



State of the stock—What do we know about existing buildings and their future prospects? ☆

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ABSTRACT

The UK building stock has seen major changes in the last 50 years, in its form, fabric and function. The context is the expansion of the building stock and built infrastructure, which takes place in most areas at 1–2% per year, with the implication that up to 75% of the dwellings of the year 2050 already exist now. This is a major challenge. The energy performance of much of this stock is generally low, while its economic, social and cultural values are often high.

The purpose of this review is to provide a brief outline of the state of knowledge of the existing building stock, and of potential advances in that knowledge. We follow a knowledge mapping approach, set out on several axes. The first is an axis from buildings as physical forms, to buildings as containers of socio-economic activity. Another axis spans between existing buildings, renovations and adaptations, and new buildings. A third axis is that of scale, from building components to large-scale settlements. There are many possible combinations of these parameters. Here we focus on those that are most relevant to the SEMBE goals of sustainable energy management across the whole building stock.

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1. Introduction

Looking back over 50 years, it is clear that existing buildings have changed in many ways, and that their uses and their users have also changed rapidly. The typical post-war house was an unimproved brick terrace with coal fires and outdoor sanitation, maintained by the woman of a household of average 3.6 persons (Muthesius, 1982). Many of the same houses still exist today, after one or more waves of modernisation and adaptation, knocking-through and subdivision, with gas central heating and fitted kitchens, for a household of average 2.4 persons, using technology that was hardly dreamt of 50 years ago (Ravetz and Turkington, 1995).

To explore the possibilities in relation to the SEMBE agenda needs a similar longer-term view into an uncertain future. This could point towards some topical questions. How far will the building stock be fit for purpose in 2050? How much can it be adapted or renewed? What are the factors for success in improving its performance?

We find that there are many perspectives on this:

- Physical perspectives including building form and fabric; building construction and maintenance; climate change

impacts, adaptation and mitigation; the physical infrastructure of utilities and transport; green structure and biodiversity; built environment of streets, blocks and pavements.

- Geographical and spatial perspectives including national and regional morphologies of industrial, post-industrial or dormitory types; spatial typologies of suburbs, inner city, outer city, etc.; accessibility, mobility and transport network factors.
- Socio-economic perspectives including behavioural issues and lifestyle trends; communications and mobility trends; property market and location values; local community and social economy issues; public or private neighbourhood services.
- Policy and governance perspectives such as 'urban renaissance' or 'sustainable community' discourse. There are issues of local governance and urban change management, in areas of high or low growth.

With this diverse agenda in mind, we look at the general state of knowledge of the building stock. We focus mainly on housing, but also point towards some key features of 'property' including the commercial, industrial and public building stock. An underlying theme is that 'form follows function'—in other words, that the life cycle and performance of the building stock is dependent on its role as a combined physical, social, economic and cultural asset. One implication is that the life cycle of physical buildings is a function of their social and economic value, and can be prolonged indefinitely if it is needed. But sound buildings may be taken down at any time if that value falls.

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1.1. Knowledge mapping

In this review we follow a knowledge mapping approach that can be visualised on several axes (Fig. 1).

- **Existing/new axis:** from a focus purely on existing buildings and their usage, through various levels of improvement or alteration, to completely new buildings. This raises the question of scale, for instance where the life of an existing settlement may be extended by targeted insertion of new buildings.
- **Physical/social axis:** from the focus on physical structures, through various levels of building performance and energy performance, to a focus on social and economic uses and users.
- **Scale axis:** from individual building components, to settlement forms at city or regional scales. Again this is contingent on other axes: for instance, the type of sanitation type in individual dwellings was used as the criterion for large-scale neighbourhood clearance in the post-war period.

There are many possible combinations of these parameters, far beyond the limits of this brief review, to be followed up in further research. Here we flag up some of the key issues that are most relevant to the SEMBE goals of sustainable energy management across the whole building stock.

1.2. General trends, projections and scenarios

The population of England and Wales is currently forecast to grow at a central estimate rate of about 0.7% per year (ONS, 2007), and household formation is forecast to grow at about 0.9% per year (CLG, 2008a). The average household size continues to fall at 1.2% per year, while the housing stock total expands at a rate of 0.8%. The result is that UK average household size is projected to fall from 2.43 to 2.1 persons per household by 2050, while the population is projected to increase from 59.5 to 66.8 million. The outcome is that households are projected to increase from 25.78 million in 2006 to 31.81 million in 2050 (Boardman, 2007a). Demolitions and replacement are locally clustered in areas of renewal, but at 8000 per year the average rate of demolition comprises only 0.03% of the total stock.

The total commercial office and warehousing floorspace also continues to grow, at a rather faster rate of 1–2% per year, but there are few long-term projections.

The result of such trends is the continuing expansion of the physical built environment. Given the many constraints on new building developments, this implies the continuation of the existing building stock, and its maintenance, upgrading, rehabilitation and adaptation. The highly topical issue of new housing, and the national target of 3 million new dwellings by 2020, is actually at the margins of a much bigger but less focused question, of the continuation of the existing building stock. Moreover, such existing buildings are not only physical structures and financial commodities. They are often central to the fabric of everyday lifestyles, communities, cultures and livelihoods. They are also embedded in the spatial form and structures of existing settlements, at various scales, and these too may need to be adapted or re-engineered for future requirements (RCEP, 2007a; Ravetz, 1999, 2000).

Over the next 50 years we might anticipate either a gradual continuation of the trends above—or major step changes in building forms, uses and users. The possibilities might be framed by two contrasting scenario axes (Fig. 2):

- Existing building forms and fabrics may be slow-changing through simple inertia and possibly disinvestment, or fast-changing via upgrading, adaptation and extension.
- Existing patterns of activity and usage could be slow-changing through more static lifestyles and social patterns, or fast-changing through lifestyle innovation, migration and social movement, new household types and social groupings, and economic or institutional pressures, which drive these changes.

The possibilities can then be sketched out:

- ‘Consolidation’ with static building stock, static socio-economic change, and only minor improvements and adjustments.
- ‘New uses for old’ static building stock and rapid socio-economic change. Here, there could be interesting possibilities in new uses and users of existing buildings.
- ‘State of flux’ with rapid change in both physical buildings and in socio-economic uses. This scenario is the most unpredictable.

KNOWLEDGE MAPPING IN THE BUILT ENVIRONMENT

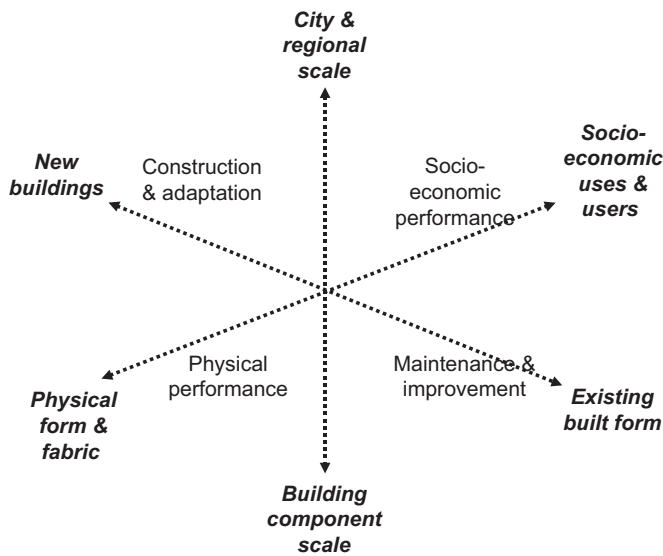


Fig. 1.

SCENARIOS FOR THE BUILDING STOCK

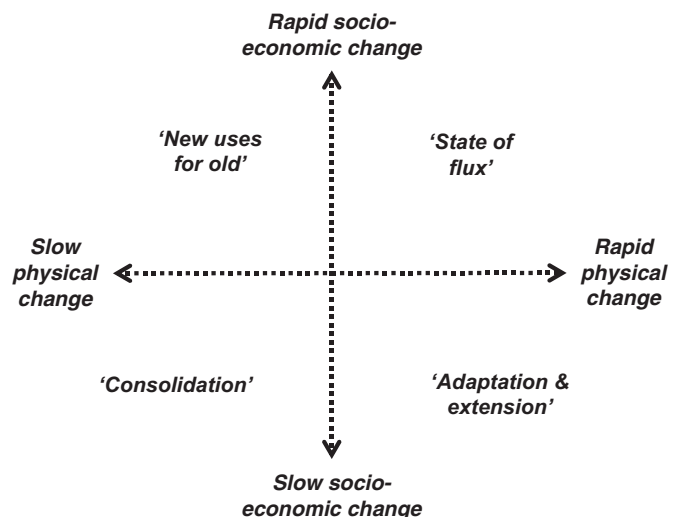


Fig. 2.

- ‘Adaptation and renewal’—rapid change in building stock, but with static socio-economic uses. This puts the focus back on the building fabric and technology.

These scenarios provide a useful background to the themes which follow—not as forecasts, but rather as tests of robustness and significance, of future issues and of decision spaces under different conditions.

2. Housing stock issues

2.1. Baseline conditions and trends

Housing is closely monitored. We know that in 2006 there were 14.6 million (70%) owner-occupying households, 3.7 million (18%) social renters and 2.5 million (12%) private renters: a total of 21.52 million households, occupying a larger total of 21.87 million dwellings in England (CLG, 2008a, b). A statistical summary is shown in Table 1.

For housing there is an extensive database, previously managed by the English House Condition Survey (EHCS), carried out every 5 years to monitor the condition of the housing stock in England. In April 2008, the Survey of English Housing (SEH) merged with the EHCS to form the new English Housing Survey (EHS). Data coverage includes dwelling characteristics, household characteristics, tenancy and occupancy, stock condition, repair and improvement, value of the housing stock, area description, and heating and energy. The EHCS shows the following headline results. They apply to England only and the devolved administrations each have their own arrangements (CLG, 2008a, b).

- ‘Since 1996 there has been a substantial reduction across all tenures in the proportion of homes failing the “decent homes” standard (a combination of “fitness”, state of repair, modern facilities and services, and thermal comfort).
- The energy efficiency of homes has been steadily improving over the last decade—the average energy-efficiency (SAP) rating has improved by 7 points from 42 in 1996 to 49 in

Table 1
Dwelling stock summary

Stock profile 2005	Numbers of dwellings ('000s)					% of total
	Owner occupied	Private rented	Local authority	Registered social landlord RSL	Total	
<i>All dwellings in England</i>						
<i>Dwelling age</i>						
pre 1919	3398	1042	106	186	4731	22
1919–1944	2931	364	362	151	3808	17
1945–1964	2780	268	811	421	4279	20
1965–1980	3350	363	738	477	4928	23
post 1980	2873	430	149	582	4035	19
<i>Dwelling type</i>						
Small terraced house	1704	445	270	246	2665	12
Medium/large terraced house	2629	365	325	315	3634	17
Semi-detached house	4728	447	419	302	5897	27
Detached house	3512	220	9	11	3753	17
Bungalow	1535	113	209	172	2028	9
Converted flat	288	309	42	78	716	3
Purpose-built flat, low rise	868	515	747	654	2783	13
Purpose-built flat, high rise	67	54	145	40	305	1
<i>Dwelling size</i>						
Under 50 m ²	1068	573	602	593	2837	13
50 up to 70 m ²	3470	821	842	623	5756	26
70 up to 90 m ²	4749	596	596	473	6414	29
90 up to 110 m ²	2598	220	103	89	3009	14
Over 110 m ²	3446	257	23	39	3765	17
<i>Neighbourhood Renewal Funded (NRF) districts</i>						
NRF districts	5335	1035	1332	838	8540	39
Other districts	9996	1432	834	979	13241	61
<i>Market conditions</i>						
Market renewal pathfinder areas	411	115	202	114	842	4
Other areas	14920	2352	1964	1703	20939	96
<i>Broad regional areas</i>						
South-east regions	4492	944	667	563	6666	31
Northern regions	4411	615	710	601	6337	29
Rest of England	6428	908	789	653	8778	40
<i>Nature of area</i>						
City or other urban centre	2782	946	711	563	5002	23
Suburban	9104	1031	1260	1024	12418	57
Rural	3445	490	195	230	4361	20
<i>Occupancy</i>						
Vacant	363	253	128	80	824	4
Occupied	14968	2214	2038	1737	20957	96
All dwellings	15331	2467	2166	1,817	21781	100
% of total	70	11	10	8	100	

Base: All dwellings. Source: Communities and Local Government, English House Condition Survey: CLG (2008a).

2006. Social sector homes are substantially more energy efficient than private homes.

- In 2006, 3.4 million (16% of) households live in areas with substantial problems. There has been little change in the proportion of households in “poor quality environments”, or for the three components of this category—“upkeep”, “traffic problems”, and “utilization”.
- Since 1996 there has been a substantial improvement in housing conditions in deprived areas.’

This national database is complemented at local level with further detail by HECA type surveys, produced by all local authorities in compliance with the Home Energy Conservation Act 1995, and by other housing policy data that are less coordinated.

What is relevant here is the issues that are not covered by this or other sources. A detailed analysis of energy efficiency of the housing stock was published by the former Energy Efficiency Office (Evans and Herring, 1989), with an updated ‘fact file’ (Shorrocks and Utley, 2003). There is more recent research on the socio-physical interface, with themes such as comfort standards, adaptation to climate change, domestic technology and determinants of housing satisfaction. It is more difficult to locate information, particularly outside the social housing sector, on cross-cutting issues such as usage of space, furnishings and fittings, social life within households, or patterns of repair and maintenance.

2.2. Current housing conditions

According to CLG (2008b), ‘housing conditions continue to improve. Between 1996 and 2005 the number of “non-decent” homes has fallen by over 3 million, from 9.1 million (45%) to 6 million (27%) in 2005.’ The thermal comfort criterion continues to be the most common reason for failing the Decent Homes Standard. Some 4.4 million homes (73% of non-decent dwellings) lack effective insulation or efficient heating required to meet the very basic thermal comfort criterion. However, there have been considerable improvements, with the number failing this criterion reducing by almost 3 million since 1996.

While thermal comfort standards improve slowly, overall environmental performance has not made much progress. CO₂ emissions from the UK housing stock have risen by 5% since 1997, in spite of the combined rhetoric of two Energy White Papers, a Climate Change Programme, the Stern Review and numerous pieces of legislation. Half of all the cavity-walled dwellings in the country are lacking insulation. The number of households in fuel poverty in the UK has doubled to 4 million since 2002. The Low and Zero Carbon (LZC) programme for domestic micro-generation currently has available less than £1 per household for the whole country, and the grants are notoriously difficult to access (Boardman, 2007a). Such a policy context may change rapidly, but clearly there is a huge deadweight in the 22 million dwellings across the country. In the face of apparently urgent climate change, there is a distinct lack of urgency in tackling existing housing.

2.3. Housing improvement and adaptation

While the majority of the UK building stock of 2050 exists today, it will be subject in future years to continuous maintenance, upgrading, adaptation and rehabilitation. On the supply side, this is a major and growing sector of the construction industry, and a major source of investment and added value. Housing ‘repair, maintenance and alteration’ is 19% of total

construction output, in comparison to new build at 16%. Across all building types, repair, maintenance and alteration comprises 40% of output (Chartered Institute of Building, 2005). On the demand side, the attractiveness of refurbishment is determined by the functions and adaptability of certain building types, the economics of replacement or upgrading, and location and investment potential. The long-term inflation in house prices across the UK has contributed to the ‘fail-safe’ nature of owner-occupier investment in alterations and upgrading, although current financial market problems cast doubt on the continuation of this trend.

The influence of past generations of retrofit technologies and building solutions is clearly visible in today’s homes. The post-war modernisation programme for basic plumbing, electrics and double glazing is now in many cases ready for a second renewal cycle (Energy Saving Trust, 2006). In each of these areas the technology is now more complex, capital intensive and crucial for the environmental performance of the dwelling. Kitchen installations become more elaborate, while lighting schemes now include multiple low-energy bulbs together with exterior lighting, security, garden and pool lighting (Hand and Shove, 2004). Consumers are still seeking new and exotic links from indoors to outdoors, involving conservatories, summer houses, gazebos, patio doors, barbecues and so on. Many of these spaces are mechanically heated, counter to all energy-efficiency advice.

Assuming that such trends could continue, we might find some topical shifts emerging:

- The dwelling as a technology centre. The integration of IT with domestic technologies increases, with items such as video walls, intelligent kitchens and appliances, and self-maintaining clothing (Mitchell, 1996).
- The dwelling as a mediated environment. Going beyond the conventional four walls, housing will be converted, extended and adapted for climate change, to provide ecological habitats, outdoor leisure and increasingly exotic combinations of indoor and outdoor environments.
- The dwelling as a fortress. Continuing the trend for security and surveillance, indoor and outdoor spaces will be subject to total monitoring and screening, with hard barriers and soft gateways (Coaffee, 2003).

2.4. Housing forms and occupation

Related to the above concerns are the physical form of dwellings and their adaptations, and the ways in which they fit a building’s occupancy and functional profile. This has been summed up as ‘how buildings learn’ from their uses and users (Brand, 1994).

The reduction in household average size at a rate of about 1% per year is well known, with the post-war level of 3.6 persons now reduced to 2.4 persons per dwelling. The largest growth sector in housing demand is from single persons, both old and young. Less publicised is the rise in flexible family structures due to serial co-habitation, dual career households, third generation extensions (‘granny flats’), and the return of young adults sharing with parents (Holmans and Whitehead, 2006). This is coupled with the input of new functions in older spaces. These include home-working and tele-working, indoor media and leisure, and virtual networks and communities, which have been made more feasible by broadband wireless connections, and by real-time GIS and GPS facilities.

Such changes in uses and users can reach a ‘tipping point,’ where radical building forms or adaptations are realised in design

solutions for conversion and rehabilitation. For example, the Urban Splash development at Langworthy in Salford, in an area of notorious housing market failure, turns the conventional inner-city terrace house form literally upside down, and rebrands it as suitable for young professionals, with an allocation for local community social housing (details on <http://www.urbansplash.co.uk>).

Other emerging trends come from rapid developments on the information technology front, for policy, business and consumers. For instance, websites such as <http://www.upmystreet.com> now enable house-buyers to research online area profiles, public service performance, house types and prices, and the nearest alternatives. Interactive online functions open up new possibilities. The EPSRC-funded SUREGEN project, now in progress, combines training, simulation and evaluation, using a variety of virtual reality models with Web 2.0-type social networking and self-organising libraries (<http://www.vp.salford.ac.uk/suregen>). Again, such trends raise interesting possibilities for changing uses and users, which in turn may influence building forms and technologies. They could point the way towards:

- New forms of finance and tenure: portable mortgages, working time-shares, 'lifetime homes' with planned flexibility in design and construction.
- Housing extension, alteration and adaptation: suburban densification with back garden developments, roof top conversions, roof gardens and new forms of conservatories and other outdoor living spaces.
- New forms of co-housing and shared facilities, already suggested by the emergence of gated communities. The emergence of social networking suggests larger-scale potential in urban development (Glasze et al., 2005).

2.5. Energy efficiency and performance

The energy efficiency of homes has improved over the last decade, but there is still a very long way to go. The average energy-efficiency (SAP) rating has improved from 42 in 1996 to 49 in 2006 (CLG, 2006b). Social sector homes are substantially more energy efficient than private homes, with an average rating of 57 compared with 47 in the private sector. In 2006, over two-thirds of homes (70%) had an energy performance rating of band D or E according to the Energy Performance Certificate (EPC) bands. Less than 10% of homes achieve a rating of band C or higher, while 20% are in the most inefficient bands F and G.

On the low- or zero-carbon agenda, there is a perceived need for more integrated and active institutional arrangements for strategic management of the housing stock (Sustainable Development Commission, 2006). This raises questions about life-cycle costing in the public and private sectors, and the conventional separation of capital from revenue accounts. One application is the current UK programme of Home Information Packs (HIPs) and Energy Performance Certificates. Although their launch in 2007 was controversial, this development may point the way towards a future where full disclosure and performance benchmarking are a standard part of every dwelling's profile, as it is already with motor vehicles. However, there are many barriers and disincentives to 'rational' investment, such as the split of responsibility between landlords and tenants and the gap between the actual and social costs of energy and climate impacts. The biggest political controversy of all may be the suggested replacement of the least efficient portion of the UK building stock, as proposed in the '40% house' research programme (Boardman, 2007a,b). However, there is a counter argument, which highlights the worst

performing housing stock as an efficiency 'resource' more than a problem (Lowe, 2007).

Moreover, many current trends run counter to the efficiency emissions reduction targets:

- New lighting technologies: although modern low-energy bulbs are five to ten times more efficient than tungsten bulbs (to be phased out by 2011), typical alterations and upgrades may use five to ten times the number of lighting sources.
- Domestic air conditioning: this very energy-intensive solution is likely to increase rapidly with the onset of climate change, in the absence of other constraints.
- Appliance diversification and new sources of high energy demand, for instance patio heaters, wide screen television, clothes driers, walk-in refrigeration and advanced security systems.

In contrast we can point to some emerging techniques for improving housing energy performance:

- Technology advances: retrofitted 'total energy design' and 'demand-side management.' This will increasingly be designed for whole houses, rather than simply being bolted onto a boiler. Other developments include ventilation with heat recovery, remote sensing and imaging to detect heat loss, integrated appliances and diurnal heat balancing.
- Retrofitted micro-generation and on-site renewables (not covered here in detail) will become more realistic and viable, and will be installed alongside alterations and upgrading.
- Policy applications: energy rating and calculation in existing buildings is becoming more detailed and responsive. There are possible linkages to responsive CO₂ targets or household budgets and to emissions trading. There are various proposals for 'Domestic Tradable Quotas' (i.e. personal carbon budgets), which could have a strong influence on housing energy efficiency, although at present none of the options is seen as ready for implementation (Defra, 2006).

There is a new debate on the balance of capital embodied energy versus energy in use, and therefore the energy and climate benefits of refurbishment (Empty Homes Agency, 2008). Recent research based on the Inventory of Carbon and Energy at Bath University suggests that embodied energy is a much larger part (27%) of the lifetime carbon cost of housing than has so far been recognised. This suggests that new housing is several times as energy-intensive as the existing stock. There is also evidence on construction supply chains to show that the totality of construction materials and indirect effects is over ten times the direct impacts of construction on site (Ravetz, 2008). The effect of urban infrastructure also needs to be included in the argument on demolition versus renovation (Schiller, 2007).

In parallel with the technology agenda, there is a growing realisation that the social and behavioural dimension can be equally important. But there is much conflicting evidence. For instance, surveys of residents in higher-density developments seemed to run counter to conventional wisdom on sustainable urban development (Bretherton and Pleace, 2008).

2.6. Housing policy and institutional innovation

Achieving the potential of such energy performance improvements will need to balance economic, social and environmental costs and benefits, on the principle of integrated asset management. But at present, the energy-efficiency agenda is a demonstration of the fragmentation and resistance of the property

industry to change. Current studies such as the ‘40% house’ show that the national climate change targets will be impossible without a strategic overhaul of the existing housing stock (Boardman et al., 2005). Such an ‘institutional business case’ for the strategic management and upgrading of the housing stock would appear to depend on new forms of investment, and on active coordination between all parties—lenders, landlords, designers, house-builders, developers, engineers, agents, owners and tenants.

- The investment case will be more effective where it is targeted by housing tenure, value, investment, building life cycle and owner life cycle.
- It will need to be planned and managed at the appropriate scale, from the building element to the neighbourhood scale.
- It will need to take account of the patterns of owner occupation, rising and falling markets, buy-to-let finance, and the problems and opportunities of overvaluation and negative equity.
- There may be various financial innovations including new forms of flexible and portable mortgage or equity share, more sophisticated risk assessments on the supply and demand sides, and life-cycle investment-return vehicles.
- There could be potential to link innovation in finance with innovation in design and technology, such as climate change adaptation, other ecological and ambient design, and protection against flooding and other risks.

2.7. Issues of scale

Housing is not simply a collection of autonomous units. It is structured into blocks, streets, neighbourhoods, city-regions and so on. While most UK housing is in the form of owner-occupation of low-rise traditional construction, there is an increasing proportion in conversions of larger buildings, alongside new warehouses-as-houses, designed to look like conversions. Even the much-reviled local authority tower blocks are in a renaissance of conversion and adaptation, often targeted at quite different socio-economic groups from their original occupants. In London and larger cities, the bulk of housing is in flats of various configurations, and these pose special challenges for energy performance. With heating requirements at a minimum, the domestic energy profile is becoming more focused on cooling and lighting, which can be challenging in traditional buildings.

At the neighbourhood scale, much of the reinvestment in the existing housing stock depends on perceptions of value and quality. Cultural heritage and townscape are two of the determinants of value, but often the conservation agenda can conflict with environmental policies. On a wider scale there are new patterns of spatial structure, new townscape policies and design solutions, and new techniques for altering or adapting historic and period buildings. Here again there are many possible advances in knowledge, such as GIS-based townscape assessment, Web 2 social networking, real-time video monitoring and so on. Such technologies may help to level the playing field between experts and the public, but risk segmenting and polarising urban populations by their values and behaviours. This would mean that the building stock would be subject to investment or disinvestment on an increasingly selective basis.

‘Sustainable urban development’ policy will also be a crucial factor in the balance between adaptation or new housing (Ravetz, 1998). The planning goals of urban containment and raising densities will encourage more suburban plot subdivisions, infill development, and large extensions. Nearly 60% of dwellings are average suburban homes originally built for a large family. By

2050 these may be extended, adapted, or infilled to produce several one- or two-person households.

3. Non-domestic buildings

Here we review some topical issues for non-domestic buildings including commercial, industrial, public and utility structures. In terms of energy demand, such property is a problem at least as large as housing, but it receives only a small fraction of the attention. Perhaps this is because it is on the ‘business’ side of the economy, where government intervention is more contentious.

3.1. Baseline conditions and trends

UK property in general is characterised by a huge diversity of size, age, condition, form, fabric, function and tenure arrangements. For commercial and industrial property there is a statistical evidence base covering all recorded property types, drawn from the Valuation Office Agency database. This covers hereditaments, floorspaces and rateable values, but not conditions, construction or other finer detail: the supply side data are covered in the Construction Statistics Annual (DTI, 2007). The data are also available at regional and local levels, through the Neighbourhood Statistics (NeSS) website service (<http://www.statistics.gov.uk/neighbourhood>). There are few recent condition or performance audits for existing property (Building Research Establishment, 1991; Herring et al., 1988). A major effort was made by the then Global Atmospheric Division of DETR, to develop a national Non-Domestic Building Stock (NDBS) database (Penman, 2000; Bruhns et al., 2000). By analysing the Valuation Office database, this inferred a comprehensive list of building forms, servicing and efficiency. One result was the National Nondomestic Buildings Energy and Emissions Model (N-DEEM), which was used to model energy policy impacts (Pout, 2000). There may be more activity on this front in the future, as the energy performance of new and existing property is now emerging as a priority (UK Green Building Council, 2007).

The total floorspace of commercial and industrial bulk class properties in England and Wales was 597 million square metres in 2007, 6% more than in 1998. Within this, the total of retail floorspace was roughly unchanged, but there was a decline in factory space, and rises of over 20% in both commercial offices and warehousing (CLG and ONS, 2008). The office floorspace is roughly parallel to the rise in service sector employment, while the trend in warehousing and larger assembly units is a sign of the shift from labour intensity to capital intensity in these sectors. A statistical summary is shown in Table 3 in the appendix.

3.2. Larger buildings and complexes

There is a rapid growth in the formation of larger buildings, building complexes, and urban complexes for retail, office and leisure use. These are pushing new boundaries in the complexity of building servicing, with close attention to the facilities management, retrofit and value-added cycle. In the USA, it was observed that commercial properties ‘don’t so much wear out, they just ugly out’ (Garreau, 1991). Existing and older building fabrics often cannot cope with the increasing sophistication of engineering systems for heating, ventilation and air conditioning, telecommunications, security and surveillance. However, there are continuing advances in the retrofit cycles, with emerging technologies for *in situ* renovation and upgrading. They include large building servicing, fire prevention, security and surveillance, maintenance management, and facilities management. Basic tasks

such as window cleaning then become high-technology programmes, with their own maintenance cycles, skill and training programmes, peripherals supply chains and so on.

3.3. Property market issues

Property market criteria such as yield factors, equity and tenure structure are crucial to the future maintenance, improvement and adaptation of existing buildings. There are location effects, particularly those caused by the segmentation of over- and under-investments in property combined with the effect of urban regeneration, environmental improvements, spatial planning and other public subsidies. There is a continual restructuring of commercial property market portfolios, due to spatial relocation and functional changes. The market is polarised by rising and falling values, and under normal circumstances the rehabilitation and upgrading cycle has to reflect this. Key advances in property performance analysis and life-cycle cost-benefit are now emerging. They include GIS-related techniques in demand management and risk assessment, new channels for user feedback on supply and demand, and market constraints and opportunities. There are new patterns of more distributed and networked employment in service sectors, which change the amount and type of demand for buildings (Worthington, 2005).

Topical examples include the retail sector. What is the most efficient and effective 'format,' given the competing demands of suppliers, consumers, policy and business? There are new barriers and opportunities coming from Internet retail, big shed retail, urban 'metro' niche formats, re-emerging local food outlets, and other developments.

For office space, there are marked generational effects. Previously deep floor plans with full environmental servicing are now being re-engineered towards day-lighting and low-energy solutions. Previously factory-like open plan floorplates are now the creative focus of facilities managers. In parallel there is a rapid growth in hotel, conference and other leisure floorspace types. Location and place quality play a larger part, while environmental standards are much quoted.

Finally, the mono-functional 'office block,' the staple of the property world, might appear to contrast with the more localised and responsive sustainability agenda. The 'sustainable community' (CLG, 2004, 2006a) aims to encourage social enterprise and cultural diversity, mixed uses, recycling, non-motorised transport and clustered development forms. Many such goals are facing in a different direction from conventional commercial activity. It will be interesting to see how far the conventional property world, with its very commercially focused objectives, can assimilate such social and environmental agendas.

4. Conclusions

In this brief review we have sketched some of the main issues and trends, which affect the future of the existing housing stock, and have referred briefly to non-domestic building.

In terms of the SEMBE project, we need to be as clear as possible about the distinction between actual developments in building design or technology and the type of knowledge or intelligence, which is needed to manage or anticipate such developments. The summary tables (Tables 2 and 4) divide these into 'issues,' 'projections' and 'key advances,' although in practice these may overlap.

Focusing on the knowledge side, and referring back to the mapping outlined at the start, we can draw some general conclusions.

- The statistical outline of the housing stock is quite detailed, but there is little coordinated evidence on 'inside the house and household' in terms of how people use their house, how they feel about it, and their fears and aspirations. Similar questions also apply at the neighbourhood level, where patterns of growth and decline are the key to investment or obsolescence of existing housing.
- The engineering and technology aspects of energy efficiency and thermal comfort are well documented. However, there is a less clear view on issues that are likely to come to the fore with changing climatic conditions, and with new patterns of usage. How do older houses perform in summer heat? Does opening windows for ventilation create a security risk? How does appliance heat gain build up?
- There is also a need for greater understanding of the components of change in existing housing. What makes people invest in conservatories or extensions, and how do they use them? How do people use limited indoor space with changing family structures? A more intelligent approach to householder financial issues is needed, which looks beyond the conventional market reports. This is especially topical at the time of writing, during the financial and property instability of 2007–2008.
- Commercial and public property, while it uses as much energy as housing, is much less well monitored and documented, except in its financial aspects. Again, there are many one-off studies on facilities management, thermal comfort and environmental design, but these would be better linked into a coordinated database for the stock as a whole. A similar approach will be needed for the institutional landlord, building manager and investor perspective, under the coming regime for Carbon Reduction Commitment (Defra, 2008).

Table 2
Housing issues summary

Issues	Projections	Key advances
Energy and environment performance and technology	Domestic air-con: appliance diversification: retrofit microgeneration: CO ₂ targets	Remote sensing and imaging: total energy design
Age, condition and maintenance cycle	Rehab as value function: new technology options: strategic replacement	Stock management: life-cycle costing: HIP/EPC programme
Physical form and occupancy profile	Falling space intensity and rise of singles: flexi- family structures: home-working patterns	Restructuring options and new markets: large building conversions
Tenure, value, investment	Owner-occupation, rising market, hyper-gearing, buy-to-let	Investment portability: risk assessments
Heritage, conservation and townscape	Area segmentation: new townscape values: historic building conservation	Historic conservation techniques: GIS neighbourhood and townscape assessment methods
Urban context, neighbourhood, spatial location	Social segmentation: urban renaissance	Online area profiling: local social spaces: virtual city technology

Table 3
Commercial and industrial floorspace

	Total	All bulk classes	Retail premises	Total offices	Commercial offices	'Other' offices	Factories	Warehouses	Other bulk premises	Non-bulk premises	Non-bulk premises with floorspace
1998	573,201	540,136	101,827	82,011	65,181	16,830	225,964	130,333	–	–	33,064
1999	578,552	543,908	103,053	83,131	66,188	16,944	224,684	133,039	–	–	34,644
2000	593,807	569,690	106,166	93,894	74,205	19,689	231,579	138,051	–	–	24,117
2001	600,165	575,905	107,459	95,517	75,477	20,039	230,527	142,402	–	–	24,260
2002	607,181	582,901	108,556	97,725	77,581	20,144	230,434	146,186	–	–	24,280
2003	609,818	586,274	109,704	99,765	79,735	20,029	228,207	148,598	–	–	23,544
2004	609,360	587,637	110,840	101,060	80,943	20,117	224,398	151,339	–	–	21,723
2005	606,259	590,572	103,095	97,875	80,916	16,959	220,392	149,007	20,203	–	15,687
2006	610,377	595,561	104,274	99,550	82,420	17,130	217,935	153,342	20,460	–	14,816
2007	610,722	596,729	105,340	100,528	83,169	17,359	212,657	157,612	20,593	–	13,993
Growth 1998–2007 (%)	6.55	10.48	3.45	22.58	27.60	3.14	–5.89	20.93			

Table 4
Commercial building summary

Issues	Projections	Key advances
Larger buildings—technology and servicing, retrofit cycle	Increasing sophistication of engineering and telecoms systems: acceleration of retrofit cycles	New possibilities for <i>in situ</i> renovation and upgrading: new ICT solutions
Property yield factors, equity and tenure structure, investment and maintenance	Restructuring of commercial property market and investment portfolios, due to spatial relocation and functional changes. Market is polarised into rising/falling value property	Increasing segmentation of financial equity and investment cycles. Increasing responsiveness to sustainable community goals
New forms of employment and service delivery	Distributed and networked employment in service sectors changes functionality and demand for large parts of the building stock	Flexibility in service delivery and employment: new uses for existing spaces and locations. New potential from 'neogeography' in reconfiguration of logistics and locational added value
Location/planning status/valuation/investment profile	Market intelligence becomes more sharp and responsive: tenant and user requirements intentions are networked	Social/business networking of spaces, locations, facilities

These issues are similar to those of housing, plus some specific issues as noted. Summary statistics, England and Wales, 1 April 1998–2007. Source: CLG and ONS (2008).

- In each of these areas the greatest single potential is probably in the use of information technology. The introduction of smart metering, automatic light switching and so on, is likely to mark the start of an era when building environments and uses are monitored on a continuous and comprehensive basis. There are continuing advances in modelling and databases, which should be deployed more widely in practice (RCEP, 2007b). The most recent and most powerful step may be in the 'neogeography,' the rapid spread of digital tools, which enable any user to create and work with customised maps, visualisations and virtual reality versions of buildings, neighbourhoods and cities (Hudson-Smith, 2008).

Overall, this all adds to the view that the physical form of the building stock is very much dependent on the 'socio-physical' interface between buildings and their functions and values. The existing stock of houses and property should not be taken for granted in 50 years from now. Instead, its future depends on continuing flows of activity, financial investment and cultural identity.

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