THE ECONOMIC ANALYSIS FRAMEWORK OF POTENTIAL DEVELOPMENT SOLAR PV ENERGY IN MALAYSIA

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Engineering Electrical.

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I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurently submitted for award of other degree.

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i	Zone
k	Year
M	Year before
η	Solar PV power plant efficiency [%]
η^{PVref}	PV module efficiency reference [%]
η'	Effective solar PV power plant efficiency [%]
G_{stc}	Global sun irradiation [1000W/m²]
A_{eff}	Area of effective [m²]
θ_i^{eff}	Temperature effective
$f\delta_i$	Factor of angle displacement
PR_{sys}^{pv}	Systems performance
AvhG_{stc}	Average hour of effective Sun radiation
fDG^{PV}	Digression of PV performance
$fstcDG^{PV}$	Standard digression of PV performance
fD*Sys*	Total derating factor of the system [decimal]
fD*Vdrp*	Derating factor for voltage drop [decimal]
f*Ddirt*	Efficiency for dirt at PV panel[decimal]
fDG^{PVinv}	Inviter digression fraction
PP_i^{pv}	Peak power PV generation [W]
PG^{PVeff}	PV effective power generating [W]
PG_i^{PVeff}	Yearly PV effective power generating [W]
$GEsys^{PV}$	Total PV energy generate for the systems [W]
$AppEsys^{PV}$	Approximate energy of PV systems.
LP^{PV}	PV performance losses
Mx_i^{pv}	Maximum PV output [W]
Tc_i^{Pv}	Operational cell temperature
$Tamb_i^{Pv}$	Ambiance temperature

$Revenue_i^{Pv}$	Revenue of PV power [RM]
FIT_k^{eff}	Affective feed in tariff [RM]
FIT_k^{Yb}	Year precedent feed in tariff value [RM]
$FIT_k^{DG\%}$	FIT digression value in [RM]
TP_i^{pv}	Total Profit of PV power [RM]

LIST OF ABBREVIATIONS

PRBlnc	Power required balance
PGen	Power of generator
Pdct	Policy Discount
RM	Ringgit Malaysia (Currency)
T_{CST}	Total cost
C_{EQ}	Equipment cost
C_{SHP}	Shipment cost
C_{LB}	Labor cost
C_{INV}	New investment cost
C_{OM}	Operation maintenance cost
TCGenOM	Total generator operation maintenance cost
AC_{FL}	Actual fuel cost
CmrOM	Minor operation maintenance cost
CmjOM	Major operational maintenance cost
CovhOM	Over hall maintenance cost
CGenRpLc	Generator replaces cost
TMU	Time utilization of generator
C_{FL}	Fuel consummation at required load
EFTYr	Year of utilizations
CFltr	Cost per liter
$NmrFrq_{250H}$	Number of frequent minor service at 250h, 500h, and 750h
CmrM	Cost of minor operation maintenance
$NmjFrq_{1000H}$	Number of frequent major service at 1000h
CmjM	Cost of major operation maintenance
GenPC	Generator price
$NovhFreq_{10\ 000H}$	Number of frequent over hall service at 10 000h
TCP_{VOM}	Total cost of PV operational maintenance
CBttOM	Cost of battery operational maintenance

CPVrOM	Cost of PV maintenance
TCHYBsys	Total cost hybrid systems
T_{profit}	Total profit
T_{cost}	Total cost
T_{RVN}	Total revenue
PV_{RVN}	PV revenue
GEN_{RVN}	Generator revenue
HybridFIT	Hybrid feed in tariff
HybridEsys	Total power hybrid energy systems
FiT	Feed in tariff
PGen	Generator generate power
PrC/Kw	Price/Kw
TC_{INT}	Total cost of installation
PPVsys	PV power generate
PGen	Generator power generate
Pbatt	Power battery
Pload	Load power
xPPVsys	Percentage of PV systems installation
yPGen	Percentage of generator systems installation
zPbatt	Percentage of battery systems installation
Pload	Total load power install
PTsysYearsSetup	Total of power performance of the systems at year setup
PTsysYearsActual	Total power performance systems at Actual year
Tcost	Total cost
Tbudget	Total budget

ABSTRACT

Nowadays, the increasing of using renewable energy (RE) as an alternative for generating power has brought an attention to the most countries. Current power generations, in which can be called conventional ones, are using the fossil fuel such as coal, gas and oil in operating the power plant. Therefore, indirectly it has faced the problem of uncertainty in fossil fuel price, resources availability, carbon emission and energy supply to remote areas. To date, Malaysia has spent more than billion in costing to acquire the fossil fuel to generate the power plant. In that reasons, the introduction of RE for energy supply is vital. Since the solar energy has become prominent in energy supply nowadays, the potential for large scale power plant is high, whereby, so far one of 8 MW solar PV power plant has been developed in Pajam. To develop a large scale solar energy is more expensive when compared to conventional ones. In economic analysis point of view, the proper framework that suite with Malaysia perspective such as environment, geographical, climate and suitable technique as a parameters needs to be carried determine first, so that the nearest prediction of return of investment can be anticipated. The analysis is presented by closer look at the plant performances and profits generated with consider the possible constraint factors that enforce by the environment factor and the technology. The case study is conducted to show the analysis assessment for large scale solar PV power plant up to 8 MW and the result will indicate the potential of solar being use as renewable energy to generate electricity and making profit. Meanwhile, the problems of supplying electricity to remote areas due to the geographical condition are studied by analyzing an economic analysis of hybrid energy supplies. An exploitation of solar energy with energy storage (battery) and diesel generator as hybrid energy sources to remote areas is proposed by come up an economic analysis of the hybrid energy system. The case studies at the remote islands (Perak and Jarak islands) are carried out. The outcome of the study case will show that with the correct sizing and design, money can be saving and dependency to diesel generator can be reduced.

ABSTRAK

Abad ini, peningkatan pengunaan tenagaboleh diperbaharui (RE) sebagai penjanaan alternatifuntuk menjana kuasatelah membawaperhatiankepadakebanyakan negara. Masalah seperti peningkatan sumber kos, bahan api yang tidak mencukupi, pencemaran alam, kesukaran menghantar bekalan elektrikke kawasan pendalaman dan pelepasan gas rumah hijun merupakan element permasalah utama yang disumbangkan oleh penjanakuasa konversional. Malaysia telah membelanjakan peruntukan lebih RM 12 ribu juta setahun untuk membeli bahan api bagi tujuan penjanaan kuasakonventional. Angka ini dijanka menokok dari semasa kesemasa berikutan harga pasaran yang sentiasameningkat dan tidak menentu.Pengunaan tenaga boleh diperbaharui seperti angin,cahaya matahari,pasang surut laut dan lain-lain merukan jalan keluar daripada kebergantugan kepada bahan api konventional (minyak,arang batu,gas) dan harga pasaran yang tidak menentu. Kajian terhadap potensi penjanakuasa solar di Malaysia telah dijalankan bagi melihat kebolehannya dalam pejanaan ekonomi. Kajian tersebut merungkai lebih mendalam tentang kebolehan dalam menjana tenaga dengan mengambil kira segala aspek dan keadaan yang boleh menjejaskan pejanaankuasa. Kajian kes ini dijalankan bertujuan untuk menambah baik dari segi penjanaan keuntugan dan menyediakan rangka kerja ekonomi kepada penjanakuasa solar yang berkapasiti sehingga 8 MW. Penyediaan elektrik dikawasan luar Bandar merupakan masalah utama yang dihadapi oleh kerajaan Malaysia. Perkara ini terjadi kerana keadaan geografi yang berbukit bukau dan hutan yang tebal, natijahnya kos untuk membekalkan elektrik ke kawasan pendalaman menjadi mahal. Tenaga boleh diperbaharui merupakan jawapan yang efektif dalam membekalkan elektrik dikawasan pendalaman. Pengunaan tenaga boleh diperbahurui memberiharapan baru kepada permasalahanini. Sesunguhnya tenaga elektrik merupakan kunci utama dalam membentuk tamadun kemodenan. Analisa dan reka bentuk teknologi hybrid akan diguna pakai dalam menyelesaikan permasalahan ini. Analisis ekonomi akan dibentangkan sejajar dengan keadaan kes sebenar dipulau yang mempunyai masalah penyediaan tenaga elektrik manpan. Teknologi ini diharapakn dapat merugkai potensi sebenar tenaga boleh diperbaharui di Malaysia dan penjimatan wang dapat diperolehi dengan mengoptimakan kapaciti sebenar.

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APPENDIX C1

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