A Framework for Urban Energy System Transformation

A Project of the USDN Innovation Fund

December 2015 Final Report

Innovation Network for Communities

Framework Contents

City Perspectives on the Challenge

"As cities become more engaged and proactive about energy use and production within their borders, as Minneapolis has, relying entirely on utilities to meet City energy goals is not an acceptable condition; communication must be better, expectations made clearer, interests more noticeably aligned.

We believe that a city that has engaged in a lengthy and inclusive data-driven planning process and adopted a strong set of energy goals like those in the Climate Action Plan needs more control or influence over energy services, either directly or through a more cooperative, collaborative relationship with the energy utilities that serve that city, in order to ensure progress toward those goals."

(Minneapolis Energy Pathways – A Framework for Local Energy Action, P. 47)

"The major challenge in developing a city-wide electricity resource plan is the fragmented nature of the provision of electricity service in San Francisco. Currently, the responsibility for purchasing and procuring San Francisco's electricity needs is divided between PG&E (75% of total usage), direct access providers (8%) and the San Francisco Public Utility Commission's municipal load (17%).

In order to significantly increase the renewable and GHG-free content of San Francisco's electricity supplies, San Francisco and its businesses and residents must either directly participate in the wholesale energy market or influence the wholesale procurement choices currently made by PG&E and other energy service providers."

(San Francisco 2011 Updated Electricity Resource Plan P. 5)

"It has become increasingly clear that the existing energy system is undergoing a historic transition. Various innovations and challenges have begun to shift the local and global energy landscape, including the expanding use of distributed generation, the increasing frequency of extreme weather events, and emerging clean technologies that have the potential to remake our energy system. Efficiency, conservation, and local generation have begun to undercut utility revenue and rooftop solar is eroding electricity demand right at the source.

Harnessing innovation and addressing Boulder's challenges requires a flexible approach and an understanding that success takes time. Here in Boulder, and around the globe, there is a rapidly growing discussion about the "utility of the future" and the role of end-users. This energy system transformation has been guiding Boulder's activities, including the alignment of the climate commitment and municipalization."

(Boulder City Council Work Session Materials on Boulder's Energy Future)

Project Background

Project Purpose

In January of 2015, the Urban Sustainability Directors Network (USDN) Innovation Fund approved a $76,000 grant to a coalition of five member cities to advance a framework on urban energy system transformation.

The overall purpose of the USDN Energy System Transformation Framework is to develop a shared vocabulary, understanding and vision for how municipalities can develop a community-wide energy planning and management system that supports a transformation of their energy systems from a fossil fuel base to 100% renewable energy.

The framework is designed to help USDN members take a leadership role in this transformation by:

1. Creating a shared language for talking about the transformation of city energy systems;

2. Clarifying the role that sustainability directors and others in local government (municipal utilities, finance, transportation, planning, public works, etc.) can play in facilitating that transformation; and

3. Defining the kinds of analysis and strategy that need to be invested in to advance the transformation.

The Framework project was staffed by John Cleveland, President of the Innovation Network for Communities.

Participating Cities

1. Boulder, CO
2. Boston, MA
3. Minneapolis, MN
4. Portland, OR
5. San Francisco, CA
6. Seattle, WA

Project Phases

Phase 1 – City Research And Interviews

Materials from the participating cities were compiled and reviewed and interviews conducted with a representative or team from each city. (March and April)

Phase 2 – Framework Development and Feedback

Profiles for each city and a draft framework were developed and shared with participating cities. (April-June)

Phase 3 – Breakthrough Convening

A convening was held July 22-23 in Boulder, CO. Participants in the convening included a combination of representatives from the participating cities, and national thought leaders who are engaged in energy systems change. The focus of the meeting was on refining the framework and identifying areas where it makes sense for cities to collaborate on an on-going basis. (July)

Phase 4 – Final Report

The energy system transformation framework and the results of the convening will be published in a final report and made available to all USDN members. (Fall, 2015)

The Big Idea

The Energy System Transformation Project Core Hypothesis

The municipal role in energy systems work is evolving from a focus on individual projects and initiatives primarily targeting greenhouse gas emissions reductions, to a more comprehensive and integrated approach to energy system planning and management that seeks to accomplish multiple community benefits simultaneously.

Cities have been drawn into the work of energy systems change primarily driven by their desire to achieve the aggressive targets for greenhouse gas emissions reductions called for in their climate action plans. This work started with a strong emphasis on energy efficiency and has evolved to encompass energy demand, energy supply and energy system resilience. As the breadth and depth of this work has increased, several insights have emerged:

- Reduced greenhouse gas emissions is only one of many community benefits that can come from a comprehensive and integrated approach to energy systems change. Over time, climate action will become one of the expected outcomes of the system, and not the core driver of its design.
- The components of energy systems management – demand reduction; supply de-carbonization; and resilience – are "parts of a whole" and need to be approached in an integrated way, and not as separate programs or initiatives.
- Energy technologies are changing rapidly, and in ways that will increase the importance of place-based design and management. The configuration and design of distributed generation, renewable energy and demand management increasingly need to be closely integrated with multiple urban systems and infrastructure designs.
- Most cities lack the technical and human capacity to engage in comprehensive energy systems management. This is not a function that has historically been thought of as a core municipal function. The responsibility for energy systems management needs to be clearly identified and the capacity to carry out the functions needs to be developed over time.
- Each city has a very different context, so there is no "one system fits all" approach.

Defining Urban Energy System Transformation

What is Urban Energy System Transformation?

Urban Energy System Transformation is the process of restructuring energy demand and supply in a municipality to radically reduce the amount of energy consumed, transition energy supply to fossil fuel-free sources, and make the system resilient to future risks.

There are three basic components of energy systems change work:

- **Reduce Energy Demand** – reducing the total amount of energy (electricity, thermal, and combustion) used in key urban systems, including buildings, transportation, industrial, and water/waste management.
- **De-Carbonize Energy Supply** – restructuring energy supply systems to maximize the percentage of energy that comes from carbon-free sources.
- **Increase Energy System Resilience** – designing energy systems so that they are resilient to climate impacts, including increasing the percentage of distributed energy resources.

These components have to be closely connected with each other (e.g. reducing demand changes the design of supply systems and visa-versa), and they have to work across all energy sources (electricity, thermal, transportation).

Climate Goals Have Provided the Initial Motivation

Achieving an “80 percent reduction by 2050” in GHG emissions will require the near-complete shift away from fossil fuel combustion (coal, natural gas and petroleum) and replacement with clean energy sources. This shift will need to be accomplished with all major current carbon-based fuel uses, including electricity, thermal combustion and transportation fuels. This will require a fundamental system transformation (not just physical, but financial, operational and regulatory) that involves aggressive efficiency measures, fuel switching, and integrated system redesign. This transformation will need to take place simultaneously at multiple scales – individual households/buildings; enterprises and organizations; and community-wide.

Now is an appropriate time to be having this discussion at the municipal level. In many places the energy system investment decisions being made over the next few years will bind communities to their associated outcomes for decades to come.

The cities engaged in this project are at different stages of strategy development on this issue. Some have taken aggressive moves to get control of their energy infrastructure. Others are in the early stages of doing a “deep dive” to understand their city energy system, and are just beginning to take stock of what it will require in terms of demand reduction and de-carbonization to achieve their 80% by 2050 GHG emissions reductions targets. Regardless of the stage of their work, all the cities will benefit from a more strategic, structured and shared approach.

Energy System Transformation Scope

- Energy Sources:
  - Electricity
  - Heating & Cooling
  - Fuels for Mobility
- Energy Strategies:
  - Reduce Demand
  - De-carbonize Supply
  - Increase Resilience

Energy System Transformation Scales

- Statewide
- Community-wide
- Enterprise-level
- Household & Individual

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Energy Is the Largest Single Source of Emissions

As noted earlier, the original motivation for engaging in energy systems change for most cities came from their GHG emission reduction goals. For the U.S. as a whole, energy accounts for 87% of all GHG emissions. (Other sources of emissions include agriculture, forestry and other land use; waste; and industrial processes.) 90% of energy emissions come from electricity or the combustion of fuels for heat or transportation. The remainder come from fugitive fuel emissions or carbon dioxide transport and storage. The table below summarizes the percent of total US energy GHG emissions by sector:

Sector	Electricity % of US Energy Emissions	Combustion % of US Energy Emissions	Sector % of US Energy Emissions
Residential Buildings	13.6%	5.9%	19.5%
Commercial Buildings	13.2%	3.9%	17.1%
Industrial	10.4%	12.6%	23.0%
Transportation	0.1%	29.9%	30.0%
TOTAL	**37.3%**	**52.3%**	**89.6%**

These percentages will vary by city depending on the types of buildings, fuel sources and electricity generation sources. Since these are national averages, in cities, the percentages linked to buildings are often much higher, and to industrial, much lower.

For cities that are pursuing deep de-carbonization strategies, what this means is that **the bulk of their work will be focused on various dimensions of their energy systems.**

Energy Management is Emerging as a New Municipal Function

For cities, work on energy systems is emerging a new municipal function – community-wide strategic energy planning and management. Energy is beginning to be seen as a basic municipal service that cities needs take responsibility for managing, in much the same way that they do planning for transportation, housing and other core services.

Energy systems also represents the creation of a new market that is not yet effectively served by private providers. Currently, the private service providers to the energy market are highly fragmented, with participants focusing on narrow dimensions of energy work (e.g. coal and wind systems; energy efficiency; grid modernization; electric vehicle systems; etc.). Private players are not yet positioned to play the large-scale system integration role that is needed. Part of the city strategy will need to be finding ways to attract private market players into this niche.

Sustainability professionals are uniquely positioned to facilitate a strategic approach to energy system transformation that takes the point of view of the customers of the system – the residents and businesses that depend on the energy supply. This point of view encompasses not only the necessary shift in utility business models, but also the essential integration of energy systems across sectors in a manner that supports community goals related to health, equity, economic vitality, environment and quality of life. It allows communities to consider opportunities to localize the long-term economic benefits of a decarbonized energy system, instead of having them accrue solely to utilities and other current energy providers. It also allows communities to focus on the resilience advantages of a decentralized energy system.

The Work of Community Wide Strategic Energy Management

1. Establishing community wide energy goals and targets
2. Analyzing community energy systems
3. Developing strategies and plans to achieve goals
4. Managing implementation and monitoring progress

The ISO Framework for Energy Management Systems

The global standards organization, ISO, recently developed a standard for energy managements systems – ISO 50001. It is the energy parallel to their quality standard (ISO 9001) and their environmental management system standard (ISO 14001).

The ISO standards are based on a continuous improvement process grounded in the Plan-Do-Study-Act cycle of the quality movement.

While this standard was primarily developed for enterprise-level application, Urban Energy Systems Transformation takes the application of this generic process to the level of the community as a whole. This represents, in essence, the development of a new professional practice at the municipal level. This professional practice is early in its development, and the cities like those participating in this project are at the forefront of "field development" for this professional practice.

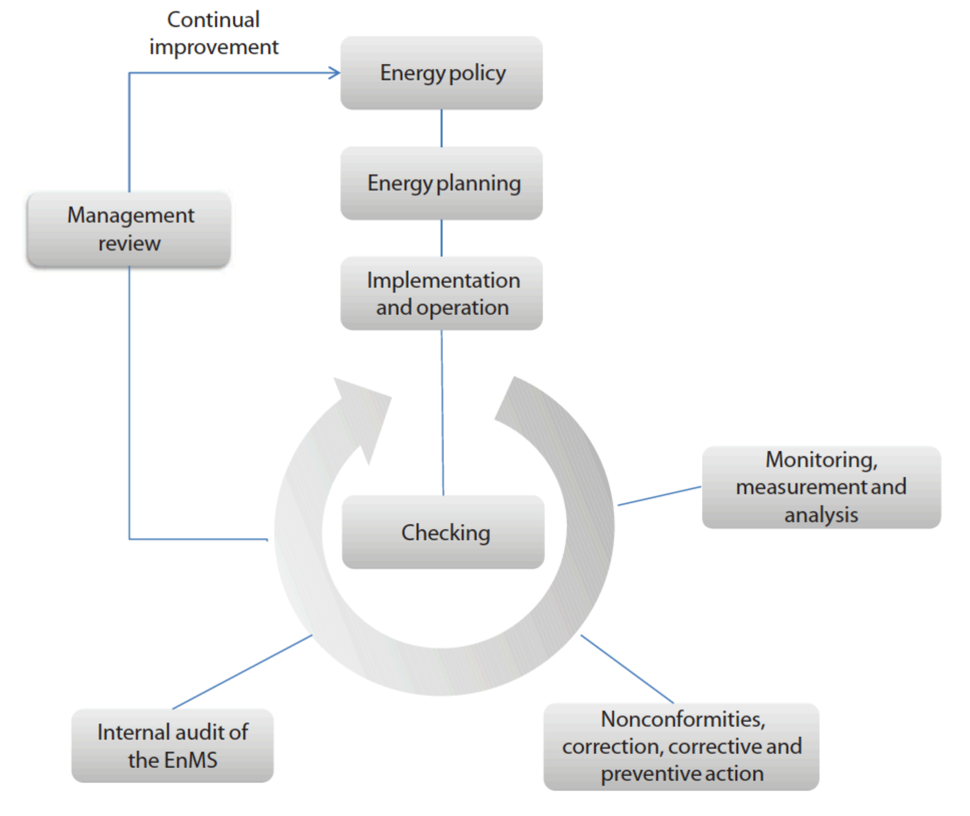

Figure 1 — Energy management system model for this International Standard

(Source: Energy management systems – requirements with guidance for use, British Standards Institute, 2011)

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How the Municipal Role Has Evolved

City energy supply practices have evolved enormously in the last decade. When cities began developing climate action plans with targets for emissions reductions two decades ago, strategies were very aspirational in nature and typically organized around relatively low impact demonstration programs. Cities did not have the staffing, technical knowledge or political leverage to engage in large scale energy systems change. Over the last two decades, that has changed dramatically.

- **More aggressive targets.** Cities have set long-term targets with much higher levels of GHG reductions. All the cities in this project now have a goal of 80% reductions by 2050 or earlier.
- **Walking the Talk.** Leading edge cities are implementing strategic energy management systems within municipal government. They are setting energy reduction targets; hiring full time energy management staff; developing dedicated funding resources; implement enterprise level and building level energy management software; purchasing renewable power; and rewarding asset managers for performance.
- **More sophisticated analysis.** Cities are investing in the capacity to deeply understand the technical details of their energy systems, including developing internal expertise in the operation of electricity and thermal grids – generation, transmission and distribution – and understanding the structure of those grids within their municipal boundaries.
- **More aggressive policy engagement.** Cities are becoming active participants in the energy sector regulatory process and developing the knowledge and skill sets (often in partnership with outside players) to intervene in utility rate cases, negotiate with utilities around their energy targets, and engage with Regional Transmission Organizations on energy supply decisions.
- **Making energy systems investments.** Increasingly, cities are willing to take on the risk of investing in and managing energy infrastructure and market mechanisms (utility municipalization; district energy systems; Community Choice Aggregation; transmission lines; etc.) if that is what they believe is needed to concretely move them towards their aspired energy future.

The Purpose of the Framework

This Framework emerged out of an desire by leading edge cities to more clearly codify what it means to engage in the work of "energy systems planning and management" at the municipal level. Because this is an early stage professional practice area, its functions, standards and methodologies are not well defined and documented. Each city is inventing their own approach to this work. By coming together to share what they are doing and evolve it into a more disciplined framework, the cities hope to set the stage for several decades of work to come.

- **Flexible tool.** The Framework is intended as a flexible tool to help USDN members think through their energy system transformation strategies; develop some common language to communicate with stakeholders; codify leading edge best practices; connect with outside partners who share common goals; and reduce the barriers to other cities taking on energy system transformation work.

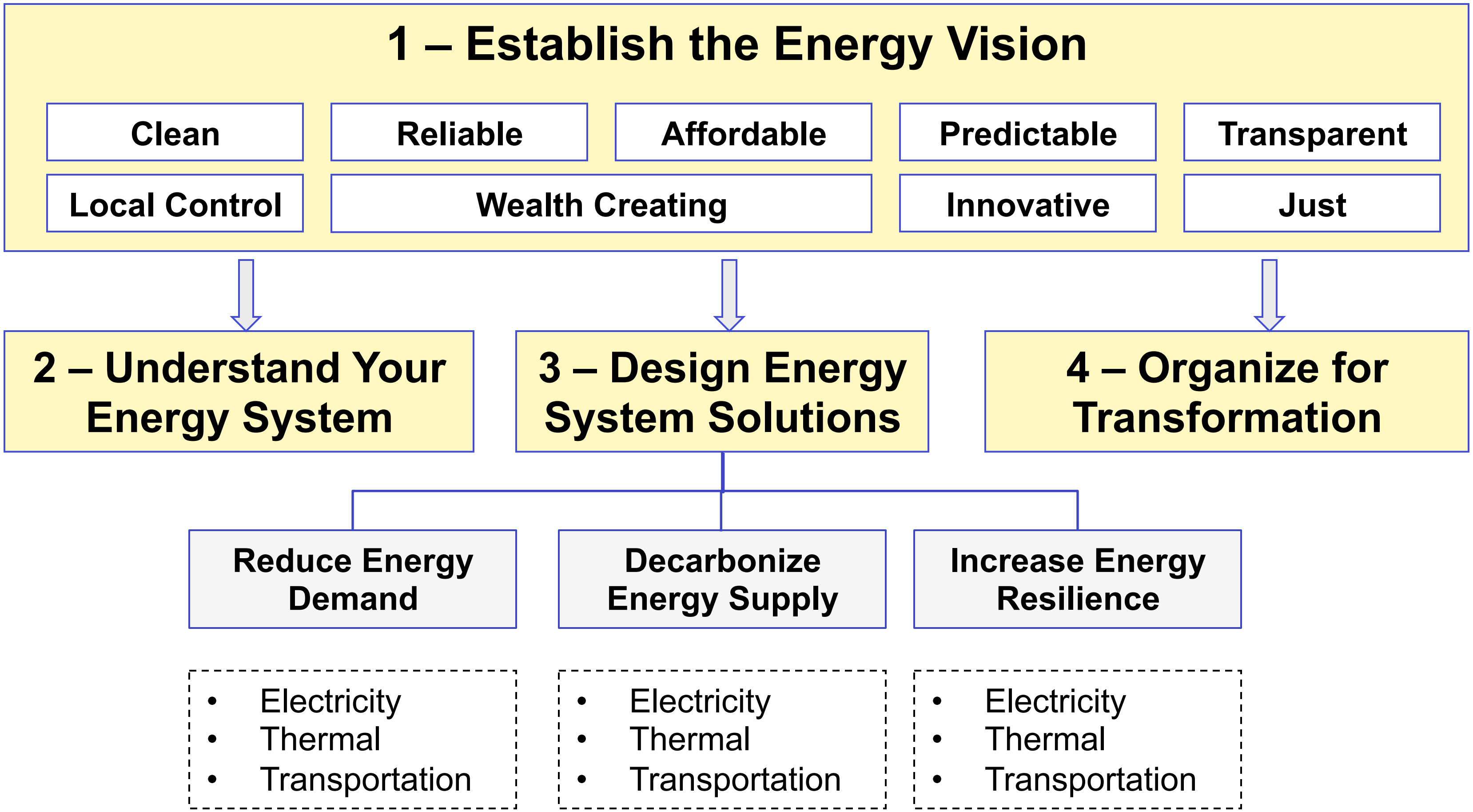
- **Not a roadmap.** The Framework is not a detailed roadmap for transforming the energy system of any particular community. The work has to be contextualized in the context of each city's energy profile, system design, level of control and power, and community appetite for risk.

- **Designed to spawn complementary projects.** The Framework is designed to serve as a platform for additional "deep dive" analysis that is can help cities remove barriers to rapid transformation. There are already several of these opportunities being developed through Carbon Neutral Cities Alliance Innovation Fund grants on thermal de-carbonization, a city-based energy "transect"; and district energy/microgrid strategies.

- **Initial practice examples focused on electricity supply.** The practice examples in this document are focused on energy supply issues,(as opposed to energy demand or resilience issues.) More specifically, most of the detailed examples are is focused on de-carbonization of electricity supply. Future versions will dive more deeply into thermal and transportation de-carbonization and integrate in examples on demand reduction and resilience.

Framework Components

Key Components of an Energy System Strategy



Framework Components

Component	Description
1 – Establish the Energy Vision	• Create a compelling logic for change • Articulate the desired outcomes • Engage key stakeholders in the dialogue
2 – Understand Your Energy System	• Describe the existing energy system "ecology" • Map energy demand and supply systems • Conduct technical analysis to support projects and policy change • Build a system for monitoring system performance
3 – Design Energy System Solutions	• Reduce energy demand • Decarbonize energy supply • Increase energy resilience
4 – Organize for Transformation	• Invest in the staff, resources and other assets that are needed to take on this work.

Summary Description of the Components

1. **Establish the Energy Vision.** Cities need to clarify, make public, and develop stakeholder support for the fact that their sustainability aspirations require an energy system that is eventually close to carbon-free, and provides a full range of benefits to community residents. Firm commitment to this aspiration, as well as a clear understanding of its feasibility and the benefits it brings, is essential to achieve the political will necessary to take on the contentious issues involved in energy system transformation. This stage typically requires deep stakeholder education and engagement to assure political support for the transition.

2. **Understand Your Energy System.** It is not possible to make informed choices about a city's energy future if you don't have deep knowledge about how the current system works. Many of the cities engaged in this project have done, or are in the process of doing, "deep dives" on their city energy systems (electricity, natural gas, steam, Combined Heat and Power, renewables, etc.) to understand the sources of power; transmission and distribution systems and technologies; and how the supply maps to key components of demand. This analysis requires, by necessity, achieving a deeper level of technical knowledge of power systems than cities are typically accustomed to developing.

3. **Design Energy System Solutions.** There are many options for structuring the transition from current energy systems to carbon-free energy systems that meet multiple community goals. The path for each city will vary based on current system structures, local resources and other variables. Multiple choices need to be made about power sources and transmission/distribution that balance concerns of emissions reductions, cost, cost volatility and reliability.

4. **Organize for Transformation**. Finally, cities need to build the internal capacity to manage the implementation their energy systems transformation strategy. This requires both building internal staff capacity and expertise, and building relationships with external partners.

Local Factors That Influence City Energy Strategies

Local conditions vary significantly from city to city. Energy transformation strategies need to be designed to take these factors into account. The list below highlights those factors that will drive the customization of a city's approach. (See Attachment 1 for more detail on how these factors vary across the cities involved in this project.)

•**The Cost of Energy.** The higher the cost of energy, the more there is a market incentive for energy efficiency, and the more competitive renewable sources are. The cities in this project represent a broad spectrum of energy costs – from very affordable to very expensive.

•**The Aggressiveness of Targets.** Different cities have set different targets for energy system de-carbonization. The aggressiveness and timing of these targets affects the strategies they undertake in the short and long term. Of particular importance is the timing of strategies that are connected to assets with long lifecycle. Decisions in the short term (such as investments in new natural gas pipelines; fossil fuel power plants; or transmission lines) can "lock in" certain patterns of energy use that are then very difficult to change.

•**Existing Power Mix.** The carbon intensity of existing power sources will influence the kinds of strategies that cities undertake. Cities with high levels of renewables in their current power mix will need less radical strategies to achieve deep de-carbonization than those that are starting from a base that has a low carbon intensity.

•**Legacy Power Systems.** The design of historical power systems will influence a range of options for cities. Factors will include the structure of district energy systems; transmission constraints; and legacy generation plants. These legacy systems affect the economic and political feasibility of different strategy options.

Local Factors That Influence City Energy Strategies (cont'd)

- **Alignment of State and City Goals.** Some cities have set targets for energy system de-carbonization that are more aggressive than their state targets. This leads these cities to need to act independent of state policy to achieve their goals. Cities whose targets are aligned with state targets are more likely to focus their system de-carbonization efforts on advancing and supporting state level implementation (such as Renewable Portfolio Standards).

- **Regulatory Framework.** Strategies for de-carbonization are heavily influenced by the nature of the state regulatory framework for the power sector. Key differences include:
  - Whether the power generation sector is regulated or de-regulated.
  - The nature of incentives for energy efficiency.
  - The nature of incentives for renewables (e.g. Renwable Portfolio Standards, net metering, feed-in tariffs, Community Solar, etc.)
  - The availability of options like Community Choice Aggregation

- **Level of Utility Control.** There is a fundamental difference between cities that have municipal utilities and those that don't. Cities are much more able to influence the carbon intensity of their municipal systems than the carbon intensity of large Investor-Owned Utilities. IOUs need to be influenced through legislation and regulatory proceedings controlled by the Public Utility Commissions and the Federal Energy Regulatory Commission, whereas municipal utilities are controlled at the local level.

- **City Capacity.** Finally, a city's strategy has to take into consideration the staff and funding capacity the city has to design and implement a strategy. Energy system transformation takes work, and work costs money. Cities need to have dedicated staff with technical expertise and budgets that can support detailed technical analysis and participation in regulatory proceedings.

Some Best Practice Principles

- **Comprehensive.** Energy systems transformation is most effective when it addresses all strategies (demand reduction; supply de-carbonization and system resilience) and all energy sources (electricity; heat; mobility) simultaneously, and pays attention to the intersections and synergies between them.
- **Integrated.** Energy systems transformation work needs to be integrated with other community planning processes, including broader sustainability frameworks and plans; climate action plans; comprehensive plans; transportation master plans; etc.
- **Multiple Scales.** Energy system transformation work is not just about utility scale change. It needs to address opportunities for change at all scales – individual households; enterprises/organizations; and community-wide infrastructure.
- **Grounded in Customer Requirements.** The process of change needs to involve deep stakeholder and customer engagement and be managed in a way that community members are able to see and experience direct benefits that add value to the quality of their lives.
- **Equitable.** The design of the new energy system needs to assure that the needs of disadvantaged populations and neighborhoods are addressed, and that benefits and costs are equitably distributed.
- **Grounded in Scalable Market Economics.** Large-scale systems change in energy systems will not happen if market forces are not aligned with targeted outcomes. Subsidies can advance innovation at small scales, but cannot support deep market penetration. Systems need to be developed that have compelling economics for users. The best renewable energy is renewable energy that is cheaper, more convenient and more reliable than its fossil fuel-based alternative. Capturing full value and pricing externalities is critical to creating a level economic playing field.

Some Best Practice Principles (cont'd)

- **Grounded in Engineering Knowledge.** Energy systems – especially electricity grids – are complex and have very specific requirements for reliable performance. Engagement in energy systems transformation requires municipalities to develop deep technical knowledge of how systems work so that their strategies for change are feasible from a technical point of view. (The challenges of balancing a grid and maintaining required frequency levels with high percentages of intermittent renewables supplies is a good example of this.)

- **Respectful of Control Limitations.** There are many aspects of community energy systems over which municipalities have limited control or influence. The City strategy has to respect these limits and be grounded in an understanding of a city's real points of leverage.

- **Willing to Exercise Influence.** Despite limitations of control, cities need to be willing to exercise their influence as major energy-consuming customers and articulate their "voice of the customer" in demanding that energy suppliers align their products and services with their energy vision goals.

1 – Establish the Energy Vision

Highlights for "Establish the Energy Vision"

- **Start with Emissions Reduction Targets.** The starting point for most cities in setting their energy vision is the GHG reduction targets they commit to in their climate action plans.

- **Set Specific Energy Targets.** Over time, cities find value in creating more detailed targets for the different components of the energy sector, and articulating a vision of the characteristics that they want to see in that system over the long term. These targets and goals shape the nature of the strategies the city seeks to implement.

- **Pursue Multiple Benefits.** Clean energy (GHG-free power) is core to this vision, but it is not the only benefit envisioned. Cities see a transformed energy system as also a vehicle for local economic development; better customer service; more reliable power; more consumer choice; reduced price volatility; lower energy costs; cleaner air; and improved equity.

- **Get Serious About Taking Control.** Aggressive targets and a determination to achieve them leads cities to focus on strategies for getting "more control over their energy futures". To achieve this control, cities are willing to be much more forceful and aggressive, and take more risk to achieve the targets.

- **Need to Communicate Complexity Simply to Stakeholders.** The details of decarbonizing energy supply are very complex, from a technical, legal, regulatory and financial point of view. All cities are struggling to find ways to simplify citizen understanding of the choices and develop deeper engagement with stakeholders so that the clean energy future constituency is broadened beyond the "usual suspects." In specific, this requires framing the vision in language that makes the multiple benefits clear to residents and taxpayers, and not only framing the transformation from a climate perspective.

Project City GHG & Energy Goals and Targets

City	Emissions Reduction Targets	Specific Energy Targets
Boulder	80% by 2050	• 50% renewables in year one of municipalization
Boston	25% by 2020 80% by 2050	• 15% of large C/I energy use from co-generation (2020) • 10 MW of commercial solar (2020)
San Francisco	25% by 2017 40% by 2025 80% by 2050	• GHG free electric system by 2030 • Offer a portfolio of energy resources to residents through a CCA that is 51% renewable by 2021.
Minneapolis	80% by 2050	• Generate 10% of electricity from local renewable sources by 2025
Portland	40% by 2030 80% by 2050	• Supply 50% of all energy used in buildings from renewable sources • 10% of building energy use supplied by on-site renewable sources
Seattle	62% by 2030 Carbon Neutral by 2050	• Maintain current carbon neutrality of electricity supply • 97% reduction in transportation emissions by 2050 • 82% reduction in building emissions by 2050

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Typical Targeted Energy System Outcomes

Desired Energy System Outcome	What It Means
Clean	Reduce carbon emissions and toxic pollutants created by the energy system.
Reliable	Minimize system downtime from outages and ensure high quality of the power delivered.
Affordable	Keep rates as low as possible and maintain competitiveness with market pricing.
Predictable	Minimize rate volatility.
Transparent	Consumers can understand their power costs and what drives changes in them.
Local Control	Give residents greater control over their energy resources and energy choices
Wealth-Creating	Keep more of the revenue in the local economy instead of exporting it to outside suppliers and helps drive local economic development, creating new businesses and jobs.
Innovative	The energy system spawns innovation, intellectual property creation, and entrepreneurship.
Just	The system promotes “energy equity”, protects vulnerable populations from undue hardship and promotes energy literacy.

Examples of City Goals and Outcomes (1)

San Francisco 2002 Energy Resource Plan Goals

- Assure Reliable Power
- Maximize Energy Efficiency
- Develop Renewable Power
- Increase Local Control
- Affordable Electric Bills
- Improve Air Quality
- Support Environmental Justice
- Promote Economic Opportunities

CleanPower San Francisco Goals

- Provide customers with a choice for their electricity supplies.
- Reduce the City's reliance on fossil fuels.
- Reduce pollution and greenhouse gas emissions associated with electricity generation necessary to serve San Francisco's residents and businesses.
- Provide electricity supplies at rates that are competitive with PG&E service and to stabilize electricity rates for City residents and businesses enrolled in the program.
- Increase local control over electricity supplies.
- Increase local green job opportunities.

Minneapolis Energy Vision Goals

- **Reliable and affordable energy services**, where all residents and businesses are supplied with competitive rates, and disparities in the relative cost of energy services for low-income households are mitigated.
- **Clean energy**, where the total carbon emissions and other waste products have substantially declined, and electricity supply is nearly carbon-free.
- Provision of **essential energy services** for all, affordably meeting the basic needs of residents, without disparity of impacts or benefits according to race, ethnicity, income, and age.
- An **increasing use of local resources** within the city, including renewable energy and efficient district heating. A robust local supply chain exists in the city for energy efficiency and renewable energy services, and Minneapolis is a national leader in advanced energy infrastructure.
- **Market integration of efficiency** that makes use of transparent data in economic and purchasing decisions. Residents and businesses are empowered to save money and reduce their environmental impact.
- **Collaborative progress** on planning and investment decisions by the energy utilities that serve the city. These decisions reflect and support the City's climate action, economic development, and social equity goals.

Examples of City Goals and Outcomes (2)

Boulder Energy Future Goals

1. **Ensure a stable, safe and reliable energy supply**.
    - System redundancy, supply quality and load management
    - Fuel source stability
    - System reliability
2. **Ensure competitive rates, balancing short-term and long-term interests**.
    - Rate competitiveness
    - Rate transparency and predictability8
    - Technology investment and managing price volatility.
3. **Significantly reduce carbon emissions and pollutants**.
    - Reduction of GHG emissions
    - Reduction of toxic pollutants
4. **Provide energy customers with a greater stay about their energy supply**.
    - Democratizing local decision-making
    - Democratizing local ownership
5. **Promote local economic vitality**.
    - Support for local business innovation
    - Economic competitiveness
6. **Promote social and environmental justice**.
    - Energy equity
    - Impacts to vulnerable populations
    - Energy literacy

Boulder Energy Localization Framework

1. **Democratize Energy Decision Making**: customers should have more direct control and involvement in decisions about their energy, including opportunities to invest in their long-term energy needs and to have a say in energy investments made on their behalf.

2. **Decentralize Energy Generation and Management**: energy should be generated locally or within the region to the maximum extent feasible, reducing reliance on external fuel sources; customers should be able to manage and reduce their energy use as directly and effectively as possible; and energy service companies should be empowered to compete and innovate within a diverse and robust local energy economy.

3. **Decarbonize the Energy Supply**: renewable and clean fuel sources should be maximized as much as possible, as quickly as possible, minimizing both short- and long-term environmental impacts and maximizing energy independence over time.

2 – Understand Your Energy System

Highlights for “Understand Your Energy System”

- **Analysis is the Foundation for the Strategy.** The energy systems analysis provides the analytical foundation for a city’s energy system transformation strategy. It creates a level of operating detail that allows stakeholders to know where the opportunities for improvement are, and what the consequences of different choices are.

- **Happens at Different Levels.** Different levels of analysis serve different purposes. At the highest level is a basic understanding of the regional energy systems the City participates in – the shape of the Independent System Operator (ISO) or Regional Transmission Operator (RTO) region; utilities and territories; power sources; transmission and distribution infrastructure; macro load profiles; regulatory players and roles; etc. As projects become more concrete (e.g. a municipal utility or a district energy system), the level of fine-grained detail increases rapidly.

- **Requires New Expertise.** Depending on the level of depth of the analysis, the energy systems analysis requires high level of technical expertise. Even if this expertise is purchased from outside sources, city staff still need to be knowledgeable enough to make qualitative and quantitative judgments about the data. Staff need to understand energy supply, transmission, distribution, regulation, pricing and maintenance practices.

- **Technical Expertise Increases System Leverage.** As a city’s knowledge of its energy system increases, so does its capacity to influence decisions about the future design of that system. It allows city staff and external partners to intervene more effectively in Public Utility Commission and ISO/RTO proceedings, and state legislative decision making. It also creates a different level of credibility with private sector players such as IOUs and renewable energy providers.

Different Levels of Energy System Analysis

There are different levels of energy system analysis that cities can invest in. Each one serves a different set of purposes. Taken together, they provide a detailed and comprehensive understanding of the energy system "ecology".

- **Energy System Overview.** This level of analysis provides stakeholders with a basic understanding of how the energy system that the city is embedded in works. It is typically more qualitative than quantitative in its contents. Some elements can include:
  - An overview of the regulatory framework (FERC; ISO/RTO; PUC; state law,; etc.) and how decisions on energy pricing, transmission and generation are made.
  - An overview of energy supply sources (utilities and their service areas; transmission lines; power generators; power mix; etc.).
  - Identification of key opportunities to transform the energy system (which creates the bridge to the strategy document).

- **Citywide Energy Studies.** Another type of analysis is what Boston refers to as a "citywide energy study." It will typically go to the next level of detail and begin building a more quantitative understanding of the city's energy system. This will include detail on: energy loads by building and area; transmission lines, sub stations and transformers; existing un-regulated generation sources (district energy and CHP); and potentials for new local generation (renewables; district energy; microgrids; CHP).

- **Project-Specific Analysis.** Specific projects require an additional level of analytical detail because they need to support investment decision making on the part of the city and other investors. Examples are municipalization efforts and district energy projects.

- **Policy-Specific Analysis.** These are technical analyses that are done to influence specific policy decisions being made by others. An example would be a proposal for new regional gas pipelines or transmission lines.

An Example of an Energy System Overview (Minneapolis)

Purpose. The Minneapolis Energy Pathways report is designed to create a framework for choices the city can make about its energy future. It includes an overview of the city's energy system, definition of possible future pathways, and recommendations on which pathways to pursue.

Analysis Components

- Current energy system landscape
  - Energy use and services
  - Types of utilities
  - State regulatory framework
  - Federal & regional regulatory framework
- Local utility franchise agreements
- Potential energy vision pathways
  - Enhanced franchise agreements
  - City-utility partnerships
  - Community Choice Aggregation
  - Municipalization
- Future technology, business models and regulatory frameworks

Types of Data Included

Electricity Market

- Electricity sales by type of utility
- Historical energy prices
- Energy consumption by sector
- Energy prices by sector

Renewable Power & Energy Efficiency

- Carbon intensity of electricity supply
- Local renewable generation
- State Renewable power sources and installed capacity
- Energy efficiency achievements by type of utility

An Example of a Citywide Energy Study (Boston)

Purpose. Boston's citywide energy study is designed to build a quantitative basis for understanding how much energy the city will demand in the future, and how much of this energy can be generated locally instead of being imported. It is designed to answer three specific questions:

- How much thermal and electric energy can we locally produce in Boston?
- How could that energy be distributed?
- What are the benefits of producing local energy for our communities and businesses?

Analysis Components

The energy study is being conducted by MIT's Building Technology Department and MIT Lincoln Labs. The analysis components will include:

- An **Energy Data Set** that is capable of modeling the energy demands of Boston's existing and future building stock.
- A set of **scenarios** for clean and renewable energy supply. These scenarios will model the impacts of deploying different mixes and different levels of local energy supply, including solar PV, solar thermal, battery storage, cogeneration, district heating, district cooling and microgrids. The scenarios will estimate the GHG emissions and energy system resilience of different combinations.
- **Software** to manage incorporation of new building data and future scenarios.

Report Outputs

- A written summary of Boston's existing and future energy demand and how the local energy supply scenarios will affect the City's environmental and resilience performance.
- Visual representations of the energy loads throughout the city.
- A summary of the clean and renewable energy scenarios.

An Example of Municipalization Analysis (Boulder)

Purpose. Boulder's energy system analysis has been largely focused on determining the feasibility of establishing a viable municipal utility from the assets of the Investor Owned Utility (Xcel) serving the city. The analysis generally fell into three phases:

1. Municipalization feasibility studies
2. Municipalization business plans and system modeling
3. Legal analysis to establish the City's rights to acquire Xcel assets
4. Transition and implementation planning

Analysis Benchmarks

Amendments to the City Charter approved by voters established very specific performance parameters the municipal utility needed to meet before being implemented, including:

- Rates that do not exceed the rates Xcel charged at the time of acquisition.
- The ability to pay operating and debt payments of the utility, plus funds equal to 25% of debt payments.
- Power reliability equal to Xcel's.
- A plan to reduce GHG emissions, reduce pollutants, and increase renewable energy.

Report Examples

Some of the key reports with links to on-line documents are listed below.

- Preliminary Municipalization Feasibility Study , R.W. Beck 2005)
- Boulder Municipal Utility Feasibility Study , Robertson-Bryan, Inc. (2011)
- Boulder Municipal Utility Business Plan , Robertson-Bryan, Inc. (2011)
- Independent Expert Findings: Review & Verification of Modeling of New Electric Utility, PowerServices, Inc. (2013)
- Review of Updated Model for New Electric Utility , PowerServices, Inc. (2013)
- Report of Transition Planning for New Electric Utility, PowerServices, (2014)

Municipalization Analysis Content

Below is a short summary of the kinds of analysis included in each phase of Boulder's municipalization process.

Utility Feasibility Analysis

- Overview of physical assets of the electricity system
  - *Distribution*
  - *Utility operations*
  - *Transmission*
- Utility goals
  - *Rate stability*
  - *Carbon reduction*
  - *Reliability*
- Financial feasibility
  - *City load*
  - *Stranded cost estimate*
  - *Acquisition costs*
  - *Start up costs*
  - *Cash and bonds*
  - *Annual budget*
- Energy sources
  - *Local renewables*
  - *Wholesale purchases*
  - *Wholesale transmission*
- Customer rates

Utility Business Plan

- Utility goals
- Utility structure
- Process for creating the utility
  - *Planning*
  - *Legal creation*
  - *Resource procurement*
- Start up tasks
  - *City staffing*
  - *Distribution*
  - *Metering*
  - *Scheduling*
  - *Accounting and billing*
- Modeling and simulation
  - *Financial*
  - *Reliability*
  - *Resource mix*
  - *Asset acquisition*
  - *Legal structure*
- Legal activities

Utility Transition Plan

- System characteristics and interconnection plan
- Organizational chart
- Critical milestones
- Scenario analysis and comparisons
- Utility functions
  - *Construction, operations and maintenance*
  - *Customer service*
  - *Energy services*
  - *Finance & accounting*
  - *Planning & engineering*
  - *Power supply & delivery*
  - *Legal/regulatory*
  - *Support services*
- Implementation steps

An Example of District Energy Analysis (Seattle)

Purpose. The International District Energy Association (IDEA) is the trade association of district energy operators. In 2012, IDEA issued a guide to developing district energy projects: Community Energy, Planning, Development and Delivery. It provides recommendations on the stages of project development, as well as the analytical data that is needed to make district energy choices. One of the case studies in this report is the City of Seattle 2011 District Energy Pre-Feasibility Study. It is a good example of the level of detail needed in this kind of project implementation.

Stages of District Energy Project Development

1. Objective Setting
2. Data Gathering
3. Project Definition
4. Options Appraisal
5. Feasibility Study
6. Detailed Financial Modeling
7. Detailed Business Modeling
8. Marketing and Business Development
9. Procurement
10. Delivery

Data Required for Analysis

- Development density
  - Heat density
  - Buildings per foot of distribution piping to be installed
- Demand loads
  - Event loads
  - Daily & yearly load profiles
  - Anchor loads
  - Projected demand growth rates
- Mix of end energy uses
- Age of buildings
- Existing gas and heat networks and electricity sub-stations
- Existing power plants and power sources
- Transportation infrastructure
- Translation of data into visual representation (“heat maps”)

Examples of Legal Analysis

Both Boulder and Boston invested substantial resources in understanding and pursuing their legal rights to pursue changes to their energy systems. In each instance the analysis focused on city rights relative to the franchise rights of utilities. While each city took a slightly different tact, both examples are illustrative of the kind of legal analysis that is often needed to support a city's ability to get control over its energy future.

Boulder Legal Analysis

A key part of Boulder's energy system analysis has included legal analysis and legal action to establish the conditions under which the City can acquire the Xcel assets needed to run its utility. Xcel sued the City to block the asset take over process on multiple occasions .

The legal issues Boulder invested resources to clarify included:

- Does Boulder have the right to condemn Xcel assets, and if so, under what conditions? (*Xcel sued based on the claim that the City failed to meet requirements set out in the City Charter. There has been no ruling yet on this lawsuit.*)
- Does Boulder need approval for its condemnation plan from the Public Utility Commission? (*Boulder is in the process of seeking PUC approval.*)
- Does Boulder need approval from the Federal Energy and Regulatory Commission (FERC)? (*FERC indicated it does not need to approve Boulder's plan.*)

Boston Legal Analysis

As part of its regulatory reform strategy, the City commissioned an analysis of the legal obstacles to microgrid development in the city by Harvard University. This report identifies a number of ways in which franchise right barriers to microgrids can be overcome.

The Harvard report sought to understand whether or not this franchise language means that utilities have approval control over microgrids – especially Multi-User Microgrids. The report found that the franchise clause would not apply to single owner microgrids, or multi-user microgrids where each of the users is also an owner of the microgrid assets, because no transfer of ownership and control of electricity occurs. In the case of a multi-user microgrid that operates without joint ownership, the report found that there is also a possible legal interpretation that would exempt such an arrangement from being subjected to the franchise clause.

(Massachusetts Microgrids: Overcoming Legal Obstacles)

3 – Design Energy System Solutions

Highlights for “Design Energy System Solutions”

- **A Practice Field in Early Development.** As noted earlier, the domain of comprehensive energy systems transformation at the municipal level is early in its stage of development. Cities are feeling their way through the process of understanding where they do and do not have leverage and what their real options for change are.

- **Grounded in City Practice.** This section of the framework describes the menu of strategies that cities can pursue to move their energy systems towards a low-carbon, reliable and wealth-creating future. This menu is grounded in the practical approaches taken by the cities participating in this project.

- **The Need for Integrated Approaches.** Energy systems change requires an integrated approach at two levels:
    - Integration of demand reduction, supply de-carbonization and system reliability strategies
    - Integration of strategies across energy sources – electricity, thermal and transportation

  Change in each of these domains has economic, legal and technical implications for the other domains.

- **The Examples in This Report are Focused Mainly on Electricity Supply.** Due to resource limitations, the strategies documented by the cities participating in this project are focused on de-carbonization of electricity supply. As a result, detailed implementation information energy demand activities, thermal and transportation de-carbonization, and system resilience strategies is not presented. Several future projects of the Carbon Neutral Cities Alliance Innovation Fund are designed to address these areas. Brief descriptions of those projects are provided at the end of this report.

Energy System Solutions Strategy Map

Energy System Solutions

Reduce Energy Demand

- **Electricity**
  - ✓ Energy efficiency portfolio standards
  - ✓ Improved grid transmission
  - ✓ Building energy efficiency
- **Thermal**
  - ✓ Building energy efficiency
- **Transportation**
  - ✓ Mode shift strategies
  - ✓ Vehicle efficiency standards

Decarbonize Energy Supply

- **Electricity**
  - ✓ Increase local clean energy supply
  - ✓ Decarbonize imported power
- **Thermal**
  - ✓ Combined Heat & Power
  - ✓ District Energy
  - ✓ Heat electrification with renewables
- **Transportation**
  - ✓ Alternative fuel vehicles
  - ✓ Alternative fuel infrastructure

Increase Energy Resilience

- **Electricity**
  - ✓ Distributed generation
  - ✓ Microgrids
  - ✓ On-site storage
  - ✓ Infrastructure hardening
- **Thermal**
  - ✓ Distributed generation
  - ✓ On-site storage
  - ✓ Infrastructure hardening
- **Transportation**
  - ✓ Redesign transportation infrastructure

Typical Strategies by Energy Source

Energy Source	Reduce Demand	Decarbonize Supply	Increase Resilience
Electricity	• Energy Efficiency Portfolio Standards • Improve grid transmission performance • Building energy efficiency: ✓ Codes and Standards ✓ Building Retrofit Programs ✓ Enterprise Strategic Energy Mgt ✓ Building Energy Mgt Technology ✓ Information Transparency ✓ Finance Innovations	• Increase local clean energy supply ✓ District energy, micro-grids and CHP ✓ Local generation Municipal Utility ✓ Clean power purchasing • Decarbonize imported power ✓ Renewable Portfolio Standards ✓ Retire fossil-fuel plants ✓ Utility Partnerships ✓ "Utility of the Future"	• Distributed generation • Micro-grids • Infrastructure hardening
Thermal	• Building energy efficiency (see above)	• Combined Heat and Power • Tri-Generation District Energy • Heat electrification with renewables	• On-site generation • Power storage

Transportation	• Mode shift strategies
	   • Walking
	   • Biking
	   • Public Transit
	• Vehicle Efficiency standards
		• Alternative Vehicle Fuels:
		✓ Electric Vehicles
		✓ Fuel Cells
		✓ BioFuels
		• Alternative Fuel Delivery Infrastructure
			• Redesign transportation infrastructure

Integrating Demand, Supply and Resilience Strategies

Energy efficiency, supply de-carbonization and resilience strategies have to be approached in an integrated way. At early stages of experimentation it may not matter, but as the strategies approach any kind of scale, they begin to have an enormous impact on each other. Some examples include:

- Energy efficiency will have a big impact on the design and sizing of distributed generation systems. An extremely energy efficient building will be able to get to "net zero" with on-site renewables, whereas a traditional building won't. And without pushing the limit on demand reduction, owners risk overbuilding systems.

- Supply de-carbonization will require new strategies for demand management (including remote systems) to manage increased variability in energy supply. The more efficient buildings are, the easier it is to do effective demand management.

- Distributed energy systems have multiple resilience benefits that need to be factored into the calculation of cost effectiveness.

- Renewable sources are less vulnerable to "single point failure" and can be designed into resilience strategies.

> *"It cannot be emphasized too strongly that continued and increased emphasis on energy efficiency is the least expensive lever to reduce San Francisco's GHG footprint. While accessing the opportunity is more complex than building or acquiring generation, is is well worth the effort and can dramatically help reduce system costs."*
>
> (San Francisco 2011 Electricity Resource Plan, P. 7)

A Focus on Electricity Supply Decarbonization

Typical Energy Supply Decarbonization Strategies

The more detailed examples in the next several pages are focused on electricity system de-carbonization strategies being pursued by project cities.

Electricity

- **Increase local clean energy supply**:
  - District energy, micro-grids and CHP
  - Local generation (individuals & enterprises)
  - Municipal Utility
  - Clean power purchasing
    - Community Choice Aggregation
- **Decarbonize imported power:**
  - Renewable Portfolio Standards
  - Retire fossil-fuel plants
  - Utility Partnerships
  - "Utility of the Future"
    - Grid Modernization
    - Transmission Planning
    - Time-Variant Pricing
    - New Revenue Models
    - Reduced Peak Load

Thermal

- **District heating and cooling systems**:
  - Heating conversion to biofuels
  - District heat pumps
- **Heat system conversion:**
  - Air heat pumps
  - Geothermal heat pumps
  - Deep water cooling

Transportation

- **Alternative fuel vehicles**:
  - Electric vehicles
  - Fuel cells
  - Hybrid vehicles
  - CNG vehicles
  - Biofuels
- **Alternative fuel Delivery Infrastructure :**
  - EV charging infrastructure
  - Hydrogen infrastructure

The examples in this report are mostly (but not only) focused here

Electricity Decarbonization – Increase Local Clean Energy Supply

Increase Local Clean Energy Supply	
Strategy	**Details**
District Energy, Microgrids and CHP	• Conduct detailed analysis of energy demand and map the opportunity for distributed generation development • Develop city-owned distributed generation projects • Create regulatory frameworks that remove barriers to district energy (DE) development • Provide technical assistance and regulatory assistance to property owners Provide financial incentives for DE • Integrate DE planning into city zoning approval processes for large developments • Conduct due diligence on DE project opportunities and aggregate customer demand to attract private developers into the market
Local Generation	• Implement solar programs to help individuals and enterprises develop on-site generation • Provide additional net metering or feed-in-tariff incentives to city residents • Increase municipal utility renewable energy generation or procurement • Incentivize Combined Heat and Power • Create a municipal utility
Clean Energy Purchasing	• Implement Community Choice Aggregation for city residents (if allowed by state regulation) • Assist large enterprises in implementing clean energy purchasing through PPAs and other arrangements

Electricity Decarbonization – Decarbonize Imported Energy

Decarbonize Imported Energy	
Strategy	**Details**
State Standards	• Increase State Renewable Portfolio Standards • Increase Net Metering limits • Close inefficient fossil fuel plants
Utility Partnerships	• Create local partnerships with utilities on supply de-carbonization

Utility of the Future	• Grid Modernization
	    • Smart Grids (Advanced Metering Infrastructure)
	    • Improved grid performance (Volt/VAR Control)
	    • Automated Demand Management
	    • Improved Storage and Frequency Regulation
	• Improved Transmission Planning
	• Time-Variant Pricing
	• New Utility Revenue Models
	    • Revenue De-Coupling
	    • Performance-Based Compensation
	    • Fixed Cost Recovery
	    • Minimize Stranded Assets
	• Reduce Peak Load Requirements

Thermal and Transportation De-carbonization Strategies

Decarbonize Thermal Energy Sources	
Strategy	**Details**
District Heating and Cooling Systems	• Implement district energy systems that radically increase the efficiency of fuel use. • Convert heating systems from fossil fuels to renewable sources of combustion. • Implement electricity-powered heat pumps at a district energy scale, and power them with renewable electricity.
Heat System Conversion	• Convert household heating systems to electric air or geothermal heat pumps. • Use natural sources for cooling, such as deep water district cooling systems.

Decarbonize Transportation Energy Sources	
Strategy	**Details**
Alternative Fuel Vehicles and Infrastructure	• Incentivize low or no-carbon fuel vehicle ownership and use • Implement alternative fuel infrastructures, such as charging stations and hydrogen stations • Convert municipal fleets to low carbon fuels • Convert public transit to low carbon fuels • Facilitate the use of municipal assets (such as solid waste and wastewater systems) to produce alternative transportation fuels

How De-carbonization Strategies Influence Each Other

Each primary de-carbonization strategy will influence the other strategies when implemented at scale. Below are some of the inter-relationships that need to get taken into consideration as cities development and implement their energy de-carbonization strategies.

Electricity

- The electricity system needs to be designed to accommodate electrification of heating and mobility.
- Depending on the level of energy efficiency, this will put large new demands on power production and transmission.
- Higher proportions of renewable sources is likely to require more transmission capability for the same amount of power. This new requirement needs to be factored into grid design and transmission pricing.

Thermal

- There are limited large scale sources of renewable thermal combustion. Therefore a deep de-carbonization strategy will likely over time require the electrification of heating systems.
- This additional load has to be taking into consideration in grid design.
- The transition to electrification has to be synchronized with grid de-carbonization to avoid unintentional increases in carbon intensity.

Transportation

- Both vehicle electrification and hydrogen production from renewable sources will put additional demands on the grid.
- When implemented at scale, EVs can become part of the grid energy management. EVs will be connected to the grid and the grid will pull and push power from then as it needs it to balance loads.

Ways Cities Can Influence Electricity Systems

Influencing the multiple players that control electricity systems is a complex undertaking. (See Attachment 2 for more detail on these players.) Cities are large customers of electricity systems, but (unless they run their own utility), they have limited control over how the system is designed or operated. They need to exercise their influence through more indirect means.

Electricity System Player	How Cities Can Exercise Influence
Utilities	• Create partnerships around implementation of renewable energy and energy efficiency initiatives. • Provide input to utility Integrated Resource Plans. • Provide input to utility grid modernization plans. • Negotiate new relationships based on franchise agreements.
Generators	• Aggregate renewable energy purchasing power to support the entrance or expansion of renewable suppliers into the generator pool.
FERC	• There are limited opportunities for municipal engagement on FERC issues.
ISOs and RTOs	• Participate in ISO/RTO planning and working groups and provide input to ISO/RTO planning and forecasting documents.
Public Utility Commissions	• Track and participate in PUC dockets. • Try to influence who is appointed to PUCs. • Intervene in utility rate cases.
Legislature	• Lobby for more aggressive Renewable Portfolio Standards and Energy Efficiency standards.

Lead Electricity Strategies For Project Cities

Electricity Supply Decarbonization

Increase local clean energy supply:

- District energy, micro-grids and CHP ← **Boston**
- Local generation (individuals & enterprises)
- Municipal utility ← **Boulder, Seattle**
- Clean power purchasing
- Community Choice Aggregation ← **San Francisco**

Decarbonize imported power:

- Renewable Portfolio Standards ← **Portland**
- Retire fossil-fuel plants
- Utility Partnerships ← **Minneapolis**
- Utility of the Future

Strategy Example – Municipalization (Boulder)

Strategy Summary. The city of Boulder decided in 2011 to explore the feasibility of establishing a municipal utility. This decision was based on two conclusions: 1) that it is not possible for the city to achieve its aggressive GHG reduction goals without an energy supplier willing to partner with the City to achieve those goals; and 2) that the current electricity supplier (Xcel Energy, an investor-owned utility) was unwilling to enter into this kind of partnership to pursue deep de-carbonization of the city's energy supply. Since 2011, the city has pursued the municipal utility implementation path, including conducting numerous feasibility studies and analyses; defending its legal rights; filing plans with regulatory authorities; legally establishing the utility; authorizing funding; and putting in place a transition plan.

Strategy Components

1. Determine that achieving carbon reduction goals require more direct control over electricity generation.
2. Get voter authorization to explore municipalization and establish performance requirements.
3. Conduct feasibility assessments.
4. Develop a utility business plan.
5. Legally authorize the utility and municipal funding for acquisition and operation.
6. Pursue legal course of action to condemn & acquire incumbent utility assets.
7. File necessary regulatory approvals.
8. Develop and implementation plan.
9. Implement the transition strategy.

Results and Current Status

- Boulder determined that it was technically and financially feasible to launch a new municipal utility saves ratepayers money, maintains system reliability and achieves a 50% reduction in electricity GHG emissions.
- As of July, 2015, the city was in the process of filing a municipalization plan for approval by the Colorado PUC.
- There is still a pending Xcel lawsuit against the city condemnation proceedings, but the City expects it to be dismissed if the PUC approves their plan.
- Assuming PUC approval, the current timeline is for the City to "go live" with the new municipal utility in January of 2018.

Boulder Municipalization Timeline

Year	Milestones
2005	• City begins researching power supply options and funds a "Preliminary Municipalization Feasibility Study".
2010	• Xcel franchise expires and the city decides not to renew it. • Boulder voters approve a utility occupation tax to replace the franchise fee.
2011	• City Council approves Boulder Energy Future purpose, framework and goals. • Voters pass a ballot measure to fund ($1.9 million per year) the evaluation of a municipal utility, and establish charter requirements for the utility. • Municipal utility feasibility plan and business plan commissioned and completed. • First Community Guide to Boulder's Energy Future and municipalization strategy is published. • Energy localization study commissioned.
2013	• Detailed analysis and modeling conducted to determine if a municipal utility could meet the Charter requirements. • City projections are validated by a third party independent review. • City Council authorizes the filing of condemnation to acquire Xcel assets if negotiations fail. • The Boulder-Xcel Task Force is launched and issues its report. • Xcel and the city decide to terminate discussions because of a lack of agreement. • Voters approve a ballot measure to authorize city bonding to purchase Xcel assets. • Voters defeat a ballot measure sponsored by Xcel that would prevent municipalization. • The Colorado Public Utility Commission issues a ruling that requires CPUC approval before Boulder moves ahead on municipalization.
2014	• City Council forms a utility in the charter. • A detailed transition plan for establishment of the utility is developed and approved by City Council. • Voters approve a ballot measure allowing the City Council to hold private executive sessions to discuss legal advice for creation of a local utility. • City files a condemnation petition in Boulder District Court. • Xcel files suit to block the City condemnation petition. • FERC affirms Boulder's right to move forward with condemnation without needing FERC approval.
2015	• City petition for condemnation is dismissed, based on a decision that the city needs to get CPUC approval first. • Boulder files a proposal for municipalization with the PUC. • Staff begin work on a broader Energy System Transformation Blueprint.

The "Utility of the Future" Concept

One of the opportunities in the Boulder experiment with municipalization is to model the transformation of the utility business model at the local level. The terms "utility of the future" or "21st Century utility" are used to denote emerging shifts in the traditional centralized fossil-fuel based utility model that are being driven by de-carbonization mandates, new energy technologies, and the rapid reduction in the cost of renewable energy.

Many of the energy systems change strategies that cities are pursuing are grounded in the same principles that are driving the "utility of the future" dialogue. (See side box.)

Three of the cities participating in this project (San Francisco, Minneapolis and Boston) are in states that are leading the regulatory reform movement to support the utility of the future. As part of their energy systems change work, cities have the opportunity to be active participants in this regulatory reform process.

Utility of the Future Characteristics

- **Customer-focused.** Flexible, customer-service oriented, and able to provide customized energy solutions.
- **Energy as a service.** Offers a new business model that provides energy as a service and is able to adjust to a decreasing demand, rather than relying on increasing electricity sales and building more generation plants as the path to profitability.
- **Adaptable.** Adaptable to new information and new expectations without unsustainable investments in nonrenewable resources or inefficient regulatory practices.
- **Reliable.** Able to provide high reliability to reduce customers' costs.
- **Clean.** Committed to securing increasingly clean power, while offering customers enhanced opportunities to manage their energy and save money.
- **Innovative.** Agile and competitive, while promoting local innovation and engaging local industry and institutional leaders in partnerships that will further enhance service.
- **Distributed.** Increasing percentages of power supply come from distributed energy resources, and the grid is able to integrate these power sources without interruption.
- **Smart.** The system uses two-way communication technology to community between power users and power suppliers, enabling multiple innovations, including Real Time Pricing, Demand Management, voltage regulation, and remote metering and fault detection.
- **Resilient.** Able to withstand future climate impacts without disruption.

Strategy Example – District Energy & Microgrids (Boston)

Strategy Summary. Boston's vision for transforming its energy system is embedded in it 2014 Climate Action Plan. The strategy focuses on three approaches – 1) advocating for continued strong state policies on energy efficiency and renewable energy; 2) creating a structured partnership with utilities; and 3) advancing district energy and microgrids. A core strategy is increasing the amount of energy supply (thermal and electrical) that comes from district energy and microgrids by expanding the district energy business model out from single owner campus structures to more multi-user microgrids (MUMs).

Strategy Components

1. Conduct a citywide energy study to understand energy demand by asset class and identify the areas of the city that are suitable for potential district energy and microgrid development.
2. Identify and address any legal barriers to district energy development, including utility franchise agreements.
3. Develop business models for Multi-User Microgrids (MUMs) and implement pilot projects to test those models.
4. Integrate microgrids and district energy requirements into the city development planning process.
5. Develop a formal community wide energy planning function for the City.

Results and Current Status

Boston is completing a citywide energy study that establishes the analytical framework for identifying opportunities for distributed generation; articulating and defining the benefits; formalizing the community-wide energy planning function; integrating district energy into the City's development planning; and removing regulatory barriers.

The City is also in the process of developing a pilot microgrid project for an area of the city (the Marine Industrial zone) that has significant property controlled by the city. The pilot project will demonstrate the feasibility of Multi-User Microgrids implemented in partnership with the existing distribution utility.

Background on District Energy and Microgrids

- A **district energy system** is a version of distributed energy that consists of a network of underground pipes carrying hot water, steam, or chilled water from a central plant to the buildings using the service.
- A **microgrid** is a localized grouping of electricity generation, energy storage, and loads that has a single point of connection to the traditional macrogrid that allows it to disconnect and function autonomously from the macrogrid.
- A **tri-generation microgrid** combines district energy and microgrids and provides heating, cooling and electricity for a group of buildings and can support mission-critical loads when the surrounding electric grid fails.
- A **Multi-User Microgrid (MUM)** is a microgrid where there is more than one entity that uses the services (in contrast to the more traditional microgrids and district energy systems on single owner campus environments where the system serves a hospital, university, company or other large organization.)

Potential Benefits of Microgrids

- Significant improvements in the efficiency with which fuel is converted to heat and power. (Separate electricity generation will have a typical efficiency rating of around 45%, whereas a combined heat and power system can be more than 80% efficient.)
- Ability to plan whole-building energy efficiency measures in conjunction with the microgrid implementation in order to properly size the system.
- Lower total energy costs.
- Reduced capital costs and operations and maintenance costs for building owners.
- Improved system resilience and reliability.

How Cities Can Integrate Microgrids into Development Planning

- Identify areas of the City that are likely to be able to economically support microgrids.
- Use zoning codes to incentivize microgrid development:
    - "District energy-ready" development requirements
    - District energy "zones" that require new development to connect to existing systems
- Conduct pre-project development and due diligence functions to attract private system developers.
- Provide regulatory and financial incentive for microgrids and district energy.

National Microgrid Initiatives

Geography	Initiatives
New York	• 2010 NYSERDA report on microgrids: "Microgrids: An Assessment of the Value, Opportunities and Barriers to Deployment in New York State" • The New York Public Service Commission "Reforming Energy Vision" process identified barriers to microgrid development, including a lack of clear legal identity and potential franchise conflicts • Recommended a statutory definition of a microgrid; incentives for financing; and accelerated technology deployment
Connecticut	• 2013 microgrid financing projects (Round I: $18 million; Round II: $15 million)
Minnesota	• 2013 report: "Minnesota Microgrids: Barriers, Opportunities and Pathways Toward Energy Assurance" • Recommends microgrids be included in utility system planning; pilot projects support by incentives and financing; and interconnection and performance standards be addressed
Massachusetts	• 2014 report by the Mass Clean Energy Center: "Microgrids: Benefits, Models, Barriers and Suggested Policy Initiatives for the Commonwealth of Massachusetts" • Recommends a microgrid challenge; emphasis on microgrids that reduce GHGs; and integrating microgrids in utility grid planning and emergency planning
Maryland	• 2014 State report: "Resiliency Through Microgrids Task Force Report" • Recommends cost recovery of "public purpose microgrids" through ratepayer assessments
Federal	• Multiple federal microgrid R&D initiatives across the country • USDOE funding for technology development and performance awards

Source: MassCEC Presentation, "Update on Microgrid Market and Policy Development", 2015

Strategy Example – Utility Partnerships (Minneapolis)

Strategy Summary. In 2014, the city of Minneapolis developed a "Minneapolis Energy Vision" and a "Minneapolis Energy System Pathways" report to guide implementation of that vision. The Pathways report explored four different possible strategies for moving toward the vision of an almost carbon free electricity supply by 2040: 1) enhanced utility franchise agreements; 2) city-utility partnerships; 3) Community Choice Aggregation; and 4) a municipal utility. The city chose to pursue options #1 and #2 simultaneously. The City used its franchise agreement renewal process to structure a partnership with its gas and electricity utilities, which it refers to as the "Minneapolis Clean Energy Partnership."

Strategy Components

1. Use the Minneapolis Energy Vision to establish long-term energy de-carbonization goals.
2. Use the Energy Systems Pathways report to layout a full menu of strategy options.
3. Use the franchise agreement renewal process to bring the utilities to the table.
4. Sign MOUs with both utilities committing the parties to joint action in support of the City's 2040 Energy Vision.
5. Establish a Board of Directors and by laws for the Partnership.
6. Establish and Energy Vision Advisory Committee.
7. Develop a joint work plan.

Clean Energy Partnership Goals

"*The Minneapolis Clean Energy Partnership ("CEP" or "Partnership") is a new approach that brings together the City of Minneapolis in a unique way with Xcel Energy and CenterPoint Energy, its electric and gas utilities, to help the City reach its Climate Action goals and Energy Vision for 2040 goals. The CEP is a collaborative leadership framework through which the City and utilities will study, prioritize, plan, coordinate, implement, market, track, and report progress on clean energy activities in the city.*" (Partnership 2015 Work Plan)

Clean Energy Partnership 2015-2016 Work Plan Elements

Clean Energy Partnership Goals

- Increase energy efficiency
- Increase renewable energy
- Develop strong City-Utility Collaboration
- Advance equity and other environmental benefits

Strategies

- Community and stakeholder engagement
- Data and information
- Policy levers

1-4 Unit Residential

- Map participation in utility programs to identify underserved areas
- Develop a community engagement strategy
- Develop an on-bill repayment option
- Develop city policies to drive energy efficiency and renewables in 1-4 unit dwellings

Multi-family

- Map participation in utility programs to identify underserved areas
- Develop a community engagement strategy for multi-family
- Develop city policies to drive energy efficiency and renewables in multi-family dwellings

Small Commercial

- Map participation in utility programs to identify underserved areas
- Monitor implementation of small business programs in the Lake Street corridor

Large Commercial

- Map participation in utility programs to identify underserved areas
- Identify buildings with the best potential to increase benchmarking scores
- Develop a tool for whole building data in multi-metered buildings
- Develop a recognition or challenge program
- Provide TA workshops to owners and managers

City Enterprise

- Begin rollout of LED streetlights citywide
- Identify options for new city fleet fueling infrastructure
- Support city resident access to Community Solar Gardening options
- Continue city-utility collaboration on city distribution infrastructure and planning

Strategy Example – Community Choice Aggregation (SF)

Strategy Summary. Beginning in 2002, the City of San Francisco initiated a deliberate process of taking control of its energy future with the issuance of its first Electricity Resource Plan (ERP). The ERP set broad and aggressive goals for creating a clean power system for the city. In 2008 the Board of Supervisors endorsed the goal of a greenhouse gas free electricity system by 2030 and directed the City to update the ERP to reflect this goal. A core strategy in the 2011 ERP is the implementation of a Community Choice Aggregation program called CleanPowerSF, which will provide all San Francisco residents the choice of procuring carbon-free power at competitive rates.

Strategy Components

1. The 2008 Council resolution sets a goal of a GHG-free electricity system by 2030.
2. The 2011 Electricity Resource Plan recommends 21 different strategies for achieving this goal.
3. Community Choice Aggregation (CCA) emerges as one of the highest impact short term opportunities.
4. The City commissions a 2014 study to recommend options for CCA implementation.
5. The study recommends that the San Francisco Public Utility Commission (SFPUC) serves as the implementation organization for the CCA program.

CleanPowerSF Implementation Timelines

- **May 12, 2015:** Present proposed not-to-exceed rates to San Francisco Public Utility Commission (SFPUC)
- **June 23:** Seek SFPUC approval to file updated CCA implementation plan
- **June 30:** Receive Board of Supervisors' and Mayor's approval for power contracting legislation
- **Aug 3:** Issue request for offers for program's electric resource supplies
- **July-August:** Approval to execute back office and customer care contract
- **Sept. 29:** Approval to execute Phase 1 supply contract(s)
- **Oct. 27:** Present final rates to SFPUC
- **Late November:** Commence pre-enrollment notification process
- **Jan. 26, 2016:** Phase 1 program launch

Background on Community Choice Aggregation

Community Choice Aggregation, (CCA) is a policy which allows cities and counties to aggregate the buying power of individual customers in order to secure alternative energy supply contracts on a community-wide basis. (It is also known as "Municipal Aggregation" and "Community Aggregation".) CCA's are de facto public utilities of a new form that aggregate regional energy demand and negotiate with competitive suppliers and developers, rather than the traditional utility business model based on monopolizing energy supply. Consumers are allowed to "opt out" of the program and be served by the traditional power supplier. In some communities, consumers are automatically enrolled unless they opt out. In others, consumers have to "opt in" to participate.

There are currently six states that allow Community Choice Aggregation – Massachusetts, Ohio, California, New Jersey, Rhode Island and Illinois. In 2014, it was estimated that CCA served close to 5% of American consumers in over 1300 municipalities.

Municipal energy aggregation can be an effective tool for cities and towns to aggressively expand both the availability and the adoption of renewable energy. It offers communities the opportunity to make large-scale change without locking in constituents who may not agree with that change. CCA strategies can advance municipal clean energy goals in several ways:

- A city or town can make increased use of renewables the default for everyone
- They can integrate local renewables into the supply by purchasing renewable energy credits from local suppliers
- They can use the aggregation to support the development of new sources of renewable energy. (As an example, the San Francisco strategy recommends consideration of a number of new local renewable energy projects as potential suppliers to the CCA.)

Strategy Examples – State Policy (Portland)

Strategy Summary. Portland is a low cost energy state with a relatively mild climate. The City has set aggressive GHG reduction goals and a target for 50% renewable power by 2030 for the city as a whole. The 2015 Climate Action Plan articulates seven strategies around energy supply issues. Because it is not pursuing a municipalization strategy (the City made an unsuccessful attempt to purchase its largest electric utility in 2005 but has not pursued municipalization since then), the City is strongly focused on advancing renewable energy supply strategies at the State level by engagement with the Legislature, the Public Utility Commission, and the utilities themselves.

Energy Supply Strategy Components

1. **Electricity Supply** – Collaborate with utilities and regulators to reduce the carbon content of the electricity supply by 3% per year.
2. **Installed Solar** – Add 15 MW of installed solar capacity.
3. **Community Solar** – Advocate for a community solar policy in the state.
4. **Renewable Energy Policy** – Participate in statewide policy discussions to expand renewable energy markets.
5. **Biogas** – Support local and regional biogas resources.
6. **District Systems** – Expand low-carbon district heating and cooling systems.
7. **Fossil Fuel Exports** – Establish a fossil fuel export policy.

Primary Targets for State Policy Reform

- **Virtual net metering.** State law does not currently require utilities to offer virtual net metering. This limits community solar implementation options.
- **State renewable tax credits.** State tax credits for renewable energy (previously a 35% Business Energy Tax Credit) expired three years ago.
- **Connecting State climate goals to utility policy.** The State has a long-term GHG reduction goal of 75% by 2050. The “Roadmap to 2050” document that describes potential strategies for achieving this goal has not been formally adopted by the Legislature or integrated into state utility policy.

Strategy Example – Municipal Utility De-carbonization Supported by Building Energy Use Reductions (Seattle)

Strategy Summary. Seattle has the good fortune of having a municipal utility (Seattle City Light) that is already carbon neutral and powered by hydro power. Seattle City Light has is committed to meeting all future load growth through a combination of conservation and additional renewables. Making good on this commitment will require deep reductions in building energy use. A significant strategy in the new Climate Action Plan is focused on achieving an 82% reduction in building energy use by 2050.

Building Energy Use Data for Reduction Strategies

In order to determine what type of policy mandates will be needed over what time frame to achieve deep building energy use reductions, the City needs to build a detailed baseline of current and projected energy use by building type. This analysis is including:

- **Existing and Forecast Population.** A projection of current and future building growth by sector, based on population and economic projections.
- **Existing Energy Use and GHG Intensity.** Base year energy use and GHG intensity data by building type for commercial and multifamily buildings; vintage, fuel splits, and major end-uses.
- **Forecast Energy Use and GHG Intensity.** Projected changes in building energy use over time based on the anticipated impacts of code changes, of cutting edge engineering practice, and of increased efficiency in mechanical equipment, lighting, hot water and appliances.
- **Energy Use and GHG Targets.** Additional energy use and GHG reductions that will be required to meet the City's 82% GHG reduction goal by 2050.

Lessons Learned from Electricity De-Carbonization Work

- **Bold goals and a bold vision enable bold action.** A clear articulation of the long-term energy de-carbonization goals, and endorsement of those goals by the political infrastructure, helps drive an aggressive systems change agenda. As an example, the Boulder strategy was motivated by the realization that they couldn't achieve their GHG reduction goals without an electricity supplier partner who shared those goals. The seriousness with which they took this GHG target commitment informed the scale of action they were willing to consider.

- **Cities have limited direct leverage over utility strategy.** Most cities cannot directly influence the business strategies of their natural gas and electricity utilities when it comes to energy supply de-carbonization. So the strategies need to be more indirect in nature – voluntary partnerships; engagement in visioning processes; engagement in regulatory proceedings; lobbying for changes in state legislation; etc.

- **Franchise agreements provide some City leverage.** Renewal of city franchise agreements are a useful tool for incentivizing city-utility partnerships. They are one of the few direct economic leverage points that cities have with utilities. In both Minneapolis and Boulder, they provided the starting point for change. Cities should be strategic about how they use renewal opportunities to advance their clean energy goals.

- **Control over some local electricity supply is a powerful advantage.** San Francisco's municipal utility provides power to the city municipal operations and selected large users, accounting for 17% of total city electricity supplies. SFPUC's supply is 100% renewable and comes from three hydroelectric power plants that SFPUC owns and operates with the City's Hetchy Hetchy reservoir system. The availability of this power supply source under city control gives the city some options it wouldn't have without it, including further greening of municipal energy sources, and the ability to manage a complex program like the city CCA initiative. Likewise, Seattle has a 100% renewable energy municipal utility, meaning it can focus its full attention on reducing energy demand and decarbonizing the transportation and thermal sectors.

Lessons Learned (cont'd)

- **The feasibility of municipalization is highly dependent on local conditions.** Municipalization is definitely not for everyone. Minneapolis looked closely at municipalization and decided it was likely far too expensive and complicated to be feasible. The Boulder strategy depended on a number of localized legal, regulatory and infrastructure conditions:
  - The city is a home rule city, so it has the legal authority to exercise eminent domain over assets necessary to achieve priority public outcomes.
  - Boulder is surrounded by rural areas, so the physical configuration of of the electricity system reduced the complexity of "carving out" transmission and distribution assets without disrupting other players.
  - Stranded asset costs that the City would be required to reimburse Xcel for (in addition to the value of the assets it condemns) are projected to be relatively low.
  - The size of the utility is small enough that it is feasible for the city to manage its acquisition.
  - Local politics favor a municipalization strategy.

- **Municipalization requires a high level of technical expertise and a significant feasibility/ analysis budget.** Boulder has invested several million dollars in technical studies, modeling analysis and legal services to support the municipalization strategy. In the process, it established a city staff unit in charge of the work, and developed a cadre of staff with expertise in all the aspects of utility operations.

- **Where it is legal, Community Choice Aggregation can be a significant tool for energy supply de-carbonization.** San Francisco's CCA initiative allows it to participate in renewable energy markets in ways that would be impossible if the city were entirely dependent on imported IOU electricity. It can negotiate directly with renewable suppliers, as well as develop its own renewable projects to supply the CCA program.

Lessons Learned (cont'd)

- **The technical, economic and administrative requirements of a large city CCA initiative are substantial.** It took San Francisco considerably longer than it planned to get its CCA program off the ground, both because of difficulty finding competitive renewable energy suppliers, and the administrative complexity of program management. The first CleanPowerSF implementation plan was developed in 2007, but the program will be launching in 2016. The city's ability to use its SFPUC's "back office" services for the program has been an important ingredient to feasibility.

- **Virtually all city strategies require deep system understanding.** All cities have invested resources in some type of technical analysis of their energy systems.

- **Keeping stakeholders engaged is critical.** As with any high risk public enterprise, it is critical to engage key stakeholders so that are informed and supportive of the strategy. Boulder invested many resources in community outreach and education, including running three successful ballot proposals related to the municipal utility. Other cities engaged stakeholders through community forums, planning processes and technical workshops.

- **Aggressive action by one city can help others.** Minneapolis has the same electricity IOU as Boulder. Several participants in Minneapolis observed that Xcel was eager to avoid the outcome they arrived at in Boulder, so were more willing to enter into a collaborative relationship with the city of Minneapolis.

- **Cities need to get engaged in regulatory and policy proceedings.** Cities wishing to influence their clean energy future need to pursue multiple strategies simultaneously. In addition to working locally with their utilities, they need to be actively engaged in regulatory proceedings at the PUC level and pushing state policy makers to set the context for a long-term carbon-free energy system. Engaging in regulatory proceedings requires development of new knowledge of the process and immersion in often arcane utility regulation details.

4 – Organize for Transformation

Energy Systems Change Requires Organizational Capacity

Each of the cities participating in this project have had to develop new organizational capacity to support their energy systems change strategies. Each city has taken a slightly different approach to this challenge.

City	Organizational Capacity to Support Energy Systems Change
Boulder	• To support its muncipalization effort, Boulder established a new position of Energy Strategy and Electric Utility Development with a full time Executive Director. • The office reports directly to the City Manager. Responsibilities include development of long term energy strategies for the city, and leadership to develop Boulder Light and Power as a new publicly owned electric utility. • In addition, energy system work is supported by several staff out of the Department of Community Planning and Sustainability.
Boston	• Boston energy strategies are managed by Brad Swing, Director of Energy Policy and Programs. • To support its municipal energy work, the City created a new Municipal Energy Unit with two full time staff. • The Renew Boston initiative is staffed by a full time embedded utility executive who is located in City Hall. • In addition, a new position of Ecodistrict Energy Fellow was established in the city development organization, (the Boston Redevelopment Authority) to manage the citywide energy plan and district energy/microgrid development.
Minneapolis	• The Minneapolis energy system work has been managed with existing staff out of the City Sustainability Office.
Portland	• The Portland energy system work has been managed with existing staff out of the City Bureau of Planning and Sustainability.
San Francisco	• San Francisco's energy systems work is jointly led by staff of the Department of Environment and the San Francisco Public Utility Commission (SFPUC), which manages the city's water and electric utilities. The Electricity Resource Plans were developed by the SFPUC.

Future Directions

Opportunities for Future Framework Development

Component	Opportunities for Further Development
1 – Establish the Energy Vision	• Development of common definitions of community benefit from energy systems change. • Development of some common metrics for measuring success. • Best practice sharing on stakeholder engagement strategies.
2 – Understand Your Energy System	• Development of a tighter taxonomy of the types of analysis. • Development of detail on the specific analytical components that should be involved in the process. • Exploration of technology platforms and systems that can help with energy systems analysis. • Best practice sharing on examples of energy system analysis reports. • Development of common RFP language for procuring energy system analysis services.
3 – Design Energy System Solutions	• Deeper dive into additional dimensions of electricity de-carbonization (utility of the future; intervening in regulatory proceedings; state-level de-carbonization strategy). • Additional detail on thermal de-carbonization strategies. • Additional detail on microgrids and district energy. • Detail on integration of electricity, thermal and transportation de-carbonization. • A framework for energy system resilience.
4 – Organize for Transformation	• Organizational designs for energy systems work at the municipal level. • Job descriptions for energy system change professionals. • Strategies for funding energy systems transformation work. • Strategic alliances with outside partners.

Boulder Convening Next Steps Ideas

The July convening in Boulder generated a large number of ideas for next steps to advance municipal energy systems transformation work. These included:

1. **Finalize the Framework**
   - Distribute to USDN membership
   - Develop communications document for external stakeholders

2. **Build an On-Going City Network Focused on Energy System Transformation**
   - Network for Urban Energy System Transformation (NUEST)
   - Formal, multi-year collaboration
   - Staffed by a knowledgeable NGO or other party
   - Uses cities as applied R&D hubs for energy system transformation

3. **Create Additional Knowledge Products**
   - Urban Energy System Architecture
   - AC to DC Conversion Opportunities (done)
   - State Policy Agenda
   - Energy System Security Framework
   - Storage Technology Impact Analysis
   - Detailed Framework for Transportation De-carbonization
   - Energy Systems and Equity Framework
   - How to Deal With Stranded Assets

Related USDN and CNCA Projects

There are several projects being funded by the USDN Innovation Fund and the Carbon Neutral Cities Alliance (CNCA) Innovation Fund that can add additional detail and depth to the Framework.

- **Microgrids Report.** The cities of Boston, Cambridge MA, Northampton MA, Somerville, MA, and Washington DC are completing a USDN-funded project focused on best practices for the technology transfer of campus scale energy systems into districts of privately owned buildings in neighborhoods and downtown. Key to this work is the exploration of business models which are applicable to both Investor Owned Utilities, Municipal Utilities, and Cooperative Utilities. The report will be completed this summer.

- **Thermal De-carbonization.** The cities of Boulder and Seattle received a grant from the CNCA Innovation Fund to develop advanced methodologies for inventorying thermal energy uses; assessing the viability of low carbon energy system substitution options; developing replacement strategies based on equipment lifecycles; and identifying issues and barriers to scaling the practice. The project is scheduled to be completed in the summer of 2016.

- **Energy Systems Analysis.** The cities of Boulder, Minneapolis and Seattle are leading a CNCA-funded project to develop a more sophisticated methodology for conducting an initial analysis of the different types of energy systems within their boundaries. This approach utilizes a variation of the urban transect methodology to create a set of development profiles that capture the majority of land use use/development patterns within each city. These profiles will then be subject to an in-depth energy systems analysis that will establish both an initial baseline of existing energy systems, and a set of scenarios for transitioning to a low carbon energy system. The project is scheduled to be completed in the summer of 2016.

- **Next Generation District Heating.** London is leading a CNCA-funded project to explore the development of "4th generation" district heating networks. These are heating networks that operate at lower temperatures, which enables a more cost effective transition to future low-carbon heat from local renewable, environmental and waste heat sources. It evolves heat networks into a flexible, future-proofed infrastructure that is capable of playing an active role in a smart energy system, the integration of heat and power, and in addressing the challenge of heat supply to more energy efficient buildings. The project is scheduled to be completed in the summer of 2016.

Attachment 1:
City Profile Summaries

City Profiles Overviews

These materials provide a very abbreviated overview of some of the work that project cities are doing on energy system transformation:

- There are additional more detailed Word documents with background on each city.

- While it is understood that energy system transformation work requires a comprehensive approach to energy demand, supply and resilience, these materials highlight the work that the participating cities have been doing on energy supply. So they are not a comprehensive view and will need to be enhanced over time.

- In addition, there is a brief summary of the contextual energy system factors that are relevant to each city, including:

  - Population
  - Type of utility regulatory scheme
  - Energy costs
  - Total energy consumption
  - Main utility suppliers
  - Renewable energy incentives
  - Current electricity supply profiles

- City strategies are evolving quickly so some aspects of these overviews are likely to be out of date by the time you read them. Please check with the cities before citing the materials.

Context Difference Across Project Cities

Context	Boulder	Boston	Minneapolis	Portland	San Francisco	Seattle
Population	103,000	655,800	382,500	583,700	852,000	640,000
Electricity Costs	Medium	High	Medium	Low	High	Low
Utility Market Regulation	Regulated	Deregulated	Regulated	Regulated	Partially Regulated	Regulated
CCA	Not Allowed	Allowed	Not Allowed	Not Allowed	Allowed	Not Allowed
IOU Renewable Portfolio Standards	30% by 2020	15% by 2020	30% by 2020	25% by 2025	33% by 2020	15% by 2020
Net Metering	Yes	Yes	Yes	Yes	Yes	Yes

Electricity Supply Profiles Across Project Cities

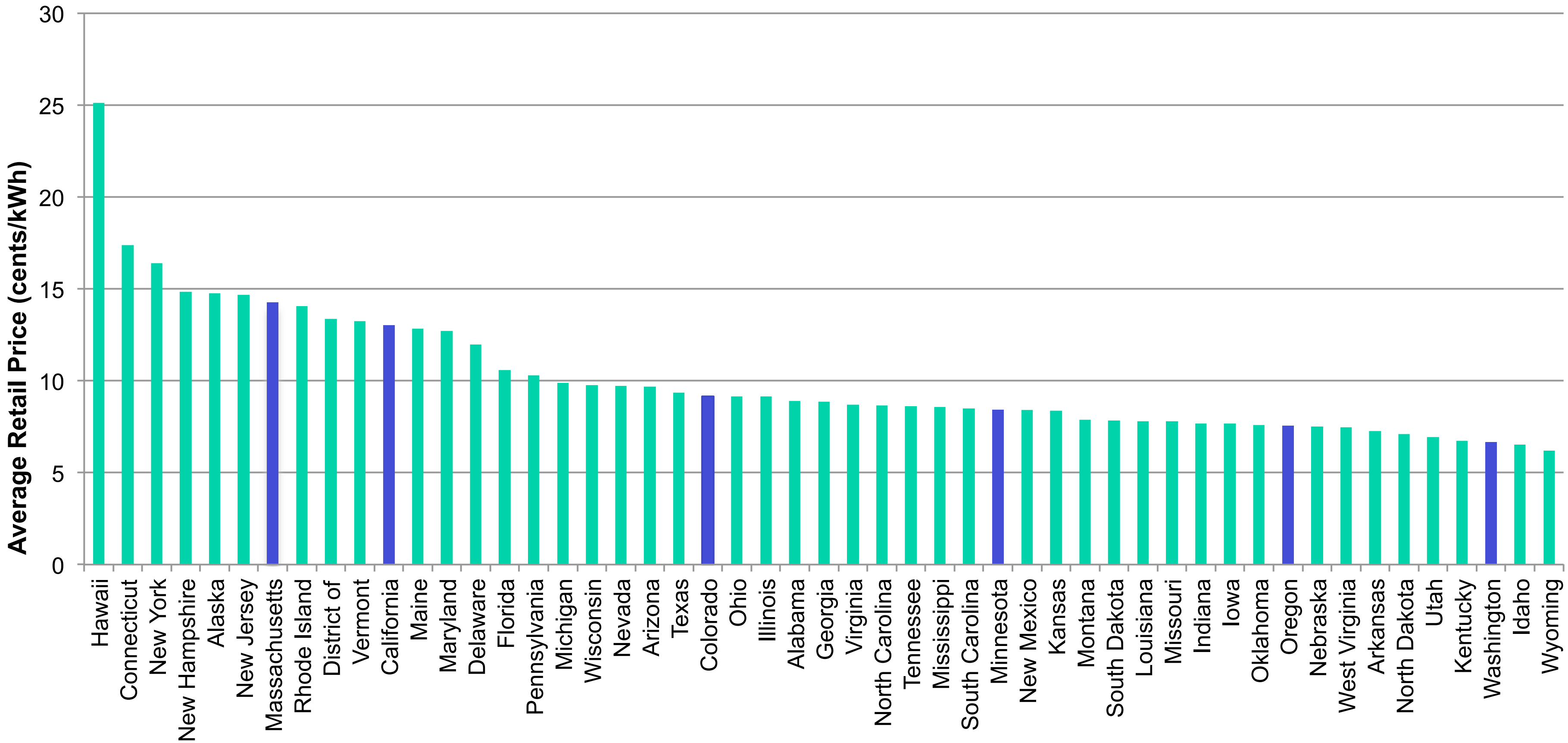
Context	Boulder	Boston	Minneapolis	Portland	San Francisco	Seattle
Coal	57%	5%	36%	43%	8%	1%
Natural Gas	31%	44%	13%	24%	39%	0%
Nuclear	0%	34%	28%	0%	22%	4%
Renewables	12%	17%	24%	31%	14%	93%
Other	0%	1%	0%	0%	1%	2%

Source: Various City Documents; figures are rounded in several cases

Electricity Prices Across Cities

The chart below shows the average retail price of electricity across the six states represented by the cities in this project.

Source: EIA



Innovation Network for Communities

Energy Goals and Targets for Project Cities

City	Emissions Reduction Targets	Specific Energy Targets
Boulder	80% by 2050	• 50% renewables in year one of municipalization
Boston	25% by 2020 80% by 2050	• 15% of large C/I energy use from co-generation (2020) • 10 MW of commercial solar (2020)
San Francisco	25% by 2017 40% by 2025 80% by 2050	• GHG free electric system by 2030 • Offer a portfolio of energy resources to residents through a CCA that is 51% renewable by 2021.
Minneapolis	80% by 2050	• Generate 10% of electricity from local renewable sources by 2025
Portland	40% by 2030 80% by 2050	• Supply 50% of all energy used in buildings from renewable sources • 10% of building energy use supplied by on-site renewable sources
Seattle	62% by 2030 Carbon Neutral by 2050	• Maintain current carbon neutrality of electricity supply • 97% reduction in transportation emissions by 2050 • 82% reduction in building emissions by 2050

Boulder Energy Supply Context

Context	Description
Population	• 103,000
Utility Regulation	• Regulated utility market • Community Choice Aggregation is not allowed • Consumers cannot choose their own suppliers
Energy Costs	• Mid-range • 11.7¢ per kWh average for residential (EIA 2013 data)
Energy Suppliers	• Electricity -- Xcel (IOU) • Gas -- Excel
Renewable Power Incentives	• RPS for IOUs – 30% by 2020 • Net metering is allowed • Community Solar Gardens allowed up to 2 MW
Electricity Supply Profile	• 57% --Coal • 31% -- Natural Gas • 10% -- Wind • 1.5% -- Hydro • 0.5% -- Solar

Boulder Energy Supply Strategy Summary

"Boulder's Energy Future" establishes the framework for the city's energy system transformation work.

Energy Future Principles

1. *__Democratize Energy Decision Making:__ customers should have more direct control and involvement in decisions about their energy, including opportunities to invest in their long-term energy needs and to have a say in energy investments made on their behalf.*

2. *__Decentralize Energy Generation and Management:__ energy should be generated locally or within the region to the maximum extent feasible, reducing reliance on external fuel sources; customers should be able to manage and reduce their energy use as directly and effectively as possible; and energy service companies should be empowered to compete and innovate within a diverse and robust local energy economy.*

3. *__Decarbonize the Energy Supply:__ renewable and clean fuel sources should be maximized as much as possible, as quickly as possible, minimizing both short- and long-term environmental impacts and maximizing energy independence over time.*

Energy Future Goals and Objectives

1. **Ensure a stable, safe and reliable energy supply**.
   - System redundancy, supply quality and load management
   - Fuel source stability
   - System reliability
2. **Ensure competitive rates, balancing short-term and long-term interests**.
   - Rate competitiveness
   - Rate transparency and predictability8
   - Technology investment and managing price volatility.
3. **Significantly reduce carbon emissions and pollutants**.
   - Reduction of GHG emissions
   - Reduction of toxic pollutants
4. **Provide energy customers with a greater stay about their energy supply**.
   - Democratizing local decision-making
   - Democratizing local ownership
5. **Promote local economic vitality**.
   - Support for local business innovation
   - Economic competitiveness
6. **Promote social and environmental justice**.
   - Energy equity
   - Impacts to vulnerable populations
   - Energy literacy

Boston Energy Supply Context

Context	Description
Population	• 655,884
Utility Regulation	• De-regulated utility market. Utilities do not generate power but have exclusive franchise rights for distribution • Community Choice Aggregation is allowed • Consumers can choose their own electricity suppliers
Energy Costs	• High • 22.5¢ per kWh average for residential (BLS 2015 data)
Energy Suppliers	• Electricity -- Eversource (IOU) • Gas – National Grid (IOU) • Downtown steam system managed by Veolia North America
Renewable Power Incentives	• RPS for IOUs – 15% by 2020; 1% per year increase after 2020 • Net metering is allowed • Virtual net metering is allowed with the same utility service area
Electricity Supply Profile	44% -- Natural Gas 34% -- Nuclear 9% -- Renewables 8% -- Hydro 5% -- Coal 1% -- Oil

Innovation Network for Communities

Boston Energy Supply Strategy Summary

Climate Plan Strategy	Description
Neighborhoods	
2.12 Accelerate Residential Solar	Continue to accelerate solar deployment by continuing the Solarize program and tackling existing barriers in the multi-family and renter market.
2.18 Transition to Low Carbon Heating Sources	Work with the Commonwealth to shift residential units and small businesses away from inefficient and carbon-intensive heating systems, including electric resistance heat, oil heat, and inefficient natural gas heat.
Large Buildings and Institutions	
1.72 Promote On-Site Combined Heat and Power and Renewables	Encourage commercial CHP, solar and ground-source heat pumps.
1.73 Facilitate Expansion Of District Energy	Expand district heating, cooling, and microgrids, through district-level planning and a potential requirement for new buildings to study the costs and benefits of connection.
1.74 Expand Municipal Installation of Renewables, CHP and District Energy Connections	Evaluate feasibility for all municipal buildings and install solar wherever possible.
1.81 Support Regional Transition to Low Carbon Fuels	Work with the Commonwealth to develop a low carbon fuel standard and increase the supply of carbon-free energy in the region.
1.82 Promote green power purchasing.	Promote renewable energy purchasing, including buildings that have linked off-site renewable projects.
1.85 Increase municipal green power purchases.	Expand renewable energy purchasing and use of electricity and renewable fuels for the municipal vehicle fleet.

Minneapolis Energy Supply Context

Context	Description
Population	• 382,500
Utility Regulation	• Regulated utility market. Utilities do not generate power but have exclusive franchise rights for distribution • Community Choice Aggregation is not allowed • Consumers can choose their own electricity suppliers
Energy Costs	• Mid-range • 12.6¢ per kWh average for residential (EIA 2013 data)
Energy Suppliers	• Electricity -- Xcel (IOU) • Gas – CenterPoint (IOU) • Downtown steam and chilled water system managed by NRG Thermal
Renewable Power Incentives	• Excel – 30% by 2020; plus 1.5% from solar • Net metering is allowed, up to 1 MW • Xcel is required to offer community solar; other utilities can be are not required
Electricity Supply Profile	36% -- Coal 27.5% -- Nuclear 13% -- Wind 13% -- Natural gas 8% -- Hydro 3% -- Biomass 0.5% -- Other

Minneapolis Energy Supply Strategy Summary

2040 Energy Vision Principles

1. ***Reliable and affordable energy services****, where all residents and businesses are supplied with competitive rates, and disparities in the relative cost of energy services for low-income households are mitigated.*
2. ***Clean energy****, where the total carbon emissions and other waste products have substantially declined, and electricity supply is nearly carbon-free.*
3. *Provision of* ***essential energy services*** *for all, affordably meeting the basic needs of residents, without disparity of impacts or benefits according to race, ethnicity, income, and age.*
4. *An* ***increasing use of local resources*** *within the city, including renewable energy and efficient district heating. A robust local supply chain exists in the city for energy efficiency and renewable energy services, and Minneapolis is a national leader in advanced energy infrastructure.*
5. ***Market integration of efficiency*** *that makes use of transparent data in economic and purchasing decisions. Residents and businesses are empowered to save money and reduce their environmental impact.*
6. ***Collaborative progress*** *on planning and investment decisions by the energy utilities that serve the city. These decisions reflect and support the City's climate action, economic development, and social equity goals.*

Minneapolis Energy Pathways

The city's Energy Pathways report recommended four pathways for analysis:

- ***Pathway 1: Enhanced Franchise Agreement.*** *Either a single franchise agreement that includes a broader set of goals, or a traditional franchise agreement with a separate agreement that addresses those goals.*
- ***Pathway 2: City-Utility Partnerships.*** *Formal City-utility coordinating entity focused on setting and tracking local goals. Not a partnership in any legal sense, but an entity in which the City and utilities agree to act as willing partners to achieve shared goals.*
- ***Pathway 3: Community Choice Aggregation.*** *City contracts directly for energy supply.*
- ***Pathway 4: Municipal Utility.*** *City owns and operates independent utility.*

The City chose Pathways #1 and #2 for immediate implementation.

Portland Energy Supply Context

Context	Description
Population	• 583,776
Utility Regulation	• Portland is regulated utility market. Utilities own generation sources and are regulated by the Public Utility Commission. • Community Choice Aggregation is not allowed in Oregon.
Energy Costs	• Low • 10.5¢ per kWh average for residential (EIA 2013 data)
Energy Suppliers	Portland is served by three Investor-Owned Utilities (IOUs): • Portland General Electric (serves 75% of the city; Portland is about a third of its total market) • Pacific Power (serves 25% of the city; owned by Pacificorp, a large seven-state utility company) • NW Natural (Oregon's largest natural gas utility)
Renewable Power Incentives	• RPS for IOUs – 25% by 2025 • Net metering is allowed, up to2 MW for commercial; 25kW for residential • Virtual net metering is not required of utilities; no Community Solar option
Electricity Supply Profile	43% -- Coal 25% -- Hydro 24% -- Natural Gas 6% -- Wind 2% -- Other

Portland Energy Supply Strategy Summary

Energy Supply Strategies in the 2015 Climate Action Plan	
Strategy	**Description**
Electricity Supply	• Collaborate with Portland General Electric, Pacific Power, customers and stakeholders to reduce the carbon content in Portland's electricity mix by 3 percent per year. • Communicate with utilities and the Oregon Public Utility Commission on the critical importance the City and County place on reducing the carbon content of electricity delivered to the City, County and other customers. • Mitigate potential cost burdens to low-income households principally through efficiency measures that reduce energy use and cost.
Installed Solar	• Add another 15 megawatts of installed solar photovoltaic capacity. • Motivate and assist households and businesses throughout the community to install solar. • Revisit City solar access policy and regulations, recognizing changing conditions due to the proliferation of residential rooftop solar energy systems.
Community Solar	• Support the development of community solar projects that benefit all residents, particularly communities of color and low-income populations.
Renewable Energy Policy	• Participate in statewide policy discussions to expand the market in Oregon for renewable energy, including solar, wind, geothermal, biogas and biomass, and remove barriers to widespread participation in renewable energy programs like community solar.
Biogas	• Continue to support development of local and regional biogas resources, including anaerobic digestion of food scraps, while minimizing disproportionate impacts on low-income populations and communities of color.
District Systems	• Continue to support development and expansion of low-carbon district heating and cooling systems.
Fossil Fuel Exports	• Establish a fossil fuel export policy that considers lifecycle emissions, safety, economics, neighborhood livability and the environment; at the state level, oppose exports of coal and oil through Oregon.

San Francisco Energy Supply Context

Context	Description
Population	• 852,000
Utility Regulation	• Partly regulated utility market. Some IOUs still own generation sources through legacy agreements. • Community Choice Aggregation is allowed
Energy Costs	• High • 22.2¢ per kWh average for residential (BLS 2015 data)
Energy Suppliers	• PG&E (IOU) serves 75% of electricity demand, plus natural gas • The San Francisco Public Utility Commission (SFPUC) Power Enterprise division serves municipal electricity requirements, supplying 17% of SF usage • 8% of electricity demand is served by independent Energy Service Providers
Renewable Power Incentives	• RPS for IOUs – 33% by 2020 • Net metering is allowed, up to 1 MW
Electricity Supply Profile	<u>PG&E</u>: 39% -- Natural Gas 22% -- Nuclear 16% -- Hydro 14% -- Renewables 8% -- Coal 1% -- Other <u>SFPUC</u>: 100% -- Hydro

San Francisco Energy Supply Strategy Summary

Strategy 1 – Empowering San Francisco Citizens and Businesses to Reduce GHG Emissions

1. **Energy Efficiency.** Improve and expand energy efficiency programs in San Francisco.
2. **Behind the Meter.** Promote the development of behind-the-meter resources.
3. **Technology Innovation.** Develop San Francisco as a "Green Test Bed" to promote and encourage the deployment of new energy technologies.
4. **Building codes.** Improve building codes and standards to promote energy efficiency.
5. **Distributed Generation.** Advance and support Community Scale Energy Systems.
6. **Storage.** Promote back-up storage deployment as an alternative to the existing use of diesel and natural gas-powered back-up generation.
7. **Community Choice Aggregation.** Implement Community Choice Aggregation consistent with guidance from the Board of Supervisors and the San Francisco Local Agency Formation Commission (LAFCo).

Strategy 2 – Increase the Renewable and GHG-Free Content of San Francisco's Electricity Supplies

1. **Transmission.** Evaluate and develop new City-owned transmission projects to increase the delivery of Hetch Hetchy and renewable power to San Francisco.
2. **Green Power Option.** Develop an optional "green pricing" option allowing San Francisco customers to voluntarily commit to purchase electric energy from zero-GHG energy sources.
3. **Regulatory Engagement.** Participate in regulatory proceedings to encourage state and federal policies to promote the use of GHG reduction strategies and encourage the development of CCA.

Strategy 3 – Continuing and Expanding SFPUC Electric Service to Guarantee Reliable, Reasonably Priced and Environmentally Sensitive Service

1. **SFPUC Rate Reform.** Develop a rate structure for the SFPUC that reflects its cost-of-service.
2. **Increased Municipal Load.** Increase the use of municipal load supplied by electric energy from Hetch Hetchy to displace fossil-fuel use.
3. **Interconnection Agreement.** Renegotiate the Interconnection Agreement (IA) with PG&E that governs the transmission and distribution of Hetch Hetchy energy to San Francisco that expires in June 2015.
4. **EJ Policies.** Continue to implement the SFPUC's recently adopted Environmental Justice and Community Benefits policies.

Source: 2011 Electricity Resource Plan, SFPUC

Seattle Energy Supply Context

Context	Description
Population	• 640,000
Utility Regulation	• Regulated utility market • Community Choice Aggregation is not allowed
Energy Costs	• Low • 7.8¢ per kWh average for residential
Energy Suppliers	• Electricity -- Municipal Utility (Seattle City Light) • Gas – Puget Sound Energy (IOU) • Enwave Seattle operates a private district steam utility in the downtown
Renewable Power Incentives	• RPS for IOUs – 15% by 2020 • Net metering is allowed
Electricity Supply Profile	• 1.7% --Coal • 4.5% -- Nuclear • 0% -- Natural Gas • 3.4% -- Wind • 89% -- Hydro • 0% -- Solar • 1.5% -- Other

Seattle Energy Supply Strategy Summary

Seattle is served by a municipal utility (Seattle City Light) that has achieved carbon neutrality and is committed to meeting all future load growth through a combination of conservation and new renewables. As a result, Seattle does not face many of the electricity supply de-carbonization challenges that the other project cities do. Instead, the Seattle strategy is focused on:

- Deep reductions in building energy use, so that more building energy supply can be served by carbon-free electricity rather than thermal sources.
- Deep reductions in transportation vehicle miles traveled
- Deep reductions in the GHG emissions per mile in Seattle vehicles

Key Transportation Strategies

Increase Transportation Choices:

- *Funding*
- *Transportation infrastructure and services*
- *Transportation demand management*
- *Vehicle fuels and technologies*

Complete Communities

Economic Signals:

- *Road pricing*
- *Parking management*

Key Building Energy Strategies

Information

- *Smart meters*
- *Energy benchmarking*
- *Home energy information*

Incentives and Assistance

- *Utility incentives*
- *Streamlined permitting*
- *Financing*

Performance Requirements

- *Energy code improvements*
- *Efficiency standards*

Energy Supply

- *Clean energy*
- *District energy*

Attachment 2: Background on Urban Energy Supply Systems

Energy Supply Systems

There are three main energy supply systems – electricity; heating and cooling; and transportation. Each of them have different fuel sources, system elements and players in the system.

Electricity

Fuel Sources:

Fossil Fuels
- Coal
- Natural gas
- Petroleum
- Propane/LNG

Renewables
- Nuclear
- Biofuel
- Biomass
- Hydropower
- Hydrogen
- Solar
- Wind

System Elements:

Power Sources
- Power Plants
- Dams
- Solar/Wind Farms
- CHP

The Grid
- Transmission
- Distribution
- Microgrids

Economic Actors
- Generators
- Utilities
- FERC
- RTOs
- PUCs
- Consumers

Thermal

Fuel Sources:
- Natural gas
- Propane
- Diesel fuel
- Biofuel
- Biomass
- Geothermal

System Elements:
- Combined heat and power
- Distribution
- Pipelines
- Storage tanks
- Delivery trucks

Economic actors
- Extraction
- Refining
- Pipelines
- Local distributors
- Consumers

Transportation

Fuel Sources:
- Petroleum
- Electricity
- Fuel cells

System Elements:
- Cars
- Trucks (light/ heavy duty)
- Commercial Rail
- Airplane
- Water transport
- Public transportation

Economic actors
- Equipment OEMs and suppliers
- Government infrastructure investors
- Regulators
- Consumers

Electricity Supply Systems

The electricity supply sector is extremely complicated from multiple levels – its technical design; levels of control and authority; pricing; and business models. Cities that seek to change the electricity supply system have to understand how this system works, where the levers for change are, and how they can influence those levers. Because it is so important to system redesign, this section of the framework provides a brief overview of the main components of electricity supply systems and how they vary across the country.

In the early days of electricity, most electricity utilities were "vertically integrated." This meant that every geographical area in the country had only one electricity utility, and that utility fulfilled all three roles in the electricity grid:

- Generation – owning the power plants that burned coal or oil or some other fuel to make electricity;
- Transmission – Owning and operating the high voltage (often 500-, 345- or 230-kilovolt) lines that do the long-distance transmission of electricity from where it was made to where it was used; and
- Distribution – Owning and operating the lower voltage (usually 120- or 240-volt) lines and local transformers responsible for actually distributing electricity to end-use customers (like individual homes or businesses).

Starting in the 1990s, many states passed laws that broke up these three separate functions and gave these separate functions to different companies. This process was called "de-regulation." In de-regulated markets, the "electricity company" is really just a "transmission and distribution" company (T&D). The T&D utility performs the last two functions described above and owns the large transmission lines that are found in utility rights of way as well as the wires and poles in your neighborhood that bring the electricity to homes and businesses.

Key Players in Electricity Supply Systems (1)

Utilities. In traditionally regulated markets, utilities provide generation, transmission and distribution services in a vertically integrated fashion. They are granted monopolies on their service areas and in return submit to regulation by Public Utility Commissions. In de-regulated markets, the utilities do not own generation and only provide transmission and distribution services. Power is provided by private generator companies.

There are two basic types of utilities in the U.S.:

- Investor Owned Utilities (IOUs). These are private, for-profit corporations that provide a combination of generation, transmission and distribution services. About 75% of the population is served by IOUs.
- Consumer Owned Utilities (COUs). These are utilities that are controlled by the customers in one fashion or another. They include municipal utilities, electricity cooperatives and Public Utility Districts. About 25% of the population is served by COUs.

Generators. Generators create electricity supply. In regulated markets, utilities own and operate generation plants. In de-regulated markets, power is sold into wholesale markets by independent generation companies. The ISO determines which generators are allowed to sell into the wholesale market. Many large energy consumers (such as universities and hospitals) generate much of their own power through on-site systems such as Combined Heat and Power or District Energy systems.

Federal Energy Regulatory Commission (FERC). FERC was created under the Federal Power Act, and it oversees interstate wholesale markets and transmission systems. Many aspects of energy sales between states and regions, and the development of transmission lines across state borders require FERC approval.

Key Players in Electricity Supply Systems (2)

Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs). ISOs and RTOs are similar voluntary organizations that plan, operate, dispatch a and provide open-access transmission services under a single tariff. ISOs and RTOs exist to meet FERC reliability and access requirements. Their purpose is to foster competitive neutrality in wholesale electricity markets and reliability in regional systems. In 1996, FERC issued what it called Order 888, which encouraged the creation of ISOs to run and oversee electricity wholesale markets. There are now several ISOs in the country, including ISO New England, New York ISO (NYISO), California ISO (CAISO), and Midwest ISO (MISO). PJM Interconnection LLC is the ISO for all or parts of 13 states that originally included New Jersey, Pennsylvania, and Maryland. Some parts of the country are served by RTOs, and some by ISOs. Some are served by neither.

The overall purpose of ISOs and RTOs is to "keep the lights on" – meaning make sure the grid is designed and managed in a way that keeps it from failing. They perform three basic functions:

- Operation of the grid in real time. The balance between power supply and power consumption needs to be managed on a minute by minute and second by second basis. Any imbalance can lead to a system "crash". The ISO/RTO tells which generators to run at what level of capacity to assure balance in the system.

- Management of the market for wholesale electricity. The ISO/RTO runs short term ("day ahead") and long-term ("forward capacity") markets that set the price of wholesale electricity on an hour by hour basis that ultimately drives the retail cost of power.

- Planning for the future of the grid and electricity markets. The ISO/RTO plans for how much generation and transmission capacity it will need in the future to assure smooth operation of the grid. This translates into processes for authorizing additional transmission lines and additional power generators.

Key Players in Electricity Supply Systems (3)

Public Utility Commissions. Regulation of IOUs is carried out by state-level Public Utility Commissions (PUCs). In return for granting them monopolies on various aspects of their markets, states limit how much the monopolies are allowed to charge. It is the PUCs that make this determination. Most state commissions consist of 3-5 appointed or elected commissioners and a professional staff. The commissions typically carry out the following functions:

- Determining the utility revenue requirements;
- Allocating costs (revenue burdens) among customer classes;
- Designing price structures and price levels that will collect the allowed revenues, while providing appropriate price signals to customers;
- Setting service quality standards and consumer protection requirements;
- Overseeing the financial responsibilities of the utility, including reviewing and approving utility capital investments and long-term planning; and
- Serving as the arbiter of disputes between consumers and the utility*

Public Utility Commissions work through a number of vehicles, including:

- Rate cases that set returns on investment and other economic conditions that determine how much revenue the utilities can collect and what they charge their customers.
- Rulings on issues of law or policy (typically managed through a series of "dockets")
- Approval of plans and utility documents, such as Integrated Resource Plans that serve as planning tools for the electricity system

PUCs are important players in implementing Renewable Portfolio Standards, Energy Efficiency programs and other legislative mandates for power systems.

*Source: "Electricity Regulation in the US: A Guide", Regulatory Assistance Project, 2011

Thermal Energy Systems

A significant municipal source of carbon emissions are energy uses for heating and cooling buildings. The primary technologies used to provide these thermal management services vary significantly, both by geographic region and by scale of buildings. However, in many regions—particularly colder climates--the predominant energy source for heating operations is natural gas (including propane) or heating oil. For commercial and industrial operations, gas may also be used to provide cooling. Thermal uses (space heating, water heating, ventilation, and cooling) account for 69% of energy uses for residential structures, and 50% for commercial structures. Achieving deep emissions reduction and a successful transition off fossil fuels requires a comprehensive replacement of these oil and gas thermal energy systems.

There are a number of additional factors that make replacement of natural gas and related fossil fuels a high priority.

- First, the proportion of overall emissions could actually be significantly higher if new research on the climate impacts of natural gas development and use result in significant increases in the assessed climate impacts of natural gas.

- Second, the proportion of emissions associated with natural gas in municipal inventories is also likely to grow quickly as efforts to decarbonizes electricity sources and transportation achieve reductions in those sector. Without viable strategies to replace these thermal energy sources, communities will continue to face challenging tradeoffs between meeting these essential living needs, and the expansion of oil and gas development to address these needs.

- Finally, the high probability of increasing temperatures and the associated cooling load demands will potentially lead to a significant expansion of gas use where it is being used to run commercial and industrial cooling systems.

Transportation Energy Systems

Nationally, mobility systems account for approximately 30% of total U.S. emissions. Most city strategies related to transportation are focused on reducing Vehicle Miles Traveled through different forms of “mode shift” – including public transportation, car sharing, on-demand transportation, biking and walking. However, to get to deep de-carbonization goals, cities will also need to find ways to influence or drive the de-carbonization of mobility fuel sources. The two main strategies that are focused on this goal include increased vehicle efficiency and fuel switching.

- **Efficiency.** Increased vehicle efficiency (miles per gallon) is primarily driven at the national level through CAFE (Corporate Average Fuel Economy) standards. Cities have minimal leverage at on fuel efficiency standards.

- **Fuel Switching.** Cities can exercise considerable influence over the implementation of alternative fuel infrastructures and alternative fuel markets. They can:
  - Incentivize low or no-carbon fuel vehicle ownership and use
  - Implement alternative fuel infrastructures, such as charging stations and hydrogen stations
  - Convert municipal fleets to low carbon fuels
  - Convert public transit to low carbon fuels
  - Facilitate the use of municipal assets (such as solid waste and wastewater systems) to produce alternative transportation fuels

Useful Energy Supply System Resources

Source	Title	Description
Regulatory Assistance Project	*Electricity Regulation in the U.S.: A Guide*	This 120 page PDF document provides an excellent overview to utility regulatory models in the U.S., including descriptions of how they vary from state to state and region to region.
Peter Fox-Penner	*Smart Power: Climate Change, The Smart Grid, and the Future of Electric Utilities*	Fox-Penner's book provides a layperson's introduction to the history of utility regulation and de-regulation, and lays out scenarios for future business models for the utility industry. It is especially useful for understanding the quirky and often illogical patchwork of regulatory jurisdictions in the utility sector, and how things got to be this way.
Boston Green Ribbon Commission	*A Guide to Electricity Markets, Systems and Policy in Massachusetts*	This Guide was written for the Commission by the Conservation Law Foundation (CLF). CLF is one of the most utility-savvy NGOs in the country and participates extensively in the ISO-New England regulatory process. It is an excellent description of the often arcane process of setting electricity prices and managing wholesale electricity markets, written in an open and accessible style.
Advanced Energy Economy	*Towards a 21st Century Electricity System in California*	AEE has been a national leader in facilitating dialogue on the transformation of the utility business model. This white paper is a joint AEE-utility industry effort to develop common principles for managing this transition in California.
Bentham Paulos	*Empowered: A Tale of Three Cities Taking Charge of Their Energy Future*	Ben Paulos' short book (44 pages) provides an overview of the efforts of Boulder, CO, Minneapolis, MN, and Madison, WI to get control of their energy futures.

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