THE LOS ANGELES LIFELINES STAKEHOLDER SURVEY:
DEFINING UTILITY PERFORMANCE OBJECTIVES FOR DISASTER MODELING IN THE LOS ANGELES REGION

by

KRISTINE TATEBE

B.Sc.(GRS), The University of British Columbia, 2004

A PROJECT SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE (PLANNING)

in

THE FACULTY OF GRADUATE STUDIES

School of Community and Regional Planning

We accept this project as conforming
to the required standard

.....

.....

.....

THE UNIVERSITY OF BRITISH COLUMBIA
August 2007

Executive Summary

Post-disaster outages of lifeline utilities such as electricity and water have substantial impacts on regional economic activity, and mitigation efforts should be continued to reduce the duration and extent of these outages. The Los Angeles Lifelines project seeks to model these outages and their recovery in the context of the Los Angeles Department of Water and Power. Informing this modeling process are performance objectives that utility providers may seek to attain in disaster response. This professional project sought to determine the appropriate format and substance of these objectives.

A targeted survey of 18 key stakeholders in Los Angeles was conducted via email, addressing types of stakeholders to include in the definition of performance objectives, appropriate means of framing the objectives, communication of these objectives, considerations in disaster-related decision-making, views of utility providers versus users, and possible challenges in the definition and use of performance objectives.

The survey concluded that a wide variety of stakeholders should be involved in the definition of performance objectives; that objectives should be flexible and context-specific, and in the format of “service recovery to critical facilities or 90% of the population within a specified timeframe.” There was found to be more consensus related to performance objectives for moderate than catastrophic disasters. Other findings included that a few scenarios of varying likelihood were the most helpful means of presenting uncertainty, and that the most effective means of communication were websites and print material. A reduction in outage to critical infrastructure, as well as a reduction in overall outage time were identified as priorities for decision-making. Utility providers consistently set less stringent performance objectives than users, although both agreed regarding decision-making priorities, stakeholder involvement, and information sharing.

Although there are uncertainties in the data due to methodological limitations, data from this survey can better enable the L.A. Lifelines model to assist in the definition of performance objectives, resulting in a Los Angeles that is better prepared to respond in the event of a disaster.

Table of Contents

List of Figures and Tables

Terms of Reference

A key component of disaster impact and resilience modeling is the development of post-disaster performance objectives. These objectives can serve an important role in setting benchmarks for community disaster resilience.

However, how does one decide upon these performance standards? How safe is “safe enough”? Previous studies determined that stakeholder involvement was required in the development of disaster service goals for utilities.

This project addressed the need for stakeholder input, through the administration and analysis of a survey of key utility stakeholders in the Los Angeles region. The hypothetical client was identified as a manager at the Los Angeles Department of Water and Power (LADWP) who is aware of disaster risk issues, and who would like more information on the attitudes of higher-level, managerial stakeholders with respect to performance objectives. Accompanying this information, the client would like recommendations to assist them with the development of performance objectives. The tasks to be performed were to:

1) Design and administer a survey of key utility stakeholders (15-30)
2) Analyze the collected data
3) Make recommendations regarding performance objectives and further research

The project proceeded in stages as follows:

1) Literature review – March 2006
2) Survey design and sample identification – April 2006
3) Administration of survey – May through August, 2006
4) Formation and maintenance of a response database – June through August, 2006
5) Analysis of data – September through November, 2006
6) Drafting of final report and recommendations October 2006 through May, 2007
7) Presentation of findings – August, 2007

Outcomes of this project include: a data set regarding performance objectives and means of information sharing/communication that can be further analyzed as necessary; a set of recommendations for acceptable performance objectives, increased awareness of disaster risk among utility stakeholders, the identification of areas requiring further investigation, and increased personal knowledge regarding disaster modeling and stakeholder involvement. Deliverables include a final written report, data set, collected and catalogued surveys (both electronically and in hard-copy), and summary Power Point presentation to be presented at SCARP.

I. Overview

1.1) Introduction

This survey was conducted as one part of a larger multi-institutional study entitled “Direct Losses, Social Impacts and Community Resilience: Los Angeles Lifelines”. Previous research activities of this project have focused on modeling disaster-related electricity and water outages in the event of earthquake related events, and the resulting restoration activities (Çag˘nan et. al, 2006).

Central to this modeling is the development of performance objectives that the utility service provider may seek to attain in the design and implementation of disaster mitigation strategies. These objectives can serve an important role in setting benchmarks for community disaster resilience (Chang and Shinozuka, 2004).

Chang and Coelho (2006) found there to be widespread support among utility sector professionals for community-based performance objectives, not only for specific mitigation decision-making, but also for policy development and public relations. Chang and Coelho corroborated with May (2004) in a study concluding that such standards should be developed via a multi-stakeholder process involving the broader community. Ahmad (2005) identified the possibility of a structured survey as a formal investigation into the definition of performance objectives, which could be accompanied by a consensus-seeking discussion. The Los Angeles Lifelines stakeholder survey attempts this broader community involvement in the form of a structured survey. This report outlines the background, research questions, methods, findings and implications of this survey.

1.2) Performance Objectives Background and Rationale

Utility performance objectives have been commonplace in the research community and increasingly in practice following the 1994 Northridge and 1995 Hyogoken-Nambu (Kobe) earthquakes (Ballantyne, 1994, Eidinger and Avila,

1999). Recent work by the Multidiscipinary Centre for Earthquake Engineering Research (MCEER) has been attempting to broaden the definitions of such objectives to include more socio-economic considerations (Chang and Chamberlin, 2004, Bruneau et. al, 2003, Chang and Shinozuka, 2004). Earlier research by Rose et. al (1997) evaluated the impacts of system outages and mitigation efforts on regional economies.

Bruneau et. al. (2003) expanded the definition of community resilience (and consequently performance objectives) to include technical, organizational, social and economic dimensions (the "TOSE" framework). Chang and Shinozuka (2004) applied this framework (in the form of performance indicators) to the water system in Memphis, Tennessee. Following this, a framework for the evaluation of the Los Angeles Department of Water and Power (LADWP) disaster resilience was undertaken (Shinozuka et. al, 2004). Benchmarks were used to evaluate different mitigation scenarios, including the regional economic losses sustained by disaster-related outages. Chang and Seligson (2003) used example performance measures in the LADWP context to evaluate mitigation scenarios. The objectives used in that study were defined by the authors for demonstration purposes only. Chang and Chamberlin (2003) stated the preliminary nature of many of the performance objectives used to date, and identified the need for further research into the definition, methods, and substance of such objectives.

May (2004) analyzed decision-making models relating to the creation of performance objectives for earthquake engineering, and identified the significant challenge behind translating the diversity of organizational needs into a meaningful set of performance objectives. He stressed the need for a contextual approach to the definition of performance objectives that was more rigorous, quantitative, and developed with the active involvement of stakeholders (May, 2004).

Chang and Coelho (2006) employed structured interviews to examine the potential for utilities to use performance objectives relating to seismic events. Utility and technical managers from seismically vulnerable communities

throughout North America were interviewed. Interviewees were asked to identify: the potential benefits / drawbacks to performance objectives in modeling, how the model might be used, how performance should be measured, and whether and how a multi-stakeholder process to develop these measures should be conducted.

Chang and Coelho concluded that most utility managers were more interested in the physical / technical aspects of objectives as they relate to the utility, and less interested in the perspective of community end-users. However, water stakeholders were somewhat more amenable to community perspectives perhaps due to the critical nature of water supply systems. Generally though, there was wide support for community-based performance objectives for policy and decision-making, and it was widely agreed that a multi-stakeholder process should be used to develop such objectives. Next steps were identified as consultation with emergency management and public policy professionals, utilizing specific examples of model outputs and performance objectives, perhaps in the form of an internet survey (Chang and Coelho, 2006).

To build on this work, a review of the hazards, environmental and health risk assessment literature was conducted with respect to participatory processes, with the goal of developing a comprehensive plan for engaging community stakeholders in urban infrastructure system planning, specifically for natural hazards (Ahmad, 2005). It was determined that surveys were an effective means of stakeholder involvement, and that respondents should include:

- Technical and non-technical (government and non-governmental officials) experts
- Emergency workers or representatives from their organizations
- Local and State officials directly involved in mitigation programs
- Police, Security and Fire Department representatives
- Community and or municipal planners and administrators
- Industry representatives and consumers
- Business owners: both large and small businesses should be included
- Commercial planners
- Structural and civic engineers
- Hospital administration and medical personnel
- Transportation officials

- Telecommunications experts or representatives
- Representatives from large, well-known structures that might be used as common gathering places (i.e. stadiums or convention centres)
- Civic leaders
- Community representatives (includes geographic as well as cultural and socio-economic community divisions)
- Social workers or those responsible for administering social welfare programs
- Local citizens (as representative of class, gender, culture and socio-economic status as possible).

In addition, it was recommended that surveys should be framed in such a way that incorporated local references, and should be understandable to the variety of stakeholder groups identified above (i.e. should assume no prior knowledge of concepts) (Ahmad, 2005).

Apart from these studies, there is little in the literature in the way of community engagement with respect to utility performance objectives as they relate to a natural disaster context. This work is timely and will make a valuable contribution to the larger research project, while endeavouring to keep the research relevant and useful to stakeholder groups. It will engage stakeholders in what has in the past been a primarily expert-driven field of work.

1.3) Research Questions and Contributions

The purpose of this study is to determine how lifeline performance objectives for natural disasters (primarily earthquakes) can be developed that involve multiple stakeholders and societal impacts. In addition to this overarching question, there are several sub-questions:

1) Who should be involved in defining disaster-related utility performance objectives?
2) What is an appropriate and meaningful way of framing these objectives?
3) How can information regarding objectives be best communicated?
4) What considerations are most important in disaster-related decision-making?
5) Do the views of utility providers differ from those of the community?

6) What challenges might be encountered in the process?

It is anticipated that utility providers will have a slightly different response with respect to the stakeholders to involve in defining performance objectives, as well as in the definition of the objectives themselves, as they will feel responsible for meeting any stated objectives, and are more aware of the costs of doing so. There may be agreement among groups on key issues such as prioritizing public safety, and disagreement as certain groups such as businesses may prioritize economic security. There are many challenges which could be encountered in the process, most of which are impossible to predict in advance.

II. Methods

2.1) Sample

Rather than random sampling, the survey on post-disaster performance objectives targeted key stakeholder groups who would be strongly affected by a disaster-related loss of water and/or power supply in the Los Angeles area. The survey sample was determined by first identifying the main stakeholder groups to be surveyed. Ahmad's work was instructive in this process. Those selected included technical users (e.g. the utility provider [LADWP], emergency managers, emergency response organizations [police, fire], hospitals, planners, transportation officials), decision makers (e.g. utility board, politicians), and the general public (via community organizations and business associations).

Once these target stakeholder groups were identified, names of prominent individuals were solicited from two key informants. Criteria for selection included their familiarity with emergency management procedures if possible (i.e. emergency managers, bioterrorism preparedness etc.), and their relative authority / expertise (with the aim to have higher-level managers as respondents). This initial list was then further augmented through internet research. The target sample size was 15-30.

2.2) Survey Instrument

An 8 page survey was designed to solicit information regarding performance goals and information sharing. The survey was anonymous, but did collect background information such as professional affiliation and job title.

The survey was designed to explicitly address the first four stated research questions.

First, to determine the stakeholders that should be involved in setting performance objectives, the following question was posed:

> Which of the following groups do you think should participate in developing utility service goals for disasters? Please check all that apply:
>
> [Utility provider, Emergency response organization (e.g. police, fire), Health care provider (e.g. hospital, clinic), Local government (e.g. elected official, planner), Community-based organization (e.g. neighborhood council), Business group (e.g. Chamber of Commerce), Non-governmental organization (e.g. Red Cross), Technical expert (e.g. consultant, professional organization), Other (Please specify)]

Following, respondents were asked to choose from a series of questions regarding the content of the objectives themselves, and to give comments on the appropriateness of these objectives as follows:

> This question provides examples (3.a. ~ 3.h.) of possible performance goals for utilities in disasters. Please select one response in each example to indicate the maximum acceptable duration of utility outage.
>
> In the case of a **moderately damaging disaster** (on the scale of the 1994 Northridge (L.A.) earthquake):
>
> a. Electricity should be available to critical facilities (e.g. police, fire, hospitals) within: Less than 1 hour, 12 hours, 24 hours, 72 hours, 7 days, 14 days, Other timeframe (Please specify here).
> b. Electricity should be available to 90% of the population within: Less than 1 hour, 12 hours, 24 hours, 72 hours, 7 days, 14 days, Other timeframe (Please specify here).
> c. Potable water should be available to critical facilities (e.g. police, fire, hospitals) within: Less than 1 hour, 12 hours, 24 hours, 72 hours, 7 days, 14 days, Other timeframe (Please specify here).
> d. Potable water should be available to 90% of the population within: Less than 1 hour, 12 hours, 24 hours, 72 hours, 7 days, 14 days, Other timeframe (Please specify here).

In the case of a **catastrophic disaster** (on the scale of Hurricane Katrina):

e. Electricity should be available to critical facilities (e.g. police, fire, hospitals) within: Less than 1 hour, 12 hours, 24 hours, 72 hours, 7 days, 14 days, Other timeframe (Please specify here).
f. Electricity should be available to 90% of the population within: Less than 1 hour, 12 hours, 24 hours, 72 hours, 7 days, 14 days, Other timeframe (Please specify here).
g. Potable water should be available to critical facilities (e.g. police, fire, hospitals) within: Less than 1 hour, 12 hours, 24 hours, 72 hours, 7 days, 14 days, Other timeframe (Please specify here).
h. Potable water should be available to 90% of the population within: Less than 1 hour, 12 hours, 24 hours, 72 hours, 7 days, 14 days, Other timeframe (Please specify here).

Do you think the types of performance goals in Question 3 above are appropriate? [Y/N]
How might these goals be improved?

Thirdly, to determine how information should best be communicated, the following questions on information sharing were posed:

We are interested in how utilities can best provide information to their users about potential outages in future disasters.

Type of Information
How helpful would each of the following types of information be for your organization's disaster planning efforts?
Please select one response for each type of information:

a. Maps of utility outage areas [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
b. Time estimates of outage duration: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
c. Number of customers without utility service [[not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
d. Number of households displaced from their homes: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
e. Number of businesses temporarily closed: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
f. Loss of regional economic production: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
g. Likelihood of major disruptions: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
h. Other (please specify)

Forms of presenting uncertainty

The uncertainty associated with future disasters can be presented in different ways. How helpful would each of the following forms of presentation be for your organization's disaster planning efforts?

Please select one response for each form of presentation:

a. Worst-case scenario ever possible: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
b. Worst-case scenario likely in 50 years: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
c. Worst-case scenario likely in some other timeframe (specify): [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
d. A few scenarios of varying likelihood: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
e. All possible scenarios together with their likelihoods of occurrence: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
f. Other (please specify)

Means of sharing information

Information on potential outages can be presented different ways. How helpful would each of the following means be to your organization's disaster planning efforts?

Please select one response for each means:

a. Print information (e.g. brochures): [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
b. CD of other electronic format: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
c. Interactive website: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
d. Public meetings: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
e. Workshops: [not at all helpful, not very helpful, somewhat helpful, very helpful, essential]
f. Other format (please specify)

Finally, the following question attempted to address disaster-related decision-making priorities:

Utilities must trade off between costs and benefits when making decisions about reducing disaster damage. The following is a list of potential benefits that may be considered. How important do you think it is to consider each of the following? Please select one response for each potential benefit:

a. Savings in the utility's post-disaster repair and emergency response costs: [not at all important, not very important, somewhat important, very important, essential]
b. Reduction in post-disaster outage time: [not at all important, not very important, somewhat important, very important, essential]
c. Reduction in outage to critical infrastructure such as hospitals, fire stations, transportation networks, etc. [not at all important, not very important, somewhat important, very important, essential]
d. Reduction in regional economic disruption: [not at all important, not very important, somewhat important, very important, essential]
e. Reduction in disruption to people's lives: [not at all important, not very important, somewhat important, very important, essential]
f. Other considerations (please specify)

2.3) Implementation

The decision was made to administer the survey via email, for expedience and ease of data collection. The survey was formatted into a form-fillable word document and sent electronically to the selected stakeholders, accompanied by a cover letter and email introducing the project. Follow-up phone calls were made several days later to encourage completion of the survey and respond to any questions or concerns, and this telephone follow-up was continued over the summer of 2006 until a reasonable number of responses were received.

As survey responses were received they were coded by number to ensure anonymity, and entered into a database for analysis.

III. Results and Analysis

3.1) Background Information

The response rate was 18 out of a possible 31 (58%). Professional affiliation was as outlined in Figure 1 and Table 1 below:

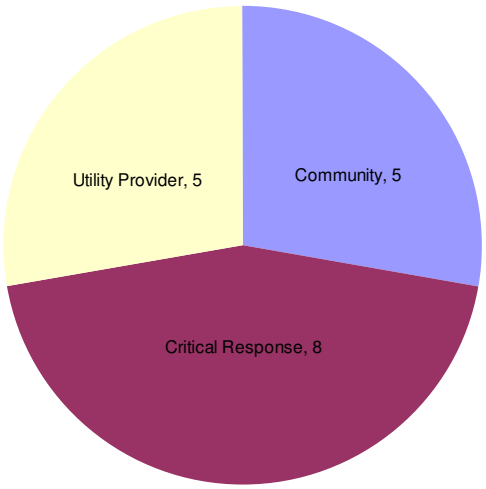

Figure 1: Professional Affiliation of Respondents - Categories

Table 1: Professional Affiliation of Respondents

Respondent Type	Number	Percentage
Emergency Managers	4	50%
Transportation Officials	2	25%
Health Department Officials	1	13%
Fire Department Captains	1	13%
Total Critical Responders:	**8**	**100%**
Risk / Emergency Managers	2	40%
Engineering Directors	1	20%
Communications Representatives	1	20%
Power Distributors	1	20%
Total Utility Providers:	**5**	**100%**
Resource Group Representatives	2	50%
Neighbourhood Council Representatives	1	25%
Business Association Representatives	1	25%
Local Community Officials:	**4**	**100%**
Total Respondents	**18**	

The response rate by category was as in Table 2 below:

Table 2: Response Rate by Category

	Surveys Sent	Surveys Returned	% Response Rate
Utility Providers	8	5	63%
Critical Responders	13	8	62%
Community Members	11	5	45%

3.2) Stakeholder Involvement

This study asked respondents who should be involved in defining disaster related utility performance objectives. Respondents identified emergency response organizations, utility providers, and local government most often when identifying stakeholders that should be involved in setting performance objectives, but all other categories were selected to roughly the same degree, as visible in Figure 2 below:

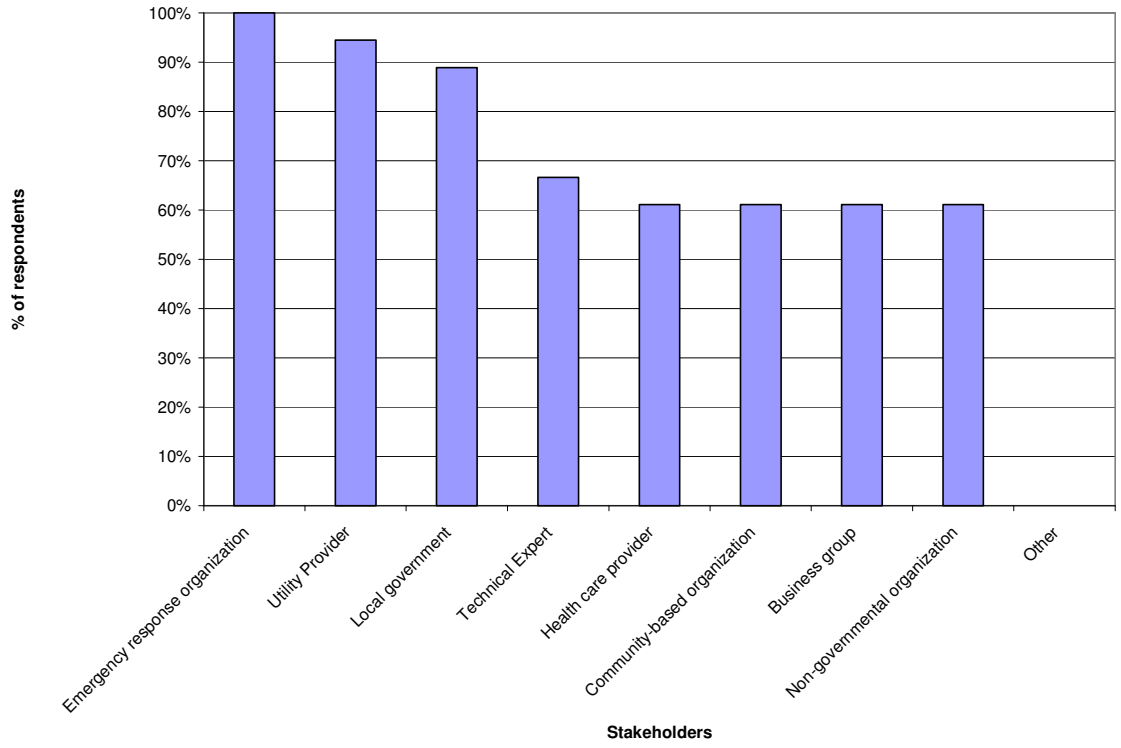

Figure 2: Stakeholders to Include in Development of Performance Objectives

For each stakeholder group, at least half the respondents felt they should be engaged in the definition of performance objectives. As visible in Table 3 below, a full 39% of respondents felt that all groups should be involved. These observations indicate support for the broad involvement of stakeholders, including professionals and community members.

Table 3: Percentage of Respondents Choosing n *Number of Stakeholder Groups (where n = the number of stakeholder groups that should be involved)*

Number of Groups Selected (*n*)	**% of Respondents**
1 group	6%
2 groups	6%
3 groups	6%
4 groups	11%
5 groups	6%
6 groups	17%
7 groups	11%
8 groups	**39%**

3.3) Performance Objectives

Information was sought regarding an appropriate and meaningful way of framing the performance objectives. The performance objectives proposed in the survey suggested that "Power [water] should be available to critical facilities [90% of the population] in (specified time period)." This phrasing is consistent with performance objectives proposed in Bruneau et al. (2003) and Chang and Shinozuka (2004). All but one respondent thought these types of performance objectives were appropriate. This respondent stated the following:

> *Our experience as a wholesaler has frequently been that we can restore service delivery before the receiving retailer can recover the capacity to take the delivery and redistribute to the end user. The foregoing performance goals do not take such realities into account.*

Further open-ended feedback from other respondents resulted in the following comments:

> *It is critical that any goals involve a back-up/alternate plan and the ability to prioritize according to the magnitude of the disaster and the resources that may be available. Flexibility needs to be added to any plan/goals.*

In addition to this flexibility, awareness of the sheer scale and diversity of the Los Angeles region could result in the need for varying objectives by geographic area, as suggested by the following comment:

> *The City of Los Angeles consists of 470 Square miles. Due to the vast area of the City there could quite possibly be an instance where water to critical facilities could be out for a longer period of time in certain areas.*

One general comment stressed the importance of communicating individual preparedness:

> *Communicating the need for individual preparedness regarding water would improve response to critical areas.*

In addition, challenges were encountered as a result of varying legislation outside of the City of Los Angeles. As informal feedback revealed;

> *In the context of Southern California (outside of the city of Los Angeles),setting performance standards which prioritize critical facilities is not appropriate, since utilities are governed by the California Public Utilities Commission, which states that providers cannot give preferential treatment to certain users over others.*

The same respondent stated that:

> *Question 3 has grossly oversimplified performance goals because every disaster is different and providers will obviously do their best to restore service as quickly as possible.*

These comments suggest that the framing of performance objectives as proposed in this survey does not function equally well in different social or political contexts, and that utility providers might disagree as to the usefulness of performance objectives.

With respect to the content of the objectives themselves, close agreement among responses (low variation across responses for each objective) can be observed in the hypothetical case of a moderate disaster (Figure 3 below). In Figure 3, solid squares represent the modal responses (most frequently identified value) for each performance goal, while the bars indicate the range of responses received. Responses in the case of a moderate disaster (on the scale of the 1994 Northridge Earthquake) are on the left of the chart, while responses with respect to a catastrophic disaster (on the scale of Hurricane Katrina) are on the right. As is visible, there was a greater variation in responses with respect to a catastrophic disaster. Despite this, all modal values were the same for the correlating objectives under each disaster scenario:

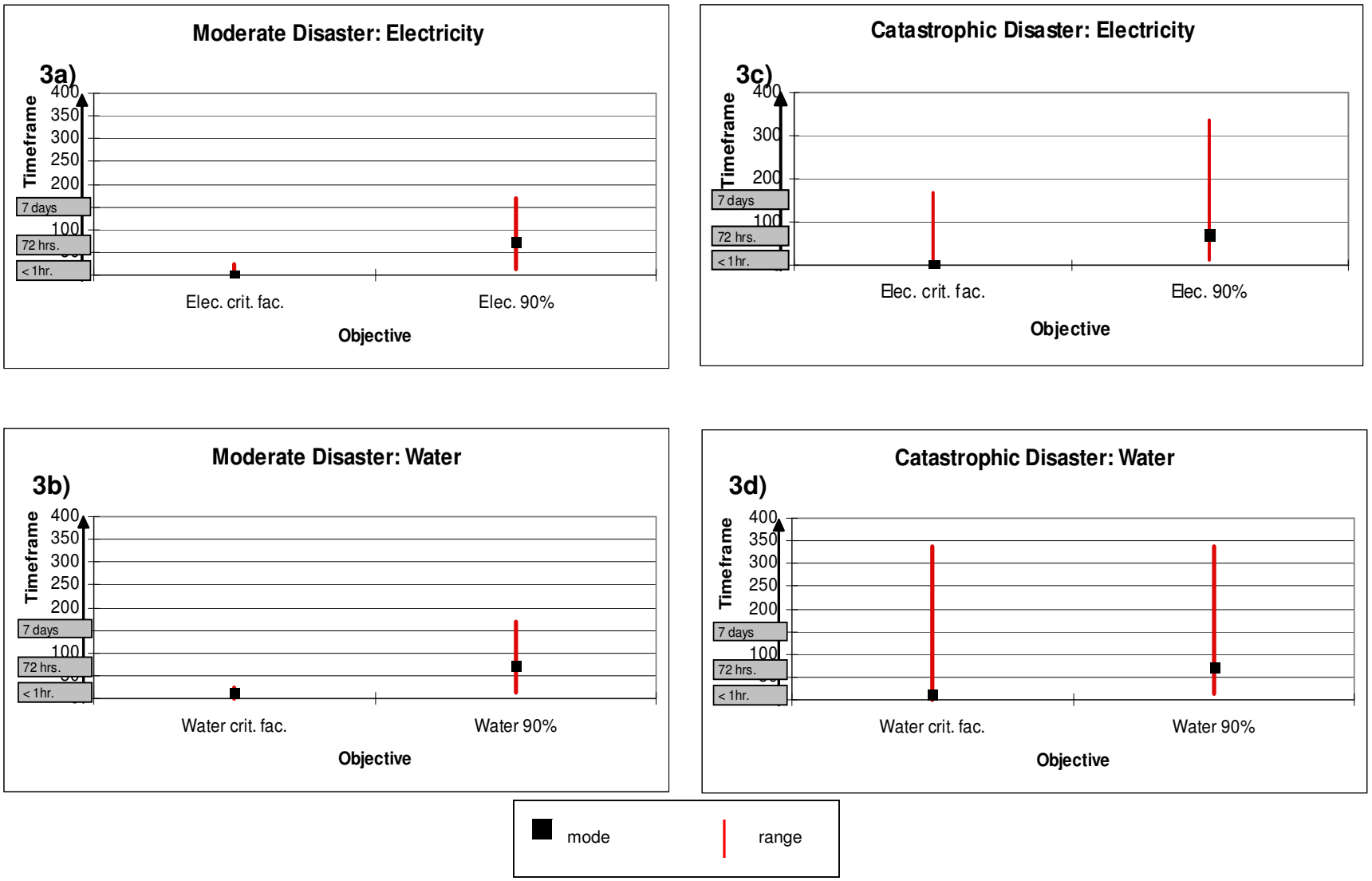

Figure 3: Performance Goals: Modal Response and Range of Responses

Interestingly, there appears to be little difference in terms of suggested modal performance objectives between water and power availability. In the case of a moderate disaster, the modal response for electrical restoration to critical facilities was less than one hour, while for 90% of the population it was 72 hours (Figure 3a). For whatever reason, the modal response for the provision of water to critical facilities was 12 hours, slightly longer than that for electricity. The modal response for water to 90% of the population was 72 hours, the same as electricity (Figure 3b). Modal responses in the case of a catastrophic disaster were the same as for a moderate disaster; less than 1 hour for electricity to critical facilities, 72 hours for electricity to 90%, 12 hours for water to critical facilities, 72 hours for water to 90% (Figures 3c, 3d).

However, when comparing the situation of a moderately-damaging disaster (on the scale of the 1994 Northridge earthquake) (Figure 3a, 3c) to a catastrophic disaster (on the scale of hurricane Katrina) (Figure 3b, 3d), there is a much greater range of responses returned in the event of a catastrophic disaster (from less than one hour to 336 hours for a catastrophic disaster, versus less than one hour to 168 hours for a moderate disaster), even though the modal values are identical across scenarios.

In both cases, respondents generally agree that power and water should be restored more quickly to critical facilities, whereas the greatest range of responses occurs with respect to restoration of both water and power availability to 90% of the population.

3.4) Information Sharing

The study sought to determine how information regarding performance objectives can best be communicated. Respondents identified the most helpful presentations of uncertainty to be few scenarios of varying likelihood, and all possible scenarios together with their likelihood of occurrence, while all other options were somewhat helpful:

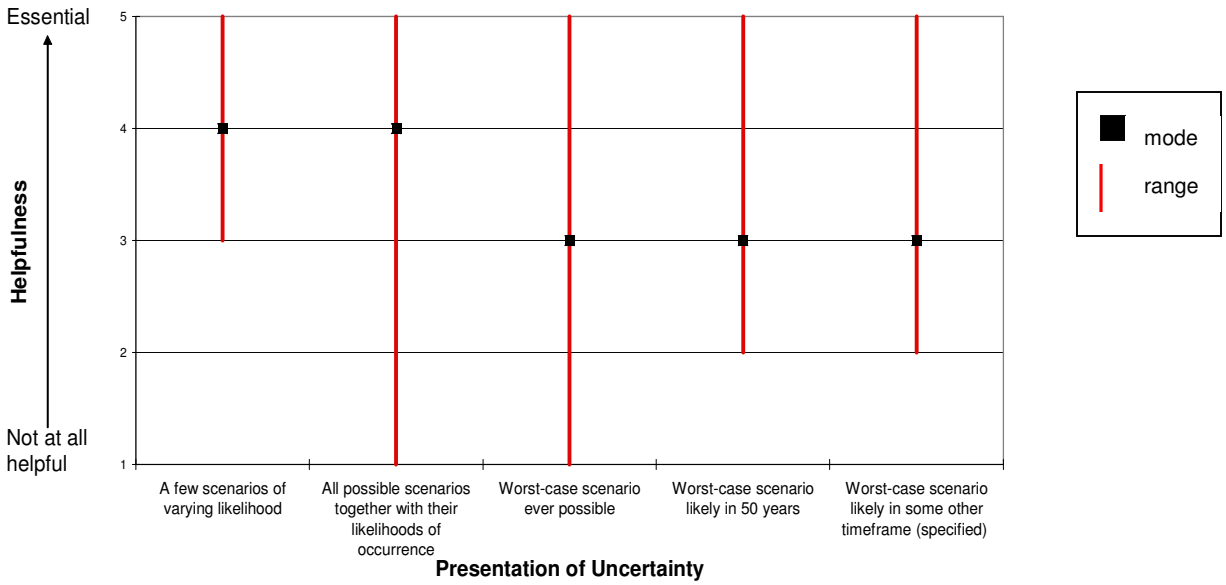

Figure 4: Presentation of Uncertainty: Modal Response and Range of Responses

Other timeframes that respondents suggested would be useful included the next few hours/days, within one year, budget year, 4-year electoral term, 5-10 years, 10 years, 10-20 years, and 100 years.

With respect to presentations of uncertainty, the following comment was made:

> *I don't know how valuable the worst case scenario would be due to the technology available, the population, ethnic diversity, transportation modes and routes etc. To me, the worst case scenario today would be drastically different in the same cities vs. say 50 years ago.*

Thus, the worst-case scenario in 50 years may not be a good method of presenting uncertainty.

In Figure 5, respondents identified interactive websites and print information as the most helpful methods of communicating information, with cd's, public meetings and workshops all identified as somewhat helpful:

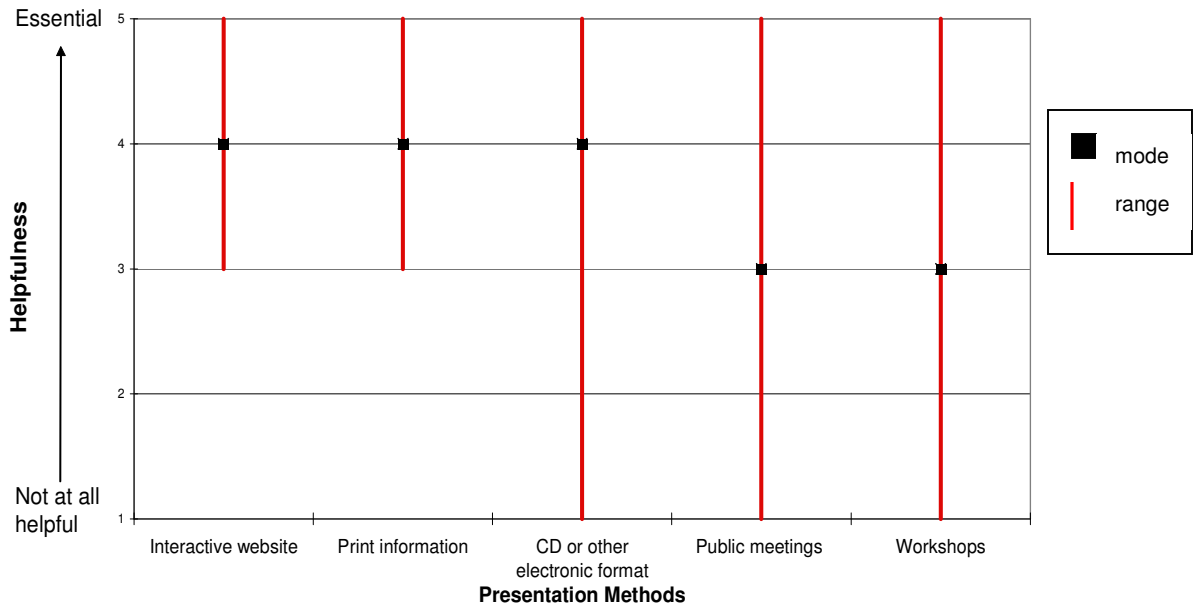

Figure 5: Presentation Methods: Modal Response and Range of Responses

In addition, general feedback stressed the importance of visual representations as a means of presentation:

> *Visuals indicating what areas come back first, by area, would be useful.*

This is one area where the model results could be compellingly communicated via the use of graphic tools such as maps output from a GIS tool.

Concern was raised that sensitive information such as vulnerabilities in power and water supply systems could be exploited by terrorist groups if made widely accessible. Thus, it was suggested that

> *A dark web site activated only when needed may be a particularly useful way of disseminating the information at the right time without fear of compromising data that may reveal exploitable vulnerabilities.*

In addition, the utility of a variety of information sharing methods was stressed, so that

> *…when really needed, all information sharing methods should be used in concert.*

3.5) Decision-Making Priorities

This study is also concerned with what considerations should be most important to disaster-related decision-making. The survey asked respondents about the importance of various considerations in disaster-related decision-making by the utility. Figure 6 shows that most people rated a reduction in outage to critical infrastructure as an essential consideration to a utility's decision-making, while consideration of a reduction in repair or response costs was generally less important. The other suggested considerations were all ranked as somewhat to very important:

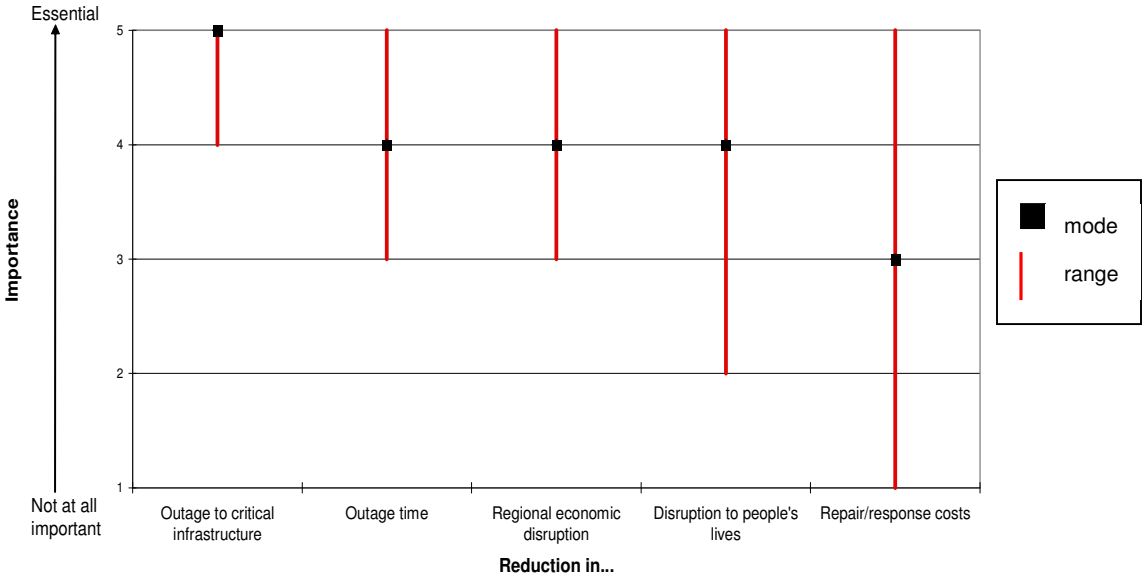

Figure 6: Importance of Various factors to Decision-making: Modal Response and Range of Responses

3.6) Utility Provider versus End User Responses

Analysis was conducted to determine how the utility's responses differed from those of the community. Examining the data by user type yields interesting comparisons.

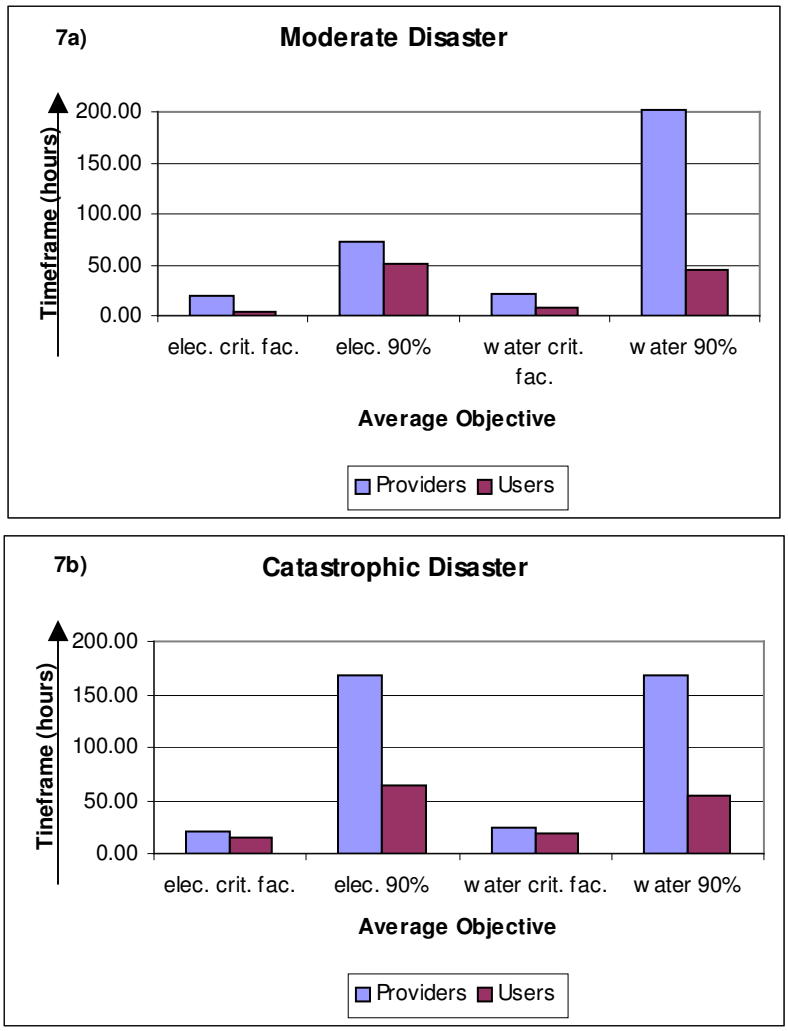

Figure 7: Utility Providers vs. Users - Average Performance Objectives

A comparison of modal responses between utility providers and users yields few differences. A comparison of average responses however (Figure 7a, b) shows that utility providers always suggest performance standards temporally longer than those suggested by community groups or critical responders, particularly with respect to the case of a catastrophic disaster (7b). In many cases the provider's suggested goals are more than double those defined by the users. This may be because it is the utility providers to which the performance objectives apply, and they would therefore suggest objectives they feel it is possible to meet, with or without consideration of what they 'ought' to be able to provide. Also, differing levels of knowledge with respect to the costs and trade-offs involved in achieving ideal goals could also produce this discrepancy. It is

interesting to note the very high average response from utility providers for water restoration to 90% of the population in a moderate disaster (201.6 hours). Half of the utility providers stated this goal as ideal. This response is considerably higher than in the case of a catastrophic disaster, which seems illogical. No obvious explanation could be deduced.

These comparisons suggest that with a different sample of respondents (e.g. more providers than users), the overall recommended performance objectives (e.g. Figure 3) could change substantially. Provider and user groups alike agreed on the stakeholder groups to involve in the definition of performance objectives however (as in Figure 2). Utility providers were only one of these stakeholder groups. Thus, based on overall modal responses from a range of stakeholders, the survey seems to have identified reasonable performance objectives which can inform further resilience modeling to aid in mitigation strategies.

There appears to be no correlation between respondent type and considerations which matter to disaster-related decision-making (Table 4). All respondents rated reductions in outages to critical infrastructure, and reductions in post-disaster outage time as the most important considerations, suggesting that there may be universal considerations across sectors.

Table 4: Average Provider vs. User Decision-Making Considerations

Reduction in…	**Providers**	**Users**
Outage to critical infrastructure	4.8	4.8
Post-disaster outage time	4.3	4.3
Disruption to people's lives	3.7	3.7
Regional economic disruption	3.5	3.3
Post-disaster repair and emergency response costs	3.3	2.7

*On a scale of 1-5, where 1 = not at all important and 5 = Essential

There also appears to be no significant correlation between respondent type and the type of information sharing, methods, and presentation of uncertainty preferred; respondents across categories preferred an interactive website as a means of sharing information.

Table 5: Average Provider vs. User Information Sharing Preferences

Means of Information Sharing:	Providers	Users
Interactive website	3.7	4.8
Print information	3.5	3.8
CD or other electronic format	3.0	3.6
Workshops	3.2	3.3
Public meetings	3.3	3.0

* On a scale of 1-5 where 1 = Not at all helpful and 5 = essential

3.7) Challenges

The final research question asked what challenges might be encountered in the process of such a study. Over the course of this survey, various issues arose which bear further consideration. The first of these issues is that of a survey methodology. During informal telephone conversations with respondents, much useful information was gleaned that would not have been apparent from survey responses alone. Also, the survey design used did not give room for elaboration (reasoning behind decisions etc.), which was also revealed during follow-up. This suggests that a depth of information exists that was not captured by the survey. A combination of more open-ended survey questions and/or semi-structured interviews might help to fill this gap. In addition, some variation in responses clearly stemmed from different interpretations of certain questions. For example, it is not clear if utility respondents interpreted the performance goals as a reflection of what they felt *should* be a reasonable service goal, or whether responses were based on what they felt was *achievable under current conditions*. The 72 hour figure returned as a median response for many of the performance objectives (Figure 3) may have been influenced by the widespread use of this timeframe in emergency preparedness guidelines, suggesting that respondents may have been responding based on what was already known, versus what they felt to be ideal. These uncertainties have not been adequately

accounted for in this study. Further study would be necessary to gain a more complete and accurate understanding of performance goals.

VI. Conclusions and Recommendations

A targeted stakeholder survey was conducted amongst key utility stakeholders in Los Angeles to help shape performance objectives which feed into resilience modeling in the region. Despite a few limitations of the methodology, this survey has validated that the nature and substance of such objectives are appropriate. Key findings relating to the research questions, as well as recommendations are as follows:

Stakeholder Involvement

- Widespread support exists for the inclusion of a diversity of stakeholders in the definition of performance objectives, particularly emergency managers, utility providers, and local governments.
- Ideally, the entire spectrum of stakeholders would be involved in the definition of objectives.

Performance Objectives

- Context is important. Varying policy and geographic environments require different objectives. A similar participatory process to determine objectives should be conducted and objectives adjusted accordingly for each new area examined in the model.
- Every disaster is different, so flexibility must be incorporated into performance objectives.
- The suggested format of performance objectives “restoration of power [water] to critical facilities [90% of the population] within X timeframe” is reasonable.
- Survey respondents indicated that in the Los Angeles context, the following objectives are appropriate: In both moderate and catastrophic disaster situations, electricity should be available to critical facilities in less than one hour, potable water within 12 hours, while both electricity and

potable water should be available to 90% of the population within 72 hours.

- There is more consensus related to performance objective targets in moderate than catastrophic events.

Information Sharing

- A few scenarios of varying likelihood was found to be the most helpful means of presenting uncertainty, particularly when combined with visual representations (e.g. maps).
- Websites and print information are the most useful means of sharing information.
- Care must be taken to ensure that sensitive information is not exploited.
- A combination of methods when really necessary is ideal.

Decision-making Priorities

- A reduction in outage to critical infrastructure, as well as a reduction in overall outage time, were identified as the most important considerations for disaster-related decision-making (e.g. for mitigation).

Differences Among Providers and Users

- Providers and users agree with respect to decision-making priorities, stakeholder involvement, and information sharing.
- Providers consistently set less stringent performance objectives than community members, raising the issue of feasibility vs. ideal values. This may be attributable to differing levels of knowledge with respect to the costs and trade-offs involved in achieving ideal goals.
- Studies should be undertaken to determine the reasons for this difference and to evaluate its impact on the model, after which a decision should be made whether objectives should be based on normative circumstances or on their likelihood of being achieved. The former would result in the proposal of performance goals for utilities for the purpose of mitigation, while the latter could be used to help the public to develop realistic service

expectations. If the overarching goal is the mitigation of socioeconomic impacts of disaster events, the former would seem the preferred course. However, this is a discussion which needs to occur.

Challenges

- There are uncertainties in the data due to methods of data collection
- In order to better understand performance objectives and fill the gaps, further study should be undertaken which utilizes various methods (e.g. semi-structured interviews, focus groups).
- Context is important to performance objectives and needs to be taken into consideration.

The results of this study will be used to inform modeling work with lifeline utilities in the Los Angeles region. Incorporating performance objectives into such a model will assist utilities to better respond in the event of a disaster, to minimize outage duration and extent, and to prepare for uncertain circumstances. Data from this study can better allow the Los Angeles Lifelines model to assist with the definition of performance objectives, and in turn assist decision-makers in policy making. Likely outcomes can be compared to desirable or acceptable outcomes based on stakeholder-defined performance objectives. This can initiate a crucial discussion regarding what level of utility disaster performance is acceptable and desirable, encouraging stakeholders and the public alike to think about disaster preparedness. Ultimately, having discussed such issues will result in a community that is better prepared to mitigate and respond to future disasters.

References

Ahmad, R. 2005. *Literature Review: Los Angeles Lifelines Participatory Process.* UBC Disaster Resilience Research Laboratory: Vancouver.

Ballantyne, D. 1994. Minimizing Earthquake Damage: A Guide for Water Utilities. Denver, CO: American Water Works Association.

Bruneau, M. Chang, S.E., Eguchi, R.T., Lee, G.C., O'Rourke, T.D., Reinhorn, A.M. Shinozuka, M., Tierney, K. Wallace, W.A., and von Winterfeldt.D. 2003. "A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities" *Earthquake Spectra.* 19(4): 733-752.

Çag˘nan, Z, Davidson, R, and Guikema, S. 2006. *Post-Earthquake Restoration Planning for Los Angeles Electric Power.* Earthquake Spectra, 22(3): 589-608.

Chang, S.E. and Chamberlin, C. 2004. *Assessing the Role of Lifeline Systems in Community Disaster Resilience.*

Chang, S.E. and Coelho, S. 2006. *"Performance Objectives for Seismic Mitigation of Utility Lifelines," 8th National Conference on Earthquake Engineering, San Francisco.*

Chang, S.E. and Seligson, H.E. 2003. "Evaluating Mitigation of Urban Infrastructure Systems: Application to the Los Angeles Department of Water and Power," in J.E. Beavers, ed., *Advancing Mitigation Technologies and Disaster Response for Lifeline Systems*, Technical Council on Lifeline Earthquake Engineering (TCLEE) Monograph No.25, pp.474-483.

Chang, S. and Shinozuka, M. 2004. "Measuring Improvements in the Disaster Resilience of Communities." *Earthquake Spectra,* 20(3): 739-755.

Eidinger, J.M. and E.A. Avila. 1999. Guidelines for the Seismic Evaluation and Upgrade of Water Transmission Facilities. Reston, VA: American Society of Civil Engineers, Technical Council on Lifeline Earthquake Engineering Monograph No.15.

May, P. 2004. "Making Choices About Earthquake Performance." *Natural Hazards Review.* 5(2): 64-70.

Rose, A. Benevides, J., Chang, S.E., Szczesniak, P. and Lim, D. 1997. "The Regional Economic Impact of an Earthquake: Direct and Indirect Effects of Electricity Lifeline Disruptions." *Journal of Regional Science.* 37(3): 437-458.

Shinozuka, M., Chang, S.E., Cheng, T.C., Feng, M., O'Rourke, T.D., Saadeghvaziri, M.A., Dong, X., Jin, X., Wang, Y and Shi, P. 2004. "Resilience of Integrated Power and Water Systems," *Research Progress and Accomplishments 2003-2004*, Multidisciplinary Center for Earthquake Engineering Research, Buffalo, NY, pp.65-86.

Appendix A: Survey Instrument

QUESTIONNAIRE

UTILITY OUTAGE AND DISASTER PREPAREDNESS

PURPOSE

The purpose of this survey is to obtain feedback from selected utility users regarding potential utility outages in earthquakes and other disasters. In major disasters, some degree of outage can be expected. We are interested in your thoughts on how much outage is acceptable, and how this should be decided. Also, we would like input on how utilities might provide information that would be most helpful to you. Your responses can help utilities to invest and prepare for disasters in ways that take into account user concerns and expectations. Ultimately, this will help the L.A. region become more resilient to disasters.

This survey should take approximately 10 minutes to complete.

QUESTIONS

Background Information:

1. Which of the following best describes your professional affiliation?
Please select one:

- ☐ Utility provider
- ☐ Emergency response organization (e.g. police, fire)
- ☐ Health care provider (e.g. hospital, clinic)
- ☐ Local government (e.g. elected official, planner)
- ☐ Community-based organization (e.g. neighborhood council)
- ☐ Business group (e.g. Chamber of Commerce)
- ☐ Non-governmental organization (e.g. Red Cross)
- ☐ Technical expert (e.g. consultant, professional organization)
- ☐ Other (Please specify here)

1a. What is your job title? (Please specify here)

Performance Goals:

2. Which of the following groups do you think should participate in developing utility service goals for disasters?

Please check all that apply:

- ☐ Utility provider
- ☐ Emergency response organization (e.g. police, fire)
- ☐ Health care provider (e.g. hospital, clinic)
- ☐ Local government (e.g. elected official, planner)
- ☐ Community-based organization (e.g. neighborhood council)
- ☐ Business group (e.g. Chamber of Commerce)

☐ Non-governmental organization (e.g. Red Cross)

☐ Technical expert (e.g. consultant, professional organization)

☐ Other (Please specify here)

3. This question provides examples (3.a. ~ 3.h.) of possible performance goals for utilities in disasters. Please select one response in each example to indicate the maximum acceptable duration of utility outage.

In the case of a **moderately damaging disaster** (on the scale of the 1994 Northridge (L.A.) earthquake):

	Less than 1 hour	12 Hours	24 Hours	72 hours	7 days	14 days	Other timeframe
a. Electricity should be available to critical facilities (e.g. police, fire, hospitals) within:	☐	☐	☐	☐	☐	☐	☐ (Please specify here)
b. Electricity should be available to 90% of the population within:	☐	☐	☐	☐	☐	☐	☐ (Please specify here)
c. Potable water should be available to critical facilities (e.g. police, fire, hospitals) within:	☐	☐	☐	☐	☐	☐	☐ (Please specify here)
d. Potable water should be available to 90% of the population within:	☐	☐	☐	☐	☐	☐	☐ (Please specify here)

In the case of a **catastrophic disaster** (on the scale of Hurricane Katrina):

	Less than 1 hour	12 hours	24 hours	72 hours	7 days	14 days	Other timeframe
e. Electricity should be available to critical facilities (e.g. police, fire, hospitals) within:	☐	☐	☐	☐	☐	☐	☐ (Please specify here)
f. Electricity should be available to 90% of the population within:	☐	☐	☐	☐	☐	☐	☐ (Please specify here)
g. Potable water should be available to critical facilities (e.g. police, fire, hospitals) within:	☐	☐	☐	☐	☐	☐	☐ (Please specify here)
h. Potable water should be available to 90% of the population within:	☐	☐	☐	☐	☐	☐	☐ (Please specify here)

4. Do you think the types of performance goals in Question 3 above are appropriate?

☐ Yes ☐ No

5. How might these goals be improved?

(Provide suggestions here)

6. Utilities must trade off between costs and benefits when making decisions about reducing disaster damage. The following is a list of potential benefits that may be considered. How important do you think it is to consider each of the following?
Please select one response for each potential benefit:

	not at all important	not very important	somewhat important	very important	essential
a. Savings in the utility's post-disaster repair and emergency response costs	☐	☐	☐	☐	☐
b. Reduction in post-disaster outage time	☐	☐	☐	☐	☐
c. Reduction in outage to critical infrastructure such as hospitals, fire stations, transportation networks, etc.	☐	☐	☐	☐	☐
d. Reduction in regional economic disruption	☐	☐	☐	☐	☐
e. Reduction in disruption to people's lives	☐	☐	☐	☐	☐

f. ☐ Other consideration(s) (Please specify here)

Information Sharing:

We are interested in how utilities can best provide information to their users about potential outages in future disasters.

7. Type of Information
How helpful would each of the following types of information be for your organization's disaster planning efforts?
Please select one response for each type of information:

	not at all helpful	not very helpful	somewhat helpful	very helpful	essential
a. Maps of utility outage areas	☐	☐	☐	☐	☐
b. Time estimates of outage duration	☐	☐	☐	☐	☐
c. Number of customers without utility service	☐	☐	☐	☐	☐
d. Number of households displaced from their homes	☐	☐	☐	☐	☐
e. Number of businesses temporarily closed	☐	☐	☐	☐	☐
f. Loss of regional economic production	☐	☐	☐	☐	☐
g. Likelihood of major disruptions	☐	☐	☐	☐	☐

h. ☐ Other (Please specify here)

8. Forms of presenting uncertainty
The uncertainty associated with future disasters can be presented in different ways. How helpful would each of the following forms of presentation be for your organization's disaster planning efforts?
Please select one response for each form of presentation:

	not at all helpful	not very helpful	somewhat helpful	very helpful	essential
a. Worst-case scenario ever possible	☐	☐	☐	☐	☐
b. Worst-case scenario likely in 50 years	☐	☐	☐	☐	☐
c. Worst-case scenario likely in some other timeframe (Please specify here)	☐	☐	☐	☐	☐
d. A few scenarios of varying likelihood	☐	☐	☐	☐	☐
e. All possible scenarios together with their likelihoods of occurrence	☐	☐	☐	☐	☐

f. ☐ Other (Please specify here)

9. Means of sharing information

Information on potential outages can be presented different ways. How helpful would each of the following means be to your organization's disaster planning efforts? Please select one response for each means:

	not at all helpful	not very helpful	somewhat helpful	very helpful	Essential
a. Print information (e.g., brochures)	☐	☐	☐	☐	☐
b. CD or other electronic format	☐	☐	☐	☐	☐
c. Interactive website	☐	☐	☐	☐	☐
d. Public meetings	☐	☐	☐	☐	☐
e. Workshops	☐	☐	☐	☐	☐

f. ☐ Other format (Please specify here)

Thank you for your time in completing this questionnaire. If you have any questions or comments, please direct them along with the completed questionnaire to Kristi Tatebe, Research Assistant at ktatebe@gmail.com