Research Plans

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Statement of Budget

FY 2015

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Central Research Institute of Electric Power Industry

Contents

Research Plans

I. Basic Points for Business Promotion

Japan is moving ahead with reforms to the electricity system, and as such, the electric power industry faces a major transition period. Discussions over energy policy, including the role of nuclear power generation, as well as the full deregulation of retail sales and the separation of power generation and power transmission, are underway.

With competition between businesses and changes in the business system anticipated, some electric power companies are devising new management strategies, which are expected to lead to changes in research and development (R&D) in the electric power industry. However, we cannot predict the specific shape that R&D in the electric power industry will take.

In these conditions, CRIEPI has designated fiscal 2015 as a year in which to prepare for transformation. We will proactively identify our own role and reformulate our research strategy and business administration system in order to lead this R&D with an eye on the future of the electric power industry. Moreover, we will further enhance our research capacity and competitiveness by steadily cultivating the basic technologies so indispensable to CRIEPI as an industrial research institute supporting the electric power industry.

Temporary reductions in benefit income will continue in fiscal 2015. However, in order to fulfill the role and functions required of us, we will continue to streamline operations and cut costs to establish a resilient business operation framework.

Given the above, we will offer timely and accurate solutions to urgent issues faced by the electric power industry and new issues arising from medium- and long-term changes through R&D bringing together our advanced expertise.

II. Research Activities

1. Research addressing changes in issues by business sector

- Changes in the electric power industry's environment affect business sectors within the industry differently. Taking into account the fact that businesses will develop in line with this impact, we will devise medium- and long-term research strategies for each sector and carry out the following research in fiscal 2015.

Nuclear power generation:

Nuclear power generation remains an important issue shared throughout the electric power industry. In particular, we will reinforce the activities of the Nuclear Risk Research Center (NRRC) established in fiscal 2014 to support nuclear power companies for continuous improvement of nuclear safety of nuclear power plants on an ongoing basis. In addition, we will work on issues aimed at ensuring the steady operation of nuclear power plants before they resume operations.

- Assessments of severe accident measures to comply with new regulatory standards.
- Development of Probabilistic Risk Assessment (PRA) methods for continuous improvement of nuclear safety
- Establishment of hazard evaluation methods for external natural events (earthquakes, tsunami, tornadoes, etc.)
- Improvement of the maintenance of components for the safe and stable operation of light water reactors

Thermal power generation:

Despite an environment marked by competition within the electric power industry, there will be many issues shared by the industry. This awareness encourages CRIEPI to pursue research aimed at resolving important issues, such as equipment diagnosis for high-temperature equipment and further reductions to the environmental load. Moreover, we are steadily engaging in research that would help to streamline the maintenance and operation of existing plants.

- Development of life assessment technologies for high temperature equipment made of high chromium steels in ultra-super-critical thermal power plants
- Development of maintenance and improvement technology of environmental facilities for thermal power plants
- Development of condition diagnostic and maintenance management technologies of thermal power plants

Electric power transmission and distribution:

We pursue research that responds to changes in electric power systems in a timely manner, such as the transition to wide-area system operations, expanded introduction of renewable energy and the change to a more active role for the demand side (consumers) that links them to the power distribution system. Moreover, we engage in research that indispensably contributes to maintain and renewal power distribution equipment in a rational way, as well as research that contributes to natural disaster countermeasures.

- Greater sophistication of analytical tools tailored to wide-area system operations (CRIEPI's Power System Analysis Tools, or CPAT, and eXpandable Transient Analysis Program, or XTAP)
- Development of system stabilization technologies for the large-volume introduction of renewable energy
- Development of technology to maintain power quality in the face of the diversity of demand-side equipment
- Development of rational maintenance technology responding to aging power distribution equipment
- Seismic resistance assessments of transmission line towers and electrical substation equipment

Services for power consumers:

We will reinforce research on the demand side from the perspective of improving customer convenience through energy use, starting with electrical power, under the auspices of the Research Team for Advanced Management of Power Supply and Demand, set up in fiscal 2014. In addition, we will strive to collaborate with research in the power distribution, which is closely related to the demand side.

- Development of tools using energy information obtained from smart meters
- Social costs and benefits assessment of supply/demand management utilizing demand response and demand-side equipment
- Development and performance assessment of heat pumps for use in various thermal demand fields

- In addition to the above, specific research plans by business sector, including hydroelectric power generation, renewable energy, the environment and business management, are laid out in the Overview of Research Plans from page 15.

2. Pursuit of research aimed at improving customer satisfaction

- After ascertaining frontline needs by communicating with electric power companies, in our role as a central research organization for the electric power industry, we will identify technical

issues in advance, and pursue research that accurately generates attractive results helpful to the industry in a timely manner.

- We aim to raise the satisfaction of the electronic power industry by responding thoroughly and with flexibility to research requests on an ongoing basis in order to help resolve urgent issues. One example would be responding to on-site accidents in the electronic power business.

- We will centralize our contact desk and build a system for offering solutions in order to provide results contributing to the resolution of on-site issues in the electric power industry in a more timely manner.

- Based on research strategies in the respective fields, we will create and utilize intellectual property in accordance with the characteristics of research results, the assumed clients and the degree of competition.

3. Expanding research funded by national government and others and seeking and pursuing new alliances

- We will proactively secure funding from the national government and others for research that helps to resolve issues in the electric power industry that is consistent with research strategies in the respective fields, as well as research taking up cutting-edge issues that will enhance and refine CRIEPI's research capacity.

- Given trends in open innovation in industrial research, we will seek and pursue alliances that go beyond previous boundaries through alliances with universities, research institutions and private companies, with the possibility of further utilizing our research capacity and securing new funding.

4. Maintaining and improving research capacity and ability to resolve issues

- We will steadily renew foundational technologies, predicting the foundational technology needed to solve problems in the electric power industry in the future, striving to preemptively acquire technology that will be needed more in the future, as well as scaling back technology deemed to be less essential in the future and shifting staff to other fields.

- We will systematically cultivate human resources with advanced levels of expertise by taking up the challenge of new issues based on innovative ideas, building up basic data and seeking the principles behind phenomena through analysis and observation.

- We will closely review the specifications for, introduce and update the large-scale research facilities and basic research facilities that serve as the wellspring of our research abilities as an in-house research institution after carefully selecting those facilities essential to resolving issues.

The primary large-scale research facilities introduced in fiscal 2015 are as follows:

- ✧ Addition of three-dimensional vibration test function to a centrifuge: This contributes to the streamlining of anti-seismic design through earthquake stability assessments on the foundation ground of nuclear power facilities and nearby slopes.

- ✧ Equipment for measurement of leakage behavior at pipe failure: Developing a method for evaluating fluid leakage behavior at pipe failure of light water reactors helps rationalization of regular inspections of components and pipings.

- ✧ Cs (spherical aberration coefficient)-corrected transmission electron microscope: Raising the accuracy of life assessments of the high-chromium steel pipes used in thermal power plants contributes to the stable operation of power plants.

- ✧ Platform unit of coordination between demand and supply at low voltage distribution line: It contributes to maintain the power quality of the distribution systems by way of evaluating the various phenomena that could occur at low-voltage distribution lines and by devising countermeasures of mass installing of photovoltaic power generation.

- We will deepen affiliates with foreign organizations with high levels of technical expertise in energy research and development (Electricite de France, EDF; Electric Power Research Institute, EPRI and others), and further strengthen research capacity by mutually complementing each other's technical skills and networks.

III. Administration

1. Initiatives supporting a new business system

- In order to strengthen the research management systems in each field in preparation for changes in the electric power industry resulting from electricity system reforms, we will augment the staff functions and set up management accounting. Moreover, we will strengthen our marketing functions with unified management of information on major clients, such as electric power firms, and sharing and utilizing this information.

- In order to reinforce our research contract functions and intellectual property management and utilization functions to prepare for an expansion in research funded by the government and alliances with various partners, we will set up divisions to take charge of this in both the Abiko and Yokosuka research bases.

- To facilitate the further use of our research results by the electric power industry and other clients, we will revise our methods of publishing results and disseminating information such as research reports and other publications. Moreover, we will provide objective information based on research results with a high degree of social interest in a timely manner, such as the safety of nuclear power, electric power system reforms and climate change countermeasures.

2. Establishing a resilient business system

- We will continue to cut cuts by thoroughly implementing competitive bidding in outsourcing and purchases, ensuring that the equipment's specifications are really necessary for their research and carrying out operations in-house, and establish a resilient system that ensures sustainable business operations.

- We will continue to cut operating and management costs other than direct research costs by accepting potential risks to business activities overall, such as eliminating operations and curbing purchases and business trips.

- We will continue with measures aimed at cutting total personnel expenditures, including reducing salaries. At the same time, we provide appropriate treatment and compensation based on abilities and results so that we can hire and retain talented personnel.

3. Steady establishment of research bases

- We will continue our work to establish a research base in the Yokosuka area, which is intended as a technology research base for the energy industry, and a research base in the Abiko area, which is intended as a research base for nature and the environment. This will raise the value of our assets as a business entity and also help to streamline operations. This is not funded by

benefit incomes, but rather by the revenue generated by the sale of some of the land in the Komae area in fiscal 2013.

- A new research building and the Material Analysis Building will be constructed ahead of the consolidation of research staff and equipment in the Yokosuka area (to be completed in fiscal 2016), and the transfer from the Komae area will gradually move ahead.

- We will move and reorganize administrative and management divisions in early fiscal 2015 to streamline operations as we establish these two research bases. Specifically, the Center for Intellectual Property and Administrative Support Center will be consolidated to headquarter and reorganized and transferred from the Komae area to the Abiko area. At the same time, research support functions at the Abiko and Yokosuka research bases will be strengthened. The Contracts Group will be reformed as the Procurement Center (tentative name), and we will strive for procurement that is more effective in supporting research activities, while ensuring that outsourcing and procurement procedures are appropriate and efficient.

4. Pursuing sound and rigorous operations

- We continue our efforts to strengthen governance, steadily implement risk management and ensure and heighten compliance awareness, and aim for a sound and rigorous self-directed business administration as an academic research organization and a non-profit organization.

- We will complete our Plan on Expenditures for Public Benefit in fiscal 2014 and hereby the transfer to general corporate foundation status without delay (Confirmation by the Cabinet Office will be expected in October 2015).

IV. Workforce

- We hire staff based on hiring plans for researchers. These plans are established in light of updates to research strategies and foundational technology in each field. We systematically train human resources with a high level of expertise who are able to support the electric power industry's foundational technology going forward. Moreover, we strive for flexibility in hiring researchers by utilizing "temporary contract employee positions."

- While we will continue to reduce staff in the administrative and management departments, we will assign and train staff with the aim of enhancing expertise as appropriate for each individual under a new system after transfer and reorganization.

- CRIEPI's current workforce plan aims to reach an equilibrium point of about 800 employees by the end of fiscal 2015, compared to 845 at the beginning of fiscal 2011, but we consider revisions to our workforce plan and necessary personnel measures to ensure a sustainable business system tailored to future expansions.

(Expected as of April 1, 2015)

Item	Number (people)	Percentage distribution (%)
1. Research	704 • Including 14 visiting researchers • Including 9 temporary contract employees	88.0
Breakdown according to fields		[100.0]
(1) Electrical Engineering	111	15.8
(2) Civil Engineering and Architecture	114	16.2
(3) Mechanical Engineering	97	13.8
(4) Chemistry	50	7.1
(5) Biology	41	5.8
(6) Nuclear	55	7.8
(7) Environment	51	7.2
(8) Information and Communication	35	5.0
(9) Socio-economics	43	6.1
(10) Research Support and Management	107	15.2
2. Office work	96	12.0
Total	800	100

Attached table: The business noted in Clause 1, Article 4 of the Articles of Incorporation and research activities in fiscal 2015 will be addressed as follows.

Business noted in Clause 1, Article 4 of the Articles of Incorporation	**Corresponding plan**
(1) Research, studies and tests on electric power, civil engineering, the environment, thermal and nuclear power, new energy and electricity applications as related to the transmission and distribution of power	II. Research activities overall
(2) Research and studies on the economy and laws related to electricity	II. Research activities overall
(3) Spread and utilization of results, such as the preparation of criteria and standards related to electric power technology	II. Research activities overall
(4) Other items necessary to achieve foundation's objectives	No applicable plans in fiscal 2015

Statement of Budget

I. Basic Points in Budget Compilation

The fiscal 2015 budget for CRIEPI operations was compiled based on research plans. The main points are as follows.

1. Changes in unrestricted net assets

(1) Recurring revenue amounted to 26,498 million yen.

- Current benefit income from electric utility companies amounted to 23,565 million yen.
- Business income stood at 2,679 million yen.
  Of this business income, funded research business income accounts for 2 billion yen.
  Other business income, including revenue from short-circuit tests and revenue from joint research, totals 679 million yen.
- Other income, such as interest revenue, amounted to 90 million yen.

(2) Ordinary expenses amounted to 28,061 million yen.

- Expenses for projects and programs totaled 26,428 million yen.
  Of these expenses, personnel expenditures such as salaries and allowances and retirement benefit expenses totaled 8,987 million yen.
  Operating expenses, including consumable costs, outsourcing costs and amortization costs, amounted to 17,441 million yen.
- General and administrative expenses related to headquarters operations were 1,633 million yen.
  Of this, personnel expenses such as executive officer compensation, salaries and allowances and retirement benefit expenses totaled 929 million yen. Operating expenses, such as consumable costs, totaled 704 million yen.

(3) Non-operating expenses and losses totaled 218 million yen, consisting of loss on retirement of fixed assets.

2. Changes in restricted net assets

(1) Subsidies received, including revenue from the Ministry of Economy, Trade and Industry, is 31 million yen.

(2) Transfer to unrestricted net assets totaled 164 million yen due to amortization costs and other factors related to the restricted net assets included in special assets.

3. Balance of net assets at fiscal year-end

Net assets in this fiscal period fell a total of 1,914 million yen, which is the sum of fluctuations in unrestricted net assets and restricted net assets. Accordingly, the balance of net assets at the end of

the fiscal year was 36,567 million yen.

II. Budget

The fiscal 2015 budget, compiled based on the above, is as follows.

Fiscal 2015 Budget for Revenues and Expenditures

From April 1, 2015 through March 31, 2016

(Unit: Million yen)

Subject	Budget	Remarks
I Changes in unrestricted net assets		
1. Operating activities		
(1) Recurring revenue		
① Benefit income		
Current benefit income	23,565	
② Business income	2,679	
Funded research business income	2,000	
Other business income	679	
③ Other income	90	
Interest revenue	5	
Facility use fees received	80	
Miscellaneous income	5	
④ Transfers from restricted net assets	164	
Total revenue and gains	26,498	
(2) Ordinary expenses		
① Expenses for projects and programs		
Personnel expenditures	8,987	
Salaries and allowances	7,180	
Retirement benefit expenses	779	
Welfare expenses	1,028	
Operating expenses	17,441	
Consumable costs	1,418	
Publication costs	381	
Lighting, heat and water utility costs	1,047	
Outsourcing costs	5,458	
Joint research contribution	690	
Repair costs	1,323	
Rental costs	298	
Tax and dues	515	
Travel and transportation costs	834	
Communication and transport costs	97	
Other operating expenses	493	
Amortization costs	4,887	
Sub-total for expenses for projects and programs	26,428	
② General and administrative expenses		
Personnel expenses	929	
Executive officer compensation	140	
Salaries and allowances	588	
Retirement benefit expenses	55	
Welfare expenses	72	
Provision for directors' retirement benefits	74	
Operating expenses	704	
Consumable costs	5	
Publication costs	42	

Lighting, heat and water utility costs	26	
Outsourcing costs	97	
Repair costs	11	
Rental costs	344	
Tax and dues	38	
Travel and transportation costs	31	
Communication and transport costs	7	
Other operating expenses	73	
Amortization costs	30	
Sub-total of general and administrative expenses	1,633	
Total expenses and losses	28,061	
Total changes in operating activities for the year	△ 1,563	
2. Changes in non-operating activities		
(1) Non-operating revenue		
Total non-operating revenue	—	
(2) Total non-operating expenses and losses		
Loss on retirement of fixed assets	218	
Total non-operating expenses and losses	218	
Total changes in non-operating activities for the year	△ 218	
Total changes in unrestricted assets	△ 1,781	
Unrestricted assets at beginning of year	37,916	
Unrestricted assets at end of year	36,135	
II Changes in restricted net assets		
① Subsidies received		
Subsidies received	31	
② Transfer to unrestricted net assets	164	
Total changes in restricted net assets for the year	△ 133	
Net restricted assets at beginning of year	565	
Net restricted assets at end of year	432	
III Balance of net assets at fiscal year-end	36,567	

Overview of Research Plans

Since fiscal 2012, CRIEPI has taken a panoramic view of the electric power industry overall and compiled the Major Issues Confronting the Electric Power Industry, which clarifies the short-, medium- and long-term issues facing the industry, and the Portfolio of Research Subjects, which consolidates the actions that CRIEPI should take to resolve these issues. We have pursued our research activities based on these two documents.

In the fiscal 2015 plan, the Portfolio of Research Subjects still forms the foundation for our research activities, and we continued to set research subjects in the eight areas of nuclear power generation, thermal power generation, hydroelectric power generation, renewable energy, electric power distribution, services for power consumers, the environment and business management in order to clarify the benefits that research has for the electric power industry and the rest of society. The section below outlines the major research plans in these areas.

In order to remain a research institution that is beneficial for the electric power industry and society, we assess the value of our research activities to the electric power industry and society in terms of the following three perspectives in pursuing our research.

◆ **Management and mitigation of risk in the electric power industry**

We help to appropriately manage and mitigate risk in the electric power industry by assessing the impact that socio-economic changes and climate events have on the electric power industry and society in general, as well as the impact that the electric power industry has on society, and by offering technologies to counter these impacts.

◆ **Ensuring reliability and affordability of electric power supply**

As the environment surrounding the electric power industry changes with reforms to electric power systems and the large-scale introduction of renewable energy, CRIEPI will provide technical support that will facilitate the construction and operation of electric power facilities from power generation to power transmission and distribution as well as its appropriate maintenance and updates. We will contribute to ensuring a stable supply of inexpensive and highly reliable power.

◆ **Creation of new value in electricity and energy supply and demand**

We contribute to the creation of new value in next-generation electricity and energy supply and demand by identifying future issues for both electricity and energy supply and demand (use) and developing technology related to electricity networks needed for supply/demand, energy conservation and environmental harmony.

1. Nuclear power generation

CRIEPI particularly focuses on research to enhance the safety of light water reactors, an important issue shared by the electric power industry. Specifically, we reinforced our support for the resumption of operations at light water reactors and activities at the Nuclear Risk Research Center, established in fiscal 2014, and contributed to the countermeasures to improve safety conducted by electric power companies even more than regulations require. In addition, under the Nuclear Power Plant Maintenance Research Team, we will work on raising the sophistication of maintenance technology of light water reactors to ensure their safe and stable operation after plant operations are resumed. We will steadily pursue research on the quantitative assessment of radiation risk as well as research on nuclear fuel cycles and backend businesses.

Advancements in safety of light water reactors

Initiatives aimed at resumption of operations

- **Technical Assessment on Nuclear Power Plant Designs against External Natural Events:** We support the evaluation of natural external phenomena (earthquakes, tsunami, tornadoes, volcanic eruptions, etc.) and countermeasures taken by electric power companies for the resumption of operations at nuclear power reactors. For example, we will experimentally evaluate the impact of tornado missiles on nuclear power facilities and present technology aimed at countering this together with the validation results of specific methods. By doing so, we will clarify its adequateness in standards based on scientific evidence.

- **Development of Evaluation and Operation Method of the Reactor Containment Failure Prevention Function:** We will carry out tests on decontamination performance using filter vent testing devices on an actual scale with a view to evaluate the decontamination capacity of the FCVS (Filtered Containment Venting System), which prevent containment failure in the event of severe accidents. We will also propose the optimum method of operation of the FCVS.

- **Enhancement of the Severe Accident Analysis Technology and Evaluation of the Effectiveness of Nuclear Facilities Measures:** Using the severe accident analysis code, we will ascertain the effect of cooling countermeasures for nuclear reactor in the event of severe accidents, and evaluate the effectiveness of measures taken to improve safety. Moreover, we will evaluate the effectiveness of measures aimed at preventing severe accidents with spent fuel storage pools.

Establishment of probabilistic risk assessment (PRA) technology

- **Improvement of Internal Fire Mitigation Methodologies in Nuclear Facilities:** In order to improve the sophistication of fire hazard evaluation methods with the aim of mitigating the risk

of fires inside nuclear power facilities and improving structures in which fires would tend to spread, we will measure the level of oxygen dependence in the combustion velocity of pump and motor oil in the event of a fire, and will augment data on combustion characteristics using existing fire models.

- **Development of Evaluation Method of Phenomena for Enhancement of PRA Technology:** We will develop advanced methods to evaluate those complex phenomena such as seismic-induced internal flood or convection behavior in containment vessels that affect the progress of severe accidents. In addition, we will accumulate technical insights required to implement PRA, such as the frequencies of individual phenomena, and develop standard evaluation procedures.

- **Development of Cross-Cutting Issues Required for Nuclear Risk Management:** In order to identify and appropriately address potential nuclear risks, we will investigate risk management methods and frameworks in Japan and abroad, and develop databases for risk-informed applications and software to identify diverse risk profiles.

- **Enhancement of PRA Technology and Establishment of Risk Management Methodology:** With the aim of utilizing PRA in decision-making on nuclear safety in risk management, we will develop PRA methodology to evaluate the overlapping impacts of multiple external events such as earthquake with tsunami, as well as internal events such as component failures and human errors. Moreover, we will establish the parameters for the assessment of the various hazards considered in PRA.

Establishment of evaluation methods for low-frequency phenomena

- **Assessment of External Natural Hazards to Nuclear Facilities:** CRIEPI will establish methods for evaluating hazards related to the scale of the natural external phenomenon and the frequency of occurrence, which is essential in assessing the safety of nuclear power reactors. For example, we develop rational and highly accurate assessment methods for seismic activity in areas close to the epicenter from estimates of bedrock ground motion from detailed local surveys. In addition, we will develop methods for predicting ash fall taking into account the scale of eruptions and frequency with the aim of facilitating evaluations of volcanic activity hazards and volcanic eruption PRA.

- **Assessment of Fragility of Nuclear Facilities due to External Natural Events:** We will develop methods of evaluating tsunami hydrodynamic force and driftage collision force utilizing a tsunami and flood channel with the aim of assessing tsunami-resistant structures at nuclear power facilities. Moreover, we will use the **centrifugal vibrating table** (device with a centrifuge to which shaking test functions have been added) to examine realistic methods of evaluating

stability during earthquakes on foundation ground and nearby slopes that were proposed by CRIEPI.

Safe operation of light water reactors

Advances to safety technology for light water reactors

- **Improvement of Pipe Wall Thinning Evaluation and Water Chemistry Control in LWR:** We examine the accuracy of the FAC and LDI Prediction Software for Pipe Wall Thinning (FALSET), which enables rational management of the thinning of pipes in light water reactors, by using actual plant data on thinning, and reflect this in the Japan Society of Mechanical Engineers' code for pipe wall thinning management.

- **Improvement of Preventive Maintenance Technology for LWR Components and Pipings:** In order to rationalize maintenance of light water reactor components and piping and appropriately carry out inspections of pipes based on their importance in terms of safety, we will introduce equipment to measure leakage behavior when pipes fail in fiscal 2015, and begin evaluating the importance of piping by investigating liquid leakage behavior when pipes break

- **Improvement of Integrity Evaluation Method for Reactor Pressure Vessels:** We will propose embrittlement prediction equations for highly irradiated RPV steels by augmenting surveillance data and microstructure observation. We will introduce the equation to the Japan Electric Association's standards.

- **Improvement of Integrity Evaluation Method for Core Internals, Pipings and Other Components:** We will investigate the thermal aging behavior of cast stainless steels to facilitate thermal aging evaluation. This is one of major aging phenomenon to be considered in Aging Management Technical Evaluations every 10 years after 30 years of operation.

Radiation risk evaluations

- **Quantitative Evaluation of Low-Dose Radiation Risk and Reflection to Radiation Protection Systems:** We will apply the concept of risk as indicated by the minimum dose at which carcinogens from radiation exposure can be detected epidemiologically in the evaluation of impact on non-cancer diseases, primarily cardiovascular disease, and clarify the contribution of radiation exposure to cancer and non-cancer diseases with the aim of deepening society's understanding of the risk of low-dose radiation.

Establishment of nuclear fuel cycle technology

- **Development of Long-Term Storage Management Technologies for Spent Fuel:** In order to facilitate the practical use of concrete casks, which are more affordable compared to metal casks,

for spent fuel storage, we will confirm the effectiveness of technology preventing stress corrosion cracking (SCC) based on experimental evaluations. SCC is a key issue for metal canisters enclosed within casks.

- **Technology Development for Safety Improvement and Stable Operation of Reprocessing Plants:** We will use simulated liquid waste in experiments to clarify the mechanisms to form volatile Ru, which is one of the main factors in radioactivity released into the environment when highly concentrated liquid waste evaporates or dries and hardens in severe accidents occurring at reprocessing plants. We will develop technology to reduce the quantity of Ru discharged into the environment.

Support for radioactive waste disposal operations

- **Development and Systematization of Long-Term Safety Assessment Technologies for Radioactive Waste Disposal:** We will develop a method of evaluating with a high degree of accuracy the permeability of clay-type (bentonite) engineered barriers with waterproofing functions in order to evaluate the quality of engineered barriers used in near-surface pit disposal of Type 2 radioactive waste (low-level radioactive waste).

2. Thermal power generation

We place particular emphasis on research into technology facilitating the operation and preservation of existing thermal power plants. Specifically, we prioritize research on longevity evaluations of equipment used in locations with high temperatures—an urgent issue—and facility diagnostic technology. We also pursue research on improving the performance of smoke exhaust and drainage treatment facilities, and on expanding use of coal ash. We are also endeavoring to generate effective results in our research on natural disaster countermeasures at thermal power plants.

Ensuring reliability of existing thermal power plants

- **Development of Condition Diagnostic and Maintenance Management Technologies of Thermal Power Plants:** We are automating the development of a highly accurate model with machine characteristics based on operating data with the aim of improving the convenience of thermal efficiency analysis software (Energy Win), which supports the rational operation and preservation of thermal power plants.

- **Improvement of Remaining Life Assessment, Diagnosis and Maintenance of Thermal Power Plant Components:** We are building a heat cycle testing method needed for the life assessment of the delamination of thermal barrier coating on gas turbine blades in order to establish life assessment techniques for the parts of gas turbines through which hot gas passes.

Moreover, we are developing an analytical method to estimate the temperature distribution of internal cooling blades when the gas turbine's load changes.

- **Development of Life Assessment Technology for High Temperature Structural Components Made of High Chromium Steels in Thermal Power Plants:** In order to improve the accuracy of evaluations for the creep life of welded parts of components made of high chromium steel we will use the **Cs (spherical aberration coefficient)-corrected transmission electron microscope** installed in fiscal 2015 to carry out structure observations and analysis for the steels used at the power plants for long-term as well as fractured materials obtained in laboratory tests. This will clarify the damage factor determining the creep life of high chromium steel, which consists of various material substructures.

- **Development of Countermeasures for Biofouling and Jellyfish Invasion at Cooling Water Intake Structure of Coastal Power Plant:** We will use a flow-type testing apparatus simulating the cooling water systems of the coastal power plant to clarify the optimal chlorine injection method, taking into account changes in biofouling species flowing into the water intake and water quality. This is intended to ultimately develop effective and eco-friendly countermeasures for the prevention of biofouling on the cooling water system piping at electric power plants.

- **Development of Performance Degradation Assessment and Enhancement Methods for Thermal Power Civil Engineering and Building RC Structures:** We will evaluate the anti-corrosion performance of materials containing corrosion inhibitors on iron-reinforced concrete parts that are showing signs of aging, and examine its applicability, in order to extend the life of iron-reinforced concrete structures along the coast through rational maintenance, management and repairs.

- **Development of Technologies for Increasing Use of Coal Ash:** In the strength test required at shipment, we will establish a new testing method, API (Assessed Pozzolanic-activity Index), that enables a faster and more accurate assessment than the current JIS testing method by promoting chemical reactions involved in strength development. This is intended to increase the use of coal fly ash mixed into concrete as an additive (JIS fly ash).

Thermal technology to mitigate environmental load

- **Development of Maintenance and Improvement Technology of Environmental Facilities for Thermal Power Plants:** We will clarify the mechanisms of the de-NOx catalyst performance drop that occurs at coal-fired power plant through a detailed chemical analysis and numerical simulation. In addition, we will evaluate the long-term performance of the online system capable of monitoring selenium concentration in desulfurization wastewater, as well as a biochemical treatment system for selenium removal from desulfurization wastewater.

- **Development of Technologies to Reduce Environmental Burden from Thermal Power Plants:** In order to support the smooth commercial operation of an integrated gasification combined cycle (IGCC) plant and next-generation IGCC designs, we will analyze and evaluate the results of the demonstration tests and identify the expected improvement. In addition, we will conduct strength tests and structure observation of heat-resistant alloys expected to be used in Advanced Ultra-Supercritical (A-USC) power plants, and will develop methods of predicting damage and useful life in particular conditions.

- **Development of Biomass-Derived Power Generation Technology:** We will identify the impact of the characteristics of carbonized woody biomass on grindability, combustibility and environmental features when mixed with coal, and will evaluate applicability in operations at high mixing rate of carbonized woody biomass in coal-fired thermal power. This aims to promote the use of biomass co-combustion for the purpose of reducing CO_2 emissions at coal-fired thermal power plants.

Diversification of fossil fuels

- **Development of Advanced Technologies to Apply Unused Fuel Resource to Thermal Power Plants:** In order to support the introduction of low-combustible bituminous coal, which has not been used such as a fuel thus far, we will evaluate the grinding and combustion characteristics when the coal is blended with ordinary bituminous coal using our grinding and combustion test facilities. In addition, we will begin developing technology capable of detecting spontaneous combustion at an early stage through smell sensors when storing coal, such as highly combustible sub-bituminous coal.

Response to large-scale introduction of renewable energy

- **Load Following Capability Improvement of Thermal Power Plants:** Advanced Humid Air Turbine (AHAT) system is expected to achieve not only high thermal efficiency but also high flexibility for load and frequency changes. We will build a dynamic analysis model based on operating results of a 40MW-class test plant, and analyze the effects of load and frequency changes on the system.

Response to risk of disasters

- **Development of Extreme Weather Forecasting and Hazard Evaluation Methods for Electric Power Facilities:** In order to support the mitigation of damage to electric power facilities from weather and marine disasters and their early restoration, we will evaluate weather and marine hazards with high resolution using a long-term database of weather and marine phenomena with a 5 km mesh carried out every hour. For example, we will present a hazard map

for high waves and high tides in a format that is easy to use, helping to mitigate the damage caused by flooding to thermal power plants.

3. Hydroelectric power generation

CRIEPI engages in research that contributes to measures countering natural disasters such as torrential rains and seismic movement at dams and other hydroelectric power facilities. We also address research on the maintenance and management of existing hydroelectric power facilities accurately and at the appropriate time based on on-site needs.

Disaster prevention and maintenance and management for hydropower facilities

- **Development of Disaster Prevention and Maintenance Technologies for Hydropower Facilities:** In order to streamline preservation of aged hydropower facilities, we will identify the dynamic response characteristics of arch dams in the face of large-scale earthquakes, as well as develop a method for evaluating the anti-seismic performance of dam-gate piers. Moreover, we will develop a method of analyzing the movement of sediment in rivers and reservoirs to predict the flow of water, which changes as sediment built up in the dam is discharged, and the shape of the scour and sand accretions with a high degree of accuracy.

4. Renewable energy

CRIEPI utilizes its basic technology to carry out research on stabilization technology for backbone systems and power distribution systems compatible with the large-scale introduction of renewable energy, and also develops technology for the expanded introduction of biomass and geothermal power distribution, which is expected to generate stable output.

Stabilization of backbone power distribution networks compatible with large-volume introduction

- **Development of Supply-Demand Operation and Control Technology Using Energy Storage System:** 5. Electric power distribution (reference)
- **Development of Next Generation Power Distribution Network System:** 5. Electric power distribution (reference)
- **Development of Accurate Power Output Estimation and Forecast Techniques of Photovoltaic and Wind Power Generation:** 5. Electric power distribution (reference)

Expanded introduction of biomass and geothermal power generation

- **Development of Biomass-Derived Power Generation Technology:** 2. Thermal power generation (reference)

5. Electric power distribution

CRIEPI carries out research with an emphasis on technical issues to strengthen wide-area network operations and interconnection technology to preserve electric power distribution facilities, and contribute to measures to counter the aging of facilities.

We will strengthen research into power distribution systems under the Research Team for Advanced Management of Power Supply and Demand, set up in fiscal 2014, in accordance with the relevance for the demand side, and carry out research responding to changes on the supply side, such as the large-scale introduction of photovoltaic power.

Moreover, we emphasize research that contributes to effective natural disaster countermeasures for electric power distribution facilities. Specifically, we evaluate the risks to power transmission towers and electric substations from seismic movement, and research countermeasures for wind and snow damage.

Response to electricity system reform

- **Development of Support Technology for Widening System Operation and Reinforcing System Interconnection:** We will pursue activities on the premise that CRIEPI's Power System Analysis Tool (CPAT) users will increase in order to respond to the necessity for wider-area system operations as a result of stronger interconnections, and will contribute to the greater efficiency of wide-area system operation and planning. Generic simulation models of line-commutated AC/DC converters for modeling frequency converter stations and DC transmission systems and that of static Var compensators have been developed and implemented in the electromagnetic transient analysis program XTAP. With these generic models, complicated simulation problems related to power system interconnections occurring today can be solved in an efficient way.

- **Development of Techniques to Maintain Power System Stability under Steady-State and Emergency Conditions:** We will develop supply/demand simulation tools that can analyze the operations of the power generation resources and storage facilities under uncertain renewable energy output in order to respond appropriately to the risk of surplus power and insufficient regulation capacity as large volumes of renewable energy are introduced. This is intended to maintain the supply/demand balance under normal conditions. Using this simulation tool, we will identify issues in ensuring supply/demand balance as renewable energy is introduced.

- **Development of ICT Infrastructure Building Techniques Based on General-Purpose Communication Technology:** In order to build a low-cost, high-performing, highly reliable power system protection, monitoring and control system for widely connected networks, we will evaluate the performance of synchronization when IP telecommunications is used between substations and investigate applicability of security measures, such as certification and encryption, to the system by verification experiments.

Construction, maintenance and upgrades of substations and transmission lines

Advancing preservation technology for aged facilities

- **Diagnostic Technology for Overhead Transmission Facilities:** We will develop methods for predicting sea salt accumulation on the inner and outer surfaces of steel pipes in transmission towers based on the results of environmental measurements and exposure tests with the aim of establishing preventative maintenance and management methods for steel tower for power transmission. We will also develop methods capable of assessing the occurrence of corrosion in steel pipes for specific regions.

- **Diagnostic Technology for Underground Transmission Cable System:** We will evaluate the residual withstand voltage performance of 20–60kV CV cables that have been removed using insulating property testing facilities, and establish a method to measure the life of CV cables in accordance with the lying condition and the type of cable in order to make rational assessments about renewal for underground power transmission facilities.

- **Diagnostic Technology for Substation Equipment:** For rational maintenance and replacement of oil-immersed power transformers, we will develop evaluation methods for internal mechanical stress and their tolerance, which deteriorates as a result of thermal aging. Based on the developed method, a new evaluation method for residual life of oil-immersed power transformers will be proposed.

Support to streamline facility design and operate facilities

- **Solutions for Electromagnetic Compatibility and Electromagnetic Interference (EMC/EMI) Caused by HV Substations and Transmission Lines:** With the aim of developing a method for rationalized lightning protection and Electro-Magnetic Compatibility (EMC) design for power facilities with digital control systems, we will evaluate the electromagnetic field distribution and electromagnetic shield performance within the structure hit by lightning through a contracted model test. We will work to elaborate a method for predicting the effect of over-voltage and electromagnetic induction attributable to lightning on power facilities and equipment.

- **Evaluation and Validation of Washing Treatment for Low-Level PCB Contaminated Transformers:** As regards the heated, energized washing technology for PCB-contaminated equipment authorized by the Ministry of the Environment, in order to expand the applicable range of equipment to be washed (by type, capacity, PCB concentration, etc.), we will develop a PCB concentration prediction model that can estimate the appropriate number of times the wash oil should be replaced and the maximum concentration that can be washed.

Response to changes in supply form and demand-side changes

System stabilization on large-scale introduction of renewable energy

- **Development of Supply-Demand Operation and Control Technology Using Energy Storage System:** With a view to stabilizing systems by utilizing storage batteries compatible with the large-scale introduction of renewable energy and operating supply/demand economically, we will devise an affordable discharge and charge plan in the event that sodium and Sulphur batteries are installed in the distribution system as a power source for peak hours, and will examine the economic effect through actual system tests.

- **Development of Next Generation Power Distribution Network System:** In order to effectively evaluate countermeasures for voltage variations in power distribution systems, such as three-phase unbalances occurring when distributed power sources such as PV for households are connected, we will develop a system analysis model for distributed power sources and distribution equipment. We will also work to improve applicability on site by incorporating this in existing integrated analysis tools for power distribution networks.

- **Development of Power System Stabilization Technology in Trunk Transmission System Assuming High Penetration of Renewable Energy:** We will develop a mega-solar analysis model included in system analysis based on actual tests of 3-phase PCS (Power Conditioning Subsystem) for PV through power system simulators in order to evaluate the impact of the mass introduction of renewable energy on trunk systems when the power system fault has occurred.

- **Development of Accurate Power Output Estimation and Forecast Techniques of Photovoltaic and Wind Power Generation:** In order to accurately ascertain actual demand in the supply area when PV is penetrated on a large scale and administer supply/demand in a stable manner, we will work to improve the accuracy of a method to predict the amount of solar radiation in a few hours using satellite data, based on the results of evaluations of solar radiation in various regions and seasons using weather prediction and analysis systems. We will also develop a method to predict PV output within a few hours based on data on solar radiation measurements on the ground.

Advanced power distribution system technology adjustable to the variation of demand region

- **Power Quality Preservation and Enhancement for Distribution Systems with Advanced Customer Devices:** We will develop a static synchronous compensator (μSTATCOM) which is installed at the end of low-tension distribution lines to curb voltage gains due to PV and voltage drops caused by EV charging on the consumers. In addition, we examine the effect that μSTATCOM has in curbing voltage volatility using a simulated power distribution system through supply/demand coordination experimental facilities for low-voltage distribution systems.

Forming, maintaining and update power distribution facilities

- **Development of Evaluation Technology on Lightning Risk Management and Fault Current Countermeasures for Distribution Systems:** We will quantitatively evaluate the internal transient magnetic field triggered by malfunctions in smart meters when lightning strikes and will propose methods for evaluating the frequency of malfunctions caused by lightning with the aim of providing a rational countermeasure for lightning damage to high-functioning power distribution facilities and smart meters, which are spreading rapidly.

Response to disaster and human risks

- **Evaluation and Measures of Earthquake Disaster Risk on Thermal Power:** We will include a method for acquiring information on damage using risk assessment models and satellite images, taking into account the indirect damage such as tsunami flotsam and felled trees, in the earthquake, typhoon and damage estimation system (RAMP) that we developed and increase the system's sophistication, with the aim of utilizing it to recover quickly from such disasters.

- **Establishment of Protective Measure Technologies against Wind and Snow Damage of Overhead Transmission and Distribution Facilities:** In order to establish a handbook of snow damage countermeasures that will contribute to the identification of points that should be addressed and the selection of products to counter damage, we will continue operating nationwide local snow damage measurement systems, including the full-scale test facilities for snow-storm damage to overhead transmission lines in the Kushiro area. We will identify the weather conditions when snow damage occurs and verify the effect of snow damage countermeasures.

6. Services for power consumers

Under the special research team on next-generation electricity supply/demand management, we will strengthen our research into the demand side with the aim of improving customer convenience and satisfaction, looking not only at electricity supply, but also comprehensive energy services. Specifically, we will pursue research on more advanced supply/demand management and technology utilizing energy information.

Promotion of energy conservation and electrification and enhanced customer satisfaction

- **Assessment of the Value of Next-Generation Demand Management:** Towards clients' satisfaction by lowering electricity tariffs through power supply cost reduction via demand peak shifts, we continue to carry out demonstration studies of consumers' behavioral changes by information provision to stimulate power savings. Based on those results, we will examine effectiveness of those management methods for both households and commercial buildings.

- **Development and Evaluation of Advanced Heat Pumps:** We will evaluate the energy conservation performance of an industrial-use steam-generating heat pump and determine technical issues for actual operations. In addition, we will use the energy consumption analysis tool (ECEP) that we developed to analyze energy consumption at actual factories and compile information effective in promoting energy conservation and electrification with the aim of providing energy conservation and electrification solutions to the industrial and consumer sectors.

- **Research and Development for Electrification Promotion of the Transportation Sector:** We will assess the electric demand through the electrification in the transportation sector. In this research, a traffic simulator "EV-OLYENTOR" is applied to examine the detail operation condition of EV usage, and we will evaluate the future demand formation by EV charging at homes and offices. We will also develop a wireless power transfer setup using loss reduction techniques. These steps results will make the EV charging more convenient.

- **Development of Energy Information Utilization Technology:** We will analyze the mutual relationship between actual data on the movement of individual equipment in the consumer's home and the room environment (humidity, conditions in room, etc.) and data from smart meters. We will also develop technology to detect equipment malfunctions in advance and measurement techniques for equipment and living conditions (anomalous occurrences, etc.) that would be effective in monitoring the elderly and in home security systems. These efforts are aimed at creating new services that will improve customer satisfaction.

7. Environment

We engage in research responding to environmental policy combatting global warming. Moreover, we are pursuing research on technical issues to achieve an efficient environmental assessment.

Response to environmental policy and regulations

- **Scientifically and Economically Rational Scenarios to Reduce CO_2 Emissions:** We will carefully examine the relationship between the rise in temperature and cumulative CO_2 emissions indicated in the IPCC's Fifth Assessment Report and lay out the direction for

long-term environmental and energy strategy, including feasible adaptation measures, given prospects for the development and spread of the most recent knowledge on climate science and low-carbon technology.

Efficient environmental assessment

- **Development of Advanced and Efficient Impact Assessment Methods for Atmospheric Environment:** We will develop numerical models, as a substitute for wind tunnel experiences, for predictions of diffusion of low-stack LNG thermal exhaust gas and wind speed at coal storage yards affected by structures and topography with the aim of simplifying and speeding up environmental impact assessments. In addition, we will model the secondary formation process in exhaust gas plumes to assess the impact of power station's exhaust gas has on secondary air pollution in the surrounding area (such as PM2.5).

- **Development of Advanced and Efficient Impact Assessment Methods for Coastal Environment:** We will develop a three-dimensional prediction model for the dispersion of cold and warm water discharge, taking into account of the warm water recirculation and the coastal bathymetry, with the aim of corresponding environmental assessments in various site conditions of coastal power plants. Moreover, we will develop a method for prompt and efficient coastal environmental assessments, integrating the data assimilation technique and the observational data with the latest remote sensing, such as marine radars, drones and next-generation satellites.

- **Development of Efficient Impact Assessment Methods for Ecosystems:** We will develop an animal survey technique using sound information processing that makes labor-saving environmental assessments possible, with the aim of developing an efficient survey and environmental prediction method for land animals and plants and ecosystems in environmental assessments. We will also work on development of a portable three-dimensional measurement system for bird flight, and develop an efficient and highly accurate bird assessment method.

8. Business management

Towards establishing robust and flexible power supply systems under dramatically changing business environment such as the electricity system reform and the large-scale introduction of renewable energy, we will exam policy and institutional issues and thereby provide information useful for countermeasures undertaken by the power utility industry.

Analysis of energy and environmental policies

- **Issues in Institutional Design of the Electricity System Reform:** We will identify the issues in operating power transmission and distribution systems after legal unbundling following electricity system reform, as well as issues and key points in the capacity market and wholesale

electricity market, by which surplus capacity is procured via market mechanisms. We will also lay out the direction for institutional design to establish an appropriate business environment.

- **Socio-Economic Analysis of Nuclear Power Generation:** We will quantitatively evaluate nuclear power policies in a multi-faceted manner in terms of long-term energy supply and demand, power generation costs and environmental impact, taking into account socio-economic trends. Based on this, we will identify the necessary measures for better communication with local stakeholders so that nuclear power plant operators can earn the public trust.

- **Effects of Large Scale Introduction of Renewable Energy:** We will quantitatively identify the effect caused by the introduction of renewable energy and the additional costs of securing coordination capacity needed as a result of this introduction, and will evaluate the cost effectiveness by scale of introduction in order to design socio-economically rational systems.

- **Evaluation and Analysis of Climate Policy:** We will evaluate various measures and policies, such as voluntary actions by the industrial sectors to reduce emissions, promotion of energy conservation, the introduction of renewable energy, the development of technologies to mitigate and counter the impact on the climate, and environmental taxes and emission trading so that Japan's global warming countermeasures are cost effective.