replaced in a managed landscape. Once its useful life is complete, like clay, if not burned, it returns to the land without pollution. In Medieval Britain timber was a local home-grown product. Nowadays, timber for construction is largely imported at great cost in terms of the expenditure of energy for transportation. It would take some time to develop in Britain the native forests from which a sustainable harvest of timber can be obtained for the construction industry. Nevertheless, if Britain is to boast a sustainable society this must be one of the country's long-term objectives: until such times it is possible to specify the use of timber from sustainable sources, a common occurrence. (For a good example of environmentally sensitive urban design, using timber, see The University of Nottingham, Jubilee Campus, in Moughtin *et al*., 2003a; pages 90–97 and Figures 4.21–4.30.)

Most building materials are not as environmentally friendly as earth when unbaked, or timber – particularly when taken from a local sustainable source. Deciding which combination of building materials causes least environmental damage is complex and a question of balance between competing factors. All constructions are *per se* damaging to the natural environment, some more than others.

In choosing a building material the first consideration is the amount of energy used in its manufacture. 'As a rough guide, however, the energy intensiveness of a building material will act as a guide to its greenness' (Vale and Vale, 1991). Building materials can be classified into three broad groups according to energy content: low, medium and high (see Table 2.1). The energy content of materials shown in Table 2.1 is measured in kilowatt-hours per kilogram. In construction work, low-energy materials such as sand and gravel are used in bulk, while high-energy materials such as steel or plastic are used in small quantities, often precisely and economically dimensioned. Clearly, the weights of each building material must be known if the designer is to estimate the total energy content of the completed construction. Table 2.2 shows the estimated energy content of three building types, which seems to indicate that small-scale traditional domestic type buildings are by far the

**Table 2.1** Energy content of materials (Vale and Vale, 1991)

| Material | Energy content: kWh/kg |
|---|---|
| *Low-energy materials* | |
| sand, gravel | 0.01 |
| wood | 0.1 |
| concrete | 0.2 |
| sand-lime brickwork | 0.4 |
| lightweight concrete | 0.5 |
| *Medium-energy materials* | |
| plasterboard | 1.0 |
| brickwork | 1.2 |
| lime | 1.5 |
| cement | 2.2 |
| mineral fibre insulation | 3.9 |
| glass | 6.0 |
| porcelain (sanitary ware) | 6.1 |
| *High-energy materials* | |
| plastics | 10.0 |
| steel | 10.0 |
| lead | 14.0 |
| zinc | 15.0 |
| copper | 16.0 |
| aluminium | 56.0 |

**Table 2.2** Energy intensity of three building types (Szokolay, 1980; quoted in Vale and Vale 1991)

| | kWh/kg |
|---|---|
| domestic buildings | 1000 |
| office buildings | 5000 |
| industrial buildings | 10000 |

least energy-intensive structure. This might suggest that the more traditional scale of built form is more appropriate for the sustainable city.

The energy content of a building material is connected with the nature of the process of refinement. For example, the energy content of earth, mud or clay is zero, while in its burnt form as bricks the figure is 0.4 kWh/kg. Generally, the low-energy materials tend to be the least polluting as less energy has been used in their manufacture. It could be argued that for purposes of achieving sustainable structures, low-energy materials should be used in preference to those of high energy content. This oversimplification has to be qualified with a strong proviso. Some forms of insulation are high in energy content, but being light result in lower energy density. More importantly, an insulating material like this – when used in the correct manner – may reduce considerably the energy demand during the lifetime of the structure. The consideration of insulation may become of increasing importance if, as feared, global warming, over the next few decades, increases the length and severity of winters in this country.* It may be prudent to prepare for this possibility and aim to 'super-insulate' all new buildings, working to the highest standards applied by our northern European neighbours with triple glazing as the norm.

Another consideration in the choice of green building materials is the energy expended in their transportation to the place of manufacture and from there to the building site. As we have seen with timber, the energy used in importing timber into this country may outweigh its advantages in terms of its low energy content. It may be useful to examine the building traditions, which pre-date the industrial revolution, when we seek a green alternative to present procedures: not it must be said in nostalgia for a return to a mythical golden age of the past, but simply to assist in the difficult search for sustainable urban forms. This country has a rich and fine-grained history of vernacular or regional architecture. The regional architecture of Britain is deeply embedded in the landscape and its underlying geography (Clifton-Taylor, 1972). The architectural landscape ranges from the timber and plaster facades of Chester, the red brick of Kent, the honey-coloured stone in the Cotswolds, to the dour stone of Yorkshire (HRH, The Prince of Wales, 1989). It is not, however, the intention here to extol the aesthetic and appealing virtues of this intricate web of vernacular architecture, which can also be found in other European countries, but to understand why it developed in that way and to see if any of those conditions might prevail in communities seeking a more sustainable future (see Figures 2.2–2.5).

Until the later stages of the industrial revolution in the nineteenth century, settlements were constructed largely from building materials obtained close to the site. Bath, for example, was constructed in the eighteenth century from Bathstone found in the quarries of Ralph Allen, one of the

*It has been suggested that with the melting of the ice cap the future of the Gulf Stream, which modifies Britain's climate, is threatened. Britain's climate, as a result of global warming, may therefore paradoxically be colder and resemble more closely conditions found in Northern European countries or Canada which are on the same latitude.