附件 1-

日立公司金門島再生能源設置蓄電池評估分析

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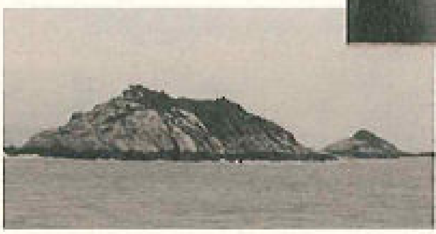
金門島への再生可能エネルギー導入にむけた
蓄電池プレFS評価のご紹介



1. 金門島の電力設備状況

Table.1: 金門島の電力設備状況

	ディーゼル発電	風力発電	計MW
塔山発電所	4×7.9=31.6 4×8.25=33	2×2=4	68.6
塔山発電所 夏興支部	2×3.169=6.336 3×3.488=10.464 1×3.612=3.512		20.312
塔山発電所 麒麟支部	2×1.54=3.08 3×1.0=3.0		6.08
		全体合計	94.992

金門島への再生可能エネルギーの導入インセンティブと課題

- 台湾政府側の金門低炭素島づくり計画策定済み
- 金門電力網は、発電機が基本的に重油を燃料として利用するので、発電コストが9元/kWh以上
- 既存風力発電による金門の停電発生
- 金門の再生可能なエネルギーは僅か4%占めている
- 貯蔵エネルギーや潮力発電で、金門の電力供給が安定しないところを解決できる
- 金門は台湾本島から遠く離れ、海底電力ケーブル敷設は不可
- 金門は観光スポットで、顕著なデモ効果が期待される。

3. 金門島における風力期待出力の評価

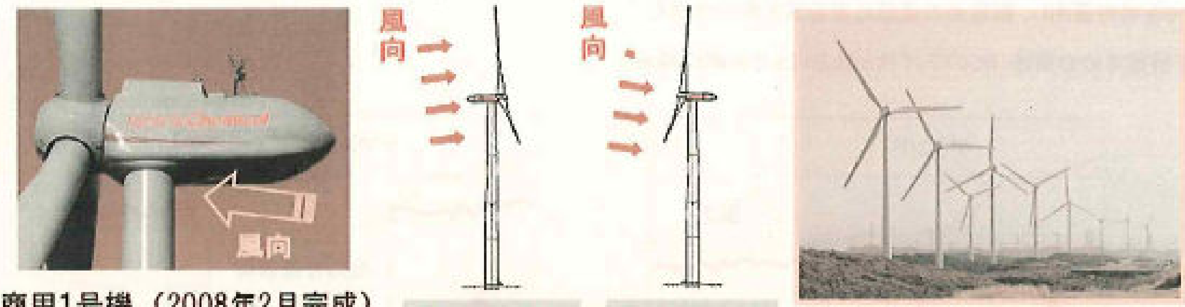


Figure.1: 検討に使用した2MW級風力タービンの仕様

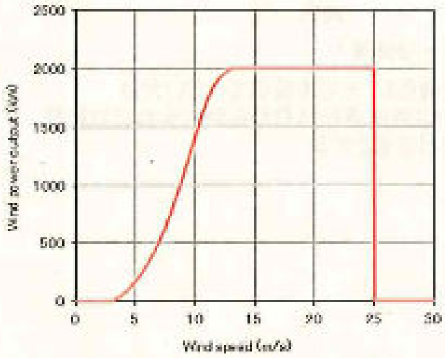


Figure.2: 風車の出力カーブ

Table.1 : Analysis conditions

No.	項目	値
1	サイト	
2	緯度(度分秒)	354725.7000
3	経度(度分秒)	1404759.4400
4	標高	3.38m
5	風速分布選択	ワイブル分布
6	平均風速(m/s)	4.6m/s
7	形状係数K	1.9365
8	尺度係数C	5.1833
9	基準ハブ高(m)	80.00m
10	冪法則係数n	5.0000
11	吹上角(°)	0.0°
12	年間時間(Hr/y)	8,760Hr/y

Table.2 : Specifications

風車設定条件			
No.	項目	風車1	風車2
1	機種	001_日立_HTW2.0-80_SN	013_日立_HTW2.0-SN
2	ローター直径(m)	80.00m	86.00m
3	定格出力(kW)	2,000.0kW	2,000.0kW
4	カットイン風速(m/s)	3.0m/s	4.0m/s
5	カットアウト風速(m/s)	25.0m/s	25.0m/s
6	ハブ高(m)	78.00m	78.00m
7	ティルト角(°)	-8.0°	-8.0°
8	設定稼動率(%)	95.00%	95.00%

Table.3 : Predicted output

発電量合計計算結果			
1	年間発電量合計(MWh/y)	2,101MWh/y (1基分)	2,240MWh/y (1基分)
2	平均発電電力(kW)	239.8kW (1基分)	255.4kW (1基分)
3	設備利用率	11.99%	12.82%

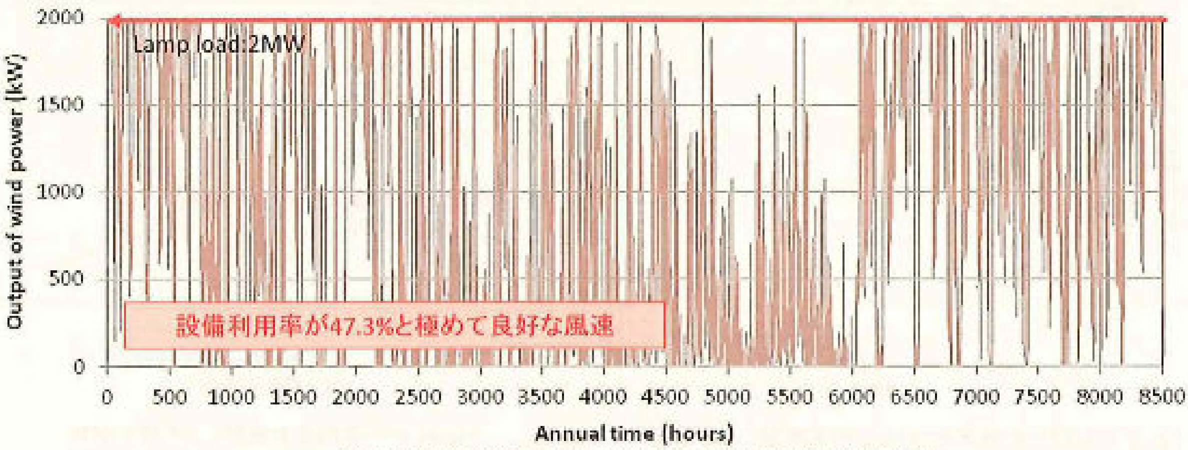
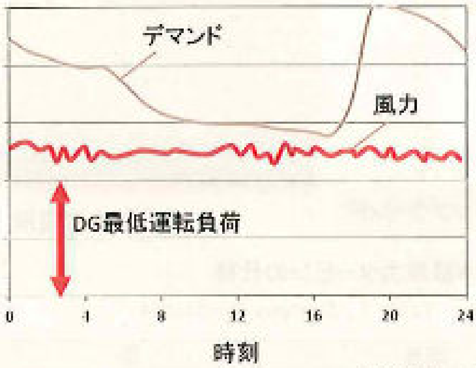


Figure.3 : Predicted output due to HTW2.0-SN at 金門島

4. 蓄電池最小のコンセプト

DGを常時運用し、蓄電池の最低必要容量を最小化する。

①蓄電池の必要性:DGの下げ代と風力V出力余剰の解消



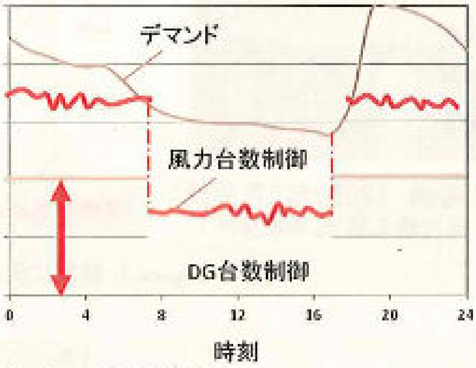


Figure.4: DG台数制限による再生可能エネルギー増強策

必要蓄電池の評価方法:風力、DGの台数制限により再生可能エネルギーを増強し、それで吸収できない分は蓄電池で余剰吸収。365日分のデマンド、PV出力、DG最低運転負荷から余剰風力出力総量(MWh/日)を計算し、365日中の最大値を必要蓄電池容量とする。

②蓄電池の必要性:PV出力変動の吸収(主にDGのガバナ機能による)

・金門島の周波数許容値:50Hz±0.5Hz(±1%変動以下)

・DGの速度調定率:

$$速度調定率 = \frac{\frac{f_2 - f_1}{f_N}}{\frac{P_2 - P_1}{P_N}} \times 100(\%) \qquad -1)$$

ここに、P_1:ある時刻の出力、P_2:変化後の出力、P_N:DG定格出力
f_1:ある時刻の周波数、f_2:変化後の周波数,f_N:定格周波数

金門島離島のDGの速度調定率を5%、周波数変動を1%以内とすると、

$$5\% = \frac{1\%}{\frac{P_2 - P_1}{P_N}} \qquad \therefore P_2 - P_1 = \frac{1\%}{5\%} P_N \qquad -2)$$

これから、パッシブに周波数変動を許容値以下に可能な風力変動量はDG定格の1/5である。

■金門島における風速の変動確率密度

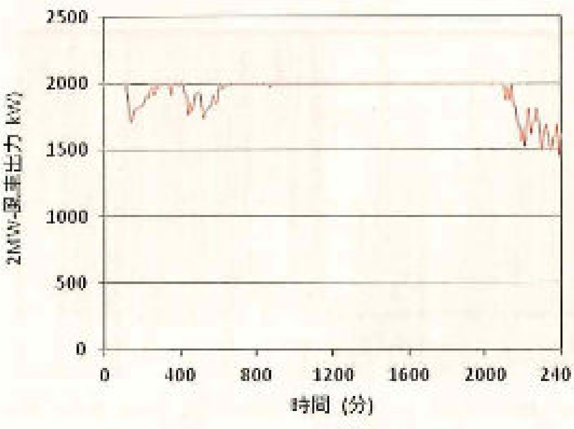


Figure 5: 10日分の風車出力トレンド(実風速による予測)

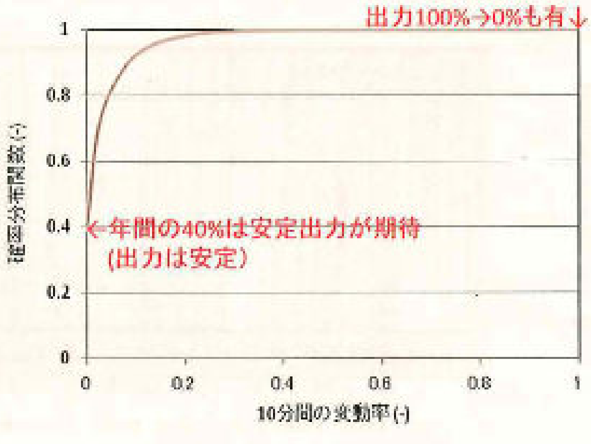


Figure 6: 一年間出力変動による確率関数
(10分間に定格の何%が変動するかの確率)

5. 現状の分析

5.1デマンド状況(年間電力需要:238GWh、発電コスト:71.3億円/年)

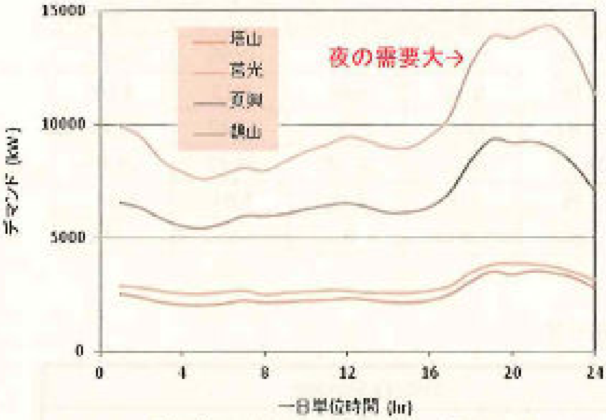


Figure.7: 金門島における日単位デマンド(1月1日)

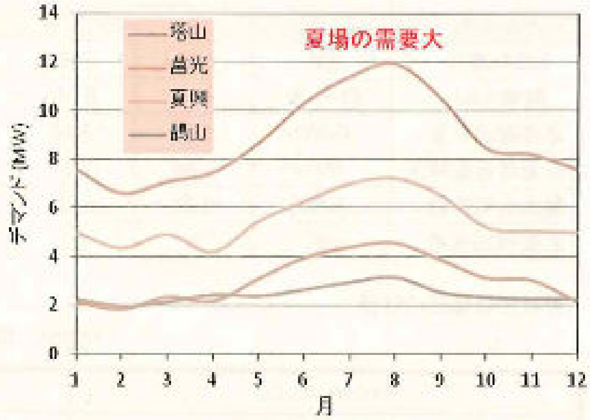
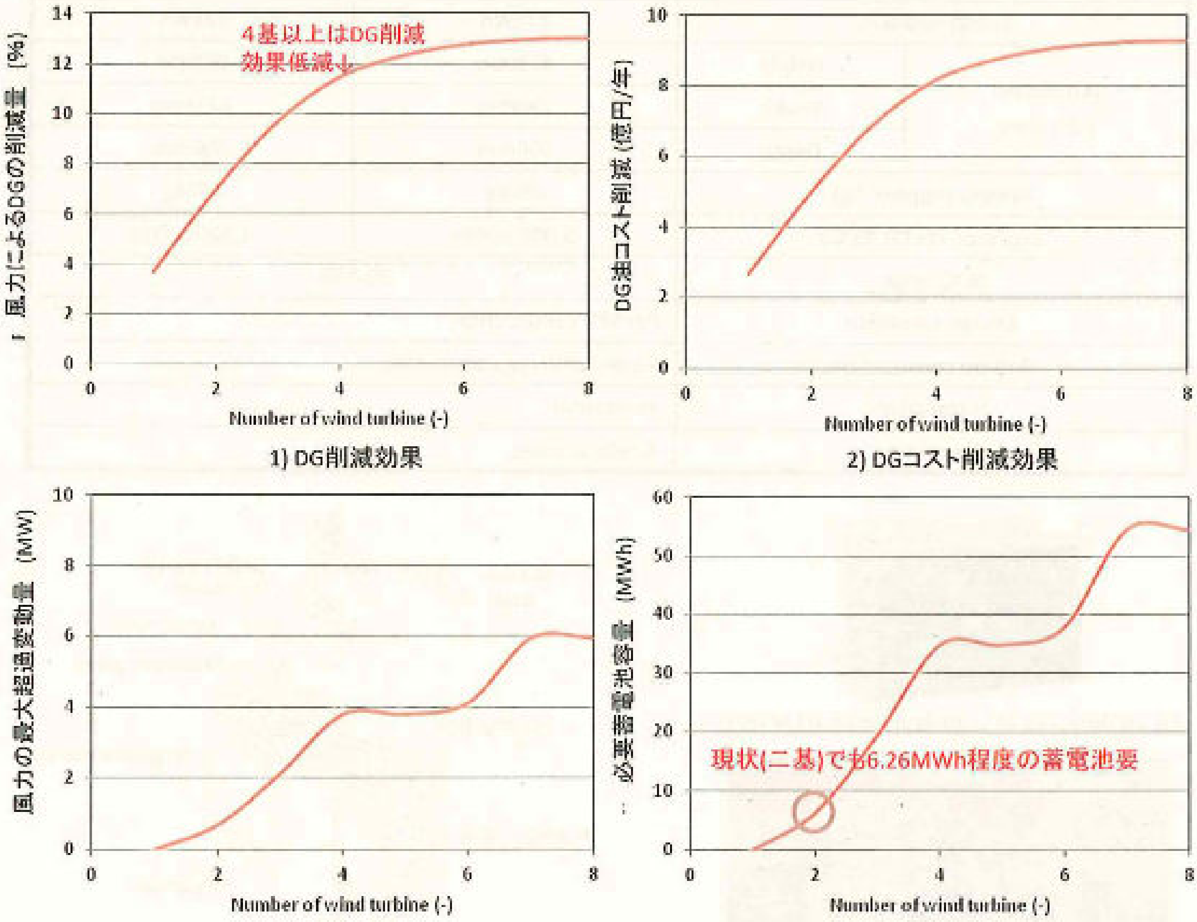


Figure.8: 金門島における月単位デマンド

5.2 風車導入可能台数、DG削減及び必要蓄電池量の評価



3) 最大出力変動　　4) 必要蓄電池容量(主に変動吸収)

Figure 9: Calculation results

結論:

①現状2本の風車を稼動させるには、6.26MWの蓄電池が必要

Table.4.:解析結果まとめ

項　目	単　位	数　値						
風車本数	(台)	2	3	4	5	6	7	8
DG削減率	(%)	6.98	9.68	11.46	12.29	12.75	12.95	13.00
削減コスト	(億円/年)	4.97	6.90	8.16	8.76	9.08	9.23	9.26
必要電池容量	(MWh)	5.70	17.74	31.61	31.61	34.33	49.47	49.47
必要電池容量補正	(MWh)	6.26	19.51	34.77	34.77	37.76	54.42	54.42
最大余剰変動	(MW)	0.68	2.13	3.79	3.79	4.12	5.94	5.94
必要PCS台数	(台)	2	5	8	8	8	12	12

6. 弊社鉛蓄電池の仕様

Table.6 : 仕様一覧

Battery model		Energy Storage	
Battery type		LL1500-8	LL1500S-8
Nominal voltage		8V	8V
Nominal capacity		1,500Ah	1,500Ah
Energy capacity		12kWh	12kWh
Dimension (±3 mm)	Height	473mm	473mm
	Width	799mm	871mm
	Depth	506mm	506mm
Weight (Approx. kg)		430kg	485kg
Expected life (at 25℃)		3,000 cycles	4,500 cycles
SOC range		30-90%	
Charge condition		Per SKE's instruction	
Battery construction		Sealed with regulated valve	
Installation		Horizontal	
Connection		4 cells in series	

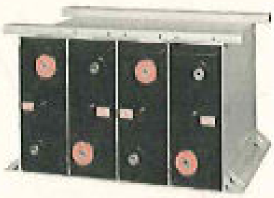


Fig.10:Overview of Lead Acid Battery(12kWh)

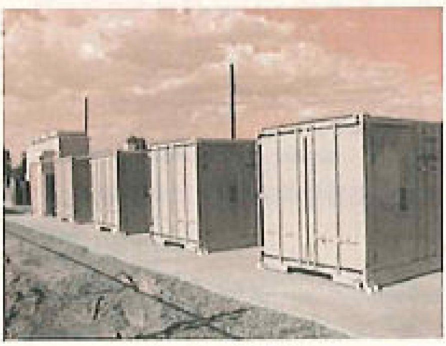


Fig.11:0.8MW-class Lead Acid Battery system in container

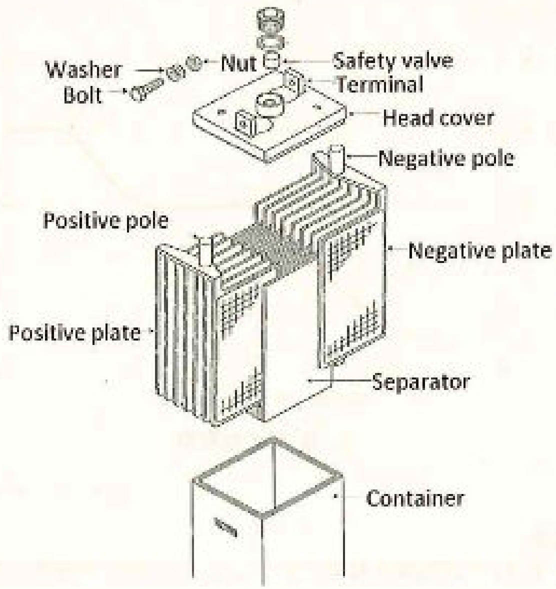


Fig.12:Structure of Lead Acid Battery

8-8. 風力出力変動緩和技術

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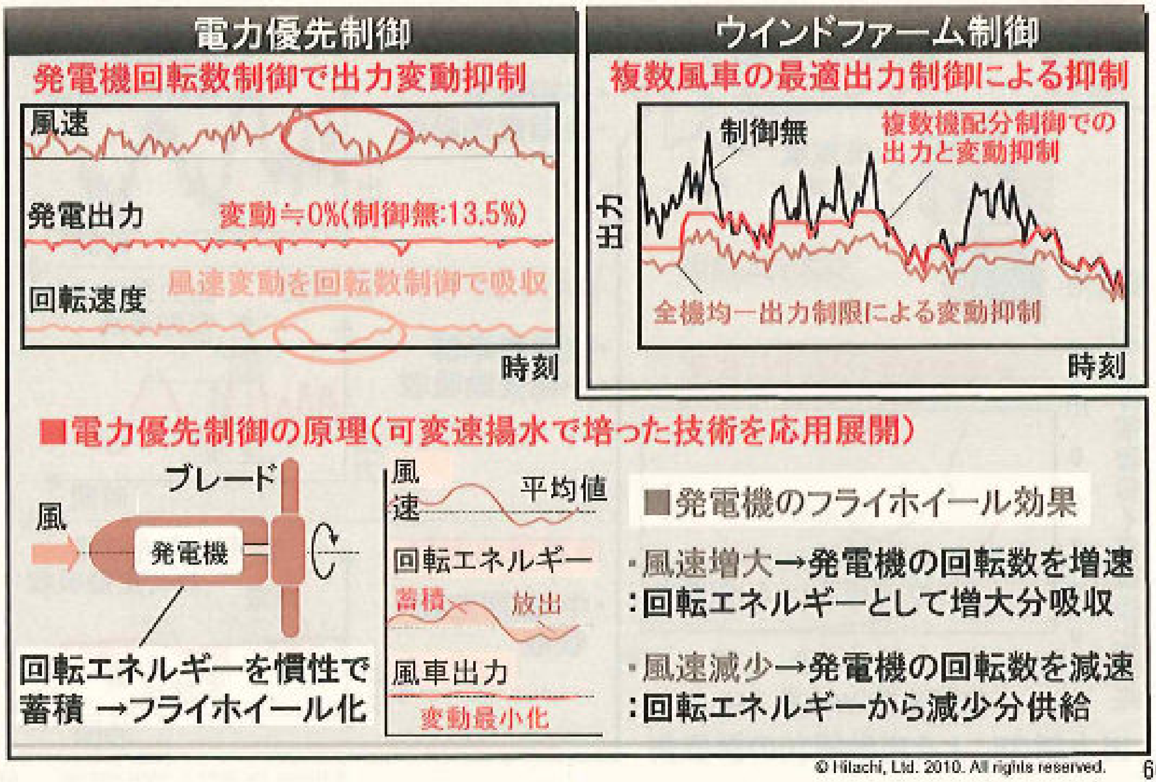

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8-9. 蓄電池との組合せによる出力変動緩和

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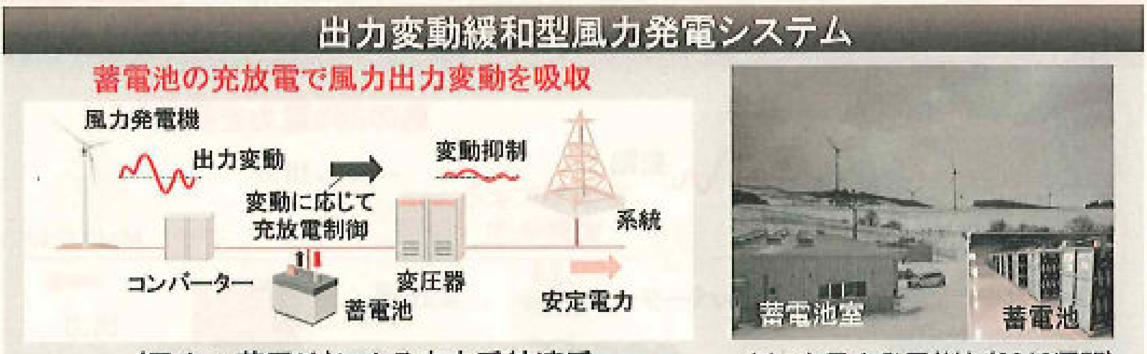
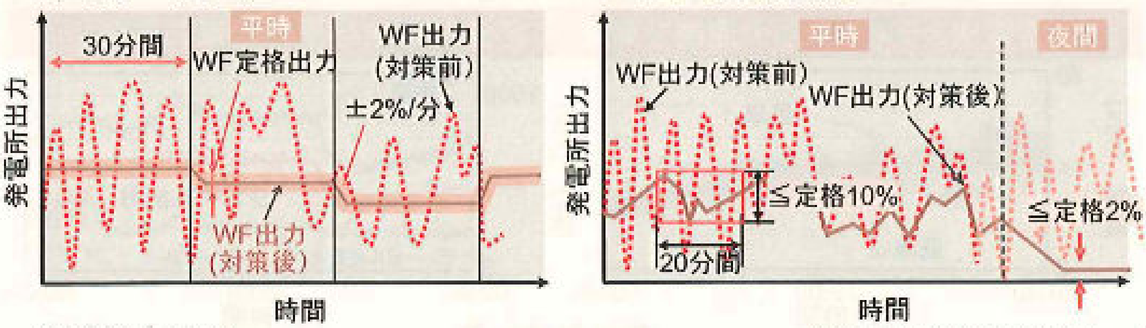


(風力＋蓄電池)による安定系統連系

くろしお風力発電(株) (2010運開)

■出力一定型

■出力変動緩和型



WF:Wind Farm

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8-10. 風力出力変動緩和技術のまとめ

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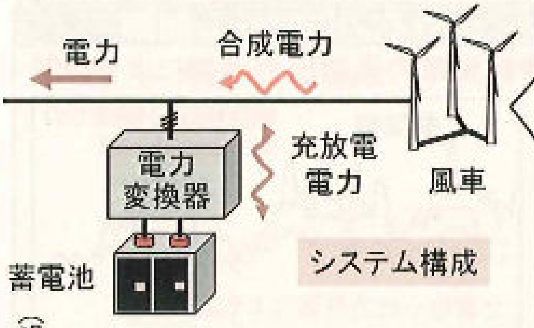
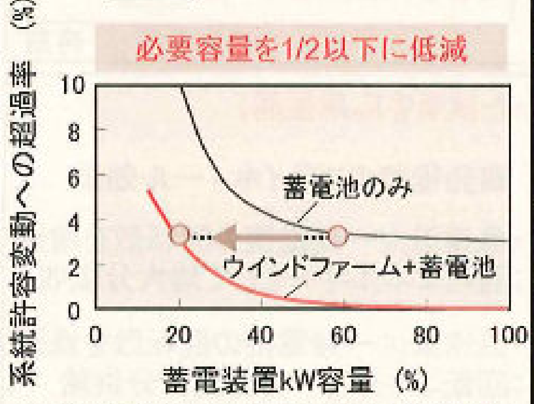
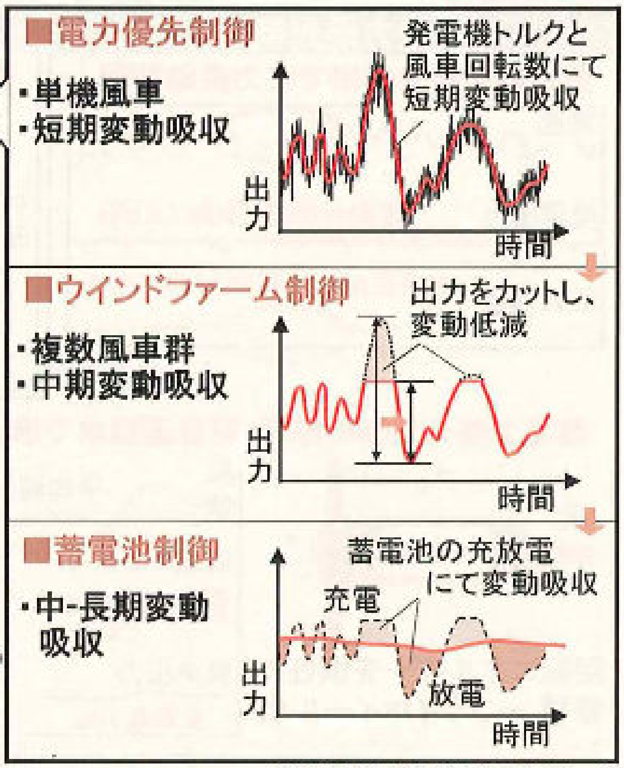




出力制御による変動緩和の評価例



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8-11. ディーゼルとのハイブリッドシステム

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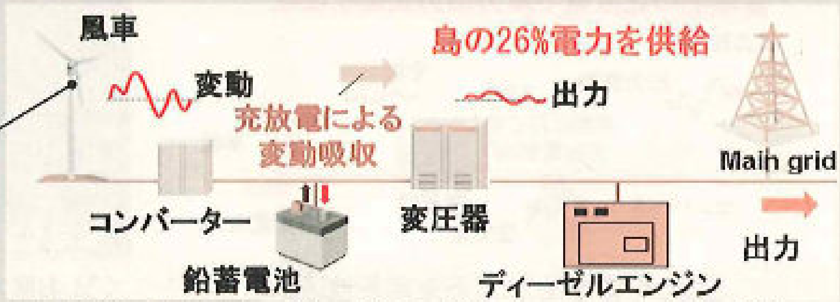
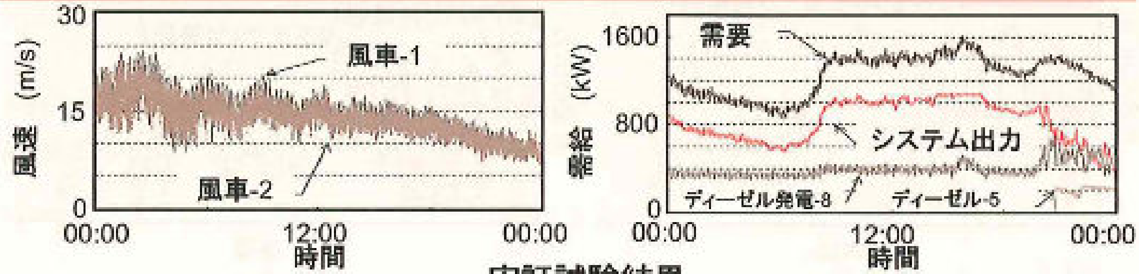
蓄電池、ディーゼルエンジン連携によるマイクログリッド



沖縄電力(株)殿 与那国島向けマイクログリッドシステム(2001年運開)

蓄電池とディーゼルの連携を実証 → 必要蓄電池容量の低減に貢献



実証試験結果

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蓄電池用の補助金制度

Hitachi Chemical
Working On Wonders

◇新エネルギー発電の普及に伴う系統安定化、各企業へのCO_2排出の削減義務、非常時の電源確保など、蓄電池が必要とされている昨今、蓄電池導入促進の為、政府（経済産業省、環境省など）から様々な補助金制度が出ている。
※補助率は1／3（一部1／2補助の場合もあり）

No	管掌	事業名称	予算額
1	経産省	エネルギー使用合理化等事業者支援補助金	700.0億円
2	経産省	独立型再生可能エネルギー発電システム等対策費補助金	30.0億円
3	経産省	定置用リチウムイオン蓄電池導入促進事業	130.0億円
4	経産省	国際エネルギー消費効率化など技術・システム実証事業	272.5億円
5	環境省	再生可能エネルギー等導入推進基金事業（GND）	245.0億円
6	環境省	離島の低炭素地域づくり推進事業	31.0億円

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附件 2- 住友電工報告

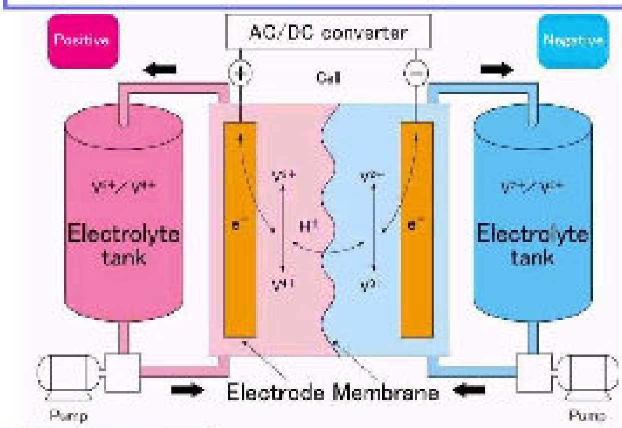
Vanadium Redox Flow Battery

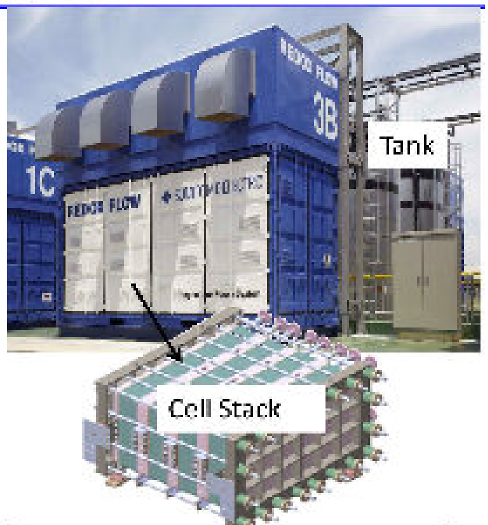
Sumitomo Electric Industries, Ltd.

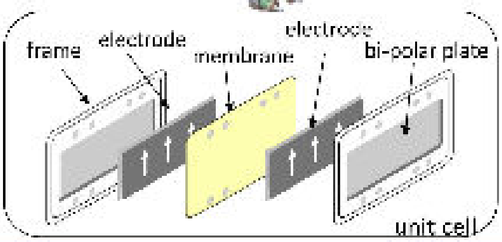
Overview of SEI's VFB

- ❑ Long History of Development since 1985
- ❑ 18 Years of Operational Experience
- ❑ More than 20 projects deployed
- ❑ SEI hold highest number of patents in the world

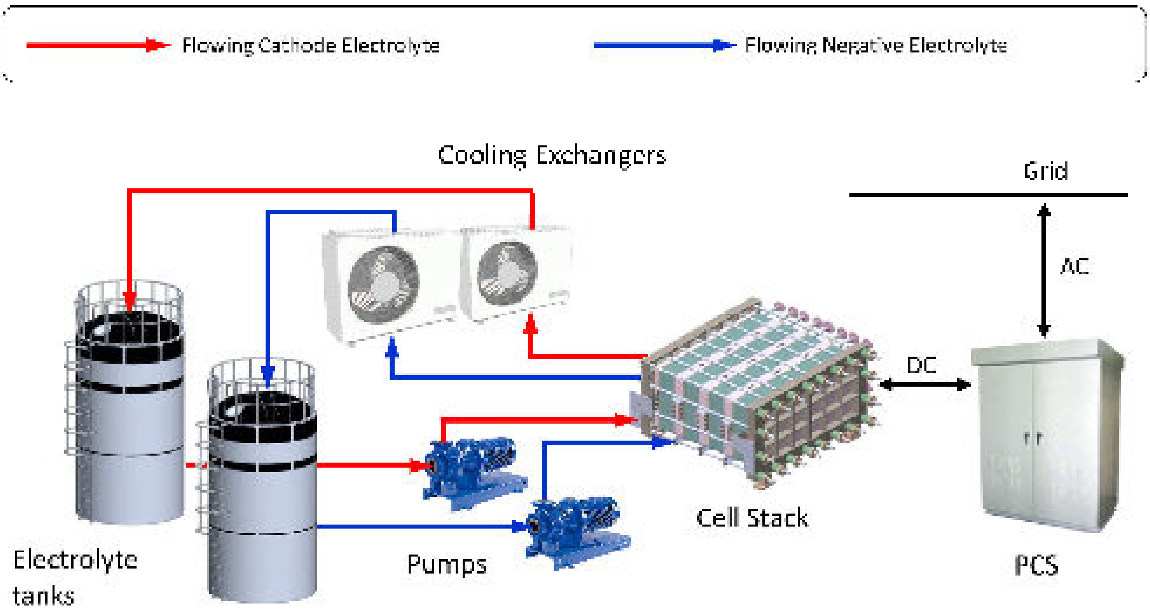
- ❑ Using the charge-state differences of vanadium ions dissolved in sulfuric acid
- ❑ No chemical reaction







System Configuration



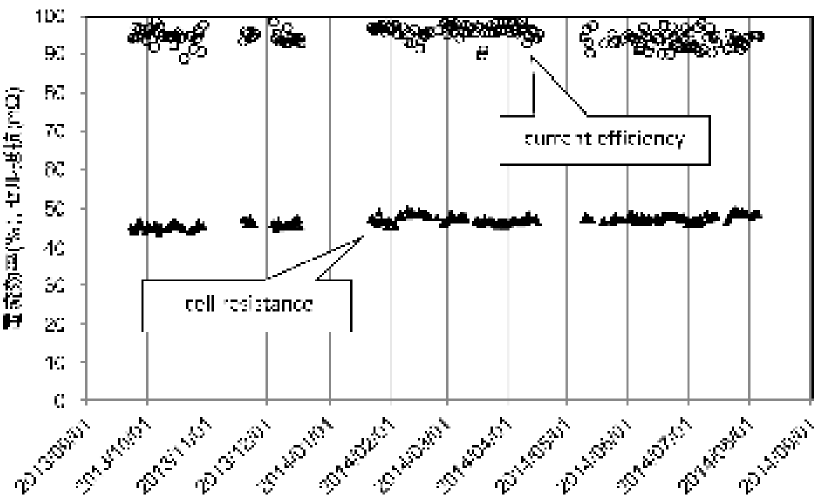
Advantages

Our VFB storage system have long life cycle and no risk of burning, suitable for both fast response (<0.2sec) and long-duration (several hrs) applications at the same time.

1. Long Life Cycle	･Lifecycle not dependent on depth of discharge ･Unlimited Charge/Discharge cycle of Electrolyte ･Electrolyte is Reusable after decommissioning
2. No Risk of Burning	･Non-flammable Electrolyte ･Flame Retardant Materials
3. Easy Operation	･Accurate and reliable SOC Management ･Ambient Temp. for operation ･Power possibly higher than Rated Power for a while ･Same Electrolyte when fully discharged
4. Multi-Purpose	･Fast response (<0.2sec) ideal for Renewables ･Long duration for Peak shift, Demand Response ･Fast Ramp (Up/Down) & long duration applications
5. Design Flexibility	･Separation of Power (MW) and Energy (MWh) ･Easy to scale up to large-size systems

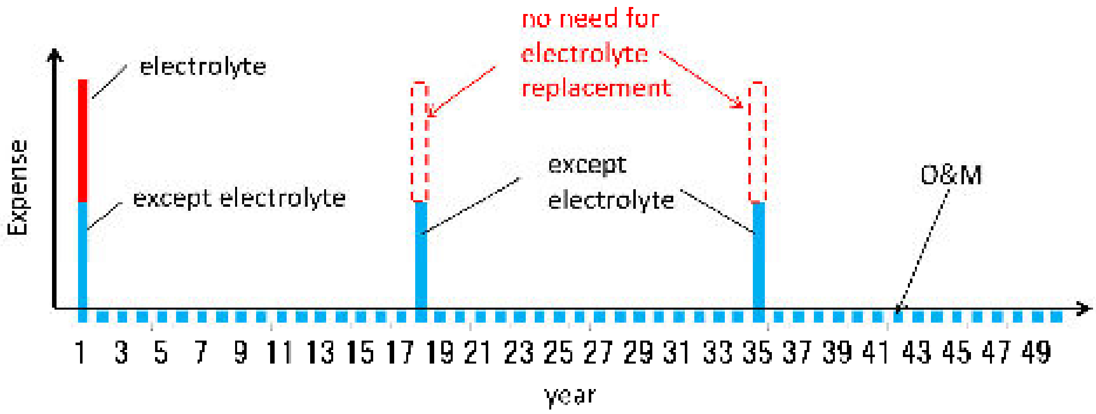
Long Life Cycle

➢ Operation data of Yokohama PJ shows there is no degradation on current efficiency and cell resistance.



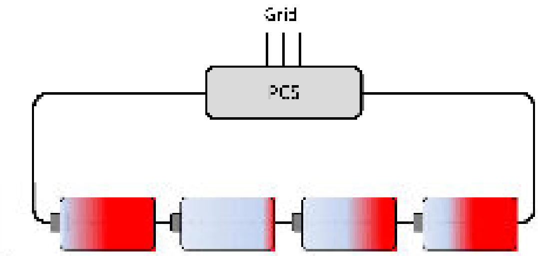
No degradation of Electrolyte

➢ Electrolyte has almost no degradation from charge / discharge.
➢ Makes electrolyte reusable for long-term.



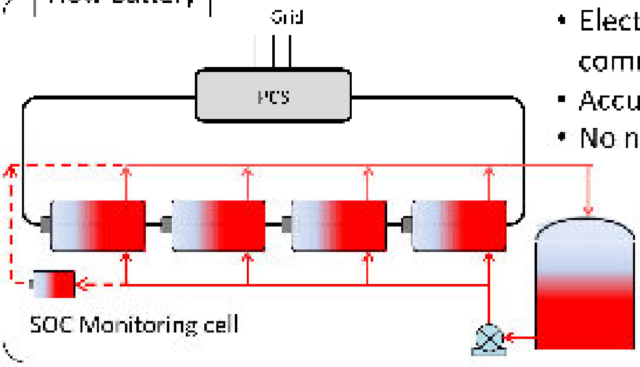
Easy Operation

Non- Flow Battery



- Electrolyte is stored inside individual cells
- Monitoring and Re-balancing SOC among many cells is NOT simple
- Scale up to large energy size is difficult
- How to avoid over-charge is critical

Flow Battery

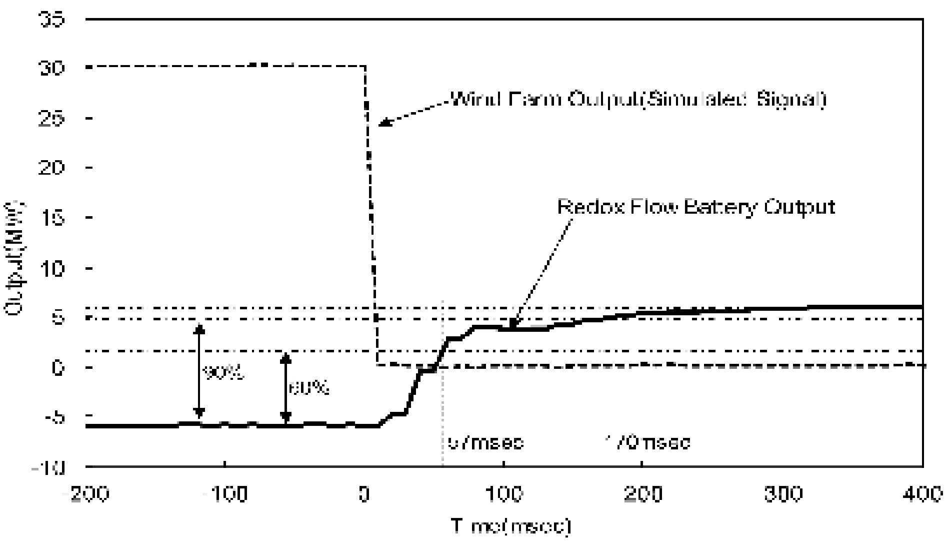


- Electrolyte is stored outside cell stack in a common tank
- Accurate & Real-time SOC monitoring
- No need of Re-balancing the SOC

- Easy operation
- Easy scale up to long duration (hrs)
- Wide range of SOC utilization for charge / discharge cycle

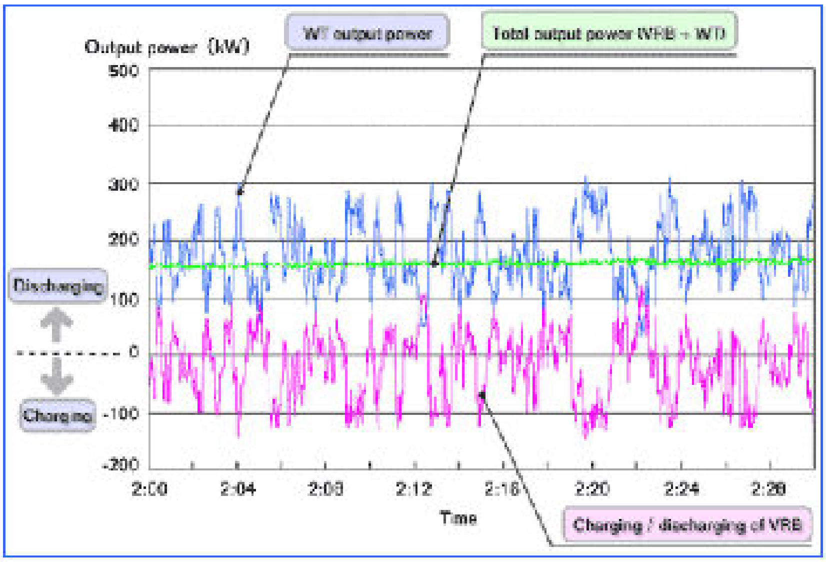
Fast Response

- The response time of VFB cell is in "ms" order.
- Measuring device and control units decide the response time to stabilize the fluctuation.



Fast Response

Example below is smoothing of wind turbine output.
It shows that the response of VFB is fast enough for frequency regulation.



SEI CONFIDENTIAL

Projects & Experiences

Field Operation Experiences: 20+projects installed

Customer	Application	Capacity	Install
Electric Power Co.	R&D	450kW×2H	1996
Office Building	Load Leveling	100kW×8H	2000
Electric Power Co.	R&D	200kW×8H	2000
NEDO	Wind Tower	170kW×6H	2000
Contractor	Solar Panel	30kW×8H	2001
Factory	UPS/Peak Cut	3MW × 1.5sec, 1.5MW × 1H	2001
Developer	UPS/Peak Cut	250kW×2H	2001
University	Load Leveling	500kW×10H	2001
Lab	R&D	42kW×2H	2001
Electric Power Co.	R&D	100kW×1H	2003
Office Building	Load Leveling	120kW×8H	2003
Railroad Co.	R&D	30kW×3H	2003
Office Building	R&D	100kW×2H	2003
Data Center	UPS	300kW×4H	2003
JST	Load Leveling	170kW×8H	2004
Office Building	LL, Emergency Power Supply	100kW×8H	2004
University	UPS/LL	125kW×8H	2004
Museum	UPS/LL	120kW×8H	2005
Electric Power Co.	R&D	100kW×4H	2005
Power Plant	Wind Farm	4MW(Max. 6MW)×1.5H	2005
Sumitomo Electric Industries	Demo Project (with Solar Panel)	1MW×5H	2012

Total : 10MW, 20MWh

Major Projects

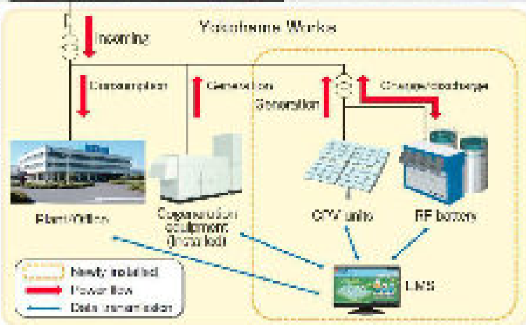
・Long History of Development since 1985 ・Operational Experience since 1996

Period	2005-2008	Since July 2012	Scheduled in 2015
Type	Co-located with generator	User premises	Distribution
Location	Tomamae Wind Farm (Hokkaido)	Sumitomo Electric (Yokohama Works)	Hokkaido Electricity Power Company (Hokkaido)
Application	•Stabilizing Wind Farm Output for Grid Integration	•Demand Side Management •Renewable Integration •Renewable Firming	•Frequency Regulation •Adjustment of surplus Renewable generation
VFB Spec	4MW/6MWh	1MW/5MWh	15MW/60MWh
Notes	•Wind farm: 31MW **•270,000 Cycles/3 years**	•Gas generator: 3.6MW •CPV : 100kW **•EVERYDAY DSM**	•Controlled by utility's control center **•Multi-applications**

Sumitomo Electric Proprietary

Sumitomo's Yokohama Works

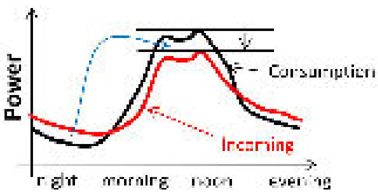
Redox Flow Battery	Max. Output: 1 MW Capacity: 5 MWh
Concentrator photovoltaic (CPV)	Max. Output: 100 kW (7.5 kW x 15 units)
EMS	Sumitomo Electric
Applications Multi Purpose	Renewable Firming, Peak Shaving, Demand Response (DR) (Yokohama Smart City PJ)

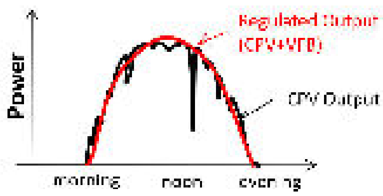


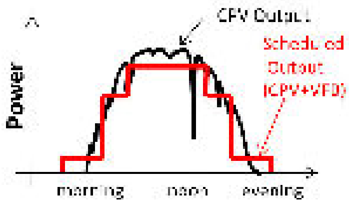
Sumitomo's Yokohama Works

Operation Types of VFB Applications

Load Leveling/ Peak Shaving	Stabilizing Power Fluctuation	Scheduled Power Supplying







Charge Electricity During Off Peak and Supply During Peak.

⇓

Load Leveling/ Peak Shaving

Max. Demand Suppression 1MW @Yokohama Works

Stabilizing Fluctuations of CPV Power by Charging /Discharging

⇓

- Reducing Dependence on Thermal Power Plant
- Increasing introduction of green energy sources

CPV and VFB Enables Scheduled Power Generation Regardless of Weather Condition

⇓

Enhancing the Value of CPV

Sumitomo's Yokohama Works

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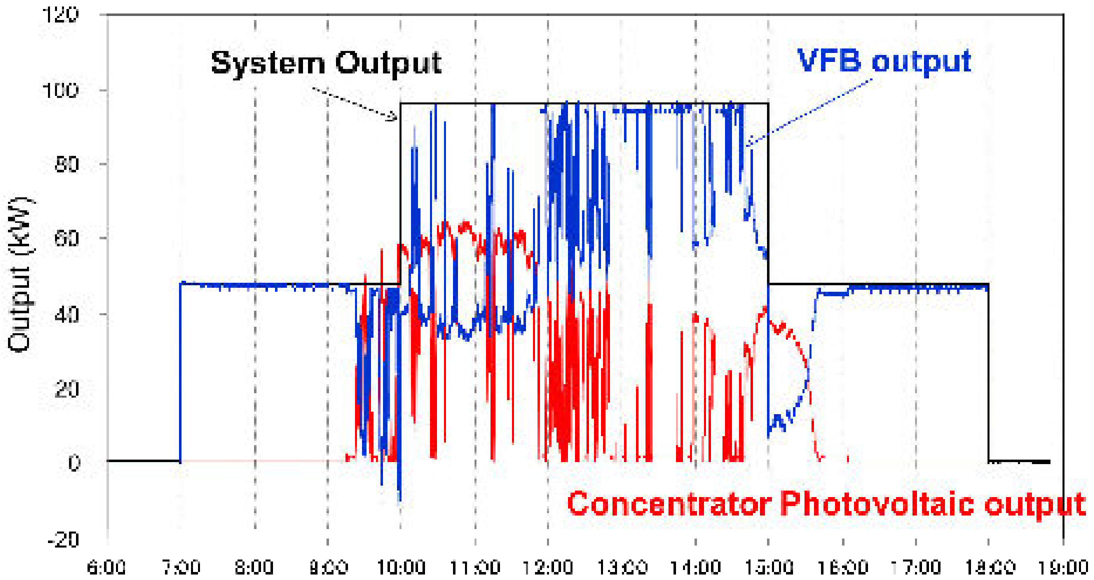
- Example of combination of Renewable Firming and scheduled discharge operation with Long Duration (from 7am to 6pm)



Ingenious Dynamics

SEI CONFIDENTIAL

SUMITOMO ELECTRIC

Yokohama Smart City National Project

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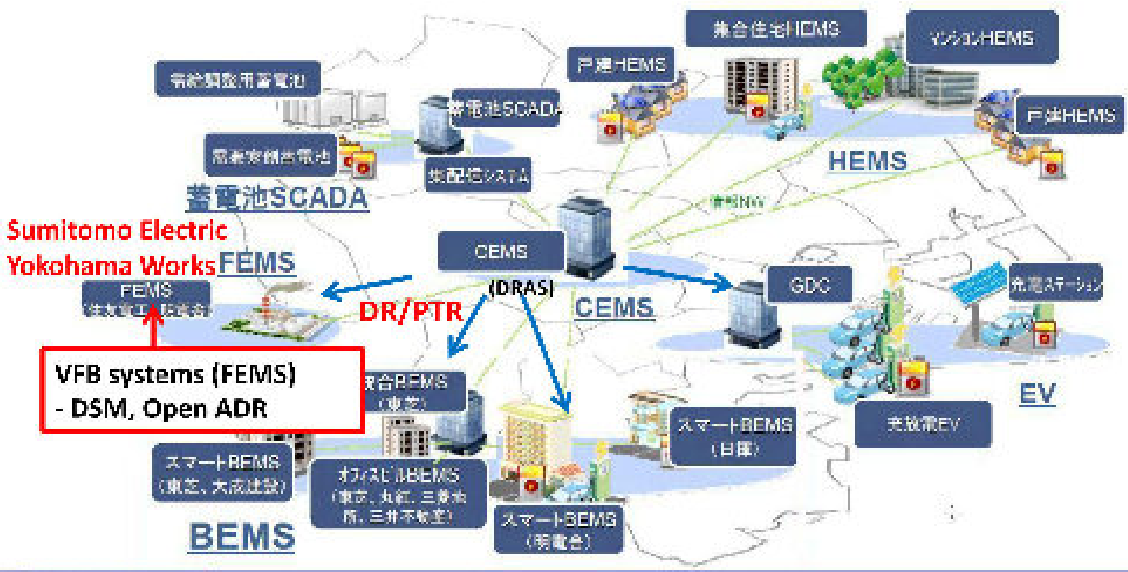
- City scale trial of Demand Response Service under support of Utility
- Aggregation of Home, Apartment, C&I (Sumitomo's Factory) and PEV



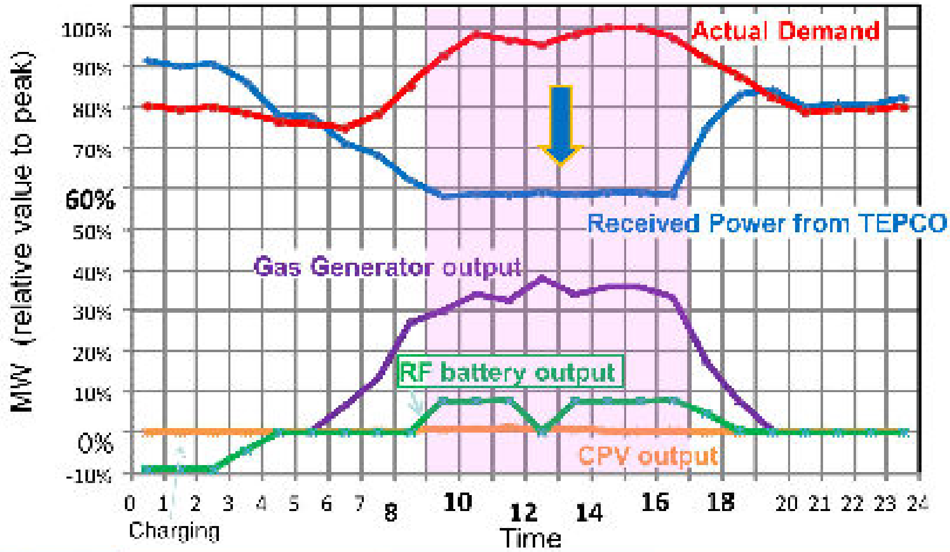
Ingenious Dynamics

SEI CONFIDENTIAL

SUMITOMO ELECTRIC

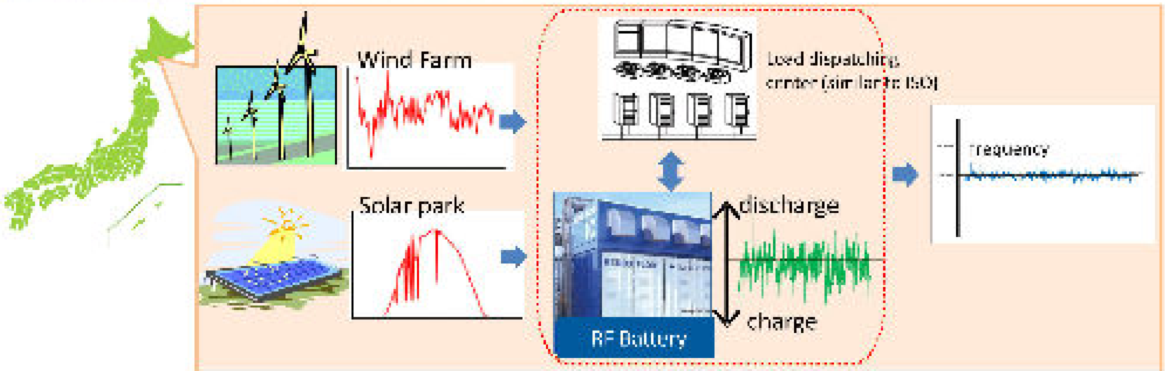
Yokohama Smart City National Project

- **Demand Response:** According to a consumption reduction request from TEPCO, SEI's Yokohama Works suppressed its receiving power at max. 40% during summer by means of our FEMS system incl. VFB systems.

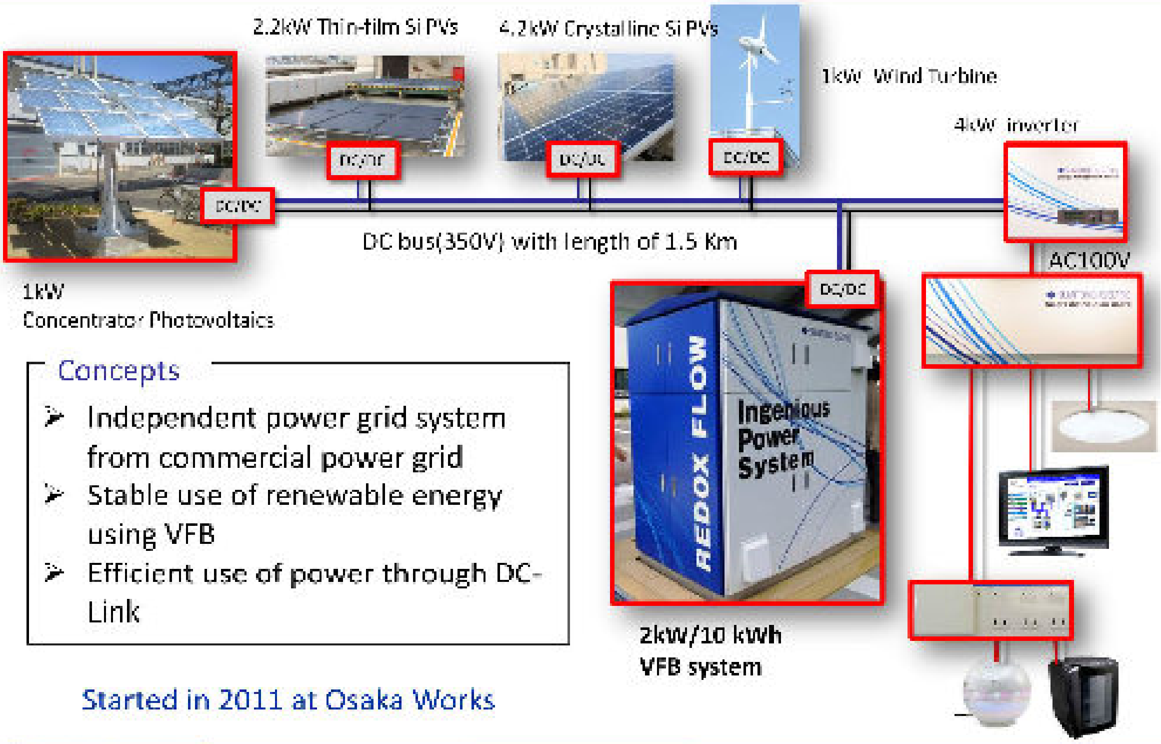


Hokkaido Electric Power Company Project

- Capacity : **15MW**
- Energy : **60MWh**
- Location: substation of HEPCO
- Application: Multi-purpose
  - frequency control
  - Surplus power adjustment



AC / DC Hybrid Micro-Grid System

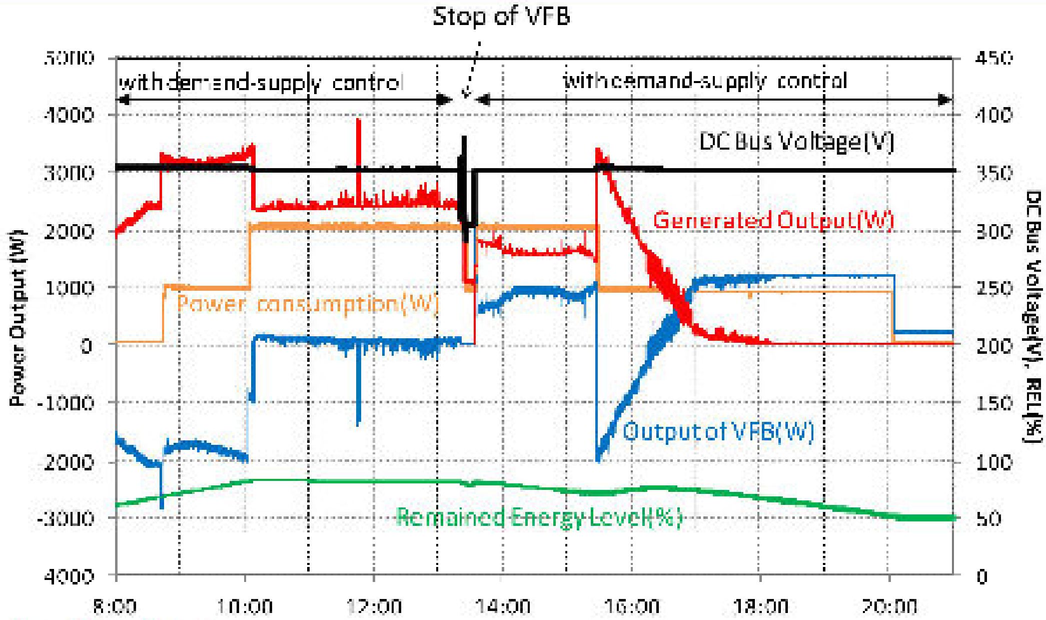


Concepts

- Independent power grid system from commercial power grid
- Stable use of renewable energy using VFB
- Efficient use of power through DC-Link

Started in 2011 at Osaka Works

AC / DC Hybrid Micro-Grid System



VFB's Role in This System

- Keep the balance between renewables and power consumption
- Keep DC voltage at 350V by charging and discharging in 100msec

附件 3- NGK 報告

NAS
Sodium Sulfur Battery

Sodium-Sulfur (NAS) Battery energy storage system

December 12 , 2014

NGK INSULATORS, LTD.

NGK

2014.12.10 AO

Today's Schedule for TPC Mr.Fang-Shuo Chuang

NGK

08:30	Pick up at hotel
08:30-08:45	Move to NGK Tokyo Office
08:45-09:15	NAS presentation
09:15-09:50	Move to Morigasaki Water Reclamation Center
10:00-10:40	Site Tour
10:40-11:00	Move to Hamamatsu-cho
11:00-12:00	Lunch

2

NGK Corporate Profile

Company Name	NGK INSULATORS, LTD.
Date of Establishment	May 5, 1919
Paid-in Capital	US 700 Million Dollar
Annual Sales	US 2,530 Million Dollar
Annual Operating Profit	US 210 Million Dollar
Representative Directors	

TakuOshima (President)
Hiroshi Fujito (Senior Vice President)

Number of Employees	3,426 (non-consolidated)
	13,159 (consolidated)
Consolidated Subsidiaries	54 companies

As of March 31, 2013

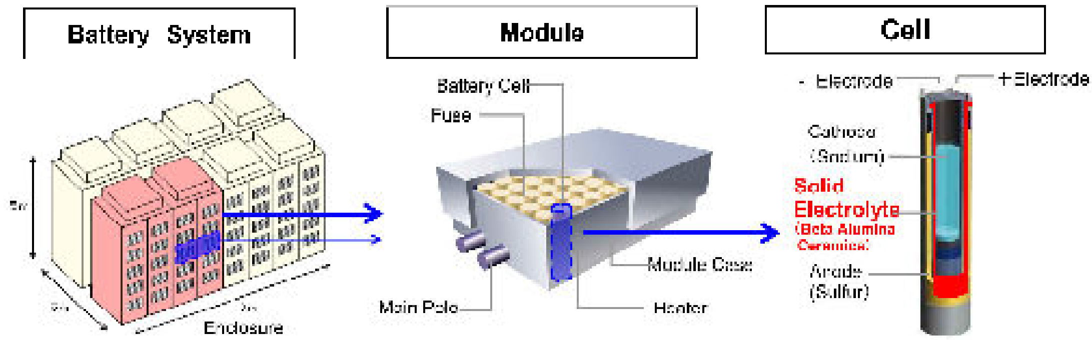
3

1. Features and Structure of NAS Battery

World Products proven in Large-Scale and Long-Term operation applications in commercial field.

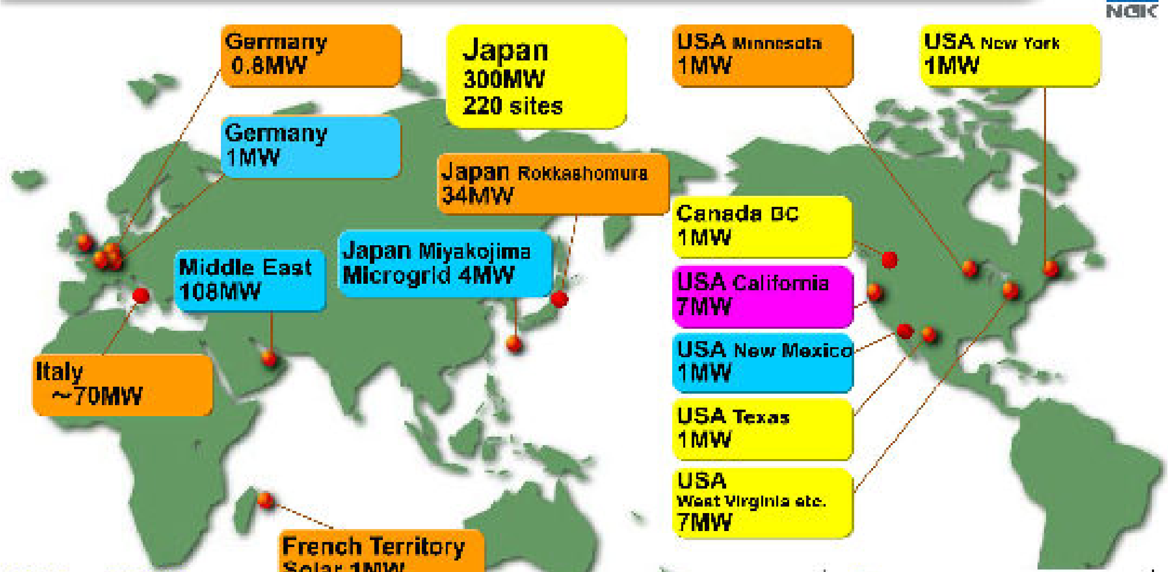
Application features

- ■Applicable for large-scale and long-term operation (More than 480MW/3,000MWh ,220 sites with 10 years experience)
- ■Large Capacity enables 6 – 7 hours continuous full discharge
- ■Compact in size (2 - 3 times energy density of lead acid battery)
- ■Longer life expectancy (15 years expected in standard conditions)
- ■Economically compatible per kWh



4

2. Supply Records : Field for all over the world

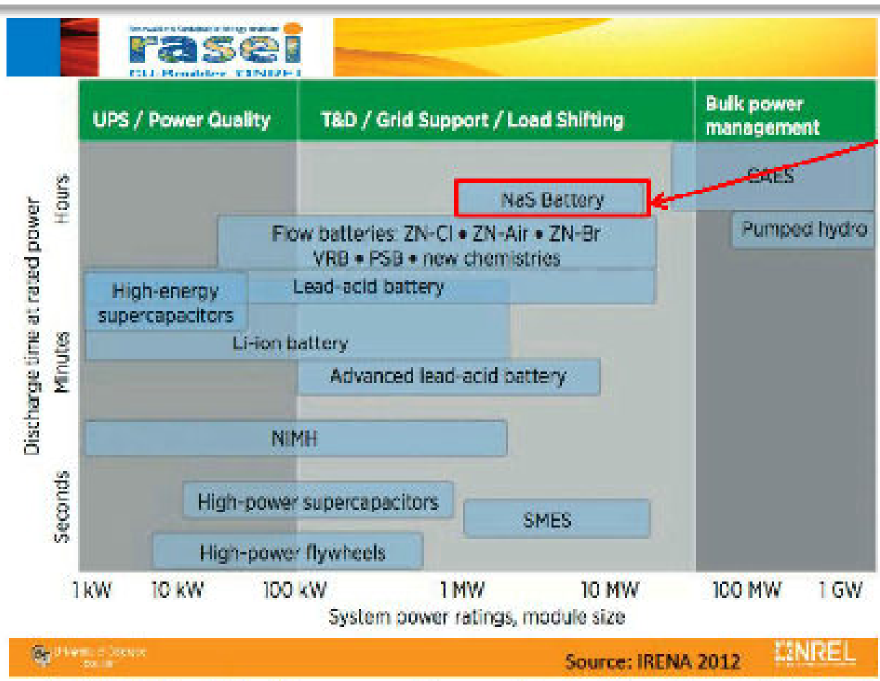


USA: 20MW
Europe: ~72MW
Japan: 300MW
Middle East: 108MW

World No.1 Supply Record
including ongoing project

5

3.Comparison of Energy Storage Technologies

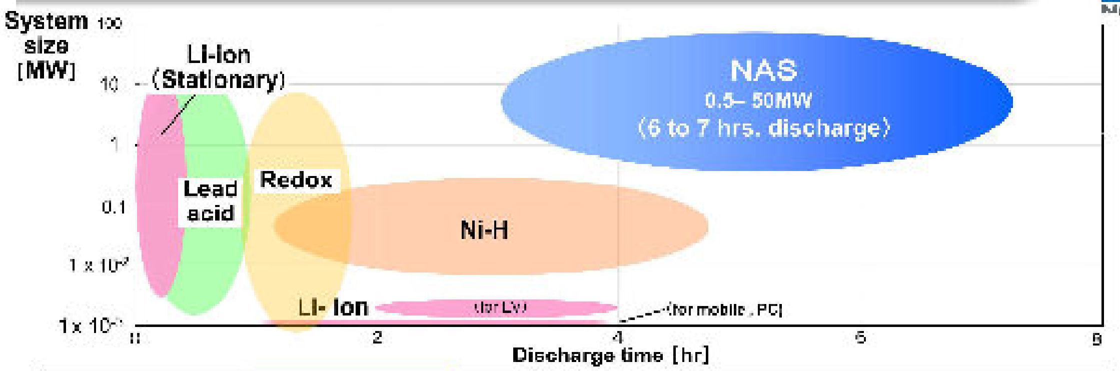


NAS
Size :1-50MW
Duration:Hours

IRENA, "Electricity Storage and Renewables for Island Power", May 2012

6

Comparison of Battery Technologies



		NAS	Li-ion	Lead acid (Long life type)	Ni-MH	Redox
System size (Max. record)		Large 200MWh	Medium 30MWh	Medium 10MWh	Small 0.1MWh	Medium 1MWh
Compactness		Small (Compact) 10m³/MWh	Small 15m³/MWh	Medium 20m³/MWh	Medium 50m³/MWh	Large 130m³/MWh
Life expectancy		Long 15 years	Medium 10 years	Long 17 years	Short 7 years	Medium 5-10years
System Cost	per kWh	Low	High	Medium	High	Medium
	per kW	Medium	Low	High	Medium	Medium

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4. Application Example of NAS Battery

Site	Application	Merits by using NAS
Factory, Office	1. Peak cut, Load leveling	・Customer : Electricity fee saving (Reduce maximum demand and peak time use) ・Power utilities: Investment deferral
	2. Emergency power/ Stand-by power for moment interruption	・Power security against line interruption(Quick back-up) ・Avoid Products damage of plant
Power Producer	3. Absorption of fluctuated renewable energy	・Clear grid connection code ・Increase grid connection capacity ・Time shift (Solar: Daytime to Evening, Wind: Night to daytime)
Power Utilities	4. Stabilization of Power Grid	・Avoid cirtailment of Renewable Energy from grid ・Avoid additional investment of Transmission line ・Ancillary Service (Adjust power supply and demand)
	5. High efficiency operation of turbine	・Reduce fuel consumption ・Reduce CO2 gas emission
	6. Network stabilization for Smart grid, local grid	For Smart grid ,Local grid (Islands, Isolated grid etc.) ・Utilization of renewable energy ・Harmonization of current power source and renewable energy, distributed power sources etc.

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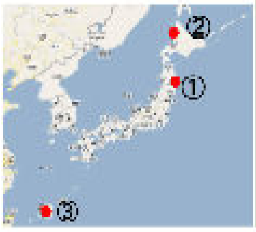
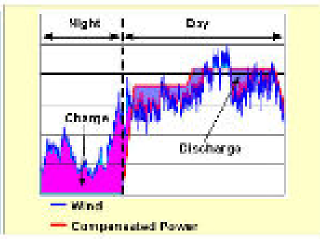
4-1. Renewables and Grid Application in Japan

① Wind Application

51MW Wind+34MW/200MWh NAS

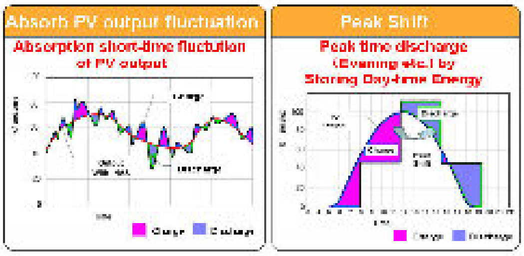
Flat Control method





② Solar Application

5MW Solar+1.5MW/10MWh NAS



NAS Battery Installations in Europe

Berlin, Germany: 1 MW NAS Battery for Younicos

NAS Battery in Micro Grid Testing Building

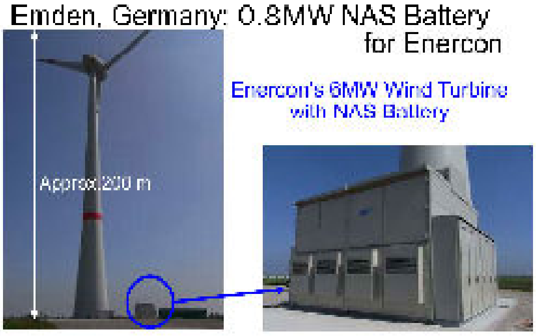
Younicos Press Release (on 6 February, 2013)

In a joint pilot project, Younicos and Vattenfall have commissioned the first large scale battery to be integrated in the European electricity balancing market.

Since the end of 2012, a 1 MW NAS battery based at the Younicos headquarters in Berlin successfully balances short-term fluctuations in the power grid. This is the first time a battery is employed in maintaining the frequency for the transmission system operator 50Hz Transmission GmbH.

Emden, Germany: 0.8MW NAS Battery for Enercon

Enercon's 6MW Wind Turbine with NAS Battery



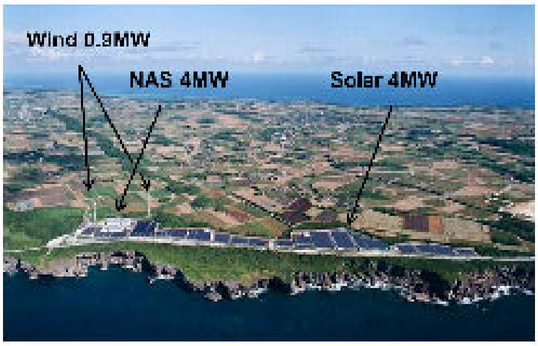
Reunion Island, France: 1,000kW NAS for EDF

Indoor Type NAS Battery and PCS

4-2. Renewables and Grid Application in Japan and Italy

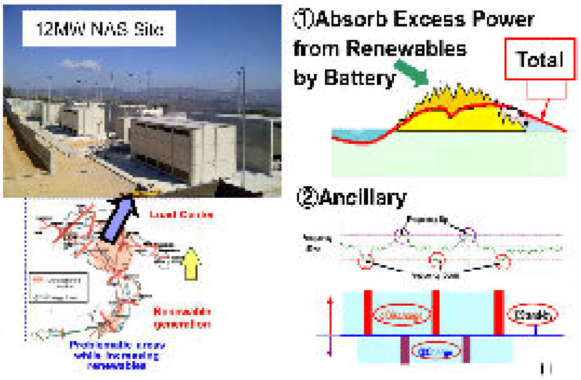
③ Smart Grid

PV : 4MW (Area : 45,000m²)
Wind : 4.2MW
(0.9MWx4units+0.6MWx1unit)
Battery : NAS battery 4MW /24MWh
(0.5MWx8 units)
Li-Ion 0.2MWh (8kWh x 25 units)
Existing : DG 61.5MW +
Gas-turbine 15MW



④ Renewables + Ancillary in Italy

Purpose for NAS Installation
①Avoid Curtailment from Renewables
Rapid Increase of Renewables
(2011: 19GW ⇒ 2016: 33GW)
②Provide Ancillary Service(Tertiary Reserve)
③CO2 emissions reduction targets
- Supply of 70MW NAS for Terna S.p.A.In Italy
- The first phase : 35MW (245MWh)



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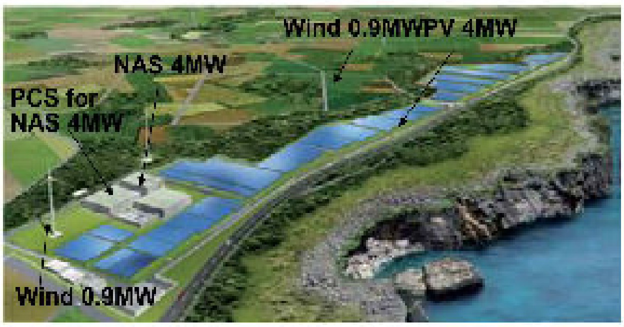
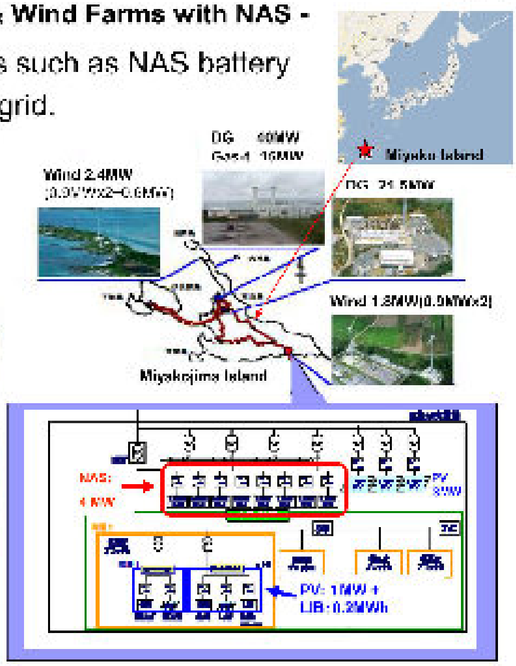
Smart Grid Application in Japan

Miyako Island / Smart Grid – PV & Wind Farms with NAS -

Demonstration test on grid stabilization devices such as NAS battery when PV & Wind generators are connected to grid.

PV : 4MW (Area : 45,000m²)
Wind : 4.2MW (0.9MW x 4units + 0.6MW x1 unit)
Battery : NAS battery 4MW (0.5MW x 8 units)
Li-Ion battery 0.2MWh (8kWh x 25 units)
Existing : DG 61.5MW + Gas-turbine 15MW
Operating from Oct.2010.





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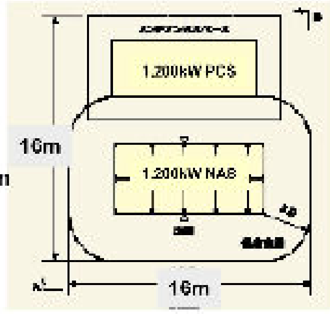
5-1. 1,200kW/7200kWh NAS System (Package Type)

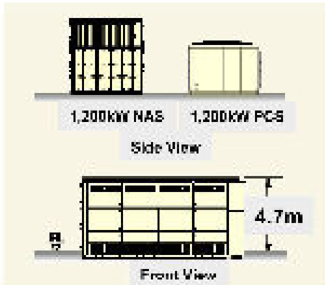
NGK

NAS Battery: 1,200kW Package type

Example of Layout



PCS: 1,200kW Package Type(Example)



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10MW NAS Battery System layout (9.6MW)

NGK

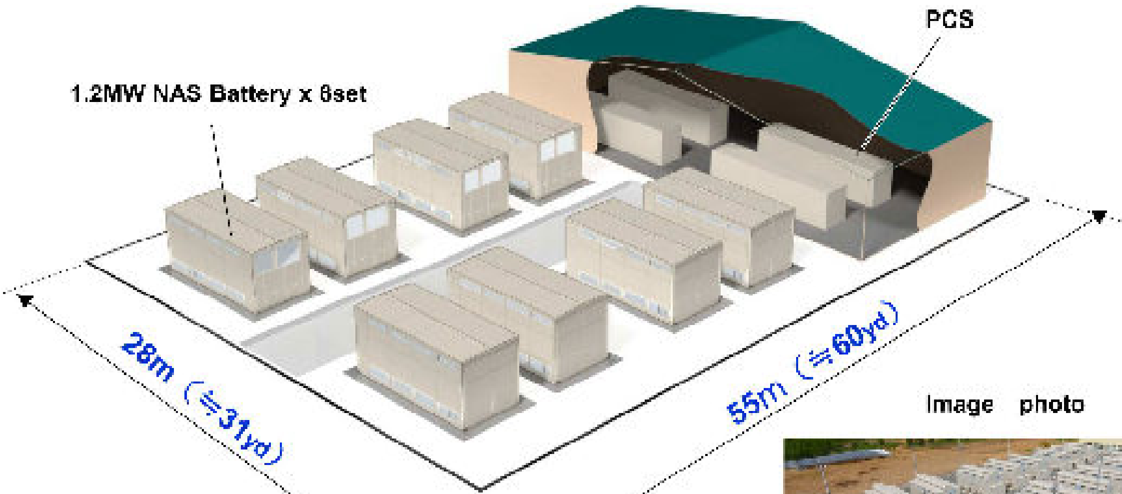

Image photo

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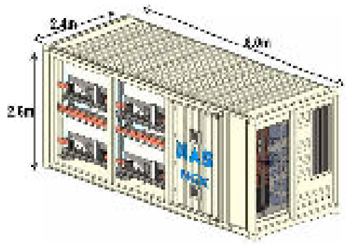
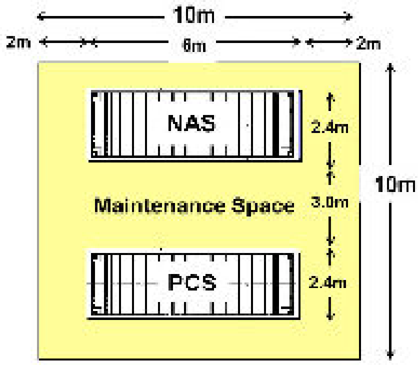
5.2. 200kW/1200kWh Container Type NAS System

NAS Battery: 20 Feet Container Type



Example of Layout



PCS: 20 Feet Container Type

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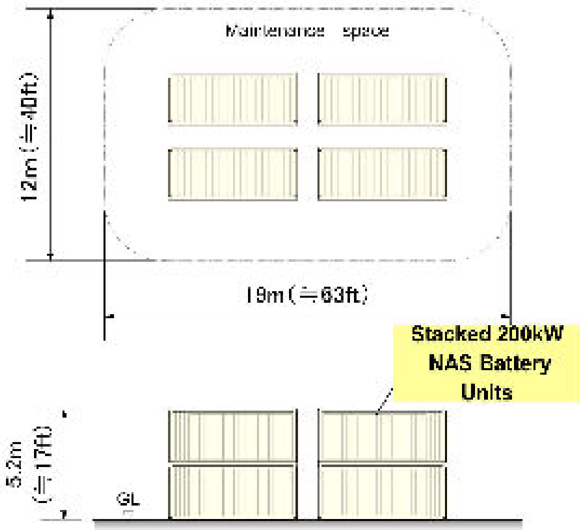
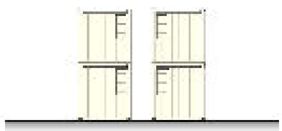
1.6 MW Containerized NAS Battery Layout





1.6MW NAS Battery	
Unit Group	0.2MW x 4
Quantity	2 set
0.8MW NAS Battery	
Weight	21 x 4 = 84 ton (23.15 x 4 = 93 short ton)
Floor Load Capacity	2.8ton/m² (2.6short tom/ sq yd)

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