reviewed paper

Methodology of target and requirements management for complex systems concerning the application field of an energy-efficient city

Karsten Rexroth, Thilo Brüggemann, Petra von Both

(Karsten Rexroth, Institut für Industrielle Bauproduktion, Universität Karlsruhe, karsten.rexroth(at)ifib.uni-karlsruhe.de)
(Thilo Brüggemann, Institut für Industielle Bauproduktion, Universität Karlsruhe, thilo.brueggemann(at)ifib.uni-karlsruhe.de)
(Petra von Both, Institut für Industrielle Bauproduktion, Universität Karlsruhe, petra.von-both(at)ifib.uni-karlsruhe.de)

1 ABSTRACT

Objectives in complex systems to be realised in the medium/long term require professional monitoring and moderation. Concerning both urban and residential area management, this brings up disparate decisionmakers as well as many interested parties with different interests, motivations and points of view. As a result, detailed and structured gathering, evaluation and documentation of targets and requirements is essential to an efficient and ongoing development process. Besides intermixing target and indicator systems, aiming at too many targets remains the main problem of existing methods concerning lasting building- and urban management-supportive target and requirement management methodologies. The systems often contradict themselves, being meant to serve both as the overall concept and a guideline to action for sustained yield requirements which tends to end up in large catalogues of requirements, allowing only few points to be addressed in detail.

This article specifies a procedure for development and structured management of a target and requirement system concerning the application field of an energy-efficient city (developed, applied and evaluated within the "Wettbewerb Energieeffiziente Stadt" (competition regarding an energy-efficient city)). It describes actual insights in the development of the procedure. The Institut für Industrielle Bauproduktion (institute for industrial building production, ifib) is part of the accompanying research group of the "Wettbewerb Energieeffiziente Stadt" which was announced by the German Federal Ministry of Education and Research (BMBF) in 2008.

(The German version of the article can be found at the ifib website: http://www.ifib.uni-karlsruhe.de)

2 INTRODUCTION

2.1 Competition regarding an energy-efficient city

The federal government has declared climate protection to be a main objective to be sorted out over the course of the next couple of years. Goals derived from this determination include a reduction of CO2 emissions by 40 % as well as doubling energy production between 1990 and 2020 [BMBF08]. Cities and communes take on an important role in order to achieve these goals, because they administrate the operating level on which many of the necessary energy-efficiency optimizations will be determined.

The German Federal Ministry of Education and Research (BMBF) announced the "Wettbewerb Energieeffiziente Stadt" (competition regarding an energy-efficient city) in 2008. It is meant to focus on the sponsorship of projects with trendsetting concepts, taking on the idea of the system as a whole as well as considering the service aspect as an important point regarding system-oriented approaches [BMBF08/2].

The competition bore 72 applications. After a process of preselection, 15 projects were asked to be further pursued. At the moment, the revision period of the preselected projects is finished. The storyboarding begin is scheduled for May 2009.

The ifib is a part of the research group which accompanies the competition and analyses it methodically. A part of the institute substantially focuses on developing, applying and imparting of integrative planning and co-operation techniques as well as on developing assisting IT tools and their prototypical implementation. The main objective is to continuously optimise the quality of planning, beginning by developping methods and tools to increase the quality of the project and of the planning process as well as increasing the planning efficiency. Target- and specifiaction-oriened planning results in a higher quality product (the planning subject) throughout its lifecycle. Therefore, integrative planning methods serve as the overall concept.

Within the accompanying research done for the „Wettbewerb Energieeffiziente Stadt", the ifib works on further developing and complementing thes methods focussing on target- and requirement management regarding the application field of an enery-efficient city.

The accompanying research group consists of the following institutes:

- IZT Institut für Zukunftsstudien und Technologiebewertung (institute for future-relevant studies and technology evaluation), Berlin
- LEE Lehrstuhl für Energiesysteme und Energiewirtschaft (chair for energy systems and energy business), Ruhr-University Bochum
- GEF Ingenieur AG (engineering public limited company), Leimen
- IFIB Institut für Industrielle Bauproduktion (institute for industrial building production), University of Karlsruhe (TH)

3 PROBLEM DESCRIPTION

Cities and communities bear a major role in order to achieve the goals in question concerning energy saving and reduction of greenhouse gases. The realisation of previous methods shows that there are enough methods and technologies available already. All the more, it is necessary to adjust and match these single concepts among each other to create a functional, polycausal linked and integrated overall concept. Such a master plan has to be created on a strategic level – in this case, this relates to the urban and municipal decision-making body.

In order to develop mentioned master plan, it is necessary to obtain detailed knowledge concerning the individual local situation. This way, the most convenient and appropriate procedures and techniques relating to the local possibilities can be identified. Therefore, an integrated analysis of the energy consumption and supply situation, involving all participating parties including residents and occupants. [BMBF08/2].

3.1 Existing Approaches

A vast multitude of tools and techniques is available to support the strategic management to develop and realise the right strategy, ranging from normative specifications and complying arranged minimum standards to competitive procedures and techniques aiming at first class performance. The following topics are concerned, amongst others:

- Quality management like ISO 9001, Total Quality Management, European Quality Award [KAM00].
- Evironment management like ISO 14001, EMAS and related, characteristic and locally varying rankings, ratings and benchmark systems for corporations [EMAS09].
- Building management like RealisBench, EnBW energy report concerning energy consumption and upkeeping optimisation at a building management level [REAL09, ENBW09].
- Overall urban energy efficiency like European Energy Award [EEA09]
- Specialised benchmarking and action programs for the municipal supply area, infrastructure, waste management, street lighting etc. [AQUA09, BIFA09, BUND09, GREE09, SAFE09].
- Intercommunal performance comparison in order to enable a structured validation of the administrative institution or of administration units (at the IKO network, for example) [KGST09].

From a generatically oriented point of view, it is also necessary to mention the models and simulation programs of the energy suppliers, energy advisers and the field of engineers, as well as building-oriented calculation and balancing methods for the building division – the energy pass, for example.

Within the focus of an energy-efficient city, the already mentioned European Energy Award offers a high level of integration at the moment – however, it still aims at immediate area of municipal administration [EEA09, LÖH08], not considering private systems yet in the overall picture. Resulting from the point of view of an urban and municipal decision-making body, we consider these methods and techniques as a partial model.

3.2 Realisation Inhibitions

Participating at certification and benchmarking programs requries an organisation to provide a certain of manpower to handle the tasks, as well as external advising and assistance at strategy development, handled

by an experienced consultant. Whereas large adminitrations incorporate specialised divisions regarding enery management, small communes only deal with rather small manning and funds. As the resulting advantage of enduring organisation, product and process optimisation is not an immediate effect and thus it is not immediately visible, communes often hesitate to make these efforts, further fueled by the extensively linked, complex and therefore confusing subject area as well as a difficulty to decide upon the right methods for the own situation. We have to take care of these inhibitions and abolish them in order to approach the problems actively and target-oriented to enduringly increase enery efficiency of cities and communes to great effect.

The inhomogeneous decision-making body, a multitude of interested parties on different levels, as well as differentiated interests originated by differing motivations, points of view and periods under review further complicate developing a consistant target system. However, developing a consistant master plan which is ratified and accepted by all parties is a basic necessity for an efficient planning and development process.

4 THE APPROACH

For solving a complex problem, concepts of the integrative planning methodology offers possible approaches:

Determining requirements and preferences regarding planning and realisation of energy-efficient and enduring city and settlement structures is meant to be assigned to the different steps of the process, making them transparent, comprehensible and traceable for all involved parties. Preliminary work on the building and settlement level done by the ifib shows that detailed gathering of requirements and objectives as well as their integration in a target system which also matches the requirements of superordinate systems (energetic, ecologic, social and economic aspects) is a basic necessity for planning. Target-oriented planning is meant to check proposals and approaches regarding their functional applicabilities, economic and ecologic feasibility and the acceptance on the side of the participating parties and the users [BOTH05].

The following diagram shows the single project development steps:

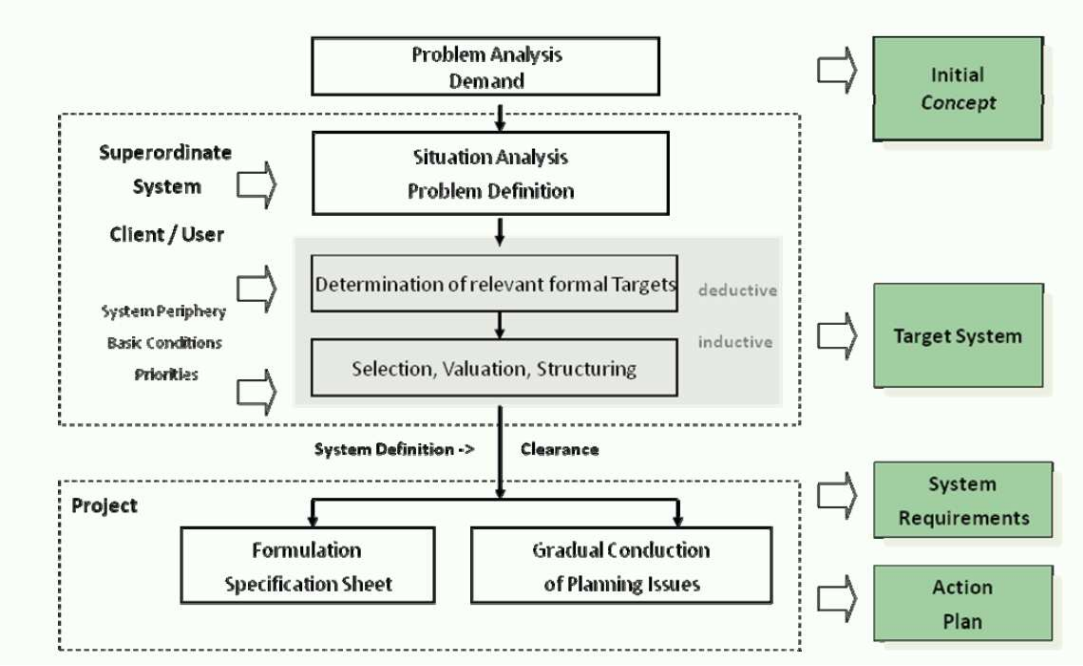

Fig. 1: Project development steps (von Both)

4.1 Benchmarking

Benchmarking is a realisation-oriented method to be applied iteratively. It is meant to to support complex innovation and optimisation processes in companies and coroporations. Assuming that there is a best practise for any problem solving, it has to be pointed out, first of all [GER98]. Strictly speaking, this is only possible by a comprehensive analysis, resulting in extensive expenses. As a result, one rather focuses on succesfull practises to keep the costs down. Accomplishing a benchmarking (or taking part at one) enables an

organisation to determine their position as well as detecting capacity vacancies and – ideally – causes enlightenment. Besides structral organisation evaluation and product evaluation regarding the process, two hierarchy levels are to be considered:

Strategic Level: Identifying effective practices (doing the right things)

Operational Level: Identifying efficient practices (doing the things right)

The originally rather simple methological level of benchmarking is specialised concerning the partial models and adapted to the respective problem.

4.2 Dynamic Target System

The basis of a solution process consists of comprehensive capturing and displaying of all relevant objectives in a consistant target system. An objective here refers to a solution-independent description of the nominal condition. Objectives are being expressed by the actors in order to communicate their wishes or ideals into a concrete action process. Even right before the beginning of a planning process, problem descriptions and objective tartgets are often rather abstract and vague [BOTH06].

The assignment of a target description is to substantiate and differentiate the objectives during the ongoing process. We refer to the as tactic objectives. If the structural information to concretisise the objectives is not available, a system analysis is necessary. When a system analysis is being made, structural links and interactions have to be identified as well as quantifying the actual state of the system substance.

In case the structural information is available, substantialising the strategic objectives into tactic objectives goes along with a change of perspective, changing from the abstract view which also includes superordinate and surrounding systems to an object-related view within the defined boundaries of the system. If the process of substantialising and differentiating objectives is continued, tactic objectives are being translated into concrete requirements. These requirements define the nominal characteristics of system components and system functions. The charactericts can be positive as a nominal value or negative as nominal non-value. However, it is important to phrase the requirements in a solution-independent manner. Overall, they allow for a comprehensive and differentiated description of the assignment of tasks without excluding possible solutions which are not yet identified by already implying an specific apporach. Defining the requirement is a basic necessity for the transition to an efficient solution process.

When developing a target system, continuous checking and evaluating of the aspired objectives regarding their effects within the system and outside the system boundaries is being carried out. This is necessary in order to recognise conflicting objectives at an early stage and also prioritise objectives. Prioritisation refers to the assignment of the objectives according to their importance within the system, therefore according to their effect. Given the basic assumption of limited funds, prioritisation also requires a time-based component.

The idea of cities and communes as a socio-technical system shows the dynamics and the multi-layered linking best. A change of the specifications for on the political, ecological, economical or the social level, for example, requires a target system which is transparent for many participants on different levels and which is also enduringly comprehensible. Regarding the system of a city, this is even more important due to the fact that the system is never finished – actors always vary. A target system will always be object to control and to criticism and must be adaptable to the dynamic changes and the further development of a city.In order to develop and continuously update a consistant and conclusive target system which can be accepted by all participating parties, a team-oriented management process fed back into a monitoring process is necessary.

4.3 Complimentary Indicator System

An indicator refers to displaying or quantisizing in order to make a statement concerning the overall system state. By monitoring an indicator over a certain period of time, the overall development of a system can be judged. The indicator selection is determined according to the evaluation and measurement of a grade concerning the target achievement and is meant to be adapted to changes in the target system. We call this a complimentary indicator system. In order to describe the condition of partial systems within an overall system, representative indicators need to be assign to the respective partial system. Ideally, a system can be

broken down into its structuctural correlations. Recognising these allowes for identification of specific indicators [DÖR83, DÖR06].

The quality behind it and the availability of the data basis is crucial for the significance of an indicator. The project „Städte der Zukunft“ (cities of the future) of the Federal Office of Architecture and Regional Development showed that a diversity of data quality depending on the field of action or the partial system can be expected. Most of the time, not all aspired targets can be assigned to a distinct indicator. To some extent, appropriate indicators based on the actual data available today can only be realised through additional manpower or even through investing in appropriate tools [BBR03].

Concerning the field of energy-efficient city development, no mandatory indicator systems are existing yet. However, such an indicator systems is necessary for a comprehensive state description as well as for controlling the development. A standardised indicator system allows for the comparability of the success of actions between cities, communes or projects, for example. Quantifying and communicating of the success of actions taken supports the transparency of the process, legitimating further steps. The resulting initialisation of awareness and of a development process on the side of the participating parties allows for an approximation to the energy-efficient city. It is probably the most important side-effect of an indicator system.

When identifying relevant indicators as well as the development of an indicator system, one should be aware of the possibility of overdoing it. The ifib already finished projects with spatially diversed planning teams concerning target specifaction and systematisation or planning and building projects on a kooperative bases. These projects were done on a building and on an environmental level [GES03]. While the participating parties were still straightforward in this case, a large number of indicators were already necessary. If the consistent distinction of target, requirement, indicator measurement remains undone, indicators within the development of a target system are already understood as a target formulation, mixing up the indicator system with the target system. The indicator system is meant as a complimenting system to the target system. An accurate descriptuion of the targets and the derived requirements (both not implying a solution approach yet) require differentiated assigning of significant indicators and specific measurements which are necessary in order to evaluate the target achievement.

4.4 Transfer and Integration

If an integrative planning approach is required, it is based on knowing that this already sets the course for the further process development at an early stage, continuously diminishing the possibility of influincing the system whereas – in the extreme case – aftermaths rise exponentially.

Acting and making lasting decisions at an early stage, being a basic necessity for the participating parties, it is important to gain expertise and experience prematurely. If this is missed, decisions are postponed or are being made only on a limited rational basis. Assuming limited funds and concentrate on a reasonable (from an econonic point of view) ideal of redundancy concerning expertise and experience, it is necessery to partition the participating parties. Within these groups, the actors take the roles they fancy. These roles are assigned to functions or tasks within the system and can fulfill – in a simplified description - controlling and executive tasks. The controlling task is meant to monitor the process, to ponder and to decide. The executing function is supposed to accept, process, store and – if applicable – transfer contents. Within a complex system, these tasks are repeatedly convoluted. If the system is a technical one, the compones have to be coordinated with each other in order to gain ideal performance in terms of the system.

This interaction and the coordination of the roles is one of the basic approaches of the intergrative planning methodology. It bears further optimisation potential. As the tasks are influencing each other in a mutual way, the interfaces have to be optimised in order to allow for the ideal system state. Furthermore, the responsibility of the different roles concerning the decision-making must be distinguished between a contentbased, expertised and hierarchical level. In reality of participating and planning teams, such an interface is not existing and is also not desirable. All the more, we have to think of an overlapping area. We call this the transfer area, which bears a high demand of communication as well as being prone to semantic conflicts.

Above and below the transfer area, we postulate amicable ideals and – to a large extent - amicable semantics and ontology within the partial systems. One optimising approach consists of the conditioning of information quality and quantity concerning the demand of the recipient.

5 CONCLUSION

In order to achive the superordinate objective of an energy-efficient city, it is necessary to generate a coordinated target system which has to be developed and approved by the urban and municipal decisionmaking body. It is also necessary to integrate private participants. If cities and communes are defined further beyond their boundaries of an organisational unit regarding their multi-causal crosslinking of partial systems, the demand of standardisation, coordination or communication between these partial systems and their processes seems obvious. According to our view, a standardisation is impossible to do. It would also be opposed to the eligibility of a multitude of specialised systems. Furthermore, coordinating and communicating between the partial systems and their models seems to be promising.

In terms of transdisciplinary approach, techniques of integrative planning, consequent target and requirement management as well as existing partial models have to be linked and complented by the divisions which are not covered yet. Such possibilities will be reviewed within the further course of the project.

The following diagram shows the crosslinking and overlapping of the relevant divisions:

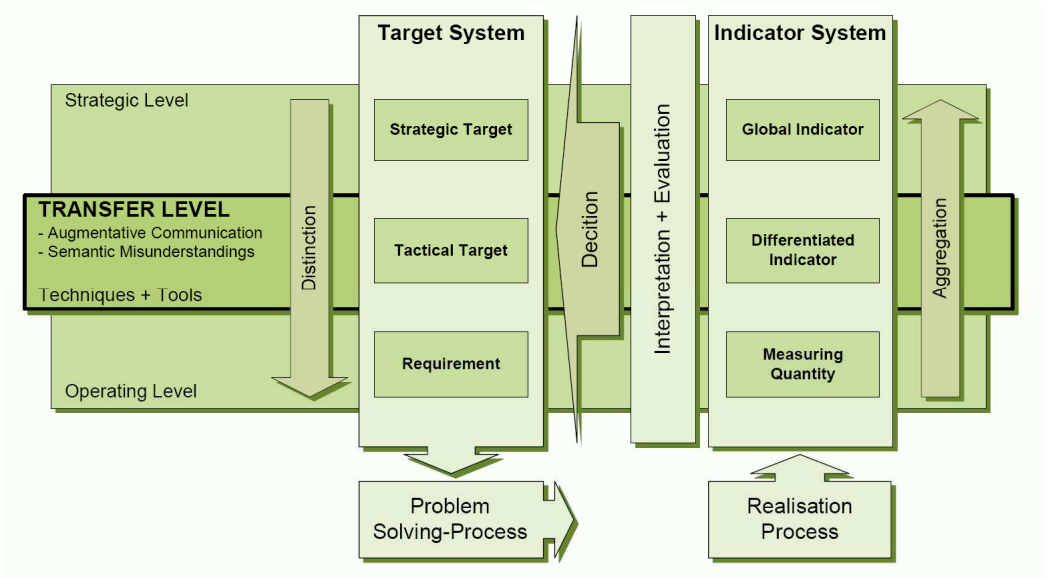

Fig. 2: Crosslinking of transfer areas

Essential theses regarding further project work:

- - Consequent target planning as a necessity for a smooth transition of the following solution and reaslisation approaches.
- - The target system has to produce transparency, constricting itself to the quintessence of the respective target layer.
- - The value of benefit of actions for increasing energy efficiency has to be analysed compared to the superordinate targets.
- - The process of target formulation and differentiation requires all participating parties. A target system requires a complimentary indicator system.
- - The necessary consolidation of the different roles to a comprehensive system requires further rules concerning the provision and transmission of information to subsequent parties, as well as determining the decision-making level.

- - The information on which the decision-making process is based on (nominal and actual state) has to comply with granularity concerning the organisational role regarding the decision-making process as well as a possible grey area of the planning period.
- - These roles constitue specifiec requirements concerning the degree of detailing and the severity level. Within the planning process, the employed analysis and simulation tools are to be machted accordingly.

6 REFERENCES

[AQUA09] Aquabench GmbH. http://www.aquabench.de
[BBR03] Bundesamt für Bauwesen und Raumordnung [Hrsg.]: Zukunft findet Stadt, Werkstatt: Praxis Heft 6/2003. Bonn 2003. selbstverlag@bbr.bund.de
[BIFA09] Bayerisches Institut für Angewandte Umweltforschung und –technik (bifa). http://www.bifa.de
[BKV09] Betriebsvergleich kommunaler Versorgungsunternehmen des Verbandes kommunaler Unternehmen (VKU). http://www.bkv-benchmarking.de; http://www.vku.de/
[BMBF08] Bundesministerium für Bildung und Foschung (Hrsg.): Grundlagenforschung Energie 2020+. Bonn Berlin, 2008. http://www.bmbf.de
[BMBF08/2] Bundesministerium für Bildung und Foschung: Bekanntmachung der Bundesministeriums für Bildung und Forschung von Richtlinien über die Fördermaßnahme „Wettbewerb Energieeffiziente Stadt“ im Rahmen des Förderkonzepts „Grundlagenforschung Energie 2020+“. Bonn, 2008. http://www.bmbf.de.
[BUND09] Bundeswettbewerb Energieeffiziente Stadtbeleuchtung. http://www.bundeswettbewerb-stadtbeleuchtung.de
[BOTH05] Petra von Both, Niklaus Kohler: An Integrated System for the Cooperative Development and Management of Project Objectives and Building Requirements; 2nd International SCRI Research Symposium, Salford Centre for Research & Innovation at the University of Salford, Greater Manchester, UK, April 2005
[BOTH06] Petra von Both: Ein systemisches Projektmodell für eine kooperative Planung komplexer Unikate. Karlsruhe : Universitätsverlag, 2006.
[DÖR83] Dietrich Dörner [Hrsg.]: Lohhausen : vom Umgang mit Unbestimmtheit und Komplexität ; [DFG-Projekt DO 200/4 Systemdenken, Lehrstuhl Psychologie II der Universität Bamberg 1981]. Bern ; Stuttgart ; Wien: Huber, 1983.
[DÖR06] Dietrich Dörner: Die Logik des Misslingens : strategisches Denken in komplexen Situationen - 5. Aufl. Reinbek bei Hamburg: Rowohlt, 2006.
[EEA09] European Energy Award. http://www.european-energy-award.de
[EMAS09] Eco-Management and Audit Scheme (EMAS). http://www.emas.de
[ENBW09] EnBW Energiebericht. http://www.enbw.com
[GER98] Claus W. Gerberich: Benchmarking. Planegg : STS Verlag, 1998
[GES03] Robin Gessmann, Markus Peter: Eine lebenszykus orientierte Planungsplattform zur Unterstützung partizipativer Wohnbauprojekte. In: Kai Kaapke, Alexander Wulf (Hrsg.): Forum Bauinformatik 2003. Aachen: Shaker, 2003.
[GREE09] The European GreenLight Programme. http://www.eu-greenlight.org
[KAM00] Gerd F. Kamiske [Hrsg.]: Der Weg zur Spitze : Business Excellence durch Total Quality Management – 2. Aufl. München; Wien: Hanser, 2000.
[KGST09] Kommunale Gemeinschaftsstelle für Verwaltungsmanagement (KGSt). http://www.kgst.de
[LÖH08] Hermann Löhner: Steigerung der Energieeffizienz in Kommunen : Entwicklung eines kommunalen Energie-Rating mittels Benchmarking. Saarbrücken: VDM Verlag, 2008.
[REAL09] RealisBench. http:/www.relisag.de
[SAFE09] Schweizerische Agentur für Energieeffizienz (SAFE). Umfrage Strassenbeleuchtung und Benchmark. http://ds1.dreifels.ch/wwf/lighting_de.aspx; http://www.energieeffizienz.ch