Annex-XV
Current Approaches on Asset Management in USA, Canada, Japan
アメリカ、カナダ、日本におけるアセットマネジメントに対する現在の取組み
and
Case Histories for “Decision-making for Maintenance Works and Upgrading of Hydro Facilities”
水力発電設備の保守業務と増強に関する意思決定」事例収集結果

4th Feb.2019

Annex-XV OA 執行責任者
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3. Idea / Concept of future case analysis
1. Current Approaches on Asset Management in USA, Canada, Japan

1.1 Results of Questionnaire Survey in Japan

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(1) General Information

● Surveyed company
  ✓ Total : 25 Nos.
    • Public-state or Municipal : 19 Nos.
    • Private-listed : 6 Nos.

● Overall Capacity
  • Public-state or Municipal : 11 ～ 355 MW
  • Private-listed : 2,446 ～ 9,871 MW

● Number of Hydro Plants
  • Public-state or Municipal : 1 ～ 32 plants
  • Private-listed : 61 ～ 209 plants

● Number of Hydro Units
  • Public-state or Municipal : 1 ～ 37 units
  • Private-listed : 111 ～ 311 units

● Average age
  • Public-state or Municipal : 33 ～ 62 years
  • Private-listed : 44 ～ 77 years

● Age Range
  • Public-state or Municipal : 52 ～ 93 years
  • Private-listed : 64 ～ 127 years

✓ The oldest hydropower plant has been in operation for 127 years.
✓ Each company owns at least one plant with more than 52 years old.
## Decision-making Drivers

<table>
<thead>
<tr>
<th>Decision-making Drivers</th>
<th>Rating</th>
<th>Number of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meet Regulatory Requirements/Compliance (a)</td>
<td>a</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Ensure Safety, Manage Social and Environmental Issues (b)</td>
<td>b</td>
<td>1 1 4 18</td>
</tr>
<tr>
<td>Meet Electricity Market Requirements (c)</td>
<td>c</td>
<td>12 4 5 1</td>
</tr>
<tr>
<td>Manage Asset Risk (d)</td>
<td>d</td>
<td>1 5 17 1</td>
</tr>
<tr>
<td>Maintain Asset Value (including production levels) (e)</td>
<td>e</td>
<td>6 17 1</td>
</tr>
<tr>
<td>Increase Asset Value (f)</td>
<td>f</td>
<td>2 6 11 5</td>
</tr>
<tr>
<td>Other</td>
<td>g</td>
<td></td>
</tr>
</tbody>
</table>

### Description:

#### Rating: Level of Importance

1. **Not considered under normal circumstances**
2. **Modest, of limited importance overall or only considered for a few hydro plants**
3. **Generally important, or highly important for a few hydro plants**
4. **Highly important across the portfolio (of hydro plants), drives major decisions**
5. **Fundamental across the portfolio (of hydro plants), decisions must address this issue**

- **Meet Regulatory Requirements/Compliance (a)**
  - These are considered as “fundamental across the portfolio, decision must address this issue” by most of the companies.

- **Ensure Safety, Manage Social and Environmental Issues (b)**
  - The level of importance is considered to be the highest by many companies.

- **Meet Electricity Market Requirements (c)**
  - Meet Electricity Market Requirements are not considered under normal circumstances by 50% of the companies.

- **Manage Asset Risk (d) and Maintain Asset Value (e)**
  - These are considered as “highly important across the portfolio, drivers major decisions” by many companies.

- **Increase Asset Value (f)**
  - It is considered as “generally important, or highly important for a few hydro plants” by many companies.
### (3) Overall Asset Management (AM) Process

<table>
<thead>
<tr>
<th>Level of Development</th>
<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>No AM process in place</td>
<td>a</td>
</tr>
<tr>
<td>Considering development of a AM Process</td>
<td>b</td>
</tr>
<tr>
<td>Committed, AM process designed, but not yet implemented</td>
<td>c</td>
</tr>
<tr>
<td>AM Process partially Implemented</td>
<td>d 3</td>
</tr>
<tr>
<td>AM Process fully implemented</td>
<td>e 205</td>
</tr>
<tr>
<td>AM Process fully implemented, with external review</td>
<td>f 421</td>
</tr>
<tr>
<td>Annual Strategic Asset Plan</td>
<td>g 241</td>
</tr>
<tr>
<td>ISO Registered (or similar)</td>
<td>h 25</td>
</tr>
</tbody>
</table>

#### Description;

- a - Reviewing and understanding the AM process
- b - Decision made to embrace AM process, with design to meet company requirements
- c - Some components completed
- d - Processes in place and followed
- e - AM Process reviewed by audit or formal process

#### Number of responses:

- a - Yes: 0, None: 28
- b - Yes: 0, None: 28
- c - Yes: 0, None: 28
- d - Yes: 20, None: 5
- e - Yes: 21, None: 7
- f - Yes: 24, None: 1
- g - Yes: 21, None: 7
- h - Yes: 25, None: 0

### AM Process (a)～(f)

- AM process is implemented partially or fully by most of the companies.
- AM process is implemented based on the safety regulations etc. under Article 42 of the Electricity Business Act.

### Annual Strategic Asset Plan (g)

- Some strategic asset plans are prepared by many companies, e.g.
  - Medium to long term maintenance plan for 5-15 years.
  - Annual maintenance plan (1 year)
  - Profit plan (1 year) , etc.

### ISO Registered (h)

- No company has registered AM process as ISO.
(4) Information on AM processes

(AM Process Component (a)～(g))

- All of components are considered in their AM Process by most of the companies.
- Condition Based Maintenance (CBM), Risk Based Maintenance (RBM) or Time Based Maintenance (TBM) is introduced by several companies. Usage situation is as follows:

### AM Process Component Check

<table>
<thead>
<tr>
<th>AM Process Component</th>
<th>Check</th>
<th>Yes</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issues</td>
<td>a</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Risks</td>
<td>b</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Issue and risk assesment</td>
<td>c</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Prioritization</td>
<td>d</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>e</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Approvals</td>
<td>f</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Implementation</td>
<td>g</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

Description;

a. Is there a formal process to identify equipment or system issues?
b. Is there a formal process to identify equipment or system risks?
c. Is there a formal process to assess issues and risks?
d. Is there a formal process to prioritize issues and risks?
e. Is there a formal process to determine appropriate levels of equipment or system treatment?
f. Is there a formal process to obtain approvals for selected treatments in terms of costs and timing?
g. Is there a formal process to deliver projects?

#### Usage situation of CBM, RBM or TBM

<table>
<thead>
<tr>
<th></th>
<th>Equipment</th>
<th>Assessment</th>
<th>Prioritization</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBM</td>
<td>for Civil</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>for Electro-mechanical</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>RBM</td>
<td>for Civil</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>TBM</td>
<td>for Electro-mechanical</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

CBM: Condition Based Maintenance  
RBM: Risk Based Maintenance  
TBM: Time Based Maintenance
(5) Information on AM processes at Asset Level

<table>
<thead>
<tr>
<th>AM Process Support</th>
<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset Plans at Hydro plant Level</td>
<td>a 24</td>
</tr>
<tr>
<td>Asset Type Plan</td>
<td>b 24</td>
</tr>
<tr>
<td>Technical support (trouble shooting and diagnostics)</td>
<td>c 24</td>
</tr>
<tr>
<td>Engineering design</td>
<td>d 24</td>
</tr>
<tr>
<td>Project Management</td>
<td>e 24</td>
</tr>
<tr>
<td>Implementation support for major works</td>
<td>f 24</td>
</tr>
</tbody>
</table>

Description:

- **Asset Plans at Hydro plant level (a)**
  - Investigation plan for each hydro plant is prepared based on the internal regulation about investigation details of each equipment by most of the companies.

- **Asset Type Plan (b)**
  - Investigation details of each equipment are stipulated in the internal regulations by most of the companies.

- **Technical support, Engineering design, Project Management and Implementation support for major works (c~f)**
  - These are provided by in-house resource or associated companies. But, some cases are provided from external resources.
(6) Information on AM Component and Strategy

<table>
<thead>
<tr>
<th>AM Component or Strategy</th>
<th>Check</th>
<th>Number of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio AM System (e.g. C55)</td>
<td>a</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Condition Assessment Software (e.g. HydroAmp)</td>
<td>b</td>
<td>3 1 1 19</td>
</tr>
<tr>
<td>Performance Software</td>
<td>c</td>
<td>1 1 1 19</td>
</tr>
<tr>
<td>Use of Key Performance Indicators (KPI)</td>
<td>d</td>
<td>2 1 20</td>
</tr>
<tr>
<td>Plant Intelligence or diagnostics system</td>
<td>e</td>
<td>3 1 1 19</td>
</tr>
<tr>
<td>Maintenance Management System (e.g. SAP, Maximo)</td>
<td>f</td>
<td>4 2 17</td>
</tr>
<tr>
<td>Risk Assessment Software or System</td>
<td>g</td>
<td>1 1 19</td>
</tr>
<tr>
<td>Others</td>
<td>h</td>
<td>19</td>
</tr>
</tbody>
</table>

Greatly affected by the answer from public-state or municipal company

- **AM Component or Strategy (a)~(h)**
  - Commercially supplied software or system has not been incorporated. Many companies have various in-house software and system.
  - Almost all companies have the following in-house system:
    - Fixed asset ledger (asset information such as acquisition and retirement of assets)
    - Facility control ledger (construction / work history information for each facility / equipment)
    - Construction history register (contract date, construction period, contractor, overview, etc.)
  - In most of the companies, “Risk Assessment Software or System” has not been incorporated.
1.2 Results of Site Visit in USA and Canada

(1) General Information
(2) Outline of each Utility
(3) Feature of Hydropower Utilities in USA and Canada
(4) Findings of Approaches for Asset Management
(1) General Information

- Period: Jul.29.2018 ~ Aug.12.2018
- Countries: USA & CA
- Visited Utilities:
  ① Copper Leaf Co., ② Fortis BC, ③ Snohomish Country PUD, ④ Reclamation Office Idaho, ⑤ Tacoma Power, ⑥ Ontario Power Gen., ⑦ CEATI, ⑧ NY Power Authority

- Hearing issues
  - Term of AM Introduction
  - Maintenance Manual
  - Data Collecting of Structures & Electric-Mechanical Equipment
  - How to find Problem
  - Phenomena for Decision-making
  - How to analyze problem and Phenomena
  - Risk management
  - Decision-making method
## (2) Outline of each Utility

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Classification</strong></td>
<td>Private Co.</td>
<td>City Public Utility</td>
<td>City Public Utility</td>
<td>USA Government</td>
<td>State Public Utility</td>
<td>State Public Utility</td>
</tr>
<tr>
<td><strong>History</strong></td>
<td>Established in 1897</td>
<td>City acquired light &amp; water company in 1893</td>
<td>Established in 1936</td>
<td>Operation started in 1949</td>
<td>Decided to establish by Congress in 1902</td>
<td>Signed by President in 1931</td>
</tr>
<tr>
<td><strong>Customer</strong></td>
<td>111,500+48,500</td>
<td>175,870</td>
<td>350,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Supplying Area</strong></td>
<td>Canada</td>
<td>USA</td>
<td>USA</td>
<td>USA</td>
<td>USA</td>
<td>Canada</td>
</tr>
<tr>
<td></td>
<td>Middle South of British Columbia State</td>
<td>Tacoma, University Place, Fircrest, Fife in Washington State</td>
<td>Snohomish, Camano Island in Washington State</td>
<td></td>
<td>New York State</td>
<td>Ontario State</td>
</tr>
<tr>
<td><strong>Line</strong></td>
<td>about 7,200 km</td>
<td></td>
<td></td>
<td></td>
<td>2,400km (Trans.)</td>
<td></td>
</tr>
<tr>
<td><strong>Hydro Asset</strong></td>
<td>The Kootenay Riv. (4 Stations) 223MW Walden North 16MW Others 599MW Total 838 MW</td>
<td>MOSSYROCK DAM 300MW MAYFIELD DAM 162MW ALDER DAM 50MW LAGRANDE DAM 64MW WYNOOCHEE RIVER PROJECT 10.8MW Total 586.8 MW</td>
<td>Jackson 48MW Calligan Creek 6MW Hancock Creek 6MW Woods Creek 0.65MW Youngs Creek 7.5MW Packwood 2MW Total 70MW (7% of electricity supply)</td>
<td>Pacific North West 10 Stations Total 7,463 MW Including Grand Coulee P/S 6,735 MW Columbia River 31 Stations</td>
<td>Niagara 2,441 MW ST, Lawewncce 800MW Belenheim PSP 1,160 MW Small Hydro 10MW Total 4,411 MW</td>
<td>Sir Adam Beck 1,997MW Des Joachime Generating Station 429MW Sir Adam Beck Pump GS 174MW Otto Holden Generating Station 243MW 65 Stations Total 7,438MW</td>
</tr>
<tr>
<td><strong>Asset except Hydro</strong></td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>LNG 1,096 MW</td>
<td>Nuclear 6,606MW Thermal 2,458MW Biomass 205MW Wind 7MW Total 9,826 MW</td>
</tr>
<tr>
<td><strong>Raised Electricity</strong></td>
<td>Bonneville Power Administration 81%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Supply</strong></td>
<td>About 1,000MW</td>
<td></td>
<td></td>
<td></td>
<td>5,507MW</td>
<td>17,264MW</td>
</tr>
</tbody>
</table>

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**Note:**
- LNG: Natural Gas
- Nuclear, Thermal, and Biomass are forms of energy production.
- Wind power is a renewable energy source.
- Total 9,826 MW is the combined capacity from various energy sources.
(3) Feature of Hydropower Utilities in USA and Canada

- There are a variety of hydropower utilities whose number of hydropower assets varies from a few to so many with not only hydropower assets but also thermal power and nuclear assets, which means there are some differences for engagement with asset management between the utilities.
- In Canada, regulation for hydropower plants is different by each state.
- Authorities’ regulation role sharing for Hydropower structures in USA is shown in the figure below.
(4) Findings of Approaches for Asset Management

a. General

- **Approaches for AM**
  - Private Utility is nervous for regulation authority’s instructions, and has higher consciousness for AM than public utility. (Fortis BC)
  - The larger scale of owned assets, the stronger its AM system is. (USBR, NYPA, OPG)
  - AM is mainly aimed for electric-mechanical equipment. Data measurement management is not so important for civil structures (especially, dams).

- **AM for structures by utility**
  - Authorities’ regulation role sharing for Hydropower structures in USA is as the previous page.
  - Some utilities are entrusted for dam operation and maintenance.
b. Practice

■ OM manual preparation
  • CEATI and OEM are referred at manual preparation stage. (Fortis BC)
    CEATI: The Centre for Energy Advancement through Technological Innovation
    OEM: Original Equipment Manufacturer
  • Measurement of structure is compliant to regulation authority manual. (FERC)

■ Data measurement
  • The present newest style of data collection is based on IOT. (NYPA)

■ Findings for Practice on OM
  • Abnormal data detection is mainly based on data measurement and check list.
  • For check list storage, tablets are utilized for data input on software such as MAPCON and EXCEL.
  • Utilization of Packaged Software
    • SAP and IBM MAXIMO are utilized for measured data collection.
    • Value Based management is adopted for some software as a method of AM.
    • SATN is utilized to make Assess Tree.
    • C55 is utilized for decision-making by portfolio optimization based NPV method.

■ Decision-making and AM
  • Utility whose AM system is almost completed recognizes that the new hydropower development era has been already finished, and they put importance on AM. (US Bureau of Reclamation Idaho, New York Power Authority)
1.3 Summary

### Japan
- The following matters are regarded as important as decision-making factors:
  - Meet Regulatory Requirements / Compliance
  - Ensure Safety, Manage Social and Environmental Issues
- AM process is implemented partially or fully by most of the companies.
- Some strategic asset plans are incorporated. e.g. Medium to long term maintenance plan for 5-15 years, Annual maintenance plan (1 year), Profit plan (1 year)
- Compliance with regulations is the basis of quality management.
- All of components (issues, risks, issue and risk management, prioritization, treatment, approvals, implementation) are considered in AM Process.
- Condition Based Maintenance (CBM), Risk Based Maintenance (RBM), Time Based Maintenance (TBM) are introduced.
- Technical support, Engineering design, Project Management and Implementation support are basically provided by in-house resource or associated companies.
- In-house software and system are used.

### USA and Canada
- Relation between owned asset and AM practice contents is as follows:

<table>
<thead>
<tr>
<th>AM Practice Contents</th>
<th>Owned assets scale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>small</td>
</tr>
<tr>
<td>OM manual</td>
<td>☐</td>
</tr>
<tr>
<td>Check list</td>
<td>☐</td>
</tr>
<tr>
<td>Data measurement</td>
<td>☐</td>
</tr>
<tr>
<td>Engineering Center</td>
<td>☐</td>
</tr>
<tr>
<td>Data storage center</td>
<td>☐</td>
</tr>
</tbody>
</table>

- OM manual, Check list, and Data measurement are essential in AM.
- The larger owned assets scale becomes, the higher the needs to study cause of abnormal value of data technically becomes. Therefore, organization such as Engineering Center is required.
- If the scale of owned assets becomes more larger, it is necessary to process big data. Therefore organization such as Data Storage Center to collect big data unitarily in one place is required.
- In many utilities, decision-making is executed in AM division.
2. Case Histories for “Decision-making for Maintenance Works and Upgrading of Hydro Facilities”

2.1 Case Histories in Japan

(1) Asset Management Methodology in Japan
(2) Collection and Analysis of Case Histories
(3) Environment surrounding Maintenance Works of Hydro Facilities in Japan
(4) Trigger, Decision Making and Risk Management
(1) Asset Management Methodology in Japan

Daily Operation & Maintenance
- Periodical Inspection
  - Visually
  - Measurement
- Periodical Maintenance

Trigger Phenomenon
- Aging Deterioration
  (Renewal & Upgrading of T/G, Improvement of Civil Facilities, Abolition)
- Disaster Recovery
  (Flood & Heavy Rain, Earthquake, Public Safety)
- Social Demand
  (Environment, Sedimentation, Flood Control, Demand from Local Community)
- Efficiency Improvement & Operation Review
  (Increase Revenue, Labor Saving of Management, Operational Change)
- Effective Utilization of Water Resources
  (River Maintenance Flow Facilities, Existing Hydropower Facilities, Others)

Risk
- Risk Management
  - Acceptance
  - Transfer
  - Decrease
  - Avoidance

Countermeasures
- Maintenance & Repair
- Renewal & Upgrading
- Refurbishment
- Expansion
- Redevelopment
- Abolition

Decision-making

Cost
- Deformation
- Abnormal Value

Benefit

Periodical Inspection
- Visually
- Measurement
- Periodical Maintenance
(2) Collection and Analysis of Case Histories

a. Data Collection

• 193 case histories in Japan are extracted in total.

b. Decision-making and its content

<table>
<thead>
<tr>
<th>Options</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance &amp; Repair</td>
<td>“Maintenance &amp; Repair” of main structures and facilities of a power plant or its ancillary facilities.</td>
</tr>
<tr>
<td>Renewal &amp; Upgrading</td>
<td>“Renewal &amp; Upgrading” of main structures and facilities of a power plant or its ancillary facilities.</td>
</tr>
<tr>
<td>Refurbishment</td>
<td>“Refurbishment” of main structures and facilities of a power plant or its ancillary facilities required from a change of surrounding social and natural environment.</td>
</tr>
<tr>
<td>Expansion</td>
<td>“Expansion” of main structures and facilities of a power plant for a power business opportunity created from a change of situation of power demand &amp; supply or power policy.</td>
</tr>
<tr>
<td>Redevelopment</td>
<td>“Redevelopment” of a power plant with large-scale construction works due to a development of another project or disaster.</td>
</tr>
<tr>
<td>Abolition</td>
<td>“Abolition” of a power plant.</td>
</tr>
</tbody>
</table>

(Note) Main Structures: Dam, Intake, Headrace, Tank, Pressure Tunnel, Powerhouse, Foundation of Machines, Tailrace, Outlet Facilities: Electrical Equipment (Turbine, Generator), Mechanical Equipment (In-house Crane, Gate, Screen, Penstock), Ancillary Facility: The Others

(c) Risk Management and its content

<table>
<thead>
<tr>
<th>Options</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Avoidance</td>
<td>Includes not acting on risk itself, or withdrawing from a risky state.</td>
</tr>
<tr>
<td>Decrease</td>
<td>Includes reducing the probability of occurrence of risk or magnitude of influence or both</td>
</tr>
<tr>
<td>Transfer</td>
<td>Various insurance, etc.</td>
</tr>
<tr>
<td>Acceptance</td>
<td>Active retention (reserves, funding, etc.), passive retention (not taking any action after recognizeing it, unrecognizable, etc.)</td>
</tr>
<tr>
<td>No</td>
<td>Other than risk management</td>
</tr>
</tbody>
</table>
(3) Environment surrounding Maintenance Works of Hydro Facilities in Japan

- Maintenance and Upgrading of various facilities are carried out in order to improve the asset value of hydropower plant, but the triggers are not solely dependent but are often influenced and closely related to each other. For implementation, power utilities are making decisions after analyzing and evaluating a plurality of triggers.

- As a primary arrangement, collected cases are classified into five main triggers and organized as shown in the figure.
## (4) Trigger, Decision Making and Risk Management

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Decision Making</th>
<th>Risk Management</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A1</td>
<td>A2</td>
</tr>
<tr>
<td>1. Aging Deterioration</td>
<td>14</td>
<td>35</td>
</tr>
<tr>
<td>(1) R&amp;U of Turbine and Generators</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>(2) Improvement of Civil Facilities</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>(3) Abolition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Disaster Recovery</td>
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<tr>
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<td>(2) Sedimentation</td>
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<td>(3) Flood Control</td>
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<td>(4) Demand from Local Community</td>
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<td>(1) Increase Revenue</td>
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<td>(2) Labor Saving of Management</td>
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<td>(3) Operational Change</td>
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<td>(3) The Others</td>
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**Remarks**
- **Decision Making**
- **Risk Management**
# 2.2 Case Histories in USA, Canada and the others

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<th>Country</th>
<th>Annex-XI</th>
<th>Hydro 2018</th>
<th>Site Vit</th>
<th>Sub total</th>
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<tr>
<td><strong>Others (3)</strong></td>
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<td>Total</td>
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<td>15</td>
<td>29</td>
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</table>
## 2.3 Trends of collected Case Histories

### a. Relation between Trigger and Decision Making

#### Trends in case of Japan
- Overall, "Refurbishment" is the largest, followed by "Redevelopment" and "Renewal & Upgrading".
- Ageing Deterioration: "Renewal & Upgrading" is the largest.
- Disaster Recovery: "Refurbishment" is the largest.
- Social Demand: Occupied by "Redevelopment" and "Refurbishment".
- Efficiency Improvement & OR: Mostly "Refurbishment".
- Effective Utilization of WR: Redevelopment is the largest.

#### Trends in case of USA, CA and the others
- Many of the collected cases are classified as "aging deterioration". There are few cases of "Disaster Recovery" and "Efficiency Improvement & Operation Review".
- Overall, "Renewal & Upgrading" is the largest, followed by "Refurbishment" and "Maintenance & Repair".

<table>
<thead>
<tr>
<th>Trigger / Decision-making</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
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</tbody>
</table>

Remarks
b. Relation between Trigger and Risk Management

**Trends in case of Japan**
- Overall, “Avoidance” is the largest.
- Aging Deterioration, Social Demand and Efficiency Improvement: “Avoidance” is the largest.
- Disaster Recovery: “Decrease” is the largest.
- Effective Utilization of Water Resources: organized as out of risk management target.

**Trends in case of USA, CA and the others**
- Overall, “Decrease” is larger than ”Avoidance”.
- Aging Deterioration and Social Demand: “Decrease” is the largest.
- Effective Utilization of Water Resources: organized as out of risk management target.

### Trigger / Risk Management

<table>
<thead>
<tr>
<th>Trigger / Risk Management</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
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</table>

**Remarks**
B1: Avoidance, B2: Decrease, B3: Transfer, B4: Acceptance, B5: -

### Trigger and Risk Management (Japan)

### Trigger and Risk Management (USA&CA, Annex-11, Hydro2018)
3. Idea / Concept of future case analysis

- **Value of Hydropower**
  - Base (kWh)
  - Peak supply (kW)
  - Ancillary Facilities have been improved accordingly.

- **Value of River Water**
  - Preventive maintenance against disaster Power
  - Flood Control and Environmental Conservation

- **Keyword of Decision-making for Maintenance Works & Upgrading of Hydro Utilities in Japan**
  - Compliance
  - Preventive Maintenance
    - Disaster risk reduction measures
    - Cooperation for flood control
    - Measures against turbid water
    - Public safety, etc.
Thank you for your attention.