IEA Hydro’s Annex-XI on
Renewal and Upgrading of Hydropower Plants

Tuesday, 14 July, 2015

Annex-XI Operating Agent
Takashi AKIYAMA
Roles of Hydropower in Japan

[ Features ]
- Low Cost
- Purely Domestic
- Clean
- Renewable
- Output Stability
- Instant Start

[ Roles ]
- Leader of Power Supply
- Main Player in the Low-carbon Society
- Provider of Ancillary Service

[ Changes ]
- Social needs
- Environmental Awareness
- Aging of Facilities
- Development of Technologies
## Progress of the Keage Hydropower Plant

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1868</td>
<td>Meiji Restoration</td>
</tr>
<tr>
<td>1881</td>
<td>First electric ramp</td>
</tr>
<tr>
<td>1912</td>
<td>COD of the Keage Plant (the first commercial power plant)</td>
</tr>
</tbody>
</table>

### Meiji Period:
- 1891: Pelton turbine
- 1897: 2 Pelton turbines (DC.)
- 1891: Power house at 2nd stage (existing)
- 1897: 20 Pelton turbines (DC. and AC.)
- 1897: 5 horizontal Francis turbines

### Taisho Period:
- 1912: 4800kW
- 1936: 5700kW

### Showa Period:
- 1926: 1760kW
- 1951: 4500kW
- 1979: 4500kW

### Heisei Period:
- 1989: 4500kW
- 2012: Present

### Environmentally-conscious development:
- 1951: Reorganization of power company
- 1979: Environmentally-conscious development
- 2012: Dam construction

### Large Dam:
- 1979: 4500kW

### Nuclear:
- 1951: Nuclear

### Oil shocks:
- 1979: Oil shocks

### Great East Japan Earthquake:
- 2011: Great East Japan Earthquake

### Fukushima No.1 crisis:
- 2011: Fukushima No.1 crisis

### Bubble burst:
- 1990: Bubble burst

### EXPO:
- 1979: EXPO

### COP3:
- 2000: COP3

### Beginning of hydropower development:
- 1868: Meiji Restoration
- 1891: Pelton turbine

### Dam construction:
- 1891: Dam construction
- 1897: Dam construction

### Large Dam:
- 1912: Large Dam
- 1951: Large Dam

### Environmentally-conscious development:
- 1979: Environmentally-conscious development
- 2012: Environmentally-conscious development

### Increasing the demand for drinking water:
- 1936: Increasing the demand for drinking water

### Utilizing the hydropower reflects God’s will:
- 1979: Utilizing the hydropower reflects God’s will.
There are growing concerns not only in Japan but also in other industrialized nations about the aging of hydropower facilities. There is a growing expectation for hydropower as a future key player in low-carbon society, as it represents a domestic, affordable and CO2-free source of energy. In the western world, small- or medium-sized pumped-storage hydropower is gaining renewed recognition as a load-balancing system to complement the intermittent wind and solar power. The taskforce is trying to gather as many good case histories as possible from around the world on the renewal and upgrading of existing hydropower plants. The information will be used to identify and convey effective policies, assistance measures and innovative technologies to the rest of the world.
## Overall Schedule

<table>
<thead>
<tr>
<th>Work Item</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agreeing on and starting the new ANNEX</td>
<td>24th</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Formulating a detailed activity plan</td>
<td></td>
<td></td>
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<tr>
<td>4. Activities</td>
<td></td>
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<td></td>
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<tr>
<td>1st Round Data Collection</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Screening Step</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd round Data Collection</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Analyzing and evaluating cases</td>
<td></td>
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<tr>
<td>Creating and Releasing reports</td>
<td></td>
<td></td>
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<tr>
<td>5. Workshops etc.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>6. ExCo meeting</td>
<td>24th</td>
<td>25th</td>
<td>26th</td>
<td>27th</td>
<td>28th</td>
<td>29th</td>
</tr>
</tbody>
</table>

*-*1: Sacramento, USA  *-*2: Washington, D.C., USA  *-*3: Bilbao, Spain  *-*4: Oslo, Norway  *-*5: Innsbruck, Austria  *-*6: Lake Como, Italy  *-*7: Portland, OR, USA
## Trigger Causes of Renewal and Upgrading

<table>
<thead>
<tr>
<th>Trigger Causes</th>
<th>Expected Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A)  Ageing and recurrence of malfunction</td>
<td>(a) Improvement of efficiency</td>
</tr>
<tr>
<td></td>
<td>(b) Improvement of durability and safety</td>
</tr>
<tr>
<td></td>
<td>(c) Cost reduction</td>
</tr>
<tr>
<td></td>
<td>(d) Easy maintenance with less labor</td>
</tr>
<tr>
<td>(B)  Environmental deterioration</td>
<td>(a) Sedimentation reduction</td>
</tr>
<tr>
<td></td>
<td>(b) Improvement of river environment</td>
</tr>
<tr>
<td>(C)  Needs for higher performance</td>
<td>(a) Addition of units, Expansion of power &amp; energy</td>
</tr>
<tr>
<td></td>
<td>(b) Role change of hydropower generation</td>
</tr>
<tr>
<td></td>
<td>Addition of new functions</td>
</tr>
<tr>
<td>(D)  Needs for safety improvement</td>
<td>(a) Improvement of safety</td>
</tr>
<tr>
<td>(E)  Needs due to third party factors</td>
<td>(a) Sustainable operation</td>
</tr>
<tr>
<td></td>
<td>Sometimes accompanied by power reduction</td>
</tr>
<tr>
<td>(F)  Accidents / Disasters</td>
<td>(a) Recovery</td>
</tr>
</tbody>
</table>
### Trend of Trigger Causes

<table>
<thead>
<tr>
<th>Trigger Cause</th>
<th>No. of Case</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A : Ageing, Malfunction</td>
<td>38</td>
<td>35.2</td>
</tr>
<tr>
<td>B : Environmental Deterioration</td>
<td>14</td>
<td>13.0</td>
</tr>
<tr>
<td>C : Higher Performance</td>
<td>31</td>
<td>28.7</td>
</tr>
<tr>
<td>D : Safety Improvement</td>
<td>11</td>
<td>10.2</td>
</tr>
<tr>
<td>E : Third Party Factor</td>
<td>9</td>
<td>8.3</td>
</tr>
<tr>
<td>F : Accidents / Disasters</td>
<td>5</td>
<td>4.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>108</strong></td>
<td></td>
</tr>
</tbody>
</table>
Summary Report
Category-1. Public Policies, Facilitation Measures, etc.

**Key Points**

a) **Energy policies** of Countries & States

b) **Investment incentives**;
   Feed-in-Tariff (FIT), Renewable Portfolio Standard (RPS)

c) **Integrated management** of water resources and river systems

d) **Asset management**, strategic asset management and Life cycle cost analysis

e) Projects justified by the **Non-monetary valuation of stabilizing unstable power system** in the up-coming low-carbon society

f) **Environmental conservation and improvement**
Summary Report

Key Points
a) Technological innovation & deployment expansion of Electro-Mechanical (E/M) equipment

b) System and Reliability Improvement in Protection & Control (P&C)

c) Technological innovation, deployment expansion and new materials used for Civil Engineering (C/E) works

d) Integration of other renewable energies into hydropower systems
<table>
<thead>
<tr>
<th>Key Point (Main)</th>
<th>No. of Case</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-a : Energy Policies</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>1-b : Investment Incentives, etc.</td>
<td>9</td>
<td>13.0</td>
</tr>
<tr>
<td>1-c : Water Resources / River Systems</td>
<td>5</td>
<td>7.2</td>
</tr>
<tr>
<td>1-d : Asset Management</td>
<td>18</td>
<td>26.1</td>
</tr>
<tr>
<td>1-e : Stabilizing</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>1-f : Environmental</td>
<td>6</td>
<td>8.7</td>
</tr>
<tr>
<td>2-a : E / M Technologies</td>
<td>13</td>
<td>18.8</td>
</tr>
<tr>
<td>2-b : P /C Technologies</td>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td>2-c : Civil / Building Tecnologies</td>
<td>13</td>
<td>18.8</td>
</tr>
<tr>
<td>2-d : Integration</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td></td>
</tr>
</tbody>
</table>
Cat.1-(a) (b) Energy Policies and Investment Incentives

**Cat.1-(a) Energy Policies of Countries & States**

- Energy policy and action plan to renewable energy in each country

  Every country, according to its own conditions, has defined specific energy policies with the aim of establishing sustainable development and a recycling society. Energy policies are heavily reflected in the individual measures and policies including supportive measures from the government, and have a big impact on business activities. This report is described with a focus on the information about renewable energy of each country’s energy policy.

**Cat.1-(b) Investment Incentives (FIT, RPS, Subsidies, Financial Assistance, Tax deductions)**

- Investment Incentives to achieve the target about renewable energy in each country
  
  - Measures, Status of the progress, Effect
  - How investment incentives ought to be
Cat.1-(c) Integrated management of water resources and river systems

Cat.1-(c)-1 River system integrated development

Hidaka River system:
4 water systems, 13 HPPs, Total Output 646MW

Kurobe River System:
1 water systems, 11 HPPs, Total Output 894MW

Kiso River system:
1 water systems, 33 HPPs, Total Output 1,074MW

Cat.1-(c)-2 Integrated Sediment Management in River Basin

Kurobe River System:
Flushing operation (Dashidaira Dam, Unazuki Dam)

Cat.1-(c)-3 Comprehensive development plan

Shin-Maruyama (Shin-Maruyama Dam): Dam Raising Project
Cat.1-(d) Asset management

Cat.1-(d) Asset management, strategic asset management and life-cycle cost analysis

Cat.1-(d)-1 Asset management using existing facilities
Shin-Kuronagi No. 2 HPP, Nagatono HPP, Ishioka #1 HPP

Cat.1-(d)-2 Asset management for improvement of safety
Ontake HPP

Cat.1-(d)-3 Asset management, Strategic asset management
Pirttikoski HPP, Poatina HPP, Tungatinah HPP, Hunsfos East HPP,
Kongsvinger HPP, Rendalen 2 HPP, Waitaki HPP

Cat.1-(d)-4 HAP (Hydropower Advanced Project)
Accelerate improvement and expansion of existing U.S. hydropower facilities to increase of annual generation and value
Flaming Gorge HPP, Us.7 Rhodhiss HPP
Cat.1-(e) Projects justified by the non-monetary valuation of stabilizing unstable power systems in the up-coming low-carbon society

Cat.1(e)-1 Power System Stabilization

Okutataragi Pumped storage HPP:
Refurbishment of Generator-Motor rotating speed from Fixed to Variable type
→ Securement of Frequency Control Ability

Estreito HPP: Added the Condenser Operation Function on existing conventional power station
**Cat.1-(f) Environmental Conservation and Improvement**

**Cat.1-(f)-1  Preservation for rare birds**  
Okutadami, Ootori

**Cat.1-(f)-2  Countermeasures for sedimentation and muddy water**  
Okuyoshino HPP, Mimikawa River System, Nishi-Yosino No.1, No.2 HPP

**Cat.1-(f)-3  Preservation for fishes**  
Shin-Takatsuo HPP, North Fork Skokomish HPP, Embretsufoss HPP

**Cat.1-(f)-4  Conservation of landscape and cultural assets**  
Shin-Takatsuo HPP, Rånåsfos Ⅲ HPP

**Cat.1-(f)-5  3R methods (Reuse, Recycle, Reduce) for industrial waste**  
Toyomi HPP

**Cat.1-(f)-6  Measures for social environment**  
Benmore HPP
Cat.2-(a)  Innovation and expansion of E/M equipment

Cat.2-(a)  Technological innovation & deployment expansion of electro-mechanical (E/M) equipment

Cat.2-(a)-1  Upgrade of output and power generation under restricted condition in discharge, head and location

Toyomi HPP, Doi HPP, Minakata HPP, Kamishiiba HPP, Tagokura HPP, Sisteron HPP

Cat.2-(a)-2  Facilities renewal to improve maintainability

Himekawa No.2 HPP, Estreito HPP, Kamishiiba HPP, Shin-Nogawa No.1 HPP, Hemsil 2 HPP, Cheoah HPP

Cat.2-(a)-3  Higher Performance of Hydropower by using Environmental Flow from a Dam

Hourì No. 2 HPP, Okudatami-Ootori HPP

Cat.2-(a)-4  Upgrade of facilities by reusing existing embedded steel structures in concrete

Tagokura HPP, Hol 1 HPP

Cat.2-(a)-5  Upgrade of the turbines which increase the design discharge within range of the vested water right

Rånåsfos III HPP
Cat.2-(b) System and Reliability Improvements in Protection & Control

Cat.2-(b)-1 Renewal of the conventional HPP control system
- Poatina HPP
- Tungatinah HPP

Cat.2-(b)-2 Upgrade of the pumped storage power plant control system
- Shiroyama HPP
- Ookawachi HPP

Cat.2-(b)-3 Constant flow system applied on a standardized package type water turbine
- Kagehira HPP
Cat.2-(c) Innovation and expansion of civil works

Cat.2-(c) Technological innovation, deployment expansion and new materials used for civil and building works

Cat.2-(c)-1 Upgrading of Dam function under Operation
Mimikawa River System

Cat.2-(c)-2 Earthquake resistance technologies
Kawaguchi HPP, Okizumi HPP

Cat.2-(c)-3 Remodeling of Existing Intake Weir and Facilities
Suikawa HPP, Kawabegawa No. 1 HPP

Cat.2-(c)-4 Application of New Materials for Penstock
Yusuhara HPP, Hanakawa HPP

Cat.2-(c)-5 Re-use of Existing Facilities and/or Equipment
Shin-Kuronagi No.2 HPP, Shin-Onagatani No.1 HPP, Taishakugawa Dam, Hanakawa HPP
Cat.2-(d) Integration of other renewable energies into hydropower systems

Togagawa No.2 HPP:
Solar power (84W × 4)
Wind power (1,000W × 1)
Battery (12V × 108Ah × 8)
Thank you for your attention!