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Innovation Network for Communities
The Building Electrification Initiative

The Building Electrification Primer for City-Utility Coordination

Acknowledgements

The Cadmus Group developed this resource in collaboration with the Building Electrification Initiative (BEI) and the participation of a network of city and utility advisors including City of Burlington (VT), Boulder (CO), Providence (RI), Washington DC, National Grid, and Burlington Electric Department.

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City leads overseeing this project include Jennifer Green (Burlington) and Cristina Garcia (New York City). Lead authors include Neil Veilleux, Jeremy Koo, and Megan Lynch at Cadmus with supporting editorial and advisory support from Jenna Tatum and Laura Tajima at BEI. Additional research, design services, and review provided by Rebecca Coombs (IFOK), Jamie Daudon, Will Sloan, and Ryan Cook (Cadmus).

Common Acronyms

Acronym	Definition
ASHP	Air Source Heat Pump
BE	Building Electrification
CE	Cost Effectiveness
COS	Cost of Service
DER	Distributed Energy Resource
EE	Energy Efficiency
EERS	Energy Efficiency Resource Standard
EV	Electric Vehicle
GHG	Greenhouse Gas
GSHP	Ground Source Heat Pump
HPWH	Heat Pump Water Heater
IOU	Investor Owned Utility
LMI	Low and Moderate Income

Acronym	Definition
MOU	Memorandum of Understanding
NOx	Nitrogen Oxides
PACT	Program Administrator Cost Test
PBR	Performance Based Regulation
PCT	Participant Cost Test
PIM	Performance Incentive Mechanisms
PUC	Public Utility Commission
RIM	Ratepayer Impact Measure
RPS	Renewable Portfolio Standard
SCT	Societal Cost Test
T&D	Transmission & Distribution
TRC	Total Resource Cost

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Objective and Approach | Overview

Goal of this Primer: To support cities in cultivating effective partnerships with utilities to accelerate the transition to building electrification by identifying challenges and collaborative solutions.

Development of this Primer included:

Advisory Group

- Composed of eight advisors representing five cities
- Met four times over the course of the project
- Reviewed and provided input on project goals, preliminary findings, and the final report

Research

- Conducted literature review of opportunities and challenges related to building electrification for utilities
- Researched typical utility business models and state regulatory models

Expert Interviews

- Conducted 20 expert interviews with city, utility, and regulatory experts in the U.S. and internationally
- Incorporated key findings into report and case studies

Objective and Approach | Advisory Committee

An Advisory Committee of city staff reviewed and provided input on project goals, preliminary findings, and the final report. Members of the Advisory Group are listed below.

Name	Title and Organization
Jennifer Green	Sustainability Coordinator, City of Burlington
Chris Burns	Director of Energy Services, Burlington Electric Department
Cristina Garcia	Policy Advisor, NYC Mayor's Office of Sustainability
Nikki Joseph	Clean Energy Communities Coordinator, Solar One
Leah Bamberger	Director of Sustainability, City of Providence
Edward Yim	Energy Policy Advisor, D.C. Department of Energy and Environment
Carolyn Elam	Energy Program, Strategy Manager, City of Boulder
Brett KenCairn	Senior Climate + Sustainability Coordinator, City of Boulder

Objective and Approach | Primer Structure

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Section 1 Overview | Definition and Drivers of Building Electrification

Section 1 covers the following topics:

Topic	Description	Slide
Defining Building Electrification	• Defines building electrification in context of the broader clean energy transformation • Describes common building electrification technologies and their applications	10 – 12
Drivers of Building Electrification	• Describes the value of building electrification for consumers, society, and the utility • Describes the opportunity for utilities and cities to collaborate to achieve common goals and mitigate key risks of building electrification	13 – 22

Defining Building Electrification | Context

On-site fossil fuel use to create heat and hot water is the largest source of energy use and GHG emissions in buildings across the U.S.

Over 70 million homes and businesses in the U.S. burn fossil fuel on-site for space heating and hot water production

In a typical U.S. city, on-site fossil fuel use in buildings accounts for between **15%-40% of total citywide GHG emissions**

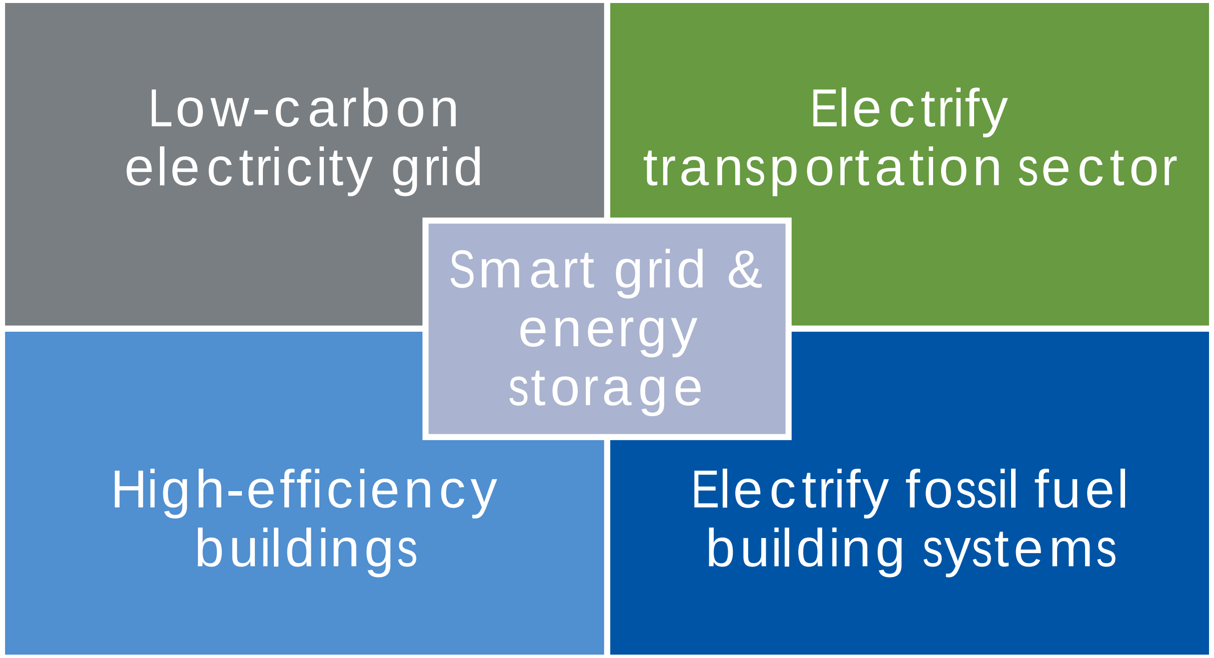
Defining Building Electrification | Beneficial Electrification

Building electrification means converting building systems that use fossil fuels (gas, oil, or propane) to high-efficiency electric equipment that can be powered by increasingly clean and renewable electricity. Building electrification can also include conversion of inefficient electric heating technologies to high-efficiency heating technologies.

“Beneficial” electrification meets one or more of the following conditions without adversely affecting the other two:

1. **Save consumers money in the long run**
2. **Enable better grid management**
3. **Reduce negative environmental impacts**

Beneficial building electrification is a key element of a broader clean energy transformation:



Defining Building Electrification | Technologies

While multiple technologies could be scaled up to decarbonize building heating systems, **this report focuses on three electrification technologies: air source heat pumps (ASHPs), ground source heat pumps (GSHPs), and heat pump water heaters (HPWHs).**

Technology	Applications			Description
	Space Heating	Space Cooling	Domestic Hot Water	
Air Source Heat Pumps (ASHPs)	✓	✓		ASHPs use electricity to transfer heat from outside air into an indoor space to provide space heating. ASHPs can run in reverse to provide space cooling like a conventional air conditioner.
Ground Source Heat Pumps (GSHPs)	✓	✓	✓	GSHPs use electricity to transfer heat from the ground. GSHPs can provide heating, cooling, and hot water heating at highest efficiencies.
Heat Pump Water Heaters (HPWHs)			✓	Similarly to an ASHP, HPWHs use electricity to transfer heat from indoor or outdoor air into a storage tank to heat water. *There are some, but limited, heat pumps that transfer heat into a hydronic loop to provide heating to a building.

Drivers of Building Electrification | Value for Customers, the Public Interest, and Utilities

Building electrification helps achieve a range of climate, social, and economic goals, providing value to customers, utilities, and the broader public interest.

Benefits	Value for Customers	Value for the Public Interest	Value for Utilities
Improves air quality and public health	■	■	
Reduces economy-wide energy consumption	■	■	
Improves comfort and provides cooling	■	■	
Potential to provide energy cost-savings	■	■	■
Reduces GHG emissions		■	■
Potential to enable new utility business models			■
Potential to provide grid flexibility			■

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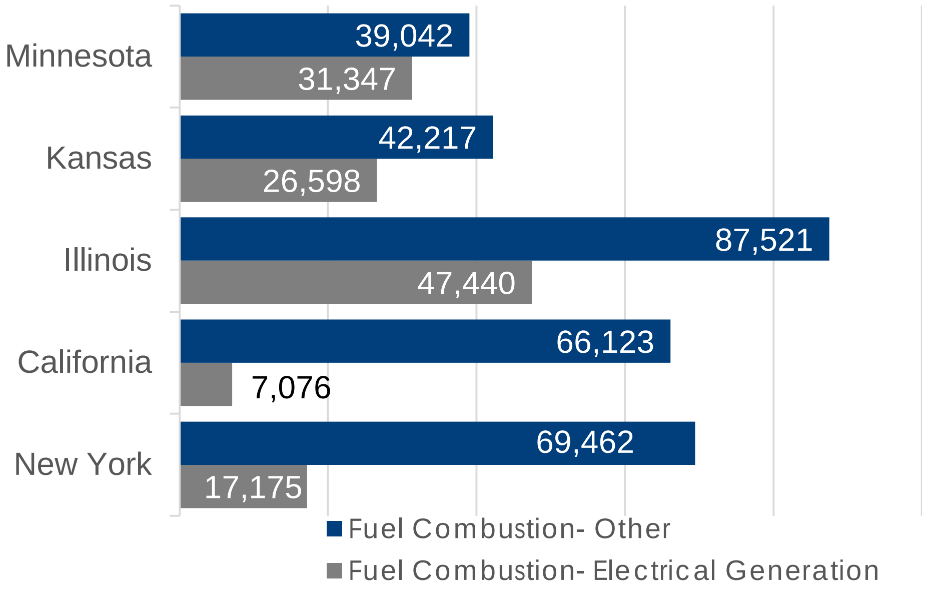
Drivers of Building Electrification | Improves air quality and public health

Electrification can lower individuals' risk for respiratory health ailments, such as asthma, by reducing the exposure to indoor and outdoor air pollutants.

- In many states, fossil fuel combustion in buildings results in more NOx emissions compared to power plants.
- Some gas appliances are linked to poor indoor air quality, leading to higher levels of NOx and carbon monoxide inside the home.
- Carbon monoxide results in roughly 15,000 emergency room visits and 500 deaths in the U.S. annually.

2014 NOx Emissions by Source (tons)



Source: EPA National Emissions Inventory (2014)
"Fuel Combustion- Electric Generation" includes biomass, coal, natural gas, oil, and other fuels combusted to generate electricity.
"Fuel Combustion- Other" includes biomass, coal, natural gas, oil, and other fuels combusted for commercial, institutional, residential, and industrial boilers.

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Drivers of Building Electrification | Reduces economy-wide energy consumption

According to several analyses, widespread building electrification in the U.S. will likely increase electricity consumption, but will decrease total economy-wide energy consumption when including the net decrease of fossil fuels.

Increased Electricity Consumption

- A recent scenario analysis by NREL suggests that that widespread deployment of electrification technologies (including EVs, heat pumps, etc.) could **increase 2050 U.S electricity consumption by 20-38%**

+

More Efficient Technologies

- Since electrification technologies are highly efficient, the quantity of electricity required to produce a specified output (e.g. heat an average home) is less energy intensive than the quantity of energy required to produce the same output through direct combustion of fossil fuels.

=

Decreased Economy-Wide Energy Consumption

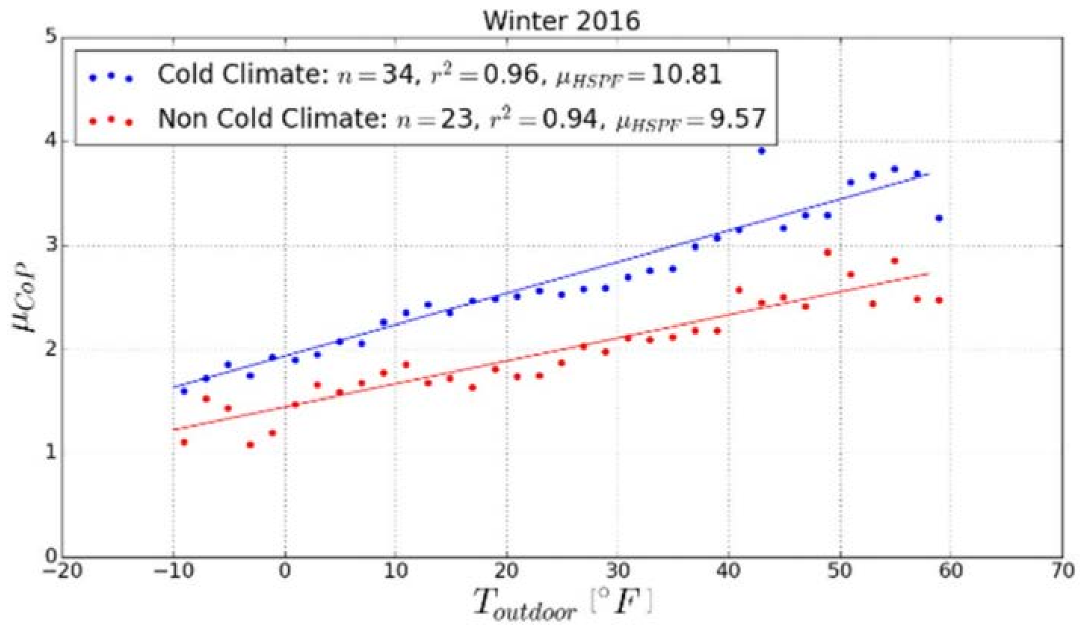
- Despite the increase in *electricity* consumption from electrification, NREL's analysis suggests that the efficiency of electrification technologies (along with overall improvements in appliance and building efficiency) could result in **13-21% lower final energy consumption**.

Drivers of Building Electrification | Improves comfort and provides cooling

High-efficiency "cold climate" heat pumps now provide flexible heating and cooling options for a wide range of climates across the U.S.

- Cold climate heat pumps can operate as low as -13 degrees Fahrenheit at efficiencies higher than conventional heat pumps and electric resistance, providing a viable option for space heating in most U.S. climate zones (particularly when paired with weatherization).
- ASHPs can also provide efficient space cooling, which is an increasing need as cities experience increasing temperatures and heat waves due to climate change.
- ASHPs can also improve occupant comfort through zoning and the use of variable speed technologies that can provide more even heating, cooling, and dehumidification.*

Measured performance of cold climate vs. non-cold climate ductless minisplit heat pumps in MA and RI



* Mini-split technologies, which do not need to be connected to ductwork, offer greater flexibility than centrally ducted ASHP applications.

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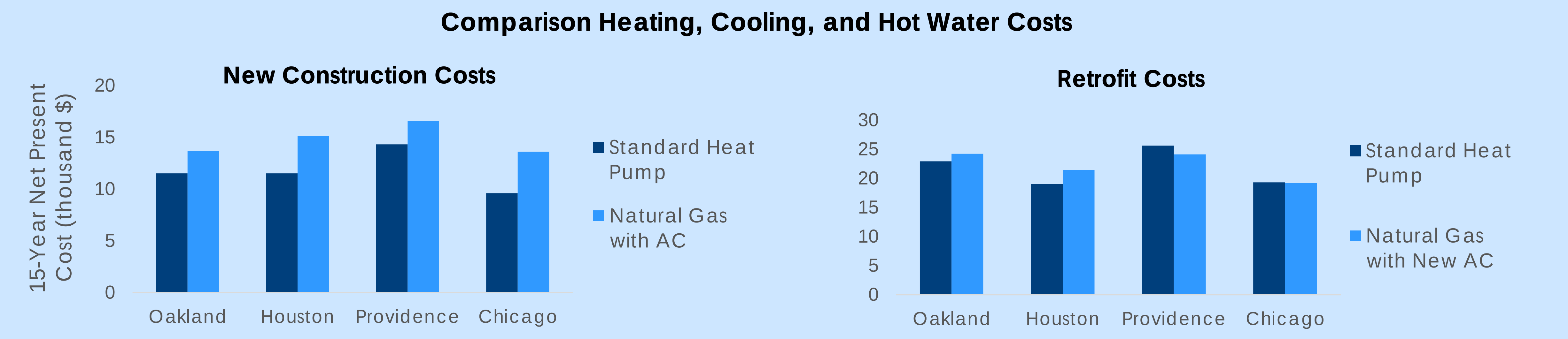
Drivers of Building Electrification | Potential to provide energy cost-savings to customers

According to several analyses, building electrification can result in energy cost-savings for customers over time, although this is dependent upon a number of factors.

- In a recent report, Rocky Mountain Institute compared the costs of electric space and water heating to fossil fueled space and water heating in home retrofit and new construction scenarios under differing rate structures in Oakland, Houston, Providence, and Chicago.
- Under the new construction scenarios, RMI found that electrification of space and water heating and air conditioning typically reduces homeowner costs over the life of the appliance. These homeowners also avoid the cost of gas infrastructure that would be unnecessary in an all-electric building.
- However, cost savings in retrofit scenarios were less pronounced and depended on specific factors, such as the cost and type of fuel the homeowner was switching away from (see figures below).



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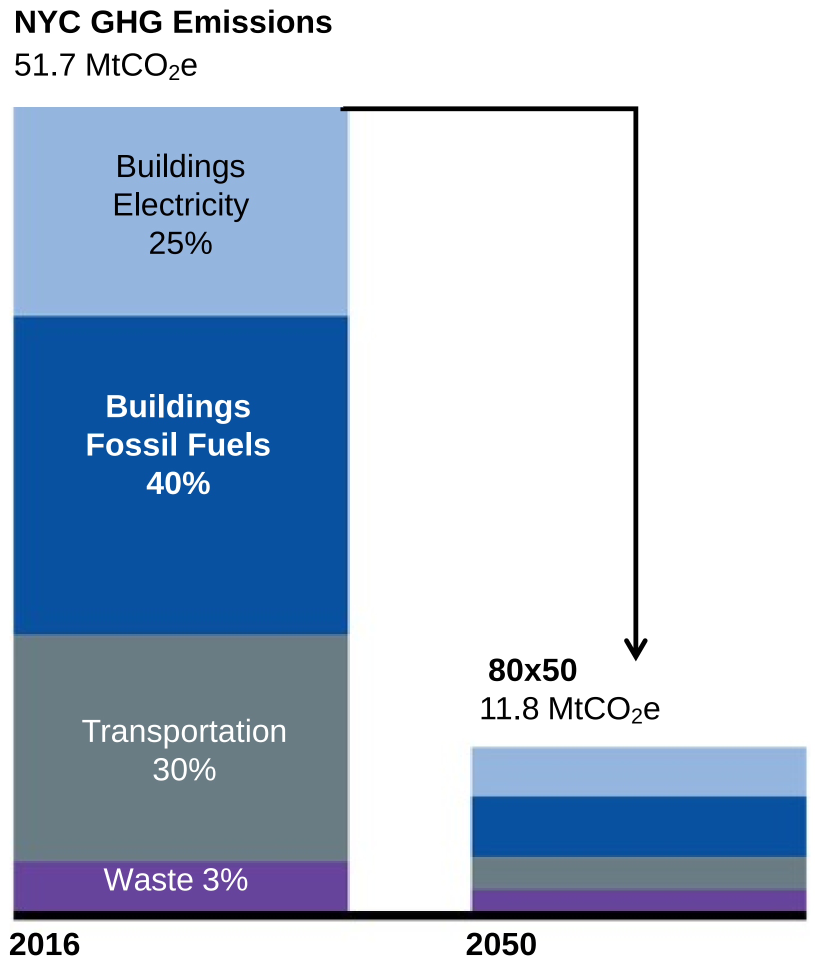
Drivers of Building Electrification | Reduces GHG emissions

Building electrification will be critical to achieving deep reductions in greenhouse gas (GHG) emissions.

- More than 280 local governments and 20 states across the U.S. have committed to GHG reduction targets.
- In heating dominated regions, fossil fuel use in buildings can be the single largest source of GHG emissions.
- Most GHG reductions to date have resulted from transitioning electricity away from coal to gas or renewables and increasing the energy efficiency of vehicles and buildings. These reductions will not be sufficient to achieve ambitious GHG reductions of 80% or more.
- Achieving necessary GHG reductions will require transitioning away from fossil fuels through building electrification.



Source: NYC Mayor's Office of Sustainability

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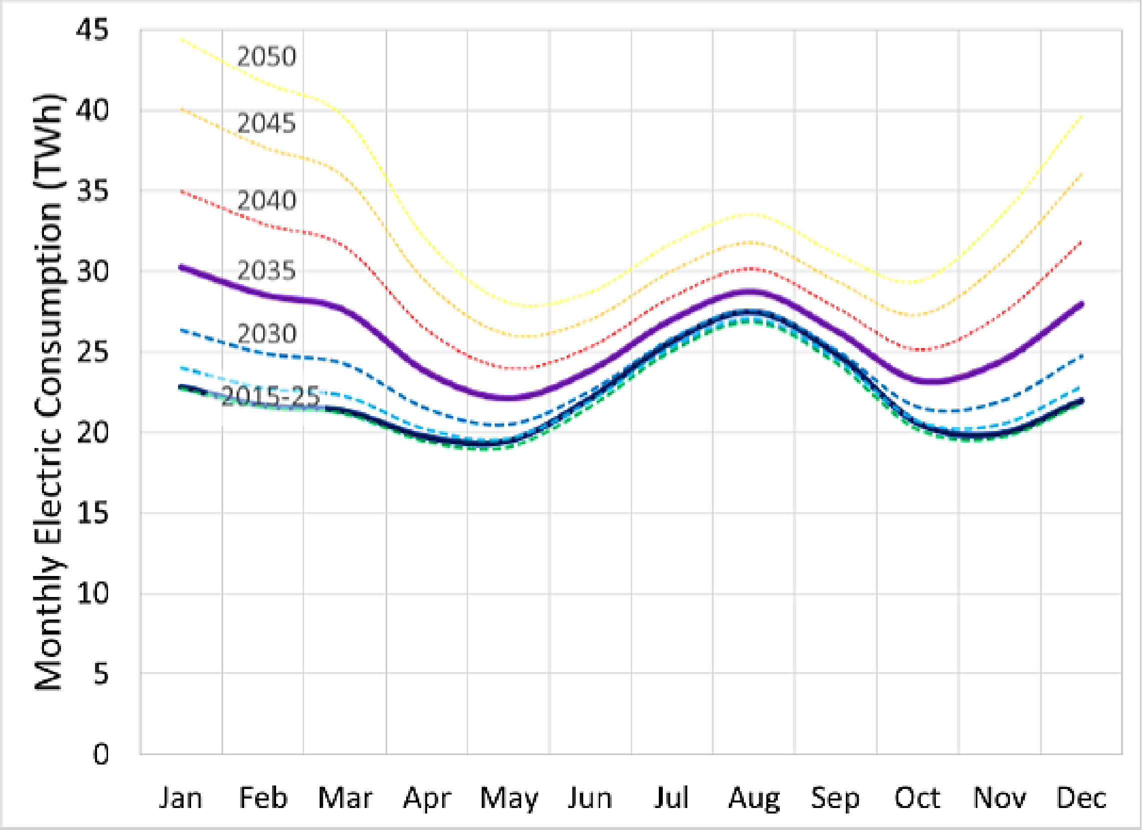
Drivers of Building Electrification | Potential to enable new utility business models

Electrification of the heating (and transportation) sectors could provide utilities with significant new loads, new customer offerings and opportunities to slow upward pressure on rates; however, the exact impacts for any given utility are unclear and could vary substantially based on local factors

- Increased electric load in the off-season can increase the overall system utilization, or load factor, of the grid. Assuming that the cost of distribution is fixed in the short term and allocated among customers based on their usage, increasing utilization should reduce electric rates because fixed costs are spread over more sales.
- The figure to the right (the so-called "butterfly curve") models this potential impact on New England grid. Here, increased electric use from heat pump deployment in the winter would increase the overall load factor of the electric grid and possibly decrease rates until 2030. At that point in time, a winter peak is introduced and additional infrastructure investment is required.
- A key consideration is whether the region's electric system is winter peaking versus summer peaking. In regions where electricity demand peaks in the summer, there may be opportunities to leverage existing grid infrastructure to support deployment of heat pumps. However, in winter peaking areas, electrification of space heating can exacerbate already strained local infrastructure—and the public is not generally supportive of expanding local transmission and distribution infrastructure.



Source: NEEP (2017). Northeast Regional Assessment of Strategic Electrification. Prepared by Synapse Energy Economics and Meister Consultants Group. Retrieved from www.neep.org.

Drivers of Building Electrification | Potential to enable new utility business models

Electrification of the heating (and transportation) sectors could provide utilities with significant new loads, new customer offerings and opportunities to slow upward pressure on rates; however, the exact impacts for any given utility are unclear and could vary substantially based on local factors

- While electrification can lead to new revenue and profit creation opportunities for utilities, these impacts are unclear and could vary substantially.
- For example, electrification could also create upward pressure on consumer rates—to the extent that utilities invest in infrastructure ahead of consumer demand (and increased electricity use) over which to spread those costs.
  - Note this issue is most prominent today for EV charging infrastructure. The EV charging market is not yet large enough to make most EV charging stations profitable, yet without public and workplace charging the market may not grow at all.
  - Cities, regulators, utilities, and other stakeholders will need to strike a balance between the utility's interest in investing in rate-based infrastructure, public policy objectives, shared costs, and the need to foster competitive markets.

Drivers of Building Electrification | Potential to provide grid flexibility

Most electrification technologies are flexible in when they can be charged and used, which helps utilities more proactively manage energy use and supports the integration of renewable energy.

- Many electrification technologies for water heating and (in some cases) space heating are flexible in when they can be charged and/or used.
- Water heating technologies in particular can function like a battery, which supports grid flexibility by allowing grid managers to shift load to other periods of the day.
- With this greater control, grid managers can reduce peaks by flexing load to times of the day where there is less demand and the grid is less stressed. Shifting load to these lower-cost hours can also save consumers money by placing downward pressure on rates.
- Grid managers also have the opportunity to shift load to periods of the day when variable energy resources, such as wind or solar, are being curtailed to increase the system's ability to accommodate variable resources and reduce its reliance on dirtier resources that typically filled these gaps.

Fostering City-Utility Collaboration will be Key

Beneficial electrification can benefit the customers, public interest and utilities, though there are risks if this transition lacks sufficient planning. Utilities will be critical partners for cities as they seek to accelerate building electrification.

- If goals and interests are aligned, utilities and cities can work together as implementation partners by providing necessary resources and expertise to support various goals, such as:
  - Scaling up and co-investing in local solutions
  - Advocating for regulatory changes
  - Cost-effectively planning for changes to electric loads
  - Increasing deployment of renewable resources
  - Reducing likelihood of stranded assets (e.g. natural gas assets)
- Collaboration can help ensure cities achieve their GHG emissions reduction targets and mitigate the risks utilities would otherwise be exposed to—including poor grid management, increasing rates for customers, and potentially stranded assets.
  - As a recent analysis by Moody's points out, such challenges lead to rising credit risk, making it more expensive for utilities to raise capital to support operations.

Section One Sources

Slide #	Slide Title	Source
10	Defining Building Electrification	• Building Electrification Initiative. About. https://www.beicities.org/about. • Rocky Mountain Institute. The Economics of Electrifying Buildings. https://rmi.org/wp-content/uploads/2018/06/RMI_Economics_of_Electrifying_Buildings_2018.pdf.
11	Defining Building Electrification: Beneficial Electrification	• RAP. Beneficial Electrification: Ensuring Electrification in the Public Interest. https://www.raponline.org/knowledge-center/beneficial-electrification-ensuring-electrification-public-interest
12	Defining Building Electrification: Technologies	• Building Electrification Initiative. Building Electrification 101.
13	Drivers of Building Electrification | Value for Customers, the Public Interest, and Utilities	• RAP. Beneficial Electrification: Ensuring Electrification in the Public Interest. https://www.raponline.org/knowledge-center/beneficial-electrification-ensuring-electrification-public-interest
14	Drivers of Building Electrification | Improves air quality and public health	• EPA, 2014 National Emissions Inventory Report, 2014 https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data • Berkeley Lab, Pollution in the Home: Kitchens Can Produce Hazardous Levels of Indoor Pollutants, 2013 https://ehp.niehs.nih.gov/doi/10.1289/ehp.1306673 • EPA, "Preventing Carbon Monoxide Poisoning," 2009 https://www.epa.gov/sites/production/files/2015-08/documents/pcmp_english_100-f-09-001.pdf
15	Drivers of Building Electrification | Reduces economy-wide energy consumption	• RAP. Beneficial Electrification: Ensuring Electrification in the Public Interest. https://www.raponline.org/knowledge-center/beneficial-electrification-ensuring-electrification-public-interest/ • NREL. Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States. https://www.nrel.gov/docs/fy18osti/71500.pdf
16	Drivers of Building Electrification | Improves comfort and provides cooling	• Rocky Mountain Institute. 2018. The Economics of Electrifying Buildings. https://rmi.org/insight/the-economics-of-electrifying-buildings/. • Department of Energy. Ductless, mini-split heat pumps. https://www.energy.gov/energysaver/heat-pump-systems/ductless-mini-split-heat-pumps • Efficiency Vermont. https://www.efficiencyvermont.com/products-technologies/heating-cooling-ventilation/heat-pumps • NEEP. https://neep.org/sites/default/files/ColdClimateAirSourceHeatPumpSpecification-Version3.0FINALMEMO.pdf • Image source: Source: http://ma-eeac.org/wordpress/wp-content/uploads/Ductless-Mini-Split-Heat-Pump-Impact-Evaluation.pdf
17	Drivers of Building Electrification | Potential to provide energy cost-savings to customers	• Rocky Mountain Institute. 2018. The Economics of Electrifying Buildings. https://rmi.org/insight/the-economics-of-electrifying-buildings/.

Section One Sources

Slide #	Slide Title	Source
18	Drivers of Building Electrification | Reduces GHG emissions	• C2ES. Greenhouse Gas Emissions Targets. (https://www.c2es.org/document/greenhouse-gas-emissions-targets). • See National Academies Press. Appendix D: State greenhouse gas emissions targets and baselines (https://www.nap.edu/read/12784/chapter/15) • Northeast Energy Efficiency Partnership [NEEP], 2017; Lawrence Berkeley National Laboratory [LBNL], 2018; Colburn, K., 2017; Mahone et al, 2018; Energy and Environmental Economics, Inc. [E3], 2017.
19	Drivers of Building Electrification | Potential to enable new utility business models	• Reeves, S., Veilleux, N. & Miller, M. (2018). "Strategic Electrification and the Changing Energy Paradigm: Challenges and Opportunities for Utilities." Prepared for the ACEEE Summer Session. Found at: https://cadmusgroup.com/papers-reports/strategic-electrification-and-the-changing-energy-paradigm-challenges-and-opportunities-for-utilities/ • NEEP (2017). Northeast Regional Assessment of Strategic Electrification. Prepared by Synapse Energy Economics and Meister Consultants Group. Retrieved from www.neep.org.
20	Drivers of Building Electrification | Potential to enable new utility business models	• Reeves, S., Veilleux, N. & Miller, M. (2018). "Strategic Electrification and the Changing Energy Paradigm: Challenges and Opportunities for Utilities." Prepared for the ACEEE Summer Session. Found at: https://cadmusgroup.com/papers-reports/strategic-electrification-and-the-changing-energy-paradigm-challenges-and-opportunities-for-utilities/ • NEEP (2017). Northeast Regional Assessment of Strategic Electrification. Prepared by Synapse Energy Economics and Meister Consultants Group. Retrieved from www.neep.org.
21	Drivers of Building Electrification | Potential to provide grid flexibility	• Regulatory Assistance Project. 2018. Beneficial Electrification: Ensuring Electrification in the Public Interest. https://www.raponline.org/wp-content/uploads/2018/06/6-19-2018-RAP-BE-Principles2.pdf.
22	Fostering City-Utility Collaboration will be Key	• Reeves, S., Veilleux, N. & Miller, M. (2018). "Strategic Electrification and the Changing Energy Paradigm: Challenges and Opportunities for Utilities." Prepared for the ACEEE Summer Session. Found at: https://cadmusgroup.com/papers-reports/strategic-electrification-and-the-changing-energy-paradigm-challenges-and-opportunities-for-utilities/ • Moody's Investor Services. (November 2017). "Prudent regulation key to mitigating risk, capturing opportunities of decarbonization". Found at: www.moodys.com.

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Section 2 Overview | Barriers to Building Electrification

Section 2 covers the following topics:

Topic	Description	Slide
Barriers to Building Electrification	• Describes the typical market barriers that inhibit deployment of building electrification technologies	27 – 34

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Barriers to Building Electrification | Overview

For city leaders to successfully engage local utilities and strengthen building electrification efforts, it is critical that they understand typical market barriers. These barriers have been well documented in literature.

Regulatory & Policy Barriers	Technical & Building Barriers	Economic Barriers	Awareness Barriers	Decision-Making Barriers	Supply Chain Barriers
• Regulations on utility programs and associated incentive models • Regulatory ambiguity	• Low technology refurbishment rates • Incumbent technologies have a firm market hold	• High installed costs (including soft costs) • Inadequate financing and ROI • Capital constraints	• Lack of consumer awareness • Lack of contractor, architect, and developer awareness • Consumers preferences	• Ownership priorities • Split incentives/ high rate of renting • Lack of confidence in technology	• Insufficient contractor base • Staff training for O&M

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Barriers to Building Electrification | Policy and Regulatory Barriers

Utility energy efficiency (EE) programs are typically not structured to encourage widespread adoption of building electrification technologies (e.g. heat pumps)

- Utility EE programs are a critical and well-funded tool that in some cases, currently incentivize heat pumps as an electric efficiency measure for cooling
    - *(e.g. incentives for purchase of a higher-efficiency system)*
- However, most EE programs are designed to encourage **incremental efficiency improvements within the gas or electric sectors** as opposed to looking at **economy-wide efficiency or emissions reductions**
- Four major EE program barriers may hinder greater deployment of heat pumps

Fuel switching rules	• EE programs generally cannot promote fuel-switching (e.g. gas/oil to electric heating or vice versa) or account for energy savings from unregulated fuels
Cost effectiveness rules	• Heat pumps may not be deemed cost effective for heating under existing EE program rules. • Cost-effectiveness tests used to determine measure/ program cost-effectiveness are not structured to integrate all potential benefits of electrification
Consumer incentives for fossil fuel appliances	• EE programs typically incentivize high efficiency fossil fuel heating systems (e.g. condensing boilers), often at comparable or higher levels than heat pumps.

Barriers to Building Electrification | Policy and Regulatory Barriers

Building electrification and heat pump deployment is inhibited by regulatory ambiguity and uncertainty about what actors have the authority to set guidance on building electrification.

- In many cases, public utility commissions have provided minimal guidance on how or whether utilities should invest in building electrification.
- Some regulators highlighted concerns regarding whether the public utilities commission (PUC) is the appropriate authority to incentivize building electrification market development. For some regulators, it is unclear how far to extend their regulatory reach—and authorize increases in ratepayer costs—in order to achieve broader carbon and public policy objectives.
- Some regulatory experts point out that a major challenge related to electrification programs is determining who should bear the costs of programs that promote fuel switching to reduce greenhouse gas emissions when the benefits of avoided emissions primarily accrue to society—not the power system or ratepayers.
- Some electric sector regulators feel they may not have the authority to set rates and/or authorize programs that aim to reduce GHG emissions through encouraging electrification of fossil fuels that are outside of their regulatory authority.

Barriers to Building Electrification | Technical and Building Barriers

Heat pump deployment is inhibited by challenges related to existing building stock and grid infrastructure.

- Refurbishment rates for heating, cooling, and water heating technologies are low, typically once every 10-20 years or longer.
- Many homeowners are unlikely to replace existing systems for heating, cooling, and water heating until near end of life or upon equipment failure. Additionally, upon equipment failure, the sense of urgency typically favors like-for-like replacement.
- ASHPs can be installed in supplementary applications for heating, but in many regions will replace the existing system. HPWHs replace the existing water heater and would likely only be replaced upon failure.
- Thus, for many homeowners, there will only be <u>one or two</u> equipment replacement cycles before 2050.

Category	Useful Life	Est. Annual Replacement Rate
Boiler/furnace	~ 15-20 Years	~ 5 percent
Central Air Conditioner	~ 15 Years	~ 7 percent
Water Heater	~ 12 Years	~ 8-9 percent

Sources/Assumptions: Equipment lifetimes vary by model (e.g. furnace vs. boiler, indirect fired vs. tankless water heater). Expected useful life is estimated based on assumptions used in the NYSERDA RH&C Policy Framework (2017) and the New York State Technical Resource Manual, Version 5 (July 2017, Appendix P). It is unclear what actual annual replacement rates are for these technologies, and replacement rates are estimated based on expected useful life.

Barriers to Building Electrification | Economic Barriers

Heat pumps face cost-competitiveness challenges, especially compared to natural gas.

- In many regions, heat pumps have **higher installed costs** and a **slow accrual of operating cost savings** due to low fossil fuel prices and/or high electricity prices.
- These factors can result in an **inadequate return on investment,** which disincentivizes the replacement of conventional systems with electrification technologies. However, payback depends on a variety of factors, including but not limited to: local fuel and electricity prices, climate conditions, the timing of existing equipment replacement, and whether a project is new construction or retrofit application.
- In most states, the environmental and social benefits provided by these systems are **not adequately valued** in the market.
- Unfavorable economics are further exacerbated by **limitations to heat pump eligibility** in existing energy efficiency incentive and financing programs.

Barriers to Building Electrification | Awareness Barriers

Low customer and industry awareness of heat pumps and their potential benefits inhibit widespread deployment

- Many customers are unaware of today's heat pumps and associated benefits to comfort and air quality. Some have negative associations with older, less efficient versions and electric heating. Poor customer awareness may be caused by a variety of factors, including policymakers focus on incentivizing high-efficiency fossil fuel systems, low levels of training for electrification technologies, limited marketing, and a lack of consumer education programs.
- Some contractors lack awareness of cold climate heat pumps and prefer familiar, conventional fossil fuel systems especially for emergency replacements.
- Architects and developers are also unfamiliar with heat pumps, which prevents them from being installed – especially in large, new buildings.
- Lastly, gas has been successfully marketed as a clean fuel and customers are attached to gas as a cooking fuel.

Barriers to Building Electrification | Decision-Making Barriers

Building owner priorities tend to inhibit adoption even when customers are aware of the technology and understand the potential benefits

- Homeowners tend to prioritize aesthetic improvements over energy-related improvements, believing that aesthetic improvements will increase resale value, or that their home is already efficient enough.
- In the commercial sector, building owners will often prioritize capital allocation to "core" business investments instead of in energy upgrades like heat pumps.
- "Split Incentives," where costs are born by owners while benefits accrue to tenants, dissuade energy investments such as heat pumps.

Barriers to Building Electrification | Supply Chain Barriers

The necessary increases in heat pumps will require more training of the existing workforce and substantial growth of contractors offering heat pump installations.

- Contractors may lack sufficient training to properly install systems and may not recommend the technology to customers.
- Labor unions have not been adequately engaged to support scaling heat pump installations.
- 22% of the HVAC workforce is expected to retire between 2018 and 2022.
  - Beyond replacing retiring workers, the overall contractor base that is able to install heat pumps must expand to meet the level of demand necessary to achieve large-scale electrification.

Section Two Sources

Slide #	Slide Title	Source
28	Barriers to Building Electrification | Policy and Regulatory Barriers	• Reeves, S., Veilleux, N. & Miller, M. (2018). "Strategic Electrification and the Changing Energy Paradigm: Challenges and Opportunities for Utilities." Prepared for the ACEEE Summer Session. Found at: Found at: https://cadmusgroup.com/papers-reports/strategic-electrification-and-the-changing-energy-paradigm-challenges-and-opportunities-for-utilities/ • Synapse Energy and Meister Consultants Group. (2017). Northeast Regional Assessment of Strategic Electrification. Found at: https://neep.org/sites/default/files/Strategic%20Electrification%20Regional%20Assessment.pdf
29	Barriers to Building Electrification | Policy and Regulatory Barriers	• Gahran, A. 2018. 2018 State of the Electric Utility. Prepared by Utility Dive in association with PA Consulting. Found at: https://www.utilitydive.com/library/2018-state-of-the-electric-utility-survey-report/ • Expert Interviews
30	Barriers to Building Electrification | Technical and Building Barriers	• NYSERDA. 2017. Renewable Heating & Cooling Policy Framework. Found at: https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/NYSERDA/RHC-Framework.pdf
31	Barriers to Building Electrification | Economic Barriers	• Expert Interviews • NYSERDA. 2017. Renewable Heating & Cooling Policy Framework. Found at: https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/NYSERDA/RHC-Framework.pdf
32	Barriers to Building Electrification | Awareness Barriers	• Expert Interviews • NYSERDA. 2017. Renewable Heating & Cooling Policy Framework. Found at: https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/NYSERDA/RHC-Framework.pdf
33	Barriers to Building Electrification | Decision-Making Barriers	• Suzanne Shelton. Shelton Group. https://aceee.org/sites/default/files/pdf/conferences/mt/2017/Shelton_Keynote_MT17_4.3.17.pdf
34	Barriers to Building Electrification | Supply Chain Barriers	• Expert Interviews • NYSERDA. 2017. Renewable Heating & Cooling Policy Framework. Found at: https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/NYSERDA/RHC-Framework.pdf • HVACR Workforce Development Foundation (2015). The HVACR Workforce: Demand Heats Up as Supply Melts Away.

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Section 3 Overview | The Utility Business and Regulatory Framework

Section 3 covers the following topics:

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The Utility Business and Regulatory Framework | Background

A utility's business model drives its planning and decision-making for new investments that will be needed to support building electrification.

The utility business model is determined by three main factors:

- **The functions or services the utility provides customers**
- **The regulations, incentives, and policies that govern it**
- **The way the utility recovers costs**

The Utility Business and Regulatory Framework | The Functions and Services the Utility Provides Customers

Utility functions are typically divided into three main categories, summarized below. Electricity market context will impact which of these functions and services a utility provides to customers.

1. Generation

- Owning and operating facilities to generate electricity.

2. Transmission

- Owning and operating infrastructure to carry electricity across long distances (e.g. high voltage power lines).

3. Distribution

- Owning and operating infrastructure to distribute electricity to end-use customers.

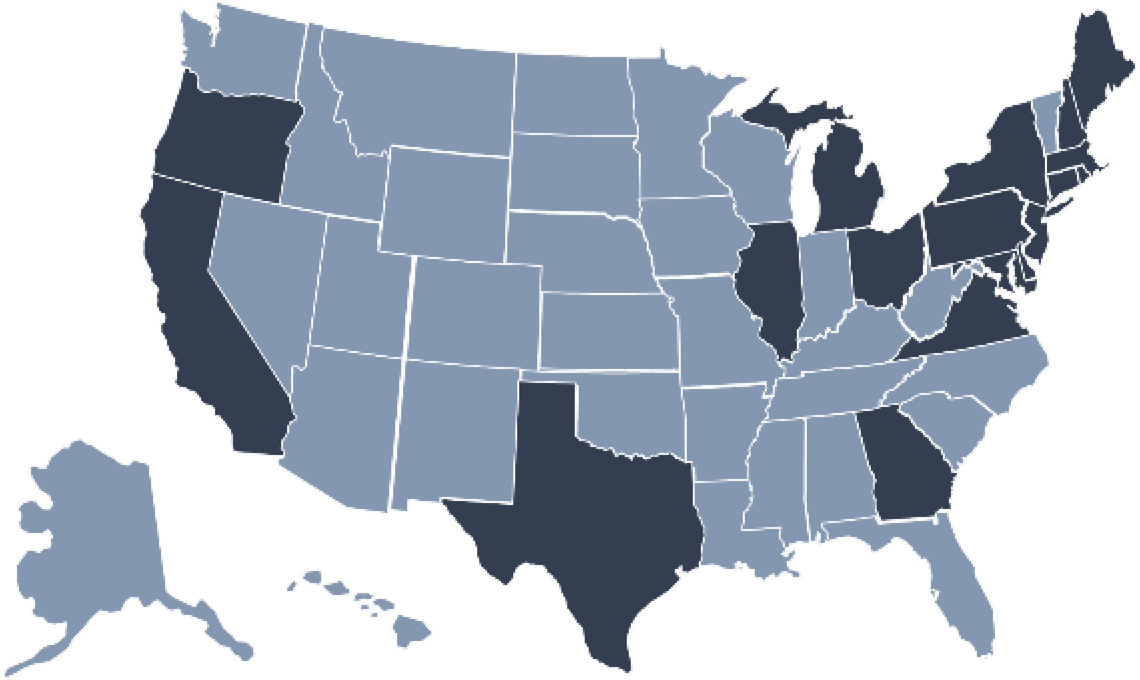
- In **regulated states,** utilities serve all functions in providing electrical service, from generating electricity to delivering it to their customers. These utilities are known as vertically-integrated.
- In these states, energy customers can only purchase electricity from the local utility.
- In **restructured states**, utilities are not permitted to invest in generation resources and, as a result, mostly function as “transmission and distribution companies”.
- In these states, energy customers may select an energy provider other than the utility (this is known as “retail choice”). In cases where the electricity customer does not select a retail electricity provider, they will receive “basic service” from the utility, which is typically energy purchased from the wholesale market.

The Utility Business and Regulatory Framework | The Functions and Services the Utility Provides Customers

Historical Context

- Until the 1990s, all electric utilities were vertically integrated. Since the 1990s, a handful of states have passed laws to “deregulate” electricity markets with the purpose of separating the generation of energy from its distribution to retail customers and enabling competitive electricity suppliers to enter the market.
- The theory behind deregulating is that competition between electricity generators would lead to lower electricity rates.

Regulated and Deregulated States



Deregulated States

Regulated States

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The Utility Business and Regulatory Framework | The Regulations, Incentives, and Policies that Govern It

The traditional regulatory model for utilities is to operate as a monopoly for generating and distributing energy in exchange for significant oversight from federal and state regulators.

- Under this model, utilities have a business model centered on **cost of service (COS) regulation**
  - Under COS regulation, regulators permit utilities to recover costs from ratepayers (or customers) for capital investments in generation, transmission, or distribution infrastructure, plus a defined rate of return, or profit, on these investments.
  - Costs on which the utility is able to earn a regulated return on are referred to as the “rate base.”
  - COS regulation enables the utility and its shareholders to earn returns, which enable the utility to access low-cost capital for making long-term infrastructure investments.
- It is the regulator’s job to review and approve utilities infrastructure investments, ensuring that investments are prudent and in the public’s interest.

Prudent	i.e. that the utility’s investment is reasonable given current knowledge
In the Public’s Interest	i.e. the investment was made for the sake of achieving reasonable costs, safety, reliability, or other objectives in the public’s interest

The Utility Business and Regulatory Framework | Cost Recovery

Under the COS regulation model, utilities and regulators establish the utility's revenue requirement, or the annual revenue a utility would need to earn in order to provide service to customers and a reasonable return to shareholders.

- The revenue requirement is determined by the state utility commission based on costs that a utility incurs during a "test year" that are assumed to be representative of the utility's future annual costs.
- A typical (simplified) formula for determining a utility's revenue requirement is below.

$$RR = O + D + T + r(B)$$

Where

- RR = revenue requirement
- O = operating expenses
- D = depreciation
- T = taxes
- r = allowed rate of return (which is set by regulators)
- B = rate base (or the regulatory asset base)

The Utility Business and Regulatory Framework | Cost Recovery

Once regulators approve a utility's revenue requirement, the utility allocates the revenue requirement across different customer classes (e.g. residential, commercial, and industrial classes) based on the relative cost of providing service to each of these classes.

- Rates are established for each customer class so that the utility can fulfill its revenue requirement. Regulators have oversight of the rates each utility files.
- Utilities and regulators can set rates using a variety of methods and structures including volumetric rates, time-of-use rates, etc.
- Comprehensive discussion of these methods is beyond the scope of this discussion, but interested readers should consult the documents in the additional resources box (right).

Additional Resources

- Regulatory Assistance Project: Rate Design 101
- Solar Energy Industries Association: Utility Rate Design and Complementary Policies
- Regulatory Assistance Project: Time-Varying and Dynamic Rate Design

The Utility Business and Regulatory Framework | Cost Recovery

COS regulation rewards utilities with profit for their investment in new infrastructure, creating what some have called an "infrastructure bias."

- Under COS, the utility is able to recover and earn a regulated return (profit) on costs that are included in its rate base, which generally includes capital costs such as infrastructure investments.
- The utility is also permitted to recover its operational costs, though these are generally not included in the rate base—meaning the utilities do not earn a return on these costs.
    - This is a driver for utilities to adopt renewables, which have no operating costs, instead of fossil fuel-powered plants, which have high operating costs.
- Accordingly, under COS regulation, utilities are incentivized to favor capital costs over operating costs, in order to maximize the share of their costs that are eligible for a return. This is known as the "infrastructure bias."

The Utility Business and Regulatory Framework | Technology, regulatory, business and market changes

The utility business model has undergone (and continues to undergo) changes as regulators and utilities adapt to competitive, incentive, and technology changes. These changes may impact utilities' rate base, allowed rate of return, or method for collecting revenue requirement (i.e. method for setting rates).

While a comprehensive discussion of these issues is beyond the scope of this document, it is important to note that the utility business model is subject to ongoing changes including:

- In the 1990's and early 2000's, many states went through **electricity restructuring,** a process in which vertically integrated utilities (i.e. utilities that owned and operated generation, transmission, and distribution) were broken up into "generation" companies and "transmission and distribution (T&D)" companies. Many utilities were required to divest of and sell generation assets and became "wires only" utilities.
- In the 1990's and today, many states have explored the use of **performance-based regulation (PBR)** in rate-making in order to strengthen utility performance incentives relative to traditional COS regulation. A variety of PBR mechanisms exist, but their common intent is to provide financial incentives for the utility to achieve desired target metrics (potentially including energy efficiency and distributed energy resources [DER]), reduce costs, or otherwise improve performance.

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The Utility Business and Regulatory Framework | Technology, regulatory, business and market changes

The utility business model has undergone (and continues to undergo) changes as regulators and utilities adapt to competitive, incentive, and technology changes. These changes may impact utilities' rate base, allowed rate of return, or method for collecting revenue requirement (i.e. method for setting rates).

- Since the 1990s, at least 30 states have implemented (some form of) **decoupling** policies, which provide a formula to automatically adjust rates if utility revenues exceed or fall short of predictions. This approach is used as a tool to remove utility incentives for selling more energy and limiting energy efficiency incentives.
- More recently, regulators and other intervenors are directing utilities to enable **greater integration of energy efficiency and clean energy technologies**—including solar, storage, electric vehicles, and heat pumps, among others. This has led to the emergence of energy efficiency resource standards and renewable portfolio standards (see right).

Energy Efficiency Resource Standard (EERS)

- An EERS requires utilities to meet specific targets for energy savings through energy efficiency programs.

Renewable Portfolio Standards (RPS)

- An RPS requires utilities to meet a certain percentage of their electricity sales through qualifying renewable sources.

The Utility Business and Regulatory Framework | Key Questions

Because of regulatory changes over the years—and the fact that much of utility regulation is governed at the state level—utility business models vary across (and within) states.

To assess the opportunities for engaging utilities on building electrification, it is important for city staff to consider several key questions regarding utility regulation and business models. Each of these questions is covered in more detail on the following slides.

Category	#	Question
Utility ownership structure & function	1	What is the ownership structure of the utility?
	2	What type of energy does the utility sell?
	3	Does the utility invest in generation?
	4	What are the grid impacts?
Regulations and Policy	5	What performance-based incentives are in place?
	6	What fuel switching rules are in place?
	7	What cost effectiveness rules are in place?
	8	What natural gas policies are in place?

The Utility Business and Regulatory Framework | Key Questions

Category	Question	Key Considerations
Utility ownership structure & function	**1) What is the ownership structure of the utility?**	Utilities may be investor-owned (IOUs), cooperatively owned (coops), or owned by municipalities (munis). The ownership structure determines the direct influence a city has as well as the types of state regulations to which a utility is subject.
	2) What type of energy does the utility sell?	Utilities may sell electricity, natural gas, or both. In many cases, building electrification is considered a direct competitive threat to natural gas sales, though some gas utilities have used BE technologies to address a lack of pipeline capacity to deliver additional load, and some are looking at it as a means of reducing overall consumer demand for energy. On the other hand, building electrification can be seen as a way to increase sales for electric utilities.
	3) Does the utility invest in generation?	Utilities may be vertically-integrated or deregulated. Vertically-integrated utilities that own electric generation may have additional drivers to encourage building electrification—specifically to support greater integration of electric generation assets.
	4) What are the grid impacts of Electrification?	Building electrification will likely have profound impacts on the grid; however, no clear understanding or alignment has emerged on what those impacts would be. Utility leaders will have to carefully consider grid and peak load impacts as they relate to electrification.

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The Utility Business and Regulatory Framework | Key Questions

Category	Question	Key Considerations
Regulations and policy	**4) What performance-based incentives are in place?**	Some regulators may work with utilities to establish performance incentives, which enable utilities to increase earnings by achieving key performance objectives (e.g. energy efficiency, integration of distributed energy resources, reduced GHG emissions, etc.) that can support deployment of building electrification technologies.
	5) What fuel switching rules are in place?	Utilities in many states are discouraged or prohibited from encouraging customers to switch from regulated (gas) or unregulated fuels (oil, propane) to electric heating technologies.
	6) What cost effectiveness rules are in place?	Cost effectiveness tests are often used by regulators to determine what kinds of investments utilities are permitted to make. Depending on the structure of the cost effectiveness test (e.g. what benefits and costs may be considered) and characteristics of the local market, these may either encourage or discourage building electrification investments.
	7) What natural gas policies are in place?	Natural gas is the primary heating fuel used in the U.S. and a source of earnings for many utilities. Over the medium- to long-term, most analysts agree that natural gas expansion is not compatible with achieving aggressive GHG emission reduction. Policies focused on preventing natural gas expansion or managing the retirement of natural gas assets can support the growth and development of building electrification.

Question 1 | What is the ownership structure of the utility?

The ownership structure determines the state regulations and ability for cities to influence their utilities. Utilities may be investor-owned (IOUs), cooperatively owned (coops), or owned by municipalities (munis). The table below illustrates key characteristics of each major type of utility.

Key Characteristics		Utility Type: Investor-Owned Utilities	Utility Type: Municipal Utilities	Utility Type: Utility Cooperatives
Governance	Ownership	Privately owned.	Typically owned by the city.	Owned by the customers they serve.
Governance	Governance Structure / Management	Company issues stock and is responsible to shareholders. Heavily regulated at the state level.	Structure varies significantly, ranging from a department within a city administration to a municipal utility district operating independently of the city administration.	Each customer is a member-owner with one vote under the "one person, one vote" cooperative principle. Member-owners elect the board of directors who make decisions.
Prevalence and Size	Total number in the U.S.	~200	~2,000	~900
Prevalence and Size	% U.S. customers served	~68%	~15%	~13%
Prevalence and Size	Size of territory & customer base	Large service territories in multiple states, serving a few thousand to a few million customers.	Generally small to mid-size customer base.	Typically large and sparsely populated service territories, serving a small customer base.

Please note that the statistics related to prevalence and size are specific to electric utilities.

Question 1 | What is the ownership structure of the utility?

The ownership structure determines the state regulations and ability for cities to influence their utilities. Utilities may be investor-owned (IOUs), cooperatively owned (coops), or owned by municipalities (munis).

Investor Owned Utility (IOU)	• Cities generally have **little direct control** over an IOU • State regulators determine most aspects of the utility's rates and services, including policies, programs, and incentives for renewable energy and building electrification • However, as important utility customers and advocates for their citizens, cities have several negotiation tools they can use to influence utilities, including: (1) Renegotiating city franchise agreements, (2) Establishing memorandums of understanding (MOUs) with utilities, (3) Influencing utility pilot program, including using city buildings for pilot programs(4) engaging in utility advisory committees, (5) intervening at the PUC in the regulatory filing process, and (6) lobbying for legislative action at the state level. Please see Section 4: Pathways forward for more information on each of these strategies.
Rural Electric Cooperative (Co-op)	• Similar to IOUs, cities generally have **little formal jurisdiction** over co-ops. • Unlike IOUs, co-ops are governed primarily by the co-op's board of directors, typically with minimal oversight from state regulators • Few cities are served by co-ops. In cases where they are, cities can collaborate with or lobby the board of directors for building electrification programs and incentives. Alternatively, cities can lobby the member-owners who elect the board of directors and seek to drive change via grass-roots outreach efforts
Municipal Utility (Muni)	• Cities with municipal utilities have the **highest degree of direct influence** over their utility. • Depending on the municipal governance structure, a city council may have full authority to appoint the utility's board members, direct or approve the utility's integrated resource plan, or secure procurement contracts.

Question 1 | What is the Ownership Structure of the Utility?

Community Choice Aggregations (CCAs) have emerged in some states, providing municipalities with high levels of control over their retail electricity supply. In some cases, CCAs can implement clean energy programs and incentives that are aligned with the municipalities clean energy goals.

- **A community choice aggregation (CCA)** is a local governmental entity that purchases electricity on behalf of a community, offering a municipality greater control over its electricity supply. CCAs present a unique opportunity for municipalities to choose the source of their electricity, and meet their electricity demand with higher percentages of renewable energy, which provides an even greater opportunity for building electrification as a strategy for reducing emissions.
- **Many CCAs also develop decarbonization programs** that encourage greater energy efficiency, transportation electrification, and building electrification.
- State legislatures must pass laws enabling CCAs that allow communities to choose to create one. To date, CCAs have been enabled in eight states, including California, Illinois, Massachusetts, New Jersey, New York, Ohio, Rhode Island, and Virginia. While the structure of a CCA will vary by state due to differences in enabling legislation and whether the CCA is operating in a deregulated or regulated electricity market context, they generally enable a local government to aggregate the electricity demand of all the homes and business within its jurisdiction and purchase power on their behalf.
- Notably, even in regions with CCAs, the utility continues to provide transmission and distribution services, delivering the energy purchased by the CCA to its customers.

Question 2 | What Type of Energy Does the Utility Sell?

Utilities may sell electricity, natural gas, or both. The way that the utilities views building electrification will often depend on how building electrification is perceived to affect these sales.

Electric-Only Utilities

- Electric-only utilities will likely view building electrification as an opportunity to increase investments in electric infrastructure and, in regulated states, sell more electricity.
- Building electrification would be expected to increase, or at least stabilize, electricity sales. If well-managed by utilities, this could increase utility profits, decrease customer rates, or both.
- However, if not managed well, it may also cause additional stress to the electric grid by increasing electric use during peak demands.
- Managed growth of building electrification will likely be a key priority for electric utilities.

Dual Fuel Utilities

- It is challenging to predict the position that a dual-fuel utility will take as it relates to building electrification.
- It may depend upon the relative strength (or exposure) of their natural gas and electric divisions (and how they interact with each other), opportunities for growth, company culture, and/or position on decarbonization
- It ultimately must be considered on a case-by-case basis.

Gas-Only Utilities

- Gas-only utilities will likely view building electrification as a long-term risk to their business model.
- By causing customers to leave the gas grid, studies suggest that building will increase costs for customers remaining on the gas network, resulting in stronger incentives for remaining customers to transition to electricity.
- If left unchecked, this could result in substantial stranded natural gas assets (i.e. assets becoming obsolete ahead of their expected economic life, and therefore the initial investment cannot be fully recovered by ratepayers) or company insolvency.
- However, some gas utilities could use building electrification technologies to address gas pipeline constraints (especially where gas pipeline expansion is not possible), and may be able to transition to other business models over the long term.

Question 2 | What Type of Energy Does the Utility Sell?

Case Study: *Electric-Only Utility: SMUD*

Utility Overview: The Sacramento Municipal Utility District (SMUD) is an electric utility that serves approximately 1.5 million customers in the Sacramento region.

Opportunities and Challenges: SMUD recognizes that for Sacramento to achieve 80x50, renewable electricity must be combined with building electrification and electric vehicles. Because SMUD is an all-electric utility, it stands to gain new customers and increased infrastructure investments by helping Sacramento residents electrify. As such, SMUD developed significant ASHP and HPWH incentives that take into account the value that building electrification provides to the utility as part of its cost-effectiveness analysis. However, while SMUD was allowed to use these calculations as a municipal utility, investor-owned utilities in California have to meet different standards.

Next Steps: SMUD is now updating its cost-effectiveness modeling to be able to offer additional incentives to its customers.

Question 2 | What Type of Energy Does the Utility Sell?

Case Study: *Dual Fuel Utility: Con Edison*

Utility Overview: Con Edison is a dual-fuel utility that provides gas and electricity for 10 million customers in New York City and Westchester County, including serving gas to approximately 1.1 million customers.

Opportunities and Challenges: Overall, peak demand for gas in the Con Edison service area has grown approximately 30 percent since 2011 and is expected to grow another 20 percent over the next 20 years. Con Edison recognizes that while conversions from oil to gas for heating have helped reduce emissions, there is a statewide desire to limit continued use of fossil fuels, including gas use. To offset the need for new gas pipelines to meet growing energy demand, Con Edison launched the Smart Solutions for Natural Gas Customers Program, to avoid the development of new pipelines through customer-side gas reduction measures.

Next Steps: Given the lack of gas supply, Con Edison has declared a moratorium on new connections in Westchester County—but recognizing the business opportunity for growth in electric customers, is now offering large incentives for electrification in the moratorium area (and potentially also the Bronx, Brooklyn, and Queens), creating a major opportunity to coordinate with New York City on building electrification efforts.

Question 2 | What Type of Energy Does the Utility Sell?

Case Study: *Gas-Only Utility: Southern California Edison*

Utility Overview: Southern California Gas (SoCalGas) is a single-fuel, natural gas utility that serves approximately 500 communities and 20.0 million customers.

Opportunities and Challenges: In it's most recent Form 10-K, which was filed with the SEC in February 2018, SoCalGas recognizes that the reduction or elimination of natural gas as an energy source in California "could have a material adverse effect" on SoCalGas' cash flows, financial condition, and results of operations.

Next Steps: In coordination with Navigant Consulting, the utility recently released a study that analyzed the role of gas in a low-carbon future in California. The paper concludes that renewable gas (RNG) could achieve similar GHG emissions reductions as electrification by 2030 and could be more cost-effective under certain conditions. Overall the paper urges continued consideration of RG in California's decarbonization strategy. Furthermore, SoCalGas has proposed a 20% RNG target by 2030.

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Question 3 | Does the Utility Invest in Generation?

Whether the utility invests in electric generation helps determine whether there is an additional incentive to pursue building electrification.

- As mentioned previously, utilities in regulated states are permitted to invest in generation. Utilities that are permitted to own electric generation may have an incentive to invest in building electrification since this will allow them to sell more electricity.
- Many utilities are investing heavily in renewable energy generation assets, such as wind and solar, to meet the state's Renewable Portfolio Standard (RPS), which requires them to use a certain proportion of renewable energy. These utilities are looking for new ways use intermittent renewable electricity, which is not always available at the times of the day customers need electricity.
- By pairing renewable generation with energy storage (such as batteries or the tank of a heat pump water heater) and smart controls, grid managers can use beneficial electrification as a strategy to increase electricity use when renewable output is high and scale back electricity use when it low. Currently, utilities may have to curtail (or reduce use of) renewable generation if demand is lower than the supply. This results in a missed opportunity to utilize renewable generation and can hinder developers' ability to pay back investors.
- Please note, utilities that are not permitted to own electric generation (i.e. utilities in deregulated states) may also have an additional incentive to encourage building electrification if this translates to increased need for new transmission and distribution infrastructure that can be rate-based, allowing for an increased return.

Question 3 | Does the Utility Invest in Generation?

Case Study: *Xcel Energy, Steel for Fuel*

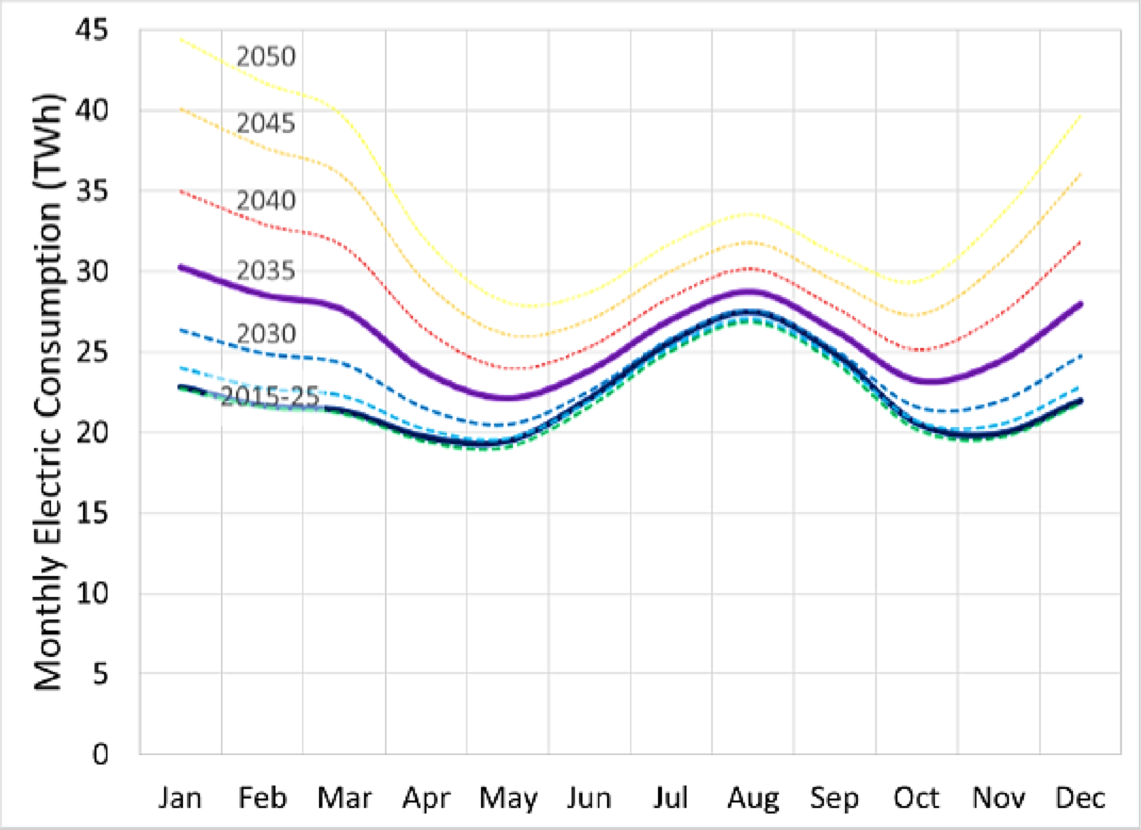
Xcel Energy, a vertically-integrated IOU that operates in eight states, has recently launched an effort it calls "Steel for Fuel," which involves transitioning away from its traditional focus on coal generation and toward solar and wind projects that are "fuel-free." The economics are compelling for Xcel as the "steel for fuel" program enables the utility to rate-base new infrastructure (wind and solar) assets, reduce operational costs associated with fossil fuel-powered plants, and leverage federal production tax credits. This effort will also support Xcel in achieving its target of zero-carbon electricity by 2050.

At the same time, the company is also investing in data analytics to reduce curtailments and increase the efficiency with which it harnesses wind on its system. Xcel expects to achieve significant benefits from electrification paired with storage by increasing electric load when there is excess wind power. The program is initially focused on transportation electrification, but could have opportunities for building electrification as well, given that wind resources are greatest during winter months when heating needs are also greatest.

Question 4 | What are the Grid Impacts of Electrification?

Building electrification is expected to have profound impacts on the grid; however, no clear understanding or alignment has emerged on what those impacts would be.

- Utility leaders generally agree that building (and transportation) electrification will almost certainly have profound impacts on the grid, especially for peak load management.
- However, no clear understanding or alignment has emerged about what those impacts would be. In fact, studies and projections suggest a wide range of possible grid impacts, which could mean a general lack of agreement (or expertise) on how to best model the impacts of electrification on the grid.
- This so-called "butterfly curve" on the right shows the potential impact of electrification on the New England grid.
- Here, increased electric use from heat pump deployment in the winter would increase the overall load factor of the electric grid up until 2030. At that point in time, the analysis shows that a winter peak will be introduced, which would likely require new grid management approaches and/or new infrastructure investment.



Source: NEEP (2017). Northeast Regional Assessment of Strategic Electrification. Prepared by Synapse Energy Economics and Meister Consultants Group. Retrieved from www.neep.org.

Question 4 | What are the Grid Impacts of Electrification?

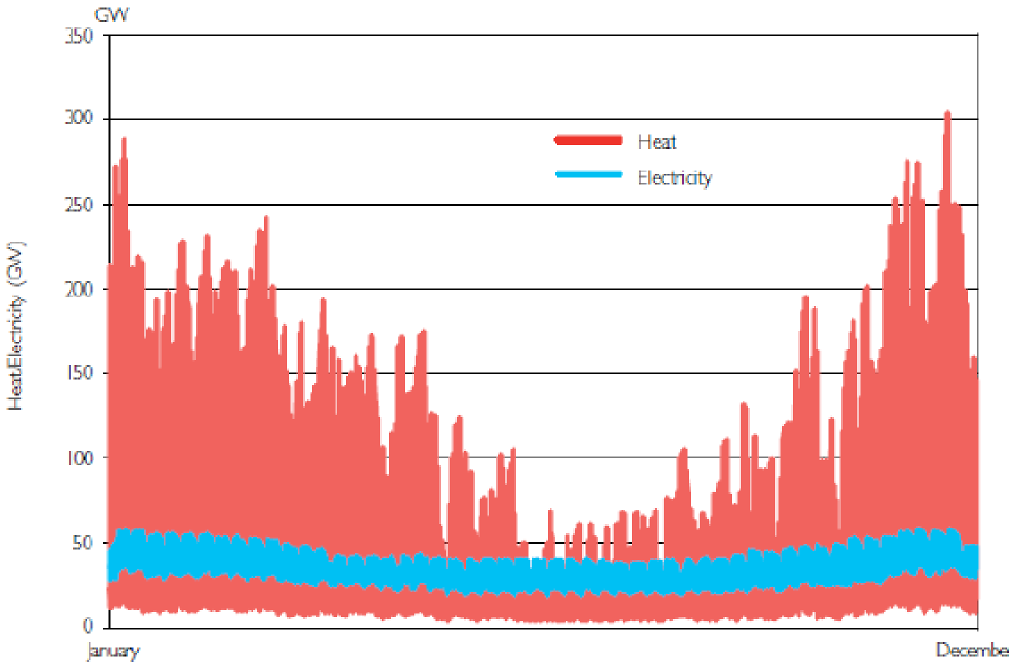
Case Study: *United Kingdom Department of Energy and Climate Change*

A 2013 report developed by the United Kingdom's Department of Energy and Climate Change (DECC) suggests that electrification of the building sector will result in approximately three- to five-fold increases in peak demand. This graphic illustrates the difference in peak demand under business-as-usual conditions for electricity and peak demand if electricity serves heating loads. Note that demand varies significantly over the course of the day, and with space heating, over the course of the year when it is particularly pronounced during winter months.

On the other hand, a preliminary analysis from California indicated that doubling energy efficiency by 2030 under California Senate Bill 350 could largely offset electric load growth during that timeframe from electrification.

A key takeaway is that building electrification could have significant ramifications for utility grid management as well as future grid infrastructure investments required to maintain reliability. Accordingly, utility leaders will have to carefully consider grid and peak load impacts as they relate to electrification in addition to developing robust modeling that can assess impacts under a range of scenarios—accounting for regional and climate differences, integration of energy and storage, natural gas demand, demand response, and energy efficiency scenarios.

Comparison of Heat and Electricity Demand Variability Across a Year



Source: UK DECC, 2013.

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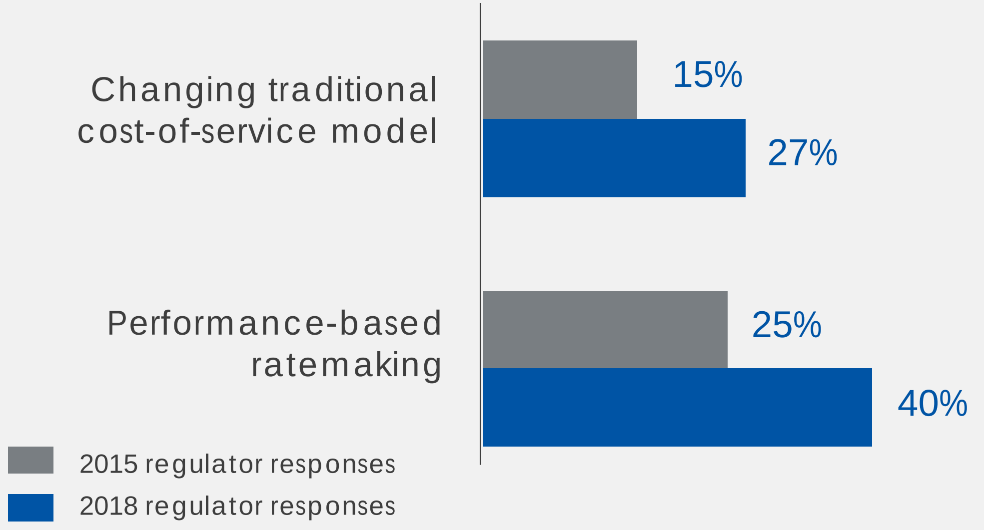
Question 5 | What Performance-based Incentives are in Place?

Performance incentives could present an opportunity to support the deployment of building electrification technologies by rewarding utilities for meeting performance goals such as GHG reductions and renewable energy deployment.

- Performance incentives enable utilities to increase earnings by achieving key performance objectives defined by state regulators. Many performance incentives focus on increased integration of distributed energy (DER) resources and reduced GHG emissions.
- Increasingly, state regulators are looking to performance based regulation (PBR) to improve performance across a wide range of public policy goals, as traditional COS regulation does not provide utilities with financial incentives to address these goals.
- A popular form of PBR is a performance incentive mechanisms (PIM), which consists of performance metrics, targets, and financial incentives.
  - PIMs have been employed for many years to address performance in areas such as reliability, safety and energy efficiency.
  - In recent years, PIMs have received increased attention as a way for regulators to create financial incentives that encourage utilities to deploy distributed energy resources (including heat pumps).

A recent survey by West Monroe and GreenTech Media found an increase in the number of state regulators changing the traditional cost-of-service model, and an increase in those implementing performance-based ratemaking

What regulatory changes are you making to promote the addition of DERs?



Question 5 | What Performance-based incentives are in place?

Case Study: *New York Reforming the Energy Vision (REV)*

In February 2015, the New York Pubic Service Commission issued an Order adopting a regulatory policy framework for Reforming the Energy Vision (REV), which described the need to reform the standard utility business model and align ratemaking practices with new regulatory and policy objectives. In May 2016, the PSC issued an Order "adopting a ratemaking and utility revenue model policy framework", which adopted a number of ratemaking changes that would enable the growth of the retail market and a modernized power system that is clean, efficient, and capable of integrating distributed energy resources.

One of the ratemaking changes the order adopts is to tie utility revenues to performance. The Order establishes new Earnings Adjustment Mechanisms (EAMs), which are essentially near-term performance based incentives that focus on four key areas including (1) system efficiency, (2) energy efficiency, (3) interconnection, and (4) customer engagement. These EAMs will ensure better alignment of utility financial incentives and near-term priorities, such as energy efficiency or improved data access.

Case Study: *Niagara Mohawk – National Grid Electric Heat Pump Initiative*

National Grid's proposed Electric Heat Pump Initiative was designed to increase customer access to high-efficiency electric heat by animating markets for cold-climate air source heat pumps (ccASHP) and ground source heat pumps (GSHP) and to reduce GHG emissions from heating. Eligible customers included all customers in the Niagara Mohawk service area that were not heating with natural gas.

The proposed program aimed to encourage replacement or displacement of delivered petroleum-based heating fuel and electric resistance heating with ccASHPs or GSHPs in the residential heating sector by offering rebates to eligible customers, engaging communities in marketing and purchasing campaigns, and engaging contractors and technology manufacturers to ensure best practices for installation, operations, and maintenance. It was expected that the program would result in the installation of approximately 1,500 heat pump systems, which would support National Grid in achieving a earning adjustment mechanism (EAM) for reducing emissions by a combined 2,700 metric tons per year of operation.

Question 6 | What Fuel Switching Rules are in Place?

Utilities in some states are discouraged or prohibited from encouraging customers to switch from regulated (e.g. gas) or unregulated fuels (e.g. oil, propane) to electricity even when the conversions are cost-effective.

- In many states with efficiency programs, fuel switching regulations prevent utilities from providing energy efficiency incentives for any customers that switch from electricity to gas or vice versa, i.e. EE funds may not be used to support fuel switching.
- Any energy savings achieved from customers who do switch fuels may not be counted towards the utility's efficiency targets.
- While the original intent of the regulations was to minimize competition between utilities, the rule also applies to many dual fuel utilities that have both gas and electric savings goals.
- It will be critical to revise state fuel-switching regulations so that utilities can leverage their existing energy efficiency programs—including use of incentive, contractor training, and marketing initiatives—to enable fuel switching and encourage building electrification. Specifically, utilities should be able to count efficiency savings (resulting from fuel switching or building electrification) toward their energy savings or GHG reductions targets.

Question 6 | What Fuel Switching Rules are in Place?

Case Study: *Massachusetts and Modification of Energy Efficiency Regulations*

The Massachusetts Department of Public Utilities approved a new three-year 2019-2021 Three Year Energy Efficiency Plan in January 2019 that takes an "energy optimization" approach to efficiency. This approach focuses on reducing overall energy use as opposed to focusing on kilowatt-hour savings. In line with this approach, the plan removes the state's regulations on fuel switching and encourages building electrification. The proposal for the plan establishes a new goal for reducing energy savings statewide across all fuels, including unregulated fuels (including heating oil and propane). The plan also amends electricity savings targets to exclude added load from electrification of fossil fuels and includes a target of approximately 62,000 cold climate heat pumps installed across residential, commercial, industrial, and low-to-moderate income sectors.

Case Study: *California and emerging support for a new GHG emissions-based standard*

There is growing support in California for a new standard, in addition to energy efficiency and renewable energy standards, to enable GHG emission reductions through building electrification. California regulators and utilities are exploring this option. Regulators and utilities are opening proceedings to deploy beneficial electrification programs as a least-cost means of achieving state GHG reduction goals. Notably, Senate Bill 1477 requires the CPUC to use gas corporations cap-and-trade auction revenues to develop a statewide market transformation initiative for low-emission space and water heating for residential and nonresidential buildings. The bill also requires utilities and regulators to develop an incentive program to fund near-zero-emission technology for new residential and commercial buildings. Moreover, the CPUC is required to develop guidelines and evaluation metrics, implement outreach strategies for hard-to-reach customers, and provide for job training and employment opportunities.

Question 7 | What Cost-Effectiveness Tests are in Place?

Regulators use benefit cost assessment (BCA) tests to determine prudence of utility expenditures. However, energy efficiency BCA tests were not designed for building electrification technologies.

Introduction to BCA Tests: The table below illustrates the five BCA tests traditionally used for utility energy efficiency programs. Each test assesses the question of cost effectiveness from a different perspective, e.g. the program participant, the program administrator, society, etc.

Test	Key Question Answered	Summary Approach
Participant Cost Test (PCT)	Will participants benefit over the life of the measure?	Comparison of costs and benefits of the customer installing the measure
Program Administrator Cost Test (PACT)*	Will utility bills increase?	Comparison of program administrator costs to supply side resource costs (and impact on utility bills)
Ratepayer impact measure (RIM)	Will utility rates increase?	Comparison of administrator costs and utility bill reductions to supply-side resource costs (and impact on utility rates). Note, this test considers impacts on non-participating customers.
Total Resource Cost (TRC)	Will the total costs of energy in the utility service territory decrease?	Comparison of program administrator and customer costs to utility resource savings
Societal Cost Test (SCT)	Is the utility, state or nation better off as a whole?	Comparison of society's costs of energy efficiency to resource savings and non-monetary costs and benefits

*Sometimes called the Utility Cost Test (UCT).

Source: National Action Plan for Energy Efficiency (2008). *Understanding Cost-Effectiveness of Energy Efficiency Programs: Best Practices, Technical Methods, and Emerging Issues for Policy-Makers*. Energy and Environmental Economics, Inc. and Regulatory Assistance Project. <www.epa.gov/eeactionplan>

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Question 7 | What Cost-Effectiveness Tests are in Place?

Regulators use benefit cost assessment (BCA) tests to determine prudence of utility expenditures. However, energy efficiency BCA tests were not designed for building electrification technologies.

Introduction to BCA Tests: The table below illustrates how costs and benefits are applied across the five tests. States may adjust the application of costs and benefits depending on their unique circumstances. Different states will use different tests as the primary means to assess cost effectiveness (e.g. some states rely primarily on SCT, others on TRC, etc.).

Component for Test	PCT	PAC	RIM	TRC	SCT
Energy & capacity related avoided costs		Benefit	Benefit	Benefit	Benefit
Additional resource savings				Benefit	Benefit
Non-monetized benefits					Benefit
Incremental equipment & installed costs	Cost			Cost	Cost
Program overhead costs		Cost	Cost	Cost	Cost
Incentive payments	Benefit	Cost	Cost		
Bill savings	Benefit		Cost		

Question 7 | What Cost-Effectiveness Tests are in Place?

BCA tests were not designed for fuel-switching measures like building electrification technologies. As a result, traditional energy efficiency BCA tests are not well suited for evaluating building electrification.

- Interestingly, BCA tests have been used for many years to evaluate heat pumps as a **cooling measure** (i.e. as a more efficient electric air conditioner).
- However, this approach does not account for the heating benefits (or costs) of building electrification, (i.e. of fuel-switching from fossil fuel [e.g. gas or oil] heating to electric heat pump heating).
- To account for the comprehensive costs and benefits of heat pumps, some states are now revising BCA tests.
- For example, some states are accounting for **costs and benefits associated with fuel switching** from oil heating to heat pumps
- Other states are incorporating GHG and economic development components into their BCA tests, which enables regulators to measure the **societal value associated with building electrification technologies**.

Question 7 | What Cost-Effectiveness Tests are in Place? Case Studies

Case Study: *New York and a New Benefit-Cost Analysis framework*

In 2016, the New York Public Service Commission, under the Reforming the Energy Vision (REV) framework, adopted a new Benefit-Cost Assessment (BCA) framework that established the Societal Cost Test (which includes a social cost of carbon) as the primary test for evaluating programs/measures and requires cost-effectiveness at the portfolio level rather than at the individual program/measure level (NY DPS, 2016).

In 2018, NYSERDA and the Department of Public Service proposed further developments to the BCA including considering benefits across different fuels and increasing the weight of benefits to participants and LMI customers. These changes will be critical in developing fuel-neutral efficiency programs and counting their savings towards the state's energy efficiency targets of 185 tera btus of cumulative annual energy savings.

New York utilities are now creating programs that specifically target installation of heat pumps in oil-heated buildings. Regulatory changes to fuel-switching and BCA tests were critical to enable utilities to incentivize and market heat pumps for oil heating customers (oil heating customers were previously off-limits to utilities).

Question 8 | What Natural Gas Policies are in Place?

Because natural gas is a fossil fuel, continued expansion of gas use over the long term is not compatible with achieving deep GHG reductions targets. Policies that prevent gas expansion and help manage the retirement of existing gas assets can have a direct impact on the growth and development of building electrification

- For many gas-only and dual-fuel utilities, gas expansion—including extending gas pipelines and connecting existing or new construction buildings—is a primary source of new earnings.
- Over the last few decades, many regulators have encouraged gas expansion as a means to provide access to low-cost energy for new construction.
- If buildings continue to electrify, and customers defect from the gas grid, there will be reduced use of (and need for) natural gas infrastructure.
  - In this scenario, the costs of operating and maintaining natural gas assets would be passed on to fewer and fewer remaining gas customers—or to the utility—which could result in increasing rates for customers and/or insolvency for a utility if it cannot support continued operations and maintenance with existing revenue.
  - Eventually, gas assets could become "stranded" (i.e. assets becoming obsolete ahead of their expected economic life, and therefore the initial investment cannot be fully recovered by ratepayers)
- As gas utilities and regulators consider the future of natural gas infrastructure, some policies have emerged.
  - Gas moratoriums on new natural gas hook ups to limit new gas infrastructure investments
  - Accelerated depreciation profile of natural gas assets (see Section 5: Case Study 2)

Question 8 | What Natural Gas Policies are in Place?

Case Study: *City of Berkeley*

On July 16, 2019, the City of Berkeley has become the first city in the United States to ban the installation of natural gas pipelines for new homes. The ordinance requires all new low-rise residential buildings—including single-family homes, town homes and small apartment buildings—to have electric infrastructure. The City anticipates expanding the gas ban to commercial buildings as the California Energy Commission completes building electrification analyses for other building types.

Berkeley's electric grid is powered primarily by renewables—and the City has a goal for 100% renewable electricity by 2035— making electric heat pumps and induction cooking a relatively clean source of energy for space heating and cooking. By contrast, gas related emissions have increased 18% due to population growth over the past year, making natural gas from buildings responsible for 27% of Berkeley's GHG emissions. Reducing emissions from natural gas will be critical for the city to achieve its greenhouse gas (GHG) emission reduction goals of reducing emissions 33% by 2020 and 80% by 2050.

Several studies suggest that the gas ban will save residents money. Eliminating natural gas use will require installation of high efficiency heat pumps that heat and cool buildings and induction stoves for cooking. The added costs of electric appliances are anticipated to be more than offset by lower construction costs, because building developers will not be required to pay for natural gas connection costs or the costs associated with internal gas plumbing.

Following Berkeley's lead, several other California cities are also considering natural gas bans.

Section Three Sources

Slide #	Slide Title	Source
39	The Utility Business and Regulatory Framework | The Functions and Services the Utility Provides Customers	• Cadmus. Pathways to 100. https://cadmusgroup.com/papers-reports/pathways-to-100-an-energy-supply-transformation-primer-for-u-s-cities/
40	The Utility Business and Regulatory Framework | The Functions and Services the Utility Provides Customers	• Cadmus. Pathways to 100. https://cadmusgroup.com/papers-reports/pathways-to-100-an-energy-supply-transformation-primer-for-u-s-cities/
41	The Utility Business and Regulatory Framework | The Regulations, Incentives, and Policies that Govern It	• https://www.utilitydive.com/news/the-next-generation-utility-business-model-what-you-need-to-know/442421/ • Environmental Defense Fund. 2019. Managing the Transition. https://www.edf.org/sites/default/files/documents/Managing%20the%20Transition_1.pdf
43	The Utility Business and Regulatory Framework | Cost Recovery	• Synapse Energy. July 2017. The Ratemaking Process. https://www.synapse-energy.com/sites/default/files/Ratemaking-Fundamentals-FactSheet.pdf • Pennsylvania Public Utility Commission. 2018 Edition. A Guide to Utility Ratemaking. http://www.puc.pa.gov/General/publications_reports/pdf/Ratemaking_Guide2018.pdf
45 - 46	The Utility Business and Regulatory Framework | Technology, regulatory, business and market changes	• Utility Dive. The next generation utility business model – what you need to know. https://www.utilitydive.com/news/the-next-generation-utility-business-model-what-you-need-to-know/442421/
50-51	Question 1 | What is the ownership structure of the utility?	• Cadmus. Pathways to 100. https://cadmusgroup.com/papers-reports/pathways-to-100-an-energy-supply-transformation-primer-for-u-s-cities/
52	Question 1 | What is the ownership structure of the utility?	• NREL. "Community Choice Aggregation: Challenges, Opportunities, and Impacts in Renewable Energy Markets." February 2019. https://www.nrel.gov/docs/fy19osti/72195.pdf • Lean Energy. What is CCA? http://leanenergyus.org/what-is-cca/
53	Question 2 | What Type of Energy Does the Utility Sell?	• Environmental Defense Fund. Managing the transition: Proactive solutions for stranded gas asset risk in California. https://www.edf.org/sites/default/files/documents/Managing_the_Transition_new.pdf
54-56	Question 2 | What Type of Energy Does the Utility Sell?	• Draft SMUD IRP Scenarios Summary Report. July 2018. Found at: https://www.smud.org/-/media/Documents/Corporate/About-Us/Board-Meetings-and-Agendas/2018/Aug/Draft-SMUD-IRP-Scenario-Summary-Report.ashx • ConEdison. Non-pipeline solutions. Found at: https://www.coned.com/en/business-partners/business-opportunities/non-pipeline-solutions • https://www.nyserda.ny.gov/About/Newsroom/2019-Announcements/2019-03-14-NYS-Announces-250-Million-Westchester-Clean-Energy-Action-Plan • Navigant Consulting. 2018. Analysis of the role of gas for a low-carbon California future. Found at: https://www.socalgas.com/1443741887279/SoCalGas_Renewable_Gas_Final-Report.pdf. • Form 10-K. December 2017. https://www.sec.gov/Archives/edgar/data/86521/000008652118000019/sreform10k.htm#s26fdf4edf0a043e6b8de01bcae1bccb0

Section Three Sources

Slide #	Slide Title	Source
57	Question 3 | Does the Utility Invest in Generation?	• Utility Dive. July 2017. Steel for future: Xcel CEO Ben Fowke on his utility's move to a renewable-centric grid. Found at: https://www.utilitydive.com/news/steel-for-fuel-xcel-ceo-ben-fowke-on-his-utilitys-move-to-a-renewable-c/446791/
58	Question 3 | Does the Utility Invest in Generation?	• Utility Dive. July 2017. Steel for future: Xcel CEO Ben Fowke on his utility's move to a renewable-centric grid. Found at: https://www.utilitydive.com/news/steel-for-fuel-xcel-ceo-ben-fowke-on-his-utilitys-move-to-a-renewable-c/446791/ • DSIRE. Renewable Electricity Production Tax Credit. https://programs.dsireusa.org/system/program/detail/734
59	Question 4 | What are the Grid Impacts of Electrification?	• Reeves, S., Veilleux, N. & Miller, M. (2018). "Strategic Electrification and the Changing Energy Paradigm: Challenges and Opportunities for Utilities." Prepared for the ACEEE Summer Session. Found at: https://cadmusgroup.com/papers-reports/strategic-electrification-and-the-changing-energy-paradigm-challenges-and-opportunities-for-utilities/ • NEEP (2017). Northeast Regional Assessment of Strategic Electrification. Prepared by Synapse Energy Economics and Meister Consultants Group. Retrieved from www.neep.org
60	Question 4 | What are the Grid Impacts of Electrification?	• Reeves, S., Veilleux, N. & Miller, M. (2018). "Strategic Electrification and the Changing Energy Paradigm: Challenges and Opportunities for Utilities." Prepared for the ACEEE Summer Session. Found at: https://cadmusgroup.com/papers-reports/strategic-electrification-and-the-changing-energy-paradigm-challenges-and-opportunities-for-utilities/ • UK Department of Energy and Climate Change. 2013. The Future of Heating: Meeting the Challenge. www.gov.uk
61	Question 5 |What Performance-based Incentives are in Place?	• WestMonroe and GreenTech Media. 2018. Planning for a distributed energy future. Found at http://www2.greentechmedia.com/l/264512/2018-12-27/7x7vn?gtm_source=Website • Lowry, MN, Makos, M., Deason, J. & Schwarz, L. State Performance Based Regulation Using Multi-Year Rate Plans for U.S. Electric Utiltiies. Grid Modernization Laboratory Consortium US Department of Energy.
62	Question 5 |What Performance-based Incentives are in Place?	• RMI. 2016. New York's next steps in the REV-olution. Found at: https://www.rmi.org/new-yorks-next-steps-rev-olution/ • New York State Public Service Commission. May 2016. Order adopting a ratemaking and utility revenue model policy framework. Found at: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={D6EC8F0B-6141-4A82-A857-B79CF0A71BF0}
64	Question 6 | What Fuel Switching Rules are in Place?	• MAPC. 2018. Massachusetts' New 3-Year Energy Efficiency Plan and What it Means for your Municipality. https://www.mapc.org/planning101/massachusetts-new-3-year-energy-efficiency-plan-and-what-it-means-for-your-municipality/.
70	Question 8 | What Natural Gas Policies are in Place?	• https://insideclimatenews.org/news/23072019/berkeley-natural-gas-ban-california-cities-incentive-all-electric-building-construction-future • https://www.sfchronicle.com/bayarea/article/Berkeley-becomes-first-U-S-city-to-ban-natural-14102242.php

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Section 4 Overview | Pathways Forward

Section 4 covers the following topics:

Topic	Description	Slide
Pathways Forward	• Presents four overarching pathways through which cities can engage with their utility on building electrification solutions. • Outlines a set of actionable strategies within each of the four pathways that cities and utilities can take to support building electrification.	75 – 102
How to Engage with Utilities	• Provides an overview on how cities can best engage with their utility to implement identified strategies.	103

Pathways Forward | How to Engage with Utilities

Cities interested in collaborating with their utilities on the strategies highlighted in this Primer should consider the following best practices and pathways to develop relationships with their utility.

Cities have four main pathways through which to collaborate with utilities on building electrification

- Pathway 1. Engaging Utilities & Developing Relationships
- Pathway 2. Collaborating on Planning & Research
- Pathway 3. Collaborating on Program & Policy Design & Implementation
- Pathway 4. Engaging State Policymakers

- **Engaging Utilities & Developing Partnerships:** Cities can often start by building relationships with utility staff and educate utilities on the broader context of goals that cities have, including equity, affordability, and climate change. It can be helpful to explain these goals in the context of the utility's goals.
- **Collaborating on Planning & Research:** Cities can partner with utilities and other stakeholders to complete research that provides information on shared areas of interest and builds a shared understanding of the local context. In particular, cities and utilities can partner to better understand customer demand, local supply chains, and energy infrastructure changes.
- **Collaborating on Program & Policy Design & Implementation:** Once a shared understanding is developed, cities and utilities can partner on pilot projects, incentive programs, outreach campaigns, or even broader policy goals. By partnering or aligning on programs and policies, cities and utilities can leverage each others' resources and strengths to achieve shared goals.
- **Engaging State Policymakers:** City staff can also engage with state policymakers to change the regulations or conditions that better enable utilities to pursue building electrification, including the state Public Utilities Commission, state energy agencies, or the state legislature.

Pathways Forward | How to Engage with Utilities

Based on these points of influence, we have identified a number of potential strategies a city could pursue to enable collaboration with a utility on building electrification goals.

#	Strategy
Pathway 1. Engaging Utilities & Developing Relationships	
1	Build Staff Capacity and Relationships
2	Identify Local Stakeholders and Partners
3	Establish a Formal City-Utility Partnership
Pathway 2. Collaborating on Market Planning & Research	
4	Gather Baseline Information on Economic, Technical & Market Conditions
5	Assess Barriers, Opportunities & Local Market Conditions
6	Develop Local Building Electrification Roadmap
Pathway 3. Collaborating on Program & Policy Design & Implementation	
7	Develop an Equitable Supply Chain
8	Increase Consumer Demand
9	“Lead by Example” Programs
10	Other City Policies and Programs
Pathway 4. Engaging State Policymakers	
11	Engage state policy makers

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Pathway 1: Engaging Utilities & Developing Relationships

Pathway 1 includes initial engagement strategies that can help build a strong foundation for future action between cities and utilities.

Key opportunities are:

1. Assess and Build City and Utility Staff Capacity

2. Identify Local Stakeholders and Partners

3. Establish a Formal City-Utility Partnership

Engage Utilities | 1. Build Staff Capacity and Relationships

Summary: As a starting point, cities can begin attending relevant conferences and webinars, assess their knowledge and capacity on relevant topics, and begin building relationships with key utility staff.

Benefits and Risks

Benefits to the City	• Increase understanding of utility's current stance toward building electrification. • Tap utility staff's knowledge and expertise to better understand opportunities and challenges for the energy sector. • Build relationships that can lead to future collaboration.
Benefits to the Utility	• Increase understanding of city goals and priorities. • Tap knowledge and experience of cities in working with their customers on broader public goals. • Build relationships that can lead to future collaboration.
Risks/ Constraints	• Potential constraints may include limited staff time or resources.

Examples of Actions

Attend relevant webinars, conferences, and trainings	• Inform one another of upcoming webinars, conferences or trainings on building electrification to attend jointly. • Organize a training between the city and utility on building electrification opportunities.
Assess staff knowledge and capacity on equitable building electrification	• Cities and their utility partners can help each other assess their knowledge and capacity on building electrification and related policy issues. • In particular, cities can help utility staff understand equity, affordability, and climate goals, while utilities can help cities understand the energy sector and utility business models and operations. • Cities can also engage the utility to understand low income utility programs and, where available, assess market insights and data.
Build relationships with key utility staff	• City staff can also benefit from investing time and effort in building relationships with utility staff, particularly those staff who are mission-aligned and can serve as liaisons in the organization. • Relationship-building strategies can range in formality, such as inviting utility staff to city events, asking them questions to leverage their expertise, or getting coffee with utility staff to build stronger professional relationships.

Engage Utilities | 2. Identify Local Stakeholders and Partners

Summary: Cities and utilities can work together to identify and begin working with key stakeholders and partners, which can help increase participation in future programs and build support for equitable building electrification.

Benefits and Risks

Benefits to the City	• Opportunity to begin engaging with new stakeholders, including utilities' customers, local contractors, and building and energy experts. • Utilities may be able to provide funding or resources for meeting spaces or participation of community groups or members in stakeholder events.
Benefits to the Utility	• Opportunity to begin engaging with new stakeholders, such as community organizations, city departments (including those working with frontline communities, including communities of color and low-income communities), and local leaders. • City involvement may increase participation in stakeholder meetings and events, as it tends to add trust and legitimacy. • Information gathered from new stakeholders can help shape incentive programming. • Increased stakeholder engagement can help improve how the utility is perceived by its customers.
Risks/ Constraints	• Involving stakeholders can make policy or program development longer.

Examples of Actions

Conduct stakeholder mapping	• Conduct a joint stakeholder mapping exercise to identify new and overlapping stakeholders. This tends to work best when done for a particular program or policy opportunity. • This can help identify where utilities and cities can leverage their strengths for building electrification strategies and actions, as well as uncover potential constraints on collaboration. • Stakeholder mapping should also help uncover potential stakeholder priorities and concerns to address.
Develop stakeholder committees or advisors	• Establish a formal stakeholder committee or identify an existing committee to advise on building electrification strategies and actions. To be most effective, ensure that the committee has representation from a wide array of stakeholders, including those who represent low income communities and communities of color. • Develop partnerships between city agencies or other community groups, particularly those closely connected to communities of color and low-income communities.
Conduct stakeholder interviews/ workshops	• Hold small group consultations, 1:1 interviews, and/or facilitated workshops involving both city and utility staff to understand community priorities and needs. These will be most successful if they begin by not presupposing community members needs or assuming that building electrification will be a top priority. • Insights from these workshops can help support goal-setting and specific strategies for cities and utilities on building electrification. Additionally, they can help cities and utilities build longer-term relationships with key stakeholders and community members.

Engage Utilities | 3. Establish a Formal City-Utility Partnership

Summary: Cities can also establish a formal city-utility partnership through a memorandum of understanding (MOU) to create a framework for shared city-utility building electrification goals.

Benefits and Risks

Benefits to the City **Benefits to the Utility**	• Clear understanding of both city and utility goals, priorities, and expectations for collaboration. • Strengthens the overall relationship between the city and utility. • Potential for increased collaboration in other key areas of overlap, such infrastructure upgrade or replacement projects.
Risks/ Constraints	• Non-binding nature of the partnership may limit one or both parties' incentive to fully uphold the agreement or remain party to the agreement.

Examples of Actions

Establish a city-utility MOU	• City and utility staff members work together to develop an MOU that outlines clear goals, priorities, and expectations for each party. • City and utility staff members establish an energy advisory board to discuss building electrification goals and priorities, laying out a process for checking-in on progress towards objectives stated in the MOU and follow-on actions. • For more information, see Section 5, Case Study 1: City of Vancouver.

Pathway 2: Collaborating on Planning & Research

Pathway 2 includes strategies that can help develop a shared understanding on key issues that affect building electrification.

Key opportunities are:

1. Gather baseline information on economic, technical & market conditions
2. Conduct research on local opportunities and barriers in the market
3. Develop local Building Electrification Roadmap

Collaborating on Research | 4. Gather Baseline Information On Economic, Technical & Market Conditions

Summary: Cities and utilities can collaborate on research to gather baseline information on economic, technical, and market conditions to assess the potential for building electrification in local context.

Benefits and Risks

Benefits to the City / **Benefits to the Utility**	• Provide baseline information on existing market conditions. • Justify city and utility investments in building electrification programs. • Support design of incentives and other strategies to enable building electrification across a wide range of buildings and communities.
Risks/ Constraints	• No risks identified. • Potential constraints may include budgetary or staffing concerns to fund studies and analyses.

Examples of Actions

Study Technical Potential	• Conduct studies on the technical potential for building electrification in the local jurisdiction, assessing the level of electrification needed to achieve the local climate goals. • These studies can create insights to help cities and utilities leaders create local plans, conduct utility resource planning exercises, and establish goals. • Technical potential studies can also be paired with economic potential studies to consider cost-effectiveness compared to alternative approaches.
Complete a Building & Market Segmentation Analysis	• Work with utility to create an inventory of citywide buildings, drawing from a variety of datasets including utility, assessor, permitting, census and other databases. • Segmentation analyses of the building inventory help identify key opportunities and barriers for heat pump deployment. This allows cities and utilities to create appropriate strategies that help buildings electrify, with tailored strategies for communities who will have the most difficulty to electrify due to economic, social, or other factors.
Conduct a Cost-effectiveness Analysis	• Analyze the cost-effectiveness of heat pumps from a variety of different perspectives and under different scenarios. It is helpful to pay particular attention to sensitivities that make installations more or less cost-effective. • When working with utilities, it can be helpful to incorporate traditional energy efficiency cost effectiveness analyses, which can include the utility cost test, TRC test, and societal cost test , as defined in Section Three. • This information can help cities and utilities justify investment in building electrification and shape development of programs and incentives.

Collaborating on Research | 5. Conduct Research on Local Barriers and Opportunities in the Market

Summary: Cities and utilities can collaborate on research to assess market barriers and opportunities to inform initiatives for market development.

Barriers and Risks

Benefits to the City / **Benefits to the Utility**	• Identify key barriers and opportunities in local market that cities and utilities can work together jointly to overcome through future programs and policies. • Develop insights into customers and supply chain practices, challenges, and needs. • Foster development of relationships with key market actors (e.g. manufacturers, distributors, etc.). • Leverages one-another's resources and expertise to result in more robust and valuable output
Risks/ Constraints	• No risks identified. • Potential constraints may include budgetary or staffing concerns to fund studies and analyses.

Examples of Actions

Assess Market Barriers & Opportunities	• Assessing local barriers and opportunities will allow city and utility planners to identify policy, technical, economic, awareness, decision-making and supply chain barriers to building electrification in the local community. • The assessment can be completed through targeted interviews and a review of relevant literature, or by more comprehensive market research activities (described below).
Research Customer Preferences	• Market research allows cities and utilities to understand consumer preferences and decision-making, as well as perceived opportunities and barriers for building electrification. • An equitable approach will emphasize surveys or focus groups with communities of color and/or low-income communities to better understand their perceptions and needs. • A key component of this research would include segmenting the market based on common building characteristics, owner/decision-maker characteristics, and resiliency and equity needs.
Research Contractor Perceptions	• Research on contractor perceptions, including opportunities and barriers scaling up heat pump deployment, will allow utilities and cities to understand critical needs for contractors, who are often the main messenger to customers. • Research may include contractor perceptions of customer preferences, training needs, and potential interest in new financing and business models. • An equitable approach will emphasize surveys or focus groups from women and minority-owned businesses to understand their perceptions and needs.
Assess Local and Regional Supply Chain	• A supply chain assessment will review the manufacturers, distributors, and contractors serving the local ASHP and HPWH market. It can also include additional analyses of installation and labor costs and projections of future market growth. • An equitable approach would seek to understand how minority-owned businesses and employees of color are engaged in the current supply chain.

Collaborating on Market Research | 6. Develop Local Building Electrification Roadmap

Summary: Cities and utilities can develop a plan to guide building electrification efforts. Equity should play a central role in such a roadmap to ensure that the most vulnerable customers and constituents benefit from city and utility investments.

Barriers and Risks

Benefits to the City / **Benefits to the Utility**	• Thoughtful engagement and coordination between cities and utilities on a Roadmap will create buy-in and support for implementation of resulting policies and programs. • City-utility engagement enables planners from both organizations to develop shared vision for the future, and identify policies and programs that address mutual needs. • Engaging in joint long-term planning processes can help leaders to plan for investments and avoid potential for unnecessary or stranded infrastructure costs.
Risks/ Constraints	• No risks identified. • Potential constraints may include budgetary or staffing concerns to fund studies and analyses.

Examples of Actions

Conduct Policy Opportunity Assessment	• Assess opportunities for building electrification to support (or inhibit) relevant city or utility policy goals, including affordability, resiliency, and/or other social equity goals. • Identify synergies with complementary city and utility programs to embed building electrification into broader strategies.
Assess Impacts on Local Energy Infrastructure	• Work with utility leaders to assess potential impact of building electrification deployment on existing electric and gas infrastructure, including changes to electric peak and depreciation of gas assets. • The analysis should seek to quantify potential impacts of building electrification on utility assets and ratepayers (with a focus on LMI customers). • For a relevant case study, see Section 5, Case Study 1: City of Vancouver.
Create Building Electrification Roadmap With Clear Goals & Metrics	• Develop a comprehensive building electrification roadmap, including policy and program recommendations, that leverages insights from previous research. • A key element of the Roadmap will be to establish near and/or long-term targets for building electrification and equity goals, along with metrics for success. • Roadmap development should include robust stakeholder engagement to achieve buy-in from city and utility leaders, industry players, building owners, state policymakers, local community groups, and other key stakeholders, who can also help support successful implementation.

Pathway 3: Collaborating on Program & Policy Design & Implementation

Pathway 3 includes strategies for cities and utilities to collaborate directly on programs, pilots, and policy implementation.

Key opportunities will help cities and utilities:

1. Develop an equitable supply chain
2. Increase customer demand
3. Pilot technologies and leading by example in municipal facilities
4. Improve implementation of city policies

Collaborating on Policies & Programs | 7. Develop an Equitable Supply Chain

Summary: Cities can work in collaboration with utilities to design and implement programs and policies that will support the development of a building electrification supply chain that can support market development.

Benefits and Risks

Benefits to the City	• Increases local ability to meet increasing demand for electrification technologies with high-quality installations. • Connects under- and unemployed workers to good paying jobs and enhance social equity by ensuring that underrepresented populations (and displaced workers) can benefit from local economic development. • Leverages existing utility trade ally network (if available).
Benefits to the Utility	• Increases installation quality of incentivized projects to ensure installations achieve necessary energy/carbon savings. • Expands contractor network and supply chain engagement to ensure that supply chain can meet volume needed to achieve utility targets.
Risks/ Constraints	• Cities and utilities can encounter legal constraints related to recommending specific contractors, products, and/or manufacturers. • Actions to grow the supply chain must be met by increased customer demand to ensure local industry and new workers can be sustained. • City and/or utility may lack direct connections to actors that can accelerate local supply chain development, necessitating effective partnerships with local or national organizations.

Examples of Actions

Contractor Training and Recruitment	• HVAC contractors active in cities may lack awareness of or technical capacity to install/service building electrification technologies. Others that are aware may not participate in any existing state or utility incentive programs. • Cities could identify trade allies (e.g. manufacturers, distributors, unions) to determine what existing training resources are available and to design programs that can incentivize contractors to offer electrification technologies and participate in utility or city market development programs. • Cities should identify what trade ally networks utilities have available and what contractor qualification programs exist to identify the best role for utility partners to support contractor outreach.
Contractor Pipeline Development Programs	• In addition to training/recruiting existing contractors, cities will need to ensure that a sufficient pipeline of new skilled workers can enter the workforce and provide high-quality services throughout the duration of the market transformation. • Cities could identify existing connections and workforce development programs internal departments have with contractors, unions, trade associations, and vocational training institutions and work collaboratively with other internal stakeholders and utilities to develop programs that encourage residents to enter trades necessary for expanding building electrification. • Some utilities may have programs in place to partner with local unions, trade schools, etc. to increase the pipeline of workers for electric and gas positions at the utility, as well as existing diversity and inclusion programs. In addition to any existing trade ally networks, cities should work with utilities to identify ways in which these existing connections and commitments can be leveraged.

Examples of Actions (Cont).

Standardize Contractor Qualification Requirements	• QA/QC and program reporting requirements are common elements of utility and city incentive programs, though contractors have reported being dissuaded from participation in some market development programs due to inconsistent or excessive qualification, QA/QC, and/or reporting requirements. • In the process of developing customer demand generation programs, cities could work with utilities to develop standardized common qualifications, program requirements, and QA/QC processes. Where utilities have existing program requirements, cities should identify how these requirements can be adopted and/or streamlined to encourage contractors to participate and reduce barriers to entry, particularly for contractors from frontline communities.

Identify Midstream or Upstream Incentive Program Pathways	• While collaboration on incentive program development is discussed further in “Increase Customer Demand,” there can be some benefits to using midstream/upstream incentive delivery pathways for some technologies and sectors, depending on the goals of the city/utility and any existing trade ally network the utility may already have in place. In particular, one such benefit is potential for greater engagement from distributors in promoting incentivized technologies (and relevant trainings) directly to contractors. • Cities could work with utilities to identify what trade ally network(s) are already in place to determine whether a midstream/upstream program is best suited for incentivizing electrification technologies. As cities often do not have connections to HVAC distributors and manufacturers reps, strong existing relationships between utilities and distributors can enable a midstream/upstream program to be more successful, particularly where existing program structures and processes can be leveraged with limited modification.

Collaborating on Policies & Programs | 8. Increase Customer Demand

Summary: Cities can work in collaboration with utilities to establish or strengthen programs that increase customer demand for building electrification. Increasing customer demand will be critical to accelerating market adoption and may be achieved through a range of marketing and education, incentive, technical assistance, and other outreach programs

Benefits and Risks

Benefits to the City	• Utilities can provide market data and customer insights that could be leveraged to strengthen city efforts. Utilities may also have robust marketing and outreach infrastructure/resources and can offer another pathway to directly engaging with customers. • Close coordination between cities and utilities on incentive and other program participation pathways can streamline processes and reduce risk of confusion for customers and supply chain actors.
Benefits to the Utility	• Collaboration with city on public-facing outreach and market development programs can increase credibility of utility efforts and provide greater access to local community groups and frontline communities. • Greater customer awareness and adoption can better enable utilities to meet incentive deployment targets.
Risks/ Constraints	• Both utilities and cities may encounter constraints on direct program collaboration when electrification goals are similar but misaligned. Coordinating joint outreach activities and messaging may be challenging when points of misalignment are encountered, limiting the extent to which cities and utilities can directly collaborate on some program activities. • Cities and utilities can be hesitant to directly endorse the work of individual contractors (e.g. due to perception of "picking winners," risk of blowback from negative customer experience). • Depending on state policies and regulations, utilities may be limited in their ability to directly supporting specific measures encouraged by city programs.

Examples of Actions

Joint Marketing and Education Campaigns	• Marketing and education activities will be necessary to raise awareness of building electrification technologies among key market segments. Cities should identify opportunities to work with utilities to launch joint marketing, education, and awareness campaigns around electrification technologies. • Marketing campaigns should not only target (and be tailored to) individual residential and commercial market segments, but also to supply chain actors (e.g. as part of developing and promoting incentive programs and pursuing supply chain development programs). • In addition to having differing resources for outreach and engagement, utilities and cities may also have different levels of credibility with and/or direct access to certain populations. For example, cities have direct access to residents and businesses, and various city departments may have significant credibility and access to specific populations through existing programs. Utilities also have direct access to customers, greater detail on energy usage of individual customers, and may have robust marketing infrastructure in place for promoting incentive programs. Identifying areas of complementary strengths and how they can be coordinated can improve the success of marketing and education efforts.

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Collaborating on Policies & Programs | 8.Increase Customer Demand

Examples of Actions (Cont.)

Community Group Purchasing Campaigns	• Cities/towns and community-based organizations across the country have launched (independently or with state support) limited-time community group purchasing campaigns that aim to raise awareness, educate residents, and connect prospective customers with qualified contractors that may be able to offer heat pump installations at a discounted rate. These programs have focused on heat pumps exclusively or have been paired with other complementary clean energy/energy efficiency measures (e.g. solar PV, home performance). • As with other joint marketing and education activities, cities may seek to collaborate directly with utilities on program design and implementation—or limit engagement to coordination on marketing and outreach activities. Cities may also opt to not select specific contractors and leverage existing utility-qualified contractors.
Downstream Incentive Programs	• Incentive programs are critical to reducing upfront costs of heat pump technologies and encouraging customers to pursue building electrification. Downstream programs provide incentives directly to customers (typically after installation of incentivized technologies). • While cities often have more limited budgets available for funding incentive programs, there may be opportunities for cities to coordinate with and build on existing utility incentive programs in order to influence program goals and structure, including but not limited to: providing additional incentives (e.g. targeted at frontline and income-eligible communities), coordinating on marketing and outreach activities, and encouraging supply chain participation.

Customer Technical Assistance Programs	• Customer assistance programs can be valuable to supplement marketing/education/group purchasing campaigns. In particular, providing energy "advisory" or "concierge" services from a trusted source to residents interested in electrification can be valuable to assist and encourage customers to proceed—and better understand challenges customers are facing in pursuing electrification. • Cities can explore opportunities to work with utilities to develop (and staff) a technical assistance offering that could support customer decision-making around building electrification and other energy-related activities that help utilities reach their incentive goals and cities achieve climate goals.
Voluntary Recognition Programs	• Recognition for sustainability and clean energy leadership can be valuable to individual members of the private sector. Providing prominent recognition to private sector leaders who pursue electrification in retrofits or new construction could encourage action from competitors, enable development of case studies, and demonstrate the value of electrification in meeting business and sustainability goals. • Cities could work with utilities to develop a joint recognition or "challenge" program to recognize and promote electrification projects of leading private and non-profit entities across various sectors (e.g. commercial real estate, healthcare, affordable housing). Depending on what programs the utility currently has, the utility may also have insights into what developers and business owners within the city have already pursued electrification during retrofits/new construction and could help to identify initial members to highlight in this program.

Collaborating on Policies & Programs | 9. "Lead by Example" Programs

Summary: Cities may consider establishing "lead by example" programs to deign and implement electrification projects and retrofit strategies in public facilities. Public sector leadership can increase awareness of building electrification technologies and encourage participation in the market.

Benefits and Risks

Benefits to the City **Benefits to the Utility**	• Cities and utilities can gain valuable insights into the process for electrifying municipal facilities, which may be leveraged to provide assistance to other entities pursuing similar projects. • Cities and utilities can share data on energy and cost impacts related to electrification, as well as test grid management measures in pilot projects, which could inform future strategic planning efforts. • Where incentives are available, coordination between cities and utilities on electrification projects can identify opportunities to streamline incentive processes. • Cities can demonstrate the effectiveness of electrification and promote electrification efforts to the general public.
Risks/ Constraints	• City officials responsible for developing scopes of work and overseeing projects at municipal facilities may not see the value of Lead by Example programs and potential for added costs.

Examples of Actions

Pilot Electrification Projects in New/Existing Municipal Buildings	• Cities may first consider piloting building electrification in a limited number of municipal buildings—e.g. a new construction project, a major renovation, and/or a system retrofit across buildings of different sizes and use cases (e.g. office buildings, public housing, recreational facilities). Outcomes and lessons learned from these pilot projects will help to inform a broader municipal building electrification strategy and efforts to assist residents and businesses. • Cities should work with utilities to identify opportunities to monitor/meter and share energy and cost data. This could also include testing impacts of grid management measures (e.g. demand response, load shifting, new pilot rate designs) or exploring options for utility-owned assets (i.e. utility-owned ground loops in geothermal systems). Utilities may also have custom incentives that could help reduce the upfront cost of installation and/or co-fund the cost of equipment for testing grid management measures.
Municipal New Construction Electrification Strategy	• Leveraging lessons learned from initial pilot projects, cities may consider developing an all-electric requirement for all municipal new construction/major renovation projects (or integrating all-electric requirements into existing new construction energy efficiency/renewable energy requirements). • Depending on outcomes from pilot projects, cities should continue working with utilities to share energy data and test out new grid management strategies that could be valuable for informing utility efforts as the private market scales, as well as to identify custom incentives for municipal projects.
Electrification Retrofit Strategy for Existing Municipal Buildings	• Building on pilot projects and a new construction electrification strategy, cities may next consider to develop a requirement for replacing heating systems at end-of-life in existing municipal buildings with heat pump systems (or considered as the first option). Given that some municipal buildings may not be possible to electrify without also making a major renovation to the building, cities identify where such (e.g. in collaboration with utilities and other technical experts) applications may be less well-suited to electrification upon replacement of the existing system.

Collaborating on Policies & Programs | 10. Other City Policies

Summary: Depending on the level of utility involvement, there may be pathways for utilities to support the design and implementation of city policies and programs.

Benefits and Risks

Benefits to the City	• City policies/programs can complement utility incentive programs, potentially increasing customer uptake and compliance to achieve the goals of both entities while also reducing market confusion over differing program requirements.
Benefits to the Utility	• Utilities may be able to publicly support and develop resources to assist city residents where incentive programs are aligned with city policies and programs.
Risks/ Constraints	• Depending on state policies and regulations, utilities may be limited in their ability to directly support specific measures encouraged by city programs.

Examples of Actions

Developing Local Energy Codes	• In states where cities have the authority to establish local building energy code requirements or stretch/reach codes, cities can explore options for developing local energy codes that can encourage electrification (e.g. net-zero stretch codes, all-electric ready construction requirements). • Given the impact local codes that encourage electrification may have on future new construction projects, cities should explore opportunities to collaborate with utilities on the local code development process (e.g. co-funding reach code studies) and to align utility incentives and education/outreach efforts to building practitioners with the requirements of code requirements.
Additional City Policies and Programs	Depending on the outcomes of a local building electrification roadmap and/or local market and technical research studies, cities could identify other opportunities to collaborate with local utilities. Examples of additional city policy/program efforts could include additional incentives targeted at developers and (if municipal utility) developing strategies to proactively increase grid electrical capacity in anticipation of increasing levels of electrification.

Category 4: Engaging State Policymakers

Category 4 includes strategies that a city may employ to create a policy and regulatory environment that encourages or enables utilities to advance building electrification.

Key opportunities are to:

1. Identify state policy and regulatory options to encourage building electrification
2. Engage with state policymakers on critical policy and regulatory options

Engaging State Policymakers | Introduction

Driving Policy Change to Enable Utilities to Pursue Building Electrification

Some utilities may be unwilling to collaborate with city leaders on building electrification. In such cases, cities may engage state policymakers to change the rules of the game in which utilities operate. There are three primary state entities that a city may engage.

State Regulatory Commission

- IOUs are primarily regulated by public service commissions (PSCs).
- Regulatory commissions typically include 3-7 Commissioners and professional staff, which are responsible for overseeing and authorizing investment decisions, operations and customer rates for IOUs.*
- Experience shows that without direct and supportive regulations and policies, utilities will not develop and offer distributed energy resource (DER) or EE programs, including building electrification. Utilities need confidence that regulators will permit them to at least recover costs associated with such programs.
- Cities can intervene in regulatory proceedings by either investing necessary time and resources—or by engaging collaborators or experts (e.g. consultants, advocacy organizations) to navigate proceedings.

State Energy Agency

- In many states, state energy agencies (e.g. Mass Dept of Energy Resources, Calif Energy Commission) have extensive authority to interpret and implement legislative policies.
- Energy responsibilities relevant to building electrification may be housed across multiple agencies, including housing, energy, or other departments.
- This may include, for example, creation and implementation of state energy plans, energy or building codes, energy efficiency and DER programs, or incentive programs, among others.
- City planners can engage their counterparts at state energy agencies to influence the development of energy policies and programs that influence the development of building electrification markets.

State Legislature

- State legislatures have broad authority to establish laws pertaining to retail electricity in their states, including requirements for utilities to invest in EE or distributed energy resource (DER) programs like building electrification.
- State legislatures are also responsible for creating regulatory commissions and state energy agencies. Accordingly, they may augment the authorities or duties of regulatory commissions and energy agencies as they see fit. In some states, the legislature may have authority to review and approve proposed rules issued by PSCs.
- Depending on their political appetite and resources, cities may engage state legislatures to influence the development of building electrification policies.

*Note, publicly-owned utilities (e.g. cooperatives and municipal utilities) are not usually regulated by state PSCs. They are overseen by a variety of somewhat comparable organizations such as coop boards or municipal governments.

Engaging State Policymakers | Introduction

Driving Policy Change to Enable Utilities to Pursue Building Electrification

Cities may engage state policymakers across a range of issues to encourage utilities to pursue building electrification. An overview of these issues is provided below:

Key Issues
Develop Favorable Building Codes
Develop New Utility Rate Designs
Enable Fuel Switching
Revise Cost-Effectiveness Tests
Establish State Targets
Establish Utility Incentives
Limit Gas Usage and Infrastructure Expansion

Engaging State Policymakers | Introduction

An example list of categories of state legislative, policy, and regulatory actions that could be pursued through engagement with state policymakers (or in key decision-making venues) is provided on the following slides. For each state action category, a description is provided as well as how the category could impact utilities and how each state entity can effect the changes.

Category	Description of Options	Impact on Utility	Role of State Entity		
			Leg.	Agency	PUC
(Name of category of legislative, policy, and/or regulatory actions)	*(Summary of action options that could be pursued through city engagement)*	*(Summary of potential impacts of implementing policy actions on utility attitudes and approaches to building electrification)*	*(State legislature)*	*(State executive agencies)*	*(State regulatory authority)*

For each category, an illustrative example will be provided summarizing the role or authority each state entity holds in implementation.

✓	Primary decision-making authority over proposed action
◐	Partial decision-making authority over proposed action
●	Limited influence over decision-making

Engaging State Policymakers | Policy & Regulatory Options

1. Develop Favorable Building Codes

Description of Options	Impact on Utility	Role of State Entity		
		Leg.	Agency	PUC
While cities in some states may have authority to establish local code requirements, most energy code requirements for new and renovated buildings are established at the state level. Cities could consider: • Encouraging state agencies to study, develop, and implement stretch zero energy/carbon building energy codes that include all-electric provisions. • Encouraging development of all-electric "ready" code requirements and all-electric compliance pathways for baseline and stretch energy codes. For more information, see Section Five, Case Study Three: City of Vienna	• Utilities can be engaged in code development process to understand potential impacts of different options to the energy grid and anticipate needs for infrastructure investment. • Many utilities have new construction and other incentive programs that encourage builders to go beyond code (or other baseline) requirements. Changes to stretch energy codes that articulate all-electric pathways could encourage utilities to align new construction program requirements with all-electric pathways to help prepare the market.	◐	✓	●
		In most states, executive agencies have jurisdiction over making code updates and developing model codes. Legislative action could direct executive agencies to focus on all-electric or more aggressive options.		

Additional Reading

In California, utilities can contribute to achieving energy savings targets by funding development of energy code studies. For example, Southern California Edison funded the development of the City of Santa Monica's Building Energy Efficiency Reach Code Cost Effectiveness Study.

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Engaging State Policymakers | Policy & Regulatory Options

2. Develop New Utility Rate Designs

<table>
<tr><th rowspan="2">Description of Options</th><th rowspan="2">Impact on Utility</th><th colspan="3">Role of State Entity</th></tr>
<tr><th>Leg.</th><th>Agency</th><th>PUC</th></tr>
<tr><td rowspan="2">Smarter electric rate designs (e.g. time-of-use rates) aims to encourage (and discourage) customer behavior in ways that benefit grid operations and efficiency. New smart rate designs could encourage beneficial electrification and adoption of other distributed energy resources, though depending on local conditions and benefits to the grid, this could favor some electric technologies over others. Cities could consider:
• Encouraging regulators, state entities, and utilities to study rate designs that could optimize grid operations and benefits to the grid, maintain utility revenue requirements, and have impacts on beneficial electrification.
• Encouraging regulators to push utilities to pilot and develop time-of-use rates that can encourage beneficial electrification.</td><td rowspan="2">• Implementation of new rate designs (and desire to maximize benefits of new rate designs to the grid) will encourage utility to promote behavior change and adoption of measures that offer the greatest flexibility for load shifting. Depending on the characteristics of the local grid and the structure of a time-of-use rate, this could encourage customers to pursue electrification and encourage utilities to promote building electrification measures to customers.</td><td>◐</td><td>●</td><td>✓</td></tr>
<tr><td colspan="3">Utility ratemaking is primarily overseen by regulators. In some cases, legislation may be needed to authorize regulators to address rate design.</td></tr>
</table>

Additional Reading

A number of utilities across the country have begun deploying time-of-use rates to encourage behavior change and load shifting to benefit the grid. These rate designs vary significantly in structure and flexibility based on the characteristics of the local/regional grid and the behaviors the utility is aiming to encourage—which can have substantial impacts on how and whether the rate design will encourage building electrification. For example:

- SMUD's residential time-of-use rate encourages load reduction during a set, year-round peak period (5-8pm) with seasonal variation for off-peak periods and provides an additional incentive for EV charging during particular off-peak periods.
- By contrast, National Grid in Upstate NY has a voluntary residential time-of-use rate that is designed for EV owners and is not well-suited to encourage building electrification due to the on-peak period being from 7am to 11pm, limiting the ability to shift electric heating and cooling loads.

Engaging State Policymakers | Policy & Regulatory Options

3. Enable Fuel Switching

Description of Options	Impact on Utility	Role of State Entity		
		Leg.	Agency	PUC
In most states, utility energy efficiency funds are restricted from being used to encourage customers to switch between regulated fuels. This can range from outright prohibition to limitations on ability to realize energy and non-energy benefits from fuel-switching. Cities could consider: • Encouraging state entities to remove restrictions to fuel-switching to achieve broader societal/public goals (including building electrification).	• Removal of fuel-switching limitations will enable deployment of ratepayer efficiency funds for building electrification. Depending on the utilities interests and other policy/regulatory requirements (e.g. cost-effectiveness, performance incentives), removing these restrictions could lead to direct incentivization of building electrification.	✓	●	✓
		In some states, regulatory agencies have authority to modify fuel-switching regulations, though in others, legislative action (to enable fuel-switching) could be necessary to authorize regulators to act.		

Additional Reading

Since late 2018, some state regulators have taken steps to reducing barriers to incentivizing fuel switching through energy efficiency programs:

- **NY:** In December 2018, the NY Public Service Commission issued an "Order Adopting Accelerated Energy Efficiency Targets" adopting a fuel-neutral/all-fuels approach to programs that can enable utilities to incentivize energy savings that involve cost-effective fuel-switching and establishes a target of incentivizing the installation of heat pumps in approximately 83,000 buildings in the state between 2021-2025.
- **MA:** In January 2019, the MA Dept. of Public Utilities approved the Three-Year Plan proposed by the MA Energy Efficiency Advisory Council which establishes an energy optimization strategy and fuel-neutral approach to energy efficiency. In conjunction with state legislative action that redefined the legal definition of energy efficiency to include strategic electrification and other distributed energy resources, utilities are now able to incentivize energy savings that involve cost-effective fuel switching, with the goal of incentivizing the installation of heat pumps in approximately 62,000 buildings between 2019-2021.

Engaging State Policymakers | Policy & Regulatory Options

4. Revise Cost-Effectiveness Testing

Description of Options	Impact on Utility	Role of State Entity		
		Leg.	Agency	PUC
Traditional cost-effectiveness tests for utility efficiency programs (e.g. Total Resource Cost, Participant Cost) account for costs of building electrification without being able to fully take into account its potential benefits (e.g. to ratepayers and society as a whole). This limits the ability for efficiency funding to be used on building electrification, particularly when cost-effectiveness testing is required for individual measures. Cities may consider: • Encouraging state entities to modify existing cost-effectiveness frameworks to enable greater accounting of benefits of building electrification (e.g. carbon emissions and pollution, fossil fuel reductions). • Encouraging state entities to allow for cost-effectiveness to be determined for efficiency programs at the portfolio level rather than at the individual measure level. This would enable efficiency programs to support electrification activities that may individually fall short of being cost-effective.	Changing cost-effectiveness frameworks could enable utilities to incentivize building electrification measures that were not cost-effective under the previous framework, unlocking utility support for city electrification efforts.	✓	●	✓
		In some states, regulatory agencies have authority to modify cost-effectiveness frameworks, though in others, legislative action to direct regulators (or state executive agencies) could be necessary to authorize regulators to act.		

Additional Reading

In recent years, several state regulators have taken steps to modify cost-effectiveness testing for energy efficiency programs that can be more favorable to electrification:

- **NY:** In 2016, the NY Public Service Commission adopted a new Benefit-Cost Analysis Framework that established a Societal Cost Test (including a social cost of carbon) as the primary test for evaluating energy efficiency programs and modified the requirement for cost-effectiveness at the portfolio level rather than at the individual measure/program level.
- **RI:** In 2017, RI Public Utilities Commission established a new "Rhode Island Test" that expands the existing default Total Resource Cost test to also include the value of GHG reductions and economic development impacts.

Engaging State Policymakers | Policy & Regulatory Options

5. Establish State Targets

Description of Options	Impact on Utility	Role of State Entity		
		Leg.	Agency	PUC
Targets for building electrification have been enacted in very few states. More broadly, many states lack energy efficiency standards (e.g. EERS) or other targets that could encourage utilities to invest in long-term efficiency programs (that could include building electrification). Establishing statewide targets for electrification (or energy efficiency more broadly)—particularly those that compel utility action—can encourage utility action and collaboration with cities. Cities could consider: • Encouraging state entities to establish new targets for building electrification (or energy efficiency in general). • Encouraging state entities to establish carve-outs within existing energy efficiency/renewable energy targets that include building electrification technologies.	• State targets establish clear goals and direction for utilities to plan around. • State targets can unlock (and justify) incentive mechanisms (e.g. performance incentives) that can drive utility engagement on building electrification issues and align utility interests with city goals.	✓	◐	✓
		Depending on the state, regulators or legislators will primarily be involved in establishing targets for building electrification and/or efficiency. In some states, executive agencies may be involved in interpreting legislation and establishing specific, quantifiable targets on behalf of regulators (or at the direction of legislators).		

Additional Reading

In December 2018, the **New York** Public Service Commission adopted accelerated energy efficiency targets of 3% reduction of electricity sales annually until 2025. The order also included a subsidiary target requiring at least 5 TBtu of customer energy usage reductions to come via heat pump deployment. The order directs utilities to prepare a heat pump proposal in 2019 and develop a formal implementation plan as part of their efficiency program filing for 2021-2025.

The **International Energy Agency** report on Renewable Heating and Cooling (see Section 4.2) has additional information on the roles of targets in supporting heat pump deployment. The report also provides examples of thermal-sector national-level targets for countries outside of the U.S.

Engaging State Policymakers | Policy & Regulatory Options

6. Establish Utility Incentives

Description of Options	Impact on Utility	Role of State Entity		
		Leg.	Agency	PUC
Utilities need financial incentive mechanisms that encourage them to pursue energy efficiency (and building electrification) programs. In states where such performance incentive mechanisms are not in place—or where incentive mechanisms are tied to energy savings targets that disincentivize electrification—establishment or modification of utility performance incentives can encourage utilities to promote electrification and collaborate with cities. Cities could consider: • Encouraging state entities to establish incentive mechanisms that encourage energy efficiency and building electrification (e.g. removing added load from beneficial electrification, fuel-neutral energy optimization targets). • Establish performance incentives for utilities tied to GHG emission reductions (which encourage building electrification). • Intervening during rate cases to encourage greater support for electrification incentives.	• Establishing utility incentives can align profit motivations with pursuit of building electrification market acceleration.	✓	●	✓
		In many states, legislators will need to pass laws establishing utility incentive mechanisms, which can then be interpreted (and applied) by regulators, with support from state agencies where necessary.		

Additional Reading

- In 2016, the New York Public Service Commission issued the Track Two Order that incentivizes utilities to achieve REV objectives (e.g. reduce carbon emissions, improve system-wide efficiency) by adding outcome-based earning opportunities for utilities.

Engaging State Policymakers | Policy & Regulatory Options

7. Limit Gas Usage and Infrastructure Expansion

Description of Options	Impact on Utility	Role of State Entity		
		Leg.	Agency	PUC
Customers that take advantage of incentives for high-efficiency gas equipment (which can often be higher than incentives for efficient electric equipment) are unlikely to pursue electrification for 15+ years. Similarly, expansion of gas networks—and associated long-term asset depreciation—will present challenges for long-term management of the gas network, especially for jurisdictions promoting decarbonization via building electrification. Limitations on gas grid expansion and interconnection, as well as elimination (or reduction) of gas equipment incentives, could produce environments that are more favorable to decarbonization and building electrification. Cities could consider: • Encouraging state entities to limit expansion of new gas transmission and distribution lines and/or potentially declare gas moratoria on new connections. • Encouraging regulators to limit incentives for gas equipment. For more information, see Section 5, Case Study 2: United Kingdom	• Limitations on gas expansion can encourage utilities to pursue growth and revenue in other areas (e.g. electrification) and could enable collaboration with cities on electrification projects that limit growth in gas demand.	✓	●	✓
		Depending on the state, regulators or legislators would enact any restrictions on gas infrastructure expansion.		

Additional Reading

- For more information on stranded assets and the risk they pose for utilities, see this report from Moody's Investor Services: Regulated Electric and Gas Utilities and Networks – Global: Prudent Regulation Key to Mitigating Risk, Capturing Opportunities of Decarbonization.
- For more information on strategies for mitigating the risks of stranded assets exacerbated by electrification, see this report from the Environmental Defense Fund: Managing the Transition, Proactive Solutions for Stranded Gas Asset Risk in California.

Engaging State Policymakers | Engagement Strategies

Cities seeking to promote policy and regulatory actions that favor building electrification may consider a range of potential activities to engage state entities. The most appropriate actions to pursue will depend on several factors, including the city's appetite for engaging in advocacy, the size of the city, and the city's resources for engaging with state policymakers across different venues.

Example activities:

- **Monitor state policies:** As a starting point, cities can begin by monitoring relevant state policy activity, which can allow cities and their partners to engage during windows of opportunity when they arise. This is a rather reactive approach to engaging on state policy, but can be a good first step for a city.
- **Submit letters or public comment during rulemaking processes:** When a policy window opens, cities can submit letters and testimony during the public comment portion of PUC rulemaking and rate cases, just like any member of the public. This is a limited intervention, but if the city leverages this in coordination with other methods of engagement with the utility, this strategy can affect both the utility's filings and the PUC's rulemaking. There may be other venues for engagement as well, such as Independent System Operator (ISO) proceedings.
- **Collaborate with community advocates and stakeholders:** Cities can also play a role in organizing or collaborating with other community members or advocates to engage in the state legislative and PUC rulemaking process, which could include businesses, institutions, grassroots organizations, and others. Cities can organize meetings or working sessions, provide data or other resources for grassroots to use in their state engagement, and/or provide letters of support to organizations' testimony. Sometimes a community advocate can take a stronger position than the city or others, which in combination with other testimony may benefit the city's interests.
- **Develop a joint engagement strategy with other cities:** There is an emerging trend of joint policy engagement across cities within a given state to work toward common policy goals. This can include developing policy and engagement agendas, monitoring developments, writing joint letters of support, and formally intervening in regulatory proceedings. This could include jointly hiring paid coordinators, adopting formalized governance structures, and requiring city dues. Examples of this strategy include the Colorado Cities for Climate Action (CC4CA) and the California Local Government Sustainable Energy Coalition (LGSEC).
- **Create team to advocate for the City at the state legislative and/or PUC level:** Many cities have state legislative offices that they may be able to leverage for top priority issues. Some cities hire external counsel to represent the City at PUC proceedings, such as New York City. Since legal counsel can be expensive, cities could also join together to hire counsel that can represent multiple city interests.

Section Four Sources

Slide #	Slide Title	Source
92	Category 4: Engaging State Policy Makers	• https://aceee.org/topics/utility-regulation-and-policy • National Consumer Law Center. A Consumer's Guide to Intervening in State Public Utility Proceedings. https://www.nclc.org/images/pdf/energy_utility_telecom/consumer_protection_and_regulatory_issues/report_may2003.pdf • The Regulatory Assistance Project. Electricity Regulation in the US: A Guide. http://www.raponline.org/wp-content/uploads/2016/07/rap-lazar-electricity-regulation-US-june-2016.pdf

Table of Contents

Section 5 Overview | Case Studies

Section 5 covers the following topics:

Topic	Description	Slide
International Case Studies	• Four international case studies that highlight strategies implemented by international cities, as well as lessons learned that can provide U.S. cities with valuable guidance as they pursue collaboration with their utility on building electrification.	107 – 124

Case Study One | The City of Vancouver: Grid Constraints Study

The City of Vancouver-BC Hydro Grid Constraints Study was selected as a case study due to the City's demonstrated history of collaborating with its electric utility on climate goals, including electrification and its implementation of several strategies identified in the Primer.

Vancouver Context	
City Climate Goals	• Aiming to reduce GHG emissions by 50% below 2007 levels by 2030 and 80% by 2050. As of 2017, the City had reduced carbon pollution 7% below 2007 levels. • Aiming for 100% renewable energy by 2050
Utility	• A crown corporation (i.e. province-owned), BC Hydro, that supplies electricity • A private utility, Fortis BC, that supplies natural gas
Energy Sector	• Electricity supply is currently 98% carbon-free due to large sources of hydropower

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City of Vancouver | Drivers and Barriers to Electrification

The following drivers and barriers have contributed to the City's efforts to engage with their electric utility on electrification efforts:

Drivers of Electrification in Vancouver

- **Reducing GHG emissions** is a primary driver of electrification for the City of Vancouver. Currently, the burning of non-renewable energy to produce space heating and hot water in buildings is the largest source of emissions in Vancouver, contributing to 59% of the City's emissions in 2017. As a result, the City has developed multiple goals and initiatives to reduce emissions from buildings. Electrification of the thermal load, including heat pumps, is a core component of this plan.

Barriers to Electrification in Vancouver

- While building electrification, as well as transportation electrification and neighborhood densification, have been identified as key elements of the City's strategy to meet its targets, the **City lacked a clear understanding of how this strategy would impact the grid.**
- Vancouver recognized a need to understand if any notable grid constraints would arise as a result of its climate policies and programs related to electrification and densification. As a result, the **City realized it needed to engage with its electric utility, BC Hydro, to better understand grid impacts.**

City of Vancouver | Approach to Electrification

To support electrification and better understand the impacts of electrification on the grid, the City of Vancouver collaborated with BC Hydro on the following strategies:

Leverage City-Utility Memorandum of Understanding (MOU)

- The City of Vancouver has held a MOU with BC Hydro since 2009. The MOU is a non-legally binding **framework that facilitates collaboration** between the two entities on key objectives, such as operations, planning, and common climate change goals.
- Additional benefits of the MOU include **better coordination between Vancouver and BC Hydro on infrastructure upgrades and replacement projects**, specifically the coordination of electrical, water, sewage and other utility projects that have avoided the need for roads and sidewalks to be torn up more than once.
- Building upon the relationship established in the MOU, the City sent BC Hydro a formal request in fall 2018 to collaborate on an assessment of electrical demand growth patterns and grid constraints that may occur as a result of building and transportation electrification and neighborhood densification.

See Pathway 1, #3-Establish a Formal Partnership for more information about city-utility MOUs

Assess Impact of Electrification on Energy Infrastructure

The Grid Constraints Study includes four key steps, including:

1. **Identification of actions** related to buildings, transportation, and neighborhood densification within the City's Renewable Energy Strategy that are expected to impact electricity demand.
2. **Quantification of potential demand growth** in each of these categories, with the City leading demand growth modeling for actions related to building electrification and land densification and BC Hydro modeling demand growth related to electrification transportation.
3. **Determination of where grid constraints may arise** by compiling each demand growth model into a spatial model of electricity use in relation to the grid.
4. **Identification of Solutions** that could be implemented by the utility and/or the City to reduce grid constraints, such as new infrastructure, demand-side management programs, and/or electric rate designs.

See Pathway 2, #6- Develop Local Building Electrification Roadmap for more information about city-utility studies.

City of Vancouver | Challenges and Lessons Learned

Stakeholders from the City of Vancouver and BC Hydro noted several key challenges and associated lessons learned that arose throughout the process of setting up and conducting the Grid Constraints Study. These lessons can provide useful guidance to cities interested in collaborating with their own utility on a grid constraints or similar assessment.

Budget Time to Identify the Right Points of Contact

- As noted on the previous slide, the Grid Constraints Study touched upon many teams and working groups at BC Hydro, yet it was not formally part of their work plan at the start of the project.
- Ultimately, the City needed to put in a formal request to corporate leadership, which resulted in **a formal agreement between BC Hydro's CEO and Vancouver's City Manager**.
- Stakeholders noted that this startup process of identifying the correct points of contact and formalizing the agreement took time, despite the preexisting MOU. For this reason, stakeholders suggest cities without this preexisting relationship should **budget a substantial amount of time for this startup process .**

Develop a Data sharing Process

- While Vancouver is leading the demand growth modeling for buildings, BC Hydro is the entity that maintains most of the data on building electricity usage.
- BC Hydro has agreed to share this data with the City; however they are **still determining a manageable process for sharing such large amounts of data**. To date, the process has entailed signing a two-way confidentiality agreement and establishing a SharePoint site for data and report sharing.
- Stakeholders provided several suggestions for U.S. cities interested in establishing a data sharing process with their utility, including:
    - Identification of common objectives
    - Obtaining senior-level buy-in and commitment
    - Signing a confidentiality agreement
    - Scheduling recurring meetings between the city and the utility

Ensure Open Communication

- Since the City and Utility are each leading different project tasks as part of the study, with the City focusing on buildings and land use and the utility focusing on transportation, stakeholders **highlighted the importance of communication between the two entities** to ensure the project is running smoothly.
- For U.S. cities interested in collaborating with their utility on a similar project, stakeholders suggested holding **monthly check-ins between the city and the utility** to provide project updates, but encouraging the entities to communicate immediately regarding any day-to-day issues that arise.

Case Study Two | United Kingdom: Accelerated Depreciation of Natural Gas Distribution assets

- The United Kingdom was selected as a case study given the UK Office of Electricity and Natural gas Market's (Ofgem) decision to accelerate depreciation of natural gas distribution assets to minimize the risk of stranded assets in a decarbonized future.
- As electrification is expected to increase the risk of stranded assets, identifying pathways for mitigating this risk is a key theme of the Building Electrification Primer.

United Kingdom Energy Landscape

- Ambitious carbon reduction commitments, including:
  - 80% reduction below 1990 levels by 2050
  - Legally-binding interim carbon budgets every five years that cap the amount of emissions that can be emitted from the UK in that timeframe
- A performance based regulatory framework established by the regulator of electricity and downstream natural gas markets that applies to network companies in the electricity and gas transmission and/or distribution sectors.

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United Kingdom | Context: The Uncertain Role of Natural Gas in a decarbonized UK

A variety of factors, summarized below, have framed an uncertain future for the role of natural gas, which is posing challenges for utilities and regulators.

Decarbonization Goals Call Use of Natural Gas Into Question

- Through the Climate Change Act of 2008, the UK government committed to reducing greenhouse gas emissions by 80% below 1990 levels by 2050.
- The Act also sets legally-binding interim carbon budgets every five years that cap the amount of emissions that can be emitted from the UK in that time. As the UK works towards its decarbonization goals, the long-term role of natural gas as a viable heating fuel has been called into question.

Stranded Natural Gas Assets Pose a Challenge

- The potential decline in natural gas demand driven by decarbonization efforts raises further uncertainty surrounding the utilization of existing gas infrastructure.
- As the customer base declines due to efforts to decarbonize (e.g. customers switch from gas to electricity), the cost of the gas infrastructure will be spread across a smaller customer base, which would result in higher rates for remaining customers if mitigating measures are not taken. Similar to the "utility death spiral" that electric utilities are facing due to increased penetration of distributed energy resources, these increased rates will likely cause additional customers to switch from natural gas, thus further increasing rates and incentivizing more customers to switch.

See Pathway 4, Limit Gas Usage for more information about stranded assets.

Regulators Are Obligated to Protect Consumers and Investors

- Regulators such as Ofgem have a responsibility to mitigate the risk of stranded natural gas assets to protect ratepayers (e.g. ensure current and future customers pay a fair rate) and investors (e.g. ensure investors' investment is recovered with the opportunity to earn a profit). In this context, Ofgem has sought out models for depreciation that would help mitigate this risk.

United Kingdom | Overview of Depreciation

Depreciation is the recovery of the cost of initial investment in capital assets made by investors over the economic life of the assets (e.g. as they are "consumed"). In other words, it is the return of capital investment to the investors over time.

Approaches to Depreciation: Straight-line and sum-of-digits

A common approach to depreciation is the **straight-line approach**. In this approach, an asset is depreciated a constant amount each year equal to one divided by its economic life. For example, if an asset cost $150 and has an economic life of five years, it will be depreciated by one fifth of its value, or $30, each year from year one to year five.

An alternative approach to depreciation is the **sum-of-digits approach**, which accelerates the amount depreciated in the near-term. Consider the same asset described above. Under the sum-of-digits approach the depreciation allowance will be set by the formula: (remaining life/sum of years digits). In this example, the sum of years digits equals 15 (1+2+3+4+5). Using this formula, the depreciation allowance per year is summarized below:

Year	Remaining Life	Applicable Percentage (Remaining Life/15)	Depreciation Amount
1	5 years	33.33%	$50
2	4 years	26.67%	$40
3	3 years	20.00%	$30
4	2 years	13.33%	$20
5	1 year	6.67%	$10
Totals:	**15**	**100%**	**$150**

Both the straight-line and sum-of-digits approach to depreciation will recover the full cost of investment, but at different rates. The sum-of-digits approach brings forward a larger proportion of cost-recovery in the early years of an asset's economic life than the straight-line approach. This can be beneficial in instances where the long-term use of an asset is uncertain because frontloading the depreciation in the early years of an asset's economic life diminishes the risk of investors under- recovering their investment.

United Kingdom | Approach to Electrification

To minimize the risk of stranded natural gas assets, Ofgem took the following approach:

Accelerated Depreciation of Natural Gas Distribution Assets

- To protect consumers, **Ofgem implemented a performance-based framework** titled RIIO (Revenue = Incentives + Innovation + Outputs). The framework implements price controls that limit how much transmission and distribution companies can charge customers and incentivizes the companies to innovate in order to cut costs for customers. The framework sets three separate price controls for eight-year periods of time that each cover a different sector, including gas and electricity transmission (RIIO-TD1), gas distribution (RIIO-GD1), and electricity distribution (RIIO-ED1).
- Throughout the process of determining the RIIO-GD1 price control for gas distribution, **Ofgem reviewed its depreciation assumptions** while considering future demand scenarios for natural gas, the current age of the network, and the average technical life of assets.
- **Ofgem decided to retain its 45-year asset life assumption, but accelerated the depreciation profile for all new gas distribution assets** (e.g. shifted from straight-line to sum-of-digits approach) to protect investors and minimize the risk of increased rates caused by potential underutilization of the network in the future.
- However, **Ofgem decided to retain the asset lives and depreciation profiles for gas transmission assets**, as the regulator assessed that there was less risk of decreased utilization of the transmission network. This assessment was in part based on expectations that that gas generation combined with carbon capture and storage would play a role in the UK’s energy future.

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United Kingdom | Challenges and Lessons Learned

Stakeholders noted several key challenges and associated lessons learned based on Ofgem's experience applying the accelerated depreciation model to asset depreciation. These takeaways can be leveraged by cities interested in engaging their utility and/or regulator on minimizing the risk of stranded assets posed by electrification.

Challenges predicting the economic life of an asset

- When determining the depreciation profile of an asset, **it is important, but challenging, to predict an accurate economic asset life** to ensure consumers are paying a fair amount over time (e.g. today's consumers are paying for today's assets, as opposed to future or past assets).
- Stakeholders interviewed pointed out that if they misestimate an asset's economic life, the wrong consumers may ultimately bear the cost of that asset. Stakeholders suggested that regulatory bodies considering a similar decision should **consider future demand scenarios of natural gas and the amount of risk of making an incorrect decision they are willing to take.**

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Case Study Three | City of Vienna: Electrification as Part of a Systematic Approach to Decarbonization

The City of Vienna was selected as a case study given its recognition as the European Heat Pump City of the Year in 2017. The award was made for the City's "systematic approach for an energy strategy" and its recognition of the potential of decentralized heat pumps combined with a centralized district heating system.

Vienna Context	
City Climate Goals	• Aiming to reduce per capita GHG emissions by 80% by 2050 from 1990 baseline levels; as of 2015, Vienna had achieved 32% emissions reductions per capita • Aiming for 50% of gross final energy consumption to be supplied by renewables by 2050
Utility	• Ownership: municipally-owned utilities (Wien Energie and Wiener Netzte) • Wien Energie: owns generation assets and sells electricity • Wiener Netze: owns transmission and distribution • Regulator: E-Control
Energy Sector	• 25% of electricity supply sourced from renewable energy as of 2018 • Heating and cooling sector characterized by a well-established district heating system • The current heating and cooling demand for space heating, hot water and air conditioning is met by natural gas (41%), district heating (39%) and electricity / heat pumps (10%) • Heating demand sourced from electricity has increased 6.6% between 2005 and 2016

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City of Vienna | Drivers and Barriers to Electrification

The following drivers and barriers have contributed to the City’s and the municipal utility’s actions in regards to electrification of the heating and cooling sector:

Drivers of Electrification

- **Reducing GHG emissions** is the primary driver behind Vienna’s interest in electrification. In pursuit of its climate targets, Vienna typically prioritizes energy efficiency and district heating, but focuses on heat pumps for newer buildings located further away from existing district heating infrastructure.
- These heat pumps in new buildings can help the City **avoid the cost** of expanding this infrastructure.
- Lastly, as many buildings in Vienna do not traditionally have air conditioning and as summer temperatures continue to warm, heat pumps have become an increasingly attractive option to **improve comfort and cooling** due to their ability to provide both heating and cooling.

Barriers to Electrification

- **Technical and building barriers** – heat pumps are not a prioritized option for older buildings (est. 90% of buildings in Vienna are over 100 years old); the City only recommends heat pumps for old, often inefficient buildings if efficiency retrofits are undertaken, and buildings codes for historic buildings often prohibit this. In most cases, district heating is the first priority for older building stock.
- **Incentive and business model barriers** – for buildings located further away from district heating, it was noted that the municipal utility tends to prefer gas sales over heat pumps. Contributing factors include the calculation that utility revenue from gas supply is higher than electricity sales via heat pumps, and that natural gas provides the utility with a major revenue source

City of Vienna | Approach to Electrification

The City of Vienna has deployed a range of strategies to promote decentralized heat pumps for buildings not connected to the district heating system. These include:

City Policy Dialogues with Utility Engagement

- The City of Vienna regularly engages with its municipally-owned utilities on its energy and heating sector-related goals and collaborates with them on program and policy design.
- Specifically, the City **engages its municipal utilities as part of dialogue processes** to develop climate and energy programs, including the Vienna Climate Protection Program and the City Energy Efficiency Program. This also includes engaging the utility in designing regulatory interventions, such as the "Energieraumpläne" (Energy Land Use Plan), a building code stipulating which types of energy consumers are permitted to use in which circumstances.
- These engagement processes were deemed to be **critical to ensuring that goals are realistic** and that policies and programs can be implemented.

Building Code Requirements

- The City's building code requires all new buildings to use "highly-efficient alternative energy systems". Under this code, new buildings not connecting to district heating are required to **meet a minimum of 20% of their energy demand from renewable sources**, which can include heat pumps, solar PV, or other sources.
- It was noted that this strategy has contributed substantially to increased use of renewable energy and heat pumps, but some challenges remain. Specifically, it was noted that to meet the renewable energy requirement **many developers still prefer to implement the cheapest solution**, which may entail using rooftop solar to meet the minimum and natural gas to meet the remaining demand and not include heat pumps.

Subsidies for Heat Pump Investment Costs

- The City offers a one-time subsidy of 50€ per square meter for subsidized housing units that meet 100% of their energy demand from renewables e.g. including heat pumps. City stakeholder emphasized that focusing on large-scale housing units is critical to ensuring larger-scale adoption of heat pumps.
- Individuals and businesses can apply for a one-time subsidy to cover **30% of the eligible investment costs of a heat pump installation**. Eligible technologies include air source heat pumps, ground source heat pumps, and heat pump water heaters. For this subsidy, a **fixed funding pot of one million euro** per year is available on a first-come, first-serve basis. City stakeholders expressed that this subsidy has been successful in incentivizing developers and building owners to adopt solar and heat pumps.

City of Vienna | Approach to Electrification

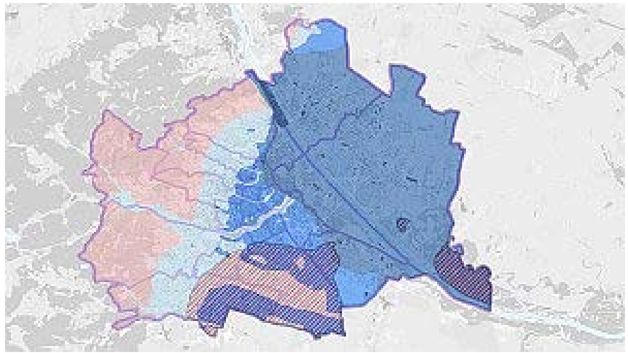
The City of Vienna has deployed a range of strategies to promote decentralized heat pumps for buildings not connected to the district heating system. These strategies have been pursued largely independently of the municipal utility and include:

Maps & Educational Resources

- To further support electrification, the City has developed a number of resources to increase awareness and understanding of heat pumps.
- One key resource includes **GIS developed maps** to inform the public on renewable energy potential across the City. This includes maps on geothermal potential and groundwater heat potential for heat pumps. These maps are online and freely accessible.
- The City has also developed **easily-accessible public information materials** about heat pumps that outline their benefits and a decision-tree to guide residents through the considerations and steps for installing heat pumps. These guides were developed with contributions from developers and heat pump associations and the City boasts a high demand for these resources (between 1.000 and 1.500 hard copies distributed thus far).

Brochure

GIS Maps



Surface Geothermal Potential GIS Map – guiding users on where GSHPs could be viable (or where ASHP would be a better alternative)

Legend shows potential surface geothermap capacity per unit, ranging from low (<1kW, GHSP not recommended) to high (>20kW, GSHP generally feasible and recommended)

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City of Vienna | Challenges and Lessons Learned

The following key lessons learned for U.S. cities were identified from Vienna's support electrification, particularly in relation to city-utility collaboration in Vienna:

Challenges and Opportunities in City-Utility Engagement

- As in many cities in the United States, the utility business and regulatory framework in Vienna lays the conditions for natural gas to be incentivized over heat pumps in exactly the circumstances where Vienna is pushing heavily for heat pumps -- buildings that cannot viably connect to district heating infrastructure.
- Nonetheless, the City of Vienna has gained successes in engaging with the utility to develop and implement various climate and energy programs and policies, including those targeting the heat pumps in the heating and cooling sector.

City Progress on Electrification Can Occur Independent of the Utility

- The Vienna case study also demonstrates strategies and successes from targeted actions largely independent of the municipal utility, by leveraging building codes, subsidy programs and public resources on heat pumps.
- The City has also further benefitted from collaboration with "forward-thinking" and innovative developers, research institutes, and other private sector and non-profit entities. The City has worked collaboratively with these stakeholders on developing pilot projects, such as pilot projects for educational campuses and residential complexes.

Case Study Four | City of Copenhagen: Electrifying District Heating and Cooling

The City of Copenhagen was selected as a case study given its reputation of success in decarbonizing its heating and cooling sector in the context of a dominant municipal district heating system. Electrifying the district heating system is a critical component of decarbonization in Europe, where district heating supplies between 10 and 50% of total heating demand in at least eight European countries. While district heating networks are less common in North America, and often steam-based where they do exist, this case study provides an opportunity to learn about unique strategies not currently under consideration in the U.S.

Copenhagen Context	
City Climate Goals	• Carbon-neutrality by 2025; as of 2016, Copenhagen has achieved 38% reduction in GHG emissions reductions compared to 2005 baseline levels • Renewable electricity supply that exceeds the City's electricity consumption by 2025 • Carbon-neutral district heating system
Utility	• Ownership: municipal utility (HOFOR) • Type of energy sales: gas, electricity and district heating, district cooling • Utility assets: generation, transmission and distribution
Energy Sector	• 71.4% of electricity supply is currently sourced from renewable energy • The City's district heating system supplies 99% of all buildings in the City • The final energy consumption for heating and cooling is largely covered by natural gas (45%) and district heating (50%)

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City of Copenhagen | Drivers and Barriers to Electrification

The City of Copenhagen views the future of the heating and cooling sector in Denmark as electric and sourced from renewable energy. The dominant drivers for electrification include:

Drivers of Electrification

- **Reducing GHG emissions** is the City's primary driver behind the City's push for electrification of the district heating and cooling system towards its goal of a carbon-neutral energy system.
- A related driver is the opportunity to **support greater integration of renewable assets**. As wind and other renewable capacity in Denmark grows, so, too does the need for integration of renewables. Simultaneously, the parallel **decrease in the cost of renewable electricity** results in electricity as an increasingly economic alternative to other energy sources currently supplying the district heating network.

Barriers to Electrification

- As the City and its municipal utility are well aligned on electrification goals and electrification of the district heating and cooling system presents favorable economics, city representatives noted that there are **no major barriers to city-utility collaboration** on electrifying the heating and cooling sector.
- Barriers do remain, however, to electrification of the heating and cooling sector more broadly. City stakeholder emphasized that that the current tax law incentivizes other types of renewable energy sources (e.g. biomass) over electricity, presenting a **regulatory hurdle** to electrifying its heating and cooling system.

City of Copenhagen | Approach to Electrification

Copenhagen, as a city with a dominant district heating and cooling system and ambitious climate goals, has adopted a unique approach to electrification that is different from cities without a district heating network. This can be summarized as follows:

Electrifying Copenhagen's District Heating System

- According to interviewees, 99% of buildings in Copenhagen are already connected to the district heating system (largely due to requirements from the City for buildings to connect to the district heating system) and as of early 2019, 80-90% of this heat demand is sourced from renewable energy.
- For the Copenhagen district heating system, the City is prioritizing expanding and developing large-scale heat pumps based on geothermal heat sources and powered by electricity from wind and solar.

Establishing New, Decentralized District Heating Systems

- An emerging focus is to establish decentralized district heating systems – this model is being prioritized for new buildings or suburban neighborhoods and villages where connecting to Copenhagen's existing district heating system is not cost-effective due to distance.
- In these cases, the City and utility are exploring the opportunity to test new technologies, such as ultra-low temperature decentralized district heating systems.
- This decentralized heating model is primarily being considered for suburban neighborhoods or villages. One decentralized district heating unit would provide district heating supply for approximately 2,000 – 4,000 housing units.

Pilot District Cooling

- The municipal utility is also currently piloting district cooling technologies as an alternative to individualized air conditioning units, particularly for industrial and service industry consumers.
- The district cooling system consists of a distribution network and two cooling plants, which uses seawater to cool down water in the distribution network. It was noted that the district cooling offers the opportunity to take advantage economies of scale, but that the business model is still being further refined in order to enable this technology to be deployed further

City of Copenhagen | Lessons Learned

With regards to the above drivers and approaches, the following summarizes key lessons learned, particularly with regard to city-utility collaboration in Copenhagen:

Insights on Technologies and Business Models for Electrification

- While district heating networks are less common in North America than in Europe and are often steam-based, there are nonetheless examples and the Copenhagen case study offers valuable insights for U.S. cities considering an array of technologies to electrify and decarbonize a district heating system.
- Cities with a district heating system may consider the emerging technologies and business models that Copenhagen is piloting and implementing – including decentralized district heating units powered by ultra-low-temperature heat pumps.

Ownership Structures Critical to City-Utility Collaboration

- Interviewees highlighted that the ownership structure for utilities is critical to aligning city and utility priorities on energy goals. HOFOR's district cooling department, for example, is a for-profit subsidiary of HOFOR, which must ensure the profitability of the district cooling model, and this has made expansion more challenging. Conversely, the HOFOR's district heating unit is a municipally-owned, not-for-profit entity in which the City has more authority to determine spending priorities.

Section Five Sources

Slide #	Slide Title	Source
107	Case Study One | The City of Vancouver: Grid Constraints Study	• Stakeholder Interviews • City of Vancouver. Renewable Buildings. Retrieved May 25, 2019. https://vancouver.ca/green-vancouver/renewable-buildings.aspx • City of Vancouver. Targets and Actions. Retrieved May 25, 2019. https://vancouver.ca/green-vancouver/goals-and-target.aspx. • Image Source: Fotolia
108	City of Vancouver | Drivers and Barriers to Electrification	• Stakeholder Interviews
109	City of Vancouver | Approach to Electrification	• Stakeholder Interviews
110	City of Vancouver | Challenges and Lessons Learned	• Stakeholder Interviews
111	Case Study Two | United Kingdom: Accelerated Depreciation of Natural Gas Distribution assets	• Stakeholder interviews • Committee on Climate Change. UK regulations: The Climate Change Act. https://www.theccc.org.uk/tackling-climate-change/the-legal-landscape/the-climate-change-act/ • Ofgem. Network regulation – the RIIO model. https://www.ofgem.gov.uk/network-regulation-riio-model • Image source: Fotolia
112	United Kingdom| Context: The Uncertain Role of Natural Gas in a decarbonized UK	• Stakeholder interviews • Committee on Climate Change. UK regulations: The Climate Change Act. https://www.theccc.org.uk/tackling-climate-change/the-legal-landscape/the-climate-change-act/ • Ofgem. Network regulation – the RIIO model. https://www.ofgem.gov.uk/network-regulation-riio-model
113	United Kingdom| Overview of Depreciation	• Stakeholder Interviews • Environmental Defense Fund. Managing the transition: Proactive solutions for stranded gas asset risk in California. https://www.edf.org/sites/default/files/documents/Managing_the_Transition_new.pdf • Aldrich Advisors. The oft-overlooked component of utility rates: depreciation. https://aldrichadvisors.com/utilities/utility-depreciation-rate/ • Regulatory Assistance Project. Electricity regulation in the US: a guide. https://www.raponline.org/wp-content/uploads/2016/05/rap-lazar-electricityregulationintheus-guide-2011-03.pdf • Accounting Tools. Sum of the years' digits depreciation. https://www.accountingtools.com/articles/2017/5/17/sum-of-the-years-digits-depreciation

Section Five Sources

Slide #	Slide Title	Source
114	United Kingdom | Approach to Electrification	• Stakeholder Interviews • Ofgem. Network regulation – the RIIO model. https://www.ofgem.gov.uk/network-regulation-riio-model • Frontier Economics. Annex 2: Review of the current regulatory framework. https://www.theccc.org.uk/wp-content/uploads/2017/11/Frontier-Future-regulation-of-the-gas-grid-Annex-2.pptx
115	United Kingdom | Challenges and Lessons Learned	• Stakeholder interviews
116	Case Study Three | City of Vienna: Electrification as Part of a Systematic Approach to Decarbonization	• Image Source: Fotolia • City of Vienna. Smart City Wien Framework Strategy. July 2014. https://www.wien.gv.at/stadtentwicklung/studien/pdf/b008384b.pdf • City of Vienna. Energy ahead! Energy Report of the City of Vienna. 2018. (Data from 2016). https://www.wien.gv.at/stadtentwicklung/energie/pdf/energiebericht2018-en.pdf
118	City of Vienna | Approach to Electrification | Utility & Policies	• Rechtsinformationssystem des Bundes, Landesrecht. (Federal Legal Information Database, State Law). Consolidated Vienna State Law: Entire Legal Provisions for New Building Ordinances 2007, 2012, 2016 and 2018. Site accessed: May 2019. https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrW&Gesetzesnummer=20000087 • City of Vienna. Förderrichtlinie Wärmepumpen 2016 für Wohngebäude Neubau/Sanierung in Wien. (2016 Funding Policy for Heat Pumps for Residential Buildings in Vienna, New Construction and Renovations). May 2016. https://www.weider.co.at/files/weider_website/downloads/foerderungen/wp-bis-2017.pdf
119	City of Vienna | Approach to Electrification | Public Resources	• City of Vienna. Erdwärmepotenzialkataster (geothermal potential resource map). Source accessed: May 2019. https://www.wien.gv.at/stadtentwicklung/energie/themenstadtplan/erdwaerme/index.html • City of Vienna. "Dauerhaft umweltschonend heizen! Eine Wärmepumpe macht es möglich! Und so funktioniert es…" (Heating the Environmentally-Friendly and Sustainable Way! A heat pump makes this possible! And this is how it works…). September 2014. https://www.wien.gv.at/stadtentwicklung/energie/pdf/waermepumpe-kundenbroschuere-bf.pdf
120	City of Vienna | Challenges and Lessons Learned	• Stakeholder Interviews

Section Five Sources

Slide #	Slide Title	Source
121	Case Study Four ｜ City of Copenhagen: Electrifying District Heating and Cooling	• Energi på Tværs (Regional Energy Steering Group). FÆLLES STRATEGISK ENERGIPLAN FOR HOVEDSTADSOMRÅDET. (Common Strategic Energy Plan for the Greater Copenhagen Area). May 2018. https://www.gate21.dk/wp-content/uploads/2018/05/EPT_F%C3%A6lles-Strategisk-Energiplan_WEB_low.pdf • Image: Fotolia
122	City of Copenhagen ｜ Drivers and Barriers to Electrification	• Stakeholder Interviews
123	City of Copenhagen ｜ Approach to Electrification	• Bøgeskov, Henrik Lorentsen, Head of District Cooling, HOFOR. "District Cooling Reduces CO2 Emissions in Central Copenhagen". Site accessed May 2019. https://stateofgreen.com/en/partners/hofor/solutions/district-cooling-reduces-co2-emissions-in-central-copenhagen/
124	City of Copenhagen ｜ Lessons Learned	• Stakeholder interviews

Appendix A

Additional Slides

Experts Interviewed

The Project Team Conducted 10 one-hour interviews with U.S. city, utility, and regulatory experts to inform the development of the Primer. Experts represented the following organizations:

Category	Organization
Regulator	Rhode Island Public Utilities Commission
Regulator	Colorado Public Utilities Commission
Utility (municipal)	Sacramento Municipal Utility District (SMUD)
Utility (IOU)	PacifiCorp
Utility (IOU)	National Grid
Utility (IOU)	Xcel Energy
City	City and County of San Francisco
City	City of Vancouver
Advocate	Natural Resources Defense Council
Consultant	Regulatory Assistance Project

Experts Interviewed

The Project Team also conducted eight one-hour interviews international experts to develop case studies and seed the Primer with best practices and innovative strategies. Experts represented the following organizations:

Category	Organization
Regulator	United Kingdom Office of Gas and Electricity Markets (Ofgem)
Association	Wärmepumpe Austria (Austria Heat Pump Association)
Association	European Heat Pump Association
Utility	BC Hydro
City	City of Vancouver
City	City of Vienna
City	City of Copenhagen