

DENSIFICATION OF SINGLE AND TWO-FAMILY HOUSES CONSIDERING GREEN SPACE AND MOBILITY

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ABSTRACT. The question of future energy-efficient creation of living space is becoming more and more important in many cities due to limited space availability and simultaneously increasing settlement pressure. Against the background of the desired space, resource and energy efficiency, cities are steadily-focusing on internal development and densification. In order to encourage a sustainable urban development, the existing densification potentials need to be mobilized by addressing the owners directly, to convince them for the measures to mobilize the given potentials. Therefore innovative GIS methods and databases are used within the research projects “BONSEI!” and “BONUS” in order to detect these potentials. Following is a gradually constructive consultation that helps house owners, depending on their needs and wishes, to find potential construction actions to increase the living space within their parcel. The research project “BONUS” further tackles problems and concerns, which come with densification, by maintaining high quality green spaces and at the same increase the usage of sustainable forms of mobility and try to reduce car usage within the districts.

KEYWORDS: Densification, internal development, sustainable development, green space.

1. DENSIFICATION AND RELATED PROBLEMS WITHIN CITIES TACKLED BY RESEARCH PROJECTS

The question of future energy-efficient creation of living space is becoming more and more important in many cities due to limited space availability and simultaneous increasing settlement pressure. Against the background of the desired space, resource and energy efficiency, cities are therefore steadily-focusing on internal development and densification. Especially single and two-family houses, which represent nearly 70 % [1] of all residential buildings in Salzburg, offer a great potential for sustainable densification and also show a high level of refurbishment needs. However more than 90 % [1] of these buildings are privately owned. One way to encourage a sustainable urban development, is the mobilization of the existing densification potentials by addressing the owners directly to convince them for the measures to mobilize the given potentials. Plans and actions of authorities and the city administration are a key element towards this process. Not only is it important to steer and enable a qualitative densification in order to minimize the negative side effects, like compensating the loss of private green space with increasing the quality of public green space, but it is also an impulse towards mobilizing existing potentials. In the case of Salzburg, densification is also implemented within the spatial development concept, to minimize land consumption

and preserve green land [2]. There are many examples of cities pursuing densification as a method for increasing living space for an increasing number of inhabitants like Rotterdam [3]. A lot of projects and research towards densification exists, for an example different GIS-based approaches like in the paper of Eggimann et al. [4]. Other research considers the dynamics that are associated to densification processes like Shukla et al. [5] or the social problems coming with this process like Afandi [6]. Contrary to this paper’s focus, Treija et al. [7] examined the densification of large housing estates. In contrary to single- and two-family houses, densification of large housing estates shows more distinct accompanying problems, like gated communities and social segregation [7].

Although densification seems to be a sustainable way to create more living space within a city without having to assign new building land, some risks and downsides exist and have to be considered.

One problem that comes hand in hand with most densification processes, is not considering green spaces and mobility, although being acknowledged in many studies [8, 9]. These two issues are important to address in order to enable a socially accepted and sustainable densification program within a city. These aspects are also important to bring cities towards a more energy-efficient future and reduce ground densification. They also often might worry neighbouring house owners. Raising the social acceptance for den-

sification projects therefore is one of the main goals of the research project “BONUS” (Optimal use of existing stock – strengthening the environment).

The quality and the impact of densification projects have already been proven in the predecessor research project “BONSEI!”. Within the project “BONSEI!” (Optimal use of existing stock – energy-efficient implementation of refurbishment!) a corresponding consulting service for addressing post-compression measures within cities was already developed. It has been shown, that qualified and personal advice is an important source of inspiration for owners in order to mobilize post-compression potentials. Using innovative GIS-methods, the densification potential can be calculated and therefore properties with the possibilities to achieve more living space can be detected [10]. This innovative data and consultation is now extended in the project “BONUS” by data and indicators for green space and mobility [11]. Because of that, elements of “BONSEI!” are reused within “BONUS” and selectively further developed.

The holistic “BONUS” consulting is implemented in pilot areas in Feldkirch and Salzburg and thus the research results are transferred directly into practice. In addition, a transferable operator model will be developed for long-term establishment of this service. In order to ensure practical suitability and innovation effectiveness, in “BONUS” nine LOI partners from Vorarlberg and Salzburg from several specialist domains / infrastructure levels (urban planning, smart city coordination, spatial planning, energy management and consulting, housing promotion, transport planning) are involved. Through the initiation of creating energy- and resource-conserving housing by the building owners, a sustainable urban development can be enabled and thus an Austria-wide transferable significant municipal added value can be generated.

The consultation within the project “BONUS” and the predecessor “BONSEI!” only considers single- and two-family houses. On a larger scale, developments are considered in other research projects like in the “Research- and Transfercenter Alpines Bauen” (<http://alpinesbauen.at>). Here the research concentrates on the development and visualization of GIS-based settlement and densification models.

2. SEQUENCE OF THE DENSIFICATION CONSULTATION FROM FIRST APPROACH TO FIRST SKETCHES

In order to mobilize the reserves, available in stock within a city, a holistic advisory offer is needed, to provide an objective, product-neutral consulting to further develop already existing buildings regarding densification and a high quality energy efficient redevelopment. Goal of this consulting is to show the house owner different approaches to develop their homes further in the aspects of energy efficiency and structural development. To get residential owners to

participate in densification consulting, they need to be approached directly using different strategies. Hereby the collaboration with the city administration has shown to be helpful, to raise awareness for the project and to demonstrate the reputation and importance of the project. The city administration also helps with advertising, by writing an official letter to the residents and also support events where the project is presented [11].

To get into contact with the house owners, different strategies are applied. When developing the approach strategies different target groups were kept in mind and how to get them interested into the densification consultation. One possibility is to use events to hand out flyers with information about the project or using media to advertise the consultation. This can be happen through newspapers or social media, in order to get the attention of the house owners. Another different approach is using energy advisor. During their work in the household, they can hand out flyers and speak about the possibility of densification as part of a reconstruction. The most efficient method is an anonymised letter distributed in the whole district of interest. This letter contains information about the densification consultation and a small text, addressed by the administration of the city, to get the reader’s attention. At this occasion, the owners are confronted with general information about densification and if they are interested in this topic and in a consultation, they can make an appointment for a first meetup with a densification advisor [11].

Once the property owners are interested in a densification consultation and want to get advised, the procedure written into an operator model takes place. This operator model contains the sequence of the consultation by describing the different steps and their content. It is further used to bring the developed densification consulting towards other municipalities and cities, by providing guidance on how to run the different steps of consulting and how the costs are splitted between the owners and the municipality. With this model, other municipalities should get a manual on how to implement and use the densification consultation on their own [11].

The consultation itself is performed by trained advisors. They built their consultancies upon data sheets including information about the property and the building (densification potential, development plan, building stock, infrastructure and environment) which they are provided with beforehand. Based on this information, an efficient consulting service is enabled. Because these building and property parameters are known to the advisors before the first talk, they can already develop and sketch different strategies beforehand. Before the first meeting, the interested house owner gets send a questionnaire with questions about their wishes and needs, as well as some easy questions about specifications of their house. The first meeting is then used to collect more detailed data of

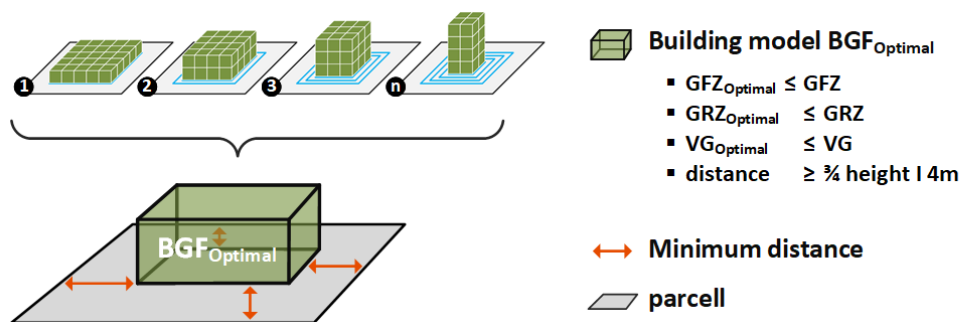


FIGURE 1. Schematic visualization of the optimal building model (Schneider & Gadocha 2019).

the property, which are not already within the data sheet or the questionnaire and also to further talk about the wishes and needs of the ones who are advised. As it appeared in previous talks within the “BONSEI!” project, especially the additional creation of living space for the family is very important for most house owner. Basis for the second meetup are individual designed solutions, based upon the wishes and needs of the house owner. According to predefined typologies, different structural measures, like addition of storeys or extension of the building, are possible. These sketches are presented to the owner as part of the second meeting and the implementation possibilities as well as the funding opportunities are discussed.

One big concern, when it comes to densification, is the fear of increasing traffic as well as the reduction of green spaces within the districts because of construction extensions and additional people living in the neighbourhood. Therefore, it is important to also include aspects like social acceptance, mobility and blue-green infrastructure within the densification consultation.

Considering mobility, it is important to strengthen more environmental friendly alternatives. Within the district, it is useful to build upon on already existing infrastructures (like cycleways and bus stops). This way, the usage of private cars could be reduced and therefore the overall mobility should be more sustainable. It is important to not limit to possibilities for car usage but to show and strengthen alternatives in order to provide new possibilities. This can happen through mobility offers and incentives for walking and biking and a comprehensive mobility management for the whole city.

The other important part that is considered in the project “BONUS” is green space. Especially high quality green spaces on buildings and green spaces next to the properties play an important role in the ecology of a city. Ecosystem services like recreation, health and biodiversity are affected the most. Another important aspect of green spaces in urban spaces is regarding the regulation of the climate, adaption to climate change and its contribution to quality of life. Therefore it is important to include climate ecological

aspects within the advisory.

For both aspects, green space and mobility, indicators are developed in “BONUS” and calculated using innovative GIS methods, that help the advisors doing their work. Another important tool that helps densification advisors, are appealing cards with selected measures regarding sustainable mobility and green space, which are shown and handed out to the house owners during consultation. They include information on how to support more sustainable mobility and for an example how to raise the quality and the amount of green spaces within their gardens.

3. SPATIAL DATA AND GIS AS A BASE FOR DETECTING DENSIFICATION POTENTIALS

Using spatial data and innovative methods of geoinformatics plays a crucial role in the mobilization and detection of densification potentials. With the developed GIS methods, it is possible to detect the existing densification reserves on a very high parcel-specific resolution. Therefore necessary input data are mapped buildings, surface and elevation models, zoning plan and key figures regarding the structural exploitability of a property.

To calculate the existing densification potentials, the maximum potential gross floor area is subtracted by the existing one of the building. The result of this calculation offers the theoretical realizable densification reserve within a parcel. To get a better overview of the calculation process, Figure 1 shows the process behind the detection of the maximum potential gross floor area for a parcel [12].

How a parcel then can be further used for densification, depends on the already existing building as well as on the available space. Because the construction type can vary from parcel to parcel, it is useful to provide the possible type of densification possibilities for each parcel to the advisor. Hereby it can be differentiated between: addition of storeys, independent additions on the parcel, demolition and building a new house and the realization of new living space through interior work and apartment division [13].

GIS can also help with controlling the densification

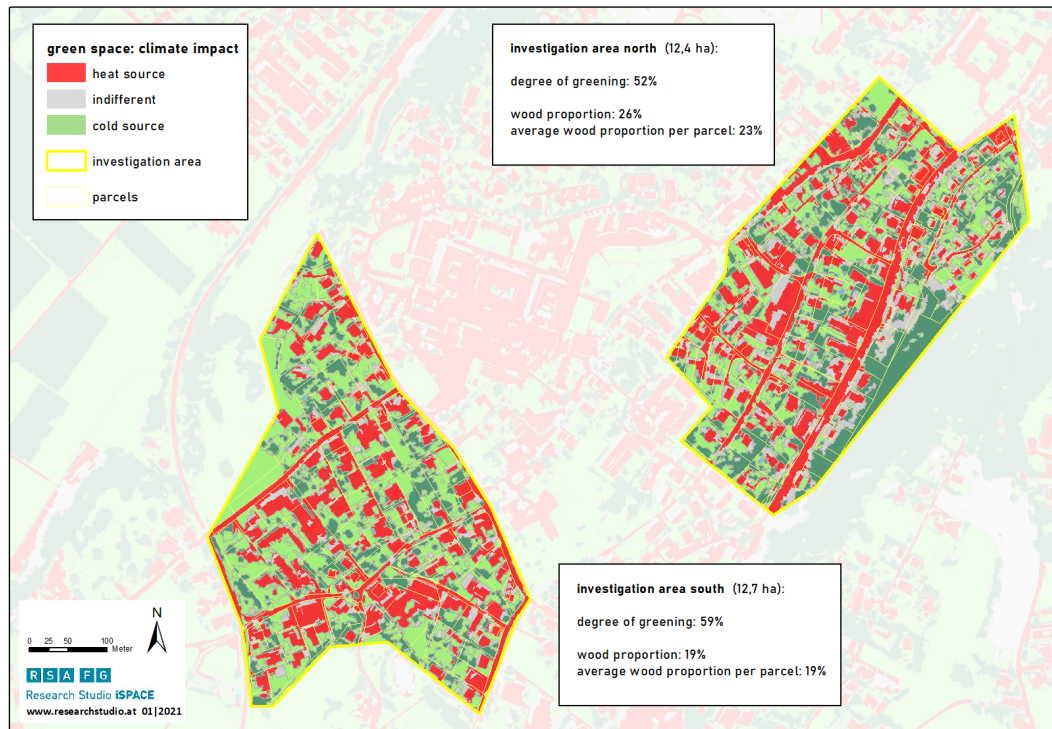


FIGURE 2. Calculated heated and cooled areas within Tisis, Feldkich (own illustration).

progress. To show the long-term effects of the densification advisory within a city, a semi-automatic GIS process was developed in the project “Nachverdichtungsmonitor Stadt Salzburg”. This tool enables the user, based on the parcel data, surface and elevation model, digital development plan, to constantly get insight into the densification potential as well as the usage of the potential for creating new living spaces [14].

4. DATABASE AND INDICATORS FOR GREEN SPACE AND MOBILITY MEASURES

In addition to the “BONSEI!” database, within “BONUS” the database is now extended with data and calculated indicators regarding green space as well as mobility. To get a deeper insight into the existing amount and quality of green spaces a broad selection of data is needed. For an example, to measure the adaption to climate change, infrared images and a surface model of the investigation areas are needed. With this input data, in combination with GIS methods, heat sources and cold sources within the study district can be detected.

This indicator, shown in Figure 2, further gives a deeper insight into the distribution and amount of green spaces and parks. In the shown map, the areas that have a heating effect as well as the areas with a cooling effect can be seen. Houses and concrete areas as well as green areas with trees and grass can be

distinguished this way. In conclusion the information gained from this analysis helps to choose appropriate measures for densification. In districts with a lot of heated areas and only few cooled areas, during densification the preservation of trees and high quality green areas should be considered more carefully, to not have too much impact on the climate within the district.

In terms of mobility, aspects like public transport stops and their accessibility as well as their quality are crucial. Another helpful indicator is the accessibility of cycle ways, as it is an important measure to see how the district is connected to a street network that enables sustainable mobility. To calculate these exemplary accessibilities, data including the public transport stops with their quality, the network of cycle paths and the street network is needed. Another example for a calculated mobility indicator, namely the distance to educational centers on a parcel sharp resolution, can be seen in Figure 3. In addition, the theoretical shortest ways used by the inhabitants to get there, are accumulated and shown within the map. Depending on the amount of their usage, the street segments are drawn with a different thickness.

Cities can benefit from the implementation of the densification consultation including the innovative database in various forms. One of them is the potential for cities to create further living space without using newly assigned building spaces. This leads to a reduced land consumption and at the same time

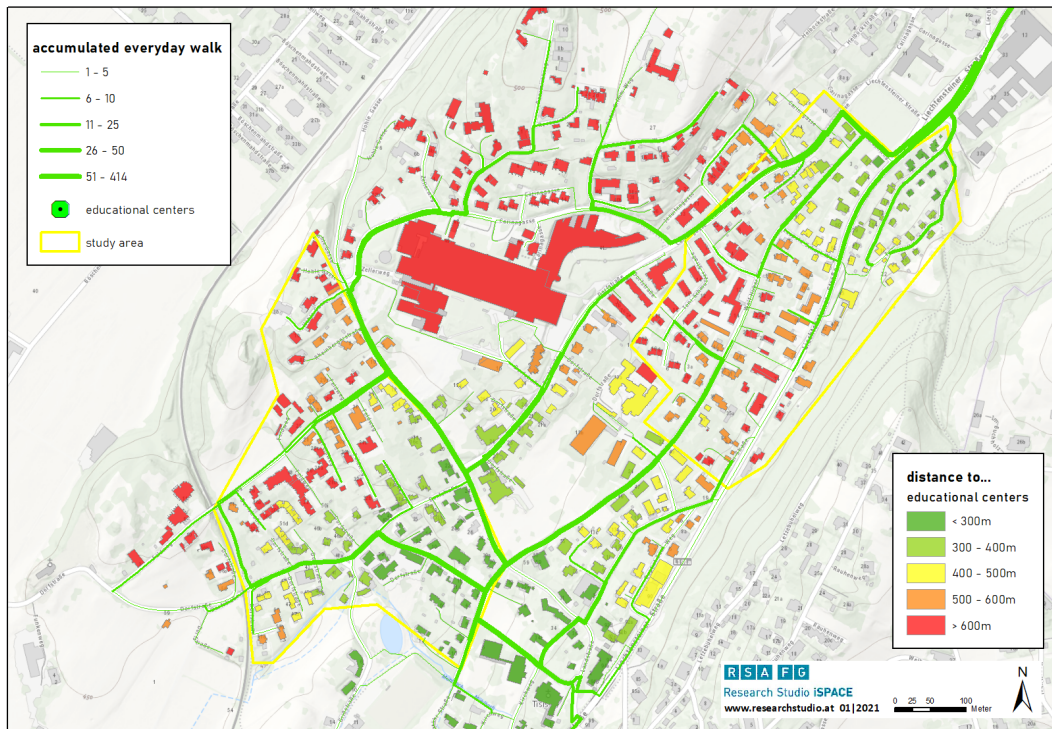


FIGURE 3. Accumulated everyday walks and accessibility of educational centers in Tisis, Feldkirch (own illustration).

to an increasing renovation rate because of structural measures on the buildings. Another point is the inclusion of different quality aspects, namely: blue-green infrastructure, mobility and social acceptance. By including them into the densification consultation, the quality of the densification within the city can be increased. The consideration of blue-green infrastructure further helps to improve the climatic interaction within urban areas. This is achieved by maintaining high quality green spaces or by strengthening them. This results into an increased adaption to climate change as well as in increasing life quality within the districts. Next to the blue-green infrastructure, considering the topic mobility is crucial. Considering this aspect in the consultation can be an important incentive towards reducing car usage and towards raising awareness and usage of environmental friendly forms of transportation. Bringing these elements together into one high quality densification advisory, by using spatial indicators, can therefore lead to a better climate adaption and further towards more socially accepted densification measures within cities.

5. EXAMPLE OF A SUCCESSFUL DENSIFICATION CONSULTATION

First densification consultations were already implemented during the research project “BONSEI!”. One example for a successfully applied advisory is the building shown in Figure 4. During the consultation the need to add living space to enable more family



FIGURE 4. Example building used for densification consultation during “BONSEI!” (source: project “BONSEI!”).

members to live here, was detected. In more detail, there should be enough additional space for up to three new inhabitants. Also, during the construction work, they wanted to reduce noise coming into the house from the surrounding environment. Based on the information, the densification advisor, in this case an architect, sketched two possible solutions that would come into question for this specific parcel and also estimated the costs that would come with this construction. For this building an addition of storeys or an addition next to the house were found to be possible densification solutions. The second solution,

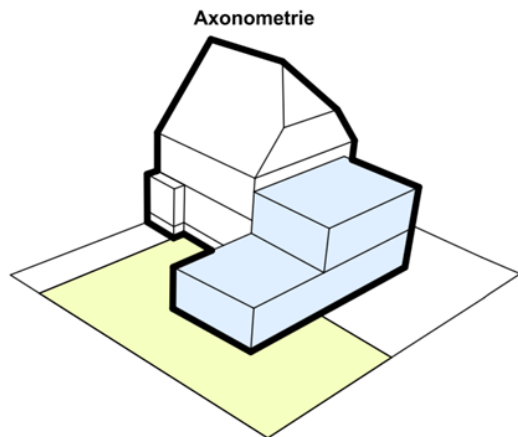


FIGURE 5. 3D Visualization of possible densification process (source: project “BONSEI!”).

adding some construction next to the building, which was suggested to the owner, is shown in Figure 5. This sketch is part of the final step within the consultation, as the aim of the project “BONSEI!” and “BONUS” is to offer possible actions and to raise awareness for further possible steps. The realisation and construction itself is not part of the project and is left to the owner.

6. CONCLUSION

Densification within cities is a sustainable way to add more living space without using newly assigned building land. The project “BONSEI!” has shown, that it is important to mobilize the potentials by speaking to the owners directly and show them the benefits, which can come with adding more living space to their parcel. The past has also shown, that there are some concerns regarding reducing green space and increasing traffic volume by densification measures and by people that move into the district. To reach socially accepted densification, it is important to consider green space and mobility, while planning possible densification measures. The project “BONUS” considers these two aspects, by using indicators regarding green space and mobility, to improve densification measures and at the same time reduce the accompanying concerns. That way, a high-quality consultation and in succession a high quality densification process can be enabled. But it shouldn’t be neglected that densification processes can also have negative side effects beside potential loss of green space and increasing traffic within a neighbourhood. One aspect is the potential increase of social relation problems within the neighbourhood [6]. As a result, a less active and harmonious dynamic within the community can occur. Also, the phenomena of gentrification, caused by densification processes must be noted. According to Afandi [6] densification and gentrification cannot be separated from each other. It is stated that these processes can trigger conflicts between citizens.

As a conclusion, densification can be an efficient

method to increase living space for a raising number of inhabitants. Ecological and social aspects should nevertheless be considered and minimized. The project “BONUS” tries to consider mobility and green space in order to make densification processes more accepted within a neighbourhood. Because the focus lays on one- and two-family houses, it has been shown within the project “BONSEI!”, the owners mainly focus on creating additional living space for family members. As a result, negative side effects like gentrification and processes aren’t that obvious but should nevertheless be also kept in mind when initiating densification processes within a city.

REFERENCES

- [1] Statistik Austria. Gebäude 2011 nach überwiegender Gebäudeeigenschaft, Eigentübertyp und Bundesland, 2011.
- [2] Stadt Salzburg. Grundlagenbericht zum neuen Räumlichen Entwicklungskonzept der Stadt Salzburg, 2021.
- [3] N. N. M. J. D. Tillie, M. Aarts, M. Marijnissen, et al. *Rotterdam – People make the inner city: densification + greenification = sustainable city*. Mediacenter Rotterdam, 2012. https://www.researchgate.net/publication/293095884_Rotterdam-People_make_the_inner_city_densification_greenification_sustainable_city
- [4] S. Eggimann, M. Wagner, Y. N. Ho, et al. Geospatial simulation of urban neighbourhood densification potentials. *Sustainable Cities and Society* **72**:103068, 2021. <https://doi.org/10.1016/j.scs.2021.103068>
- [5] A. Shukla, K. Jain, R. Ramsankaran, E. Rajasekaran. Understanding the macro-micro dynamics of urban densification: A case study of different sized indian cities. *Land Use Policy* **107**:105469, 2021. <https://doi.org/10.1016/j.landusepol.2021.105469>
- [6] I. N. Afandi. Gentrification and densification as determining factors of orientation and quality of neighbors relations in Indonesia (a hypothetical study). In *Proceedings of the 8th International Conference of Asian Association of Indigenous and Cultural Psychology (ICAAIP 2017)*, pp. 140–143. Atlantis Press, 2017. <https://doi.org/10.2991/icaaip-17.2018.31>
- [7] S. Treija, U. Bratuškins, A. Korolova. Urban densification of large housing estates in the context of privatisation of public open space: the case of Imanta, Riga. *Architecture and Urban Planning* **14**(1):105–110, 2018. <https://doi.org/10.2478/aup-2018-0014>
- [8] B. Lin, J. Meyers, G. Barnett. Understanding the potential loss and inequities of green space distribution with urban densification. *Urban Forestry & Urban Greening* **14**(4):952–958, 2015. <https://doi.org/10.1016/j.ufug.2015.09.003>
- [9] C. Haaland, C. K. van den Bosch. Challenges and strategies for urban green-space planning in cities undergoing densification: A review. *Urban Forestry & Urban Greening* **14**(4):760–771, 2015. <https://doi.org/10.1016/j.ufug.2015.07.009>

- [10] T. Prinz, W. Spitzer, S. Gadocha, et al. Bestand optimal nutzen – Sanierung energieeffizient implementieren. 2018. *Berichte aus Energie- und Umweltforschung*, 12/2018.
- [11] T. Prinz, F. Schöpflin, A. Schmidbaur. Potenziale der Nachverdichtung. Nachverdichtung in Ein- und Zweifamilienhausgebieten am Beispiel der Stadt Salzburg und deren Aktivierung durch qualitative aktive Beratung. *ÖGZ – Das Magazin des Österreichischen Städtebundes* (3):28–30, 2021.
- [12] C. Schneider, S. Gadocha. BONSEI! – Bestand Optimal Nutzen – Sanierung Energieeffizient Implementieren! In *Tagungsband BauZ! Wiener Kongress für zukunftsfähiges Bauen*, pp. 40–43. 2019.
- [13] T. Prinz, S. Gadocha, W. Spitzer. Bestand optimal nutzen – GIS-gestützte Modellierung von Entscheidungsgrundlagen zur energieeffizienten Nachverdichtung. *AGIT – Journal für Angewandte Geoinformatik* (4):326–331, 2018. <https://doi.org/10.14627/537647041>
- [14] W. Spitzer, J. Reithofer, T. Prinz. Monitoring der Nachverdichtung in der Stadt Salzburg. *AGIT – Journal für Angewandte Geoinformatik* (3):383–389, 2017. <https://doi.org/10.14627/537633042>