Europa-Universität Flensburg

Report:

Tiny Houses

Are Tiny Houses the more sufficient housing alternative in terms of energy demand compared to conventional housing in Germany?

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31st July 2022

Flensburg

Abstract

The trend of living in urban areas is one of the factors that causes a space shortage in cities of Germany. At the same time people are becoming more concerned with their impact on the environment and are generally interested in lifestyles that promote more sustainability. One of the solutions to this problem are Tiny Houses. But are they really a more sustainable alternative to conventional housing? This work takes a look at their sufficiency, one of the three aspects of sustainability, by comparing the energy demand of different housing types. For this comparison three relevant scenarios are developed. Scenario 1, a single person household moving from an apartment to a wheeled Tiny House. Scenario 2, a four-person household moving from a townhouse to a module Tiny House. And Scenario 3, a two-person household moving from a detached house to a mini house. The calculations and comparison show that only scenario 3 achieves a reduction in heating demand after moving, displayed in the top figure. Even though the common evaluation method is used for demand calculations the results only show an incomplete picture of the subject by comparing demand per square meter of living space. In a second calculation this was therefore changed to demand per house member. These results are displayed in the bottom figure. It shows that scenario 1 only has a slight increase in heating demand while the other scenarios show a strong decrease. All in all, it seems that a certain scenarios Tiny Houses are more sufficient but more research is needed to cover additional aspects of grey energy and plot development.

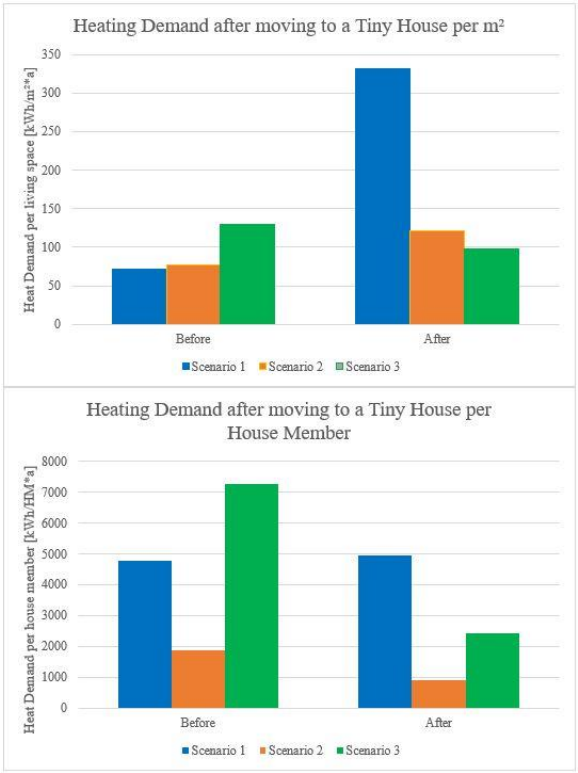

Figure 0: Results for Scenarios

Introduction

More and more people want to live in urban areas. From 1950 till 2015 the share of Germanys population living in cities increased from 68% to 77% and is estimated to further increase to 84% until 2050 (United Nations, 2018). Adding to that, the living space per capita increased from 34,9 m² per person in 1991 to 46,7 m² per person and is estimated to further increase in the future (Destatis, 2022). This causes a lack of space and increased cost of living space in urban areas.

At the same time another problem rose to even more attention, namely climate change. People nowadays are more interested than ever before in topics of sustainability and how their behavior might negatively influence the environment (The Economist Intelligence Unit Limited, 2021).

One of the trending solutions to these problems are Tiny Houses which are advertised as **minimalistic**, **more affordable**, and **sustainable** (Brecht & Wagner, 2022). They are a type of housing that focuses on sufficiency measures of needing less in terms of living space or by self-sufficiency. The idea is that having less living space might lead to reduced needs for energy and materials therefore being a more sustainable alternative to conventional living. This work investigates a first part of the new housing alternative and tries to answer the question:

Are Tiny Houses the more sufficient housing alternative in terms of energy demand compared to conventional housing in Germany?

Methodology

To start, the housing types are defined for comparison. Afterwards relevant scenarios are developed for moving from one housing type to a Tiny House followed up by a comparison in energy demand. Looking at the main contributor to CO2-Emissions from housing, room heating has the biggest share with 65% in 2018 which is why this work focuses mainly on heating demand (Destatis, 2021 a).

Defining Tiny House

A Tiny House can be defined as a smaller, free-standing house in comparison to conventional housing. It can be differentiated into three types. First is the Wheeled Tiny House, which uses less than 15 m² of space, it can be relocated and is not technically sealing any surfaces as it is on wheels. It can be built from shipping containers, from construction trailers or from scratch. Second is the Module Tiny House, which uses between 15 and 100 m² space. It can consist of multiple Tiny Houses and can have multiple levels. Third is the Mini House it uses up to 100 m² space, is built from scratch and can have multiple levels (Schmid, 2019). In general, all these houses can be built with connections for freshwater, wastewater, electricity, district heating, gas, and telecommunication or without. But German laws dictates that new properties need

to be developed even if none of the beforementioned connections are used. Additionally, buildings of 50 m² or less are counted as “kleine Gebäude” in the “Energiesparverordnung” 2014, Anlage 3 also called EnEV and have lessened requirements for thermal transmittance.

Defining conventional housing

For this work three conventional types are defined. First is the Detached Home (EFH), which can consist of one or two apartments. Second is the Town House (RH), which consists of multiple apartments with each having its own floor level entrance. Third is the General Apartment (M+G) which is a combination of Multifamily House (MFH) and Greater Multifamily House (GMH) which consists of multiple apartments.

Developing likely scenarios of moving from one living space to Tiny House

To compare these housing types three scenarios are created of people moving from their current housing to a Tiny House. In 2018 42% of households were single-households with 70% of them being rented apartments. Households with more members were distributed with 34% for two people, 12% for three people and 9% for four people households (Destatis, 2021 b). General Apartments have the most households and are the cheapest type of housing. Going with this, the focus of this Tiny House should be on the most **affordable** option which is a Wheeled Tiny House with low amounts of insulation. Therefore, the most likely scenario, **Scenario 1**, will be **one person** moving from a single-household of a **General Apartment** into a 15 m² **Wheeled Tiny House** with low amounts of insulation.

The second scenario is for parents living with their children. The average number of children per couple is estimated with 1,75 which translates into around four persons in one household (Destatis, 2019). Living with children can require more rooms and barrier-free housing, hence a Townhouse seems to be a convenient but still partly affordable type of housing. Moving from such a Townhouse to a less spacious, less convenient but affordable Tiny House suggest the focus on **sustainability**. Therefore, **Scenario 2**, will be **four persons** moving from a **Townhouse** to two reasonably insulated **Module Tiny Houses** with 30 m² in total, as it allows for more space while reusing materials such as trailers and containers for its construction.

The third scenario was chosen after an interview with a consultant for Tiny Houses. It was revealed that a majority of their customers are around 60 years old and are looking to reduce in living space. The reason being that their children had moved out and that a big house is too much work for just two persons (Wiehe, 2022). The focus of this Tiny House should be on **reducing in size** compared to the previous type of housing while expanses and sustainability are of minor concerns. Therefore, **Scenario 3**, will be **two persons** moving from a **Detached House** to a well-insulated but more expensive **Mini House** of 50 m².

Calculation and Comparison of Scenarios

Each mentioned housing type for the scenarios needs to be calculated first for comparison. For the **Scenarios Before Moving** the classes of housing are decided by share of apartments from the data of the IWU. For scenario 1 a Multifamily House of class E is the most common, for scenario 2 a Townhouse of class C is the most common and for scenario 3 a Detached House of class E is the most common. All these housing types are assumed to have modernization package 1 (Institut Wohnen und Umwelt GmbH, 2005). Together with values for heating demand of each class the following data could be calculated (Institut Wohnen und Umwelt, 2015, S. 40):

Table 1: Scenario Overview

		Scenarios Before Moving			**Scenarios After Moving**		
Variable	Unit	1	2	3	1	2	3
House Member	HM	1	4	2	1	4	2
House Type	-	M+G	RH	EFH	Wheeled	Module	Mini
Space	m²	66	98	112	15	30	50
Space per Member	m²/HM	66	24	56	15	7,5	25
spec. Heating demand	kWh/m²*a	72	77	130			
Heating demand	kWh/a	4778	7517	14548			
Heating Demand per HM	kWh/HM*a	4778	1879	7274			

For the **Scenarios After Moving** only the roof, walls, floor, and windows are considered. For the Wheeled Tiny House, the thermal transmittance values for an insulation thickness of 3,5 cm are used. For the Module Tiny House, the recommended thermal transmittance values for 10 cm insulation thickness are used, based on a recommendation for Tiny House Efficiency (Haupt, 2018). For the Mini House, the minimum thermal transmittance values for the EnEV 2016 are used. The calculations are done by the standard "DIN 4108-6: 200 Anhang D" with the additional inclusion of heating from number House Members. It was assumed that each House Member spends on average half a day each day of the year inside the house. Important differences between the envelops that need to be considered are that the two Module Tiny Houses are connected over the smaller sidewall. Furthermore, the Wheeled Tiny House and the Module Tiny House don't benefit from a reduction factor as they are not grounded in a foundation. The same type of windows is used throughout the calculation of all Tiny Houses.

Results

Table 2: Heating Demand of Scenarios

Scenario	Before Q_h" [kWh/m²*a]	After Q_h" [kWh/m²*a]	Before Q_HM [kWh/HM*a]	After Q_HM [kWh/HM*a]
1	72	331	4778	4963
2	77	122	1879	914
3	130	97	7274	2430

Table 3: Space Demand of Scenarios

Scenario	Before Living Space Demand [m²/HM]	After Living Space Demand [m²/HM]
1	66	15
2	24	7,5
3	56	25

Discussion

The results for scenario 1 show that moving as a single-household from General Apartment to a Wheeled Tiny House increases the heating demand per living space manyfold with a value of 331 kWh/m²*a. The EnEV 2016 requires for new permanent residencies in Germany that heating demand does not exceed 120 kWh/m²*a. This regulation has a purpose of reducing energy demand in households but in this case the Tiny House does not need to comply with it as it is a “klein Gebäude”. This indicates that Tiny Houses are still not considered in policies as of now. But looking at heating demand per house member shows a different result of only a slight increase in heating demand from 4778 to 4963 kWh/HM*a.

The results for scenario 2 show a similar picture that moving as a four person household from a Townhouse to a Module Tiny House increases heating demand per living space. But the recommended insulation managed to almost achieve the 120 kWh/m²*a of EnEV 2016 showing sufficient energy savings can be achieved. However, looking at heating demand per house member shows a better result to scenario 1 as it decreased from 1879 to 914 kWh/HM*a.

The results for scenario 3 show the best results with a decrease on both heating demand per living space and per house member by moving a two person household from a detached residency to a Mini House. This scenario improves heating demand per house member from 7274 to 2430 kWh/HM*a.

In these calculations scenario 1 achieves the worst results even though the decrease in living space per house member is the highest of the scenarios by moving from 66 to 15 m²/HM. Contrary to this, scenario 3 achieves the best results with the lowest decrease in living space per house member by moving from 56 to 25 m²/HM. Scenario 2 is placed in the middle while it still has the lowest heating demand per house member before and after moving from 24 to 7,5 m²/HM. This shows that not only a reduction in living space is important for a decrease in heating demand but a good insulation as well.

But there are multiple limitations to this work. First, scenario 3 may have shown the best results for reduced heating demand but the additional use of materials could be the highest of the Tiny House Types as it is not built from reused materials like containers or work trailers. Also, it can be expected that a Tiny House needs more materials the bigger it is hinting at the problem of grey energy. Second, this work only considers living space but not property space. An average Tiny House size in 2019 is 29 m² for which provider "Wohnglück" recommends land plots of 150 to 200 m² (Schmid, 2022). This would have the biggest impact on scenario 1 as it could mean moving from 66 m² with no garden to 15 m² but onto its own 150 m² land plot. Adding to that, insulation takes up additional living space not considered in the calculations as of now which may be a problem for the smaller Tiny Houses. Thirdly, the connection to infrastructures like sanitation are not considered which are required in Germany when developing a new property.

Conclusion

The emerging trend of Tiny Houses could result from the rising prices of living space in urban areas. Even though only 42% of Tiny House owner intend to use it as a permanent residence, the general interest to own one is in minimalism, affordability, and sustainability (Schmid, 2022). Tiny Houses can be a more sufficient alternative to conventional housing by using less space and more possibilities for self-sufficiency with technologies like photovoltaics or composting toilets. The results of this paper show that the heating demand of Tiny Houses and conventional housing should not only be compared per square meter but per person. Disregarding this work's limitations, scenario 3 promises the biggest reduction in energy saving by moving a two-person household from a Detached House into a well-insulated Mini House. As a final conclusion, this work gives first hints to the sufficiency of Tiny Houses by showing that moving to a Tiny House can reduce the heating and therefore energy demand to less than half per House Member.

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