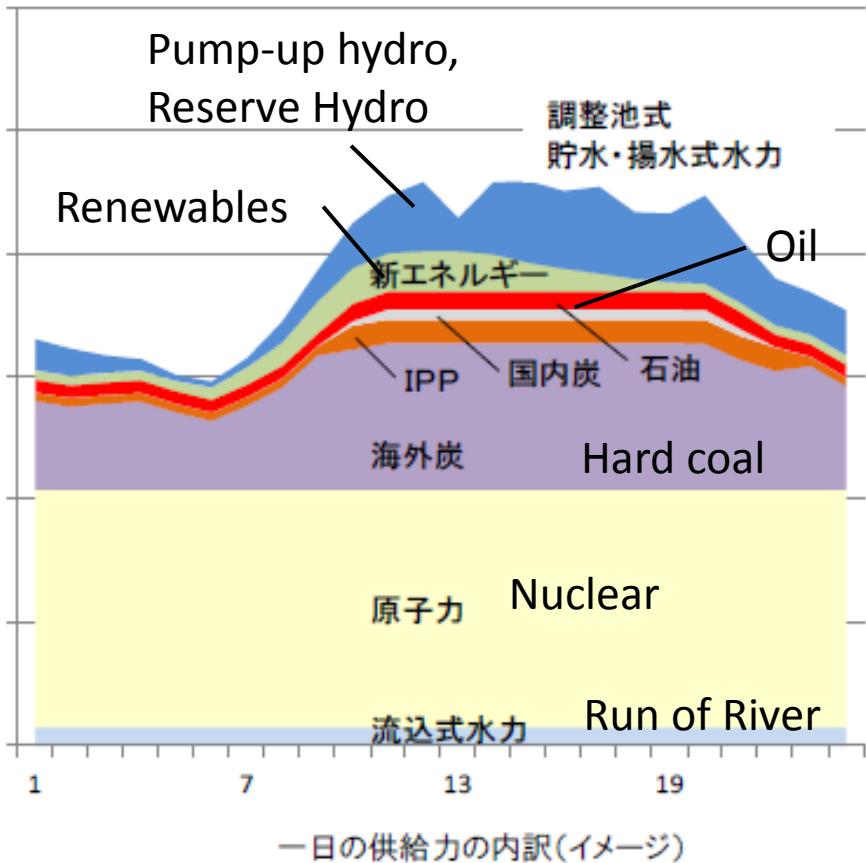
(+) : 予定供給力が実需給に対し不足

(-) : 予定供給力が実需給に対し過剰

Conclusions

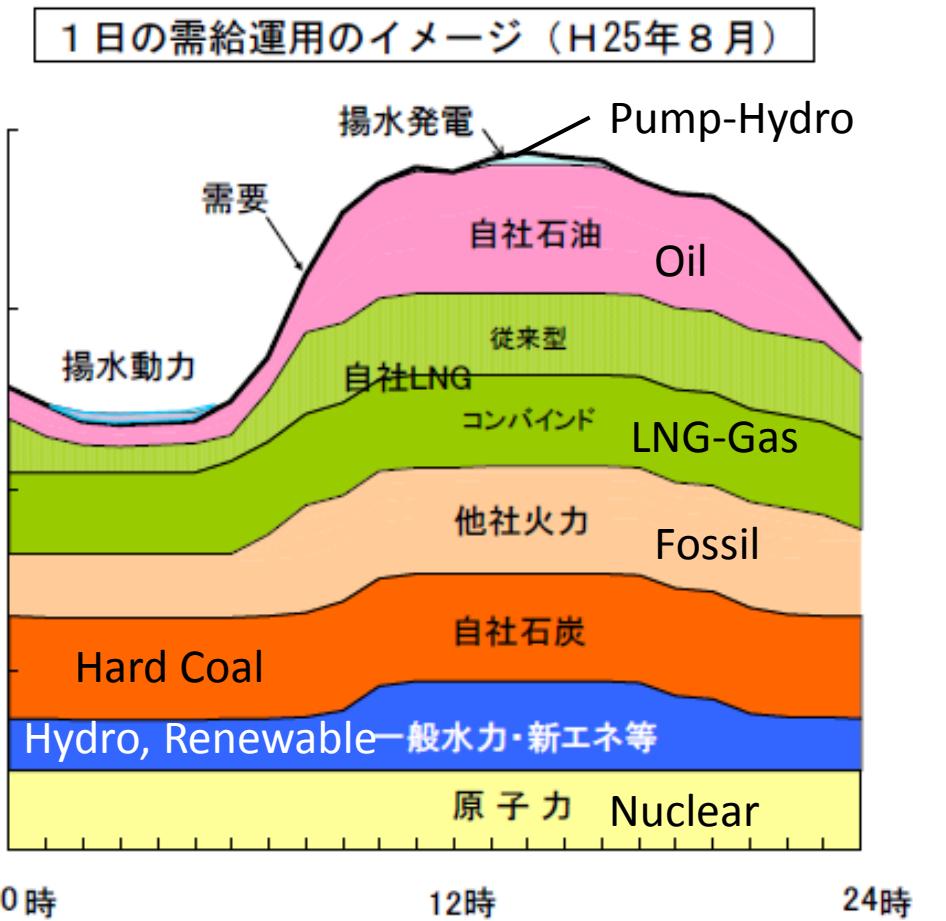
- Around 70 % of wind feed-in in 50hertz zone was fed into German domestic market. Around 30 % of wind feed-in was exported to neighboring countries, although (50Hertz zone, 2012).
- Flexible grid operations are important for decentralized generation:
 - Better utilizing inter-zone transmission lines
 - Power feed-in from lower-voltage-grid to higher-voltage grid
- ◆ For Japanese policy makers: What Japan must learn from 50Hz experiences
- Proper investments in grid expansion and enhancement are needed. (Automatic tap changers, voltage control devices in the grid system).
- The law must regulate grid operators to give a priority feed-in and obligatory grid expansions for renewable energy sources.
- Feed-in data from renewables must be disclosed to the public and renewable operators, by MW by 15 minutes unit. Especially, wind and solar feed-in data
- The law must regulate obligations of data disclosure on wind and solar feed-in.

- ◆This research is based on the data disclosed by 50Hertz Transmission GmbH.
- ◆15minutes time unit data, [MW]
 - Wind feed-in real-time, Wind feed-in forecast
 - PV feed-in real-time, PV feed-in forecast
 - Load actual
 - Cross-border exchange
 - Vertical load
 - Anpassungen nach § 13 EnWG (Redispatch and output reduction)
- ◆Hourly data, [MW] Grid load
- ◆Reference:
 - 片岡、荻本、齊藤他(2012), 風力発電ならびに残余需要ランプの予備的分析. 電気学会全国大会講演論文集。
 - 齊藤哲夫(2012)「風力発電出力予測と電力系統運用:出力平滑化効果とスペインにおける系統運用」(風力発電系統連系可能量確認WG配布資料)
 - Asami Takehama (2013) Grid Integration Issues of Renewable Energy in Japan and Its Transparency of Grid Data. (REFORM Group Meeting 2013, Salzburg) <http://www.polsoz.fu-berlin.de/polwiss/forschung/systeme/ffu/veranstaltungen/termine/downloads/13_salzburg/Takehama-Salzburg-2013.pdf>
 - 竹濱朝美 (2013), ドイツにおける風力発電の給電データ開示制度と系統運用の現状. 日本風力発電協会, JWPA 9号, 2013年。
 - 竹濱朝美, 齊藤哲夫 (2013), 太陽光発電と風力発電にかかるドイツの給電データ開示制度, 50 ヘルツ区域の需給運用の現状. 日本太陽エネルギー学会・日本風力エネルギー学会合同研究発表会.. 2013年11月28日。
 - 安田陽, 大野照男, 近藤潤次, 他, 日本風力エネルギー学会, 「風力発電導入のための電力系統工学技術講習会」資料。2014年1月27日。
 - Thomas Ackerman, ed., Wind Power in Power Systems. Willy, 2012.



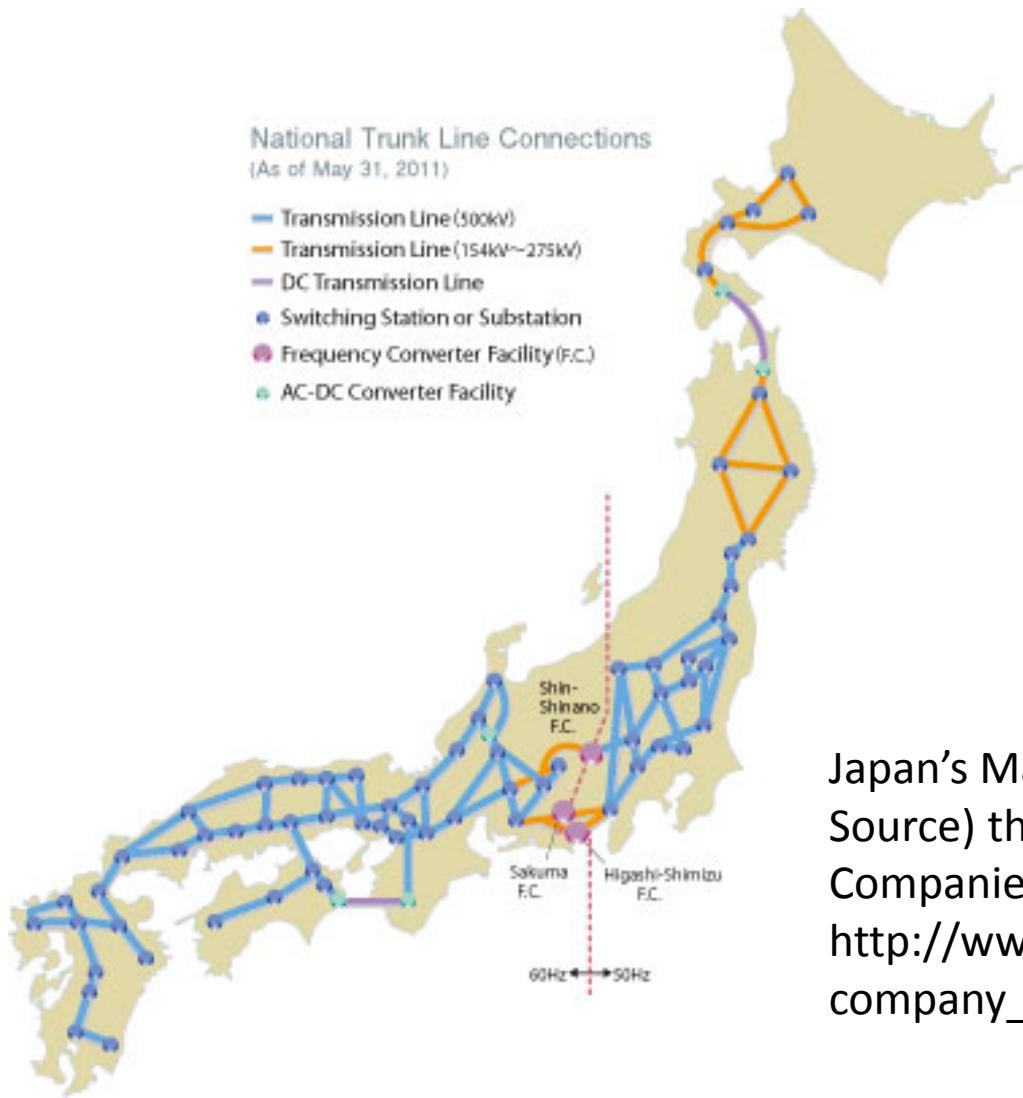
Hokkaido Power has NO gas power plants. BUT, the zone has much potential of wind energy.

Source) Hokkaido Power Co., (2013) , The document for the investigation committee of electricity rate increase)



Merit order at Kyushu Power Co.,
Aug 2013

Source) Kyushu Power Co., (2012), the Document for the investigation committee of electricity rate increase.



Japan's Major Tie Line Connections,
Source) the Federation of Electric Power
Companies (FEPC)
[http://www.fepc.or.jp/english/energy_electricity/
company_structure/sw_index_02/index.html](http://www.fepc.or.jp/english/energy_electricity/company_structure/sw_index_02/index.html)