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Implementation of Energy Strategies in Communities—From Pilot Project in Salzburg, Austria, to Urban Strategy

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ABSTRACT

Research from the Organisation for Economic Co-Operation and Development suggests that cities are major contributors to carbon dioxide (CO_2) emissions. It is essential to undertake the wide-scale development of more sustainable cities and communities to avoid the full impact of climate change and shortages in energy supply and resource, by drastically reducing both energy use and resulting emissions. In the past, research in the building sector has focused on technological innovation and improvements at the fragmented scale of the individual building. This has been partially successful. However, to achieve global climate and energy-related goals, more emphasis should be placed on achieving system-wide reduction of energy demand and CO_2 emissions and on incorporating a higher share of renewable energy into the integrated infrastructures of our cities, including transportation and industry. Such a transition would progress from the optimization of building parts in single buildings to optimized solutions for whole neighborhoods and communities.

The city of Salzburg, Austria, has realized a pilot project on an optimized energy concept for an inner-urban area, composed of both new buildings and renovated existing building stock. An increase in the use of district heating and solar energy (>35%) has drastically reduced primary energy demand. Monitoring results became available in the summer of 2014. Based on this experience and other case studies documented and analyzed in International Energy Agency—Energy in Buildings and Communities (IEA-EBC) Annex 51, the city of Salzburg has put high priority on the optimization of its communities. After an analysis of the building stock and structure of ownership in Salzburg, the city has prioritized new, community-scale projects, planned to start early in 2014, that will jointly involve urban planning, housing associations, and utilities.

Experience shows that merging energy planning and urban planning is a challenging task that goes beyond the implementation of optimized technological solutions. The new IEA-EBC Annex 63, "Implementation of Energy Strategies in Communities," focuses on the development of methodologies to implement optimized energy strategies on the community scale.

PILOT PROJECT "STADTWERK LEHEN," SALZBURG

In 1998, the city of Salzburg adopted a general development plan with ambitious sustainability goals that included quantified goals for building efficiency and the use of renewable energy. The development plan, coordinated between the municipality and the regional utility, is based on the optimization of the district heating system. A detailed mapping of buildings and heat demand in the city was used to develop a strategy for centralized heat supply. A similar project for Stadtwerk Lehen was developed in parallel.

The district of Lehen is situated quite close to the city center of Salzburg. From 1950 to 1970, Lehen was primarily composed of residential buildings, interspersed with many school buildings, Salzburg's main soccer stadium, a utility headquarters, and a main traffic artery.

Most of the buildings in the residential quarters were unrenovated. This, in combination with heavy automobile traffic, placed the district in danger of falling into social and economic decline. City planners noted that the location had great potential for development into a new and attractive Salzburg district. The opening of a new train station in Lehen connected the area to the new city train network, which improved the quality of life in the district. Plans to move the util-

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ity headquarters and the soccer stadium to other sites offered opportunities for further development. Construction of a new residential and commercial area was initiated on the site of the former utility headquarters. The main city library was established on the site of the former soccer stadium.

A competition was held to develop a master plan for the Stadtwerk Lehen project. The master plan included residential buildings with apartments and commercial areas, a kindergarten, a student hostel, and a "Competence Park" with four life science buildings, a hotel, and a renovated former office building. The existing building stock in the area near the utility headquarters is composed of residential buildings built from 1950 to 1960, most of which have unrenovated, individual heating systems fueled by oil or gas. The introduction of improved technologies into the newly built area was also seen as an opportunity to begin to retrofit the surrounding areas. The city planners' concrete plans to implement improved energy efficiency and the concept of integrated energy supply in the new Stadtwerk Lehen buildings stimulated the requirement for overall renovation in the subsequent stages of project development. Table 1 lists the key area parameters.

The Stadtwerk Lehen project was created as a pilot project for sustainable urban development. Its main energy performance criteria were as follows:

- Low-energy standard for buildings
- Energy-efficient pumps and lighting of public areas
- High rate of renewable energy for energy supply.

The focus of this development project was to optimize the concept of energy supply. In addition to establishing an efficient energy-supply system that integrates renewable energy, the system was also optimized to take advantage of the existing district heating system, which derives most of its energy from available industrial waste heat resources.

It became apparent that—to bring the project to a successful conclusion—there was a need for an optimized methodology to coordinate the various project activities, the different approaches required by new building construction and renovation, the contributions of involved partners, and stated targets defined by funding programs. The project was scheduled to begin in 2005 and to reach completion in 2013. Table 2 shows the project timetable.

Building Standards

The Stadtwerk Lehen project focused on incorporating a high share of renewable energy to satisfy both heat and electricity demand. High building energy performance was seen as the basis for achieving the targets. On the other hand, funding requirements limited certain housing investments. To meet these requirements, a minimum low-energy standard was set instead of the more ambitious passive-house standard. Table 3 shows the targets for new and for renovated buildings. Minimum U-factors for new and retrofitted buildings were based on this target.

For new buildings, the required standards were included in contracts with involved housing associations and in the calls for bids. Due to cost reasons, insulation was done with polystyrene. For existing buildings, the project had to begin by stimulating the motivation for renovation, because some tenants saw no immediate need for overall renovation. Thus, a detailed study was done to evaluate the possibilities of using this strategy to modernize one part of the existing area, called Strubergassensiedlung. This study

Table 1. Key Parameters for Stadtwerk Lehen Project

Parameter	Measure
Total area	155.000 m^2
Owners	Social and commercial housing associations, city of Salzburg
Existing buildings	50.000 m^2
Number of dwellings	623
Average age of existing buildings	60–70 years
Type of buildings	85% residential 15% commercial
New buildings	105.000 m^2
Number of dwellings	550
Type of buildings	80% residential 20% commercial

Table 2. Stadtwerk Lehen Project Timetable

Preparation Phase	2005–2007	
Planning Phase	2007–2010	
Construction Phases	2009–2011	For new residential buildings
	2009–2014	For commercial buildings
	2011–?	For modernization and renovation of residential buildings

Table 3. Minimum Requirements for Thermal Building Standards

	Specific Heat Demand, $kWh/m^2 \cdot y$
New buildings	< 20
Renovation	< 30

was done by an external (unbiased) expert who had no further involvement in the project. The goal of this study was to show the effects of renovation, including improvements in energy consumption, related quality of life issues (quality of apartments, public spaces), and economic benefits. Based on a detailed analysis of the buildings and of the energy standards, several project variants were explored:

- Standard renovation
- Factor 10 renovation: New buildings should achieve 10% less energy demand than the existing demand (a reduction by a factor of 10)
- Passive-house standard renovation, respectively for the addition of another story

Table 4 shows the required thermal standards for the main renovation components.

A renovation plan for the whole area was created that considered the different standards that applied to each Strubergassensiedlung building and the individual approaches that might be used to apply the actual standards. For example, the plan suggested a the high end of the standard renovation category for buildings that had already achieved a "high" rating for a criterion like "quality of apartments." On the other hand, the plan suggested applying the passive-house standard to buildings requiring a total renovation.

Energy Supply Concept

The challenge to integrate renewable energy in the city's existing supply system was resolved by following a strategy based on solar energy and the district heating system. Additional improvements were necessary to meet the goal of incorporating a high share of renewable energy. An increase of solar fraction was achieved by installing heat pumps to increase the efficiency of solar collector fields. In addition, the plan projected a micronet to supply heat to the whole area. In combination with planning directives for all of the housing projects, the micronet allows the heating system to operate at low temperatures, resulting in higher solar gains. Figure 1 shows the hydraulic scheme, including the main components: solar collector, storage tank, heat pump, and micronet.

A detailed simulation based on the heat supply concept was done to optimize the whole system. Planning parameters were varied to simulate the following several scenarios:

- assumptions of heat demand due to different timetables of planning (new residential buildings)
- new commercial buildings, existing residential buildings
- size of collector field
- size of storage tank
- size of heat pump
- return temperature of micronet
- type of heat pump (electricity, gas)

For example, Figure 2 shows the influence of the return temperature of the micronet on the collector yield.

Figure 2 clearly shows that the return temperature has a generally high influence on system efficiency due to the lower efficiency of the solar system and the lower capacity of the storage tank. The influence of the return temperature on solar yield can be reduced by using a heat pump. Simulation shows that there is a

Table 4. Thermal Standards for Main Renovation Components.

Building Component	Stock	Variant 1 Standard		Variant 2 Factor 10		Variant 3 Passive-House	
	U-factor, W/(m²·K)	Insulation, cm	U-factor, W/(m²·K)	Insulation, cm	U-factor, W/(m²·K)	Insulation, cm	U-factor, W/(m²·K)
Outer wall	1.015	16	0.180	20	0.138	25	0.114
Basement ceiling	1.111	12	0.231	20	0.151	25	0.124
Ceiling above upper floor	0.812	20	0.143	25	0.119	30	0.101
Pitch of the roof	1.127	27	0.154	30	0.131	35	0.113
Staircase-wall to cellar	1.722	16	0.194	20	0.146	25	0.119
Staircase-wall to attic	1.722	16	0.194	20	0.146	25	0.119
Outside door	2.800	—	1.250	—	1.250	—	0.800
Interior door between unheated and heated room	2.800	—	1.250	—	1.250	—	0.800
Window	—	—	0.9	—	0.85	—	0.8
Outer wall to soil	1.596	16	0.192	20	0.158	25	0.129

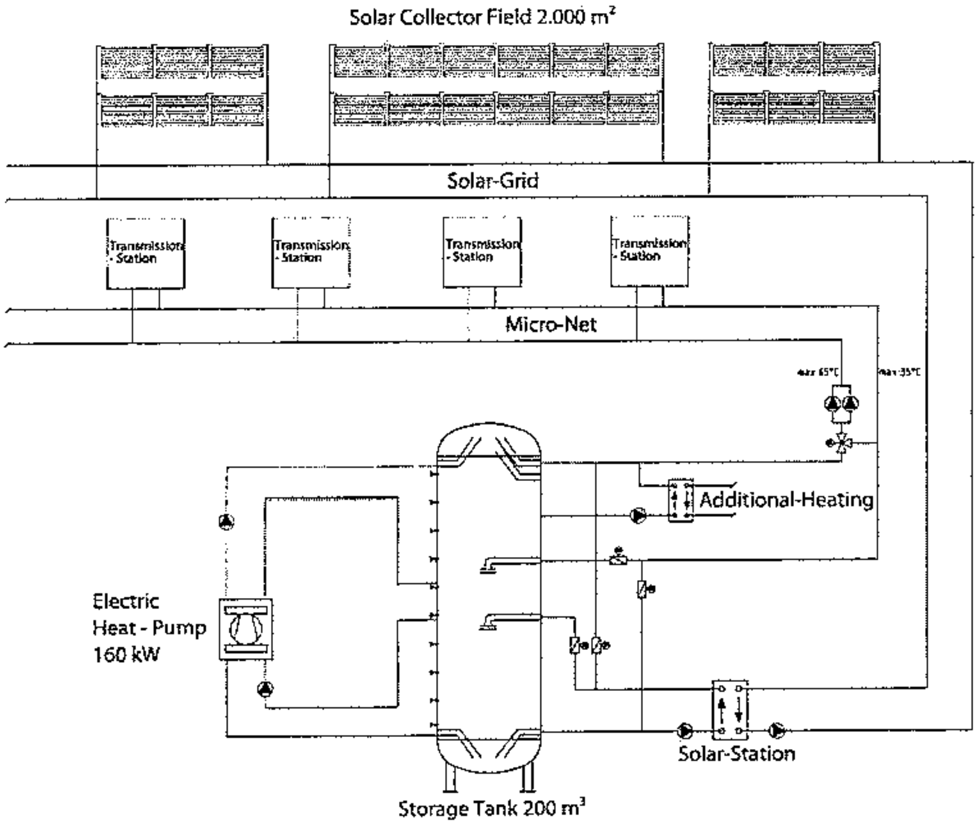

Figure 1 Hydraulic scheme.

higher solar yield with a 122°F (50°C) return temperature in combination with a heat pump, in comparison to a 86°F (30°C) return temperature without a heat pump.

The calculation of primary energy demand for several variations of the energy concept (Figure 3) showed that a system with solar collectors, in combination with electric heat pumps, achieves the maximum reduction of nonrenewable primary energy demand, in comparison with an energy supply based on district heating and solar energy. (Note that the result depends very much on the primary energy figures of the electricity.)

A final solution was determined using a solar fraction of about 30% in combination with a high specific solar yield greater than 400 $kWh/m^2 \cdot y$. Parameters required to achieve this performance were the following:

- reduction of heat demand by very-well-insulated buildings
- installation of 2.000 m^2 solar collectors
- installation of a 200 m^3 storage tank
- use of 160 kW_{th} heat pump to increase the storage capacity and solar yield
- configuring a low-temperature supply system with heat substations in every flat
- providing 50 kW photovoltaic (PV) modules to provide needed electricity demand in public areas

Monitoring

A monitoring system for the entire heat-supply system (solar, district heating, micronet) was installed, including 300 measuring points. A monitoring system with different types of feedback for selected apartments was also installed. The monitored measures of energy balance data will help evaluate how well the project goals, such as specific heat demand and solar fraction, have been met. Interim monitoring results show that the goal of increased specific solar gains of almost 500 $kWh/m^2 \cdot y$ are about 18% higher than expected (Figure 4). The total solar fraction is about 26%, even though the residential units achieve a solar fraction of only 38%. In summer months, the solar fraction is almost 100%. The planning phase defined a minimum goal of 30% total solar fraction. However, monitoring also showed that heat demand of apartments is 29% higher than expected. The final monitoring report, which will be available by the end of the year 2014, will provide detailed information. The final monitoring report will also include additional information on tenants' acceptance of the four different methods of individual energy consumption, based on direct feedback.

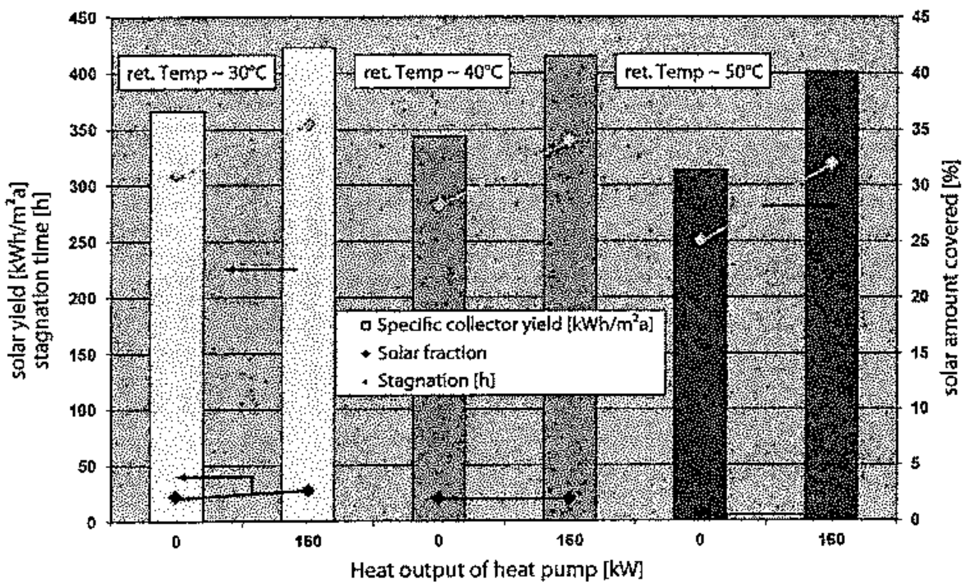

Figure 2 Influence of return temperature.

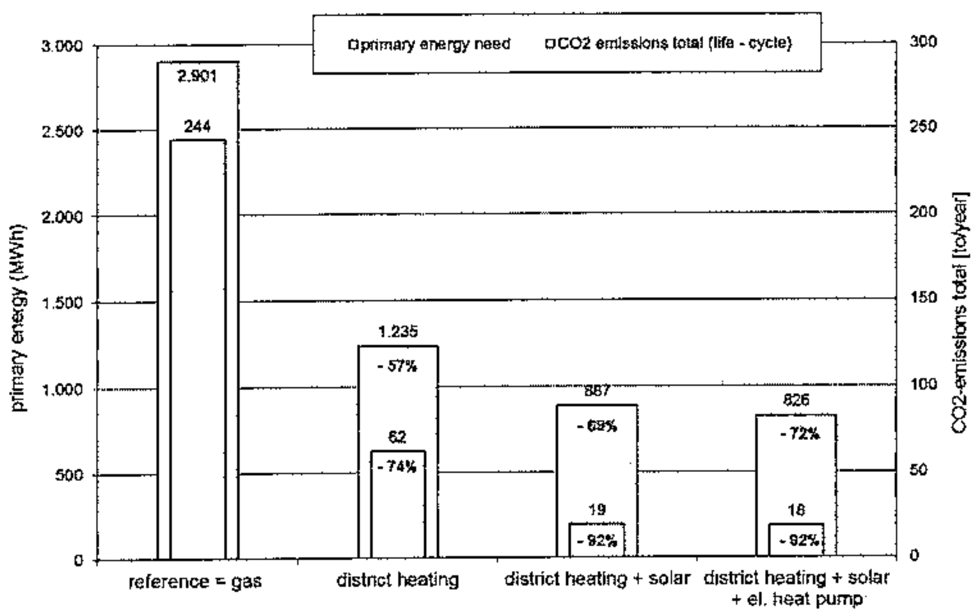

Figure 3 Primary energy demand and CO_2 *emissions.*

Realization of the Process

The relevant players and their roles must first be identified to effectively steer the process to successful realization. Furthermore, it is also essential to establish the instruments that will propel and effectively monitor the process. In this case, players include the city of Salzburg, several social housing associations and project developers, and the former utility that was/is the owner of the area involved. Since each partner plays a different role in the project, their roles must be clearly identified and defined.

All involved parties signed a "high-quality agreement" that guaranteed coordinated cooperation to attain ambitious quality goals concerning energy efficiency, renewable energy, ecology, mobility, and social factors. The agreement includes thermal standards for the buildings and requirements derived from energy concepts as described previously.

A steering group of leaders of the key actors was created to monitor fulfillment of the quality agreement. The steering group has monthly meetings and is chaired by the

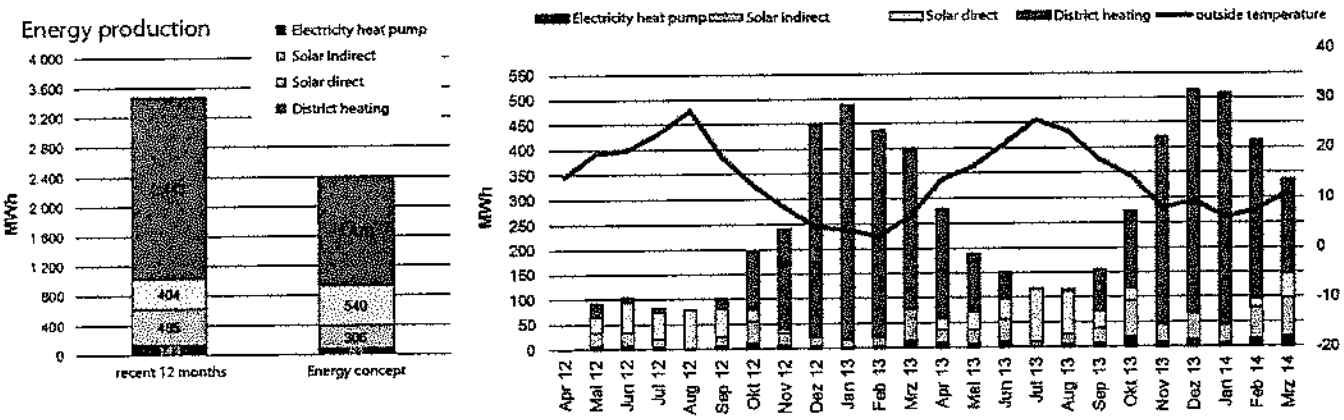

Figure 4 Interim monitoring results.

city of Salzburg. In addition to the steering group, two working groups were established to address the main issues of the project: the energy concept and the renovation.

Pilot Project Stadtwerk Lehen—Conclusions

A holistic approach to the modernization of communities offers a chance to integrate renewable energy into urban areas. The Stadtwerk Lehen project contains a number of aspects of a holistic approach: implementation of a sustainable urban development plan, new buildings and renovation, integration of solar energy in an urban district heating system, and instruments to implement optimized solutions and to initiate and steer the processes.

The construction of new building areas allows the integration of solar energy, even into urban areas. However, effort must always be made to optimize entire systems to achieve both ecological and economical benefits. To achieve further improvements, system optimization must consider ecological quality of both local electricity supply and district heating. New building areas can additionally give impetus to further improvements for existing surrounding neighborhoods. For example, modernization and renovation activities can improve the quality of life for a whole community; application of energy supply concepts to existing buildings by replacing old boilers can simultaneously yield ecological benefits. Nevertheless, the inclusion of existing building stock in development plans forces planners to consider such additional parameters as the following:

- figures about actual heat demand
- figures about expected heat demand after renovations/ modernizations
- schedule of renovation process

Furthermore, communities are often characterized by complex structures of ownership, each with different interests. It is highly relevant to devise optimized processes to coordinate such complex projects. Integrating energy planning into future urban planning processes needs more attention.

URBAN STRATEGY, CITY OF SALZBURG: DEFINITION OF MASTER PLAN AND ITS IMPLEMENTATION

The success of the Stadtwerk Lehen pilot project, combined with several other best practices, motivated the city of Salzburg to launch a stakeholder process in 2009–2010. Housing associations, utilities, research institutes, consulting organizations, nongovernmental organizations, and others participated to devise a vision for a "Smart City Salzburg" for 2050. Twenty-five sub-goals for 2020 and measures were defined based on these visions. For example, any increase in the renovation rate of a building sector up to 3% must be accompanied by a renovation strategy for the whole community. In line with the sub-goal of integrated planning, questions of energy supply and mobility are also addressed at the community scale.

In September 2012, the city council created a master plan, after which they established a coordination center within the city administration and installed a high-level steering group (the mayor, a councilman, and the managing utility director). The coordination center and steering group are in charge of implementation of the master plan. Figure 5 shows the organizational structure for implementation of the master plan.

An analysis of the existing building stock was done under the supervision of the Urban Planning Department to improve the energy standards for the building stock. The main objective of this activity was to identify areas with high potential for renovation on a community scale. The analysis considered thermal standards and energy supply, and also the complexity of the ownership structure criteria for building selection using a geographic information system (GIS) tool. Figure 6 shows GIS mapping of the potential for renovation at the community scale.

Based on this mapping, specific renovation projects are in discussion with owners (most of them social housing associations). The overall objective of this step is to identify win-win solutions that are acceptable to all involved parties and that

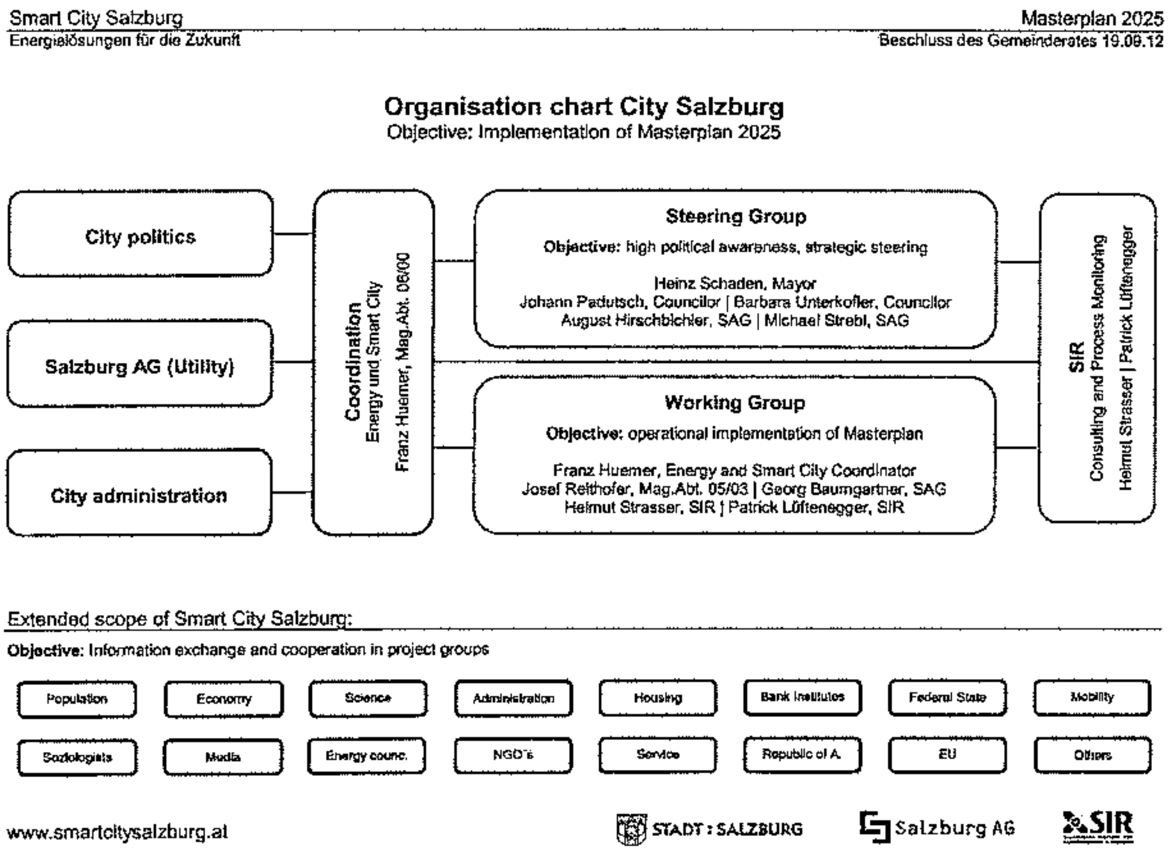

Figure 5 Organizational structure for implementation of the master plan.

Figure 6 Mapping of the potential for renovation at the community scale.

involve well-defined, achievable objectives. For example, housing associations commit to building improvement (thermal renovation, implementation of CO_2-neutral energy supply) while the city commits to improving other infrastructure elements (quality of green areas, connectivity to public transport, parking situation) and, under specified conditions, to discuss an increase in building density. Once the financial considerations have been clarified, the first planning activities have started in 2014. In total, 25 other measures (smart grid demonstrations, photovoltaic installations, PV for public transport, rent-a-bicycle, e-mobility, etc.) are underway, all under coordination by the city of Salzburg.

INTERNATIONAL RESEARCH ACTIVITIES: IEA-EBC ANNEX 63 "IMPLEMENTATION OF ENERGY STRATEGIES IN COMMUNITIES"

There is a growing awareness that urban strategies are especially relevant to successful energy and climate policies. Although IEA-EBC Annex 51 revealed many opportunities for community-scale energy optimization, there is still a need for a good methodology to broadly implement such optimization. One of the key findings highlighted by case studies was that there is an insufficient link between energy planning and urban planning. Optimized community energy strategies will only be successfully implemented when they are embedded in an urban strategy and urban planning framework. In particular, ongoing city developments should be one of the main drivers of energy optimization. Urban planning departments must identify win-

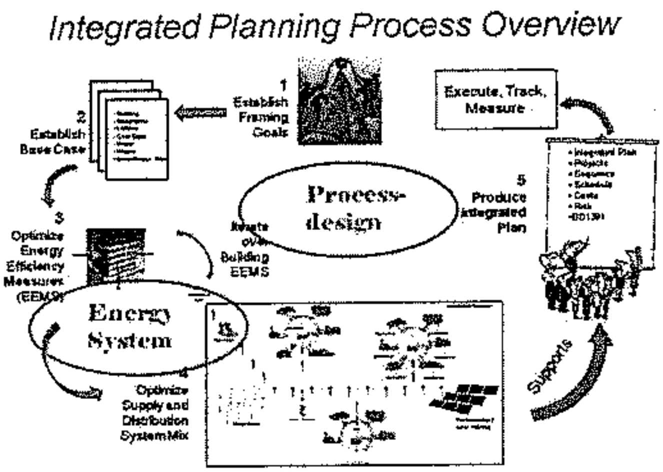

Figure 7 *Energy planning embedded in urban strategy.*

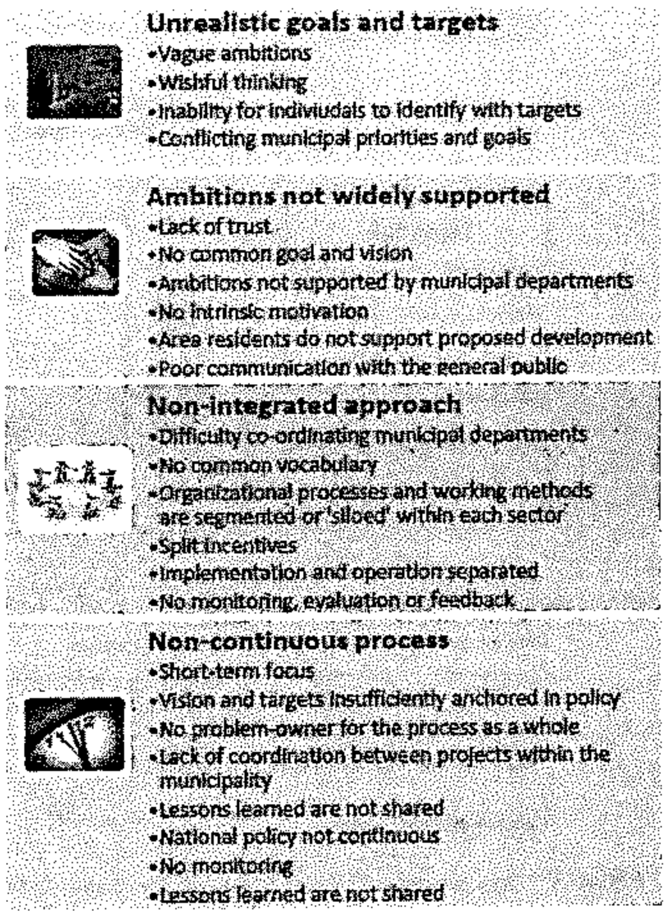

Figure 8 *Typical reasons for bottlenecks.*

win solutions that benefit the city, the building owners, and tenants to improve the existing building stock and to accelerate implementation of urban energy strategies. In all cases, implementation of energy technologies on a community scale must be in line with urban energy strategies (see Figure 7).

Research to improve energy technology is not enough; research must also focus on methodologies to improve the implementation of that technology. Once a city has made the decision to pursue ambitious energy and CO_2 emissions goals, it must do a bottleneck analysis to reveal the main criteria for success (see Figure 8), and it must derive a methodology to realize its concrete goals.

Since urban planners are one of the main target groups, the operation of Annex 63 (July 2014 to July 2017) emphasizes the involvement of cities. IEA-EBC Annex 63 will focus on the following:

- Development of recommendations for implementations of optimized energy strategies of communities.
- Methodology for effective translation of a city's energy/CO_2 goals to the community scale.
- Advancement and optimization of policy instruments for the integration of energy/CO_2 goals into common urban planning processes.
- New techniques for stakeholder cooperation along with holistic business models involving a wide range of stakeholders.
- Methods for monitoring and evaluation at the community scale.

SUMMARY AND DISCUSSION

National and international energy and climate policy requirements have stimulated increasing numbers of cities to introduce local policies on energy-related issues. How to achieve such policy goals is a separate issue. Certainly, the building sector is an important contributor to energy consumption and CO_2 emissions. While efforts on the scale of single buildings already show good results, the sum of individual optimized buildings does not necessarily lead to an optimized community; the translation to city-scale optimization is still missing. Synergies that accommodate different building uses, and additional options for energy production, energy supply, or mobility issues, as part of the energy system (e.g., storage capacity for electricity) may lead to many different optimized solutions.

IEA-EBC Annex 51 has shown that embedding energy issues into urban planning processes is one of the challenges for changing energy systems in cities. Lessons learned from the pilot projects indicate that urban strategies must integrate the planning and implementation of energy measures. Specifically, urban planning departments must be involved, since urban planning instruments and procedures play an important role.

Community-related projects require a multi-stakeholder approach. Urban planning departments must identify win-win solutions that benefit the city, the building owners, and tenants. Energy and urban planners must find a common language to set realistic goals, to define adapted inputs at the right time and the right scale within the planning process, and to consider co-benefits that mutually encourage the implementation of energy solutions. They must also consider systems for adequate evaluation and quality management of community-scale energy strategies. Pilot projects, such as those in Stadtwerk Lehen and Salzburg, have shown how complex issues can be resolved to achieve an optimized community with low primary energy demand and CO_2 emissions.

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