

ORGANISING LARGE SCALE GREEN COVERED ROOFS

Classification of green roof specifications and green roofs implementation; the economics of green roofs

PETER G. TEEUW

Delft University of Technology, Faculty of Architecture
P.O.Box 5043, NL-2600 GA Delft, The Netherlands
p.g.teeuw@tudelft.nl
www.smart-architecture.nl

CHRISTOPH MARIA RAVESLOOT

Rotterdam University of Applied Science
P.O.Box 54503, NL-3008 KA Rotterdam, The Netherlands
christophmaria@ravesloot.nl

Abstract

Last two decades the use of plants on rooftops has grown fast. Municipalities use different arguments to initiate policies for large-scale programs for green roofs. However, there is an intriguing intertwining of two scales: building and city. To accelerate policy execution the scales should be combined, but they are not. The stakeholders, not accustomed to collaboration in this new context, keep their natural roles in their traditional organisational patterns. New patterns and new collaborations have to be established soon to speed up the process of change. This paper shows the arguments for mitigation and adaptation approaches on the scale of buildings and cities, from the point of cost and benefits for the major stakeholders. Calculations of municipalities showed that benefits for private partners, investing in green roofs, are less compared to the public benefits. Private benefits may even be negative, nevertheless the summation of private and public benefits is mostly positive. However, the accountability of calculations is minor. There is no uniform method of calculating or monitoring the effects of green roofs on building or city scale. This calls for change. A classification of uniform methods to calculate and measure effects is needed to enlarge customers confidence in the product and to suppress emerging bureaucracy due to different local approaches of policy making and policy implementation.

Keywords: green roofs, public policy, classification of specifications, classification of policy implementation.

INTRODUCTION

All over the world cities proclaim policies to support the construction of green roofs. It seems easy to argue why large areas of roofs covered with plants may contribute to mitigation of and adaptation to e.g. climate problems. One argument is that green covered roofs contribute to reduction of CO₂ emissions on the local scale of the building, which is mitigation. CO₂ reduction can be realised because there is a contribution to extending the life expectancy of the roof. There is a potential reduction in fossil energy use, especially for cooling. On green roofs water can be retained and particular matter (PM) can be captured, which are adaptation approaches. This would reduce the effects of urban heat island. Literature of green roofs specifications is available in several countries according to local circumstances (Getter Rowe

2006). When roofs are covered with plants on a large scale this will also contribute to adaptation, often being part of sustainable water management. It became clear during the last decade that an accelerated implementation of green roofs on a large scale is necessary but not easy to realise.

EFFECTS OF GREEN ROOFS FOR A BUILDING

Green roofs have positive effects on the environmental impact of a building and on the comfort in the building. Green roofs are also known as functional extra space on top of buildings with aesthetic value. How consistent are these claims?

Additional space and aesthetic value

Plants grown on roofs provide space for people and provide a place for plants and animals to live. People may use the roofs as a visual object, or as a place to stay.

Clearly, a plants grown roof can make up for a lack of green, and it can be a place for living in the summer (if the roof is slightly tilted or flat). We may conclude that green roofs also can be used as an outside space for living and as a source of greenery. However, we may conclude that it is unlikely to be useful using the roof for the production of food include meat.

Some advantages are more or less intangible. These intangible claims are difficult to discuss, because they deal with subjective matters, such as aesthetic and psychological matters. Aesthetic claims state that a green roof is attractive and it can be an architectural highlight in a city. Of course this claim can also be reversed. Other people may say the roofs are extremely ugly. Psychological claims include the exciting experience you get seeing and smelling plants grown on roofs.

Extension of lifetime of roofing

When a layer of soil has been applied on a roof this layer protects the construction of the roof. The roof is protected due to different effects. First, the skin of the roof is not exposed to sunlight. Secondly, people walking on the roof do not easily damage the roof. Finally, the skin of the roof is not exposed to a great variety of temperature. Usually gravel layers are used on roofs to provide a smoothing of temperature fluctuations on a roof; vegetation layers have the same effect so much more. This may even be the main thermal argument for construction green roofs. The fact is that the less the temperature fluctuations the longer the lifetime of the roofing. The influence of the green covered roof on temperature differences on the roof and consequential the influence on the durability of the roof can be technically measured and proofed (Teeuw Ravesloot 2011).

Thermal isolation

Some manufacturers of green roofs claim their particular green roof systems provide extra insulation for heat and cooling. These claims can be substantiated with calculations and measuring. However, even if these calculations and measuring would be more or less accurate and accountable, which they probably are, it would not help accelerating the application of green roofs in cities. Although cooling may be likely due to the plants and the mass of the roof, only in some rare cases a green roof system is claimed to insulate thermally, where no evidence is available. Moreover, the specifications on thermal isolation cannot be used in comparison of different green roofs systems of different manufacturers (Teeuw Ravesloot 2011). Consumers are confused by different claims that cannot be compared.

Water management

On the scale of one building the buffering of rainwater and the slowing down of rainwater run off is in rare cases profitable for the building owner or user. Substantial amounts of water on the roof will contribute to extra thermal cooling in summer, but on the other hand it cannot be excluded the same water contributes to extra thermal losses in winter situations, due to de-icing and vaporizing. On the scale of the city nevertheless, buffering and slowing down of rainwater run off can be claimed to have a profitable effect for the municipality.

EFFECTS OF GREEN ROOFS FOR A CITY

From epidemical research it is known that in cities inhabitants die earlier if exposed to extreme periods of high temperature and after exposure to smog from ozone and particular matter (PM) (Buringh Opperhuizen 2002). Especially elderly people will be affected (Luscuere et.al. 2002). The Urban Heat Island effect directly indicates the early death of people around hot and dusty areas. This is why, it is claimed that green roofs contribute directly to healthier conditions in inner cities.

Urban heat island effect

Green roofs have a positive effect on the city climate and have a buffering effect on the temperature and humidity. This dampens the Urban Heat Island effect (UHI).

Because green roofs radiate less heat, temperatures in the city would not rise as high compared to the surrounding land (city) without green roofs. The Ryerson University in Toronto has conducted studies on the impact of green roofs on the temperature in the city (Ryerson University, 2005). The studies were made for the city of Toronto (Ontario, USA). The research revealed that local and incidental green roofs reduce not really the Urban Heat Island in the city. But if really widespread green roofs were applied, the average temperature in the city of Toronto would decrease with 0.5 to 2.0 degrees Celsius, depending on the season.

Also a good green structure with parks and corridors may reduce heat stress and provide thermal reduction. Green roofs may contribute importantly to this concept. In case city planners and urban designers would cooperate, policies to counterattack UHI effects would probably be more successful (Teeuw Ravesloot 2009).

Urban water management

Cities in general and high-density inner city areas in particular have problems coping with heavy rainfall. Not only will the buffering in open water structures be compromised, also sewerage can become incapacitated. Managing urban water becomes an important matter of hygiene.

Buffering rainwater

When the green roof is designed to store water, only a very limited amount of water reaches the drains. Rainwater pipes may even be unnecessary.

Slowing down rainwater run off

The most important characteristic is the reduction of peak load in case of heavy rainfall. When raining, the rainwater falling onto the roof will not immediately flush away into the drains. It is easy to understand the principle. Normally rainwater falling on a roof directly flushes away into the drains. On a plants grown roof water is retained by the soil-layer (or draining) of the roof. Later on, some of the water evaporates and partly the vegetation

absorbs the water, only a minor part disappears into the sewer. Due to this one can have smaller drains. Besides the wastewater may be cleaner because of the filtering effect of the roofs.

It is likely that greening of roofs can contribute to urban water management, however it will be a modest contribution (Mentens 2006).

Urban clean air program

A lot of municipalities have programs to get cleaner air. Combustion engines and other devices using fossil fuels emit particulate matter possibly causing early death of inhabitants of inner city areas. Clean air programs often include policies to cover roofs with vegetation. Vegetation binds dust and particulate matter (PM) from the air and reduces smog as is shown in practice and research. It is unlikely however that green roofs will contribute significantly to the binding of PM from city smog. Green walls are more likely to contribute since there is usually a larger leaf surface and counting PM on leaves is more accurate and valid (Ottel  et.al. 2008).

INVESTMENT IN ADAPTATION AND MITIGATION OF EFFECTS

Some effects of covering flat roofs in cities with vegetation will, on the scale of the city, contribute to mitigation of environmental pollution and degradation, especially in case of large-scale introduction of the green roofs. The mitigation effects will mainly be the reduction of cooling energy and in some cases the reduction of energy use for heating buildings. Expansion the life span of roofing materials can probably also be accounted as a mitigation effect.

Effects on the noise-reduction in cities and inside buildings, health effects as a result of clean air and intangible effects like aesthetics and the resultant direct health impact might be more adaptation. Using green roofs for buffering rainwater and slowing down the rainwater run off from roofs is most definitely a clear adaptation measure cities can provide.

Each tangible and intangible effect, adaptation and mitigation, will have a different set of stakeholders, interested in participating in the costs and mostly in the benefits of greening programs.

Each local initiative will have to face similar complex conditions to maintain interest in public benefits from investments, taking into account the context of smaller financial benefits for private investors. Several perspectives can be distinguished. From the designers perspective e.g. it seems not clear how the potential of green covered roofs can be fully organised.

Remarkable results were achieved in a London City survey for participants in the design and construction process (see figure; Voll et.al. 2007). The hypothesis was: "The physical structure of many buildings prevent the use of green covered roofs". Only yes and no answers were allowed. It is very interesting to see that especially the initiators and decision makers do not specifically approve to using green covered roofs. Even 92 percent agrees with the thesis, whereas only 27% of the construction engineers agreed.

The explanation can be found in lack of knowledge on this aspect. Other - secondary - explanations could be:

- Lack of policy from public authorities.
- Benefits and positive effects are unknown.
- Many participants assume that costs are higher, but do not have a clue about how much higher.

- Many parties do not want to take risks in design tasks they do not know.
- Most of all the collaboration between design parties is insufficient.

Profession	Percentage of agreement
Actor analysts	67
Architects	40
City designers	33
Construction engineers	27
Developers and investors	92
Advisors ecology and water	13

Figure: Results of the London city survey

From the construction contractors perspective it is important that their product will fit the private investors needs as well as the public subsidies interests and still make a profit.

The common interest of all parties involved is that no green covered roof will ever have any kind of problem. Any leakage or other damage will cause damaging of the public image of green roofs.

ECONOMICS OF GREEN ROOFS FOR BUILDINGS

The environmental effects or the image of a green roof might not be in accordance with the interest or the wish of the architect or the client. The decision making to realise a green roof involves many criteria, some of these are of economic nature.

Costs of green roofs

The costs of green roofs versus the costs of traditional roofs can easily be estimated. The roofing itself will be a little costly, further supplemented by the costs for the substrate and vegetation on top of the roofing. Considering the total building the extra costs are minor. The maintenance costs of a green roof, if grown with so-called extensive vegetation, are considered to be equal to that of traditional roofing. On the on the hand, roofs grown with so-called intensive vegetation, e.g. roofs gardens, are more expensive and do not always have a positive cost-benefit ration (Ravesloot Teeuw 2010).

Benefits of green roofs

The life cycle costing of green roofs is positive, since the life expectancy of the roofing is doubled (Voll et.al. 2007). Added value from green roofs is the decrease of the cooling demand in case cooling would be required. In some cases green roofs add extra thermal insulation and heat losses in winter situation will drop, although due to the humidity one may not rely on this. Sometimes a building owner or user benefits from the slowing down of rainwater run off and the buffering of water on the green roof. In cases the dimensions for rain pipes and sewer can be diminished. These will safe money from the initial investment budget as well from the maintenance budget. It can be concluded that apart from the higher investment costs, the life cycle costing of green roofs mostly turns out to be positive.

INTERTWINING OF SCALES

Convincing arguments for fast introduction of green roofs are known. However the calculating of effects on green roofs and the supporting arguments are executed with different methods, as well is the monitoring of these effects. Besides the weights of the arguments and the balancing of the arguments to either the scale of the building or to the scale of the city is not clear yet. Prioritizing seems to depend on local circumstances and local customs. The intertwining of those two scales complicates discussions. Technical knowledge and knowledge of costs and benefits cannot be combined properly and accurately.

It is not always clear how negative and positive environmental effects of green roofs can be explicitly identified by calculation or by measuring. A life cycle assessment (LCA) is not easy to make and it is not always evident how the costs and benefits can be estimated on the scale of a building as well on the scale of a city and how they are related.

Concerning the issues of the discussion about the method to express the environmental effects of green roofs uniformly into numbers a discussion will enrol how to express these numbers into economical estimations on both the scale of the building as on the scale of the city. The economics of green roofs are intertwined on both scales. For companies designing and constructing green roofs it will help to expand their market if it would be possible to estimate specifications more accurately and more uniform. In those case customers themselves can compare performances in relation to costs and benefits. Uniform specifications could relate to procurement criteria and product delivery systems more easily (Huovila Ravesloot 2010). To harvest the potentially major benefits of green roofs for the municipality asks for new organisational methods. Otherwise city policies and innovation of green roofs will suffocate in bureaucracy. If implementation of local policies is uniform throughout the country, private companies can put their effort in innovating their product towards customers' wishes avoiding bureaucracy.

This paper ends with the conditions for positive and successful change, organising innovation from the side of manufacturers and construction industry and de-organising organising bureaucracy of public city policies. Change in the intertwining of economics might simplify the organisation of large scale green covered roofs.

ECONOMICS OF GREEN ROOFS FOR CITIES

Municipalities use different arguments to promote policies for large-scale green-roofs programs. Goal is to achieve benefits for mitigation and adaptation approaches or to achieve sustainable water management on the scale of the city.

Calculations of the municipality of Rotterdam showed that benefits for private partners, investing in green roofs, are less compared to the public benefits on a larger scale. If the benefit from expanding the life span of the roofing material itself is not calculated as private benefit, the total private benefit even becomes negative (Moppes, Klooster 2005). However, the summation of private and public benefits is positive. The calculations also show that the total benefits are the largest in the high-density areas surrounding the city centre and the least in industrial areas. The city centre itself is most beneficial for public benefits.

For the city of Rotterdam many different kinds of calculations can be made to support public investment in private roofs. The simplest calculation would be to compare the cost to create more water buffer areas in the city centre and in its surrounding, highly populated, areas. The construction of one cubic meter of water buffer as adaptation measure in case of heavy rainfall would cost approximately Euro 1000,= to 1500,=. However, this would not be

sufficient, because there is little space to realise such buffers. The public spaces at street level are all occupied until several meters underground. To make an equivalent amount of water buffering of about 15 l/m² on a flat roof you would need about 70 m² of flat roof. So it is wise to spend Euro 1000 on creating 70 m² of green roofs instead. The extra investment of green roofs compared to traditional black flat roofs can vary from 15 Euro (simple do-it-yourself construction with extensive vegetation) to Euro 50 (complicated roof with intensive vegetation). With these numbers you can see that a contribution of Euro 20-25 Euro's of the public authorities for the private investment in green roofs in down town Rotterdam can be motivated.

The more complicated calculation of private and public benefits and costs on a larger scale shows remarkable little sensitivity for variations in input variables of 50 %. Sensitivity is only high on the assumption of life span extension of the roofing material. Changes in investment costs for the greening of the roof also can cause some variation. Otherwise the social return on investment on the scale of the city here is about Euro 15,= per m².

Most likely each city with a program and subsidy for greening roofs will have constructed some kind of similar calculation. Of course variables, input data, methods and numbers will vary and different calculation cannot always be compared. Clear understanding of the factors involved and a good management of the process can create a positive balance in a social cost-benefit analysis for all stakeholders at both scales.

DISCUSSION

However the understanding of the factors involved in organising green roofs on a large scale is not the same from all stakeholders' perspective. There is an intriguing difficulty in organising the intertwining of the two described economics. Although green roofs appear in the political policies of many cities, it is rarely part of (urban) planning in the various sectors. New patterns of collaboration have to be established between policy makers, urban designers, building owners and investors. Sometimes new collaborations appear spontaneously, but they may be hard to organise, since the stakeholders keep their natural roles in their traditional organisational patterns. They are not accustomed to collaboration in a new context. New patterns and new collaborations however have to be established soon to speed up the process.

Intertwining Organisation

Speeding up the process incorporates the differentiation of subsidised green covered roofs according to local urgency and needs and to stimulate the use of green covered roofs to enlarge the effects of urban water management. Subsidy may prevent that one may hesitate to invest in green roofs and stimulate the efforts to get urban quality by means of green roofs. Instead of subsidising the green roofs it may even be better to subsidise the work of architects and urban designers in their effects to realise green roofs.

Also the management of process and maintenance plays an important role. The logistics of building a green covered roof determines the price. Of strong influence is the market situation during the year. Nevertheless, a designer can influence the price positively by designing with care in an early stage of the process. In this way many problems and thus a lot of money can be saved. Given the different roof structures of green covered roofs, additional requirements should be taken in the Dutch legislation. A major hindrance is the lack of a uniform method of calculating and measuring technical specifications of green roofs, like thermal capacity, capturing of particulate matter, buffering of rainwater and slowing down of stormwater run off. The lack of uniform demands from public authorities subsidising green roofs is creating

unnecessary bureaucracy. Also different approaches in policymaking and in policy evaluation hinder to accelerate.

The introduction of a uniform classification of technical specifications will accelerate the introduction of green covered roofs in Dutch building industry. Companies can concentrate on the innovation of their green roof systems, instead of bothering which daily arguments they have to fulfil to defend that their products meet the various requirements of the granting authorities best. In case a classification to apply for subsidies from public authorities fits within the technical classification of green roofs, rise of bureaucracy may be counterattacked. In fact the market for designing and constructing green roofs may expand rapidly, because the consumer will have less doubts on the benefits of green covered roofs. The competitions between companies will focus on quality and services, more than on declaring claims that cannot completely be substantiated. Differences in systems from different companies can be compared and can be tailored to the subsidy requirements by public authorities. Applying for subsidy will be the same in every city offering an active green-roof-policy.

CONCLUSION

The knowledge how to design, construct and maintain green roofs is available and at a high standard (Getter Rowe 2006; Teeuw Ravesloot 2011). Local initiatives show the importance of public authorities to support the construction of green roofs on a large scale. The cost-benefit of green roofs on the scale of a building is mostly positive for extensive green roofs, if the calculation is made within life cycle costing. The same might be valid for social cost-benefit calculations on the scale of a city. However, the many variables and the uncertainty of the input variables make the accountability small. Green roof technology may innovate more towards the specifications issued from public authorities. It seems that public need is more important than private interest. To align public interest and private potential it is needed to uniform the methods of calculation for green roofs specifications. This would be important for those specifications that serve public interest as well: thermal insulation for cooling and heating, water buffering and slowing down rainwater run off, as well as catching particulate matter. Such a classification would enlarge customers' confidence in green roofs. On the other hand it would be suggested to make uniform formats and procedures for local authorities, legally, financially and politically in order to reduce emerging bureaucracy. Bureaucracy is an important hindrance for innovation by the green roof companies.

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