Renewable Energy System Design for a Commercial Facility in Trinidad and Tobago

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Abstract. The objective of this study is to design, optimize and evaluate an appropriate renewable energy (RE) system for a commercial facility in Trinidad and Tobago (TT). An energy load profile was developed and utilized in HOMER Pro software to generate simulated models. Sensitivity analyses were conducting varying subsidy and sell back rates. The analysis showed that the facility had an associated electrical consumption of 56644 kWh/yr. with emissions of 39651 kgCO2/yr. In terms of possible scenarios, an optimized 15kW system grid tied PV system without grid sell back at an unsubsidized rate of 0.12 US$/kWh, performed with a 34.2% RF, 0.11 US$/kWh LCOE, 26720 kgCO2/yr emissions and has an IRR of 8.83% with 9.44 years simple payback. A 58kW grid tied PV system using the unsubsidized rate of 0.12 US$/kWh and sell back rate of 0.0865 US$/kWh was favorable with a RF of 77.4%, 15884 kgCO2/yr. emissions and has an IRR of 7.5% with 10.46 years simple payback. The LCOE was 0.0587 US$/kWh, almost equal to subsidized grid power cost of 0.06 US$/kWh. The results clearly demonstrated that RE systems such as grid tied PV are relevant in TT if systems such as Net Metering, Net Billing or sale of surplus electricity is factored and supported through regulation changes such as subsidy reductions in TT's energy policy.

Key words: homer pro, wind turbine, LCOE, IRR, NPC, operating cost, simple payback.

Introduction

Trinidad and Tobago (TT) like many Small Island Developing States (SIDS) is especially vulnerable to the negative effects of climate change. In 2020, TT was ranked as the second-highest emitter of carbon dioxide per capita worldwide (Mycoo, 2018). As outlined in the 2019 Vulnerability and Capacity Assessment Report, mitigation of climate change needs to be facilitated through the promotion of renewable energy (RE) (European Commission, 2019). In keeping with the Paris Agreement, the Nationally Determined Contributions (NDC) of TT sets to reduce overall carbon emissions by 15% (equivalent to 103,000,000 tonnes of CO2e) by 2030 from a Business as Usual (BAU) 2013 baseline. TT, via its National Development Policy Vision 2030 document, aims to develop and implement appropriate policy instruments including a feed-in tariff policy to create the enabling environment required for the development of RE technologies at the national level (Ministry of Planning and Development, 2016). The implementation of energy efficiency, alternate fuels and renewable energy technologies (RET) will also significantly help to reduce the carbon emissions from the power, transport and industrial sectors. Other suggestions such as removal of the subsidy provided by the natural gas industry to TT's electricity generation sector are being considered (Energy Chamber, 2021) as it is considered a financial burden on the economy and is contributing to sustainability challenges negatively impacting energy efficiency and the utilization of RE resources. A case study by Smith & Urpelainen (2017) supports this view as they found that the consumption of subsidized fossil fuels through artificially deflated prices, contribute to climate change and air pollution.

Due to TT's geographic location near the equator, the islands have a relatively favorable distributed solar potential of approximately 1600-1800 kWh/kWp/yr and a land wind power density distribution potential at 100ft of approximately 260-420 W/m^2 (IRENA, 2021). Table 1 shows the key indicators associated with TT.

Table 1. Trinidad and Tobago's Key Indicators

Total area / Evaluated area	5,130 / 5,130 km^2
Population (2018)	1,389,858
GDP per capita (2018)	16,844 USD
HDI / rank (2017)	0.78 / 67
Electricity consumption per capita (2014)	7,093 kWh/year
PV installed capacity (2018)	3 MWp
Average theoretical potential (GHI) / rank	5.385 kWh/m / 75
Average practical potential, level 1 / rank	4.349 kWh/kWp / 93
PV equivalent area	0.87%
PVOUT seasonality index (country range)	1.19 (1.14 – 1.24)
LCOE average (country range)	0.10 (0.09 – 0.10)
Source: IRENA, 2021	

There are many advantages for business and commercial enterprises in TT associated with plans to diversify its economy from fossil fuels and transition towards the use of RET including increased marketing opportunities, reduction of emissions and lower energy costs. The conditions under which RE sources will become economically feasible and the identification of other associated requirements to drive the incorporation RETs in business and commercial entities in TT need to be studied. A review of the literature has revealed limited information on these issues for TT and this information gap presents a significant challenge preventing the implementation of policies and an enabling environment to facilitate the increased use of RE locally. In this regard, this case study will involve the evaluation of possible RE designs via simulations for a commercial facility (a packaging, labelling & marketing company) in TT. The commercial facility is grid connected with no RE or energy efficiency measures implemented.

There is significant research worldwide for the development of innovative, highly efficient, more reliable and cost-effective RETs to significantly improve energy security, diversify energy mix and create a resilient, secure power grid that is independent of the geopolitical energy crisis and international market shocks (Suresh et al., 2020; Byrtus et al., 2022; Ersöz & Bülbül, 2022; Rácz et al., 2018; Shatnawi et al., 2018; Fujinuma et al., 2018; Seedath et al., 2021; Arjoon et al., 2022). A recent study by Bentouba et al. (2021) evaluated the suitability of the HOMER Pro and RTScreen Expert commercial simulation software that were used to predict the performance metrics of a large 20 MW photovoltaic power plant in a hot climate similar to TT. The simulation data from HOMER Pro was found to be 14% more accurate than RTScreen and only 5.1 % less than real monitoring data and was able to define simulated parameters in more detail than RETScreen Expert. Also, some of the errors came from the inaccuracies of the weather databases that the simulators use. Several other studies were also able to use the HOMER Pro software to simulate accurately the reduction of Net Present Cost, Cost of Energy and CO2 emissions and will be used in this study to evaluate the commercial facility (Suresh et al., 2020; Khalil et al., 2021; Vargas-Salgado et al., 2022). This study will include an energy audit on the facility to determine energy consumption patterns and build load profile. The load profile will be used to design and simulate renewable energy system models, which would be evaluated.

Material and Methods

The sequence of methodologies conducted in this study is shown in Fig.1.

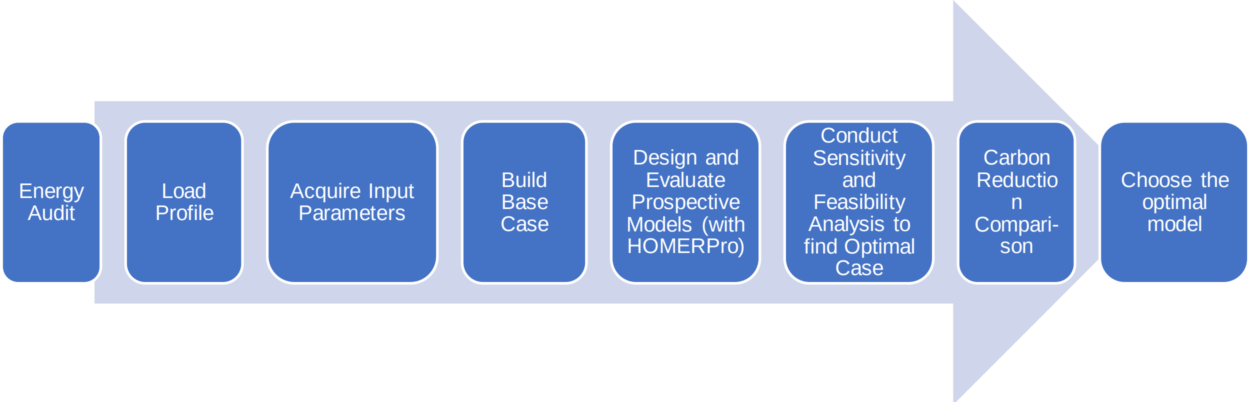

Fig.1. Flowchart of Methodologies used in this study

Energy Audit

The energy audit was conducted in accordance to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Level 1 Audit Standard 211P: Standard for Commercial Building Energy Audit (US Department of Energy, 2021).

Load Profile

The load profile for the facility was developed consistent with previous studies (Bentouba et al., 2021; Suresh et al., 2020; Khalil et al., 2021; Vargas-Salgado et al., 2022). The hourly load profile corresponding to monthly energy consumption patterns from utility bills for the year 2021 was developed and the load profile cumulative kWh usage verified using the actual utility bills. The energy load profiles were then inputted into the ‘HOMER Pro’ software as the electric base load for the models built.

Input Parameters

Solar data and wind/temperature data were obtained from HOMER Pro using the NREL radiation and NASA databases respectively based on the location of the commercial facility.

Cost of electricity and grid (feedback) sell back prices

The subsidized commercial electricity rate in TT use was US$0.06/kWh (T&TEC, n/d) while an estimated un-subsidized commercial electricity rate was US$0.12/kWh (T&T Parliament, 2021). Based on the effects of the COVID 19 Pandemic, the war in Ukraine and the volatility of oil and gas prices, estimated un-subsidized electricity rate can be higher in the vicinity of US$0.18/kWh. According to Martinez & Hosein (2018), unsubsidized cost of electricity in other Caribbean countries averages around $0.35. Sell back price rates of US$0.06/kWh (100% subsidized rate) and US$0.03/kWh (50% subsidized rate) will; be considered in this study.

Capital and Operational Expenditures

Capital and operating expenditures obtained from the literature (Resscott, 2022a; Resscott, 2022b; Resscott, n/d; AliExpress, 2022) are shown in Tables 2 and 3.

Table 2. Showing component capital expenditure

Component	Cost
Solar PV Panels	US$1000 /kW (lifetime 25 years)
Converter	US$500 /kW (lifetime 15 years)
Deep Cycle Batteries	US$200 /kW (800 kWh throughput)
Wind Turbine	$3500usd/3kW (lifetime 10 years)

Table 3. Showing component operational expenditure

Component	Cost
Solar PV Panels	US$10 per kW/year
Deep Cycle Batteries	US$10.00/year
Wind Turbine	US$180.00/year

Emissions Rate

According to Marzolf (2015), the carbon emissions from electricity generation from natural gas in T&T is 700g/kWh.

Build Base Model

Currently the facility has no RE technology implemented, so the Base Model will be constructed using the generated profile and grid electricity cost data to model actual trends of energy consumption on HOMERPro as previously done (Khalil et al., 2021).

Build Prospective Models

Other models were also built by adding/removing components to/from the base case system built previously, and then simulated using the 'Homer Pro' software. The component specifications were kept constant to ensure that the system design was the variable.

Optimization of Models and Sensitivity Analyses

The ‘HOMER Pro’ Optimizer option was utilized to determine their best/favourable performance metrics. Sensitivity Analyses were performed on models where selected input variables such as PV efficiency and diesel price were assigned a range of values and simulated to determine their effects on the system performance.

Selection of the Winning Architectures

The simulation and optimization results were analysed for both the off-grid and grid-tied connected systems, and the winning architectures were chosen based on the lowest LCOE achieved with other economic factors such as IRR, ROI and simple payback and emission reduction as benefits (Suresh et al., 2020; Khalil et al., 2021; Razmjoo et al., 2022).

Results and Discussion

Main Facility Description

This facility is a packaging, labeling and marketing company. The warehouse building has approximately 10000 sq.ft. of space and approximately 10000 sq.ft. of parking space. There are four (4) offices each with 144 sq.ft. of space. The building has one (1) kitchen with 100 sq.ft. of space and 2 bathrooms. The main hours of operation are between 7am and 5pm and currently the building has no renewable energy sources of energy.

Energy Load Profile

Utility bills for the year of 2021 were acquired to compile the monthly energy requirements for the facility, this data is displayed in Fig. 2 below.

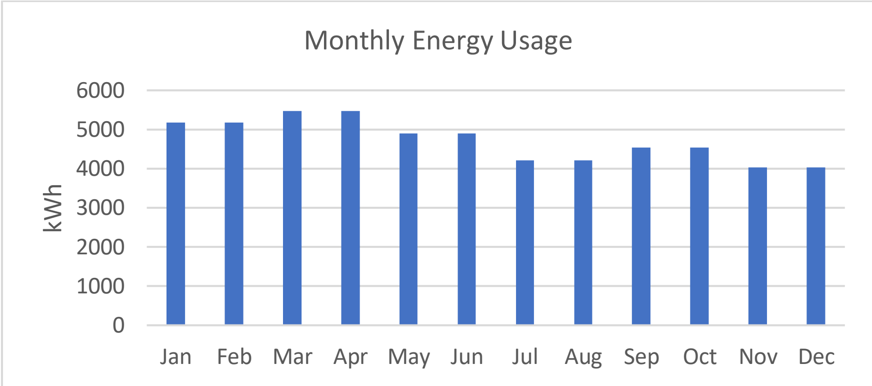

Fig. 2. Bar graph showing monthly energy requirements for 2021

Consistent with work done by Khalil et al. (2021), an estimated hourly load profile was compiled by identifying respective equipment energy requirements and time of day usage to generate the typical day energy load profile corresponding to monthly energy consumption patterns obtained from utility bills. The typical load profile is shown in Fig.3.

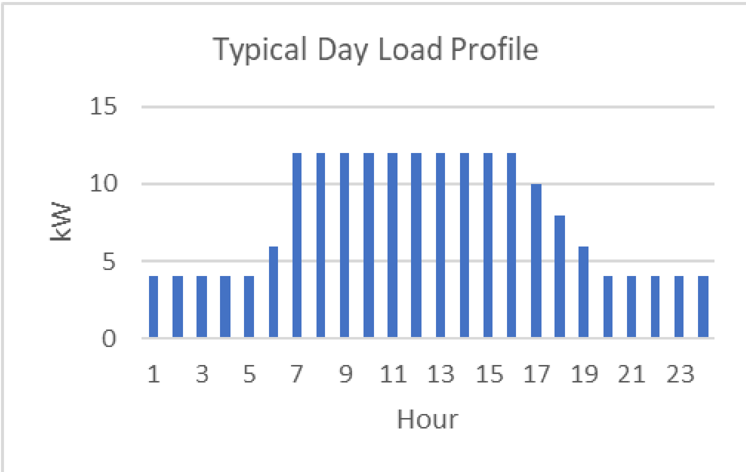

Fig. 3. Bar graph showing the typical load profile of the facility

Simulate energy load profile

As outlined by Suresh et al. (2020), the estimated hourly load distribution throughout the day for each month for the year of 2021 was inputted into HOMER Pro software and simulated with a random variability of 14% for day-to-day and timestep to generate a more realistic load profile for the entire year and the profile generated is shown in Fig.4. The daily load profile generated shows that the majority of energy is used between 6 am and 4pm, which is consistent with the working hours associated with a commercial facility in TT.

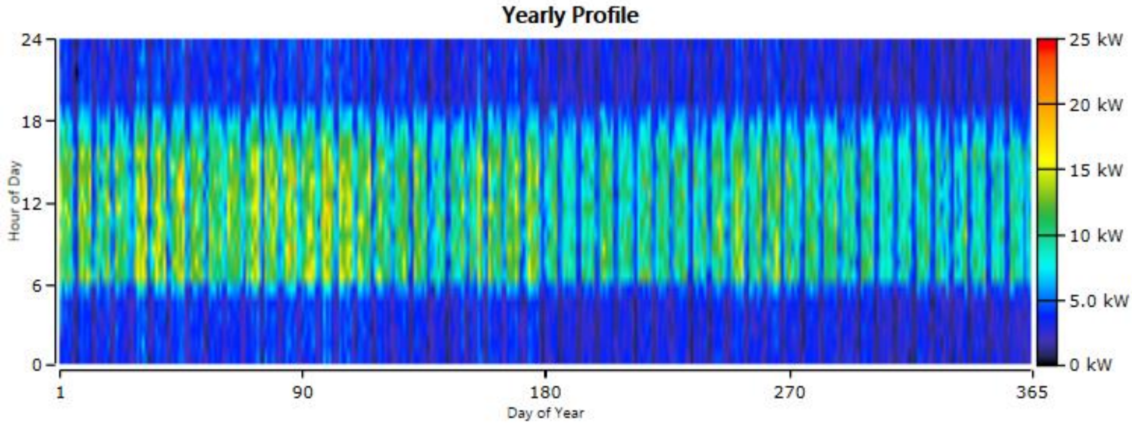

Fig. 4. Energy load profile generated from simulation software “HOMERPro”

Design and Evaluation of Simulation Models

Currently, the commercial facility has no renewable energy systems implemented and utilizes grid supplied power only. This base case scenario was simulated using HOMER Pro and the results shown in Table 4 and shows that the current facility with no RE systems implemented has system emissions of 39651 kgCO2/yr and electrical consumption of 56644 kWh/yr.

Table 4. Performance metrics of the Grid only base case Scenario

Metric	Base Case
NPC (US$)	$43936
COE (US$/kWh)	$0.06
Operating Cost (US$/yr)	$3399
Electrical Consumption (EC) (kWh/yr)	56644
System Emissions (SE) (kgCO2/yr)	39651
Renewable Fraction	0

Three alternative grid tied scenarios were simulated and optimized: PV as shown in Fig.5, wind turbines as shown in Fig.6 and a system with both PV and wind turbines as shown in Fig.7.

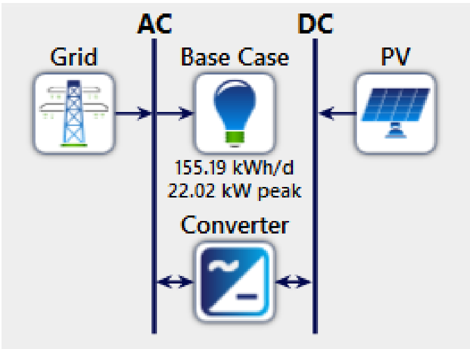

Fig. 5. Schematic of PV grid tied system

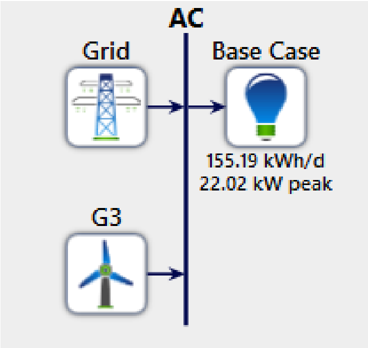

Fig. 6. Schematic of Wind turbine grid tied system

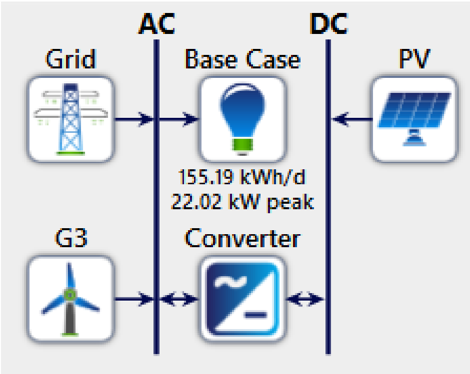

Fig. 7. Schematic of PV-wind turbine grid tied system

The grid price of electricity was adjusted for each of three grid tied scenarios until the RE fraction became relevant and RE started to be utilized. Table 5 shows the performance results of the three models at the grid price associated with RE relevance. The results demonstrate that for the wind turbine grid tied system, RE became relevant at the lowest grid price of 0.05 US$/kWh. Due to the location of the commercial facility, adoption of this scenario will not be practical as the current facility is located in a highly populated area with several buildings and infrastructure nearby that will hinder consistent wind flow at the required intensities (GASCO NEWS, 2022). For this reason, for further evaluations, the PV grid tied scenario will be considered for future evaluations although it is associated with the highest grid price of 0.09US$/kWh.

Table 5. Showing performance metrics for grid tied scenarios

Metric	PV	WIND	PV & WIND
Grid price at which RE system starts to be utilized (US$)	0.09	0.05	0.05
Renewable Fraction (%)	11.7	19	21.5
Solar PV Capacity (kW)	5	-	1
NPC (US$)	65869	36066	36968
COE (US$/kWh)	0.0899	0.0491	0.0503
Operating Cost (US$/yr)	4592	2519	2473
Initial Capital (US$)	6500	3500	5000
PV Prod. (kWh/yr)	7344	-	1469
Wind Turbine Capacity (kW)	-	3	3
Wind Turbine Production (kWh/yr)	-	10822	10822

Electrical Consumption (EC) (kWh/yr)	56646	56850	56855
Excess Electricity (kWh/yr)	378 (0.658%)	0	0
Grid Power Equivalent Emissions (GPEE = 700gCO2/kWh x EC) (kgCO2/yr)	35019	32220	31246
ROI (%)	3.8	5	3.2
IRR (%)	5.9	7.6	5.1
Simple payback (yr)	11.91	9.98	12.19

Effect of Subsidies on the PV grid tied scenario

The performance metrics of the PV grid tied system utilizing subsidized, un-subsidized and the average rate of Caribbean countries are shown in Table 6 and the comparison between RE penetration and power prices for the solar PV grid-tied system is shown in Fig.8. The results show that although the COE is the lowest for the subsidized rate and highest using the Caribbean rate, the Caribbean rate was associated with the highest ROI% and IRR% with lowest simple payback rates and significantly least carbon emissions. The graph in Figure 8 shows that as the price of power gradually increases from the subsidized rate of 0.06 US$/kWh to the average Caribbean rate of 0.35 US$/kWh, the RE Fraction also increases to over 60%.

Table 6. Showing performance metrics at subsidized, un-subsidized and avg. Caribbean rates

METRIC	SUBSIDIZED	UN-SUBSIDIZED	AVERAGE CARIBBEAN
Cost of Electricity from Grid	0.06	0.12	0.35
Renewable Fraction (%)	2.46	34.2	60.9
Solar PV Capacity (kW)	1	15	37
NPC (US$)	44655	82205	171370
COE (US$/kWh)	0.0610	0.11	0.196
Operating Cost (US$/yr)	3338	4850	9804
Initial Capital (US$)	1500	19500	44500
PV Prod. (kWh/yr)	1469	22033	54349
Electrical Consumption (EC) (kWh/yr)	56644	58027	67533
Excess Electricity (kWh/yr)	0	1133 (1.88%)	11063 (13.7%)
Grid Power Equivalent Emissions (GPEE = 700gCO2/kWh x EC) (kgCO2/yr)	38674	26720 (33% reduced)	18488 (60.9% reduced)
ROI (%)	0	6	18.5
IRR (%)	0	8.8	22.6
Simple payback (yr)	24.96	9.44	4.36
Present worth ($)	-719	5668	84924
Annual worth ($/yr)	-56	438	6569

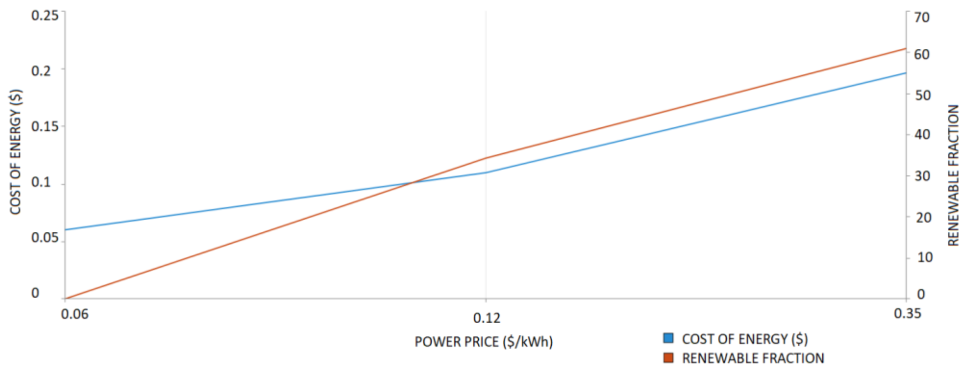

Fig. 8 Comparing RE Fraction to Power Price

Simulation results also show that for the optimized 15 kW PV system at the un-subsidized rate of 0.12 US/kWh, the annual cost for energy is $6,797 US with operating cost of $4,850 US per year with a payback of 9.44 years and an IRR of 8.83%. For the estimated average Caribbean rate of 0.35 US/kWh, the annual cost for energy is $19,826 US and an optimized 37 kW PV system's annual operating cost is $9814 US with a payback of 4.36 years and an IRR of 22.6%.

The energy consumption trends for each system at different power rates is shown in Figure 9. For the subsidized rate, there is minimal RE usage, but as the subsidy is removed and grid prices are increased, the RE usage also increased.

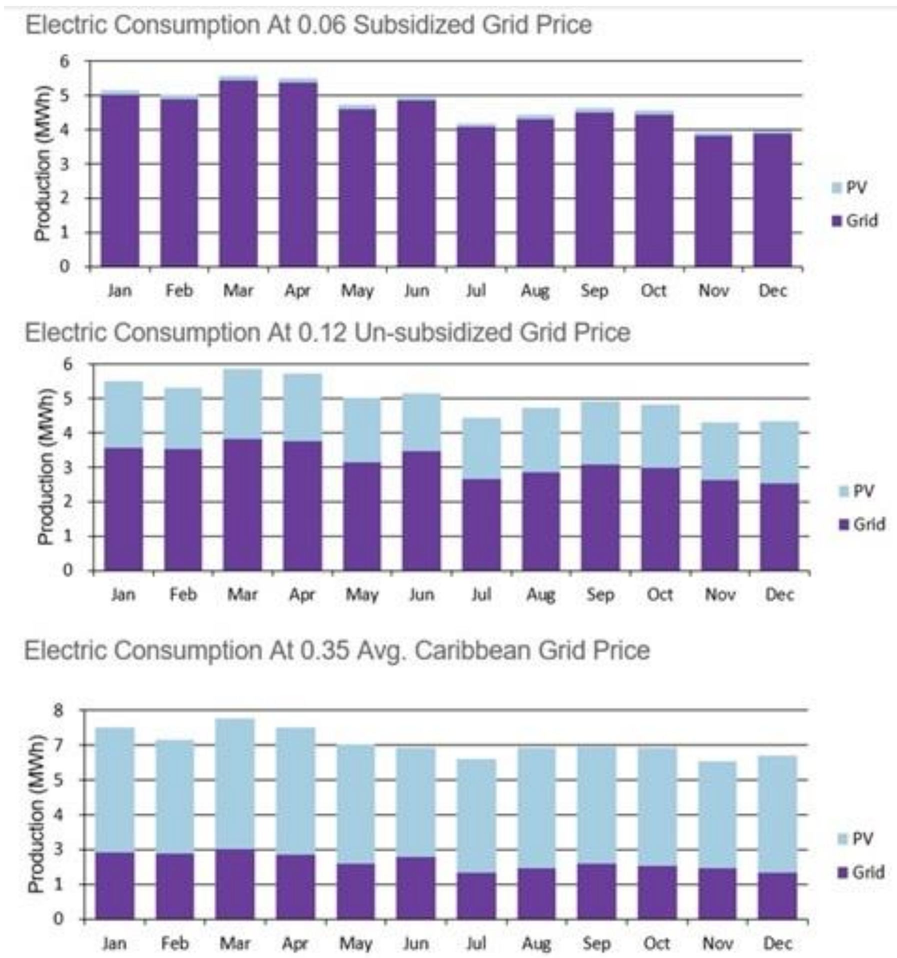

Fig. 9. Energy consumption trends at different grid prices

Effect of Grid feedback prices

Table 7. Showing performance metrics for subsidized grid rate at different sellback prices

Metric	Subsidized 0.06 $/kWh		
Sellback Rate ($/kWh)	0.03	0.06	0.0865
Renewable Fraction (%)	2.46	2.46	2.46
Solar PV Capacity (kW)	1	1	1
NPC (US$)	44655	44655	44655
COE (US$/kWh)	0.0610	0.0610	0.0610
Operating Cost (US$/yr)	3338	3338	3338
Initial Capital (US$)	1500	1500	1500
PV Prod. (kWh/yr)	1469	1469	1469
Electrical Consumption (EC) (kWh/yr)	56644	56644	56644
Excess Electricity (kWh/yr)	0	0	0
Energy Sold (kWh)	0	0	0
Grid Power Equivalent Emissions (GPEE = 700gCO2/kWh x EC) (kgCO2/yr)	38674	38674	38674
ROI (%)	0	0	0
IRR (%)	0	0	0
Simple payback (yr)	24.96	24.96	24.96
Present worth ($)	-719	-719	-719
Annual worth ($/yr)	-56	-56	-56

The effect of grid feedback pricing on the performance of the grid tied PV system using subsidized rates was evaluated and the results are shown in Table 7. The results clearly demonstrate that the RE system is not feasible at the subsidized rate of 0.06US$/kWh using any of the sell back rates 0.03, 0.06 or 0.0865 US$/kWh evaluated due to the fact that the associated COE is higher using the RE system when compared to the grid alone scenario.

Table 8. Showing performance metrics for un-subsidized grid rate at different sellback prices

Metric	Un-Subsidized 0.12 $/kWh		
Sellback Rate ($/kWh)	0.03	0.06	0.0865
Renewable Fraction (%)	38.1	47.2	77.4
Solar PV Capacity (kW)	17	22	58
NPC (US$)	81495	80144	76133
COE (US$/kWh)	0.107	0.101	0.0587
Operating Cost (US$/yr)	4602	3995	10.29
Initial Capital (US$)	22000	28500	76000
PV Prod. (kWh/yr)	24971	24971	85195
Electrical Consumption (EC) (kWh/yr)	58699	61344	100254
Excess Electricity (kWh/yr)	1434 (2.34%)	1810 (2.8%)	3550 (3.29%)

Energy Sold (kWh)	2054	4700	43610
Grid Power Equivalent Emissions (GPEE = 700gCO2/kWh x EC) (kgCO2/yr)	25437	22655	15884
ROI (%)	6	5.8	4.9
IRR (%)	8.8	8.6	7.5
Simple payback (yr)	9.45	9.58	10.46
Present worth ($)	6378	7728	11739
Annual worth ($/yr)	493	598	908

The results of the evaluation of the RE system utilizing the unsubsidized rate of 0.12 US$/kWh at the various sell back rates are shown in Table 8. The results demonstrate that as the sell back rates gradually increased from 0.03 to 0.085 US$/kWh, the COE and the operating cost decreases. The performance metrics for using the average Caribbean grid rate at different sellback rates is shown in Table 9 and shows that at a sell back price of 0.0865 US$/kWh, the majority of the electricity is being used from the PV system (77.4% RF). This scenario is associated with the least Grid Power Equivalent Emissions.

Table 9. Performance metrics for using the average Caribbean grid rate at different sellback prices

Metric	Average Caribbean 0.35 $/kWh		
Sellback Rate ($/kWh)	0.03	0.06	0.0865
Renewable Fraction (%)	64.1	74.7	92
Solar PV Capacity (kW)	40	53	156
NPC (US$)	166689	158019	132908
COE (US$/kWh)	0.181	0.133	0.0453
Operating Cost (US$/yr)	9142	6963	-5538
Initial Capital (US$)	48500	68000	204500
PV Prod. (kWh/yr)	58755	77851	229145
Electrical Consumption (EC) (kWh/yr)	71189	92104	226805
Excess Electricity (kWh/yr)	10744 (12.7%)	5444 (5.38%)	9437 (3.42%)
Energy Sold (kWh)	14544	35457	170160
Grid Power Equivalent Emissions (GPEE = 700gCO2/kWh x EC) (kgCO2/yr)	17905	16323	12657
ROI (%)	18	14.9	8.4
IRR (%)	22.2	19	11.8
Simple payback (yr)	4.45	5.13	7.67
Present worth ($)	89606	98276	123387
Annual worth ($/yr)	6931	7602	9545

The results of the evaluation of the RE system utilizing the estimated average Caribbean rate of 0.35 US$/kWh is shown in Table 9. The results show that as the sell back rates increase from 0.03 US$/kWh to 0.0865 US$/kWh, the COE also decreased from 0.181 US$/kWh to 0.0453 US$/kWh. The energy consumption trends for the system in Figure 10 show that at a sell back price of 0.0865 US$/kWh the majority of the electricity is being used from the PV system 92% RF with 229145 kWh/yr produced, 170160 kWh/yr sold to the grid and excess electricity being 3.42%.

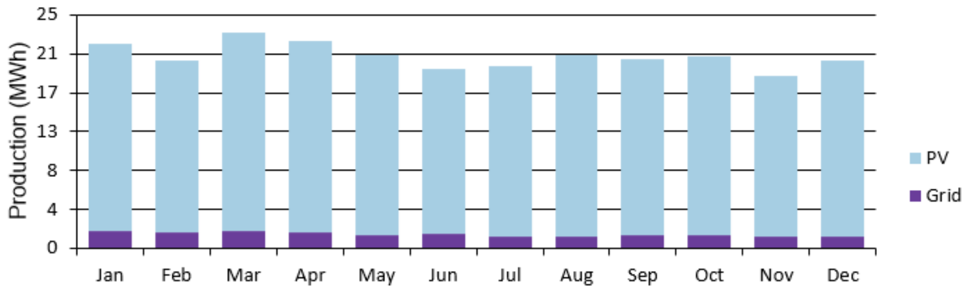

Fig. 10. Energy consumption trends using 0.0865 US$/kWh sell back price

No grid scenario

The off-grid performance metrics obtained for the stand-alone PV system is shown in Table 10. The results show that the COE. is 0.476 US$/kWh which is significantly higher than that obtained using the subsidized rate of 0.06 US$/kWh and the estimated un-subsidized rate of 0.12 US$/kWh. The results do demonstrate the unique benefit of this system as it has 0% carbon emissions per kWh, high reliability factor and is not susceptible to power outages and remote area applicability. As far as the facility is concerned, the energy needs are met using a 113 kW of PV and 426 kWh of battery capacity with an operating cost of $US 10,729/yr. The bar chart in Fig.11 shows the monthly electricity consumption of the facility using the stand-alone PV system by the off-grid system

Table 10. Showing Off-Grid performance metrics

Metric	Off-Grid
Renewable Fraction (%)	100
Solar PV Capacity (kW)	113
Battery quantity	426
Autonomy (hr)	39.6
NPC (US$)	348404
COE (US$/kWh)	0.476
Operating Cost (US$/yr)	10729
Initial Capital (US$)	209700
V Prod. (kWh/yr)	165983
Electrical Consumption (EC) (kWh/yr)	56617
Excess Electricity (kWh/yr)	101387 (61.1%)
Energy Sold (kWh)	0
Grid Power Equivalent Emissions (GPEE = 700gCO2/kWh x EC) (kgCO2/yr)	0

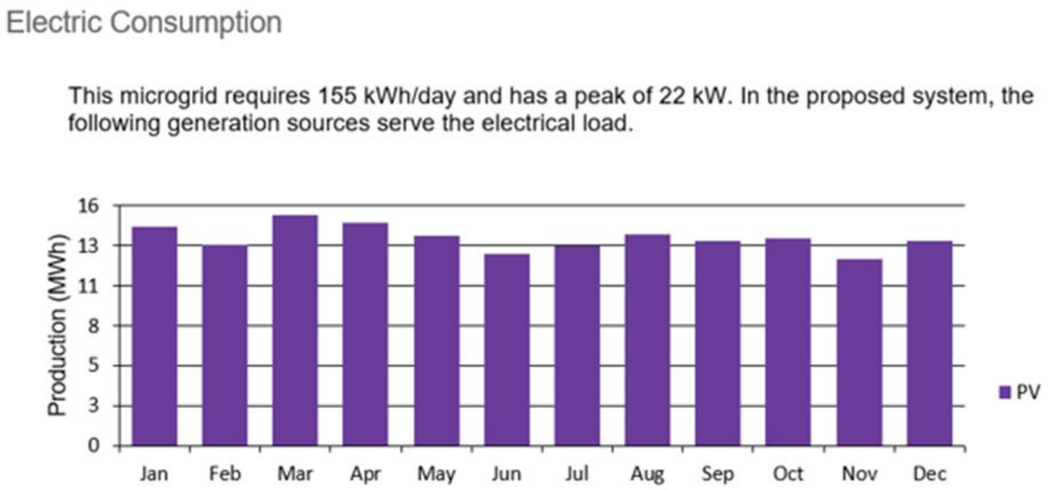

Fig. 11. Off-grid energy consumption trends

Carbon emissions comparison

The results of an evaluation of the various simulated systems with regards to carbon emissions reduction and RF % are shown in Table 11 and graphically in Figure 12. It can be seen that the un-subsidized system using 0.06 US$/kWh sellback was associated with a 43% carbon reduction, which can have quite an impact on the country's gross emissions if adopted by the commercial sector and contribute significantly towards TT achieving its NDC targets. Further grid price increases towards the average Caribbean rate of 0.35 US$/kWh and introduction of sell back rates from 0.03 US$/kWh up to 0.0865 US$/kWh will further lead to increases in CO2 emissions reduction and RF% values.

Table 11. CO2 emissions reduction comparison

Scenario	CO2 Emissions (kgCO2/yr)	RF (%)	CO2 Reduction %
Base Case (no RE)	39651	0	0
Unsubsidized (PV System)	26720	34.2	33
AVG. Carib. Rate (PV System)	18488	60.9	53
Unsubsidized (PV System + 0.03 sellback)	25437	38.1	36
Unsubsidized (PV System + 0.06 sellback)	22655	47.2	43
Unsubsidized (PV System + 0.0865 sellback)	15884	77.4	60
AVG. Carib. Rate (PV System + 0.03 sellback)	17905	64.1	55
AVG. Carib. Rate (PV System + 0.06 sellback)	16323	74.7	59
AVG. Carib. Rate (PV System + 0.0865 sellback)	12657	92	68
OFF GRID	0	100	100

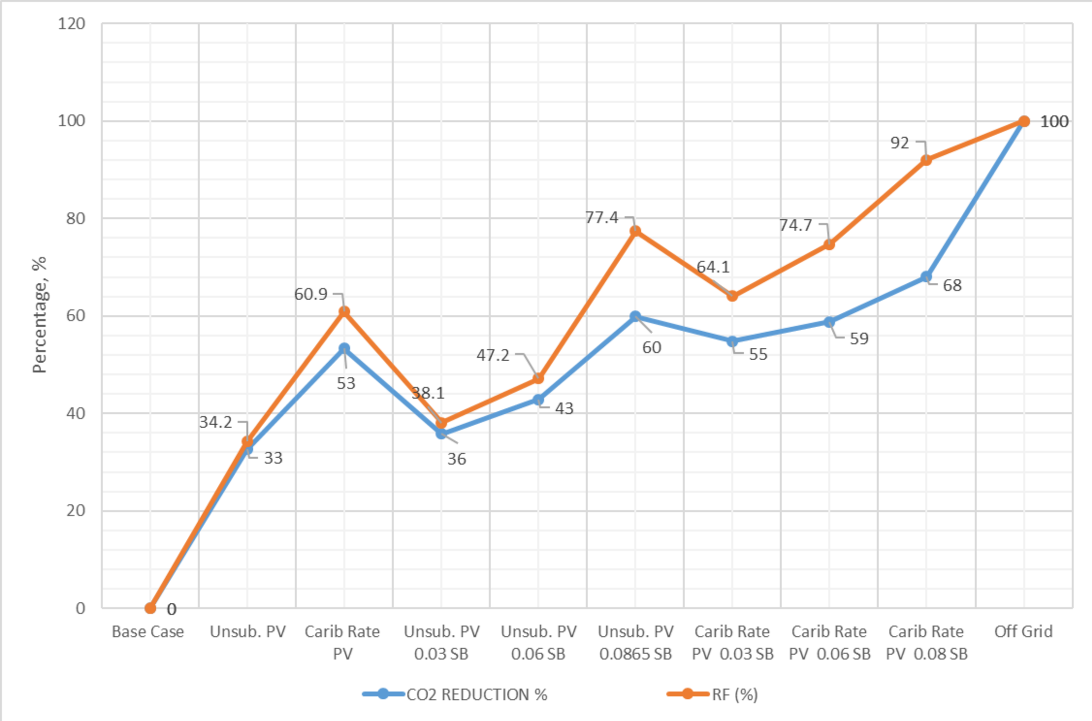

Fig. 12. CO2 emissions reduction comparison

Conclusion

The commercial facility under investigation has no RE systems implemented utilizing electrical consumption of 56644 kWh/yr. with system emissions 39651 kgCO2/yr. The no grid and wind associated systems were not feasible. An optimized 15kW system grid tied PV system without grid sell back at an unsubsidized rate of 0.12 US$/kWh, performs with a 34.2% Renewable Fraction, 0.11 US$/kWh LCOE, reduces emissions to 26720 kgCO2/yr and has an IRR of 8.83% with 9.44 years simple payback. Feasibility of this system is further improved if the estimated average Caribbean rate of 0.35 US$/kWh is utilized. If grid sell back was considered, a 58kW grid tied PV system using the unsubsidized rate of 0.12 US$/kWh and sell back rate of 0.0865 US$/kWh was favorable as the Renewable Fraction was 77.4% emitting only 15884 kgCO2/yr. and has an IRR of 7.5% with 10.46 years simple payback. The LCOE was 0.0587 US$/kWh, almost equal to subsidized grid power cost of 0.06 US$/kWh. The results clearly demonstrated that RE systems such as PV are relevant in TT if systems such as Net Metering, Net Billing or sale of surplus electricity is factored and supported through regulation changes such as subsidy reductions in TT's energy policy.

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