

GREEN ROOF RESEARCH IN THE USA

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As with any technology whose development can be attributed to a single country, Germans have a special feeling of ownership toward extensive green roof technology. The feeling of ownership may be even more acute because the US ignored the technology for so long, then adopted it and is beginning to develop it in its own way. Why has it taken Americans so long to recognize the value of green roofs? What is its state of development in North America, what are the differences between extensive green roofs in the US and Germany, and, finally, what part will Germany play in further development of the technology? First, we need to understand that green roof technology is a first-world technology, since only nations at an advanced state of industrialization like the US or Germany can afford it. Second, when a technology or product begins to expand, others eye the potential of the North American market, because the market is so large. Others view everything in the US as huge: market, people, and problems.

Because there are so few extensive green roofs in the US, installation numbers are unavailable. However, in Germany the rate of green roof installations seems to be increasing and today number close to 100 million square meters. If this figure were adjusted for the size difference between the two countries, it becomes apparent that there is potential for a North American green roof industry worth several trillion dollars.

As with any new industry, individuals or companies try to develop products or processes that will “insert” them into the market. We sometimes call these miracle products Snake Oils. These products are of questionable value and are

sold by the personality of the producer rather than on their real worth. Products that will hold more water, enhance media structure, make plants grow faster, look better, or encourage greater biodiversity, fit into this category.

Even though Germany and other European countries have used extensive green roof technology for more than 30 years, why has it not been adopted in US? Answers to this question are varied and sometimes depend on the part of the US you are referring to. Adoption of green roof technology has been slow because most of the information developed in German institutes and universities is published in German. Although there are skilled translators available in the US, our experience is that the few are able to interpret the unique terms associated with extensive green roofs. Another problem appears to be that much German green roof information is published in popular or semi-technical publications, and very little in peer-reviewed, scientific journals. Even these journals seldom report data sets or statistical evaluation of their results. Although this does not call into question the competence of German researchers, it does deprive other scientists from properly evaluating their results.

Another reason for publishing in scientific journals outside Germany is that regulatory agencies in the US, such as the EPA, are used to evaluating replicated data sets associated with their own quality control requirements. Thus it is easier to sway their opinion when peer-reviewed, statistically significant results are presented to them.

Even the limited information that is available is not being directed to those who really need it: building architects, landscape architects, and engineers. As educators, one of our biggest opportunities is to educate those involved in the extensive green roof industry. Knowledge of plant culture and the fundamentals of soil science related to green roof media are of critical importance. While Penn State is now teaching its first green roof technology course, we know of no other universities or colleges that teach a similar course. Even landscape architects, the professionals most frequently called to design a green roof, have little knowledge of soils and plants. As a result, several projects have been compromised or have failed.

A Canadian group has sponsored two green roof conferences, but there are few other conferences, seminars, short courses, or other opportunities to educate installers. As with any new technology, there is fear of the unknown. For instance, building owners are afraid of the consequences of a leak. Fortunately,

leak detection mechanisms are available, but may not be necessary if a high quality roof membrane is installed. It is necessary to educate the building owner that lower membrane temperature extremes and the absence of UV rays which degrade non-green roof membranes lengthen membrane life. Even though we have been involved in green roof research for several years, we have failed to convince Penn State University to install a green roof. Regardless of the environmental or long-term economic benefits, university officials state that they cannot justify the added cost unless a return on their investment can be realized within 5-7 years. Even more frustrating is that while green roofs have been specified in the initial phases of building construction for our campus, when cost cutting is required, the green roof is usually the first to be eliminated.

US insurance companies have little experience with green roofs and are wary of fire damage. Again, education is critical. While some architects would like to have large areas of grass or other high biomass vegetation on the roof, educating them to the potential fire danger is critical. Furthermore, accumulation of large quantities of biomass could eventually weaken the roof.

Americans tend to be insular. We are land- and water-rich, and less environmentally conscious than Europeans. Because most of Europe is much more densely populated and industrialized, they have had to develop solutions to environmental damage problems. Now the same environmental mistakes caused by excessive stormwater are catching up with Americans. We Americans are faced with huge infrastructure cost if we continue to apply traditional stormwater solutions.

While green roof installation costs in Germany are low ($\sim \$40/\text{m}^2$), cost in US is high ($\$80\text{-}200/\text{m}^2$). Why? First, economies of scale that are present in Germany are lacking in the US. Further, in Germany, one company, for instance, a Zinco, Optigrun, or Xweroflor, may be involved in the entire installation contract. In US there are many subcontractors, each doing a small part of the green roof construction, and each adding to the overall cost.

For the American market, importing German green roof material can be prohibitively expensive. Further, the quality some German materials may be unnecessarily high for the American market based on building life expectancy. City construction costs in US may be controlled by unions whose wage demands and rules may make the entire project uneconomical to install. Also, cost:benefit ratios for American roofs are non-existent. Few figures available from Germany

would apply to the American market. Finally, in the US, because of the way urban areas are developed, there is a disconnect between who bears the cost of a green roof and who gets the benefits. For example, a speculator may erect a building, intending to sell it as soon as constructed. To keep costs low and maximize his profits, amenities like green roofs will not be included unless zoning laws specifically require them. Zoning laws that would benefit both speculator and owner would promote green roof installation, but so far, only a few cities like Portland, and some municipalities in the Baltimore-Washington area, have such incentives.

Germany can more easily legislate stormwater mitigation. The US will require economic incentives such as permission to build larger, taller, building etc. Although building codes and zoning ordinances exist within most American cities, most people in charge of enforcing these codes have no knowledge of the benefits that green roofs can have for stormwater mitigation. Also, American building codes generally permit lower weight bearing capacities than German construction. We construct for a 40-year building life, Germans construct for centuries of use. This presents both problems and opportunities. Because German roofs bear more load, green roof installers are not as concerned with the weight of the green roof medium as American installers. Here are opportunities to develop new, light weight systems.

In the past, American municipalities have relied on engineers to design larger pipes to get rid of stormwater, the so-called end-of-pipe solution. Green roofs mitigate stormwater at the source. This is a “soft” or more ecological solution which engineers find hard to accept because of their training. However, the billion dollar costs for stormwater upgrades facing Pittsburgh, Washington, DC, Cincinnati, New York City, and others may well force officials to investigate “green” or ecologically friendly solutions

Germans view the water supply and water disposal as a single system, where water that leaves the property may be even more expensive (to dispose of) than the drinking water coming in. In most American cities, sewage (both gray and black) water is charged to the building owner. However, stormwater is generally not charged, even though it may flow in the same pipes. Again, until US cities view stormwater runoff created by impervious areas like parking lots or roofs as a real cost, little progress will be made. Laws specifically limiting runoff either don't exist or are not applied uniformly. Further, the American

cowboy mentality of “damn it, it is my property and I will do as I please with it.” is alive and well.

Roofing membranes specifically certified for green roofs must be imported. Even though US companies manufacture membranes that may be adequate for green roofs, there is no testing procedure to certify their green roof use. In Germany, many different qualities and types of other materials like edgings are available. In the US they must either be adapted from other uses, or be imported at high cost. Substrate materials used in North America are adapted from lightweight concrete manufacturing and often must be moved long distances. For instance, one clay company mines raw product in Louisiana, processes or expands it, and moves it 1500 miles (2500km) up Mississippi to Pittsburgh. This is roughly equivalent to moving materials from Cairo to Stuttgart. In contrast, lightweight volcanic materials are available on the Pacific coast, but may be even more expensive if transported to the Atlantic coast.

Mechanization is also different between the two countries. Germany has many types of trucks and other conveyance vehicles to move substrate materials. US material handling trucks must be adapted from other uses and are often large and awkward. Many US building owners want native plants as their green roof vegetation without considering either their growth habit, knowledge of their hardiness, adaptability to the green roof medium, or how much biomass they will produce. Somehow, Crassulacean plants like sedums although well adapted to green roof use, have little appeal. Germans have access to many nurseries that produce cuttings, plants, or grow mats. At present, there is only one nursery in the US producing exclusively for the green roof industry. One of the most discouraging features of producing plants is when the installation is delayed and requires the nursery to hold plants for as much as a year. This is an added cost that must be built into the contract between the installer and the plant producer.

Production costs for green roof plants in the US are generally higher than in Germany, probably because of the lack of specialization and volume. Mat culture not well understood and is expensive, as much as \$60/m². Post-harvest knowledge about shipping or holding sedum cuttings is unavailable, but we know there are significant differences among taxa as to how long they can be held before losing their ability to root.

No substrate standards exist in the US and FLL standards may be unnecessarily complicated, especially for US installers to understand. The vast

majority of construction specifiers in the US have no knowledge of green roof media physical and chemical properties. Many landscape architects want to include more organic matter (up to 50% of the volume) than necessary, without realizing that green roofs can be established with no OM. On the other hand when the roof stabilizes, OM should be around 2-4%. Excess organic matter can lead to other problems, such as long term stability of the roof and medium subsidence.

Maintenance is one of the most overlooked parts of a green roof in both Germany and the US. For as much progress as Germany has made with green roofs, they face the same human failing as we do: when the job is finished the building owner does not want to put any more money into it. Understanding the need for maintenance on a roof that is not highly visible is a continuing problem. Many post installation problems can be overcome if a post installation maintenance contract written.

In summary:

We all know the great advantages of extensive green roof installation. While Germany has pioneered this technology, it has not been universally adopted by industrialized countries. Dissemination of information and education about the benefits of green roofs remain major impediments to the expansion of green roof installation in North America. Further, all would benefit if more information were published in international scientific journals where data can be more effectively evaluated.

Even though many German roofs are more than 20 years old, evidence exists that where proper maintenance is not consistently applied, roof effectiveness and function is impaired. Even worse, some American installations have not been properly installed and no amount of maintenance will improve them.

What does the future hold? Americans will likely further embrace extensive greenroofs, but the technology and industry will evolve in a uniquely American way. Like the old Pennsylvania German said, "we grow too soon old and too late smart," so even if we adopt basic German principles we will have to adapt it to American conditions, especially with the vast climatic differences that exist in the US from tropical Florida, to desert Phoenix, Arizona, to sub-arctic Minnesota.

Finally, green roof installation in industrial nations will not save us from future global pollution problems. In fact, the industrial explosion we are seeing on the Asian continent may make European and American pollution problems seem like child's play.