

Designed vs. Actual Occupant Behaviour in Buildings – A Historical Perspective.

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Abstract. Energy efficiency and actual energy use in buildings depend on various factors. As building technology, construction quality, climate representation, advanced design tools and other non-human-related aspects are under scientific investigation and development for many decades, energy consumption in buildings started to decrease and reached a certain level. However, the desired net zero or even net positive energy consumption levels are far from reality yet in many cases. It was found that there is an essential component which is still underestimated and little researched: humans. Without understanding and appropriately representing building occupants and their needs in the design process, it seems impossible to estimate real, in-use energy consumption levels. In the 2nd half of the 20th century, occupant needs and behaviour were in the centre of many design cases. For example, prefabricated concrete block apartment buildings that were mass-produced in the Soviet era in Eastern Europe. These residential units were designed to fit the era's occupants in all aspects. The purpose of the rigorous design process was to make sure that the mass-produced buildings will fit well the families moving in. Somewhat differently, today our goal in occupant-centric design is to improve energy efficiency and to make sure that occupants have a comfortable and easy-to-use space to live or work. However, the results and methods applied by our ancestors should be examined and from many aspects their rigorous occupant-investigations can teach us a lot and can improve our practices today. This paper analyses the process of module-design of the 50-60's and their resulting apartment and occupant type "templates" using documents of the era and interviews with designers and other participants of that process and highlights the parts that are adaptable to today's design practices.

Keywords. Occupant behaviour, occupant-centric design, personas, history of design

DOI: <https://doi.org/10.34641/clima.2022.57>

1. Introduction and literature review

It is now accepted in the research community that occupant behavior can play an important role in building performance and it should be considered when designing a building and developing simulations [1]. Occupant behavior needs to be investigated and appropriately represented in research on the building life cycle as it is critical in achieving the goal of low or nearly zero energy (nZEB) buildings [2].

This paper contains the findings of a research focusing on three different aspects of occupant behaviour research: occupant types (personas), occupant-centric design methods and the influence of occupant behaviour in a specific historical era (1945-1960) in Hungary. In later sections, these concepts are introduced and then historical findings are presented which may be relevant to today's experts of the area of occupant behaviour in

buildings.

1.1 personas

There is a new method applied in occupant-centric design projects where instead of using one single "standard" occupant (and its presence, needs and behaviour) developed by designers or relying on standards and guidelines, designers build up types of occupants or personas to represent different groups of occupants during simulations and design decision-making [3]. Occupants can be grouped together based on various aspects depending on the actual design context and level of detail.

A study [4] determined categories based on indoor environmental quality (IEQ) perceptions and attitudes: the ones who are satisfied with their indoor environments, the ones who complain about indoor noise, and the ones who are bothered by indoor air and temperature. Hong et al. used personality traits linked to occupant actions to determine 6 types of patterns: average, reserved,

environmentally friendly, role model, self-centered, and mechanist [5].

Ortiz et al. has built up residential archetypes: Restrained Conventionals, Incautious Realists, Positive Savers, Sensitive Wasters, and Vulnerable Pessimists. Their attitudes could be connected to energy use behaviour [6].

Czétány et al. analysed residential smart meter data using clustering to examine daily electricity use profiles of household types. 3 different clusters were built: 1 is even throughout the days, 2 have morning and evening peaks in different types and magnitude. Also, settlement types were investigated and they had some influence on the daily user profiles. Villagemeters showed an earlier afternoon peak and highest morning peak compared to those in towns and cities. However, the consumption data do not support the belief that people would rise significantly earlier in villages compared to towns and cities. Regarding building types (condominiums, old and new single-family houses), no significant differences were found in daily consumption profiles [7].

Another study has created lighting preference profiles: users can be profiled based on their control behaviour, regarding characteristics as activeness, dominance, lighting tolerance, and dimming level preference [8].

The use of personas can be beneficial in many phases of the life cycle of a building. Starting at the early conceptual design phases, where architects are supported by more specific needs and occupant scenarios when deciding on spatial distribution. Then, during detailed design, comfort and performance models and simulations can be made more precise with the additional information on user diversity. Also, in the post-occupancy phase, they can be used for in-use model calibration and for fine-tuning building automation systems.

The main question of the application of personas is the data availability and the methods of building up these occupant types. It is often an obstacle that future occupants are unknown or there is a lack of data available on them. However, it is not always necessary to build up large databases and creating "new" archetypes of occupants. This paper introduces occupant types used in the past showing that it might be beneficial to look back and search for earlier "personas" to enrich our today's knowledgebase.

1.2 occupant-centric design methods

There is a new tendency in the research area of building design methods that argues that a more occupant-centric design approach is needed. [9] Not only the physical needs and presence of a human should be considered during the course of design but they should be captured in whole, as a coherent part of a physical and a social environment.

Horayangkura states that this movement for a more social and environmental approach in building design dates back to 1969 to a meeting of the Environmental Design Research Association. Back then a more technical approach was accepted in the early design phases [10]. Eversince an enormous body of research was conducted both in human sciences and environmental design. Social design practitioners have played vital roles in matching behaviour, spatial design and other building settings to improve the habitability of the built environment. In 1997, the idea of the "social cushion" emerged which argues that every individual exists in a social context of a given culture and the physical environment is "lost" as a separate reality [10]. Although the social cushioning effect sounds to be only an abstract idea, but it is certain that individuals in a building should be considered during the lifecycle of a building not only with physical factors but also with psychological, social and contextual variables.

Some research studies have been already conducted to capture the extent of the match, how a designer managed to match the real essence and needs of its future occupant. Azar et al. found many studies using space-use efficiency metrics to describe if a designed space is used as intended in reality [9]. These metrics can be an appropriate indicator whether the designer managed to find the ideal space-distribution for future occupants. These metrics mentioned in the study cited above are mostly used for the office context but in the future they could be extended for residential settings as well.

In the framework of this research, early examples are introduced from Hungary where designers tried to abstract and capture their future occupants not only in a traditional way but using unusual techniques such as wardrobe element counting or detailed household type picturing. Later, residents of the earliest experimental housing estates reflected on their success which may serve with lessons learnt for today's scientists and designers as well.

1.3 influencing occupant behaviour

In many cases, scientific evidence shows that actual residential energy use may significantly differ from modelled assumptions [11] [12]. Byrne argues that everyday practices of occupants should be considered when residential energy use variations are investigated [13]. It has been demonstrated that changing occupant behaviour alone can achieve significant energy savings [14] [12].

As scientists and designers have acknowledged the potential in residential behaviour change, many approaches were developed to do so. Modifying occupant practices and everyday life is an approach to influencing household energy demand. This approach posits that energy use is mainly affected by practice or by how a certain activity is carried out. Practices in turn are the result of habits, knowledge

(skills, competence), motivations (image, meaning) and technology (stuff, material)[15] [16] [17].

Another approach to affect behaviour has been through influencing attitudes [18], providing information and social norms and delivering feedback [13]. However, such top-down approaches were heavily criticised arguing that intrinsic motivation and needs should be always taken into consideration to have significant impact on someone's behaviour [19]. Another approach for providing feedback for behaviour change is when technologies such as smart metering and in-home are used to deliver feedback to households and make them more aware of their own energy use [20] [21]. However, this is claimed to have only short-term effects in most cases [19] [22].

It can be seen that changing and influencing an occupant's behaviour in a building has been a hot topic recently. It raises not only ethical, cultural and psychological questions but there are doubts about the efficiency of these measures also.

This paper introduces the idea of a top-down behaviour change attempt in the post-war era of Hungary when the state initiated the change and "improvement" of occupants' apartment use and the overall way of living of the people. Later some evidence of the failure of this approach are introduced.

1.4 historical context

In 1946, Gádoros has evaluated the post-war number and condition of residential rooms in Budapest [23]. The SUM of rooms was 481 280 out of which 5.4% was destroyed, 18.4% was damaged but restorable. He calculated that with the current average 3-year apartment building rate (110 000/3 yrs), it is impossible to supply citizens with an appropriate number of apartments (destroyed or severely damaged and new needs: 230 000/3 yrs). He concludes that a completely new housing strategy is needed with "optimized" needs and argues that the pre-war upper-class large apartments do not suit the needs of modern residents. He and Kismarty-Lechner were contracted by two architect members of the Communist Party to work out a concept for reforming housing in Hungary. Their concept is introduced in section 3 in detail.

They formulate their goal as follows: "It is the task of our era to equalize and eliminate class differences in society" [24]. "We fully drew the case of new apartment building under common care, direction and control" [24] Kismarty-Lechner sets the foundations of the ideal apartment design and distribution system in Hungary in 1947. He states (representing architects of the era) that income levels should never decide the type and size of apartments of anyone. Rather occupant number, habits and profession should be the determining factors.

At the beginning of the 50s, the first 5-year economic plan was announced in Hungary stating that residents will be provided with +50% raise in the standard of living country-wide compared to the era before world war II [25]. In 1954, the 2-year programme of apartment type development was launched by the Ministry of Construction [26]. This was the first step of the period where the layouts of mass-produced concrete apartment block buildings were designed.

In 1955, Csordás states that class-differences in society should be gradually eliminated. Bigger and better apartments should not be the privilege of upper classes. [26] The only factors influencing the type of apartment of a household should be the number of people living in the apartment, user habits and profession of occupants (resembling the ideas of 1947 above).

Reischl wrote a chapter in Fórizs's book about the ideal solution for the apartment supply crisis in 1958 [27]. At that time, 237 persons were living in 100 rooms in Budapest on average and 267 outside of it in Hungary. He compared this situation to 1955 levels which was 170 persons in Hungary and 73 in Switzerland, 120 in the Federal Republic of Germany. Therefore, he draws attention to the urgency of the housing problem in the country as well and reinforces the socialism's principle: "if the needs of the working population were fulfilled entirely, also the production levels of the country will rise".

1.5 aim of research

The historical context explains the specific problem of the era. From it, it can be seen how eager the era's designers might have been to find optimal solutions fitting the needs of residents as urgently as possible. The aim of this research is to find out what we can learn from this historic era, from our ancestors which can support today's occupant-centric design and occupant behaviour research professionals.

2. Methodology

1945-1958 literature was scanned focusing on the design, construction and post-occupancy evaluation of the first soviet-type mass-produced apartment buildings in Hungary. Architectural journal archives are available in an online collection called Arcanum [28]. Relevant books and ministry-issued publications could be found in Széchenyi National Library in Hungary. Transcripts of interviews with designers of the era and also with residents of the first experimental housing estate were available in the Oral History Archive of the 1956 Institute in Hungary [29].

The literature review focused on personas, occupant-centric design methods and influence on occupant behaviour in the post-war architectural discussions and the process of the apartment-types development of the new mass-produced housing estates (later on

constructed from 1958 to 1986). This was followed by interviews with experts of the field of societal history of the era and prefabricated concrete block building construction and energy-related behaviour.

3. Results

The very first concept for formulating the apartment types fitting all households was introduced in 1947. Kismarty-Lechner determined 5 apartment types based on the initial idealistic set of requirements: [24]

- A. 1 person – 1 room + cooking chamber
- B. 2 persons – 1-2 rooms + cooking chamber + dining area
- C. 2 persons – 1-2 rooms + kitchen with storage+ dining chamber + bathroom
- D. 4 persons – 2 rooms + kitchen with storage + dining room + bathroom
- E. 6 persons – 3 rooms + kitchen with storage + dining room + bathroom

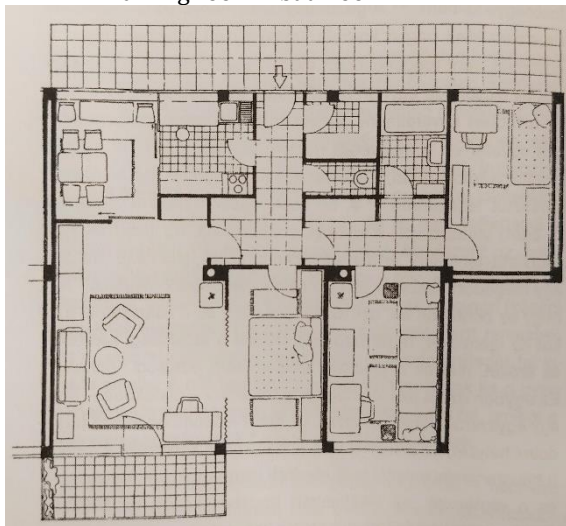


Fig. 1 – Template apartment design for 6 persons. [24]

(Families with more than 4 children should move to a single family house.) Apartment types A and B were to assign to young either single persons or freshly married but in any case they should be separated into different buildings from families with children to avoid conflicts. It is also mentioned that there is a tendency that only a few wives have in-home assistance, therefore designers should support their work in the kitchen and dining area with more efficient kitchen layout design and furniture prototypes.

3.1 personas

Later apartment type concepts put more focus on the specific types of residents based on profession and everyday habits. Csordás states that there are 5 types of professions where separate characteristics and living needs can be determined in the following aspects: wives working or not; children at home or in children’s institutions; number of staying at home

¹ Heating can be controlled in each room if occupied at different times.

and night-shift working household members; furniture possession and needs; food purchasing and storing habits; heating options; intellectual work at home; social life needs and habits; culture of living: [26]

UNSKILLED WORKERS: low salary, workers who are traditionally used to village-life;

MINERS: occurring in very specific regions, also used to traditional village housing culture;

INDUSTRIAL and TRANSPORTATION WORKERS: mainly living in housing estates in larger towns, cities and in Budapest;

STATE ADMINISTRATION, COMMERCE EMPLOYEES; INTELLECTUALS.

He argues that the other determining factor of assigning a given apartment type to a family is the total number of people in the household. [26]

Reischl established 4 specific types of personas based on the profession of the head of the family in 1958: [27]

FARMER: entire family works, rests, eats at the same time; work place is around the house; self-sustaining household; low fuel stock; local traditions are important; usually lives in villages with no electricity, water or sewage utility service.

MINER: family works in different shifts; eats, rests at different times; wants to spend as much time outdoors as possible; gardening, backyard poultry; high level of fuel stock (as a benefit from coal mines); miner towns equipped with electricity and water service but not sewage; more salary earned by hard work therefore can afford enjoy miner town benefits (childcare, minerclubs).

INDUSTRIAL WORKER: “each family member (even women) demand the conditions of an independent life”; women work and earn, housework is shared; everyone eat outside at the factory or school; homes are equipped with electricity, water and sewage utility services, sometimes even natural gas for central heating and hot water; family enjoys “city-life services”.

INTELLECTUAL: very similar to category industrial worker but family members work at home as well.

Tab. 1 – Apartment design needs of profession-based personas in 1958.

	Farmer	Miner	Industrial worker	Intellectual
Rooms	1-2, not separated	Separated ¹	Separated ²	Separated

² Equipped with bed, wardrobe and a reading area as a minimum.

	ed			d ³
Kitchen	In room	Yes, large	Yes, small	Yes, small
Bathroom	No ⁴	Yes ⁵	Yes, with washing machine	Yes, with washing machine
Storage	8-14 m ²	coal storage + 4-5 m ²	1 m ² ⁶	1 m ² ⁷
Work room	No	No	No	Yes, for every working family member

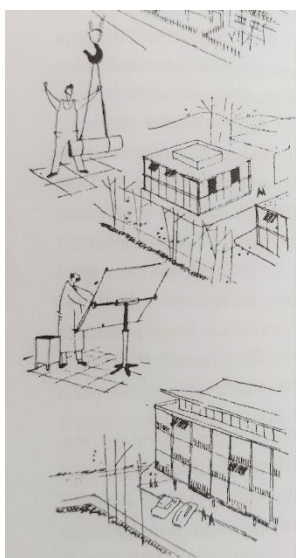


Fig. 1 – Vision for ideal living conditions for different occupantions. [27]

3.2 occupant-centric design methods

Kaesz states in the foreword of Gádoros’s book from 1946 that “today’s architect should be the organizer of measures and sizes where the human body should be the base” [23]. He refers to Adolf G. Schneck and Ernst Neufert who established the size and measure system for building and furniture design between the two world wars. However, he states that it needs to be supervised and actual minimum space needs should be determined based on an “average resident with average needs” and amount of belongings.

Gádoros made an exhaustive list of belongings of a man (34 types of clothing items – e.g. 2 winter and 2 summer suits, 4 pijamas, 12 shirts, etc.; 14 types of other items – e.g. 2 hats, 2 black shoes, 2 brown shoes, 6 towels, etc.), a woman, a 3-6 and a 6-12 years old child and for an infant. He collected the items of a kitchen as well and then produced exact sizes for kitchen cabinets and wardrobes and all other furniture based on the size of these average people

³ Equipped with bed, wardrobe and a reading area as a minimum.

⁴ Until no water and sewage utility service is available.

⁵ WC separately

and their belongings.

Reischl states in 1958 [27] that all apartments should fulfil the general needs of the family members (protection⁸, bathing, visitors, cooking). Then a given template apartment design should reflect the profession and family structure of the residents. Architects are suggested design layouts and furniture of the template apartments to follow the personas developed by the author and introduced in section 3.1 of this paper.

The results and overall acceptance of this “space minimization” program can be seen in the interviews with residents of the first Experimental housing Estate in Óbuda, Budapest (built in 1958) [30]. Residents complain that everything in the apartments are extremely small and narrow, especially bathrooms and kitchen. The idealistic kitchen cabinets were not deep enough to fit the era’s standard cooking pot.

3.3 influencing occupant behaviour

In the post-war socialist housing concept, the theory was that to achieve an “ideal society”, “ideal apartments” should be provided which were designed based on “good and correct” (approved by the state) principles. [31] Also, the primary intention was to “determine, improve and reform” the residents’ way of living, habits and overall use of their apartments especially from 1945-1950 and from 1955. [31]

Several examples were found in the framework of this research where either the Ministry of Health, or other government-hired architects formulate recommendations on the use of the apartments and behaviour and lifestyles of residents.

The Ministry of Health issued two publications in 1951 which contained several detailed recommendations on the healthy use of an apartment and tried to prescribe the use of an apartment and occupants’ behaviour: [25][32]

- **External surfaces and heating:** low conductivity, waterproof, soundproof, no moisture inside. Assimetric radiant temperatures should be avoided (cold, wet walls and hot stoves) to avoid sicknesses. [25] External wall and floor surfaces should be kept at room temperature, a maximum of 2-3°C air temperature difference is allowed between a person’s head and the floor. Stove surface temperature should be below 70-80°C to avoid burning house dust on surface. Heating should be controlled easily and working efficiently. It is important to find the best location of the stove in the apartment. Central heating systems are the best solutions but still mostly unavailable

⁶ Family does daily shopping in the city.

⁷ Family does daily shopping in the city.

⁸ Also referring to heat and sound insulation and heat storage capacity of building structures.

and expensive [25]. Indoor air temperature should be between 18-20°C during winter [32].

- **Artificial lighting:** electric bulbs are suggested (not candles or gas-fired lights to avoid air contamination [32]) with even distribution, no glare and with blue/yellow white colour [25].
- **Ventilation:** intermittent cross-ventilation: either door+opposite window opened for 3 minutes or opposite windows opened for 5 minutes 3 times a day and windows should be opened any time an odour can be smelled [25]. Another publication proposes 5-10 minutes window opening per day for winter period and 20-30 minutes for summer [32]. Also stating that extra humidity should not be released in living- or bedrooms from washing, drying or cooking.

Reischl states in 1958 that an apartment is a place where a resident rests, studies, meets culture and starts a new family [27]. He argues that the housing condition of wide social classes determines the “level of culture of the population”. Seemingly, architects of the era were committed that with providing modern and “better” apartments for a large percentage of people, they can influence their everyday life habits and the affinity to culture.

At the time of the first apartment template design efforts, literature on how to use “appropriately” a small apartment started to appear. In Gyarmati’s book, clear guidance is given how to use a small place for different purposes in different times (e.g. a room for rest, visitors, dining) with practical furniture and room separation tricks (sliding doors, curtains). [33]

Pataki gives specific recommendations about heating setpoint temperatures and heating methods for working women in 1956. [34] Desired heating setpoint of an apartment should be 18-20°C, not lower during the nights and not higher to avoid sicknesses. Halls, other ancillary rooms should be kept at 15-16°C, whereas bathrooms should have a temperature of 20-22°C. Right before the chapters on clothes moths and indoor flowers, a very detailed typology and user manual is given on iron stoves, co-fired boilers with 1 or 2 chambers and filling holes. Pataki also argues that “the ancestors’ standpoint on women’ role in the household should be eliminated” thus suggesting a lifestyle change and promoting the equal share of housework at home.

In the interviews with residents of the first Experimental housing Estate in Óbuda, Budapest (built in 1958), also some feedback can be found on the apartment-use recommendations of the era [30]. For example even though central heating was built in most of the apartments, residents tend to disconnect from it as usually a landlord was responsible to heat it up manually many times during the day and it usually happened only once or twice a day which made it extremely uncomfortable. Many interviewees mentioned the semi-permanent tricks of taking out built-in furniture or reorganizing spaces because they could not use the apartments “as

intended”. Many times, residents moved in the apartments with much more furniture that could be placed in the new apartment comfortably. Some residents managed to get a washing machine which was a rarity in that era and put it in the middle of the bathroom as nowhere else could fit and lived their life tiptoeing around it for decades.

4. Discussion and Conclusions

Based on the findings of this research regarding residential personas, it was interesting to see what were the parameters which determined a given occupant type’s characteristics. Nowadays, in occupant-centric and environmental design processes, experts categorize occupants based on IEQ perceptions, attitudes, environmental control usage, settlement or building types. Whereas back in the post-war era of Hungary, designers established occupant categories based on household size, profession, home occupancy, lifestyle and culture of living aspects. The question here really is which parameters describe the best an occupant’s characteristics and expected behaviour in which context and phase of a building’s life-cycle. To answer this question, more research has to be done to connect social, cultural, psychological parameters to indoor comfort and energy-use behaviour.

Based on the results of the occupant-centric design investigations of the era, two issues can be further concluded. Firstly, that the previously developed space-use efficiency metrics could be interpreted for a residential setting in the future as in the framework of this historical experiments, evidence was shown that in many design cases post-occupancy feedback is available on space-use as well. And it can provide a valuable “feedback loop” for original designers improving their design practices for the future.

Weakness of the template design methodologies introduced in this paper lies in the lack of references to the methods applied to collect information on the actual layers and state of demographical layers in the country. According to conference transcripts of the era and interviews with experts of this period, it seems that architects were considered to have enough experience and expertise about these issues based on their multiple design projects and life experience. This is of course a very strange concept with today’s eyes but supposedly no one questioned their authority on this matter. There is some literature on the idea of architects being the engineers of the society. [35][36] This of course raises the question of the role of an architect in the design process but this is outside of the scope of this paper. However, it explains why this research has not found any kind of record of involvement of social scientists or other experts into the template apartment design process of this era.

It has to be noted that even though some apartments were designed and built following the principles developed in the era introduced, in many cases the

occupant selection and the apartment-assignment process was not working ideally. These apartments were assigned to applicants based on a credit system by housing committees. Late post-occupancy interviews (after regime change) revealed some irregularities of the system. Therefore, when an occupant states that the apartment design did not fit his/her actual needs, it does not necessarily imply that the design itself was poor but sometimes it was the lack of consistency of the system (e.g. miners moving into apartments designed for intellectuals or villagers moved into small housing estate studios). At the same time, the most important question arising from this very specific design case remains what metrics and parameters could be used to evaluate the post-occupancy “goodness” and usability of a building’s design which might teach a lesson for designers for the future.

Also, Keller states that often architects and designers developing template apartments had to represent the state’s principles to some extent [30]. Applying these template designs were obligatory for state-financed or co-financed new housing estates which made up a significant share (40-50% between 1950-60) of all new apartment buildings in Hungary. This significant influence coming from the state shows that the template designs were predestined to unfit future occupants to a certain level shown in the post-occupancy interviews by residents.

Regarding the intention to change residents’ way of living, the post-occupancy interviews also show that the theoretical methods did not work out well in practise. Current research also suggests the weakness of such top-down approaches. Interestingly, the recommendations by the Ministry of Health introduced above contained information on thermal comfort and indoor environmental quality which implies that the state’s primary intention with changing behaviour was not only using the new apartment types with minimized floor areas efficiently but also to improve comfort levels of the occupants.

This paper introduced historical findings from one specific era and country focusing on three aspects of the occupant behaviour research area. In the future, it would be beneficial to do the same exercise focusing on different periods of time, different regions and also different design problems in different geo-political contexts. Author believes that such future research projects using a historical approach might add to our current knowledgebase on the role of occupants in building design.

5. Acknowledgement

This paper was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences.

Data access statement: data sharing not applicable to this article as no datasets were generated or

analysed during the current study.

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