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Developing Urban Energy Efficiency

Tehrān-Karaj

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Accomplishments and Objectives

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Project Dimensions

In the following, all of the fourteen Project Dimensions are introduced with regard to their respective objectives and accomplishments to date, in order to show the broad range of research issues encompassed by the overall project. The interdisciplinary aspects within the overall research project are mainly covered by the pilot project articles above.

Project Dimension Urban Planning and Urban Design

Energy-Efficient Urban Form for Low Carbon Cities

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Fig. 1: Mixed use units in the courtyards

Urban Planning and Design can have remarkable influence on climate change mitigation and adaption since both disciplines determine spatial structures, directly or indirectly influencing energy consumption (OECD 2010): Firstly, urban planning and design defines urban form, which directly influences energy-consumption through heating and cooling demands (*Physical Dimension*) (Santamouris 2009: 6). Secondly, urban planning and design take structural decisions on densities, land use patterns and transport systems—thus influencing the distribution of goods and users. This indirectly affects the energy consumption required for transportation (*Structural Dimension*) (Jenks and Jones 2010: 7). Thirdly, urban planning and design manages the procedure of plan-preparation and implementation. This is particularly important since both get increasingly complex, consequently effecting interactions between 1. climate change, 2. mitigation and 3. adaptation measures in urban agglomerations (*Procedural Dimension*) (Tyndall Centre 2009: 5). These three basic assumptions form the focus of the Dimension, aiming at developing, implementing and evaluating approaches for energy-efficiency on the scale of neighborhoods. According to the three dimensions, the Team researches structural aspects (land use), physical aspects (density, compactness) and procedural aspects (procedural management) and its impacts on mitigation and adaptation.

The work on the structural aspects started with a review on the interrelations of land use and energy consumption with a special focus on mixed land use strategies. The strategies theoretically proofed the energetic capacities of the mixed-use approach on the quarter level, shorter travel distances and increased use of public transport, whereas on the building level it was

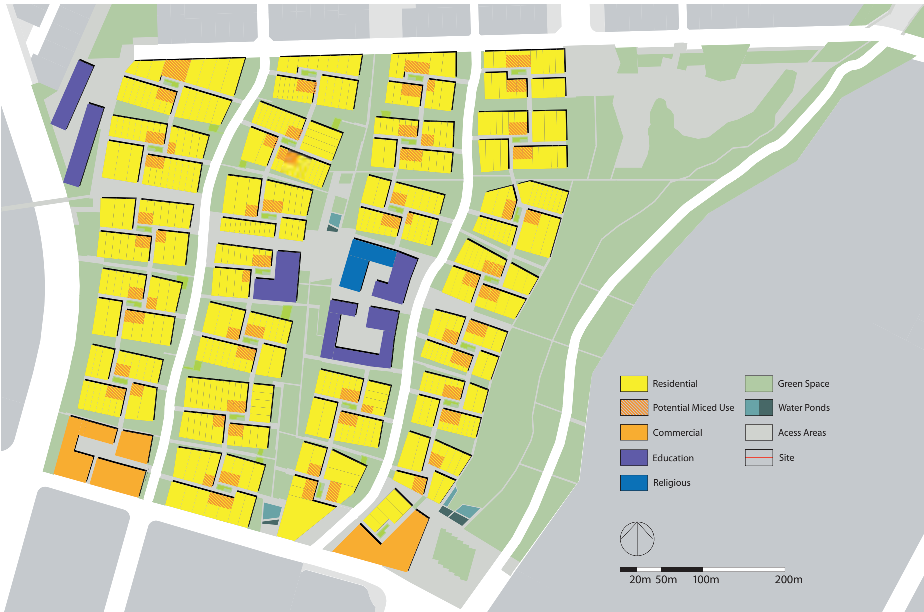

Fig. 2: 35 ha Mixed Use District with Mixed Use Areas (in orange)

through waste-heat utilization (e.g. Cervero 1996, Bretschneider 2007). The results were followed by an analysis of land use approaches in both the traditional and contemporary Iranian city (Hashtgerd New Town), which led to initial considerations for a mixed-use quarter, aiming at a vital, yet energy-efficient neighborhood with a strong economic impetus. These goals translate into a land use concept that proposes a strong district center with larger social and commercial functions and a fine mix of smaller commercial and residential uses on the sub-neighborhood scale in "Vertical Mixed Units". They provide space for smaller non-residential uses on the ground floors of houses around the courtyards (see fig. 1). Distances between housing, work, supply infrastructure and social infrastructure are kept short; the integration of larger social functions within walking distance and the connection to the city-wide public transportation system, as well as to walking and cycling routes supports this approach. All elements of this proposal are part of the "Mixed Use District" (MUD) as defined in the "Tarh-e Tafsili" (see fig. 2).

Starting the work on the physical topics, in the first step a literature analysis proofed the influence of compact urban form on energy efficiency (e.g. Burton 2002). This was deepened by an analysis of the energetic potentials of traditional Iranian urban form, which proofed the huge local benefits in this field, especially regarding passive design strategies. These analyses led to a further elaboration of the already developed "low rise—high density" approach on the urban design level. The design studies were accompanied by simulations in ENVI-met (microclimate), VISEVA+ (transport) and ECOTECT (energy) and proofed remarkable energy reductions in

Fig. 3: 35 ha Area Urban Concept

comparison to common Iranian housing design only through spatial measures such as compactness. It can minimize exposed building surfaces und thus reduces thermal loss. Another major factor is the orientation of each building—the north-south orientation of the buildings reduces the cooling demand by up to 23 % and heating demand by up to 16 % compared to unfavorable building orientations on the 35 ha site. Moreover buildings and open spaces were designed according to sun, wind and vegetation. This reduces energy consumption but also creates outdoor thermal comfort. One example is the arrangement of buildings, which block the prevailing western and northwestern winds as well as the hot and dusty winds from the southeast in summer. At the same time it allows the cool north-south winds from Alborz Mountains to channel through the site. The simulation results showing calm wind in inner courtyards in 2 m height support this hypothesis. Another important factor is the vegetation with its potentially positive effects on the microclimate in summer months. The increase of open and green spaces on 35 ha compared to the original land use program of the site fosters cooling by vegetation: e.g. simulations have shown that planted tree can decrease the surface temperature by 9°K compared to scenarios with no trees.

The third dimension covers the question of adequate plan making and plan implementation for energy efficient quarters focusing on formal planning instruments (legally binding detailed plans, Iranian "Tarh-e Tafsili"). Result of an analysis of the Iranian regulations and procedures additionally with the comparison to best-practice in Germany was the need to further develop the Tarh-e Tafsili as it currently mainly concentrates on physical and technical elements (such as plot ratio or parking facilities). Aspects of sustainability, e.g. energy efficiency or environmental protection, are not sufficiently covered; moreover the depth of regulation is not effectual for these issues. This resulted in an approach to complement contents with additional innovative elements and methods from the German planning system. The plan now introduces a range of innovative regulations, mainly on energy-efficiency and environmental protection. Examples of these are the

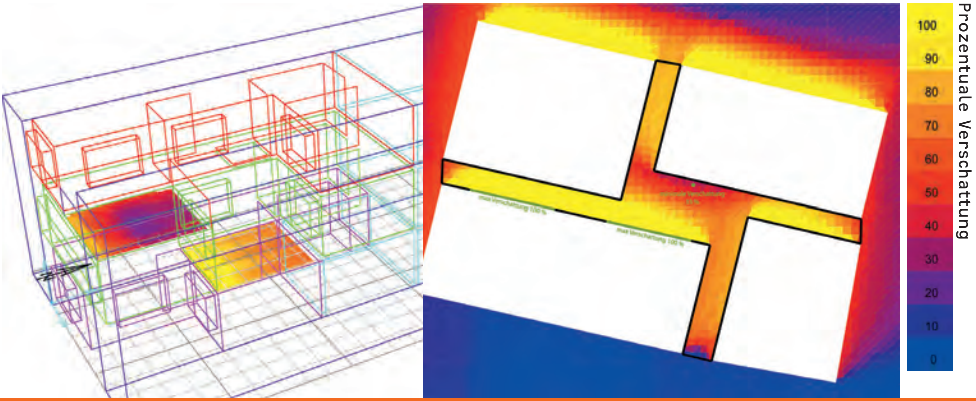

Fig. 4: Shading simulations on compact urban form

introduction of mixed-use zones, the designation of building lines, the integration of public transport and the integration of an environmental assessment (see Project Dimension Environmental Assessment). All mentioned elements were adapted and applied during the elaboration of the Tarh-e Tafsili for the 35 ha area and documented in an explanatory report.

References

Bretschneider, B.:
Remix City. Nutzungsmischung: ein Diskurs zu neuer Urbanität.
Frankfurt a. M., 2007.

Burton, E.:
Measuring Urban Compactness in UK Towns and Cities.
In: Environment and Planning B: Planning & Design,
Vol. 29, 2002. pp. 219–250.

Cervero, R.:
Mixed Land-uses and commuting:
Evidence from the American housing survey.
In: Transport Research, Vol. 30, Nr. 5, 1996. pp. 361–377.

Jenks, M.; Jones, C. (ed.):
Dimensions of the Sustainable City. Series Future City, Vol. 2.
Heidelberg, London, New York, 2010.

Organisation for Economic Co-operation and Development (OECD):
Cities and Climate Change.
Paris, 2010.

Santamouris, M. (ed.):
Environmental Design of Urban Buildings. An Integrated Approach.
London, 2006.

Tyndall Centre for Climate Change Research:
Engineering Cities:
How can cities grow whilst reducing emissions and vulnerability?
London, 2009.

Project Dimension Urban Design and Architecture

Architecture and Urban Design for Energy-Efficiency in Social and Climate Context

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Architecture and Urban Design articulate the spatial expression of functional need. As the physical application of creating space, architecture and urban design have to integrate the aims of energy-efficiency in the socio-cultural, climate and topographical context of the specific site of Hashtgerd New Town.

Besides the approach of optimizing through technological efforts (e.g. materials and construction), a starting point for energy-conscious research is the spatial organization of the different scales in the urban form. The continuum of scales from the city to the quarter to the single building, reveals the interfaces and references of all planning dimensions concerning urbanity, landscape, energy and mobility.

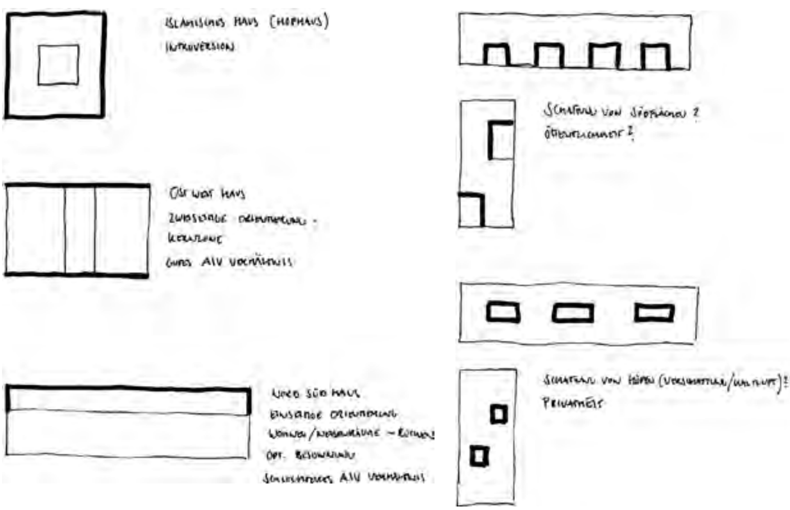


Fig. 1: Orientation of buildings

The research on architecture and urban design for mass housing in compact urban form analyzes the spatial consequences of energy-efficiency, under consideration of the research results of the dimension urban planning and urban design, with focus on the physical application in the 35 ha pilot project. The references to socio-cultural and climate aspects are investigated in research on vernacular architecture and urban design (cp. Bianca, Wirth).

A central task of the research by design process—the development of housing typologies for the 35 ha Area pilot project—is a design study for the application of scientific results concerning energy-efficiency in the compact urban form of the pilot project. With the goals of the urban design mas-

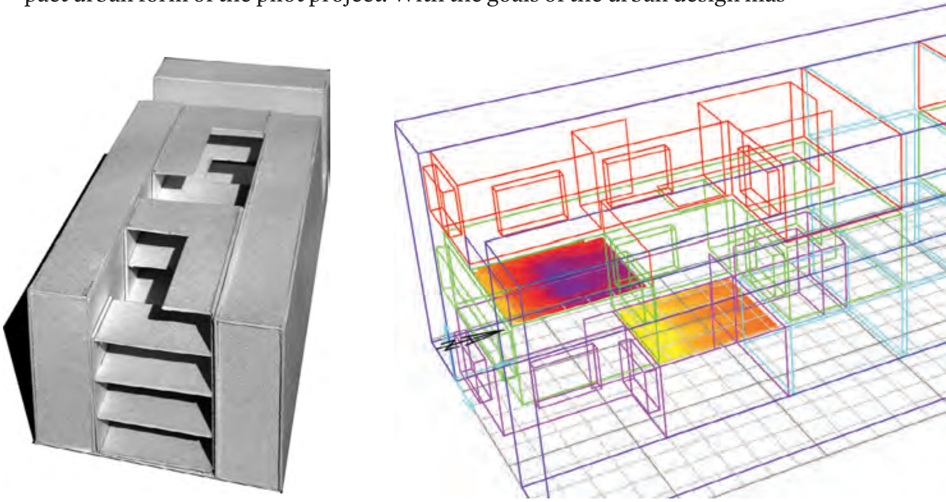


Fig. 2: Design study and shading simulation of housing unit
Fig. 3: Housing typology in urban context, urban clusters of sub-neighborhood in the 35 ha Area

ter plan as a starting point, the project focus was drawn to the energy gain that could be realized through compactness and the opportunities of traditional housing in the socio-cultural context of Iran (cp. even Hönger et al.).

Therefore the research started with the analysis of vernacular housing forms in Iran and their relevance for the urban arrangement and the climate context as well as the existing building typologies in Hashtgerd New Town. The first result of this analysis was the finding of a spatial hierarchy from public to private in the traditional city, regarding the socio-cultural and climate situation and its comparison to the modern international style (cp. Wirth).

The identified urban space system offered an approach for a contemporary application in the 35 ha pilot project with continual guidance from urban to building scale.

This approach is characterized on one side by the importance of privacy in a compact urban form, formulated by the introversion of the courtyard house typology (cp. Bianca, Wirth). On the other side, introversion serves as a climate-regulating element, regarding the influence of sunlight and wind on buildings and their relevance for energy consumption (fig. 1) (cp. even Hönger et al., Edwards et al., Hegger et al.).

Fig. 4: Housing typology for compact urban form in 35 ha

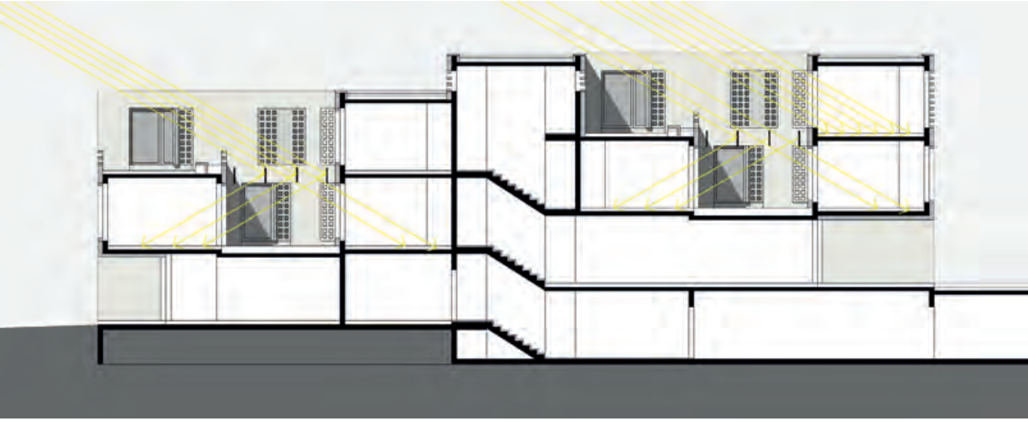
Out of this approach the design studies for housing typologies seek to combine traditional aspects with the needs of the contemporary energy-efficient New Town.

By sculpting the building volumes through implementation of courts and niches, the south orientation of the housing units for sun impact as passive energy gain can be reached in narrowness of compact urban form. With the vertical organization of apartments, a good exposure to daylight for every unit is possible in the compact urban form of 35 ha pilot project (fig. 2, fig. 5).

The layout of plots and buildings are also determined by the urban concept (fig. 3). For flexibility an axial system in the plot dimensions allows variations in the typological architecture on the different sites by keeping vertical constructive continuity. This system allows for simple constructions concerning the height of max. three storeys above-ground and the conventional measuring of room dimensions (fig. 4). Basement parking can be provided. The ground floor zone offers space for services and the proposed "mixed use" zones, as worked out in the urban approach.

Beside the reduction of energy demand out of the described geometric basic principle, upgrading through supplementary technical measures enable an additional increase of efficiency. The use of sub-soil-energy reduces the heating and cooling demand while light shelves or photovoltaic fabrics regulate the sun-incidence (fig. 6).

Fig. 5: Private Courtyard in Housing Unit



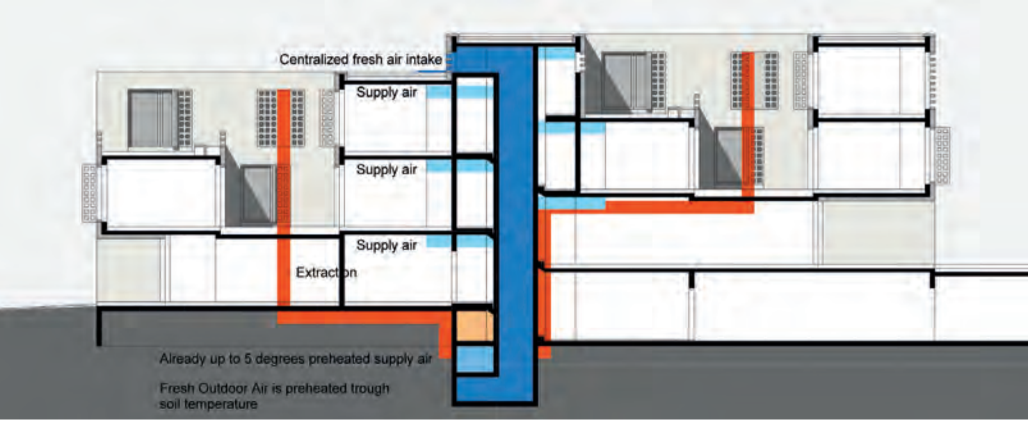


Fig. 6: Sub-Soil Energy and Light Shelves

References

Bianca, S.:
Paradies und Hofgarten
Der Lebenskreis der Familie: Wohnhaus und Innenhof.
München: Beck, 1991, pp. 196–252.

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

Hegger, M.; Fuchs, M.; Stark, T.; Zeumer, M.:
Energie Atlas: Nachhaltige Architektur.
München: Birkhäuser/Edition Detail, 2008.

Hönger, C.; Brunner, R.; Menti, U.-P.; Wieser, C.:
Das Klima als Entwurfsfaktor/Climate as a Design Factor.
Luzern: Quardt, 2009.

Wirth, E.:
Die Orientalische Stadt: Privatheit als prägende Dominante städtischen Lebens im Orient.
Mainz: von Zabern, 2000, pp. 325–336.

Wirth, E.:
Die Orientalische Stadt: Die Städtischen Wohnviertel.
Mainz: von Zabern, 2000, p. 337–402.