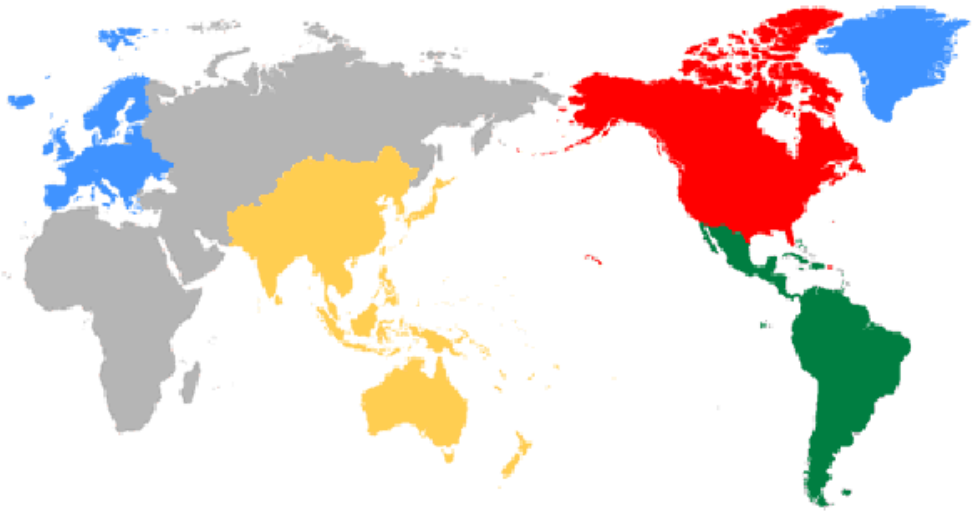
IEA - INTERNATIONAL ENERGY AGENCY

IMPLEMENTING AGREEMENT FOR

HYDROPOWER TECHNOLOGIES AND PROGRAMMES

Annex-2: Small Scale Hydropower
Sub-Task B2 "Innovative Technologies for Small-Scale Hydro"

"Summary Report"



October, 2010

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Acknowledgements

All Annex gatherings, including the preparatory and executive committee meetings as well as the open workshops, were held in an open and cooperative atmosphere. Steady progress has been made in our activities, and all participants have had the chance to expand their mutual understanding of the function of Annex II Subtask-B2 activities.

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October 2010
Yoichi Miyanaga, Subtask Leader for Annex II/Subtask-B2

1. Introduction

1.1 Purpose

The purpose of this sub-task is to collect and disseminate practical information for the development of new hydropower plants and the upgrade of existing facilities. Recent innovative hydropower installations and equipment were surveyed and evaluated based on their capability to expand the potential for small hydropower development, improve the equipment efficiency and to ensure conservation and protection of the environment.

1.2 Participants

Canada, Japan and Norway have formally agreed to participate in this sub-task in cooperation with ESHA. All participants were requested to take part in the collection of information and evaluation of new innovative technologies and case studies as well as assisting in the preparation of the final report.

1.3 Sub-task Leader

The representative from Japan acted as the sub-task leader.

1.4 Summary of Subtask B2 activities

Aug. 2006	Work plan presented in Portland, US
Dec. 2006	Work plan revised and agreed in Annex-2
May 2007	List of technologies presented in Ottawa, Canada
Jul. 2007	Proposed questionnaire form in Chattanooga, US
Sep. 2007	Questionnaire dispatched
Jun. 2008	Progress reported in Rovaniemi, Finland
Feb. 2009	Questionnaire survey completed and collected data evaluated by hydro experts
Oct. 2009	Draft final products approved in Echigo-Yuzawa, Japan
Feb. 2010	Final products approved in Tromso, Norway
Jul. 2010	Final products presented in Charlotte, US (Scheduled)

2. Methodology

2.1 Identification of Key Categories for Small Hydropower Development Technologies

The key categories for small-scale hydropower development technologies that were developed are identified in Table-1 in a classification chart based on technological categories and objectives. In this chart, 32 key categories are listed based on the results of a preliminary survey. Technologies were typically limited to those that have applications to projects of less than 10MW, but this limit was not a prerequisite in all cases.

Table - 1 Key Categories for Small Hydropower Development Technologies

Topic	Objective	Key Categories
1. Electrical & Mechanical Equipment		
	11. Cost/Time Reduction	111. High-efficiency Turbine
		112. Cost-efficient Turbine
	12. Expansion of Applicability	121. Low-head Turbine
		122. Variable-speed Turbine
		123. Permanent Magnet Generator
		124. High-efficiency Turbine
	13. Improvement of Reliability	131. Valve Technology
		132. Inspection Technology
2. Planning & Design of Project		
	21. Cost/Time Reduction	211. Computerized Planning Tools
	22. Design Optimization	221. Computerized Design Tools
	23. Safety Assurance	231. Assessment Methods for Geology and Foundation
3. Construction (Civil Work, E&M)		
	31. Cost/Time Reduction	311. Utilization of Previous Facilities
		312. Use of New Materials
		313. Simplification of Facilities
		314. Penstock Drilling Technology
	32. Safety Assurance	321. Foundation Stability Works
4. Operation & Maintenance		
	41. Cost/Time Reduction	411. Simplification of E&M Maintenance
		412. Automatic Control System
	42. Efficient Management	421. Sediment Control
		422. Floating Debris Management
		423. Assessment Methods for Rehabilitation and Safety
		424. Efficiency of E&M Maintenance
5. Environment		
	51. Fish Conservation	511. Fish-friendly Turbine

	512. Fish Bypasses
	513. Fish Barriers
52. Water Quality Conservation	521. Environmentally-friendly Lubricate
	522. Machinery without Oil
53. Landscape Conservation	531. Landscape Design
	532. Greening
	533. Underground Structures
6. Social Acceptance	
61. Multi-Purpose Application	611. Multi-Purpose SHP Project
62. Benefit Sharing	621. Cooperation with Local Communities

2.2 Survey of Innovative Technologies

Technologies were identified by conducting a literature review of international publications and conferences (Hydro, Hydroenergia, HydroVision and Waterpower etc.) and based on the recommendations of Annex-2 members (Canada, Norway, and Japan). These technologies were selected and categorized based on the key categories identified in Table-1. The technologies were described according to the following aspects:

(1) Technological Classification
(2) Technical Characteristics
(3) Scope of Applicability
(4) Results of Application

Those technologies selected as innovative technologies were not necessarily new. Technologies were recognized as innovative if they contributed to cost reduction, provided an increase in efficiency, improvement of reliability, support for operations and maintenance or provided environmental mitigation.

2.3 Collection and Evaluation of Innovative Technologies

The selected innovative technologies were classified by key category and evaluated of their applicability with regard to the following;

- Contribution to Cost Reduction
- Improvement of Efficiency
- Improvement of Reliability
- Enlargement of Applicability
- Support to Operation and Maintenance
- Mitigation of Environmental Impact

The technologies and their evaluation are summarized and documented in a simple and

easy-to-search data sheet format; The categories and contents of a sample data sheet is provided as Table-2. An electronic version is available to the public on the website (http://www.small-hydro.com/).

Table-2 Item and Contents of Data Sheet for Innovative Technologies for Small-Scale Hydro

	Item	Contents
1	Project Title	
2	Project Classification	Technological Categories
		Target Categories
		Key Words
3	Organizations	Funding Organization
		Development Organization
4	Abstract	
5	Features and Advantages	Technological Performance
		Cost Performance
		Environmental Performance
6	Scope of Application	Basic Specifications
		Purpose of Application
		Technological Conditions for Application
7	Status of Project	Present Status
		Period
8	Results of Application	Results of Experiments or Demonstration Tests
		Results of Sales or Practical Applications including Technical Data
9	Evaluation	
10	References	
11	Appendixes	
12	Inquires	Organization and Department
		Address
		TEL・FAX
		URL・Email

3. Outlines of Innovative Technologies

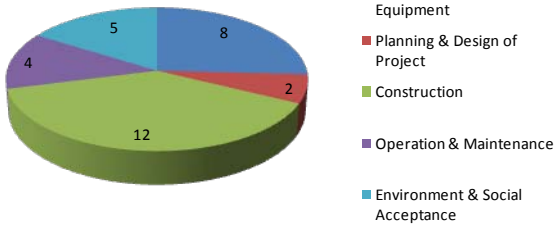
Of the 78 technology submissions that were collected and reviewed 31 of the technologies were considered to meet the criteria for being considered innovative. The technologies were then categorized according to the 32 Key Categories (Table-1). No technologies were considered to relate to the following categories:

- 13. Improvement of Reliability in 1. Electrical & Mechanical Equipment
- 23. Safety Assurance" in 2. Planning & Design of Project

As it was not the focus of this investigation, only 1 technology corresponding to "51. Fish Conservation" in "5. Environment" was screened from the questionnaires, although there were many submissions related to this topic.
Submissions for technologies corresponding to the categories "New and Improved Turbine" and "Civil Engineering Technology for Construction and O&M" made up the majority of the 31 screened questionnaires. Just over half of the submissions, 17 in total, were from Japan.

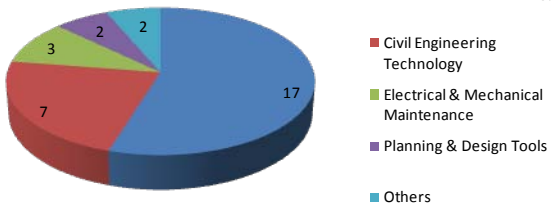
(1) Topics

- Electrical & Mechanical Equipment 8
- Planning & Design of Project 2
- Construction 12
- Operation & Maintenance 4
- Environment & Social Acceptance 5



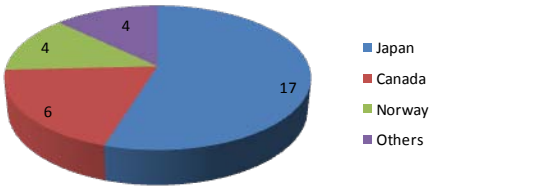
(2) Categories (modified)

- New/Improvement Turbine 17
- Civil Engineering Technology 7
- Electrical & Mechanical Maintenance 3
- Planning & Design Tools 2
- Others 2



(3) Country

- Japan 17
- Canada 6
- Norway 4
- Others 4



Technical features for 17 technologies on new/improved turbines that are the majority of 31 innovative technologies are summarized in Table-3. Many of these technologies were applied to undeveloped hydro potential in pipelines for water supply or agriculture irrigation channels and/or designed below 1,000kW. Some of them are applicable to "Very Low Head" below 3m. Technologies related to improving efficiency and/or maintenance for conventional turbines are also shown.

Table-3 Technical Features for New and Improved Turbines

Classified No.	Technical Features	Output (kW/unit)	Head (m)
<Output : over 1,000kW>			
112-2	Francis turbine manufactured by simplified procedure	500 - 4,000	50 - 230
112-4	Hooped Pelton Turbine	4,400 - 4,900	280 - 450
122-1	Variable Speed Turbine Generator	1,000 - 20,000	45 - 84
124-1	Francis Turbine improved by Exit Stay Apparatus	-	-
311-6	Vertical Bulb Turbine	13,500	15.5
<Output : less 1,000kW>			
112-1	Vertical Micro Pelton Turbine	15 - 150	> 30
121-1	Very Low Head Turbine Generator	100 - 500	1.4 - 3.2
123-1	Micro Cross Flow Turbine Generator Unit	0.5 - 1	2 - 10
311-3	Micro Kaplan Turbine	30	2 - 3
311-5	Screw Turbine Generating System	3 - 300	1 - 10
313-2	Bottom Entry Siphon type Small Hydropower Unit	130	4
112-3	In-line type Francis Turbine	< 200	30 - 70
311-1	In-line type Hydraulic Turbine Generator	3 - 90	3 - 70
311-2	Micro Tubular Water Turbine	3 - 250	2 - 20
311-4	In-line type Micro Francis Turbine Generator System	0.5 - 9	8 - 39
313-1	Turbine-Generator Integrated Unit	1 - 200	2 - 20
511-1	Fish Friendly Turbine Generator	-	< 30

4. Summary and Conclusion

Future development of small-scale hydropower should seek to make advancements related to cost reduction, increased efficiency, improved reliability, and expansion of applicability to exploit previously undeveloped resources. These advancements are required as there is generally no scale advantage to be gained over larger developments. Also, it will be necessary to simplify operations and maintenance to foster new hydropower development and to reduce potential environmental impacts in order to gain public acceptance. In order to make effective use of non-traditional and previously un-utilized hydropower potential in existing facilities, further ingenuity will be required.

In this sub-task, we were able to collect information on 31 valuable innovative technologies that overcome these challenges for new development or the renewal of existing small hydropower facilities. However, it is clear that further innovation in all areas of technology development will be required.
We hope that the innovative technology information will be accumulated continuously and systematically to contribute to further development of hydropower.

（Appendix）

Data List of Innovative Technology

Classified No.	Title	Organizations
112-1	Vertical Micro Pelton Turbine	Stjørdal 3D Verksted
112-2	Francis Turbine manufactured by simplified procedure (Sheet-metal turbine)	Norwegian University of Science and Technology (NTNU)
112-3	In-line type Francis Turbine (Linkless hydropower)	Tanaka Hydraulic Machinery Works Co., Ltd.
112-4	Hooped Pelton Turbine	ALSTOM Power Hydro
121-1	Very Low Head Turbine Generator	Novatech-Lowatt Turbine Inc.
122-1	Variable Speed Turbine Generator	New Energy Foundation (NEF)
123-1	Micro Cross Flow Turbine Generator Unit (Liter Hydropower System)	SINFONIA Technology Co., Ltd.
124-1	Francis Turbine improved by Exit Stay Apparatus	Natural Resources Canada, and Alexander Gokhman (Consultant)
211-1	Resource Mapping by GIS	Norwegian Water Resources and Energy Directorate (NVE)
221-1	Engineering Work Support by Excel-based Program (HYDROHELP)	Natural Resources Canada (CANMET)
311-1	In-Line Hydraulic Turbine Generator (Linepower)	Kubota Corporation
311-2	Micro Tubular Water Turbine	Fuji Electric Systems Co., Ltd.
311-3	Micro Kaplan Turbine (Hydro Agri)	Electric Power Development Co., Ltd.
311-4	Inline type Micro Francis Turbine Generator System (Energy Recovery System)	Hitachi Industrial Equipment Systems Co., Ltd.
311-5	Screw Turbine Generator System (Hydrodynamic Screw)	Ritz-Atro GmbH
311-6	Vertical Bulb Turbine	Tohoku Electric Power Co.
312-1	Alternate products for the Penstock (FRPM/FRP Pipe)	New Energy Foundation (NEF)
313-1	In-line type Turbine Generator Integrated Unit (Ring Hydroturbine)	Kawasaki Plant Systems, Ltd.
313-2	Bottom Entry Siphon type Small Hydropower System (BEST packaged small hydro station)	Rapid-Eau Technologies Inc.
314-1	Penstock drilling technology (Norwegian Hard Rock Drilling, Norhard)	Sira-Kvina Kraftselskap AS
314-2	Development of Technology for Micro Tunnel Boring Machine	New Energy Foundation (NEF)
321-1	Rationalization of Foundation Treatment for Low-Head Hydropower Plant Dams	New Energy Foundation (NEF)

422-1	Debris Reducing Mixer in Water Intake System	Tohoku Electric Power Co.
422-2	Floating Debris Management	Shuken Consultants Co.
423-1	Assessment Methods for Rehabilitation and Safety	Vienna University of Technology
424-1	On-Line Machine Monitoring System (AGMS)	Vibro SystM Inc.
511-1	Fish Friendly Turbine Generator (L-Shape Fish Friendly Turbine)	Rapid-Eau Technologies Inc.
522-1	Water Lubricated Bearings	ALSTOM Power Hydro
531-1	Landscape Design (Kokuto No. 3 HEP)	Hokuriku Electric Power Co.
533-1	Underground Pondage	New Energy Foundation (NEF)
621-1	Hydro-Valley Development Program	New Energy Foundation (NEF)