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Integrating a land use transport model with a serious game for supporting planning decisions under rising energy prices

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Abstract

This article presents and evaluates the integration of a land-use and transport model with a political serious game. This methodological design was tested within a research project, which intended to assess the impacts of energy price increases in the metropolitan region of Hamburg. Models are tools commonly employed by planners to describe, explain and forecast land-use and transportation-related processes. However, the sole use of models has some major limitations. Models are not able to simulate the political decision-making process that can radically change outcomes and scenarios used for model forecasts. Particularly, models designed for facilitate long-run decisions at the strategic level can produce distorted outputs and scenarios if policies in response to major structural changes are not (well) assessed. Connecting a modeling framework to a qualitative experiment in an interactive way could enhance quality of supporting tools for planners and stakeholders dealing with complex issues. A serious game can contribute to enhance the quality of model input-data and, hence, to enhance the reliability of model outputs. By reporting the experience of the project "€LAN – Energy prices and land use" this paper contributes to expand the empirical knowledge on the potentials of employing serious games in the planning field. Within the research project, it could be observed that the use of the framework has helped decision-makers to gain a better understanding of complex problems, to deepen spatial policy integration, and to design innovative strategies coping with increasing energy prices.

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Keywords: Land use and transport model, energy prices, political serious game, planning policy

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1. Introduction

This paper aims to discuss to which degree the integration of a political serious game can overcome certain boundaries of conventional planning practices and contribute to improve the sustainability of decisions in the context of urban planning and policy making. The investigation is mainly based on results of the research project "€LAN – Energy prices and land use", which aims to simulate the impacts of steady increasing energy prices on land use and mobility patterns in the metropolitan region of Hamburg, Germany over a period of 20 years.

While the integrated model of €LAN simulates household decisions in various fields like labor market, housing market and transportation, the serious game involves representatives from politics and administrative bodies of the Hamburg metropolitan region to simulate the political course of action as reaction to rising energy prices. Model and serious game results are methodologically connected in an interactive way.

We expect that coupling a model with a serious game provides a planning-political "test field" which can enhance the appropriateness of model assumptions, the likelihood of generated scenarios and provide an overview on the modeled mobil.TUM012_Liueffects of the policies suggested by stakeholders, especially when complex issues – like energy-price increases, demographic changes or greenhouse gas emissions – are regarded.

The paper is structured as follows. After this introduction section 2 presents the €LAN research project and its methodology. Section 3 exposes briefly the reasoning behind the use of serious games in the planning context. Section 4 describes the setup, the structure and the dynamics of the €LAN serious game. Section 5 depicts and analyses the results achieved in the serious game. Finally, conclusions are drawn based on the results of the study.

2. The €LAN research project

2.1. Main questions and objectives

Mobility and housing – two crucial factors for land use – are narrowly connected with energy costs. Thus, energy price variations affect numerous planning fields and pressure private households for behavioral changes. For instance, travel mode and residence location choices are acknowledged as being directly linked to fuel and heating costs. But the consequences of new energy scenarios are expected to have much broader structural spatial consequences, influencing also the labor market, demographic developments and public finances.

Numerous studies have aimed to analyze the effects of energy price increases on private behavior through the estimation of the price elasticity of fuel consumption or other types of sensitivity tests (Anas and Hiramatsu, 2012; Hautzinger et al., 2004; Litman, 2013; Puller and Greening, 1999).

This issue has gained broad political attention since the oil price peak in 2008, when the price of the crude oil barrel exceeded the psychological level of US$ 100, which was for a long period thought to be an unrealistic price (see Fig. 1). In the Anglo-American context, concerns regarding the negative impacts of fuel and heating costs over private households have paved the way for the emergence of the concept "energy poverty" (Fahmy et al., 2011; Fahmy and Gordon, 2007; Guruswamy, 2011; Nussbaumer, 2012).

In Germany a non negligible share of private households spend about half of their net income for these two expenditure items. This issue has gained an increased political concern since the expenditure share for housing and mobility is expected to rise even more in the coming future with the growing demand of developing countries for energy and the simultaneous shortage in the world wide supply.

Funded by the German Ministry of Education and Research and carried by an academic consortium, the research project €LAN (Energy prices and land use) has been concerned with the impacts of rising energy prices on land use and mobility patterns, and how these impacts can be countered by policymakers in the metropolitan region of Hamburg, Germany. The main research questions of the project are:

- Which regions are particularly affected by rising energy costs?
- How will households react in the short and in the long run?
- How will politics respond to this situation?

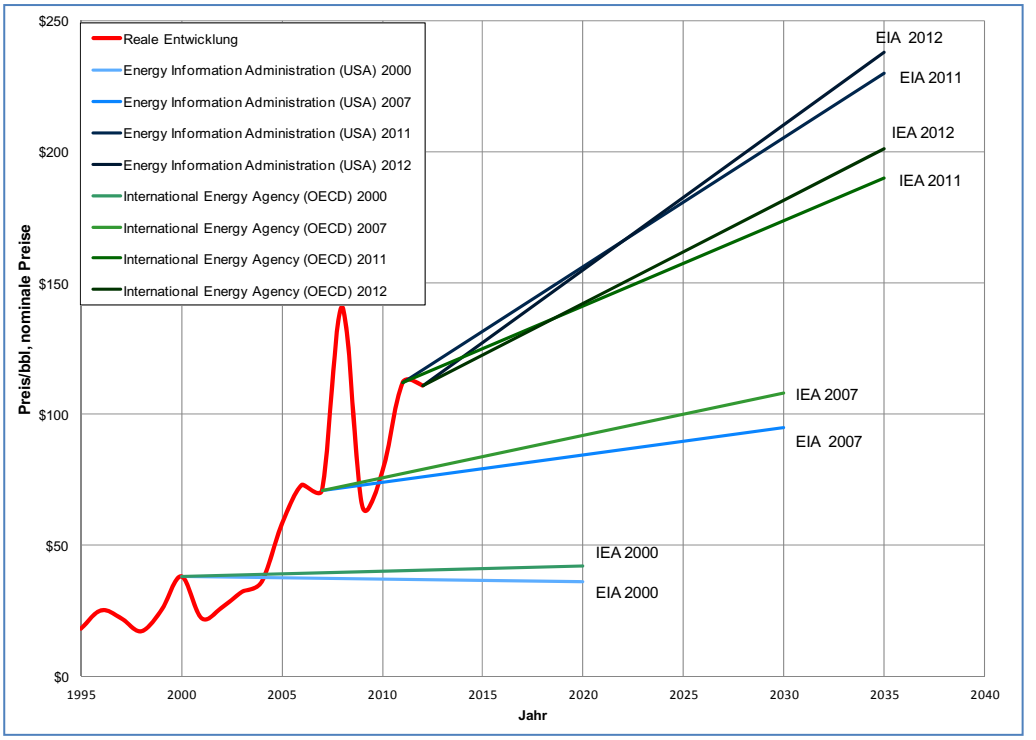

Fig. 1. Energy price forecasts and real development

Energy price increases may have different social and spatial impacts. On the one hand it can be expected that persons living in rural areas and outer suburbs built with low energy standards in the post-war period and with a poor accessibility by public transport will be particularly affected. On the other hand higher energy prices tend to increase the attractiveness of central areas. As a consequence the rent and real estate price gap between the central neighborhoods and surrounding areas enlarges. Low income households living in well accessible neighborhoods cannot afford these neighborhoods anymore and are forced to search for cheaper housing in the outer suburbs, having to spend more on heating and mobility, if they keep their usual activity pattern (Bohnet and Gertz, 2011).

2.2. Methodological framework: model and serious game

Based on intensive interdisciplinary cooperation, researchers developed an innovative approach consisting of an integrated land use and transport model coupled with a political serious game.

The simulation of land use and mobility pattern changes (both dependent on energy price levels) takes place in an integrated model over the period of the next two decades grounded on challenging energy scenarios. The €LAN model is a computer-based microsimulation framework that aims to simulate individual and household decisions taken by the population in the Metropolitan Region of Hamburg with regard to the fields of housing, mobility, land use, labor market, housing market, and demographics. It is assumed that the crude oil barrel – a reference for the energy prices for private consumption – will cost US$ 200 per barrel in the year 2015 and US$ 400 by 2025. Neither value has been yet reached, although the former is cited as a high value in the current specialized literature (Institut für Mobilitätsforschung, 2010). With this modeling tool, long- and short-term adaptive responses of households and businesses are quantified.

The reactions of decision-makers to rising energy prices are depicted within a political science experiment. Decision-makers representing their own local, state and federal level are invited for developing strategies for their administrative areas, which differ regarding their population sizes, economic structure and energy-related potential vulnerability. The simulation consisted of a series of moderated sessions that mapped the specific decision-making process within realistic financial frameworks. The decision-makers were faced with the high price scenarios generated by the model and asked to discuss options for action and to design adaptation strategies. From the developed strategies in the serious game concrete interventions were derived and modeled, affecting in turn the results of the next round model simulation. Together, both methodologies – the land use and transport model as well as the serious game – create an iterative structured simulation experiment depicted in Fig. 2.

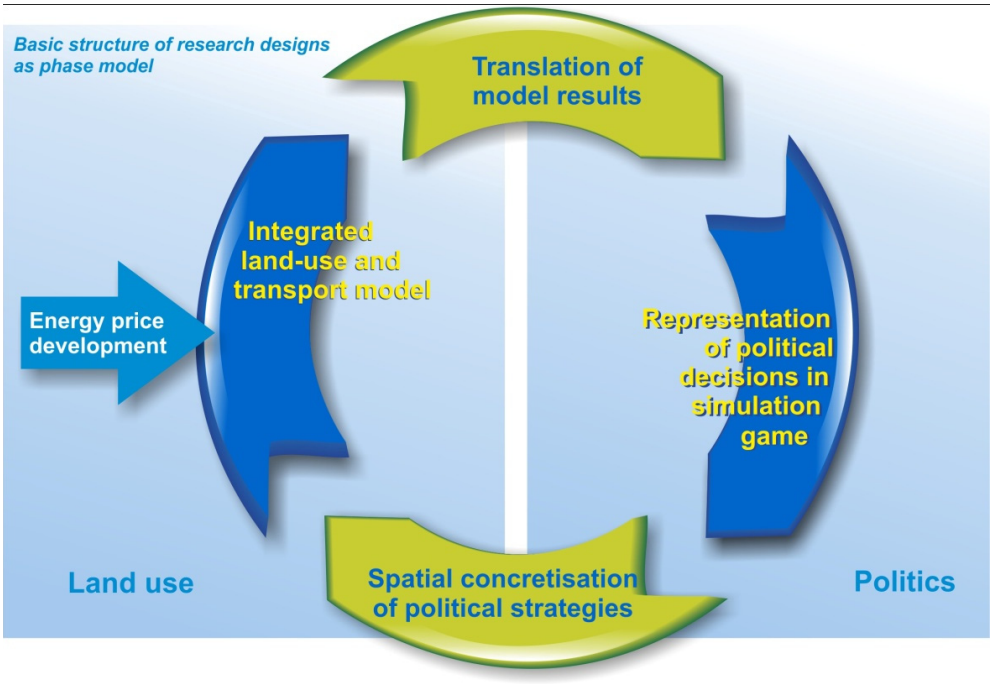

Fig. 2. Integration of model and serious game in the €LAN project

From a methodological point of view, the €LAN approach explores the interfaces between quantitative and qualitative planning methods. The reasoning behind the adoption of this research design is linked to following factors:

- the acknowledgement of the methodological limits of a pure quantitative framework by dealing with unique and extreme situations;
- the generation of more likely model scenarios through the direct participation of decision-makers already involved in the political process and with knowledge of the particularities of their own regions and administrative bodies;
- the possibility of identification of political reaction patterns through an appropriate selection of political representatives for the serious game.

3. Serious games in a changing planning context

The main motivation behind the use of a serious game together with a model within the €LAN project is the complexity of the energetic issue in planning, which affects many intervention fields and shall require an integrated response from policymakers.

In general, planning became a more complex task. Currently, planners deal with a number of interrelated issues with impacts distributed over different time ranges, spatial scales and different social groups. Furthermore, planning issues may be related to different stakeholders. Largely because of it, the planning process evolved into a more participatory approach and effective interventions increasingly require coordination and integration. In this context, it is recognized that complex problems cannot be dealt with routine procedures, but there is no consensus on the most appropriate planning technique. On the other hand, the space for trial-and-error experiments is for most challenging issues reduced, because of limited time and financial circumstances of most political stakeholders and because of the severity that certain social groups would be affected by the implementation of inadequate decisions.

A common way of coping with more complex planning issues is developing more complex mathematical models. Models are tools commonly employed by planners to describe, explain and forecast land-use and transportation-related processes. Models help planners to assess consequences of measures and to test scenarios that, for several reasons, cannot be experimented and compared in reality. Wider models were developed to support those processes being now more dimensional with more interdependent aspects. Planners needed the models to help decision-makers with the new complexity to visualize and forecast the outcome of certain planning decisions and also to involve the non-expert-public better in a participatory way. Decision-makers became more detached from the decision-making process in a way that they have to rely on the prediction and forecasts set by the planners and the "black-box"-model, which itself became more and more complex. Models remained therefore mostly a very important tool used by external experts to provide authorities with the needed expertise, whereas serious games as a qualitative approach are rarely seen in the decision-making process and remain mostly on the interactive side when it comes to exchanges between decision-makers and the public.

However, the use of models has some major limits. Besides boundaries broadly discussed in the literature (like those concerning model structure, transparency etc.) models are not able to simulate the political decision-making process that can radically change outcomes and scenarios used for model forecasts over a longer period of time. Particularly models designed for facilitate long-run decisions at the strategic level can produce distorted outputs and scenarios if policies in response to major structural changes are not (well) assessed.

Under growing complexity in planning issues, the need for external expert knowledge increases. Planners and especially the decision-makers cannot oversee all relevant dependencies and consequences that the once taken decision might have, especially not with all possible interdependencies in conflicting areas like for instance transport. Models can only predict from the data gathered and display the outcome over the desired time span but do not incorporate human decisions that can influence or completely alter the "setting" of a scenario on the way. Models alone can therefore support planning but lack the very important "human factor" of decision-makers and have thus only incomplete data to be on a more precise predictive level. On the other hand, planners are still viewed "as impediment for development and less as problem solver" (Gnest and Priebs, 2008). Therefore, additional methods or tools are required. €LAN employed serious games – a method which can help planners gaining the required skills to deal with complex problems and can generate a safe environment for testing and evaluating planning policies.

In essence, a simulation or a serious game can be defined as a method by which, under a set of rules, participants interact among themselves and take decisions. The game takes place in several rounds in different points over the 20-year-period and in each round participants are confronted with the consequences of the decisions taken before. Serious games were first used in Germany in the end of the 18th century. Until the 1950s, serious games were mainly employed as strategic war games. Over time, serious games were increasingly employed in education, social sciences, management and administration for training, teaching, consulting or evaluation purposes. Nevertheless, such simulation games are still rarely used as an active instrument in the planning process. They have been used for political consulting to enhance the skills of the participants as well as to support the decision-making processes

within the last 10 to 20 years (Böhret et al., 1997). Some of them are computer-supported simulation games, which allow for the systemic environment to be represented by a simulation model. Böhret et al. (1997) give a more detailed view on the types of serious game. Several serious games exist and have been used in political consulting over the last years and decades like the examples given by Herz and Blätte (2000) to support decision-makers.

4. The €LAN serious game

4.1. Setup and outline

An important initial step concerning the serious game regards the choice of its participants. The selection did not happen randomly, but considered relevant aspects according prior expectations of the research. Selected participants should be able to represent locations of various population sizes and density, with different social and economic structures and are situated across the metropolitan territory.

Moreover, they should be able to treat a very broad set of planning issues that would probably arise in the discussions, like they would in their daily work. The dynamics of the serious game should run well by itself and do not depend on external factors or circumstances. This condition has three direct consequences for the serious game setup:

- First, professionals with decision power or holding strategic positions in their organizations were preferred over professionals acting in lower hierarchical levels.
- Second, participants with a wide experience in different planning issues like housing, transport, environmental planning, regional planning, and strategic development were preferred over highly specialized professionals. The option for professionals with broader experience should also facilitate the finding of a common communication basis among all the participants.
- Third, given the political flows in the German federative system, regional and federal representatives should also be included in the serious game, since local participants could develop strategies which are dependent on financial support or conditions determined or influenced by higher administrative levels.

On the other side, the overall group size of the serious game should allow for a productive interchange of ideas and the development of strategies within the limited time of the various meetings during the project. In other words, the total number of participants should be restricted. Since it is a qualitative approach, it was not intended to generate a statistically valid sample among the decision-makers and administrative personal of the entire region in order to guarantee the viability of the serious game.

A key feature of serious games is that participants stay in their actual role and represent their own regional planning authority or institution in the field of administration or politics (Fig. 3). Moreover, the serious game rules allow only for realistic adaption strategies within their natural legal boundaries and financial constraints. A moderator (at best vastly familiar with planning and policy processes) coordinates the serious game sessions in order to enforce the mentioned constraints, to facilitate the communication flow and to ensure that each participant fills out her position for each scenario. For the project it was also crucial that the same participants partake throughout the entire project in order to ensure the continuity of policymaking and to control for individual-specific variations.

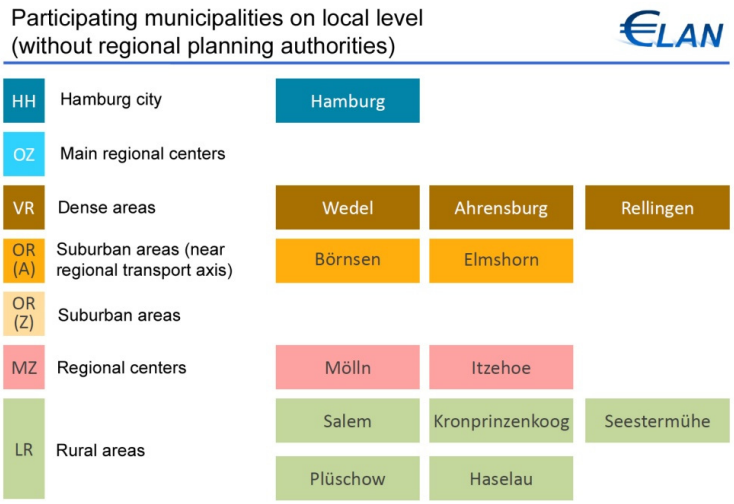

Fig. 3. Participating municipalities in €LAN in two corridors (without regional planning authorities)

Obviously, participant's scope of action varies depending on their status in the German federal level. But also participants of the same level may face different restrictions according to their local settings (for instance, conditions of a typical rural municipality differ from those of a central city).

Overall 13 and 12 representatives on the municipal level in two different corridors and 8 representatives on the federal and state level took part in the €LAN serious game, which outline is the following: First the municipal level is given their predicted socio-economic numbers in a model-based scenario with rising energy prices. To be able to better grasp the scenario on a professional and personal basis various tools are used. Participants were for one equipped with a regional planning report, similar to their usual reports, as well as media clippings gathering the "public voice", which were written and designed by a media professional based on the model data (Fig. 4).

Participants are asked to react to the scenario and develop a strategy consisting of various measures counteracting the effects of rising energy prices. Additionally they state requests for the government and federal level, concerning frameworks or legal settings formed by those levels, which need to be altered or reformed to cater their strategies. In the next step the federal and state level has to react to the same scenario developed by the model and the requests voiced by the municipality level. The measures and strategies developed by both levels are then "translated" and feed back into the model. The model generates a new scenario further into the future with the input from the serious game. This cycle is then repeated (see Maaß and Gertz, 2013). In this framework, there are reciprocal connections between the serious game and the model.

Fig. 4. Materials used within the serious game: media clippings and regional planning report

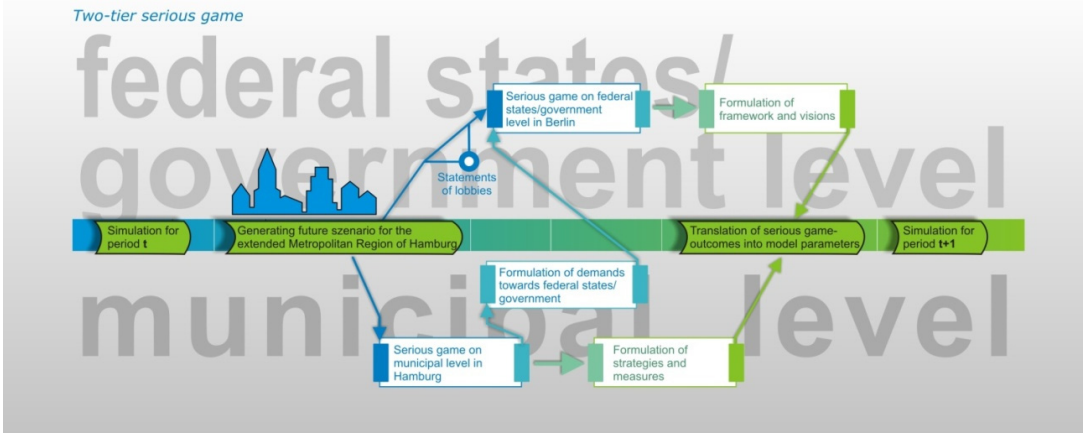

Fig. 5. €LAN serious game outline

4.2. Presenting model results

Adaptive responses of private households facing rising energy prices can occur in several forms in the short as well as in the long-term. Households could use cars more efficiently, choose alternative transport means, reduce the frequency of activities, consider location decisions, or even shorten other household budgets in order to adapt to the new situation (Fig. 6). Each decision-maker is allowed to take decisions according to this logic, whereby the fields marked in yellow are options not considered in the €LAN model.

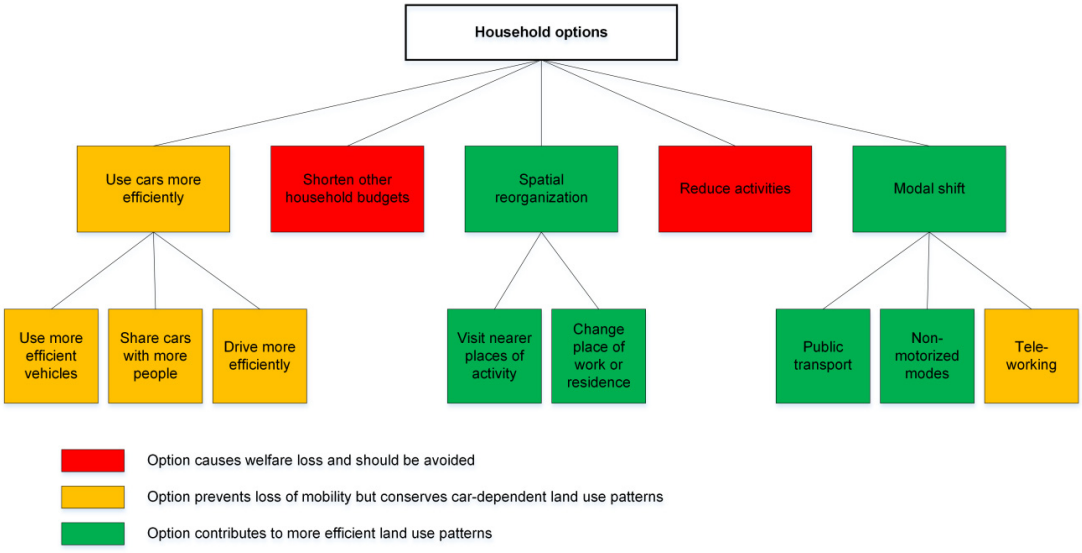

Fig. 6. Possible reactions of private households to rising oil prices

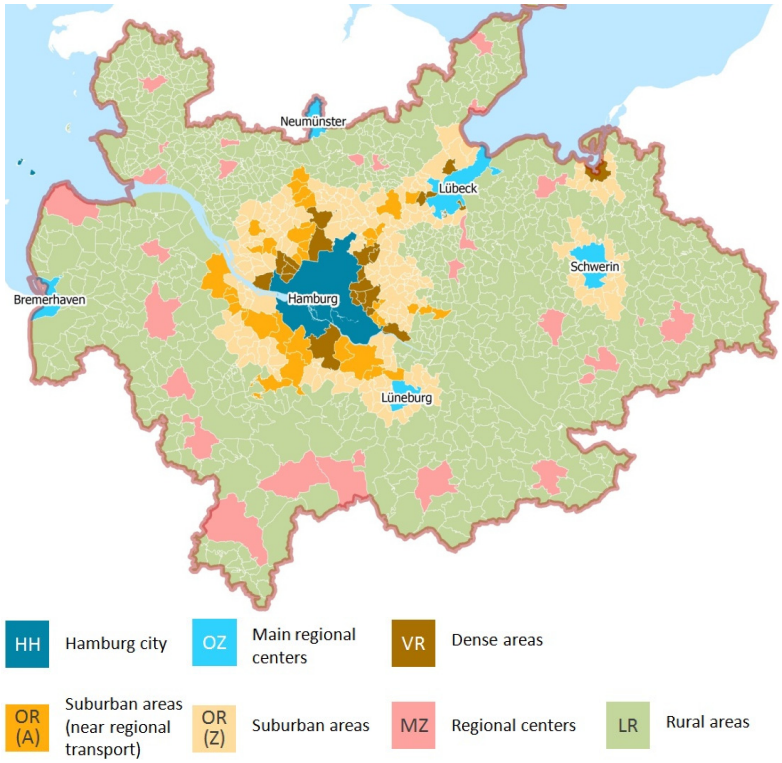

Fig. 7. Spatial typology of the study area of the research project €LAN

Aggregated impacts of increasing energy prices were presented to the serious game participants in form of a set of indicators grouped accordingly to an adequate spatial typology. Results were shown for the city of Hamburg, the group of five main cities in the region, the dense region around Hamburg, the suburban areas, the group of municipalities with central functions and the rural area, as displayed in Fig. 7.

In order to focus the discussion on the main results in the given time framework, results presentation was conceived in a simple way. Graphs depicting seven main developments calculated by the model and aggregated by region types were presented. These graphs covered: population development, employment variation, development of housing prices, of kilometers traveled, and of private expenditures for housing and mobility for three ordinary example households (family with four members, old couple and single parent). Multilayered maps as well as assertions of single municipalities were avoided to be able to discuss possible transferrable implications for the defined municipality types. This way of presenting model results was well accepted by the participants.

With scenario assumptions, indicators – which were then presented to serious game participants – show significant different development patterns for these spatial units and household types. For instance, while the population of the city of Hamburg and the surrounding densification area shall increase, it is expected that in the period 2015-2025 the number of inhabitants will drop by 13% and 20% in suburban and rural areas, respectively. In the same period, housing costs are expected to develop differently according to the region type and household structures.

Middle-income families with children will spend over 15% more to live in the core city, while housing in the rural areas will be about 15% cheaper. Families living in the main regional centers, which possess main urban facilities and infrastructures, will pay more for housing as well, in opposition to those living in geographically less influent regional centers.

Travel demand is also affected by the new scenarios. While the patronage of public transit is expected to stay at the same level of 2015, the number of kilometers traveled by car shall increase in suburbs and in rural areas. The increase of the mileage is accompanied with the amount spent for mobility. But, in general, middle-income families with children will spend between 60% and 80% of their income for housing and mobility. This share lays over 70% for low-income single parent households – a critical situation that will also be experienced by those living in Hamburg in 2025, fostering adaptive reactions and also future challenges for policy making.

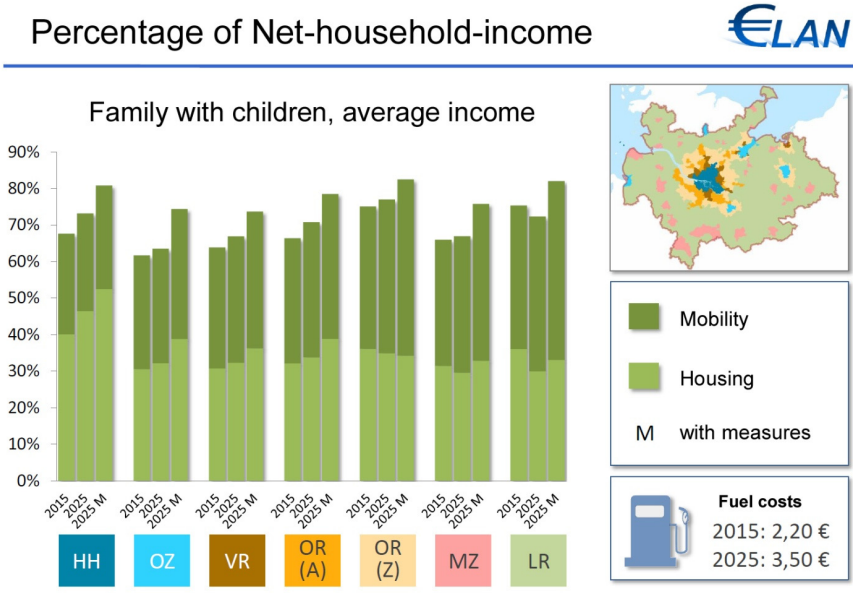

Fig. 8: Percentage of family income spent on combined housing and mobility in 2025

5. Results

In this section we provide a general overview on the results obtained within the serious game employed in the €LAN project. In each policy field a series of measures was suggested by the serious game participants in reaction to the presented scenarios which take in account different energy price levels. Some of the intervention fields and the measures proposed by the stakeholders are:

- housing and land use (e.g. promotion of higher energetic standards for existing housing for every type of municipality, new housing only in central municipal locations or along the rail network),
- social and technical infrastructure (e.g. bundling of public services in one place, more internet based public services, improvement of child and other daycare facilities, broadband internet in rural areas),
- transport policy (expansion of the rail network, ride sharing in rural areas, innovative solutions for freight and public transport),
- energy and environmental policy (energy advice services for private households, organization of local/regional energy markets).

It is not straightforward for the discussion to present here a detailed list of all suggested policies and strategies, but rather to present the main directions according to the different regional types. The most strategies were considered appropriate only for part of the region. That is very clear in the field of transport policies: Where big cities and regional centers emphasize the capacity improvement of existing public transport systems, the focus of middle and little municipalities tend to lay on the supply of alternative transport services and on the upholding of the rudimental existing transport systems.

A full report of all suggested policies in the serious game rounds would take us beyond the purposes of this article. But the main directions of the strategies developed by the simulation game participants are following: Rural areas, which do not benefit from a well-developed infrastructure, rely more on strategies promising the highest self-sufficiency regarding the supply of infrastructures in order to avoid high population losses. To counter the tendency of public services dying away in rural areas due to population losses, accumulation of public services in one single site or to provide better broadband services to cut overall journey numbers for inhabitants and save fuel costs seems to be the main emphasis. Tendencies to become more self-sufficient in services and energy consumption may lead to an unsustainable competition between the municipalities themselves.

Regional center representatives identify opportunities by activating the local real estate market and by expanding transport infrastructure (connecting themselves better to areas with high job opportunity supplies like Hamburg), as reactions to the significant surplus of possible inhabitants that these cities experience under rising energy prices from the surrounding more rural areas.

Central or major cities face rising attractiveness due to shorter ways between workplaces and domicile areas. Skyrocketing housing prices as well as capacity restraints on the public transport network are the identified crucial areas of concern and also the most expensive fields to adjust.

For reasons like the abstraction degree or limits of the modeling framework, not all the recommended policies could be translated into the model. Several proposals were developed within the meetings in a very generic way (e.g. “promotion of higher energetic standards for housing”). Some of them could be formulated more precisely through a questionnaire fulfilled by the participants. Other mentioned policy options had to be discarded because their mathematical representation would require a disproportional development effort (e.g. “social commitment and more voluntary work”). The participants accepted these points to be omitted in the model.

Another acknowledged problem was related to the degree of spatial generalization of policies in the model. This question is linked to the fact that the sample of serious game participants does not represent the universe of decision-makers in the entire region. Consistent to that, the measures proposed by them are not necessarily the same measures that all other decision-makers (of a certain region type) would support. In addition to existing numbers, some assumptions based on attributes of the participating municipality types and the representation and situation in the

whole survey area of €LAN had to be made to translate and convert e.g. the development of "bioenergy villages" for the whole metropolitan region of Hamburg.

With the data provided and then translated into the model, scenarios for the next simulation period were generated. As discussed before, scenarios were defined by a set of key indicators. The impacts of single policies (recommended by the participants) on each indicator were not assessed. For the participating municipalities it became apparent in the experiment that the frameworks set by federal and state governments will not change significantly up to € 3 per liter fuel consumer price. It follows that the current political pattern is unlikely to change even with a doubling in current energy prices.

Most important point is the observation for the participants that despite the measures developed in the context of one's own possibilities to counter the negative effects of rising energy prices, measures are often unlikely to dampen the effects by themselves alone.

In consequence, especially inter-municipal cooperation aiming for regional sustainable results can lead to positive results. Especially coupled with strategies on demographic change or the reduction of emissions, the developed measures can provide synergies. However, the high costs of this consultation and negotiation processes to achieve such inter-municipal cooperation schemes require new approaches in planning practice.

The answer to the question how municipalities, states and the federal government should handle rising energy prices cannot be generically answered. But based on the project results some possible outcomes can be asserted:

- **Knowledge exchange and problem understanding:** The possibility to meet and to exchange ideas with municipal representatives from different structural contexts was stated by all participants to be very beneficial. The exchange between the participants was an important step to alleviate the information asymmetry among them. Hearing about problems and possibilities of other municipalities concerning rising energy prices was considered to be a value for itself.
- **Awareness building for complex problems:** Based on scenario analysis, municipalities discovered how and to what extend rising energy prices can affect their own administrative areas. As public budgets are set under enormous pressure, there will be an even higher need to explore integrated solutions in the fields of transport, housing, social policies, etc. Some possible synergies with other topics of major importance in the long-run like demographic and climate change were recognized as complex but very important to address in the future. Differences as well as similarities in terms of vulnerabilities between different types of municipalities (e.g. urban and rural municipality) were acknowledged.
- **Room for new ideas:** In the day to day business of the serious game participants there is barely room for testing innovative approaches and to discuss problems related to transversal planning issues like the impacts of energy price increases. The participants of the serious game appreciated the possibility to come up with new ideas, to try out strategies and to get direct and open feedback from their colleagues. Some municipalities even did bring some of the approaches or ideas back into their institutional meetings and peer groups.
- **Acknowledgement of limits of own actions and cooperation building:** One finding was that not only neighboring communities could profit from cooperation schemes, but unconventional alliances between small rural municipalities, cities and the corresponding district authority could be very promising by tackling concrete planning issues or for strategy formulations. Where small communities are not able to implement certain measures by themselves alone, which might also be beneficial for other municipalities, an alliance could bring the desired outcome. The current planning law can in this context be seen as counterproductive. Every municipality is to seek the best possible standing for itself, which stifles cooperation efforts between neighboring communities and or district authorities in their beginnings.
- **The role of the federal government:** One of the main findings is that the developed strategies and considered measures within the serious game might not be able to counter rising energy prices when exceeding 2.20 EUR per liter (at US$ 200 per barrel crude oil). Without the support of higher governmental levels (i.e. the federal or the state level), municipalities might experience severe difficulties for providing services and infrastructures for their citizens under rising energy prices. It was therefore clear that the federal government would need to play a more active role, if energy prices sharply increase.

The results obtained by the €LAN research project suggest that a planning-political design consisting of a model and a serious game could also be helpful for decision-makers at the local and regional level in dealing with other long-run complex questions to get an idea of how their actions might influence future developments. The scarcity of financial resources faced by many municipalities, and in particular the lack of knowledge on the potential of cooperation for dealing with multidimensional consequences of a complex question, are the main motivations for supporting the introduction of innovative approaches.

The integration of a serious game in the usual policymaking could be positive in the sense of guaranteeing a privileged discussion space for the exchange and the preparation of thematically as well as regionally coordinated decisions concerning strategic long-run planning issues (for instance, structural demographic changes or mitigation of global warming). The serious game should not replace current decision-making practices, but provide an interface with different stakeholders, fostering cooperation and the knowledge gain on underlying social, economic and political trends.

The joint use of an integrated model and serious game may enhance decision-making quality but is associated with a restructuration of current administrative practices. Applying this design in practice may confront a consolidated planning culture and challenge legally established administrative competences as well as the strict labor division between planning and decision-makers inside administrative bodies. How to overcome such resistances was not explored by the €LAN project and may be an issue to be assessed in future research projects.

Most benefits of the serious game could be created, if this arrangement would be allowed to produce results for decision makers respectively planning practice itself, which are binding. Otherwise, political decisions are prone to be taken in the conventional way. The implementation of a planning-political design might imply a rethinking of current ways of decision-making processes.

6. Conclusions

In this article, we presented a planning supportive design which combines a quantitative simulation tool – an integrated land use and transport model – with a qualitative one – a serious game – employed within a research project in order to assess impacts of energy price increases and related policy options. The qualities of this unconventional research design shall be assessed carefully (a) since the methodology was not tested against an alternative setup, (b) since the inputs from the serious game are unique and cannot be repeated as in laboratory conditions and (c) because of the risks of making general assertions based on a single experiment. However, some advantages of employing this research design can be highlighted.

The involvement of politic actors can deliver a realistic basis for model inputs in each simulation round and for the scenario building than that provided by a restricted research team. A serious game can contribute to enhance the quality of model input-data and, hence, to enhance the reliability of model outputs. Of course, quantity and quality of inputs from serious game participants depend on the setup of the game itself (selection of participants, moderation, materials, rules of the game etc.).

This design also allows assessing probable interactions and interdependencies between different actors. Since local solutions do not considerably alleviate the negative consequences of extreme energy price increases, the project suggests that inter-municipal cooperation schemes will gain considerably importance with the energy price increases or other complex challenges. This is especially true for deepening urban-rural relationships. This result challenges an historical trend by which municipalities compete for resources and cooperate only within very specific, target-oriented projects. Therefore, the function of the serious game as a transversal, trans-disciplinary and non-hierarchical communication platform and as a “test field” should not be underestimated.

In general, €LAN showed that the joint use of a model and a serious game could enhance the quality of decision-making with regard to a better understanding of complex problems, to a deeper spatial policy integration, and to the potential of generation of innovative solutions.

Several participants of the serious game highlighted the importance of the exchange between different planning authorities and bodies at the search for efficient answers for the situations generated by increasing energy prices.

The "test field" generated by the joint use of an integrated model and a serious game in the scope is very appreciated but so far there is no formal structure or guideline how to incorporate the idea in the common planning practice.

It is still necessary to analyze the adequacy of the employed model design with its input data, level of complexity and indicators (or of other supporting instruments) for a satisfactory development of the serious game.

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