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Can brownfield land be reused for ground source heating to alleviate fuel poverty?

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ABSTRACT

Brownfield land is a legacy of industrial retraction in many towns and cities worldwide, where land remains vacant long after it has gone into disuse, and is often a barrier to redevelopment. Using this land for renewable energy generation is one option that can support development of a low carbon economy and also stimulate regeneration. Fuel poverty is an increasingly pertinent social issue due to rising energy costs. This is particularly true for space heating, accounting for nearly half of all the energy consumed in North European climates. Addressing fuel poverty has become a key consideration in Scotland's internationally leading renewables policy. This article considers how deployment of renewables on brownfield land can be targeted towards addressing heat poverty in social housing. Using Glasgow as a case study, the quantity of available derelict land is calculated, then the spatial association of social housing and urban brownfield land is demonstrated. Technology options for meeting household heat requirements from brownfield land are presented, including scenarios using vertical or horizontal ground source heat pumps. The results suggest that the available urban land could easily supply the needs of all households in fuel poverty, if this scale of investment and non-market intervention was justified.

1. Introduction

The move towards increased renewable energy provision has seen a transformation in the way energy is managed and generated. In the UK, the drive to meet mandated climate change targets [1] as well as regional devolved targets [2] has seen carbon-heavy fossil fuel generation gradually replaced by a greater reliance on dispersed renewables, such as wind technology [3]. Closures of generating facilities up to 2025 [4], as well as stricter UK Government emission controls [5], mean that it is an ever-increasing challenge to develop a strong, secure, and resilient "energyscape" [6] in the move towards a low carbon economy.

How this step change in energy supply and demand is implemented in towns and cities is an important factor in determining what renewable energy options are viable [7]. For example, the rollout of smart meters from 2015 [8], is giving energy suppliers and energy users an unprecedented view of how energy is distributed and consumed, as well as supporting the transformation to "smart" cities [9]. It is important that solutions are also affordable and reflect end-user needs. In particular, when energy costs fluctuate and rise, irrespective of static household income, this can contribute to greater incidences of the growing phenomenon of fuel "poverty" [10], which has serious potential impacts on public health and is a growing consideration in energy policy [11].

Strategies for the built environment [12,13] provide a strong basis for a low carbon economy, but require a diverse portfolio of renewables [13], interconnected flows of information [14], energy affordability and security of supply [12]. Moreover, socially motivated energy provision could also simultaneously serve to enhance other policy and decision-making [15], such as the alleviation of fuel poverty, and the regeneration of socially and economically deprived zones within cities [16]. Here we consider novel ways of reusing "brownfield" land to achieve these ambitions.

1.1. Brownfield land

Due in part to the frequent use of the term "brownfield" in various contexts, a variety of possible definitions exist. According to Alker et al. (2000) brownfield land is "any land or premises which has previously been used or developed and is not currently fully in use, although it may be partially occupied or utilised. It may also be vacant, derelict or contaminated" [17]. For the UK, brownfield land

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is usually synonymous with “previously developed land” which is “land that is or was occupied by a permanent structure and any associated fixed surface infrastructure” [18]. It is anticipated that many such sites are also contaminated [19,20] although minor levels of contamination may not always need remediation, depending on the type of reuse [17]. The definitions used in the UK serve to promote a pragmatic approach to reusing a brownfield site, where contamination may not be present, known or disproved until it is fully investigated. The USA definition presumes contamination, since brownfield land is classed as “real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant” [21]. Both UK and US definitions serve to show that, following previous use of a brownfield site, contamination may or may not be present, so it can be assumed that some form of investigation and possible remedial action may be required before redevelopment can take place, whether that be simple site clearances or more detailed contaminant remediation.

The potential for contamination can be a disincentive to redevelopment of brownfield land, even with incentive schemes [22], meaning many sites across the UK remain vacant long after they have gone into disuse, in some cases for up to 30 years [23,24]. Due partly to the differing availability of sites across the country, no overall targets were originally set for the regeneration of brownfield land in the UK in the 2012 UK National Planning Policy Framework [25], through which local councils and communities were encouraged instead to assess where is best for local development to occur. In 2016 the concept of brownfield registers was launched as a pilot in 73 council areas in England, with the aim of providing 1 million more homes and having planning permission in place on 90% of suitable brownfield sites [26]. Planning is a devolved issue, however, meaning individual countries within the UK have their own decision-making powers. Furthermore, planning is directed towards sustainable development, so is not only focused on reusing brownfield land, but should include regard to other policy issues.

1.2. Fuel poverty

Boardman (1991) was the first to recognize fuel poverty as an issue, and defined it as “when a household is unable to provide sufficient energy services for 10% of income” [10,27]. This means that when a household is classed as being in fuel poverty they spend a disproportionate percentage of their income on the cost of energy. In this instance energy means all heat and power that is used to constitute a suitable living environment i.e. utility costs for heating, lighting, and general electrical power use, but excluding transport costs. Thus fuel poverty is also inextricably linked to income, energy prices, building fabric or its energy efficiency, and energy use habits.

In Scotland fuel poverty is determined by comparing the cost of household energy against total income available before housing costs [28]. This means that deductions such as council tax, income tax, and national insurance (i.e. local and national taxes, social security charges) come off the available income before it is compared to energy costs, whereas rental or mortgage payments (i.e. housing costs) do not. The Scottish Executive's (2002) use of this definition of income mirrors its application at a national level within Scotland for fuel poverty calculations [29]. Households that fall within the definition of fuel poverty are predicted to experience a standard of living that is unacceptable. This could be in the form of cold, damp, overcrowded rooms, or health effects on individuals that are linked to being fuel poor [27,30].

With so many interrelated factors, locating the fuel poor is also difficult. Social housing has a long history of helping low-income households, traditionally housing vulnerable persons and those that are disadvantaged within society [31]. Here prerequisites such as low income will serve to compound incidences of fuel poverty. Although fuel poverty is also found in privately rented/owned properties, this sector is more difficult to evaluate due to the mixture of rental and owner-occupiers in many private housing estates and apartment buildings.

Fuel poverty is not solely a UK phenomenon, but is now on the agenda in other parts of the world, although here the focus may be on broader energy poverty or simply low household income [32]. Such is the current concern in the UK that the Government and devolved administrations had set a target to eradicate fuel poverty, as far as was reasonably practicable, by 2016 (2018 for Wales) [33]. The target for 2016 was not met.

The seriousness of fuel poverty cannot be overlooked. For England alone, it is estimated that cold related ill-health costs the National Health Service £1.36 billion per year [34,35]. The human cost of this is an estimated 26,700 excess winter deaths every year [27]. It is also estimated that people spend a higher proportion of the day at home than away from it [27]. Targeting space heating for the poorest households makes many of these adverse consequences preventable, being a direct result of low household incomes and/or poor building energy efficiency.

Whilst household income can be increased through accessing government benefits (where eligible), there is no support that directly helps with the costs of fuel [27]. With energy prices rising faster than income levels for the poorest households [36], the provision of low-cost renewable energy for space heating is a strategic opportunity to address public health and the impacts on healthcare systems caused by fuel poverty.

1.3. Reusing brownfield land for energy provision

It is possible that reusing brownfield land partly as an energy resource during regeneration and local development could provide low-cost energy to help alleviate fuel poverty. To determine whether this integrated approach has the ability to simultaneously meet brownfield land regeneration and fuel poverty intentions, the availability and energy potential of brownfield land in proximity to energy users must be considered. In moderate climates, such as the UK, space heating accounts for more than 50% of total energy consumption [37] in the domestic sector. If appropriate renewables are directed towards brownfield land, such as heat pumps or locally used biomass, there is the potential for large gains to be achieved in carbon reduction, as well as assisting individuals with lower heating costs. Thus two socio-economic issues could be addressed simultaneously with wider positive impacts for society [38].

The consideration of environmental factors such as land condition within the fuel poverty debate could also serve to mitigate a lesser-known relationship between land quality and public health. Morrison et al. (2014) have shown that the chemical quality of soil is spatially linked with deprivation, being higher in deprived areas, specifically in Glasgow [39]. For England, Bambra et al. (2014) have shown a significant relationship between brownfield land intensity and morbidity [40]. Together, land condition is shown to have an important, often overlooked, contribution to public health.

The aim of this paper is to identify the quantity of land that could be available for the provision of renewable energy for heating using Glasgow (Scotland) as an example, to determine its distribution and how it could be used for ground source heat pumps as part of an integrated approach to reusing brownfield sites.

2. Methodology

In order to quantify the brownfield land available for energy