# A Framework for Urban Energy System Transformation

**A Project of the USDN Innovation Fund**

**December 2015 Final Report**

**EXECUTIVE SUMMARY VERSION**

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# 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

# 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

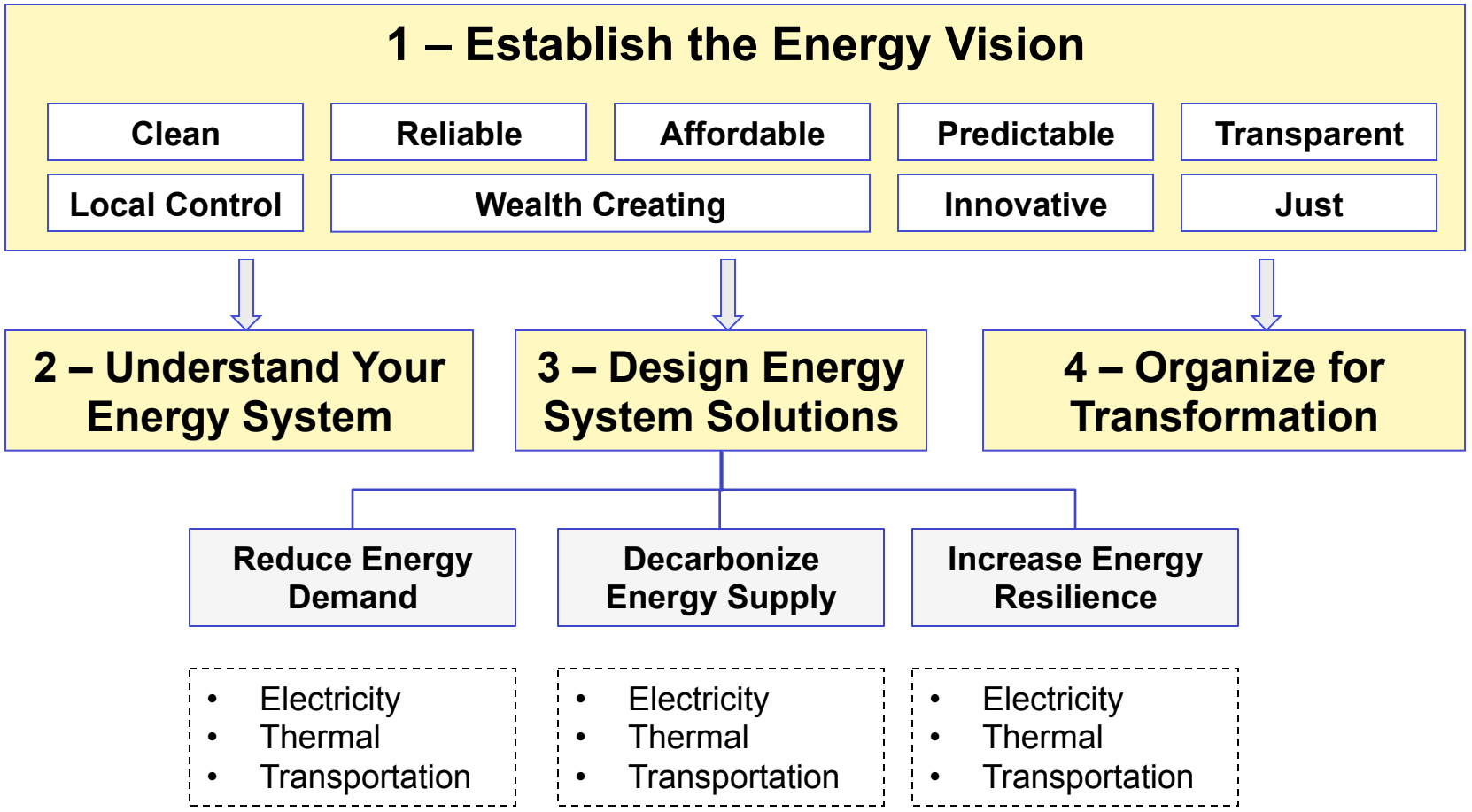
# How the Municipal Role Has Evolved

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.

# Framework Components

# Key Components of an Energy System Strategy



# Framework Components

| Component | Description |
|---|---|
| **1 – Establish the Energy Vision** | • Create a compelling logic for change<br>• Articulate the desired outcomes<br>• Engage key stakeholders in the dialogue |
| **2 – Understand Your Energy System** | • Describe the existing energy system "ecology"<br>• Map energy demand and supply systems<br>• Conduct technical analysis to support projects and policy change<br>• Build a system for monitoring system performance |
| **3 – Design Energy System Solutions** | • Reduce energy demand<br>• Decarbonize energy supply<br>• 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.

# 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.

# 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. |

# 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.

# 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.

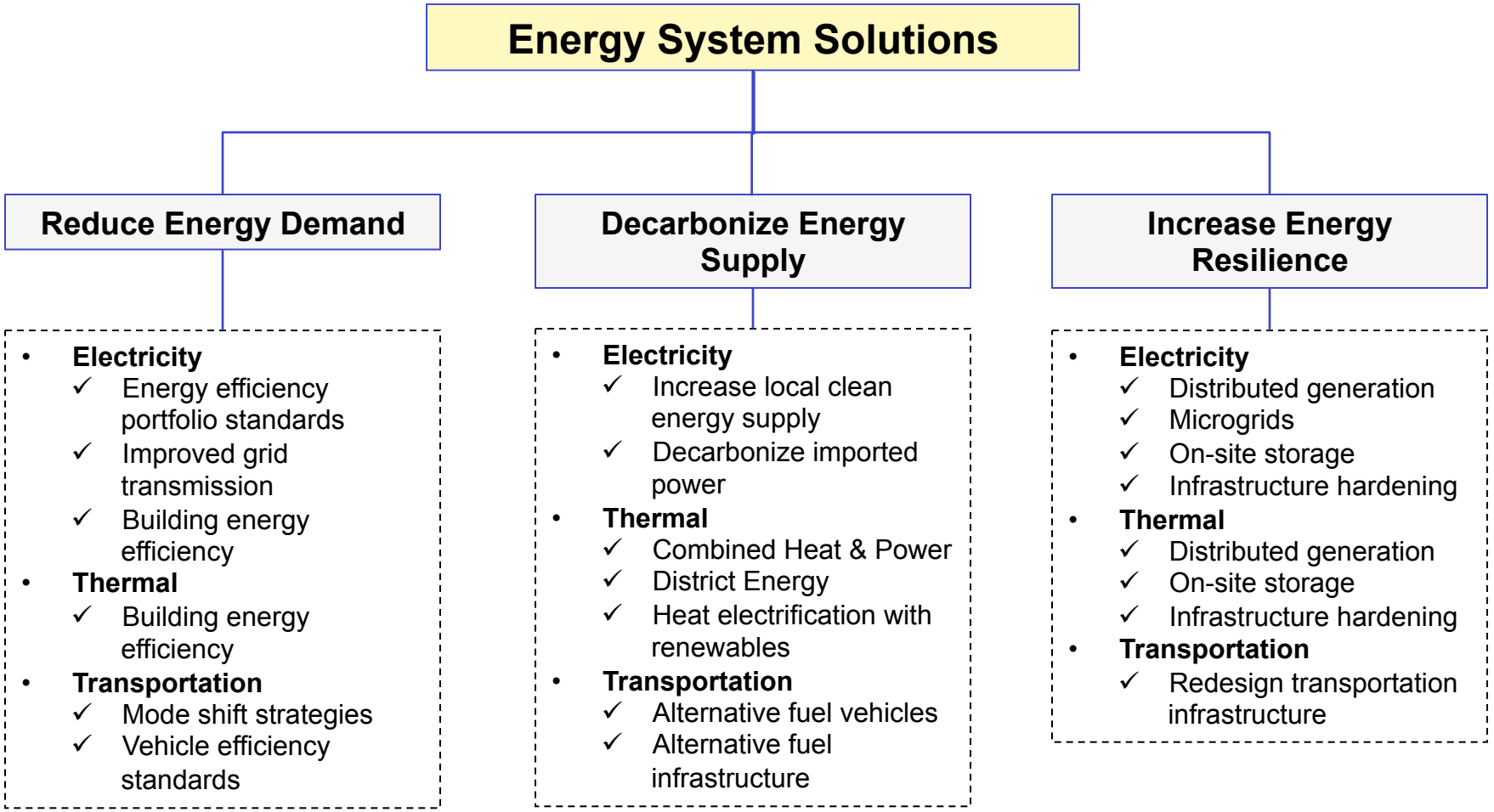
- **Grounded in City Practice.** This section of the framework describes the menu of strategies that cities can pursue to move their energy systems towards a low-carbon, reliable and wealth-creating future. This menu is grounded in the practical approaches taken by the cities participating in this project.

- **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



# Typical Strategies by Energy Source

| Energy Source | Reduce Demand | Decarbonize Supply | Increase Resilience |
|---|---|---|---|
| ***Electricity*** | • Energy Efficiency Portfolio Standards<br>• Improve grid transmission performance<br>• Building energy efficiency:<br>✓ Codes and Standards<br>✓ Building Retrofit Programs<br>✓ Enterprise Strategic Energy Mgt<br>✓ Building Energy Mgt Technology<br>✓ Information Transparency<br>✓ Finance Innovations | • Increase local clean energy supply<br>✓ District energy, micro-grids and CHP<br>✓ Local generation Municipal Utility<br>✓ Clean power purchasing<br>• Decarbonize imported power<br>✓ Renewable Portfolio Standards<br>✓ Retire fossil-fuel plants<br>✓ Utility Partnerships<br>✓ "Utility of the Future" | • Distributed generation<br>• Micro-grids<br>• Infrastructure hardening |
| ***Thermal*** | • Building energy efficiency (see above) | • Combined Heat and Power<br>• Tri-Generation District Energy<br>• Heat electrification with renewables | • On-site generation<br>• Power storage |
| ***Transportation*** | • Mode shift strategies<br>◦ Walking<br>◦ Biking<br>◦ Public Transit<br>• Vehicle Efficiency standards | • Alternative Vehicle Fuels:<br>✓ Electric Vehicles<br>✓ Fuel Cells<br>✓ BioFuels<br>• 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)

# 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<br>• Develop city-owned distributed generation projects<br>• Create regulatory frameworks that remove barriers to district energy (DE) development<br>• Provide technical assistance and regulatory assistance to property owners Provide financial incentives for DE<br>• Integrate DE planning into city zoning approval processes for large developments<br>• 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<br>• Provide additional net metering or feed-in-tariff incentives to city residents<br>• Increase municipal utility renewable energy generation or procurement<br>• Incentivize Combined Heat and Power<br>• Create a municipal utility |
| **Clean Energy Purchasing** | • Implement Community Choice Aggregation for city residents (if allowed by state regulation)<br>• 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<br>• Increase Net Metering limits<br>• Close inefficient fossil fuel plants |
| **Utility Partnerships** | • Create local partnerships with utilities on supply de-carbonization |
| **Utility of the Future** | • Grid Modernization<br>  • Smart Grids (Advanced Metering Infrastructure)<br>  • Improved grid performance (Volt/VAR Control)<br>  • Automated Demand Management<br>  • Improved Storage and Frequency Regulation<br>• Improved Transmission Planning<br>• Time-Variant Pricing<br>• New Utility Revenue Models<br>  • Revenue De-Coupling<br>  • Performance-Based Compensation<br>  • Fixed Cost Recovery<br>  • Minimize Stranded Assets<br>• 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.<br>• Convert heating systems from fossil fuels to renewable sources of combustion.<br>• 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.<br>• 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<br>• Implement alternative fuel infrastructures, such as charging stations and hydrogen stations<br>• Convert municipal fleets to low carbon fuels<br>• Convert public transit to low carbon fuels<br>• 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.

# 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

# 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.<br>• 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.<br>• 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.<br>• To support its municipal energy work, the City created a new Municipal Energy Unit with two full time staff.<br>• The Renew Boston initiative is staffed by a full time embedded utility executive who is located in City Hall.<br>• 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.<br>• Development of some common metrics for measuring success.<br>• Best practice sharing on stakeholder engagement strategies. |
| **2 – Understand Your Energy System** | • Development of a tighter taxonomy of the types of analysis.<br>• Development of detail on the specific analytical components that should be involved in the process.<br>• Exploration of technology platforms and systems that can help with energy systems analysis.<br>• Best practice sharing on examples of energy system analysis reports.<br>• 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).<br>• Additional detail on thermal de-carbonization strategies.<br>• Additional detail on microgrids and district energy.<br>• Detail on integration of electricity, thermal and transportation de-carbonization.<br>• A framework for energy system resilience. |
| **4 – Organize for Transformation** | • Organizational designs for energy systems work at the municipal level.<br>• Job descriptions for energy system change professionals.<br>• Strategies for funding energy systems transformation work.<br>• 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 "4$^{th}$ 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

# 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<br>80% by 2050 | • 15% of large C/I energy use from co-generation (2020)<br>• 10 MW of commercial solar (2020) |
| **San Francisco** | 25% by 2017<br>40% by 2025<br>80% by 2050 | • GHG free electric system by 2030<br>• 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<br>80% by 2050 | • Supply 50% of all energy used in buildings from renewable sources<br>• 10% of building energy use supplied by on-site renewable sources |
| **Seattle** | 62% by 2030<br>Carbon Neutral by 2050 | • Maintain current carbon neutrality of electricity supply<br>• 97% reduction in transportation emissions by 2050<br>• 82% reduction in building emissions by 2050 |

# 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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