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Economic Analysis of Micro Hydel Plant-A Case Study

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Abstract*: A reliable, economical and impregnable supply of energy is consequential for economic development. This has been true for the past and present and will remain authentic for the future. However, over time, changes have taken and will take place with regard to energy utilization, both with regard to the amount as well as with regard to the type of energy utilized. Many factors have played a role in bringing these vicissitudes. Availability, security of supplies, price, ease of handling and use, external factors like technological development, introduction of subsidies, environmental constraints and legislation are some of these factors. This research paper is an in-depth scenario and economic analysis of the micro hydro energy in Punjab.*

Keywords: micro hydel plant, payback period, economic analysis

1. Introduction

The hydro power plants with engendered power less than 10 MW are becoming more captivating considering both technical - economic aspects and environmental issues. Supplementally, this type of energy production is environmentally amicable, contributes toward gas emission and global warming reductions and can be habituated to regulate the watercourses.

Hydro power plants according to their installed power can be "small power plants" when they engender from 2 to 10 MW, "mini" when between 2 and 0.5 MW and "micro" when less than 0.5 MW. From the standpoint of water height, hydro plants can be relegated as "low" when the height of fall is from 2 to 20 m, "average" for the range from 20 to 150 m, and "high" when it emanates over 150 m[1]. Micro hydro is the well-known principle of utilizing water to drive a turbine and generate electricity; however micro hydro is executed on a much diminutive scale including private residences and businesses. Not only micro hydro is a non-polluting energy source, but also it is much more efficient than the burning of fossil fuels for electricity generation. In deference to coal burning, the most mundane energy source, micro hydro power is greatly more efficient. Efficiency of micro hydro units range 60% to 90% while modern coal burning units are 43% to 60% efficient [2].

This case study is predicated on a micro-hydro power plant with an average height of water of 2.84 m, an average water flow rate of 29.94m3/s and a global efficiency of 90%.

2. Economic Analysis

The performed economic analysis exhibits the expenses and revenues of the system and enables one to estimate the economic indicators required to state the viability of the solution.

The system had the initial investment of 14 crores, including costs of building, electrical parts and mechanical parts, as summarized in Table 1.

Table 1: Investment Costs

Project/Preliminary studies	1 crore
Grid Connection	1 crore
Administrative costs	0.5 crore
Civil work	5 crore
Mechanical parts	2.5 crore
Turbine/generator and accessories	2.5 crore
Electric parts	0.5 crore
Total	14 crore

Investment of the plant=14 crore = Rs -140000000
Generation of plant= 1MW = 1000 KW
Number of units produced per day = 1000*24
= 24000 KWH
= 24000 units
Number of units used for plant auxiliaries = 960
Therefore approximately 23000 units are being sold to PSPCL.
Rate of one unit given by PSPCL= Rs 3.25
So, income per day = 23000 *3.25
= Rs 74880
Income per year = 74880*365 days
= Rs 27331200
Operation cost = 10 paisa per unit

Operation cost for 24000 units = 24000*0.1 = Rs 2400 per day
Operation cost per year = 2400 * 365=Rs 876000
Maintenance cost = 33 paisa per unit
Maintenance cost for 24000 units = 24000*0.33=Rs 7920 per day
Maintenance cost per year = 7920 * 365 = Rs 2890800
Cash flow = Income - (operation cost +maintenance cost)
= 27331200 – (876000 + 2890800)
= Rs 23564400
Payback = Investment + cash flow
= -140000000 +23564400
= -116435600

Analysis of the plant has been done for 25 years

Case 1: Taking the constant income for all 25 years

Table 2

Year	0	1	2	3	4	5
Income		27331200	27331200	27331200	27331200	27331200
Operation costs (Year rate:5%)		-876000	-919800	-965790	-1014080	-1521120
Maintenance costs (Year rate:3%)		-2890800	-2977524	-3066850	-3986905	-4106512
Investment	-140000000					
Cash flow		23564400	23433876	23298560	22330215	21703568
Payback		-116435600	-93001724	-69703164	-47372949	-25669381
IRR(25years)				-27.92%	-14.803%	-6.478%

Year		6	7	8	9	10
Income		27331200	27331200	27331200	27331200	27331200
Operation costs (Year rate:5%)		-1597176	-1677035	-1760887	-1848931	-1941378
Maintenance costs (Year rate:3%)		-4229707	-126891	-4487296	-4621915	-4760572
Investment						
Cash flow		21504317	21297567	21083017	20860354	20629250
Payback		-4165064	17132503	38215520	59075874	79705124
IRR(25years)		-0.871%	3.034%	5.835%	7.893%	9.437%

Year		11	12	13	14	15
Income		27331200	27331200	27331200	27331200	27331200
Operation costs (Year rate:5%)		-2038447	-2140369	-2247387	-2359756	-2477744
Maintenance costs (Year rate:3%)		-4903389	-5050410	-5201922	-5357980	-5518719
Investment						
Cash flow		20389364	20140421	19881891	19613464	19334737
Payback		100094488	120234909	140116800	159730264	179065001
IRR(25years)		10.616%	11.528%	12.243%	12.809%	13.261%

Year		16	17	18	19	20
Income		27331200	27331200	27331200	27331200	27331200
Operation costs (Year rate:5%)		-2601631	-2731713	-2868299	-3011714	-3162300
Maintenance costs (Year rate:3%)		-5684281	-5854809	-6030453	-6211367	-6397708
Investment						
Cash flow		19045288	18744678	18432448	18108119	17771192
Payback		198110289	216854967	235287415	253395534	271166726
IRR(25years)		13.625%	13.920%	14.160%	14.356%	14.517%

Year		21	22	23	24	25
Income		27331200	27331200	27331200	27331200	27331200
Operation costs(Year rate:5%)		-3320415	-3486436	-3660758	-3843796	-4035986
Maintenance costs(Year rate:3%)		-6589639	-6787328	-6990948	-7200678	-7560712
Investment						
Cash flow		17421146	17057436	16679494	16286726	15734502
Payback		288587872	305645308	322324802	338611528	354346030
IRR(25years)	14.98%	14.649%	14.7590%	14.8496%	14.924%	14.98643%

CASE 2: Increasing income by year rate of 2%

Table 3

Year	0	1	2	3	4	5
Income		27331200	27877824	28435380	29004087	29584169
Operation costs (Year rate:5%)		-876000	-919800	-965790	-1014080	-1521120
Maintenance costs (Year rate:3%)		-2890800	-2977524	-3066850	-3986905	-4106512
Investment	-140000000					
Cash flow		23564400	23980500	24402740	24003102	23956537
Payback		-116435600	-92455100	-68052360	-44049258	-20092721
IRR(25years)				-27.00%	-13.530%	-4.9416%

Year		6	7	8	9	10
Income		30175852	30779369	31394956	32022855	32663312
Operation costs(Year rate:5%)		-1597176	-1677035	-1760887	-1848931	-1941378
Maintenance costs(Year rate:3%)		-4229707	-4356598	-4487296	-4621915	-4760572
Investment						
Cash flow		24348969	24745736	25146773	25552009	25961362
Payback		4256248	29001984	54148757	79700766	105662128
IRR(25years)		0.85947%	4.9112%	7.8255%	9.9742%	11.5917%

Year		11	12	13	14	15
Income		33316578	33982909	34662567	35355818	36062934
Operation costs(Year rate:5%)		-2038447	-2140369	-2247387	-2359756	-2477744
Maintenance costs(Year rate:3%)		-4903389	-5050410	-5201922	-5357980	-5518719
Investment						
Cash flow		26374742	26792130	27213258	27638082	28066471
Payback		132036870	158829000	186042258	213680340	241746811
IRR(25years)		12.831%	13.7936%	14.552%	15.1547%	15.6390%

Year		16	17	18	19	20
Income		36784193	37519877	38270275	39035681	39816395
Operation costs(Year rate:5%)		-2601631	-2731713	-2868299	-3011714	-3162300
Maintenance costs(Year rate:3%)		-5684281	-5854809	-6030453	-6211367	-6397708
Investment						
Cash flow		28498281	28933355	29371523	29182600	30256387
Payback		270245092	299178447	328549970	358362570	388618957
IRR(25years)		15.6390%	16.0309%	16.3504%	16.8283%	17.0072%

Year		21	22	23	24	25
Income		40612723	41424977	42253477	43098547	43960518
Operation costs(Year rate:5%)		-3320415	-3486436	-3660758	-3880403	-4074423
Maintenance costs(Year rate:3%)		-6589639	-6787328	-6990948	-7200676	-7416696
Investment						
Cash flow		30702669	31151213	31601771	32017468	32469399
Payback		419321626	450472839	482074610	514092078	546561477
IRR(25years)	17.54%	17.2801%	17.28%	17.38407%	17.471%	17.545%

CASE 3: Constant from year 1 to 5; Decreasing year rate: 2% - from year 6 to year 25.

Table 4

Year	0	1	2	3	4	5
Income		25623000	25623000	25623000	25623000	25623000
Operation costs(Year rate:5%)		-876000	-963600	-1059960	-1165956	-1282552
Maintenance costs(Year rate:3%)		-2890800	-3064248	-3248103	-3442989	-3649568
Investment	-140000000					
Cash flow		22644600	21595152	21314937	21014055	20690880
Payback		-117355400	-95760248	-74445311	-53431256	-32740376
IRR(25years)				-30.324%	-16.959%	-8.3738%

Year		6	7	8	9	10
Income		25110540	24608329	24116162	23633839	23161162
Operation costs(Year rate:5%)		-1410807	-1551888	-1707077	-1877785	-2065564
Maintenance costs(Year rate:3%)		-3868542	-4100655	-4346694	-4607496	-4745721
Investment						
Cash flow		19831191	18955786	18062391	17148558	16349877
Payback		-12909185	6046601	24108992	41257550	57607427
IRR(25years)		-2.7467%	1.0974%	3.80853%	5.7686%	7.2245%

Year		11	12	13	14	15
Income		22697939	22243980	21799100	21363118	20935856
Operation costs(Year rate:5%)		-2272120	-2499332	-2749265	-3024192	-3326611
Maintenance costs(Year rate:3%)		-5030464	-5332292	-5652230	-5991364	-6350846
Investment						
Cash flow		15395355	14412356	13397605	12347562	11258399
Payback		73002782	87415138	100812743	113160305	124418704
IRR(25years)		8.31347%	9.1369%	9.7646%	10.2449%	10.6126%

Year		16	17	18	19	20
Income		20517139	20106796	19704660	19310567	18924356
Operation costs(Year rate:5%)		-3659272	-4025199	-4427719	-4870491	-5357540
Maintenance costs(Year rate:3%)		-6731897	-7135811	-7563960	-8017798	-8498866
Investment						
Cash flow		10125970	8945786	7712981	6422278	5067950
Payback		123286275	132232061	139945042	146367320	151435270
IRR(25years)		10.8932%	11.1054%	11.2633%	11.3777%	11.4567%

Year		21	22	23	24	25
Income		18545869	18174952	17811453	17455224	17106119
Operation costs(Year rate:5%)		-5893294	-6482623	-7130885	-7843974	-8628371
Maintenance costs(Year rate:3%)		-9008798	-9549326	-10122286	-10729623	-11373400
Investment						
Cash flow		3643777	2143003	558282	-1118373	-2895652
Payback		155079047	157222050	157780332	156661959	153766307
IRR(25years)	11.51%	11.50678%	11.5328%	11.5389%	11.53781%	11.51290%

3. Results and Discussion

The results presented in Table 2, were obtained using present-day conditions applicable to micro-hydro power plants in Punjab. Under a 25-year scenario these conditions will transmute. Mainly, the following situations could occur:

- Decrease in the feed-in tariff;
- Increase in the operation costs and maintenance costs;
- Lower water flow rate.

Table 3 illustrates the results if the income increases by 2% every year. Taking into consideration the factors mentioned for Table 2, the following scenario is considered which is illustrated in Table 4:

- Constant feed-in tariff (present-day value) during the first 5 years;
- After year 5, the feed-in-tariff decreases 2%/year;
- Operation costs increase 10%/year (rate doubled);
- Maintaining costs increase 6%/year (rate doubled);
- The efficiency of the group turbine-generator decreases to 75%.

The analysis presented in table 3 is economically captivating with its IRR of 17.54% and payback within 6 years.

For the worst case scenario (Table 4), these indicators decrease, with an IRR of 11.51% and payback within 7 years.

Another economic indicator for the three scenarios is the Net Present Value, which provides the following values:

- Table 2 scenario, NPV=102333927.8 rupees
- Table 3 scenario, NPV= 5982460 rupees
- Table 4 scenario, NPV=42075352.3 rupees

Net Present Value (NPV) is the quantification of an investment's profitability.

4. Conclusion

This paper presents an overview of the sundry economic issues of the micro hydro power plant .Economic aspects of the power plant are analyzed by calculating its payback period. The cost of the MHP is site categorical and varies remarkably depending on the remoteness of the site and physical features of its major components, namely, civil works, generating equipments and transmission/distribution lines. The performed analysis limpidly points out the vigorous and impotent aspects considering economic issues.

As a final remark it is to verbally express that these micro hydro power plants are very efficacious in meeting energy demand and contribute to the reduction of dependence on polluting power plants. Due to their typical advantages, more and more micro hydro power plants should be established to regulate the water courses.

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