

Managing Building Adaptation

A Sustainable Approach



Maintenance and Repair

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Glossary

- **Corrective maintenance** - Any maintenance activity which is required to correct a failure that has occurred or is in the process of occurring.
- **Degradation** - Changes over time in the composition, microstructure, and properties of a component of material which reduces its performance.
- **Life cycle costs** - The present value of the total costs of a building over its operating life, including initial capital costs, occupation costs, operating costs, and the cost or benefit deriving from disposal of the building at the end of its life.
- **Maintenance** - Combination of all technical and associated administrative actions during the service life to retain a building or its parts in a state in which it can perform its required functions.
- **Performance Qualitative** - level of a critical property at any point of time.
- **Performance criterion** - Minimum acceptable level of a critical property.
- **Planned maintenance** - Maintenance organised and carried out with forethought, control, and the use of records to a predetermined plan.
- **Preventive maintenance** - Maintenance carried out at predetermined intervals or to other prescribed criteria and intended to reduce the likelihood of an item not meeting an acceptable condition.
- **Reactive maintenance** - Maintenance organised and carried out following tenants' complaints.
- **Refurbishment** - Modification and improvements to an existing building or its parts to bring it up to an acceptable condition.
- **Repair** - Return of a building or its parts to an acceptable condition by the renewal, replacement, or mending of worn, damaged, or degraded parts.
- **Service life** - Period of time after installation during which a building or its parts meets or exceeds the performance requirements.
- **Void repairs (void work)** - Maintenance carried out during tenancy turnover.

Introduction

Houses are complex man-made artefacts and can only survive by means of regular reinvestments in maintenance and adaptation. Maintenance is required to maintain a building's initial performance capacity. Without maintenance, performance will not meet the demand and eventually will drop below the limit of acceptance of residents. In practice, both the demand and the limit of acceptance will gradually rise over time as a result of improved technology, rising standards, and growing prosperity. Improvement and renewal are required to answer the accordingly rising expectations. As a result, the total life cycle costs will generally be a multiple of the initial building costs.

Maintenance is a combination of all technical and associated administrative actions during the service life to retain a building or its parts in a state in which it can perform its required functions. All building components have during their service lives to contend with degradation and performance loss through ageing, use, and external causes. The quality of housing is guaranteed by executing the right maintenance activities at the right time, preferably 'just-in time'. This assumes professional skill and a forward planning of maintenance and repair.

Tenure is decisive for maintenance management of dwellings. There are essential differences between rented and owned property, as well as between profit and nonprofit, and between single and common ownership. Social and institutional landlords are (as a rule) organisations with skilled professionals and a systematic approach to maintenance but have limited control on usage and care of the dwellings by the inhabitants. Single owner-occupiers generally lack any proficiency, but have (in principal) full control on usage and care. Small landlords in the private rented sector and condominium owners take a middle position, with limited control on usage and care and often lacking professional maintenance support.

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Social and institutional landlords maintain and improve their stock in a regularly planned way. The outcome of maintaining the quality of dwellings might be a 'combination' of residential (customer) satisfaction, liveability of the neighbourhood, ecological sustainability, and preservation of the value of the built assets. For homeowners, housing is an investment and consumption good. From a maintenance and repair perspective, housing as a consumption good seems much more important than as an investment good. Owners are in general aware of the main disrepair problems; however, maintenance and repair is often neglected. A forward planning of maintenance and repair is almost nonexistent. There is lack of awareness about the importance of maintenance and repair and financial and organisational constraints to work away maintenance backlogs. Improving the functioning and comfort of a dwelling rather than needed technical maintenance to maintain the initial performance capacity is a far greater motivation to carry out improvements.

Construction Activities

Construction activities for new buildings involve replacement and additional building. On the contrary, technical (property) management relates to construction activities for the existing building stock, that is, the distinctive activities of maintenance and improvement.

New construction in most Western countries has faded down below an annual production of 1% of the existing stock, and often well below. Parallel to this, the

ageing existing stock draws growing attention. The construction market is facing the shift from new built to improvement and the delivering of maintenance services during the service lives of houses.

Maintenance and Improvement

Maintenance means the neutralisation of the loss of performance of a building, to the extent that this loss of performance is acceptable. Whether this loss of performance is 'acceptable' or not depends, in turn, on the demands set by the owner and/or the user. Over a period of time, the gap between the standards demanded by the owner and/or user and those provided by the building is likely to widen, as shown in Figure 1. However, the representation is a very simplified one as, in reality, the relationship between the growth of residents' requirements and the deterioration of the performances of a building (dwelling) is usually nonlinear. Moreover, cleaning activities may slow down the deterioration in performance.

Acceptable performance loss and the implementation of appropriate maintenance activities depend on legal requirements, technical and functional motives, environmental motives, and financial means. Housing management organisations may apply different performance levels to different target groups (such as the elderly or students) identified in the asset management, assuming that the maintenance policy is related to their strategic asset management.

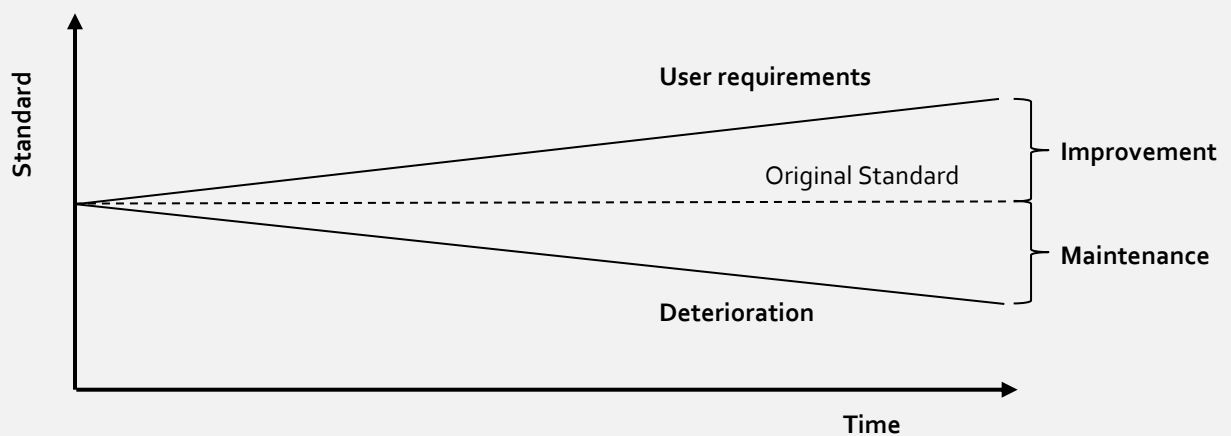


Figure 1: The distinction between maintenance and improvement. Adapted from Wordsworth P (2001) *Lee's Building Maintenance Management*, 4th edn. Oxford, UK: Blackwell Science.

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Maintenance Regulations and Legal Standards

Technical construction legislation sets the lower limits for the housing quality level. In any case, dwellings have to satisfy the minimal requirement of national legal standards for the existing housing stock. Legal standards comprise responsibilities for the owners to provide healthy conditions, construction and fire safety, energy performance, and proper working of installations for the supply of water, gas, and electricity, sanitation, space heating, and heating water. Building regulations are enforced by local authorities building control officers.

Obviously, owner-occupiers are responsible for the quality of their home. In the case of housing providers and tenants, the tenants often have some responsibilities, addressed in the national private law or the rent contract.

Decent Homes Standard

Each of the devolved administrations in the United Kingdom has a national housing quality standard: The Decent Homes Standard in England and Northern Ireland, the Welsh Housing Quality Standard in Wales, and the Scottish Housing Quality Standard in Scotland. The Decent Homes Standard is a technical standard for public housing introduced by the UK government in 2000, which aimed to provide a minimum standard of housing conditions for all those who are housed in the public sector – that is, council housing and housing associations. The criteria for the standard are as follows:

- It must meet the current statutory minimum standard for housing
- It must be in a reasonable state of repair
- It must have reasonably modern facilities and services
- It must provide a reasonable degree of thermal comfort.

The standard was updated in 2006 to take account of the Housing Act, 2004, including the implementation of the Housing Health and Safety Rating System (HHSRS).

Maintenance in the Dutch Civil Code

The responsibilities of landlords and tenants in the Netherlands set out in the 'Besluit kleine herstellingen'

[Small repairs decree, 2003], derived from the Dutch Civil Code (7: 240). In general, tenants are responsible for small repairs. Tenants' obligations regarding maintenance are conditional on the accessibility of the building component to be repaired, and restricted costs relating to the repair. All other repairs fall under the responsibility of the landlord, with the exception of adaptations and additions made by tenants and defects that are resolved by tenants. The tenant may ask the landlord to perform small repairs that fall under the tenant's. In that case, the landlord is allowed to charge the tenant for the costs of making these repairs. In order to stimulate Dutch landlords to perform maintenance, the 'gebrekenregeling' [arrangements relating to defects] was set up in 1999. This arrangement enables a rent committee – that is, an independent arbitration board that is in charge of settling disputes between tenants and landlords – to decide on rent decreases in the case of a certain defect. These decreases may amount to 20% of the statutory maximum rent. The actual size of the rent decrease is dependent on the severity of the defects.

Market Regulations

European public tendering rules for (maintenance) services and works apply to public and private social housing organisations that use public funds. moreover, national public procurement rules apply under the European threshold for public entities in, for example, Belgium and France. The fundamental principle of public procurement rules is that the contracts with a budget higher than a defined threshold must be opened to a nation-wide or EU-wide tender. Key questions are then the extent to which maintenance jobs reach the thresholds and whether the maintenance constitutes works or services. While the methods of tendering for these categories are largely the same, different thresholds are involved, meaning that a shift in the application of procedures and regulations may occur. Regular planned maintenance, void repairs, and response maintenance in the dwelling may all be considered to be 'services', unlike major maintenance

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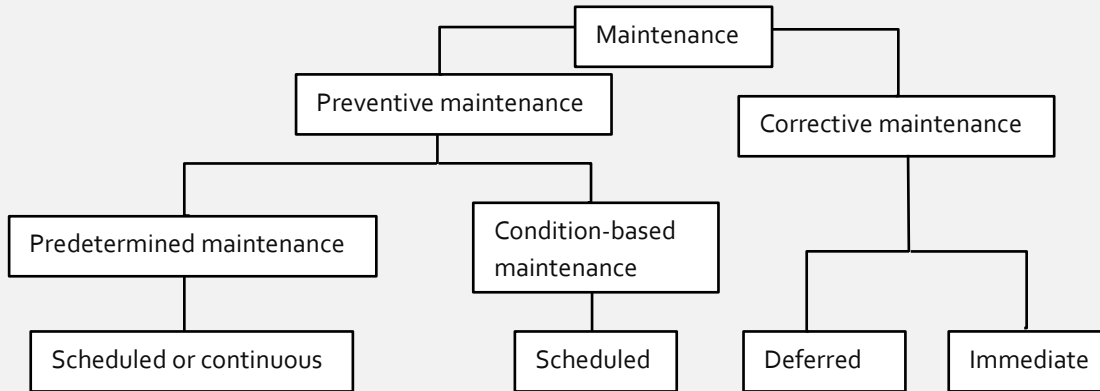


Figure 2: Maintenance overview. Adapted from CEN (2001) EN 13306 Maintenance Terminology. Brussels: CEN

and refurbishment, which may be considered to be 'works'.

Maintenance Processes

Generally, maintenance can be divided into preventive and corrective maintenance. Preventive maintenance is carried out at predetermined intervals (e.g., time-based or use-based) or to other prescribed criteria (e.g., defects and condition) and intended to reduce the likelihood of an item not meeting an acceptable condition. Corrective maintenance is any maintenance activity which is required to correct a failure that has occurred or is in the process of occurring (see Figure 2).

Homeowners and housing providers are free in choosing the appropriate instruments for the asset management and maintenance management being used in maintaining their house(s). Owner-occupiers reinvest less regularly in their homes than large property owners. Maintenance is mainly reactive and corrective. In several countries condominium owners are forced to make a preventive maintenance planning.

Housing management organisations have to decide to emphasise preventive or corrective maintenance in its maintenance policy and maintenance services. Normally, the maintenance services are divided into three managerial processes as follows:

1. Planned (preventive) maintenance: activities scheduled at regular intervals;
2. Reactive maintenance: realised on residents' initiatives (complaints), often after breakdowns

(also called responsive maintenance or daily maintenance); and

3. Void repairs: maintenance realised in between tenancy periods.

By far, the majority of planned maintenance work is conducted to the exterior of houses. Concurrently, by far

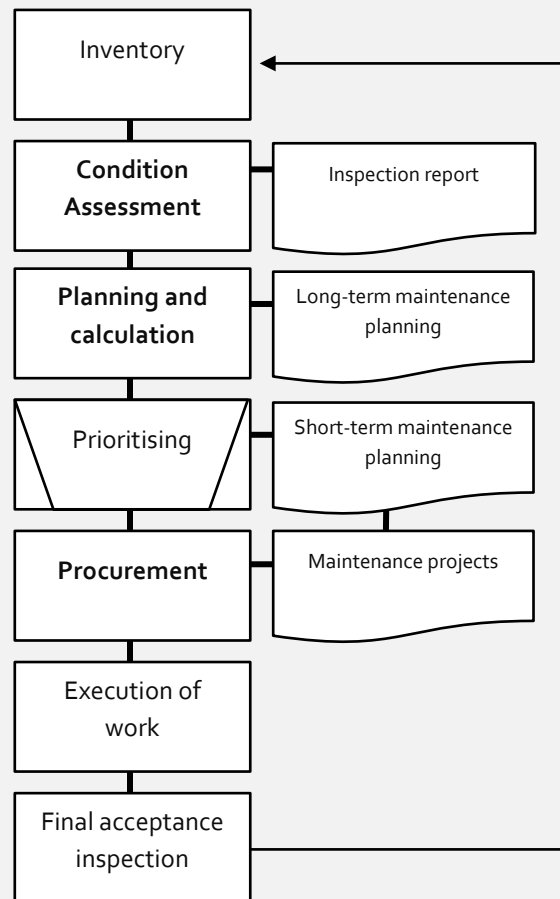


Figure 3: Maintenance planning and execution process.

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the majority of reactive maintenance is conducted by housing management organisations inside dwellings. Residents are being confronted by the execution of planned (preventive) maintenance at their own dwelling, and in case of multifamily dwellings, the common parts of the building. Moreover, residents are directly involved in reactive maintenance (emergency and reactive day-to-day repairs) in the request of repairs and the set of appointments.

Often separate departments of housing management organisations are responsible for construction and maintenance. In addition, most organisations have separate departments for planned maintenance and for response maintenance and void work.

The strategic asset management and maintenance policy of a housing management organisation should be based on objective, reliable information about the performance of housing estates, dwellings, and building components. Data are required on the technical state of building components, the housing quality (e.g., services, kitchen), the environmental quality (e.g., use of materials, energy use, water use, kind of heating system), adaptability for changes in housing and environmental quality, and the realised costs for maintenance and improvements. Property managers may use a selection of relevant maintenance data for policy-making.

Planned Condition-Based Maintenance

A condition-dependent approach to maintenance leads to a decoupling of condition assessment from the determination of maintenance activities and maintenance planning. It also provides possibilities for differing performances of building components and formulating performance levels, to control performance and to work with maintenance contractors in a new manner.

The design of the maintenance planning and execution process is of crucial importance to secure the performance of the building components. Generally, the process of maintenance planning and execution takes place as shown in Figure 3. Condition assessment, planning and calculation of maintenance activities leading to the long-term maintenance planning, and

procurement of the maintenance work are key processes in condition-based maintenance. Not all (sub)processes are shown in Figure 3. For instance, budgeting and budget control are left out.

Data collected during a condition survey on-site are needed for strategic policy-making to underpin the long-term maintenance cost expectations and for maintenance planning by the maintenance staff.

The short-term maintenance planning leads to maintenance projects that have to be executed in the following year(s). The goals of the housing management organization and the characteristics of maintenance services determine the used procurement methods. Generally, a distinction can be made between a prescriptive and a nonprescriptive method. Traditionally, housing providers tendering maintenance services use a prescriptive, detailed specification of the work to be performed. Performance-based specification is an alternative to traditional prescriptive specifications for maintenance.

After the procurement process, the work is carried out by an external maintenance contractor or by direct labour, followed by a final acceptance inspection. The process will start all over again with an inventory of the building components or with a condition assessment.

Performance and Defects

All building components have to contend with performance loss through ageing, use, and external causes. Performance and performance loss can be seen as the opposite of degradation and defects. However, this observation is too simple, because the initial performance requirements of building components are so many and because the knowledge about performance loss and service life, and performance loss, degradation, and visual defects is limited or unknown for many building components. The relationship between degradation and performance loss could take place according to three patterns as follows:

1. Performance loss manifests itself as continuously decreasing while degradation continuously increases

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2. The performance remains constant while degradation declines continuously; performance loss is manifest abruptly
3. Performance loss and degradation act independently.

This distinction is essential to know the turning points in performance loss and degradation and to determine optimal points of time for maintenance actions. Under ideal circumstances, it would be possible to have the maintenance of a building completely planned into a series of cleaning and replacement cycles (preventive and 'just-in-time'). If failures have occurred, one has to carry out repairs (corrective maintenance).

Condition Assessment

Data collected during a condition survey on-site can be used for the maintenance planning of each building. Supplementary technical information, like the size and location of defects, is needed for the detailed planning and executing of maintenance work. Although the actual performance of most building components can be measured directly, using destructive and nondestructive instruments, in practice the performance of building components is measured indirectly by assessing visual

defects. This is done by performing a defect assessment. The defect assessment is called condition assessment if a rating scale is being used. The use of condition marks of building components makes the technical status transferable between building inspectors and property managers. Property managers can exercise control over maintenance performance levels and maintenance costs. It also makes the technical status transferable between the maintenance department and the department and employees involved in setting up the asset management.

Dutch Standard for Condition Assessment

As a result of several research projects and the use of the method by the Dutch Government Buildings Agency and in the Dutch Housing Quality Survey, the process of condition assessment using a six-point condition scale has become popular with property managers,

consultants, and contractors in the Netherlands. The six-point scale is the basis of the standardised method.

The condition categories are of a chronological order that describes possibly occurring defects without references to remedial work. **Table 1** gives the general descriptions of the condition marks. The condition assessment process follows the pattern in **Figure 4**. The assessing of defects occurs first. Without this information one could not formulate maintenance activities and estimate costs. Subsequently, the inspector passes through the following condition parameters: importance of defects, intensity of defects, and extent of defects. The extent and the intensity of a defect combined with the importance of the defect lead to a condition mark, probably with a defect score as an intermediary product.

The importance of the defect indicates to what extent it influences the functioning of building components. The Dutch Standard for Condition Assessment classifies the importance of defects of distinct building components into minor, serious, and critical. Critical defects significantly threaten the

Condition mark	General condition description
1	Excellent
2	Good
3	Fair
4	Poor
5	Bad
6	Very Bad

Table 1: Six-point scale (Dutch Standard for Condition Assessment)

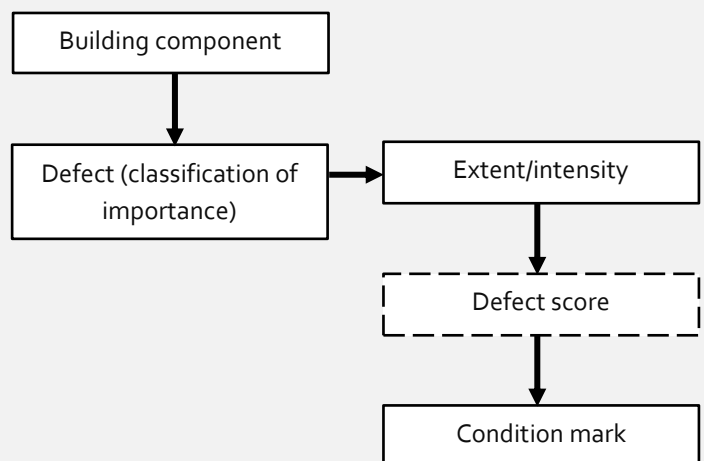


Figure 4: Condition assessment process: Dutch Standard for Condition Assessment

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function of the building component. Serious defects are gradually damaging the performance of building components, for example, defects in the material surface. Defects to the finishing, for example, coatings, are classified as minor defects. We give an example of the defect list for window frames, door frames, windows, and doors (see **Table 2**). important to notice is the fact that for finishing coats a separate defect list exists.

Planning and Calculation of Maintenance

Formulating maintenance performance levels in planned maintenance means deliberating about the maximum performance loss, the appropriating maintenance activities, and the needed financial means. Input for the planning and calculation phase and also the prioritizing phase of condition-based maintenance are the available budget for maintenance (per building estate) and the

desirable quality. In general terms, housing management organisations use three quality levels: a basic level, a lower level if a technical intervention of the housing estate (e.g., refurbishment) in the near future is foreseen, and a higher level that is based on the position of the housing estate on the housing market.

The maintenance planning can be adjusted to one of these levels through setting requirements for the type of maintenance activities, the use of materials and the maintenance activity cycles, and by setting priorities. Insufficient budget means priority setting of maintenance activities. Maintenance activities can be distinguished according to the type (cleaning, repair, and replacement), the part of the building component to which an activity applies, the specification of materials, the quantity of the work, the frequency of short cyclical preventive maintenance actions, and the character of an activity (preventive or corrective).

Importance	Type	Defects
Critical	Basic functioning	Sealants defect Be ajar Leakages
	Basic constructional Material intrinsic	Cramps defect Wood rot Moisture retention Capillary moisture absorption Cracks Cold bridges Condensation
	Basic quality	Wrong use of materials Failing drainage constructive parts Sharp edges jambs and sills
Serious	Minor constructional	Distortion Missing parts Connections undone Failing stiffness and stability
	Material surface Basic quality and ageing of secondary components	Mechanical damages Ironmongery defects Failing width windows Failing outline Failing putty and sealants glazing and panels Nonprofessional repairs
Minor	Finishing	Algal growth, moss Pollution, surface deposit Discolouration
	Basic quality and ageing of tertiary components	Failures secondary fastening Failures element parts Defects connections frames and wall

Table 2: Defect list: window frames, door frames, windows and doors (Dutch Standard for Condition Assessment)

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The planning and calculation of maintenance activities can occur on the basis of standardised performance levels: the (minimum) condition of building components after executing maintenance work, for example, by setting a lower limit in a condition rating scale and thereby setting norms for the maximum performance loss. Maintenance managers are able to do so by forecasting the condition status of building components after executing maintenance activities, dealing with more and less acceptable remaining defects.

To perform efficiently and effectively, the performance of a building component after executing maintenance work should be clear. However, general knowledge about maintenance activities and performance recovery is scarce. After an integral replacement of the component, the condition status will be as new. In case of partial replacements and repairs, the condition gap and the performance recovery before and after execution of the maintenance activity are indistinct. The new condition depends on the solved defects at that particular moment of time. Cleaning and repainting of surfaces does not influence the technical performance of substrates. The degradation will just process more gradually. Nevertheless, the aesthetic performance of a surface improves. Through a functional material modification of the building component performance alterations take place: the characteristics of the building component change and the original performance capacity increases.

The short-term maintenance planning leads to maintenance projects that have to be executed in the following year(s). Condition assessments are not meant for short-term maintenance planning and drawing up technical specifications. Supplementary information, for example, the precise location of the defects and causes of defects to take adequate maintenance actions, is needed in the phase of preparing procurement and execution of remedial work.

Maintenance Procurement

Maintenance work is being executed based upon a prescriptive technical specification or a performance-based specification. A technical prescriptive specification means that the throughput of the maintenance contractor is being described, not the result of the maintenance work. Housing management organisations

procure the majority of planned maintenance projects traditionally through a process of soliciting three to five competitive bids and choosing the lowest one.

Performance-based specification is an alternative to traditional prescriptive specifications for maintenance. The performance-based approach means that maintenance contractors no longer act as suppliers of maintenance work capacity but as active participants in the overall maintenance process. They give advice on maintenance strategies, maintenance scenarios, performance specifications, and activities. First the housing management organisation has to specify performance requirements for its housing estates. Then the requirements are specified at the operational level based on functional statements of the building components, for example, construction safety, aesthetic performance, and energy saving. The performance requirements and the maintenance budget and exploitation period that apply to each housing estate are input for the maintenance contractor. The contractor develops maintenance strategies within the constraints of performance criteria, maintenance budget, and exploitation period. Initially, contractors need to assess the condition status of the building components to diagnose the causes of deterioration and the climate conditions to make recommendations on the likely success and performance of remedial measures. The remedial measures are set down in maintenance scenarios and activity plans, presenting net present values of life cycle costs and performance criteria.

The result of maintenance is indicated as the performance of building components. A performance-based maintenance partnership can be based on the minimum performance of building components. To verify the results, a minimum percentage of measurements, taken at random, should meet the performance criteria. Criteria are expressed in the properties of defects, such as size, percentage, and intensity. Long-term agreements should include performance criteria at the start (completion of work) and at the end of the contract period. In a performance-based partnership, the contractors themselves measure the achieved performance after completion of the work and report to the housing management organisation. The housing management organisation assesses the completion of the work and the performance

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measurements undertaken by the contractors. The contractor is made responsible for the performance of the building components during a certain period. This implies that the contractor periodically monitors the degradation processes of building components using performance measurements and reports on the agreed performance criteria to the housing management organisation.

Maintenance Supply

The supply market for homeowners' maintenance differs a lot from the supply market for professional housing providers. In the first place a lot of maintenance work is done by the homeowners themselves, served by the do-it-yourself market. The illegal 'black' market is also quite important. Next, homeowners face problems in selecting reputable builders. Often, the professional market working for homeowners is far from professional, lacking the needed skills and competences.

Housing management organisations will carry out the maintenance work by direct labour organisations (in-house) or contract it out to maintenance suppliers. Debates about the benefits of employing tradesmen directly concern financial, managerial, and technical performance as well as ideological arguments. In the Netherlands, housing associations' own maintenance departments are responsible for a small portion of total maintenance expenses, being less than 10%. However, in the United Kingdom, for example, the market share of direct labour organisations is much greater.

The maintenance market is traditionally divided into multiple sectors like (small) construction work, roofing, painting and decorating (including plastering, tiling and glazing), heating and ventilation, plumbing and drainage, and electrical. Many small and medium-sized suppliers operate in the maintenance market. Some are specialised, whereas others combine multiple disciplines. The high degree of fragmentation and lack of transparency in the market hinder the creation of long-term competitive advantage. Competition is mainly on costs and on personal contacts with clients, the latter being a condition for involvement in tenders or being awarded private contracts.

The considerable fragmentation is connected with the low entry barriers to the sectors, which, in turn, are linked to low levels of investment needed for a

business start-up. The fact that labour takes a high proportion of the costs makes it difficult to achieve economies of scale. The substantial amount of labour in the process and the relative simplicity of the implementation processes almost preclude improvements in productivity. Furthermore, each customer has different maintenance requirements, which means that adjustments have to be made with every new contract. Certainly, in the case of planned maintenance, almost every contract is unique, which hampers development and the repetition of methods and techniques. Neither may improvements in productivity be allowed to detract from service quality, which cannot be taken for granted in view of the front office's major role in service provision (many workers are in contact with the residents). Transport costs are another relatively important factor in the maintenance process, binding services to a particular area, and further hampering economies of scale. Some sectors are also affected by cyclical and seasonal fluctuations, which is another obstacle to long-term investment. This means that there is no guarantee of continuity, forcing companies to keep fixed costs low. Finally, many maintenance companies are one-person or family businesses, meaning that there are emotional exit barriers in addition to purely commercial ones. Many factors thus explain the fragmentation of the sector. Attempts are sometimes made to erect barriers to entry, particularly in specialised market sectors. This takes the form of process certification. Certification acts both as a barrier to new entrants and a quality guarantee for housing management organisations and homeowners.

Residential Satisfaction with Maintenance

An important measurable outcome of maintaining the quality of dwellings for social and institutional landlords is residential satisfaction. A way of examining residential satisfaction with maintenance is by measuring the number and severity of complaints and to examine the scores given by individual residents on attributes of the quality of service supply. Another way of securing high-quality service supply is to measure occurrences. For the result of maintenance, this is usually done by supervising activities carried out, particularly in the case of planned

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maintenance and void repairs. For reactive maintenance it is possible to track crucial moments in the handling of complaints, such as the information supply to the resident about the maintenance process.

The determinants of service quality by maintenance contractors are directly related to the general determinants of service quality, being reliability, responsiveness, assurance, empathy, and tangibles (appearance of physical facilities, equipment, personnel, and written materials). The determinants of service quality by maintenance contractors are as follows:

- Sticking to execution planning agreements
- Flexibility in making appointments
- Provision of information before the start of maintenance activities
- Resident participation in maintenance through options
- Evaluation and service recovery
- The quality of the result of maintenance
- The competence of maintenance workers
- Limiting the time taken for the work
- Completing maintenance activities in a single visit
- Having maintenance workers wear smart uniform overalls
- The politeness of maintenance workers
- Being addressed in the language of the resident
- Being available to answer questions and receive complaints
- Avoiding damage to personal property
- Limiting nuisance caused by noise and vibration
- Limiting and tidying up litter and dust around the work site.

The most important aspect from the perception of residents is 'the quality of the result of maintenance', followed by 'the competence of maintenance workers' and 'completing maintenance activities in a single visit'. The latter implicates that maintenance workers perform their maintenance job without unnecessary rework or extra site visits.

See also: Housing Pathology; Private Sector Housing Management: Europe.

Further Reading

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