



THE INTERNATIONAL ENERGY AGENCY TECHNOLOGY
COLLABORATION PROGRAMME ON HYDROPOWER

IEA Hydropower

Annex XVI Task-4 R&Is found in good practices by Task-2

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JEPIC



Scope of Case Histories

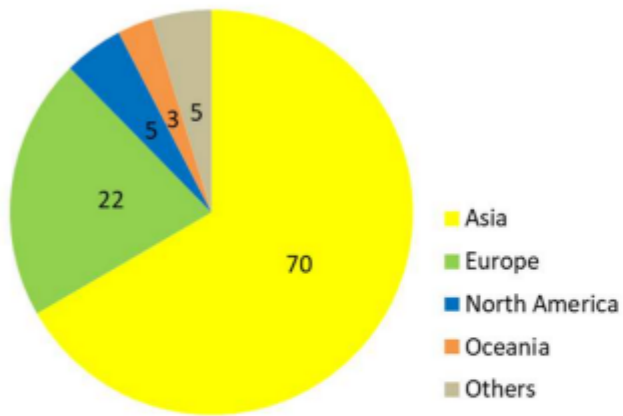
- ▶ Type of Projects
 - i. Renewal and upgrading of existing facilities
 - ii. Expansion and redevelopment of existing facilities
 - iii. Operational improvement of existing hydropower plant
- ▶ Requirements for HUHOs
 - A) Development of untapped potential
 - B) **Technical innovation/ advancement**
 - C) Response to the market/ social needs

Good Practices of “B)” are mainly abstracted for Task-4.

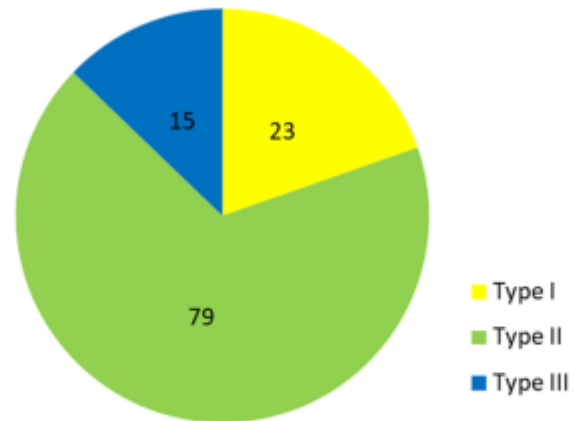


Status of case history study

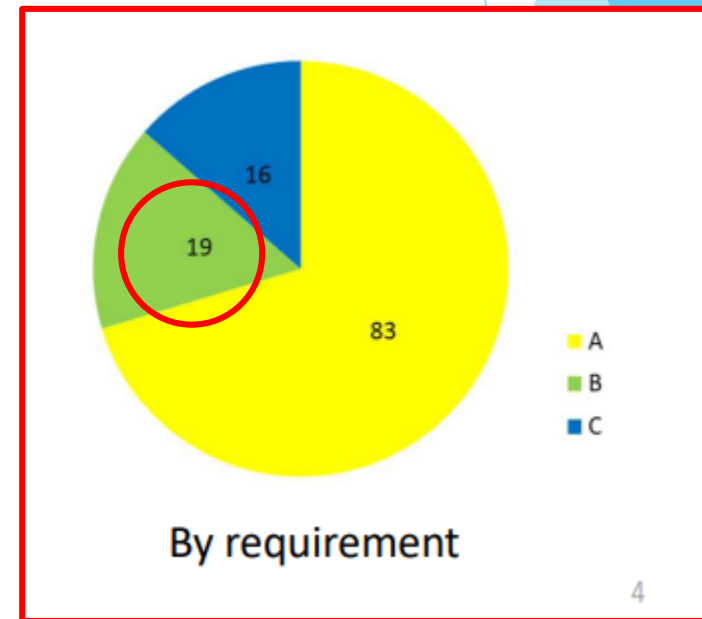
- ▶ Based on the project type and the requirements for HUHOs
- ▶ Source: Annex XI, Annex XV and other literature
- ▶ 105 case histories for HUHOs have been collected as of April 2021.



By region



By project type



By requirement



Required R&I by Type of Projects

Type of Projects	Requirements for Implementation	Applied R&I
Type I Renewal and upgrading of existing facilities	● Turbine Optimization for given Q and H	• CFD
	● Basement Concrete Excavation for new turbine generator installation	• Low vibration excavation method (Slot Drilling Method, Water Jet Method)
	● Diversion from Other Catchment Area	
	● Discharge Capacity improvement	
	● Renewal or Refurbishment of Dam (Weir)	• SR Weir
Type II Expansion and redevelopment of existing facilities	● Project Optimization (New Layout, Additional Water Way, Inflow increase for more energy)	• Effective use of existing structures (Non-destructive inspection)
	✓ New Intake at existing dam	• Existing Dam excavation such as Tunnel Boring Machine with low vibration • Temporary Shut Off Structure
	✓ Diversion from Other Catchment Area	
	● Effective use of unutilized water	• Choice of Suitable type of turbine (P, Q, H) • (New Type Turbine Development)
Type III Operational improvement of existing hydropower plant	● Turbine operation range expansion	• Sensor for turbine by GE Web app (Sensor, IOT, DX)
	● Keep intake discharge within permitted value	• Automatic Intake gate Operation system (Sensor)
	● Reservoir Operation Optimization	• Remote Sensing, AI, Dynamic Programming



Findings

- ▶ CFD is the key R&I for upgrading of existing turbine generator for Type-I
- ▶ Low vibration excavation method for basement concrete is required for renewal of existing turbine generator for Type-1 (in Japan)
- ▶ SR weir can be applied for Renewal or Refurbishment of Dam (Weir) for Type-I and II.
- ▶ Existing dam excavation method with Temporary Shut Off Structure can be applied for intake installation for existing dam for new water way for Type-II.
- ▶ Choice of Suitable type of turbine or development of new type turbine is required under topographic limitation for type-II.
- ▶ Many new element technologies can be applied for effective operation and maintenance for type-III.



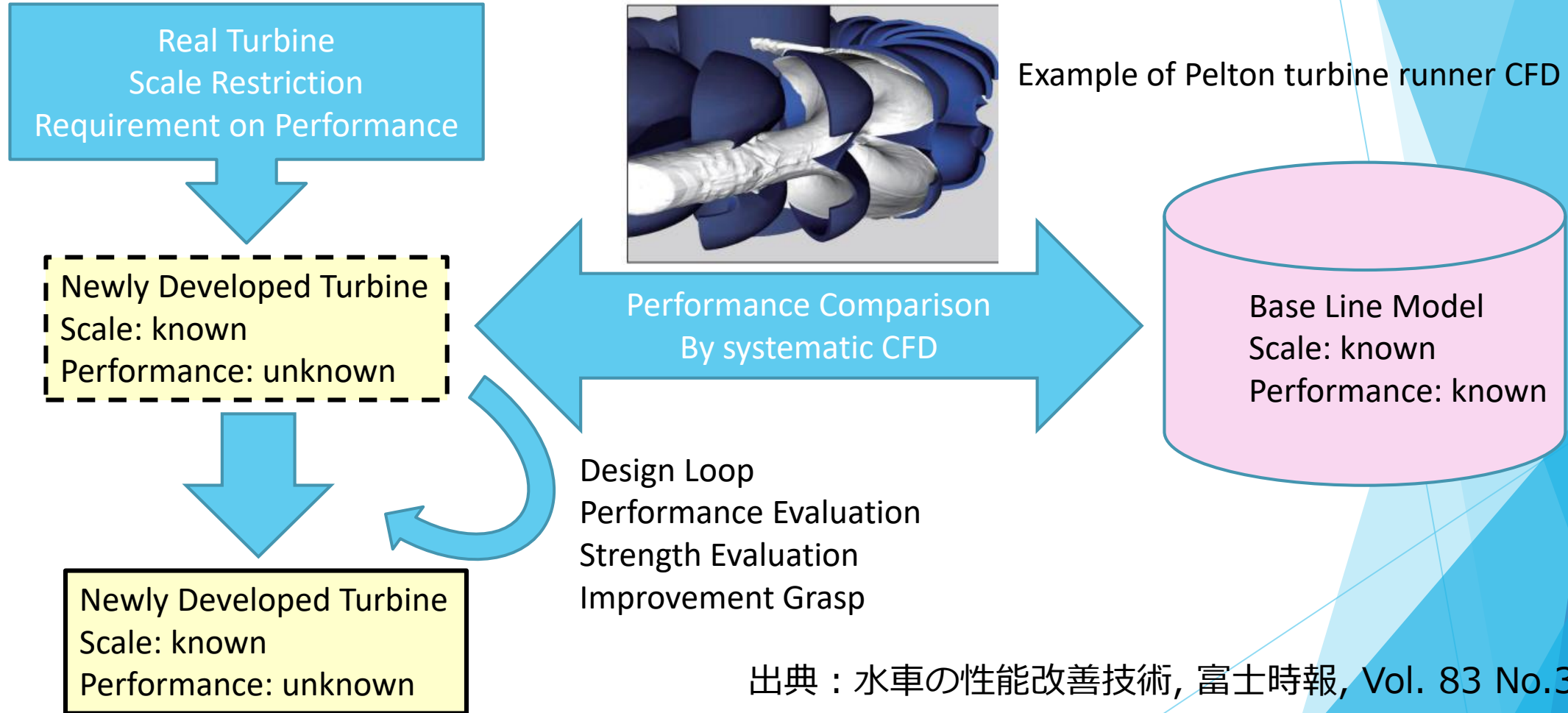
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Appendix: Applied R&Is



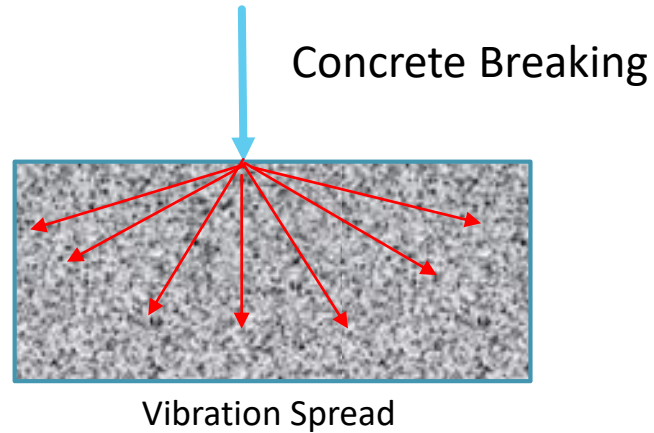
CFD (Computational Fluid Dynamics)



出典：水車の性能改善技術, 富士時報, Vol. 83 No.3 2010



Low vibration excavation method for basement concrete



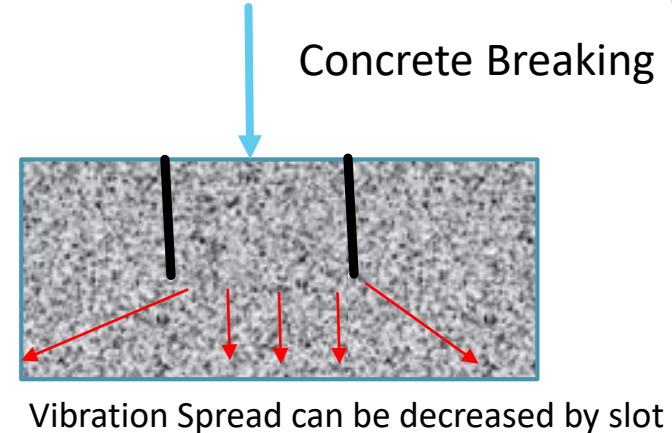
Concrete Excavation by Water Jet



Concrete Pillar Breaking



Concrete Breaking at Narrow area



Slot Drilling Method



Slot Drilling at Basement Concrete



Slots at Basement Concrete



SR Weir (Steel and Rubber Hybrid Weir)



Downstream View

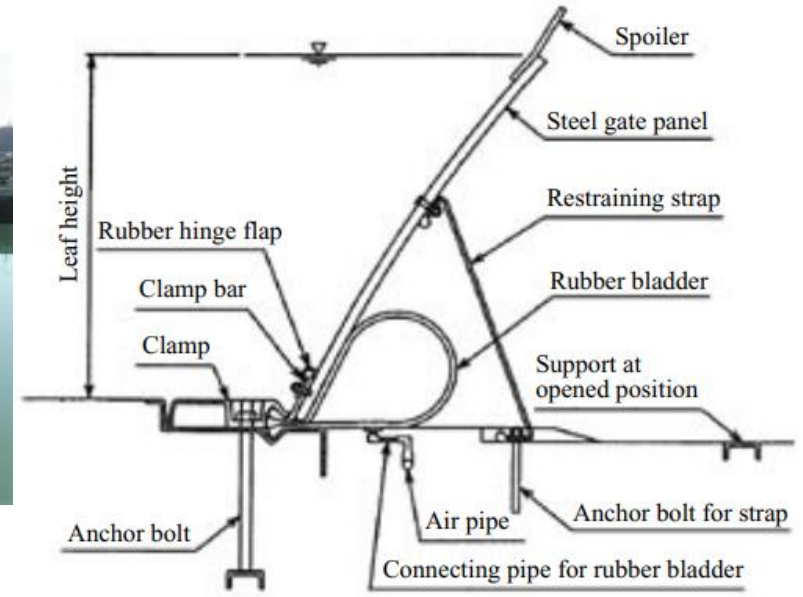


Upstream View

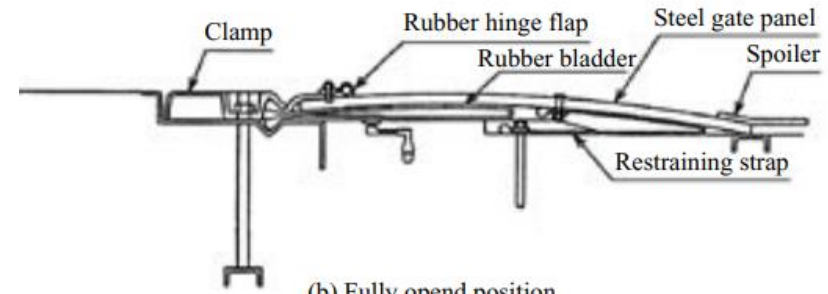
島川原発電所西浦ダム改良工事 東京電力パワーグリッド(株)
純径間 約33m×有効高 3.00m× 3門

http://www.iida-tekko.co.jp/products_sr.html

Renewal Work of Nishiura dam by TEPCO Power Grid
(Span 33m, Effective Height 3m, 3 Gqates)



(a) Fully closed position

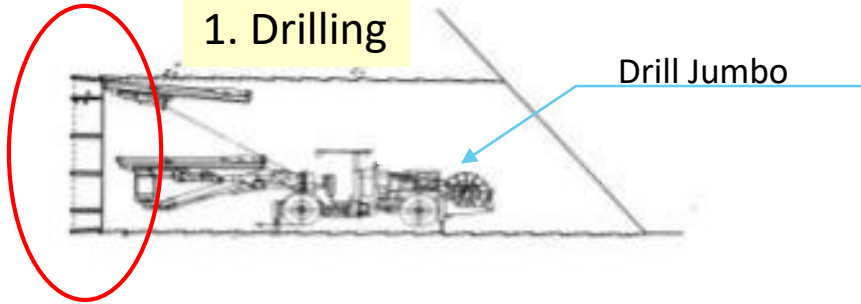


(b) Fully open position

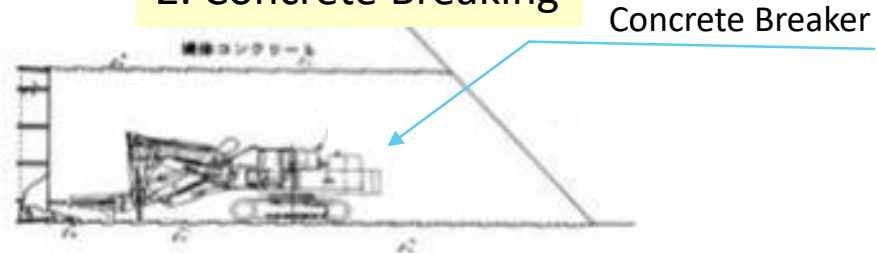


Existing Concrete Dam excavation process

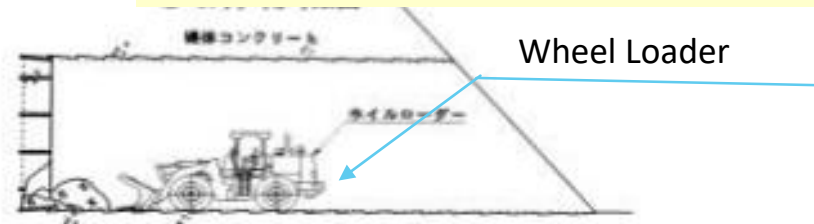
1. Drilling



2. Concrete Breaking



3. Concrete Wastes Carrying out



Drilling



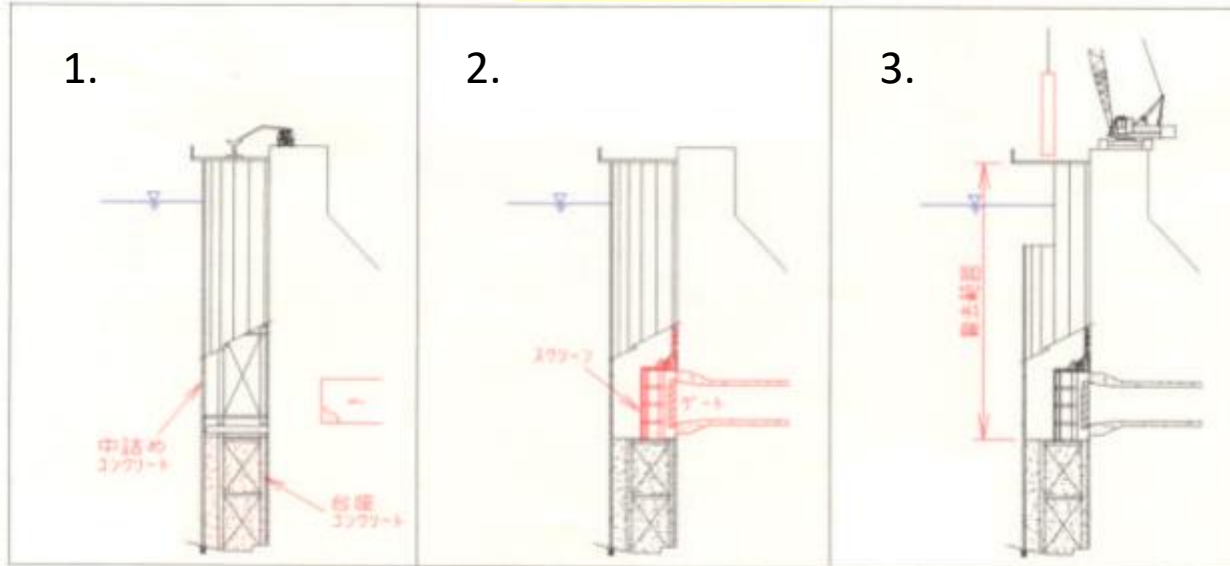
Temporary Shut Off Structure

After Excavation



Temporary Shut Off Structure

Work Process



1. Temporary Shut Off Structure Setting
2. Building Intake Structure, Intake Gate and Penstock installation
3. Temporary Shut Off Removal

<https://www.toyo-const.co.jp/wp/wp-content/uploads/2014/03/20020220.pdf>



Temporary Shut Off Structure Setting



Temporary Shut Off Structure Overview

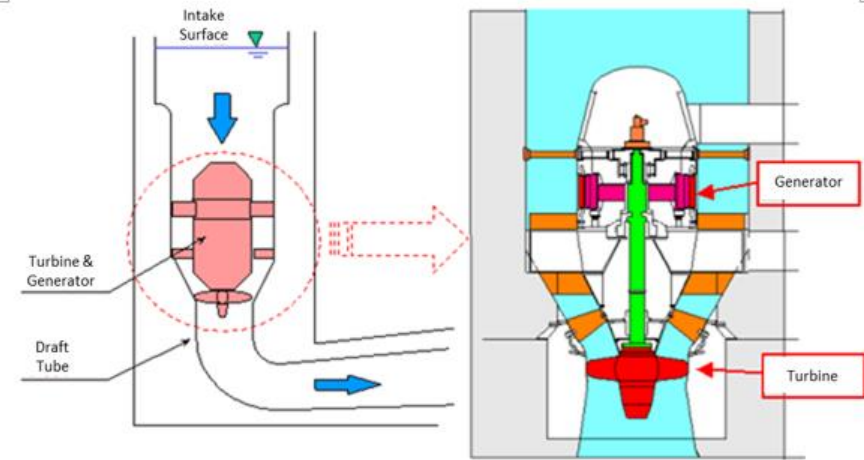


Temporary Shut Off Structure Inside

Choice of Suitable Turbine Practice



Plan View of Kaminojiri No.2 PS



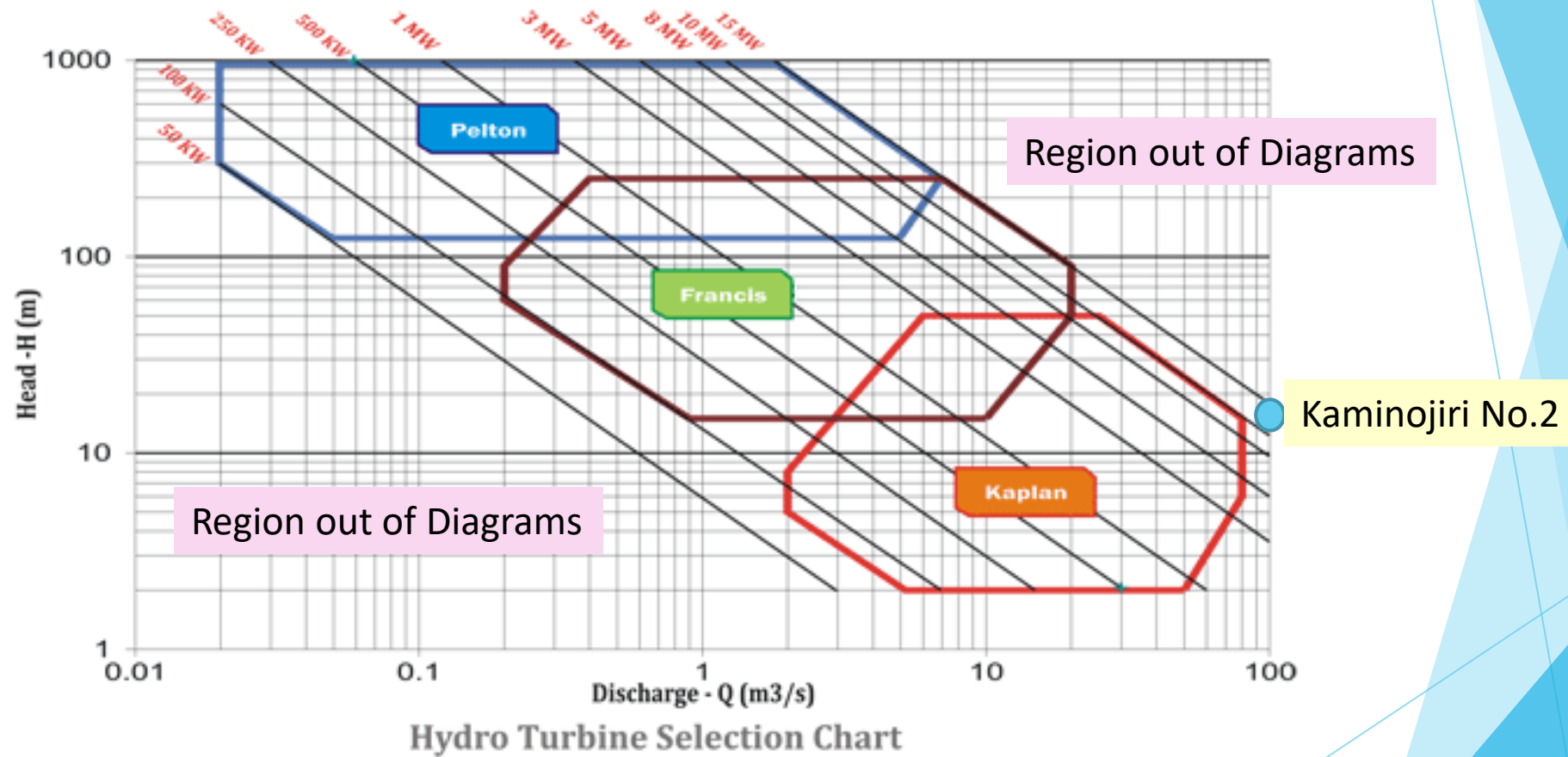
Schematic diagram of vertical bulb turbine

Specification of Kaminojiri No.2 PS

Item [↔]	Constructed Station [↔]
Name of power plant [↔]	Kaminojiri No.2 Power Station [↔]
Name of river [↔]	Agano River [↔]
Type of power plant [↔]	Dam type [↔]
Year of commission [↔]	2003 [↔]
Maximum output (MW) [↔]	13.5 [↔]
Maximum discharge (m ³ /s) [↔]	100 [↔]
Effective head (m) [↔]	15.54 [↔]
Annual power production (GWh) [↔]	44.4 [↔]



New Type Hydro Turbine Development



New type turbine development in Region out of Diagrams is requested.



Sensor by GE web app (IOT, DX)

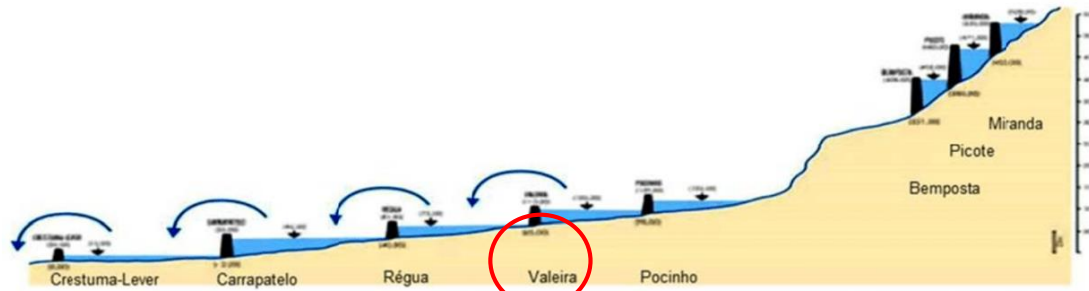


Figure 1: Douro river Cascade

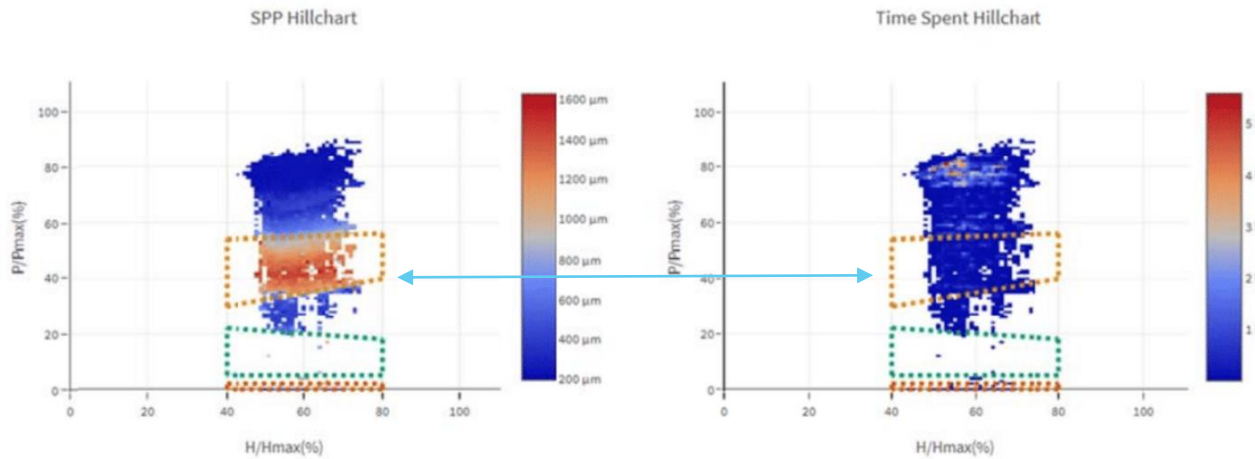


Figure 2: severity chart (left) and history chart (right) as available on GE web app for Alqueva II

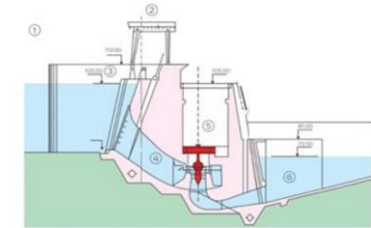


Figure 3: Valeira dam and powerhouse section

Figure 4 shows a typical operation regime of the Valeira power plant where the regular and fast load changes are clearly visible, as well as the various starts and stops.



Figure 4: Typical operation scheme of Valeira over 3 days

The main characteristics of the turbine (meta data) for Valeira, are shown on the table below.

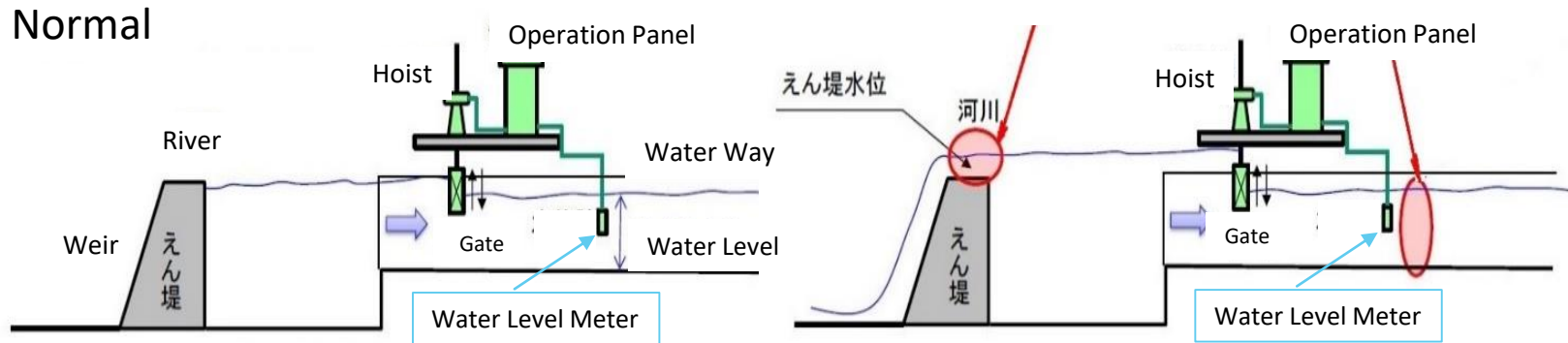
	Valeira
Rated Net Head (mWC)	28,5
Rated Speed (r.p.m.)	115,4
Rated Power (MW)	82
Runner Outlet Diameter (m)	6,0
Blades number	5
Stay vanes number	24
Wicket gates number	24

Actual pressure is smaller than designed value.
Operation discharge range can be extended to increase generation.



Automatic Intake Gate Operation

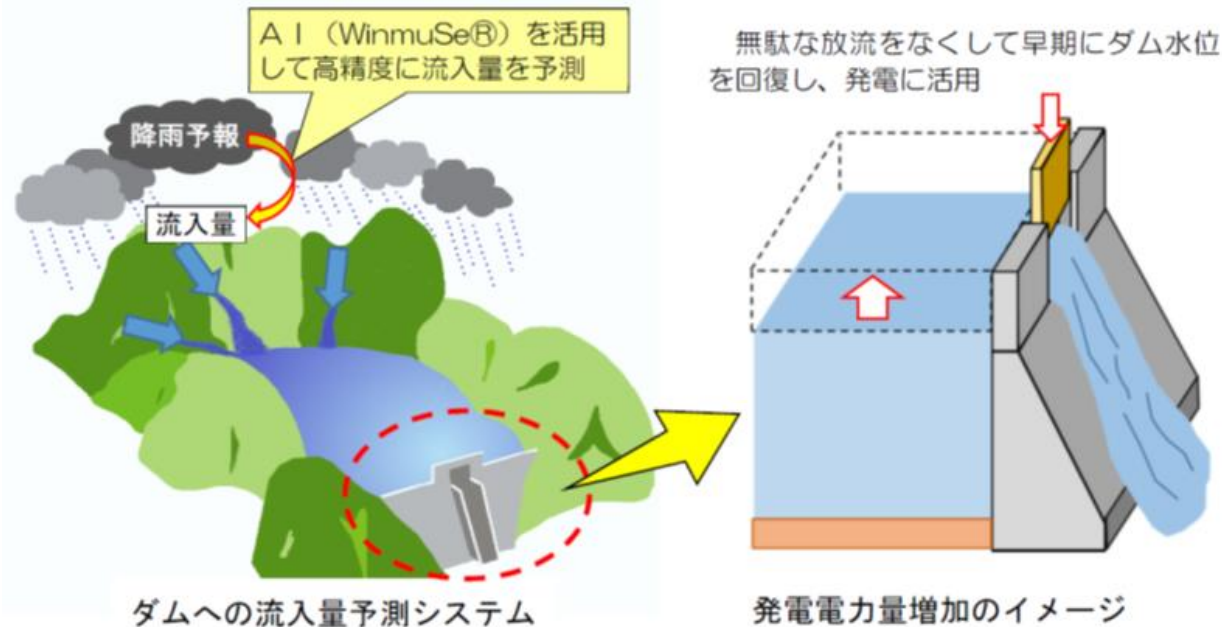
in case of increased river discharge



Difficulty of Intake gate control in case of increased river discharge

1. Intake water level (IWL) is determined by normal river water level back watered by weir under “River Law”.
2. In case of increased river discharge, it is difficult to keep water way water level under IWL while river discharge flows over weir, especially by man power.
3. Therefore, automatic intake gate operation system is applied to keep law, increase energy, and save labor.

Remote sensing, AI, and Dynamic Programming



Thank you for your attention!