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A renewable energy solution for Highfield Campus of University of Southampton

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ABSTRACT

In today's world where the global warming is one of the biggest problems for mankind, sustainable energy generation is becoming more and more important every day. This project focuses on the Highfield Campus of the University of Southampton and aims to achieve a more sustainable way of heat and electrical energy generation in order to help protect the environment.

The electrical energy to the Highfield Campus is provided from the national grid which primarily burns fossil fuels whereas the heat energy is mainly obtained by burning natural gas. None of these methods are sustainable and are major sources of greenhouse gas emissions. As the project objective, more sustainable ways of energy production in the campus are investigated, analysed and discussed in this report.

For this purpose, data acquisition is done by obtaining the energy consumption figures of the buildings within the campus. On the other hand, feasibility studies for various types of renewable energy sources are conducted revealing their potential contributions and applicability. All the data are then worked through to design more sustainable energy systems sticking to the project aims.

The resultant electrical and heat energy generation designs satisfy the project objective by utilizing alternative energy sources and reducing the greenhouse gas emissions of the campus, even though not in huge amounts. The results obtained are satisfactory in the sense that the proposed designs are both technically and economically feasible.

To conclude, these designs proposed in this project can be the first steps toward a more sustainable campus and get even more tempting with relevant technological improvements in the future.

Contents

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Nomenclature

T_c	temperature of the cell (°C)
T_a	temperature of the ambient air (°C)
NOCT	normal operating cell temperature (°C)
G	irradiance (W/m^2)
$I_{SC}(G)$	short circuit current at certain irradiance (A)
$V_{OC}(SC)$	open current voltage at standard conditions (V)
N_{cells}	number of cells in the solar module
FF	fill factor (%)
P_{max}	maximum power (W)
η_{panel}	efficiency of the panel (%)
A_{panel}	area of the panel (m^2)
$A_{windows}$	the area of the windows (m^2)
$A_{p.doors}$	the area of the personal doors (m^2)
$A_{f.wall}$	the area of the front wall (m^2)
$A_{f.windows}$	the area of the front wall of windows (m^2)
$A_{r.wall}$	the area of the rear wall (m^2)
$A_{r.windows}$	the area of the windows of the rear wall (m^2)
$A_{s.wall\,1}$	the area of the side wall 1 (m^2)
$A_{s.windows\,1}$	the area of the windows of the side wall 1 (m^2)
$A_{s.wall\,2}$	the area of the side wall 2 (m^2)
$A_{s.windows\,2}$	the area of the windows of the side wall 2 (m^2)
A_{floor}	the area of the floor (m^2)
A_{roof}	the area of the roof (m^2)
M_{rear_wall}	the empirical coefficient of ambient temperature at rear wall
M_{front_wall}	the empirical coefficient of ambient temperature at front wall
$M_{side\_wall\,1}$	the empirical coefficient of ambient temperature at side wall1
$M_{side\_wall\,2}$	the empirical coefficient of ambient temperature at side wall2
$N_{windows}$	the number of the windows
$N_{p.doors}$	the number of the personal doors
$N_{f.windows}$	the number of the windows on front wall
$N_{r.windows}$	the number of the windows on rear wall
$N_{s.windows\,1}$	the number of the windows on side wall 1
$N_{s.windows\,2}$	the number of the windows on side wall 2
$N_{windows.direction}$	the number of the windows at the direction in question
$P_{windows}$	heat loss through the windows (W)
$P_{p.doors}$	heat loss through the personal doors (W)
$P_{f.wall}$	heat loss through the front wall (W)
$P_{r.wall}$	heat loss through the rear wall (W)
$P_{s.wall\,1}$	heat loss through the side wall 1 (W)
$P_{s.wall\,2}$	heat loss through the side wall 2 (W)
P_{floor}	heat loss through the floor (W)
P_{roof}	heat loss through the roof (W)
$P_{n.vent}$	heat loss by natural ventilation (W)
$P_{total\ loss}$	total heat loss through building in question (W)
P_{sg}	solar gain as a function of month and direction (W)
$P_{occupancy}$	internal heat gain from occupants inside building in question (W)
$P_{lightening}$	internal heat gain from lightening inside building in question (W)
$P_{elec.}$	internal heat gain from electrical device inside building in question (W)
$P_{internal}$	total internal heat gain (W)
P_{total_gain}	total heat gain (W)
P_{heat}	total maximum heat requirement of building in question (W)
$U_{windows}$	the thermal transmittance coefficient of the windows (W/(m^2 K))
$U_{p.door}$	the thermal transmittance coefficient of the personal door (W/(m^2 K))
$U_{f.wall}$	the thermal transmittance coefficient of the front wall
$U_{r.wall}$	the thermal transmittance coefficient of the rear wall (W/(m^2 K))
$U_{s.wall\,1}$	the thermal transmittance coefficient of the side wall 1 (W/(m^2 K))
$U_{s.wall\,2}$	the thermal transmittance coefficient of the side wall 2 (W/(m^2 K))
U_{floor}	the thermal transmittance coefficient of the floor (W/(m^2 K))
U_{roof}	the thermal transmittance coefficient of the roof (W/(m^2 K))
T	temperature differences between ambient air and inside the building (K)
ΔT_{soil}	temperature differences between ambient soil and the floor (K)
ΔT_{SH}	increase in gas temperature in suction line (K)
n	number of air changes per hour (natural ventilation ratio)
$V_{building}$	the volume of the building (m^3)
$Sp.ht$	specific heat factor for air
$C_{p,air}$	specific heat capacity of air (kJ/(kg K))
P_{air}	the density of air (m^3/kg)
S	solar gain factor
q_{sg}	mean solar load as a function of month and direction (W/m^2)