Public Participation and Decision Support Systems: 
Theory, Requirements, and Applications

Michael P. Johnson
H. John Heinz III School of Public Policy and Management
Carnegie Mellon University
Pittsburgh, PA 15213-3890
johnson2@andrew.cmu.edu

Abstract:

Public-sector policy design is inherently complex: there are multiple stakeholders, multiple objectives, and ambiguous or unknown evidence regarding effective policy interventions. One response to this problem is the design of decision support systems (DSS) to help ordinary citizens as well as policymakers make choices that enrich their daily lives and participate in policy and planning processes. DSS typically combine information technology tools for data storage, analysis, and visualization with decision models that help users formulate and solve problems that might otherwise appear impossible to formulate clearly or are computationally intractable. This paper proposes a framework for developing DSS for public sector policy making that reflects a number of key principles. First, DSS should be values-based—reflective of ethical and moral considerations that motivate users to address problems of public interest. Second, it should be evidence-based—containing data and functional relationships that represent best knowledge and practices. Third, it should be model-based—containing representations of real-world systems that generate actionable recommendations based on multiple choice alternatives. Last, it should facilitate creativity and negotiation—enabling multiple stakeholders to collaborate and explore “what-if” questions easily and identify “best-compromise” solutions quickly. Evidence to support this theory of public DSS comes from current projects on increasing citizen participation in initiatives to reduce energy use, policy design for senior services provision, and choosing new neighborhoods for use of tenant-based housing subsidies.

Keywords: Decision support, public policy, citizen participation, policy systems.

Presented at Association of Public Policy Analysis and Management Fall Conference, Madison, WI, November 3, 2006
I. Introduction

Information technology-enabled decision-making is ubiquitous in developed countries such as the United States. In the commercial domain, bidding and trading networks such as eBay (www.ebay.com) and Craigslist (www.craigslist.com) allows users to buy, sell or barter just about anything. Recommender systems enable users to rate items for use or purchase, or to recommend items for others. For example, Pandora (www.pandora.com) allows users to receive suggestions for music based on preferences they record on the site. Many sites providing diverse goods and services incorporate features of recommender systems (Amazon.com for product reviews, NewYorkTimes.com for restaurant, book and moving ratings and reviews). Google Maps (www.google.com/maps), MapQuest (www.mapquest.com) and Yahoo! Maps (maps.yahoo.com) allow users to plan travel routes and learn about geographic regions. Social networks such as Facebook (www.facebook.com) and Myspace (www.myspace.com) allow users to choose the individuals, organizations and social movements to which they wish to affiliate, and to share information that can result in changes to their daily activities. Geoffrion and Krishnan (2001) present an overview of commercial decision modeling applications.

Information technology-enabled decision-making and decision support is also visible in the non-commercial arena. CommunityViz (www.communityviz.com) enables users to create community development models using scenarios, forecasting and 3-D visualization. Stopglobalwarming.org (www.stopglobalwarming.org) is representative of sites that allow users to learn of strategies to reduce energy usage and collaborate with others to promote conservation. Emily’s List (www.emilyslist.org), which allows users to support female political candidates, is one of many sites promoting political engagement. Federal, state and local governments use the Internet to make large volumes of data publicly available online, and facilitate routine activities such as applying for permits, or seeking out government officials (see O’Looney 2003 for a survey of decision support-oriented e-government applications).

However, there are a number of limits to IT-enabled decision support. IT-enabled services for search, service provision, recommendations and advice are less common for vulnerable or technologically-inexperienced populations: low-income persons, the elderly, the homeless, persons in the criminal justice system, those with mental or physical disabilities, as well as persons who work with or advocate for vulnerable populations. There are few applications that
enable individuals to leverage the expertise and diversity of on-line social networks to identify, formulate and solve problems. In addition, there are few applications that enable public organizations to systematically organize best practices, collect data from diverse sources, collaborate with stakeholder groups and manage a variety of analytic models in order to pursue system redesign.

The purpose of this paper is to develop a framework for IT-assisted decision support for public choice and public action. In addition, this paper provides three case studies of research initiatives that represent contributions to this domain: counseling support for low-income housing mobility, policy support for senior services provision, and leveraging social networks to reduce energy consumption.

There are three ways that IT-assisted decision support applications might improve the quality and/or extent of public policy participation and personal action. First, these applications may improve the quality of high-stakes decisions affecting tangible, long-term outcomes for individuals and families. Examples of these decisions include choice of housing and neighborhood, career options and job training/retraining, behavioral change, drugs, services or providers to improve health quality, and family support services to assist households in crisis. In all of these cases, an established social service infrastructure exists to support individual choices. However, high-quality, easily accessible and personalized IT-enabled assistance provided in such a way as to improve the efficiency and effectiveness of human providers are not generally widely available (see e.g. the widely-criticized “Medicare Prescription Drug Plan Finder”, http://www.medicare.gov/MPDPF/Home.asp but also Vitolo and Vance 2002 for a successful example of a DSS to assist dislocated defense workers find new careers). Second, these applications may improve the quality of high-stakes decisions affecting outcomes for entire stakeholder groups, communities and regions. Examples of these decisions include provision of senior services, urban and regional planning, public safety service provision, and health care (see e.g. Timmermans 1997 for a collection of essays on spatial DSS for urban planning). Third, these applications can improve the quality of routine or repeated decisions that can improve the quality of everyday life. Examples of these include choice of transit route, changes in energy or food consumption and expanding or diversifying social networks for work, recreation and learning.
Developing decision support applications for public policy and personal action will require research to clarify a number of important issues. First, additional research will be required to understand the decision-making capabilities and preferences of typical application users, especially members of vulnerable or under-represented groups. Though the research literature on behavioral decisionmaking is extensive (see e.g. Parker and Fischoff 2005, Scott and Bruce 1995), there is less understanding of the role that race, ethnicity, class and other personal characteristics may play in policy-related decision-making. Second, research will be required to understand how information should be presented to users to clarify decision alternatives. There is an extensive literature on the graphical presentation of quantitative information (see e.g. Tufte 2001, Bederson and Schneiderman 2003), but less understanding of presentation characteristics (type – maps, tables, charts; medium – paper, computer, video, verbal; style – prescriptive/suggestive, descriptive) and quantity of alternatives that best enable inexperienced users to frame and solve policy-related decision problems using information technology. There is also a need for research to understand how complex decision problems can be conveyed meaningfully on hardware other than personal computers, e.g. cellphones. Third, decisions may be performed using a wide variety of prescriptive methods (Eiselt and Sandblom 2004): compensatory versus non-compensatory methods; utility function-based compensatory methods versus non-utility function-based compensatory methods, and so on. However, there is no consensus regarding the decision methods that add the greatest value for inexperienced users solving policy-related decision problems.

The case studies in this paper provide limited and suggestive evidence to answer the questions listed above. Experience with housing mobility counseling support systems provides evidence that low-income families can make productive, IT-assisted decisions, but serving organizations face high barriers to empowering clients and re-aligning services to meet the needs of diverse clients. Policy systems for senior services provision have demonstrated that the significant potential for multiple models, data and expertise to support system redesign is counterbalanced by difficulties in sustaining the application in a resource-constrained environment. Preliminary research on use of social networks to reduce energy consumption indicates that changing intentions and the information base for making decisions is likely to be much easier than changing and sustaining actual energy consumption behaviors, but that online networks offer the potential for sustainable, long-term changes in daily behavior across large populations.
The remainder of the paper is organized as follows. Section II presents principles of DSS for public policy change and personal action. Section III contains a case study of housing counseling support systems. Section IV surveys research on policy support systems designed to improve senior services provision. Section V introduces a new research direction: information technology to induce and support changes in energy consumption. Section VI concludes and identifies next steps.

II. Principles of Decision Support Systems for Public Policy Change

In this section we present principles that are asserted to be important in designing decision support systems for public policy action and individual choice.

Values

While personal values as a basis for decision-making are important in all domains, the importance of values that clarify decision choices in the non-commercial domain is especially great, since there is less consensus regarding individuals’ motivations for actions that don’t involve commercial transactions. Keeney’s “value-focused thinking” model (Keeney 1996) represents a useful framework for understanding individual and organizational motivations for decision-making and action. (Of course, there are many other methods for clarifying goals, alternatives and attributes in policy-related problem-solving; see e.g. Bardach’s (2004) eight-fold path for policy analysis.) Keeney asserts that clarifying the relationship between shorter-term, more easily-quantifiable “means” objectives and longer-term, more qualitative “ends” objectives can help identify decision alternatives, or strategic directions, that are more likely to be consistent with decision-maker preferences. He also asserts that clarifying the relationship between basic, or fundamental ends objectives, and more specific ends objectives that clarify the dimensions along which decisions can be made can help identify measurable attributes by which decision alternatives might be ranked.

We assert that DSS for public policy and public decisions should be designed on the basis of a rigorous values analysis, distinguishing between individual values, organizational values and societal values. For example, should a housing counseling support system have as a fundamental aim helping users choose among affordable housing units known to be available to a housing authority (risking selection bias in neighborhood quality), or instead help users to better navigate the private and public housing markets themselves (risking confrontation with barriers such as
housing discrimination, or difficulties in identifying feasible housing alternatives)? Should a policy system for senior services be motivated by the desire for incremental changes in the existing system (where should a new senior center be located?) or fundamental change (should the senior center system be based on a traditional bricks-and-mortar model for site-based services, or something different?) A system for encouraging reductions in individual energy consumption use as motivation individuals’ desire to save money, or enjoy positive regard from peers, or take action to improve the environment? While there is some preliminary evidence from surveys and field research that can address these questions, the body of evidence is currently thin.

Evidence

Modern policy analysis relies on evidence for and against specific proposals, derived from studies of existing policies and analytical models representing policies not yet implemented (see e.g. Bardach 2004). However, it is difficult to incorporate evidence into public DSS, as it is often contradictory, hard to summarize effectively, or simply not known. Examples of sources of evidence include social services, public policy and engineering. In housing counseling, evidence might come in the form of data on fair housing complaints in various jurisdictions, or summaries of studies indicating observed housing and life outcomes for families making choices similar to those considered by the current user. In policy systems for senior services design, evidence might be white papers or links to research that summarize strategies for services provision, or provide specific guidance in applying analytical methods. In applications to reduce energy consumption, evidence might be estimates of reductions in carbon emissions, or reductions in out-of-pocket costs, associated with specific energy-saving choices. DSS for public action should enable users to identify and assess the evidence supporting specific action alternatives, or for a variety of problem types, quickly and easily.

Models

As indicated previously, decisions are made using a wide variety of models, some explicit, others not. Herbert Simon (1955, 1990) powerfully advocated for decision models that accommodate conceptual limitations of ordinary users. Also, extensive research on decision-making styles (Scott and Bruce 1995) shows a wide range of attitudes regarding individuals’ capability to make coherent decisions on the basis of well-articulated values and evidence. Finally, there is a
substantial literature in management science on prescriptive decision models (Eiselt and Sandblom 2004).

However, there is no consensus on the type, and sophistication, of decision models that are most-appropriate for public policy decisions and individual action, especially for vulnerable and under-represented populations. We assert that these DSS should facilitate model-based decision-making. This would seem obvious, except that from different perspectives, models per se are often not seen as central to the goal of the decision support process. For example, surveys of housing counselors that led to the development of the housing counseling support system (Johnson 2005c) found that they saw their fundamental role as administrative (ensuring that clients followed the rules of assisted housing programs) rather than participatory (ensuring that clients make the housing relocation decisions that are best for them). Models of decision-making were thus irrelevant to their conception of assisted housing services provision. Also, current research on applications to reduce energy consumption is confronting the problem of representing the energy reduction choice: should it be a single recommendation that is accepted or rejected by the user, or multiple recommendations, accompanied by a decision model that can help users choose a most-preferred alternative?

Therefore, public DSS research should address both descriptive models to increase the capacity and skills for human decision-making, and prescriptive models to increase the technical proficiency in identifying and quantifying decision alternatives and choosing most-preferred courses of action.

Creativity and Collaboration

In order to add value to decision-making processes, DSS must actually be used. However, technical design of DSS, and design or redesign of administrative processes to facility DSS usage is challenging. Recent research on a decision support system for evidence-based medicine practice in an outpatient setting (Zheng et al. 2005) found that, despite an application designed according to expressed preferences of users and administrators, actual usage was lower than expected, usage styles ran counter to the application design, and social networks that might support usage relied heavily on perceived support from administrators, whether or not they actually used the system, and self-assessed computer knowledge negatively influenced system usage, while self-assessed enthusiasm for IT positively influenced system usage.
We assert that DSS for public decision-making must facilitate creativity and collaboration in order to maximize usage. First, systems should reflect characteristics of individual users. Personalization of energy reduction recommendations to account for user sociodemographic characteristics is a key component of the system for energy reduction choices currently under development. Second, systems should allow users to test alternative assumptions and hypotheses. For example, the housing counseling support system allows users to define multiple queries in order to identify a candidate set of housing units and/or neighborhoods, and allows users to rank alternatives using two different decision models. Third, systems should allow users to collaborate within and across stakeholder groups. For example, proposed policy systems for senior services design allow multiple users to add to the knowledge base, and the proposed system to encourage energy usage reductions is based on the ability of social networks to influence usage behavior. Last, systems should provide rapid feedback to modify choices: based on decisions generated by support system, a user should be able to easily revise values, or quantitative criteria by which decision alternatives are generated, or criteria used to rank alternatives. While many existing general DSS software have these features (Creative Decisions Foundation 2006, Visual Decision, Inc. 2004), they are less common in the types of public policy-oriented systems considered in this paper. While the housing counseling support system prototype does not yet allow users to easily revert between decision outcomes and decision inputs, the proposed “footprints” system is intended to allow users to consider different energy reduction recommendations based on a range of personal usage characteristics and values.

III. Case Study: Counseling Support for Housing Mobility

The first application of decision support systems for policy change and individual action is a counseling support system for assisted housing programs, specifically vouchers for private-sector rental housing. The motivation for this application is a large current body of research associated with the Moving to Opportunity Program for Fair Housing (MTO), a national demonstration whose goal is to measure outcomes associated with enabling families from high-poverty communities to relocate to low-poverty communities with housing vouchers and targeted counseling. While current evaluations of MTO are not as positive as initial evaluations (U.S. Department of Housing and Urban Development 2003), MTO offers the possibility of significant improvements in living conditions and life outcomes for very low-income families. Such areas include: risk of criminal victimization, housing quality and mental health. The Pittsburgh
Housing eCounselor exists to answer the question: if a program like MTO were implemented on a large scale, how could IT assist counselors, clients and landlords in connecting low-income families to good-quality housing in opportunity-rich neighborhoods?

This research confronts a number of gaps in current knowledge. First, the actual decision-making process by which housing mobility program participants (or clients of the conventional Housing Choice Voucher Program) search for housing is not known to this author. Thus, Johnson (2005c) proposed a decision-making process on the basis of field research at an actual public housing authority (PHA). Second, the extent to which PHAs and other housing service agencies can assist creative decision-making by clients who may face multiple life challenges is limited by a lack of technical knowledge on IT-assisted decisionmaking and the necessary IT infrastructure. Some insight into this limitation appears in Johnson (2005b) for a single local PHA, and in Johnson (2000) for a small sample of PHAs nationally. Last, the ability of low-income families to frame and solve difficult problems using decision models and IT is unknown in general. However, field research by Johnson (2005b) provides some suggestive evidence that low-income families can interpret tabular data and spatial data consistently; additional research by Johnson (2005a) provides limited support for the notion that low-income families can make productive use of multi-criteria decision models that are cognitively demanding.

The Pittsburgh Housing eCounselor (www.housing-ecounselor.org) (Johnson 2005b) is a prototype spatial decision support system that guides users through the process of identifying candidate housing units and neighborhoods, and ranking these candidate sites with two alternative multi-criteria decision models. The eCounselor uses Keeney’s value-focused thinking method (Keeney 1996) to enable clients and counselors together to identify characteristics of housing units and neighborhoods that are important to the client and generate a subset of housing units and/or neighborhoods based on user-defined criteria. This process is represented by Figure 1, in which users start the search by identifying candidate neighborhoods or candidate housing units through appropriate queries, rank candidate destinations using MCDM, and given these candidates, choose acceptable housing units or neighborhoods and conclude by re-ranking, if necessary, the set of acceptable housing units in acceptable neighborhoods to generate a list of housing units as the basis for site visits.
Neighborhood characteristics are represented with spatial data describing demographic, employment and housing characteristics of Allegheny County, PA and displayed in Web-accessible format using ArcIMS (Environmental Sciences Research Institute 2002). Figure 2 shows an example of this spatial data display, for fair housing complaints in Allegheny County.

[Figure 2: Search Pittsburgh Neighborhoods - Fair Housing Complaints]

Housing unit characteristics are represented with tabular data describing actual housing units available for rent in the city of Pittsburgh and displayed in Web-accessible format using Microsoft Access with Active Server Pages. Figure 3 shows an example of a search page for housing units that allows the user to specify a wide range of housing characteristics.

[Figure 3: Search Registered Housing Units]

Neighborhoods or housing units can be ranked using one of two MCDMs: elimination by aspects, or simple sort, in which users rank candidates in ascending order according to attribute values, or PROMETHEE (Brans and Vincke 1985), in which users specify the form of preference functions that measure the extent of a users’ preference for one alternative over another with respect to the difference in performance of any pair of alternatives according to a single attribute. For example, a user could specify an increasing preference for one alternative over another as a linear function of the difference in crime rates of two neighborhoods. A display of the user interface for the PROMETHEE MCDM is shown in Figure 4.

[Figure 4: Rank Neighborhoods using PROMETHEE]

The current version of the Pittsburgh Housing eCounselor prototype has the neighborhood selection function implemented as an ArcView 3.2 project with a user interface coded using the scripting language Avenue, and has MCDMs implemented as a desktop application coded in Java. Development of a fully-integrated, professional-quality SDSS is a goal of future research.

To measure the extent to which the Pittsburgh Housing eCounselor could be integrated into a comprehensive counseling support system, a recent student course project has developed a Web-based counseling support system prototype for a local nonprofit that provides housing counseling. Based on extensive field research and application design focus groups, this application collects a wide variety of data on client-counselor encounters in order to develop a
counseling plan customized to the client needs. An example of the user interface is shown in Figure 5.

[Figure 5: CCTS – Case Summary Information]
The client for whom this application was developed ultimately decided not to deploy it in the field.

How do these two applications—a SDSS for housing mobility counseling, and a MIS for housing counseling services—jointly address the issues of values, evidence, models and creativity and collaboration listed in the previous section? The SDSS uses an explicit values modeling perspective as the basis for system design, while the MIS uses more conventional user requirements analysis. The SDSS uses current research on assisted housing policy using vouchers, and housing mobility in particular, to identify a potential need for IT-based housing counseling support that could improve the state of current practice. The MIS was not developed using rigorous evidence of the efficacy of current housing counseling systems, either manual or computerized. Instead, qualitative impressions of the inadequacy of the current system used by the counseling agency, as well as those of competing firms justified the development of the current prototype.

The SDSS project motivated subsequent field research to better understand the ability of typical clients to make use of various MCDMs. A sample of eight housing voucher clients of a local public housing authority used a custom application coded in Excel and Visual Basic for Applications to rank hypothetical neighborhoods using three MCDMs: simple additive weighting using rank sum weights (Malczewski 1999, p. 199), Analytic Hierarchy Process (Saaty 1990) and PROMETHEE. Seven of the eight participants were able to complete the ranking process without substantial coaching. Two-thirds of participants believed that the models helped them choose hypothetical neighborhoods, but 86 percent felt that the MCDMs did not improve the quality of the decision they would have made without the models. The additive weighting and PROMETHEE methods were most-preferred by 42 percent apiece of participants. 57 percent of respondents rate additive weighting and AHP as the easiest and next-easiest MCDMs, respectively; 43 percent of respondents felt that AHP and PROMETHEE were the hardest of the MCDMs.
The final analysis performed was to measure the consistency of rankings between the three MCDMs by respondent. Consistency was measured in two ways: the Spearman Correlation Coefficient, which represents consistency between two lists of values, and the Kendall’s Coefficient of Concordance, which represents consistency between an arbitrary number of lists of values. The average value of the Spearman coefficient across all eight observations was computed as 0.75 for additive weighting as compared to AHP; 0.28 for additive weighting as compared to PROMETHEE and 0.04 for AHP as compared to PROMETHEE. The average value of the Kendall’s coefficient across all eight observations was computed as 0.11.

These results indicate that typical assisted housing clients appear to appreciate the increased insight of MCDMs such as PROMETHEE, even as they acknowledge difficulty of use, and that neighborhood rankings were largely dissimilar across the three MCDMs. Thus, this research is supportive of the notion of model-based decision methods as a tool for improving housing counseling, and provides suggestive evidence that a range of MCDMs may allow clients to choose the application that is best-suited to their skills and preferences.

The assisted housing counseling system evaluates less well according to creativity and collaboration: though the application is intended to be used by clients, counselors and property managers, there is no explicit means by which multiple persons, within or across stakeholder groups, can interact within the application.

IV. Case Study: Policy Support for Senior Services Provision

The second application of DSS we consider focuses exclusively on organization-level policy design. Referred to as “policy system” or “policy shop” (Gorr, Johnson and Roehrig 2004), it is defined as a collection of hardware, software, communication technologies, persons, procedures, protocols, and standards driven by and for the purpose of advancing an organization’s mission in regard to policy analysis, planning, and program evaluation decisions. A policy system supports activities that change the underlying structure of public goods and service delivery systems. In contrast, MIS supports management and operations, activities that strive for efficiency within established organizations and programs. The motivation for this definition is the fact that organization-level public-sector policy design is in certain ways more complex than private-sector strategy design: skilled staff may be more likely to take new jobs for more salary, the quality and quantity of IT infrastructure may be limited, the policy problems addressed are
inherently multi-stakeholder and multi-objective, and certain statutory responsibilities often require public oversight of policy decisions and processes.

Policy systems are comprised of: professionally educated staff members, external experts who have access to and can contribute to the policy system, white papers that define policy issues for study and drive the collection of data and construction of models, a data warehouse derived from internal and external sources, perhaps including spatial data, organization-wide standard software such as database, GIS, statistical, and Web development packages, a model base that contains analytical models for both descriptive and prescriptive analyses, and a Web site for access by government staff, stakeholders, external experts, and concerned citizens.

There are no examples known to this author of policy systems currently in use, although the elements of policy systems listed above are widespread. For example, Baltimore CitiStat (http://www.ci.baltimore.md.us/news/citistat/index.html) enables users to examine different indicators of service and neighborhood quality in order to identify problem areas and reallocate resources. The Allegheny County Department of Human Services’ Office of Information Management (http://www.county.allegheny.pa.us/dhs/Support/OIM.html) has developed an extensive data repository to facilitate cooperation across different service units within DHS. The Fannie Mae Foundation manages a website called KnowledgePlex (www.knowledgeplex.org) that contains links to scholarly articles, white papers, reports and popular news accounts related to housing and community development. The absence of a single policy shop may be explained by knowledge gaps in current research. For example, there is little academic research on the level of institutional support for information technology- and decision-aided policy design (as distinct from, say, e-government initiatives to connect constituents to services), especially for not-for-profit, community-based organizations. Also, it is not clear what characteristics of policy problems organizations face (size, frequency, complexity, etc.) would justify the development of a policy shop. Finally, there is little research on the relative efficacy of different decision models for service provision and system design that might comprise a policy system’s model base.

The policy system we describe here has its origins in student projects to assist a local agency providing various supportive services to elderly citizens to better understand the nature of existing services, and to make well-founded decisions regarding changes in the service network, for example the best location for a single new senior center. It is also motivated by research
focusing exclusively on decision models for region-wide system design for meals-on-wheels kitchens (Gorr, Johnson and Roehrig 2001, Yildiz, Johnson and Roehrig 2005) and senior centers (Johnson, Gorr and Roehrig 2005). Senior services that would be a focus of this policy system include these two, as well as home-based care, adult foster care, on-demand transportation, protective services, and senior companions.

Key tasks for policy planning for elderly services include demand forecasting, identifying stakeholders, eliciting preferences for needs to be provided through IT-enabled services, quantifying and balancing the needs of different stakeholder groups, producing specific analytic tools accessible to various stakeholders, and defining specific policy alternatives that optimize chosen criteria.

An application to meet policy needs for senior centers, an “e-Policy Shop”, has been designed to identify gaps in the coverage of the elderly population in Allegheny County by senior centers and to provide a planning model for estimating the impact of new senior centers for filling the gaps\(^1\). The resulting Web site\(^2\) includes white papers, data, documentation, standardized software products, models, tutorials for data preparation and modeling, and results.

Important elements of this policy system include issues tracking and forecasting, technologies for institutional memory, modeling, and stakeholder involvement. For example, the e-Policy Shop contains a white paper on demographic trends of the elderly population in Allegheny County, including forecasts to the year 2010 that has been widely used by the client agency. The application uses ArcView (Environmental Sciences Research Institute 2001) for desktop GIS analysis and ArcIMS (Environmental Sciences Research Institute 2002) for Web-enabled GIS analysis to perform spatial analyses over the county, taking into account current and future population demographics, likely demands on senior services facilities, availability of transportation and local amenities, current and projected funding, and other considerations.

While application documentation is a typical challenge, the e-Policy Shop includes an entire component is devoted to tutorials and documentation, as seen in Figure 6.

\[\text{Figure 6: Access to Tutorials for Reusing GIS Models}\]

---

\(^1\) The local agency charged with senior services has reviewed, approved and used the e-Policy Shop; however, due to administrative and budgetary reasons the agency does not currently manage the site.
\(^2\) URL: \texttt{http://itclass.heinz.cmu.edu/aaaweb}; Login: heinz\texttt{\textbackslash aaaweb}; Password: heinzaaaaweb.
To enable public access and stakeholder involvement in the policy system, the e-Policy Shop makes available to the public some of its data sets, models (and tutorials for their use), and products (model results, reports, and so forth). Two examples of these application components include suitability analysis for potential new senior centers to be located in Allegheny County (see Figure 7), and a spreadsheet model to forecast elderly demand for senior centers available for download, along with data sets and instructions for use.

[Figure 7: Covered and Suitable Municipalities for Senior Centers, Allegheny County, PA]

The e-Policy Shop has significant strengths when evaluated according to the principles of values, evidence, models and creativity for policy-oriented DSS listed in Section II. It is responsive to real needs of practitioners, representative in terms of policy systems components, and conforms to key principles such as access, openness and replication, analytical capability, and information asset management. In particular, it allows for the incorporation of multiple decision models for system design, each of which provides for extensive “what-if” analysis. Collectively, the data, policy knowledge, models and technology flexibility allow diverse users to collaborate and develop alternative strategies.

V. Case Study: Leveraging Social Networks for Reductions in Energy Consumption

The last case study presented in this paper addresses the use of IT and online social networks to reduce energy consumption. Consumption of fossil fuel to generate energy used in the residential and commercial sectors in the United States has resulted in residential and commercial energy consumption that has created 2.2 billion metric tons of carbon dioxide (CO2), a greenhouse gas presumed to be the major cause of climate change (U.S. Department of Energy 2006). Murphy (2006) argues that “nearly half of Americans’ total average ... consumption is more or less under their personal control”. Thus, a solution to reducing greenhouse gas production and the corresponding impact on climate change depends in part on change at the individual level to reduce energy consumption. Indeed, many individuals take action on their own to reduce their energy consumption: they choose to drive smaller cars, or take mass transit, or live closer to central cities, or live in more energy-efficient homes, and so on. Examples of energy reducing activities are contained in Table 1, derived from a recent survey of 100 Carnegie Mellon University students, staff and faculty. Also, as mentioned in the Introduction, there are a number
of online resources for information about energy conservation and reductions in carbon dioxide emissions.

[Table 1. Mean Frequency of Performing Energy-Reducing Behaviors on a Scale of 1 (Rarely or Never) to 5 (Almost Always)]

One barrier to changing consumption habits is educating general citizenry on the links between everyday actions, such as driving to work or leaving a light on while away from home, the energy consumption and emissions generated from those actions, and the resulting ecological impact. Most people have serious misconceptions about climate change (Bostrom et al. 1994a,b), and do not connect climate change to personal energy consumption activities. With knowledge of the link from personal action to ecological impact, people can make better decisions about their actions to minimize their burden on the environment. However, contextual factors such as individual opportunities and abilities may have a big influence (Poortinga, Steg and Vlek 2004), pointing at the need for personalized information.

The Internet can play a unique role in increasing individuals’ understanding of these links and providing ongoing support for change. In particular, social networking, facilitated by Internet technologies, is a popular and potentially powerful medium for educating consumers and motivating change. It is possible that that virtual social networks membership can be used to motivate personal change, by enhancing actionable suggestions presented to consumers frequently in an integrated fashion.

Thus, the goal of this project is to “piggy-back” on popular social networking sites to encourage individuals to reduce carbon consumption. This will be done in the following way: First, current members of the social networking site who have agreed to be part of an initiative (“Footprints”) to reduce individuals’ “carbon footprints” will have their homepages modified to provide information about their energy usage and the usage of those persons in their immediate network (see Figure 8). Second, based on detailed information on energy usage habits, personal characteristics and decision-making style, the Footprints software will provide personalized suggestions regarding specific actions. Examples of generic suggestions and their personalized counterparts are contained in Table 2.

[Figure 8: Simulation of Footprints Information Shown on Yahoo! 360 User’s Homepage]

[Table 2: Different Ways of Presenting Energy Reduction Actions May Affect Adoption]
Users will also be encouraged to report creative new ideas. This will help to ensure that fresh material (popular new ideas) is always present on a user’s page, helping to draw the user’s attention. Users will be able to vote on ideas, and it is hoped that the new idea system will also encourage participation through competition. This will allow users to receive frequent feedback, and to leverage information about group membership to motivate change, both of which are important sources of motivation (Annesi 1998, Becker 1978, Seligman and Darley 1977).

There are a number of gaps in research knowledge that this project is intended to fill. First, it is not known how online social networks can be used to support behavioral change. While there is an extensive literature on the interaction between social networks, social movements and social change (e.g. Passy and Guigni 2000a,b) and online social networks can be seen as an analogue to churches in the black South as an organizing vehicle during the Civil Rights Movement (Williams 2002), more needs to be known about how online communities can induce or encourage sustained behavioral change. Second, it is not known how effective recommendations for personal action can be when they are personalized (reflecting specific sociodemographic or energy usage characteristics of users) and/or values-based (incorporating an appeal to actions that may achieve more important, fundamental goals) as compared to more generic presentations (see Table 2, above, for a comparison of the three types of recommendations). For example, recent results of a survey regarding energy usage (Table 1, above) indicate that certain suggestions for energy-reduction actions are more likely to appeal to users than others. Third, it is not known how choices of energy-reducing actions, which are decision problems, can be presented in a user-friendly and parsimonious way that takes best advantage of known user attitudes towards decisionmaking and the wide range of multi-criteria decision models available (see e.g. Eiselt and Sandblom 2004). Current research on customized recommendations for evidence-based medicine practice in an outpatient setting has found some evidence of sustained DSS usage (Zheng et al. 2005), but impacts of that medical DSS on long-term changes in physician behavior and/or patient outcomes is unknown.

Currently, the Footprints project is at the system design stage. It is anticipated that funding will allow the research team to develop the IT application, deploy it widely across multiple commercial social networking sites and build a unique database of users, preferences, energy usage characteristics, suggested actions and performed actions.
When completed, this application will have substantial potential to fulfill the promise of policy-oriented DSS for individual action. It is values-based: the motivation for individuals to use the system can lie in desires to reduce energy consumption, to reduce energy costs, or to affiliate with like-minded individuals in one’s own social network. It is evidence-based: the recommendations for energy consumption are based on current knowledge in environmental engineering and behavioral change. It is model-based: the recommendations will reflect best understanding of decision-making styles and decision models that enable users to choose energy reducing actions that are best aligned with their preferences. Finally, it facilitates creativity and negotiation, since it will be deployed across large social networks, intended to constantly reflect new suggestions for energy reduction actions, and use competition within social groups to encourage individuals to achieve specific energy reduction goals.

One potential limitation of this project, however, is exclusivity among user groups. The survey of Carnegie Mellon University students, faculty and staff described above had extremely low participation rates by African-Americans (1%) and Hispanics (2%). If existing commercial online social networks have similarly skewed demographic characteristics, then there could be substantial gaps in our understanding of individual and group behavioral change within U.S. populations. (Recently, an online social network targeted at minorities, MinoritySpace, http://www.minorityspace.com, has been launched.)

VI. Conclusion and Next Steps

The primary motivation for this paper is an observed gap between the high penetration of information technology into daily use and the relative paucity of public-sector IT applications that facilitate personal choices and system change. It is asserted that public-sector DSS initiatives should be better aligned with end-user abilities, expectations and constraints. In particular, these applications should be values-based, evidence-based, model-based and facilitate creativity and negotiation.

Case studies of three public-sector DSS applications, all in prototype or system design phases, indicate significant promise to increase capacity of individuals and organizations to influence daily behavior. A spatial DSS for housing counseling support has been shown to reflect observed capacities of low-income typical users to assimilate spatial and tabular data and to use multiple decision models in an experimental setting successfully. This application, the Pittsburgh Housing
eCounselor, represents an opportunity to develop professional-quality counseling management systems that incorporate client intake, caseload management and personalized housing search strategies. A policy system for senior services design, the e-Policy Shop, has been shown to reflect needs of service agencies for applications that can store large volumes of data, information on analytic strategies and best practices and alternative descriptive and prescriptive models for system design. A proposed Internet-enabled application for social networks, Footprints, has been shown to be relevant to current individual efforts to reduce energy consumption and thus carbon dioxide emissions. It promises to address a number of important research questions regarding the extent to which online social networks and decision models can be combined to induce long-term change in energy consumption behaviors.

The first priority for each of these applications is to implement them in real-world organizations, and observe impacts on individual and organizational behavior, as well as longer-term outcomes. This is not an easy task: many DSS (including the first two applications discussed in this paper) stop at the prototype stage. One reason for this is significant technological and organizational barriers to daily application usage that might disrupt established workflows. In response, two research initiatives are proposed. First, academic research should increasingly treat IT applications as social-service interventions for which behavioral changes and life outcomes are precisely measured, personal, group and societal benefits and costs are estimated, and potential impacts of widespread usage are modeled. Second, government, in conjunction with private corporations should take the lead for large-scale citizen-oriented decision support initiatives, since the cost and complexity of such systems are beyond the scope of non-profits and academic research alone.

**Acknowledgements:**

This research was supported in part by the National Science Foundation Faculty Early Career Development (CAREER) Program, “CAREER: Public-Sector Decision Modeling for Facility Location and Service Delivery”, SES-0134890.
References:


Tables and Figures:

[Figure 1: Destination Search Algorithm]
[Figure 2: Search Pittsburgh Neighborhoods - Fair Housing Complaints]

Source: Johnson (2005c)
Source: Johnson (2005c)

[Figure 3: Search Registered Housing Units]
The following form displays the neighborhoods or housing units with associated attributes ready for ranking. Please specify values in the empty cells!

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>MARRIAGE/MOONLESSNESS</th>
<th>ECONOMIC STATUS</th>
<th>TOTALSECTIONS</th>
<th>MIN/MAX</th>
<th>PREFERENCE FUNCTION</th>
<th>PARAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRIME RATE</td>
<td>1.0</td>
<td>0.0</td>
<td>1.0</td>
<td>Min</td>
<td>V-shaped</td>
<td>0.5</td>
</tr>
<tr>
<td>BLACK PERCENT</td>
<td>1.0</td>
<td>2.0</td>
<td>1.0</td>
<td>Min</td>
<td>V-shaped</td>
<td>0.5</td>
</tr>
<tr>
<td>VAKANTHUNITS</td>
<td>74.0</td>
<td>538.0</td>
<td>34.0</td>
<td>Max</td>
<td>V-shaped</td>
<td>20</td>
</tr>
<tr>
<td>TOTAL COMPLIANT</td>
<td>1.0</td>
<td>0.0</td>
<td>0.0</td>
<td>Min</td>
<td>V-shaped</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**Definitions of min/max**

a. "Min": If smaller values are preferable to larger values, choose the smallest possible value for this attribute.
b. "Max": If larger values are preferable to smaller values, choose the largest possible value for this attribute.

**Definition of “preference function”**

A preference function expresses the strength of desire of the user for one alternative as opposed to another with respect to a particular attribute. This desire is measured as a number between 0 and 1: 0 means that the user is indifferent between the two alternatives and 1 means that the user strongly prefers the alternative with the more desirable value. A preference function value greater than 0 and less than 1 means that the user moderately prefers the alternative with the more desirable value.

As an example, assume that the user prefers neighborhoods with smaller commute times to downtown as compared to those with larger commute times. The input to the preference function is the difference between the two attribute values. For example, if neighborhood 1 has a commute time of 25 minutes, and neighborhood 2 has a commute time of 20 minutes, the difference between the two attribute values is 25 - 20 = 5 minutes.

Source: Johnson (2005c)

[Figure 4: Rank Neighborhoods using PROMETHEE]
Urban League of Pittsburgh
Client Counseling and Tracking System

[Figure 5: CCTS – Case Summary Information]
EPS Tutorial

Table of Contents

Module I: Processing Service Delivery Data
  Lesson: Manipulating Raw Data Sets
    Goals: Transforming Raw Data into Meaningful Information
    Topics:
    - Prepare Data in Microsoft Excel
    - Process Data in Microsoft Access
    - Convert Files to ArcView GIS Format

Module II: Building ArcView GIS Maps
  Lesson A: Creating Base Maps
    Goals: Displaying the Locations of Senior Centers
    Topics:
    - Import Data
    - Match Address to Physical Locations

Lesson B: Manipulating Census 2000 Data

Source: Gorr, Johnson and Roehrig (2004)

[Figure 6: Access to Tutorials for Reusing GIS Models]
[Figure 7: Covered and Suitable Municipalities for Senior Centers, Allegheny County, PA]

Source: Gorr, Johnson and Roehrig (2004)
<table>
<thead>
<tr>
<th>Action</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn off lights when leaving the room</td>
<td>4.34</td>
<td>1.08</td>
</tr>
<tr>
<td>Turn off music when out of hearing range</td>
<td>4.01</td>
<td>1.24</td>
</tr>
<tr>
<td>Combine shopping trips</td>
<td>3.86</td>
<td>1.05</td>
</tr>
<tr>
<td>Wear a sweater rather than turn up the heat</td>
<td>3.52</td>
<td>1.12</td>
</tr>
<tr>
<td>Adjust thermostat to 70 or less in winter and 72 or higher in summer</td>
<td>3.48</td>
<td>1.29</td>
</tr>
<tr>
<td>Use the computer sleep feature</td>
<td>3.33</td>
<td>1.55</td>
</tr>
<tr>
<td>Wash laundry in cold water</td>
<td>2.96</td>
<td>1.41</td>
</tr>
<tr>
<td>Use energy efficient light bulbs</td>
<td>2.94</td>
<td>1.33</td>
</tr>
<tr>
<td>Take short showers (5 minutes or less)</td>
<td>2.57</td>
<td>1.31</td>
</tr>
<tr>
<td>Unplug electronics when not in use</td>
<td>2.50</td>
<td>1.61</td>
</tr>
<tr>
<td>Buy locally farmed produce</td>
<td>2.36</td>
<td>1.31</td>
</tr>
<tr>
<td>Air dry clothes</td>
<td>1.84</td>
<td>1.28</td>
</tr>
<tr>
<td>Take cloth bags to grocery store</td>
<td>1.73</td>
<td>1.28</td>
</tr>
</tbody>
</table>

Source: Mankoff et al. 2006a

[Table 1: Mean Frequency of Performing Energy-Reducing Behaviors on a Scale of 1 (Rarely or Never) to 5 (Almost Always)]
Source: Mankoff et al. 2006b

[Figure 8: Simulation of Footprints Information Shown on Yahoo! 360 User’s Homepage]
<table>
<thead>
<tr>
<th>Simple presentation</th>
<th>Personalized presentation</th>
<th>Values based presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order online instead of driving to the store</td>
<td>Add CDs to your collection at CDStore.com</td>
<td>Ordering online instead of driving long distances alone can save money; reduce transportation energy use and increase air quality</td>
</tr>
<tr>
<td>Turn off appliances at the outlet</td>
<td>Turn off your DVD player and Stereo at the outlet when not in use</td>
<td>Your appliances may use power even when “off.” Turning them off at the outlet saves the average American $150/year and stops the unnecessary waste of non-renewable resources</td>
</tr>
<tr>
<td>Use stand-by mode instead of a screensaver</td>
<td>Use your laptop’s “Better Energy Savings” mode</td>
<td>Your screensaver uses more power than most applications. Save battery time and reduce waste by using stand-by mode.</td>
</tr>
</tbody>
</table>

Source: Mankoff et al. 2006b

[Table XX: Different Ways of Presenting Energy Reduction Actions may Affect Adoption]