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# Renewable-energy clusters for remote communities

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**Abstract**

Remote rural communities are especially vulnerable to the reliability of conventional electricity supply methods and many of these communities are post-industrial and therefore suffer from fuel poverty. In this study, the potential contribution to electricity supply to a remote community based on emerging technologies for embedded solar and wind renewable energy, is investigated using simulation modelling. The technologies focus on photovoltaic "slate" roof coverings and micro-vertical-axis wind-turbines. A new model for photovoltaic energy-supply is developed and combined with an existing method for modelling wind-turbine energy. These supply-side models are matched to an existing model of domestic electricity-demand for a whole village community. Results show that in excess of 40% of annual electricity-demand can be relied upon from these sources, provided that a mechanism for surplus power export is available. In the absence of surplus power management, however, only 8% of the annual electricity demand could be met by these sources.


*Keywords:* Remote communities; Renewable energy; Microgrids; Photovoltaics; Micro-wind turbines; Domestic electricity demand

## 1. Introduction

This study focuses on the special case of future electricity generation and utilisation in remote communities in the United Kingdom. Significant regions of Britain contain

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**Nomenclature**

| | |
|---|---|
| $I, I_{0,0}$ | Current (A); diode saturation current density ($Am^{-2}$) |
| $q$ | Standard electron charge ($=1.602 \times 10^{-19}$ C); heat transfer rate (W) |
| $V$ | Voltage |
| $R$ | Resistance (ohm) |
| $A$ | Diode ideality factor (dimensionless); area ($m^2$) |
| $k$ | Boltzmann's constant ($=1.381 \times 10^{-23}$ $JK^{-1}$) |
| $T$ | Temperature (K) |
| $K$ | Constant ($Am^{-2}W^{-1}$) |
| $K'$ | Constant ($m^2W^{-1}$) |
| $G$ | Constant ($Km^2$) |
| $S$ | Total in-plane solar radiation ($Wm^{-2}$) |
| $F$ | Photovoltaic fill factor (dimensionless) |
| $N$ | Total (number of) |
| $C$ | Thermal capacity ($JK^{-1}$) |
| $t$ | Time (s) |
| $L$ | Length (m) |
| $u$ | Velocity (wind speed – $ms^{-1}$) |
| $P$ | Power (W) |
| $\Sigma A$ | Total floor area ($m^2$) |
| $E$ | Electrical demand (W) |
| $LEL$ | Low energy lamp usage factor (dimensionless) |
| $DF$ | Electrical demand factor (dimensionless) |

*Greek Symbol*

| | |
|---|---|
| $\tau$ | Transmissivity (dimensionless) |
| $\alpha$ | Absorptivity (dimensionless) |
| $\beta$ | Angle of surface tilt |
| $\varepsilon$ | Emissivity (dimensionless) |
| $\eta$ | Power matching effectiveness (dimensionless) |
| $\phi$ | Power utilisation (dimensionless) |
| $\sigma$ | Stefan-Boltzmann's constant ($=5.67 \times 10^{-8}$ $Wm^{-2}K^{-4}$) |

*Subscript*

| | |
|---|---|
| L | Light (current) |
| 0 | Saturated state |
| s | Series |
| sh | Shunt |
| oc | Open circuit |
| sc | Short circuit |
| m | Module |
| r,sky | Radiation to sky vault |
| r,sur | Radiation to surroundings |
| c | Convection |
| ao | Ambient air |