Annex-II Small-Scale Hydropower Subtask A5 "Sustainable Small-Scale Hydropower in Local Communities"

IEA Hydro Technical Report

Summary Report

March 2017

IEA Hydro: Annex II

JAPAN

NORWAY

USA

OVERVIEW OF THE IEA TECHNOLOGY COLLABORATION PROGRAMME ON HYDROPOWER

The IEA Technology Collaboration Programme on Hydropower (IEA Hydro) is a working group of International Energy Agency member countries and others that have a common interest in advancing hydropower worldwide. Member governments either participate themselves, or designate an organization in their country to represent them on the Executive Committee (ExCo) and on the Annexes, the task forces through which IEA Hydro's work is carried out. Some activities are collaborative ventures between the IA and other hydropower organizations.

Vision

Through the facilitation of worldwide recognition of hydropower as a well-established and socially desirable energy technology, advance the development of new hydropower and the modernisation of existing hydropower

Mission

To encourage through awareness, knowledge, and support the sustainable use of water resources for the development and management of hydropower.

To accomplish its Mission, the Executive Committee has identified the following programme-based strategy to:

- Apply an interdisciplinary approach to the research needed to encourage the public acceptance of hydropower as a feasible, socially desirable form of renewable energy.
- Increase the current wealth of knowledge on a wide array of issues currently associated with hydropower.
- Explore areas of common interest among international organizations in the continued use of hydropower as a socially desirable energy resource.
- Bring a balanced view of hydropower to the worldwide debate on its feasibility as an environmentally desirable energy technology.
- Encourage technology development

IEA Hydro is keen to promote its work programmes and to encourage increasing involvement of non-participating countries. All OECD and non-OECD countries are eligible to join. Information about membership and research activities can be found on the IEA Hydro website www.ieahydro.org.

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ACKNOWLEDGEMENTS

Since the proposal document of the IEA Hydro Annex-II Subtask A5 was presented in December 2011, nineteen meetings have been held including 9 Expert Meetings, 4 open workshops, and 6 Executive Committee Meetings. Steady progress has been made in our subtask activities, and all the participants in these meetings have intensified their mutual understanding of the importance of Subtask A5 activities.

We wish to thank the members of Annex-II and Subtask A5, Japan's Domestic Expert Committee and Executive Secretariat for their constant and dedicated contributions to subtask activities over 5 years: Kearon Bennett, Boualem Hadjerioua, Munetoshi Inakura, Torodd Jensen, Masayuki Kashiwayanagi, Tatsuyuki Kusui, Kazunari Morii, Toshikazu Murakami, Yutaka Nakagawa, Hirokazu Nakanishi, Niels Nielsen, Patrick O'Connor, Koji Oda, Masayuki Oomae, Kjell Erik Stensby; Takashi Akiyama, Ryota Hamamoto, Masakazu Hashimoto, Goichi Kaneda, Toru Kasahara, Hisashi Kobayashi, Hiroshi Kojima, Shogo Nakamura, Niro Okamoto, Masahiro Onishi, Daisuke Sakagawa, Masahiro Takahashi, Masahito Takizawa, Soji Toriya, Nobuhiro Tsuda, Kenji Yokokawa,

We thank the authors of Good Practice draft report, those who accepted our request upon site visit survey, those who provided valuable information on Good Practices, and the staff of European Small Hydropower Association who gave us appropriate guidance and advice for collecting information on Good Practices in Europe.

We thank the members of the IEA Hydro Executive Committee and Japan's Domestic Committee, and officials of Japanese Agency for Natural Resources and Energy for their valuable comments and suggestions.

March 2017
Yoichi Miyanaga, Annex-II Subtask A5 Leader

EXECUTIVE SUMMARY

Annex-II, the Small-Scale Hydropower Working Group of the IEA Technology Collaboration Programme on Hydropower has conducted a study by setting up a subtask on economic and social sustainability of small-scale hydropower in local communities between 2012-2016. This subtask was led by Japan with cooperation from Norway and the USA. The study aimed to collect and document case histories of successful, sustainable small-scale hydropower projects by recognizing "Good Practices" - example of projects that provide economic and social benefits to local communities - among operating commercially viable projects around the world, disseminating information of Good Practices to hydropower industry with a view to contributing to the promotion of small-scale hydropower development in the future.

Good Practices were selected according to the viewpoints of “economic viability of the project”, “economic benefits to local communities” and “contributions to local communities and environment”. Based on the definition of Good Practice, 23 cases were collected worldwide through questionnaires, literature reviews and field surveys. Each case was documented in a "Good Practice Report" covering project design, economic viability, economic benefits, and social benefits to local communities. Literature surveys were also carried out on the current status of small-scale hydropower in the countries where the Good Practices were selected as background information.

Economic sustainability for each case was analyzed and evaluated based on three criteria: recovering initial investment cost, paying for operation and maintenance cost and gaining appropriate profit. Furthermore, social sustainability was evaluated for economic benefits considering five factors including tax revenue or grant income of local municipalities, creation of employment opportunities, local industry development, economic effects from promotion of inter-regional human exchange, and sharing of project benefits with local communities, and for social benefits considering seven factors including improvement of local infrastructure, preservation of natural environment and ecosystem, preservation of history and culture, activation of local community through promotion of inter-regional human exchange, education / training / human resources development, development of local resources, and contributions to state and local government policies.

Based on the result of analysis and evaluation of case histories, the following specific and effective measures have been identified as providing good examples of economic and social benefits to local communities in accordance with economic viability of the project.

Effective measures for economic sustainability of the project:

- Financial measures including utilization of public financial schemes such as investment grants or low-interest loans, long-term power purchase agreement, utilization of FIT or RPS scheme, cost reduction by joint investment and innovative contract types;
- Technological measures including introduction of innovative technologies and new materials, selective site conditions, design optimization, rationalization of operation and maintenance, and utilization of existing facilities.

Effective measures for social sustainability of the project:

- Promotion of local industry by developing tourism, attracting enterprises, and developing new hydropower projects;
- Creation of employment opportunities by construction and operation of plants, tourism and the flow of funds to the community;

- Economic benefits and social activation by promoting inter-regional human exchange;
- Improvement of roads, water channels, the environment surrounding the dam and fire prevention facilities;
- Preservation of forests, rivers, reservoirs, fish, wildlife, etc.;
- Preservation of landscape, local history and culture, and indigenous life and culture;
- Development of local resources such as unused renewable energy, water resources, tourism, recreational opportunities and local brands.

These key findings provide useful guidance for improved social acceptance of new small-scale hydropower developments and improved relationship with local communities for existing project site areas.

1. Introduction

1.1 Background

The importance of expanding the development of renewable energy projects has been increasing worldwide from the standpoints of taking measures against global warming, ensuring energy security and maintaining sustainable growth. The IEA Technology Roadmap: Hydropower (IEA, 2012) notes the scenario for the installed capacity of hydropower to reach 2,000 GW globally by 2050 to meet climate change targets. This is almost double present global capacity.

Small-scale hydropower plants are normally less efficient economically than large-scale hydropower plants, but they usually have less impact on the natural and social environment without submergence of large areas of land and resettlement of local communities. They are also utilized for rural electrification of off-grid remote areas or islands as a stable distributed power source (UNIDO/ICSHP, 2013).

The major issues facing the development of small-scale hydropower continue to be the enhancement in economic viability, improvement in related regulations and approval procedures, and enhancement of social acceptance of communities in the project areas (IEA, 2012 and ESHA, 2012). Of these, the issues related to economic viability and regulations have been improved to some extent through financial support programs, de-regulations, development of new technologies, rationalization of project management and other measures. On the other hand, the issue of social acceptance is not very well improved as this issue has not been incorporated in the relevant legal framework or policies despite a number of efforts made in individual projects.

Regarding the relation between hydropower project and the local community, the “Update of Recommendations for Hydropower and the Environment” (IEA Hydro, 2010) presents a recommendation that “hydropower projects should benefit local communities throughout the project life.” Furthermore, the Hydropower Sustainability Assessment Protocol (IHA, 2010) provides a tool for promoting sustainable hydropower projects as well as identifying general environmental and social impact assessment methods, These list the key topics on benefit sharing with local communities as “project affected communities and livelihoods”, “project benefits” and “indigenous people”. These topics are therefore deemed highly significant for future small-scale hydropower development and it is important to implement such recommendations and assessment tools and to understand the lessons learned from previous projects that have enhanced social acceptance of hydropower development.

As an initiative to address the above issues, Annex-II on small-scale hydropower set up Subtask A5 “Sustainable Small-Scale Hydropower in Local Communities” in 2012. The work included an intensive study focusing on economic and social sustainability of small-scale hydropower projects, with the results summarized in this report.

1.2 Overview of Subtask A5

The purpose of Subtask A5 “Sustainable Small-scale Hydropower in Local Communities” is to collect and document case histories of successful, sustainable small-scale hydropower projects by recognizing "Good Practices" - example of projects that provide economic and social benefits to local communities.

Subtask participants are led by Japan as Task Leader and included Norway and the United States. The leader coordinated overall activities including set up, implementation and completion of the subtask, with the activity spanning five years from 2012 to 2016.

The collection of Good Practices was selected according to the viewpoints of “economic viability of the project”, “economic benefits to local communities” and “contributions to local communities and environment”. In principle, such projects are candidates that maintain economic viability, provide favorable economic benefits to local communities and achieve social and environmental contributions to local communities. Target number of the collection was aimed at about 20 projects globally. Data on Good Practices were collected through questionnaire and literature surveys in principle, and hearing from project staff if necessary. Each case was documented in a "Good Practice Report" in a consistent format. Moreover, literature surveys were also carried out on the current status of small-scale hydropower in the countries where the Good Practices were selected as background information.

2. Method

2.1 Definition of Good Practice

The Good Practice of small-scale hydropower projects studied in Subtask A5 is defined as “an existing small-scale hydropower project which has been proven economically and socially sustainable in the local communities from the commissioning to the present time.”

“Economic sustainability” is required to meet the following three criteria by the profit gained from the project:

- Recovering initial investment cost;
- Paying for operation and maintenance cost;
- Gaining appropriate profit.

These are requisites for a project to be economically viable. The cost of a project, however, is not necessarily covered entirely by the developer who may receive external financial support or incentives for renewable energy. Also, projects promoted by social enterprises return all operating profits to the local communities in most cases. Thus the economic sustainability of the project was assessed flexibly according to various financial conditions.

“Social sustainability” is evaluated by the economic benefits or social benefits the project endows the local communities thereby establishing and maintaining a favorable relationship.

The following five factors are considered as primary indices of economic benefits.

- Tax revenue or grant income of local municipalities;
- Creation of employment opportunities;
- Local industry development;
- Economic benefits from promotion of inter-regional human exchange;
- Sharing of project benefits with local communities.

Social benefits should be evaluated from wide-ranged viewpoints. They are divided into contributions to local environment and local community, consisting of the following seven factors in total.

Contributions to local environment:

- Improvement in local infrastructure (including energy infrastructure);
- Preservation of natural environment and ecosystem;
- Preservation of history and culture.

Contributions to local community:

- Activation of local community through promotion of inter-regional human exchange;

- Education, training and human resources development;
- Development of local resources;
- Contributions to state and local government policies.

The above “development of local resources” refers to various hardware / software resources which activate local industry such as energy, water, tourism, local specialty, recreational opportunity, local brand, etc.

Concerning the scale of the project capacity, 10 MW or less per plant is a basic condition in principle. However the definition of small-scale hydropower varies among countries. Thus three projects of greater than 10 MW were selected as Good Practices.

2.2 Collection of Good Practice Data

Appendix A3 provides a list of literature surveyed in this study.

The survey was conducted by sending a questionnaire which covers topics shown in Table 1 to the relevant project development staff. Good Practices in Japan were selected through literature survey and recommendations from the members of Japan’s Domestic Committees that have assisted the IEA Hydro. Good Practices in other countries were selected also through questionnaire and literature surveys and recommendations from the members of Subtask A5, the Operating Agent of Annex-II, the members of IEA Hydro and others.

An online survey was also carried out to solicit recommendations for Good Practices by linking an electronic questionnaire containing the same topics as Table 1 to the web site of Annex-II (www.small-hydro.com).

Furthermore, hearing surveys for the responsible developer of the project were conducted adding to the questionnaire survey on the projects of Atlin (Canada), Praterkraftwerk (Germany), Jorda (Norway), Storfallet and Veslefallet (Norway), Eigg Island (UK), Torrs (UK). Abernethy Trust (UK), Power Creek and Humpback Creek (USA), Delta Creek (USA). (See Table 3).

Table 1 Questionnaire Survey Items

1. Outline of the project	Description (including reasons for Good Practice)
2. Power plant information	Name, country, water system, commissioning year
3. Owner information	Name, ownership type, market type
4. Power plant specification	Installed capacity, maximum discharge, effective head
5. Financial viability of the project	Self-evaluation of economic viability on a scale of 4 levels, and prospective profitability on a scale of 4 levels
6. Economic benefits of the project	To be selected from tax revenue, employment, tourism, industrial development, and others
7. Social aspects of the project	To be selected from 18 items such as infrastructure improvement, fish passage development, landscape preservation, and regional development

2.3 Documentation of Good Practices

The collected data of Good Practices were documented as “Good Practice Report” in the unified format as shown in Table 2.

Table 2 Format of Good Practice Report

Heading Information	Contents
・Name of power plant	1. Outline of project
・Country (state/province)	2. Financial viability of project
・Owner of power plant	3. Economic benefits of project
- Name of owner	4. Social aspects of project
- Type of ownership	4.1 Local environment
- Type of market	4.2 Local community
・Commissioning year	5. Reasons for success
・Project evaluation	6. Outside comments
・Keywords	7. References
・Abstract	

The “type of ownership” in the heading information in Table 2 is categorized into five types as follows:

- (Electric) Utility;
- Public (Electric) Utility;
- Wholesale Power Supplier;
- Power Producer;
- On-site Power Generator.

The “type of market” in the heading information in Table 2 is categorized into seven types as follows:

- (Electric) Utility;
- Public (Electric) Utility;
- Wholesale Power Supply;
- Power Purchase Agreement (PPA);
- Support Scheme including Feed-in Tariff / Feed-in Premium / Renewable Portfolio Standard;
- Power Production and Sales except PPA and Support Scheme;
- On-site Power Generation.

In case the owner is not primarily specialized in power generation, its organization structure is also presented.

The “outside comments” under Chapter 6 in Table 2 includes media coverage, articles in journals, awards given by the state or academic groups, etc.

2.4 Analysis and Evaluation of Good Practices

The collected Good Practices were analyzed and evaluated based on 15 criteria in total, three on economic sustainability and 12 on social sustainability as defined in Section 2.1. Though the evaluation is qualitative, it focuses on specific features of each criterion whereby the project provides apparently favorable effects.

3. Overview of the Collected Good Practices

3.1 Overview

We have collected 23 Good Practices in 10 countries as shown in Table 3 (a). The code in the first column refers to the Case History in Appendix 2.

By region, eight projects are from Asia, eight from Europe, five from North America, one from South America, one from Africa, of which, seven, the highest number from a single country, are from Japan. (Fig.1)

By ownership type, six projects are owned by Power Producer / Private Company, six by On-site Power Generator, three by Electric Utility, three by Wholesale Power Supplier, three by Power Producer / Others, and two by Public Utility. (Fig.2) Power Producer / Others includes Local Municipality and Landowner.

Table 3 (a) Outline of the Good Practices Collected

Code.	Name of Power Plant	Country	Commis-sioning Year	Ownership Type	Market Type	Installed Capacity (MW)
CA01	McNair Creek	Canada	2004	PP/PC	PPA	9
CA02	Rutherford Creek	Canada	2004	PP/PC	PPA	49
CA03	Atlin	Canada	2009	WP	WP	2.1
CL01	Mallarauco	Chile	2011	WP	WP	3.43
DE01	Prater	Germany	2010	PUT	FIT	2.5
JP01	Kachugawa (3 plants)	Japan	2005	OP/LM	FIT	0.046 in total
JP02	Taio	Japan	2004	OP/LM	FIT	0.066
JP03	Nasunogahara (5 plants)	Japan	1992	OP/LRD	PPA	1.5 in total
JP04	Fujioiro (2 plants)	Japan	1914	OP/LRD	PPA	1.3 in total
JP05	Shin-Taishakugawa (2 plants)	Japan	2003	UT	UT	13.4 in total
JP06	Kochi Prefecture Public Corporation Bureau (3 plants)	Japan	1953	WP/LM	WP	39.2 in total
JP07	Ochiairo	Japan	2006	PP/PC	FIT	0.1
NO01	Ljøsåa	Norway	2008	PP/PC	PPS	2.4
NO02	Jorda	Norway	2012	PP/LO	PPS	2.4
NO03	Storfallet (2 plants)	Norway	1990	PP/LO	PPS	7.7 in total
PH01	Ambangal	Philippines	2010	PP/LM	PPA	0.2
PT01	Canedo	Portugal	2008	PP/PC	FIT	10
UK01	Eigg Island (3 plants)	UK	2008	LUT	LUT	0.112 in total
UK02	Torrs	UK	2008	PP/IPS	PPA	0.063
UK03	Abernethy Trust	UK	2010	OP/NPO	FIT	0.089
US01	Power Creek (2 plants)	USA	2002	LUT/EC	LUT	7.25 in total
US02	Delta Creek	USA	1994	PUT/LM	PUT	0.8
ZA01	Brandkop Conduit Hydropower	South Africa	2015	OP/WUT	OP	0.096

PP=Power Producer, PC=Private Company, WP=Wholesale Power Supplier / Supply, UT=Utility
PUT=Public UT, OP=On-site Power Generator / Generation, LM=Local Municipality
LRD=Land Reclamation District, LO=Landowner, LUT=Local UT, IPS=Industrial and Provident Society
NPO=Non-Profit Organization, EC=Electric Cooperative, WUT=Water UT, PPA=Power Purchase Agreement
FIT=Feed-in Tariff, RPS=Renewable Portfolio Standard, PPS=Power Production and Sales

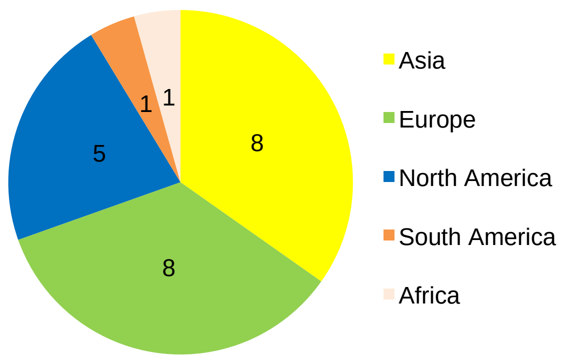

Fig.1: Good Practices by Region

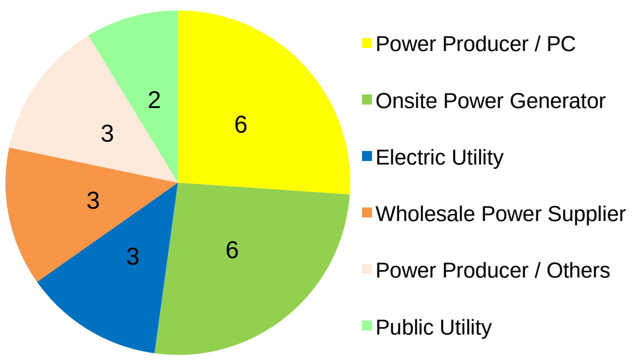

Fig.2: Good Practices by Type of Ownership
(PC=Private Company)

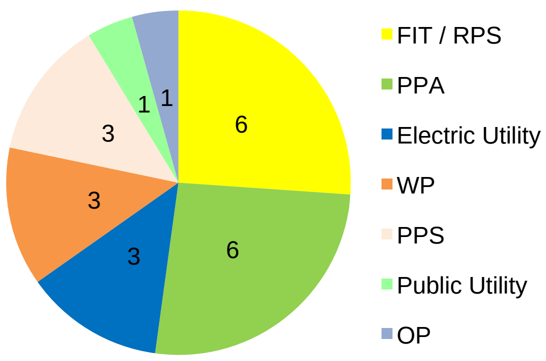

Fig.3: Good Practices by Type of Market
(FIT=Feed-in Tariff, RPS=Renewable Portfolio Standard, PPA = Power Purchase Agreement, WP=Wholesale Power Supply, PPS=Power Production and Sales, OP=Onsite Power Generation)

By market type, six projects are managed by FIT / RPS Scheme, six by Power Purchase Agreement, three by Electric Utility, three by Wholesale Power Supply, three by Power Production and Sales, one by Public Utility, and one by On-site Power Generation. (Fig.3)

The commissioning years of those plants range from 1914 to 2014, and all of them are still in operation today. Some of them have been refurbished.

Table 3 (b) Characteristics of the Project and Major Social Aspects in the Good Practices Collected

Code	Characteristics of the Project	Major Social Aspects
CA01	Development in first nation's traditional area	Employment, Environmental conservation
CA02	Development in first nation's traditional area	Employment, Recreational use of tailrace
CA03	First nation's initiative in off-grid area	Education, training and employment
CL01	Collaboration of PC and irrigation union	Maintenance of facilities and cost reduction
DE01	Underground SHP in urban area by PUT	Municipality carbon strategy, Urban landscape
JP01	Public participation on-site SHP by municipality	Municipality environmental / regional strategy
JP02	On-site SHP using existing dam by municipality	Regional exchange, Tourism, Forest protection
JP03	On-site SHP using irrigation channel by LRD	Maintenance of facilities and cost reduction
JP04	On-site SHP using irrigation channel by LRD	Maintenance of facilities and cost reduction
JP05	Redevelopment of aged power plant by UT	Natural park, Tourism in dam reservoir
JP06	Wholesale power supply by public corporation	Improvement of environment around the dam, Forest conservation
JP07	Regeneration of decommissioned SHP by PC	River environment for tourism and fishery
NO01	Collaboration of PC and landowner	Agriculture promotion, Unused hydro potential
NO02	Collaboration of PC and landowner	Agriculture promotion, Unused hydro potential
NO03	Development by a landowner company	Agriculture promotion, Unused hydro potential
PH01	Public participation granted SHP by NGO	Conservation of historical rice terrace & culture
PT01	Reservoir type SHP by PC	Plant operation for irrigation and fish farm
UK01	Micro grid system in off-grid island	Stable power supply by demand management
UK02	Social contribution oriented SHP by IPS	Community support, Environmental education
UK03	On-site SHP by non-profit charity organization	Outdoor education program for young people, Dissemination of SHP
US01	Micro grid system in off-grid area by EC	Enterprise attraction, Support for first nation's renewable energy development
US02	Micro grid system in off-grid area by PUT	Stabilization of electricity fee in remote first nation's area
ZA01	On-site conduit SHP by water utility	Reduction of GHG from water supply plant, Excess power supply to electricity-deficit area

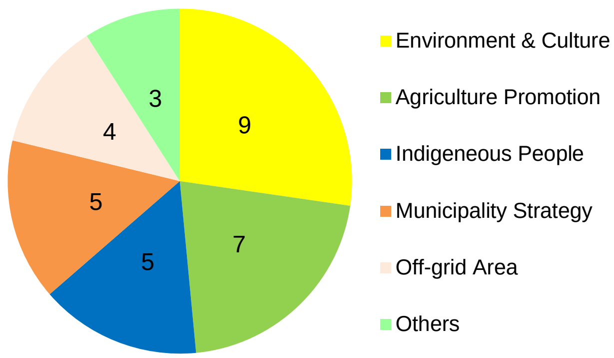

Fig.4: Good Practices by Keyword for Project Characteristics (some cases overlapped between keywords)

Characteristics of the Project and Major Social Aspects in the Good Practices are shown in Table 3 (b) and Fig.4. Relatively large numbers are appeared for cased on environment and culture, agriculture promotion, indigenous people and municipality strategy.

3.2 Current Status of Small-Scale Hydropower in the Countries Studied

(1) Developed Capacity and Potential of Small-Scale Hydropower

Figure 5 shows a comparison between developed capacity and undeveloped potential of small-scale hydropower in nine countries based on the statistics of the national report (Appendix A1).

Undeveloped potential seems to be relatively large in Canada, Chile, Japan and the United States. It should be noted that the statistics of Canada include the capacities of 50 MW or less, covering a wider range than that of the other countries of 10 MW or less. Importance of developing these small-scale hydropower potential will increase in case energy price rises or low-carbon trend will be accelerated.

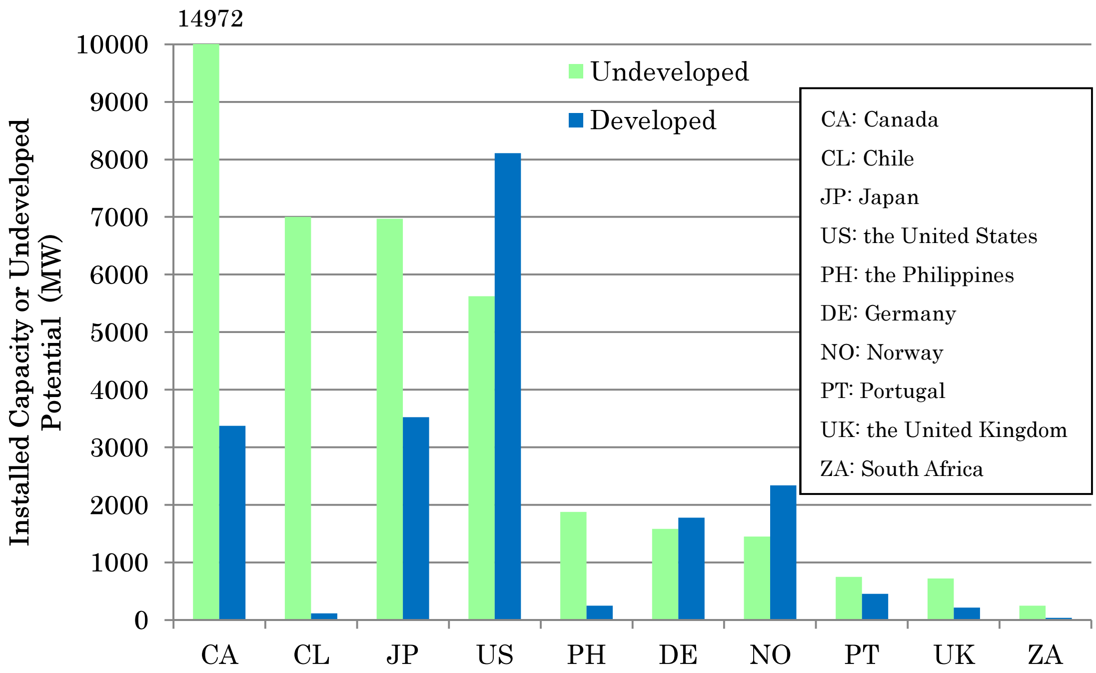

Fig.5 Installed (Developed) Capacity and Undeveloped Potential of Small-Scale Hydropower in the Countries Studied

(Statistics of 2010-2016 of 50 MW or less for Canada, 30 MW or less for developed capacity in the United States, and 10 MW or less for others. Undeveloped potential of UK in MW is estimated from that in GWh using the developed capacity/generation ratio)

(2) Electric Power Market

The electric power market has been totally liberalized in the United Kingdom, Germany, Portugal, Norway, the Philippines, and Chile, wherein power generation, transmission and distribution have been separated. All of the Good Practices in these countries were commissioned after the market was liberalized except one case in Norway commissioned in 1990.

The two Good Practices in the United Kingdom, however, are hydropower projects for a local distribution (including the sale of surplus power through the power grid) using private supply system and for a micro grid system on a remote island. Therefore the liberalized market may have had little influence on these projects. Also the Good Practice in Germany utilizing FIT scheme is managed by a vertically-integrated local public corporation “Stadtwerke” which almost monopolizes power supply in the area, and thus has not been affected much by the market liberalization.

In Japan, the power market began to be partially de-regulated in 1995, and totally liberalized in 2016. However, all seven Good Practices in Japan are projects commissioned in the regulated market.

In the United States, wholesale market was liberalized in 1992 and generation, transmission and distribution sectors have been separated, but the liberalization of retail market differs among states. The State of Alaska where two Good Practices were selected from keeps a regulated market. Canada also liberalized wholesale market upon request from the United States, but the retail regulations vary in different states. In British Columbia where three Good Practices are located, partial de-regulation is only allowed for large-scale industrial consumers. BC Hydro, an electric utility owned by British Columbia manages power generation, transmission and distribution, and proactively purchases power from renewable energy producers to promote expansion of small-scale hydropower projects.

(3) Regulations

An authorization system of water rights has been implemented in all countries. Release of environmental or ecological flow is also obligated except in Portugal and South Africa. In Chile, the concept of regulation is quite different from other countries. Water rights have been recognized as private property since 1981, and they can be obtained through a relatively simple procedure and traded among participants in the water resources sector.

Some regulations in certain countries could not be clarified in this survey.

In Europe, Water Framework Directive by European Union is strictly enforced as environmental regulations, which results in deterioration of economic viability of some projects or prolonged period for permit approval procedures (ESHA, 2012). In Portugal, it usually takes 3 to 11 years to go through approval procedure due to an inefficient approval system coupled with dispersed responsibilities among relevant bureaus and complicated procedural requirements (ESHA, 2012).

In Canada, consultation with indigenous residents (called First Nations) is required, and the collected Good Practices in British Columbia have implemented various measures considering indigenous local communities.

(4) Incentives

Eight of the countries, the United Kingdom, Germany, Portugal, Norway, Japan, the Philippines, South Africa and Chile, have made the purchase of renewable energy obligatory (RPS, Renewables Obligation, Green Certificates, etc.) or introduced price-based scheme (FIT, FIP, etc.), while Canada and the United States have introduced at least one of the above schemes in a number of states other than those from which Good Practices were collected. It shows that many countries have introduced these schemes as effective incentives to promote renewable energy.

Other incentives include investment grants for planning and construction under certain conditions, purchase of renewable energy by electric utilities, competitive bids arranged by the state government, tax reductions, low-interest loans, etc. Particularly in Canada and the United States, some incentives are schemed considering indigenous communities and off-grid areas.

Although it was difficult to obtain sufficient information from some counties, a tendency can be found in Canada, Japan and the United States with relatively large undeveloped potential shown in Fig.5 that they diversify the types of incentives in comparison with other counties.

4. Analysis and Evaluation of Good Practices

4.1 Measures for Economic Sustainability

Table 4 shows a list of effective measures and the corresponding Good Practices based on the analytical results.

Table 4 Effective Measures for Economic Sustainability and the Corresponding Good Practices

Criteria	Effective Measures	Corresponding Good Practices	No.
Recovering Initial Investment Cost	Utilization of investment grants	CA03, JP01-06, UK01-03, US01-02	12
	Introduction of innovative technologies	CA01-03, CL01, DE01, JP01-03, JP06, PT01	10
	Utilization of incentive schemes (FIT, RPS, etc.)	DE01, JP01-02, JP07, NO01-03, UK03	8
	Rationalized design	JP01, JP05, NO01-02, ZA01	5
	Long-term power purchase agreement	CA01-03, JP03-04, UK02	6
	Utilization of existing facilities	JP02, JP05, JP07, ZA01	4
	Alternative use of diesel power generation	CA03, UK01, US01-02	4
	Innovative contract method	CA01-02, PT01	3
	Joint investment	DE01, UK01-02	3
	Utilization of low-interest loans	CL01, JP04	2
	Rate-of-return regulation	JP05-06	2
	Bond floatation	JP01-02	2
	Local procurement of construction materials	CA03, UK02	2
	Participation of local residents in construction work	PH01*, UK03	2
	Pre-paid charging system	UK01	1
Paying for Operation and Maintenance Cost / Gaining Appropriate Profit	Utilization of incentive schemes (FIT, RPS, etc.)	DE01, JP01-02, JP07, NO01-03, UK03	8
	Long-term power purchase agreement	CA01-03, JP03-04, PH01, UK02	7
	Rationalization of operation and maintenance	JP01, JP03-07	6
	Introduction of innovative technologies	CA01-02, JP01, JP03	4
	Alternative use of diesel power generation	CA03, UK01, US01-02	4
	Utilization of low-interest loans	CL01, JP04	2
	Rate-of-return regulation	JP05-06	2
	Optimal operation of reservoir and power plant	CL01, PT01	2
	Innovative contract method	UK03	1
	Volunteer operation and maintenance	UK02	1
	Pre-paid charging system	UK01	1

* Although PH01 does not require recovery of initial investment cost, this measure is effective for reducing initial investment cost in PH01.

The largest number of Good Practices utilizes investment grants for reducing initial investment cost. This is the case with 12 projects in Canada, the United States, the United Kingdom, and Japan. In Canada and the United States, public financial support is well organized for power supply to off-grid areas and indigenous communities. The second most common measure is introduction of innovative technologies, which is implemented by 10 projects. This involves high-efficiency and compact design of water turbine, steel and rubber synthesized inflatable weir, FRPM pipe, omission of anchor block with buried penstock, etc. Other measures include ingenuity in contract types such as EPC and section-specific contracts, bond floatation, joint investment, utilization of existing facilities, rationalized design, community participation in construction work, and local procurement of construction materials.

For maintenance cost and profit, the largest number, eight projects, employed incentive schemes such as FIT or RPS. These are quite important for securing stable income sources as well as the second most common long-term power purchase agreement and enhancing economic viability of the project. These are also effective for the recovery of initial investment cost.

The third common measures are rationalization of operation and maintenance which involves a combined management of multiple plants nearby. Other measures are utilization of low-interest loans, rate-of-return regulation, introduction of innovative technologies (such as countermeasures against sedimentation in intake facilities, simple remote monitoring system using a mobile phone, etc.), electricity billing income by replacing diesel power generation in remote islands or areas, etc.

Of the above, rate-of-return regulation has been applied to electricity tariff or wholesale prices in the regulated market of Japan prior to the recent liberalization, whereby general or public electric utilities can basically secure the economic viability of projects. This system contributed to the development of such Good Practices as JP05 Shin-Taishakugawa Power Plant and JP07 Kochi Public Corporation Bureau, but after 2016 when the retail market is completely liberalized, they need to implement measures to ensure economic viability without depending on rate-of-return regulation.

One exceptional case is PH01 Ambangal Project in the Philippines which was planned by an international NGO, Global Sustainable Electricity Partnership (GSEP). Power plant was built by GSEP and donated to the Government of Ifugao Province. Thus the project owner, the Government of Ifugao Province, does not need to recover the initial investment cost, and ensures economic viability by conducting power generation together with the maintenance of the world heritage rice terrace.

4.2 Measures for Social Sustainability

Table 5 shows a list of effective measures and the corresponding Good Practices based on the analytical results.

For the economic benefits the largest number, 16 cases have contributed to tax / grant revenue and the second largest 14 cases to local industrial development. However the amount of revenue from fixed property and corporate taxes is relatively small and their economic benefits to the local economy are limited, except the grant in the case of JP05 Shin-Taishakugawa Power Plant in Japan. It is called “Grants for Areas Locating Electric Power Stations” with relatively large amounts and used for improving public facilities or infrastructure of local municipalities. The local industrial development includes benefits for tourism related to dam reservoirs, forestry industry to maintain forests in the area, attraction of enterprises by renewable energy supply, further development of new hydropower projects, etc.

The third largest economic benefit is creation of employment opportunities as seen in 12 cases. In addition to the temporary employment for construction, those projects created stable employment for operation and maintenance of plants as well as indirect employment generated by funds flow in the region such as in tourism industry.

Other measures are economic benefits by promoting inter-regional human exchange and sharing of benefits with local communities. The latter was evident in two cases of reduction of charges imposed on farms using irrigation water supply, management of the world heritage rice terrace fund and regional contribution funds.

Table 5 Effective Measures for Social Sustainability and the Corresponding Good Practices

Criteria	Effective Measures	Corresponding Good Practices	No.
Economic Benefits	Tax / grant income	CA01-03, CL01, DE01, JP03-07, NO01-03, PT01, UK02, US01	16
	Local industrial development through tourism, forestry, enterprise attraction, new hydropower projects, etc.	CA02-03, CL01, JP03, JP05-07, PH01, PT01, UK01, UK03, US01-02, ZA01	14
	Creation of employment opportunities for maintenance of power plant, tourism development, regional money flow, etc.	CA01-03, CL01, DE01, JP02-03, NO03, PH01, PT01, UK02, US01	12
	Economic benefits by promoting inter-regional human exchange	JP01-06, UK01-02	8
	Sharing benefits with local communities	JP03-04, NO01-03, PH01, UK02	7
Contribution to Local Environment	Alternative for diesel power generation, improvement of roads, water channels, surrounding area of dam, fire prevention facilities	CA01, CA03, CL01, JP02-06, NO01, PT01, UK01, UK03, US01-02, ZA01	15
	Preservation of forests, rivers, ponds, fish, wildlife, ecological flow release	CA01-03, DE01, JP01-07, PT01, UK02, US01	14
	Preservation of landscape, history, culture, preservation of indigenous culture / life	CA03, CL01, DE01, JP04-05, JP07, NO01-02, PH01, PT01, UK01-02, US01-02	14
Contribution to Local Community	Development of local resources such as renewable energy, tourism, water resources, recreational opportunities, local brands, etc.	CA01-03, JP01, JP05-07, UK01-02, US01-02, ZA01	12
	Education, training, human resources development	CA03, CL01, JP01-04, JP06-07, PH01, UK03, US01, ZA01	12
	Contribution to environmental policies and local activation policies of state and local government.	CA03, CL01, DE01, JP01, PH01, UK01-02, US01-02, ZA01	10
	Local activation by promoting inter-regional human exchange	JP01-06, UK01-03	9

Regarding the contribution to the environment, 15 cases are largest and evaluated for their regional infrastructure improvement involving cases wherein hydropower replaces diesel power generation as precious energy infrastructure in off-grid areas, or improvement in roads, water channels, and the surrounding environment around the dam, installation of fire-hydrants for forest fire prevention, as well as use of hydropower supply as an emergency power source in the area by separating it from the power grid in disaster.

The second largest 14 cases can be identified for both preservation of natural environment and ecosystem and preservation of history and culture. Since preservation of natural environment and ecosystem is a common issue for most of hydropower projects, the other cases not included in this group also conducted environmental impact assessment as required by law and regulations to obtain water rights. Preservation of history and culture includes natural and urban landscape, historical buildings, rice terrace, and indigenous culture.

For the contribution to local communities, local resources development and education, training and human resources development ranked top with 12 cases respectively. Local resources include unused renewable energy, tourism resources, multi-purpose use of water resources, heat supply using surplus power, recreational opportunities, local brands, etc. For example, CA02 Rutherford Creek Project in Canada installed a kayak slalom water channel using the discharge canal of the power plant, thus creating a unique and attractive leisure facility.

Education, training and human resources development are mainly provided by plant visiting tour or energy / environment education, using the power generation facilities, while the projects in the Philippines and Canada provide education and training on operation and maintenance of the plant facilities to the local or indigenous residents.

Other measures range from local activation by promoting inter-regional human exchange, contributions to policies of state and local governments on global warming or regional activation. DE01 Praterkraftwerk Project in Germany has been developed as part of the “renewable energy expansion strategy” promoted by Stadtwerke Munchen (SWM) for achieving the CO_2 reduction target set by the City of Munich. The citizens of Munich are assisting this strategy and cooperating in the promotion of further renewable energy development by paying voluntary surcharge. Although it is not an effect brought about only by the Praterkraftwerk Project, it is surely contributing to the local community policy.

4.3 Balance of Economic and Social Sustainability

In the development of sustainable small-scale hydropower in local community, it is important to balance economic and social sustainability as separately discussed in section 4.1 and 4.2. From this viewpoint, Table 6 summarizes effective measures for each Good Practice based on Table 4 and 5.

Note that in Table 6, the number of effective measures in economic sustainability is duplicated when there is a common measure between two criteria, while there is no duplication of measures among three criteria in social sustainability. Taking account of this, the number of effective measures in social sustainability seems to be larger than that in economic sustainability in all of the Good Practices as the result of simple comparison of total number. This means that social sustainability is considered as crucial as economic sustainability in the Good Practices.

Particularly large number appears in Table 6 for CA03 Atlin Project and US01 Power Creek Project on power supply in off-grid first nation’s community, JP03 Nasunogahara Project on utilization of irrigation water by land reclamation district, JP06 Kochi Prefecture Public Corporation Bureau’s Project on environmental improvement around the dam and forest conservation in the watershed, UK02 Torrs Project by social enterprise with an objective of regional environmental conservation. On the other hand, relatively small number was identified in Good Practices in Norway NO01-03.

However, these three projects have almost the same social aspects to promote agriculture and develop local community in remote area with a high priority to social sustainability of the projects.

Table 6: Measures for Economic and Social Sustainability in each Good Practice.

Code	Name of Power Plant	Number of Measures for Economic Sustainability			Number of Measures for Social Sustainability			
		Initial Invest-ment Cost	OM Cost and Profit	Total	Economic Benefits	Local Environ-ment	Local Commu-Nity	Total
CA01	McNair Creek	3	2	5	2	2	1	5
CA02	Rutherford Creek	3	2	5	3	1	1	5
CA03	Atlin	3	2	5	3	3	3	9
CL01	Mallarauco	2	2	4	3	2	2	7
DE01	Prater	2	2	4	2	2	1	5
JP01	Kachugawa	4	2	6	1	1	4	6
JP02	Taio	4	1	5	2	2	2	6
JP03	Nasunogahara	3	3	6	5	2	2	9
JP04	Fujioiro	3	3	6	3	3	2	8
JP05	Shin-Taishakugawa	4	2	6	3	3	2	8
JP06	Kochi Prefecture Public Corporation Bureau	1	2	3	3	3	3	9
JP07	Ochiairo	4	2	6	2	2	2	6
NO01	Ljøsåa	2	1	3	2	2	0	4
NO02	Jorda	2	1	3	2	1	0	3
NO03	Storfallet	1	1	2	3	0	0	3
PH01	Ambangal	1	1	2	3	1	2	6
PT01	Canedo	1	1	2	3	3	0	6
UK01	Eigg Island	4	2	6	2	2	3	7
UK02	Torrs	4	2	6	4	2	3	9
UK03	Abernethy Trust	3	1	4	1	1	2	4
US01	Power Creek	2	1	3	3	3	3	9
US02	Delta Creek	2	1	3	1	2	2	5
ZA01	Brandkop Conduit Hydro	2	0	2	1	1	3	5

4.4 Analysis of Reasons for Success

From the analysis of the reasons for success in Good Practices, the following common reasons or factors of the success can be drawn: clear vision regarding local contributions of the responsible developers, strong needs of local communities for hydropower project, leadership performed by the developers, utilization of partnership, communication with local communities, and support from government policies. High technological capability is also an important factor in reducing construction and maintenance cost. Table 7 indicates these common factors and the corresponding Good Practices. Table 7 clearly shows the common reasons related to many of the Good Practices, such as communication with local people, support from government policies, and having a clear vision regarding how to contribute to local communities. It is deemed advantageous to implement many of the factors listed in Table 7 in order to successfully carry out various measures for achieving sustainability of the project.

Table 7: Common Factors for Success and Corresponding Good Practices

Common factors for success	Corresponding Good Practices	No.
Communication with local communities	JP01, JP03-07, PH01, CA01-03, CL01, PT01, UK01-03, US01	16
Support from government policies	CA01-03, DE01, JP01-07, UK01-02, US01-02	15
Clear vision regarding local contribution	CA03, DE01, JP01-03, JP07, NO01-02, PH01, UK01-02, US01-02	13
Utilization of partnerships	CA03, CL01, DE01, JP01, JP03, NO01-02, PH01, UK01-03	11
Strong local needs for hydropower project	CA03, CL01, DE01, NO01-03, UK01-02, US01-02	10
Leadership performed by the developers	CA03, DE01, JP01-04, NO03, UK02, ZA01	9
High technological capability	CA01-02, DE01, JP05-06, ZA01	6

5. Summary and Conclusion

Based on the results of analysis and evaluation of Good Practices of small-scale hydropower projects in the world, the following specific and effective measures are summarized to provide economic and social benefits to local communities in accordance with economic viability of the project.

Effective Measures Related to Economic Sustainability of the Project:

(1) Financial measures

- Utilization of FIT or RPS schemes;
- Long-term power purchase agreement;
- Cost reduction by joint investment and innovative contract types;
- Utilization of public financial schemes.

(2) Technological measures

- Introduction of innovative technologies;
- Selective site conditions, design optimization, rationalization of operation and maintenance;
- Utilization of existing facilities.

Effective Measures for Social Sustainability of the Project:

(1) Economic benefits

- Promotion of local industry by developing tourism, attracting enterprises, and developing new hydropower projects;
- Creation of employment opportunities by construction and operation of plants, tourism and funds flow in the area;
- Economic benefits by promoting inter-regional human exchange;
- Income from grants issued for local municipalities;
- Sharing of benefits with local communities through reduction of charges imposed on farms or management of local contribution funds.

(2) Contributions to local environment

- Improvement in energy security in off-grid areas;
- Improvement in roads, water channels, environment surrounding dam and fire prevention facilities;
- Preservation of forests, rivers, reservoirs, fish, wildlife, etc.;
- Preservation of landscape, local history and culture, and indigenous life and culture.

(3) Contributions to local communities

- Development of local resources such as unused renewable energy, water resources, tourism, recreational opportunities, and local brands;
- Education, training, and human resources development;
- Activation of local communities by promoting inter-regional human exchange;
- Contribution to environmental and local activation policies of state and local governments.

More detailed information can be obtained in the attached "Collection of Good Practice Reports" (Appendix A2).

These key findings provide useful guidance for improved social acceptance of new small-scale hydropower developments and improved relationships with local communities for existing project site areas.

6. Recommendations

(1) Much more attention should be paid to the importance of social sustainability in hydropower development.

Strategies of previous hydropower development prioritizing economic sustainability cannot overcome the issue of social acceptance. It can be possible to break the bottleneck by changing the basic concept of hydropower development to improve social sustainability of the project. It is necessary for policy makers and developers to have common and thorough understanding on the definition, evaluation and necessity of social sustainability of hydropower projects in local communities.

(2) Hydropower development addressing "sustainable small-scale hydropower in local communities" should be promoted in all areas in the world by a wide variety of developers.

At the moment, sustainable small-scale hydropower tends to be developed mostly on mini / micro scale as power supply in off-grid areas or as "community power plant". In the future, however, development of sustainable hydropower projects of wider specification in different areas by various type of developers possibly generate new business models and project schemes, leading to further expansion of development. It is necessary to make clear effective measures for further expansion and to develop solutions to the challenges.

(3) Good Practices of "sustainable small-scale hydropower in local communities" should be utilized to provide opportunities for general public to renew their appreciation of the value of hydropower generation.

It is not easy for people in general to understand the value of hydropower generation. It may be possible to generate a favorable cycle wherein increased opportunities for people in general to recognize the social contributions of hydropower arouses social concern, which in turn enhances social acceptance of hydropower development, and then developers can put more emphasis on social sustainability. Strategy in public awareness is necessary to increase social understanding of sustainable hydropower in collaboration with media, educational institutions and NGOs, with the aid from project site communities.

(4) Information of “sustainable small-scale hydropower in local communities” should be further accumulated, analyzed and organized for sharing among hydropower experts.

At present only a few studies or reports have been presented on economic and social sustainability of hydropower in local communities based on the case histories. It is therefore important to collect more cases and data, to clarify the success factors and to organize such information for sharing among hydropower experts including policy makers and developers.

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