

Small-Hydropower Development: The Process,  
Pitfalls, and Experience  
Volume 3: Summary and Analysis of Technology  
Development Projects

---

EM-4036, Volume 3  
Research Project 1745-15  
DOE Contract ID/12254-1

Final Report, September 1987

Prepared by

MORRISON-KNUDSEN ENGINEERS, INC.  
180 Howard Street  
San Francisco, California 94105

Principal Investigator  
J. P. Christensen

Prepared for

U.S. Department of Energy  
Idaho Operations Office  
785 DOE Place  
Idaho Falls, Idaho 83402

DOE Project Manager  
P. A. Brookshier

and

Electric Power Research Institute  
3412 Hillview Avenue  
Palo Alto, California 94304

EPRI Project Manager  
C. W. Sullivan

Energy Storage and Hydroelectric Generation Program\*  
Energy Management and Utilization Division

\*Now with  
Hydroelectric Generation Program  
Advanced Power Systems Division

## CONTENTS

<u>Section</u>		<u>Page</u>
1	INTRODUCTION	1-1
2	NATIONAL SMALL HYDROPOWER PROGRAM	
	General	2-1
	Technology Development Subprogram	2-2
3	SMALL HYDROPOWER TECHNOLOGY TRANSFER PROJECT	
	General	3-1
	Scope	3-1
	Task A - Feasibility Studies/Licensing Activities	3-1
	Task B - Technology Development Projects	3-1
	Task C - Recommendations Manual	3-2
	Task D - Technical Committee	3-2
	Results of the Project	3-3
4	STUDY METHODOLOGY	
	General	4-1
	Sources of Data	4-1
	DOE Reports	4-1
	Data Collection Form	4-3
	Processing of Information	4-5
	Accuracy of Data and Analyses	4-6
5	PROJECT DATA SUMMARY	
	General	5-1
	Demonstration Projects	5-1
	Site Data	5-1
	Project Data	5-4
	Construction Data	5-10
	Operation Data	5-12
	Cost and Financial Data	5-12
	Other Projects	5-17

<u>Section</u>		<u>Page</u>
6	ANALYSIS	
	General	6-1
	Data Categories	6-1
	Comparison of Data	6-2
	Analysis of Cost Data from Demo/Other Projects	6-17
	Analysis of Performance Data from Demo/Other Projects	6-20
	Economic Comparison of Small Hydro with Conventional	
	Electrical Energy Sources	6-22

#### APPENDIXES

<u>Appendix</u>		
A	INDEX TO PROJECTS BY CHARACTERISTICS AND CATEGORIES	A-1
B	GLOSSARY	B-1
C	DATA COLLECTION FORM	C-1
D	INDIVIDUAL PROJECT SUMMARIES FROM TECHNOLOGY DEVELOPMENT PROJECTS	D-1
E	INDIVIDUAL PROJECT SUMMARIES FROM OTHER COMPLETED PROJECTS	E-1
F	INDIVIDUAL PROJECT SUMMARIES FROM INCOMPLETE DOE DEMONSTRATION PROJECTS	F-1
G	DOE SMALL HYDROPOWER TECHNOLOGY DEVELOPMENT SUBPROGRAM ANNOTATED BIBLIOGRAPHY OF REPORTS AND PUBLICATIONS	G-1

## ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
5-1	Locations of Projects	5-3
6-1	Site Characteristics	6-3
6-2	Regional Distribution by Categories of Installed Capacity	6-5
6-3	Regional Distribution by Categories of Average Annual Flow	6-5
6-4	Regional Distribution by Categories of Gross Head	6-6
6-5	Project Features - 240 Feasibility Studies	6-7
6-6	Project Features - Demo/Other Projects	6-8
6-7	Plant Factor	6-9
6-8	Turbine Data	6-9
6-9	Transmission Data	6-10
6-10	Total Development Time	6-11
6-11	Licensing Time	6-12
6-12	Construction Time	6-12
6-13	Turbine Procurement and Delivery Time	6-13
6-14	Project Capital Cost (per kW of Installed Capacity)	6-14
6-15	Project Capital Cost (per kWh of Energy)	6-15
6-16	Annual Operating Cost (per kW of Capacity)	6-16
6-17	Annual Operating Cost (per MWh of Energy)	6-17
6-18	Capital Cost Variance	6-18
6-19	Capital Cost Breakdown	6-19