young cities

Developing Urban Energy Efficiency

Tehrān-Karaj

Young Cities Research Briefs | 10

# Energy-Efficient-Homes

## Designing Energy-Efficient Architecture in an Urban Context

Philipp Wehage, Annette Wolpert, Elke Pahl-Weber

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# Preface

The “Energy-Efficient-Homes” present a “research by design” based process for sustainable housing in the MENA (Middle-East North-Africa) region based on the case study for Hashtgerd New Town in Iran.

The pilot area of the case study, the “Shahre Javan Community”, is situated in Hashtgerd New Town, about 65 km north-west of Tehran. Within the existing framework, the program provides a housing quarter for about 8,000 inhabitants in about 2,000 dwellings, including the necessary social infrastructure.

The “Energy-Efficient-Homes” highlight the potential of spatial design regarding energy- and resource-efficiency. The task for urbanism and architecture was to develop spatial strategies and measures to maximize the use of passive energy impact and to minimize the consumption of natural resources. The final design is an adaptation of the process findings to the site specifics of the pilot area. It shows the design scenario for one urban unit for about 250–300 inhabitants.

Due to the fact that about 70% of the whole MENA region is classified into arid and semi-arid climate and that the Islamic rooted society constitutes the socio-cultural context of a wider supranational region, project results gathered against this background, can be used for further dissemination through e.g. transfer and adaptation to other locations in the region.

The study was conducted by the “Young Cities” Project at TU Berlin in the research dimension “Urban Design and Architecture”. It was published in the “Young Cities Paper Series, Volume 04” of TU Berlin in 2013. The authors would like to thank Cornelia Saalmann of the Project Centre at the TU Berlin to enable this publication and Prof. Elke Pahl-Weber and Prof. Peter Berten for their expertise and support.

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# 1 Introduction

Housing is the central, if not the original objective of architecture. The human need for a climate adapted envelope and the areal formulation of the smallest social unit has always followed specific social and spatial visions. In a fast growing society like Iran, the demand for mass produced housing requires efficient strategies for the planning and construction processes. These challenges in mind, a typological approach for the design of an energy-efficient housing architecture, that derives from the planning process directly, has been chosen as the appropriate method. This "research by design" method provides the opportunity to apply a typological approach to the development of an energy-efficient estate. The pilot area selected is the "Shahre Javan Community". Here, the "research by design" approach serves as a tool to develop design solutions that incorporate the urban context of the pilot area. Respecting the aims of the urban design and its relevance concerning the spatial arrangements for energy efficiency, the housing typologies follow the needs of the local culture, which means creating places for privacy in a compact urban context. The design of residential architecture is therefore the outcome of simultaneous aims, those for energy efficiency and those concerning the spatial need for privacy.

## 1.1 Goals and strategies

Supposing the general scientific principles for energy efficiency as well as the need for privacy applied in the pilot project are comparable to regional demands, then the design resulting in the "Shahre Javan Community" project does not just stand for this specific location. Despite the fact that design solutions are always connected with the "genius loci", these are in fact transferable to other regions in the Middle East as they respect the general climate conditions and the socio-cultural demand in the region. Geological (e.g. earthquake resistance) and geographical (e.g. topography) aspects that are specific to each site need to be reflected and adapted to local demands. Therefore, the aim of this typological work is not to give fixed answers for mass housing in the whole region, but to give a catalogue of planning measures and processes that can be adapted to specific applications and standards.

The research process involved in developing the energy-efficient architecture for the "Shahre Javan Community" pilot project is characterized by the relation between the general scientific principles (physical and technical) and the local and regional conditions (climate and site). The housing for Iran's new towns demands an analysis of the country's present situation in regard of urban design and architecture and the potentials of vernacular architecture for future developments in semi-arid regions. By analysing the spatial formulations of architecture and urban design regarding energy efficiency, it was possible to categorize suitable organizational forms. The energy efficiency value of the general architectural and urban findings on the site with its specific features concerning climate and topography has been adjusted to the socio-cultural context. The result of this research is formulated in a catalogue of architectural criteria as an approach for further design solutions.

## 1.2 Housing in the orient and Iran

### 1.2.1 Housing in the orient – tradition and today

In the architectural traditions of Iran and the Orient, a home is characterized by the demand for absolute privacy. Following the hierarchy of public and private space in urban designs, the following consequences can be outlined:

Integrated in the hierarchical definition of space, the house represents the final step into the private realm (Wirth, 2000, p. 325 ff). The introversion of the traditional courtyard house is one spatial expression of the need for tranquillity and intimacy. This hierarchical system of space in urban designs is accepted and also pursued in the organization of the house. Areas for access, guests, services and family-life are integrated in a well-defined floor plan around one or several central courtyards which form the centre of the house (Edwards et al., 2006, p. 21 ff). The layout illustrates the hierarchical system from public to private areas inside the dwelling (Bianca, 1991, p. 196 ff). The open spaces attached to the courtyard houses, such as access paths, are minimized as the focus is on the spatial quality of private space

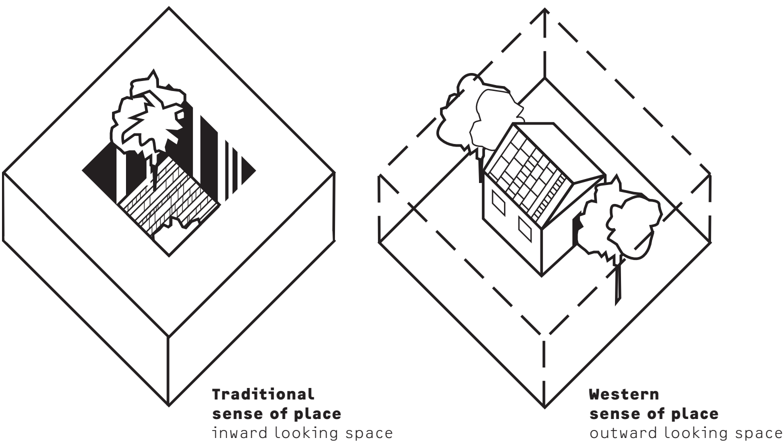



Fig. 1: The sense of place according to S. Manzoor

inside the house. The introverted housing scheme allows for a climate-sensitive urban arrangement, which is characterized by compactness through the attachment of units in closed coverage. Elements for ventilation, such as wind towers, optimize the climate conditions, especially in hot arid regions (Edwards et al., 2006, p. 155 ff.).

The adaptations of modern housing typologies in the 20th century have transformed the dwelling into an extroverted volume in a Western style. The definition of space, as known in the introverted traditional style, has been turned inside out. This break in tradition has made available the advantage of exposition to light and air on the outside by opening up the façades, and therefore the possibility of creating multi-storey buildings.

The former organizational scheme of the neighbourhood has been transformed – from a horizontal to a vertical arrangement. The consequence is that the inhabitants have to react by defining a new spatial organization or by changing their habits. The stairway, for example, has been transformed into a vertical "dead end" and defined as a semi-private space according to Islamic tradition (Wirth, 2000, p. 398ff).

But the separation between private indoor and public exterior space was disturbed by opening up the façades. The informal result of this spatial turnaround is that the apertures are now covered up with curtains. The private open areas attached to the façades and facing onto the streets, such as gardens, balconies and loggias, are not frequented due to their visibility from the public space and have therefore developed a backyard character. They are often used for storage or technical supplies (e.g. air conditioning equipment). On an urban design level, this relation of the façade to the exterior creates relic open spaces in the Islamic regions of the Orient (Diba, 2002).

The extroverted housing schemes in new towns often apply linear building arrangements, comparable to housing developments in the Western world. The broad and wide linear urban space between the building volumes appears as a relic negative space with a lack of quality, because there has been no cultural adaptation.

The contradiction between privacy according to a traditional Islamic understanding and the Western-style vertical housing typology has not yet been addressed, neither the urban principles of developments in new towns nor in the renovations of existing structures in the large cities like Tehran or Karaj.

### 1.2.2 Housing in Hashtgerd New Town

The common housing typology for the medium density of Hashtgerd New Town is based on the orthogonal layout of the urban masterplan (Wehage et al., 2012, p. 39ff). This system orients buildings in a north-south direction, such that access to the buildings is either from the north or the south. The plots are arranged in a rectangular layout without regard to topography. The common plot width is 15 to 18 m. The common plot area is about 600 m². The position of the building volume on the plot is defined by regulations on distance, which are based on light exposure, privacy aspects and regulatory plot coverage. Ignoring light orientation, the staircases are often positioned in the street-side façades. This type of attached building ("closed coverage type") leads to a linear structure of building volumes. The linear arrangement of buildings leads to uniform linear open spaces oriented towards the public and private sides of the houses (Fig. 2–3). The only spatial measure for defining the private open space is the enclosure of the plots with walls. Thus the spatial boundaries of the north-south oriented open spaces, e.g. streets and parks following the topography, are not properly defined. Furthermore, the ends of the linear building structures are simply cut off with a closed shear wall, lacking any architectural corner design.

Fig. 2: Housing blocks in Hashtgerd NT – view from the south

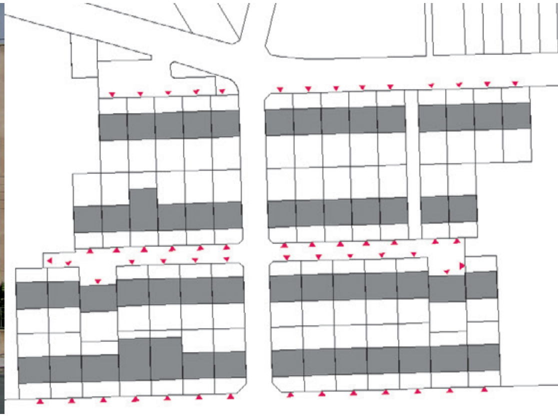


Fig. 3: Housing blocks in Hashtgerd NT – site plan

## 1.3 Energy-efficient urban design and architecture

The position and configuration of the building volume and its orientation to the sun is an important factor for energy-efficient architecture. Because of its relevance concerning the spatial organization on an urban scale, defined for example by access situations and morphological settings, the position in the urban fabric must be considered.

The main aspects of the urban context are determined by the orientation, as a factor for passive energy gain, and the compactness, as a factor for minimizing energy loss through the thermal envelope (Hegger et al., 2008, p. 62ff).

The ideal volume for the use of solar incidence, as the main passive energy yield, is characterized by a glazed façade for all main rooms oriented to the south and a more closed façade to the north enclosing secondary rooms. The north-south orientation leads to large areas with an east-west direction and small depths in the north-south direction. It is for this reason that this layout is not practical for compact urban schemes.

The courtyard houses in Iran are traditionally located in arid and semi-arid regions. The compact urban form of courtyard houses guarantees good climate conditions inside the buildings. Only selected rooms and spaces are oriented to the sun. The use of these areas depends on the heat impact of the sun. Special (often temporary) functions make use of the solar heat input in winter. The compact, almost closed volumes, ensure a more constant micro-climate in contrast to the considerable daily and seasonal fluctuations on the macro-level outside.

To improve the micro-climate in high density areas, traditional elements, such as air circulation by making use of vertical shafts or shady courtyards with plants or water basins, can be used as vernacular low tech devices for better energy efficiency.

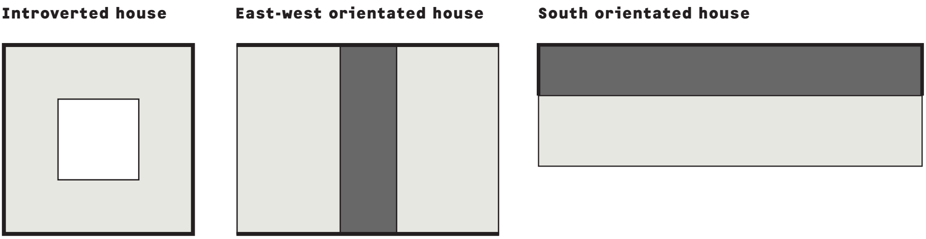



Fig. 4: Housing typologies and energy efficiency

## 1.4 The climate context

The semi-arid climate in the region of the pilot project is characterized by warm and dry summer periods, with extreme temperatures of more than 35°C during the day and colder and more humid winters with occasional frost periods (FU Berlin, 2010). Because of the extreme seasonal temperature range, energy for cooling as well as heating is required to provide thermal comfort in the building. The significant difference between the day and night-time temperatures of up to about 16°C is also characteristic of the local climate. In the context of the urban configuration and climate of the "Shahre Javan Community" site, the following findings regarding energy-efficient aspects are outlined:

The linear arrangement of the existing housing typologies in Hashtgerd New Town and the maximization of south-oriented façades is a good approach for the use of passive solar energy. The need for privacy however contradicts the need for opening up the façades, and the greater consumption of land demanded by such typologies conflicts with energy objectives on an urban scale. Furthermore, the high demand for cooling energy in summer needs to be considered in the architectural design.

The compactness of traditional courtyard housing schemes in dense urban layouts avoids energy loss for heating and cooling via the thermal envelope. The shaded courtyards and their micro-climates produce thermal comfort and air circulation according to the building morphology. The solar heat gain in winter periods is restricted to south oriented subzones. The introversion of this typology respects the demand for privacy.

# 2 Research methodology: a research by design process

The chosen research methodology for the Energy-Efficient-Homes is performed for a residential pilot project in the "Shahre Javan Community" area in Hashtgerd New Town. To ensure the appropriateness to the pilot project, the methods of research are integrated in a planning process. The method suitable for combining scientific and planning results is the research by design process. In a systematic work process, the findings of a general approach and specific design allow for the evaluation and definition of further steps. By applying this scenario-specific methodology for architectural and urban design suppositions, that have been obtained from a general approach, to real planning situations, the assessment can be performed on different scales. Finally, the results gathered in the design process are used to revise the formulation of the initial approach.

The data collection process and the analysis of preconditions for the task "energy-efficient housing" is characterized by general dimensions (e.g. general aspects for energy efficiency and volumetric matters) and specific dimensions (e.g. site and socio-cultural context). The influence of general and specific aspects enables the transferability of the results to a general dimension (e.g. energy efficiency through spatial design) and a specific dimension (e.g. climate and social adaptation). The graphic shows the research by design process with the design and examination steps in a linear arrangement. The final step shows the conceptual design for one urban unit in the pilot area as a standard definition and design solution for application in the "Shahre Javan Community" context (see Fig. 5).

## 2.1 Energy-Efficient-Homes in the "Shahre Javan Community" – parameters of influence

The development of housing design solutions is affected by several groups of parameters: spatial, social, economic and technical.

The different groups of parameters function as tools for the assessment. The influential degree of each parameter group on the final design solution is the result of their consideration, discussion and integration in the design process. Several parameters can influence different groups (for example orientation as an aspect of urban design as well as energy efficiency). This highlights the complex relations and influences amongst the groups. They should never be seen isolated. Thus, the design for the architecture of housing typologies is the result of an integrated planning process.

Following the approach that every architectural design is part of an urban configuration, the influences of general dimensions on the architectural design solutions has to be proved by specific site characteristics and conditions. The discussed requirements for the Energy-Efficient-Homes in the "Shahre Javan Community" have led to the following parameter groups:

***Urban design***
The first group of parameters describes the influence of the urban design:

In continuation of the urban design criteria established in the project prephase, the typologies must follow the urban morphology. The architecture of housing typologies is directly influenced by the determination of urban design features with a technological and socio-cultural background. The "hard facts", such as the access system, the technical infrastructure, the plot orientation and the design requirements to avoid earthquake hazards are preconditions for the site. The so called "soft facts", such as identity, flexibility or the implementation of mixed-use schemes, should be integrated in the development of housing typologies and are defined by the spatial measures of architectural and urban design. They establish the 'sensuous' dimension of architecture.

***Users and codes***
The second group is characterized by the analysis of users and stakeholders. It determines the requirements in a technical and spatial dimension. Building codes, technical principles, materials, the demand for energy efficiency, as well as local and regional specifications and urban design preconditions are analysed in an integrative process with the project partners.

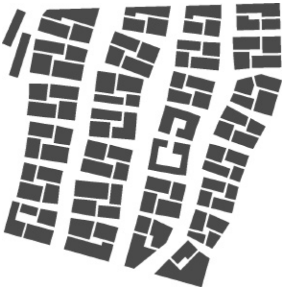
The analysis of users, in the sense of a target group, helps to define the technical requirements in a socio-economic context and encourages the image and marketing strategies of the design.

***Energy efficiency***
The third group defines aspects of energy efficiency. Several aspects can be derived from the urban design, like the orientation of volumes or technical basics, which again define the strategy on a building scale. Following the need for energy efficiency, aspects such as the surface-to-volume ratio and the floor-organization influence the building design directly. The technical standard of energy efficiency ('high tech standard' or 'low cost standard' as possible benchmarks) depends on the preconditions of the local and regional situation.

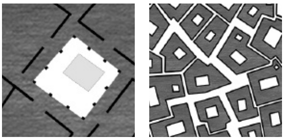
***Sense of place and vernacular architecture***
The fourth dimension is developed according to the research on vernacular architecture and urban design. It shows the socio-cultural dimension of architecture. Traditional Iranian urban and housing designs support the building typology following energy-efficient urban design criteria. The understanding and use of space from public to private areas and vice versa influences traditional Iranian cities. The compact form is one approach for the creation of energy-efficient housing typologies and an identity of space.

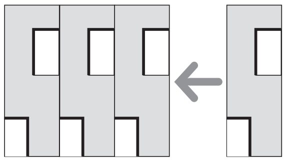
**Input from analysis** | **Parameter** | **Design approach**

## Urban design

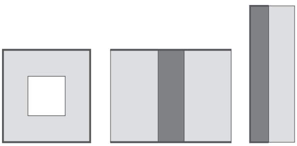


## Users and codes

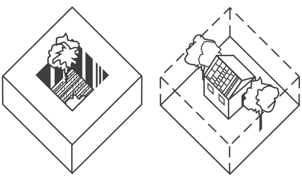




## Energy efficiency



## Sense of place



| Criteria | Design concept | Design measures |
|---|---|---|

**Definition**
of access system and urban morphology

**Adaption**
to site and topography

**Ground Floor**
with mixed-use potential

**Spatial hierarchy**
from public to private

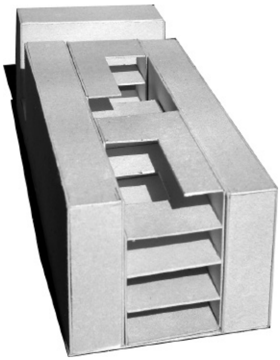
**Potentials**
multi-floor courtyard house

**Orientation**
Of volumes and surfaces

**Application**
Of simple constructions

**Energy Efficiency**
as a result the architectural design

**Architectural concept**
as an expression of identity



**Orientation + dimension**
- Optimize sun orientation through sculptural modelling
- Possible vertical organization of units in building volumes
- Closed coverage in an east/ west direction
- Façade openings to exterior space in N and S

**Organization + structure**
- Modular space system as structural pre-condition for functional and constructive organization
- Vertical continuity for provision of economic and simple construction methods

**Access + vertical connection**
- Entrance from path
- Provision of additional entrance from garage
- Provision of central stairway inside the volume

**From public to private**
- Potential commercial unit and entrance hall on ground level accessed from path
- Semi private stairway
- Graduation of privacy inside unit through organization around courtyard

**Variety + flexibility**
- Horizontal organization for small units
- Vertical organization for big units
- Morphological variety through sculptural modelling of upper floors

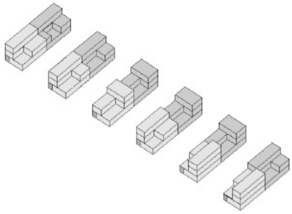
Fig. 5: Design process of Energy-Efficient-Homes

**Design study sub-neighbourhood**

**Adaptive measures**

**Typological catalogue and design scenarios**

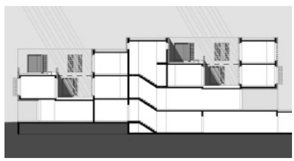
**Site adaptation**
- Choice of type
- Morphological variety through plot layout and dimension
- Morphological variety through sculptural modelling of building volume based on modular space structure



**Functional adaptation**
- Choice of type
- Access system
- Use (mixed use/housing)
- Vertical or horizontal floor organization
- Variety of floor plan layout

**Standard adaptation**
- Choice of type
- Construction and materials
- Facade structure and design
- Energy efficiency
- Supporting systems
- Interior arrangement and equipment

**Energetic adaptation**
- Choice of energy system
- Supportive, energy-efficient measures on an urban scale
- Supportive, energy-efficient measures on a building scale
- Construction and materials
- Technological input



## Innovations

## Design for urban unit

## Conceptual design

### Basic principle

**Courtyard house**
Resource protection through building configuration

**Modular space**
Cost and energy – efficiency through planning process

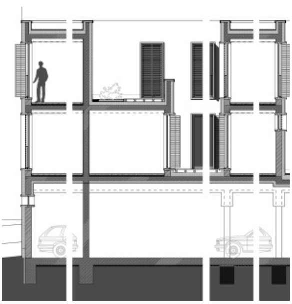
### Upgrades

**Sun shutters**
Energy impact regulation through facade elements

**Light shelves**
Energy gain through individual natural light and heat control

**Photovoltaic fabric**
Energy gain through individual control of natural light and heat

**Geothermal energy and heat exchangers**
Energy reduction through air-driven, combined heating-cooling-ventilation system



### Urban unit

**Architectural plans**

- Site adaptation to technological, functional and economical context
- Spatial organization of urban unit according to basic principle
- Spatial integration of innovative upgrades
- Spatial organization of floor plans and apartment layouts
- Preliminary plans concerning construction and materials
- Preliminary plans concerning construction and materials
- Visualization of spatial and physical qualities
- Integration of energy efficiency concept on an urban and building scale

### Perspectives

- Basis for tendering and execution planning
- Basis for construction and detail research
- Basis for adaptation to other sites in the Shahre Javan community
- Basis for mitigation in a regional context

# 3 Design strategy – analysis and design approach

The analysis of preconditions and the definition of requirements determine the influential framework of architecture. A certain vagueness in the formulation (e.g. target group) can be replaced by assumptions or as a safeguard for flexibility. Because this development of housing typologies is bound to the application on the ”Shahre Javan Community” site in Hashtgerd New Town, a “research by design” strategy was chosen for this specific scheme. In a first step, the morphological and functional demands, as a result of the research on energy efficiency and the urban design framework, were analysed and transferred into a design strategy.

The strategy represents the aim of combining the advantages of two main topics relevant for the energy efficiency in architecture and urban design: orientation and compactness. In a second step, strategies and measures for energy-efficient housing typologies specific to the site conditions were determined by adjusting the morphological study with the gathered groups of parameters. The identified criteria were put into a catalogue as a tool for the evaluation, adaptation and transferability of the site-specific design.

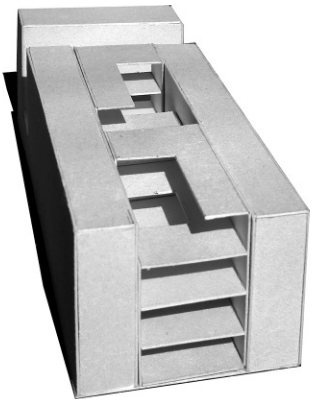


Fig. 6: Model study of energy-efficient housing in a compact urban form

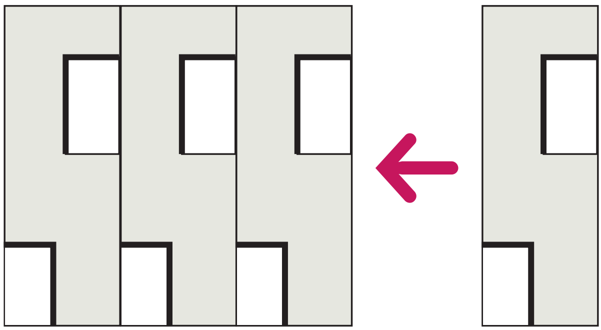


Fig. 7: Approach for energy-efficient housing in a compact urban form

## 3.1 Energy-efficient housing for a compact urban form

In order to ensure the ideal amount of sunlight in a horizontally organized apartment building, the distance between the urban volumes has to be enlarged. This however limits the density in a low-rise area.

Compactness, as the second most important factor for energy-efficient architecture and urban design, provides thermal comfort inside the building, but limits the use of passive solar energy due to the orientation of the volumes (Schramm, 2005, p. 79ff).

The volumes in the compact urban design scheme have to take advantage of their individual positions. The orientation is defined by access systems and plot design – parameters which are determined by the urban layout. A plot design with a north-south direction offers south-oriented buildings attached at the western and eastern sides of the plot. This volumetric organization guarantees south orientation for every plot, in particular if the compactness is maintained and the façade surfaces facing east and west are reduced.

To gain greater width in the south façade, "supplementary south-facing surfaces" can be produced by shaping the volume with courtyards and niches.

In addition, due to the vertical organization of dwellings with duplex or maisonette typologies, the floor organization can follow the demand of sunlight exposure. Rooms in need of direct sunlight, like major living areas, can be organized on the upper level and behind the "supplementary south-facing surfaces" in rear zones of the building volume. Sleeping or service areas need less direct sunlight and can therefore be arranged in darker zones.

This strategy makes use of both advantages, the energy savings achieved by reducing the cooling and heating loads through the compact form and the energy gains through solar energy input achieved by the supplementary south-oriented façades (Brunner et al., 2009, p. 42ff). Seen economically, the façade surface can be reduced by up to 30% by attaching compact building forms as described above. The result of this study can be seen as a contemporary and economic approach to vertically organized courtyard housing.

## 3.2 Criteria for energy-efficient architecture in the region

A criteria catalogue was compiled by analysing the parameter groups with regard to their morphological consequences. This catalogue helps to identify planning aspects for future evaluation, transferability and adaptation of the typological study. The criteria function as important indicators (tools) and, in total, as a task catalogue for design solutions.

### 3.2.1 Building criteria – strategy for designing housing typologies in the "Shahre Javan Community"

The combination and discussion of the aspects formulated by the parameter groups define the task of designing housing typologies for the "Shahre Javan Community". The result is a catalogue of 'building criteria' that describes a design strategy for energy-efficient architecture and the urban design of mass housing in a regional context. The criteria are named as follows:

*Definition of access system and urban morphology*
The typology must follow the urban design criteria. The process of designing the typology perpetuates the findings of the urban design and raises it to a more detailed level in terms of functionality and identity.

*Adaptation to site and topography*
The typology is adaptable regarding plot layout and topographical specifications.

*Ground floor with mixed-use potential*
As a provision for flexible use, the ground floor offers potential for different commercial functions with housing on the levels above.

*Spatial hierarchy from public to private*
This is the definition of a functional spatial design in a socio-cultural context. Design quality and its local acceptance is achieved through the adaptation of regional customs and traditions.

*Potentials of multi-floor courtyard houses*
Introversion as an expression of privacy and climate-friendly organization of volumes with regard to light exposure and quality of life.

*Orientation of volumes and surfaces*
Climate adaptation/optimization by adjusting building surfaces through architectural design (e.g. supplementary south-facing elements).
*Application of simple constructions*
Economic and ecological building constructions in consideration of the regional technological conditions. Design as a step towards efficiency.

*Energy efficiency as result of the architectural design*
Design as a strategy for energy efficiency. An integrated design approach instead of isolated technological optimization.

*Architectural concept as an expression of identity*
The architectural design in the urban context of the 'low rise – high density' scheme creates a spatial identity for energy efficiency in the region.

# 4 Design solutions

Fig. 8: Private courtyard in an Energy-Efficient-Home

Reflecting the criteria for energy-efficient housing in the context of its application in the "Shahre Javan Community" led to different design scenarios for a specific site in a variety of stages and scales. The conceptual scale allowed for a study within a specific framework. The basis for the study was the development of a typological approach using the criteria catalogue. Through a modular space concept, typological characteristics of the approach were defined in terms of access, floor organization, constructive principles and urban implementation. The outcome of the modular space concept describes three basic types with a range and variety of dwelling sizes and different housing styles as a first adaptive measure. The results of the concept were monitored in models and sketches; studies and simulations were carried out to determine the energy efficiency achieved using systems specifically chosen to suit the local climate. The application to a specific site on an urban scale in the pilot area gave a first impression of the concept's potential to vary the typology. The conceptual design of one urban unit in the "Shahre Javan Community" is used to refine the design scenario in several revisionary steps and serves as a planning basis for a specific application with the prospect of dissemination through energy-relevant elements.

## 4.1 The classification of types

The typological approach in architecture is characterized by the classification of a hierarchical system of basic modules, their variations in arrangement and adaptation to the site. The development of the building typology starts with the adjustment of the gathered building criteria as the scientific, theoretical and urban framework for the site specifications of the pilot area, which is then used as a practical and physical basis.

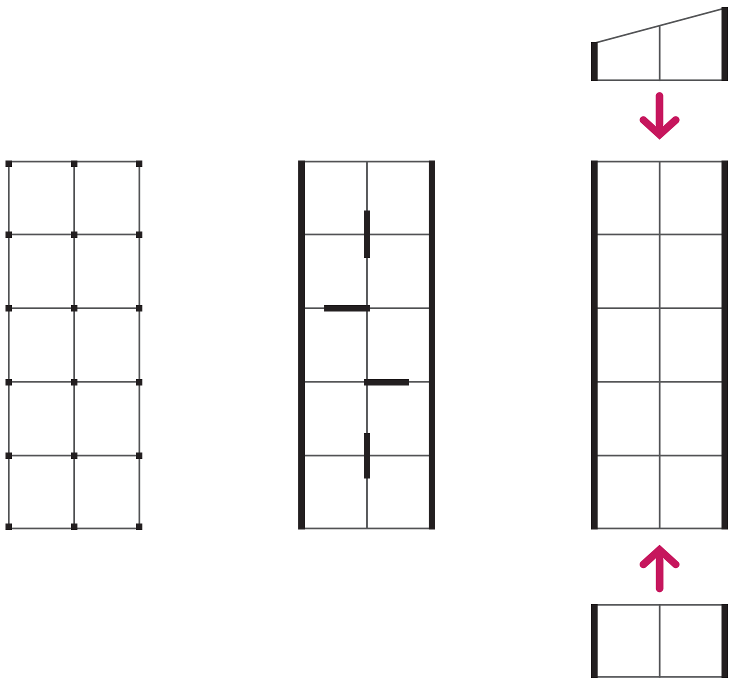


Fig. 9: Modular space concept of the Energy-Efficient-Homes

The chosen scenario allows for the classification using a work process. Integrated in the urban design concept, the first step of the typological approach is carried out as a parallel process with an analytical (top down) and synthetic (bottom up) classification.

Beginning with the definition of types in an urban context, the analytical framework is provided by the site specifications and the demands for the "energy-efficient housing in a compact urban form" (see 3.1). The developed structure in the first draft of three housing types expresses the typological approach. Due to the fact that the typology is adaptable to the length of the site as a consequence of the urban design and the method of construction, the classification is characterized by the width of the plot (7.5, 9 and 15 m types). A modular space system, developed for introverted housing schemes in a compact format, is the tool used for this adaptation process. By organizing and arranging spatial modules according to the depth of the site and maintaining standardized widths, various floor layouts, sizes and designs are possible.

The transfer of the carved-out types to the "Shahre Javan Community" project on an urban scale and in a defined urban unit of the sub-neighbourhood highlights the potentials for adaptation of this typology, as is shown exemplarily in the second step of the typological development. The results gathered from this design scenario are then used to establish a typological classification. In order to evaluate the potentials of modifications and variations of the building types within the typological concept and according to the site conditions, the functional aspects, technical standards and adaptive characteristics must be filtered out. In a third step, the characteristics are defined and depicted in design studies and different scales. A catalogue of possible variations of these basic types shows the morphological variations and their urban relevance. The variety offered in the typological catalogue can be regarded as a tool to create identity on a building and urban scale and is an expression for the correlation between architecture and urban design. The display of exemplarily variations on a building scale, in terms of floor plans, sections and elevations, is therefore designed to evaluate the architectural qualities. By illustrating the strategies and measures of constructional concepts and elements for upgrading the energy efficiency through additive technical equipment, a categorisation of standards can be achieved for the identification of basic principles and additive upgrades. Thanks to this categorisation, measures and strategies for energy as well as economic alterations are easily identified.

The main components of the typological design process are as follows:

*Orientation and dimension*

The urban design led to plots on the site of the "Shahre Javan Community" with lengths of around 25–35 m, mostly with north-south orientations. Cutouts and courtyards are applied to the volume to increase the length of south-oriented façade to generate greater solar yield. These structural incisions create private locations and improve the climate conditions. A vertical arrangement of setbacks produces further differentiation and enables direct sunlight to reach into every dwelling unit.

*Organization and structure*
A structural system forms the basis of the layout strategy. A modular space system with room axes for different room sizes is the structural basis for construction and use. With its vertical continuity and the low building height, with a maximum of three storeys, the structure can be organized with a simple system of walls and ceiling slabs or as a frame structure. The vertical continuity even offers the opportunity to provide underground parking. The structured volume facilitates a high variety of floor layouts.

*Access and vertical connection*
The house is accessed at street level and, in addition, by an entrance from the underground parking. A hallway leads to the central stairway. Besides its purpose of access and level connection, the stairway can also function as a vertical air shaft. In smaller types with up to two dwelling units, the central stairway can be replaced by interior private stairs.

*From public to private*
On the ground floor, the area facing onto the street is a potential commercial unit. Together with the apartment above, it is possible to establish a mixed-use scheme. The ground level functions as the first threshold from the public area of the urban space into the private housing zone, with the commercial unit and the entrance hallway as a semi-private entity. The stairway marks the transition point from the semi-privacy of the interior access zone to the privacy of each apartment. The vertical organization of apartments around a central courtyard again creates different degrees of privacy affecting the interior space. Areas for guests, service zones (kitchen, bathrooms, inner stairways, etc.) and private family space can be organized individually due to the flexibility of the structure.

*Variety and flexibility*
The structural system and the morphological concept permit a variety of layouts; the morphological adaptation allows for different size dwelling units. The vertical continuity of structural and technical elements also enables a vertical connection of space (e.g. duplex units). The inner organization of the units is regulated by a few structural elements (e.g. party walls on the long sides of the building and staircases). The distribution and use of rooms is therefore very flexible. A sloped location can offer greater dwelling areas due to additional façades.

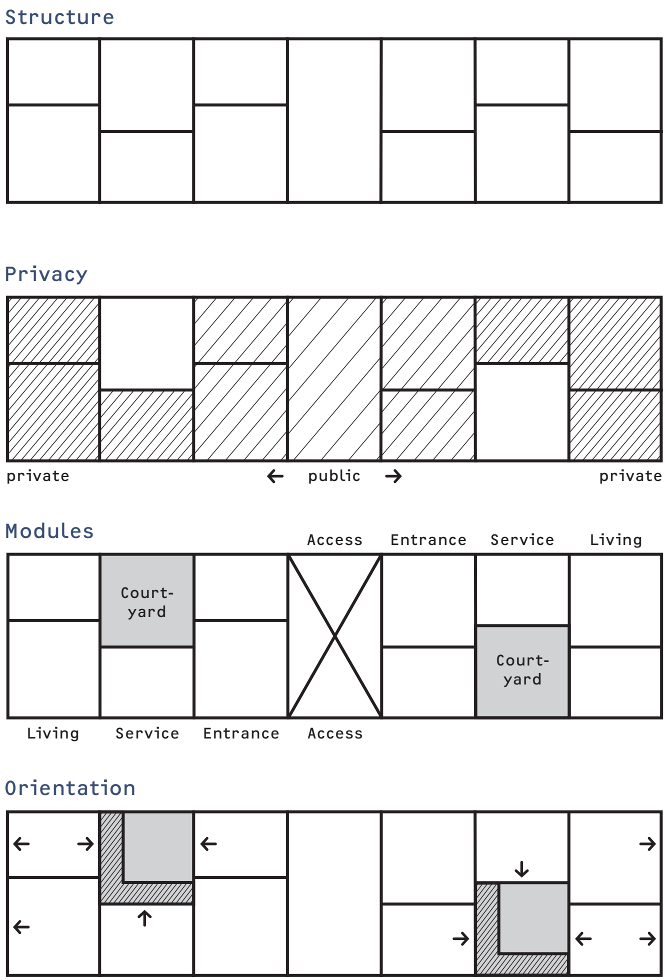



Fig. 10: Structure of the Energy-Efficient-Homes

### 4.2 Scenario and transfer – the adaptive typology

The scenario work for the "Shahre Javan" site reviews and evaluates the project aims and design results. The evaluation of the planning results for a specific application helps to revise the developed concept. The detail planning for the "Shahre Javan" site ('Tarh-e-Tafsili' – see also Young Cities Research Paper Series, Vol. 3) ascertains the potential for changes and improvements of the housing typologies as a necessary part of each planning process. The conceptual design, as a basis for the execution planning, defines the final design solution for one urban unit in the "Shahre Javan Community".

Re-transferring the first scenario to the general typological concept shows the potential of the architectural design approach and enables a morphological study of all basic types. Moreover, it highlights that the large number of variations can function as an adaptive tool. This large variety on a conceptual scale illustrates the potential for flexibility, especially in regard of functional and technical adaptations, as well as the integration of identity aspects. The consequences of a step-up in scale and an exemplary adaptation of a specific type are revealed in floor plans and sections. The identification of characteristics and the definition of measures for possible alterations are the result of this work process.

### 4.2.1 Fixed and flexible elements

Elements and components with their technical, constructional and sensuous characteristics ensure structure and functionality and are the basis of the Energy-Efficient-Homes. They can be termed as flexible or fixed elements.

Modifications or adjustments to the volume and floor layout allow for adaptation and transferability and are necessary to achieve variety and identity. While modifications and adjustments to meet the demands of specific sites and functions are an adaption to the so-called “fixed” characteristics, flexibility in the typology is required in the planning process. Concerning the typology in the “Shahre Javan Community” area, the following characteristics are representative and significant:

The modular space system serves as a framework for the construction and organization of the dwelling units (fixed). On the other hand, the modular framework enables the organization of private zones and service zones in different floor layouts (flexible). The vertical continuity of the structure offers constructional and technical functionalities (fixed). The arrangement of space modules to form different building morphologies on different plot sizes is necessary to meet the functionality, privacy and energy efficiency in a specific urban context (flexible).

Flexibility, meaning temporarily adaptable, is only provided by measures for façade design. For example, a certain combination of fixed and flexible construction elements has a direct impact on light and energy efficiency as well as the degree of privacy. It is achieved by the fixed structures in the façade and the flexible regulation of mechanical shading elements. Due to the fact that flexible elements have higher requirements in terms of technical details, they also have a direct impact on building costs. Thus their application should be considered carefully.

Identifying fixed and flexible elements allows the formulation of adaptive strategies for the transfer of research and planning results as well as the specification of elements to create architectural and urban identity and variety. The strategies for adaptation are classified according to different aspects of the architectural design:

- *Morphology* – as a volumetric feature to perform adaptations in an urban context

- *Floor layout* – for a functional and spatial adaptation within a single building
- *Passive and active energy measures* – spatial and technical design features for the adaptation of energy consumption
- *Appearance and construction* – design and structural measures for the adaptation of social and economic standards

***4.2.1.1 Morphology – strategy for site adaptation***

The design approach of the housing typology respects the urban design concept as a spatial denominator for the insertion of a building. Thus every building is a specific element in a larger spatial arrangement.

Due to this commitment, the design concept of the building must offer suitable adaptive tools. Regarding the site, the developed modular space scheme is adaptable by performing morphological measures.

The length of the building is the first adaptive measure. In a sequence of modules, the length of the building can always respond to the plot size.

Depending on the length of the plot, in smaller vertical-organized housing types (7.5–9 m), the private courtyard is enclosed on three sides by private rooms (in longer units) or only on two sides (in shorter units – north, east or west), simply by adding or removing a space module.

For bigger housing types (12–15 m or more) and on longer plots, a second courtyard is integrated in the building volume; on smaller plots, it is only one courtyard.

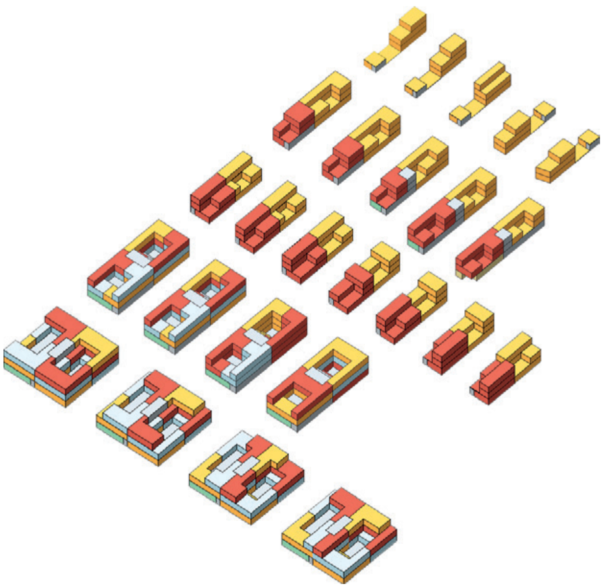


Fig. 11: Typological catalogue

The second measure is the orientation of the volume. In order to achieve variations in the orientation, improve energy efficiency and/or the degree of privacy, the upper storeys in vertically-organized units can be modified. By arranging the volumes, adding terraces or varying the layouts of the upper levels, it is possible to regulate the incidence of sunlight and privacy. These measures have a direct influence on the urban appearance and can also be seen as a tool for creating identity.

### *4.2.1.2 Floor layouts – strategy for functional adaptation*

For functional reasons, the housing typology must offer flexibility in its use. On the one hand, this flexibility is necessary to meet the different needs of users, on the other hand, the changing requirements in terms of target groups or the insertion of commercial units for a mixed-use scheme demand flexible floor layouts. A graduation of flexibility must therefore be defined. It is not the aim of the architectural concept to create a fully flexible space, which is only fixed by the building envelope, even if the modular space system were able to fulfil such a demand. The structural requirements to achieve such a high degree of flexibility are more suitable for frequently changing floor layouts as is the case in office buildings. It is more important, in this case, to keep open the choice of construction method (from traditional solid construction to pre-fabricated building elements) with space module dimensions, which allow for a certain number of variations. In order to maintain this flexibility, the arrangement of the spatial modules offer different room as well as unit layouts and various fittings. Experience has shown that most of the layout determinations are made in the planning phases before construction. Thus, the focus on flexibility is determined by the following measures:

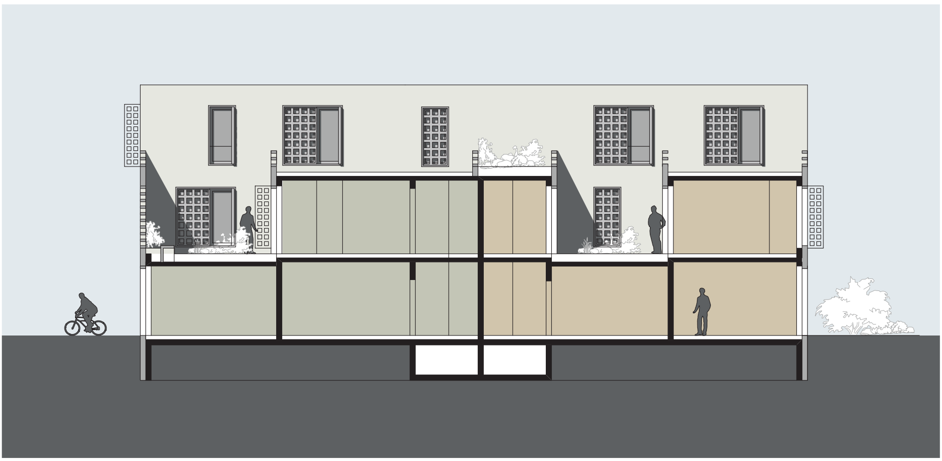


Fig. 12: Section through a 9m-type building with two dwelling units, each with its own private courtyard


Fig. 13: Floor plans of a two and three-storey dwelling in a 9m-type with a private courtyard and zoning inside the dwelling

The smaller types (7.5–9 m) provide two vertically organized dwelling units with separate access at ground floor level. The staircases can be set inside the private units with a first emergency exit via the entrance hall and a second one via the apertures in the façades. As the demand for privacy is not easy to fulfil at ground floor level, because of the visibility from the public streets, a mixed-use scheme with a commercial unit might be the right the solution. Here a joint staircase for the units above is necessary as part of the modular space scheme. The maximum number of dwellings in these types could be four. The commercial unit can be planned as part of the apartment above or as an independent space.

For the bigger types (12–15m or more), the size and number of dwelling units depend on the chosen floor layout. The combination of levels to form vertical units is also possible within this typology. In buildings with single-floor apartments, the number of units that can be arranged around one courtyard ranges from one to two, and a maximum of eleven units in total in one building. A joint staircase is always necessary in this case. In all types, the size of the staircase must allow for the incorporation of an elevator to provide barrier-free access. Depending on the position of water and energy supplies, different room layouts, such as closed or open kitchens, are possible.

All in all, the organization of floor layouts is flexible enough to accommodate individual needs in terms of a unit. Furthermore, the flexibility of unit sizes and layouts is a suitable tool to meet demands on the housing market.

#### *4.2.1.3 Passive and active energy measures – strategy for energy-related adaptation*

Besides achieving energy efficiency through the building's configuration, further improvements can be made by performing additional measures. Renewable resources, such as sunlight and ground temperature, can be used by carrying out simple constructions.

*Sunlight incidence and its effect on the energy demand*

The amount of daylight use influences directly the demand for electricity to provide artificial lighting. In the case of unfavourable light incidence or angles, daylight can be redirected by using reflecting devices. The light diversion can be used as a protection against too much light exposure or for increasing daylight incidence, for example in deep rooms. In both cases, the light diversion reduces energy consumption. On the one hand, it reduces the

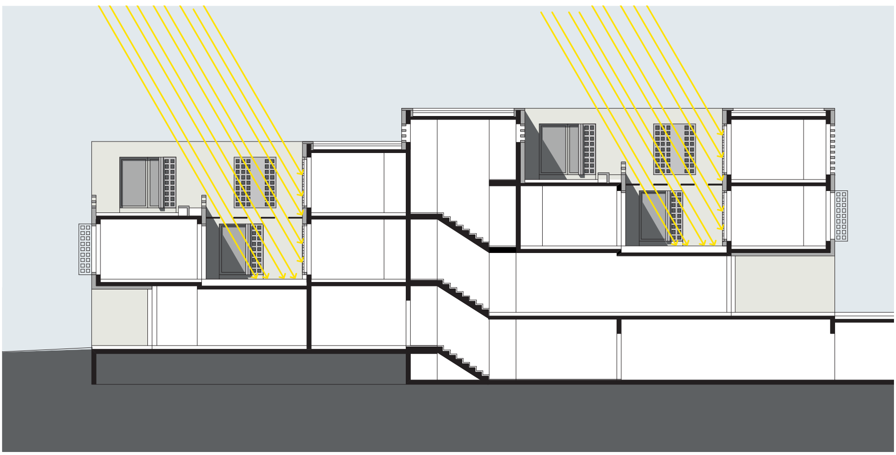


Fig. 14: Light shelves (louvres) – summer position

cooling energy demand as it prevents overheating in summer; on the other hand, the reduction of artificial lighting reduces energy consumption directly. The provision of daylight depends on various factors, for example the degree of sun exposure, the angle of incidence, the general layout, the number and dimension of transparent openings, the glass type and factor of light transmission as well as the position of openings.

Light-diverting devices are available for internal and external use. External devices are the most effective. Daylight is redirected into the room by using, for example, external reflectors, mirrors or prism plates, which are normally used for sun shading, but are very effective for diverting light. The downside of external devices can be, depending on the form and position, the dirt accumulation on devices, which reduces the efficiency and results in higher maintenance than that required for internal light diverting devices.

In the "Shahre Javan Community" project, the configuration and compactness of the buildings is responsible for reducing heat loss in winter and avoiding overheating in summer. Furthermore, the north-south orientation captures the intense radiation from the south and avoids the more critical east and west sun in summer, which is more complicated to control.

Duplex units, which are positioned back to back, form a deep north-south oriented housing complex. Inner courtyards with large south-oriented openings help to provide an even amount of light throughout the apartment. The ratio of street width to building height and the dimensions of the inner courtyards optimize the relation between maximum illumination of the rooms and negative impact of heat during summer (Nytsch-Geusen et al., 2012).

In winter, the same light shelves in a vertical position receive approximately 50% of the sun and divert it into the north-facing rooms adjoining the courtyard. This means that the rooms opening up towards the courtyard

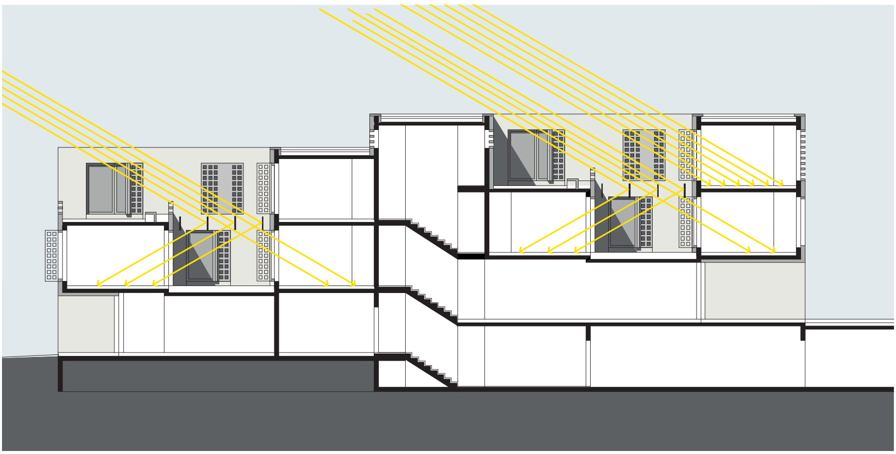


Fig. 15: Light shelves (louvres) – winter position

Fig. 16: Earth tube system in an urban unit

are all lit and preheated by the sun. The above-mentioned downside of higher maintenance is negligible due to the overall dimensions of the courtyards and the reachable position of the shelves, which means that the maintenance can be carried out by the inhabitants.

As an alternative to the large rotatable shelves stretching across the courtyard, a sun screen made of photovoltaic fabric can cover the courtyard in summer. It prevents the inner courtyard and adjacent rooms from overheating and produces energy. In the evening, this energy can be used to partially illuminate the same area. In winter, the fabric is pushed aside and the sun can warm and lighten up the inner courtyard and adjoining rooms.

*Heat-exchange to reduce the energy demand for heating/cooling*

Currently most Iranian households use evaporative cooling systems in summer. For an apartment of 120 m² with a room height of 2.8 m, an air-exchange rate of 25 l/h is required to keep the temperature within a comfortable range. This leads to an energy demand of 2.920 kWh of electricity and 63.5 m³ of water per cooling season (Nytsch-Geusen et al., 2012).

Considering the high air exchange rate and the fact that the exhaust air is still much cooler than the supply/outside air, it is obvious that the temperature difference between the exhaust air and supply air should be used to precondition the supply air. Preconditioning the supply air with exhaust air works both in summer and winter. In summer warm/hot supply air is cooled with the cooler exhaust air and in winter, when the exhaust air is much warmer than the supply air, it is used to preheat the outside air and reduce the energy demand for heating.

This preconditioning of supply air can be achieved by installing a heat exchanger. A heat exchanger relies on the fact that energy media want to be in balance, which means that heat will dissipate and move to cooler materials. A heat exchanger simply transfers heat (energy) from one medium to another. The use of a heat exchanger enables the recovery of otherwise "lost" energy contained in the exhaust air.

The described heat exchanger for use in a building/apartment can be integrated into the ground as an earth tube to supply a whole neighbourhood with preconditioned air. The constant ground temperature at a depth of approximately 1.5–4 m below the surface is used to precondition the supply/outside air.

A central supply air intake can be installed for several buildings and dwelling units. The fresh air is drawn in through earth tubes that run in loops and is either heated or cooled by geothermal energy through direct contact with the soil. At a length of 50 m and a depth of 2 m the supply air can be heated or cooled by at least 5°C. This is a rough estimation for the Hashtgerd region and its climate conditions, as no simulations were carried

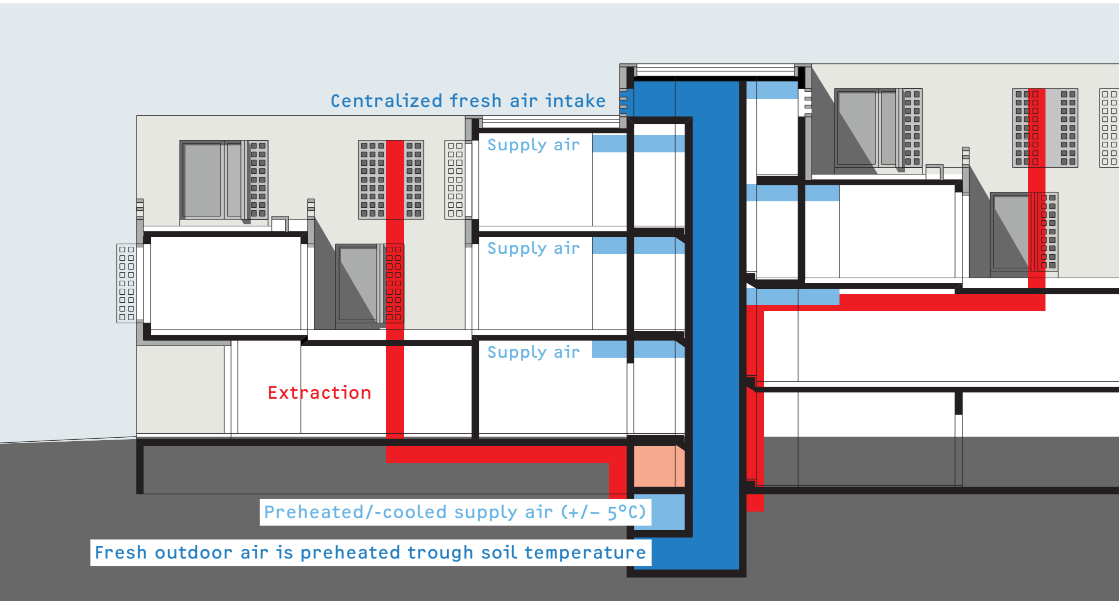



Fig. 17: Building section with heat recovery system

out during the project. However, the assumption is based on detailed studies for different regions and climate data, which has shown that the air temperature can be lowered or raised by up to 10–11°C depending on the specific climate conditions (Blümel et al., 2001).

The combination of several dwelling units allows for a more economic installation and use of earth tubes. For a sub-neighbourhood area, this could involve a division into four zones. While the supply air intake is centralized, the exhaust air system would be decentralized and work with a heat exchanger on a building scale as described above.

#### *4.2.1.4 Appearance and construction - strategy for standard adaptation and identity*

*Façade as a relevant element for energy impact and identity*

Alongside the morphological arrangement (see above) as a strategy for creating an energy-efficient structure on an urban scale, the design of the façades also has an influence on the appearance of a building. The structural method, the floor layouts and shapes as well as the architectural design of the apertures characterize a building's façades. The aperture typology is influenced by role as energy impact element. Due to the fact that the south orientation is important for the use of solar heat gain, the design of the apertures within the façades is a very important tool for energy efficiency. Considering the morphological arrangement of closed coverage and compactness, the surface of the façades is initially reduced to a minimum. The south façades of the single units, facing onto paths, courtyards and open areas, have to provide most of the sunlight for the living rooms. Therefore, the proportion of apertures in south-facing exterior walls should be as high as possible.

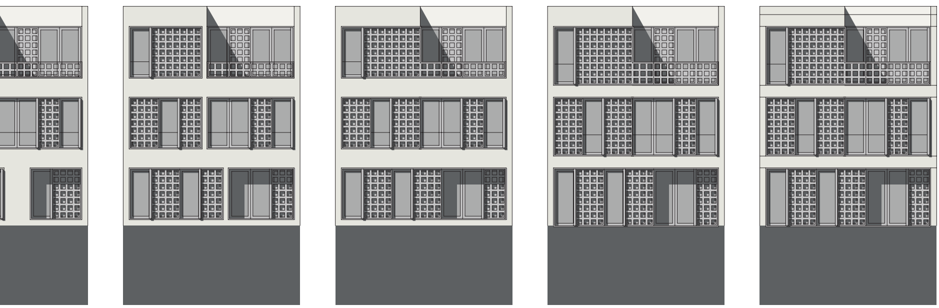
Due to the high density of the "Shahre Javan Community" urban concept, the positioning and dimensioning of openings must balance the need for low energy consumption and privacy. The strategy used for balancing and planning the façade design for the housing typology chosen is performed on two levels. On the first level, the design of the façade is characterized by the fixed elements of the building`s structural system, the construction of

Fig. 18: Study of different south façades for 7.5 m building type

the exterior walls and the zoning of closed and open elements. On the second level, flexible elements to control light and sun incidence structure the façade.

The dense configuration of the “Shahre Javan Community” pilot project requires measures for privacy. As a first measure, the width of standard apertures with a higher privacy factor is reduced, but the proportion of glass is maintained by choosing vertical, room-high apertures. A staggered arrangement of apertures on opposite façades avoids direct views and is a second measure to achieve privacy. From an economic point of view too, high, narrow openings with a simple mechanism are more reasonable than horizontal ones.

Alongside the demand for good technical standards as a means to increase the quality of the windows’ thermal insulation, the design of the apertures is a tool for regulating sun incidence and a first opportunity to achieve variety within the exterior appearance. Size, number and location of apertures, however, depend on the façades structure. In order to maximize the aperture surface, the window is no longer only an opening in a closed wall, but a constructive element of the building envelope. A frame structure means that façades are classified as non-load-bearing walls and there are greater possibilities in regard of the arrangement and construction of elements. The appearance of the façade is thus characterized by the layout of load-bearing and non-load-bearing elements and by the design and positioning of the apertures within the closed walls (e.g. thermal insulation composite system). Windows can, for example, be aligned with the outer or inner surface of the external wall. Set into the wall, a small overhang is formed which already reduces the heat load of the high sun in summer. This structural shading of the frame is a “fixed” measure. On a second level, the individual control of view and energy input is achieved with “flexible” measures. By installing sun shutters or blinds on the outside of the façade, individual control is made possible. Flexible, mechanical control of the elements regulates the energy input during daytime, but also provides a means of controlling the amount of privacy in the living areas.



*Construction method – application of simple constructions*
The modular space system of the building typology allows for a variety of construction methods.

The room axes are the basis for construction and use, and define the modular space system. As described earlier, the different plot types start with a 6 meter axis-centre distance and can reach a width of 15m in 1.5m steps in an east-west direction. This modular system offers a great variety of floor layouts with the most economic structural span being of 7.5 m. The depth of the building structure can be adapted according to the plot layout by adding spatial modules in north and south direction. The terrace ends with façades facing the open areas are set on the boundary lines. The chosen modular system is based on an economic construction grid. With its vertical continuity and the low building heights, featuring a maximum of three storeys, the structural system is kept simple and a frame mode of construction is possible. Pre-fabrication, in-situ construction methods or a combined solution with semi-precast elements are all possible and depend on site conditions, traditional building methods/ education of workmanship, availability of material and budget. The same applies to the range of possible construction materials. A frame construction made of concrete can be combined with light wall materials or bricks. The difference in thermal behaviour at the interface of the materials is evened out by installing a thermal insulation composite system (ETICS). A monolithic system without exterior insulation in combination with a concrete frame structure must be assessed regarding its thermal properties. A system for a monolithic structure could involve shear walls and concrete ceilings. The shear walls must be placed inside the unit as the façade, in this case, only functions as a non-load-bearing thermal envelope, for example using perlite or mineral wool-filled bricks or light concrete blocks. Due to the special demands concerning earthquake resistance in the region, the choice of the construction system and materials is very much dependent on the site conditions. A concrete framework with concrete bracing walls inside the units and ETICS as the thermal envelope was chosen as the structural system for the Energy-Efficient-Homes in the Hashtgerd New Town pilot project area. The choice of the remaining façade materials (e.g. bricks) can be made according to ecological as well as economic aspects.

### 4.3 "Basic Principle" and "Upgrades"

The result of the design process for adaptive measures and the identification of urban, architectural and technical elements for developing the Energy-Efficient-Homes led to a distinction between a basic principle and possible upgrades. This categorisation helps to define different standards as well as a scientific basis for the planning process of energy-efficient housing in the region.

The basic principle is the design strategy for energy-efficient architecture and urban design from a spatial approach without any additional technical demands. It contains all planning and design measures to increase energy efficiency through spatial configuration, such as building orientation and compactness, site suitability and cultural context. It can be seen as a low-cost approach and defines a minimum standard for energy efficiency in the Middle East.

The upgrading measures include possibilities to raise the standard of the basic principle. Supplementary technologies can be integrated into the spatial approach. (see 4.2.1.3 and figures 14–17)

Possible upgrades include simple mechanical elements for light and energy guidance, such as sun-shutters, furthermore the use of the ground temperature by means of earth tubes and a concept of heat exchangers, and finally the application of higher technological materials, such as photovoltaic fabrics to generate supplementary energy. The measures are characterized by a planning dimension as well as a technological and economic dimension. The choice of upgrading measure is dependent on the economic and technological context. The upgrade defines the standard for maximum energy efficiency in the region.

## 4.4 The conceptual design

The findings of the design and research process for the Energy-Efficient-Homes are transferred to a final design proposal for an urban unit in the "Shahre Javan Community" pilot project. By transforming the design and adaptation measures from the typological approach into a specific design scenario, the challenges for the practical application of such a general approach can be weighted and evaluated. Furthermore, the realistic scenario serves as a basis for cost estimations, energy simulations and constructional detailing. Architectural models and drawings of the architecture in the "Shahre Javan Community" to a scale of 1:100 to 1:20 are used to define a standard for materials and energy objectives.

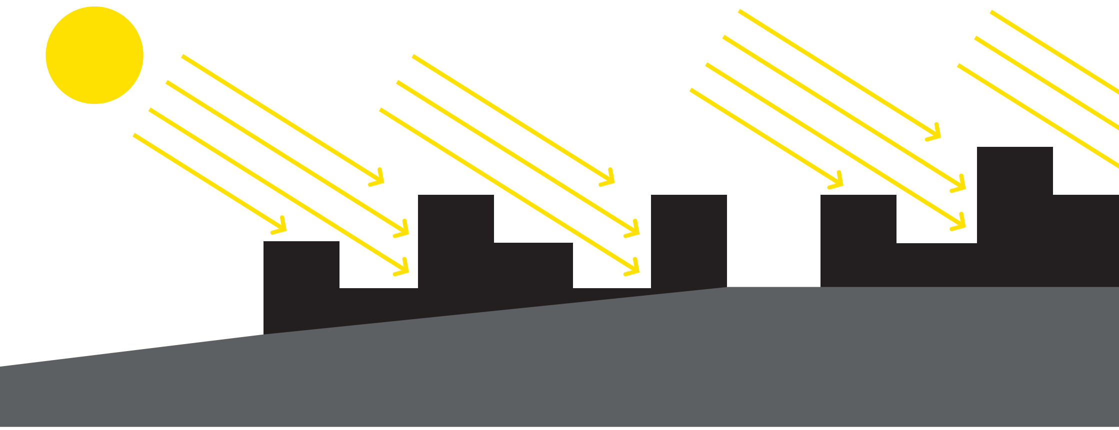


Fig. 19: Basic principle of Energy-Efficient-Homes

Fig. 20: Areal view of urban unit from the southeast

The chosen site in the centre of the pilot area (sub-neighbourhood 3.3) is located on a ridge with access from the collecting road coming from the eastern valley and bordered by the central public green of the western valley.

Following the determinations of the "Tarh-e-Tafsili" (Detailed Plan), developed by the Strategic Dimension Urban Development and Design at TU Berlin, the urban outline as well as the inner access routes are fixed by building lines. Parking is provided below the building development with access from the collection road. The inner access paths are for pedestrians as well as for supply and emergency traffic. The paths structure the urban unit into four building sections. A small urban square, positioned at the crossing of the access paths, is the social and spatial centre of the urban unit.

The density on the building plots was estimated using a floor area ratio of about 1.7–2.0. The range in apartment sizes was set at 75-200 m² for at least 75% of the dwelling units. A possible replacement of different housing types creates flexibility. For example, to gain greater variety, the seven 7.5 m types in the south-western section can be replaced by six 9 m types still staying within the building lines.

**4.4.1 The architectural design solution in an urban context**

The conceptual design shows a specific design scenario for one urban unit from the typological approach with adaptations to the site specifications using the described morphological strategies, the floor layouts, the energy-related measures and the choice of construction method.

The design of the urban unit should offer a large variety of dwelling types. Alongside the single-floor apartments on broader plots, single family housing is also provided. The suitable basic types determined in the topological approach are the 15 m type for single-floor apartments and the 7.5m and 9m types for duplex units. For an effective infrastructure and a clear urban identity, all buildings are accessed from the inner paths of the sub-neighbourhood. By placing the parking level underneath the southern plots, the site`s slope is exploited. A main exit from the parking level with stairs and a lift is placed on the central square of each sub-neighbourhood.

The distribution of building types is aimed at maximizing direct sunlight. The south orientation of the plots and the sloped topography ensure maximum passive solar heat gain in winter. The overheating of open spaces, such as paths and courtyards, is avoided in summer by installing suitable shading devices. Positioning three-storey apartment buildings on the northern plots of each sub-neighbourhood and two-storey duplex units on the southern ones enhances the use of passive solar energy in the northern buildings, which are separated by narrow paths. The north-south directed green areas between the sub-neighbourhoods are wider than the 6m-wide paths within the sub-neighbourhoods. Thanks to the natural slope of the site, sunlight is never an issue for the southern plots in the sub-neighbourhood. Terraces on the third floors of the apartment buildings are designed to provide supplementary light to the rear zones of the buildings as well as more differentiation in the façades.

The second measure to enhance light input is a partial set-back of some of the duplex units on the southern plots. This has more than one advantage. First of all, the partially enlarged paths can function as semi-public entrance zones for the duplex units, secondly it allows the parking level to be naturally ventilated and lit through apertures in the ground. Last but not least, it improves the lighting conditions of the northern buildings. Thus the morphological measures for greater efficiency ensure, at the same time, spatial quality and low energy consumption.

**4.4.2 Design solution for the residential buildings**
The multi-storey apartment buildings are organized around a large central courtyard. The central stairway with lift separates every floor into two units. Setbacks on each level are used to generate at least one private terrace for each dwelling unit. Every apartment has façades facing private zones (courtyard) and public areas (path or open space). The main openings are always oriented south. This solution considers the desired use of passive energy and maximizes privacy by avoiding direct views between two opposite units.

Due to setbacks in the upper floors of the spatial modules, the courtyard is enlarged and the apartment size changes. The apartment layout is divid-

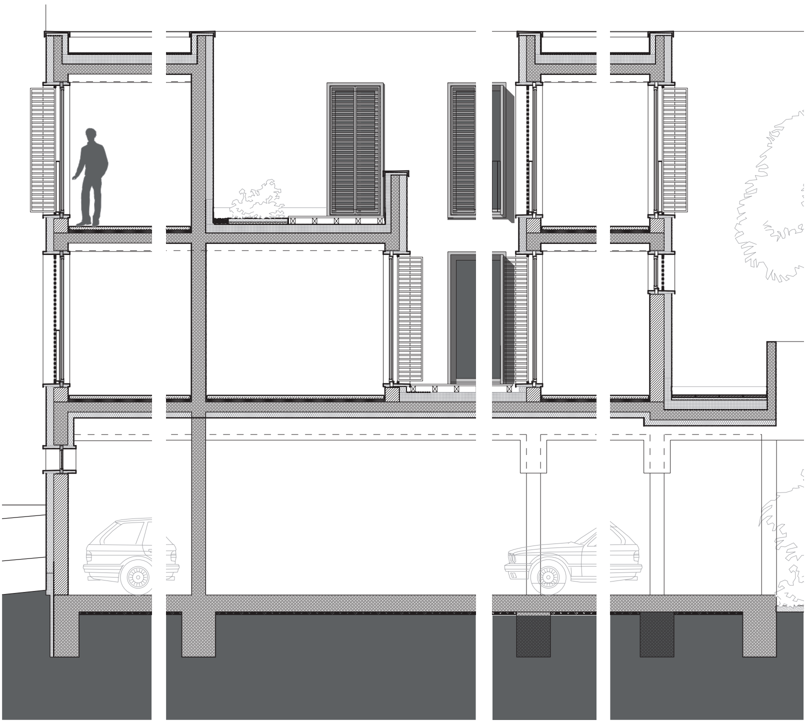


Fig. 21: Detail section of the conceptual design

ed into private and public zones. The private bathroom and bedroom zone is separated from the more public living and kitchen zone. Depending on the size of the apartment, the distinction between private and public zones within the apartment is solved differently. In large apartments, the public zone includes a large entrance hall and a flexible space either for office use or as a guest bedroom including a small bathroom. The kitchen block separates the public zone from the private living zone with bedrooms and bathrooms set in the rear of the apartment.

The units on the ground floor, facing the central square, are used as commercial units and are therefore part of a mixed-use scheme.

The buildings with two duplex units, each facing south, are more introverted. The two storeys of each unit are organized around a private courtyard. Morphological measures in the courtyard arrangement, as described earlier, enhance the use of passive energy. Due to setbacks on the upper level within the modular space system, the incidence of sunlight is maximized. The north façade facing the private courtyard is also set back on the upper level allowing more direct light to penetrate the south-facing façades. Like in the multi-storey apartment buildings, the roof created by the set-back can be used as a private terrace on the upper level, in the case of duplex units, this is within the same unit. Thanks to this arrangement, even the rear zones within the deep building volumes receive natural daylight. This has the effect that the façades visible to the public require very few openings. The two units in every building are organized in a back-to-back arrangement.

Following the hierarchy from public to private space, the semi-private entrance courtyard (widening of path as described earlier) provides the first step into privacy, at the interface of the urban and building design. The two-unit building type is accessed from this zone. The subsequent hall and corridor are a "dead end" in the sense of the traditional spatial hierarchy (see 1.2.1). Within the private unit, the hall, with a central internal stairway, is part of the vertical and horizontal arrangement. In apartments with two levels, it is easy to make a distinction between private and guest/ public floor areas (as shown in the floor plans of the dwelling units). With the public zones on the lower level, the upper level ensures absolute privacy. If the private zones are accommodated on the ground floor, guests are immediately guided up the stairs without passing the private zones.

The floor plan layouts illustrate the relation between energy efficiency and privacy. Although the arrangement of private zones at ground floor level does not comply with Iranian traditions and culture, advantages in terms of energy efficiency and privacy can be achieved.

Private bedrooms do not require as much light and heat as living zones. The façades of private zones can be designed with a smaller proportion of window surface. Transom windows deliver sufficient light at the same time as avoiding views into the private rooms from the street.

The parking level is dependent on the construction of the buildings above. Placed in an earthquake-prone area, the load-bearing elements have to be continued down to the foundations. Shear walls and columns are organized in the modular space arrangement. The main exit, with staircase and lift in the urban square, guarantees central accessibility even for disabled persons. Further stairs and the entrance/exit ramps serve as emergency exits. The main lane is positioned beneath the access path. General facilities used by the whole sub-neighbourhood, such as the grey water supply system and the energy plant, are located beneath the central square.

With the help of the typological approach, the conceptual design for the Energy-Efficient-Homes illustrates the strategies for adaption on different levels and scales.

### 4.4.3 Conclusion of the conceptual design

In accordance with the provisions of the detailed plan (Tarh-e-Tafsili) of the "Shahre Javan Community", adaption of the typological approach on an urban scale is achieved in the conceptual design of the Energy-Efficient-Homes by:

- the choice of type and its position as a functional adaptation measure
- shape and organization of the volumes, e.g. by implementing entrance courtyards and setting back volumes, as a morphological adaptation measure.

Adaption on a building scale is achieved by:

- the floor layout, such as the arrangement of private and public zones, the cut-outs in upper levels for better light conditions in the courtyards, as a morphological and functional adaptation measure.

The energy efficiency is enhanced on a detail scale by:

- adapting the façade design to suit the site, e.g. by integrating sun shutters
- provision of system-relevant elements, such as the technical plant beneath the central square and the earth tubes at parking level
- choice of materials with respect to site conditions, availability, required standards, energy-related objectives and economic aspects, e.g. choice of materials for the thermal envelope and construction system.

# 5 Perspectives

Fig. 22: Urban path in sub-neighbourhood

The research process in this design concept is aimed at providing a planning concept for energy-efficient housing in the Iranian New Town programme with a potential for dissemination and adaptation.

The spatial strategy, which considers the energy-relevant aspects of urban and architectural morphology within a specific social context, has led to a concept of basic practical energy standards that are adapted to the region. The courtyard housing scheme of the Energy-Efficient-Homes shows a new development based on the origins of vernacular architecture.

By adding technical supply systems (e.g. light and sun directing ele-

Fig. 23: Urban square in sub-neighbourhood

ments or earth pipes to make use of geothermal energy), it is possible to upgrade the energy efficiency already achieved by the basic standard through spatial organization and design.

The volumetric arrangement incorporates socio-cultural references to Iranian vernacular architecture. The urban and architectural design combines the aims for energy efficiency and a regionally adapted identity by integrating spatial aspects into the socio-cultural context.

### 5.1 Potential for realization

The developed design solution for the Energy-Efficient-Homes is a conceptual guideline for the detailed planning of the “Shahre Javan Community” pilot project. The typology needs to be examined carefully regarding the chosen construction method (especially the earthquake resistance), site topography and building quality standards (target groups). The gathered adaptive measures describe a future work process. These include, among others, the choice of typology as a tool for controlling the size and number of units as well as the choice of construction method and façade appearance as a tool for economic issues and identity within the estate.

### 5.2 Potential for transferability in the region

Because of its high degree of variability concerning unit size and morphological adaptation, the typology can serve as a basis for transferability to other sites in the region. The developed housing scheme, based on traditional spatial arrangements, offers culturally adapted energy-efficient housing for the Middle East. The energy-relevant advantages of the compact urban form and its building configurations could change to provide higher spatial quality for new towns as the concentrated building volumes create clear defined open spaces with public relevance. The simple basic layout and structure of the introverted, individually controlled dwelling units also accounts for the specific technical and economic conditions in the region.

# 6 Architectural plans

**Urban Design and Architecture**

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**Date**
November 2011

Fig. 24 Site plan of the "Shahre Javan Community" with the urban unit marked magenta (Sub-Neighbourhood 3.3)


Fig. 25: Ground level floor plan

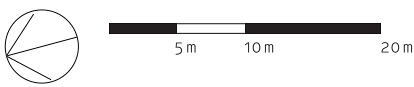



Fig. 26: First level floor plan

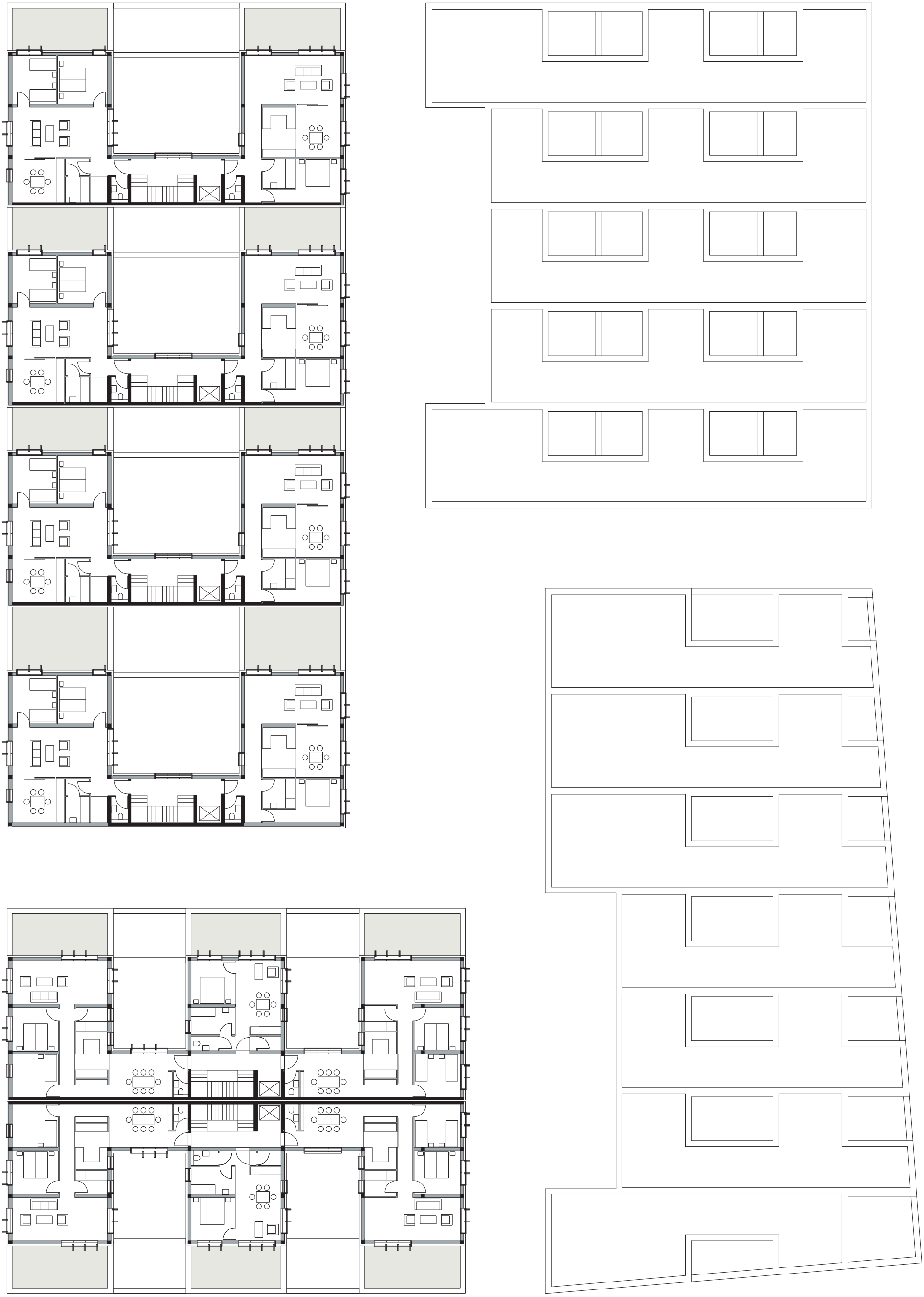


Fig. 27: Second level floor plan

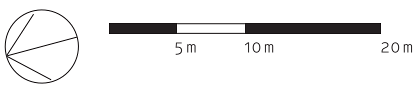



Fig. 28: Basement floor plan

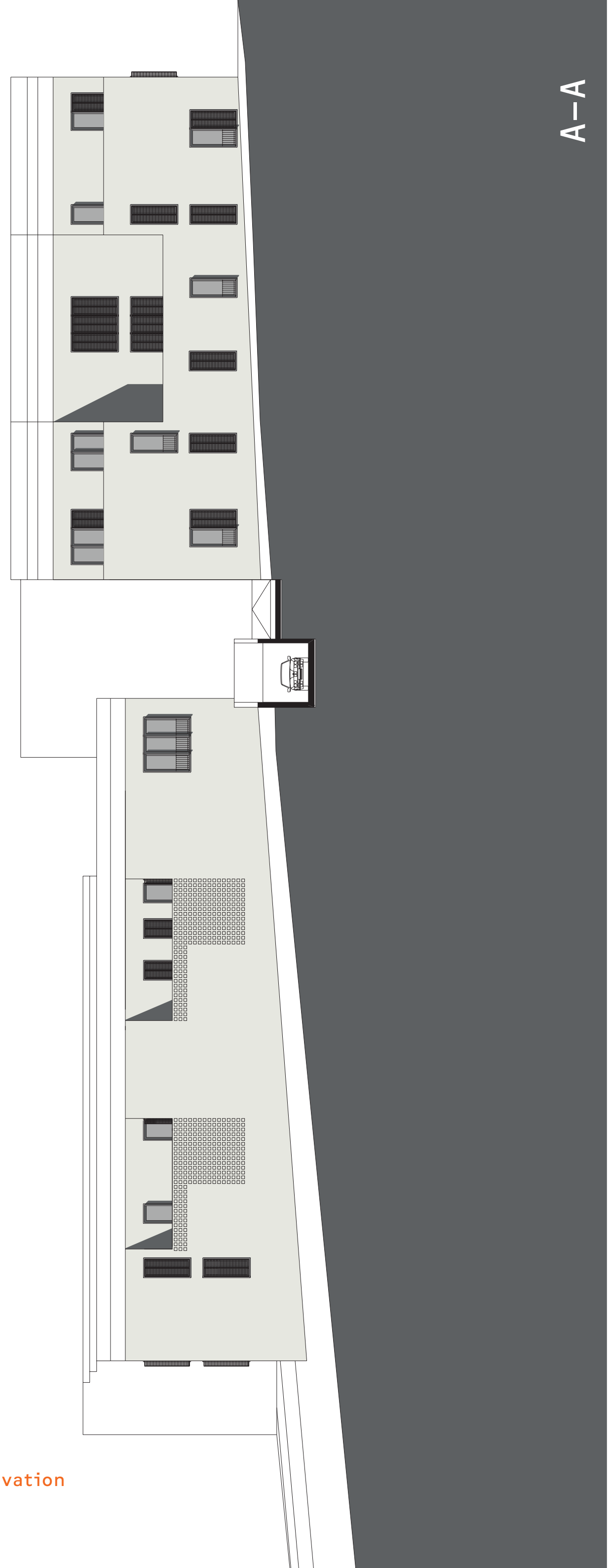
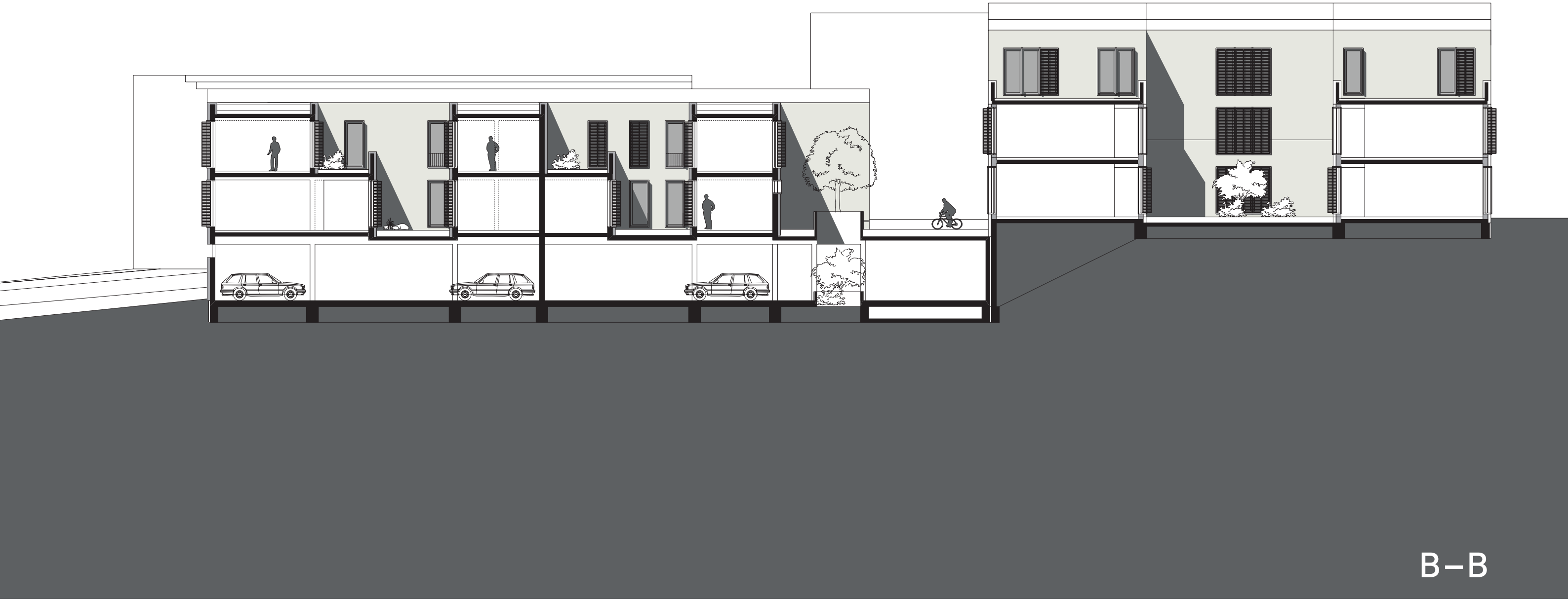



Fig. 29: Section and east elevation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# 7 References


**Bianca,** S.:
Hofhaus und Paradiesgarten. Architektur und Lebensformen in der islamischen Welt. München: Beck, 1991.

**Blümel** E., Fink C., Reise C.:
Handbuch zur Planung und Ausführung von luftdurchströmten Erdreichwärmetauschern für Heiz- und Kühlanwendung, Gleisdorf, 2001.

**Brunner,** R., Hönger, C., Menti, U. Wieser, C.:
Das Klima als Entwurfsfaktor. Luzern: Quart, 2009

**Diba,** K.:
What Islamic Architecture Is Not; in: Petruccioli, A. et al. Understanding Islamic Architecture. New York: Rutledge Curzon, 2002.

**Edwards,** B., Sibley, M., Hakmi, M., Land, P.:
Courtyard Housing. Past, Present and Future. Abingdon: Taylor & Francis, 2006

**Hegger,** M., Fuchs, M., Stark, T., Zeumer, M.:
Energie Atlas. Nachhaltige Architektur. Basel: Birkhäuser , 2008.

**Nytsch-Geusen** C., Huber J.:
Pilotprojekt 35 ha, Simulationsbericht Team 2, Version 1.4, Berlin 2012.

**Schramm,** H.:
Low Rise-High Density, Horizontale Verdichtungsformen im Wohnbau. Wien: Springer, 2005.

**Wirth,** E.:
Die orientalische Stadt im islamischen Vorderasien und Nordafrika. Städtische Bausubstanz und räumliche Ordnung, Wirtschaftsleben und soziale Organization. Mainz: Von Zabern, 2000.

**Wehage,** P., Pahl-Weber, E.:
Architectural Studies in: Pahl-Weber, E., Seelig, S., Ohlenburg, H.: The Shahre Javan Community Detailed Plan – Planning for Climate Responsive and Sustainable Iranian Urban Quarter. Berlin: Young Cities Research Paper Series, Vol. 3, 2012.

# Imprint

**Design/Typesetting** büro-d | Communication Design Berlin

**Publisher**
Universitätsverlag der TU Berlin
Universitätsbibliothek
Fasanenstr. 88
10623 Berlin | Germany

ISSN 2196-517X (Print)
ISSN 2196-6583 (Online)
ISBN 978-3-7983-2565-4 (Print)
ISBN 978-3-7983-2566-1 (Online)

www.univerlag.tu-berlin.de

*Simultaneously published online on the Digital Repository of the Technische Universität Berlin*
URL http://opus.kobv.de/tuberlin/volltexte/2013/4022/
URN urn:nbn:de:kobv:83-opus-40225
[http://nbn-resolving.de/urn:nbn:de:kobv:83-opus-40225]

All texts are based on scientific research performed within the Young Cities Project. All pictures, tables and graphics are courtesy of the respective article's authors, unless otherwise mentioned.

The volume before you results from the federal funded research project “Young Cities – Developing Urban Energy Efficiency”.
It has been written by

**Technische Universität Berlin**
***FG Bestandsentwicklung und Erneuerung von Siedlungseinheiten***
Hardenbergstraße 40a
10623 Berlin | Germany

www.bestandsentwicklung.tu-berlin.de

German-Iranian Research Project
**Young Cities**
Developing Energy-Efficient Urban Fabric in the Tehran-Karaj Region

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