young cities
Developing Urban Energy Efficiency
Tehrān-Karaj

05

Young Cities Research Paper Series, Volume 05

Urban Challenges and Urban Design

Approaches for Resource-Efficient and Climate-Sensitive Urban Design in the MENA Region

Elke Pahl-Weber, Sebastian Seelig, Holger Ohlenburg, Nadine Kuhla von Bergmann (Eds.)

1 Planning Processes for Resource-Efficient and Climate-Sensitive Neighborhood Design

Philipp Wehage

Sustainable planning is a comparatively young form of planning and is not generally defined in international science and practice. Although the planning procedure is often regulated in national or regional codes, the specific project process requires contextualized measures and approaches in order to generate successful, regionally and locally adapted, sustainable planning results.

The urban and regional framework, as well as the plot and building scale, define the benchmarks for the planning and design processes. Programmatic and technological requirements need to be integrated within a complex, functional, and spatial unit of the urban quarter, the neighborhood, or the building. The complexity of planning steps should be reflected in an integrated process which incorporates the various requirements of the different scales and disciplines involved.

	Spatial Dimension	Technical Dimension	Socio-Economic Dimension
Region	·· Regional Setting ·· Topography	·· Waste ·· Mobility	·· Economics ·· Demography
City	·· Climate ·· Urban Form	·· Water ·· Energy	·· Employment ·· Market
Neighborhood	·· Buildings ·· Green Space	·· Information and Communications Technology	·· Education ...
Stakeholders & civil society			
Process Design			

Fig. 38: Exemplified aspects of scales and dimensions in the integrated planning process (Pahl-Weber 2012)

A strategic planning process should aim to generate visionary and long-term results. This definition calls for sustainable development of urban settlements which includes a specified degree of flexibility for local and future adaptation.

1.1 Participants and Stakeholders in Integrated Planning and Design

In general, the basic disciplines needed for integrated planning and design are: Regional and Urban Planning, Architecture, Landscape Planning, and Landscape Architecture. The main common task for these disciplines is the development of a balanced design for human habitat which incorporates the requirements of all stakeholders and planning disciplines.

Because there is no binding international code for the planning disciplines and their fields of action, a precise process definition, per task and context, is necessary. To begin with, the interfaces between disciplines can be defined in terms of scale (e.g. urban or building), planning measures (e.g. process governance and spatial design), and physical characteristics (e.g. open space and built up space). More detailed definitions are bounded by national or regional legal regulations, although professions like “urban planning” do not have official descriptions (Pahl-Weber 2010, p. 489).

Engineering and planning disciplines, including transportation, energy supply, water and waste management, as well as environmental assessment need to be integrated into one holistic approach for resource-efficient and climate-sensitive neighborhood planning (as formulated in Chapter III 2).

Two main groups of planning process stakeholders can be identified by analyzing influences on urban development:

- The stakeholders affected by the process result, e.g. target groups, investors, administration.
- The stakeholders who are process actors, e.g. the planning disciplines, investors, and responsible administration.

Some actors are based in both groups. For example, the local administration has, on the one hand, great interest in planning results in terms of local development while, on the other hand, it is responsible for legal regulations concerning the planning process (e.g. planning supervision, mostly installed in local/regional/national administration). Because of this, planning processes are characterized by integrative governance at both procedural (e.g. public consultation) and operational levels (e.g. integration of planning disciplines).

The central task for governance of any urban planning process is balancing customer and stakeholder goals at the programmatic level with the requirements of technological, economic, environmental, and social dimensions.

1.2 Integrated Planning Processes—Approaches

One central task, and benefit, of a successful integrated planning process is the consideration and balancing of interests. Early integration of all relevant stakeholders allows conflicts between programmatic and technological requirements to be more easily identified and helps avoid expensive corrections during the implementation phase. Moreover, synergies between disciplines can be identified, which increases resource efficiency.

Although there is no pre-defined optimal planning procedure, at neither regional nor international levels, international developments of recent decades show movement away from the ideal visionary "master-planning" to the process orientated "strategic planning" (UN-Habitat 2009, p. 47). The process is defined by a strategic approach with three planning phases (OBauB Bay 2010, p. 48):

- The first phase is the analysis and definition of goals, which forms the framework for further planning. Through a discussion based process, political, administrative, and citizen stakeholders come together with various experts to define and evaluate project goals in light of the local socio-geographical background.
- The second phase is the planning process of the disciplines as they define goals for scale-specific and legally binding planning products.
- The third phase is project implementation, followed by a monitoring phase which evaluates the project results including stakeholder satisfaction.

Although this phase-model suggests a linear process, feedback and adjustment loops between the phases are a beneficial and necessary part of the process and avoid top-down master-planning. This participative, balanced method characterizes the entire project—from goal-definition though to the final development.

The integrative approach is the core of successful sustainable planning. However, the planning method which characterizes modern planning approaches, in the MENA region and globally, is based on the perspective of a single planning discipline. Generally, in master-planning, the integration of sectoral planning results is arranged in a more or less independent, consecutive procedure. This means that the sectoral results must fit within a pre-defined urban vision and valuable synergies which emerge in a parallel working method are lost. Participation of all sectors from the beginning of the planning process is highly beneficial for a project. This allows stakeholders and disciplines the opportunity to weigh, and thus balance, the advantages and disadvantages of their goals, requirements, and measures.

Urban Form

- The strategic planning process is characterized by integrated planning results and continuity across scales. The determinations of planning products influence products and processes of other scales. By specifying spatial framework determinants, such as density, and classifying a certain land-use as the functional framework, the neighborhood design can begin to be formulated.

Urban Resources

- Sustainability is rarely considered in the existing regulations and codes of the MENA region, creating a challenge for further development of planning processes.

Urban Technology

- In integrative planning, all stakeholders and disciplines are involved from the very beginning. This allows for careful weighing of the advantages and disadvantages of each sectors goals, requirements, and measures, resulting in a better overall design.

Urban Governance

- In integrated planning, the procedural framework for neighborhood planning needs to be adapted to the specific technical, economic, environmental, and socio-cultural project context.
- The consideration and integration of sustainability in planning processes can be achieved at two levels: by defining programmatic tasks as result of case specific findings in a specific project context or by integrating process findings into legally binding planning tools (i. e. codes or guidelines).

Strategic planning is characterized by continuity across scales and integrated planning results. The determination of planning products influences the products and processes of other scales. Regional or city level land-use specifies the broader programmatic and spatial framework. By specifying spatial framework determinants, such as density, and classifying a certain land-use as the functional framework, the neighborhood design can begin to be formulated. Integrating sustainability aspects, such as green and open spaces, programmatic provisions (e.g. Mixed Use Zones), or technical and social infrastructure (e.g. energy systems), also influences land-use and spatial determinations.

Density as a spatial determination for land has to balance resource sustainability and economic interests. In other words, the economic benefits of different densities should be discussed in connection with the long term benefits of a sustainable development.

Density significantly influences energy efficiency in both social and technical aspects. The level of resource sensitivity (e.g. through passive energy impact) is also density-dependent and must be balanced with the other goals of this context.

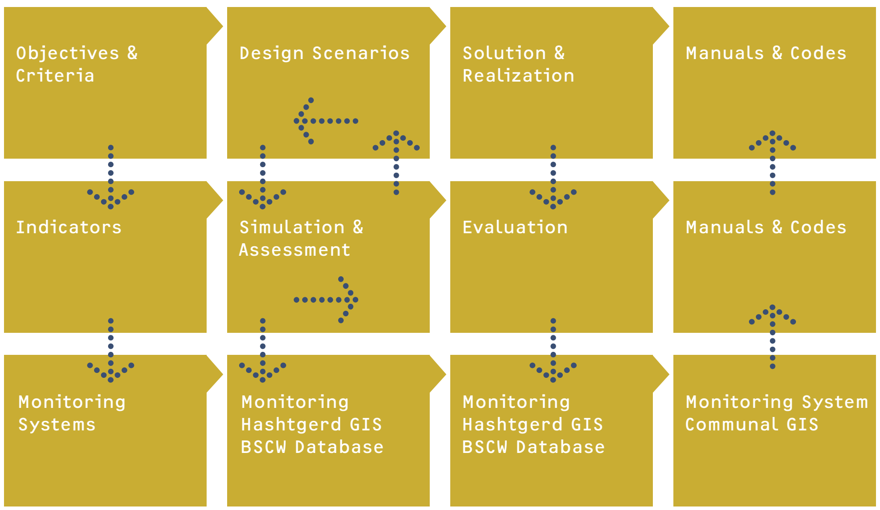


Fig. 39: Example of a methodological approach: "Design, Simulation and Documentation" from the Hashtgerd New Town pilot project (Pahl-Weber et al. 2010, p.61)

The revision and updating of planning results is crucial for strategic and integrative processes. The integration of the results of a participative milestone (e.g. public consultation) creates a revised planning product (e.g. Detailed Plan). The weighing and balancing of interests allows for a holistic and contextualized result.

1.3 Scenario and Revision

The procedural framework for neighborhood planning needs to be adapted to the specific project context and planning steps are in need for revision.

One suitable process that allows for this revisionary approach is scenario work. By considering several options (e.g. design scenarios), the various perspectives of disciplines and stakeholders are highlighted. By comparing different design scenarios (e.g. in plans and sketches), planning results and consequences are assessed and revised which helps to define the next steps. This method allows for swift adjustment and decision making.

Another example of revisionary processes is the participation of stakeholders via public consultation.

1.4 Resource Efficiency and Climate Sensitiveness in the MENA region—Goals and Results

The integration of sustainable and resource efficient aims in neighborhood design is highly influenced by the contextual definition of land-use at local and regional scales.

Most of the MENA countries have planning regulations and codes which rarely include sustainability, making incorporation of sustainability goals a challenge.

The consideration and integration of sustainable aims in future planning processes can be achieved on two levels: the definition of programmatic tasks as result of case specific findings in a specific project context, or the integration of planning process findings into binding planning results (i.e. plans) as general legal requirement

Existing regulations and codes can conflict with sustainable aims. For example, the "car free neighborhood" is an excellent form for low carbon urbanism, yet most MENA region national codes are still based on private vehicles with the infrastructures and access systems regulated accordingly. This creates challenges on two levels: first, exceptions from the existing law will need to be made; second, a fundamental task of the planning process will be to provide a real alternative to private vehicle mobility.

Planning codes should be checked for sustainability and the revisionary process can provide adaptations to present and future sustainability requirements.

2 Integrated Design Solutions for Resource-Efficient Urban Form in the MENA Region

Philipp Wehage

Resource-efficient and climate-sensitive neighborhoods, as a social, spatial and functional unit of urban form, arise from an integrated design process which considers all relevant components. An integrated process incorporates the complex interdependencies and relational aspects of all functional and design components and disciplines.

The local and regional contexts, in combination with the population's socio-cultural background, are major influencing factors in the designing of urban form. Possible contradictions between the requirements of the different components and disciplines involved, need to be balanced in a site specific design solution.

2.1 The Actors in Urban Form

Creating a resource-efficient urban form involves certain, specific planning approaches. In general, the integrative work of shaping the urban layout is based in the disciplines for spatial design, like urban planning, architecture, landscape planning and landscape architecture. The disciplines and stakeholders which must be integrated are based on two levels:

- Programmatic level and
- Technical execution level.

The programmatic level is characterized by the requirements and goals of stakeholders. These emerge from the economic, social, and environmental goals and need of a project. Stakeholders in urban development projects include: political and administrative authorities, investors, present and future users, and any other relevant representative.

The technical and executional aspects of all the disciplines involved in planning have a direct impact on the final urban layout. The main disciplines are outlined in Chapter III 2.1 and depend on the specific project. This chapter focuses on the aspects most relevant to creating sustainable and resource efficient urban form in the MENA region, including:

- land-use and density,
- building configuration and design,
- movement and access,
- open space design,
- energy supply.

2.2 Strategic Approach for Urban Form

Resource-efficient urban form is a spatial arrangement of urban agglomerations which capitalizes on synergetic benefits between various planning needs and disciplines. The local context and specific project conditions need to be analyzed project-by-project in order to accurately identify potential beneficial synergies. The formulation of a context-based approach for designing a resource-efficient and climate responsive urban form which maximizes possible synergies includes both the structure of the planning process and the planning vision.

2.3 Characteristics of Urban Form in the MENA region

2.3.1 Designing a Socio-Cultural Adapted Urban Form

A major characteristic of the MENA region is its socio-cultural background rooted in the religion and culture of Islam. The lifestyle associated with this common background influences and creates a framework for future development. Although local specifics deviate from the broader character, general assumptions and principles are still useful. Wirth (2002) gives general information about the culturally rooted tradition of urban form in the MENA Region.

The origin of vernacular urban form and its elements are not exactly provable and the characteristics are not always transferable to contemporary and advanced designs. But the knowledge and reflection of main aspects help to find cultural adapted design solutions.

One main characteristic of traditional urban design and architecture in the MENA region is a specific spatial and functional arrangement of the Middle Eastern city (Bianca 1991 and Wirth 2002). From ancient to modern times, a cultural definition of privacy within the spatial hierarchy—from city to quarter, neighborhood and house—greatly influences the region's urban form.

In traditional cities based on this spatial hierarchy, the urban form was fitted to the population, vehicles and energy sources of previous eras. The contemporary context of today's MENA region is defined by personal-vehicle based mobility and the consumption of fossil based energy. Contemporary neighborhood design in the region often tries to merge the culturally rooted sense of place with modern lifestyles, combining the formal organization scheme of traditional neighborhoods with the needs of current infrastructure systems.

The local administrative context is a further influencing factor in the urban form of neighborhoods. Guidelines regulate the urban form on several levels, but in part due to the high demand for and mass production of housing, resource efficiency is generally no the focus. New or revised measures and tools are needed for planning processes to develop strategies for sustainable settlements, as well as to help support the debate with the local authorities.

The challenge for future development of resource efficient urban form in the region is to reflect the cultural and spatial phenomenon of the neighborhood and city design while considering resource relevant aspects and contemporary needs. The design and dimensioning of public and private spaces in urban form is a crucial aspect of integrating technical and functional needs into the social and spatial unit of the neighborhood.

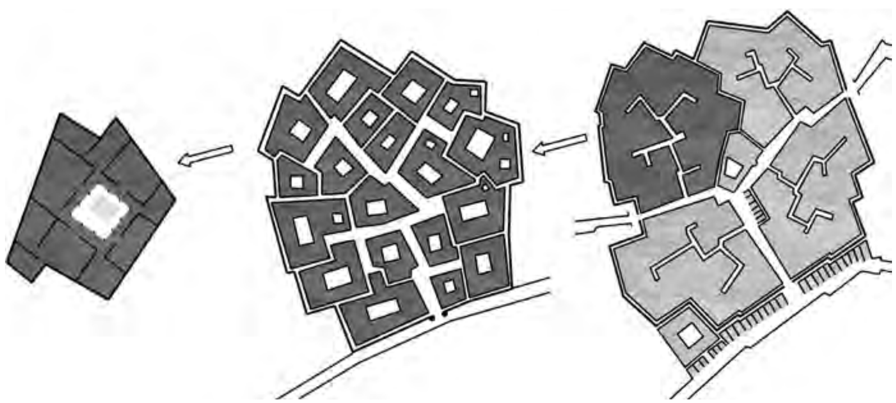


Fig. 40: Quarter, neighborhood, and house (based on Bianca 1991, p.151)

Urban Form

- The proportion of open space to built area should be designed to support the definition of public and private space.
- Dense urban form and a compact building configuration go together. Closed coverage reduces façade surface area and, thus, energy loss.
- Take full but careful advantage of the potential passive energy benefits of compact urban form while considering and balancing these advantages with potential thermal losses.

Urban Resources

- Reducing sealed soil through dense urban form improves the micro-climate and creates open spaces. Climate adapted vegetation in green areas, in combination with shaded open spaces, reduces evaporation of water and increases infiltration.
- Reducing the built area offers the possibility to create open space with innovative systems to improve climate quality and enhance resource efficiency, such as gray water treatment.

Urban Technology

- A dense urban form facilitates efficient infrastructure systems. Compact and dense urban units allow for efficient and unit sized energy systems such as block heat and power plant (BHPP) or Earth Tube Collector.

Urban Governance

- Mixed-use schemes should be prioritized. Combining housing with facilities for the provision of everyday local commercial needs creates livable neighborhoods and reduces the need for vehicle mobility while providing ready-made economic and social infrastructure.
- The arrangement of plots should allow for a variety of shapes. Building lines should guarantee implementation of the spatial concept and requirements of public-private spaces of the urban form.

2.3.2 Designing a Site-Adapted Urban Form

Another major relevant aspect of resource efficiency is the geographical context. Topography and climate have direct influence on resource- and energy-efficient design for urban form.

Almost 70% of the MENA region is characterized by an arid climate, as stated in Chapter I 10, but the great extent of the region makes local analysis necessary. The urban form, the arrangement of built and open spaces, influences the micro-climate by determining sun and light exposure (e.g. solar incidence and shading) as well as affecting natural ventilation (e.g. wind and air exchange). Wind and sun incidence depend on the specific local climate and are influenced by the topography of the site. Topography, the naturally formed ground, both influences (speed and direction wind) and is influenced by (wind or water exposure) climate conditions. Similarly, wind, sunlight, and temperature all influence vegetation, while the vegetation influences the micro-climate. The ground, with its mineral materials and value for natural cycles, also has a high impact on local climate.

Supposing that every building on neighborhood scale creates an artificial topography, the impact on local climate is obvious. Likewise, the local geographical context can influence the resource efficiency of the urban form, e.g. through passive energy impact.

The urban form greatly influences the local climate and can allow for the use of renewable resources.

The high solar radiance in the arid and semi-arid climate of many locations in the MENA offers extensive passive energy potential. However, this impact needs to be consciously regulated to avoid overheating. A dense building configuration in a compact urban form allows for shaded spaces and surfaces to avoid overheating, reduces heat and cold loss by minimizing building surfaces, and creates a good micro-climate.

Through scenario work, the feasibility of transferring general principles of urban form can be checked in a specific site context.

For example, a generally efficient rectangular urban grid would be very difficult to plan and construct in extreme topography. Design scenarios can illustrate a project's scale and the site specific visions for urban form. By comparing several scenarios, one particular design solution can be formed from multiple ideas and serve as the basis for further detailed planning. The continuity of scale is a crucial characteristic of spatial design and should be the basis for scenario work. Determinations made on the urban scale establish requirements of other scales, for example at level of individual buildings. Moreover, specifying urban patterns requires coherent strategies in building design; for example, a dense and compact urban form does not fit with single detached building typologies.

Scenario work is a central tool for all design disciplines. It contextualizes general approaches to the specific conditions of the site and task. It does not stop on a specific scale or level, but rather starts anew after every milestone in the design process.

2.5 Resource-Efficient and Climate-Sensitive Urban Form

Within the local and regional context, several strategies can develop a site- and socio-cultural adapted urban form solution. With the integration of relevant planning disciplines at the technical execution level (according to

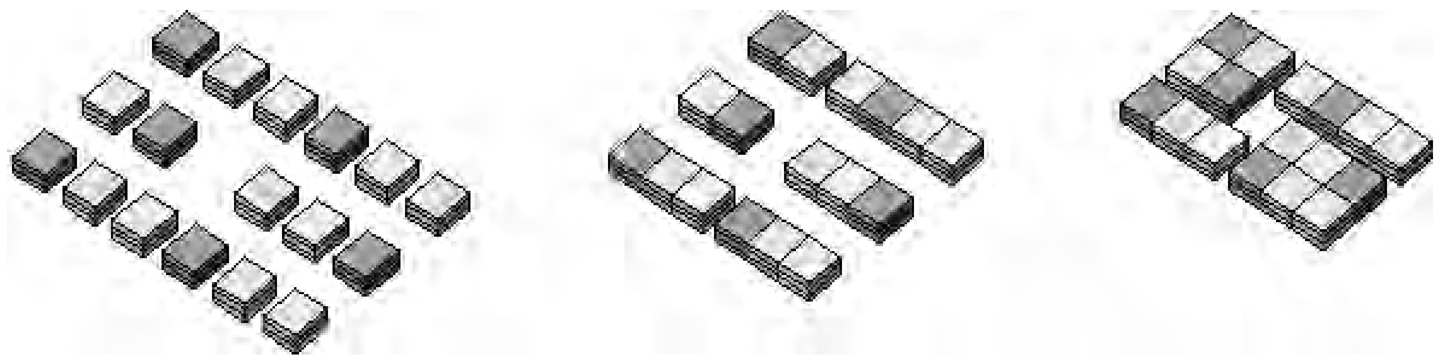


Fig. 41: Low rise and densification (Wehage 2012)

2.4 Methodology—the Scenario Work

The basis for designing a resource-efficient urban form is analysis of the local context. Analyzing the geographical and socio-cultural context allows planners to develop criteria for design scenarios. Creating scenarios is a suitable tool for showing different urban approaches and giving a visual impression of the project goals, as well as for comparing different strategies and their expected outcomes.

Chapter III 2.1), the main strategies for resource-efficient urban form are:

- minimization of thermal loss,
- maximization of passive energy impact,
- minimization of land consumption,
- optimization of mobility,
- optimization of infrastructure,
- optimization of synergies through land division and use.

Resource efficiency in urban form can be achieved through passive measures. Instead of enhancing efficiency through optimized technologies, the urban form offers the opportunity to generate efficiency through innovative and intelligent spatial arrangements. Optimized building and urban design can reduce energy consumption.

2.5.1 Minimization of Thermal Loss—Closed Coverage, High Density for Compact Urban Form

Optimizing building volumes can, among other things, stabilize a building's thermal behavior through compactness and surface to volume ratios. This reduces thermal loss through building surfaces and efficiently regulates the interior climate against extreme outside temperatures and seasonal or daily temperature peaks. Depending on surface- design and material, the influence of outside climate on interior spaces can be greatly reduced. This strategy must be developed in tandem with architectural design (see IV 3).

2.5.2 Maximizing Passive Energy Impact—Orientation of and Distances between Buildings

Maximizing passive energy impact means that urban form is adapted to use regenerative energy. The main regenerative energy sources are the sun, wind, and water. Passive energy impacts help to reduce the active energy demand for cooling and heating and, in turn, CO_2 emissions. Solar radiation is very intense in most MENA region climates. Many of the region's traditional urban form patterns were created in response to the intensive sun and wind exposure. Street layout was intended to combat high outdoor temperatures by channeling wind and providing shade. In regions with cold winters, sunlight on southerly oriented surfaces helped to reduce the need for heating.

The design of neighborhoods greatly influences the solar incidence and is directly related to architectural design of surfaces, openings and floor layout.

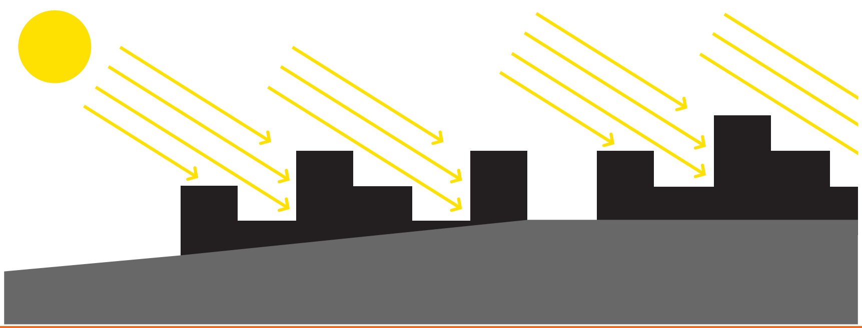


Fig. 42: Basic principle: passive solar impact (Wehage 2013)

2.5.3 Minimization of Land Consumption—Densification of Built Area

Growing urban settlements are in need of land to construct new neighborhoods. To limit development's impact on natural resource cycles, the consumption of land should be reduced to a minimum. The compact and dense urban form of traditional MENA cities is a good approach for minimizing land consumption with a defined spatial system. Patterns with this low rise, high density scheme are economically and resource efficient. While the historic densification was motivated by the need for protection in conflicts or from climate events, today, the gained ground is an environmental asset, and could also, for example, be used for agriculture (a crucial resource for regions with little fertile ground).

Beyond the recreational potential of open spaces, the unsealed soil is also an important asset for natural resource cycles within modern urban settlements.

Because of water scarcity in arid MENA regions, the resource cycle value of unsealed soil is significant. Innovative concepts for active resource recycling can be installed in close relation to newly built areas. Some examples include: wastewater treatment, micro climate benefits of plant evaporation in green areas, or infiltration of rain water for closed water cycles,

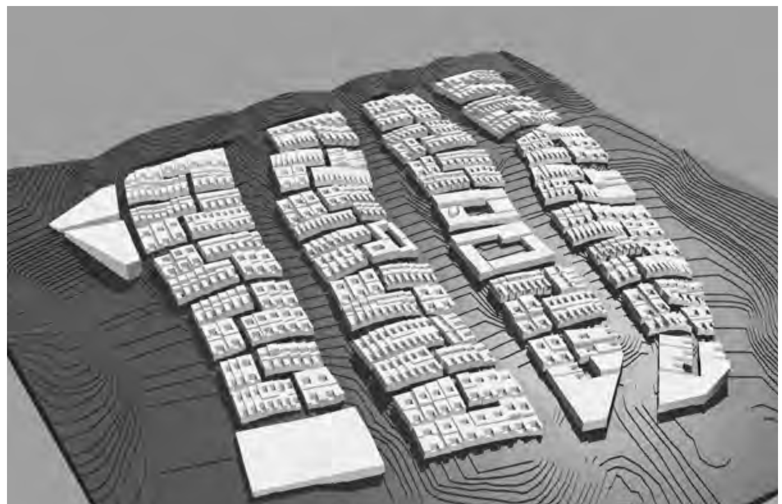


Fig. 43: 3D Simulation of Shahre Javan Community (Pahl-Weber, Seelig and Ohlenburg 2011, p.63)

2.5.4 Optimizing Mobility—Provision and Integration of Innovative Mobility Systems

Urban Form is in part determined by functional processes and, thus, mobility systems influence design. Each transportation mode requires a specific provision and dimensioning of space. Mobility in the MENA region is mostly composed of individual vehicles, one of the largest sources of CO_2 emissions. Sustainable alternatives to individual vehicles must be found.

An efficient public transport system needs to be developed and integrated within a city or region's concept in concert with efforts to minimize long distance travel in everyday lifestyles. This requires a good work-life balance based on a balanced land-use and mobility approach.

The provision of places to work and for the supplying of everyday needs in close vicinity to neighborhoods, through mixed-use areas inside or nearby housing, can reduce the need for motorized travel.

Advanced para-transit systems such as car sharing and e-mobility can also help to reduce emissions and minimize spatial demand for traffic.

2.5.5 Optimization of Infrastructure—Providing Feasible Systems and Integration into the Urban Form

Technical infrastructure is often related to supply systems. Defined urban units with high density, such as neighborhoods, can allow for semi- or de-central systems, such as block power plants.

The intensive solar radiation of most MENA countries has great potential for energy production via solar heaters and photovoltaics.

Solar exposed surfaces, such as roofs, offer extensive installation space for such systems. In terms of water and wastewater infrastructure, treated gray water can be reused, as mentioned before, for irrigation of local open green spaces. All these systems can directly link production and consumption in a close spatial relationship. Thus, the construction required for technical infrastructure can be reduced. The spatial provisions for these infrastructure innovations have to be integrated into the urban form at an early stage.

2.5.6 Optimization of Synergies through Land Division and Use—Balancing Requirements and Finding Synergies in the Spatial Design Process

Urban form integrates a variety of different and sometimes contradicting demands.

The urban form is the spatial, functional unit of the design solution where balancing needs can offer opportunities for synergies.

For example, relation between mobility and land-use described above (see IV 2.5.4) allows for site specific synergies concerning energy consumption. In dense urban configuration, the close distances between housing and work space or social infrastructure avoids long travel distances while supporting the liveliness of the neighborhood by increasing walkability and use of local streets and paths for social interactivity. Beyond the synergetic resource efficiency effects, a second major benefit is the balancing of the requirements of the spatial framework with the needs of inhabitants' lifestyles. This culturally and technically adapted urban space is crucial for the acceptance and success of sustainable planning.

3 Integrated Architectural Design Solutions for Resource-Efficient Buildings in the MENA Region

Philipp Wehage

The continuity of scales is a necessary part of an integrated design process as mentioned in Chapter IV 1 and IV 2. Every building is part of a larger urban arrangement and every urban unit is composed of smaller spatial units, thus spatial design scales are interlinked and interdependent.

Architecture, as traditional integrative design discipline, collects the individual needs of users and clients and balances them with the requirements of engineering a building.

In other words, a site specific building design solution is the result of balanced planning. This process is very complex; it must simultaneously consider numerous influences, impacts, and parameters. These factors are different in every project, and the holistic design approach of each sustainable, architectural project must be individually developed (McDonough and Braungart 2012).

Urban and architectural design are interlinked, and the definition of a site's urban concept determines the architectural framework. Characteristics and standards of land use, density, plot- and building design, and technical infrastructures are pre-determined by the urban design. Physical aspects of construction methods and materials influence functionality and have a significant sustainability impact. Intelligent choices for their provision must be made within the economic context of a project.

Beyond physical aspects and the availability of materials and technologies, the socio-cultural background also influences the external architectural appearance as well as the inner organization of the building.

3.1 The Actors of Architectural Design Processes

As mentioned in Chapter IV 2, the needs and requirements of both the programmatic as well as the final technical execution levels must be integrated at an early stage in order to create a sustainable spatial arrangement. For resource-efficient and sustainable building design in the MENA region, the architect's work intersects with the disciplines of urban design, urban planning, landscape design, civil engineering, and energy systems. The architect must know the work of all relevant experts, from the initial geological survey to the construction phase.

3.2 Strategic Approach for Architectural Design

Sustainable architecture has to be seen as contextualized design (McDonough and Braungart 2012). Thus, the architectural design adapts general aspects, such as type of use, to the specific project context. The site context is partially defined by the results of the urban design process. Geographical aspects such as topography and climate, urban form and plot layout, access and infrastructure all formulate the spatial and functional framework for architectural design. However, the programmatic framework, with its social and economic aspects, is borne of the socio-cultural background and of stakeholder participation. Together, these set the parameters within which sustainable and resource-efficient architecture must work, and become part of balancing the design process.

3.3 Characteristics of Building Design in the MENA Region

3.3.1 Socio Cultural Context—Designing a Culturally Adapted Housing Form

The continuity of scale as described in Chapter IV 1 and IV 2 regarding urban form has a similar significance for architecture too.

Building forms and types are decided by their functional purpose, such as housing or commercial use, and are defined by the culturally rooted habits and needs of the local population. The characteristic elements of such types can be identified by specific features in drawings of floor plans, sections, and elevations. The architectural scale of for the building design process generally ranges from 1:500 up to a detailing level of 1:1.

The spatial hierarchy deals with community and privacy, and is a central parameter for architectural design in the MENA region. The final step in this hierarchy is the absolute privacy of the individual home.

With all its local individualities, the archetype of the courtyard house represents a significant and suitable building type for housing in the compact urban form of most mid-eastern traditions. The type, generated as a climate- and socio-adapted housing form in vernacular architecture, combined Islamic culture's high demand for privacy with the demands on thermal envelopes in mostly arid and semi-arid climates (Wirth 2002). It represents the interaction of socio-cultural and geographical contexts.

> ***The adoption of international modern housing typologies in the 20th century organized the housing complex in an extroverted western tradition. The definition of space, as known in the introverted Islamic tradition, was turned inside out.***

This break in tradition allowed exposure to light and air by opening up the outer, public facing façades and led to the possibility of a multi story building. The former organizational-scheme of the neighborhood was turned vertical. The inhabitants had to reinvent the spatial organization or change their habits. The stairway was adapted as a vertical 'dead end' and defined as a semi-private space within Islamic tradition, yet the definition of privacy was broken by the opening up of the outer façades. An informal result of this spatial out-turn was the covering of windows with curtains. The private open spaces attached to the façades, such as gardens and loggias, are not frequented because of their public visibility and have, therefore, become peripheral use areas. They are often used as storage or

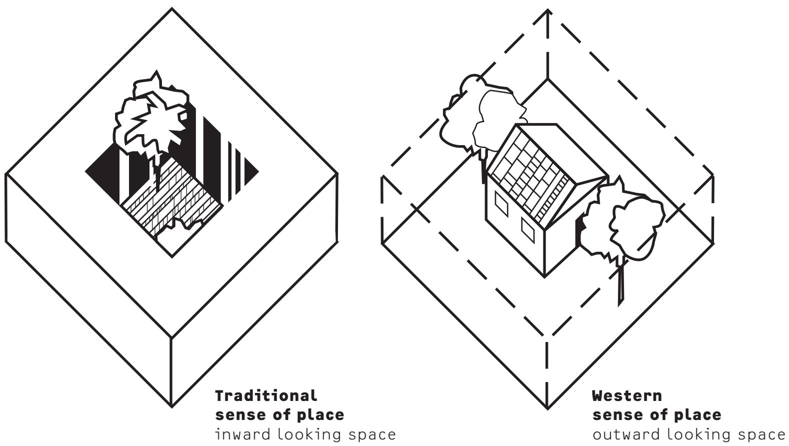


Fig. 44: The sense of place (Wehage et al. 2013, according to S. Manzoor)

technical supply zones (e.g. a space for air conditioners). In this sense, the relation of the façade to the outside creates residual-type open spaces in urban design of the MENA region.

The application of extroverted housing schemes in the MENA region often shows linear building arrangements, comparable to housing developments in the western world of the international modernist style. The broad, wide, linear urban space between the buildings, is a negative space

Urban Form

- Privacy is especially important in the MENA region. Introverted housing schemes, e.g. courtyard houses, offer climate and culturally adapted typologies in a dense, compact urban form.
- Coupled with dense urban form, the compactness of traditional courtyard housing reduces thermal envelope energy loss. Shaded courtyard micro-climates can deliver thermal comfort and air circulation through building morphology.

Urban Resources

- The technologies and materials of buildings should be chosen in relation to regional availability and quality. Simple constructions with vertical continuity of bearing elements reduce technological efforts.
- The thermal envelope is the most important element for the control of energy benefits and loss.

Urban Technology

- Because engineering requirements, such as construction methods and energy supply systems, significantly influence building design and construction costs, the related planning disciplines should be integrated early in the architectural design process. This integrated approach optimizes design in the planning phases and can reduce cost intensive changes in execution.

Urban Governance

- In most of the MENA region, the high solar incidence can create a surplus of heat, especially in summer. This must be considered in the planning of building volumes and southerly orientated surfaces. The façade design should provide shading devices to combat over-heating in summer.

which lacks quality due to its non-cultural adaptation.
The contradiction between privacy in a traditional Islamic understanding and the vertical housing typology in a western style is not yet sorted out (Wehage et al. 2013). Every housing design in the region should consider the local, cultural desire for privacy.

3.3.2 The Geographical Context—Design a Local Climate and Topography Adapted Housing Form, Respecting the Site Context
Regulations and parameters generated in the urban design process and given by local topography and climate form the spatial framework for every building design. Compact and dense urban form combined with the climate and topography of the MENA region, as mentioned in Chapter IV 2, is in need of suitable building types. Linear building arrangements, as a commonly used housing form in the MENA region from the 20th century through to today, exemplify a good approach for passive energy impact by maximizing the southern orientation of their façades. But contextualization conflicts with geographical and social aspects: both the need for privacy contradicts the need for opening up the façades and the high cooling demand for most of the MENA region in summer need to be considered in the architectural design.

In regard to topography, linear arrangements are well adaptable to plains. Mountainous topography needs differently adapted building typologies. Furthermore, the intensive land demand of linear building types conflicts with energy aims at the urban scale. Given the high costs of execution and the need to protect both the natural climate and resources, topographical interventions which prepare land for large linear building arrangements would be more effective if they first consider their economic and ecological effects.

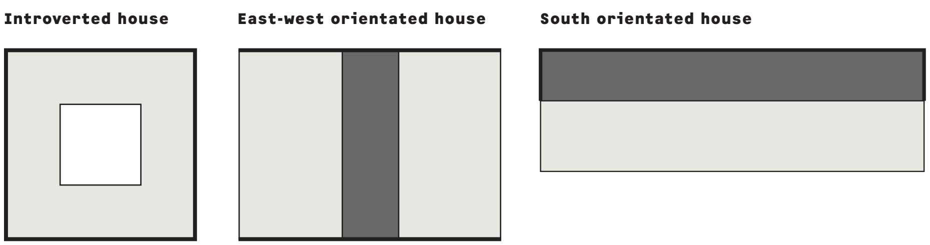


Fig. 45: Housing typologies and energy efficiency (Wehage et al. 2013)

As explained in Chapter IV 2, vernacular building types offer well adapted regional building typologies. The compactness of the traditional courtyard housing scheme is perfectly suited to dense and compact urban form. The shaded courtyards and their micro-climate deliver thermal comfort via air circulation catalyzed by the building morphology. But the sun impact and energy gain in winter periods is reduced to southerly oriented subzones. The introversion of this typology respects the demand for privacy. Of course, new designs for housing typologies should consider the historical, contemporary, and future social and technological contexts. New technologies and materials as well as changed habits in everyday life call for modern buildings. The vernacular elements and typologies need to be transferred to and transformed by compliance with today's societies.

3.4 Methodology—Typology and Scenario
The main aspects of architectural design processes lead to two methodological approaches:
- The Analytical Approach, characterized by a "top down" process, from a typological approach to a defined, specific solution.
- The Synthetic Approach, characterized by a "bottom up" process, from a specific context to a defined solution.

Design processes for sustainable architecture can come from both approaches.

Design approaches dealing with general aspects (e.g. typology, use, and function) have to be contextualized (e.g. to urban and climate context) and vice versa.

The Design process is an interactive development of solutions at different scales and levels, from overarching to detailed. The results of every step impact the definition of tasks for each subsequent step. There is no final recommendation for one design approach. No matter what defines the approach, a successful design process is a more or less simultaneous process of creative production and monitoring.

3.5 Resource-Efficient and Climate-Sensitive Buildings
Resource-efficient and climate sensitive architecture in the context of the MENA region contains aspects of volumetric and structural design as well as technological factors. This is the link to engineering disciplines. Volumetric design enhances passive energy impact and reduces thermal loss. Optimization of structural systems is a key factor in economic design. Technological optimization represents strategies for reducing energy consumption through application and use of innovative materials and systems. In other words:

The level of resource efficiency is dependent on measures of static design as well as on the operation of technical systems. Both types of measures are integrated in the spatial functional unit of the building.

Beyond this building scale, synergetic effects on urban scale allow for further enhancement. Passive design measures, such as shading or exposure to wind and sun, must be considered in the urban context. The successful application of innovative energy systems, such as decentralized energy supply, is dependent upon the urban framework.

3.5.1 Design Measures and Strategies for Resource-Efficient and Climate Sensitive Buildings

Building types can be characterized by specific attributes or elements, to facilitate identification of design measures.

Two main architectural elements represent approaches for resource-efficient and climate sensitive building design:

- The envelope, the physical shell between the interior (volume) and exterior of a building.
- The floor design, with the building access as the fixed anchor for the inner organization of the building volume.

The façade, as the thermal envelope of the building, defines the boundary between inside and outside. The structure of the façade is related to constructive and functional aspects as well as site-specific characteristics. Openings, which allow light and air incidence, guarantee the proper functioning of the building's volume-envelope relationship. The socio-cultural and physical dimensions of architecture, e.g. the graduation of privacy or the construction methods, are visible in the façade. Because the façade defines the interface of the private interior of the building to the public exterior of urban space, it also represents the interface between urban design and architecture.

The floor plan is related to the building type, and balances user needs with the site context of the building volume. A main characteristic of the building type is the method of access. Defining the routes of access, allows for identifying approaches to the floor plan and greater structure. This access system is a fixed dimension in architectural design. The floor design represents the user specific arrangement inside the building. It is defined by the method of entrance from outside, and it defines the accessibility of floors, dwellings and rooms within the building. The structural context, in construction and technical terms, combined with the access system and the building envelope paves the way to a graduated flexibility in floor organization.

For the building volume and arrangement, two main principles can be identified: maximization of passive energy impact and minimization of energy loss. For construction requirements, the choice of a contextualized structural design with suitable materials is a crucial factor for the planning of resource-efficient and climate sensitive buildings.

Maximization of passive energy impact

South oriented façades with numerous openings expose building volumes to the climate (Brunner et al. 2009). This measure allows for a high level of solar incidence and the associated passive energy impact. The floor design should be organized by this fact. Main living zones should be placed along the south façades to reduce the heating demand. This floor arrangement leads to more or less linear building volumes, which need to be considered in the urban configuration. On one hand, the density of buildings is limited by the distances necessary for solar incidence and by building height; on the other hand, the linear orientation must in accordance with the urban form.

In most areas of the MENA region, the high solar incidence can create a surplus of heat, especially in summer. This fact must be considered in the planning of building volumes and south orientated surfaces. The façade should be designed with shading devices to combat over-heating in summer.

Minimization of energy loss

In essence, the compact building form hides building volumes from the climate and thus helps avoid thermal loss (Brunner et al. 2009). The volume to surface ratio influences the compactness of building volumes. The thermal envelope (roofs, façades and ground-slaps) is the most important element for control of energy benefits and loss. Because of the high demand for quality in construction and detailing, the surface is a cost intensive building element. By optimizing the surface area through compactness, building costs can be reduced and a constant interior climate can be achieved for a deep volume. The floor organization must consider the high ratio of interior spaces with little natural lightning. One measure is to install an access and service zone in the inner zones of the volume (e.g. staircases and bathrooms) or, in deep volumes, to implement courtyards or niches for supplying inner zones with light and air. The supplementary surfaces, created by niches or courtyards decrease the compactness. In dry and hot climates, like in most areas of the MENA region, this measure could help to reduce the outside temperature of façades through shading.

Both strategies help to optimize resource efficiency in architectural design without any further technical- or infrastructural investments. A mix of these strategies should be used with caution, especially when

3.5.2 Design Measures and Strategies in the Planning Process

The base layer of measures and strategies for resource-efficient and climate sensitive buildings are largely architectural design measures based in planning disciplines for volumetric design.

The method by which design of the building volume influences the demand on energy is based in general physical principles.

confronted with possible contradictions (e.g. high ratio of façade surface for passive solar impact in relation to the optimization of volume to surface ration).

Construction systems and materials for resource efficiency

The technologies and materials of buildings should be chosen in relation to regional availability and quality. Simple constructions with a vertical continuity of bearing elements reduce technological efforts. The provision of traditional methods and materials can help to support local workmanship and companies as well as reduce efforts for fabrication and transport. The International Residential Code provides the basis for what is referred to as the conventional construction method, a method which generally allows for affordable building costs. The dimensions of housing, dwellings and room sizes should allow for the more efficient room widths. Flexibility in use is limited by these design specifications. Building height is another important factor. Especially in seismic hazard zones, construction efforts required for seismically safe high-rise buildings are remarkable. Because of the significant influence of building volume and floor arrangement, construction determinations should be integrated in the architectural design process at an early stage.

3.5.3 Design Measures and Strategies for Raising Efficiency Through the Application of Advanced Technologies

The next layer of measures and strategies for resource-efficient and climate sensitive buildings is based in the integration of efficient technologies in architectural design.

> ***Efficiency can be enhanced on neighborhood and building level through the application of advanced technologies. These measures need to be integrated into the energy supply systems of buildings and neighborhoods.***

Combining measures for both, neighborhood and building scales creates benefits for the community and the individual. Two suitable levels can be identified for integration of such measures in the building design: integration into the interior arrangement of building design and integration into the building design as an additional design layer.

Integration of systems in building design

One strategy for enhancing efficiency is integrating technologies through provision and arrangement of elements or spaces in the building design. One example is the heat recovery system. Advanced architectural design is in need of air conditioning; the vernacular architecture includes a regionally rooted system of air exchange which capitalizes on thermal principles. In combination with advanced technologies it is possible to significantly reduce a building's energy demand. A suitable system, which requires little technological effort is the heat exchanger. In combination with a pre-tempered air supply, e.g. through an earth tube collector at the neighborhood scale and building distribution via a constructed air-channel, the heat exchanger recovers the already tempered inside air and uses it for pre-tempering fresh outside air. The pre-tempering helps to reduce energy demand for cooling and heating.

Integration of additional design layer

The second strategy is the integration of technologies as additional layer of design. Shading devices help regulate solar impact on the building. Especially in hot summer regions, shading through curtains or covering of open spaces creates micro-climate benefits. An element from vernacular architecture is the covering of courtyards through mechanical or textile elements which reduces the direct solar impact and creates a comfortable semi-open space. In advanced technologies, these elements can be combined with the effect of light guidance (e.g. for naturally shaded spaces in winter) or the energy benefits of high-tech fibres (e.g. photovoltaic fabric). Because of the advanced technology and high quality standard of such elements and systems, the economic and technological standard of the region and specific project need to be considered first.

2 Energy-Efficient Design Solutions for Dense and Diverse Neighborhoods for the Shahre Javan Community

Annette Wolpert | Sebastian Seelig | Philipp Wehage

Fig. 106: Shahre Javan Community pilot project area in Hashtgerd New Town with Alborz mountains in the background, 2008 (Wehage)

Considering the local conditions and pilot area settings described ion page 130 f., it is clear that an approach adapting to the highly complex climatic, topographic, and geologic patterns is urgently needed.

Adaptive requirements for urban agglomerations of the region can be summarized as follows:

- Urban structures should react to seasonal variances—high heat stress in summer, cooler, wet winters, and strong diurnal variations;
- Urban structures should react to the topography—changes in temperature and precipitation as altitudes get higher, as well as wind directions;
- Urban structures should react to the risk of earthquakes.

Among the many already well-known elements of energy-efficient urban fabric, the technical-scientific and procedural innovations of the pilot project were achieved through strategic integration of all required planning disciplines: urban development concepts were linked to detail planning and adjusted to technologies concerning urban infrastructure (energy, water, traffic, and green spaces). This led to a multi-scale approach involving various levels—from the entire city to the single item—in order to achieve overall optimization and advancement.

2.1 Objectives and Accomplishments of the Integrated Planning Process

The task was to develop a sustainable and energy-efficient urban quarter for a population of 8000 inhabitants with approx. 2000 residential units in a central part of the already outlined area of New Hashtgerd. The "low-rise—high-density" pattern of traditional Islamic cities served as a model for a climate sensitive design, as it reflects the cultural need for privacy with its clear definition of private, semi-private, and public areas. From the very beginning of basic organization of compact urban form clusters, various requirements of different dimensions had to be considered and weighed. The height, length, and width of each block had to be considered in combination with street width and orientation in order to:

- Achieve a flexible organization of the block with a large variety of unit numbers and sizes,
- Reduce energy consumption through an optimized use of shading in summer and direct sun impact in winter,
- Optimize the channeling of wind for cooling effect and to minimize air-pollution,
- Reduce construction efforts through a low rise approach, especially in regard to seismic hazards,
- Reduce travel demand through optimized access and transportation systems,
- Minimize soil movement and sealing and preserve existing, valuable green space for recreational purposes,
- Create an urban identity through spatial design, perceivable throughout the spatial hierarchy from urban quarter to neighborhood to building.

In four rows, 28 clusters, each of approx. 100 m by 60 m, are lined up from north to south. This organization helps block the unpleasant prevailing winds from the west and northwest and the hot and dusty summer winds coming from the southeast. Furthermore, the north-south orientation of the streets helps to channel and take advantage of the cool northerly winds from the mountains in the summer. This was simulated using the microclimate simulation software Envi-met.

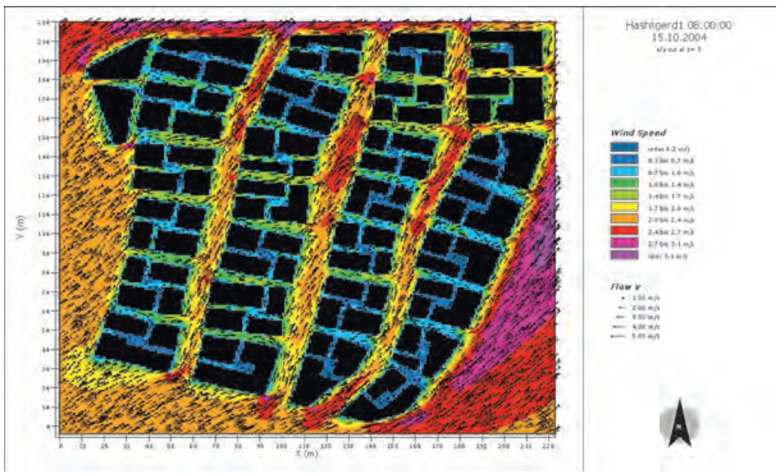


Fig. 107: Wind speed simulation within the Shahre Javan Community with Envi-met (Langer 2012)

Each residential cluster forms a sub-neighborhood with a central square of 15x30 m as a semi private focal point. The sub-neighborhoods are accessible only via 6 m wide footpaths, which divide the Cluster into four building groups. The buildings, with a maximum height of three stories (carpet style), follow the topography of the site, with a more or less continuous offset of about one story. This arrangement and ratio of built and unbuilt area together with the north-south orientation optimize the benefits of potential shading in summer (to reduce cooling demand) and projected solar incidence in winter (to reduce heating demand).

The semi-private plaza of each sub-neighborhood is part of a mixed-land-use scheme, which was combined with the urban, landscape, and transportation concept.

The mixed-use concept was composed of two layers: one central and the other de-central. Central mixed-use means that, apart from a large regional shopping center which is positioned on the southeast corner of the site, all main functions, such as the cultural center, mosque, and schools, are located in the center of the site in order to make it the focal point of urban life. The idea was that all main amenities should be within in easy walking distance of every resident. The de-central portion of the concept translates into smaller commercial units surrounding the semi-private plaza of each sub-neighborhood, accommodating the everyday needs of the residents and helping to create sub-neighborhood identity and livability.

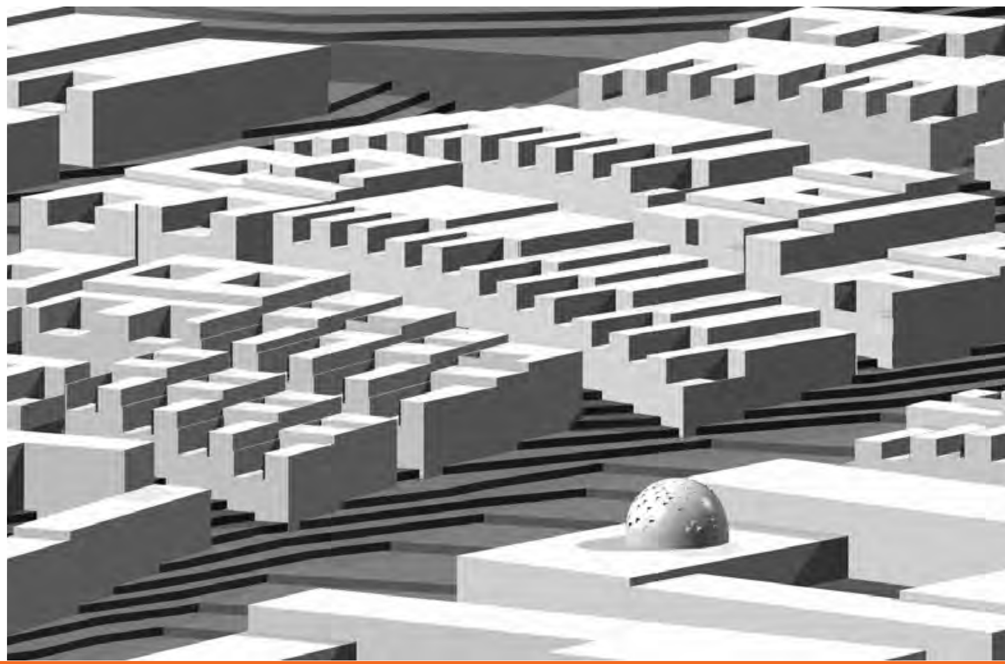


Fig. 108: 3D Rendering of the Shahre Javan Community pilot project area Urban Concept (Timme 2009)

2.2 Traffic

This layout reduces travel demand and, apart from supply and emergency traffic, keeps motorized traffic out of the residential areas (cp. VI 6). Simulations with VISUM proved that this compact urban layout and land-use concept for the Shahre Javan Community pilot project area can reduce individual car trips by 3% and the use of public transport by 7%.

An Eco-Mobility and Transportation Concept was investigated for both the Shahre Javan Community pilot project area and the region of Hashtgerd as a whole. It became obvious that too much was afforded to the future demand for individual motorized traffic and not enough for the alternative of a public transportation system. Developing a well-considered public transportation system would enable people to move out of unsustainable transportation habits, reducing individual motorized traffic. A system with a city-bus, rapid transit buses, and light rail would be sustainable, comprehensive, and integrate the Shahre Javan Community pilot project area into the larger City of Hashtgerd. These systems would also complement the planned Hashtgerd-Karaj-Tehran metro line for commuters going in and out of the City of Hashtgerd. The benefits of such a system include:

- Reduced vehicle-based mobility and, thus, energy consumption,
- Increased access to services, jobs and shopping,
- Increased flexibility to accommodate the changing needs of inhabitants and investors,
- Increased urban quality, liveability, identity, and security,
- Increased level of economic activities in residential areas.

Fig. 109: Transportation concept and land-use concept with small-scale, mixed-use areas (striped) (Schäfer et al. 2010, page 67)

The clear distinction between motorized routes and pedestrian or bicycle lanes, together with the relation between very dense built zones and unsealed, partly green corridors, also meets the demands of the Landscape Architecture, Environmental Assessment, and Water and Wastewater dimensions.

2.3 Environmental Assessment, Extensive Landscape Design, and Wastewater Reuse

The Environmental Assessment analyzed the environmental factors of flora, fauna, soils, groundwater/surface water, climate/air, and landscape, investigated the environmental impacts of the proposed urban development, and developed measures for mitigating those impacts. The compactness of the built area should reduce the amount of sealed soil while the wind channeling of the urban structure should protect or enhance the local climate by improving air quality and avoiding urban heat stress by providing a fresh supply of cool air. Valuable green structure has been preserved and measures have been proposed to develop the existing environmental structures (cp. VI 8).

The compact urban form helped create an expansion of available open space and recreational areas for the inhabitants. The project aspired to a minimum of 7 m² public greenery per capita, a standard which could be raised up to 12.5 m² per capita if the adjacent greenery will be preserved (cp. VI 7).

The water scarcity challenge has motivated the integrated development of an Extensive Landscaping Concept as well as an efficient Water and Wastewater Management System (cp. VI 5). In the early development stage, the dense and mixed use urban form was interconnected with an efficient Wastewater and Disposal Concept, which includes a separate collection of two different wastewater streams: graywater from sinks, showers, washing machines, and bath tabs and blackwater coming from kitchen sinks and toilets. After being treated in decentralized constructed wetlands, the graywater could be reused for irrigation or service water. Water treatment areas (constructed wetlands), especially graywater, should be located in the near proximity of the residential units of each sub-neighborhood. Thus, their placement had to be considered at the very beginning. The benefit of these relatively simple planning considerations is extraordinary, as they allow up to 70% of used water to be repurposed into the water cycle of the city of Hashtgerd. The introduction of constructed wetlands, with low water consuming, regionally adapted vegetation, helps to reduce the energy demand simply by reducing the need for pumping, enhances the microclimate, and improves the quality of the open spaces as a design element.

2.4 Architecture

Based on an urban concept derived from the pattern of traditional Islamic cities, the building typology of the Shahre Javan Community pilot project area is rooted in the traditional courtyard house of semi-arid and arid regions. This typology offers privacy and the courtyards' microclimates are helpful for dealing with the challenges of hot climates.

The four building plots within each sub-neighborhood are 20 to 35 m deep and predominantly orientated in a north-south direction. These large plot depths are only usable when further insertions via courtyards and niches are introduced to allow for sufficient natural daylight (cp. VI 3).

It is well known that the main environmental gains that can be achieved at the building level are through general planning principles such as orientation and compactness, followed by further energy gain through low cost building optimization systems—the most expensive active systems have the relatively least benefit. This led to a distinction of two approach levels. The basic level is benefits achieved through planning principles only. Given this, the first measure was the development of a housing typology, which allowed for a wide range of building standards and sizes: from single-family duplex units with private courtyards up to multi-family apartment buildings around large shared courtyards. Multiple variations for site adaptations and construction methods are possible with a modular space design using 1.5 m steps for unit width, starting from 6 m and ending at 15 m.

The introverted courtyard housing types in the modular scheme allow for private living in low rise high density:

- The main living areas are organized around a private courtyard, with solar light and warmth even in rear zones of the buildings.
- A separation of private and guest areas is possible as guestrooms are always accessed directly after entering the apartment/house without passing private zones.
- The shaded courtyards improve the micro-climate, especially in hot summertime.

2.6 Benefits

The benefits of the measures described above can be summarized as follows:

Urban Form

Climate-Sensitive Design

System of Hierarchy:

- Clear definition of public, semi-private, and private spaces and access systems.

Low-Rise—High-Density:

- Reduces heat loss,
- Shading effects,
- Free movement of air with a fresh, cool supply,
- Increased quality of green space,
- Reduced motorized transport,
- Reduction of sealed area.

Street Layout and Microclimate:

- Street layout helps to keep streets accessible even after earthquake hazard,

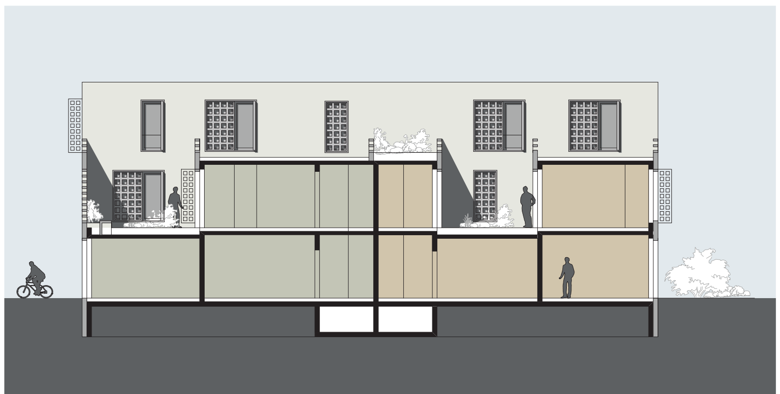


Fig. 110: Section through 9 m type residential building (Wehage 2013)

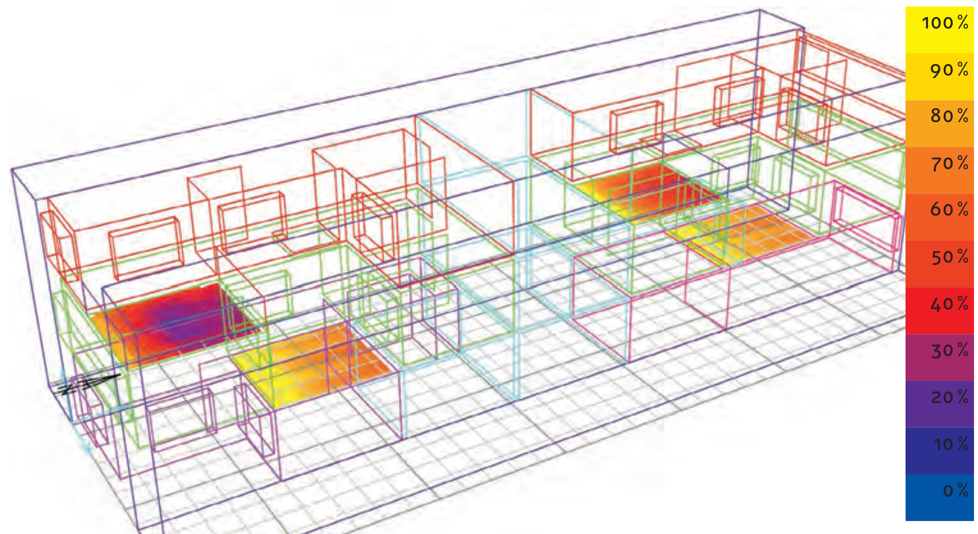


Fig. 111: Simulation of the opacity of courtyards in the buildings (Wehage and Pahl-Weber 2012, p.79)

2.5 Awareness Raising

The project dimension Awareness Raising hopes to make the environmentally friendly design attractive to residents and raise its local acceptance. A survey of Hashtgerd New Town's citizens' consumption patterns was taken, followed by a public exhibition about the plans of the pilot project area, in order to start an exchange with the inhabitants as a necessary prerequisite to successful implementation (cp. VI 9).

- Orientation/dimension of streets: east-west orientation of streets promotes the north and south solar exposure of the buildings, which can be more readily controlled as a result of the greater solar altitude (according to Givoni 1998, p. 368). Unfortunately, streets running north-south have better shading conditions in summer and better light conditions in winter. This is a conflict that can be solved by diagonal streets, orientated northeast-southwest (Ibid.),

- This street orientation allows for cooling and ventilation by afternoon and evening winds.

Topography and Site:
- Climate: harnessing cool winds for ventilation and cooling in summer by avoiding buildings in breezeways and by blocking hot winds with buildings and building groups,
- Optimized building orientation and form: buildings should not be blocked by other objects; location on a slope; south- or southwest-facing slopes are particularly suitable due to greater solar gain (Stadt Essen 2009, p. 5f.).
- Seismic hazards: Low rise building type reduces construction efforts and offers a larger variety of construction methods in seismic endangered areas

Extensive Landscaping
Provision of 7 m² quality green space per capita:
- Provides sufficient recreation area.

Green areas planted with adapted, low water consumption vegetation:
- Bind, and thereby decrease, atmospheric CO_2.

Small representative green areas with more water intensive plants and water saving irrigation systems:
- Reduced water demand results in reduction of need for pumping.

Eco-Mobility and Transportation
Soft Policy—mobility package with information and services:
- Informed inhabitants are more likely to change their habits and shift towards eco-mobility.

Hard Policies—public transport network including footpath, bicycle system, minibus-, citybus- and bus rapid transit-lines:
- Well developed public infrastructure reduces private motorized traffic and sealed areas for parking, remaining parking demand can be organized underground.

Urban Resources
Mixed Land-use Schemes
Mixed land use:
- Shorter travel distances reduce travel demand, which reduces fossil energy use.

Decentralized Mixed Use Schemes:
- Keeps motorized traffic out of the quarter; commercial uses around the plaza makes it a visible, lively center of the neighborhood.

Efficient Water and Wastewater Systems
Wastewater concept with decentralized constructed wetlands:
- Graywater used for irrigation of green areas; reduced energy use through reduced need for pumping; 70% of used water is kept in the water cycle.

Environmental Assessment
Environmental Impact Assessment:
- Reduces negative impacts such as soil sealing,
- Preserves existing valuable green structures,
- Creates supplementary green structures as compensation and recreational areas,
- Improves general environmental conditions, e.g. local climate issues, (as air quality, fresh/cool air supply, urban heat stress).

Urban Technologies
Energy Supply Systems
Improving existing systems and technologies:
- Low cost measurement (e.g. insulation of pipes) with improvements of up to 60%.

Use of New Technologies:
- Use of renewable energy sources, such as solar heat and ground temperature, as support for heating and cooling; using synergy effects of larger entities.

Regionally Adapted Architecture
Adaptation/Contemporary interpretation of regional traditional courtyard house:
- Local acceptance; offering privacy despite high density; maximizing energy impact through supplementary southern façades; using benefits of improved/controlled microclimate.

Urban Governance
Citizen Participation
Awareness Raising:
- Raising acceptance and attractiveness of project concept to habits towards climate friendly consumption patterns.

3 Steps and Measures for Energy-Efficient-Homes for the Shahre Javan Community

Annette Wolpert | Philipp Wehage

This chapter is based on the publication, “Energy-Efficient-Homes for the Shahre Javan Community” (Wehage, Wolpert and Pahl-Weber 2013), which addresses the need for “Energy-Efficient-Homes” against the background of fast growing societies. Here, the focus is on the different steps and measures of the housing development process, assigning them to four aspects, as outlined in Chapter III 2 and IV 2: Urban Form, Urban Resources, Urban Technologies, and Urban Governance.

3.1 Preconditions and Principles for the Design Process

In a fast growing society like Iran, efficient strategies for planning and construction processes are crucial to meeting the high demand for mass produced housing. In this regard, one of the best methods for the design of an energy-efficient home is a typological approach deriving directly from the planning process.

This “research by design” process is characterized by harmonizing general scientific principles (physical and technical) with local and regional conditions (climate and site). Energy-efficient housing in the New Town context in Iran calls for an analysis of the current urban design and architecture situation in Iran, and the potentials of vernacular architecture for future development in the semi-arid region. The energy efficiency value of the general architectural and urban findings are adjusted to each site’s specific climate, topography, and socio-cultural context. The result of this research is formulated in a catalogue of architectural criteria as approaches for design solutions.

The data collection and analysis of preconditions for creating energy-efficient housing is characterized by general dimensions (e.g. general aspects for energy efficiency and volumetry) and specific dimensions (e.g. site and socio-cultural context). The influence of general and specific aspects affords the transferability of the results in a general dimension (e.g. energy efficiency through spatial design) and a specific dimension (e.g. climate and social adaptation).

Figure 113 shows the research by design process with the design and examination steps in a linear scheme. The final step shows the Conceptual Design for one urban unit in the pilot area as a standard definition and design solution for realization in the “Shahre Javan Community” context.

3.2 Definition of Framework Requirement

The development of housing design solutions is effected by four parametric groups: spatial, social, economic, and technical. These aspects serve as tools for assessment during the housing design process. Several parameters are part of multiple groups and should never be seen as isolated factors. The principals and preconditions for Energy-Efficient-Homes, discussed above, define these groups and are elaborated in more detail below:

Urban Form—Urban Design

The first parametric group describes the influence of urban design: To ensure continuity of the urban design criteria of the project pre-phase, the typologies must follow the urban morphology. In this, there is a distinction between “hard facts,” such as the system of access as part of the mobility system, the technical infrastructure, the plot orientation, etc., and “soft facts,” such as identity, flexibility, or the implementation of mixed use schemes—this is the “sensual” dimension of architecture.

Urban Resources—Sense of Place and Vernacular Architecture

The second group is derived from research on the vernacular architecture and local urban design. It reveals and embodies the socio-cultural dimension of architecture.

Urban Technologies—Energy Efficiency

The third parametric group defines aspects relevant to energy efficiency and can be deduced from the urban design, like the orientation of building volumes, which delineate the strategy at the building scale. The technical standard for energy efficiency, “high tech standard” or “low cost standard,” for example, depends on local and regional circumstances.

Urban Governance—Users and Codes

The fourth group is characterized by the analysis of users and stakeholders. Requirements of this group, in both technical and spatial dimensions, include: building codes, technical principles, materials, the demand for energy efficiency, Iranian conditions, and urban design preconditions.

3.3 Analysis and Design Approach

Analyzing the preconditions and naming the requirements defines the framework of influence for architecture. Certain vagueness in the formulation (e.g. target group) can be replaced by assumptions or need to be integrated as they are to allow for flexibility in the final design. Thus a "research by design" strategy for developing housing typologies is site-specific and, in this case, is bound in application to the Shahre Javan Community site in Hashtgerd New Town. In the first step of this process, research on energy efficiency and the local urban design framework allowed for an analysis of the site's morphological and functional demands, which was then translated into a site-specific design strategy.

The goal of the strategy is to combine the advantages of two main aspects of energy efficiency in architecture and urban design: orientation and compactness. The second step was the development of site-specific strategies and measures for energy-efficient housing typologies by adjusting the morphological research with the parameter groups gathered in the analysis. The criteria identified in this step were then put into a catalogue to be made available as tool for evaluation, adaptation, and transferability for site-specific designs.

3.3.1 Energy-Efficient Housing for Compact Urban Form

The building volumes in the compact urban design scheme need to take advantage of their positioning. The plot design is based on a north-south orientation, determined in the urban design layout. This volumetric organization guaranteed a southerly orientation for every plot by keeping the compactness and reducing façade surfaces to west and east. Finally, the strategy of introducing "supplementary south-facing surfaces" via courtyards and niches harnessed two advantages: the energy savings by reducing the cooling and heating demand through the compact form and the energy gains through sunlight impact due to supplementary southerly façades (Hönger et al. 2009).

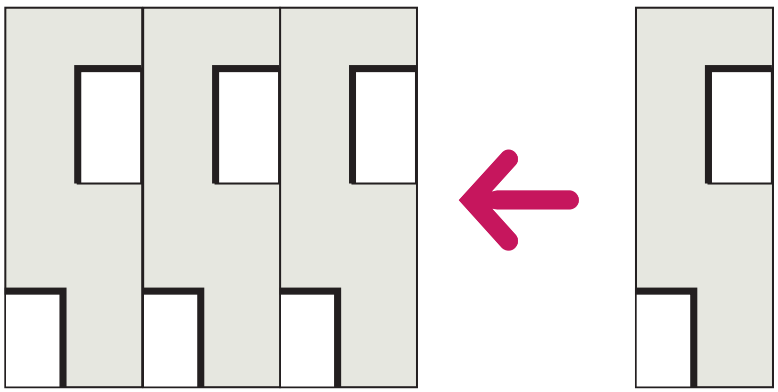


Fig. 112: Approach for energy-efficient housing in compact urban form (Wehage et al. 2013)

A criteria catalogue for energy-efficient housing typologies was gathered by examining the parameter groups of the initial analysis with regard to their morphological consequences (see IV 3). The criteria are as follows:

Urban Form

Definition of Access System and Urban Morphology

The typology must follow the urban design criteria, but needs to further develop the criteria on other scales in order to fully meet functionality and identity requirements.

Adaptation to Site and Topography

The typology is adaptable in regard to plot layouts and topographical specifics.

Potentials of Multi-Floor Courtyard-Houses

The typology includes introversion, as an expression of privacy for quality of life, and as a climate-friendly volume morphology in terms of light exposure.

Energy efficiency as Result of Architectural Design

Design as a strategy for energy efficiency: using an integrated design approach instead of isolated technological optimization.

Orientation of Volumes and Surfaces

Climate adaptation/optimization by adjusting building surfaces through architectural design (e.g. supplementary south orientated façades).

Urban Resources

Ground Floor as Potential Mixed Use Area

As a flexible-use provision, ground floors offer a potential space for a variety of commercial uses while maintaining residences on the upper levels.

Spatial Hierarchy, from Public to Private

Definition of spatial hierarchy with regard to the socio-cultural context. Achievement of design quality and its local acceptance by adapting to regional habits and traditions.

Urban Technologies

Application of Simple Constructions

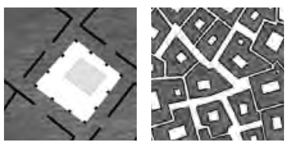
Economic and ecological building construction, which considers the regional technological conditions. Design as step towards efficiency.

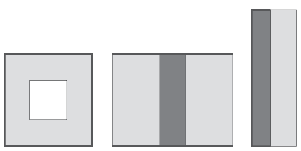
3.4 The Classification of Types

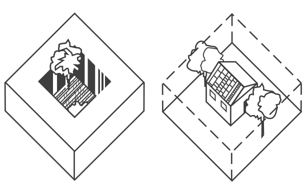
Considering the criteria for energy-efficient housing in the context of its application to the Shahre Javan Community led to design scenarios for a specific site in different steps and scales, and a modular spatial concept which influences the floor organization and construction principles.

The first result of this modular space concept is the formulation of three basic building types, which, due to their large variety in unit sizes

Input from analysis







Parameter

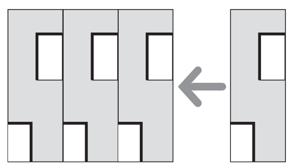
Urban design

Users and codes

Energy efficiency

Sense of place

Design approach



Criteria

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

Design concept

Design measures

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

Design study sub-neighborhood

Adaptive measures

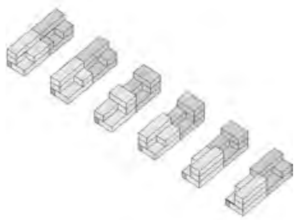
Site adaptation
- Choice of type
- Morphological variety through plot layout and dimension
- Morphological variety through sculptural modelling of building volume based on modular space structure

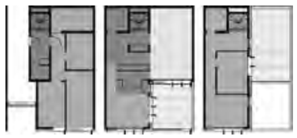
Functional adaptation
- Choice of type
- Access system
- Use (mixed use/housing)
- Vertical or horizontal floor organization
- Variety of floor plan layout

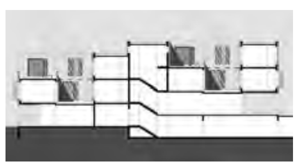
Standard adaptation
- Choice of type
- Construction and materials
- Façade structure and design
- Energy efficiency
- Supporting systems
- Interior arrangement and equipment

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

Typological catalogue and design scenarios







Innovations

Basic principle

Courtyard house
Resource protection through building configuration

Modular space
Cost and energy efficiency through planning process

Upgrades

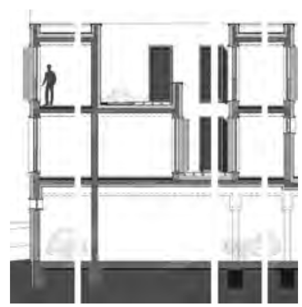
Sun shutters
Energy impact regulation through façade elements

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

Design for urban unit



Conceptual design

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

Fig. 113: Design process for Energy-Efficient-Homes (Wehage et al. 2013)

and housing styles, allow for adaptation to specific sites and regional conditions and therefore serve as the first adaptive measure.

The first step of the typological approach is carried out as a parallel process of analytic (top down) and synthetic (bottom up) classification. A modular space system, developed for introverted housing schemes in compact form, is an adaptive tool. Organizing and arranging spatial modules within the site volume while keeping standardized widths ("7.5-, 9-, 15 m types"), allows for a variety of floor organizations, sizes and designs. The various options, made possible by the typological catalogue, become a tool for creating identity at the building and urban scale and are an expression for the correlation between architecture and urban design. An evaluation of architectural qualities can be achieved by showing exemplarily variations of floor plan, sections, and views at the building. The main findings of the typological design process are:

Fig. 114: Private courtyard in an Energy-Efficient-Home (Pahl-Weber, Wehage and Wolpert 2011, p.111)

Urban Form

Orientation and Dimension

The urban form consists of long plots with north-south orientation. Volumetric shaping increases the number and size of southerly façades, creates private areas and improves microclimate conditions.

Organization and Structure

A structural system underlays the shaping strategy. A modular spatial system, with vertical continuity and low-rise (with a maximum of three stories) results in a simple, economic structural system and facilitates a high variety of floor organizations.

Access and vertical connection

House is accessible from the street and underground parking garages. Depending on housing type, the upper and lower levels are connected with a private or semi-private flight of stairs. Semi-private stairs can also work as a vertical air chimney.

Urban Resources

Public to Private

The ground floor's mixed use potential. The ground floor is the first step from public to semi-private through commercial unit or entrance hall, with the commercial unit and the entrance hallway as semi private areas. The stairwell marks the change from semi-privacy to the privacy of the apartment. The vertical organization of the area around the central courtyard also creates different degrees of privacy.

Urban Technologies

Variety and Flexibility

The structural system and the morphological concept both provide various layouts. The morphological adaptation allows for different unit sizes. The vertical continuity of structural and technical elements offers vertical combinations of space (e.g. duplex units). A sloped location can offer even more housing area/variety.

3.5 The Adaptive Typology

The scenario work for the "Shahre Javan" site reviews and evaluates the project aims and design results. The conceptual design, as the basis for execution planning, defines the final design solution for each 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. Moreover, a morphological study of all basic types shows how the many variations function as an adaptive tool providing flexibility in planning and execution, especially regarding functional and technical adaptation, as well as the integration of identity-forming aspects.

3.5.1 Fixed and Flexible Elements

Elements, components, and standards, with technical, construction-based, and sensual characteristics, guarantee functionality and are the basis of this typology. While modifications and adjustments to specific sites and functions are adaptations to "fixed" characteristics, flexibility in the typology is required by the planning process. The modular space system serves as framework for construction and organization of the housing 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 constructive and technical functionality (fixed). The arrangement of the space modules in building morphologies on different plot layouts aims for functionality, privacy, and energy efficiency in a specific urban context (flexible).

Identifying fixed and flexible elements enables the formulation of adaptive strategies, which allow for transfer of research and planning results, as well as specification of elements for creating architectural and urban identity and variety. The strategies for adaptation are classified in different layers of architectural design:

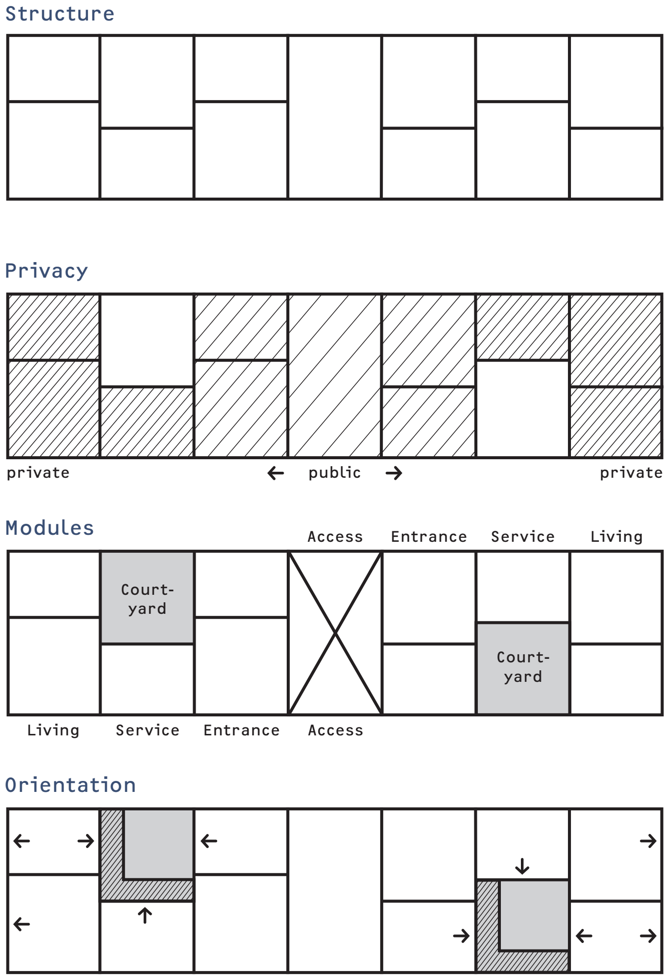


Fig. 115: The structure of Energy-Efficient-Homes (Wehage et al. 2013)

Urban Form
- Morphology—as a volumetric adaptation in the urban context

Urban Resource
- Floor organization—as a functional and spatial adaptation for the single building

Urban Technologies
- Passive and Active Energy Measures—as spatial and technical design measures for energy adaptations
- Appearance and Construction—as design and structural measures for adapting to social and economic standards

3.5.2 Strategy for Site Adaptation

The design approach of the housing typology respects the urban design concept as a spatial determination within which buildings must fit. Thus, every building is a specific unit of a bigger spatial arrangement.

Due to this situation, the design concept of the building must offer suitable adaptive tools. The developed modular space scheme allows for morphological adaptations to the specific site.
- *Length*—the length of the house depends on the plot size;
- Courtyard Layout—depending on plot size, the courtyard is enclosed on two or three sides;
- *Number of Courtyards*—depending on plot size, a second courtyard can be introduced;
- *Orientation*—influences solar incidence, privacy, and identity (see Fig. 115).

3.5.3 Strategy for Functional Adaptation

For functional reasons, the typology must offer flexibility in use. The focus on flexibility is determined by the following measures:
- *Type of staircase*—a staircase for two units or a staircase inside private units;
- *Mixed use*—commercial unit on ground floor, making the building mixed use. The commercial unit can be part of the upper apartment or independent;
- *Horizontal/vertical layout*—units can be organized horizontally or vertically;
- *Unit size and number of units*—number of units per plot can vary, depending on plot size and unit sizes;
- Apartment layout—the possibility of open and closed apartment layouts (including kitchens).

To summarize: the floor organization is flexible to individual needs at the unit scale, and the flexibility of unit size and layout is a suitable tool for housing market requirements.

3.5.3 Strategy for Energy-Based Adaptation

Beyond achieving energy efficiency through building configuration, optimization can be achieved through additional measures. Renewable resources, such as sunlight and ground temperature, can be used by applying simple constructions.

- Configuration/compactness reduces heat loss in winter and helps to avoid overheating in summer. Furthermore, the north-south orientation captures intense solar radiation from the south and avoids the east and west sun in summer, which is more complicated to control;
- Light-shelves in the courtyards (see Fig. 118) shade the courtyards in summer and in winter they help to lighten the front and back of the yard equally;
- Photovoltaic fabric can cover yard in summer to provide shading, simultaneously producing energy that can be used in the evening. In winter it can be pushed out of the way;

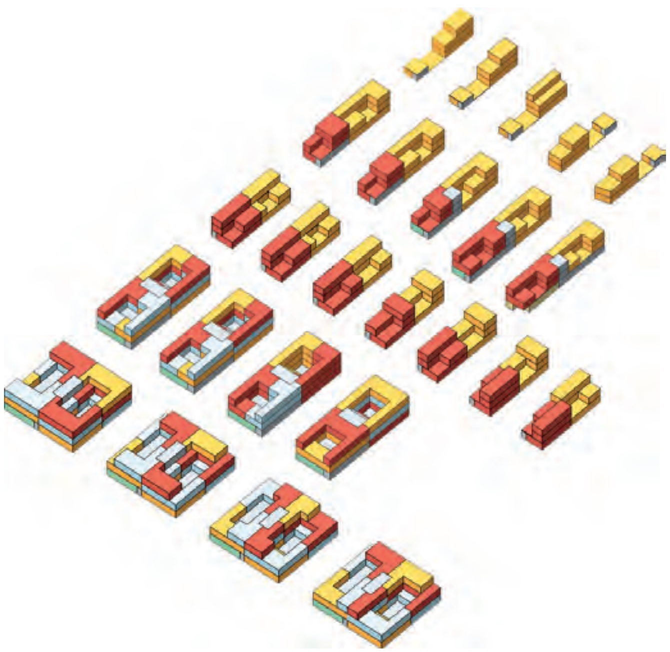
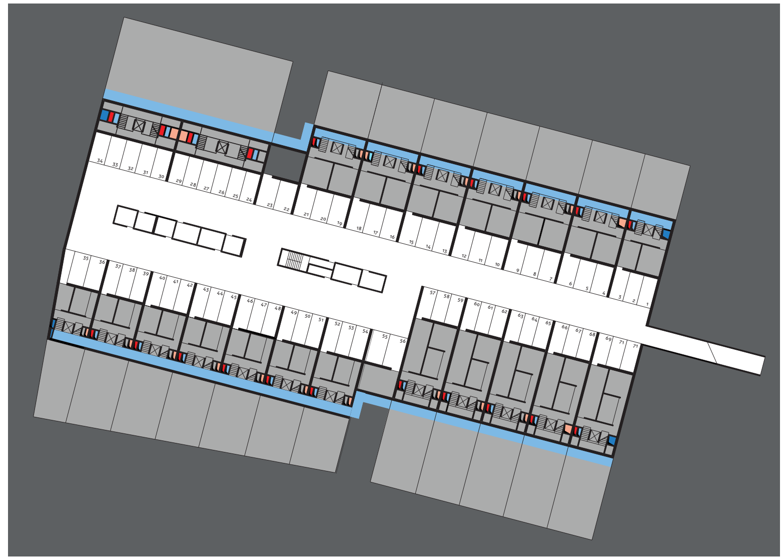


Fig. 116: Typology catalogue (Wehage et al. 2013)

- A heat exchanger, installed at the building level, recovers the otherwise “lost” energy of exhaust air;
- A heat exchanger, installed at the sub-neighborhood-level (see Fig. 117), uses constant soil-temperature from 1.5–4 m depth to precondition the supply/outside air.

3.5.4 Strategy for Identity

Other than the morphological arrangement, as a strategy for energy-efficient identity on urban scale (see Fig. 119), the design of the façades determines the appearance of the buildings. The structural method, floor-organization, floor-formation, and architectural design of the apertures characterize the buildings’ façade. The aperture typology is influenced



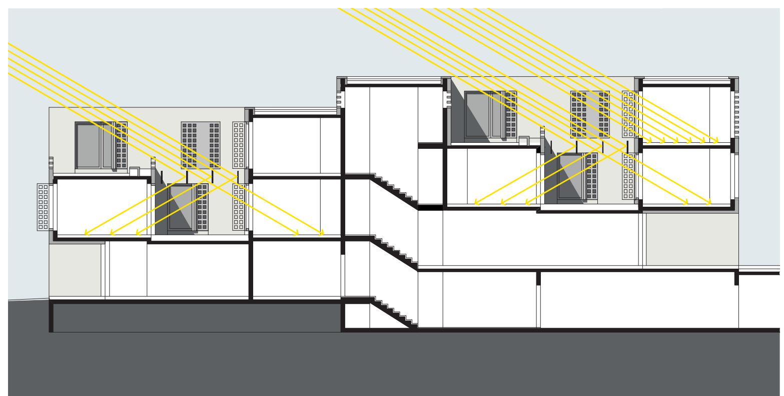


Fig. 117: Earth tube system in urban unit (Wehage et al. 2013)
Fig. 118: Lights-shelves (louvres) in winter position (Wehage et al. 2013)

by the importance of the façade’s role in energy impact, or solar incidence. Indeed, south-orientated façades are highly relevant for passive energy impact and the design of the façades’ apertures is a very important tool for energy efficiency. The closed coverage and compact morphological arrangement initially reduces the surface area of the façades to a minimum. The southerly façades of the single units, orientated towards the street, courtyards, and open spaces, are responsible for much of the sunlight, which reaches the living rooms. Therefore, the southerly façades should have a high share of apertures (see Fig. 119).

The positioning and dimensioning of openings will need to balance energy efficiency with privacy, within the confines of the "Shahre Javan Community" urban concept.

As a measure for privacy:

- *Layout of aperture (fixed measure)*—high and narrow aperture (room-high);
- *Position of aperture (fixed measure)*—shifting the arrangement in opposite façades;
- *Sun-shutter (flexible measure)*—can shield the rooms from outside eyes.

As a measure for energy efficiency:

- Façade as non-bearing wall (fixed measure)– flexible arrangement of façade elements e.g. windows are pushed in, self-shading through "overhang" due to wall-thickness;
- Sun-shutters (flexible measure)—can be open in winter to maximize solar incidence and closed in summer to prevent overheating.

The modular spatial system of the building typology allows for a variety of construction methods. A simple structural system consists of:

- Plot types are 6 to 15 m in 1.5 m steps, maximum structural span is 7.5 m;
- The depth of the building structure is adaptable to the plot layout by adding spatial modules in the north and south. Buildings are always ending at the building line designated in the detailed plan;
- Vertical continuity;
- Low-rise with a maximum of three stories.

Systems depend on: site conditions, traditional building methods and the education of workers, availability of materials, and the budget. The same applies for the spectrum of possible construction material. A frame mode construction of concrete can be combined with light wall materials or bricks. The choice of the remaining façade materials (e.g. bricks) can follow environmental as well as economic aspects. For the Energy-Efficient-Homes in the Hashtgerd New Town pilot project area, a concrete framework with concrete bracing walls inside the unit was chosen as the structural system, with ETICS as the thermal envelope of the building.

3.6 Basic Principle and Upgrading

The result of the design process for adaptive measures of the Energy-Efficient-Home housing typology combined with the identification of the urban, architectural, and technical elements led to the definition of a basic principle and possible upgrades. The Basic Principle is the design strategy for energy-efficient architecture and urban design derived from a spatial approach without any additional technical demand. It contains all planning and design measures to advance energy efficiency with only spatial configuration, such as building orientation and compactness, adapted to site and cultural context. The Upgrading contains all measures for raising the standard of the Basic Principle. Supplementary technologies can be integrated into the spatial approach. The choice of upgrading measures is dependent on the economic and technological context.

3.7 The Conceptual Design

The findings of the design and research process for Energy-Efficient-Homes are transferred to a final design proposal for an urban unit in the Shahre Javan Community pilot project. Via a specific design scenario of

Fig. 119: Study for different south façades of 7.5 m building type (Wehage et al. 2013)

Simple structures allow for different structural systems:

- Pre-fabrication;
- In-situ-construction methods;
- Combined solution with semi-precast-elements;
- Low-rise with a maximum of three stories.

the architectural and urban design concept and its adaptive measures, developed from the typological approach, the challenges of application can be weighed and evaluated. Furthermore, the realistic scenario serves as a basis for cost estimates, energy simulations, and the detailing of construction. A spatial organization in 1:100 scale together with sample detailing of the architecture in the Shahre Javan Community in 1:20 scale can help define the standard for materials and energy goals.

Fig. 120: Areal of urban unit from the southeast (Wehage et al. 2013)

A sample sub-neighborhood in the center of the pilot area is located on a ridge, with access from the collecting road coming from the eastern valley and edged by the central public green on the western valley. Following the determinations of the "Tarh-e-Tafsili" (detailed plan), developed at TU Berlin in the Urban Planning and Design Dimension, the urban outline and the inner access structure were both fixed in the placement of building lines. Parking is provided below the building development, with access from the collection road. The inner access paths are mostly for pedestrians, the only motorized traffic allowed is for supply and emergency situations. The paths structure the unit into four building plots. A small urban square, positioned at the crossing of the access paths, is the social and spatial center of the urban unit.

The density of building plots is estimated with a floor area ratio of 1.7–2.0. The range in apartment sizes was estimated to be 75–200 m² for at least 75% of the housing units. A possible replacement of different housing types enables flexibility. For example, to gain more variety, the seven 7.5 m unit types on building plot C can be replaced by six 9 m types, fitting within the same building outline.

With the help of the typological approach, the Conceptual Design for Energy-Efficient-Homes illustrates the strategies for adaption at different levels and scales. Within the determinations of the detailed plan (Tarh-e-Tafsili), adaption is achieved by:

At the urban scale:
- Choice of typology and its position as a functional adaptation;
- Shaping and organizing the building volume, such as the planning of forecourts for the entrances and the tiering of floor volumes, act as morphological adaptations.

At the building scale:
- Floor organization, such as the arrangement of private and guest zones and the tiering of upper levels for better light incidence in the courtyards, act as morphological and functional adaptations.

At a detailed level:
- Adapting façade design to site context, for example, through integrating sun-shutters;
- Provision of system-relevant elements, such as a necessary common utilities underneath the central square and earth tubes at the parking level;
- Choice of materials with respect to site conditions, availability, required standards, energy goals, and economic factors, e.g. in choosing the thermal envelope and construction method.

3.8 Perspectives

A spatial strategy, which considers energy relevant aspects of urban and architectural morphology within a specific social context, results in a practicable basic energy standard concept, which is adapted to the region. The courtyard housing scheme of the Energy-Efficient-Homes, described here, represents a new development borne of the background of vernacular architecture.

Because of its high degree of variability in unit number and size as well as morphological adaptation, the typology can be easily transferred to other sites in the region. The developed housing scheme, based on Islamic tradition, offers culturally adapted energy-efficient housing for the Middle East. The energy relevant advantages of the compact urban form and its building configurations could create higher spatial quality for New Towns as the concentrated building volumes create clearly defined open spaces with public relevance. Moreover, the simple, basic layout and structure of the introverted, individually regulated housing units responds to the specific technical and economic conditions of the region.