

The Minimum Impact House

*Applications of the Frankfurt Prototype for sustainable building
in Cities of the European Rhine Region*

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Abstract

The Minimum Impact House in Frankfurt am Main is a sustainable solution for low cost living within city centers - a prototype typology with minimal footprint, built on a leftover urban space. The planning process itself became part of a scientific study.

The ecological advantages of building in the city were integrated in a real building project with new typology, ecological construction-technique and materialization. The goal was to minimize environmental impact through construction and operation of the building. In a comparative study we compared advantages and disadvantages of a single-family house in the centre versus new building zones. This included qualitative and quantitative comparison over a life cycle of 50 years with construction, running, maintenance, disassembly and location related mobility.

1.1 Research and Design on the Minimum Impact House

The Minimum Impact House in Frankfurt am Main is a sustainable solution for low cost living in city centers - a prototype typology with minimal footprint on a leftover urban space. There are two essential innovations realized within the Minihouse. First we wanted to prove that it is possible to construct a passive house standard in the heart of the city, and second, show how construction as well as operation of the house could provide a significant reduction of environmental pollution, and especially of CO2 emission.

These targets required a prototype of both individual and more general validation. Specificity and transferability of the design and research work were framed by these two aims.



Fig. 1 Minimum Impact House exterior, photo: Ronald Rovers Fig. 2 interior photos by the authors

1.2 The House as a Sustainability Problem

A house is not only the simplest accountancy unit for an ecological study, but it also represents a specific private microcosm. This project too was developed out of private

imagination. For being such a small house, the Minimum Impact House has quite a long story to tell.

When the project started in 2004 we were fascinated with the design potential of light wooden buildings, such as the photo studio Staub [1] just outside Frankfurt, and the Spiral House Pigniu in the Swiss Alps [2]; timber construction could actually meet our demanding expectations if applied in a different way. We were thinking about using such techniques for an urban low cost dwelling too.

Frankfurt citizens, especially young families, often leave the city when they grow into their thirties - a common phenomenon in many European cities. This attitude is causing an unpleasant development to our generation, which was born during the first oil crisis. Since the 80s our generation has developed an ecological awareness and practices a lifestyle of ecological responsibility. By moving to the suburbs, we thought, we would have to give up these principles. We would have to spend more time, money and energy on mobility, we would have to use our cars more often - not only for our daily commute to work, shops, or schools, but also because the cultural activities take place in the cities and the intercity trains only stop in their centers.

The growing demand of the housing market has led to a dramatic increase of land consumption in suburban areas. It is a propelling paradox that, as a consequence of land use for houses in green surroundings the essential reason for this demand is spoiled: The green landscapes we long for are being filled up with houses, roads and highways. A major part of these new dwellings consists of detached or semi-detached houses for single families, with a maximized land consumption. City authorities and the adjacent municipalities compete for new citizens with land sales and often even generate direct income by selling land.

The growth of suburbs often undermines planning of social development of the centers and accelerates the destruction of natural and agricultural spaces. As a result, building an affordable and energy efficient house in a green area outside of town was not a viable option.

On the other hand, land prices in a city like Frankfurt often are unaffordable. However little niches do exist in the urban fabric - especially in those cities distorted by war. What if we could find such an empty space in the city of Frankfurt? We began searching the area around our Frankfurt office for minuscule sites to construct single family houses. We also studied the urban housing of Japanese cities where sites for construction often are extremely small. Thus we integrated our ideas on architecture and life into a new concept: We were going to construct a Minihouse in the very center of Frankfurt.

Along with these considerations and personal observations came the desire to see this project in a broader perspective. We examined the life-cycle energy consumption of the minimal size house and the environmental impact of its construction.

The common apartment in town is still regarded as unsuitable for families. So it was of great importance to us to build a house that, being evidently sustainable, would also realize the dream of a single family house. An improved sustainability requires that attitudes about location are no less important than innovations in design and technique. This new awareness leads to a non site: the building gap.

1.2. Building with Minimum Impact

After a rather long process with a lot of hurdles to be cleared the Minimum impact House was completed in 2008. With a footprint of only 29m² we realized 154m² of inhabitable surface. The Minimum impact house is also one of very few multi stories timber buildings in Germany.

The Minihouse is not a common urban house - many people stop by when they see it for the first time: Its timber clad facade cantilevers out over the sidewalk. It seems to be loved more by the public than by architects - perhaps because it disproves many prejudices of the guild. Both reactions make us proud. The Minihouse is about responsibility; it demonstrates holistic

thinking and differentiation. It is also an idealistic house, though not naive, and it is built, functioning, and inhabited.

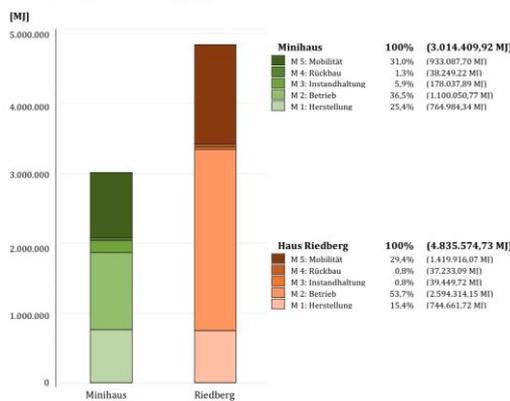
Together with the building process we fully monitored all energy-use and CO₂-output effects of the building, not only concerning construction and operation but also demolition, and the mobility and infrastructure and the land used by it's inhabitants. These data were compared in a parallel case study with the house "Sabina" in a suburb of Frankfurt.

We found out that in conventional construction the running uses about 50% of the primary energy, the rest is divided into the modules fabrication and mobility. The total energy use of the prototype is 63% lower than the compared conventional new building under existing rules. The climate-change effect (in kg CO₂ equivalent) could be reduced by 68% per housing unit.



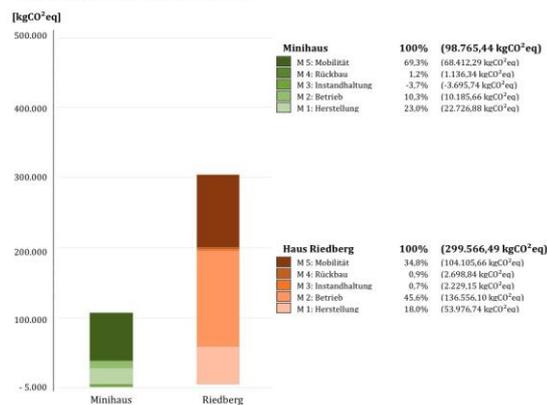
Fig 3 Assessment Scheme Modules 1 to 7

Wirkungsabschätzung Modul 1 - 5; Wirkungskategorie Primärenergie, gesamt



Ökobilanzierung - Graphische Auswertung; Wirkungsabschätzung Modul 1 - 5; Wirkungskategorie Primärenergie, gesamt

Wirkungsabschätzung Modul 1 - 5; Wirkungskategorie Treibhauspotential GWP



Ökobilanzierung - Graphische Auswertung; Wirkungsabschätzung Modul 1 - 5; Wirkungskategorie Treibhauspotential GWP

Fig. 4 Energy Minihouse (green) and House Sabina (orange) Fig. 5 Global Warming Potential Modules 1 to 5

Because of the small plot, the overall cost of the project was roughly equal to the suburban house with the same floor area. The increased cost for the development and construction of the prototype was compensated for by the reduction of the annual running costs of the house itself. The design of the facade and the integration of highly-efficient technology reduce the energy-consumption to the passive-house level of 15kWh/sqma with a calculated value of 13,9kWh/sqma at the Minihouse in comparison to 46kWh/sqma at house Sabina [3 p.158]. A more detailed monitoring will be shown in our oral conference presentation based on consumption data. The Building Primary Energy Input is 3'644 MJ/sqm not renewable and 1'777MJ/sqm from renewable sources as opposed to 4'756 MJ/sqm (n.m.) and 1'111 MJ/sqm (rn.) respectively [3 p.156]. The total live cycle energy use is 3,01 Mio MJ at the Minihouse as opposed to 4,84 Mio MJ at House Sabina (Fig. 4). The Global Warming Potential of the Minihouse over the five Modules in Fig. 3 is 99 tons of CO₂ equivalent for the Minihouse as opposed to almost 300 t at Sabina (Fig. 5).

The main aspects of technical solutions in design are heat recovery ventilation systems, airtightness, joint design, avoiding thermal bridges and using reliable Insulation and steam resistance Values (u-values). We relied on best practice solutions but were especially interested in using CO2 absorbing materials like wood or other natural fibers to reach a positive effect in the life cycle CO2 balance. Paradoxically many of these natural and composite products are not suitable for standardized passive house certificates.

With many of the most progressive techniques with low impact in construction we had to rely our choices onto a weighting of different aspects. So in many cases we decided for materials with no certificates available. We relied on non-certified data and as a result design a non certified passive house without fulfilling the requirements of the German Passivhaus Institute.

On such a small spot, the organization of the different functions in the house had to be vertical instead of horizontal. We can not give an exact division of used and circulation surfaces. The concept of the Minihouse is in many ways not fitting into standards. It is rather exploring new answers to the fundamentally new question of sustainability in architecture. This would also demand more creativity in marketing and use of buildings and a greater influence of responsible users onto the market. As illustration may serve one of 3 main usage scenarios (Fig. 6) with a small business below and a small family in the upper floors.



Fig. 6 Flexible use of spaces, scenario 1 of 3 [3 p.90f] drawings by the authors

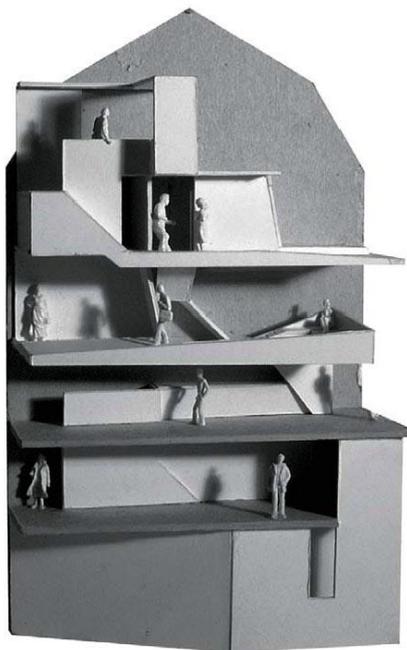


Fig. 7 Model photograph [3 p.64] by the authors

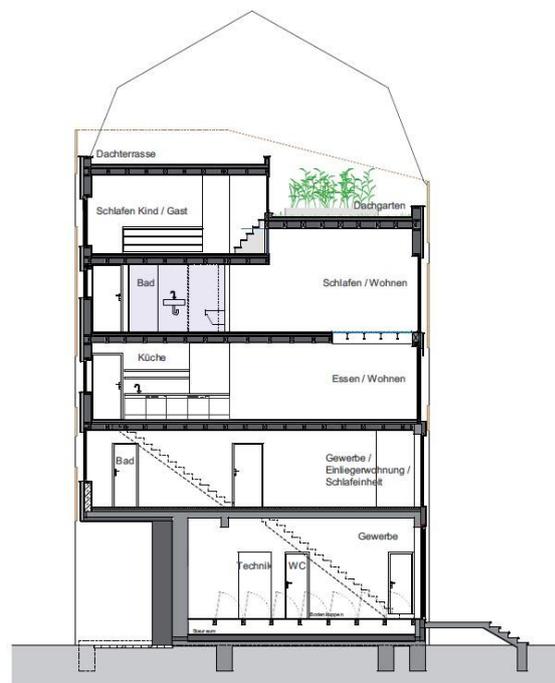


Fig. 8 Section with functions [3 p.65] by the authors

The Minimum Impact House study at TU Darmstadt, chair for energy efficient building was sponsored by Deutsche Bundesstiftung für Umwelt. This made it possible to monitor the process in a comparative case study and to make the results public with a series of publications, sponsored by other partners as well. The Minimum Impact House was awarded in 2008 with „Besondere Anerkennung vorbildlicher Bauten in Hessen“ and „Holzbaupreis Hessen“. In we received the national DENA Award Effizienzhaus 2009 and the Green Building Award of the City of Frankfurt, together with (among others) Lord Norman Foster's Commerzbank. It was published in popular magazines about home improvement and green

building, architectural reviews and local and national media including ARD Television [4]. The Minihouse serves not merely as showcase but first of all as a living proof of the possibility of realizing sustainable building in the city, in a context more efficient than the suburb. Recently most of the results have been published in a Minibook [3].

2.1. Building more Minihouses in Frankfurt and in the Randstad

Our office was founded in 1999 in three cities Frankfurt, Rotterdam and Zurich. After a period of concentration to Zurich, where our Architekten AG joint-stock company was established in 2001, and our presence in Frankfurt where we have become an independent Architekten GmbH in 2005, we are present at these three countries again since 2008. This gives us the unique possibility of comparing the state of sustainable building in different countries. Despite common goals and coordinated policies of our respective governments, there are huge differences in how clients, officials, the industry, education and architects deal with the questions and issues of sustainability.

In Switzerland a high energetic performance has become almost a standard requirement to architectural design, not much discussion needs to be led on the subject although recently the usefulness of the undoubtedly successful Minergie Standard among experts are vivid and healthy.

While we follow standards widely accepted in the Swiss building industry we still see a lot of work ahead with our site-specific approach to sustainability. At present our offices in Frankfurt and Rotterdam are developing several follow up projects to the Minihouse, all of which encounter some difficulties that are either related to external factors (in the German projects) or to a general lack of understanding for sustainability issues (in the case of the Dutch projects).

In Frankfurt we designed Minihouses II and III in the last 2 years. Minihouse No. I served as a reference to these projects and it is interesting to compare similarities and differences throughout design and building process. Both projects were for private clients and land-owners who developed on their own risk. The site of Minihouse II is occupied by a small bar. The owner intends to rent the house as a private investment. Minihouse II shall be built above the bar. Its timber construction is completed by several steel columns to reinforce the corners and by an extensive glazing. Compared with our first Minihouse realization, the project has advanced remarkably fast, but also came to an abrupt end when the client's personal economical situation changed drastically.

Minihouse III was designed in cooperation with Architect Hendrik Schoop who consulted us on the fire protection of the Minihouse I. Our client was interested in extending a corner house in a passage and onto the roof. An existing Kiosk was replaced and we studied several strategies of ownership and rental models with flexibility to change in the future. Also here the personal situation of the client changed dramatically and the project is on hold.

In Germany we find a lot of positive feedback to the Minihouse I and had a bit of bad luck. Private clients from remote cities as Bonn and Munich approached us and we are sure once the financing market becomes more propulsive we will be able to realize some more of these projects.

In the Dutch context we find it hard to build with private clients. Even if many people see the good in our goals, they do not think of starting at their own projects. In fact many clients usually would save the architect from their building plans and seem to have a mentality problem with investments into sustainable architecture.

As most building in the Netherlands is institutionally organized and commercially privatized since the 1980ies, the tendency of urbanizing the countryside is still unrestrained - with all the negative consequences seen above. In addition to these there are specific threats such as water management and the rise of the sea level. The research project Green Living in the City should explore new typologies for the construction of sustainable housing in urban centers.

With 500,000 new homes to be built in the decades to come, the Dutch metropolitan Randstad region is not expected to become any greener.

Green Living in the City suggests two main fields of green innovation: an improved use of public and private green space by ways of combining architectural and landscape design, and green building: promoting sustainable technology for building, running and maintaining the living space. For the Dutch context we proposed several types of green Minihouses in different architectural competitions.

In 2009 a competition, *Hardop Dromen* (Dreaming Aloud), was announced by the province of Nord-Holland, in order to get proposals for sustainable building in an agricultural area. As might be expected, there were a great number of excellent proposals with nice houses covered with green. Our somewhat offensive counter proposal : *Hardop Zeggen* (Saying Aloud), had proved that it would make more sense to realize the 200,000 living units in question in the 18 largest towns of Nord-Holland and thus proposed 500 units of housing along a green ribbon in northern Amsterdam [5].

In realizing the Dutch *Green Living in the City* project we found in Peter Krol a young Dutch real estate developer that was very interested in working with us. For a developers competition we worked on a pre-sale concept involving the growing sustainable responsibility of young dwellers into our marketing concept. This we proposed for The Hague to a local housing cooperation in together with Rudolph Eilander Architects [6]. We filled a series of 3 to 4 minimum Impact houses in a flexible scheme. We chose a timber construction based on the requirement for light, cheap and quick building. Monumental concerns and a texture play with Arab immigrant's cultural influences led us to clad our project with recycled brick. Recycling bricks' overall sustainability has been tested and assessed in a project of Darmstadt research colleague for Hamburg [7].

Our projects for Amsterdam and The Hague couldn't provoke a change of mind and thus did not win the competition. The project is still mentioned here because it shows that even for cities with extremely different structures and problems, potentials for the realization of green living dreams can be found - if only there is a will to find them.

We are more confident into planting our seeds in the context of the university. The strong motivation of young designers to improve their capabilities on the subject of sustainability, and their general understanding for the problematic is our specific point of attack. In Workshops at Copenhagen [8] or Antwerp [9] and our Studio at the Münster School of Architecture [10] we try to train students in sustainable thinking and strategies that could generate future architecture. Our focus is to not only teach an extra layer of information but actually make the students understand how to generate the know-how about specific problems and solutions themselves. We not only give them tools like energy mapping or suggest certain technologies, but try to teach them to work on the conceptual integration of site, building, program and energy concept. They have to develop their own understanding fundamentally in order to be able to confront the problems of the future.

2.2. Thinking Beyond This Paper

Planning officials and the privatized housing cooperations propagate sustainability with a stunning amount of initiatives like congresses, debates or architectural competitions. But in reality, to be honest, most of our follow-up projects lack funding and sponsors. We find ourselves with a pile of prices and a lot of "this is how it should be done" – but less doings. Still we are very glad to be able to present our work at occasions like this conference.

Since we can assume that many people present here are policy or decision makers in the building sector we would like to conclude with a short plea: If you happen to encounter projects that aim at sustainable targets or if you are looking for such projects with the targets already set do not think of it as a question of focusing but rather as one of widening your scope. Do not reduce your scope and do not select your solution too early. Try to understand the total impact of your doings and planning. Sustainability is not merely about technology or

limitations but about thinking ahead. Think about a sustainable future and decide what to do now, despite of constraints of the present. Remember that Architecture is about building the future and if you happen to be in charge think strategically or get advice.

Not all of us architects are always strategically evaluating sustainability, but, believe me, we are working on it and the next generation of architects will be trained to do so, if it's up to us. The role of the architect as a humanistic generalist must be practiced and propagated if we are seeking a truly sustainable solution to our current problems. When describing the applicability of the Minihouse project to others and maybe new fields of work, we had the methodical proceedings in mind. The range of problems building has to deal with in this day and age is extremely complex. The solutions demand a refinement of methods and the confidence in architecture as a discipline strong enough to cope with them.

Even though it uses traditional techniques and materials, the Minihouse at Walter-Kolb-Strasse in Frankfurt is a built peculiarity. And in being so, it is not transferable. But one can transfer its technical and conceptual strategies, its architecture. Architecture is not a question of building but of thinking.

So, what matters in this project is not only the sustainability of the construction but above all the sustainability of the theoretical approach of its design. The result of a sustainable design is the point of departure to new projects: Our building changes our thinking - as our thinking changes our building.

We sincerely hope this paper made you think. Thank you for your attention.

Notes

- [1] Photostudio Staub <http://www.dgj.eu/project-types/photostudio-staub-neu-isenburg.html>
[2] Spiral House Pigniu published for example in Charles Broto, superb cabins Small Houses in Nature Barcelona 2007 <http://www.dgj.eu/project-types/pigniu.html>
[3] Hans Drexler, Esther Götz, Kristina Klenner, Daniel Jauslin, Marcella Lantelme, Anna Mohn, Susanne Sauter, Jörg Thöne, Eva Zellmann *Minimum Impact House, Prototype for Sustainable Building* Wuppertal (Verlag Müller + Busmann KG) 2010 ISBN 978-3-928766-95-1 <http://www.dgj.eu/publications/books.html>
[4] <http://www.dgj.eu/publications> and <http://www.dgj.eu/project-types/minihouse-i-minimum-impact-house.html>
[5] <http://www.noord-holland.nl/web/Projecten/Structuurvisie/Totstandkoming-1/DROOM.NH.htm>
Project: <http://www.dgj.eu/project-types/oppervlaktesspanning-green-living-in-the-city.html>
[6] Competition: <http://www.staedion.nl/reypoort/> Project: <http://www.dgj.eu/project-types/minihouses-reypoort.html>
[7] Based on a advice of Sebastian El khouli Dipl.-Ing. Arch <http://www.ee-concept.de>
[8] UIA Workshop Copenhagen Climate Conference 2009 Summit, Detailed References to the different Design Studios see http://www.dgj.eu/academia_en/teaching.html
[9] Are You Happy, Now? An Exercise in Self Sufficient Design. Artesis Hogeschool Antwerpen ADSL Workshop 2010 Antwerpen Link to facebook presentation at http://www.dgj.eu/academia_en/teaching.html
[10] i.e. MSA WS 2009 master Spacecraft / Islands- Sustainable Architecture as performative System Münster School of Architecture. PDF at http://www.dgj.eu/academia_en/teaching.html



Fig.9 Drexler Guinand Jauslin Architects Venice 2008



Fig. 10 D. Jauslin, H. Drexler, F. Curiel Antwerp 2010

Authors

Hans Drexler and Daniel Jauslin are co-founders and principals of Drexler Guinand Jauslin Architects since 1999 in Frankfurt, Rotterdam and Zurich. DGJ are authors of more than 160 projects in architecture, landscape architecture, urbanism, new media and design. Federico Curiel worked on most of the follow-up projects as a project architect at Drexler Guinand Jauslin Architects since 2009.

DGJ have been teaching landscape architecture at the University of Innsbruck and spatial design with new media at the Zurich University of Arts. Hans Drexler is a professor in replacement at Münster School of Architecture and set up the Minihouse research as scientific employee of chair for energy efficient building TU Darmstadt. Daniel Jauslin is currently a researcher at the chair of landscape architecture, department urbanism, TU Delft and PhD-candidate on „Architecture with Landscape Methods“ and leads a design research teaching laboratory at Rotterdamse Academie voor Bouwkunst. Together they have also been teaching at Artesis Hogeschool Antwerp in 2010 with teaching assistant Federico Curiel.