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Building cost and eco-cost aspects of tall buildings

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Peter De Jong

Ing. P. (Peter) de Jong is a lecturer in Design & Construction Management and Building Economics at the faculty of Architecture, department Real Estate & Housing of Delft University of Technology. De Jong teaches
Buildings Costs and Cost Awareness during Design, amongst others in the High Rise Workshop. This workshop has been an ultimate challenge for several hundreds of (international) students over the past 16 years. Inspiring lectures of special guests like Klemencic, Poon and Zils, and the stimulating work of the founding fathers of this workshop, Berenbak and Vambersky, triggered De Jong to go more into depth on High Rise Cost Modelling as subject of a doctoral research. The first focus is on building costs in the (conceptual) design phase but other aspects in the (social and economic) feasibility, like the (Dutch) market for high rise, land use and policy, regulations, acceptance and sustainability are becoming at least equal important chapters.

Hans Wamelink

Prof.dr.ir. J.W.F. (Hans) Wamelink has been appointed as professor of Design & Construction Management in the faculty of Architecture, department Real Estate & Housing of Delft University of Technology since April 2006.
His main focus is on the co-operation between the various parties involved in the building process, the relation between costs and quality, on steering possibilities in development and realization of building projects. Topics in the research within the chair of Design & Construction Management are design management and building process innovation. Wamelink is doing research on what kind of tools are needed to reduce these high failure costs, new ways of contracting that will facilitate the parties to work together in a different way and comparison of problems in the building sector with similar and different industries abroad. Wamelink is promoter of amongst others Peter de Jong. After the retirement of Berenbak Wamelink took up the High Rise Workshop.
Wamelink is also partner of Infocus, consultancy and building management.

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Abstract

Compared to other countries, the Netherlands is hardly a leader in the development of tall buildings. Only a limited number of Dutch high rise projects have actually been realised. Numerous plans exist, however, making this a pertinent time to take building costs analysis to a higher level. A cost model is used to integrate and evaluate existing European research. The objective was to obtain a detailed estimate of the building costs of high rise office buildings in the initiative and early design phases, while limiting the number of required design parameters to those known at the initiative phase. The research began by conducting a literature review and interviewing experts working on high rise projects and cost modelling. This resulted in an integrated model, which is currently being evaluated. The eventual model will be used in future design and construction initiatives.

As far as developers are concerned, building costs are only part of a project's steering attributes. Compared with low rise projects, the earning capacity of high rise office buildings is more limited by the efficiency of floor plans (the ratio of lettable floor area to gross floor area). Reaching the limits of the feasibility of high rise projects, externalities become very important. Many stakeholders must be convinced by the qualities delivered. From this perspective, sustainability is a key factor. We examine how the Eco-cost/Value Ratio can be appropriately combined with the cost approach, offering insights into the sustainability of tall buildings.

Keywords: Building costs, Eco-costs/Value, Real estate & urban economics, Integrated building cost model, Initiative design phase

Introduction

Basically, an estimate of building costs at element level can be made in the following way: first, consider the cost of the element; then, find out how much of the element is needed in the building; the total cost per element is given by the quantity multiplied by the cost per element; and by adding up the total cost of all elements, the 'direct building costs' are obtained. If one adds the cost of the contractor, one knows the 'building costs'; and if one includes land costs, additional costs and taxes, *voila*: the investment is revealed.

The same approach can be used to calculate the 'environmental load.' Determine the depletion of materials, the energy consumption, and toxic emissions, and by elaborating all the building quantities, the environmental burden of producing the building, or the total 'damage' to the environment, is also revealed.

Every factor listed above could be the subject of an entire article, of course. In Dutch regulations, for example, the meaning of 'additional costs' is constantly being redefined. The upcoming standard regulation will lead to yet more amendments, due to the impact of the redefinition on the parties involved. The process of agreeing on international definitions of methods and terms in the field of sustainability is only just beginning.

The statue in Figure 1, Ossip Zadkine's 'Ruined City,' is an icon of war damage and the rebuilding of Rotterdam following the bombardment of the Second World War.

Figure 1: Zadkine's 'Ruined City', Rotterdam

Due to its shape, placement and surroundings, the sculpture is also becoming an icon for high rise, for which Rotterdam is nationally renowned. It may become an icon for high rise modelling as well. In this paper, the sculpture is seen as symbolic of the mutual interests shared by developers and municipalities, in which costs as a step-up to value and sustainability are set next to each other, and in which the relationship between the two is tackled.

This paper is one of the interim outcomes of the 'High Rise Ability' (HRA) research project (De Jong, Oss et al. 2007; De Jong, 2007a), which focuses on building costs. Feasibility is much more influenced by location and market and less by quality, however, than one might expect (Koppels and Remøy, 2007). As a colleague working in Hong Kong put it, 'Land costs are so dominant, it does not matter how you make high rise, as long as you make it!'

The cost of land is one reason for going higher in very dense sites such as Hong Kong, New York and London. Nevertheless, the establishment of 'super high rise' has almost ceased in the United States. The economic limits seem to have been reached. During the last five years, for example, no high rise building in New York passed the 250m mark, aside from the Bloomberg Tower (roof 246m) with its antenna (287m).

The HRA research project aims to clarify these economic limits, focusing on the Dutch context. The project's starting point was the fact that building costs have a large impact. Impact and size are different entities, however. Even when one is talking in millions, building costs as a proportion of construction costs play a modest role in the total process, due to the following factors:

- Building costs only form part of the total investment. In a feasibility study, land costs and other additional costs may become more of a focal point and are more negotiable.
- Value creation can mean more to a project than only considering the cost-side of the balance. This is particularly the case in the initiative phase, in which the building costs or even the investment may be treated as a fixed figure, or based upon indices and the required gross floor area (GFA). A project's sustainability seems to become more important in negotiations and in terms of willingness to pay; the municipality, as well as some tenants, will consider a sound environmental approach to be of added value.
- Building costs and total investment costs are only a fraction of life cycle costs. The design itself may have a large impact on the life cycle costs, however.
- The building costs appear to be extremely modest when compared with the turnover of a building during its lifetime (Ward, 2007). Design and building costs can have a huge impact on whether or not a building meets its users' needs, and thus the turnover.

At the same time, it is vital to have a proper understanding of building costs. In this field, where market, rental revenues and land costs are hard to adjust on a given location, all participants are looking to design to provide a way out. The designer(s) must consider future users' needs in order to trigger willingness to pay. A project's feasibility depends on the balance between revenue and expenditure. To a significant degree, the total investment depends on the relation of building costs to design. The building costs become even more critical, because other factors such as general contractor costs, building site costs, design and advisory fees, taxes, interest, and so forth, are related to the building costs. This is at least the case in the early stages, when the percentage approach is very common.

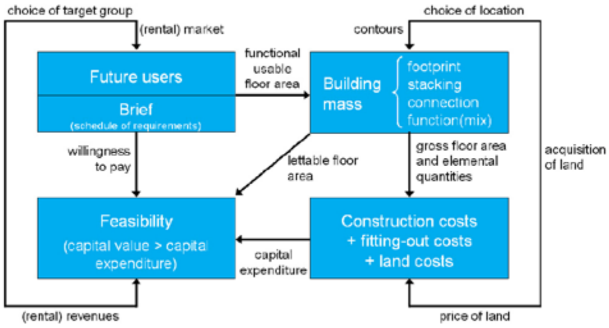

Figure 2: Development of buildings. Source: Soeter et al. (2005)

Likewise for the Living Building Concept (De Ridder and Vrijhoef, 2007), where creation of value in a dynamic situation is the key focus and rapid reflection on costs is a recurring issue, making quick tools necessary.

Focusing on building costs would thus seem a useful contribution to Dutch high rise building practices. The results of the HRA project reveal, however, that the Dutch market for high rise is far from healthy. Unlike in London (Kalita and Watts, 2007), commercial rents and land values are too low for the development of substantial tall buildings, and developers are searching for boundaries. With local government as the key actor in land supply, feasibility depends on land policy. Local government has its own urban arguments for high rise. Given the Dutch political climate, social feasibility with a focus on sustainability will be the only option to change land policy to make high rise financially feasible. Sustainability, which is elaborated in the second part of this paper, is thus one of the HRA project's main research topics.

Specific high rise costs

Looking around the world, one finds many different definitions of high rise/tall buildings. The HRA research uses a physical lower limit of 70m, due to the fact that specific regulations are applicable in the Netherlands from that height upwards. In Germany, 'high rises are buildings in which the floor of at least one occupied room is more than 22m above the natural of a prescribed ground level' (Kloft, 2002). This is also related to fire protection and effective use of fire escapes.

A more appealing definition is offered by the Council on Tall Buildings and Urban Habitat: 'A tall building is not strictly defined by the number of stories or its height. The important criterion is whether or not the design, use, or operation of the building is influenced by some aspect of tallness.' Otherwise, it would just be a case of stacking floors. According to this definition, high rise projects are buildings in which specific measurements are taken with regard to that height.

The Council's definition includes specific measurements, and therefore specific costs. Langdon and others note the peculiarity of these additional costs (Reus, 2004; Watts, 2002; Watts et al. 2002), which include:

- increased wind loadings and heavier frames;
- vertical transportation requirements, particularly elevator capacities, speed, zoning, and so forth;
- the larger capacities of plant and distribution systems, together with the increased pressures or hydraulic breaks that are required to deal with the increased vertical distances;
- the effects of the buildings' scale and complexity on the movement of materials and labour;
- the risks associated with the unique nature of the buildings, and the fact that these risks are intensified by scale and the need to access a limited pool of skills and expertise;
- the potential interest in including elective security and safety enhancements in response to possible risks.

The literature suggests the introduction of a height charge as one means of coping with these effects; this factor brings the additional costs for the specific conditions into account. Gossow (2000) offers a detailed example of such a charge.

Height	150	200	250	Height charge
Cost (€) structural work offices per m³	140	155	170	0.0021
Cost (€) completion offices per m³	160	160	170	0.0006
Average				0.0014

Figure 3: Height charge. Source: Gossow, 2000

Using the factor of Figure 3 should only be possible after indexing the costs (columns 2-4) to the actual year of building. The height charge itself will be more resistant to the influence of time.

Building cost model

The HRA project aims to gain insights into the economic context of high rise in the Netherlands. This should result in an applicable product, namely, a calculation model for building costs and the financial feasibility of high rise (the HRA model). This calculation model will be achieved by means of a building cost model, which will then be transformed into a design model.

In the Netherlands, the number of realised high rise projects is limited. Project-based research has been carried out into the investment costs of high rise buildings. The following research uses a cost model to integrate and evaluate existing European research. Our objective was to obtain a detailed estimate of the building costs of high rise office buildings in the initiative and early design phases, while limiting the number of required design parameters to those known at the initiative phase. The research began with a state-of-the-art literature review, and interviewing experts working on high rise projects and cost modelling. This resulted in an integrated model, which is now being evaluated in practice.

The modelling approach is based on the 'Svinsk' model developed to calculate an initial cost estimate for office buildings (De Jong, 2006), and the PARAP research (Bijleveld and Gerritse, 2006). This PARAP research started with the analysis of historical data, providing the layout for a descriptive model, and ultimately developed into a more designer rule-based application. The HRA model focuses on buildings in the range of 150-250m. Historical Dutch data cannot take the effects (as summarised by Langdon) into account, due to the fact that there are no buildings of that height in the Netherlands. There are, however, numerous high rise initiatives in the 150-200m range, suggesting that there is still valuable further research to be done in this field.

The HRA model describes the characteristics of high rise buildings and defines essential parameters. This interim result was needed in order to analyse the reference projects, case-studies and interviews. Experts were selected for interview on the basis of experience. The interviewees included contractors, developers and advisors with experience of Dutch high rise projects (that is, the most substantial contributors to the 20 highest buildings in the Netherlands). A few international experts were also interviewed. The information collected was used to draft the model. After the model was finished, the information was re-verified with the same parties, and tested against several actual proposals in different phases, from initiatives to tendered plans.

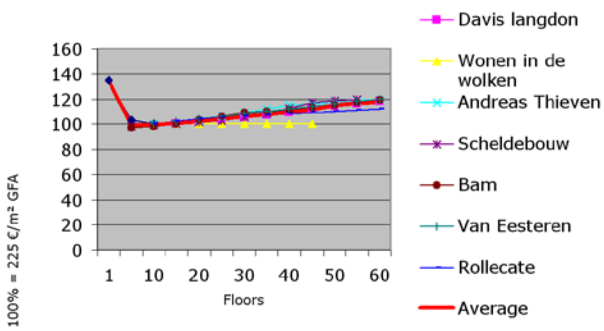

Figure 4: Increase of façade costs due to height. Source: Van Oss, 2007

A relatively straightforward result is given for the façade (Figure 4). The graph gives the percentage increase in relation to the number of floors. Below eight floors, the smaller project size results in higher costs. Neither the model nor the experts focus on low rise. A useful starting point is thus eight floors with an average of 225 €/m² GFA. As a basis for further calculations, this figure should be indexed to the appropriate year. The percentage increase is time-persistent until, for example, the introduction of an innovative means of vertical transport. The incomparable value of 'Wonen in de wolken' ('living in the clouds') can be ignored in this case. The theoretical model disregards the influence of height on the façade. The graph indicates a height charge for the façade of 0.4% per floor.

Structure offers a comparable result: a significant increase after ten floors, with consistency across most sources (Figure 5). More spectacular is the percentage increase itself. The structure has to cope with the same wind-load as the façade, but the dead weight also goes hand-in-hand with the height, resulting in a stronger response to the height.

More heterogeneity can be noted when it comes to expert opinion. Different contractors and advisors assume different construction methods; Dutch structural engineers and contractors would choose concrete where, in the UK, steel would be the focal point. Prefab is rising. The extent of heterogeneity in expert opinion could be read as indicating that a substantial amount of further research remains to be A design model should opt for different construction types and different structures, as well as optimising the various combinations.

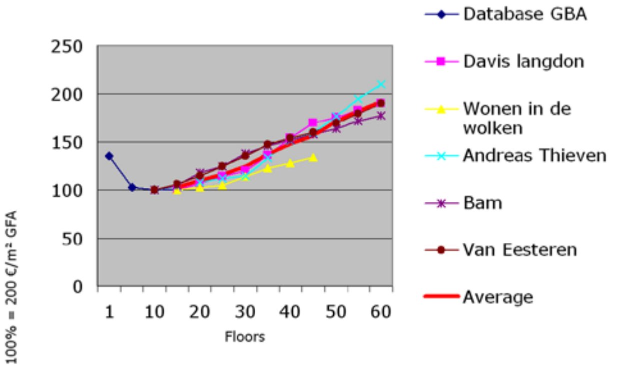

Figure 5: Increase of structure costs. Source: Van Oss, 2007

If all the results are combined into a single graph and stacked per ten floors (Figure 6), it is notable that structure, installations, and elevators are the main cost-risers, contributing to the total direct building costs by an average of 16%, 25% and 3% respectively. Site costs are also significantly influenced by height, as shown by cases such as 30 St Mary's Axe in London (the Swiss Re Building).

The HRA model, which is based upon existing data, inputs detailed information in order to calculate quantities. This results in an estimate for building costs (direct building costs and contractor/site costs).

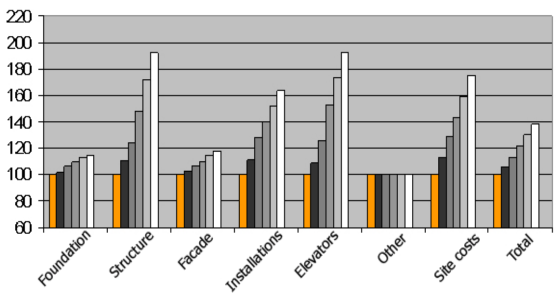

Figure 6: Increase of costs due to height. Source: Van Oss, 2007

Along with other examples, the 'Maastoren' can be used to validate the model. This tower, which has a GFA of 69,995 m², 42 floors, and a height of 162 m, was calculated by a contractor for the bid. Every element of the estimation is within acceptable limits, as far as the validation is concerned, with the exception of the structure. The contractor confirmed, however, that this aspect was kept low in order to secure the job. Using many subcontractors, structure becomes the main factor that allows contractors to make competitive offers.

Figure 7: Maastoren. Source: Van Oss, 2007

The next part of the HRA research was to develop this descriptive model into a design model (De Jong, 2007b). Again, structure and façade were critical factors. Special attention was paid to the increasing use of prefabrication in high rise projects, a development in which the Netherlands appears to be playing a substantial role (using almost 50% of all concrete in prefab, compared with 12% in the US). With regard to efficiency, we explain the design model's objective using the example of elevators.

Design model

From the developer's perspective, building costs only form part of the steering attributes, and their importance is relative to other conditions. Compared with low rise buildings, the earning capacity of high rise office buildings is limited by the efficiency of floor plans; that is, the ratio of lettable floor area (LFA) versus GFA. Depending on the design, this efficiency can also be dictated by the height.

The number of elevators in a building is determined with reference to several key parameters, the most importance of which is function. In comparison with a residential building, an office building will have a completely different scope with respect to waiting times, with traffic peaking in a relative small time frame. The time taken from entering the building until arriving at the workplace is essential, not only for office organisation, but also for people's satisfaction levels. Other factors include the number of people, the building's height, floor size, and floor height.

Specifically in the case of high rise buildings, the configuration of the elevators can also influence costs. Dividing elevators into groups to serve different building zones (in height) makes a positive contribution to the total capacity. Waiting times are subsequently reduced, there is a decreased number of passengers per elevator, elevators can be smaller and, most importantly, shaft sizes can be reduced. Too many groups in the elevator configuration will increase the number of shafts, by which the positive contribution is diminished. Above 60 floors, additional arrangements can become necessary, such as sky lobbies and double-deck elevators. Our model is currently limited to 200-250m, however, so such options are hardly considered.

Different calculation methods provided by the main elevator companies resulted in slightly different divisions of groups. The model has a default group division, but this can be altered for optimisation. The model calculates on the basis of the group division, the number of floors, and the number of employees (the necessary transport capacity). Consequently, a lift configuration was selected listing the logical solutions. Dutch regulations require an office with a height above 20m to have a special elevator for fire-fighting; for those offices above 70m, two such elevators are required. The elevators have separate shafts and must capable of stopping on every floor, each in an area with smoke separation. In practice, these requirements are often met by modifying the elevator group reaching the highest level, and closing off the elevator lobby by means of a fire-resistant door.

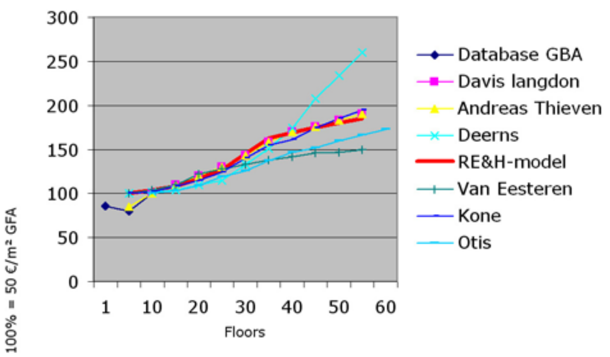

Figure 8: Increase of elevator costs. Source: Van Oss, 2007

The model's default uses two separate fire-fighting elevators. An option is given, however, to combine the fire-fighting elevators with the highest group.

The elevators take up a considerable portion of the GFA. According to Dutch regulations, these square metres are normally not part of the LFA, and minimising this space is thus profitable for the financial feasibility of the building.

In a 50-floor office building with 50,000 m² GFA, for example, the model calculates an elevator scheme with three groups, each with four elevators with a capacity of 1000kg, and an additional two fire-fighting elevators. This scheme requires approximately 90m² per floor and a total of 2260m² (that is, 4.5% of the GFA), including the elevator installation.

The costs of an elevator are comprised of:

- the basic installation;
- a surcharge for additional stops;
- a surcharge for passed stops;
- a surcharge for groups.

This example results in €650,000 for the first group (18 floors); €1,018,000 for the second group (34 floors); €1,154,000 for the third group (50 floors); €770,000 for the first fire-fighting (personnel) elevator; and €944,000 for the second fire-fighting (service) elevator. The total cost comes to €4.5 million.

Seven experts were consulted on this subject, and the results of these consultations are represented in the figure above. The thick line represents the model. Up to 30 floors, all experts agreed on the expected costs. There has been less experience of building above 100m in the Netherlands, however, and expectations started to diverge at this point as a result. The largest deviation was shown by an installation consultancy company that, depending on their philosophy, uses sky lobbies at 160m. Other experts introduced such adjustments at the 200m-level, as does the model.

The cost of the elevators may be massive, mainly due to the amount of floor space that they use. Including the required fire-fighting elevators in the previous example of a 50-floor building, the elevators could take up almost 5% of the GFA. This figure does not even include other forms of vertical transport, staircases and service shafts.

Efficiency

While building costs are related to the GFA, revenues are based upon the lettable area (LA). The feasibility of high rise projects is a matter of controlling the efficiency of the building. In this case, efficiency is defined by the ratio between the LA and the GFA. Not only the building process, but also the use of the high rise building, can be compared with making a ship in a bottle. Every piece of material has to pass through the bottleneck, meaning that aspects such as logistics and vertical transport become exceptionally important.

Number of floors	Efficiency (%)
2 to 4	88-91
5 to 9	84-88
10 to 19	77-85
20 to 29	75-83
30 to 39	74-79
40 +	72-77

Figure 9: Building efficiency. Source: Langdon, 2002

Langdon shows that while costs increase with height, the earning capacity of a building decrease. In this sense, vertical transport – with the elevators taking up 5%

of the GFA – has a substantial impact. The graph below (Figure 10), which shows a similar result to that of the model, depicts a similar decrease in efficiency, although here the number of floors is combined with the floor area.

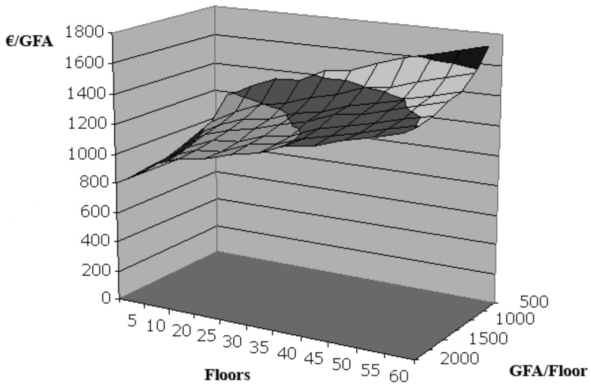

Figure 10: Increase of building costs in relation to height and size of floor plan. Source: Van Oss, 2007

The worst results, in terms of efficiency and feasibility, appear in tall buildings with small floor plans. Dutch regulations on daylight requirements for office workers, however, restrict the use of Sears-Tower like floor plans (67.5m² x 67.5m²). Floor plans such as that of the 'Nationale Nederlanden' (which, until the end of 2007, will be the tallest office building in the Netherlands) are more common (22.5m² x 45m²). The graph in Figure 10 could be simplified into a linear expression (average floor size of 1000m²), in which efficiency decreases at around 0.40% per floor.

Developer versus municipality

Dutch local government is responsible for the supply of land. It is normal for the municipality to buy-up land that has been zoned for development in the ensuing period (using compulsory purchase powers to ensure compliance by land owners when necessary), provide infrastructure, and to sell the sites to construction firms for development (Evans, 2004). In this way, the Netherlands differs significantly from Britain and the US. The municipality intervenes in the setting of land prices, exercising a functional land-price policy. Commercial real estate prices are based on the standardised residual value approach, which is in turn based on average construction costs and additional expenses. These construction costs and additional expenses are assumed pro function (Van der Post, 2007).

In most cases, high rise in the Netherlands is a combined action by the developer, who takes the initiative, and local government, which provides the land and sets the rules. The developer and local government may have different reasons for wanting to reach a certain height. The developer wants to realise a certain volume for its investor or the future owner. With a given plot size, the required height can be calculated with mathematical certainty. Some developments may require the establishment of an icon or landmark. Local government, on the other hand, wants to create a certain density at a location in order to optimise land use.

Implemented conditions	Amsterdam	Houston	Frankfurt	Stockholm
Dominant actor	Local government	Market	Market	Local government
Public ownership	Substantial (80 % municipality)	Only open space	Only open space	Substantial (70 % municipality, 20 % state)
Land supply	Public body	Private	Private	Public body
Intervention in land price setting	Yes	No	No	No
Protection private spatial property	Weak	Strong	Strong	Weak
Coordination planning system	Restrictive	Free	Free	Restrictive

Figure 11: National differences in land policy. Source: Van der Post,

The developer, confronted with height-related feasibility limits, may initially search for an internal solution in order to achieve the desired height. The residual approach is not an option if land cost is related to the GFA, which is normally the case in the Netherlands. An alternative different subdivision would be more reasonable, lowering the cost of land in favour of the building cost. Alternatively, an external approach can be taken. If external economies are taken into account, then the group of stakeholders and contributors can be enlarged. It would seem obvious to consider external diseconomies as well.

Clients requiring sustainable offices and sustainable residential projects for 'green' customers can have a significant impact, but governmental institutions are expected to be the main actors pushing for a more substantial environmental approach.

Eco-cost/Value Ratio

In his search for a proper tool to evaluate the ecological impact of alternatives to interventions in the housing stock, De Jonge (2005) compared many options before selecting the Eco-cost/Value Ratio (EVR). Due to their shared cost approach, EVR is applicable to the HRA model.

EVR is an assessment tool based on life cycle analysis (LCA) that expresses the ecological burden of a product or service in terms of 'eco-costs.' The ratio compares eco-costs with value. A low EVR indicates that the product is fit for use in a future sustainable society. A high EVR suggests there is no market for such a product (De Jonge after Vogtländer, 2001). Eco-costs are defined as the cost of technical measures intended to prevent pollution and resource depletion to a level that is sufficient to make society sustainable. The model is based on 'virtual eco-costs '99', being the sum of the marginal prevention costs of:

- *Depletion of materials*: equal to the market value of raw materials when these are not recycled. When (a fraction of) the material is recycled, a correction is made.
- *Energy consumption*: energy eco-costs are based on the assumption that fossil fuels have to be replaced by sustainable energy sources. The eco-costs of energy are thus set to the price of renewable energy. This includes the whole life-cycle, so that energy consumption during the production phase, the operating phase and the end-of-life (demolition and waste separation) phase is taken into account.
- *Toxic emissions*: the cost of the measures is determined according to the virtual pollution prevention costs '99, completed with the marginal prevention measures to reach the (Dutch) target for reduction of landfill (Vogtländer, 2001).
- *Environmental burden of labour*: labour itself hardly causes any environmental burden, but the conditions related to labour do have an impact (heating, lighting, commuting, and equipment).
- *Environmental burden of the use of equipment, buildings, and so forth*: the eco-costs related to the fact that fixed assets are used to produce a building are also taken into account. The calculations relating to the indirect eco-costs of the use of fixed assets have the same characteristics as cost estimates for investments.

Cost factors	EVR
Site facilities and general equipment	0.10
Transportation	0.85
Site management	0.10
Overheads in the building sector (medium-sized company)	0.14

Figure 12: Eco-costs/Value Ratio of building site costs and overheads. Source: De Jonge, 2005

In a detailed example of a new building consisting of 37 apartments plus a parking basement, the traditional construction costs per apartment are €108,674 (excluding VAT) and the eco-costs are €54,034, resulting in an EVR of 0.50 (De Jonge, 2005).

Case research

The EVR method can be used to rate different high rise buildings according to their 'environmental performance.' In 2008, we will recalculate a few of the cases that were used for the development of the HRA model on the basis of their eco-cost.

ING Real Estate has proposed a new high rise project in the Wilhelminapier, the recently developed high rise area in Rotterdam. The Baltimore will be located between Norman Foster's completed 'World Port Center,' Rem Koolhaas's proposed 'Rotterdam,' and the low rise Cruise Terminal. This building, also by Foster & Partners, will not only become the highest (170m), but also promises to be the most sustainable office building. For the construction, as many sustainable materials as possible will be used. Energy behaviour will be far above average, competing with levels normally seen in low rise offices. With this development, ING Real Estate aims to contribute to the City of Rotterdam's policy of reducing CO_2 emissions by 50% in 20 years. Other themes will be water, green, comfort, and the wellbeing of the tenants. The Baltimore will consist of offices with a commercial area in the plinth, with a GFA of around 50,000m^2. Construction is expected to start in 2008, with the building to be completed in 2011.

Figure 13: Baltimore (left). Source: ING Real Estate, 2007

Given this objective, the Baltimore has to compete with the Helena, as discussed in the CBTUH Journal (CBTUH, 2007). Within the framework of the HRA research, the Baltimore will be compared with other high rise developments and low rise alternatives using the EVR approach. Given the previously-described relationship between developers and municipalities in the Dutch context, and small margins for the development of tall buildings, sustainability may prove to be a necessary externality and provide the basis for more in-depth participation by municipalities. Cities are becoming increasingly interested in urban-level sustainable development. One anticipated means of translating this interest into policy, for example, would be to reward sustainable buildings and impose fines on the worse offenders. The research will also look at the extent to which there is willingness to change policy.

Results

The proof of the pudding is in the eating. Our research on the Baltimore and the EVR has yet to commence, and the results could go either way. It is expected that the increased wind loadings and heavier frames would lead to a relatively higher building mass. A relation eco-cost with the height, similar to the building costs is expected. In the low rise variant, more material would be wasted by use of standard solutions (that is, standard wall- and floor thickness). Vertical transportation requirements and the high service level would lead to higher energy consumption. The high-density solution would allow for heat storage and regeneration options, however, such as using the River Maas for cooling, which is less likely in the low rise variant. There would be additional possibilities for using wind energy. Due to the fact that greater effort is put into tall buildings' façades, a larger contribution may be expected to reduce installations.

Early calculations suggest that a positive result can be expected if land-use is also taken into account. The preparation of land for building takes a lot of energy and, in the Dutch context, can often mean dealing with toxic waste. If land used for housing in the low rise variant is used for forest restoration in the high rise variant, for example, then the latter may be more beneficial. Changing land policy through a carbon offset scheme.

Conclusion

High rise ability has a great deal to do with building costs, regardless of whether the project in question is a 'straight lipstick' or a Johnson 'Lipstick Building' (Dupré, 1996). Higher buildings lead to higher costs, which lead to higher rents. Although a good perspective on building costs and cost reduction is essential, the creation of value by the required quality is the only trigger for clients to pay these high rents. This paper should by no means be understood as an appeal for building cheaply.

Further research will initially concentrate on the realisation of the design model. Focusing on the Dutch context, multiple regression analysis will be used to evaluate the results of the HRA model at the output level, and controlling the amount of user activity at the input level. A public web-based application is scheduled for 2008. The core will be formed by designer rules, however; the main objective is to identify usable suggestions for improving the ratio between the GFA and the LA (Figure 14).

With respect to feasibility, sustainability will certainly remain an important topic, as an aspect of value creation. Other topics remaining to be addressed include the market for high rise developments (offices and residential), and solitude high rise versus high rise zoning.

We will have to wait until the case study has been completed before drawing conclusions on the evaluation of the case research, and the possible impact of high rise as an externality in developer-municipality negotiations on sustainability. Local government will be involved in the research; its carbon neutrality policy is promising, and the City of Rotterdam is also aware of the lack of feasibility of high rise in the urban planning of specific zones.

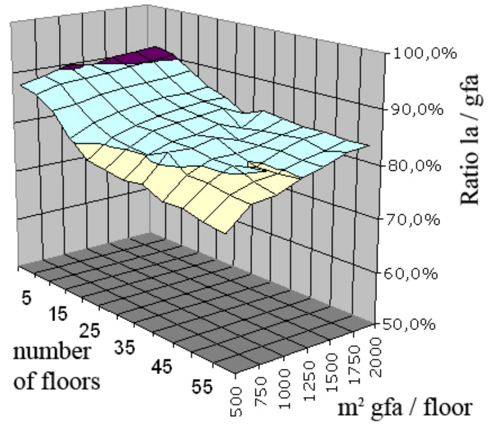

Figure 14: Ratio gross floor area and lettable area. Source: Van Oss, 2007

We would consider it to be a good outcome if, using an LCA, sustainable high rise were able to compete with 'traditional' high rise. It would be even better if small feasibility margins were to force the involvement of all parties, which would be a positive result for the entire project environment. High rise projects contribute to increasing density in urban areas, allowing the preservation of the last few green spaces in the west of the Netherlands. It appears to be very difficult to balance the financial feasibility of a single project with social feasibility on a nationwide scale, however. The HRA project's ultimate goal is to contribute to this tricky task'.

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