Extension of the Social MARKAL Concept to Residential Heating in TIMES Romania Country Model

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Reference
EXTENSION OF THE SOCIAL MARKAL CONCEPT TO RESIDENTIAL HEATING IN TIMES ROMANIA COUNTRY MODEL

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1. INTRODUCTION

Unlike the predictive models whose aim is to provide an insight on possible future evolution of the global demand, optimisation models are used to find the optimal investment path into technologies, while minimising the global cost of the entire energy system with all the investment, operation, maintenance costs as well as the cost of energy carriers used, and while all the useful demands are satisfied, for a given evolution of the demands, energy prices and technology costs. One such model called MARKAL [1], [2] developed since early seventies under the aegis of the International Energy Agency, has over decades evolved into an integrated tool to assess the optimal investment in the energy sector with more and more applications bringing additional constraints, be they technological, economical or political, such as greenhouse gases emissions. Recently, a successor model generator appeared, called TIMES [3].

2. INCLUDING CONSUMER BEHAVIOUR CHANGE INTO COMPETITION WITH TECHNOLOGY PROGRESS

Based on neo-classical premises, a classical MARKAL model is supply-oriented where the energy production is optimised to satisfy a given demand for energy services. However, the demand side becomes important when the scope of the model is reduced from global or country level to regional or community level, or when the model is deliberately oriented toward demand side management (DSM) measures. In these cases, the consumer behaviour becomes an issue because the key assumptions of the model, such as perfect information and perfect economic rationality, are no more satisfied. Consumers are making frequent investment choices on small amounts based on a certain number of non-economic criteria. For example, even if the optimisation model forces an immediate abandon of old incandescent bulbs because of higher global cost of their use, in the real world, people are continuing to buy them until a complete administrative ban on their sales. In case of passenger cars or household appliances, the dominant criterion for the acquisition may be entirely extra-economic, such as design or colour of the vehicle. A further cause of over-consuming energy is then the driver's behaviour. Often, seeking pleasure is the primary reason for driving, which behaviour obliterates all the assumptions of economic rationality. In case of residential heating, irrational behaviour is concentrated more on the user's operating mode than on the building's technology.

In order to eliminate the systematic error that results from extrapolation of the model parameters beyond their initial domain of validity, real consumer behaviour can be measured using special-crafted sociological surveys to extract technical coefficients for the optimisation model. The basic modelling approach for the case of residential lighting in MARKAL Nyon city model is described in [4] and [5], a description how to get from sociological surveys to MARKAL coefficients in [6] and mathematical aspects in [7]. The principle is to define three classes of consumers. First, the part of people behaving rationally. The assumption of a model based on the concept of a market equilibrium is that 100% of
people are rational, however in the real life this parameter is much smaller and can be measured using a sociological survey. Then, another part of people who do not behave rationally because they lack the information but, if better informed, they will either save energy or invest into technology switch. Last part of people will not change their behaviour regardless of the cost because they have extra-economic reasons to keep their habits. Only an administrative ban on sales can oblige them to adopt the new technology [6].

Another possible approach to address behavioural issues is to use a combined top-down bottom-up and discrete choice simulation model called CIMS [10] or to use a hybrid simulation-optimisation model where a discrete choice simulation in form of nested multinomial logit model is used as input to a TIMES model [11].

3. FROM RESIDENTIAL LIGHTING TO BUILDINGS HEATING

Nyon, a small city half-way between Geneva and Lausanne, has a very simple Reference Energy System (RES). There is no extraction and no transformation of the energy so all the energy agents are imported in form of final energies and directly consumed in demand devices to produce useful demands, energy services. In case of residential lighting, the only energy agent used to satisfy the demand is electricity. The resulting RES shown in Figure 1 is very simple and well suited to show the concept. In addition to two tangible technologies, incandescent bulbs and low-consumption bulbs, there are two virtual technologies representing the information-triggered moderate use and technology switch. The cost of behaviour change itself is zero, but the upstream information campaign has a non-zero investment cost and has to be considered as lumped investment. In [5], it is shown that these two types of virtual technologies are covering all the possible cases.

![Figure 1. Reference Energy System for MARKAL Nyon city Residential Lighting Demand, from [1].](image-url)
The case of residential heating is not as simple. There may be more possible energy agents capable to satisfy the useful demand and more types of demand devices, some with multiple input (switchable oil/natural gas heating bodies) or output (co-generators producing heat and electricity). There also is a discrepancy in attitude toward investment and use of the buildings.

Decision makers may be different when it comes to the building's envelope, the heating technology and, of course, the thermal behaviour of inhabitants. This discrepancy is bigger in presence of a dichotomy of interests between owners and tenants than in case of a single owner who is living in his own house and bears all the consequences of his decisions, i.e. whether to invest in the thermal properties of the building, or to pay for the higher energy consumption. In table 1, we see that people are more willing to save energy if the energy form is visible than when it is invisible.

<table>
<thead>
<tr>
<th></th>
<th>Part of people trying to save resources</th>
<th>Part of people not trying to save resources</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>97.8 %</td>
<td>2.2 %</td>
<td>100 %</td>
</tr>
<tr>
<td>Heat</td>
<td>86.4 %</td>
<td>13.6 %</td>
<td>100 %</td>
</tr>
<tr>
<td>Electricity</td>
<td>98.1 %</td>
<td>1.9 %</td>
<td>100 %</td>
</tr>
</tbody>
</table>

Table 1. People more frequently admit to have no particular reflex to save heat than for water or electricity. Data from sociological survey conducted from September 2011 through January 2012 in Geneva region by LEM, Laboratoire des Etudes de Marché at Hautes Etudes de Gestion de Genève.

In the transition economies, there are additional barriers to take into account, such as limited access to investment capital in an undercapitalised society, survival behaviour of economic agents preferring a short-term optimisation horizon, and a general attitude of people who do not believe that their living conditions can be changed by their own action, leading to passivity in investment and an inertia in over-consuming energy.

In order the modeller to be able to assess different sets of decision possibilities available to different decision makers, the tangible technology, residential buildings, can be described as a union of three distinct virtual technologies: building's envelope, heating system and consumer's behaviour, each with a certain number of discrete decision choices. Investment choices for the building's envelope will put into competition the building's envelope (walls, windows, roof, cellar) before the renovation and after the thermal renovation when the decision is without perfect information and economic rationality, with an additional possibility of triggering more renovations through information campaign, but also other actions such as making easier the access to investment capital. It is reasonable to set up an additional set of technological constraints such as no heating system renovation without renovating the envelope first, or no window renovation without thermal isolation of the walls.

The complete situation for the case of buildings can be schematically drawn as follows (see on Fig. 3). Technology switch can occur for virtual technologies of envelope and for heating system. For virtual technology of inhabitants' behaviour, the alternative is a moderate use of energy. Information is not the only possibility to trigger an action. It can also be an energy
price change beyond the perception limit that modifies consumer's behaviour. These parameters still have to be evaluated by a series of sociological surveys in Romania. Currently, the Social TIMES Romania model consists of three demand sectors: residential, transportation and others, while all the supply side is modelled through virtual energy imports within a time frame 2010 through 2026 with the aim to systematically cover the entire demand side.

Figure 2. Aggregated block diagram RES to describe a tangible technology (Residential Building) through three virtual technologies (Envelope, Heating System, Behaviour), interconnected with virtual energy flows.

4. CONCLUSIONS

The Social MARKAL approach can be extended to demand technologies beyond lighting, as shown in this example for residential heating, but also to the transportation sector. Of course, the modeller has to take into account the case's specificities. The approach can be implemented regardless of the scope (city or country model) and of the tool used (MARKAL or TIMES). In both cases, it may contribute to better management of residential buildings.

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