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PowerPlay: Exploring decision making behaviors in energy efficiency markets

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Abstract

Computer models are widely used to analyze decisions about energy efficiency improvements in the residential and commercial sectors. Few models exist that can actually be run interactively by decision makers to play out alternative future scenarios. None are available that interactively capture the dynamics, subtleties and complexities of interdependent decisions by utilities, households and firms in an ever-changing technological and economic environment.

This paper presents the features and experiences of PowerPlay, a computer-facilitated game which fills that gap and does more: it is a game to be played by at least a dozen player groups who interact with each other, make deals (or break them), plan for the future and revise decisions. The computer model functions like a game board to trace actions and offer choices. The observed behaviors can be analyzed to advance understanding of investment strategies and consumer choices; to generate experimentally-based data on energy efficiency changes; and to provide the basis for analyses that can substantiate or complement historical, time-series driven specifications of energy models.

Keywords: Energy Efficiency; Efficiency gap; Simulation game; Energy policy; Greenhouse gas emissions; Consumer choice; Household appliances; Experimental economics; Technology policy

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1. Introduction

Games are becoming increasingly popular tools to explore with decision makers the consequences of their decisions in situations where information flow among "players" is limited and environmental conditions cannot be known with certainty. There is a wide range of such games. At one extreme are game-theoretic models that attempt to identify optimal strategies for two or more players in often static or comparative static settings [1,2]. At the other end of the range are computer-based simulation games, such as SimCity [3], that concentrate on the evolution of systems in which typically a single player interferes in a system's dynamics through various choice variables. In between the two lie studies in experimental economics (e.g. [4,5]), which attempt to substantiate, in game-like settings, the postulates on which economic models are built.

Game-theoretic models assume a small number of actors and choice variables, are frequently highly context-specific and require advanced mathematical skills for their solution. In contrast, computer-based simulations often lack strong theoretical ties, require considerable time to be played, and rarely are transparent enough that players can (ex post) clearly evaluate the success of alternative strategies within the context of myriad variables. Studies in experimental economics typically create decision environments within which researchers can explore the validity of behavioral economic assumptions. The experiments are often highly stylized in order to reduce the influence of confounding factors on behavior and focus on key drivers behind decisions that can be easily isolated in the experiment. Few of the experimental economics approaches use sophisticated computing technology that would allow tracing the impacts of a multitude of interacting factors in a near-real world experiment.

All three types of approaches, and various combinations of them, have been used to explain the persistence of energy efficiency gaps – the presence of discrepancies between actual energy efficiency choices by households and firms, and choices that would be considered economically optimal for them [6]. Optimality is typically understood in the context of rational economic decision making. Theoretical, econometric, simulation and gaming-based investigations continue to explore the roles of market failures and the characteristics of energy users that may contribute to the emergence and maintenance of efficiency gaps [7–13]. Insights from this research will be relevant in determining the roles of government regulation, information dissemination and other interventions designed to promote higher energy efficiencies.

PowerPlay has been developed at the confluence of several recent approaches – theoretical, econometric, simulation-based and gaming-oriented – to better understand the evolution and dynamics of energy efficiency markets. PowerPlay uses empirically and theoretically grounded insights to enable multiple players to interact with each other so that players and researchers may learn about the potential consequences of energy use decisions. Specifically, the game incorporates basic economic and engineering concepts to frame choice options for players, utilizes a dynamic computer model to facilitate the game, draws into the game experts and decision makers, and reports back to those players and the scientific and decision making communities at large the insights generated by the game.

PowerPlay is not a computer game, although its execution is facilitated by computers. Comparable simulation games have been created for other aspects of the energy sector, such as for electricity markets and oil trading, but this is the first known game to include a diverse and responsive demand-side. This feature gives greater insight into the dynamics of energy demand and efficiency strategies. The computer's role is to simulate the rest of the economy, allow for chance events to occur which influence basic economic variables, receive the choices of players as inputs into the model, compute the