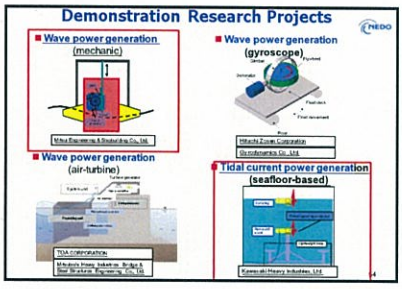
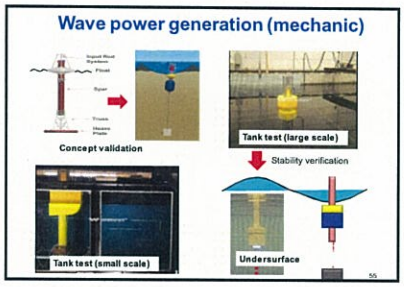
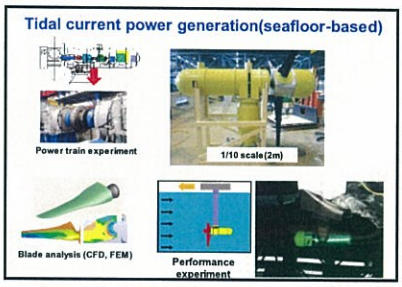
Demonstration Research Projects



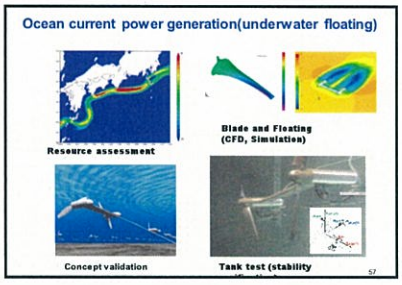
Wave power generation (mechanic)



Tidal current power generation(seafloor-based)



Ocean current power generation(underwater floating)

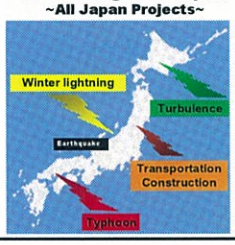


Summary

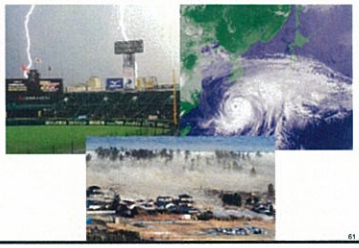
- Grid-connected RE in Japan (2012)
  47GW, 5.9GW, 2.6GW, 2.2GW, 0.5GW
- NEDO is conducting all kind of innovative RE technologies for all over the world.
  - Offshore wind: 7MW wind turbine, high availability
  - Marine Energy: wave and tidal energy converter etc

CONTENTS

5. Challenges of Japan ~All Japan Projects~



We have a lot of challenges in Japan



5.1 Environment Induced Accidents in Japan

5.2 Wind Farm Geography of Japan and Europe

5.3 Similar Accidents in Asian Region

Saurashtra, Gujarat, India June 8-9, 1998
129 turbines(30MW) out of 315 were destroyed

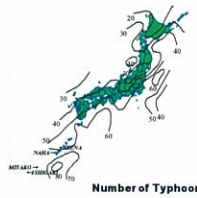
Estimated maximum wind speed at hub height: over 72m/sec

5.4 Environmental Condition

5.4.1 Tropical Cyclones

Distribution

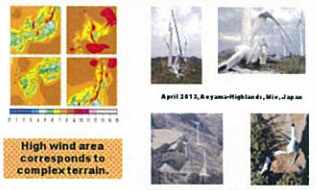
5.4.1-1 Typhoon in Japan



Number of Typhoons direct hit in 70 Years

5.4 Environmental Condition

5.4.2-1 Complex Terrain (Turbulent Wind)



High wind area corresponds to complex terrain.

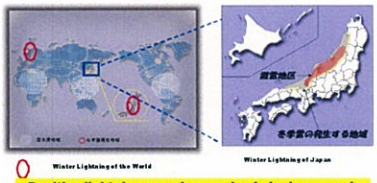
5.4 Environmental Condition

5.4.2-2 Complex Terrain

(Transportation / Construction at Mountainous Site)

5.4 Environmental Condition

5.4.3 Lightning Strike



Winter Lightning of the World

Winter Lightning of Japan

> Positive lightning are observed only in Japan and west coast of Norway.

5.4 Environmental Condition

5.4.4 Earth Quake

Seismic design is essential → Need of earthquake-resistant Wind Turbine design

Source: Kamisu city hall Web page, 14 April 2011

5.5 Growing Wind Energy Market

>> Mitigations for severe wind conditions caused by tropical cyclones and complex terrain for wind turbine are strongly required.

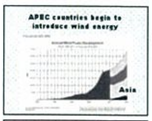
Steps for Tomorrow
~Ongoing Japan National R&D Projects~

Three Agencies conduct offshore projects

- NEDO (under METI)
  - ·Research and Development of Offshore Wind Power Generation Technology (FY2008 - 2013)
    - Choshi Chiba Offshore
    - Hibikinada Fukuoka Offshore
- Ministry of Economy, Trade and Industry
  - ·Floating Offshore Wind Farm Demonstration Project (FY2011 - 2015)
    - Fukushima Offshore
- Ministry of the Environment
  - ·Floating Offshore Wind Turbine Demonstration Project (FY2010 - 2015)
    - Goto Nagasaki Offshore

Contributions from Japan

APEC countries begin to introduce wind energy



Collaborative Research and Technology Transfer

Wind conditions in Japan
·Typhoon
·Mountain induced turbulent wind
·Earthquake
·High population density
·Monsoon region

Differ from Existing standards

New Challenge of Offshore

Japan created wind technologies that adopt APEC countries

Academy, Meteorological Observation, Assessment, Consultant, Wind Turbine, Construction, Financing, etc

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Limitation of Connection to the Grid

◆ Since the initiation of the Feed-in-Tariff system, renewable energy has been actually introduced in a mass scale, and new challenges have emerged, including the need for limitations on the power systems.

Possibility for general electricity utilities to connect with the grid and the amount of their generation capacity already connected with the grid

	The amount of electricity that can be connected to the grid (10,000kW)	The amount of electricity already connected to the grid (10,000kW)
Hokkaido	56	29.9
Tohoku	200	54.2
Tokyo	Without setting the amount of electricity that can be connected to the grid	37.1
Chubu	Without setting the amount of electricity that can be connected to the grid	22.4
Hokuriku	45	14.6
Kansai	Without setting the amount of electricity that can be connected to the grid	7.8
Chugoku	100	29.9
Shikoku	45	16.6
Kyushu	100	36.1
Okinawa	2.5	1.4
	548.5-	249

Source: Created by NEDO from the report of the Electric Power System Council of Japan (October 2012)

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Power adjusting capability and start-up time for thermal power generation

		[illegible]						[illegible]	
Type		[illegible]			[illegible]			[illegible]	[illegible]
[illegible]		Oil	LNG	Coal	Oil	LNG	Coal	LNG	LNG
[illegible]		●	●	●	●	●	●	●	●
[illegible]		●	●	●	●	●	●	●	●
[illegible]		○	●	○	●	●	○	Unseated △ / Series ●	Unseated ○ / Series ●
[illegible]		30% - 100%	20% - 100%	30% - 100%	15% - 100%	15% - 100%	30% - 100	Unseated 80% - 100% Series 20% - 100%	Unseated 50% - 100% Series 20% - 100%
[illegible]		3%/minute	3%/minute	1 %/minute	5 %/minute	5 %/minute	3%/minute	7 %/minute	10 %/minute
[illegible]	[illegible]	20 - 30 hours			30 - 40 hours			12 hours	
	[illegible]	3 - 5 hours			5 - 10 hours		—	1 (parallel, 0.5) hour	

Challenges for a Mass Introduction (4) Overseas Expansion

◆ **What sort of support will be required to promote the overseas expansion of Japanese technologies** in the field of renewable energy which is expected to be a new mega market in the future?

Trend of new investments in renewable energy

[0.1 billion dollars]

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Source: Created by NEDO from Bloomberg New Energy Finance

Measures and Specific Efforts for Overcoming the Challenges Facing a Mass Introduction of RE

Chief Measures for Overcoming the Challenges Facing a Mass Introduction of RE

(1) Toward the attainment of the objective of introducing new energy technologies specified in the Basic Energy Plan etc., NEDO will work on the development of required technologies and **the solution of technical challenges accompanying a mass introduction of renewables** as well as cost reduction of solar cells, wind power generation etc.

(2) NEDO will pursue unprecedented **innovative energy technology development** as well as the differentiation, value-addition and wide spread use of technologies, and promote innovation in the field of new energy sources.

(3) As for technologies at the commercialization stage such as fuel cells and hydrogen technologies, in addition to required technology development, NEDO will pursue wide-ranging efforts including standardization and optimization of regulatory frameworks to ensure **the "social implementation" of new technologies**.

(4) From the standpoint of proactively supporting **the overseas expansion of Japan's new energy technologies**, establish strategic partnership with related agencies of many countries, and provide support utilizing a variety of tools including demonstration projects, joint researches, information exchange, and capacity building etc.

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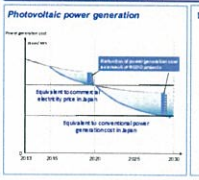
(1) Measures to Overcome Technical Challenges Facing a Mass Introduction of RE

◆In order to reduce power generation cost to a level comparable with the key source of energy in the long term, in the field of solar photovoltaic power generation, pursue technology development concerning cost reduction including the improvement of conversion efficiency while paying attention to system organization and cost structure.

Photovoltaic power generation



Wind power generation

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Measures to Overcome Technical Challenge Facing a Mass Introduction of RE

◆In order to resolve siting limitations, analyze the factors hampering the expansion of introduction and develop technologies which will contribute to the enlargement of the potential for introduction.

Photovoltaic power generation

◆Technology development for promoting the installation in unused areas

Geothermal power generation

◆Development of components for environment-conscious high performance geothermal power generation systems

◆Development of small-sized binary power generation systems for the effective utilization of low-temperature geothermal resources

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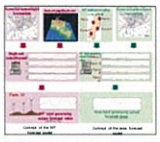
Measures to Overcome Technical Challenges Facing a Mass Introduction of RE

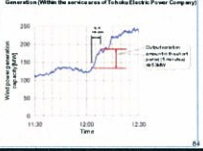
◆Toward the expansion of the potential for introducing renewable energy, examine and develop power generation output forecast systems for the purpose of enhancing the predictability of variation in the output of variable power sources such as wind power generation.

System-Supporting Technology

A schematic diagram of the forecast model image



An actual example of a sudden change in the output of wind power Generation (Within the service area of Tohoku Electric Power Company)



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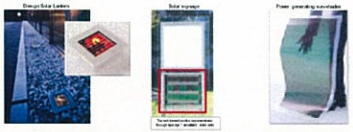
Differentiation by Means of Innovative Energy Technologies

◆Realize the value-addition of solar photovoltaic power generation by means of exploring new usages and designability etc. with a view to enhancing competitiveness by differentiation and expansion of usages as well as creation of new businesses by value-addition.

Photovoltaic power generation

◆Development of next generation solar cells which are light-weight and easy to process, allowing for power generation using faint light, and various designs including curving choices



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Standardization and optimization of regulatory frameworks etc. to ensure the "social implementation" of new technologies

◆In order to ensure the "social implementation" of new technologies, in addition to formulating guidelines for the installation, operation and maintenance of off-shore wind power generation facilities, provide services such as the provision of data etc. required for setting the surcharge under the FIT system.

Off-Shore Wind Power Generation

◆Summarize the results of verification research and environmental impact assessment relating to designing, construction and maintenance/operation in guidelines etc., and prepare the basis for off-shore wind power generation systems in Japan

◆Organize equipment cost and operation/maintenance cost etc., and summarize the basic data useful for the review of procurement prices etc. under the Feed-in-Tariff system

Hydrogen Energy

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Support for the Expansion of Global Reach

◆In future, with a view of establishing a partnership among countries where the renewable energy market is expected to expand, NEDO will carry out technical verification projects corresponding to the local needs, in addition to enhancing the network through policy dialogues and cultivation of human resources etc.

Human Resources Training Programme

◆In future, cultivate engineers in the countries and regions where the dissemination of relevant technologies is expected, in order to support the industrial version of Japan to expand their business overseas.

◆By means of a partnership with IRENA, establish a solid network with the Middle East and African Regions etc.

Overseas Verification

◆A verification project for industrial waste power generation, unprecedented in the Socialist Republic of Viet Nam, has been launched.

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Summary

- In recent years, policies and market environments surrounding renewable energy have progressed/evolved considerably. The industrial competitive environment has also changed considerably.
- The role of renewable energy, as a low-carbon domestic energy, will be more important in future, from the viewpoint of energy security and establishment of a low-carbon society.
- We have made efforts to overcome technical challenges for future targets up to this time, but in future, it will be required to overcome various challenges facing a mass introduction of renewables, which has become an actual target just before our eyes.
- Based on the recognition that making effort to overcome these challenges not only contributes to the dissemination of domestic renewable energy sources, but also lead to the enhancement of the competitive capacity of Japanese companies, NEDO will work on the solution of challenges by concentrating industry, academic and government wisdom.

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4.1 Accurate Wind Atlas and Estimation

Development of Local Area Wind Energy Prediction System (LAWEPS)

Accurate wind energy prediction over complex topography
Applicable to coastal / mountainous area in Japan

NEDO LAWEPS Development (FY1999 - FY2002)

- **Model design (1999)**
- **Model validation / revision (2001-2002)**
- **System completion (2002)**

Target : Within 10% error for annual mean wind speed prediction
Attained : 4.7 % error

NEDO : New Energy and Industrial Technology Development Organization of Japan

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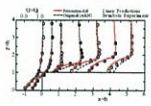
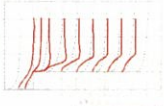
4.1.1 LAWEPS Calculations and Existing Code A

○ : experiment (wind tunnel)
Red lines: new model calculation

Black lines: code A calculation
Red lines : new model calculation





- Japan model simulates real distribution.
  Weak or inverse wind (vortex region) on the cliff.
- Code A shows only slight modification of inflow.

4.1.1-1 Accuracy (annual mean wind speed)

Observed Site		Shiono Misaki A Wakayama	Shiono Misaki B Wakayama	Iroesaki Okinawa	Sumida Iwate	Nejime Kagoshima
Topographic Features		Coastal cliff	Coastal complex terrain	Island Flat	Inland mountainous	Coastal cliff
Site inclination	%	3.7	5.8	2.5	17.0	9.5
Actually observed	m/s	5.31	4.29	6.69	6.97	6.79
LAWEPS (JAPAN)	m/s error%	5.51 +3.77	4.17 -2.80	6.16 +1.16	6.37 +4.71	6.61 -2.83
Code A	m/s error%	3.66 -31.10	4.35 +1.40	5.35 -11.20	6.85 -0.33	8.71 +28.88
Code B	m/s error%	4.40 -17.10	4.69 +6.70	–	–	–

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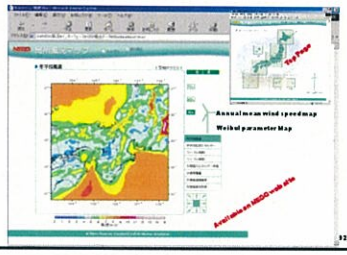
4.1.1-2 LAWEPS Display



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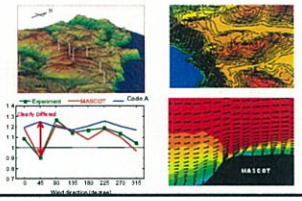
4.1.2 MASCOT

Non-Linear Calculation for Complex Terrain

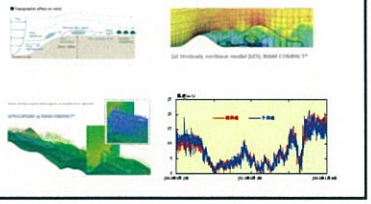
University of Tokyo



4.1.3 RIAM COMPACT

Unsteady Non-Liner Numerical Simulation

Kyushu University



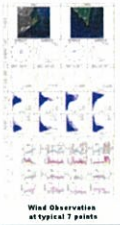
4.2 Development of Adequate Design Technology and Guideline

Countermeasure Developments (National level Tackle)

- **Design Guide and Exposition for Structure and Support (2007,2010 by Japan Society of Civil Engineers)**
- **Design Guide For Typhoon in Japan (2008 by NEDO)***
- **Design Guide for Turbulence in Japan (2008 by NEDO)***
- **Design Guide for Lightning in Japan (2008 by NEDO)***
- **Wind Turbine Design Standard (in process by JEMA)****

* Available from NEDO website in Japanese language
**Japan Electrical Manufacturers' Association

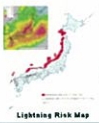
4.2.1 Design Guide For Typhoon / Turbulence in Japan

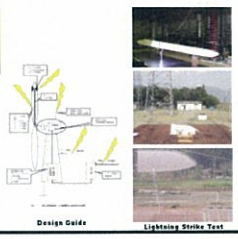


Wind Observation at typical 7 points

4.2.2 Design Guide for Lightning in Japan

Lightning Strike Observations





Lightning Risk Map | Design Guide | Lightning Strike Test

4.2.4 Introduction of new design standard of wind turbine that adapts to real environment condition

Proposal from Japan National Committee of Wind

International Standard IEC61400-1 Wind turbines-Part1 Design requirements

For tropical cyclone regions;

- New WT class for tropical cyclone regions (Class T for Tropical cyclone regions)
- Flexibility in ratio of V_{ref}/V_{ave} for tropical cyclone regions
- Advanced prediction methodology for extreme wind speed by Monte Carlo simulation

For high turbulence regions;

- New turbulence category for high turbulence regions (Category H for High turbulence regions)
- New model for wake and mid-term turbulence taking into account the complex terrain effect

Proposal of additional class and category in IEC 61400-1

Class	I	II	III	T	S
V_{ref} [m/s]	50	42.5	37.5	57.5	Values specified by the designer
V_{ave} [m/s]	10	8.5	7.5	10	
				8.5	
				7.5	
I_{ref} H	0.18				
a	0.16				
b	0.14				
c	0.12				

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4.2.5 Strength Demonstrated
Case of the Earthquake and Tsunami to Offshore Windfarm

Offshore windfarm is made by 7 FHI/Hitachi's SUBARU80/2.0 2MW WTGs.

The location is 300km far from the epicenter.

Shaking level was 5- and 6 m height tsunami attacked the farm.

But turbines are safe and start operation again on March 14 2011, 2days later of the disaster.

Windpower Kamisu

Drifting and Debris of Tsunami at the quay of Windpower kamisu

4.2.6 Construction Technology for Complex Terrain

Construction without Heavy Crane

Concrete Tower

Special Transporter for Long Blade Tower

7. International Cooperation
7.1 NEF Renewable Energy Researchers Invitation Program

Invited Researchers

Fiscal Year		2008	2009	2010	2011	2012	2013	Total
Invited Researchers		19	24	21	15	15	17	111
Research Fields	Biomass	19	24	21	15	10	8	97
	Wind					3	4	7
	Geothermal					2	3	5
	Common						2	2
Number of Countries		6	8	9	9	5	8	13
Dispatch Country	Cambodia				1			1
	China	1	1	3	1	1	1	8
	India		2	1	1			4
	Indonesia	4	5	6	6	6	4	30
	Lao			1		1	2	4
	Malaysia		2	3	3		1	7
	Myanmar						1	1
	New Zealand						1	1
	Philippines	2	1	1	1			5
	Singapore	1	1	1				3
	South Korea				1			1
	Thailand	10	6	2	2	3	3	26
	Vietnam	1	6	4	1	4	4	19

7.2 Dispatch Organizations (2008-2013)

7.3 Host Organizations (2008-2013)