Sufficient Reconstruction of the Post-War Modernist Residential Neighborhoods in Vienna

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Abstract

This paper introduces **Sufficiency** as a strategy; employed in order to outline the potentials and evolve the sustainable use of both buildings and devices. The main focus of research lies upon analysis of sufficient use of space and electrical devices in the social housing stock of the Austrian post-war Modernism. Further focus is the research of potentials for application of renewable energy technologies in this kind of building typologies and urban settlements. Through interdisciplinary analysis of the building typologies of residential apartment blocks of the post-war era, involving four disciplines (housing research, life cycle analysis, energy efficiency and energy systems) the potentials for sufficient use of space and floor areas, energy efficiency, and energy production will be identified and systemized.

Three basic innovative reconstruction MODELS will be proposed and evaluated:
1. **„Low impact**"= Sufficient remodeling*,* none to moderate measures of energy efficiency of the building skin),
2. **"Pasive House Standard"**= Sufficient remodeling + „Passive house"-Standard performance (Heating energy consumption less than 15kWh/m² year)
3. **„Active House "**for "0-energy" to "Plus-energy" performance (Sufficient remodeling, measures to increase energy efficiency and achieve energy production of the building skin, application of renewable energy resources e.g. Photovoltaic und Solar Panels)

Final goal is the development of an evaluation tool for measuring of sufficiency in planning: **"Sufficiency Factor".** Further expected results are generation of comprehensive database of sustainable use, such as Life Cycle Cost (construction cost, yield, operation, maintenance), and energy consumption (kwh/m² GFA) for the social housing building typology in Austria from 1945 till 1970.

Keywords: sufficiency, energy efficiency, sustainability, building stock, Passive House Standard, 0-Energy Standard, Plus-energy Standard

Introduction

Heating energy consumption per square meter of apartment-unit has decreased since 1970s, yet the floor area occupied by a single person has since risen significantly. The number of households is also increasing; the household-size however is at the same time decreasing. Sustainable housing policy should therefore aim for development of strategies that are decelerating the increase of floor area per person and encourage and promote a sustainable life-style in dense urban areas. Economic factors imply that principle of sufficient and not only efficient use of natural and manmade resources is fundamental for truly sustainable long term development. Long term goals and strategies for further reduction of CO_2 emissions and resources consumption in general must be based both upon energy efficient building technologies, as well as on sustainable use of urban spaces and existing stocks.
The supporting and promotion of sufficiency must belong to the primary aims of the sustainable housing policy. Building technologies for optimization and achievement of energy efficiency of the building envelope were strongly improved throughout the last few years, the state of the art in residential sector being the low-energy standard currently in Austria, with strong tendency towards the passive house standard. However on the contrary to the new construction there is a large existing building stock which calls for immediate and urgent thermal refurbishment. However, energy efficiency is only one of the aspects of the sustainable development.
The housing unit maximal sufficiency calls for the optimization in planning of the functional organization, size (areas) and volume of individual apartments depending on household size, lifestyle and special needs of inhabitants. Further crucial aspect is the flexibility throughout the life cycle, which can be implemented as strategy within the planning process; as well as the consideration of the housing-unit within its closer and wider neighborhood-context.
The main idea of the project is the reduction of the living area on the sufficient maximum. Additionally, following topics will be researched: outsourcing of the housing functions, new communal uses, especially co-housing (participatory developed communal facilities in residencies) , the collective use of the household appliances outside the housing unit, outlining of potentials for implementation of regenerative energy systems, empowerment of neighborhood and city quarter through modernization.

Project Scope

The project will be carried out through the integrated planning approach, based on interdisciplinary research - the project team consists of several disciplines working together on the common research topic – sufficiency.
Following partners, covering four research areas are involved into this project:

- Department for Housing and Design, Faculty of Architecture and Regional Planning, covering Housing Research Area
- Department for Industrial Building and interdisciplinary Planning, Faculty of Civil Engineering, covering Life cycle analysis and life cycle oriented planning Research Area
- Department for building physics and Acoustics, Faculty of Civil Engineering, covering Energy Efficiency Research Area
- Department of Electrical Power Systems, Faculty of electrical engineering and IT, covering Electrical Power Systems Research Area

The **aim** of the research is interdisciplinary development of planning principles for the modernization of existing housing building stocks based on the principle of sufficiency.
The **main hypothesis** is that total energy-consumption reduction and saving in the building stocks is based on refurbishment concepts for multi-storey buildings, which offer optimized and more efficient occupancy per person of m² existing area, and additionally through the energy efficiency of the building envelope.
Hereby, the existing spatial resources and hidden spatial potentials in different apartment and housing typologies should be identified, which should consequently lead to optimized and reduced planning effort for modernization of individual apartments or buildings.
In the course of study, the sufficiency–reserves of household appliances and heating systems will be gathered and the potentials of implementation of renewable energy systems in context of specific settlement and building typologies will be outlined.
The basic research is based on three basic temporal periods for existing building stocks:

- Period I: early post-war modernism (1945 bis 1960)
- Period II: late post-war modernism (1960 bis 1970)
- Period III: 70ies (from 1970)

The existing residential building stock typologies will be systematically recorded and analyzed, in order to record the existing sub-optimal occupancy of the living areas but also to prove the potential for outsourcing of functions and joint use for future additional requirements.
In the next step different models will be defined and evaluated in detail. The evaluation will be carried out upon all three building periods.

Proposed models

The three proposed models are:
1. **„Low impact**"= Sufficient remodeling, none to moderate measures of energy efficiency of the building envelope,
2. **"Passive House Standard"**= Sufficient remodeling + „Passive house"-Standard performance (Heating energy consumption less than 15kWh/m² year)
3 **„Active House "**for "0-energy" to "Plus-energy" performance (Sufficient remodeling, measures to increase energy efficiency and achieve energy production of the building envelope, application of renewable energy resources e.g. Photovoltaic und Solar Panels)
Through the model "Active House" ecologic, as well as economic and socio-cultural potentials together with possible obstacles for the implementation of the plus-energy-houses within the existing building stocks will be researched.

Final goal is the development of an evaluation tool for measuring of sufficiency in planning: **"Sufficiency Factor".** The factor is based upon the optimal balance of energy efficiency and energy saving potentials versus cost efficiency and life-cycle cost analysis. It should reflect sufficient sizes and functional organization of the housing units, multi-storey buildings and settlements; as well as demonstrate the potential for implementation of renewable energies.

Table 1: Combination Matrix for three models

	COMBINATIONS (for Building periods I., II., und III.)		
Models	**Standards of energy-efficient refurbishment**	**Sufficiency and Renewable energy systems Measurements**	**Evaluation**
Three Models: Low impact Sufficient refurbishment Active house	**Standards to be researched:** Present state (no improvement) Low-Energy Standard Passive House Standard	Sufficient reorganization Outsourcing of functions Barrier Free Refurbishment Communal use of household appliances Improvement of building envelope Renewable Energies (PV+ ST) Warm water through Solar gains Change to local energy supply	Energy consumption survey Sufficiency Factor survey LCC LCA – social sustainability
LOW IMPACT	No thermal refurbishment	Sufficient reorganization Outsourcing of functions Communal use of household appliances Barrier Free Refurbishment Warm water through Solar gains Change to local energy supply	Energy consumption survey Sufficiency Factor survey LCC LCA – social sustainability
LOW IMPACT	Low-Energy Standard	Sufficient reorganization Communal use of household appliances Good improvement of building envelope (Low-Energy Standard) Warm water through Solar gains Change to local energy supply	Energy consumption survey Sufficiency Factor survey LCC LCA – social sustainability
Sufficient refurbishment + **PASSIVE HOUSE STANDARD**	Passive House Standard	Sufficient reorganization Communal use of household appliances Passive house standard improvement of building envelope Warm water through Solar gains Change to local energy supply	Energy consumption survey Sufficiency factor survey LCC LCA – social sustainability
ACTIVE HOUSE (existing stock)	Plus Energy Standard Scenario Existing Stock	Sufficient reorganization Outsourcing of functions Barrier Free Refurbishment Communal use of household appliances Passive house standard improvement of building envelope Renewable Energies (PV+ ST) Warm water through Solar gains Change to local energy supply	Energy consumption survey Sufficiency Factor survey LCC LCA – social sustainability
ACTIVE HOUSE (demolition and new construction)	Plus Energy Standard Scenario demolition and new construction	Sufficient reorganization Outsourcing of functions Barrier Free Refurbishment Communal use of household appliances Improvement of building envelope Renewable Energies (PV+ ST) Warm water through Solar gains Change to local energy supply	Energy consumption survey Sufficiency Factor survey LCC LCA – social sustainability

Research Areas

Research Area Housing

Collection of data:

Data on existing building stocks for different housing typologies, typical for Vienna during the period 1945 until 1970 will be gathered. The emphasis is on housing estates with detaches multi story buildings.
The aim of this research stage is to collect and evaluate data on characteristics of each of the different typologies, through analysis of use, most notably the functional organization of dwelling units, the outsourcing of functions which can lead to reduction of floor space and new demands (work – live, patchwork families) which at least temporarily lead to an increase of necessary space. Social aspects and prognosis on demographic development will be assessed as well.
The **analysis** will be based on the occupancy evaluation of the apartments through inventory of the areas, appliances and people, as well as through image analysis (methodology visual sociology or visual anthropology) (G. Rose, 2007)
The **methods** will include interviews with inhabitants and stakeholders in housing as well as visual methodologies such as using photos to support social science research (Rose 2007, J. and M. Collier1986) and time charts to record actual use.

The topic of storage and sufficiency is highly interesting. Peter Smithson identified this problem which he calls “glut” in 1999. “These not-at-present-in-use-maybe-never-again objects are more or less dead-storage, but there is also the live storage of clothing and accessories in daily use and a third category, the storage for tools and equipment for the maintenance of the dwelling itself (P. Smithson, cited in Ed. Heuvel/ Risselada, 2004). According to Smithson, 30% of the dwelling’s volume is needed for storage space. The solution to reducing the space of the well tempered and highly energy demanding environment lies in outsourcing of some of the storage space from the housing unit as well as the building itself. In order to capture the potential for storage outsourcing, data on what kind of objects are stored within the housing unit, how often are they needed during the everyday routines and how much volume do they take up. Inventories of different objects and corresponding time charts with use frequency will allow us to define this sufficiency potential.

Evaluation will include following steps:
For the dwelling unit statistics on floor space and functions, data on stored objects, data on furniture will be collected. A close scrutiny of everyday routines will complement the hard statistical facts.
On the level of building itself it is essential to acquire data on the qualities of space provided and if there is a potential of underused space that could be used for outsourcing of functions such as storage, work and joint use of appliances.

Research Area Energy efficiency

The energy efficiency evaluation will be carried out by the means of the Department-owned and validated simulation-models. All the data gathered through the primary analysis will be systemized and will build a point of departure for the future simulation. The typologies of the each building period will be systemized according to the possible impact-measurements:

- Thermal refurbishment in different qualities (ranging from minimal thermal improvement to the implementation of measurements for minimal energy loss)
- Reorganization of the floor plans of the housing units (e.g. density of occupancy)
- Collective, temporally limited used spaces
- Use of the technical facilities for energy gain (involving integrated building solutions or additional, later add-ons')

The energy efficiency aims that should be achieved through refurbishment will be based upon the analysis and systematization of the housing typologies and the matrix of three models; upon which the different scenarios will be validated through energy-simulation. The saving potentials will be allocated based on maximization of sufficiency.

Research Area Energy Systems

Appliances in households
The outcome of research will include synthetic profile loads for normative user groups based upon typical user profiles in Vienna, according to statistical data and in relation to chosen housing typologies. The use and the consumption will be analyzed. The data on consumption can be assigned to different rooms of the housing unit.
More efficient household appliances allow less energy consumption. This potential for energy saving measures will be assessed during the whole life cycle of the appliances. Correct usage of the appliances bears further potential for energy saving. The questions of collective use of some of the household appliances such as:

- Which appliances were traditionally used in collective spaces, which new appliances have the potential for collective use?
- How much space in the housing unit itself can be gained through such measures?
- How does the increase in floor area correlate to increased energy consumption?

are central to this research area.

Distributed energy production:
The existing building structures will be the basis for research on the potentials of distributed power production. As in Vienna the potential for wind power is relatively low, the emphasis will be on integration of photovoltaic. The existing stock of roof and façade surfaces will be examined.

Power consumption in passive / active house
In buildings which comply to passive house or active house standard a higher consumption of electric power is expected. On the overall, energy consumption is lower due to highly efficient building envelope. These lower consumption levels relate to thermal energy and heat consumption alone. Controlled ventilation systems in passive house can lead to increase in electric power consumption by 10 %. Necessary heating power is thus to some degree substituted for electric power.

Standards
The outcome of research will be gathered in defined standards on energy consumption and appliance facilities, ranging from lowest level (minimum standard) to different standards with the potential for scaling down. The standards will be

defined by consumption in kWh/a per person, so that comparison between different housing typologies and energy efficiency standard can easily be identified.

Research Area Lifecycle analysis and Life cycle oriented planning

The aim of the research is the cost-benefit analysis and verification of the investment costs for refurbishment of the housing stocks versus the life cycle cost (LCC) of energy-efficiency building technologies or technologies for energy production (energy-active building).

Following alternatives will be considered:

1. Verification of the increased re-construction cost (initial investment) through significant decrease of the following costs (heating, cooling, lightning, electricity, household appliances, maintenance)
2. Verification of the increased re-construction cost (initial investment) through optimized, efficient spatial use of the living space (rental area surplus), optimized yields or sell values.
3. Proposal of sustainable building refurbishment models, which are based upon a balanced relation of LCC and profits, energy consumption, spatial use and user satisfaction based on balance of economic, ecologic and social interests

Methodology is based upon 2 focii:

1. Life cycle oriented cost-benefits analysis: with specific focus on life cycle cost (LCC) in coherence with life cycle energy consumption
2. Post Occupancy Evaluation (POE) of the three proposed refurbishment models together with development of different scenarios

The life-cycle oriented **cost-benefit analysis** of the housing stocks will employ Flow-methodology analyzing in- and outputs occurring throughout life cycle of the building (Kohler, Lützkendorf, 2002).

Life cycle cost, as monetary flow will be categorized in:

- Investments
- Yields
- Following costs: heating, cooling, electricity, cleaning, maintenance, inspection/service,

The life cycle resources and energy consumption, with main focus on the energy consumption will be gathered and categorized in:

- Heating energy consumption
- Cooling energy consumption
- Electricity + Household appliances

The metrics for cost systematization as well as the energy demand will be carried out in units of €/m² GFA (gross floor area) or RA (rental area) and it will be split in three time (age) periods. The yields will be calculated by the means of simplified developer calculation (yield, return of investment) for two cases:

- Sale of the apartment
- Rent of apartment

The **Post Occupancy Evaluation** (POE) (Mendel et al, 2006) will evaluate the three proposed models on the sustainability potential, concerning the balance of the economic, ecologic and social issues.
The main problem for such evaluation represents the ambivalent nature of building as composition of tangible, qualitative characteristics, and the intangible, quantitative ones.
The tangible data are building's quantitative characteristics: ecological (consumption of resources and energy, emissions) and economic data (initial investments, life cycle cost, yields). The intangible data is expressed through qualitative characteristics such as formal, cultural and functional aspects.

The equal consideration of both tangible and intangible building and urban features is crucial for a sustainability-oriented POE.
As a tool for sustainability oriented POE, a holistic, life-cycle oriented **Building Performance Evaluation** (BPE) which quantifies the sustainability potential of a building through:

- definition of parameters determining sustainability
- analysis of the coherences of the parameters
- grading of indicators

will be implemented.
The parameters employed in the holistic BPA are structured in three level-model. Primary structure differentiates among three KEY ISSUES:

- ecology,
- economy
- socio-cultural

aspects of building performance.

Each key issue is subdivided into planning OBJECTIVES, which again are described by sustainability INDICATORS on the third level.

KEY ISSUES ⇒
PLANNING OBJECTIVES ⇒
Indicators

Sustainability indicators reflect the ambivalent nature of a building, as the set of tangible and intangible characteristics.
Therefore, some indicators are measurable through monitoring and benchmarking, some are immeasurable and to be evaluated through interview-answers. Both tangibles and intangibles will be evaluated by the means of scale-rating (1-5), resulting with a final absolute value of **sustainability performance potential**.

Development of different scenarios, according to the level of refurbishment and energy efficiency will be represented in a report:

- By the means of tables (Grading system with weights)
- Graphical representation through Cob Web Diagram with systematic representation and evaluation of the tangible and intangible data

Evaluation
Three representative models (Table 1) will be conceptualized for the visualization of the building refurbishment concepts. These will be analyzed and evaluated by the means of the holistic BPE.
The interdisciplinary work could be carried out and unified in the system-evaluation catalogue as following:
e.g. the increased construction cost for the technical changes for the energy efficiency (e.g. thermal insulation refurbishment of the façade , PV-facility) will be calculated by the LCA Team, together with the following cost calculation (maintenance, inspection, cleaning) and the expected yields, the possible needed reorganization and optimization of the living space together with the user-satisfaction analysis will be carried out by the Housing Team, transmission values calculation and energy simulation by the Energy Efficiency Team, energy demand and energy saving and accumulation by the Energetic Systems Team. The data and the model parameters flow into a communal scenario-dependant POE.

CONCLUSION

The project will result with housing stock **Catalogue**, containing the systematized data gathered in the course of research, together with the evaluation of the three proposed models:

- "Low impact" (sufficient refurbishment, no till moderate improvement of the thermal performance of the building envelope)
- "Sufficient Refurbishment + Passive house Standard
- "Active House" Standard

As final output a **"Sufficiency Factor"** tool and calculation method for sufficiency potential of the concrete refurbishment, reconstruction and modernization will be compiled.
Further expected results are generation of comprehensive database of sustainable use, such as Life Cycle Cost (construction cost, yield, operation, maintenance), and energy consumption (kwh/m² GFA).
The database and the evaluation-tool can be applied for benchmarking in the planning processes of concrete building projects.

The research should contribute to the development of deeper knowledge on:

- Maximum sufficient size of the housing unit according to the lifestyle, household size, rate of income
- Definition of the new standards for necessary and redundant functions within the apartment organization, especially within the existing stocks
- Integration of the renewable, decentralized energy production and accumulation as well as warm water preparation in the area of neighborhood
- Solutions for outsourcing functions, storage problems, increasing percentage on fitting an furniture, efficient use of household appliances
- Measures for potential reduction of density, through dismantling and renaturation in densely build urban neighborhoods
- Strategies for increase in efficiency of electricity consumption through more effective use of the living area, communal use and modern, energy saving devices
- Reduction of the electricity consumption through the transfer to passive/active house standard

As further output the data-base creation based on:

- End-Energy consumption at different scenarios according to three model-matrix
- Synthetic load profiles for standardized user-groups
- Differentiation of the consumption according to the different uses
- Data in the coherence of the energy consumption and spatial structure
- Data on potential of the available roof and envelope areas for use of regenerative, local energy sources
- Benchmarks for comparison and evaluation of the buildings with similar context

can be expected.

Innovation Aspects

The most innovative aspect of the project is the principle of sufficiency itself, representing the guiding principle in all of the research areas.
This principle is seen as the complementary concept to the energy efficiency, and is expected to reinforce the total efficiency.
The further innovative aspect is the integral, interdisciplinary approach, based on cooperation of four different research teams. The four disciplines include housing research based upon in daily life routines, life-cycle oriented planning, evaluation of energy efficiency.
The combinatory model-matrix will undergo a cost efficiency evaluation, which will allow the application in planning practice for evaluation of refurbishment processes of existing building stocks.

The **"Sufficiency Factor"** tool is specially developed for the practical application for evaluation of feasibility studies and different scenarios in construction and operation of the buildings, ranging from low tech to active house.
The "sufficient use" principle can be transferred and applied to other building typologies of existing stocks such as office buildings, schools, retail and other.

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