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Urban Time and Energy (UTE) – Time-Space-Energy Scenarios in Urban Areas

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1 ABSTRACT

The temporal map of a city – its fast and slow speeds, working and opening hours, the location of its businesses and its mobility infrastructure – is of major importance for the quality of life in a city. Several policy measures such as changing public transport intervals, transition to flexible working times, changing opening hours of public services, and spatial planning have changed and will change urban patterns of time use and have an effect on both the economic performance (synergies, production and consumption patterns, income, etc.) and the natural environment (energy flows). Time-use structure of household members (phenomena such as "time squeeze" and synchronization of activities of different persons), the energy demand of households and the spatial organisation of cities entail each other. In the 1970s first concepts appeared to integrate time aspects in regional sciences (Hägerstrand 1970). The demand for equal opportunities for men and women and for a better work-life balance marks the beginning of time policy in the 1980s, a young interdisciplinary field aiming to integrate time aspects in urban development planning and decision-making processes. Spatial planning plays a significant role in the design of time structures. The currently starting project UTE (urban time and energy) aims to gain a better insight into the drivers of time-use patterns and energy use by focusing on time-policy measures that consequently impact on energy and material consuming activities of urban households and on the necessary urban infrastructure. The project will base its assumptions on the case study of Vienna. An integrated socioecological simulation model will be developed to study the inter-linkages between time-use patterns in differently structured areas of the city of Vienna. Time-space-energy scenarios will highlight the potential of time-use structures for energy-use reduction.

2 INTRODUCTION

Several policy measures such as changing public transport intervals, transition to flexible working times, changing opening hours of public services and spatial planning have changed and will change urban patterns of time use and have an effect on both the economic performance (synergies, production and consumption patterns, income, etc.) and the natural environment (energy flows). Time-use structure of household members (phenomena such as "time squeeze" and synchronization of activities of different persons), the energy demand of households and the spatial organisation of cities entail each other. Reaching the goal of an activity faster requires more energy for the same achievement. Similarly, larger distances between locations of activities require either more time or more energy or both. "Time sovereignty", which is some freedom of choice over one's time use, is considered a key feature of quality of life. Available time – as much as available money – governs everyday decision making of household members concerning living space, consumption patterns and means of transportation. All of these activities are energy consuming (transport energy, heating/cooling energy, etc.). Consequently, lack of time often translates into spending more money and more energy, severely constraining individual and household choices.

The UTE project aims to gain a better insight into the drivers of time-use patterns and energy use by focusing on time-policy measures that consequently impact on energy and material consuming activities of urban households and on the necessary urban infrastructure. An integrated socio¬ecological simulation model will be developed to study the inter-linkages between time-use patterns in differently structured areas of the city of Vienna and urban energy consumption by addressing the following questions:

- Is there a link between time-use patterns in a city and urban energy flows?

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- How can time-policy measures in a city change quality of life, i. e. work-life balance, time-affluence, time-pressure, family life, educational situation, recreational situation and how do they affect energy consumption?
- Could an awareness of these interrelations help to improve spatial settings and infrastructures in cities, as a win-win connection between quality of life and energy savings?
- How can a socio-ecological model further our understanding of the interplay of socioeconomic and natural drivers (time-use patterns) influencing urban energy use?
- What is the potential of the developed simulation model to serve as decision support tool for municipalities, urban planners and traffic management?

Time-space-energy scenarios will highlight the potential of time-use structures for energy-use reduction. Model results concerning emission reduction potential will be critically challenged in order to take rebound effects into account. The project will elaborate basic principles for integrated systematic solutions in practice. This entails the following innovative conceptual as well as methodological development:

- Furthering our understanding of time-use patterns as drivers for energy use of urban households.
- Developing an integrated causal toy model capable of simulating changes in household energy use based on different time-use scenarios.
- Testing the applicability of the integrated model for one case study region in Vienna as a decision support tool time, space and energy.

3 TIME, SPACE AND ENERGY

3.1 Time-policy and Time-use research

Time policy and its research is a young interdisciplinary field aiming to integrate time aspects in urban development planning and decision-making processes. Beginning in the 1980s in Italy largely as a result of linking gender issues to urban planning and transport (Bonfiglioli, 2005; Bonfiglioli et al., 2000; Stadtgemeinde Bozen, 2006; Mairhuber, 2001), it also has a tradition in Germany (Henckel , 2000; Deutsche Gesellschaft für Zeitpolitik, 2003; Eberling and Henckel, 2001) and France (Boulin and Mückenberger, 2000). These studies address the question of how major changes in western industrialized societies over the past 50 years – i. e. the increase in female employment, the shift to a knowledge society and changes in production and consumption patterns (Post-Fordism, precarious work, internationalisation of labour) – lead to new patterns of time use, and how arising issues of time pressure and time conflicts can be addressed in terms of political measures concerning the times of a city (Läpple et al., 2010). A city's time map – its fast and slow speeds, working and opening hours, the locations of its businesses and its mobility infrastructure, which together set the pace for how its inhabitants move about in it – is of major importance for the temporal quality of city life and work (Mückenberger and Boulin, 2005; Kramer, 2005).

The project will draw on the international preliminary work and experiences gained from time-policy projects in Italy, Germany, France and the Netherlands. Vienna has recently launched an assessment of the potentials of communal time policy in a feasibility study (Mairhuber and Atzmüller, 2008). Similar to other international model projects, this study aimed at optimizing time issues in order to improve citizens' quality of life and their "time affluence". The relevance of such communal time policy for energy and resource consumption has not yet been researched.

In sustainability sciences, it is important to find indicators to assess quality of life and changes therein. Time-use is an integrative aspect of many facets of quality of life and is seen as helpful in its monitoring (Carlstein, 1981; Fischer-Kowalski and Schaffartzik, 2008; Mückenberger and Boulin, 2005; Moe, 1998; Garhammer, 2001; Garhammer, 2008; Mischau and Oechsle (eds.), 2005; Schaffer, 2007). The terms 'time scarcity' and 'time affluence' (Rinderspacher, 2002; Heitkötter, 2007; Kränzl Nagel and Beham, 2007; Schor, 2010a) are used to link economic and social factors and to find alternatives to a solely economic notion of growth and development (Sanne, 2002; Kasser and Sheldon, 2010; Graaf, 2003). Eurofound, the European Foundation for the Improvement of Living and Working Conditions, examines in its European Quality of Life Survey a range of issues, such as employment, income, education, housing, family, health, work-life balance, life satisfaction and perceived quality of society. "Having sufficient time to fulfil both professional and personal goals – raising children, caring for older relatives, maintaining social and family contacts – is a crucial element in determining a good quality of life. However, findings from the European Quality of Life Survey 2007 indicate that work–life balance remains an elusive goal for many working Europeans." (Eurofound, 2010, p. 3, see also Boulin, 2003).

A number of European nations conduct time-use surveys on a regular basis. These data are widely used to analyse changes in gender relations (Eurostat, 2003; Statistisches Bundesamt, 2004; Döge, 2006; Sellach et al., 2005; Bundesministerin für Frauen, 2010) and socioeconomic changes like family and household structures, working hours, recreational behaviour and consumption patterns (Schor, 2010b; Hartard et al., 2006; Stahmer and Schaffer, 2004; Gershuny, 2000). Statistics Austria finalized a new time-use survey for Austria in 2009 (Statistik Austria, 2009).

Linking sustainability research with time-use research is attaining some importance in socio-economic national accounting, in non-monetary input-output approaches (Stahmer et al., 2003; Schaffer, 2006; Minx and Baiocchi, 2010) and in other new attempts to strengthen socioeconomic features within sustainability discourse (Chiou, 2009; Vinz, 2005; Jalas, 2002; Jalas, 2008; Hayden and Shandra, 2009).

3.2 Time Structures and Urban Planning

First approaches to integrate time aspects in regional and geographical studies already appeared at the beginning of the 1970's. A central model was the space-time aquarium of Hägerstrand (1970). The movement of humans is demonstrated in a three-dimensional model, whereby the area is represented as two-dimensional map and the temporal dimension in the vertical Z-axis is supplemented. Range of movement and speed depend on outside factors and are subject to certain restrictions. Hägerstrand divides these restrictions in three categories: capability constraints, coupling constraints and authority constraints (Hägerstrand 1970, 12).

Contemporary models of urban architecture and spatial planning aim to align themselves again with the historical city. Knoflacher (2007) states a "space-time dimension on the human scale" in the historical city whereas the "new city" is oriented along a "space-time dimension for machines". Concepts of the "compact city" or the "city of short distances" are favoured in contrast to the inflexible, divided and homogenous use of spaces. In opposition to these efforts to counter large-scale expansion in area terms, land-use is constantly growing. A study by the University of Natural Resources and Life Sciences, Vienna, shows that in Austria 15 hectares of land are swallowed daily by construction and transport development (Weber, 2008). Along with the loss of land as an important future CO2 sink and source of energy and raw materials, the high ensuing costs (infrastructure costs for construction, maintenance, repair and renewal) and all further climate-related consequences of urbanisation (increase in individual motorised transport, expansion of additional traffic routes, great use of fossil energy sources, etc) are alarming.

3.3 Urban Energy Use

Departing from energy metabolism as crucial concept in assessing society-nature interaction and sustainable development (Haberl, 2001a; Haberl, 2001b) we focus on energy use. Urban energy use can best be understood from a demand perspective, not just for final energy forms, such as electricity or transportation

fuels, but for energy services (Lovins, 1976; Jochem et al., 2000). Each household and economic activity in urban areas can be interpreted as a demand for energy services, such as mobility (physical access to certain destinations and certain goods), ambient temperature (hotter or colder than the local climate), or working appliances (for home, office and industry, communications, etc). These urban energy services are common to most urban areas, but the energy consumed to provide them varies greatly. Household demand for energy services changes depending on several factors, which can be categorized as economic, demographic and behavioural.

The positive correlation of income and energy use has been long established in the traditional energy literature, especially in national level analyses. Energy use correlation with income has been measured for households in the Netherlands (Vringer and Blok, 1995), India (Pachauri and Spreng, 2002), Brazilian cities (Cohen et al., 2005), Denmark (Wier et al., 2001) and Japan (Lenzen et al., 2006), with similar results for GHG emissions in Australia (Dey et al., 2007) and CO2 emissions in the USA (Weber and Matthews, 2008). Urban dwellers consume energy directly, in their homes and vehicles, and indirectly, through the goods and services they purchase. Since urban incomes are often higher than the national average, by this metric alone, urban populations can be expected to consume more energy than non-urban populations.

Demographic factors such as population growth, household size, average household age and migration influence urban energy usage. Household size plays an important role in energy use: above 2 persons per household, economies of scale can reduce the energy consumed per capita. Urban populations may have significantly smaller household sizes than rural populations, due to smaller family sizes and a larger generation gap as well as smaller dwellings, and are thus less likely to shelter extended families or many generations under the same roof. The evidence for the influence of age is mixed. In Sydney, increasing age was correlated with higher residential energy consumption but lower transportation use (Lenzen et al., 2004). The most important effect of age may be through resulting changes in household sizes.

Behavioural or cultural factors clearly influence energy use: e. g. using a car, especially a big car or SUV, as a social status symbol, compared to using the bus or a bicycle. Individual behaviour and household decisions on dietary patterns, eating habits, preferred ways to spend leisure time and many others are surveyed in research on sustainable consumption and possible rebound effects (Kletzan et al., 2006; Duchin, 2005; Hertwich, 2005; Jackson, 2005; Bruckner, 2008; Binswanger, 2002; Sorrell and Dimitropoulos, 2008). Recent research on energy consumption and gender aspects (Räty and Carlsson-Kanyama, 2010; Carlsson-Kanyama and Linden, 2007), on household behaviour according to energy use (Linden et al., 2006; Duchin, 2003) and studies on individual mobility types (INFAS, 2002) and sustainable lifestyles (Graham et al., 2009; Sutcliffe et al., 2008) will supply valuable guidance for potential time-use and energy scenarios.

3.4 Urban Time and Energy Scenarios

UTE aims to explore the options for future development which depend on internal choices (of households) as well as on changes in the framework conditions, such as time-policy measures. Using the “magic triangle of sustainability” (Fischer-Kowalski et al., 1997) as the model concept and guide for this innovative approach, we try to link concepts and knowledge from different scientific disciplines and data from different accounting systems. The model analyses the decision-finding process of households according to their energy use (mostly transport and heating energy) using a ‘sustainability triangle’ (see Figure 1) in which each corner represents one of the core sustainability dimensions (social / ecological / economic dimension).

To apply this so-called ‘magic triangle of sustainability’ to households, the three dimensions are:

- Household energy consumption (ecological dimension)
- Income of household members and working situation (economic dimension)
- Household time-use pattern (social dimension)

Figure 1 shows these dimensions in their interdependencies on household level (Smetschka et al., 2009).

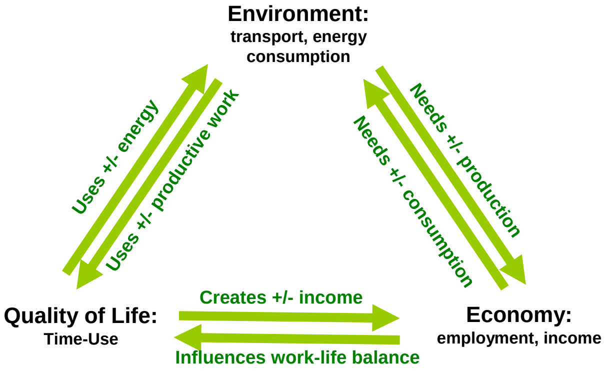

Fig. 1: Zooming in on the models’ “Magic triangle of sustainability”

In analysing changes in the use of energy in the city it is important to take into account that these changes are based on human decision making, occurring at a very local scale on a day-to-day basis. Recent developments in computational science allow for the application of numerical models for the systematic analysis and simulation of human decision making and its direct and indirect effects. Modelling such as agent-based modelling can be applied as a means for testing hypotheses about interrelations in complex human-environment systems (van der Leeuw, 2004, Lawrence et al., 2007, Liu et al., 2007) in cases where approaches limited to the analysis of social or biophysical parameters alone are insufficient. Moreover, model development provides a transdisciplinary platform for stakeholders and experts to communicate on an equal footing throughout the research process. Participation of this kind is described as key to enabling social actors or social systems to learn from, or be stimulated by, a research process (e. g., Hare and Pahl-Wostl, 2002, Pahl-Wostl, 2002), and represents a core methodology of sustainability science (Kates et al., 2001).

4 UTE APPROACH

4.1 Linking Time-use and Energy-use

UTE aims at studying the full cycle of time-use patterns in selected urban areas in the city of Vienna and energy use of households by focusing on decision-making processes of households in relation to their time-use strategies. The interlinkages between time use and energy use will be modelled for different household types (distinguished by socio-demographic and employment status) according to the actual data of the urban model area.

Existing scientific models mostly reflect theories and concepts developed within single disciplines and usually focus on ecological, social or economic aspects. Thus, to analyse socioecological systems and impacts of external drivers on these systems, the approaches of different disciplines are needed. Integrated modelling in terms of integrating different modelling approaches (agent-based, stock-flow, etc.) makes it possible to integrate social-science based approaches with concepts from the natural sciences (van der Leeuw 2004). The model presented here belongs to this new model type that can deal with local situations and aim to integrate biophysical issues (e. g., built infrastructure, energy supply) with socioeconomic factors (e. g., Time-use patterns, energy consumption).

4.2 Case Studies

4.2.1 Participatory modelling

An initial goal of UTE is to design an accompanying process throughout the whole project duration with iterative methodological elements such as qualitative partially structured interviews, workshops, explorative focus groups and national & international co-operations on the one hand. By using qualitative interviews with representatives of important stakeholder groups, UTE aims to generate first assumptions about time-use patterns and energy use. On the other hand, the collected qualitative information will be implemented in a simulation model. Consequently, those interviewed will gain systematic understanding of the time-policy relevant questions in their respective area of competence and work in correlation with energy use.

The study brings together insights from a range of diverse subjects, combining them to develop an interdisciplinary approach to analysing links between time-space and energy use such as:

- Local times and infrastructure (opening hours of municipal offices, public/private services and shops, hours of school and childcare facilities, etc.)
- Urban planning and development, urban renewal (distancedependent times, i. e. mixing of residential areas with social infrastructure, etc.)
- Transport and mobility (working hours, time schedules of public transportation, etc.)
- Buildings (energy services, household preferences)

It is in the interplay of these areas that the study will investigate in how far time-policy measures can result in added energy efficiency and altered energy consumption.

The developed model will build upon the first version of a residential location decision model developed for Vienna in the FP 7 project SUME (Sustainable Urban Metabolism in European cities, http://www.sume.at/). This model focuses on households and their residential location decisions in relation to their economic and demographic situation. Based on assumptions according to their internal structure (more or less family members, age, income situation) and external urban planning decisions changing infrastructure access in different areas in Vienna, households need or want to move to another place of residence. This provides an excellent starting point for our proposed model, as it already delivers a spatially explicit distribution of households in Vienna according to their socioeconomic situation. UTE will use this spatial model of Vienna and extend it with assumptions about time-use requirements of households and time-affecting services in urban areas. In order to structure and implement the decision-making process of each single household, the magic sustainability triangle will be applied (see Figure 2).

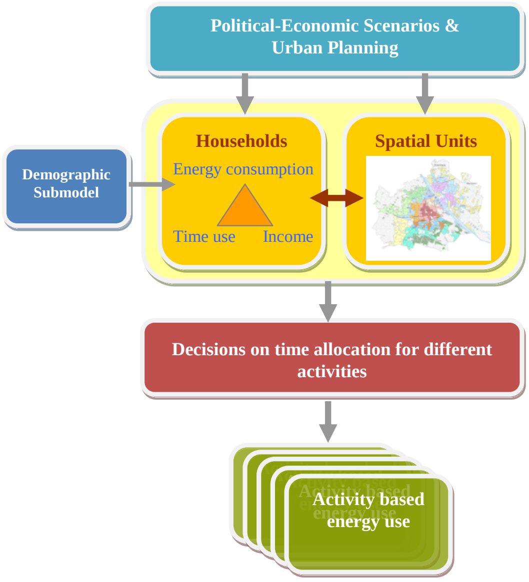

Fig. 2: Overview of the model concept

4.2.2 Implementation in different types of urban areas

An overall model concept will be adapted to different types of urban areas, such as urban renewal area, new urban residential area and urban development area (see Table 1).

	Urban renewal areas	New urban residential areas	Urban development areas
Urban Development structure	densely built-up area, traditional block perimeter development with narrow courtyards	five to seven-storey buildings, ribbon or block perimeter development	moderate building density, mixed structural types
Age of the buildings	up to 50 % built before 1918 (promoterism), numerous buildings from the inter- or post-war period	up to 60 % built after 1990	future planning
Location	inner city, centrally located, directly adjacent or close to the historic centre	periphery, suburban location	suburb
Land use types	small scale residential and commercial use	uniformly residential area	residential buildings, offices, commercial and educational institutions
Transport and mobility infrastructure	good public transport accessibility, restricted accessibility for private vehicles (narrow traffic lanes, restricted parking areas, congestions)	restricted access to public transport (limited number, intervals and directions), good accessibility for private vehicles	high-level public transport system, good accessibility for private vehicles but with restricted areas (pedestrian zones)
Social infrastructure and services	well-established infrastructure, short distances (walking distance)	limited social infrastructure and services (choice, long distances)	good infrastructure for everyday necessities (shops, restaurants, libraries...), moderate offer of educational and public institutions
Green and open space structure	barely parks and open spaces	parks or wide-open green spaces and wilderness areas in the immediate surroundings	parks or wide-open green spaces and wilderness areas in the immediate surroundings

Table 1: Description of the typical characteristics of the three urban areas for the toy models

After implementing the model and using the model results, future scenarios and policy measures developed in our case study, we will design a transfer process enabling us to learn more about the model. This will primarily enhance cooperation with stakeholders and people interested in applying the model.

5 RESULTS

The principal outcome of the project is a model-based integrated understanding of the interrelation between time use and energy use in a city. Time-space-energy scenarios will highlight the potential of time-use structures for energy-use reduction. The project's potential for successful application is to develop a decision support tool which can be used by stakeholders of communal administration, urban development and planning bodies in politics and civil society. This tool can trigger and guide time-policy measures of the city's administration and planning processes which integrate time policy, participatory processes and energy saving. One feature of the planned agent-based model is that it can easily be handled by users not belonging to the scientific community through an user-friendly interface. Given a participatory process, its graphic design will show the most interesting influencing factors for these actors as interactively changeable sliders. The realization of a commercially or politically useable model should be envisaged with industrial partners in a subsequent project.

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