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Expert Group Meeting and
Study Tour on Standardized
Small Hydropower Plants

Hangzhou, China, 18-28 May 1987

REPORT*

177

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CONTENTS

	<u>Paragraphs</u>	<u>Page</u>
Introduction	1 - 7	1
Agreed conclusions and recommendations	8 - 21	2

Chapter

I. ORGANIZATION OF THE MEETING	22 - 33	4
II. SUMMARY OF DISCUSSIONS	34 - 58	7
III. CLOSURE OF THE MEETING	59 - 61	10

Annexes

I. LIST OF PARTICIPANTS		11
II. PROGRAMME OF WORK		16
III. LIST OF DOCUMENTS		18

INTRODUCTION

1. The Expert Group Meeting on Standardized Small Hydropower Plants was held in Hangzhou, People's Republic of China, from 18 - 21 May 1987.
2. The meeting was attended by 49 experts from 23 countries of Asia, Latin America, Africa and Western Europe. (The list of participants appears under Annex I).
3. Following the meeting, 24 participants took part in the Study Tour of SHP plants and equipment manufacturers in Zhejiang Province, Jinhua and Conghua counties from 22 - 28 May 1987.

Background to the Meeting and Study Tour

4. This Expert Group Meeting and Study Tour on Standardized Small Hydropower Plants was part of the follow-up activities to the recommendations of the Second Consultation on the Capital Goods Industry with Special Emphasis on Energy-Related¹⁾ Technology and Equipment held in Stockholm, Sweden, 10 - 14 June 1985.
5. That consultation called upon UNIDO to, inter alia:
 - (i) promote regional cooperation in the field of electric power equipment manufacturing;
 - (ii) analyse the costs and benefits of and limits to technology unpackaging in the electric power equipment industry while recognizing the advantages thereof;
 - (iii) prepare regional directories of firms manufacturing electric power equipment and their products;
 - (iv) organize interregional expert group meetings on new and renewable sources of energy for rural development adapted to each region's conditions with participation of both developing and developed countries.
6. This Expert Group Meeting and Study Tour was organized by UNIDO to fulfil the above mandate with particular attention to Small Hydropower (SHP) Plants. The decision to focus on SHP was taken by the Task Force on Capital Goods Industry, which met on 27 September 1985 to deliberate on follow-up activities to the Second Consultation on Capital Goods. It was also decided at that meeting to explore the issue of standardization of SHP plants as a possible strategy to reduce cost of SHP installations and promote regional cooperation in this field.
7. Subsequent activities of the UNIDO Secretariat on this subject were thus directed to the preparation of the studies and background documents as well as organizing the Expert Group Meeting and Study Tour.

1) Report of the Second Consultation on the Capital Goods Industry with Special Emphasis on Energy-Related Technology and Equipment, Stockholm, Sweden, 10 - 14 June 1985 (ID/338)

AGREED CONCLUSIONS AND RECOMMENDATIONS

Conclusions

8. The meeting found the two main background documents on electromechanical equipment and civil works extremely useful. They substantially advance the cause of making available to developing countries simple designs and methods to manufacture and install SHP plants largely by their own means, and represent a valuable contribution to the literature on the subject.
9. The standardized SHP models proposed in the background documents were considered suitable for indigenous manufacturing in developing countries. Additional information on design of models (e.g. Turgo and Pelton units) for application outside the range considered in the present study is desirable. Furthermore, for all models there is need to document information on manufacturing technology. Turgo and Pelton units were considered suitable for production in medium and less developed countries. The more advanced developing countries may also consider manufacturing of S-turbines of the full Kaplan type. River current turbines although of interest to some developing countries would need further research and development work before being considered for wider application. Other electromechanical equipment suitable for local production includes low capacity asynchronous generators, low speed synchronous generators and electronic load control equipment.
10. Participants considered it desirable that, additionally, detailed design and manufacturing information be made available on models developed in developing countries, such as the standard ZD-760 and S-turbines in China, the multi-purpose power units used in Nepal and the OLADE turbines in Latin America.
11. It was considered essential that actual needs and suitable market conditions, as well as sufficient knowledge and skill on different levels should exist when local manufacturing is started. The necessary training in direct workshop manufacturing should be in depth (several months, not a few days or weeks) and might require exchange of skilled workers and foremen with a workshop in a developed country.
12. The participants stressed the need of information of suppliers of components to SHP plants, especially of those based and working in the developing countries. Existing directories, mainly covering developed countries and Latin American countries need to be supplemented.
13. The participants noted the importance of the Regional Network for SHP in the Asian and Pacific countries, and concluded that similar network activities would also be beneficial in Africa and Latin America.
14. It was also considered necessary that international cooperation be mobilized to create some prototype SHP stations, based on the existing proposals. The prototypes did not necessarily have to be chosen in conformity with the six models detailed in the report, but could be any of the 27 cross-flow, 39 Francis or 21 propeller type proposals, as long as they lie within the proposed area. The creation of such prototype SHP stations should also provide the possibility of direct application of the design and installation methods presented in the document related to civil works.

15. There was a general agreement among the participants of the benefits that technology unpackaging may give. It was understood that the first steps of indigenization might require certain costs for support to prototype units, for example. Economic assessments should, however, not be considered in relation to single stations, but with regard to complete programmes.

Recommendations

It is recommended that within available resources, UNIDO should consider to:

16. Support an extension of the existing studies to include turbine types in the high head range; in the large flow low head range, as well as certain electrical equipment and civil works components, such as surge tanks and buried penstocks. The completed studies should preferably be translated into other languages and published to ensure wider dissemination.

17. Explore the possibility of obtaining detailed design information from developing countries, such as China and Nepal, and to spread information on the OLADE programme, including its detailed designs, to all interested countries.

18. Provide short-term specialized technical expertise and create possibilities for long-term training of skilled workers, foremen and workshop engineers. The latter may be undertaken through an exchange of shift programmes between workshops in developed and developing countries.

19. Continue with compilation of information on available SHP manufacturers and to distribute it in the form of a directory.

20. Support the creation of some pilot projects within developing countries, so proposals and methods can be practically demonstrated and tested.

21. Assist in the creation and establishment of regional SHP networks in Latin America and Africa, based on the model of the network operating in the Asia and Pacific Region.

I. ORGANIZATION OF THE MEETING

Opening of the Meeting

Statement on behalf of the Ministry of Water Resources and Electric Power

22. The meeting was addressed by Mr. Deng Bingli, Director of Rural Electrification in the Ministry of Water Resources and Electric Power. He extended a cordial welcome to all participants and UNIDO officials. He expressed confidence that with the gathering of so many experts on Small Hydropower discussing pertinent issues, mutual understanding between experts from different countries will be enhanced and the exchange of experiences will speed up development of SHP in those countries and throughout the world.

23. He underscored the importance of water as a renewable source of energy and especially development of small hydropower to satisfy needs of electricity supply for rural and remote communities in developing countries. China is still a developing country. In order to utilize fully and effectively water resources for SHP development, the Chinese Government set up a series of supporting policies over several years. The machinery building industry has also attained great achievements in manufacturing SHP machinery and equipment. By the end of 1986, China has constructed some 67 000 SHP plants with a total installed capacity of 10,090 MW. The construction of these plants has provided cheap power for irrigation, drainage, country- and town-run enterprises and factories, agricultural products processing as well as domestic lighting. The benefits of this programme can be particularly seen in the remote mountainous areas that are bypassed by the electricity grid.

24. He stated that although China has made significant achievements in development of SHP, it still faces some problems, especially in aspects of management and advanced technology. He therefore welcomed this opportunity to have technical information exchanges with experts from other countries on these two and other aspects. He concluded by wishing participants a happy stay in China and the meeting a success.

Statement on behalf of the Hangzhou Regional Centre (Asia and Pacific) for Small Hydropower

25. The meeting was also addressed by Mr. Zhu Xiaozhang, Director and Chief Engineer of the Hangzhou Regional Centre (Asia and Pacific) for Small Hydropower. He expressed appreciation to UNIDO and the Government of the People's Republic of China for selecting the Hangzhou Regional Centre (HRC) as the host institution of the meeting. He welcomed all the participants and experts to China. The Chinese Government accorded great importance to the meeting as evidenced by the presence of senior officials of the Chinese Ministry of Water Resources and Electric Power (MWREP) as well as of the Zhejiang Province local Government. He went on to introduce the senior officials present, who included Mr. Deng Bingli, Director of the Department of Rural Electrification in MWREP; Mr. Zhao Giafu, Director of the Office of Foreign Affairs of the Zhejiang Provincial Government; Mr. Hu Wuangli, Deputy Mayor of Hangzhou Municipality; Mr. Hu Guisun, Deputy Director, Department of Foreign Economic Relations and Trade, Zhejiang Provincial Government; Mrs. Zhou Huilan, Deputy Director, Department of Water Resources, Zhejiang Provincial Government; Mr. Zhu Shuilin, Assistant Chief Engineer, Bureau of Electrical

Industry, Zhejiang Province; and Mrs. Lian Yuan Xia, Division Director, Commission of Science and Technology of Zhejiang Provincial Government. He concluded by wishing the meeting every success in attaining all objectives that were preset for it.

Statement by the Director of UNIDO System of Consultations Division

26. The Director of UNIDO System of Consultations Division expressed gratitude and appreciation to the Government of the People's Republic of China and to the Hangzhou Regional Centre for their kind acceptance to host the meeting and study tour. He also thanked the Government of Switzerland for providing the substantive financial support for the meeting. The Government of Sweden also provided support by funding one of the main studies carried out in preparation for this meeting. He expressed appreciation to these Governments for not only their continued firm political support to the UNIDO System of Consultations but also to the assistance given to enable the System realize more action-oriented activities, such as this meeting.

27. He explained that this meeting was a direct follow-up of some of the recommendations of the Second Consultation on the Capital Goods Industry with Special Emphasis on Energy-Related Technology and Equipment held in Stockholm, Sweden, June 1985. Thus this meeting constitutes part of UNIDO's continuing programme to assist developing countries in promoting development of the capital goods sector and thereby raise the technological capabilities of these countries. He referred to UNIDO's activities in SRP over the last eight years and the establishment of the Asia and Pacific Regional Network for SHP and the Hangzhou Regional Centre as some of the fruits borne from these activities.

28. One of the major constraints faced by developing countries in the capital goods sector, that was highlighted at the Stockholm Consultation, was the limited domestic market. The problem is compounded by the diversity of imported technologies which makes the process of absorption and adaptation of technology even more difficult. A degree of standardization to the extent feasible could offset some of these difficulties, although the constraints of standardization have to be carefully checked. He introduced the two major reports prepared for the meeting, covering electromechanical equipment and civil works components. After re-stating the objectives of the meeting he wished the participants a very successful meeting.

Election of Officers

29. The following officers were elected:

- Chairman: Mr. Zhu Xiaozhang (China)
Director and Chief Engineer
Hangzhou Regional Centre (Asia and Pacific) for SHP
- Vice-Chairman: Mr. Leonardo Gabriel Galinsky (Argentina)
Adviser to the New Power Sources and Conservation
National Energy Department
- Rapporteur: Mr. Estomih Ngaya Sawe (United Republic of Tanzania)
Head
Renewable Energy Development Section
Ministry of Energy and Minerals

Adoption of the Programme of Work

30. The meeting adopted the work programme as shown in Annex II.

Documentation

31. Documents issued and presented at the meeting are listed in Annex III.

Adoption of the Report

32. The report of the meeting was adopted by consensus at the final plenary on 21 May 1987.

Study Tour

33. Twentyfour participants took part in the study tour. They were accompanied by representatives of the Hangzhou Regional Centre and the local governments in Zhejiang, Jinhua and Conghua. At the end of the study tour, the UNIDO Secretariat representative, on behalf of UNIDO and all participants, thanked the study tour organizer (HRC) and the local governments for all the arrangements done to ensure successful completion of the tour.

II. SUMMARY OF DISCUSSIONS

34. A representative of the UNIDO Secretariat made a presentation of the document entitled "Report on Standardization for Indigenous Manufacturing of Small Hydroelectric Power Plants", highlighting the philosophy, scope and main findings. He explained that the basic objective of the report was to provide information on the design of standardized electromechanical equipment in a form that could be easily assimilated. The report focuses especially on design of turbines that are considered suitable for manufacturing in moderately equipped workshops. Six standard model designs were presented, including three crossflow, two Francis and one propeller turbine. These models are categorized in an ascending order of complexity of manufacturing technology and thus countries may select appropriate models in accordance with the level of their technological development.

35. Another representative of UNIDO Secretariat presented the second major background document of the meeting, entitled "Report on Standardization of Civil Works for Small Hydropower Plants". He described the "Lego System" philosophy upon which the standardization of civil works components has been tackled in the report and presented design examples covering water intakes, desilting works, water ways, forebay, penstock, powerhouse and tailrace.

36. Experts from participating countries made presentations on the scope of SHP activities in their countries.

37. The Coordinator of the Regional Network (Asia and Pacific) for SHP described the historical development, mode of operation and range of activities undertaken by that network.

38. A representative of UNIDO Secretariat gave an account of UNIDO's activities in the field of SHP, emphasizing the integrated energy/industry development strategy adopted. In this respect the role of SHP for promotion of small-scale industries in rural areas was stressed.

39. In discussing the presentations, several participants commended UNIDO Secretariat on the high professional quality of the two main documents prepared for the meeting. The documents were considered to be a valuable contribution to the literature on SHP development strategies and in this respect their wider dissemination would be highly desirable. For effective utilization among a greater number of developing countries, it would be necessary to include translations of the documents into other languages as well.

40. The participants noted with satisfaction that the present effort undertaken by UNIDO constituted a follow-up of some of the main recommendations of the Second Consultation on Capital Goods, with emphasis on energy-related technologies and equipment. They emphasized the lack of standardization in the SHP field as a main impediment to rapid development of SHP in developing countries.

41. With specific regard to the report on standardization of civil works components, there was consensus that the information included, namely the simplified methods of calculation, data based on actual experience and practical examples with detailed drawings, would provide considerable guidance in the planning and realization of SHP projects. The participants observed that there was increasing awareness of benefits of SHP in rural areas in developing countries.

Integration of SHP with irrigation and water conservation systems would provide local communities with basic energy needs for irrigation, water pumping, small industries (e.g. food packaging and refrigeration) and domestic lighting. Rural electrification is thus an essential component of rural development activities for which financial assistance from industrialized countries could be more forthcoming than for large hydro-electric projects. It was further observed that whereas the cost per kilowatt installed for SHP plants was relatively high, the factor cost was by no means prohibitive within an overall economic assessment of well conceived rural development schemes.

42. Participants expressed the following views regarding specific SHP civil works components:

- a) Access roads - these could not easily be included in the standardization philosophy as presented in the background document. Participants felt that attempts should be made to have the cost of access roads met by local authorities who normally provide such services to the community.
- b) Surge tanks - although not included in the background document, several participants requested that on account of their importance, detailed information be provided for these as well.
- c) Construction materials - although the cost of construction materials to be used for SHP was important, the overriding consideration is often the availability, or otherwise, of such materials.
- d) Penstocks - Given suitable soil conditions, these could be buried instead of laid above ground, as recommended in the report. The calculation method in the report remains valid but the temperature stresses for open-air penstocks need no longer be considered.
- e) Powerhouse - this should be kept as simple as possible and a module design could be considered where several units are to be installed.

43. Participants were unanimous that standardization could lead to significant cost-savings for both civil works and electromechanical equipment as well as training programmes.

44. Effective and experienced project management was emphasized as a major requirement for SHP projects. Timely project completion within budgeted cost (or lower) depends to a large extent on the ability of the project manager.

45. The establishment of regional networks for SHP was seen by many participants as a useful and desirable institutional set-up for coordinating and promoting SHP development. Based on the experience gained in the Asia and Pacific Regional Network for SHP, participants from Argentina and Ethiopia expressed the willingness of those countries to initiate, with the support of UNIDO and other international organizations, the establishment of regional networks for Latin America and Africa, respectively. With regard to the establishment of regional centres similar to the Hangzhou Regional Centre (Asia and Pacific), participants took note that a major portion of the cost of such an undertaking will have to be borne by the host country itself. This was especially so for the civil works construction cost. Participants from Argentina expressed the readiness of their country to make available the existing National SHP Misiones (CREDMHI) for development into

a Latin America Regional Centre.

46. A major function of regional SHP networks highlighted by several participants was to facilitate wider information exchange, especially that related to indigenous manufacturing. Thus documentation on design, development, manufacturing and trouble-shooting of SHP equipment as well as civil works design and construction techniques, based on actual experience of countries in a regional network, should be developed and exchanged widely. However, some participants expressed reservations on the practicality of such information exchange since the technology owners may be reluctant to make such information readily available.

47. Several participants requested UNIDO to extend the present study on standardized models to include detailed design and manufacturing information on other models developed by some developing countries like China and Nepal. The participants took note of the development of standardized series of SHP turbines in China and the multipurpose production units (MPPU) developed in Nepal. The participants from Nepal confirmed their readiness to make available to any interested country all information on design and manufacturing of the MPPU with no claims on patent rights. A number of participants expressed interest in promoting manufacture of MPPU's in their countries with assistance from UNIDO. UNIDO was requested to explore the possibility of obtaining similar detailed information from other willing developing countries and to facilitate the wide dissemination of such information.

48. A number of participants expressed the need to develop prototypes and pilot projects based on the design philosophies embodied in the two main documents of the meeting, as a logical follow-up to the work already undertaken by UNIDO.

49. Training of technicians and artisans in manufacturing facilities of SHP equipment suppliers was considered very instrumental in transferring SHP production technology. Such training programmes could be organized in both industrialized as well as developing countries involved in SHP equipment production.

50. The participants from one developing country stated that their country would wish to acquire technology of S-tubular and propeller turbines, and would need assistance in organizing training programmes as well as construction of a pilot project to demonstrate the feasibility of such technologies.

51. The participants from another developing country stated that their country would like to develop their own designs but may need specialized expertise from UNIDO and industrialized countries. These participants felt that the needs of different countries are varied and as such technical cooperation should be tailored to specific needs, e.g. expert designers etc.

52. The participant from yet another developing country expressed the interest of that country in acquiring technology for low-head turbines, especially tubular turbines with pulley coupled runners.

53. One participant felt that turbine manufacturing development should be based on existing models. It may not be necessary for many countries to develop turbine manufacturing capacities due to low domestic markets. Turbines could

be imported from other developing countries that have already developed the technology on the basis of a large domestic market. This view was however not shared by several participants who saw the need to develop their own manufacturing capacity as of top priority.

54. Several participants stated that it was desirable that workshops involved in production of SHP equipment should also produce other equipment, such as agricultural implements. Experience has shown that several workshops could not maintain their production operations solely specializing on SHP equipment.

55. Many participants stressed the importance of an integrated development strategy for SHP involving irrigation schemes, small industries and power generation.

56. A number of participants observed that while the six SHP models proposed in the UNIDO document and the two Chinese models presented at the meeting could satisfy some of the needs, it is however desirable to include other models, especially for high head applications.

57. Some participants felt that the standardization strategy should also include equipment, such as electronic head controllers, electromechanical governors, generators. In addition, many countries lacked turbine testing facilities, and cooperation in establishing such facilities was sought.

58. A number of participants submitted information on SHP manufacturing facilities in their countries.

III. CLOSURE OF THE MEETING

59. The meeting was closed by Mr. Deng Bingli, Director of Rural Electrification in the Ministry of Water Resources and Electric Power, who congratulated the participants for having attained all the objectives that were preset for the meeting.

60. The Chairman of the meeting thanked all experts for their contributions in making the meeting a success and pledged the willingness of the Hangzhou Regional Centre to continue cooperating with all interested countries in the field of SHP.

61. On behalf of UNIDO, the Director of the System of Consultations thanked the participants for the hard work and the serious manner in which discussions were conducted. He reaffirmed UNIDO's determination to continue supporting developing countries in the SHP field to the extent that available resources permit and called upon all experts to assist towards realization of the recommendations that were adopted. He also once again thanked the Governments of Switzerland, China and Sweden for their support for organizing the meeting and invited other countries and agencies to join UNIDO in supporting SHP development in developing countries.

Annex I

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Annex II

PROGRAMME OF WORK

17 May 1987	All Day	Arrival in Hangzhou
18 May 1987	8.30 - 9.30	Registration of participants
	9.30 - 10.00	Opening remarks by representatives of the Government of the People's Republic of China, Hangzhou Regional Centre and UNIDO
	10.00 - 10.30	Coffee
	10.30 - 10.45	Election of officers (Chairman, Vice-Chairman and Rapporteur)
	10.45 - 12.15	Standardization for Indigenous Manufacturing of Small Hydroelectric Power Plants
	12.15 - 14.00	Lunch
	14.00 - 16.00	Standardization of Civil Works for Small Hydropower Plants
	16.00 - 16.30	Coffee
	16.30 - 17.30	Micro Hydropower Models
19 May 1987	8.30 - 10.00	Application of Standardized SHP installations
	10.00 - 10.30	Coffee
	10.30 - 12.15	Country Case studies
	12.15 - 14.00	Lunch
	14.00 - 16.00	Continuation of country case studies
	16.00 - 16.30	Coffee
	16.30 - 17.30	Plenary discussions
20 May 1987	8.30 - 10.00	SHP Development: Role of UNIDO The Asia-Pacific Regional Network for SHP
	10.00 - 10.30	Coffee
	10.30 - 12.15	Working Group discussions on: (a) SHP Civil Works (b) SHP electromechanical equipment
	12.15 - 14.00	Lunch
	14.00 - 15.30	Working Group discussions
	15.30 - 16.00	Coffee
	16.00 - 17.30	Working Group drafting of conclusions and recommendations
21 May 1987	8.30 - 12.15	Preparation of final report and visit to HRC
	12.15 - 14.00	Lunch
	14.00 - 15.30	Adoption of final report
	19.00 - 21.00	Concluding remarks by representatives of Government of People's Republic of China, HRC and UNIDO
22 May 1987	7.30 - 10.15	Visit to Hangzhou Electric Equipment Works
	10.20 - 12.30	To Tonglu county
	12.40 - 13.40	Lunch at Fuchungjiang Power Plant
	13.50 - 15.30	Visit to Fuchungjiang Power Plant
	15.30 - 16.40	Visit to Fuchungjiang Hydraulic Machine Works
	16.45 - 18.30	Back to Hangzhou

23 May 1987	5.15	To Jinhua by No. 379 train
	11.30 - 12.30	Lunch at Jinhua Guesthouse
	13.00 - 14.30	Visit to Andi 1st Cascade Station
	14.30 - 15.00	To Sumen Power Station
	15.00 - 16.00	Visit to Sumen Power Station
	16.00 - 18.00	Visit to Guofu Power Station
	18.30	Dinner and Stay at Jinhua Guesthouse
24 May 1987	7.30 - 8.30	To Double-Dragon Power Station
	8.30 - 11.30	Visit to the Station and Sightseeing
	12.15 - 13.15	Lunch at Jinhua Guesthouse
	13.30 - 18.00	Visiting West-lake Power Station and Sightseeing
25 May 1987	8.00 - 10.00	To Jinhua Turbine Works and Visit
	10.00 - 11.00	Visit to Jinhua Electro-machine Works
	11.30 - 12.30	Lunch at Jinhua Guesthouse
	13.30	To Hangzhou by No. 380 train
	19.00	Dinner at Hangzhou Airport
	20.45 - 22.40	Flying to Canton by CA 3502
26 May 1987	9.30	To Conghua county
	13.00 - 17.00	Visit to SHP Stations
		Overnight at Conghua
27 May 1987		Visit to SHP Stations
		Overnight at Conghua
28 May 1987	7.30	Back to Canton
29 May 1987	a.m.	Leaving China for Home Countries

Annex III

LIST OF DOCUMENTS

1. Discussion Paper --
2. Report on Standardization for Indigenous Manufacturing of Small Hydroelectric Power Plants --
3. Report on Standardization of Civil Works for Small Hydropower Plants ID/WG.468/11 (SPEC.)
4. The Standard Series of S-type Tubular Turbine in China ID/WG.468/1 (SPEC.)
5. Axial-Flow Turbine Series ZD760 for Low Head ID/WG.468/2 (SPEC.)
6. Experiences in the Standardization of Small Hydropower Stations ID/WG.468/3 (SPEC.)
7. Small Hydropower Development in Argentina ID/WG.468/4 (SPEC.)
8. Small Hydropower for Developing Countries: The Role of UNIDO ID/WG.468/5 (SPEC.)
9. Application of Standardized Small Hydropower Installations in China ID/WG.468/6 (SPEC.)
10. Small Hydropower Development in Morocco ID/WG.468/7 (SPEC.)
11. Small Hydropower Development in the Philippines ID/WG.468/8 (SPEC.)
12. Small Hydropower Development in Tanzania ID/WG.468/9 (SPEC.)
13. The Asia and Pacific Regional Network for Small Hydropower ID/WG.468/10 (SPEC.)
14. HRC and its Function in Technical Co-operation of SHP in the Asia-Pacific Region --