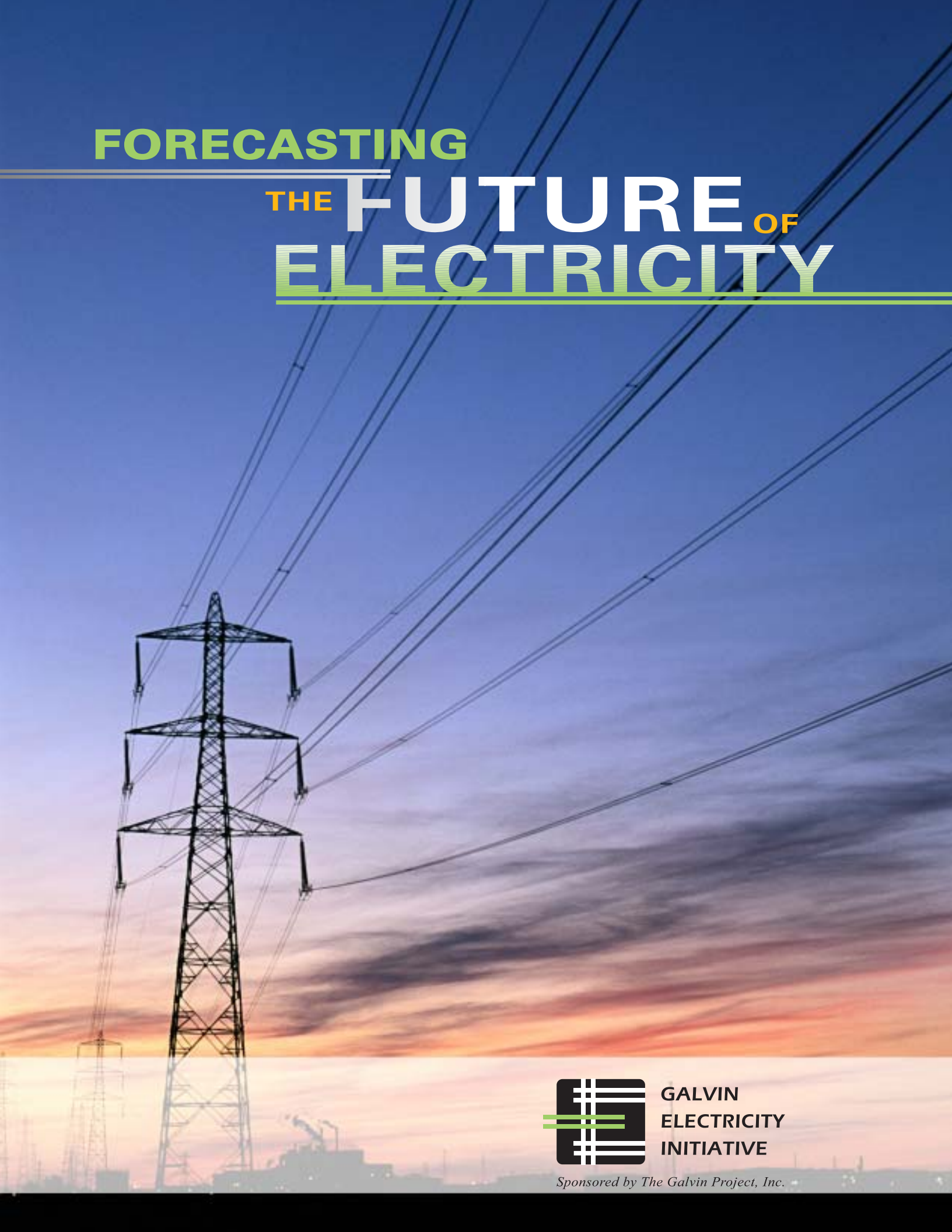
FORECASTING
THE FUTURE OF
ELECTRICITY
GALVIN
ELECTRICITY
INITIATIVE
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Forecasting the Future of Electricity

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Galvin Electricity Initiative

The Galvin Electricity Initiative seeks to identify opportunities for technological innovation in the electric power system (broadly defined) that will best serve the changing needs of consumers and businesses over at least the next 20 years. Of paramount importance will be insuring that the electricity system provides absolutely reliable and robust electric energy service in the context of changing consumer needs.

For more information about this publication or the Galvin Electricity Initiative, please contact Galvin Electricity Initiative at 650-855-2400 or visit us at www.galvinelectricity.org.

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Scenarios of Consumer Needs in 2025
Task 1 Report

Executive Summary

One of the greatest technological achievements of the 20th century was the creation in the U.S. of an electric power system – spanning power generation, transmission, distribution, and end-use applications – that enabled countless technical and economic advances and enhancements to the quality of life. By the end of the century, however, a variety of circumstances were combining to challenge the ability of the electric power system to continue meeting the needs of American society. These challenges included the digital revolution and the proliferation of electronic devices requiring higher levels of power quality, growing evidence that traditional ways of generating electricity may contribute to climate change, and new concerns about the vulnerability of the power system to terrorism and natural disasters. In short, both the needs of consumers for electricity and the environmental context of electricity use were changing.

If recent history is any guide; the pace of change in society, technology, and consumer needs is unlikely to slow down. This, in turn, means that the electric power system itself needs to change and grow to meet the emerging demands of the 21st century.

The purpose of the Galvin Electricity Initiative is to define the electric power system that will most perfectly meet the evolving needs of consumers in the 21st century, as well as the technological innovations that will be required to make this system a reality. To provide a firm foundation for this effort, the first task of the Initiative was to develop a rich set of scenarios – or alternate visions – of how the U.S. might evolve socially and economically between now and 2025, how this evolution will affect the fundamental needs and aspirations of Americans, and how these needs and aspirations will affect requirements on the electric energy supply and service system. This report summarizes the results of this task.

To develop these scenarios we first identified a list of more than a hundred factors that are likely to substantially alter U.S. society in the next twenty years. These factors fall into six categories of change – demographics, economics, the environment, national security and health care, society and culture, and technology.

Within each category, we looked at the most **robust trends** – issues that can be foreseen with a high degree of probability and which all plausible scenarios of the

next twenty years have to accommodate. We also examined the **key uncertainties** that could push the future development of U.S. society in very different directions. Finally, we considered **wildcards** – low-probability developments that, if they were to occur, would change the nature of U.S. society in dramatic and discontinuous ways.

Working with a distinguished panel of futurists and industry thinkers, we ultimately converged on two key drivers which, taken together, define **two axes** against which future consumer needs and expectations can be usefully mapped. The first axis deals with how unified or fragmented U.S. society will be, while the second addresses the extent to which society embraces mass-market vs. customized solutions. The intersection of these two axes creates the framework for four basic scenarios of U.S. society in 2025:

- ***Wal-Mart World*** – a scenario characterized by social fragmentation and mass-market solutions – is a world where consumers are focused on sub-cultural identities but bound together by a common striving for – and definition of – economic prosperity.
- ***The Wild Party*** – characterized by social fragmentation and customized solutions – presents an individualistic and somewhat chaotic America where social and technological changes, along with growing income disparity, leading to tremendous diversity in how people live.
- ***Unity in Diversity*** – characterized by social unity and customized solutions – describes an America that combines agreement on basic values with tremendous creativity in the way people live out those values. Individualized solutions to common problems emerge through collaborative, peer-to-peer innovation.
- ***Pleasantville*** – characterized by social unity and mass-market solutions – is an America in which renewed commitment to traditional middle-class values sets the stage for more centralized planning and communal solutions to problems.

After developing and elaborating on these scenarios, we turned our attention to the implications of the scenarios for the future of electric energy services. We concluded that three very robust drivers for the evolution of electric energy services cross-cut all of these scenarios. The first is an intensified focus on energy efficiency and domestic energy resources in the face of global competition for oil and natural gas. The second cross-cutting driver is increasing requirements for power quality and reliability. The third universal driver is the additional pressure on electricity prices and generation sources that will result from an increasing consensus regarding the impact of electricity production from fossil fuels on the environment.

Although these three factors are likely to be robust across any scenario of social development in the U.S., the diversity of the four scenarios described above point to a range of specific electricity service needs as outlined in Figure 4. Finally, these scenario descriptions and implications are intended to stimulate, not limit, the reader's visionary imagination. Please share your further insights or differences by emailing them to caren@galvinelectricity.org.

Introduction

The ultimate goal of the Galvin Electricity Initiative is to define the electric power system that will most perfectly meet the evolving needs of consumers in the 21st century, and what technological innovations will be required to make this system a reality. The purpose of Task 1 of the Initiative was to develop a rich set of scenarios – or alternate visions – of how the U.S. might evolve socially and economically between now and 2025, how this evolution will affect the fundamental needs and aspirations of Americans, and how these needs and aspirations will affect requirements on the electric energy supply and service system. This report summarizes the results of Task 1.

Because the future is inherently unknowable, many of the needs or requirements that consumers will place on the electricity service system in the coming years cannot be predicted with certainty. But, by considering a number of divergent, provocative and credible scenarios we can identify a broad and demanding set of consumer needs that will challenge electric technologies in diverse ways. Ultimately, if we design an electric power system that is robust enough to meet the requirements of these scenarios, we can be confident that we have designed the most perfectly reliable and valuable system possible to meet the needs of the 21st century.

The scenario descriptions in this report, as well as the key drivers that shape them and their implications for the electricity service requirements, reflect the insights and collaboration of many individuals. A complete list of contributors and a discussion of how the scenarios were developed can be found in the Appendix.

The Galvin Electricity Initiative and consumer needs

Goals of the Galvin Electricity Initiative

The Galvin Electricity Initiative seeks to identify opportunities for technological innovation in the electric power system that will serve the changing needs of consumers and businesses over the next 20 years and beyond. The goal of these innovations is to provide absolutely reliable electric energy service that perfectly meets 21st Century consumer needs and expectations and is robust over as broad a set of circumstances as can be envisioned. In the context of this Initiative, electric energy

service is defined as the end-use service ultimately provided by electricity. This future electricity service will utilize to best advantage an optimal combination of the traditional electricity infrastructure plus advanced power generation, energy storage, and energy delivery technologies; it will also implement a transformed electrical interface with the consumer that incorporates innovative energy consuming processes, devices, and appliances.

The Initiative will also examine opportunities for marrying this transformed electric energy service capability with innovative electrotechnologies that are able to improve productivity and enhance the quality of life for all consumers. This extends beyond the existing interface between consumers and service providers (i.e., the utility-owned meter that measures kilowatt-hours of electricity sold by the utility and consumed by the customer). It extends all the way to the energy-consuming device or appliance on the customer's premises and includes all elements in the chain of technologies that ultimately enable electricity to be utilized as motive power, lumens of light on a work surface, or digitized processes.

Why start with consumer needs?

To identify opportunities for technical innovation in electric energy service, we begin by examining how consumer and business needs and aspirations may evolve. In effect, how are the broad consumer values of confidence, convenience, and choice likely to manifest in the coming years? This type of "outside-in thinking" explores how Americans may be working, raising families, and entertaining themselves in 2025, and how that is different from the dominant patterns we see today. In turn, we also ask "how might business and society be changing to respond to these new patterns of economic, social, and cultural activities?"

Why start so broadly, when our ultimate interest is what Americans will require from their electricity service? Why not simply begin by identifying consumer and business needs for reliability, power quality, energy efficiency, portability, etc. in 2025? We begin with consumer needs and aspirations in the broadest sense because these needs and aspirations will drive consumers' expectation for their electricity service. And, new requirements for electricity services and innovative applications of technology will evolve in response to these consumer needs and aspirations. To anticipate those new requirements, we begin by considering all of the forces—technological and otherwise—that are likely to impinge on American society in the next 20 years.

Using scenarios

The key challenge for Task 1 was to develop a workable set of plausible and provocative scenarios of U.S. social and economic development between now and 2025. In this context, a scenario is a story of what the world (and the U.S. in particular) might look like in 2025—how people will be living, what their hopes and

fears will be, what aspects of life will be different from what they are now, and which ones will be the same. A scenario is not a prediction or a forecast. Rather, it is one of several plausible stories of how things could turn out.[1] More than anything else, scenarios are tools to organize our thoughts about an uncertain future and to highlight the forces that may drive different future outcomes.

Factors shaping the U.S. in 2025

The first step in developing the scenarios was to identify the principal factors that will have a substantial impact on how the U.S. evolves in the next twenty years. In this process, the scenario team considered more than 100 potential drivers of economic and social change. We summarize and organize the most significant of these in six clusters:

- Demographics
- Economics
- Environment
- Security and health
- Society and culture
- Technology

Within each cluster, we discussed the most **robust trends** – issues that can be foreseen with a high degree of certainty and which all plausible scenarios of the next twenty years have to accommodate. We then discussed the **key uncertainties** that could push the future development of U.S. society in very different directions. Finally, we considered **wildcards** – low-probability developments that, if they were to occur, would change the nature of U.S. society in dramatic and discontinuous ways.

Demographics

Demographic trends and transitions will generate both challenges and opportunities for U.S. society in the next twenty years. Among the **robust** demographic trends are:

- An aging population with 19% (62 million) over 65 in 2025, compared to 13% (38 million) today.

[1] Our discussion of scenarios, and the scenario building process we used, is adapted from "Plotting Your Scenarios," by Jay Ogilvy and Peter Schwartz, in Liam Fahey and Robert Randall, eds, *Learning from the Future* (New York: John Wiley & Sons, 1998).

  - While the population is aging in an absolute sense, this chronologically older population is simultaneously getting relatively "younger" Life expectancy at any given age (say, 60, 70, or 80) is longer than it has been for individuals of the same chronological age in earlier generations. Many retiring "baby boomers" will want and need to remain economically productive, working at least part time to augment retirement income. Many are likely to want to keep connected to family and to stay more physically active than have "seniors" of earlier generations.
  - However, as they age, a growing number of these older Americans will require increased levels of therapeutic care and social services, ranging from family support to assisted-living to full-time medical treatment. Another potential challenge for many aging "boomers" is that they may maintain a healthy body far longer than they remain sound of mind. This could require new methods for mental stimulation and the care of the elderly.

- By 2025, 50% of the U.S. population will have been born and raised in the so-called "digital age" (after 1990). This represents a fundamental step-change in traditional human functionality. Skills, capabilities and experiences are no longer based primarily on analog mechanical technologies, but rather on digital electronic technologies. The resulting shifts in consumer needs and expectations between generations are likely to be profound.
- Immigration will almost certainly be the driving force in U.S. population growth during the period between now and 2025. By 2020, birthrates in the U.S. Caucasian non-Hispanic population are likely to decline to levels similar to those observed in Europe and Japan in 2000. Higher birthrates in immigrant and non-white communities will lead to a "majority of minorities" in many U.S. states by 2025.

At the same time, several demographic **uncertainties** could play out in different ways during this timeframe, including:

- Housing patterns: Will we see a continued exodus from urban and rural areas to suburbs and "Edge Cities" in this timeframe? The answer could have significant implications for both the size and energy-intensity of housing and transportation between home and work (where the dominant pattern could vary from lengthy commutes to short commutes to telecommuting).
- Geographic and social mobility: How often will U.S. families change homes in 2025? How often will individuals move between economic classes? Recent trends point to substantial geographic mobility among professional elites, but less social and economic mobility overall. Will these trends continue, slow, or reverse in this timeframe?

Although demographic change is typically slow and relatively predictable, **wildcard** events are possible. For example, two events that could occur within the next twenty years are a global pandemic or, at the other extreme, a dramatic increase in life expectancy in the developed world. Joel Garreau, author of a recent book on the effort to enhance human capabilities through bioscience,[2] notes that some people involved in research on human aging believe that the first person who will live to be 150 has already been born, and that in 20 years a person with sufficient wealth will be able to live as long as they want.[3]

Such a radical leap forward in life expectancy, particularly if it offered the promise of a very long and healthy life only to those who could afford it, could have deeply divisive social and economic implications – particularly in a society already struggling with increasing health care costs and the implications of an aging population.

Economics

Several **robust** economic trends will challenge the U.S. in this timeframe:

- The combined financial stresses of an older more dependent population, rising defense and security costs, and increasingly costly service on the national debt will leave little budget for public investment in education, R&D or infrastructure. As a result, the burden of R&D investment, as well as the need to improve worker skills and civil infrastructure, will continue to fall primarily on the private sector.

[2] Joel Garreau, Radical Evolution: The Promise and Peril of Enhancing our Minds, Our Bodies, and What it Means to be Human (Doubleday, 2005).
[3] Joel Garreau, personal communication, June 1, 2005.

- The U.S. economy, under the pressures of globalization, will become more resource-limited and financially constrained. Growing demand for oil to fuel the transport sectors of the global economy will likely keep the world oil price above US$ 40 per barrel for most of the period from now to 2025. As a result, the U.S. will be forced to move more aggressively to develop its abundant domestic energy resources and efficiency opportunities. The alternative would be increasingly severe market competition for incremental additions to shrinking global crude oil reserves. In a global, multi-polar political economy, this is likely to lead to intense, counterproductive geo-strategic competition among the major oil-consuming countries including the U.S., the European Union, Japan, Russia, China, India, Brazil, and Mexico.
- The continuing transition from a manufacturing-led to a service-based economy will likely lead to the disappearance of most remaining high-salaried manufacturing jobs in the U.S.

Most of the key economic **uncertainties** over the next twenty years pertain to how the U.S. responds to the economic challenges outlined above:

- Education and infrastructure: How effective will the private sector be in upgrading worker skills and rehabilitating civil infrastructure?
- Free trade vs. protectionism: Will the U.S. response to the challenge of globalization continue to emphasize free market competition, or will the domestic social and economic costs of globalization lead to a resurgence of protectionist policies?
- The future of the U.S. middle class: Will globalization and the loss of manufacturing jobs accelerate the shrinking of the U.S. middle class during this timeframe? Or will technological and economic innovation create enough new opportunities to avoid the institutionalization of a permanent underclass in U.S. society?
- The meaning of "retirement:" Will aging baby boomers be an effective source for domestic job-outsourcing, and thus become a viable asset in the global economy? Or will seniors be unable to find or hold suitable jobs and, therefore, face ever-larger expenses for health and welfare maintenance and the feeling of being generally under-valued by the mass culture? What will be the political impact of this growing population group?
- Energy efficiency: Will the rising cost of energy create the economic incentive for greater energy efficiency throughout the U.S. economy? Will investments in energy efficiency be promoted by state and national policy?

- Impacts of rising fuel costs: Will the rising cost of energy and increasing urban congestion lead to greater emphasis on telecommuting, with associated communications and electricity infrastructure improvements?
- The role of emerging actors: How much volatility will characterize the global economy during this period? In particular, what will be the net impacts of China, India and other major developing economies as they industrialize and become major global economic players?

Wildcard events that could dramatically change the economic picture during this timeframe might include the development or discovery of a new energy source (or large, previously unknown fossil fuel deposits). On a less optimistic note, a combination of oil shocks and structural deficits in the federal budget could trigger an economic collapse in the U.S.[4]

Environment

It is very difficult to predict with confidence either the state of the U.S. environment or public attitudes toward environmental protection. Nonetheless, there are a few trends that are likely to be relatively **robust** over the next twenty years:

- Significant changes in regional weather and storm patterns and increasing intensity of extreme weather events will lead to U.S. acceptance of the need to limit anthropogenic influences on climate change. The most likely result is the development of a global market in carbon-emission offsets and the implementation in the U.S. of market-oriented limits on carbon emissions. Policy measures will be designed specifically to promote technological advancement.
- Considerations of indoor air quality, as well as water quality and availability, become important factors in national environmental protection policies.
- Consumer attitudes like NIMBY ("Not In My Backyard") and BANANA ("Build Absolutely Nothing Anywhere Near Anyone") will remain strong and will only be moderated by major crises that consumers recognize as posing even greater personal threats.

A number of key **uncertainties** will affect how the U.S. approaches environmental issues in 2025:

[4] A particularly concise and detailed description of such a scenario was described in James Fallows, "Countdown to a Meltdown," *Atlantic Monthly*, July/August 2005.

- Complex interactions: Will the interplay among concerns about reliability, energy security, fuel cost, and environmental risk lead to a growing preference among both consumers and investors for ever-cleaner domestic energy sources? This could drive greater private investment in distributed renewable energy to help offset the impacts of greater reliance on domestic coal.
- Sustainability and stewardship: Will sustainable preservation of the world's environment and resources for future generations become broadly accepted both economically and politically? Several forces may converge that encourage this concept of comprehensive environmental stewardship. These include (a) tangible stresses affecting the level and global environment, (b) the rising cost and declining availability of natural resources, and (c) technology advances that enable commercially viable industrial and urban ecological initiatives.
- Federal vs. local leadership: Will leadership on environmental issues come primarily from the federal government or the local level?
- Role of international standards: Will international agreements or the environmental standards of America's major trade partners (particularly China) slow or accelerate the pace of environmental requirements in the U.S.?

Wildcards that could substantially alter the environmental policy landscape might include catastrophic and indisputable evidence of anthropogenic climate change or, alternatively, a major study from a reputable university, for example, "debunking" the link between greenhouse gas emissions and climate change.

Security and Health

Any plausible scenario of U.S. development over the next twenty years will have to deal with the **robust** challenges posed by terrorism and rising health care costs:

- The globe is increasingly divided among the "haves" and the "have nots". The willingness of the four billion people who are "poor " to continue quietly supporting the one billion who are "rich" will decline.
- Inter-civilizational conflict and associated asymmetric warfare (terrorism) remain enduring realities of everyday life. Much of the underlying animosity remains focused on the U.S. as the perceived leader of Western capitalist-based economic globalization and the guardian of the geo-political status quo.

- The response to perceived security threats creates economic inefficiencies in many market sectors but also encourages compensating innovations.
- Rising costs for traditional health care make it unaffordable to an increasingly large fraction of U.S. society. This may force a shift away from the traditional health care model that focuses on treatment toward an emphasis on preventative care and individualized health monitoring that makes use of advances in nanotechnology and bioscience.

The key **uncertainties** in this category center on how severe the challenge of terrorism and health care costs will be and how the U.S. will respond to these challenges:

- Domestic vulnerability: Will there be additional terror attacks on U.S. soil in this timeframe? How frequent and severe will they be? Will they include the use of biological weapons?
  - Will increasing terror attacks (if they occur) lead to a sense of shared purpose in U.S. society (i.e., a "war footing")? Or will such attacks only intensify the polarization of American society around issues of security, foreign policy, and military policy?
  - Will the vulnerability of networked infrastructures (especially, electricity and telecommunications) be exploited by U.S. adversaries? Episodic attacks on key infrastructural elements would have a far-reaching impact on the U.S. economy. Public pressure would likely increase to make these infrastructures adaptively robust in the face of rapidly changing human and electronic threats.
- Rising costs: How will the U.S. resolve the dilemma of increasing health care costs? Will de facto rationing eventually give way to a revolution in U.S. health maintenance and nutrition practices (supplementing or replacing the current medical/disease model)? Will it lead to the creation of a single-payer national health care system? Such shifts could be triggered, for example, by a resurgence of infectious diseases resulting from a large underclass without conventional health care.
- Spreading disease: Will pandemics of infectious diseases occur and create a dramatic shift in U.S. attitudes toward public health? Will dealing with the threat (and reality) of pandemics become a national priority?

Wildcards in the realm of security and health might include the rise of a strong "Moderate Islam" movement that serves to reduce the threat of terrorism on American soil or – at the opposite extreme – the successful deployment of a weapon of mass destruction in a U.S. urban center.

Society and Culture

There are at least two cultural trends that are likely to be **robust** over the next twenty years. Both are the product of demographic and generational changes:

- U.S. society steadily becomes less of a cultural "melting pot" and more of a cultural "salad bowl" as individuals from countries outside of Europe become an increasing proportion of U.S. immigration. Ethnic and religious communities strive to maintain a cultural identity that is distinct from the mass consumption culture.
- The transformative change from an analog mechanically-based culture to one based on a digital, electronic technology creates significant inter-generational "reality" gaps over the next two decades in terms of consumer needs and expectations.

At the same time, there are several key **uncertainties** about social and cultural development that could dramatically impact the U.S. during this period:

- Social fragmentation: Will growing differences between ethnic and religious groups, generations, political ideologies, and socioeconomic classes continue to fragment the U.S. or will we see a renewed sense of common identity and shared values?
- Customization of consumer goods: Will consumers demand increasing customization in goods and services, and will this desire ultimately lead to a breakdown of the traditional mass-market economy? Or will consumers embrace mass-market solutions?
- Temporal focus: Will there be greater institutional and political support for long-term strategic planning, or will most individual and collective decisions continue to be made with an overriding emphasis on short-term advantage?
- Role of rugged individualism: Will society favor individual or collective solutions to problems?

- Assessing quality of life: Will quality of life be defined primarily in terms of wealth and material possessions or more in terms of family and leisure time? What role will religious or spiritual values play in assessing the quality of life for the individual and the community?

Social or cultural **wildcards** can be thought of as radical changes in the trajectory of cultural values. Within this time frame, for example, a rejection of consumerism and materialism on the part of a significant minority (or even majority) of Americans would be a wildcard event. Such a dramatic change would not only reshape "consumer" aspirations, but would also send shockwaves through the economy.

Another potential wildcard might be a dramatic increase in the appeal and influence of fundamentalist religious sects. Such a change might or might not bring with it a rejection of consumerism, but could undermine support and funding for science and technology development in the U.S.

Technology

A number of technological trends appear to be **robust** during this timeframe:

- Society will be fully digital using all manner of networked electric/electronic devices, with each individual functioning within an invisible, portable "information field." Continuous and ubiquitous computing will become universally accessible throughout the U.S. Wireless internet access, available almost everywhere, will combine with the proliferation of inexpensive wireless computing platforms and specialized appliances to dramatically transform work and entertainment for many Americans.
- As a result of the previous trend, the number and diversity of portable electronic devices carried by the average American will increase. This will place a premium on the longevity and efficiency of portable power sources, such as rechargeable batteries.
- Electric drive technologies for transport applications will expand considerably as a result of rising petroleum costs and environmental pressures. This electric drive growth sector is also likely to include a much larger commitment to telecommuting to reduce the need for physical transport. The growth in electric drives, like the growth in portable electronic devices, will stimulate advances in energy storage devices and materials – ranging from nickel to lithium to lead to ultra-capacitors.

- Advances in genetics, pharmacology, and biotechnology will continue to expand the possibilities for medical treatment and human performance enhancement. The always-on, always-connected digital environment will enable continuous remote health monitoring and diagnostics.

The **key uncertainties** with respect to technology pertain to how fast specific technologies will advance and whether the U.S. will lead the world in developing these new technologies.

- Global leadership: Will the U.S. maintain a leadership position in technology development, or will many of the cutting edge developments occur overseas? Biotech is an obvious area where the U.S. might lose its leadership position due to self-imposed restrictions on research, but other factors could emerge to make this a broader issue in the R&D arena.
- Incremental change or sudden breakthroughs: Will technological development be primarily characterized by steady progression or rapid, discontinuous change during this period?
- Role of nanotechnology: Will nanotech-based health monitoring and diagnostics become available (and widely accepted) within the next twenty years?
- Robotics and healthcare: Will robotics-based assistive technologies for the aging provide more cost-effective options than pharmacology? How will the demand for, and cost of, new therapies further exacerbate social tensions over health care costs?
- Telecommuting: Will universal broadband access and public policies that encourage telecommuting enable and encourage U.S. businesses increasingly to outsource knowledge-based work to domestic "contractors" without creating adverse, globally competitive consequences?
- Smart vehicles: Will "smart" vehicles and smart roads provide solutions for urban congestion and commuting?
- Alternatives to travel: Will advances in "tele-immersion," enabling a more robust simulation of an individual's presence at a distance than video conferencing, emerge as a practical alternative to business travel?
- Decentralized fabrication: Will nanotechnology give rise to decentralized fabrication, where modestly sized devices can produce a wide range of physical artifacts to spec and on demand?

- Bio-engineering: Will bioengineering, including the ability to synthesize functionally specific genomes, enable new methods of high-efficiency matter/energy conversion? Will bio-engineered organisms improve renewable energy production and utilization? Will genetically engineered organisms transform pollutants and waste products into commercially viable raw materials?
- Photovoltaics: Will cost-effective photovoltaic energy conversion systems be integrated into residential, commercial and public structures, reducing the external energy demands of these structures and their occupants?

Technological **wildcards** might include the emergence of truly disruptive advances. These could include the development of a cost-effective fusion reactor or the ability to bio-engineer organic and inorganic materials with such precision that traditional farming and manufacturing became obsolete.

Defining the scenarios

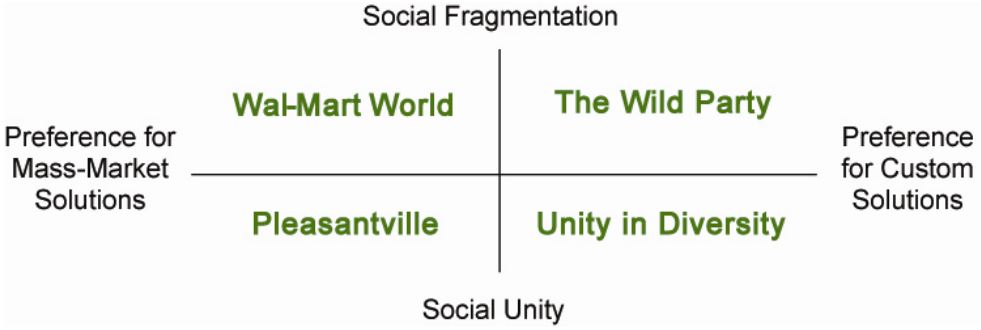
To create a set of scenarios that represent plausible yet divergent visions of 2025, the project team and Workshop participants sifted through the uncertainties outlined in the previous section to identify two major drivers which, taken together, define **two axes** against which potential future consumer needs and expectations can be most diversely and creatively mapped. The two axes are:

- **Social fragmentation vs. social unity**: This axis reflects the dynamic tensions between ethnic groups, generations, political ideologies, and socioeconomic classes at play in the U.S. At one extreme, the increasing fragmentation of America along these dimensions results in a society that in many ways no longer functions as a single nation or culture. At the other extreme, a resurgence of emphasis on shared values and a common cultural identity works to overcome sub-cultural differences.

- **Preference for mass-market solutions vs. customized solutions**: This axis highlights consumers' preferred retail market products and solutions. At one extreme, consumers prefer similar, mass-market products and solutions. This end of the spectrum reflects a rejection of the notion that more choices are better in favor of generic, workable solutions that do not demand much active participation by consumers. At the other extreme, consumers demand products and solutions that are customized to reflect individual values. This extreme involves conscious, choice-based consumption and places a premium on individual expression. It also implies a world in which technological developments in distributed fabrication have made true customization economically practical.

Arrayed against one another, these two axes create a two-dimensional matrix whose quadrants define our basic scenarios (see Figure 1). We emphasize that these scenarios are not intended to be forecasts or predictions, but rather represent a diverse set of possible futures, highlighting the range of consumer needs and expectations that might evolve over the next twenty years.

Figure 1. Four future scenario quadrants



Four visions of the U.S. in 2025

This section provides an overview of the four scenarios, organized around answers to three critical questions:

- What is important to consumers/citizens?
- Who has the primary power to affect change?

- How are changes made?

By focusing on these contextual questions, we provide a concise summary of the critical differences among the scenarios. Figure 2 compares and contrasts our four scenarios. It highlights what is important to consumers/citizens in each scenario, who has the primary power to affect change, and how changes are made in each scenario.

Figure 2. Answers to critical questions by scenario

	Wal-Mart World	The Wild Party	Unity in Diversity	Pleasantville
What is important to consumers/ citizens?	Sub-cultural identities/ affiliations, personal safety, economic prosperity.	Diversity, personal safety, change and experimentation.	Creativity, collaboration, and strength through diversity.	Economic prosperity, social conformity, and traditional middle-class values.
Who has the primary power to affect change?	Corporations and sub-cultural groups.	Individuals (particularly the wealthy) and corporations.	Creative individuals, entrepreneurs, and government.	Government, corporations, and other institutions.
How are changes made?	Market mechanisms.	Locally and individually.	Peer-to-peer adoption and adaptation of new ideas.	Centralized planning; national institutions.

In the next sections, we provide a description of each scenario:

- These descriptions begin with a review of the **early signs** pointing the way toward this scenario; i.e., what are the existing trends that could lead us to this world?
- This is followed by a discussion of the **driving forces** shaping the scenario. How does the interaction of the two axes/key drivers shape this world?
- Next comes the **storyline**: How have the robust trends and key uncertainties (demographic, economic, environmental, security and health-related, social/cultural, and technological) played out in this world?
- Then we consider how one or more **wildcards** could lead to **alternative paths** for this scenario.
- Finally, we look at the implications of each scenario for energy use and electricity service requirements.

Wal-Mart World – social fragmentation with mass-market solutions

Early signs

- Increasing globalization leading to
  - Increasing price competition in all sectors
  - Corporate mergers
  - Reduction in domestic U.S. manufacturing
  - "Big box" stores squeeze out small retailers
- Growing ethnic diversity and political polarization

Driving forces

Wal-Mart World is an America fractured along economic, ethnic, religious, regional, and political lines. Political polarization leads to extended federal government grid-lock on key issues, leading to a conflicted mosaic of state and local policies. Corporate marketers are able to adapt to this reality more successfully than politicians, increasing their relative influence on society.

The storyline

Social fragmentation leads to severe market segmentation. Well-defined clusters or "affinity groups" appear. They are divided by income level, ethnicity, geography, and other markers of group identity. Competition for customers is intense within these market segments. Advertising focuses on identity marketing, highly dependent on endorsements from sub-cultural "heroes" (i.e., athletes, rock stars, and actors).

This fragmentation leads to increasing loyalty within groups, and increasing competition for economic success and social and political influence between groups. The latter trend makes it difficult for the major political parties to create coalitions that are broad enough to support major policy initiatives. The result is perpetual grid-lock in Washington and many state capitals. The power of corporations grows relative to government because corporations can quickly and flexibly adapt their products and services to differentiated groups while public policies are often slow to change.

Low-margin, high-volume behemoths dominate in retailing. Major players target specific combinations of market segments. Consumers develop intense loyalty to particular distribution channels (e.g., Wal-Mart, Nordstrom's, Amazon, and EBay) rather than to traditional brands. In the food sector, customers choose their favorite "flavor" of vendor and stick with it (Whole Foods, Shopper's Food Warehouse, etc.). The exception to the consolidation of distribution channels in food are local Farmers'

Markets, which blossom in response to the desire for higher quality produce than mass-market distribution channels can deliver.

Auto manufacturers expand the number of nameplates to connect with particular sub-groups. The trend toward off-shore manufacturing accelerates.

Ironically, in *Wal-Mart World*, neighborhoods return to prominence. People live in affinity group communities. Gated communities, "family compounds," and "ghettos" are the rule, not the exception. The trend of middle class flight from cities continues. Cities become gentrified pockets reserved for elites and surrounded by "villages" of immigrant communities, religious communities, and the disenfranchised.

"Edge Cities" thrive, co-locating work and living spaces within relatively short commutes. Telecommuting also grows in importance. These trends are driven by the economics of higher gasoline prices, the desire to spend less time commuting, and increasingly the desire to live and work within relatively homogenous "bubbles." The distance the average American drives in a year declines slightly.

There is a significant increase in crimes of violence and crimes against property – often driven by ethnic hostility or perceived economic inequities. Repeated episodes of spectacular white collar crimes lead to continuing political scandals and loss of faith in governing institutions.

U.S. society remains polarized around questions of foreign policy. The growing tensions between the collective need for security vs. individual needs for civil liberties, and over equity concerns about who pays and who gains, makes a coherent and proactive Federal approach to homeland security impossible. Where key infrastructure elements are privately owned, their corporate owners begin working together on security issues. This is especially true for the transportation networks that move manufactured goods into and around the country.

Overall, environmental degradation accelerates. Urban air pollution increases the incidence of severe asthma and upper respiratory problems among children and seniors. The presence of persistent organic pollutants (POPs) in drinking water is linked to the spread of various cancers. An inability to achieve consensus among competing groups results in limited national policy attention on environmental protection or health maintenance.

The exception to this pattern is climate change, where major corporations invest in climate/sustainability initiatives to address the concerns of several key market segments. Many analysts argue that uniform, mandated standards for carbon

emissions would be more effective, but efforts to impose them continue to stall in Washington.

A house remains the American dream. The typical single-family, detached house continues to grow as middle class houses add specialized function rooms. Homeowners' expectations rise in a number of areas including pinpoint climate control, monitored home security and surveillance systems, in-home "WiFi," and – increasingly – electric powered "slaves." As a result, the amount of energy the average household consumes through electrical outlets ("plug load") increases dramatically.

Commitment to (and funding for) public education continues to decline. Metropolitan school systems are characterized by de facto segregation. National educational norms (based on standardized tests) lead to a "dumbing down" of education. Focus on critical thinking gives way to "teaching the test." Enrollment in science, math, engineering, and languages declines. The popularity of extracurricular activities such as competitive sports, dancing, music, and video games increases. Sub-cultural groups that place a higher value on education increasingly form their own private schools.

Fewer workers support more retirees. Health care continues to focus on the "medical model" with its emphasis on curing disease rather than maintaining health, and the lack of a national consensus makes it impossible to create a meaningful national health care system. An increasing fraction of the population needs life support. Many families are unable to afford assisted living facilities, resulting in a growing number of multi-generational households where seniors are cared for by their adult children and grandchildren.

Wildcards and alternative paths

Wal-Mart World would have a particularly difficult time (at least initially) dealing with the challenge posed by major disasters that require a unified response. For example, if hurricane Katrina was followed by a ten-year period in which multiple class 4 or 5 hurricanes hit Florida or the Gulf Coast each year, the socially fragmented, corporate-lead *Wal-Mart World* would have to deal with the short-term (but recurring) economic and social disruptions these storms caused and demand longer-term solutions (such as relocation of key infrastructure or strengthening of storm preparedness and response measures). Addressing either the short-term or long-term issues would likely require a renewed emphasis on the role of the central government. The net effect would be to move *Wal-Mart World* a bit closer to *Pleasantville* (by forcing the country to unite in the face of a common challenge). A major increase in terrorism would have a similar effect.

Another wildcard that would substantially alter *Wal-Mart World* would be the growth of a significant movement opposing conspicuous consumption. This could result from a reaction to an economic downturn or a more serious cultural shift away from consumerism. The advocates of such a movement might focus on non-traditional definitions of quality of life (e.g., spirituality, simple living). Although corporations and marketers would try to adapt their strategies to reach this new "market segment," they would have limited success – particularly if, in the most radical version of this wildcard, the segment members eschewed the high paying jobs many of them would otherwise have been qualified for to gain more time for contemplation. This would result not only in reduced demand for a variety of products and services, but also in a reduced demand for labor at a time when demographics are already straining the domestic labor market.

Implications for energy use and electricity service requirements

Power reliability and power quality

The need for highly reliable, digital-grade power continues to grow in this scenario, but the rate of growth varies by market segment. Industrial energy users, many commercial users, and even some residential energy consumers (particularly those who telecommute) require essentially perfect power reliability and quality. Other residential and commercial customers have less strenuous demands, in some cases due to sub-cultural differences in what is viewed as acceptable.

Energy efficiency

Energy efficiency is not a primary focus of the electric energy system in this scenario. Although energy efficiency measures are implemented by businesses when they have a short-term payback, and more efficient technologies (such as compact fluorescent lights (CFLs) and light emitting diodes (LEDs)) penetrate commercial lighting markets, efficiency is largely ignored in the residential sector. Indeed larger homes, the increasingly wired nature of homes, and the growing presence of electric powered "slaves" drives toward ever increasing electricity use. A portion of the residential market begins using software-based systems to control their major electricity demands, thus smoothing out energy demand across the day and night periods. These systems do little to reduce overall electricity consumption, however.

Environmental impact of energy use

The environmental impact of electric power generation gets some attention, but only insofar as key market segments demand it. Other environmental issues are largely ignored.

Indoor environments

The growing importance of Big Box retail puts increasing pressure on zonal space conditioning and lighting systems. Lighting and environmental controls in the home are not growth areas, other than an increasing interest in indoor air quality solutions among high-end homeowners.

Impact of security issues on electricity use

Security concerns make electronic security systems with redundant power sources a growth market. Increasingly, home security and safety are defined to include backup power and power quality solutions for those homes with elderly family members dependent on in-home medical equipment.

Industrial energy use

Industrial energy use declines. Most industrial energy is imported (embodied in manufactured products) rather than consumed on-site. Automation of remaining factories enhances production quality, raises energy efficiency, and reduces energy intensity. The center of gravity of industrial production shifts toward the duplication of knowledge-based products (i.e., CDs, DVDs, books, etc.) and away from energy-intensive goods.

Transportation

Higher costs for traditional transportation fuels place a premium on increasing the energy efficiency of both personal and industrial transportation systems. In industrial transportation the primary focus is on more efficient marine and rail freight systems, reflecting the reality that most manufactured goods are imported. There is little growth in public mass transit.

The Wild Party – social fragmentation with customized solutions

Early signs

- Growing ethnic diversity and political polarization
- Widening gap between rich and poor
- Increasing distrust of globalization and corporations among many segments of the population
- Decline of the U.S. as a world economic player
- Rapid pace of development in infotech, biotech, nanotech, and robotics – ultimately leading to the development of small scale, distributed fabrication capabilities

Driving forces

Like *Wal-Mart World*, *The Wild Party* is fractured along social, ethnic, religious, political, and – especially – economic lines. Rapid technological developments have made it possible for groups and individuals to be more self-sufficient, largely eliminating the unifying force of mass-market consumerism. The result is a world that feels somewhat chaotic and occasionally dangerous. Unlike *Wal-Mart World*, large transnational corporations have not gained sufficient public confidence to fill the leadership gap.

The storyline

Significant class distinctions exist, with wealth becoming ever more concentrated. Bad monetary, taxation, and trade policies have caught up with us. But the marketplace is freer than ever; upscale consumers shop globally, and highly skilled professionals participate vigorously in global labor markets. The less affluent adopt a wide range of lifestyles, creating numerous market opportunities. The poor are frequently subjected to organized frauds, including bogus medical treatments, fake lottery tickets and pyramid schemes.

The Wild Party is a world that values diversity, change, and experimentation. Group identities are important, but constantly morphing as sub-cultures continue to subdivide. Ubiquitous computing, peer-to-peer networks, nanotech, and distributed fabrication technologies give individuals tremendous control over the form of their personal environment (and increasingly their own bodily forms). These technologies accelerate the cultural trends toward individualism and small-group identification and away from widely shared identities.

Centralized government still exists but is ineffective in most arenas. The federal budget is almost wholly devoted to the military and interest payments on the national debt. The U.S. defaults on its debt at least once before 2025, but gets away with it – in part because the country is "too big to fail" and in part because of America's continuing military superiority.

The lack of a strong central government means there are no meaningful national strategies for dealing with health care, infrastructure security, climate change, or similar crises. The wealthy find their own solutions and the rest muddle through.

For those who can afford them, artificial glands monitor the body and provide last-stage synthesis of drugs to titrate as needed and as directed over the net. Reliable regenerative medicine is also available for those who can afford it, though it may require frequent travel to China for treatments. Regenerative medicine for the majority of Americans is found at Wal-Mart's "Hometown Clinic" and is somewhat

effective. The richest members of poor communities gain the medical benefits of the rich; become hero supermen to their peers, living larger and longer.

In *The Wild Party,* people travel less. Telecommuting becomes tele-emersion (technologies to effectively mimic a person's physical presence at a distance) and home-based fabrication and e-commerce make going to stores largely unnecessary. It is also less safe – crime rates are up, car bombings happen with some degree of regularity, and there is always the possibility of another pandemic (the last one was actually kind to the wealthy, but many remain squeamish about travel nonetheless).

In some urban areas the infrastructure breakdown has grown so severe that travel is difficult in addition to being dangerous. Roads are not repaired and abandoned cars remain where they stopped.

The wealthy live in large homes, often in gated communities. Many have robotic "security guards" at the gate. They are not very smart or dependable yet, but in many ways that makes them even more intimidating.

The rest of America is characterized by high-density, but not collective, living. Suburban houses are broken up into flats, the gaps between filled in by high density housing units. It is unfashionable to keep the same furniture for very long. The old stuff is digested and reformed into the latest designs, as downloaded from the web.

Increasingly online education and virtual reality (VR) training simulators supplement (or take the place of) traditional schools. All but the poorest kids are forced into VR for many hours a day. As early as toddler age, they receive training on how to get ahead in this brave new world. Chinese lessons are a top priority.

Wildcards and alternative paths

The somewhat pessimistic tone of *The Wild Party* would be substantially altered if the development of distributed, home-based fabrication technologies, along with their supply infrastructure, emerged in the U.S. under the control of U.S. based corporations. If America pioneered this new approach, new, high-value domestic industries would emerge. They would be devoted to the manufacturing and exporting of "home fabbers," the production and distribution of fabrication raw materials, and the design of fabrication templates. This would fuel job growth in the U.S. and create the tax base to support infrastructure redevelopment. The result would be a world in which much of the diversity and energy of *The Wild Party* coexisted with a reasonably strong central industrial and economic capacity. In many ways this would be a half-way point between *Wal-Mart World* and *The Wild Party*, with some of the advantages of both scenarios.

Implications for energy use and electricity service requirements

Power reliability and power quality

The Wild Party is not a scenario conducive to infrastructure investments. So, while the need for highly reliable, digital-grade power grows, individuals are largely responsible for meeting this need themselves. Backup power and local power quality solutions are the norm for those that can afford them. Many cannot, however, which leads to differential power reliability experiences across social and economic strata.

Energy efficiency

The energy efficiency of buildings increases in this scenario more than it does in *Wal-Mart World*. This is a result of a growing movement toward zero-energy homes, which combine energy efficiency measures with on-site power generation to make the homeowner independent from the power grid. The driver for this movement is less money savings than a lack of faith in the energy delivery infrastructure.

Environmental impact of energy use

The environmental impact of energy use and electric power generation is largely ignored. Many individuals attempt to be "green" in a variety of ways, but these efforts have little overall impact on the environment due to a lack of coordination and scale.

Indoor environments

With the advent of in-home fabrication, the lighting and climate control needs of the residential sector grow more complex. The need for indoor air quality solutions also grows as people spend more time at home and as home-based fabrication introduces new airborne contaminants to the residential setting.

The use of traditional retail establishments and office buildings declines, which places less emphasis on commercial lighting and climate control technologies. The one growth area in this sector is modular systems for environmental control. These systems allow the construction of commercial buildings as shells or "racks" which tenants can customize or build out to suit their needs. They also make it easier to recycle or reuse existing commercial spaces for new purposes.

Impact of security issues on electricity use

Electronic security systems – increasingly incorporating robots – are a growth market for upscale consumers.

Industrial energy use

Industrial energy use grows, but in an unexpected way. It shifts from centralized fabrication of consumer goods to distributed or home-based fabrication, which leads to a resurgence of domestic manufacturing overall. The centralized manufacturing facilities that remain produce feedstock for distributed fabrication.

Transportation

There is less emphasis on the development of energy-efficient transportation options than in *Wal-Mart World* because people are traveling less.

Unity in Diversity – social unity with customized solutions

Early signs

- Growth of blogging and peer-to-peer networks
- Increasing comfort with diversity, especially among younger generations
- Growing citizen participation in democracy, both through referenda and through "high-tech activism" (e.g., protests organized in real-time through wireless connectivity; online communities organized to promote political or economic change)
- Rapid pace of development in infotech, biotech, nanotech, and robotics – ultimately leading to the development of small scale, distributed fabrication capabilities

Driving forces

Unity in Diversity is a dynamic and creative world with societal agreement on a set of broad common values. The dynamism comes from the many and constantly changing paths people can take to reach their goals. Rapid technological developments and an ethic of collaboration have made it possible for self-expression to flourish and innovators to prosper.

The storyline

This is a world in which broadly-accepted goals are met by a great variety of alternative pathways. Mass markets exist, but are primarily concerned with commodity goods and services; a greater part of the economy is focused upon the production of goods and provision of services uniquely suited to particular customers and citizens. Moreover, a sense of shared identity means that, although individuals may choose different paths to the same goals, they're willing to help their fellow citizens make the best choice and choose the best designs – for a fee.

At the same time, the abundance of choices coupled with shared identity and responsibilities results in a breakdown in privacy – individuals are free to choose their own path, but society is free to judge as it judges the overall costs of that path.

Economic activity is influenced much more by small start-ups and individual entrepreneurs than it was even during the Internet Bubble of the 1990s. The concept of open standards, developed collaboratively but subject to frequent revision, has penetrated almost every sector of the economy. The result is rapid prototyping of new product and service concepts.

As with *The Wild Party*, the advent of distributed fabrication technologies plays a key role in allowing collaborative design and rapid customization to move into the realm of manufactured goods. A person with back problems, for example, can download the design for an ergonomic chair from the internet and manufacture it at home. If, after using it for a couple of days, they decide the chair is not quite perfect, they can tweak the design and re-manufacture it (recycling the first version to produce the second). Once they have a design (and chair) that they like, they upload the new design to the internet where it can be used and modified by others. Changes to intellectual property laws allow individuals great latitude in modifying designs as long as they maintain the chain of attribution.

Diversity is seen as a characteristic of social unity. Personal expression is encouraged, but within certain (broad) normative bounds. Innovation is the basis for the new economy. This provides tremendous opportunities for creative individuals, but brings problems for those unable to participate (for reasons of talent, training or opportunity).

With ubiquitous computing, communications, and real-time collaboration as their tools, individuals with a stake in – or passion for – confronting particular societal problems succeed in building coalitions and pressuring government and corporate America for change. Health care and climate change are among the first problems to receive attention in this fashion.

Health care continues to place emphasis on the medical model, but it now includes a significant component of "wellness care." At the core of the health care system is a national single-payer plan that provides a basic level of coverage. Individuals may purchase numerous options from insurance companies (or gain access to experimental biotech regimens by agreeing to serve as beta testers). In keeping with the ethic of allowing individual expression as long as it is not too socially costly, those who choose to engage in habits destructive to their health (such as smoking) must pay higher fees for related illnesses, even under the single-payer plan.

Citizen activism has a similar impact on climate change, pressuring both government and industry toward carbon limits and trading mechanisms. Creative solutions emerge from unexpected places as a result of ubiquitous communication and real-time collaboration.

Communications and information technology advance rapidly. Diverse media and device types exist, but with compatible formats and standards.

Transportation is characterized by diverse vehicle designs within a standardized network (i.e., rapid convergence on an underlying post-petroleum fueling technology, but with abundant variation of physical form and control systems). Experiments with "Personal Mass Transit" (i.e., individual cars that can link up and be routed together) show success in some urban areas. Vehicles (and other technologies) are able to reconfigure controls, interface, and even physical layout upon recognition of the user.

Security, like most things, is dealt with collaboratively. The ubiquity of portable communications and video cameras enables each citizen to be a mobile node in a nationwide security monitoring network. The advent of intelligent agents embedded in these devices means that this vigilance requires little or no active attention from individuals. An individual may opt out of the security network, of course, but the next cell phone will cost more.

Wildcards and alternative paths

The collegiality and optimistic acceptance of diversity at the core of *Unity in Diversity* could be challenged by many events. For example, the discovery of a therapy that radically increased the productive human lifespan would stress this society in multiple ways. First, would come the question of who owned the rights to this discovery. In general, intellectual property laws have been relaxed to encourage innovation and collaboration, but this discovery is orders of magnitude more important and more valuable than a new video game design. As a result, those who played the primary role in developing it want to protect their rights to market it as they see fit.

Next would come a furious online debate over the economic and social costs and benefits of extending human lives this far. The therapy's developers would claim this was an academic discussion at this point and that "the genie couldn't be put back in the bottle." Then, they would begin selling the treatment while the debate continued. A significant fraction of the citizenry would contend that this behavior broke the social compact (that is, fell outside the bounds of acceptable freedom to innovate) and that the government should confiscate the research.

Ultimately a development like this that called into question the underlying assumptions of *Unity in Diversity* (open source architecture and the willingness to be guided by the broader good) would push this scenario in the direction of either *The Wild Party* or *Pleasantville* (depending on how the dilemma was resolved).

Implications for energy use and electricity service requirements

Power reliability and power quality

Highly reliable, digital-grade power is a fundamental requirement for participation in the electronically-mediated and home-fabrication based economy. And because the culture of *Unity in Diversity* believes in the value of enabling everyone to participate to the limit of their abilities, assuring essentially perfect power reliability and power quality for everyone is a high priority.

Energy efficiency

A substantial movement toward improved energy efficiency is driven by both higher energy costs and growing concerns about the environmental impacts of energy use. A significant fraction of the residential market makes use of the wealth of collaboratively designed and tested energy efficiency measures available online, and seeing how close they can come to a zero energy home becomes a point of pride for many homeowners. The greatest push toward energy efficiency is seen in "legacy" systems such as lighting, heating/cooling, and common household appliances. For newer electronic devices, functionality is of paramount importance and efficiency ranks second.

Environmental impact of energy use

Because the majority of citizens/consumers understand the linkage between energy choices and environmental impacts, this scenario addresses the environmental impact of energy use in general, and electric power generation in particular, more effectively than either *The Wild Party* or *Wal-Mart World*. .

Indoor environments

As in *The Wild Party*, the advent of in-home fabrication leads to increased requirements for lighting, climate control, and indoor air quality solutions in the residential sector. With the move away from traditional offices and retail establishments, the need for new commercial lighting and climate control solutions lessens.

Impact of security issues on electricity use

The reliance on a ubiquitous surveillance network as the backbone of society's security solution drives the need for both enhanced wireless broadband connectivity

(with redundant power sources for the stationary nodes in the network) and portable power supplies that are recharged easily (or self-charged).

Industrial energy use

Industrial energy use patterns and requirements are similar to *The Wild Party*. Domestic manufacturing (and energy use) rebounds in the form of home-based, distributed fabrication. The remaining centralized manufacturing facilities largely produce feedstock for distributed fabrication.

Transportation

The collaborative spirit of this scenario leads to a greater willingness to embrace mass transit systems. Technological advances in transportation abound, although the need for energy efficiency in the transport sector is mitigated somewhat by the fact that people travel less.

Pleasantville – social unity with mass-market solutions

Early signs

- Growing social (though not necessarily economic) conservatism
- Pop cultural nostalgia – recycling styles and trends rather than creating new ones
- External threats encourage greater social and political unity around shared values and priorities in a hostile world

Driving forces

Pleasantville is an America characterized by social unity and a shared sense of national purpose, reinforced by mass-market consumerism.

The storyline

Civil society is dominated by the cultural and consumption habits of a broad, inclusive middle class. Although income disparities remain visible in all regions, the tone of popular culture is set by ubiquitous advertising in TV, radio, Internet, email, and cell phone devices. The broad buying public of this middle class is the target of advertising, which highlights the aspirations of the middle class to live like their celebrity "heroes."

Social unity leads to markets dominated by iconic brands. Mass-production goods are designed to avoid offending anyone.

Although regional and ethnic differences remain, popular culture reflects a common set of values and expectations. Advertising focuses on being cool, being one of the in-crowd, and developing brand loyalty among opinion-leaders and key market segments (e.g., teenagers and retirees).

A renewed sense of common identity and purpose creates the political will to address some increasingly urgent problems (e.g., national health care, climate change). This is especially true in dealing with terrorism. The nation ultimately unifies in the face of increasing terrorism on American soil, willingly trading some personal liberties for safety and the greater good. This same spirit of unity creates the political will for strategic investments in infrastructure security.

At the same time, the culture is centered on nostalgia and striving for the mass market consumerism and pop culture of the late 20th century (spiced with new high-tech toys, of course). This consumption-driven culture ignores all problems that are not recognized as crises (e.g., environmental degradation, addictive behaviors, and the declining educational performance of America's youth).

Environmental degradation is mainly an abstract concept. Suburban neighborhoods with green lawns and clean streets seem to be safe havens from pollution, and few associate rising cancer rates with environmental contaminants.

The exception to this rule is climate change. There is increasing evidence of the link between carbon emissions and global warming, in addition to increasingly destructive climatic shifts. These lead to a federally imposed $C0_2$ emission cap and trading system and more stringent requirements on automobile emissions and fuel efficiency.

In *Pleasantville,* most people live in suburban tract houses. Central cities shrink in size and political power as middle class flight to "Edge Cities" continues. As in *Wal-Mart World*, cities become more socially and economically diverse. They incorporate gentrified pockets for elites and "villages" of immigrant communities, religious communities, and the disenfranchised.

Gated communities and "ghettos" rule. The new ghettoes are not defined by ethnicity or national origin. Rather they are defined by homogeneity of economic status or occupation and stage of life. A housing development of young middle class families all of whose "bread-winners" work for high-tech IT firms in California's Silicon Valley is an example.

Middle class Americans move back into row houses and condos. Mixed housing in new developments means a combination of town houses, row houses, high-rise condos and traditional, detached, single-family homes. Nearly all new homes have a

garage for the family car. The typical household is a couple, usually a man and woman, living as a nuclear family unit.

Health care continues to focus on a medical model that favors intervention once an illness has occurred over prevention. An increasing fraction of the population needs therapeutic care and social services; ill individuals are sent to institutions for care. An HMO-based, single-payer, national health care system is put in place.

National health policy is geared to finding spectacular cures. Research concentrates on big programs to cure the mega-diseases – breast cancer, prostate cancer, spinal cord injury, HIV. Little emphasis is placed on health or fitness, and addictive behaviors proliferate. Obesity becomes endemic in American culture. Partly as a consequence, popular images of beauty begin to change in the mass culture to accommodate this reality – but new fad diets emerge every few years that still earn their authors millions.

The U.S. economy continues to be driven by consumption rather than investment. Ballooning public-sector deficits are financed by long-term borrowing through the sale of U.S. Treasury bills to foreign investors. The U.S. exercises its politico-military hegemony to ensure favorable trade treatment by all its suppliers in exchange for the security of Pax Americana.

Knowledge industries and dual-use technologies remain among the few sectors that achieve continuing innovation and success in export markets. US exports are dominated by software, entertainment, commercial aircraft, and weapons.

Retailers reach consumers through multiple channels. Big box retailers and warehouse clubs dominate family purchases of daily needs. Young people get the latest cool things by internet purchases from Amazon and EBay rather than from traditional brick and mortar retailers. In the food sector, customers buy mainly the national brands of processed foods that are advertised on TV.

Major consumer goods are increasingly leased, not purchased. Used goods are returned to the manufacturer for recycling. Leasing of high-end consumer goods follows the model developed by the Interface Corporation (e.g., office carpeting is leased from Interface, returned and replaced with “new” carpeting). Cradle-to-cradle recycling reduces both carrying costs for consumers and waste disposal costs for communities. The growth of leasing means that corporations can control the final recycling/disposal of their products, thus avoiding liability for products improperly disposed of by others.

Personal mobility moves toward mass transit; new communities are typically planned with mass transit in mind. Bus rapid transit systems running in dedicated lanes offer an alternative to congested freeways in most urban centers.

Vehicle ownership declines to less than one vehicle per licensed driver but vehicle miles traveled (VMT) per vehicle remains over 10,000 miles/yr. Appeals to macho sentiment and security fears for Moms continue to drive new vehicle sales toward light trucks and SUVs despite high oil prices. Brand loyalty in the auto sector gives way to fleeting affection for what's "cool."

Commitment to public education becomes an important rhetorical issue. Emphasis is placed on national standardized tests and norms. Focus on critical thinking gives way to "teaching the test." Suburban school systems thrive; city school systems shrivel from lack of funds. For those that can afford them, private schools take the traditional place of public education in cities.

Crimes of violence and crimes against property decline. As neighborhoods become more homogeneous, "Neighborhood Watch" programs discourage assault, murder, rape, and crimes against property. White collar crime increases but most people see it only as a nuisance, not a crisis or a threat. Sexually explicit images become illegal but pedophilia and spousal abuse increase.

Church attendance at mainline protestant churches declines severely, while fundamentalist religious sects expand and flourish. Social conservative activists seek to insert their own religious values into the public square. Tolerance for non-traditional lifestyles and values shrinks, remaining strong only in a few isolated communities.

Wildcards and alternative paths

If, as is implicit in this scenario, national unity results from a perception of external threat (i.e., terrorism), then the disappearance of that threat would cause the unity to unravel. This might occur through the rise of a strong "Moderate Islam" movement that shifts the focus of Islamic radicals from the U.S. to moderate Muslim states. Because the underlying causes of social fragmentation are still present in *Pleasantville* (e.g., ethnic and religious differences, generational conflict, political disagreements and economic disparities) removing the sense of external danger would likely result in a resurgence of sub-cultural disagreements and a questioning of the value of centralized authority. The net impact of this would be to move this scenario closer to *Wal-Mart World*.

Implications for energy use and electricity service requirements

Power reliability and power quality

Highly reliable, digital-grade power is seen as both a consumer "right" and an important component of America's competitive advantage. Favorable conditions for infrastructure investment help make essentially perfect power reliability and quality a reality.

Energy efficiency

Energy efficiency is all but ignored in the residential sector. Average home size continues to grow. Middle-class houses add specialized function rooms (e.g., electronic entertainment rooms, hobby/craft rooms, exercise rooms, billiard rooms, and even libraries). Fads proliferate, with waves of specialized 'appliance' purchases for home use that increase plug loads.

Commercial energy use also increases, though overall energy use in retailing declines as purchases migrate to Big Box stores and Internet vendors. The number of brick-and-mortar retail stores declines, while average size increases. Vendors redesign stores for iconic customer types (i.e., "Soccer Mom," "Geeky Dad," "Hip Teen," etc.)

Energy use in "Entertainment Complexes" and "Theme Parks" grows dramatically, as do plug loads in offices. Although telecommuting is gradually growing in importance, traditional offices remain a core aspect of work life for most professionals.

Rising prices for all forms of energy drive many actors in the commercial sector to make investments in energy efficiency. Energy demand for lighting declines as more efficient CFLs and LEDs penetrate commercial lighting markets.

Environmental impact of energy use

While environmental issues in general are ignored, growing evidence of destructive climate change resulting from carbon emissions leads to government mandates to reduce CO_2 emissions from cars and power plants.

Indoor environments

As in *Wal-Mart World*, the growing importance of Big Box retail leads to greater requirements for zonal space conditioning and lighting systems. Lighting and environmental controls in the home are not growth areas, other than an increasing interest in indoor air quality solutions among high-end homeowners.

Impact of security issues on electricity use

Falling crime rates and a renewed sense of security within homogenous neighborhoods dampens market demand for electronic security systems. At the same time, a renewed focus on infrastructure security seeks to reduce the vulnerability of the electric power system to terrorism and other threats.

Industrial energy use

Industrial energy use is somewhat greater than in *Wal-Mart World* as the government promotes the consumption of American-made goods. Automation of factories enhances production quality, raises energy efficiency, and reduces energy intensity.

Transportation

Mass transit is centrally planned, promoted, and funded as a way of dealing with both urban congestion and carbon emissions from automobiles.

Summarizing the scenarios – similarities and differences

Figure 3 compares the character of society in each of the four scenarios and summarizes the similarities and differences in the scenarios' responses to three key challenges (health care, terrorism/security, and climate change). It also notes the developmental trends within each scenario with respect to the residential, commercial, and manufacturing sectors.

Figure 3. Summary of scenarios

	Wal-Mart World	The Wild Party	Unity in Diversity	Pleasantville
Character of society	Many coherent groups Loyalty w/in groups; competition and aggression between groups Competition for safety and economic success Acceptance of market mechanisms Government gridlock	Individualism; group affiliations shift frequently Extreme polarization of wealth No commonly shared values	Dynamic, energetic society; very wired Many, constantly shifting groups Agreement on a core set of values (fairly broad, with diversity front and center) Competition and collaboration live in harmony; participatory market mechanisms	Conformity to traditional middle class values Economic striving Centralized government is powerful; planning is possible
Health care	No national health care Medical model dominates Community & family-based care	No national health care Excellent medical care and preventative health monitoring for those who can afford it Spotty health care for most	Basic "safety net" level of national health care Many options for those willing to pay or be test subjects Wellness and preventative health monitoring shares stage w/ medical model	National health care (single payer, HMO) Medical model dominates
Terrorism/ security issues	Muddled response Corporations begin to assume responsibility Selective investment in infrastructure	No unified response Diverse solutions for personal safety Infrastructure vulnerabilities ignored	Everyone responsible for security Collaborative surveillance Willing to trade some liberty for security	Strong, unified response Investment in infrastructure security Willingness to trade some liberties for security

	Wal-Mart World	The Wild Party	Unity in Diversity	Pleasantville
Climate change	Business leads development of carbon trading Driven by growing concern among several key market segments	No coherent response Crisis not big enough to create consensus	Citizen initiatives push business and government to develop carbon limits Creative solutions emerge	Govt. mandated carbon caps and trading
Residential housing	Larger, single-family homes Homogenous neighborhoods Edge Cities	Gated communities for wealthy Diverse housing for the rest Homes slightly larger to accommodate fabrication	Homes slightly larger to accommodate fabrication Diverse living patterns (urban and Edge Cities) Medium density	Larger, single family homes Less emphasis on homogenous neighborhoods Planned communities
Commercial buildings	Fewer but larger retail establishments More Big Box retail Growth in office space	Fewer and smaller retail establishments Decline of Big Box retail Fewer office buildings Consolidation and reuse of space Commercial "rack space"	Fewer and smaller retail establishments Decline of Big Box retail Fewer office buildings Consolidation and reuse of space	Fewer but larger retail establishments Growth of Big Box retail Growth in office space
Manufacturing	Decline in domestic manufacturing More automation	Less centralized manufacturing Growth of distributed or home-based fabrication	Less centralized manufacturing Growth of distributed or home-based fabrication	Partial resurgence of domestic manufacturing; "buy American" More automation

From consumer needs to electric technologies

The earlier discussion of factors shaping the U.S. by 2025, as well as a number of similarities across the scenarios just described, underscores three very robust fundamental drivers for the evolution of electric energy services. First, the increasing global competition for oil and gas creates an imperative for greater energy efficiency and greater dependence on domestic energy resources. Electricity is the primary vehicle for realizing this imperative by virtue of its unique ability to bring the array of domestic energy resources (including nuclear, coal and renewables) to market while enabling greater end use efficiency through "smart" electric services and appliances. This suggests an increasing role for electricity as the primary end-use form of energy for both stationary and mobile applications.

Second, the comprehensive transformation from an analog, mechanical to a digital, electronic U.S. economy and society correspondingly transforms the requirements for electric service quality and reliability. Essentially perfect power quality from a digital perspective becomes the new service norm. This is orders of magnitude higher than the traditional level of electric service needed to just "keep the lights on", for which today's bulk electricity supply system was designed.

Third, additional pressure on electricity price will result from an increasing consensus regarding the impact of electricity production from fossil fuels on the environment. While all environmental regulations are expected to tighten, it is increasingly likely that CO_2 emissions will also be restricted. These restrictions will result in a significant cost, reflecting carbon capture and sequestration, which will either be imposed by taxes or by mandates.

Beyond these fundamental drivers of the electric energy system of 2025, the scenarios in this report point to a number of specific electric service requirements – some of which would be stronger in one scenario than another. Figure 4 summarizes the relationship of these needs to the four scenarios.

Figure 4. Electricity service needs and technologies by scenario

	Strength of Need by Scenario			
Electricity Service Need	**Wal-Mart World**	**The Wild Party**	**Unity in Diversity**	**Pleasantville**
Zero-energy homes and buildings[5]	Low	Medium	High	Low
High-efficiency buildings	Low - Med	Medium	High	Low
Greater end-use energy efficiency	Medium	Medium	High	Medium (depends on application)
Reduced environmental impact of energy use	Medium	Low	High	High
Increased power reliability & quality	Medium	Medium	High	High
Highly reliable, digital grade power	Medium	Medium	High	High
Differentiated demands for reliability	High	High	Medium - High	Medium - High
Need for separation from load serving entity	High	High	Low	Low
In-home fabrication	Low	High	High	Low
More complex/ precise climate controls	Low	High	High	Low
Refrigeration, climate control, & lighting for large, differentiated retail spaces	High	Low	Low	High
Higher quality artificial illumination	Medium	Medium - High	Medium - High	Medium

[5] Zero energy needed at the building or complex perimeter. Needed electricity is generated within.

	Strength of Need by Scenario			
Electricity Service Need	**Wal-Mart World**	**The Wild Party**	**Unity in Diversity**	**Pleasantville**
Integration of electricity-related energy services	Medium	Low	High	Medium
High-efficiency mobile retail vehicles	Low	High	Low	Low
Minimize costs of remodeling energy systems	Medium	High	High	Medium
Modular systems for commercial buildings	Low	Medium	Low	Low
Maximized use of existing infrastructure overlaid w/re-development	Low	High	High	Low
High-performance manufacturing with greater automation and lower energy intensity	High	Medium	Medium	High
More energy efficient marine & rail freight transportation	High	Low	Low	Medium
More energy efficient personal transportation	High	Medium	Medium	High
More energy-efficient mass transit	Low	Low	Medium	High
Improved portability of electricity	High	High	High	High
Personal illumination & comfort	Low	Medium	Low	Low
Improve indoor air quality	Medium	High	High	Medium

	Strength of Need by Scenario			
Electricity Service Need	**Wal-Mart World**	**The Wild Party**	**Unity in Diversity**	**Pleasantville**
Increased water availability	High	High	High	High
Improved water quality	Medium	Medium	Medium	Medium
Improved medical diagnostics to include convalescing at home	High	Medium	Medium	Low
Enhanced personal security	High	High	High	Medium
Enhanced electrical system security	Medium	Low	Medium	High
Connectivity	High	High	High	High

Finally, Figure 5 takes the analysis one step farther: linking the electricity service needs shown above both to the broader social changes that would give rise to them and to the specific technologies that would be required to meet these needs. These suggest ways in which the fundamental consumer values of confidence, convenience, and choice – coupled with technological advances – may be manifested in future innovations. By definition, of course, no such list of innovations can ever be complete. The reader is invited to provide comments on or additions to the technology needs in Figure 5 by emailing them to info@galvinelectricity.org.

Figure 5. Social changes, electricity service needs, and technology implications

Social Change	Electricity Service Need	Additional Specifications	Technology Needed
Larger homes, more individual dwellings	Zero energy homes	High speed communications Enhanced quality and reliability	Building integrated photovoltaics Storage (electricity and thermal) Personal fuel cells Plug-in fuel cell vehicles High-efficiency heat pumps (ground, air & water-source) High efficiency appliances
Independence from centralized, bulk power system	Differentiated demands for reliability and quality Need for separation from load serving entity	Need for connectivity to wholesale markets Differentiated third-party suppliers Integrated energy systems	Active power quality filters Custom power devices Integrated mitigation equipment Energy portals Distributed energy resources Monitoring & control Direct current (DC) microgrids Combined heat and power (CHP)

Social Change	Electricity Service Need	Additional Specifications	Technology Needed
Increased focus on the environmental impact of building energy use	High-efficiency buildings & zero energy commercial buildings	Fully functional and integrated lighting, heating, and cooling High level of quality and reliability	Building integrated photovoltaics Active solar water heating Passive solar Domestic water heating with heat pumps Daylighting materials & controls High-efficiency appliances Combined heat & power (CHP) New thermal appliances for CHP Integrated building design
Reduced consumer energy costs	End-use energy efficiency Consumer management of electric energy services	Improved quality of energy service Enhanced consumer monitoring and control capability	High-efficiency lighting High-efficiency heating, ventilation, and air-conditioning (HVAC) technologies High-efficiency motors High-efficiency refrigeration Advanced process controls Smart electrotechnologies
Reduced environmental impact of energy use	Energy efficiency (see above) Mitigate environmental impact Facilitate urban and industrial ecology	Green buildings Fundamental process change Tail-pipe clean up Maximize resource recovery and utilization	New materials Cradle to cradle process design High-efficiency electrotechnologies Technologies to reduce the need for water and chemicals

Social Change	Electricity Service Need	Additional Specifications	Technology Needed
Perfect electric energy service	Unqualified consumer confidence, convenience, and choice Absolute consumer value	Absolute energy security High power quality Perfect reliability (system never fails) Most cost-effective energy service	IntelliGrid technology portfolio Distributed energy resources Power quality technologies Direct current (DC) microgrid
In-home fabrication	Micro-scale fabrication capabilities	Exceptional quality and reliability Distributed quality control	New electrotechnologies
Precise control of interior space conditioning	Individualized climate control Indoor air quality monitoring and control	Safe concentration of volatile organic compounds Zero airborne bacteria Perfect humidity	Sensors Electro-filters and mitigation New energy management systems Decentralized conditioning, control, and monitoring systems Dehumidification Heat recovery
Larger big box stores	Refrigeration, climate control, & lighting for large, differentiated retail spaces	Zonal space conditioning Enthalpy control	Combined heat & power (CHP) Dual path HVAC systems Distributed refrigeration with heat recovery Dehumidification Sensors Advanced energy management systems

Social Change	Electricity Service Need	Additional Specifications	Technology Needed
Regulated lighting quality improvement	Highest quality artificial illumination	Highly efficient Excellent disability veiling brightness (DVB), color rendering index (CRI), balance of brightness (BoB), and enhanced zonal foot candles	Advanced lighting technologies
Increasing telecommuting, e-commerce, open-source fabrication, electronic education	Universal connectivity Highly reliable, universal, digital grade power access	Ultra high speed connections Ability to specify enhanced levels of reliability (mean time between failures, number and length of momentary or extended outages)	IntelliGrid technology portfolio GridWise Failsafe software Distributed energy resources Power quality technologies
Mobile retail establishments	Small, high efficiency trucks/vans	On-board mini-technology Maximize portable energy	Electric hybrid and plug-in hybrid trucks & vans
Structural remodeling	Minimize costs of remodeling energy systems	Flexible energy systems Retrofitable direct current (DC) systems	Retrofit technologies for HVAC & lighting Enhanced space conditioning control technologies
Builders construct commercial building shells; tenants build their own spaces to suit	Modular and adaptable energy systems	Energy systems that are adaptable to individual consumer needs	Modular technologies for HVAC & lighting Enhanced control technologies
Brown field conversion	Maximized use of existing infrastructure overlaid w/ re-development	Optimal electricity, natural gas, telecom, water, transportation, and waste management retrofits (cost, time, and efficiency)	Integrated essential community service infrastructure Distributed energy resources Plug-in hybrid electric trucks and vans

Social Change	Electricity Service Need	Additional Specifications	Technology Needed
Enhanced productivity	Reductions in energy intensity of manufactured goods Improved process control High performance manufacturing Automation	Fewer kilowatt-hours required per dollar of gross domestic product Reduce material use Improve product quality	New electrotechnologies Advanced sensors Next generation programmable logic controllers
Distributed communities	Efficient personal transportation Improved light rail Telecommuting	Speed Energy use/mile Reduced environmental impact	Plug-in hybrid electric vehicles Small electric vehicles that are shared by commuters Power quality technologies
Relieve traffic congestion	Efficient mass transit Telecommuting	Reduce travel time Reduce energy used More Mb/sec High quality and reliability	Reduced cost light rail Trains of cars Coordinated traffic control IntelliGrid architecture Improved communications
More connected & mobile society	Portability not constrained by electricity supply Ubiquitous real-time computing	Increased power quality and reliability	Advanced batteries Super & ultra-capacitors High efficiency power supplies Local power quality solutions
Personal illumination & comfort	New smart methods to heat, cool, and illuminate	Improved comfort Reduced energy needs	Personal heating & cooling devices New smart illumination systems

Social Change	Electricity Service Need	Additional Specifications	Technology Needed
Indoor air quality	Eliminate indoor air quality health risks Improve consumer satisfaction	Reduce worker absenteeism Improve productivity Reduce medical costs	Technologies to mitigate airborne bacteria and volatile organic compounds
Water quality & availability	Increase water availability Improve water quality	Increase potable water reserves	Technologies to clean waste water, improve drinking water quality, and reduce water use
Aging population	Real-time medical monitoring and diagnostics to enable convalescing at home Increase healthcare affordability and value	Highly reliable, digital grade power Portability	Medical diagnostics At-home technologies
Vulnerability to terrorism and crime at home	Enhanced personal security monitoring	Universal home security Absolute power reliability	IntelliGrid architecture Consumer Portal
Increased threat of terrorism impacting energy security	Enhanced electric system security	Self-healing power delivery system Distributed backup power Undergrounding Stockpile of critical components	IntelliGrid architecture Instant islanding capability Cyber security Recovery technology and system

Appendix A: Methodology

Scenario development is more art than science. Above all, it requires outside–the-box thinking and a willingness to embrace uncertainty.

When the focal questions for scenario development are as broad as the one facing this project – how the U.S. might evolve economically and socially in the next 20 years, how this evolution might change the needs and aspirations of Americans, and what these changes would mean for how consumers use energy and electricity – it also requires the contributions of a diverse set of thinkers.

For Task 1 of the Galvin Electricity Initiative, we began soliciting these contributions through interviews with academics, authors, and members of the business community with varying perspectives on the evolution of society and consumer needs. We interviewed the individual listed below. Those names in bold font also participated in a two-day workshop where the broad outlines of the scenarios in this report were developed.

Task 1 contributors

- Jesse Ausubel, Director of the Program for the Human Environment at Rockefeller University
- **Jamais Cascio**, futurist and scenario developer
- Martin Cooper, CEO of ArrayComm and inventor of the cell phone
- **Rita Erickson**, anthropologist focusing on the cultural context of energy use
- Joel Garreau, journalist and author of books on the co-location of work and living space, and the prospects for biotech to enhance human capabilities
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- **Jaron Lanier**, computer scientist and scenario developer
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- **Bill Spencer**, former head of Sematech
- Sherry Turkle, Program in Science, Technology, and Society at MIT
- David Victor, Center for Environmental Science and Policy at Stanford University
- Dirk Voelkel, Roche Diagnostics (changing needs for medical equipment)
- **Evelin Wheeler**, Director of Strategic Planning for Public Service New Mexico

Project team members

In addition to the individuals highlighted above, several members of the project team for the Galvin Electricity Initiative were present at the Task 1 workshop and made substantive contributions to the evolving scenarios. These included Kurt Yeager, Clark Gellings, Ingrid Rohmund, John Kotowski, Patricia Hurtado, and Gene Oatman.

Finally, we were fortunate to have the sponsor and guiding light of the Galvin Electricity Initiative, Bob Galvin, participating in the Task 1 workshop. His observations and contributions were invaluable, as were those of all of the project's contributors. Final responsibility for the content and conclusions of this report, of course, rests with the author and the Task 1 team.

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