2.1 WHY CREATE SCENARIOS?

To assess how information and communications technologies (ICTs) will affect electric power over the next 20 years, one must estimate what ICT developments will occur and what their effects are likely to be. While this clearly is not an easy task, there are various approaches, or methodologies, that can be employed as aids: technology forecasts, roadmaps, assessments, and scenarios.

The first three of these approaches usually focus on a technological end point, range, or path. A technology forecast is, as the term suggests, a prediction about the characteristics of a particular technology at a particular future time (Martino, 1978, pp. 1–2). The forecast may be a point estimate or an estimated range incorporating the level of uncertainty associated with the prediction. A technology roadmap depicts the key scientific and technical advances needed to reach a desired end state, or “destination.” A technological assessment is principally concerned with “evaluating the social consequences of [a] technological change” (Pool, 1983, p. 2). Like technology forecasts, roadmaps and assessments generally treat uncertainty as an excursion around a preferred path or destination.

In contrast, a scenario includes uncertainty as an essential feature of the exploration. It develops both the technical and nontechnical characteristics of “an alternative future plus a description of the path

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1Technology roadmaps relevant to this study include EPRI, 1999a; and Info-Communications Development Authority of Singapore, 2000.
that goes from today to that future” (Dewar, 2002), its goal being to provide a self-consistent future world with a credible narrative leading to a plausible end point. Together, several scenarios span a space that is considered likely to contain the actual future state, although any individual scenario is by itself unlikely to be realized.

We chose the scenario approach because we believe changes in ICTs are happening too fast and with too much turbulence to permit forecasting, mapping, or assessment over a 20-year period. In the words of a recent National Research Committee report on the future of the Internet, “The middle of a revolution is a difficult point from which to gauge long-term outcomes” (Computer Science and Telecommunications Board, 2001a, p. 2). By offering several plausible alternative paths and end points, scenarios can aid policymakers by challenging assumptions, revealing possible gaps in planning, and suggesting adaptive or hedging strategies for contingency planning and research and development (R&D) programs.2

2.2 APPROACH TO DEVELOPING ICT SCENARIOS

In constructing the ICT scenarios, we followed a process that RAND has used for other scenario-building exercises. In our case, it involved the following six steps:

- Review ICT trends and developments;
- Review recently published scenarios and planning documents;
- Characterize current and future ICT applications;
- Interview ICT and other experts to identify important technical and nontechnical driving factors;
- Identify likely and possible implications of ICT developments;
- Synthesize the results into a small number of scenarios that depict different ICT development paths and societal outcomes.

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2Beginning in the late 1960s, Royal Dutch/Shell pioneered the use of scenarios in these ways for business planning. For accounts of the Royal Dutch/Shell experience, see Wack, 1985; Schwartz, 1991; and Van der Heijden, 1996. Also see Smil, 2000.
When considering technology trends, it is useful to look back at least as far as one intends to look forward. Consequently, we reviewed ICT studies from the late 1970s through the present that were conducted by the National Research Council, the Office of Technology Assessment, the Aspen Institute, and others. Recent scenarios of interest included, among others, those created for the Central Intelligence Agency (National Intelligence Council, 2000), the U.S. Air Force (Air University, 1995), the European Commission (Information Society Technologies Advisory Group, 2001; and Botterman et al., 2001), the Millennium Project of the American Council for the United Nations University (Glenn and Gordon, 2000), and the Department of Energy (DOE) Interlaboratory Working Group (2000). A number of recent trade books by ICT stakeholders also provided popular and often insightful accounts of prospective ICT developments.

To be useful to corporate decisionmakers or government policymakers, scenarios must be interesting, relevant, and few. If there are many scenarios dealing with multiple outcomes or possibilities, the situation quickly becomes unmanageable and the scenarios therefore unhelpful. “Never more than four” is a consistent theme among successful scenario builders (Wack, 1985b). As a consequence, we had to sift through a large number of possible influences on ICT evolution to find one or two drivers to form the framework for very different but self-consistent future paths and end states.

2.3 ICT DRIVING FACTORS

A great many technical and nontechnical factors interact in influencing the path and pace of movement toward a digital society:

- Innovations in ICT products and services, which make them better, cheaper, and easier to use;

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4See, for example, Negroponte, 1995; Gates, Myhrvold, and Rinearson, 1996; Mitchell, 1997; Dertouzos, 1998; Norman, 1998; and Kurzweil, 1998. A more complete list of recent trade books about digital technology can be found at http://www.nytimes.com/books/specials/digital.html (last accessed August 30, 2002).
• Development of new and/or better ICT network applications;
• Investments in ICT and related infrastructure;
• Demand for ICT products, services, and applications, which drives their adoption and diffusion rates;
• Industry and market structures for ICT products, services, and applications;
• Extent of regulation or other government controls;
• Public trust and confidence in ICT networks, services, and applications;
• Overall economic, political, social, and security environment.

An essential characteristic of a digital society is near-universal access to and pervasive use of ICT equipment, services, and networks in all ordinary pursuits and venues: working, learning, traveling, doing routine chores, interacting with friends and family, and relaxing at home. Widespread availability and use of digital technologies seem far more important than does the nature of the technologies themselves. In fact, the closer the United States moves toward a digital society, the more embedded and invisible the technologies become. This is a major theme in most of the literature cited earlier, just as it was in the interviews with experts and brainstorming sessions we conducted during this project.

As a result, we selected ICT level of use as the first of two principal drivers of the scenarios. We also discovered from our literature search and personal discussions that there is a strong correlation between use and trust—a discovery that, in hindsight, should not have been very surprising. Individuals and institutions must have trust in networked ICT products and services before they will use them (or permit them to be used by others in their organization) for important functions. The link between trust and use has been observed consistently in the adoption of ICTs ranging from telephone answering machines to automatic teller machines, and today this link regulates the expansion of e-commerce and other Internet applications.5

5The Computer Science and Telecommunications Board (1999, p. 13) provides a good definition of trust in a networked information system (NIS): a “trustworthy NIS does
Society’s approach to regulating or controlling networked ICTs constitutes the second principal driver of the scenarios. Specifically, we distinguish centralized economic, governmental, and social controls from those that are more decentralized or distributed. Monopoly provision of goods and services, rules set by large organizations, and strong federal laws embody centralized controls—compared to the decentralized controls represented by (economically efficient) markets for goods and services, policies set by small organizations, and local government regulation. We chose the locus of control as a scenario driver partly because it is important for both ICT and energy systems, but more because centralized controls and decentralized controls lead to quite different evolutionary paths toward a digital society.

2.4 DATA, ASSUMPTIONS, AND UNCERTAINITIES IN THE SCENARIOS

Baseline data for the scenarios and analysis were taken from many government and private sources (cited here and in the chapters that follow). Population, demographic, and household data are from the 2000 U.S. Census (2001a); estimates of the size and scope of the U.S. “digital economy” are primarily from recent Department of Commerce documents (Margeherio et al., 1998; and U.S. Department of Commerce, 2000). Electricity and related energy data are from the Energy Information Administration (2001)—specifically, the Annual Energy Outlook 2002 with Projections to 2020, which we refer to in this report as the AEO 2002—and from EPRI6 and other industry sources. Our 2001 estimates of U.S. stocks and use of computers and other ICT equipment and services are based on Census data; on studies/surveys conducted by Lawrence Berkeley National Laboratory,7 Arthur D. Little, Inc. (Roth, Goldstein, and Kleinman, 2002), the Pew Internet and American Life Project (2002), and the UCLA Center for Communication Policy (2001); and on estimates from a variety of industry experts, industry associations, and trade journals.

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6Formerly the Electric Power Research Institute.
7Chapter Four provides the relevant references.
The scenario projections through 2021 are entirely our own responsibility, but they were aided by and compared with projections in the AEO 2002 and in shorter-term industry forecasts. The assumptions underlying the scenarios are described in the following chapter and in greater detail in Appendix A. Uncertainties are largely built into the scenario structure—for example, each scenario makes its own assumptions about consumers’ use of e-commerce two decades from now. Technology availability thus leads to very different consequences in different scenarios.

We have tried to make the assumptions in the scenarios as explicit and transparent as possible; but, of course, many additional details and possibilities are left out. We do not, for example, examine the consequences of “high” or “low” energy prices in future years, as does the AEO 2002. Nor do we estimate the effects of differing assumptions about future economic growth or lifestyle that are not ICT related. Perhaps most important, our scenarios do not include major international events such as wars, long-term disruptions of oil or gas supplies, or environmental catastrophes. Our focus is on ICT-driven effects on the U.S. economy and society, although we do recognize that national security and political drivers can easily overwhelm results stemming from technological change.

Our ICT scenarios complement scenarios being created elsewhere to explore international and other driving factors, all of which will contribute to the overall planning efforts of the Office of Energy Efficiency and Renewable Energy (EERE) and DOE. They are intended to help decisionmakers who are thinking about the uncertainties inherent in technology and energy projections and considering what actions can be taken now as possible hedges against the adverse consequences of future surprises.