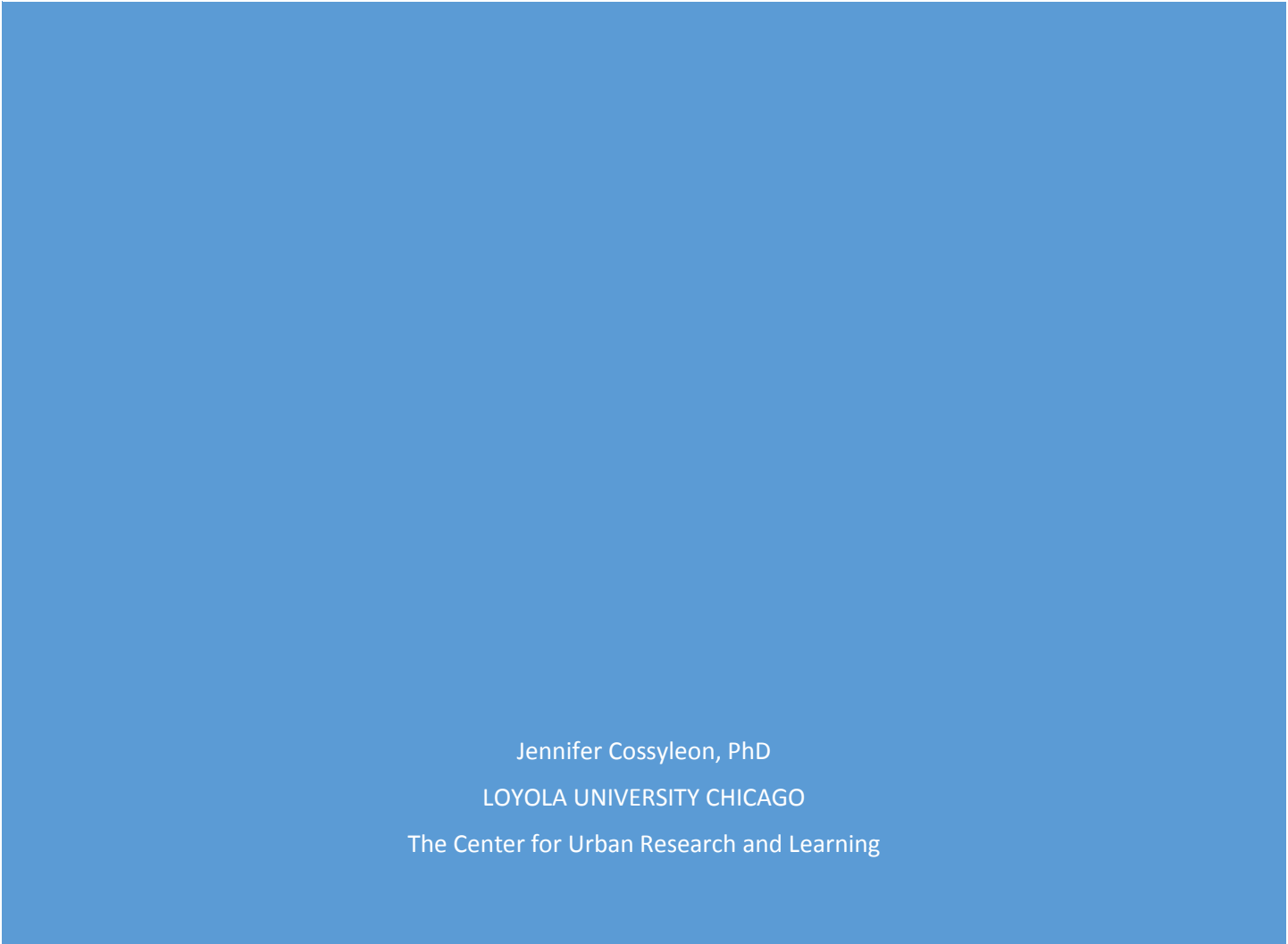




NEW TECHNOLOGIES AND CONSUMER
KNOWLEDGE: A REFERENCE FOR SMART GRID
EDUCATION

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Introducing the Smart Grid

The smart¹ grid encompasses a two way dialog where electricity and information is exchanged between consumers and the utility provider (Smartgrid.gov). Distinct from the traditional electric grid where electricity is transferred one-directionally from a power plant to a home or business, the smart grid allows for mutual information sharing. Smart grid technologies allow customers to be more involved in their daily usage behaviors and to receive timely feedback about their energy usage, which can help reduce costs and harmful emissions that accelerate global warming (Rodriguez-Molina et al 2014; Zhong et al 2009). In 2007, Congress passed Title XIII of the Energy Independence and Security Act (EISA), which acknowledged the benefits of the smart grid and provided support for national modernization efforts. In Illinois, the Energy Infrastructure and Modernization Act (SB1652), also known as the 2011 Smart Grid Bill, endorsed utility companies to make \$3.2 billion in upgrades to the Illinois power grid. As is true with any major utility infrastructure change, consumer education and knowledge is a vital component of the transition to smart grid technologies.

First, this report surveys research in diverse fields of study including sociology, economics, and public health to suggest best practices of information-sharing, public education, and the spread of knowledge through social networks. Second, this report reviews recent studies that measure consumer knowledge about the smart grid and other technologies. Last, this report documents possible strategies for tracking knowledge attainment as a result of targeted community educational efforts. Combined, this information may assist agencies across the nation to spread awareness about the existence, benefits, and use of smart grid technology.

¹ Self-Monitoring Analysis and Reporting Technology

The Diffusion of New Technologies

Scholars have dedicated their careers to understanding diffusion or how “information or a behavior moves through a network” (Jackson 2008: 209). However, the diffusion of new technologies is often a slow process. For example, it took 14 years to adopt centralized traffic control and 12 years to embrace industrial robots (Mansfield 1989 as cited in Geroski 2000). Technical changes involve a process of learning towards the reduction of uncertainty about its utility, relevance, and potential (Rosenberg 1996). The diffusion of new technology tends to follow what scholars have called an “S-curve².” This means that diffusion rates first rise rapidly then decrease, pick up again, and this process repeats itself. The most common model for understanding this S-curve is the “epidemic model,” which argues that the speed of usage of new technology is dependent on the information available about the new technology, which includes how one uses the technology and what benefits it brings (Geroski 2000). Another model is the “probit model,” which suggests that variances in the use of new technologies can be explained by the goals, needs, and abilities of the consumers. Thus, one model is more focused on the availability of information while the other is attentive to the visions and capacity of users; and, arguably, these two models can intersect. In the following quote, Geroski (2000) discusses some relevant factors in the diffusion of technologies:

Diffusion is likely to be faster for simpler technologies where software knowledge is easily learned and transmitted, for populations which are densely packed and where mixing is easily, where early users spread the word with enthusiasm and do not die or forget what they have learned, and in situations where the new technology is clearly superior to the old one and no major switching costs arise when moving from one to the other (607).

² “S-curve: diffusion rates first rise and then fall over time, leading to a period of relatively rapid adoption sandwiched between an early period of slow take up and a late period of slow approach to satiation” (Geroski 2000: 604).

Factors including community connectedness, cost, ease of use, and word of mouth all impact the speed at which new technologies are diffused across communities.

In an article that offers suggestions for best diffusing medical innovations, Berwick (2003) encourages seven strategies, three of which are relevant for this review. First, investing in early adopters of technology who are willing to test changes and interact with others about these experiences, particularly through one-on-one conversations. Second, innovations need to be adapted to fit the needs of consumers, particularly based on their own feedback. And third, those who “champion the spread of the innovation” must lead by example and use the innovation first (1974).

There are subtle but important distinctions between knowledge and information (Brown and Duguid 2000). “Knowledge is something we digest rather than merely hold. It entails the knower’s understanding and some degree of commitment” (Brown and Duguid 2000: 120). Conversely, information is something that is passed around, accumulated, and or compared (Brown and Duguid 2000). Today information is widely available, yet this does not necessarily translate into consumer knowledge. Concerning the spread of smart grid technologies, it is important that the spread of knowledge be the ultimate goal within these efforts in order to create a sustainable commitment to its use.

Introducing the Smart Grid to Communities

With the help of social science research, energy service providers have explored how to best introduce smart grid technology to communities. Because the “benefits of the smart grid can only be achieved with the cooperation of the end-users” (Anda 2014:122), it is important for consumers to be informed about the smart grid transition. Direct communication with

consumers is key; this may include phone calls, e-mails³, mailings, community workshops, and one-on-one conversations. Scholars have coined these interactive strategies as community-based social marketing (CBSM), which can facilitate education, gain consumer feedback, and inspire potential consumer behavior change (Anda 2014).

The CBSM model can facilitate at least four outcomes. First, through CBSM, service providers can educate consumers about the smart grid and the benefits of the new technology. Second, providers can receive feedback from consumers about products and services. Third, when appropriate, CBSM strategies can help motivate consumers to reflect on their energy consumption and its environmental impacts. And last, through CBSM, providers can connect neighbors to one another to set community-wide goals towards becoming more energy efficient. It is important to conduct community-based research and develop trust within communities before introducing the smart grid. It is also important to have ongoing conversations with energy consumers about their unique needs, especially with underrepresented groups like low-income and elderly consumers (Anda 2014).

Social Learning: The Dissemination of Community Knowledge and its Impact on Behavior

Research points to the effects of *social networks* as greater predictors of behavior change than knowledge alone (Finger, 1994). Broadly, a social network is comprised of individual members and the links among these individual members through which information, goods, and resources are shared (Maertens and Barrett 2012). In *Social and Economic Networks*, Matthew Jackson (2008) argues that “social networks play a central role in the

³ Notable, Morimoto and Chang (2006) find that consumers perceive unsolicited emails as more intrusive and irritating than direct mail to their address.

sharing of information and the formation of opinions.” He suggests: “it is critical that we have a thorough understanding of how the structure of such networks affects learning and the diffusion of information” (223). Social influence shapes behavior, regardless of whether the influence is intentional (advertising) or unintentional (observing neighbor) (Marsden and Friedkin 1993). As such, consumers are impacted by the behavior and opinions of people within their social networks who share information and set precedents for the use of innovative technologies.

In a study that explored how farmers learned about new technology, researchers surveyed 450 people in four villages in Ghana (Conley and Udry 2001). They collected data on how pineapple farmers interacted, who they talked to, and inquired about conversations with other farmers about farming (i.e. fertilizer use). The researchers found that when each respondent was matched randomly with 10 other farmers in their village, only 11 percent of these matches had at least one person who had ever received advice about farming from the other individual. These findings persisted even though within 30 percent of the matches, at least one respondent said they could approach the other farmer about farming. *Researchers suggest that information flows through sparse social networks, which are not necessarily geographically linked.* In other words, their data showed that despite close proximity, people did not regularly share information about farming with neighbors within the same village. Moreover, social learning involves “higher order reasoning,” where people consider not only the knowledge/information received from a social tie, but also how that social tie learned about this knowledge through personal experience. To understand optimal learning behavior for one person, one could “keep track of long histories of actions and experimental outcomes of

everyone with whom that [person] communicates,” but there is no simple formula to understand broader social sharing and learning (10).

Public Education through Lay Community Workers and Hair Stylists

I now turn to efforts to disseminate preventative health knowledge as a guide for spreading information about new technologies. Medical health professionals have led efforts to spread breast cancer awareness through lay men and women as community health workers. This method has served to effectively reach a wider range of people, particularly those from low-income and medically underserved populations. In a systematic review of the impacts of community health workers as an intervention to increase the use of mammograms in the US, Wells and colleagues (2011) discovered several key factors that impacted the success of this model. First, they found that programs conducted in urban settings proved more effective. Second, they found that programs where the community health workers were of the same race or ethnicity of the intervention/experiment participants demonstrated stronger impacts of increasing mammograms. Third, they found that program outcomes were stronger for participants who were recruited at medical sites. Information sharing through lay community members can be applied to other information sharing efforts.

Another similar study examines the effectiveness of hair salons in spreading information about breast cancer among African-American and Afro-Caribbean women (Wilson et al 2008). In this study, researchers randomly assigned 28 hair salons in an urban area to provide information about breast cancer to their clients and 12 salons to serve as controls. On average, each salon serviced 200 clients over a 3-month period, thus serving as key information hubs. First, at least two stylists at each experimental site was trained and offered literature on breast

cancer screenings. Then, clients at both the experimental and control sites completed a seven question survey, which showed no statistically significant differences in breast health behaviors or intentions to complete a self or clinical breast exam. Next, researchers implemented another survey one to three months after to assess whether clients reported receiving breast cancer messages within the past three months (n= 1,210), and to gauge clients' actions and plans regarding breast health screenings. Survey findings indicate that clients from experimental sites reported receiving more breast health messages than those at controls sites (10% versus 37%). Those who reported receiving breast health messages within the past three months (n= 335), were more likely to have greater intentions to complete a monthly breast self-exam and to receive a clinical breast exam, although these differences were not statistically significant. Researchers conclude that trained stylists at salons can effectively help promote behavioral intentions and actions around breast health screening.

Public education and Media/Social Marketing Campaigns

Research on social learning and knowledge management aims to better understand how and when knowledge impacts individual behavior. Just because someone knows about a new technological innovation or environmental fact does not mean they will change their behavior in any particular manner. To address this gap, studies have examined the effectiveness of workshops (Gray, Elliot and Wale 2013) and social marketing campaigns, also known as media campaigns for initiating the spread of information (Marcell, Agyeman and Rappaport 2004; Jenkins et al 1999). Social marketing can be particularly useful within efforts to influence consumer actions as this method is highly suggestive of specific behaviors.

In a recent study of healthy eating habits among elementary school students, researchers compared a school-based nutrition education program with a school-based and social marketing intervention, and a no-treatment comparison group. The social marketing intervention, which was meant to influence parents and their children to use low-fat or fat-free milk and consume more vegetables, included: billboards; television and radio ads; educational family events; and leafletting. Researchers found that the social marketing intervention was indeed more effective than the school-based educational program alone (Blitstein et al. 2015).

Another study evaluated a 24-month breast and cervical cancer awareness media campaign to understand the effect of public education on knowledge and preventative action steps around this topic. Media efforts included but were not limited to: newspaper ads; brochures; billboards; pamphlets; and short videos at local clinics. Using a control area that had not been privy to the local media campaign, researchers surveyed over 400 randomly selected women in each area in California (separate control and intervention areas) before and after the education efforts. After controlling for demographic differences, researchers found that women in the intervention group were significantly more likely to have heard of a range of medical tests than those in the control group, although they were not more likely to be up to date on suggested medical tests (Jenkins et al 1999).

Word of Mouth

Word of mouth information sharing is a conduit for spreading knowledge about new technologies. Word of mouth is related to but distinct from educational campaigns because it involves informal interactions outside of instructional settings. Although the informality of word of mouth information sharing makes it difficult to track, sometimes the best “source[s] of

information” are actual users of technology (Geroski 2000). Because the word of mouth model necessitates a “base of users” to accelerate the spread of information (Geroski 2000: 606), the capacity of the base users to share information is important. One might consider recruiting “opinion leaders” or people who highly influence the decisions of others as the base of users for spreading information (See Katz and Lazarsfeld as cited in Jackson 2008).

In a study of how consumer decisions are influenced by word of mouth, Goldenbert, Libai and Muller (2001), aimed to understand whether strong ties, weak ties, or marketing efforts had a greater influence on the dissemination of information. Using a modeling technique that simulates information dissemination, researchers determined that each participant had anywhere from five to 29 strong ties and five to 29 weak ties. The study found that the effects of strong ties on the dissemination of knowledge were larger than the effects of weak ties and marketing efforts. However, factoring time to knowledge attainment, researchers found that in the early stages, marketing efforts were twice as strong in disseminating knowledge as weak and strong ties. On the other hand, in later stages, the effects of marketing efforts diminished while weak and strong ties persisted. *This work emphasizes the short-term effects of marketing efforts, while also bringing to light the longstanding impacts of sharing information through word of mouth.* Importantly, these findings add to previous research that suggests: 1) people are more likely to act on mass-media information when the same information is spread through personal ties (Rogers 1962 as cited in Granovetter 1973); and 2) the level of knowledge sharing is likely to increase when the knowledge source and recipient have similar social positions (Kang and Kim 2010).

Most studies that examine how knowledge and opinions spread through networks have focused on individual people and places as facilitators of information sharing. In a classic study which sought to identify which people influence opinions, Katz and Lazarsfeld (1955 as cited in Jackson 2008) interviewed women twice a couple of months apart and asked them about their opinions regarding goods, fashion, politics, media and the like. If the interviewer noticed a change in an opinion during a follow-up interview, they asked the women to identify who influenced that change. Also, they asked the women to identify who, if anyone, they themselves had influenced regarding a given topic. Katz and Lazarsfeld (1955) found that a small number of people influenced the changes in opinion of many. Notably, the influential opinion leaders were described as highly sociable, had larger families, and they were more often of the same social status as those they influenced. The study found that information that influenced consumers' opinions and knowledge often spread through family, educational settings, organizations, places of worship, and volunteer sites.

Scholars have identified issues with a word of mouth method of spreading knowledge. Word of mouth knowledge spreading is likely to remain among people who are similar in age, race, gender, religion, who have similar educational, social status, and even ethno-racial attributes (Rogers 1995, as cited in Geroski 2000). One possible alternative is implementing a mixed information model, where non-users have the potential of being informed by two sources of information: a common source of knowledge and through word of mouth. For smart grid, this can encompass information through the media, mail, and e-mail along with a base of opinion leaders who use smart grid technologies and are willing to spread information about it.

How “Green” Behavior Can Be Influenced by Others

Research shows that consumers are more likely to change their energy consumption behavior if 1) they recognize their contributions to the environment and 2) their neighbors and communities are also invested (McKenzie-Mohr; Anda 2014). Studies in the US as well as those in developing countries have sought to understand both the effects of environmental education and how marketing influences consumer behavior (Barone, Miyazaki and Taylor 2000; Hamid, Khan, Kiani, Sha, Kiani 2014; Bagheri 2014). For instance, in a study of sustainable consumption, researchers evaluated the effects of a social marketing campaign on students’ energy conservation. Using a pre and post survey eight weeks apart, researchers found that a social marketing campaign, or directly encouraging students to turn off their personal computers when not in use, was more effective in changing student’s electricity use than an education program about greenhouse emission alone (Marcell, Agyeman and Rappaport 2004).

Hamid and colleagues (2014) surveyed employees of companies that had taken corporate-initiated environmental steps to see how this shaped employee’s own sustainable behavior. They found a significant relationship between companies’ green innovation processes and their employees’ consumer behavior. Researchers suggest education needs to be comprehensive in that it goes beyond environmental awareness towards companies’ use of innovative technologies. In other words, the more people are exposed to innovative sustainable technologies, the more they are likely to adopt and use them themselves.

Given that consumption is a learning process, consumers learn based on the information they are exposed to. Notably only a small percentage of this exposure is initiated on their own (i.e. when a consumer searches for information). The large majority of information is learned

through an actor's social environment and the communicative acts of others. Although consumers are inevitably influenced by a "conformist bias" or the tendency to choose the option that is most accepted by the population (Henrich and Boyd 1998, as cited in Zhu and Huberman 2014), the changing behavior of others could impact sustained behavior. As Buenstorf and Cordes (2008) argue, green consumption patterns cannot be "locked in" and are not self-reinforcing (647). Overall, this and other research suggests ongoing education is preferable over short-term information sharing in order to maintain the flow of information and influence.

Consumer Knowledge about the Smart Grid

Although there is a dearth of research on the ways information about the smart grid is shared among consumers, select studies have explored consumer knowledge and confidence about the smart grid (Poncea et al 2016; Krishnamurti 2012). Through 22 open-ended phone interviews and 126 surveys with potential smart grid customers within a US Mid-Atlantic electricity utility area, Krishnamurti (2012) found that consumers were optimistic about the smart grid, but they were unclear about the technology and its potential benefits. For instance, many customers perceived the smart grid would: increase costs; limit their control over their electricity usage; and risk their privacy regarding patterns of energy consumption (Krishnamurti 2012). Another study highlighted consumers' concerns regarding radio frequency emission through smart grid technologies (Gupta 2012). This research points to mixed perceptions of consumer knowledge about the smart grid and the potential need to educate communities.

Discussion

There exists a dearth of research on how to methodologically measure the impacts of public education. However, existing research presented in this review highlights the importance of word-of-mouth and targeted community education for the dissemination of information (Geroski 2000; Goldenbert, Libai and Muller 2001). Particularly, research presented in this review has highlighted how personal networks influence behavior (Long, Harre and Atkinson 2014). Although studies show that information has a greater weight for mirroring certain behavior when it comes from existing networks (friends, family, co-workers), other mechanisms of word of mouth can also be utilized.

Information sharing through door-to-door mini information sessions might be an option for spreading knowledge about smart grids. This aligns with community organizing models that train community members and then hire them as ambassadors to spread information about free meal sites, early learning enrollment options, and health initiatives within their own neighborhoods. Door knocking, usually accomplished in pairs, may benefit from the existing networks of the ambassadors; create an informal setting for information sharing and inquiry; and lessen possible cultural and language barriers to reaching consumers.

The study by Wells and colleagues (2011) on the use of lay community health workers to increase knowledge and use of mammograms provides important implications for planning public education trainings. The study finds that the spread of knowledge is best accomplished in urban areas and within culturally competent settings where the educator is of a similar racial or ethnic group. Related findings also highlight the importance of recruiting “opinion leaders” (See

Katz and Lazarsfeld as cited in Jackson 2008) who are already inclined to show interest about the topic (ie. Medical settings for health technologies).

To Consider for Future Research

The Wilson and colleagues (2008) study on breast health messages shows that the tracking of actions and intentions to act concerning particular topics can be accomplished through surveys of people connected to hubs of information within a defined area. It is notable that the before and after surveys were not longitudinal (they did not follow one person over time), but rather were implemented to all willing clientele who may or may not have received information—which arguably can account for some effects of information sharing tied to a particular information hub. If we connect this to smart meters, it seems plausible to assign several social sites as experimental locations with a control site. Clients could be surveyed at baseline to assess any differences in knowledge about the smart grid across sites. Last, clients could be surveyed after an intentional educational effort in the experimental sites to assess the impact of educational efforts regarding clients' knowledge of the smart grid.

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