

Behavioral Economics Perspective for Demand Response in Energy Systems

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Keywords: Demand response (DR), Behavioral economics, Prospect theory (PT), Consumer behavior.

Foundations

- ❑ The classical model: EUT (expected utility theory) and DUM (discounting utility model, with exponential discounting).
- ❑ Anomalies in axioms of EUT, from lab. experiments and field data.
 - Ex.: 'happiness treadmill', 'disposition effect', 'end-of-the-day' effect, etc.
- ❑ Prospect Theory (PT) - Prospects are evaluated following four main principles: reference points, loss-aversion, diminishing marginal sensitivity and decision-weighting. (Kahneman & Tversky; Thaler)
 - Implications in the utility function.
 - Other models: the priority heuristic, imprecision theory, and configural weights models.
- ❑ Intertemporal Choice (IC) – Anomalies in DUM: 'sign effect'; the 'magnitude effect'; the 'delay-speedup' asymmetry; the 'date/delay effect'; preference for improving sequences; and violations of independence and preference for spread.
 - Hyperbolic discounting; Modifying the instantaneous utility function (both explain time-inconsistent preferences).
 - Alternatives: concepts of projection bias, mental accounting models, multiple-self models, dual-self models and the procedural approach.
- ❑ Social Norms (SN) – Anomalies in the standard model of 'self-interest'.

Experimental evidence in energy consumption and DR

- ❑ 1.4 – 3.3% - OPOWER, shows the power of social comparisons in environmental conservation to reduce electricity consumption. Allcott & Mullainathan (2010) doi:10.1126/science.1180775
- ❑ 8% - Environment and health-based information strategies outperform monetary savings information to drive energy conservation. Asensio & Delmas (2015) doi:10.1073/pnas.1401880112
- ❑ 7 – 11% - To show information emphasizing the losses related with energy consumption, instead of simple consumption information, reduces consumption. Bager & Mundaca (2017) doi:10.1016/j.erss.2017.04.008
- ✓ Effect of nonprice incentives to motivate energy conservation behaviour;
- ✓ Consumption reduction in households;
- ✓ Heterogeneity of results;
- ✓ Effectiveness (short term) and Persistence (long term)
 - Most studies address effectiveness;
- ✓ The populations studied.

Simulation and decision-making tools for DR

- ❑ Agent-based model - Analysis of the social interactions between consumers, the relationship with the power utility, and its implications on the overall consumption. Siebert et al. (2017) doi:10.3390/en10060768.
- ❑ EV Scheduling model, decision-making method of participation willingness based on the PT. MIP problem. Li et al. (2021) doi:10.1051/e3sconf/202129901015
- ❑ Reliability DR program, ESS, non-cooperative game model, prosumers preferences follow PT. Data of the Korean DR market. Ryu & Kim (2023) doi:10.1016/j.egy.2022.12.016
- ❑ Stackelberg games:
 - Single-leader, multiple-follower. Subjective decision-making behavior of the prosumers using framing effect in PT. El Rahi et al. (2019) doi:10.1109/TSG.2017.2750706
 - 3-layer multi-objective game. Model endowment effect by a penalty factor in the cost function. Lin et al. (2022) doi:10.1016/j.energy.2021.121667
- ✓ Utility function from the PT:
$$v(x) = \begin{cases} (x - r)^\alpha & \text{if } x \geq r \\ \lambda(r - x)^\beta & \text{if } x < r \end{cases}$$
- ✓ Probability weighting functions.
- ✓ Decision making biases impact results of demand response.