FEASIBILITY OF CONCENTRATED SOLAR THERMAL POWER PLANT FOR GRID CONNECTED SYSTEM IN SRI LANKA

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DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Abstract

Electricity generation through concentrated solar thermal energy is a rapid developing technology in the world. In order to successfully adapt this technology for Sri Lankan conditions, it is necessary to identify the suitable technology and suitable locations in the country. Also it is a must to evaluate how a small scale concentrated solar power plant performs as the first step since it is a new technology for the country. This research focused on selecting the most suitable technology and location for implementing a concentrated solar power plant through literature review and studying how it performs technically and financially through a software simulation.

Literature review depicted that the parabolic trough is the most suitable technology since it is commercially well proven and most matured technology for grid connected power generation systems. Hambanthota is most suitable location in the country since its Direct Normal Irradiation level is more than 1600 kWh/m^2/year. An empherical model of a parabolic trough solar thermal plant of capacity 10 MWe at Hambanthota was simulated using the software, System Advisor Model to obtain the performance parameters. This study further focused on finding out the optimum value of solar multiple, the optimum size of thermal energy storage, the best heat transfer fluid and best collector type for the plant under study.

Simulation results has shown that a 10 MWe plant can generate 45.8 GWh in the first year with a capacity factor 52.8%. Optimum solar multiple was 3.5 while the optimum thermal energy storage size was 7 hours. Therminol 66 was identified as the most suitable heat transfer fluid and Solargenix SGX-1 was the suitable collector type for this application. The levelized cost of energy was 0.276 $/kWh which is a high value at the moment. The internal rate of return was 3.6% and the net present value was negative indicating that the project is not financially attractive for the investors. The power purchasing agreement price for solar PV, which is 0.1148 $/kWh was used in this simulation. This study was further extended to see how the plant financially performs in future, considering the rate of capital cost reduction of 30% for solar thermal plants in future for every five years time. It has been identified that the project is financially feasible to start after 15 years resulting a positive net present value and levelized cost of energy 0.11 $/kWh. A comparative analysis has shown that it takes more than 15 years for a plant without storage to be financially feasible. Future work is needed to validate the results of the simulation by a physical model.

Key words – Concentrated solar power, Parabolic trough, Direct Normal Irradiation, System Advisor Model, Solar multiple, Heat transfer fluid, Thermal energy storage, Levelized cost of Energy, Net present value

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List of Abbreviations

Abbreviation	Description
CLFR	Compact Linear Fresnel Reflector
CSP	Concentrated Solar Power
CWEC	Canadian Weather for Energy Calculation
DNI	Direct Normal Irradiation
DSG	Direct Steam Generation
HCE	Heat Collection Element
HFC	Heliostat Field Collector
HTF	Heat Transfer Fluid
IRENA	International Renewable Energy Agency
IRR	Internal Rate of Return
ISCC	Integrated Solar Combined Cycle
IWEC	International Weather for Energy Calculation
LCOE	Levelized Cost of Energy
LFR	Linear Fresnel Reflector
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
NSRDB	National Solar Resource Data Base
PDC	Parabolic Dish Collector
PPA	Power Purchase Agreement

PTC	Parabolic Trough Collector
PV	Photovoltaics
SAM	System Advisor Model
SCA	Solar Collector Assembly
SM	Solar Multiple
SWERA	Solar Wind Energy Resource Assessment
TES	Thermal Energy Storage

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