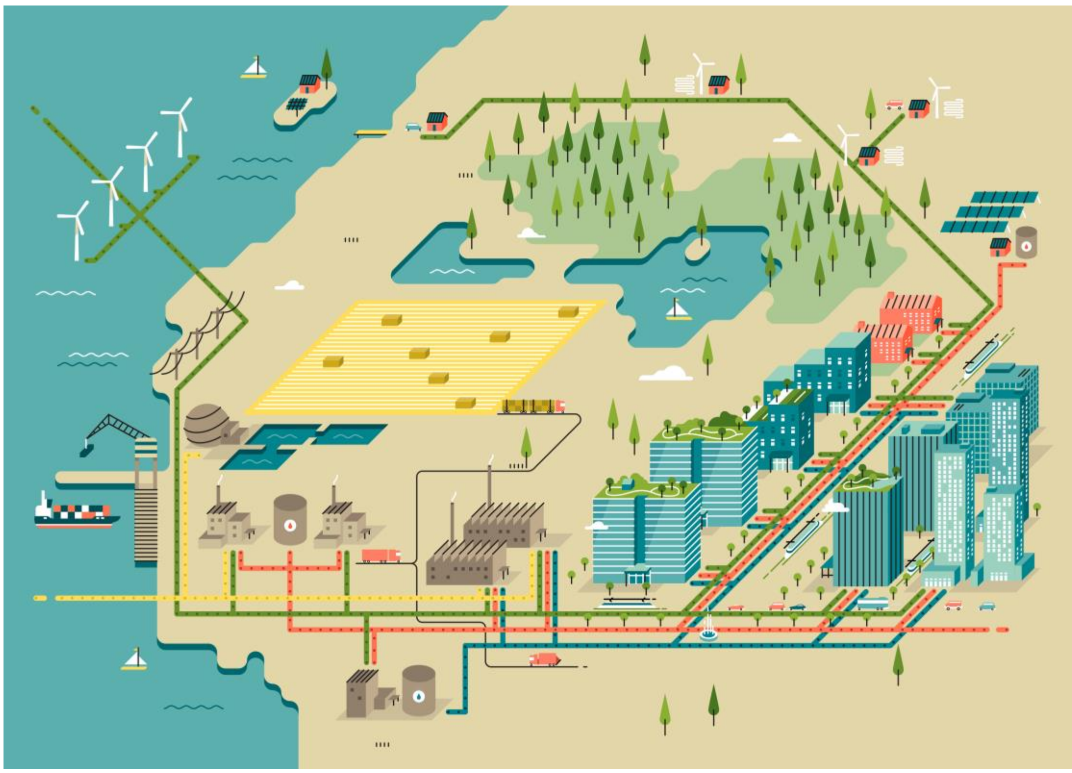
CITY OF CAMBRIDGE

LOW CARBON ENERGY SUPPLY STRATEGY



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DESCRIPTION
The City of Cambridge engaged a consultant team led by Ramboll to undertake a Low Carbon Energy Supply Strategy study in support of the City's commitment to reach carbon neutrality by 2050. The purpose of the study was to determine current and future energy demand, assess the potential for renewable energy generation in Cambridge, develop technical scenarios for renewable energy delivery systems, and evaluate the risks, benefits, and feasibility of each scenario along with discussion of potential implementation pathways.

ACKNOWLEDGEMENTS:

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EXECUTIVE SUMMARY

In late 2016 the City of Cambridge engaged a consultant team led by Ramboll, a Danish consulting firm with significant international experience in renewable energy master planning, to undertake a Low Carbon Energy Supply Strategy study ("the study") in support of the City's commitment to reach carbon neutrality by 2050. The purpose of the study was to determine current and future energy demand, assess the potential for renewable energy generation in Cambridge, develop technical scenarios for renewable energy delivery systems, and evaluate the risks, benefits, and feasibility of each scenario along with discussion of potential implementation pathways. The 12-month study process was supported by a stakeholder advisory committee representing city departments, utilities, developers, property managers, universities, state agencies, and adjacent cities.

KEY BACKGROUND INFORMATION

In June 2015, a Net Zero Action Plan for buildings was adopted by the Cambridge City Council.[1] The action plan contains the following 5 focus areas to be addressed over the next 25 years in order to meet the objective of reducing greenhouse gas emissions by 70% by 2040 and set Cambridge on the pathway to carbon neutrality by mid-century:

1. Energy Efficiency in Existing Buildings
2. Net Zero New Construction
3. Energy Supply
    - **3.1 Low Carbon Energy Supply Strategy**
    - 3.2 Rooftop Solar Ready Requirement
    - 3.3 Memorandum of Understanding with Local Utilities
4. Local Carbon Fund
5. Engagement & Capacity Building

OBJECTIVE

The objective of this study is to provide a better understanding of the potential for and barriers to a transition to renewable energy and low carbon energy solutions in Cambridge considering the following framing questions:

- **Key Question 1:** What is the current and future energy demand from buildings?
- **Key Question 2:** What local and regional low carbon energy sources could be utilized in Cambridge to change its energy supply?
- **Key Question 3:** Which low carbon energy sources and scenarios are technically viable and meet Cambridge's financial, environmental and social objectives?
- **Key Question 4:** How can the goal for clean energy generation be advanced over the next 25 years in order to achieve the options outlined herein and the City's carbon neutral objective?

For the purposes of the study, the City adopted a set of goals, closely modeled after goals developed by the Carbon Neutral Cities Alliance[2], for a future energy supply system. The energy supply system should be:

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[1] See the full Net Zero Action Plan at http://www.cambridgema.gov/CDD/Projects/Climate/NetZeroTaskForce

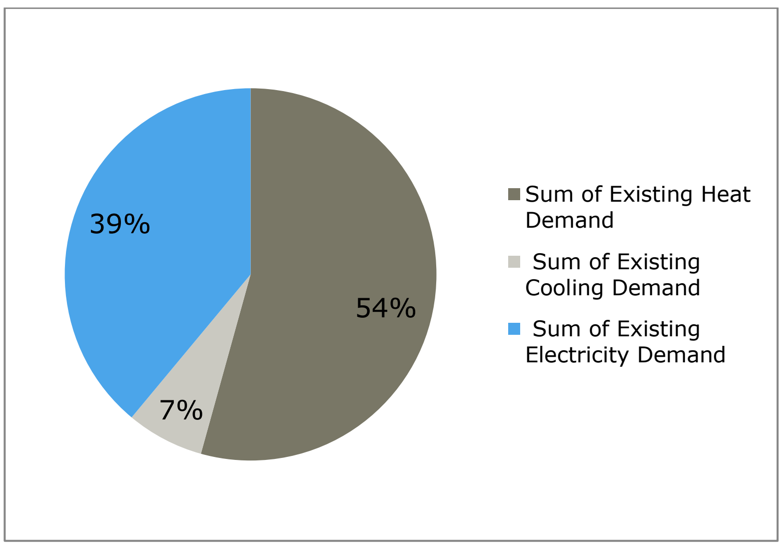
[2] From the Carbon Neutral Cities Alliance *Framework for Long-Term Deep Carbon Reduction Planning*, p. 60, available at http://usdn.org/uploads/cms/documents/cnca-framework-12-16-15.pdf

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

APPROACH

The largest energy demand in the City to be supplied by low carbon energy today and in the future is the thermal demand to heat and cool Cambridge's buildings. Addressing this will derive the biggest impact when converting the energy supply to a low carbon energy supply system with a subsequent reduction in fossil fuel consumption.

Figure 1 Existing Energy Demand Split in Cambridge by use type



Over the next 20 years, it is expected that the total building energy demand will reduce by 35%, with a 59% decrease in heat energy consumption and a 28% decrease in electrical energy consumption resulting from improvements in building and equipment energy efficiency as well as reduced heating demand due to climate change. Increased summer temperatures, however, will lead to a 115% increase in cooling energy consumption.

To satisfy this energy demand, a total of 10 energy supply scenarios were developed, 3 of which were shortlisted and brought forward for assessment in this report in comparison with a Business as Usual case:

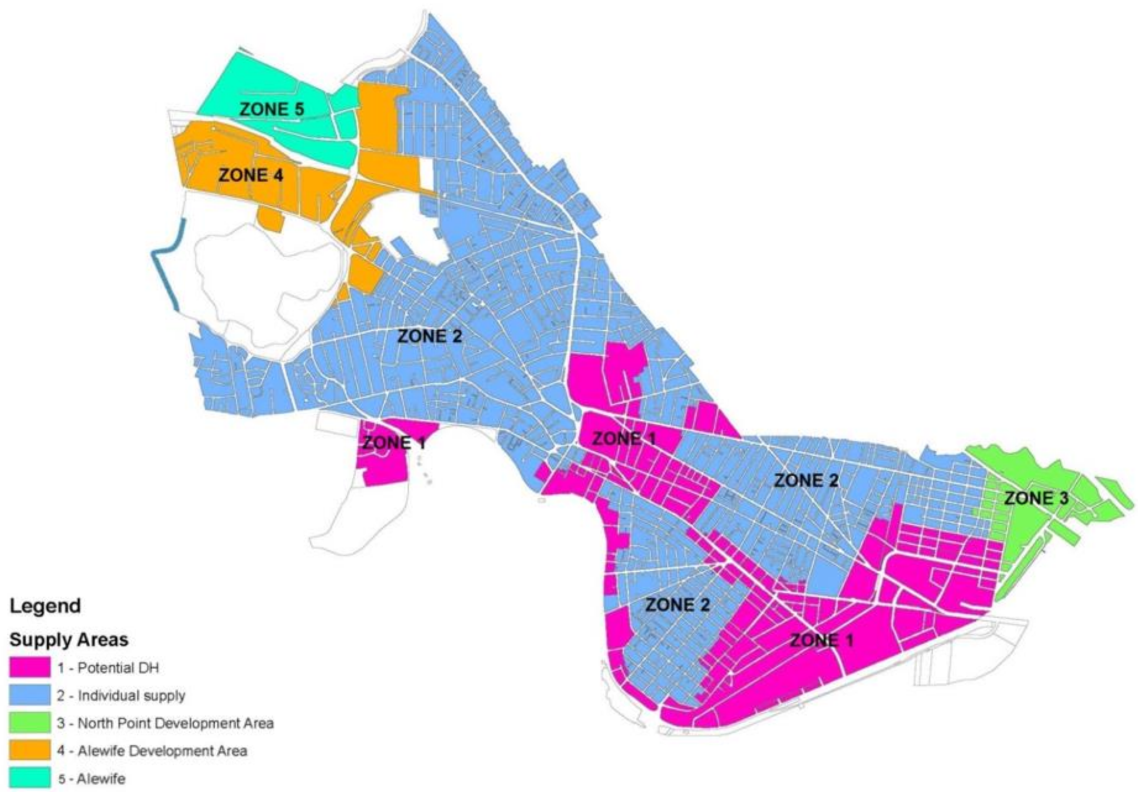
- Scenario 1: Individual building electrification
- Scenario 2: Individual building electrification with district heating/cooling where viable

- Scenario 3[3]: District heating and cooling with multiple supply technologies

For the purposes of the assessment, the city was split into zones based on thermal energy demand intensity:

- Zone 1 – Potential District Heating (high demand)
- Zone 2 – Individual Supply Area (mainly residential)
- Zone 3 – North Point Development Area (growing demand)
- Zone 4/5 –Alewife Development Area (growing demand)

Figure 2 Energy Zones Based on Energy Demand Intensity



The conclusions in the report are different for each scenario and zone.

For the **Business as Usual** (BAU) scenario it is assumed that the existing technologies for heating and cooling production are continued throughout the planning period from 2020 to 2040. Necessary reinvestments in the technologies are included. Heat pumps and gas boilers are assumed as the technologies of choice for new buildings in the development zones.

For **Scenario 1** it is assumed that heating technologies in all buildings are to be converted to 100% electric technologies such as heat pumps and electric boilers for heat production. A heat pump extracts energy (low temperature) from one source (typically air, ground or water) and supplies the energy to another source (higher temperature) or vice versa for cooling. Heat pumps can operate at a higher rate of efficiency than electric boilers, and so deliver more heat per unit of electrical energy consumed. Solar thermal (producing hot water utilizing the energy of the sun) is also a potential technology but it is assumed that in the future roof tops are already used for solar photovoltaic (PV) electricity production

[3] Scenario 4 in the main report has been changed to Scenario 3 in the Executive Summary for ease of reading.

and the available space for additional energy equipment is limited. Production of chilled water for cooling is assumed to continue to be based on electrical chillers as it is today.

Implementation of Scenario 1 will require the electrical transmission and distribution system to handle a significant capacity increase due to all thermal energy supply being delivered via the electrical grid versus the use of natural gas and other fuels today. It will be necessary to reinforce the entire electrical infrastructure in the city with a focus on Zone 1 and the main high voltage lines supplying the city.

Scenario 2 is very similar to Scenario 1 but with the addition of district energy infrastructure where viable. A district energy system consists of central energy production to create hot water or chilled water, a water pipe network distribution system, and a heat exchanger station (also called "Energy Transfer Station" or ETS) located at the consumer end. The network supplies the energy produced centrally to each consumer. Furthermore, there is often large thermal energy storage capacity connected to the network to enable independent production of electricity and heat, if the production technology is based on combined heat and power cogeneration. Such networks are often citywide and can supply several thousand consumers with hot or chilled water, but can also be developed at the district scale.

In order to demonstrate the technical potential of an efficient heat source in the vicinity of Cambridge, Scenario 2 assumes that heat for Zone 1 is produced by large-scale electrical heat pumps driven by energy extracted from the Mystic River at the approximate location of the existing Mystic River power plant. Extracting heat from the Mystic River is an economically and technically viable option, with the potential to supply 40% of the annual thermal demand of Zone 1, with the remainder coming from electric boilers. The heat pump will produce approximately 3 units of heat using 1 unit of electricity and two units of energy from the river. As a result, the increase in electricity consumption over BAU will be lower compared to the electric boilers necessary for Scenario 1.

In **Scenario 3**[4] numerous energy sources were investigated and assessed as potential alternative supply options for Cambridge, with the following being determined to be unviable sources of energy supply due to lack of sufficient production capacity or other barriers:

- Deep geothermal energy (>0.6 miles depth)
- Waste heat from sewers
- Waste heat from the MBTA tunnel system
- Heating / cooling from the Charles River
- Open system Aquifer Thermal Energy Storage
- Heat recovery from electricity substations
- Industrial waste heat recovery

The potential for a waste to energy plant to be sited in Cambridge was also investigated but rejected. Waste to energy plants combust municipal solid waste (MSW) as a fuel source to produce heat and electricity (it is possible to attain 95%+ efficiency at the Lower Heating Value). In addition to the issues with siting such a plant in the city, the waste streams generated in the city would meet only a very small percentage of the total future energy demand of the city, requiring the city to be a waste importer to use such a technology to meet its energy demand. Anaerobic digestion was discounted for the same reasons.

Due to the city's size, built out nature, close proximity to other cities and limited access to alternative energy sources there is limited potential for energy generation within the city's boundaries. Full roll out

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[4] Note that this is referred to Scenario 4 in the body of the report because it was the fourth of the six scenarios considered initially before three scenarios were advanced for final analysis.

of photovoltaic and solar thermal technologies in available space within the City was modeled against demand, and this would not be able to supply a significant portion of citywide energy demand.

As a result, some options outside the city boundaries were also investigated. Siting a biomass combined heat and power (CHP) facility at the Mystic River power plant site was assessed and determined to be an economically and technically viable option with the delivery of biomass via ship along the Mystic River. Such a plant would produce heat and electricity using biomass as a fuel source.

Today in Massachusetts, biomass CHP plants with efficiency in excess of 60% receive a Renewable Energy Certificate (REC) for every MW produced which has monetary value, but the REC system is determined by state policy and is subject to change over time. In addition, there are outstanding questions to be resolved with regard to biomass in Massachusetts and whether it is truly carbon neutral since burning biomass does produce GHG emissions that may or may not be fully balanced by the GHGs absorbed by the growing of biomass, as well as where a sustainable feed stock would come from due to the limited supply chain currently in existence in Massachusetts.

STUDY RESULTS

Summary of Conclusions

Decarbonization of the energy supply for Cambridge buildings will require a combination of approaches over time. There are limited energy supply resources within Cambridge, yet a Business as Usual pathway locks in fossil fuel infrastructure in buildings and the supply chain in a way that precludes meeting the commitment of carbon neutrality by 2050. Electrification of buildings with grid-supplied electricity is likely to play a central role, but can't achieve acceptable levels of cost and environmental efficiency without introduction of district energy systems in areas of high energy demand and depends on decarbonization of the regional grid. District energy offers increased system efficiency, resilience and flexibility of energy sources, including biomass, which requires further consideration. Achievement of a future low carbon energy supply for Cambridge must be considered in the context of a regional clean energy transformation. Such consideration should occur through a regional stakeholder group which can identify and address key questions and barriers in a coordinated manner.

The results of the study show that Scenario 3 with hot water district heating combined with thermal energy storage and supplied by combined heat and power plants using low carbon fuel sources, such as biomass, has both the lowest cost as well as the lowest equivalent carbon emissions compared to alternative supply scenarios developed under this study if biomass can be determined to be carbon neutral. Additionally, this scenario has the potential to meet all of the City's goals for its future energy supply. Water based district energy also facilitates the following benefits:

- The use of both heat and power from CHP plants, thus providing highly efficient energy generation and making the most of primary energy used
- Thermal storage integrated into the energy system improves generation efficiency and resilience
- District energy networks and thermal storage can be used to store excess renewable electrical energy, increasing the electrical grid stability as a result and maximizing use of variable renewable energy sources
- Lower operation and maintenance costs than traditional steam networks
- Lower installed generation capacity is necessary as heat (or chilled water) is not needed at the same time leading to reduced capital investment

- Opens the potential utilization of low temperature waste heat sources such as those from industry, waste water treatment plants, data centers, rivers, geothermal etc.

District cooling is viable in clusters for all city zones except the residential Zone 2. District cooling will improve the efficiency of the cooling supply, reduce the load on the electrical supply and subsequently improve resilience where installed.

Electrification of the whole city is shown to be the costliest alternative scenario with the highest GHG emissions based on electrical grid carbon intensity forecasts for Massachusetts which incorporate future Renewable Energy System (RES) generation forecasts that do not achieve carbon neutrality during the study period. However, due to the lower thermal energy demand of the residential Zone 2, electrification should be pursued in this zone under all scenarios by promoting the use and understanding of the following technologies: air source heat pumps; ground source heat pumps; electric boilers; chillers; air conditioning units; solar photovoltaic and solar thermal.

Outlined in Table 1 below are the economic assessment of the scenarios as discussed above.

Table 1 Final economic results of all scenarios (Net Present Value; M$)

Financial results	BaU	Scenario 1	Scenario 2	Scenario 3
Fuel costs	4,111	5,637	4,618	3,531
Variable operation & maintenance	72	74	86	91
Fixed operation & maintenance	112	67	56	171
Capital expenditures (CAPEX)	600	2,942	1,689	1,386
Total	**4,896**	**8,721**	**6,449**	**5,180**
Additional cost compared to business-as-usual	---	+3,825	+1,553	+284

Outlined in Table 2 below are emissions per scenario together with the cost of offsetting the carbon emissions by buying carbon credits in 2040.

Table 2 Emissions per scenario in 2040

Emissions results[5]	BaU	Scenario 1	Scenario 2	Scenario 3
CO_2 equivalent (kton)	387	162	136	63
SO_2 emissions (ton)	27	1	1	38
NO_X emissions (ton)	286	112	92	193
$PM_{2.5}$ emissions (kg)	1,126	211	165	5,456[6]
Cost of off-setting carbon emissions with a carbon price of 50 $/ton (M$)	19.35	8.1	6.9	3.2

[5] CO_2: carbon dioxide; SO_2: sulfur dioxide; NO_x: nitrous oxides; $PM_{2.5}$: particulate matter

[6] It should be noted that PM2.5 is reported in kilograms here and not tonnes. The emissions level indicated for Scenario 3 is based on Best Available Technology standards for emission control in the Industry Emissions Directive in Europe http://ec.europa.eu/environment/industry/stationary/ied/legislation.htm. This emissions level can be further reduced, but the costs increase significantly to do this and this level of emissions is deemed acceptable across Europe for emissions from industrial plants. To give further context to this, the current permit for the Kendall Square plant shows a limit of 86.3 TPY (tonnes per year) or 86,300 kg/year total PM emissions (PM10+PM2.5) based on their permit MBR-00-COM- 029: https://www.mass.gov/files/documents/2016/08/ta/op-kendallgreen.pdf

KEY CONSIDERATIONS FOLLOWING THE STUDY

- The thermal heating and cooling demand of Cambridge today and in 2040 exceeds the electrical demand of the City (excluding any increases in demand due to electrification of vehicles).
- Continuing with the current energy supply approach locks in fossil fuel infrastructure in buildings and the current supply chain in a way that precludes meeting the commitment of carbon neutrality by 2050.
- Fuel costs constitute a significant proportion of the total net present value over the next 20 years for each scenario, ranging from 84% for the Business as Usual case to 68% for Scenario 3. This emphasizes the impact of utilizing primary energy efficiently to generate and distribute thermal energy and power to consumers, as well as understanding the certainty of fuel costs under each scenario.
- Decarbonization of the electrical grid is necessary to achieve emission reduction goals for Scenarios 1 & 2, the continued use of electricity for cooling, and the electrification of low density areas such as Zone 2. Yet the carbon intensity of grid electricity is very dependent on the regional grid and electricity market stakeholders: Eversource, NEPOOL, ISO-NE, etc. Current plans for the grid do not achieve a low carbon supply by 2040. However, shifts in policy could change this condition.
- Full roll out of photovoltaic and solar thermal technologies in available space within the City should be pursued where possible, but will not make a significant effect on the renewable energy supply of the City.
- Low carbon energy sources within City limits are limited.
- Electrical grid upgrades should be planned and implemented to facilitate building electrification where required and the bearer of these costs needs to be considered in relation to who benefits from the changes.
- Biomass is proposed in Scenario 3 as the cogeneration low carbon fuel supply. Today this is the best low carbon fuel supply for on-demand generation and is more sustainable than fossil fuel alternatives. This is currently supported by the state policy-driven Renewable Portfolio Standard scheme which provides RECs for biomass energy generation, provided it meets certain energy generation criteria. However, the true carbon neutrality of biomass is still subject to significant debate and Cambridge will need to determine its position before pursuing this course. As with all fuel supply for energy projects, the logistics and market supply of biomass will also need to be considered further for each specific project proposed.
- Due to the limited renewable energy generating potential in the city and the fact that the electrical grid is expected to still have a moderate to high carbon intensity by 2040, there may be a need for the City to utilize a suitable carbon offsetting mechanism to meet its Net Zero objective. Options for this include establishing a renewable electricity project outside the City boundaries, Power Purchase Agreements (PPAs) or Community Choice Aggregation (CCA) expanded beyond the current program.
- Cambridge is a small city situated within numerous cities in the greater Boston Metropolitan Area. Due to the built-out nature of the cities and the limited alternative resources available to each, it is important that a regional approach be pursued to identify and address the key outstanding questions and barriers to achieving a low carbon energy supply. Such a regional approach could incorporate the involvement of the following stakeholders:
    - Neighboring communities
    - MAPC

- State agencies, such as DOER, MassCEC, MassDEP, DPU
- Relevant utilities
- Potential district energy network participants (customers, operators, etc.)

OUTSTANDING QUESTIONS FOLLOWING THE STUDY

Technical Basis for a Low Carbon Energy Supply

This study has investigated, assessed and modeled numerous energy supply scenarios involving multiple technologies for Cambridge in order to determine the best path forward towards the carbon neutral target for its energy supply.

The study provides a menu of solutions and pathways for to how to proceed, which can be used as a template regionally to build regional solutions for achieving a low carbon energy supply.

The following sets of questions can help Cambridge advance the key conclusions of the study.

How does Cambridge transition to all-electric buildings?

Heat pumps will likely play a key role in decarbonizing the heat supply of the residential Zone 2 and in other city zones where district energy connection is not viable. Under the state Alternative Energy Portfolio Standard (APS) scheme, financial incentives are provided for installation of ground and air source heat pumps.

If such technologies are to be further incentivized, it should be structured in such a way to encourage ground source heat pump installation over air source heat pumps when the option is available as done by the current APS. Ground source heat pumps are more efficient than air-source heat pumps, as the ground provides a more consistent heat source, so require less electricity capacity to power them. However, ground source heat pumps and the associated installation have a higher capital cost and so may not be invested in by consumers, even when they have the space to install them.

Some additional questions to be considered with regard to all-electric buildings include:

- How to match the regional grid capacity and grid modernization process with Cambridge thermal demand needs?
- How to utilize the existing city outreach and support network to make consumers aware of electrification technology and incentives?
- All customer uses and need for resilience should be considered when progressing; who bears responsibility for building and grid-level capacity, resilience, and necessary upgrades?
- How best to incentivize and motivate building owners to make such a change to electrification?

How does Cambridge establish hot water district heating and cooling networks in the high-density areas of the city?

Establishing district heating and cooling infrastructure, business, and institutional arrangements would require considering many elements as outlined below.

Technical Considerations

- What is the existing heating technology in place in the building, the cost of changing to water-based systems, and the benefits of district heating connections?
- Where will the long term energy supply source and location for the greater heating network be?

- How can district energy be used by the City to meet energy storage goals? How can thermal energy storage and greater use of district energy be used regionally to facilitate integration of intermittent generation sources while improving resilience?

Economic Considerations

- Which consumer types will connect to district energy in the high density area?
- Which buildings have sufficient energy demand to make connection viable, and who will finance the cost of their conversions to utilize the network?
- What buildings can fulfill the role of anchor consumers to establish initial networks from which to expand?
- What is the best business model for district heating and cooling implementation?

Regulatory Considerations

- Existing large heat generation sources in the city are likely to have over-capacity available for supply at certain times which could be used to contribute to a district energy system. What technical and regulatory approaches can enable the use of this capacity?
- Hot water district energy and tariff regulation need to be established at the state level to facilitate the purchase and sale of heat between multiple parties and will require state agency engagement.

Where will clean energy come from to meet Cambridge's energy demand?

In addition to methods of energy transmission such as the electrical grid and district energy networks, additional low carbon energy needs to be generated in order to be supplied. The following questions should be considered in this context.

Technical Considerations

- What is the technical and political viability of biomass as a low-carbon fuel source in Cambridge?
- How to maximize local renewable energy generation, e.g. solar PV?
- How can large generation plants be sited to supply Cambridge in context of the greater Boston region?

Policy Considerations

- How best to enable state and utility action to modernize the grid and develop renewable energy to meet low carbon requirements?
- How to drive the development of more grid-scale renewable energy using tools such as the Renewable Portfolio Standard and joint renewable energy procurement?
- Does carbon offsetting meet the requirements of the Net Zero target?
- Do Power Purchase Agreements (PPAs) or Community Choice Aggregation (CCA) providing Renewable Energy Certificates (RECs) from outside of the Regional Greenhouse Gas Initiative (RGGI) states meet the requirements of the Net Zero target?

Regulatory Considerations

- What potential is there for regional agreement on how and where additional clean energy could be generated in order to meet the regional low carbon intensity electrical demand which ISO-NE cannot provide?
- How to manage the transition away from fossil fuel and its infrastructure such as the natural gas networks?

Economic considerations

- Who will drive the process of and pay for grid modernization?
- How to finance the construction cost of clean energy facilities in Cambridge and the region?

Next Steps for Cambridge

Collaborative Stakeholder Driven Approach Required

Ramboll has undertaken a change management assessment in parallel with the technical feasibility stage for this project. This process has identified the steps that could be followed in Cambridge in order to achieve the decarbonization of the city's energy supply.

Achieving a low carbon energy supply will be a significant challenge with complex parts to be addressed, many of which are not under the City's direct control, but require decisions and actions by utilities and state agencies and are best undertaken at a regional scale across municipal boundaries. In order to make progress towards identifying a common strategy for achieving a carbon neutral energy supply, a stakeholder group should be identified to drive this agenda and continue to push for the changes needed to make progress on a timeline that will lead to carbon neutrality by 2050. This group could include the members of the study Advisory Committee who represented local academic institutions, utilities, businesses, state agencies, and City Departments. Additional state and regional entities such as the Department of Public Utilities and ISO-New England should also be included. An organization and leadership structure will need to be established for this group, with potential coordination by the Metropolitan Regional Planning Council (MAPC). Initial questions for the group to address include:

- What are current state energy-related planning processes and what allowances do they make for municipal collaboration?
- What form would regional project organization for implementation take and who would lead such efforts regionally?
- What are the enabling factors for regional approaches to challenges raised above?

Based on the study conclusions, action on the following areas should be prioritized for implementation of a low carbon energy supply strategy in Cambridge:

Residential Electrification

A common aspect of the study's findings is that electrification of the energy supply in low density residential areas of the city should be pursued under all scenarios. This includes the installation of solar PV and the transition to electric heating systems such as air and ground-source heat pumps. The Cambridge Energy Alliance can be an effective proponent of these measures through programs such as Sunny Cambridge[7] and a new platform to connect consumers to vendors of renewable thermal systems.

Existing Infrastructure Strengthening

Electrification would include the heating, cooling and cooking aspects of energy demand in low-density residential area and replacement of related equipment. A key step to facilitate electrification is increased investment in grid strengthening and modernization in partnership with Eversource. This will build on their Grid Modernization and Planning (GMP) program to ensure that the increased electricity needs identified in this report can be met.

[7] http://www.sunnycambridge.org

Electrification of these residential areas would also require changes to the building stock to accommodate an electric heat source. This effort should be integrated with the implementation of the Cambridge Net Zero Action Plan.

Enabling District Energy

Densely populated areas of the city with high thermal energy demand should work towards the development of water-based district heating and cooling networks. As described in detail in Section 6 of the report, eight steps have been drawn from the United Nations Environment Programme report on District Energy in Cities:[8]

Step 1: Assess existing energy and climate policy objectives, strategies and targets, and identify catalysts

The City has set a 2050 target for reaching carbon neutrality. A technical analysis has been undertaken, demonstrating the viability of district energy in current or emerging high-energy demand districts.

Step 2: Map local energy demand and evaluate local energy resources

This step has been completed but will need to be regularly updated and expanded upon (see Step 5).

Step 3: Strengthen or develop the institutional multi-stakeholder co-ordination framework

The Advisory Committee assembled under this study has provided significant input and opinion to develop this study. For the realization of a district energy utility, there would be a need for multiple stakeholders to be assembled to work within a coordinated framework.

Step 4: Determine relevant regulatory and policy design considerations and integrate district energy standards into state and/or local energy strategy and planning

Water based district energy is not an established utility in the City today and no regulatory framework exists at the state level, although the benefits and economic viability exist to support its establishment. In order to catalyze its establishment as a utility there will be a need for well-considered state and local policy and regulatory design to encourage its establishment.

It is recommended that district energy with relevant modern standards be incorporated into state plans and regulations through agencies such as the Department of Public Utilities and citywide planning recommendations and that, once hot water district energy is enabled at the state level, any necessary changes be made to the municipal zoning ordinance to enable and encourage its adoption in the zones highlighted within this report.

Step 5: Carry out project feasibility and viability

The feasibility assessment of district projects should include further evaluation of district energy boundaries and participants and an economic viability model that considers: available incentives at the time of development to support the utility's installation; how gas consumers could be switched over; and the approach to transitioning institutions and infrastructure away from the use of natural gas.

[8] http://staging.unep.org/energy/portals/50177/Documents/DistrictEnergyReportBook.pdf

Step 6: Develop business plan and financing approach

A project business plan serves as a blueprint to guide and supervise the project's objectives, policies and strategies. A business model which is replicable and scalable both technically and financially at the district level will be key to the acceleration of district energy in the City.
Some business model options include:

- The "wholly public" business model
- The "hybrid public and private" business models
- The "wholly private" business models

Financing will depend on the business plan developed and the model for implementation. With all investment, the lower the risk and the higher the return, the more attractive the investment becomes. For district energy projects, capital is typically invested prior to the connection of customer buildings; thus, the greatest risk in system deployment is load uncertainty.

Step 7: Analyze procurement options

In cases where a municipality plans to maintain ultimate ownership of the utility, whether through a concession contract or some form of Public Private Partnership (P3), the preferred method of Utility Operator procurement should be assessed once a project has been defined and the business model and plan are established.

Step 8: Set measurable, reportable and verifiable project indicators

Milestones can be set by working backwards from the carbon neutral target year of 2050 and establishing critical pathways to ensure success. The milestones and their associated indicators need to be measurable and verifiable to facilitate management of the program and maintain progress.