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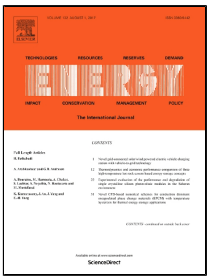

Analytical model for electric back-up power estimation of solar box type cookers

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Analytical model for electric back-up power estimation of solar box type cookers

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Abstract: The major hindrance in popularization of box type solar cookers (SBCs) is cooking incapability of these appliances in low availability of sun light and in night. This paper introduces a new parameter "required electric back-up power (P_{rb})" for SBCs to remove this limitation. An analytical model is presented here to derive P_{rb} for SBCs under different weather and cooking time conditions. To validate proposed model, a Solar cum Electric Cooker (SEC) has been fabricated as per P_{rb} value estimated via analytical model. SEC has been tested under different conditions. Experimental results are in support to the analytical approach. SEC is capable for cooking of 1.2 kg food load under indoor and outdoor. For outdoor, cooking time on sunny day without back-up is recorded between 1.5 and 2.5 h. The cooking time on scattered cloudy day with back-up is found to be 100 min (back-up is 0.12 kWh that is 82% less than the conventional electric heater). For indoor, cooking time is found to be 85 min (with 0.23 kWh electric back-up). Paper also reveals that electric back-up in SBC also reduces its payback period and increases its net present value (NPV) in respect to different cooking fuels.

Keywords: cook stove, electrical back-up, solar box type cooker, payback period, mica-sandwich trip heater

Nomenclature

τ = Overall transmissivity
α = Absorptivity of the absorber,
$(\tau\alpha)_b$= Transmissivity-absorptivity product for beam radiation
$(\tau\alpha)_d$ = Transmissivity-absorptivity product for diffuse radiation
η_e = Electrical back-up efficiency
η_o = Optical efficiency
A_p = Aperture area of the absorber (m^2)
EC = Electricity consumption (kWh)
E_a= Total available energy (J)
E_l= Total energy loss (J)
E_u= Total utilizable energy (J)
F_1= First figure of merit (°C m^2/W)
I_b = Intensity of beam radiation on horizontal surface (W/m^2)
I_d = Intensity ofdiffuse radiation on horizontal surface (W/m^2)
I_s = Intensity of total solar radiation on horizontal surface (W/m^2)
$(MC)_c$ = Thermal capacity of aluminum container (J/°C)
$(MC)_r$= Thermal capacity of rice (exemplary ingredient) (J/°C)
$(MC)_w$ = Thermal capacity of water (J/°C)
N= Payback period (months)

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