Thermal Decarbonization: First Stage Findings in Developing Renewable Heating and Cooling Alternatives for Residential and Municipal Buildings

City of Boulder, Colorado
(Residential Thermal Decarbonization Analysis

City of San Francisco, California
Municipal Building Thermal Decarbonization Analysis

CNCA
CARBON NEUTRAL CITIES ALLIANCE

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EXECUTIVE SUMMARY

> *"Achieving an 80% percent GHG reduction by 2050 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, natural gas/thermal*** *and* ***transportation fuels...****This transformation will need to take place simultaneously at multiple scales—individual households/buildings, enterprises and organizations; and community-wide"* From A Framework for Urban Energy System Transformation, Innovation Network for Communities, a USDN Innovation Fund Project. 2015

As early explorers in the largely uncharted territory of large-scale energy decarbonization, the member cities of the Carbon Neutral Cities Alliance (CNCA) have recognized the importance of strategies that reduce or eliminate dependence on fossil fuels for heating and cooling applications. Unlike the electricity and petroleum use sectors where substantial work and investment has been applied to renewable energy-based alternatives by many entities, there has been relatively little work in the development of larger-than-building scale strategies for thermal decarbonization.

The Importance of Thermal Decarbonization

The importance of work in this sector cannot be understated. At a larger energy systems level, both utilities and oil and gas interests are actively pushing for the expansion of natural gas as the primary energy source in both electricity generation and heating and cooling system uses. This has resulted in the push for large-scale expansions of new distribution infrastructure—both domestic and export oriented. These investments would commit many cities and regions to decades of additional dependence on an emissions source with massive impacts on both local areas and the global climate emissions balance.[1] Beyond these global impacts, advances in hydraulic fracture drilling systems ("fracking") have also led to enormous expansions in drilling activity in both land and ocean areas. These developments are creating significant environmental and social impacts in many areas across the US and internationally.

At a more local level, natural gas, propane, and heating oil usage for heating in residential and commercial/municipal settings subject building owners to enormous price volatility and uncertainty. Natural gas and fuel oil are some of the most volatile commodities traded with price swings that can double or greater within a single season. http://www.wsj.com/articles/volatility-has-natural-gas-traders-scrambling-1424199729

[1] Natural gas (CH_4) is up to 86% more damaging to the climate than CO2. A report released in late 2014 found actual leakage rates from natural gas operations were 2-6X the currently estimated rates. If these findings are characteristic of the larger industry, natural gas could be recognized as a more climate damaging energy source than coal. See http://onlinelibrary.wiley.com/doi/10.1002/2014EF000265/full

This puts both households and business at significant risk, particularly lower income members of communities.

Other factors also underscore the importance of finding alternatives to natural gas and other fossil fuels in this sector of uses. These include:

- Climate impacts -- the recognized impact of dependence on these fuels could 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
- Emission goals -- the proportion of emissions associated with natural gas and other fossil fuel thermal energy source in municipal inventories is also likely to grow quickly as efforts to decarbonizes electricity sources and transportation achieve reductions in those sector.
- No-win trade-offs -- 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. Boulder, and more broadly Colorado, are at the center of this dilemma as a major production zone for oil and natural gas using highly controversial practices such as fracking to maximize well outputs.
- Climate change resilience -- the high probability of climate change-driven increases in 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.

Exploring Routes to Renewable Heating and Cooling

The two projects summarized in this report were the first stage of investments made by the member-driven CNCA to begin developing city-scale exploration of renewable heating and cooling transition opportunities. Each project took a separate sector for its focus. The Boulder, Colorado project focused on the development of tools and strategies that can accelerate the adoption of residential-scale renewable heating and cooling technology. The San Francisco project developed a method for conducting a municipal building heating and cooling system assessment that included a first stage analysis of the logistical and financial feasibility of renewable heating and cooling systems change outs.

The outcomes of this project proposed at its outset included the following:

1. A replicable assessment and strategy development framework for both residential and municipal thermal decarbonization that can be easily customized to support similar initiatives in other cities.
2. A detailed analysis and case study in each of the two cities—Boulder on residential systems and San Francisco on municipal systems--that includes:
   (a) An assessment of the characteristics of thermal energy use,

(b) An assessment of existing replacement alternatives
(c) A draft thermal decarbonization strategy with specific intervention options in the five strategy areas identified above,
(d) A pilot project implementation strategy.

3. Local partnerships established to assist in implementing thermal decarbonization strategies

Findings

Two stand alone reports follow. The first report summarizes the methodology and findings for the City of Boulder's effort to build an approach to residential thermal decarbonization in single family detached dwellings. The second report describes San Francisco's assessment of decarbonization options for a portion of its municipal building analysis. In the attachments section of this report you will find the more detailed analysis supporting the results for each study.

Residential Thermal Decarbonization – The Boulder project has resulted in a number of outputs that will support Boulder's climate and energy objectives and potentially serve other communities. These include:

- A methodology for compiling publicly available data that builds an energy information management system cities can utilize to formulate city-wide residential renewable heating and cooling strategies and programs.
- Using this information management systems, the city can also provide every building owner with a preliminary energy transition roadmap covering both their thermal uses as well as integrating information related to energy efficiency, solar capacity, and the integration of EV based transportation cost reductions.
- An analysis tool that can projects viability, financial cost and benefit, and emissions reductions potentials related to replacement of natural gas systems or other fossil fuel-based heating systems with renewable-ready systems (primarily heat pump).
- The potential capacity to model the utility scale impacts of both neighborhood and community-scale transition off fossil-fuel based heating systems.
- Preliminary policy recommendations cities could use to guide thermal decarbonization.

Municipal Thermal Decarbonization – The San Francisco analysis provides a valuable foundation and methodology for cities to build a similar thermal decarbonization assessment approach. Elements of particular relevance to other cities could include:

- A methodology for dividing and analyzing a city's building inventory to identify renewable heating and cooling options and implications.
- An analysis approach for preliminary building level system evaluation
- A preliminary assessment of different technology options
- A set of policy recommendations for cities to consider to support similar initiatives.

Policy and Program Recommendations

Each study also includes a set of recommendations for next steps in expanding the implementation of thermal decarbonization strategies in each respective sector considered. For those interested in going directly to these recommendations, a compilation of the major recommendations for cities interested in implementing renewable heating and cooling adoption efforts is included as an attachment to this Executive Summary.

Limits in the First Stage Analysis

It should be noted that both projects were conducted using very limited resources—approximately $30,000 for each city. Each city committed significant additional resources to the implementation of these assessments. In both cases, the project consultants also went significantly above and beyond the scope and budgets initially provided in an effort to maximize the value of these efforts. However, as a point of reference for funding scale, a detailed analysis of a single boiler replacement in a large commercial building could cost more than the total amount allocated for both city's projects.

As a consequence, the findings for each city's work should be viewed as a first-stage assessment intended to simply lay the groundwork for additional analysis and development. In an effort to both ground-truth the findings of each study and provide additional policy recommendations relevant to each context, Meister Consulting Group was retained to provide a review and recommendations for each city's reports. These assessments were then integrated into the final copies of each city's reports.

ATTACHMENT A:

General municipal policy and program recommendations for supporting thermal decarbonization

Meister Consultants Group

August 2016

Introduction

Achieving municipal thermal decarbonization will require addressing barriers to deployment of renewable heating and cooling (RH&C) technologies. Municipal policymakers have opportunities to implement a variety of policies and programs that can drive thermal decarbonization. These policy and program actions that can be broadly categorized under five primary categories which are discussed further below:

- **Municipal planning and purchasing**
- **Incentive programs**
- **Financing and business models**
- **Mandates, regulations, and product standards**
- **Outreach and education**

For all recommendations discussed below, there are a number of key considerations based on the municipality's climate zone, available resources, and overall progress towards achieving climate goals.

Municipal planning and purchasing

Municipal governments can help jumpstart local RH&C markets by engaging internal and external stakeholders, developing a comprehensive energy plan, and "leading by example" (e.g. retrofitting municipal buildings with RH&C and changing their internal purchasing decisions to favor RH&C options— as pursued by San Francisco's project). As described in the Box 1 below, the Arup report identified a number of policies within the municipal planning and purchasing category. The following highlights additional options that Boulder and San Francisco may consider.

- **Employ strategic energy management framework like the "virtuous cycle" to drive change.** Climate-related public sector initiatives, including thermal decarbonization, can often be best addressed through a comprehensive strategic energy management framework, which creates a virtuous cycle to help leaders drive forward institutional change. In order to ensure that thermal decarbonization actions maintain momentum, cities should ensure that a nexus of five mutually-reinforcing strategies are pursued:

    1. **Committing to targets** (e.g. setting goals for gas replacement technologies in municipal buildings; setting targets for community deployment of RH&C; completing

municipal baselining and benchmarking projects necessary for measuring compliance and identifying opportunities)

2. **Investing in people** (e.g. assessing and building institutional capacity for managing wide-ranging thermal decarbonization initiatives; engaging and training facilities and procurement staff)
3. **Identifying funding sources** (e.g. establishing avenues for financing municipal gas replacement technologies; exploring innovative financing approaches for energy efficiency and RH&C)
4. **Implementing projects** (e.g. retrofitting of municipal buildings with envelope upgrades and gas replacement heating technologies; implementing community demonstration projects)
5. **Sharing results** (e.g. conducting outreach to consumers; hosting public events; directly engaging commercial building owners and managers; disseminating of performance data from municipal demonstration projects)

- **Conduct comprehensive technology analysis for the local jurisdiction.** The ideal RH&C technologies in each jurisdiction may differ based on local climate considerations, costs of fuels, and availability of local resources. While the analyses in San Francisco and Boulder focused primarily on electric heat pump technologies, system economics and potential for achieving GHG reductions may differ for such technologies in other jurisdictions. Some states like Maine and New Hampshire, as well as many European countries, have focused on deployment of biomass-based heating technologies, while others have placed greater emphasis on solar thermal applications. For municipalities in states with minimal or no renewable portfolio standards, use of electric heat pumps can potentially increase emissions relative to gas due to lack of grid-tied renewables. Municipalities should conduct similar comprehensive technology analyses as part of developing community thermal decarbonization strategies.

Box 1. Municipal planning and purchasing recommendations from the Arup report.

The Arup report identified the following recommendations that fall within the municipal planning and purchasing category:

- Conduct a thorough inventory of municipal buildings, including all existing equipment (e.g. size, age, condition, capacity), daily or hourly energy usage, and existing building electrical capacity.
- Develop custom strategies for addressing the most energy-intensive buildings
- Develop purchasing guidelines that mandate purchase of electric heat pump technologies to replace gas technologies
- Engage facilities staff to provide training, review O&M procedures, and build capacity as needed to support deployment of replacement technologies
- Assess electrical infrastructure to identify needs for upgrades
- Support research for replacement technologies for process heating loads

- Adopt other general best practice recommendations if such policies have not yet been implemented (e.g. adopting a climate action plan, building energy data benchmarking and reporting ordinances)

Incentive programs

RH&C technologies can provide long-term energy savings to homeowners and businesses in some applications, but high upfront capital costs can be prohibitive and represent a significant barrier to adoption. The implementation of robust incentive programs can help businesses and residents to overcome upfront investment costs and realize cost-effective economic returns. Box 2 discusses policies identified by Arup that fit within the incentive program category. As discussed below, incentive schemes can be a crucial component of larger energy outreach programs – or can move beyond providing basic rebates based on deemed performance or capacity to incentivize actual energy performance and whole-building decarbonization.

- **Implement home energy assessment and efficiency program.** Municipalities should ensure that residents have access to efficiency programs (e.g. state, utility, municipal) that provide no-cost home energy assessments as well as incentives for energy efficiency upgrades and RH&C technologies. Such programs not only provide residents with options and incentives for cost-effective energy improvements, but also can provide an opportunity for contractors to educate homeowners about RH&C technologies and potential applications for their homes. For jurisdictions that lack access to state or utility programs, municipalities should explore opportunities for working with utilities and other private sector entities to establish and fund an efficiency program. For jurisdictions in which residents do have access, there are still opportunities for municipalities to build on such programs through public-private collaborations to provide a wider range of incentives, include technologies that are not provided by utilities (e.g. do not pass utility cost-effectiveness tests), and contextualize existing programs to match local conditions (e.g. the Renew Boston program worked with the Mass Save program and utilities to create new incentives to target renters, multifamily buildings, and low- and moderate-income households).
- **Explore opportunities for providing incentives based on energy performance.** Cities pursuing aggressive zero net energy building programs, such as San Francisco, Boulder, and Cambridge, MA, are reviewing options for providing next-generation policies that incentivize deep reductions in actual home energy performance. Rebates for RH&C and other high-efficiency technologies are valuable for driving the market, but they are based off of deemed or capacity-based performance rather than actual building performance and do not account for factors that may limit real world energy reductions (e.g. poor installation quality, unsuitable distribution system). While “pay for performance”-type incentives may not be suitable for every municipality (and implementing such incentives requires greater emphasis on evaluation, measurement and verification (EM&V), the

implementation of incentives that reward measured energy use or emissions reductions represent an important next step towards driving buildings towards deeper decarbonization.

Box 2. Incentive program recommendations from the Arup report.

The Arup report identified the following recommendations that fall within the incentive program category:

- Provide incentives for passive energy efficiency upgrades
- Provide incentives for electric heat pump technologies (particularly in commercial applications), which could be provided upstream to vendors
- Develop early replacement incentive programs for least-efficient technologies (i.e. electric resistance heating)
- Develop local demand response programs in order to offset winter peak loads from proliferation of heat pump technologies

Financing and business models

Incentive programs may be inadequate to sufficiently lower upfront costs of RH&C technologies to a level that many consumers can afford to purchase outright. Increasing access to low-cost financing (in combination with incentives) is critical to drive uptake of RH&C technologies. Municipalities have opportunities to implement or improve access to such financing programs and encourage development of innovative financing and business models.[2]

- **Establish/improve access to low-cost financing for RH&C.** Access to low-cost financing for RH&C technologies is critical for driving uptake. For example, a major heat pump manufacturer reported that as many as three-quarters of residential ASHP installations in Massachusetts have been installed through the HEAT Loan program where a 0% interest HEAT Loan is available for up to $25,000 over a 7-year term. Contractors there reported that the availability of this financing mechanism is considered to be a more valuable mechanism for driving homeowner action than the availability of incentives.

  Municipalities may have limited resources to establish new low-cost financing programs for RH&C, but other approaches can serve to improve access to low-cost financing for homeowners and businesses. Outreach by municipalities and community groups to local banks and credit unions can help to unlock opportunities to reduce the cost of financing for RH&C technologies. Additionally, Property Assessed Clean Energy (PACE) financing programs allow homeowners and businesses to access low-cost financing through municipal bonds repaid through property taxes. While PACE programs have been enabled through legislation in 33 states (13 of which enable residential PACE

[2] Note, the Arup report did not address policy recommendations for financing RH&C technologies.

programs),[3] municipalities must pass an enabling ordinance and establish a PACE program in order to make PACE financing available. Municipalities interested in increasing access to private capital for financing RH&C upgrades should consider taking such steps if their state has passed PACE-enabling legislation. Other opportunities for driving

- **Encourage development of third-party ownership models.** Third-party ownership (TPO) models (i.e. leasing agreements and power purchase agreements) have been very successful at catalyzing growth in the solar PV market, with the majority of PV capacity in major markets like California, New York, and Arizona installed under third-party models. The deployment of TPO models or other energy service models (as utilized by energy service companies) could help to drive deployment of RH&C by reducing upfront costs and/or offering "heat as a service."

  While such models are designed and deployed by the private sector, local policymakers can foster supportive environments for deploying these models through providing risk guarantees and incentives and engagement of local and regional developers. Municipalities can also engage utilities in developing utility-owned models for RH&C. Utility-owned models for solar PV are emerging such as the Arizona Public Service Solar Partner program and the Orlando Utilities Commission Community Solar Farm leasing program. Green Mountain Power established a residential cold climate ductless heat pump leasing program (zero-down starting at $42/month for 7, 10, or 15 year terms) in 2013.[4] Such leasing programs can be effectively established in jurisdictions with municipal utilities through public-private collaborations: Lakeland Electric established a leasing program for solar water heating in collaboration with PosiGen, which offers customers a locked-in lease rate of $34.95/month for 20 years.[5]
- **Identify financing opportunities for municipal gas replacement projects.** As shown in the analyses conducted, many electric heat pump technologies are not currently cost-competitive with gas heating. However, as Boulder's approach has highlighted, combining deep energy efficiency upgrades and on-site solar PV with natural gas replacement can greatly improve system economics and make overall upgrades cost-effective. Municipalities that face challenges in financing gas replacement systems alone should consider bundling gas replacement with other deep efficiency and/or distributed generation upgrades—or by working with ESCOs to get the full package of improvements financed and implemented.

[3] PACENation. (2016). PACE Programs Near You. Available at: http://pacenation.us/pace-programs/
[4] Green Mountain Power. (2016). Ductless Heat Pump. Available at: http://products.greenmountainpower.com/product/ductless-heat-pump/
[5] Lakeland Electric. (2016). Solar Water Heater. Available at: http://www.lakelandelectric.com/customers/programs-services/solar-water-heater

Mandates, regulations, and product standards

Local mandates, regulations, and product standards can be powerful tools for driving deployment of RH&C technologies. Building codes, technology mandates and standards, permitting requirements, licensing requirements, and municipal utility mandates and other measures can be effective opportunities for municipal governments to drive adoption of RH&C technologies and drive high quality/high-efficiency installations. The Arup report discusses policy recommendations for mandates, regulations, and product standards at length, which are summarized in Box 3 below.

- **Explore opportunities for reducing permitting costs.** While local ordinances can drive the adoption of RH&C technologies, they can also inhibit deployment by increasing soft costs that are ultimately passed onto the consumer. Moreover, different municipalities may have different ordinances with regards to permitting requirements and fees. Options for streamlining permitting and inspection include: reducing or establishing a flat fee for permitting; eliminating community-specific licenses for installations; reducing inspection appointment windows and the number of required inspections; and implementing an online, expedited permitting process.

Box 3. Mandates, regulations, and product standards recommendations from the Arup report.

The Arup report identified the following recommendations that fall within the mandates and regulations category:

- Enact building codes that encourage adoption of passive load reduction measures (e.g. adoption of most recent ASHRAE code, stretch codes)
- Explore approaches to assess code compliance and effectiveness of energy efficiency measures over time
- Support integration and accurate modeling of commercial heat pump water heaters and variable refrigerant flow technologies in code compliance software
- Mandate commercial reporting of energy usage data for benchmarking purposes
- Adopt local minimum efficiency standards that are not covered by federal standards (e.g. commercial heat pump technologies)
- Limit or ban applications of electric resistance heating
- Mandate duct testing and sealing during equipment replacement
- Advocate for more effective test procedures and efficiency standards for commercial heat pump technologies
- Support ongoing initiatives to drive development and certification of cold climate air source heat pumps

Outreach and education

Municipal governments are in a unique position to drive outreach and education for RH&C technologies among business and residents. In addition to helping achieve climate and energy goals, educational initiatives can help government leaders better serve constituents by helping business and residents identify opportunities to reduce energy costs, manage risk (e.g. reduce energy price volatility), or increase building comfort, among other goals. In some cases, community leaders have also formed bulk buying groups (i.e. solarize) to help local renewable energy industries scale up. Municipalities also are well-positioned for driving outreach to industry, especially to support workforce development or in advance or in conjunction with launching major outreach programs. The potential for municipal leaders to drive outreach and education initiatives was largely not treated in the Arup report; however, the following provides a number of high level recommendations that municipal leaders may consider.

- **Develop comprehensive community outreach programs for RH&C.** Municipalities are ideally positioned to drive community outreach efforts around energy, particularly by leveraging partnerships with local community groups. Such educational initiatives will likely be very important as municipalities seek to displace conventional heating fuels like natural gas and heating oil. Specific actions may include developing direct consumer marketing campaigns, online (one-stop shop) informational resources, or targeted network building initiatives that garner buy-in from key constituent groups (e.g. low-income developers, multi-family business owners, etc.).

  A key first step is analyzing the local market. As identified in Boulder's market segmentation analysis, some buildings may be better candidates than others for adopting RH&C technologies. Thus, it is also recommended that municipalities conduct basic market segmentation analyses using available data to identify high-potential candidates based on key building and occupant characteristics (e.g. heating with oil, propane, or electric resistance; income level; estimated age of existing heating system).

  Based on findings from such analyses, community leaders can then develop customized outreach messages to drive RH&C education campaigns and help local residents make informed purchasing decisions. As noted above, the activities and messaging of the outreach campaign will depend upon the goals of the community and potential for local partnerships, though various outreach activities may include direct mailing, social media campaigns, coalition building, public events, or other initiatives.

- **Design and implement community bulk procurement programs.** As a part of RH&C outreach, municipalities may also design and implement community bulk procurement programs. The "Solarize" model has proven to be an effective means to accelerate solar PV adoption and jumpstart market development by aggregating customer leads in a bulk purchasing program for solar PV. This approach helps community leaders mobilize

community members through outreach and educational events to purchase solar PV together at a lower group rate. A similar approach could be adapted to suit RH&C technologies.

A number of local organizations have piloted programs that modify the Solarize model to serve electric vehicles, RH&C technologies, and energy efficiency (e.g. HeatSmart Tompkins, WePowr, Solar Benefits Colorado). Initial results clearly show that municipalities, in collaboration with community groups, can provide credibility to support development of local energy markets and increase awareness of and trust in the performance of new technologies such as RH&C systems. There are a number of technical resources that communities can leverage to support such campaigns. For example, the WePowr platform (www.wepowr.com) – which was initially developed with funding from the Massachusetts Department of Energy Resources – is providing technical assistance to communities across the U.S., including Boston, Providence (RI), Portland (ME), and Sanibel Island (FL).