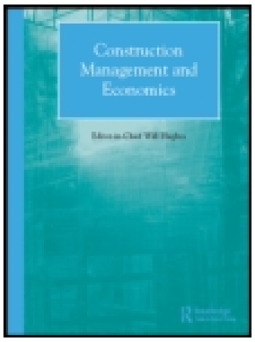

Routledge
Taylor & Francis Group

Construction Management and Economics

ISSN: 0144-6193 (Print) 1466-433X (Online) Journal homepage: www.tandfonline.com/journals/rcme20

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To cite this article: David M. Gann & James Barlow (1996) Flexibility in building use: the technical feasibility of converting redundant offices into flats, Construction Management and Economics, 14:1, 55-66, DOI: 10.1080/014461996000000007

To link to this article: https://doi.org/10.1080/014461996000000007

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Construction Management and Economics (1996) **14**, 55–66

Flexibility in building use: the technical feasibility of converting redundant offices into flats

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Received 3 March 1995; revised 7 May 1995

The potential for converting empty offices into housing depends upon demands for converted space, the ability to finance conversions and attitudes of owners of empty buildings, together with flexibility in planning and ability to overcome technical constraints. This article explains the reasons for the large stock of redundant office buildings in the UK and questions whether some of these can be converted to provide much needed affordable housing. Technical constraints on their own are rarely insurmountable but the cost of making necessary changes may often be higher than other options of demolition and new building. Case studies of converted buildings show that it is necessary for project managers to deal with a range of issues from planning, location and finance to the accurate assessment of technical criteria in order for successful outcomes. It has often been difficult to find sites where all the necessary variables coincide in a positive manner and for this reason, the conversion of offices into flats has limited potential. It cannot therefore be seen as a panacea for housing shortages or for the reuse of redundant office buildings. Lessons from the experience of the UK property and construction industries illustrate the need to incorporate greater flexibility to meet unforeseen changes in use in the future.

Keywords: Offices into flats, conversion, change of use, technical feasibility, flexibility.

Introduction

The end of the commercial office building boom in the early 1990s resulted in an enormous oversupply of office space in many cities around the world. The phenomenon was widespread in Europe, from London, Paris and Amsterdam to Stockholm and it affected the US, particularly New York and Australia, especially Sydney and Melbourne. In central London alone, empty office space amounted to the equivalent of 35 Canary Wharf towers, yet there was a need to create thousands of new homes, including 100 000 affordable housing units a year. This combination of trends in commercial office supply and use, together with a restructuring of housing provision formed the environment within which there was a potential to convert offices into flats. However, there has been little systematic analysis of the issues concerning change of use of buildings from commercial to residential accommodation.[1]

[1] The only reports on the subject published in the UK were *The Home-Office Report* and *Planning for Chameleons* (Publishing Business Ltd, 1992; A. Helm, 1993). Since these were written, a number of conversions have been completed and the financial, planning and technical issues have become clearer.

We carried out a study (Barlow and Gann, 1993) in the UK to assess the feasibility of reducing the stock of unoccupied office buildings through conversion to meet demands for new housing, focusing on the following key issues: property market dynamics and the economics of conversion, the planning system and location of buildings and technical constraints to conversion.

Three related ideas influenced our approach. First, the need to assess the adaptability of existing buildings for accommodating future unforeseen uses, second, the need to create areas of mixed use or 'urban villages' within our cities and, third, the concept of 'rent gaps' to explain patterns of change in land use. (For further details see Habraken (1972), Newman *et al.* (1992) and Smith (1979). The issue of 'rent gaps' is explained more fully in Barlow and Gann (1993).)

Our initial research was carried out between January and June 1993. This involved literature reviews, trade press and journal searches and analysis of offical property, housing and construction statistics. A postal questionnaire survey of 24 local planning authorities was undertaken and a total of 64 semi-structured interviews were carried out with planning officers, property devel-

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opers, owners, consultants and academics, architects, contractors and building component suppliers, housing associations, university estates departments and government officials. The survey was designed to explore the extent of conversion activities in different regions and attitudes of different planning authorities to granting or refusing consent to changes in use. The interviews were carried out to examine the reasons why conversions had been considered and the constraints to implementation. Further research was carried out in December 1994, during five regional workshops in London, Edinburgh, Cardiff and Manchester, involving practitioners from all sides of the property and construction industries.

This article focuses on the technical feasibility of conversion, updating our original work with issues of particular relevance to property developers and owners, project managers, surveyors and estates agents, local authorities, housing associations and other potential housing clients such as universities and health authorities and those responsible for housing, commercial property and planning within central government.

The article is organized in four sections. The first assess the causes, extent and type of oversupply in office buildings. The second section explores variety in housing need and the potential of using empty office space to meet different housing requirements. The third section describes the technical viability of conversion and constraints found in different building types. Finally, we conclude with policy recommendations for those considering conversion and we examine the general lessons relating to the need to design flexible buildings to meet a variety of unforeseeable future uses.

Oversupply of offices

The boom

Between 1986 and 1991 the property and construction boom in the UK resulted in the biggest changes in the landscape of many major cities since the Second World War. This boom was concentrated in central London and the London Docklands and regional centres in the South East and South West of England. Its huge scale was made possible by a number of structural changes in the traditional property institutions and a qualitative change in demand for office space, for example, the strategies and activities of property developers changed, demand increased for new types of office buildings to accommodate information technology, new methods of financing projects were devised and new planning legislation was introduced.

The commercial property sector can be understood as a series of linked markets, bringing together property users, investors and developers (Nabarro, 1990). The user market comprises owner–occupier firms buying and selling office space. The property investment market is made up of specialist property companies and financial institutions which own and trade buildings, the aim being to secure a return on investments from rising rental and capital values. The property development market is where new buildings are produced and old buildings redeveloped. During the 1980s, the property development industry used the concept of 'intelligent buildings' as a marketing ploy to generate and meet demand for buildings designed to accommodate information intensive activities (Gann, 1992).

The growth of information-intensive work initially had the largest impact on business districts in city centres, concentrated in London and the South East. In Greater London, employment in financial services grew from around 520 000 in 1981 to 720 000 by 1986[2]. To accommodate the changes brought about by information-intensive work, firms needed to adapt their use of existing buildings or move to new ones. The use and control of digital information became of strategic importance to many organizations whose demands for buildings included the need for adaptable and upgradable cabling for data and communication networks, air-conditioning and environmental control to remove excess heat generated by office equipment, disaster prevention, including a clean, uninterruptible power supply, fire protection and security and adaptable space to accommodate changing organizational structures (Gann, 1992). The ability to reorganize the use of space became a critical element of competitive success for many firms who needed to respond to rapidly changing market conditions. Large continuous and adaptable floor spaces became fashionable, replacing the rigid layouts of 1960s and 1970s cellular offices.

The 1980s was marked by the highest levels of trading in buildings ever experienced as fund managers realigned their property portfolios towards more modern buildings. Technical obsolescence meant that many buildings acquired before the early 1970s were no longer prime investments; these were therefore disposed of. The large stock of second- and third-grade buildings became available for refurbishment or demolition as financial institutions restructured their portfolios towards more modern buildings. By 1988, 35% of the value of the institutions' office portfolios comprised buildings which had been completed during the 1980s or were still under construction. A further 31% comprised buildings dating from the 1970s, while only 10% comprised buildings from the 1960s (Nabarro, 1990).

[2] By 1988, approximately 75% of all employment in the City of London was office work carried out in 6.5 million m^2 of office space (Duffy and Henney, 1989). The trend in growth of jobs in financial services subsequently reversed.

Changing demand for office space, coupled with an initial undersupply of modern buildings capable of accommodating work with information technology resulted in a boom in property returns after 1986. This boom in returns induced a massive increase in new development and refurbishment.

A 'funding gap' emerged between the property user and investor, into which new specialist property companies began to move (Key *et al.*, 1990)[3]. These 'merchant developers' were distinct from the established investor developers such as Land Securities, which pursued long-term investment programmes. Merchant developers such as Rosehaugh, Mountleigh, Heron and Stanhope, were more entrepreneurial in their development and acquisition strategies than the older companies. They specialized in searching for new opportunities and bringing together the necessary parties to develop and sell buildings. Merchant developers therefore differed from investor developers in that they built speculatively for sales, rather than for long-term rental returns and capital growth. The funding gap also meant that alternative financial instruments had to be found to fund property development (Beveridge, 1991). Loan financing grew rapidly, especially by overseas banks, using highly complex instruments.

A favourable environment for property development was reinforced by changes to the planning framework. For example, the City of London increased plot ratios from 3.5:1 to around 5:1. The Use Classes Order (1987) brought in a new category of floorspace (B1) to take account of the need for space to accommodate new forms of business use including office, light manufacturing and research and development functions. This was designed to introduce a more flexible system of development control and make it easier for the use of buildings to be changed without the need for planning permission.

The demand for office space failed to grow as rapidly as the provision of new space and supply had outstripped demand as early as 1986 (Key *et al.*, 1990). The stock of offices expanded by approximately 20% between 1986 and 1992 while employment in financial and business services was actually falling (DTZ Debenham Thorpe, 1993). These indicators were not recognized by many property companies and by the early 1990s the industry was experiencing the worst slump since the Second World War[4].

[3] The rise and fall of merchant developers is a well-established phenomenon of post-war property cycles. A new generation emerges at each boom; some then disappear in the subsequent crash (Rosehaugh and Stanhope), while others mature into investor developers such as Land Securities.

[4] Investors and property developers were slow to acknowledge signs that the property boom was running out of steam. This was partly due to a lack of reliable data on commercial property markets. Data on the net take-up of office space are limited because of the lack of information on vacancy and quit rates.

The slump and subsequent recovery

Three dimensions characterized the slump in commercial property markets: an oversupply of offices and high vacancy levels, falling returns and rising property company bankruptcies, together with a high exposure of banks to property loans.

The collapse in demand for office space and the slump in property markets coincided with recession in the UK economy. The recession exacerbated the property market slump for three reasons: first, the demand for space diminished as firms went out of business, second, many occupiers required less space as they trimmed their operations in order to survive and, third, firms in older properties were reluctant to move to newer, higher grade premises at a time when they were seeking to reduce expenditure. The cost entailed in moving could be prohibitive and firms were often locked in to lower grade buildings because of existing lease agreements.

The amount of available office space peaked in London in the summer of 1992 at approximately 3.2 million m^2. This represented a vacancy rate of 20%. By mid-1993, London's office vacancy rate had fallen to nearly 18%, including 38% of offices vacant in the Docklands area (*Financial Times*, 13 August 1993, 16 December 1994 and interviews). Vacancy rates continued to fall during 1994.

The stock of unoccupied offices is segmented in terms of building quality, type and age. Property market analysts in the UK distinguish between three main grades of office building.

1. Grade 1: the best quality buildings built or refurbished after the beginning of the 1980s boom.
2. Grade 2: older (1970s) buildings in good locations or newer buildings in the City fringe.
3. Grade 3: 'non-marketable' buildings (constructed in the 1960s and 1970s), deemed to be virtually unlettable for the foreseeable future.

The portfolio realignment of institutional investors left a large stock of unoccupied second and third grade offices. It was estimated that in December 1991, 220 000 m^2 of office space in the City of London was 'virtually unlettable' (HBHR, 1992). This figure rose to some 500 000 m^2 by 1995, representing a 'permafrost layer' of unusable low-grade offices.

By 1994 the beginnings of an upturn in property markets were discernible. Private investors, especially from outside the UK, were said to be returning to the market, prompted by the fall in value of the pound. Large institutional investors were said to be reappraising the market with a view to restructuring their portfolios. Economic recovery and the movement of tenants from lower grade to higher grade premises meant that the

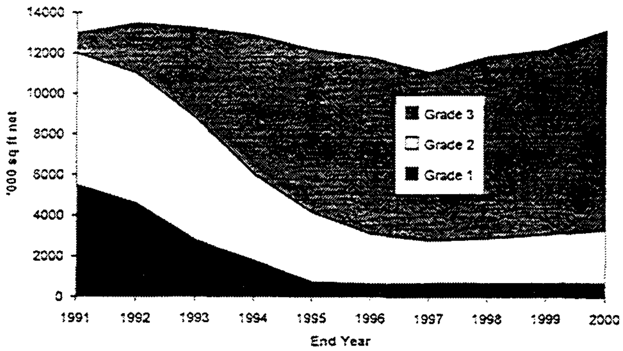

Figure 1 The changing pattern of empty space through the 1990s. Source: adapted from Waterman (1993)

surplus of top quality offices began to fall substantially by the mid-1990s.

If demand remains strong it is likely to shift towards second-grade offices after high-grade offices have been let. In spite of this, the large number of unlettable third-grade office buildings is likely to increase as more buildings fail to provide the technical facilities and space for modern office work[5]. Figure 1 illustrates the changing pattern of empty first-, second- and third-grade space through the 1990s.

Unmet housing requirements

In the early 1990s there was unmet demand for new affordable housing: estimates showed that between 74 000 and 130 0000 new 'affordable' dwellings were needed annually (Wilcox, 1990; Bramley, 1991; Audit Commission, 1992; Whitehead and Kleinman, 1992). The Housing Corporation had sufficient funding for 51 000 new housing association dwellings annually for the period 1992–1995. But in London the 'affordability gap' – the gap between mean incomes and mean house prices, remained high. Only 14% of single adults under 30 years and 58% of households with both adults under 30 years were able to afford cheap second-hand housing (Bramley, 1991). In 1993, there were estimated to be more than 100 000 'concealed' households, unable to move from relatives' or friends' houses. There was a further 50 000 priority and single homeless households and the number of 'street' homeless had grown substantially to around 3000 (Kelly, 1992; LPAC, 1992).

Furthermore, new patterns of housing demand were emerging in the 1990s. Some existing households were seeking accommodation closer to places of work as transport costs and congestion increased. Other new sources of demand, such as from further education establishments for student housing, were also growing.

Criteria for assessing housing need include access to 'affordable' housing, 'suitable' housing, housing of adequate quality and physical standards, housing with security of tenure and housing in a preferred location in relation to employment, medical and social needs. The key point is the suitability of accommodation for the specific type of need. Housing need can be described in terms of a number of different categories, which have implications for the type of accommodation and therefore for the type of building and facilities. Different households have different needs, for example, high rise flats may be unsuitable for families with small children who need to play outside or for elderly people requiring regular care. These needs can be matched against accommodation generated from different types of conversion. Table 1 illustrates these categories and the most suitable type of conversion.

Those most in need of housing are unlikely to be able to pay for conversions. It is therefore institutions such as housing associations, educational establishments and health authorities which have taken the lead in promoting conversions, together with a few new private sector

Table 1 Examples of housing need and type of conversion

Type of housing need	Type of conversion
Short stay/move-on, overnight shelters or winter cold shelters for off-the-street single homeless	Basic facilities; minimum impact on existing building – easy to convert back to offices
Hostels and longer term accommodation for students, nurses and young people	Medium impact on building, making use of shared facilities such as kitchens and bathrooms – potential to convert back to offices
Care in the community and special needs housing, including sheltered housing for the elderly	Medium to high impact on building, including some shared facilities but installation of 'special needs' facilities may be required – expensive to convert back to offices
Housing association standard accommodation	Full conversion required – unlikely to convert back to offices
Low-cost owner-occupied housing	Permanent conversion
Medium-cost owner-occupied housing	Permanent conversion with high specification fit-out
Luxury owner-occupied housing	Permanent conversion to luxury specification fit-out

[5] Office-building life cycles declined from 40–50 years in the 1950s and 1960s to 20–25 years in the 1980s. Since then they have continued to fall, boosting the potential stock of redundant office buildings.

developers, such as MBE Homes, which have emerged in the hope of exploiting new market opportunities of conversion.

The extent to which conversion schemes are promoted depends on the attitude of building owners. Much of the third-grade stock is owned by large investors.

Owners of unlettable space will make decisions based upon an assessment of future possible returns set against current costs, the option of 'constructive vandalism'[6] and later reinstatement to reduce current costs and the cost of conversion set against the sales price, so long as finance for conversion can be arranged.

Whether or not owners are likely to consider the option of conversion depends on their discounted cash flow (DCF) analysis of the possible income streams. With 'hopeless case' buildings a trade-off between demolition and refurbishment needs to be made. The latter may be viable if the future income stream can be offset against current losses, depending on the extent to which investors are prepared to write down unlettable property. Demolition may be a preferable option to refurbishment or conversion if investors are financially capable of holding on to vacant sites until they are ripe for development in a future market upturn. It is within this context that we considered the technical feasibility of conversion.

Technical viability of conversion

Empty offices in the UK can broadly be categorized into four groups according to their age and type of construction: nineteenth-century office buildings, offices built between 1900 and 1945, offices built between 1945 and 1980 and offices built during the 1980s.

Some offices are easier to convert into housing than others due to the type of construction. Those built during the nineteenth century are often of brick load-bearing wall construction. In many older towns, nineteenth-century housing has been converted into offices for solicitors and accountants or for doctors' surgeries. From a technical point of view, it is relatively easy to convert these buildings back into housing. Most offices built this century are constructed using steel or concrete frames, with a variety of different cladding systems and internal partitioning. The ease with which these can be converted depends on the following issues:

1. size and height of building,
2. depth and building,
3. building structure,
4. building envelope and cladding,
5. internal space, layout and access,
6. building services,
7. acoustic separation,
8. fire safety and means of escape.

The most important consideration in the change of use from offices into flats is that of meeting fire regulations, particularly because conversion introduces a new risk due to people sleeping overnight[7].

The technical feasibility of conversion depends upon the new use intended for a particular building. For example, it may be feasible to convert some buildings into hostels with shared kitchens and bathrooms, therefore minimizing the distribution of new building services installations, while conversion into single self-contained units may not be feasible because of structural constraints on running new services. These points are illustrated together with an indication of their implications for the economics of conversion in the case studies in the fifth section. In this section, we consider each technical issue, the limits to conversion, the effects of these limits on design options and the choice of technology for conversion.

Size and height of building

The size and height of the office building has implications for the potential number of units and occupant densities. This in turn may influence the choice of conversion for different types of occupants and whether a profitable rate of return can be gained from conversion. There is no optimum size for any particular type of conversion, although the size of buildings converted to date typically ranges between 1000 and 8000 m^2. Large modern office blocks of over 10 000 m^2 may, if converted, result in high residential densities with significant implications for building management and unacceptable pressures on local amenities and car parking space. Figure 2 shows the size and type of different offices in the City of London and the City fringe.

Building height is unlikely to be a major constraint on conversion, because the overall floor area is likely to impose limitations due to high densities which override the issue of height. Elderly and disabled people experience difficulties in gaining access to rooms in buildings above single-storey height and the additional fire risk for these occupants should be considered. In addition, families with small children prefer lower storey accommodation and policies of local authorities generally aim to minimize the need to place this type of household in high-rise accommodation. Access for other

[6] Vacant office buildings attract 50% of the full uniform business rate. This can significantly affect owners' cash flows. If, however, the building is rendered 'incapable of beneficial use' or 'uninhabitable', exemption from the UBR can be obtained. Taking a building out of beneficial use requires removal of major facilities which in itself can be expensive. This activity is known as 'constructive vandalism'.

[7] *The Building Regulations 1991* should be consulted when assessing the technical details of conversion (DoE, 1992).

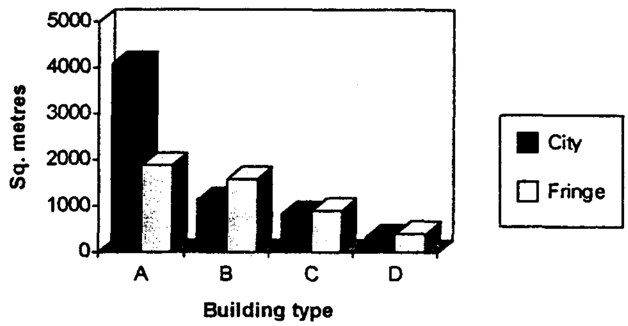

Figure 2 Mean size of empty offices, city and fringe, 1994. A, constructed after 1988, high technical specification, never occupied; B, constructed after 1988, high technical specification, second-hand; C, constructed before 1988, with air-conditioning; D, constructed before 1988, without air-conditioning. Source: Richard Saunders and Partners (1994)

residents in tall converted buildings is unlikely to present a problem because residential occupancy densities will be lower than those originally intended had the building been used as offices. Existing lifts and stairs are therefore likely to be adequate for most types of conversions. Problems may occur in some older buildings with single staircases, where the change of use to include people sleeping overnight will increase the need for adequate means of escape in case of fire. Other problems which may occur in residential use can usually be resolved by good management, for example, to ensure that lifts and access ways are well maintained and are free from obstructions.

Depth of building and internal layout

Office buildings designed before the 1980s often have a floor plan with shallow, cellular rooms located either side of a central corridor. The floorplate and depth of these buildings does not usually pose a problem for the design of conversions. Existing partitions generally need to be replaced or upgraded and they may need to be moved. This was the case in three different types of conversion.

1. Middlesex House, Brent, was a 15-storey, reinforced concrete frame office building, built in 1960. The key dimension of the building was its 13.3 m width, allowing a corridor to be placed down the spine and open plan offices on each floor to be subdivided into flats. The floor to ceiling height was sufficient to allow installation of suspended ceilings for services. Four two-bedroom flats and two one-bedroom flats have been created on each floor, with flats averaging 72.5 m^2. The final scheme has created a total of 78 housing association flats and various communal facilities (playgroup, youth project and a future mother and baby unit).
2. Allied House, London, is an eight-storey, purpose-built office building, constructed in 1964. The building has a concrete frame and the floor plan is rectangular. Some of the site is used as an NCP car park. English Churches Housing Group obtained permission to use the premises as a temporary cold-weather shelter. Initial impressions were that the building was too large for use as a hostel, but it was attractive because the existing division into offices was such that temporary double bedrooms could be created without the need for new partitioning (on one floor partitioning had to be reinstated). Existing toilets could be used on each floor and the building contained a fully fitted-out kitchen and canteen. Showers were provided in a temporary cabin located in the car park.
3. Jupiter House, Hayes, was a 1924 former office headquarters of load-bearing brick construction with a symmetrical floor plan, permitting an easy conversion into student study–bedrooms. Internal divisions between offices consisted of a mixture of lightweight and load-bearing partitions. The building is said to have an ideal floorplan because of its width and window spacing. The scheme proposed conversion to create 223 study–bedrooms, divided into flats, with mobility accommodation on the ground floor, an average of 5.2 studies per flat.

More recent buildings designed as open-plan offices tend to have deeper floorplates. The main consideration for conversion is the depth from central access and service points to windows – core to window depth. In deep buildings, problems may arise due to the desire to introduce natural lighting and ventilation into all habitable areas, including those close to the core. This follows current design practice in which most housing in Britain is designed to maximize day lighting and utilize natural ventilation. In consequence, there is a commonly held view that deep-plan buildings are unsuitable for use as residential accommodation, although conversions are feasible, such as at South Quays in the Docklands.

Nevertheless, it is feasible to design conversions for deep-plan office buildings in which kitchens and bathrooms can be located on internal walls leaving natural lighting in living areas. The conversion of Trade Towers at Plantation Wharf into luxury flats is an example of this type of design.

Trade Tower was originally designed as a nine-storey, mixed use building, with B1 class offices on the ground to sixth floor and penthouses on the top three floors. Construction began in January 1988. By December 1989, the developer recognized a downward trend in the residential market and changed the consent of the building to office use, at the same time adding three floors. The developer went into administrative receivership in August 1990 when the concrete frame was up to the tenth floor and the brickwork had been completed as far as the fourth floor. The receivers, with the support of the bank syndicate, decided to complete the external envelope of the tower and convert to luxury owner-occupied flats. The building has a footprint of 3200 ft^2 and floor to ceiling heights of 3.7 m with windows of up to 3 m high. Two staircases and three lifts were installed. A mix of one-, two-, and three-bedroomed apartments ranging in size from 550 ft^2 to 1900 ft^2 were created. Floor to ceiling windows were identified as the main advantage of the building in terms of its marketability as residential space. High ceilings were another feature not usually available in modern apartment buildings and these were used to contribute to a feeling of space in the building. The main living areas were designed to take maximum advantage of natural light. Bathrooms, kitchens and storage areas were located on internal walls to ensure that most living spaces had windows and views. The roof space, originally required for air-handling equipment, was opened up to create two rooftop penthouses.

The problem of gaining adequate cross-ventilation and removal of condensation remains and this usually requires installation of mechanical ventilation systems. Heat-loss through air changes can be minimized using heat recovery systems. Examples of deep apartment buildings in the United States demonstrate that such designs work effectively. Moreover, recent experiments at the Building Research Establishment demonstrated that adequate air flows can be achieved in buildings of up to 10 m in depth, using single-sided ventilation.

It can therefore be concluded that technical constraints to converting deep office buildings into flats are not insurmountable, but the cost implications will need to be evaluated in each individual case.

Building structure

The main issue of conversion relating to building structure is the need to install new service ducts. Piercing the structure with holes for services will also have implications for fire protection and acoustic separation.

Most office buildings are constructed with frames rather than load-bearing walls. The type of frame may affect location of services.

1. Steel-framed buildings are the easiest to convert because services can be run close to beams. Units can be partitioned along beam lines and services can be placed close to partition walls.
2. Concrete structures have shear stresses which are greatest close to beams and it is therefore better to pierce slabs in the middle of rooms. Unfortunately, this is often the least desirable location for services and such a design may result in odd-shaped bathrooms and kitchens, for example, in the case of Middlesex House.
3. Beam and slab concrete structures are more flexible for conversion than flat concrete slabs. Hollow pot concrete floor construction suffers from the problem of having wide strip beams which cannot be pierced for services.

Building envelope

Office buildings may be clad in a variety of different ways ranging from brickwork to patent glazing or curtain walling systems. Window heights in some office buildings may make them inappropriate for use as dwellings, particularly if floor levels are altered due to the removal of raised flooring. Three further issues relate to the type of building envelope: first, the need to reduce excessive solar heat gain from large glazed areas, second, the need to provide natural ventilation and, third, the need to fix higher quality internal partitioning suitable for residential use. Buildings with large panel or *in situ* masonry cladding systems are the most suitable for conversion.

The heat gains close to exterior walls clad in patent glazing and some curtain walling systems are likely to be too great for residential purposes, particularly if perimeter mechanical ventilation systems have been removed. Expensive modifications or recladding work will therefore be necessary for conversion into housing. Furthermore, many office facades have non-openable windows and modifications may be necessary to provide natural ventilation, for example, in the case of Trade Towers.

Most cladding systems are designed to accept partitioning on the inner wall or mullion. Mullion-type cladding fixings are unlikely to be acceptable for unit to unit walls in converted offices because they will not accept wide enough walls to provide adequate acoustic or fire separation. Patent glazing-type strip windows are less amenable to conversion. Wider mullion strips, or partition-receiving devices may be required in these cases.

Building services

The provision of building services to each new housing unit in converted offices is one of the most difficult and expensive technical aspects of conversion. Services such as hot, cold and drinking water and plumbing for sanitation are generally limited to core areas in office buildings. Heating is usually distributed from a central boiler and may be provided as part of an air-conditioning system. Offices with centralized air-conditioning or perimeter heating will need to have this replaced with unit by unit heating systems.

New supplies to and wastes from each unit will need to be installed in permanent accommodation. Additional ventilation and fire protection will be necessary if gas is supplied to each unit for cooking and heating. Such extensive work may not be necessary in temporary accommodation, as was the case in the Allied Lyons building.

Separate metering of gas and electricity will be necessary in most types of conversion. Furthermore, connection costs may be considerable if water authorities levy an 'infrastructure charge' rather than an individual charge for mains supply.

A system for household and kitchen waste disposal will be needed. This generally requires carefully planned building management, rather than a technical solution. However, the issue can be resolved in buildings with several lift shafts by converting one for waste disposal, as in the case of Middlesex House. External waste shutes should be avoided as they are unpopular with occupants, neighbours and building managers.

Acoustic separation

Conversions need to be designed to provide acoustic separation from sound transmitted in three ways: noise coming into the building from outside, unit to unit noise transmitted from one floor to the next and unit to unit noise coming from adjacent flats.

The degree to which noise from outside the building causes problems depends upon the performance of the facade. The main source of noise pollution in cities is usually from road traffic and aircraft. Noise from railways is usually found to be easier to tolerate, as in the conversion of a B1 office development at Richford Gate, Hammersmith. The problem of external noise increases where openable windows are installed, as is the case in most residential buildings. Double glazing helps to reduce noise and better acoustic insulation is achieved with systems in which each pane of glass is of a different thickness and where there is a wide gap between panes.

In buildings close to major roads it is advisable to plan the internal layout so that living areas are shielded from the noise source by locating utility and service areas facing the source. This may not always be possible and it will depend on the building's orientation. In deep buildings it will involve a trade-off between installing service areas close to the core with living space adjacent to windows and using service areas as a buffer against noise.

Most cellular offices have demountable partitions which are not usually designed to the acoustic standard required in housing. The conversion of most offices will therefore require installation of new unit to unit walls designed to meet the standards specified in the Building Regulations[8].

Designs which leave a gap between skins of internal walls and the mass of building material are important in reducing sound transmission. This usually requires construction of internal walls with an independent lining of double plasterboard, which should be free standing, rather than mounted against the party wall. Room to room sound insulation can be lower within each unit and stud and plasterboard partitioning is usually adequate.

Attention to detailing is very important in reducing noise. Small gaps can reduce acoustic performance. Holes for services should be kept as small as possible and gaps left around penetration of services should be packed with rockwool and sealed using a non-setting mastic. This should be used in all risers and ducts. Cross-talk attenuators should be fitted in ducts spanning between individual units.

Impact noise tends to cause more problems for vertically adjacent residents than other types of sound transmission: this can be reduced by installing carpets.

The level of vertical sound transmission depends upon the type of stucture. In the case of concrete slabs, these can usually be insulated using a floating floor made from tongue and groove chipboard, located on battens on a neoprene pad.

Additional independent false ceilings made from two layers of plasterboard can be installed. It is particularly important to seal junctions at the end of walls. Partitions should be taken to soffits, rather than to the false ceilings to stop flanking transmission.

Steel frame buildings may cause problems due to resonance which can be transmitted from lift motor rooms and other machinery. This noise source may not be noticeable in daytime office use, but it could be a problem at night in converted offices when residents are trying to sleep. Some of the noise can be buffered by designing the layout with a corridor around the lift shaft.

Fire safety

Every conversion scheme must comply with the 1992 edition of the Fire Regulations, which stipulates that any 'material alterations' to a building need to be approved[9]. A material alteration is deemed to be any change which is likely to increase the fire risk of using a building. The main issue in conversion of offices into flats is the

[8] See Section E of *The Building Regulations 1991* (DoE, 1992).
[9] See Section B of *The Building Regulations 1991* (DoE, 1992).

assessment of the 'sleeping risk', due to the change of use in which people will be sleeping in the converted building.

Designs must meet criteria in the fire regulations associated with the following.

1. Means of escape – this is likely to be adequate, especially where former offices were of a cellular design; the travel distance to means of escape needs to be checked.
2. Access for fire brigade – including provision of a firemen's lift and access to external facades, a proportion of which should be available for fire-fighting equipment.
3. Fire detection and alarm systems – these may need to be upgraded.
4. Means of preventing the spread of flames and provision of fire-fighting hoses in common areas.

Other factors which should be considered are the disposal of rubbish, which can conflict with means of escape and communal areas such as kitchens which may result in a higher fire risk and should be enclosed. Fire stopping of services risers to partitions and to suspended ceilings will also be necessary. Buildings constructed before 1980 will probably need to be upgraded with suitable fire-resistant doors between units and to means of escape.

Those seeking to convert offices into flats should first seek approval of fire regulations from the Building Control Office before contacting their local fire officer. Building Control should be given definite proposals on which to comment, in order to speed the process of approval. Building Control will then be in a position to contact the local fire officer and proceed with detailed discussions of the proposed alterations.

Technologies for conversion

A number of different approaches can be taken to the technology of conversion, ranging from the use of traditional construction materials and skills on-site, to fully prefabricated modular units.

The most expensive and labour-intensive aspects of conversion usually involve stripping out and installing new mechanical and electrical equipment for the distribution of water, gas, electricity, heat, light, air and removal of waste: up to 60% of the cost of refurbishment is in this element. Careful design, linking the planning of new layouts to provide ease of access for new building services can help to reduce this cost, for example, by making use of a redundant lift shaft for waste chutes. In some cases it may also be possible to specify the installation of small-bore waste services perhaps using vacuum pressure waste systems (successfully used in Norway) to minimize the need to punch large holes through the existing structure.

It is possible that some recently constructed open-plan offices would accept fully fitted-out plug-in modular units, reducing the time taken for conversion. The use of prefabricated techniques can provide significant cost and time advantages, by reducing the number of separate specialist trades required on-site, shifting tasks into factory environments. Nevertheless, this will require a change in approach to management of projects, in which activities in factories would need to be coordinated alongside site-based activities. This can result in hidden cost disadvantages.

However, the economic viability of this approach needs to be calculated against the number of units to be installed (high volumes for economies of scale is desirable) and the availability of off-the-shelf units. The Open Building Group in The Netherlands has experimented with such technologies for refurbishing 1950s apartment buildings, but existing catalogue items may not be suitable in most cases and it may be too expensive to develop prefabricated modules for each individual project. Nevertheless, if the volume of conversion work were to increase, prefabricated subassemblies for bathrooms, kitchens, walls, ceilings and floors could be used rather than fully prefabricated modules. Systems such as those manufactured by Toto are already used successfully in Japanese new-build and housing refurbishment.

Policy issues: choice of technology and flexibility of design

The experience of attempting to convert empty offices into flats indicates that only a small proportion of schemes are likely to be viable. No more than approximately 1000 bedspaces have been created in the UK so far, although we believe there is a potential to create 10 000 bedspaces in London alone. Conversion cannot therefore be seen as a panacea for meeting housing shortages.

There is no simple formula for the conversion of empty offices into housing. The success of conversion attempts depends upon the positive outcome of a wide range of social, political, economic and technical variables. For example, the right type of building needs to be found to meet a particular housing need, the building owner must be willing to agree to a change of use and an appropriate source of finance needs to be secured and it must be possible to overcome technical constraints in an economically viable manner. It is then necessary to gain planning consent for conversion. In most cases failure in one area will jeopardize the viability of the proposed scheme. But there are many different ways in which the positive outcome of these variables can coincide, resulting in successful conversion.

Technical constraints to conversion are rarely insurmountable on their own: the major technical points to be considered are summarized in Table 2, together with the degree to which change is possible.

We found the following.

1. It is technically easier to convert older brick-built offices or offices in former houses than purpose-built office buildings.
2. The ease with which purpose-built offices can be converted depends on the size and height of the building, its depth, envelope and cladding, internal structure, services, acoustic separation and fire safety.
3. There is no optimum building size, but large modern office blocks may result in unacceptably high densities if converted.
4. Technical feasibility also depends on the proposed use, for example, conversion into a hostel might be easier than conversion into permanent flats.
5. Office buildings designed before the 1980s are inherently easier to convert than modern buildings: steel-framed buildings are easier to convert than concrete structures because of implications for the installation of services. Buildings with large panel or *in situ* masonry cladding systems are more suitable for conversion.
6. The main fire safety issues are means of escape, access for fire brigade, fire detection and alarm, prevention of flames spreading.
7. A number of different techniques can be used for conversion, including the use of prefabricated modular units which may speed conversion and reduce costs under certain circumstances.

Many technical aspects of conversion relate to economic, planning, fire control and environmental health issues. It is essential that appropriate project management skills are employed to work through these issues simultaneously. Early negotiations with the relevant authorities can reduce the cost of subsequent changes made in meeting regulations. It is also necessary for developers to gauge the possible response of local residents especially to hostels and student accommodation. An early response to local concerns is essential to avoid delays in planning permission.

Successful schemes are those in which detailed site investigation work is carried out and original drawings are consulted. It is necessary to allow enough time for

Table 2 Technical limits to conversion

Limit area	Limiting factor	Degree of limit	Options
Site	Orientation	xxxx	Optimize internal layout
	External noise source	xxx	Double glaze and careful design of internal layout
	Car parking and amenities	xxx	
	External access	xxx	Redesign layout of external space
Size	Total floor area	xxxx	
	Height	xxxx	Improve access in high buildings
	Depth of building	xxxx	Optimize internal layout
	Floor shape	xxxx	Optimize space planning
	Grids	xxxx	Work within grids
	Floor to ceiling height	x	Reduce height using false ceiling
Structure	Penetration for services	xx(x)	Optimize internal layout
Envelope	Cladding	xx(x)	New glazing or cladding system
Services	Installation of services to individual units	xx(x)	Locate in new risers and/or in ceiling voids
Acoustic separation	Floors and partitions	x	Install new unit to unit walls and suspend floor
	Flanking transmission	x	Install partitions to soffits, install sound proofing in all ducts between units
Fire protection	Means of escape	xx(x)	Install new staircase or use air pressurization
	Access for fire brigade	x(xx)	Depends on changes to cladding
	Fire detection and alarms	x	Install new system
	Preventing spread of flames	x	Install fire stops in all unit to unit partitions and ducts

Degree of limit: change impossible, xxxx; change difficult, xxx; change possible, xx; change relatively easy, x.
Note: adapted from Boyd and Jankovic (1992, Table 2, p. 109)

detailed estimates, risk analysis and preparation of drawings which are required in a comprehensive tender document. The cost of project management should not be underestimated, but this expenditure can save money in helping to reduce the overall cost of construction work, through better planning of the process, leading to less waste and fewer variations.

Lessons for the future

Issues raised in this article relate to choice of technologies in building design, set within a framework relating change of use to flexibility in planning, the need for developers and property owners to maximize returns from their buildings and the need to remove urban blight and revitalize city centres.

A number of social, economic and political forces are creating new demands on the built environment. These include the need to contain urban sprawl, to reduce pollution and time wasted due to commuting and changing working patterns which are beginning to blur the distinction between activities carried out in offices and at home. To meet these demands, it is becoming more desirable to create vibrant districts within cities in which people can live close to their place of work. The Urban Villages Group was formed in the UK in 1989 to promote mixed-use urban developments and shift away from the out-of-date monoculture of separate zoning (Aldous, 1992).

To achieve this, buildings designed to maximize the potential for adaptation to accommodate different uses are required, together with appropriate transportation and communications infrastructures. Yet most buildings are designed to satisfy the needs of existing forms of use, they are rarely designed to meet future requirements. Moreover, most of the buildings which will be needed over the next 25 years have already been constructed. The issue is whether they can be adapted to meet changing uses. The costs sunk in the existing stock of buildings is enormous and it is inconceivable that this can be written off in the short-term to be replaced with new buildings. This means that a considerable amount of housing demand must be met from the existing building stock.

The quality of a building and its capacity for change of use depends to an extent on its location, its surroundings and the local infrastructure such as energy supply, communication facilities, parking and amenities, waste disposal, shops and recreation and transport nodes. It also depends on the building structure and fabric. Change of use can therefore be understood in terms of the degree to which different elements of the built environment can be adapted. For example, the urban infrastructure, such as street layouts, is difficult to change. This is at the highest level of permanence because change would require large resources and involve major planning considerations. Individual buildings are changed more frequently through demolition and new building activity. At a lower level, the partitioning, equipment and layout of many commercial buildings is frequently changed to meet different user requirements. Most speculative office buildings constructed to 'shell and core' specifications during the 1980s were designed to meet unpredictable patterns of use. Future unknown occupiers could 'fit-out' open plan floor spaces to meet their specific needs. These buildings provided the supports and basic services to accommodate a variety of office-related uses.

Viewing the built environment in terms of a hierarchy of levels, according to the ease with which changes can be made (Cuperus and Kapteijns, 1992), provides a fresh approach to making decisions about building use. Higher levels, such as the urban infrastructure need to have the capacity to support flexibility in lower levels, such as the structure, fabric and services within buildings themselves. The degree to which the fit-out of a building can be changed will therefore depend upon decisions made about the structure and core services provided. These decisions are made in the context of the perceived return on investment from different types of building occupancy.

A 'capacity to change' index (Brouwer and Cuperus, 1992) is required to promote increased flexibility in design: this could be added to the current BREEAM assessment methods (BRE, 1990, 1993) to encourage better future utilization of the built environment. The capacity to change depends to an extent on local infrastructure and amenities – there is a direct relationship between the way that design decisions affect the future use of a building and constraints imposed by planning and building control systems.

The fact that there is a large number of empty offices in undesirable locations in many cities indicates a failure of planning policies as well as of developer judgement. The recent property boom and slump indicates an increase in the speed of obsolescence of office buildings, demonstrating that too many buildings were designed to meet static user needs without consideration of the dynamics of building use. This has implications for the future designs of office buildings to meet unforeseen changes in use.

Empty offices in single-use zones have created ghost towns in our inner cities. The push for sustainable development may reinforce policies to locate traffic generators such as offices closer to public transport, rendering more of the existing zoned office locations and office buildings as marginal or undesirable. But to achieve sustainable development, the housing, employment and transport elements of local plans need to be brought together in a much more coherent manner encouraging lower energy use and higher density urban forms.

The conversion of redundant office buildings is one way of achieving this. Many office buildings in Fitzrovia and Clerkenwell in London are well suited for conversion and could help to create new 'urban villages'. In cases where it is not feasible to convert empty offices into housing, owners may wish to consider the option for mixed use, for example, by providing retail, health care and other facilities within schemes. Lack of space in urban areas as well as pressure against further greenfield development means that it is not always possible to provide detached, semi-detached or terraced housing. Reclaiming cities in which people can live as well as work will mean providing a variety of types of housing including flats.

Acknowledgements

The authors are grateful to the Joseph Rowntree Foundation for sponsoring the research discussed in this paper.

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