CHAPTER 6

DISCUSSION AND CONCLUSION

In conventional village hydro systems, where neither automatic control mechanisms for generation on demand needs nor energy storage systems are present, excess energy generated has to be wasted in ballasts. According to the survey findings, average daily energy consumption is approximately 30% of available potential in most conventional systems. In the point of view of energy conservation, this is a highly unacceptable situation. Further, problems encountered in village hydro systems can be broadly categorized as technological issues, resource inadequacy issues, financial constraints and social issues. This research was aimed at finding a solution to these problems.

As far as energy recovery in village hydro systems is concerned three methodologies can be applied in broad sense viz. mechanical or electronic control systems, hydro storage systems and energy storage systems. Expensive components are included in control systems and therefore such control systems are not a viable option for village hydro systems. In consideration of hydro storage, ponding is not allowed by statutory regulations and the particular option is not viable in regulatory aspects. Therefore, the methodology used is energy storage system, where a battery bank is used to store unutilized energy for later use. Six case studies were carried out to evaluate the viability of proposed energy storage solution. The system has been proven to be technologically and economically feasible.

Conventional power plant capacity is determined to suit the peak demand and this leads for waste of material, time and money of the villagers, as the systems are usually over sized. This is causing unnecessary burden on the people, leading to discourage implementation on many occasions. When the capacity is taken to satisfy the peak demand, the project cost becomes quite high and the financial issues become more difficult and the operation and maintenance costs increase. Therefore augmenting a conventional village hydro system to an energy storage system is more viable than constructing a new community electrification system in view of the expensive system components like new transmission lines as opposed to extending the transmission line of an existing system. In fact, an augmentation is financially far more viable than a new project as this can be done with very little additional resources causing very little environmental damage, yet providing a lot of social benefits of some additional households. As a solution to the problems related to the capacity, an energy storage system is proposed, where only the energy supply and demand are required to be matched at low cost. The energy storage concept can be used, where a meagre hydro resource, hitherto discarded as inadequate can be exploited to serve a community, by providing electricity to some additional households or if such households are not there, by increasing the capacity provided for existing households.

A case study carried out earlier for Dothaluoya, a conventional village hydro system has revealed that the annual energy utilization factor of the village hydro system is 11.5%. The average energy utilization factor in the proposed system is 40%, which is a considerable improvement in comparison to conventional village hydro systems. Considering the energy storage application, energy storage systems are used in hybrid applications like diesel-wind, solar-low head hydro, etc. These applications are economically viable, and the proposed system can be considered as a further step for excess energy recovery applications.

Financial viability is one of the most important factors for any project to become feasible, in view of the low income levels of the rural poor. In stand alone, self financing village hydro systems, socio-economic aspects such as affordability too inherently affects the system economics due to the fact that consumers are required to pay the full cost of electricity unlike the rural communities served by the national grid who are recipients of a massive capital subsidy and a massive consumption subsidy. The tariff of electricity consumed by the village consumers should be decided in such a way that it would be sufficient to repay the investment and bear the operation and maintenance cost. The model village discussed in Chapter 5- Analysis, the IRR is 10.0%, 12.9%, and 13.7 % for electricity price of Rs 6.00, Rs 6.75, and Rs 7.00 per kWh respectively, making the project financially feasible. Viability of an augmentation project further increases if the new households to be electrified are within or just outside of an existing distribution network of a conventional system.

Further, viability of the project could be validated by a pilot scale project implemented at Dodampitiya in the Opanayake area. In this case, the power plant capacity is 0.98 kW and 13 households could be provided with electricity using energy storage system; whereas only 4 households would have been catered to if a conventional system was used.

Considering the issues in relation to the energy storage application in village hydro systems, type of batteries has to be deep-cycle discharge type and non availability of deep cycle batteries in the local market, requiring direct importation of batteries at far greater cost than direct purchase is a major issue. As far as the repairs and maintenance are concerned, it is a severe problem to get the repairs done on time due to the ignorance of the technology by the villagers. Therefore there should have a mechanism to disburse the technology to enthusiastic personnel. So, further studies on technology transfer and capacity development in rural areas are required.

As far as adopting the battery bank energy storage system to a new site is concerned, calculation procedure has to be followed at the fundamental level in view of the site-specific nature of the method. Also, even though village hydro system development has been done for quite a long period, designers have used the same conventional methodology and if the proposed system design is not user friendly it will not be applied by the designers. However, with more studies it will be possible to develop a simpler model and standard procedures. Therefore studies on simplified modeling and standardization are recommended as further research areas in energy storage systems.

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APPENDIX

Table A1, Results of Mini-Hydro Survey

Divisional Scretory	Plant design Capacit y(kW)	System Out Capacity(kW)	Supplied Watage(W)	Number of Buildings	Energy Generation(kWh) /day	Energy Demand(kW)/villa ge/day
Yatiyanthota	4.8	3	100	20	72	2
Yatiyanthota	12.8	8	100	85	192	8.5
Yatiyanthota	8.8	5.5	100	40	132	4
Yatiyanthota	38.4	24		1	576	0
Yatiyanthota	32	20	175	120	480	21
Yatiyanthota	16	10	200	59	240	11.8
Yatiyanthota	7.2	4.5	175	26	108	4.55
Yatiyanthota	3.2	2	210	9	48	1.89
Yatiyanthota	3.84	2.4	100	24	57.6	2.4
Yatiyanthota	24	15	200	60	360	12
Yatiyanthota	16	10	100	58	240	5.8
Neluwa	0.48	0.3	300	1	7.2	0.3
Neluwa	0.4	0.25	250	1	6	0.25
Thawalama	1.28	0.8	800	1	19.2	0.8
Neluwa	0.8	0.5	500	1	12	0.5
Thawalama	0.64	0.4	400	1	9.6	0.4
Walallawita	4	2.5	125	14	60	1.75
Akurassa	5.6	3.5	100	20	84	2
Akurassa	3.52	2.2	100	15	52.8	1.5
Akurassa	4	2.5	100	50	60	5
Yatiyanthota	28	17.5	250	40	420	10
Neluwa	7.2	4.5	200	45	108	9
Neluwa	6.4	4	300	30	96	9
Neluwa	12	7.5	110	63	180	6.93
Neluwa	8	5	100	41	120	4.1
Neluwa	8	5	80	35	120	2.8
Neluwa	6.4	4	100	37	96	3.7
Neluwa	3.2	2	20	20	48	0.4
Akurassa	1.6	1	100	8	24	0.8

Table A2, Results of Mini-Hydro Survey

Divisional Scretory	Plant design Capacity(kW)	System Out Capacity(kW)	Supplied Watage(W)	Number of Buildings	Energy Generation(kWh)/day	Energy Demand(kW)/village /day
Akurassa	0.32	0.2	200		4.8	0
Yakkalamulla	4.8	3	100	25	72	2.5
Yakkalamulla	4	2.5	100	22	60	2.2
Pitabadda	400	250	250	factory	6000	#VALUE!
Pitabadda	59.2	37	250	130	888	32.5
Thotapola	94.4	59	0		1416	0
Thotapola	24	15	25		360	0
Thotapola	8.8	5.5	190	48	132	9.12
Pitabadda	4	2.5	100	20	60	2
Pitabadda	1.28	0.8	100	7	19.2	0.7
Pitabadda	18.4	11.5	200	50	276	10
Thotapola	4	2.5	200	12	60	2.4
Thotapola	8.8	5.5	150	38	132	5.7
Thotapola	2.4	1.5	100	12	36	1.2
Thotapola	5.12	3.2	320	1	76.8	0.32
Thotapola	12	7.5	200	21	180	4.2
Thotapola	5.76	3.6	160	10	86.4	1.6
neluwa	0.96	0.6	600	1	14.4	0.6
Thotapola	5.6	3.5	100	30	84	3
Thotapola	5.6	3.5	350	8	84	2.8
Pasgoda	0.16	0.1	100	1	2.4	0.1
Pasgoda	0.16	0.1	100	1	2.4	0.1
Pasgoda	3.2	2	100	18	48	1.8
Pasgoda	17.28	10.8	120	89	259.2	10.68
Mulatiyana	5.6	3.5	150	20	84	3
Mulatiyana	2.4	1.5	100	15	36	1.5
Mulatiyana	4	2.5	100	14	60	1.4
Mulatiyana	4.8	3	125	22	72	2.75
Mulatiyana	3.6	2.25	150	16	54	2.4
Mulatiyana	0.64	0.4	400	1	9.6	0.4
Mulatiyana	9.28	5.8	100	39	139.2	3.9

Table A3, Results of Mini-Hydro Survey

Divisional Scretory	Plant design Capacit y(kW)	System Out Capacit y(kW)	Supplied Watage(W)	Number of Building s	Energy Generation(kW h)/day	Energy Demand(kW)/village/ day
Yatiyanthota	8	5	200	22	120	4.4
Yatiyanthota	14.4	9	200	37	216	7.4
Yatiyanthota	7.2	4.5	300	15	108	4.5
Yatiyanthota	4.8	3	150	15	72	2.25
Yatiyanthota	16	10	250	39	240	9.75
Yatiyanthota	15.2	9.5	150	57	228	8.55
Yatiyanthota	4.8	3	100	24	72	2.4
Yatiyanthota	4.8	3	100	24	72	2.4
Yatiyanthota	18.4	11.5	200	48	276	9.6
Yatiyanthota	8	5	200	19	120	3.8
Yatiyanthota	14.24	8.9	300	24	213.6	7.2
Yatiyanthota	12	7.5		5	180	0
Yatiyanthota	21.92	13.7	240	50	328.8	12
Bulathkohupitiya	0.8	0.5			12	0
Bulathkohupitiya	480	300			7200	0
Bulathkohupitiya	1280	800			19200	0
Bulathkohupitiya	20	12.5	100	82	300	8.2
Daraniyagala	72	45	360	125	1080	45
Daraniyagala	19.2	12	200	50	288	10
Daraniyagala	4.8	3	200	12	72	2.4
Daraniyagala	4.8	3	300	7	72	2.1
Daraniyagala	9.6	6	240	18	144	4.32
Daraniyagala	28.8	18	240	76	432	18.24
Daraniyagala	9.6	6	300	21	144	6.3
Daraniyagala	19.2	12	360	33	288	11.88
Daraniyagala	2000	1250			30000	0
Daraniyagala	848	530			12720	0
Daraniyagala	1024	640			15360	0
Daraniyagala	1.6	1	500	2	24	1
Daraniyagala	10.4	6.5	150	40	156	6
Daraniyagala	10.4	6.5	150	36	156	5.4
Daraniyagala	72	45	130	35	1080	4.55
Daraniyagala	9.6	6	200	28	144	5.6
Daraniyagala	12.8	8	200	30	192	6

APPENDIX

Normal Load Operating Hours of Village Hydro Power Plants

Time of the day	Load operation (%)	Energy generation(kWh)/day
6 pm – 10pm	100	24
10pm – 5 am	50	21
5 am – 7 pm	100	12
7 am – 8 am	50	3
8 am – 6 pm	50	30
total	**350**	**90**

Table A.4, Normal Load Operating Hours of the Plants

Considering the rainy seasonal variation at least three months per year is subjected to a dry period according to the Sri Lanka climatic changers. Therefore 730h*3 (8760h/12* three months) hours are operating at half load and the rest 730h*9 hours are operating on normal pattern therefore excluding the seasonal variation the hours of operation of the year is 5201h(730h*3*0.5 + 730h*9*0.625) considering the maintenance of the plant 4 hours per week or 16 hours per month. The actual operating hours of the conventional village hydro plants is 5000h. But the resource is available for generating energy for 8760 h per year.

Normal operating hours of the village hydro plants =5000 h

Available time for energy generation = 8760 h per year

Operating hour factor (0.57) =5000/8760