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How can you make a Rural Community Carbon Neutral?

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Abstract

The UK Government has set out its ambition to reduce CO_2 emissions by 80% of 1990 levels by 2050 (Climate Change Act 2008). Achieving the required reductions in carbon emissions necessitates a wide-scale transition to a low carbon energy system from the current carbon intensive infrastructure and behaviours. Carbon intensive lifestyles and consumption patterns have co-evolved with the energy infrastructure, with the result that citizens feel 'locked-in' by social norms and the cultural, economic and social contexts around them. Carbon Neutrality is one method to change this.

The term carbon neutral is still one that is used controversially though there are many communities starting to either claim carbon neutral status in the UK or have developed schemes working towards it. The paper is based upon a village in County Durham called Edmondsley as it has been the subject of several studies which have identified how Carbon Neutrality can be achieved without having a major impact or lifestyles or behavioural changes. It considers three technology options on achieving carbon neutrality with the final proposal being to size system demand upon the electricity load of the village and a resulting theoretical method of achieving carbon neutrality.

Introduction

In recognition of the climate change imperative, the UK Government has set out its ambition to reduce CO_2 emissions by 80% of 1990 levels by 2050 (Climate Change Act 2008). Achieving the required reductions in carbon emissions necessitates a wide-scale transition to a low carbon energy system from the current carbon intensive infrastructure and behaviours. This transition requires not only the development, commercialisation and deployment of new, and modified, energy supply and demand technologies, but also changes to consumption practices and new institutional arrangements.

As discussed by Mander (2007) the UK is currently 'locked-in' to a carbon intensive energy system technologically, institutionally and in relation to the structure of society. Technology is embedded within a system whereby society and institutions are constantly adapting to accommodate its evolution (Unruh, 2000). The co-evolvement of carbon intensive lifestyles and consumption patterns with the energy infrastructure, has resulted in the general public feeling 'locked-in' by social norms and the cultural, economic and social contexts around them (Sanne, 2002; Michaelis, 2003). Any change must overcome the huge inertia created by the interdependencies between elements of the system (Unruh, 2000). This in turn requires policy makers to consider how such a transition may be brought about.

There is little academic work on carbon neutrality rather focusing on either individual technologies, renewable fuel supplies or best practice which would be utilised within a carbon Neutral scenario. For example improving the energy efficiency of housing stock,

rather than concentrating on new-build issues as discussed by Verbeeck and Hens (2004). Goodacre et al (2002) also describe the wider benefits (including macro-economic, social and environmental) of upgrading of existing housing. A range of non-academic literature has been published on theoretical approaches and how these may be applied including offsetting emissions through tree planting, though the work of Keppler et al (2006) shows that trees may be responsible for significant methane emissions causing greater problems than burning carbon based fuels. The work of Abvu-Sharkh et al (2006) argues that the combination of photovoltaics and micro- combined heat and power (chp) and a small battery requirement gives a micro-grid that is independent of the national electricity network. While not carbon neutral as gas is burned via the chp unit, the concept is one that can be applied to create a carbon neutral community.

Carbon Neutrality is a way to make this transition. It is an important step in combating Climate Change, securing energy supply for future generations and giving a long -term sustainable future for local communities. In 2007, the Intergovernmental Panel on Climate Change (IPCC), the world's most authoritative body on climate change, concluded that "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic (man-made) greenhouse gas concentrations"(IPCC 2007). It is therefore not the intention of this study to determine either the causes of climate change or the reasons behind the political face of it, rather to accept that Climate Change is taking place and that anthropogenic emissions are one of the causes of it.

The recent escalation of fuel prices has shown how vulnerable the UK's and indeed Europe's energy requirements are to global markets and changes in political situations. Most of the world's fuel tends to be supplied from Countries that are politically unstable and together with an ever increasing spiral in demand of the Worlds Oil, Gas and Coal supplies, this causes fluctuations in pricing which leaves the consumer bearing the brunt of the changes.

Carbon Neutrality together with energy efficiency and greater awareness is a means by which an individual, home, community, organisation etc can help tackle the causes of climate change whether by taking action in reducing their carbon imprint through actions such as the installation of renewable technologies or by offsetting their emissions through tree planting. Either way it provides a method by which action can be taken against a problem that threatens significant changes across the whole of the planet.

There are also has many social, economic and environmental benefits arising from carbon reduction activities on a local level. This is shown by Figure 1 below (Tyndall 2002).

This paper looks at what a carbon neutral community is, how it can be defined and by using the definition how it can be implemented using a case study of a village called Edmondsley in County Durham.

What is a Carbon Neutral Community?

The term Carbon Neutral is used to show that companies, individuals, flights, concerts and even villages are offsetting their carbon emissions and trying to make a difference in tackling Climate Change. There are many communities and developments throughout the UK and the world that have declared their intention to become Carbon Neutral, but the methods by which they are achieved vary.

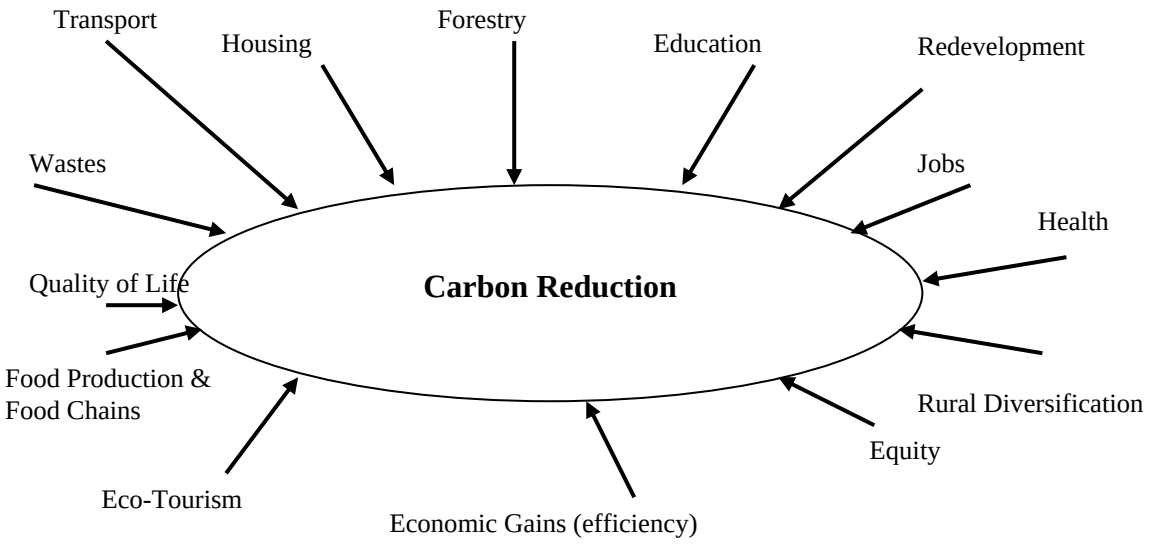


Figure 1. Examples of Multiple Consequences of Carbon Reduction at the local scale

While carrying out the research into those communities and settlements that have set up or developed carbon neutral schemes, I have been able to define three main methods that are currently practised to achieve Carbon Neutral status

- The first method is to create a new community. This is effectively building a new community and making it as sustainable as possible – high levels of insulation, renewable technology to generate electricity and heat and eco-friendly building materials used in its construction. Examples include Bedzed, the Hockerton Housing Project and Sherwood Energy Village with many more under development and being implemented.

- The second method is in an existing community or settlement. Here a community led project will firstly tackle the energy efficiency of the homes, so ensuring that all properties are insulated to the highest possible specification, double or triple glazing is used, gas condensing boilers are fitted, low energy light bulbs are standard and people practice good energy saving techniques – e.g. switching lights out, turning stand-by buttons off, not leaving the mobile phone charger plugged in etc. The next stage of this process is to calculate the carbon emissions of the village and then offset these emissions by planting trees.

- The final method follows the second through to best practice, then instead of offsetting, the emissions technology is applied to neutralise its footprint. At present Keilder village in Northumberland is the only one that I have identified in the UK that has applied this solution. However this was not under the guise of going Carbon Neutral, but was about creating a practical sustainable solution to high energy bills form the use of fuel oil.

This final option is also the proposed solution for the case study village of Edmondsley in County Durham. The proposal is to use woodchip to generate heat and energy to meet the

demand of the village and reducing the carbon footprint of the village to zero (for energy consumption)

But is Carbon Neutral achievable? The term Neutral indicates neither positive nor negative which would indicate that the only true way to be carbon neutral is not to participate in any activity that would emit carbon. That is impractical where the reality is more about carbon balancing. A carbon balanced community is one where the carbon used is matched by the carbon saved through another method. In the case of biomass – this is perfectly balanced as the carbon used from the burning of wood is absorbed by trees planted to replace the ones being used for fuel.

In 2004 Chester-le-Street District Council together with the Edmondsley partnership, commissioned a feasibility study into answering the question for the village. This initial study was carried out in 2005 by the Energy Savings Trust. It looked into the usage and levels of consumption of energy in the village along with an outline questionnaire into see if the residents would support and commit to a project. The findings of the study led to several other studies being carried out including a thermographic imaging scheme of the dwellings to identify where energy efficiency improvements could be made and a follow-up interview process to identify knowledge and support of the issues, awareness of the proposed scheme and how the community itself should be engaged in the process.

The project still has not been carried out for several reasons including planning and funding, even though a solution has been identified and an agreed way forward based upon knowledge and delivery developed with the residents as part of a PhD which is still being carried out.

Defining Carbon Neutral

The definition of the term "Carbon Neutral" is open to debate and although there have many organisations and communities that have claimed to achieved carbon neutrality or have started working towards it, there is no standard or definition that can be applied across the board. The Department of Energy and Climate Change launched a consultation on the term and in 2009 published guidance towards achieving carbon neutrality. This entails the completion of the following three separate stages (DECC 2009):

1. Calculating emissions
This stage requires the determination of what emissions will be calculated, including setting a clear boundary for emissions covered (in terms of the gases included, the organisational context and the sources of emissions). Once the boundary has been set, emissions can be calculated by collecting activity data (for example, the amount of electricity and gas consumed) and applying the appropriate emissions factors.

2. Reducing emissions
This stage involves assessing what internal emissions reductions can be made through e.g. energy efficiency measures. These will usually be carried out because they are cost effective over time, helping to save money at the same time as reducing emissions. Reductions can be based on absolute emission reductions or emission reductions relative to a common business metric or unit of output. Those seeking to become carbon neutral should decide how to reduce emissions, how to calculate reductions and how to communicate this.

3. Offsetting residual emissions
This third stage requires the acquisition of carbon credits to offset any residual emissions after calculating emissions and achieving internal reductions. The precise amount of offsets required needs to be calculated, with enough credits bought to reduce emissions to net zero. When offsetting, consideration should be given to the type of offsets bought to be sure they are good quality and represent a real (tonne for tonne) emissions reduction.

Taking these three stages together: ***"Carbon neutral means that – through a transparent process of calculating emissions, reducing those emissions and offsetting residual emissions – net carbon emissions equal zero."*** (DECC 2009)

Implementing the definition

For any community to become Carbon Neutral it is necessary to look at all aspects which use energy in day to day living – essentially the Carbon Footprint. To assess it accurately it has to look at all its inputs and outputs in terms of carbon emissions. This is shown diagrammatically in Figure 2 below:

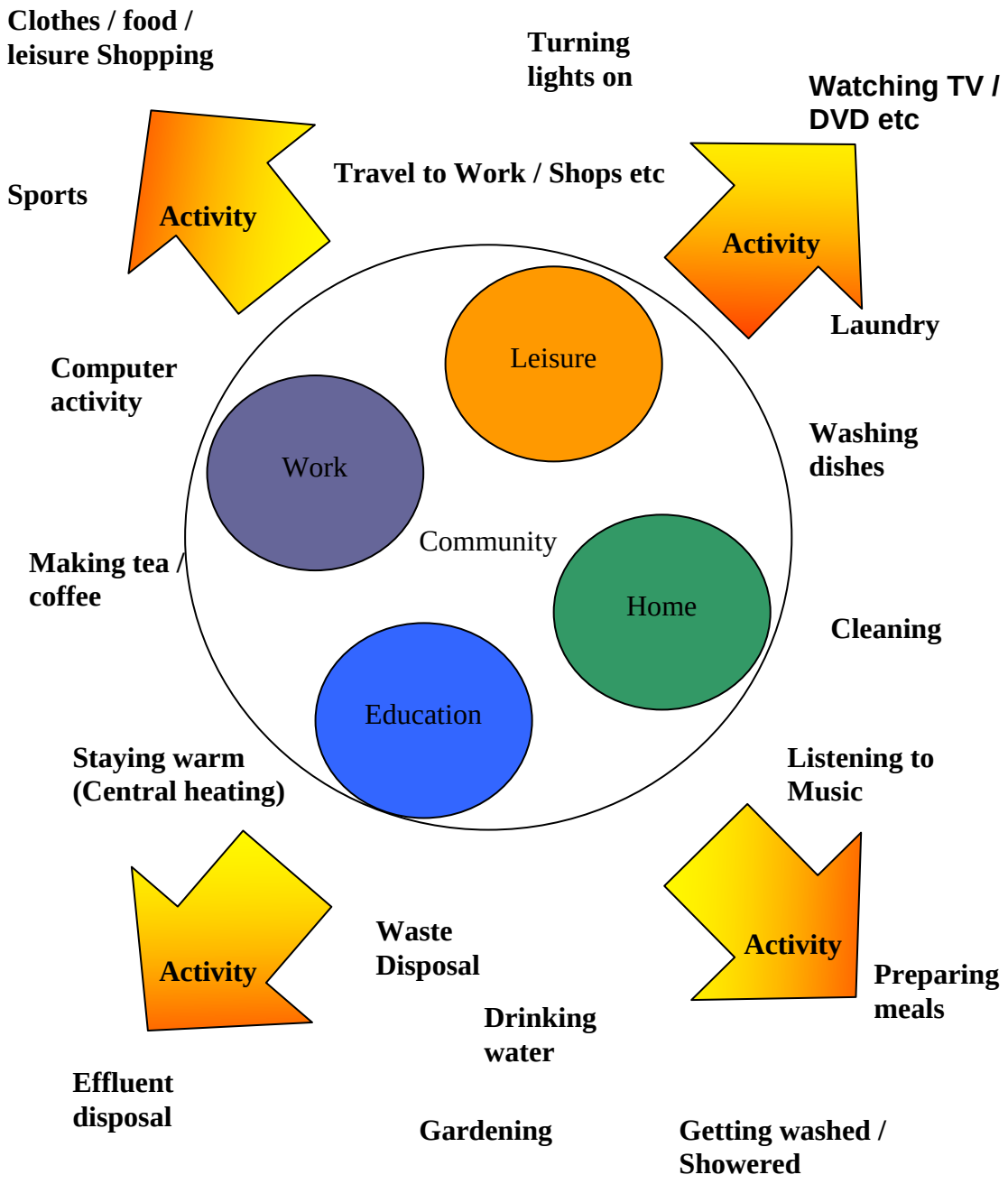
For the purpose of this report I have taken the community to be made up of 4 distinct areas – home / work / leisure and school / education, though it could be broken down into many more. This is because the study village daily activities are based around these four areas. The activities listed (by no means a comprehensive list) around the outside of the community hub are carried out on a fairly regular and frequent basis. They all require energy in some form and all leave a Carbon Footprint.

The actual size of the carbon footprint depends upon so many variables it is very difficult to calculate accurately and so assumptions must therefore be made. Once the footprint has been calculated and a greater awareness of what activities use most energy, steps can be taken to alleviate the footprint and to start to strive towards carbon neutrality.

The EST study focused purely on the carbon emissions associated with the primary fuel sources involved for heating and lighting the community for several reasons. Being rural in nature the community will always require transport for journeys such as shopping (only a small local shop exists), medical visits and recreation and will require a major shift to negate carbon emissions through transport, this area is therefore outside the scope of the paper. Equally, the "hidden" carbon emissions from indirect sources such as the carbon footprint from the food miles, clothing manufacture, etc is also out of the scope of this paper as while the residents can make choices on the food and clothing they buy, there will always be carbon emissions associated with them. Again completing a study on these hidden costs is beyond the scope of this paper. Following the DECC guidance above and the requirement of the study to ensure that energy efficiency is maximised in each property in the village, for the purpose of this paper it can be taken that by implementing the recommendations that the Village of Edmondsley can become Carbon Neutral as discussed below.

The results of the initial study showed that carbon neutrality was possible to achieve by using a range technologies based around micro-renewables in particular photovoltaic's (PV) and a district heating system with a CHP unit powered by biomass. Using wood chip as the fuel the boiler is sized against the heating and hot water load of the village. The additional demand in electricity being taken up by either PV or wind. Known as a locally embedded energy system, it is often discussed as a way forward in many situations.

Figure 2 – The community carbon footprint



A locally embedded energy source tackles many other issues that off-setting carbon emissions can not. These include security of supply – locally produced biomass and electricity is not subject to any political instabilities elsewhere in the world which may mean loss of fuel such as the closure of gas pipelines or a reduction in oil supply and generation losses from the high in-efficiencies in the generation of electricity and the transmission around the network. Local embedded generation does not suffer from these problems (Abu-Sharkha, et al, 2006). The work of E. Entchev et al (2004) also highlights that micro-generation is able to satisfy all of the space and water heating loads in a house and in some cases export some electricity back to the grid.

Figure 3 below show's how Edmondsley currently meets its energy needs. Electricity is generated via a central energy system and is transmitted to its point of use through the national grid. The heat demand is met by burning a primary fuel – gas, oil or coal in a boiler located within the home. This system can be seen to generate carbon emissions and heat losses from the home and the central generating source.

Figure 3. A conventional distribution system

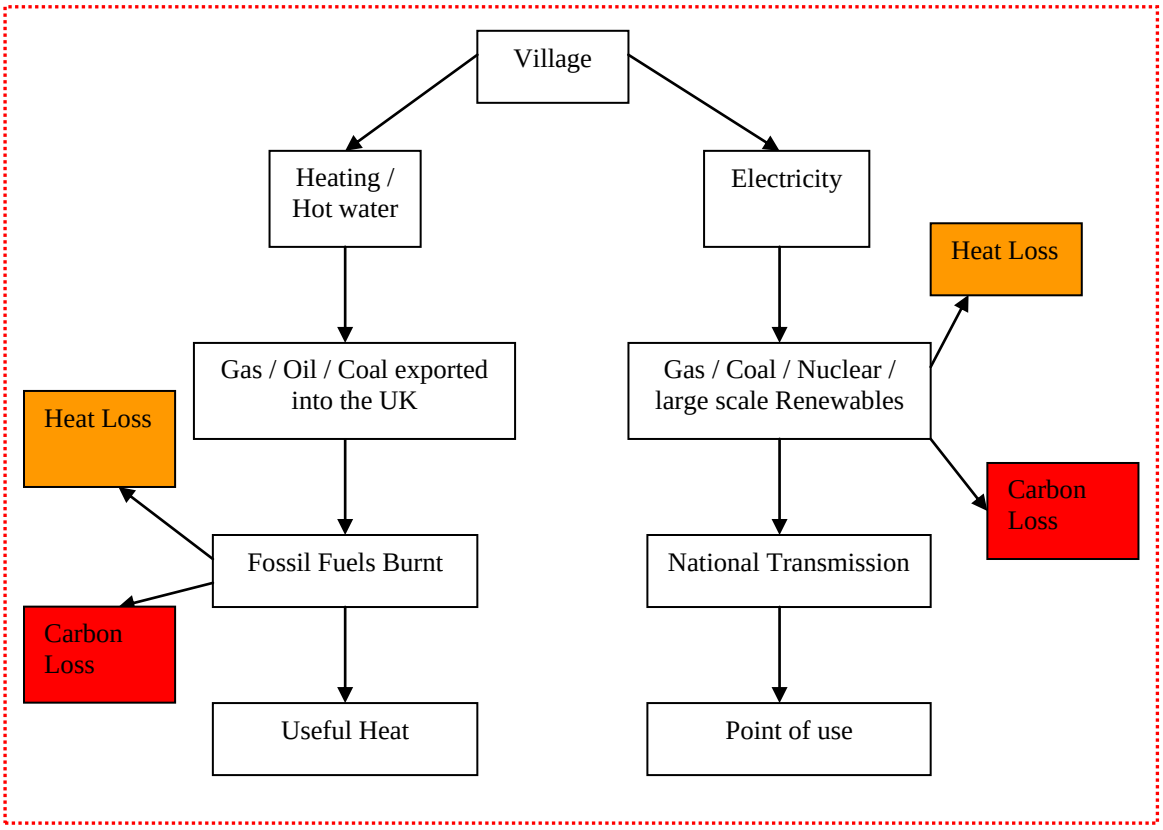
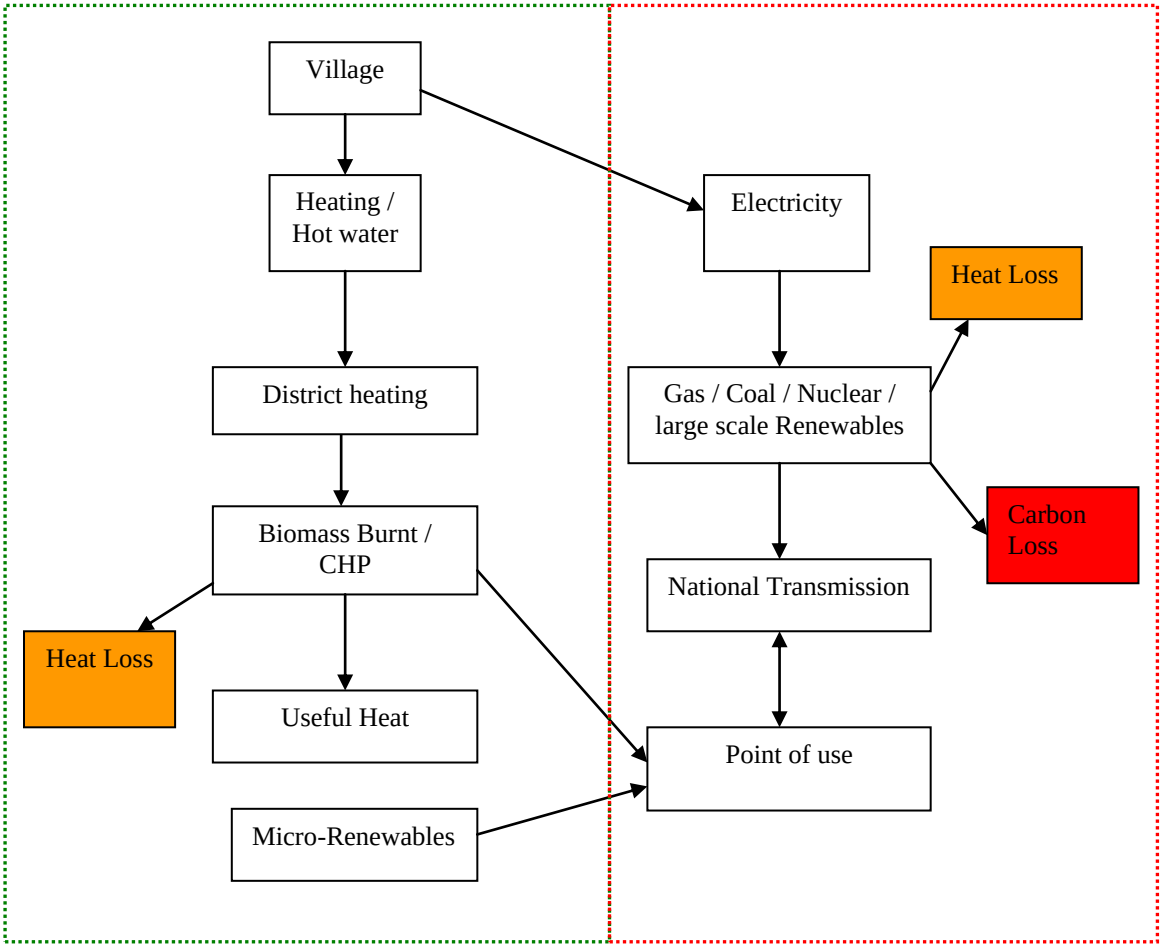


Figure 4 below, shows the results of the EST study and how carbon neutrality can be achieved. Carbon emissions from the installation of a biomass CHP district heating network with micro-renewable technology to meet the additional electricity demands of the village. The processes within the green box are deemed to be carbon neutral as the carbon emitted from the burning of the biomass is taken up by crops that have been planted to replace it forming its own carbon cycle. Carbon is still emitted from the electricity generation at a national level but can be made carbon neutral by taking the demand from the micro-renewable technology instead.

However, as Sauter and Watson (2007) discuss, domestic micro-generation requires active acceptance by homeowners, whereby individual households become part of the electricity supply infrastructure. Acceptance may therefore be expressed in various forms: attitudes, behaviour and—most importantly—investments. The term 'social acceptance' includes the two concepts 'social' and 'acceptance' with potentially quite different understandings and approaches. 'Social' refers to the whole society and its different groups (consumers, producers, etc.).

Figure 4. Proposed carbon neutral scheme by District Heating scheme using Biomass

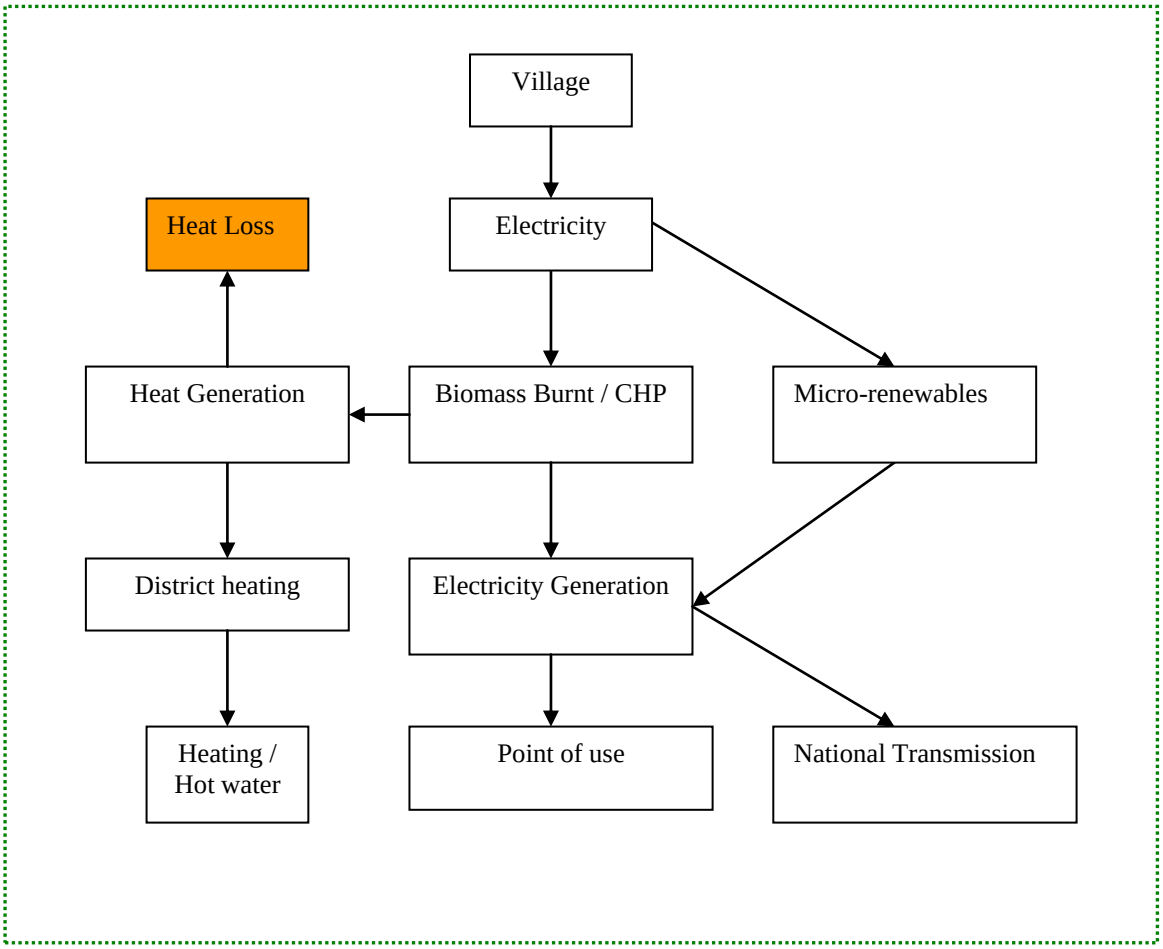


'Acceptance' can range between a rather passive consent and an active approval in form of an active involvement. This implies a very broad spectrum both in terms of the social groups considered and the degree of acceptance involved (Williams and Mills, 1986). Infrastructure technologies such as central power plants traditionally require a rather passive acceptance by the local population or in a broader perspective by 'public opinion'. Therefore acceptance of technologies has often been measured in terms of public attitudes towards technologies. A study reviewing over 30 surveys of UK public attitudes towards energy technologies showed that public opinion in general supports investment in renewable energy technologies in terms of a passive consent (e.g. high score for renewables in rankings of different electricity generation technologies) (McGowan and Sauter, 2005).

This acceptance however is questioned when it comes to a more active form of acceptance in terms of willingness to pay for a higher share of renewables. It is therefore important to distinguish between public and private attitudes towards energy technologies. While public preferences show the moral values of such technologies, e.g. tackling climate change, private attitudes or preferences reflect peoples' personal situation and are more likely to be concerned with financial implications e.g. capital cost outweighing reduced utility charges (Ek, 2005). Micro-generation requires a householders' acceptance in terms of both positive public and private attitudes to achieve market up-take of these technologies.

The introduction of the Feed in Tariff in April 2010 and the renewable heat incentive due to be introduced on April 1st 2011, have potentially addressed some of these issues. This has been done by paying the consumer to generate electricity and heat from renewable sources at a level above the standard charges for gas and electricity. By giving a financial incentive, installation of the technologies has become more acceptable, it has also however allowed a second model to be developed with the residents of Edmondsley during consultation that reflects a fully carbon neutral solution (Figure 5).

Figure 5. A Carbon Neutral Solution?



This model is potentially a carbon neutral scheme. Biomass is used to generate the village's electricity requirements at peak time rather than the traditional model as in figure 4 of heat requirements. The additional heat generated will be used to meet the heating and hot water demand for the village. As the heat generated by the CHP unit is in the ratio of 3:1 as opposed to electricity, there will be more heat than is required by the village. This then presents an opportunity for business to utilise the additional heat (if existing) or utilised to grow local crops through use in poly-tunnels. It will also help "fuel poverty proof" a village. As excess heat is produced it can be either given away or sold at a low price. This allows those who most need it the access to cheap heat allowing them to stay warm in winter. It also assists in the financial modelling and business planning for the projects as income generated for the electricity and heat will offset the initial capital costs of the project and can be used to keep bills low for the residents.

Conclusion

Creating a Carbon Neutral community is theoretically possible. Figures 4 and 5 highlight two apparent models which could be applied in different situations. In the case of Edmondsley, further research and a series of interviews with Edmondsley residents has identified that the proposed solution in figure 5 is the preferred choice as the scheme brings significant advantages to the community as a whole. While this is the potential solution, the scheme has not yet been started due to financial and political reasons. However the same model is being applied to a project that is under development in Chiltern in County Durham. Dalkia are building a biomass energy plant and the waste heat produced will be used in a district heat network to supply both a new housing development currently being built and the existing settlement, a total of 600 dwellings. Consultation is currently underway, but the final solution is one that needs to be identified by the community itself to ensure its support. The model proposed is one that could help create a sustainable energy and under the definition given by DECC, a carbon neutral one.

References

Abvu-Sharkh, S. Arnold, R.J. Kohler, J. Li, R. Markvart, T. Ross, J.N. Steemers, K. Wilson, P. Yao, R. (2006) Can microgrids make a major contribution to UK energy supply, *Renewable and sustainable energy reviews* 10, pp78-127

Climate Change Act 2008

DECC 2009. Guidance on carbon neutrality, Department of Energy and Climate Change

Ek, K., (2005). Public and private attitudes towards ‘‘green’’ electricity: the case of Swedish wind power. *Energy Policy* 33, pp1677–1689

Entchev, E. Gusdorf, J. Swinton, M. Bell, M. Szadkowski, F. Kalbfleisch, W. Marchand, R. (2004) Micro-generation technology assessment for housing technology, *Energy and Buildings* 36, pp925 – 931

Goodacre, C. Sharples, S. Smith, P. (2002); Integrating energy efficiency with the social agenda in sustainability. *Energy and Buildings* 43, pp53 - 61

IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Forth Assessment Report of the Intergovernmental Panel on Climate Change (Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)). IPCC, Geneva, Switzerland, 104 pp

Keppler, F. Hamilton, J. T. G. Brab, M. Rockman, T (2006) Methane emissions from terrestrial plants under aerobic conditions. *Nature*, Vol. 439

McGowan, F., Sauter, R., (2005). Public opinion on energy research: a desk study for the research councils

Mander, S. (2007) Uncertainty and the Tyndall decarbonisation scenarios. *Global Environmental Change* (2007), doi:10.1016/j.gloenvcha.2006.11.004)

Michaelis, L. (2003) Sustainable consumption and greenhouse gas mitigation, *Climate Policy* 3**,** pp. 135–146

Sanne, C. (2002); Willing consumers – or locked-in? Policies for a sustainable consumption. *Ecological Economics* 42, pp. 273 - 287

Sauter, R., Watson, J., (2007). Strategies for the deployment of micro-generation: Implications for social acceptance. *Energy Policy* 35, pp. 2770 - 2779

Unruh, G. C. (2000) Understanding carbon lock-in. *Energy Policy* 28, pp. 817 - 830

Verbeeck, G. Hens, H. (2004). Energy savings in retrofitted dwellings: economically viable? *Energy and Buildings* 37 (2005) pp. 747–754

Williams, R., Mills, S., (1986): Introduction. In: Williams, R., Mills, S. (Eds.), *Public Acceptance of New Technologies: An International Review*. Croom Helm, London, pp. 1–18