# Feasibility analysis of a small hydro power project using RET Screen

***Susan Khadka* [1],**

[1,2]Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation,
Vaddeswaram Guntur, A P, India.

***S N Padhi*[2]**

[1,2]Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation,
Vaddeswaram Guntur, A P, India.

## Abstract

This feasibility study aimed to assess the viability of a small hydropower project using RETScreen, a software tool designed for renewable energy project analysis. The study evaluated the technical, financial, and environmental aspects of the proposed project, considering site-specific factors such as water flow, turbine efficiency, and grid connection. The results indicated that the project was feasible, with a potential capacity of 1MW . The financial analysis showed a positive net present value and internal rate of return, indicating that the project was financially viable. The environmental assessment indicated that the project would have minimal impacts on the local ecosystem and would contribute to reducing greenhouse gas emissions. Overall, this study demonstrated the usefulness of RETScreen in evaluating the feasibility of small hydropower projects and provided valuable insights for project developers and investors.

**Keywords:** Small Hydropower, Feasibility Study , RETScreen,Renewable Energy, Financial Viability

## Introduction

The demand for energy is increasing day by day with the growing industry and living standards of people. To overcome this demand new energy facilities are under construction all around the world. Dependence on fossil fuels to generate electricity results in high greenhouse gas emissions, which led to global warming and climate change. Moreover, the cost of electricity is getting higher due to the high fossil fuel prices. Those disadvantages increase the importance of renewable energy [1-5].

Hydropower is the most reliable sources of new generation into the future, and its share is more than 92 % among the renewable energy generated. However, there is a great opposition against large scale hydropower projects worldwide. Despite the benefits of large dams, there are social, environmental and economic disadvantages to be concerned. Due to these factors small hydropower (SHP) systems gain more importance. SHP plants combine the advantages of hydropower with those of decentralized power generation, without the disadvantages of large scale installations. We know that SHP emerged as an energy source is accepted as renewable, easily developed, inexpensive and harmless to the environment [6, 7].

The dependence of imported sources to generate electricity is more than 70 % in Turkey. Turkey has a great untapped small hydropower (SHP) potential. Unexploited SHP potential of Turkey is equal to approximately 70 % of unexploited SHP potential of all European Union countries. To use the untapped SHP potential of Turkey, especially after the foundation of Energy Market Regulatory Authority (EMRA) in 2001, many local and foreign investors have entered to the energy market [8-12].

In this study, a number of alternative formulations are developed for small hydroelectric power plant (SHEPP) located in Kathmandu Nepal and its profitability compared by using benefit-cost analysis of RETScreen. Alternatives with longer channels instead of tunnels resulted in higher net benefits.

## Hydropower for sustainable development

Renewable hydropower is a reliable, versatile and low cost source of clean electricity generation and responsible water management. Modern hydropower plants are helping to accelerate the clean energy transition, providing essential power, storage, flexibility and climate mitigation services. Hydropower is also a key asset for building secure, clean, electricity systems and reaching global net zero targets. On the other hand, there are four main types of hydropower plants: run-of-river, storage, pumped storage and offshore hydropower. Only a small minority of the world's dams are built for hydropower, with the majority used for irrigation, water supply, flood control and other purposes.

Many hydropower dams are used for multiple purposes beyond electricity generation, providing infrastructure to supply clean water for homes, industry and agriculture, as well as recreation and transportation services. Hydropower projects can be used to regulate and store water to mitigate the impacts of extreme weather events such as floods and drought, which are on the rise due to climate change. Around 60% of all renewable electricity is generated by hydropower. The sector produces about 16% of total electricity generation from all sources. Hydropower installed capacity reached 1,330 GW in 2020 as generation hit a record 4,370 TWh. China, Brazil, the USA, Canada and India are the largest hydropower producers by installed capacity. Figure below shows the global total hydropower capacity by countries.

## Definition of small hydropower

There is no internationally accepted definition for small hydropower. In China, small hydropower can refer to capacities up to 25 MW, in India the limit is 15 MW; whereas the limit in Sweden is 1.5 MW. Moreover, within the range of small hydropower, depending on the installed capacity, the type of the plant is named as; mini, micro, and pico hydropower which have an upper limit for installed capacity as; 1 MW, 100 kW and 5 kW, respectively. By this way, they can provide energy to a central grid, an isolated grid or an off-grid load.

## Evaluation of the project formulations using RETScreen

Feasibility analysis of small hydropower using RETScreen is a valuable tool for assessing the economic and technical viability of small hydropower projects. The following is an overview of a potential case study analyzing the feasibility of a small hydropower project in Kathmandu, Nepal, using RETScreen.

## Background

Kathmandu, the capital city of Nepal, is located in the central part of the country. Nepal has significant hydropower potential, with more than 6,000 rivers and streams flowing through its mountainous terrain. The government of Nepal has set a target of achieving 15,000 MW of hydropower capacity by 2030, with the majority of the capacity expected to come from small hydropower projects.

## Objective

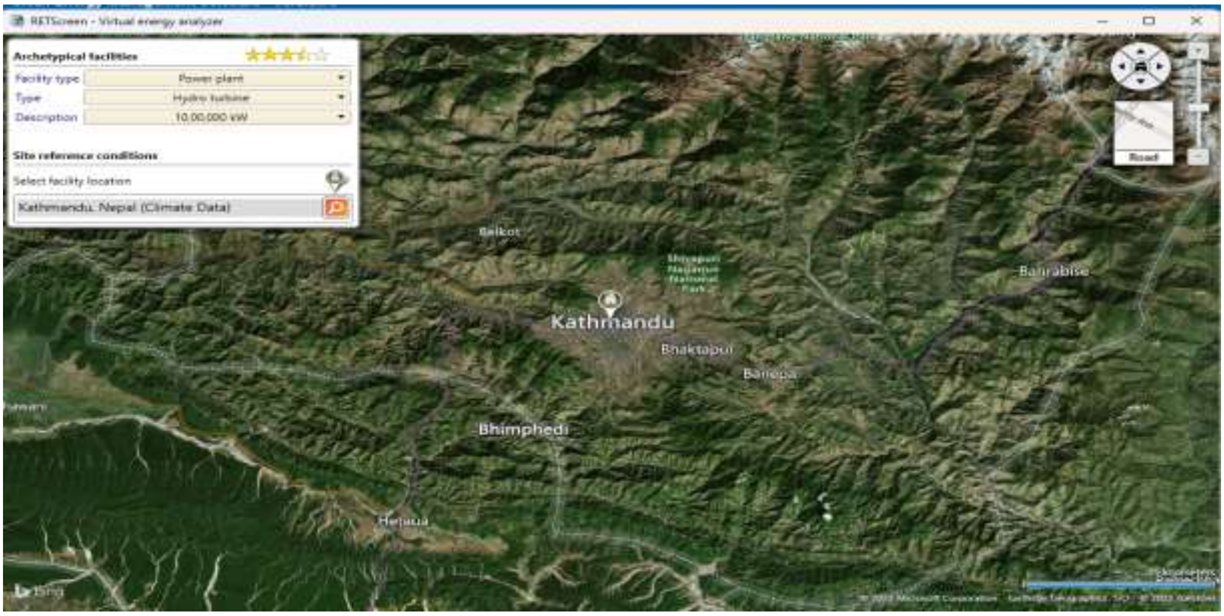
The objective of this case study is to determine the feasibility of a small hydropower project in Kathmandu, Nepal, using RETScreen. The analysis will focus on the economic and technical viability of the project, taking into account the specific characteristics of the site and local energy market conditions.

## Methodology

The feasibility analysis will be conducted using RETScreen, a comprehensive software tool developed by Natural Resources Canada for evaluating renewable energy projects. The following steps will be followed:

## Location selection

A suitable site for the small hydropower project will be selected based on the availability of water resources, topography, and other site-specific factors. For this project we are going to select location as Kathmandu Nepal.



RETScreen - Virtual energy analyzer

**Archetypical facilities**

Facility type: Power plant

Type: Hydro turbine

Description: 10,00,000 kW

**Site reference conditions**

Select facility location

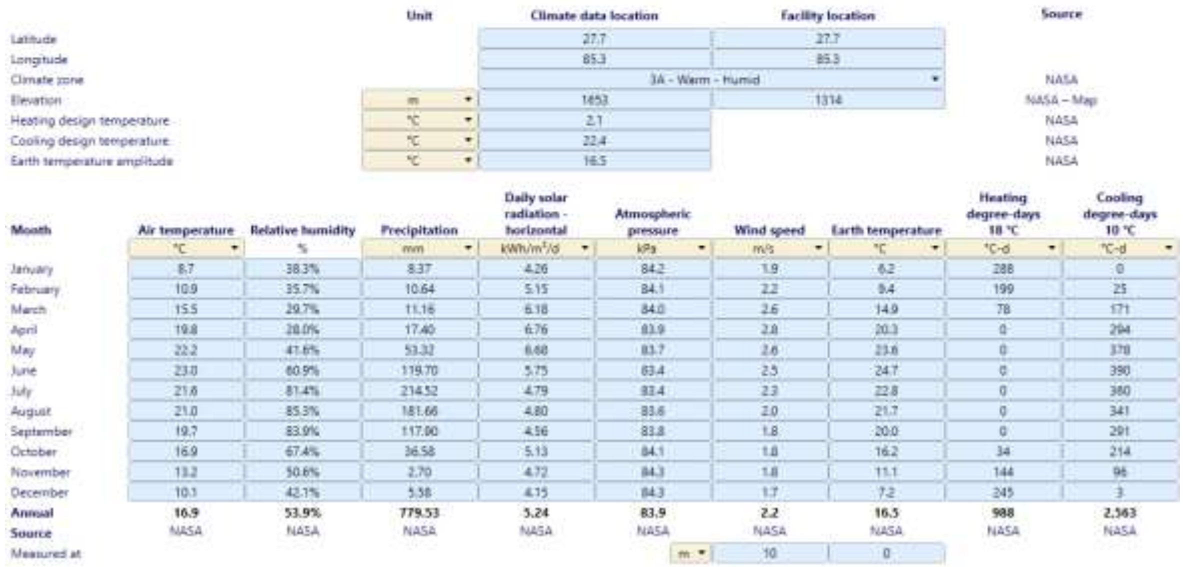
Kathmandu, Nepal (Climate Data)

Fig.1: Location map of proposed hydropower project

After selecting the climate data location we redirect to another interface. We enters the climate data location with the most representative climate conditions for the facility. we can consult the RETScreen Climate Database for more information. To access the RETScreen Climate Database,

Note that the user has to either select a climate data location via the climate database and paste the data to the worksheet or enter the climate data manually in the yellow and blue cells.

Table-1: Climate and Facility location data



| | Unit | Climate data location | Facility location | Source |
|---|---|---|---|---|
| Latitude | | 27.7 | 27.7 | |
| Longitude | | 85.3 | 85.3 | |
| Climate zone | | 3A - Warm - Humid | | NASA |
| Elevation | m | 1653 | 1314 | NASA – Map |
| Heating design temperature | °C | 2.1 | | NASA |
| Cooling design temperature | °C | 22.4 | | NASA |
| Earth temperature amplitude | °C | 16.5 | | NASA |

| **Month** | **Air temperature** | **Relative humidity** | **Precipitation** | **Daily solar radiation - horizontal** | **Atmospheric pressure** | **Wind speed** | **Earth temperature** | **Heating degree-days 18 °C** | **Cooling degree-days 10 °C** |
|---|---|---|---|---|---|---|---|---|---|
| | °C | % | mm | kWh/m²/d | kPa | m/s | °C | °C-d | °C-d |
| January | 8.7 | 38.3% | 8.37 | 4.26 | 84.2 | 1.9 | 6.2 | 288 | 0 |
| February | 10.9 | 35.7% | 10.64 | 5.15 | 84.1 | 2.2 | 9.4 | 199 | 25 |
| March | 15.5 | 29.7% | 11.16 | 6.18 | 84.0 | 2.6 | 14.9 | 78 | 171 |
| April | 19.8 | 28.0% | 17.40 | 6.76 | 83.9 | 2.8 | 20.3 | 0 | 294 |
| May | 22.2 | 41.6% | 53.32 | 6.68 | 83.7 | 2.6 | 23.6 | 0 | 370 |
| June | 23.0 | 60.9% | 119.70 | 5.75 | 83.4 | 2.5 | 24.7 | 0 | 390 |
| July | 21.6 | 81.4% | 214.52 | 4.79 | 83.4 | 2.3 | 22.8 | 0 | 380 |
| August | 21.0 | 85.3% | 181.66 | 4.80 | 83.6 | 2.0 | 21.7 | 0 | 341 |
| September | 19.7 | 83.9% | 117.90 | 4.56 | 83.8 | 1.8 | 20.0 | 0 | 291 |
| October | 16.9 | 67.4% | 36.58 | 5.13 | 84.1 | 1.8 | 16.2 | 34 | 214 |
| November | 13.2 | 50.6% | 2.70 | 4.72 | 84.3 | 1.8 | 11.1 | 144 | 96 |
| December | 10.1 | 42.1% | 5.58 | 4.15 | 84.3 | 1.7 | 7.2 | 245 | 3 |
| **Annual** | **16.9** | **53.9%** | **779.53** | **5.24** | **83.9** | **2.2** | **16.5** | **988** | **2,563** |
| **Source** | NASA | NASA | NASA | NASA | NASA | NASA | NASA | NASA | NASA |
| Measured at | | | | | m | 10 | 0 | | |

This chart shows the different parameter values in different months over the year of that particular location.

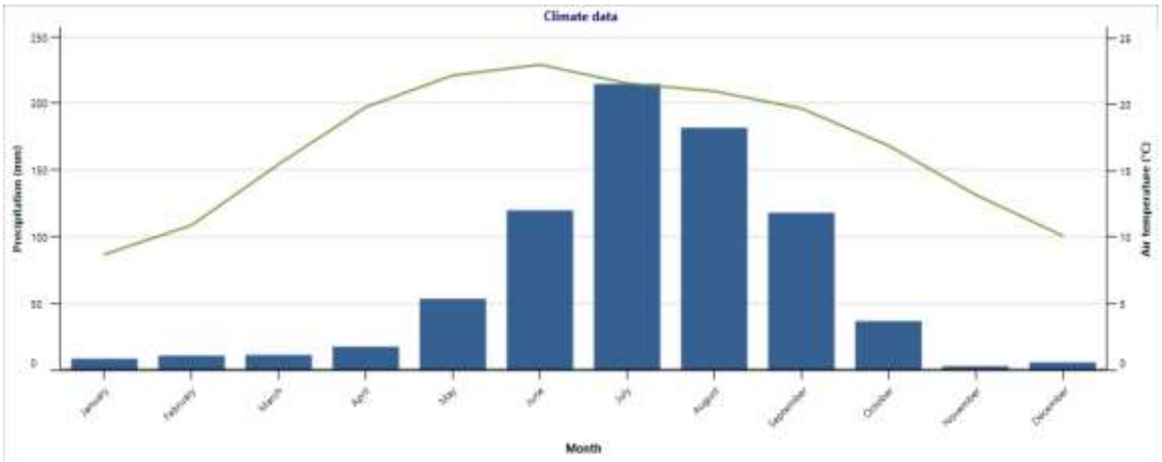


Fig 2: Precipitation over the proposed years

Given bar graph shows the precipitation rate in (mm) and green line shows air temperature value in that particular location.

## Facility

As part of the RETScreeen Clean Energy Management Software, the *Facility* worksheet is used to enter general information about the facility. We also have the option to prepare a benchmark analysis for the facility.

RETScreen - Facility

Subscriber: Viewer

Facility information

|  |  |
|---|---|
| Facility type | Power plant |
| Type | Hydro turbine |
| Description | 10,00,000 kW |
| Prepared for | TP-2 |
| Prepared by | Susan khadka |
| Facility name | feasibility analysis of small hydropower |
| Address | Nepal |
| City/Municipality | Kathmandu |
| Province/State | Bagmati |
| Country | Nepal |

Fig 3 : Facility data for the proposed Project

## Benchmark

The Benchmark section allows to compare the energy performance, GHG emissions and costs of a facility to other reference facilities.

These values provide a "first guess" of the energy situtiion, GHG emissions and costs for the facility. Benchmark values can come from the RETScreen Benchmark database, corporate benchmarking efforts, company targets, industry averages or any other appropriate metric to help compare the facility with performance objectives. After completing this high-level Benchmark Analysis, the user can then prepare a more detailed Feasibility Analysis and/or Performance Analysis (Project life analysis for both) to better estimate the energy savings, GHG emissions reduction, cost savings, and/or production potential for the facility. The user can also update this plan at a later date when more accurate information is available as a result of the Feasibility and/or Performance analysis prepared in RETScreen.

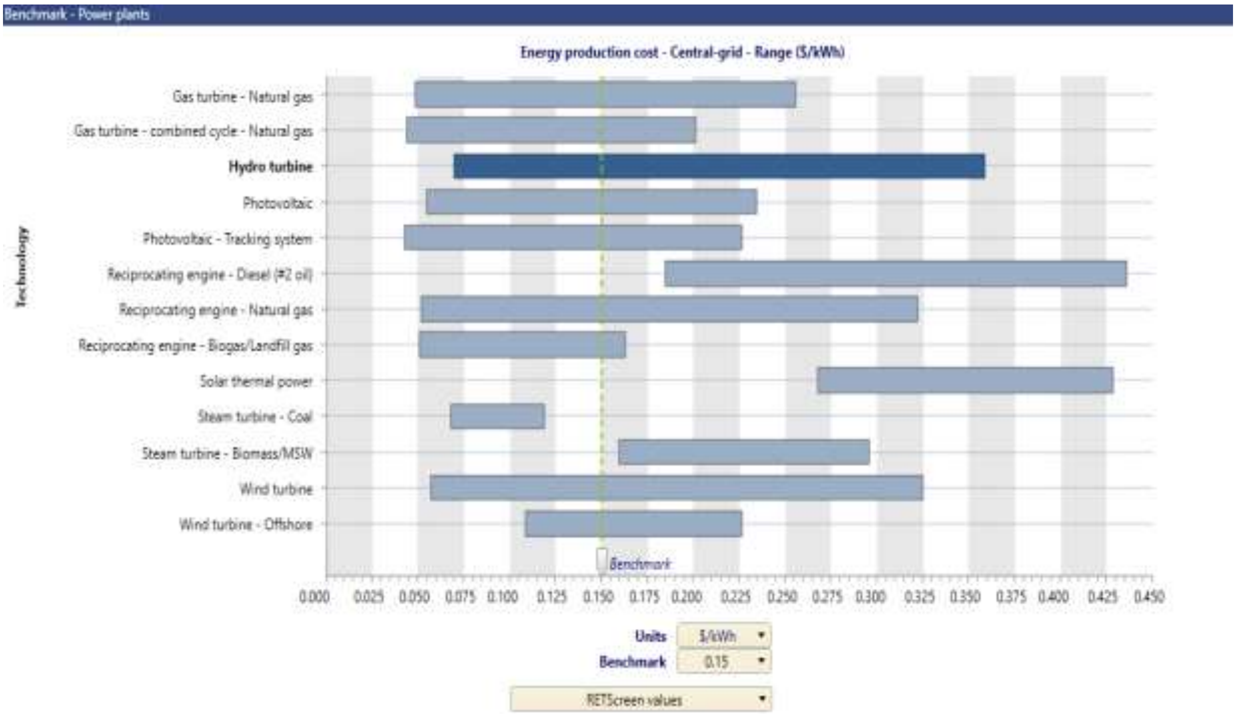
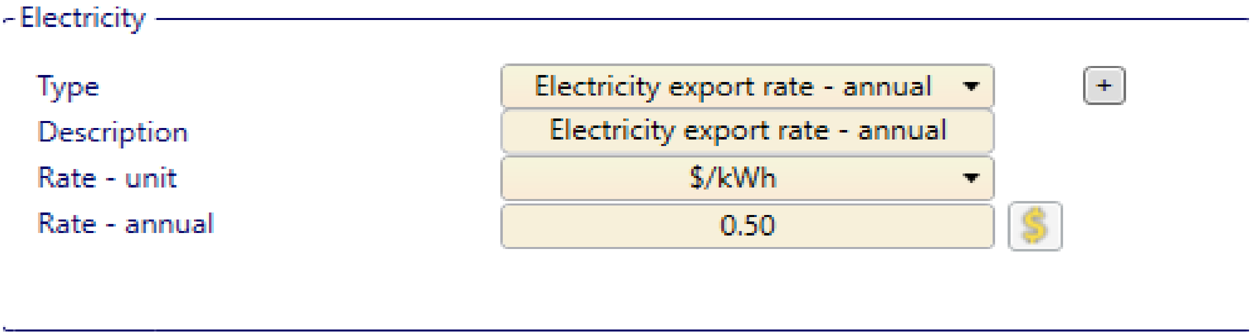


Fig 4 : Benchmark for power production by different technology

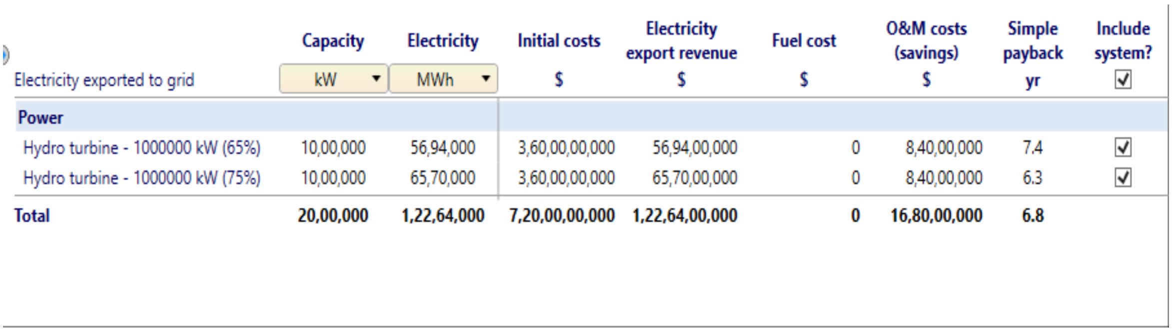
## Energy

The energy model worksheet is used to simulate the energy consumption and/or production of various types of facilities, including individual measures and systems.


- Electricity

| | |
|---|---|
| Type | Electricity export rate - annual |
| Description | Electricity export rate - annual |
| Rate - unit | $/kWh |
| Rate - annual | 0.50 |

Table 2 : Data on electricity exported to the grid



| Electricity exported to grid | Capacity<br>kW | Electricity<br>MWh | Initial costs<br>$ | Electricity export revenue<br>$ | Fuel cost<br>$ | O&M costs (savings)<br>$ | Simple payback<br>yr | Include system?<br>☑ |
|---|---|---|---|---|---|---|---|---|
| **Power** | | | | | | | | |
| Hydro turbine - 1000000 kW (65%) | 10,00,000 | 56,94,000 | 3,60,00,00,000 | 56,94,00,000 | 0 | 8,40,00,000 | 7.4 | ☑ |
| Hydro turbine - 1000000 kW (75%) | 10,00,000 | 65,70,000 | 3,60,00,00,000 | 65,70,00,000 | 0 | 8,40,00,000 | 6.3 | ☑ |
| **Total** | **20,00,000** | **1,22,64,000** | **7,20,00,00,000** | **1,22,64,00,000** | **0** | **16,80,00,000** | **6.8** | |

Above figure shows the capacity of power plant, total electricity production in(MWh) , initial setup cost, saving per year and payback year by combining those two turbines.

## Cost

RETScreen Clean Energy Management Software, the Cost Analysis worksheet is used to helps estimate costs (and credits) associated with the proposed case. These costs are addressed from the initial, or investment, cost standpoint and from the annual, or recurring, cost standpoint. We can refer to the RETScreen Product Database for supplier contact information in order to obtain prices or other information required.

Table 3 : Cost analysis data

**RETScreen - Cost Analysis** **Subscriber: Viewer**

| Initial costs (credits) | Unit | Quantity | Unit cost | Amount |
|---|---|---|---|---|
| Initial cost | | | | $ 7,20,00,00,000 |
| Show data | | | | |
| **Power system** | | | | |
| Hydro turbine - 1000000 kW (65%) | | | $ 3,60,00,00,000 | Update cost |
| Hydro turbine - 1000000 kW (75%) | | | $ 3,60,00,00,000 | Update cost |
| User-defined | cost | | | $ - |
| **Total initial costs** | | | | **$ 7,20,00,00,000** |

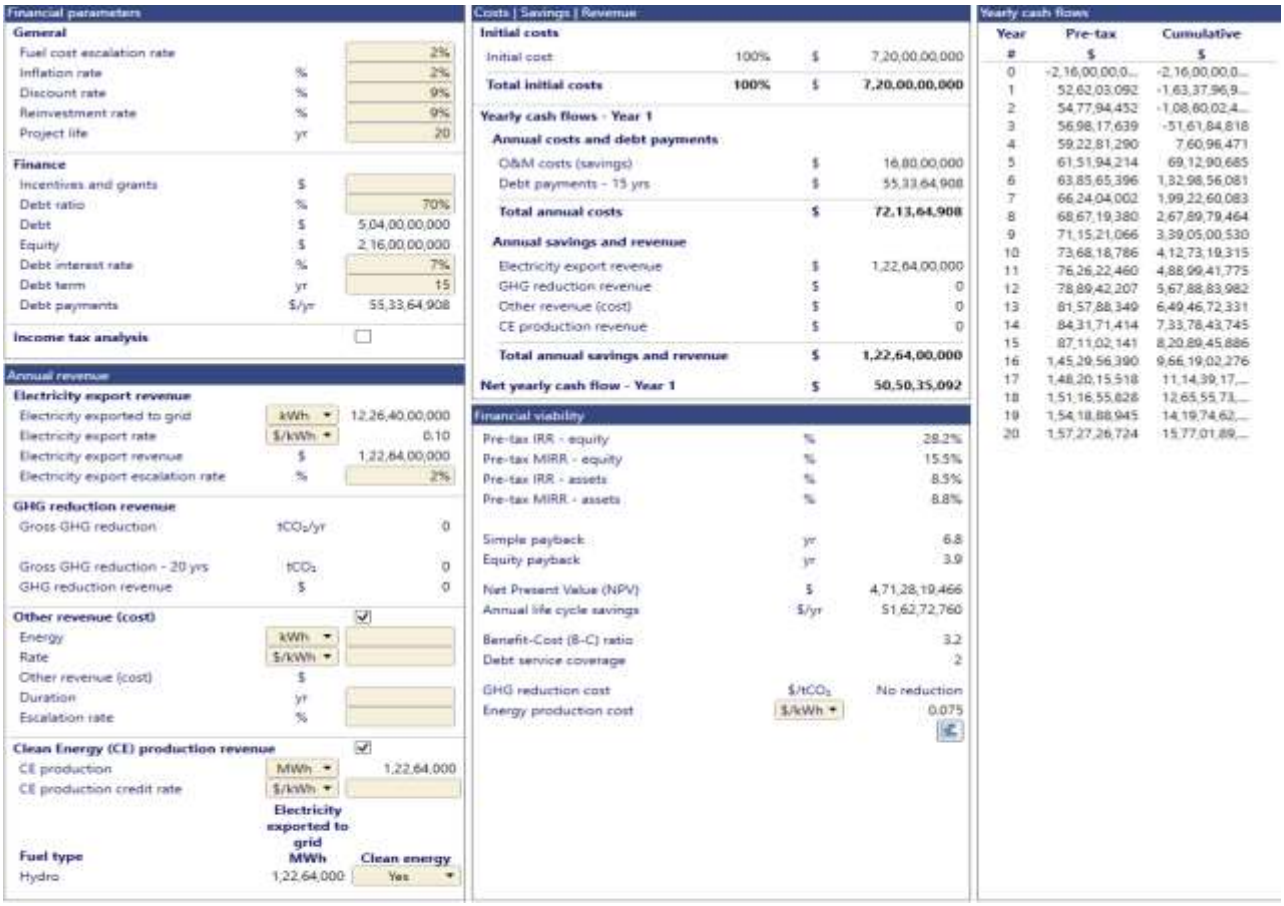
| Annual costs (credits) | Unit | Quantity | Unit cost | Amount |
|---|---|---|---|---|
| O&M costs (savings) | project | | | $ 16,80,00,000 |
| Show data | | | | |
| **Power system** | | | | |
| Hydro turbine - 1000000 kW (65%) | | | $ 8,40,00,000 | Update cost |
| Hydro turbine - 1000000 kW (75%) | | | $ 8,40,00,000 | Update cost |
| User-defined | cost | | | $ - |
| **Total annual costs** | | | | **$ 16,80,00,000** |

## Financial analysis

RETScreen Clean Energy Management Software, a Financial Analysis worksheet is provided for each facility evaluated.

One of the primary benefits of using the RETScreen software is that it facilitates the project evaluation process for decision-makers. The Financial Analysis worksheet, with its financial parameters input items (e.g. discount rate, debt ratio, etc.), and its calculated financial viability output items (e.g. IRR, simple payback, NPV, etc.), allows the project decision-maker to consider various financial parameters with relative ease. A description of these items, including comments regarding their relevance to the preliminary feasibility analysis, is included below.

Table 4 : Data on Financial analysis



**Financial parameters**

| | | |
|---|---|---|
| **General** | | |
| Fuel cost escalation rate | | 2% |
| Inflation rate | % | 2% |
| Discount rate | % | 9% |
| Reinvestment rate | % | 9% |
| Project life | yr | 20 |
| **Finance** | | |
| Incentives and grants | $ | |
| Debt ratio | % | 70% |
| Debt | $ | 5,04,00,00,000 |
| Equity | $ | 2,16,00,00,000 |
| Debt interest rate | % | 7% |
| Debt term | yr | 15 |
| Debt payments | $/yr | 55,33,64,908 |
| **Income tax analysis** | | ☐ |

**Annual revenue**

| | | |
|---|---|---|
| **Electricity export revenue** | | |
| Electricity exported to grid | kWh ▾ | 12,26,40,00,000 |
| Electricity export rate | $/kWh ▾ | 0.10 |
| Electricity export revenue | $ | 1,22,64,00,000 |
| Electricity export escalation rate | % | 2% |
| **GHG reduction revenue** | | |
| Gross GHG reduction | $tCO_2$/yr | 0 |
| Gross GHG reduction - 20 yrs | $tCO_2$ | 0 |
| GHG reduction revenue | $ | 0 |
| **Other revenue (cost)** | | ☑ |
| Energy | kWh ▾ | |
| Rate | $/kWh ▾ | |
| Other revenue (cost) | $ | |
| Duration | yr | |
| Escalation rate | % | |
| **Clean Energy (CE) production revenue** | | ☑ |
| CE production | MWh ▾ | 1,22,64,000 |
| CE production credit rate | $/kWh ▾ | |

| **Fuel type** | **Electricity exported to grid MWh** | **Clean energy** |
|---|---|---|
| Hydro | 1,22,64,000 | Yes ▾ |

**Costs | Savings | Revenue**

| | | | |
|---|---|---|---|
| **Initial costs** | | | |
| Initial cost | 100% | $ | 7,20,00,00,000 |
| **Total initial costs** | **100%** | **$** | **7,20,00,00,000** |
| **Yearly cash flows - Year 1** | | | |
| **Annual costs and debt payments** | | | |
| O&M costs (savings) | | $ | 16,80,00,000 |
| Debt payments - 15 yrs | | $ | 55,33,64,908 |
| **Total annual costs** | | **$** | **72,13,64,908** |
| **Annual savings and revenue** | | | |
| Electricity export revenue | | $ | 1,22,64,00,000 |
| GHG reduction revenue | | $ | 0 |
| Other revenue (cost) | | $ | 0 |
| CE production revenue | | $ | 0 |
| **Total annual savings and revenue** | | **$** | **1,22,64,00,000** |
| **Net yearly cash flow - Year 1** | | **$** | **50,50,35,092** |

**Financial viability**

| | | |
|---|---|---|
| Pre-tax IRR - equity | % | 28.2% |
| Pre-tax MIRR - equity | % | 15.5% |
| Pre-tax IRR - assets | % | 8.5% |
| Pre-tax MIRR - assets | % | 8.8% |
| Simple payback | yr | 6.8 |
| Equity payback | yr | 3.9 |
| Net Present Value (NPV) | $ | 4,71,28,19,466 |
| Annual life cycle savings | $/yr | 51,62,72,760 |
| Benefit-Cost (B-C) ratio | | 3.2 |
| Debt service coverage | | 2 |
| GHG reduction cost | $/$tCO_2$ | No reduction |
| Energy production cost | $/kWh ▾ | 0.075 |

**Yearly cash flows**

| Year<br>\# | Pre-tax<br>$ | Cumulative<br>$ |
|---|---|---|
| 0 | -2,16,00,00,0... | -2,16,00,00,0... |
| 1 | 52,62,03,092 | -1,63,37,96,9... |
| 2 | 54,77,94,452 | -1,08,60,02,4... |
| 3 | 56,98,17,639 | -51,61,84,818 |
| 4 | 59,22,81,290 | 7,60,96,471 |
| 5 | 61,51,94,214 | 69,12,90,685 |
| 6 | 63,85,65,396 | 1,32,98,56,081 |
| 7 | 66,24,04,002 | 1,99,22,60,083 |
| 8 | 68,67,19,380 | 2,67,89,79,464 |
| 9 | 71,15,21,066 | 3,39,05,00,530 |
| 10 | 73,68,18,786 | 4,12,73,19,315 |
| 11 | 76,26,22,460 | 4,88,99,41,775 |
| 12 | 78,89,42,207 | 5,67,88,83,982 |
| 13 | 81,57,88,349 | 6,49,46,72,331 |
| 14 | 84,31,71,414 | 7,33,78,43,745 |
| 15 | 87,11,02,141 | 8,20,89,45,886 |
| 16 | 1,45,29,56,390 | 9,66,19,02,276 |
| 17 | 1,48,20,15,518 | 11,14,39,17,... |
| 18 | 1,51,16,55,828 | 12,65,55,73,... |
| 19 | 1,54,18,88,945 | 14,19,74,62,... |
| 20 | 1,57,27,26,724 | 15,77,01,89,... |

## Yearly cash flows graph

It indicates whether or not the yearly and cumulative cash flow graphs are plotted. These cash flows over the project life are calculated in the model and reported in the yearly cash flows table.

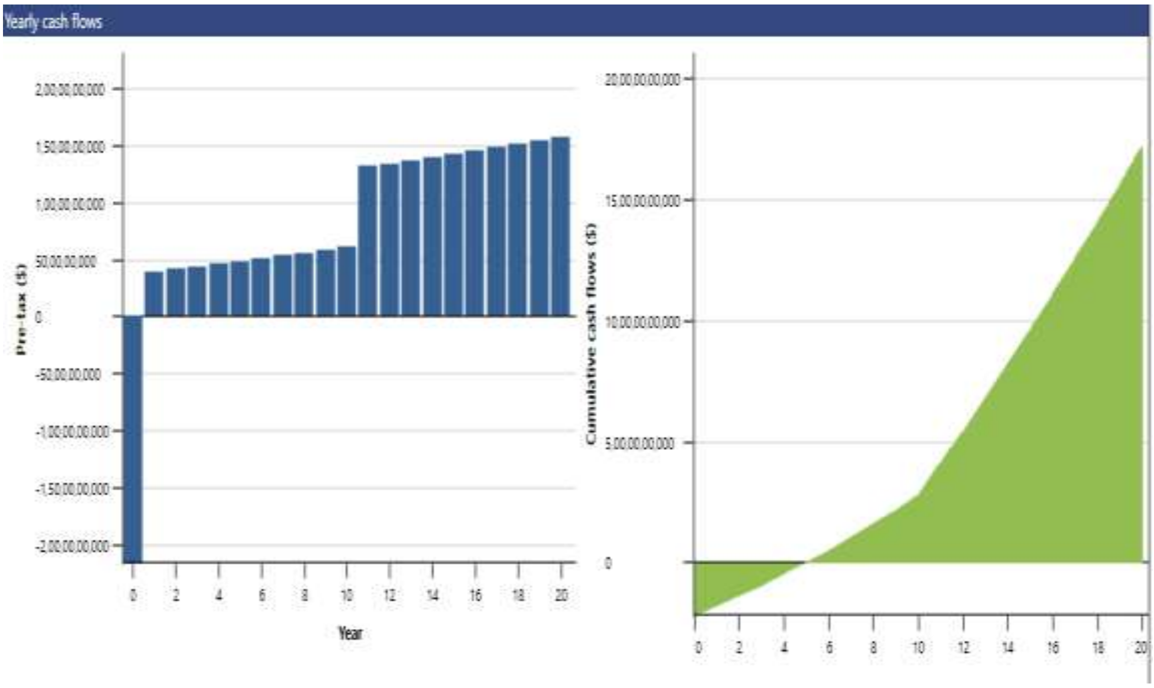


Fig 5 : Cash flow over the project life

## Sensitivity and Risk Analysis

A Sensitivity & Risk Analysis worksheet is provide to estimate the sensitivity of important financial indicators in relation to key technical and financial parameters. This standard sensitivity and risk analysis worksheet contains two main sections: Sensitivity analysis and Risk analysis. Each section provides information on the relationship between the key parameters and the important financial indicators, showing the parameters which have the greatest impact on the financial indicators. The Sensitivity analysis section is intended for general use, while the Risk analysis section, which performs a Monte Carlo simulation, is intended knowledge of statistics.

Impact

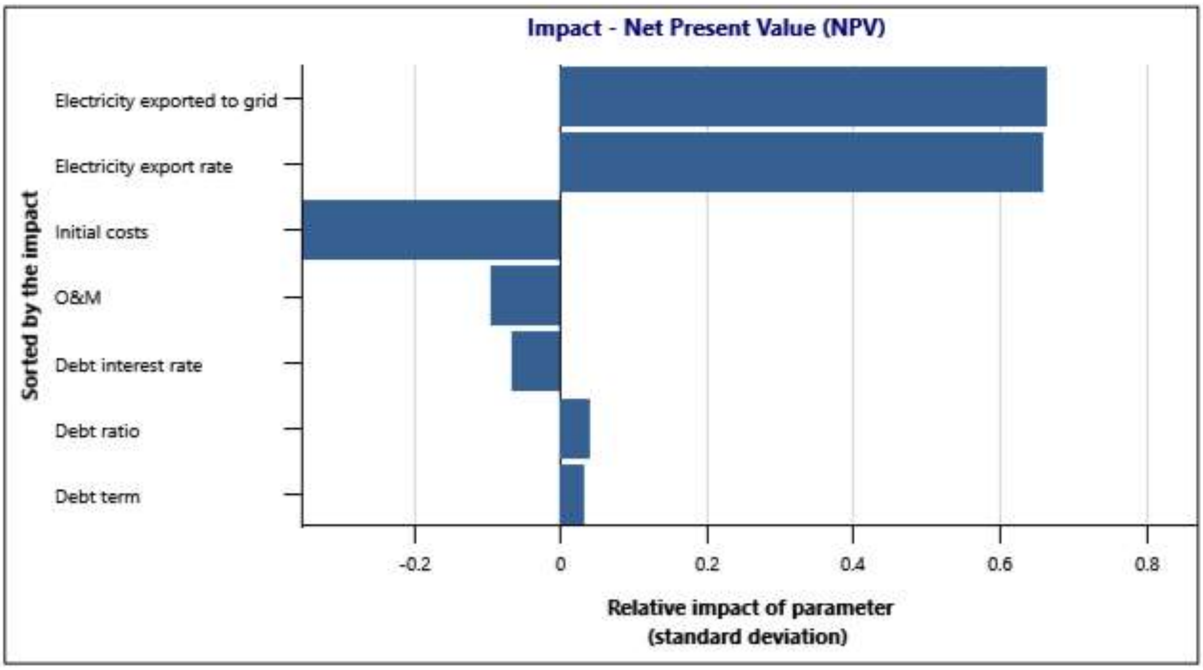


Fig 6 : Impact of different parameters

Distribution

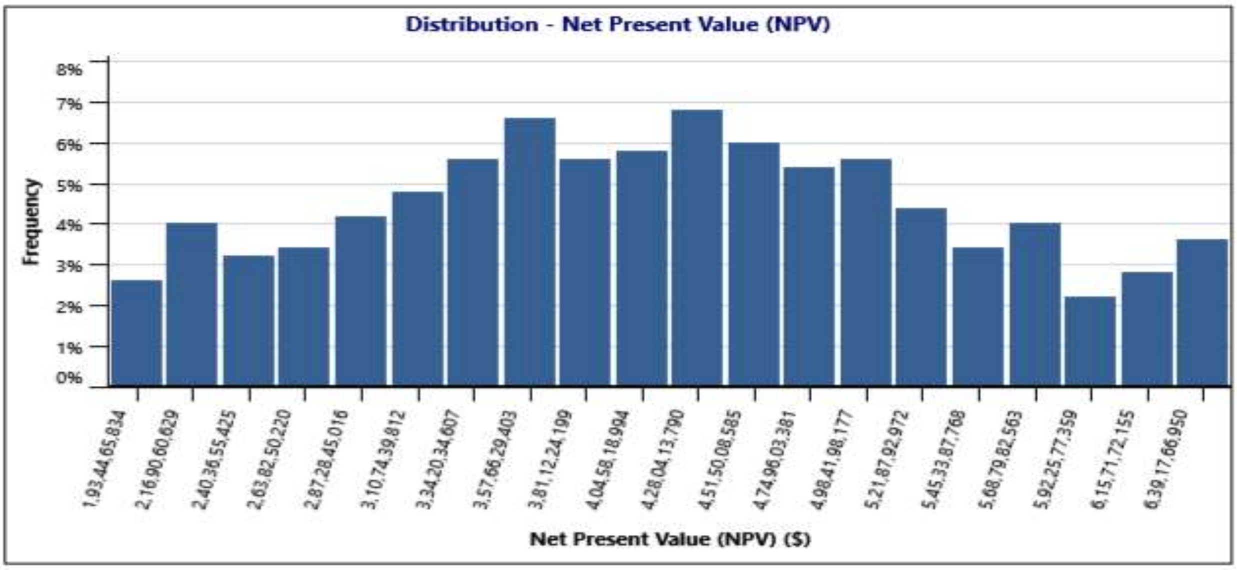
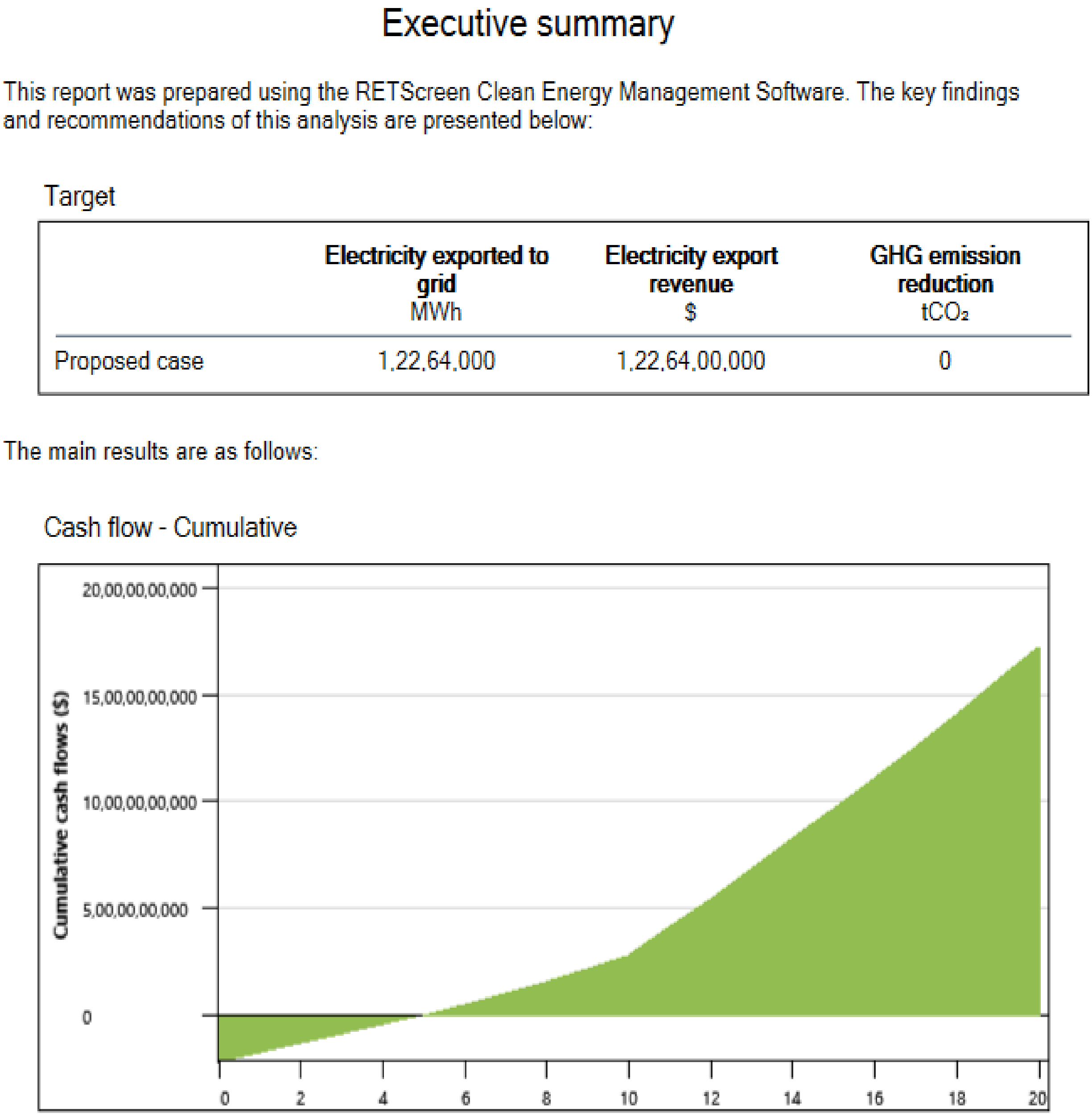


Fig 7 : Frequency over NPV

This histogram provides a distribution of the possible values for the financial indicator resulting from the Monte Carlo simulation. The height of each bar represents the frequency

(%) of values that fall in the range defined by the width of each bar. The value corresponding to the middle of each range is plotted on the X axis.



## Executive summary

This report was prepared using the RETScreen Clean Energy Management Software. The key findings and recommendations of this analysis are presented below:

Target

| | **Electricity exported to grid**<br>MWh | **Electricity export revenue**<br>$ | **GHG emission reduction**<br>$tCO_2$ |
|---|---|---|---|
| Proposed case | 1,22,64,000 | 1,22,64,00,000 | 0 |

The main results are as follows:

Cash flow - Cumulative

Fig 8 : Cumulative cash flow analysis

## Conclusion

The feasibility analysis of small hydro power using RETScreen software is a comprehensive and reliable approach to assess the potential for generating electricity from small hydro power projects. The RETScreen software provides a user-friendly interface to evaluate the technical, economic, and environmental aspects of small hydro power projects.

Based on the results of the feasibility analysis using RETScreen software, it can be concluded that small hydro power projects have significant potential to generate electricity in a cost-effective and environmentally friendly manner. The software can help project developers and investors make informed decisions by providing reliable estimates of project costs, revenues, and potential environmental impacts.

However, it is important to note that the results of the feasibility analysis are only as accurate as the inputs and assumptions used in the analysis. Therefore, it is crucial to conduct a detailed and accurate site assessment, gather reliable data on project costs and revenues, and make realistic assumptions about project operations and maintenance.

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