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Energy Consumption Evaluation of Air Cooled Chiller With Cold Storage System Powered by Photovoltaic (PV) Modules

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Thesis submitted in partial fulfillment of requirements of the degree

Master of Science in Renewable Energy & Sustainability

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ABSTRACT

Renewable energy becomes an appealing technology that used in many applications in our life. Environmentally it reduces the CO_2 emissions and enhance the systems sustainability. This research study the beneficial of using PV-system with thermal storage tank (TST) to power an air cooled chiller, associated with three different scenarios.

The simulation methodology is adopted in this research to study the various scenarios of the combination of the utility, PV-system, thermal storage tank and air cooled chiller. The scenarios are based on the annual simulation building library of the TRNSYS simulation software. The three scenarios investigated in this study include supplying an air cooled chiller using PV-system with the grid, PV-systems with grid and TST and finally fully supplying the system by PV-system and TST .

The first scenario gives a reduction in energy consumption from the grid by 81%, and the CO_2 emissions by 72%, in addition the payback period equal to 9 years with 4,350$ total profit along the project life cycle. The second scenario saves 75.6% of the utility energy consumption and decrease the CO_2 emissions by 68%, moreover the payback period becomes 12.4 years with 3,202$ total profit. The final scenario, chiller is 100% supplied from the extended PV-system size and TST volume, which leads to the best reduction in the amount of CO_2 emissions by 89.5%, furthermore the payback period equal to 12.5 years with 4,206$ total profit.

تقييم استهلاك الطاقة للمبرد الذي يتم تبريده باستخدام الهواء مع نظام لتخزين الطاقة الحرارية على شكل برودة والذي يتم تشغيله باستخدام الواح الطاقة الشمسية

اعداد: زيد جمال الناظر

الملخص:

اصبحت الطاقة المتجدد تكنولوجيا جذابة يمكن استخدامها في العديد من التطبيقات في حياتنا العملية. من ناحية بيئية تساهم الطاقة المتجددة في تقليل انبعاث غاز ثاني اكسيد الكربون بالإضافة الى تحسين استدامة الانظمة المستخدمة معها . هذا البحث يدرس الفائدة من استخدام نظام الالواح الكهروضوئية مضافا له خزان للطاقة الحرارية بهدف تزويد المبرد الذي يتم تبريده عن طريق الهواء بالطاقة الكهربائية وذلك من خلال ثلاثة سيناريوهات مختلفة.

استراتيجية المحاكة تم اعتمادها في هذا البحث بهدف دراسة السيناريوهات الثلاثة من خلال الربط بين شبكة الكهرباء الرئيسية ، نظام الالواح الكهروضوئية ، خزان الطاقة الحرارية بالإضافة الى المبرد المراد تغطية الحمل الكهربائي له. هذه الاستراتيجية تم تنفيذها باستخدام برنامج المحاكاة TRNSYS. السيناريوهات الثلاثة التي تم استخدامها في هذه الدراسة تتمثل في تغذية المبرد باستخدام نظام الالواح الكهروضوئية والشبكة الرئيسية ، الالواح الكهروضوئية والشبكة الرئيسية بالإضافة الى استخدام خزان للطاقة الحرارية و اخيرا تزويد المبرد بالطاقة الكهربائية بشكل كامل باستخدام الالواح الكهروضوئية وخزان الطاقة الحرارية فقط.

السيناريو الاول يعطي تقليل في استهلاك الطاقة الكهربائية من خلال الشبكة الرئيسية بنسبة 81% و ايضا تقليل في انبعاث غاز ثاني اكسيد الكربون بنسبة 72% ، بالإضافة الى ان فترة الاسترداد لهذا السيناريو تساوي 9 سنوات مع 4,350 دولار كفائدة لاستخدام هذا السيناريو خلال فترة المشروع. السيناريو الثاني يخفض 75.6% من الطاقة المستهلكة من الشبكة بالإضافة الى تقيل انبعاث غاز ثاني اكسيد الكربون بنسبة 68% وفي هذا السيناريو فترة الاسترداد تساوي 12.4 سنة مع 3,202 دولار قيمة الفائدة من استخدام النظام. السيناريو الاخير يعمل على تغطية الطاقة الكهربائية للمبرد بشكل كامل من خلال زيادة عدد الخلايا الكهروضوئية وحجم الخزان الحراري ، وهذا من شانه ان يقودنا الى افضل تقليل في انتاج غاز ثاني اكسيد الكربون بنسبة 89.5% ، بالإضافة الى فترة استرداد تساوي 12.5 سنة مع 4,206 دولار كفائدة لاستخدام هذا السيناريو .

DECLARATION

I declare that the Master Thesis entitled" **Energy Consumption Evaluation of Air Cooled Chiller With Cold Storage System Powered by Photovoltaic (PV) Modules** " is my own original work, and herby certify that unless stated, all work contained within this thesis is my own independent research and has not been submitted for the award of any other degree at any institution, except where due acknowledgement is made in the text.

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DEDICATION

To my Family ………….……. For their support

To my Teachers ……........ For help me until the end

To my friends ………………. Who give me Positive sentiment

To oppressed people throughout the world and their struggle for social justice and egalitarianism

To our great Palestine

To my supervisor Dr Ishaq Sider

To all who made this work is possible

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LIST OF ABBREVIATIONS

AC	Alternating Current
C.T	Cooling Time
COP	Coefficient of performance
CRF	The Constant Rate Factor
CTES	Cooling thermal energy storage
DC	Direct Current
DSC	Differential Scanning Calorimeter
EGWS	Ethylene Glycol Based Water Solutions Tank
EPS	Environmental Process Systems Limited
E_{Annual}	Total electrical energy obtained using each scenario.
h	hour
i	Inside
ITS	Ice thermal storage
MPPT	Maximum Power Point Tracking
NIS	New Israeli shekel
No	Number
NOCT	Normal Operating Conditions Test
o	outside
O&M	Operation & Maintenance Cost
PBP	Payback Period
PCM	Phase change material
PV	Photovoltaic
RM	Malaysian Ringgit
SPV	Solar photovoltaic
STC	Standard Test Condition
TES	Thermal energy storage
TFM	Transfer Function Method
TR	Refrigeration Ton
TRANSYS	Transient System Simulation program
TRNBuild	TRANSYS Building input data visual interface
TST	Thermal Storage Tank
WHO	World Health Organization
Wp	Watt Peak

LIST OF SYMBOLS

Variables	Units	Description
A	m^2	Surface area
a	1/h	Times of air change
Cp	kJ/kgK	Specific heat
E_{annual}	Wh	Annual electrical energy
h	$W/m^{2o}C$	Conviction heat transfer coefficient
h_{fg}	kJ/kg	Air enthalpy
i	----	Loan intrest
k	W/m^oC	Thermal conductivity
m	kg	Mass
m^*	kg/sec	Mass flow rate
n	Years	Project life cycle
η_{exe}	----	Exergetic efficiency
P_{elec}	W	Electrical Power
P_{peak}	W	Peak Electrical Power
Q	W	Thermal cooling load
q_c	kJ/h	Conviction heat flux
Q_{inf}	kW	Infiltration heat gain
q_{it}	kJ/h	Infiltration heat flux
q_{prod}	kJ	Product cooling load
Q_{prod}	kW	Product gain
q_s	kJ/h	Conduction heat flux
Q_{total}	W	Thermal cooling load for chamber
T	^oC	Temperature
T_r	$	Tariff price
U	$W/m^{2o}C$	Overall heat transfer coefficient
V	m^3	Volume
V_f^*	m^3/sec	Volumetric flow rate
ω	Kg/kg dry air	Air humidity ratio
ρ	kg/m^3	Air density
ΔT	^oC	Temperature difference
Δx	m	Layers thickness