

Household Energy Use and Behavior Change Tracking Framework: From Data to Simulation

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Climate is changing and its adverse impacts are felt worldwide. The greenhouse gas emissions from human activities are driving climate change and continue to rise (UN, 2017). Consumers are one of the main drivers of energy transition. The distributed nature of renewables, the increasingly competitive costs of renewable technologies, and new developments in smart grids and smart homes make it possible for energy consumers to become active players on this market (EU, 2017). However, quantifying aggregated impacts on behavioral changes is a challenging task. Often behavioral shifts among households are modelled very rudimentary assuming a representative consumer (group), rational optimization choices and instantly equilibrating markets. The growing body of empirical literature in social sciences indicates complex behavioral processes among household who consider changes in their energy consumption and related investments. There is a number of barriers and drivers, which could trigger households to make a decision and change their behavior, for example regarding their energy use. In particular, a large body of empirical studies in psychology and behavioral economics shows that consumer choices and actions often deviate from these assumptions of rationality, and there are certain persistence biases in human decision making, which lead them to have different behavior. We did an extensive literature review of relevant theories in psychology (environmental psychology specifically) to identify theoretical basis for these barriers and drivers as well as existing empirical evidence. In this paper we aim to quantify and assess impacts that behavioral changes of households may have on the cumulative energy use and emission reduction. Towards this end, we run a comprehensive survey among households and combine it with agent-based modeling techniques. Our survey carried out in the Netherlands and Spain in 2016 is rooted in psychology theories that allow us to elicit behavioral and cognitive factors in households' decision making in addition to traditional economic factors. The survey is designed to elicit the factors and stages of a behavioral process with respect to the three types of energy-related actions households typically make: (1) invest in an energy saving equipment, (2) energy conservation due to a change in energy consumption habits, and (3) switching to another energy source. To reach to any of these decisions a household is assumed to follow the three main steps: knowledge activation, motivation, and consideration. At each step, several psychological factors, economical, socio-demographic, social, and structural and physical drivers and barriers are considered and estimated. In parallel, we develop an agent-based BENCH model grounded in the Norm Activation Theory and the survey data. BENCH was designed to integrate behavioral aspects into a standard economic decision of an individual regarding household energy use and to study the cumulative impacts of these behavioral changes at a regional level as well as dynamics of these changes over time and space. BENCH is parameterized based on the survey run February-June 2016 in the Overijssel-The Netherlands (N=1000 households). We run the empirical BENCH model for a period of 2016-2050 under different behavioral assumptions and two shared socioeconomic pathway (SSP) scenarios (business as usual and high technology cost).