DIGITAL ENERGY TRANSITION: DIFFUSION OF NEW SOCIAL PRACTICES AND THEIR IMPACT ON THE ENERGY SYSTEM

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Overview

The last decade has seen an exponential growth of the adoption of information and communication technologies (ICTs). ICTs have the potential to reduce the energy consumption, increase the efficiency and substitute physical products with digital product(s), but rebound effects related to their use can lead to increased energy demand [1]. To understand the disruption effect of ICTs in energy sectors and their positive or negative effect on energy consumption, the starting point is their diffusion in the households' daily activities (social practices): a household is gradually turned into a digital actor (e-actor). For example, the "home office" practice that is increasingly replacing the conventional practice of "commuting", is directly linked to the diffusion of ICTs and it has an indirect effect on the transport demand, in the energy consumption in the residential sector and in e.g., services sectors (figure 1). Several studies apply empirical research to assess the change in social practices due to the integration of ICTs. However, the assessment of how the practices will evolve in the future and the quantification of their direct and indirect impacts on the whole energy system has not performed in a consistent and integrated way yet. This paper aims at providing a methodology to fill this research gap, by introducing an agent-based model to: a) simulate the adoption and spread of new practices related to ICTs, starting from the ones currently performed by households; and b) to identify future trends and related direct and indirect energy impacts on other sectors. The model is linked to an energy system model based on the TIMES modelling framework of IEA-ETSAP [2], which minimizes the total energy system cost and provides energy flows, investments on technologies and environmental indicators, in order to quantify the implications for the whole energy system and provide insights for policymakers. The methodology is applied to the case study of Switzerland, that is ranked 5th in the IMD World Digital Competitiveness in 2019 and where the planned phase out from nuclear energy requires the exploration of sector coupling strategies and a deep understanding of the citizens' role in achieving long-terms energy goals. The methodology can be adapted to other countries as well.

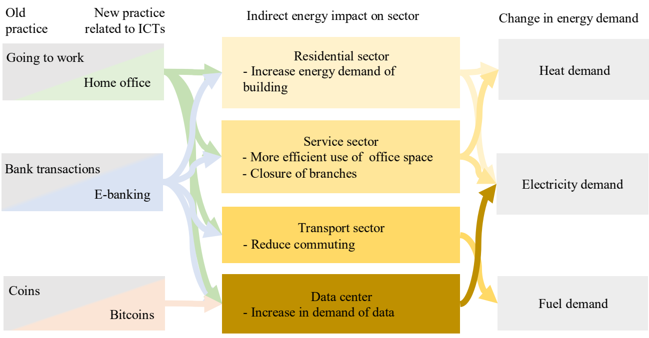

Figure 1. Example of the indirect impact of social practices related to ICTs on different energy sectors.

Methods

The use of ICTs in daily activities (social practices) requires the acquisition of "new skills" (how to use a technology to perform a practice) and "new meanings" (why to choose this technology from a pool of alternative ones): using a laptop (new skills and material) for working introduces the "new meaning" of the mobile office. To analyse the decision process that leads to exercising a particular social practice we develop the DISPEC (DIgital-based Social Practices' Energy Consumption) agent-based model. The proof-of-concept, described in Balke [3], is expanded and developed in our model by introducing different types of agent-decision-makers that influence a particular sector. For example, households' decisions influence the residential sector, while office managers' decisions affect the service sector. The agents are characterized by a set of meanings, such as cost, comfort or environment, with the value of each meaning reflecting its importance to the agent. The agent's decision process considers these values to assess which practice is likely to be performed [4] (see also Figure 2, A). To consider the complexity of information spread in a digital society, the common approach of only developing a physical social network of agents' interactions is not enough. In DISPEC, a second "virtual" network of social interaction is introduced to simulate the impact of ICTs on the diffusion of information. The learning process due to interaction and the related change in the meaning values are different between the two networks, depending on agent's social-relationships-attributes, on its skills in using ICTs and on its level of trust on the information's source. (fig.2, B). The influence in the decision process that an agent exercises on others in the real world is modelled in DISPEC with different mechanisms of interaction. Between agents of the same type, a gradual change in the agent's meanings is the result of a shared-influence mechanism. A forced-influence mechanism occurs between agents of different type, leading to an immediate change of the meanings of one of the agent involved (e.g. when in an office more than two-thirds of the employees do home office, then the office could "force" the rest of its employees to also do home office to reduce operating costs). The main outputs of the ABM are the shares of the practices and the consequent impacts on energy demands. The latter are used as input to the energy system model to study the effects on the whole energy sector (fig.2, D). Compared to other technology-choice oriented ABMs, DISPEC assesses the decision process for exercising an activity and how the surrounding environment influences that decision, analysing the technology choice in a second phase.

Thus, we split the decision factors of the social practice theory between the energy and the agent-based models: meaning and skills are introduced in DISPEC, while the material choice is done in TIMES. For each material the DISPEC passes to TIMES an average meaning value as a social cost (fig.2, C), which is used to couple the models: the social costs considers the willingness of agents to adopt a specific material which will be used in a given practice. The interaction of the two models closes by having the penetration of new materials in TIMES to be used for introducing new meanings and new practices in DISPEC (fig.2, red arrows). Via its coupling with DISPEC, the TIMES-based energy system model analyses the effects on the overall energy system (fig.2, E), including the energy supply and use, that are arising from the introduction of ICTs in a digitalized society. Societal, energy and climate policy scenarios are defined in DISPEC by altering the meanings values of agents, and in TIMES by introducing taxes, subsidies and other efficiency or climate target constraints.

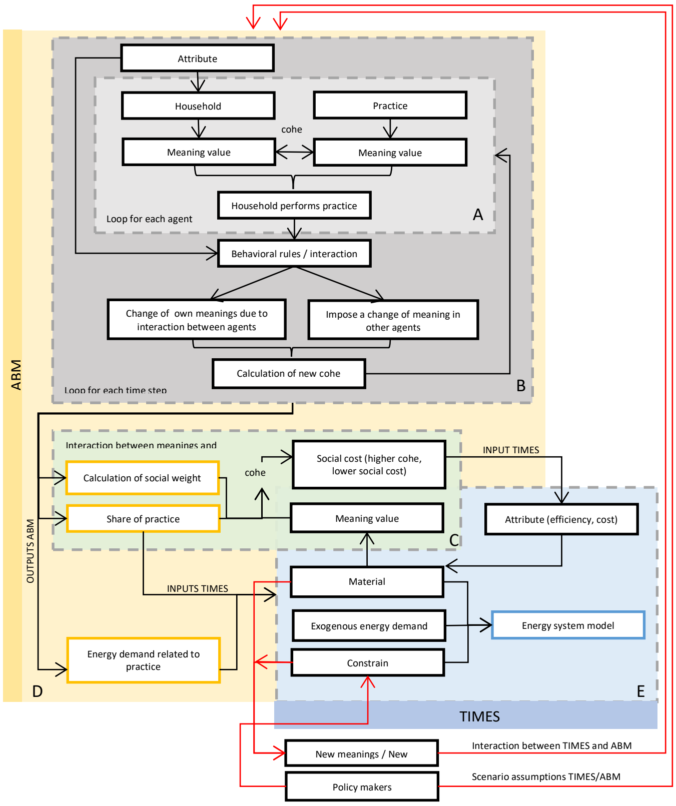

Figure 2 Methodology steps and interaction between ABM and TIMES model

Results

The methodology is applied to a case study for Switzerland. As the first step, a number of social practices and the related affected sectors are analysed, as shown in figure 1. By employing the coupled model approach our preliminary results (Figure 3a, 3b) indicate that the growing trend of home office practice as consequence of change in households' habits in 2040 will lead to: a) a decrease in the transport demand; b) an increase in the demand for public transport. Households who exercise home office change their perception of meanings related to commuting, e.g. the importance of comfort and time savings decreases with the reduction of commuter trips per week. The change in meanings offers households the opportunity to modify their mode for travel; c) an increase in the energy demand of residential buildings. The full set of results will be available by the time the paper will be presented at the conference.

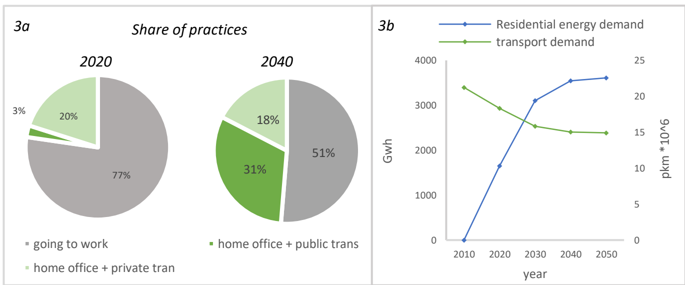

Figure 3a. Share of practice and related change in transport mode. 3b. Increase in the energy demand of buildings and decrease in transport demand related to home office practices.

Conclusions

Citizens are now in the centre of the energy transition. Empowered by digitalisation, they choose the services they need and the way they use energy. They become active players in this new landscape of more connected and efficient energy systems. As new social and business practices are emerging via the diffusion of ICTs and old ones are phased-out, their impact on the energy system is the core of this analysis that brings together societal elements and robust technical-economic energy systems frameworks. The integration of the two models allows quantifying direct and indirect effects on energy sectors due to the utilisation of ICTs, driven by the individual-behaviour and decision of agents.

References

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