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comment

Bring behaviour into the digital transformation

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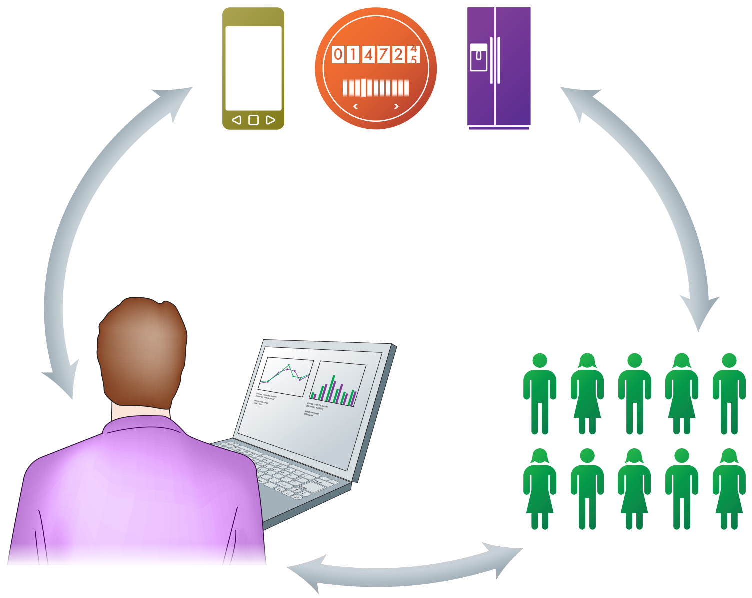
Smart technologies in the energy sector could benefit from social science research — and vice versa.



Despite significant technological progress and energy efficiency gains, such as better-insulated buildings and more-efficient appliances, energy consumption in households has increased by 35% worldwide in the period 1990–2011 (20% over the same period in countries in the Organisation for Economic Co-operation and Development; OECD)[1]. Residential energy use, which accounts for a quarter of energy use worldwide[1], largely depends on human behaviour and the context in which energy-relevant decisions are being made. Depending on the inhabitants, even energy consumption in homes with identical building characteristics and in the same location may vary substantially[2]. Consumers systematically fail to make even seemingly cost-effective investments in energy efficiency (for instance, replacing their old electric appliances with more efficient models that would pay for themselves quickly)[3] and often focus their conservation efforts on actions with minimal impact on energy use (for example, turning off lights)[4]. Consequently, policymakers are increasingly seeking effective strategies to foster cost-effective investments in energy-efficient technologies and promote high-impact energy-saving practices among citizens.

Information technology (IT) can provide decision support regarding investments in energy-efficient equipment and more sustainable behavioural practices. In the utility sector, millions of smart meters are being rolled out around the globe to monitor electricity, gas, and water consumption; in the EU alone, 195 million electricity smart meters are to be deployed by 2020[5]. Utility companies, policymakers, and technology providers have placed high hopes on these technologies to engage customers and, ultimately, to better manage demand: smart meter data can be visualized on in-home-displays, web portals, or smartphone apps. These can provide household electricity consumption feedback, tailored energy conservation tips, and alerts to inhabitants when the heating system is malfunctioning. The underlying hypothesis is that this kind of information will help citizens make better-informed decisions regarding their energy use and empower them to focus their conservation efforts on high-impact domains[6].

Earlier meta-studies suggested that smart-meter-based campaigns that delivered electricity consumption feedback to households could yield 4–20% conservation effects[7,8]. However, more recent experiments with larger, more representative samples provide evidence that most programmes fail to live up to those expectations: average electricity savings range between 1–4% (ref. 9) and even in opt-in studies (that is, based on voluntary, active enrollment) the vast majority of participants lose interest in the information available within the first few weeks or after a single interaction with the feedback technology[10].

These results are, in fact, not very surprising: in the design and rollout of those technologies and projects, utility companies and programme administrators focus their attention primarily on technical and legal aspects, in particular on protected and reliable data acquisition and transmission. While these aspects are clearly crucial for secure and reliable operation, flawless technical processes alone are not sufficient to successfully engage consumers. Moreover, the majority of today's programmes are designed with the purely rational decision-making individual in mind. Those designs primarily rely on standard economic theory, which posits that consumers will adjust their demand for energy (and also for energy-efficient appliances) in response to financial incentives; for example, price increases during peak hours[11], or subsidies for purchasing energy-efficient appliances[12]. Yet, substantial price levers are necessary to make many consumers respond to purely monetary incentives[11], making these campaigns fairly expensive, and the effect of subsidies is often limited to individuals who would have replaced their equipment

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anyway. By contrast, programmes that (also) tap into non-monetary strategies based on behavioural insights (for instance, health-based messages or comparisons with homes in the neighbourhood) have proven to be successful motivators of behaviour change and are more cost-effective[13,14].

IT benefits from social sciences

Utility companies and others already use data analytics as a regular part of their business practice to gather customer insights. For instance, they build models to predict which households will participate in load shifting or weatherization programmes, or (in liberalized markets) how likely their customers are to switch to a competing provider. While these data-driven models make it possible to identify target customer segments based on proxies such as housing type or electricity load profiles[15], these insights only provide crude heuristics of whom to target; they do not reveal how to successfully and cost-effectively engage customers with heterogeneous preferences. Clearly, utility programmes and smart technologies would benefit from integrating behavioural insights that have been generated over decades in social psychology, behavioural economics, management, or sociology. These disciplines have documented a variety of phenomena and powerful mechanisms that go against the paradigm of rational choice upheld in standard economics[16]. For instance, most people are sensitive to social norms (what others do and how a behaviour is looked upon)[17], and systematically pay disproportionally little attention to fuel costs and future savings compared to today's investments[18]. Furthermore, social science researchers have repeatedly noted the importance of considering the social fabric in which energy consumption takes place, that is, studying behavioural practices in their socio-cultural context, rather than decision-making of individuals in isolation[2].

While social scientists could contribute valuable insights to energy policy and to the design of programmes and technologies, most of the theoretical discourse and insights from laboratory research have not yet made their way into large-scale applications in the field[13], with a few exceptions. Several utility companies have substantially increased the sales of 'green' electricity in their portfolio without any traditional tools such as tax breaks or other monetary incentives by making the 'green' tariff the default choice[19]. New customers can still freely choose between the conventional 'grey' electricity mix and a 'green' tariff from renewable energies; but, rather than requiring individuals to take action to opt into the more expensive green tariff, they now need to actively check the box for the conventional electricity mix. Opower has rolled out cost-effective 'home energy reports' that tap into social norms to reduce residential electricity consumption to millions of households[13]. Finally, Amphiro's smart shower meters provide feedback in real time on a single, energy-intensive activity (showering), yielding large average conservation effects on the target behaviour of more than 20% (ref. 20).

Caution is warranted, however, in integrating behavioural insights into IT, in particular in the energy sector. The sector's predominant engineering and economics mindset comes with the risk that 'soft science' aspects get implemented superficially, without paying attention to the complexity of the issues at hand, and without a deeper understanding of the mechanisms and interdependencies at work. What may seem like a harmless tweak to the user interface may have dramatic consequences on public acceptance or cost–benefit ratio. For instance, prescribed conservation targets that are too simple or too difficult can affect programme acceptance and subsequent energy savings[21]. Providing seemingly helpful additional information on monetary savings can crowd out intrinsic motivation[22], reducing overall programme impact in terms of kWh saved or tons of CO_2 abated. Similarly, social comparisons may create a backlash among certain population segments[23].

Thus, information technologies that promote energy efficiency or load shifting could have more impact if insights from social science research were integrated in the technology design from an early stage, yet in order to maximize their impact and cost-effectiveness and to avoid negative side effects it is necessary to understand the underlying mechanisms and the specific context in which these systems are being deployed. And this is where social science can benefit from IT.

Social science also benefits from IT

While the majority of companies take advantage of IT to collect and analyse customer data to improve their operations and services, most social science researchers seem more hesitant to embrace its scientific potential[24]. Technologies available today such as smart meters, smart appliances, and smartphones already make it possible to collect granular (hourly, minute-level or even second-level) real-world data on energy use and human behaviour from hundreds of thousands of individuals and groups.

The deployment and evaluation of interventions in the field enables the development and validation of theory in real-world settings, for instance how consumers respond to financial, environmental, or health-based information strategies for energy conservation[14] or how they react to social comparisons of their home's energy use to similar households in the neighborhood[13]. This provides new research opportunities that are complementary to the controlled and often artificial environment of laboratory experiments. Moreover, while laboratory research is often limited to student samples for logistics and budget reasons, IT-based field experiments do not require participants to physically come to a laboratory. Thus, IT can simplify the recruitment of larger and more representative samples of participants. This not only improves the external validity of experiments, but also facilitates comparisons across different cultures.

Another key advantage of IT-based field research is scalability: many utility companies have already rolled out smart meters to the majority of their residential customers. New software programmes (for example, mobile apps to visualize consumption data) that are developed on the basis of that infrastructure can be deployed at almost zero marginal cost to a large number of households.

Furthermore, the price of sensors, communication infrastructure, processors, and storage units has fallen dramatically in recent decades[25]. As a result, more and more granular data can be collected, transmitted, processed, and stored at dwindling costs, for instance minute-level or second-level data on the electricity use of specific appliances or activities. This opens up new possibilities to implement elaborated experimental designs and to systematically assess impacts of various treatments on electricity demand, gas consumption, or hot water usage. As high data granularity reduces the background noise in datasets, it becomes easier to detect with good precision which interventions have a measurable impact on energy consumption and under what conditions. The ubiquity of sensors also makes it possible to collect data on the environment (for example, location, ambient temperature, occupancy patterns of a home, interactions between individuals) in which the activities of interest take place. Conditional on privacy terms that allow processing customer data for specific purposes, smart-meter data could be combined with various other data sources (for example, smartphones or smart appliances) that are increasingly monitoring our behaviour all the time. While big data do not automatically imply meaningful

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inferences about cause-and-effect relationships, those datasets may contain valuable information about the context in which behaviour occurs.

IT-based field research also supports tracking behaviour over time. While lab experiments are typically limited to relatively short timespans over a few hours or days, sensors and devices deployed in the field make it possible to study to what extent and under which conditions the effects of an intervention or observed phenomena persist over time[26]. At the same time, IT enables prompt delivery of interventions and the provision of feedback in real time, during an energy-intensive activity[20]. Timely data collection also paves the way for continuous evaluation and improvement of interventions: due to the flexibility and adaptability of IT, different ways of promoting energy efficiency or load-shifting can be tested in parallel or in rapid succession with respect to their acceptance and effectiveness under real-world conditions. Interventions could even be adapted to heterogeneous user preferences, offering different approaches for different subgroups, and tailored to the specific situation of each household.

Finally, the possibilities offered by IT can help social science researchers in their struggle for funding. The value and practical relevance of experiments in real-life settings (for example, systematic A–B testing to identify optimal solutions) with quantifiable outcomes is easier to communicate to policymakers, funding agencies, companies, and wider society, than the purpose of research in artificial laboratory settings, or self-reported survey data. Beyond practical funding benefits, collaborations with industry partners also foster reality checks and facilitate integration of knowledge from domain experts at early project stages and promote knowledge transfer into practice. One important caveat is that companies may be reluctant to share their data or the insights it offers with third parties, as this might jeopardize their competitive advantage. While researchers need to exercise caution with the data entrusted to them, they also need to reserve the right to publish their results. While it is not always possible to align those concerns and interests, companies may be more willing to share data that is not at the core of their business, or with researchers with whom they have established a relationship.

Joining forces

Both technology providers and social scientists can reap large benefits from joining forces, and both researchers and practitioners would profit from the empirical validation of social science concepts in real-world settings, from investigating the scalability and long-term impact of programmes to evaluating broader welfare implications and potential side effects. The combination of the scalability, speed, and adaptability of IT with the stability of behavioural insights has the potential, on the one hand, to generate new behavioural insights and advance theory, and on the other hand, to build powerful and beneficial real-world applications with a population-level impact. Consequently, social science research should become an integral part of IT design to prevent the large-scale rollout of costly technology that fails to engage consumers in the field. Conversely, behavioural researchers should embrace the potential of IT to gain insights from real-world settings. Policymakers can foster these collaborations by setting up more funding mechanisms for interdisciplinary research. Universities could expand interdisciplinary education in their curricula by offering social psychology classes for engineers and computer scientists, or programming classes for social scientists. Such efforts would help to lay the foundation for more mutual comprehension and openness between those disciplines — a first and crucial step to bridge the current gap between social scientists and IT experts, and to leverage the large potential for energy savings (among other benefits) that the symbiotic collaboration between those disciplines offers. ❐

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References

1. *Energy Efficiency Indicators: Essentials for Policy Making* (International Energy Agency, 2014).
2. Gram-Hanssen, K. *Archit. Eng. Des. Manag.* **10,** 91–107 (2014).
3. Gillingham, K. & Palmer, K. *Rev. Environ. Econ. Policy* **8,** 18–38 (2014).
4. Gardner, G. T. & Stern, P. C. *Environ. Sci. Policy Sustain. Dev.* **50,** 12–23 (2010).
5. *Benchmarking Smart Metering Deployment in the EU-27 with a Focus on Electricity* (European Commission, 2014); http://ses.jrc.ec.europa.eu/smart-metering-deployment-european-union
6. Southern California Edison installs 1 million smart meters. *T&D World Magazine* (2010).
7. Darby, S. *The Effectiveness of Feedback on Energy Consumption* (Environmental Change Institute, 2006).
8. Ehrhardt-Martinez, K., Donnelly, K. A. & Laitner, J. A. S. *Advanced metering initiatives and Residential Feedback Programs: a Meta-Review for Household Electricity-Saving Opportunities.* (ACEEE, 2010).
9. McKerracher, C. & Torriti, J. *Energy Effic.* **6,** 387–405 (2013).
10. Gölz, S. *Feedback Seeking as an Active, Goal-Oriented Behavior — a Psychological Reframing of Energy Consumption Feedback.* Dissertation, Univ. Marburg (2016).
11. Jessoe, K. & Rapson, D. *Am. Econ. Rev.* **104,** 1417–1438 (2014).
12. Davis, L. W., Fuchs, A. & Gertler, P. *Am. Econ. J. Econ. Policy* **6,** 207–238 (2014).
13. Allcott, H. & Mullainathan, S. *Science* **327,** 1204–1205 (2010).
14. Asensio, O. I. & Delmas, M. A. *Proc. Natl Acad. Sci. USA* **112,** E510–E515 (2015).
15. Beckel, C., Sadamori, L., Staake, T. & Santini, S. *Energy* **78,** 397–410 (2014).
16. DellaVigna, S. *J. Econ. Lit.* **47,** 315–372 (2009).
17. Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J. & Griskevicius, V. *Psychol. Sci.* **18,** 429–434 (2007).
18. Allcott, H., Mullainathan, S. & Taubinsky, D. *J. Public Econ.* **112,** 72–88 (2014).
19. Ebeling, F. & Lotz, S. *Nat. Clim. Chang.* **5,** 868–871 (2015).
20. Tiefenbeck, V. *et al. Manag. Sci.* http://doi.org/bz4k (2016).
21. Loock, C.-M., Staake, T. & Thiesse, F. *Manag. Inf. Syst. Q.* **37**, 1313–1332 (2013).
22. Ryan, R. M. & Deci, E. L. *Contemp. Educ. Psychol.* **25,** 54–67 (2000).
23. Costa, D. L. & Kahn, M. E. *J. Eur. Econ. Assoc.* **11,** 680–702 (2013).
24. Watts, D. J. *Everything is Obvious* (Crown Business, 2011).
25. Bughin, J., Chui, M. & Manyika, J. Ten IT-enabled business trends for the decade ahead. *McKinsey Quarterly* (2013).
26. Allcott, H. & Rogers, T. *Am. Econ. Rev.* **104,** 3003–3037 (2014).

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