Chapter 11
How Emerging Technologies Are Finally Matching the Policy Leverage of Cities with Their Political Ambitions

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Abstract U.S. cities are typically "policy-takers," operating within a narrow range of possibilities for housing, transportation, education, health, and energy policy as defined by states and the federal government. Cities' energy use is bound to a large network of interlocking infrastructure, market, and policy systems—all of these cities have limited capacity and ability to directly influence. Despite these governance limitations on local energy control, the past decade has brought remarkable technological innovations that are set to disrupt the status quo, creating opportunities for cities to become powerful platforms for emerging clean energy systems. The generation, movement, and sale of energy is becoming increasingly decentralized. Whereas cities are already playing a powerful role in shaping local adaptation to climate impacts, the decentralization of energy will increasingly allow cities to play a pivotal role in emission mitigation as well. Thanks to distributed generation, battery storage, smart metering, microgrids, load aggregation, and electrification, cities are beginning to look like "prosumers"—both producing and consuming electricity depending on the time and day. This new autonomy will allow cities to leverage local policies targeting improved efficiency and circularity, decarbonization, renewable fuels, and offsets, thereby furthering a just and efficient energy transition.

Cities around the world recognize that the energy system produces most of the emissions that drive climate change. In response, they are setting goals—often ambitious ones—and leveraging the policies and programs tied to their own local energy systems. For cities, energy supply and demand largely determine the outcome of their CO_2 reduction goals.

In previous work, we have argued that city efforts are grossly insufficient to confront climate change (Hughes & Colijn, 2018; Serpell, 2017). This is not for lack of

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commitment but for lack of jurisdiction. In this chapter, however, we modify this critique. Ongoing changes in the energy system are disrupting the balances of power in the governance of the energy system. These changes in technology and resulting market structure create new opportunities for cities to realize their aspirations.

11.1 Introduction

In the United States, cities traditionally exert jurisdiction over a range of issues that are formally granted to them by higher levels of government. Typical examples include land and building regulation, waste management, or public safety. Often these issues create benefits beyond a city's boundaries, and these spillovers are sometimes reflected in intergovernmental transfers, user fees, and regional authorities. But on a much larger range of issues, U.S. cities are "policy-takers," playing by rules and operating under constraints defined by higher levels of government and with little, if any, autonomy. States and the federal government largely define a narrow range of possibilities for housing, transportation, education, health, and environmental policy in cities.

With the century-long development of a global energy system defined by initial endowments of, and international trade in, fossil fuels, cities have been, until very recently, "policy-takers" on energy as well. State and federal law and regulations govern energy production and distribution. Cities import their energy through much larger policy and market structures, over which they exert little influence. While cities do have some leverage over energy consumption inside city boundaries, traditional pricing structures (especially tariffs and contracts that do not fully reward the system-level benefits of efficiency and conservation) have limited the impact of city policy making.

Consider building codes. In the United States, building codes are mandated and enforced by state legislatures, but many cities are granted an option to pass codes more stringent than their state requirements. For example, in 2017, the Pennsylvania legislature passed House Bill 409, bringing statewide building codes up to the 2015 International Energy Conservation Code (IECC). This legislation also allowed Philadelphia a one-time opportunity to update to the IECC 2018 code for commercial construction, surpassing state mandates and creating a real opportunity to improve efficiency in a city where 60% of all carbon emissions are associated with the construction and operation of the building stock (Philadelphia Office of Sustainability, 2018). Philadelphia estimates that new commercial construction will be as much as 30% more efficient under the adopted code. But, even this local span of control is not complete and faces constraints that are significant and often underappreciated. Perhaps the most significant example is that building codes almost exclusively limit their requirements to new construction, leaving huge stocks of existing buildings operating with levels of energy performance from decades, or even generations, ago.

U.S. cities operate within the overlapping footprint of many larger, interlocking infrastructure, market, and policy systems—all of these cities have limited capacity and ability to directly influence. To continue with Philadelphia as an example, its wholesale electricity market is managed by PJM Interconnection LLC, a regional transmission organization (RTO) that serves 65 million customers in 13 states and numerous big cities, including Chicago, Philadelphia, and Washington D.C. PJM also monitors system load and coordinates and directs electricity generation across its geography. Grid transmission and distribution infrastructure (such as substations) in the Philadelphia region are maintained by the regional electric utility PECO, a subsidiary of Exelon. These powerful actors are regulated by the Federal Energy Regulatory Commission (FERC), which oversees the wholesale transmission and sale of electricity that crosses state boundaries, and also by the Commonwealth of Pennsylvania, which oversees intrastate energy matters (Hughes & Colijn, 2018).

Despite these governance limitations on local energy control, the past decade has brought remarkable innovations to the energy system that is starting to reveal a near future of transformative change. After decades of being largely captive to state and federal energy regulations and policy, emerging technologies being deployed by disruptive companies are creating opportunities for cities to become powerful platforms for emerging clean energy systems. This new role for cities has been triggered by technological breakthroughs in renewable energy that are weakening *both* the market actors that convert fossil reserves *into* useful energy and deliver them as fuels or electricity to consumers and the governing structures that regulate these actors. These technological breakthroughs are transforming the energy system from a centralized, concentrated series of producer conversions (extraction to combustion to consumer demand) into decentralized, distributed networks of prosumers managing ubiquitous energy supply and demand at small-scale. These distributed networks are much smaller than previously possible: households rather than utility service territories; cities rather than states. Disruptions remain small in the context of a U.S. energy system still dominated by fossil fuels powering multi-state wholesale electricity grids and over 250 million gasoline vehicles (Hedges and Company, 2020). However, on the margin, these new technologies are exerting enormous pressures on incumbents. It is increasingly clear that a fundamental energy transition is underway.

Climate change has become the single most important driver of energy policy in the last decade. Climate change and climate policy have forced a global reconsideration of the true costs of carbon-based energy and have forged a global commitment to limiting additional greenhouse gas emissions in accordance with a science-based "carbon budget." Cities are playing a powerful role in shaping local adaptation to climate impacts (at least to the extent that cities have the financial capacity without assistance from higher levels of government). But the role for cities in mitigating climate change itself has always been less clear and more limited. Emissions reduction can be achieved by competing energy policy goals, as demonstrated by the use of the phrase "net-zero emissions," but alone is insufficient to provide cities with an impactful role in the energy transition. Without an alternative to the existing carbon energy system, the world would be focused on lowering the carbon intensity of the existing energy system, such as switching from coal to gas, capturing new emissions from combustion and removing existing emissions from the atmosphere, improving the efficiency of buildings and processes, and so on. Under these conditions, cities would still be policy-takers in a centralized and concentrated system of producers and consumers. They would have little ability to divert any public funding away from local climate adaptation and toward climate mitigation through local energy policy.

11.2 Technology Drivers Empowering Cities

Technology innovation is the driver of energy policy that makes it possible for cities to play the impactful role that they have sought for decades. Cities now have the leverage they need to make significant progress toward their state policy goals, expanding the role for cities in shaping energy policy and energy systems. We now turn to a quick review of the most important of these technological breakthroughs.

Regional transmission grids are a marvel of modern engineering. However, the electricity grid has, historically, significantly limited cities' autonomy when it comes to energy governance. By geographically separating production and consumption, a unidirectional grid is a hindrance to any local effort to decarbonize energy, by placing the levers of change far beyond city boundaries.

Emerging technologies for generating, coordinating, pricing, metering, and consuming electricity are transforming this historically centralized system. Thanks to distributed solar generation, battery storage, smart metering, microgrids, load aggregation, and electrification, regional grids are quickly transitioning from unidirectional delivery systems to multidirectional networks of shifting supply and demand. In this emerging electricity network, cities need no longer be confined to the role of consumer. Instead, cities begin to look like "prosumers"—both producing and consuming electricity depending on the time and day. This finally allows cities to leverage the unique advantage of density to not only improve energy efficiency as consumers but to directly produce low-to-zero carbon energy at the point of consumption and profoundly impact regional energy systems.

11.2.1 Smart Grids

The internet has transformed how we share information in nearly every aspect of our lives. Now the "internet of things" enabled by 5G and 6G—the latest generations of cellular networking—will continue to expand the possibilities for distributed services on the electricity grid, allowing grid operators and utilities to monitor consumption and generation in real time and allowing for rapid changes and adjustments in pricing and load. The internet allows electricity markets to track sales in a far more complex and multi-nodal network, rather than as a unidirectional energy highway.

11.2.2 Energy Storage

A second technological breakthrough reshaping the electricity system is energy storage. Smartphones and laptops have become ubiquitous over the last three decades, and every year the power demand of these machines grows. Today, an iPhone has many times the computational power of a supercomputer from the 1980s, yet we require it to last a full day using only the electrical energy stored within it (Routley, 2017). This wireless existence would not have been possible without the development and improvement of advanced, high-density, rechargeable batteries. Thanks to these growing demands for storage of electricity, we now have lithium-ion battery packs capable of storing enough electricity to power a car or serve as a back-up power source for a home. Energy storage is a key technology in stabilizing the capacity for renewable energy sources like solar and wind to provide reliable and continuous power. Energy storage manages the intermittency of these energy sources over time and facilitates the flow of energy among uses, such as buildings and vehicles.

11.2.3 Distributed Generation

Together, a more ubiquitous energy supply via solar and wind and a more powerful storage system via batteries and other means have produced a third technological breakthrough known as distributed generation. Fossil fuels exhibit enormous economies of scale. Extracting, refining, and transporting fossil fuels require big, expensive capital investment that is most productively managed by huge companies and utilities. Solar and wind power, on the other hand, can be generated at the point of demand wherever the sun shines or the wind blows, and local storage can help manage times when it is dark or calm. Distributed generation carries many benefits to owners, beyond a drop in individual carbon emissions. In fact, in a country like the United States that has never placed a price on the social costs of carbon emissions, one could argue that nearly all individual benefits to the owner of distributed energy systems fall outside of the shared climate benefits of reduced emissions. Distributed generation and storage not only allow intermittent energy sources to meet a greater share of overall demand, these technologies also empower individual energy consumers, by allowing them greater flexibility to decide when and how they use grid electricity.

As areas of high-density, high-demand, intensive capital investment, and continuous innovation, cities also account for more than 75% of energy use and 60% of greenhouse emissions (United Nations 2021). The emerging energy transition to renewable, distributed, and decentralized prosumer networks gives cities an important role to play. In the remainder of this chapter, we present some of the significant ways in which cities around the world, and especially in the United States, are leveraging emerging technology to reinvent energy and mitigate climate change.

11.3 City Policies that Leverage Technology Drivers

The leading strategy for a just and efficient energy transition consists of four related components:

- Improve energy efficiency and circularity where possible
- Decarbonize major sectors of the economy (electricity, transportation, industrial processes, and buildings)
- Shift activities from difficult sectors into sectors that have made the greatest progress toward low or zero-carbon energy
- Replace any remaining fossil fuel use with renewable fuels (such as hydrogen) or offset remaining emissions with carbon capture investments

In the following brief review, we organize major policy examples from cities around the world in terms of energy efficiency in buildings and other energy sectors, followed by electricity decarbonization through ownership and other instruments, then electrification of sectors that currently rely on combusting fossil fuels, and finally on capturing or otherwise avoiding the carbon emissions that remain in industry and other sectors.

11.3.1 Energy Efficiency and Circularity

Owing to the density of cities, their high carbon emissions are primarily attributable to residential and commercial buildings. When considering the steps cities can take to improve urban energy efficiency, a pragmatic place to start is with residential and commercial buildings—employing policies and actions that reduce energy consumption and carbon emissions. To achieve progress in this area, city officials need to work closely with building owners, real-estate developers, and building occupants in both residential and commercial properties.

11.3.1.1 Energy Building Codes

Energy building codes are powerful tools that cities and states can adopt to ensure minimum energy efficiency standards for new construction. Recent codes have provided 30% more energy savings than codes from a decade ago (U.S. Department of Energy, 2016a, 2016b), and for the period of 2010–2040, residential and commercial building energy codes are projected to save $126 billion in energy costs, 841 million metric tons (MMT) of avoided CO_2 emissions, and 12.82 quads of primary energy (U.S. Department of Energy, 2016a, 2016b). The stringency of these codes is partly a reflection of the technological progress made over the years in lighting, insulation, and heating. Without technological progress in these areas, new building codes would be prohibitively costly.

The codes are developed by two private organizations (ASHRAE and the International Code Council) and updated every three years. The most recent codes, approved for implementation in 2021, failed to include electrification provisions, such as installing electric vehicle charging stations in residential and commercial buildings and installing electric circuits to allow future conversions to highly efficient electrified equipment (Bresette, 2020). When implementing this new code, cities will have to decide how serious they are about electrification and the decarbonization of the building sector. They could add these (and other) provisions in, as was done by some California municipalities that banned gas connections to new buildings.

Two factors make the codes particularly powerful in achieving efficiency goals. First is the slow capital stock turnover or the time it takes to replace building technologies after they are adopted (Jaffe et al., 1999). As building systems can last decades, building codes may lock in fossil-fuel-dependent technologies for decades, delaying decarbonization efforts if they fail to adopt clean technologies. Second is the cost of retrofitting versus the cost of including technologies from the construction process. When it comes to new buildings, it is more cost-effective to include a new technology in the initial construction rather than by retrofitting (Billimoria et al., 2018).

11.3.1.2 Weatherization Programs for Low-Income Households

Many cities in the United States—Seattle, Baltimore, Austin (through its utility), and Cleveland—offer free or subsidized weatherization services to residents who meet income qualifications. Services may include energy audits, insulation, heating systems, air sealing, bathroom fans, and more. Seattle also offers low-interest loans to low- and moderate-income residents through its Home Repair Loan Program. Programs like these allow cities to make use of the most cost-effective and efficient lighting, insulation, and heating technologies, which can help reduce the energy burden on low-income communities.

11.3.1.3 Energy Consumption Building Benchmark and Building Energy Performance Standards

Many cities are leveraging the power of data by adopting energy benchmark programs that require buildings to disclose their energy consumption for comparison with other buildings in the city (U.S. Department of Energy, 2019). Below is a map

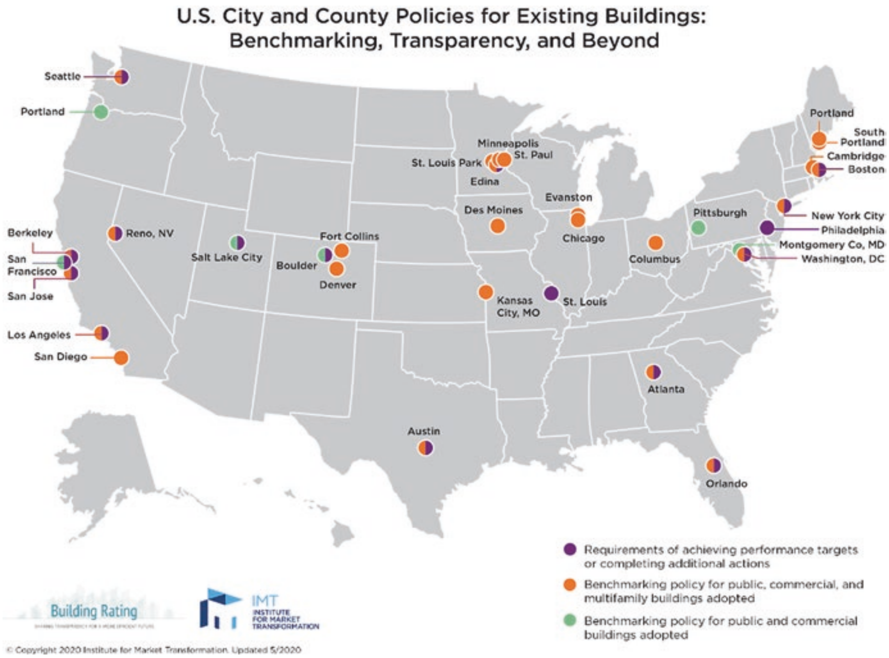

Fig. 11.1 Catagorizing policies related to performance requirements and efficiency benchmarking in US cities

from the Institute from Market Transformation (IMT) with the cities that have adopted benchmarking for different types of buildings. In some cases, the purpose of the benchmark is to allow buildings to track, monitor, and detect abnormal energy consumption while providing the incentives to improve energy efficiency. Since the data is public, no one wants to be seen as the laggard. In other cases, the data provided by the buildings establishes specific performance targets that the building must achieve by a specific date. Failing to achieve the target may result in fines. This kind of benchmarking and performance tracking, especially real-time tracking, is only now becoming possible, thanks to technological advancements in distributed and autonomous monitoring and sophisticated data aggregation and analysis software (Fig. 11.1).

11.3.1.4 Managing Traffic

Congestion generates costs for the city economy, increases gasoline use, and increases CO_2 emissions and air pollution. In New York City alone, congestion costs the metropolitan region's economy up to $15 billion annually, consuming nearly 300 million extra gallons of fuel (NYC Government, 2019). Tackling congestion is an effective way for cities to reduce emissions, improve air quality, and achieve climate targets while improving city livability. Many cities around the world curb traffic by restricting vehicle circulation on certain days by plate number (Mexico City, Bogota, Beijing, and Athens). The progress in image-based tolling and automatic license plate recognition technology, as well as the development of the smart transponders and GPS technologies (U.S. Department of Transportation, 2008) enabled the implementation of congestion charges to enter a city's congested zones (London, Stockholm, and Singapore), or even banning inefficient vehicles from certain areas by declaring Low Emissions Zones (LEZs), thus incentivizing drivers to upgrade their cars. These policies have been effective in changing vehicle use, and, in some cases, they have achieved a reduction in congestion and emissions. Careful steps need to be taken, however, to ensure that these policies do not create perverse incentives, such as in Mexico City where many drivers acquired a second car which was usually older (and thus more polluting) to circulate on those days when their first car had restrictions (Davis, 2008).

Even the most climate-committed cities in the United States have not implemented these vehicle restrictions yet, due in part to the popularity of car use and the relatively low concern with urban air pollution. That said, Chicago and Los Angeles have commissioned studies on congestion charges and New York City's congestion charge has been years in the making, with the proposal recently being blocked by the Trump administration. It is expected that under the Biden presidency, the NYC congestion charge will finally be approved (Snyder et al., 2021). In the past, the federal government expressed concerns over congestion prices on the basis that it would be regressive or disproportionately impact poor households (U.S. Department of Transportation, 2017). Evidence to the contrary shows that across the United States, poor, urban households generally do not use cars for transportation, but instead rely on public transit (King et al., 2019). Other initiatives that American cities have implemented for congestion are car-free zones, reduced parking spaces, and dedicated bus lanes in central areas.

As ride sharing, curbside deliveries, and autonomous vehicles all become prominent fixtures of society, city traffic and congestion policy have the potential to play an increasingly large role in urban energy policy. Local authorities in many cities have, for example, started to implement curbside restrictions and have made various attempts to control or limit the scope of ridesharing apps, such as Uber and Lyft (OECD, 2018).

11.3.2 Electricity Decarbonization

Even with dramatic improvements to energy efficiency, cities will always be major hubs of energy consumption. One of the most effective and technologically achievable strategies for reducing the carbon footprint of remaining energy demand is to shift electricity generation from coal and natural gas power plants to renewable sources like wind and solar. Two factors determine the control of a city over its electricity supply: ownership of the electric utility and the market structure in which the utility operates. In the United States, utilities can be owned by private investors, municipalities, cooperatives, or even by the federal government. They can operate in a restructured market where they cannot own generation assets, and therefore need to purchase power from the wholesale market. They may face competition when their customers have the option to choose an energy supplier. On the other side of the spectrum are the vertically integrated utilities. Many of these integrated utilities own generation assets or can directly sign power purchase agreements with merchant generators. They tend to have captive customers, as they operate in a retail sector that is not open to competition.

Municipally-owned, vertically-integrated electric utilities have control of their supply mix and can help local governments achieve climate targets. This is the case for the city of Los Angeles. In 2019, as part of the city's Green New Deal, the Los Angeles Water and Power Department was directed not to update or repower three coastal natural gas power plants—representing 38% of the city's natural gas portfolio—and replace them with renewable energy. The decision allowed LA to accelerate its transition to 100% renewable energy and put the city on track to meet its carbon-neutral target by 2050 (Stark, 2019).

According to the American Public Power Association, for the period 2005 to 2017, public-owned utilities decreased CO_2 emissions by 33% while the average emission reduction for all utilities (private and public) was only 24%. Moreover, a study about local clean energy policy decisions in the United States found that cities with investor-owned utilities adopt fewer renewable energy policies than cities served by public-owned utilities (Curley et al., 2021). Not surprisingly, some cities have attempted to reclaim public ownership of local electric and gas utilities as a method of implementing climate policies. In the past, municipalization efforts focused on reducing rates or improving reliability. Today, there are movements in cities like Boston, New York, San Francisco, and Chicago that seek municipal control of the utilities to reduce rates, improve utility worker conditions, expand low-income assistance, and accelerate decarbonization, among other objectives (Ambort, 2020) In many Californian cities, after the bankruptcy of Pacific Gas and Electric, municipalization seems to be a popular option.

But municipalization can be a lengthy and costly process that does not always achieve utility ownership change. Boulder, for example, spent more than 10 years fighting to buy their local electric utility from Xcel Energy. In November 2020, voters finally decided the city would enter into a 20-year franchise agreement with Xcel Energy, a move that paused the city's efforts. Despite this outcome, Xcel committed to reduce greenhouse gas emissions by 80% from 2005 levels and to work together with the city to implement energy-efficient initiatives that support Boulder's goal of 100% renewable energy by 2030 (Sakas, 2020).

Whether cities exist within a restructured market or they have a municipally-owned, vertically-integrated electric utility, the changing technology that cities can leverage to reduce grid emissions are often similar.

11.3.2.1 Renewable Power for Government Buildings

Even under conditions where cities have little control over the electricity supply, cities are large energy customers. Procuring clean energy for government buildings could significantly contribute to emission reduction targets. This is the case in Philadelphia, a city with a private electric utility operating in an unregulated market. In 2018, the city signed a power purchase agreement directly with a renewable energy supplier to ensure that at least 22% of the electricity consumed by city buildings would come from renewable energy (City of Philadelphia, 2020). Some other cities, like Phoenix, have used similar agreements to lease solar panels installed on government buildings. Although this can be a more expensive option, the onsite generation "behind the meter," helps to reduce peak consumption, decrease electricity bills, and meet climate goals (Miller, 2016). Enacting power purchase agreements with at-scale renewable energy providers is an example of how energy markets are adapting to the rapidly decreasing costs associated with solar and wind development. In the recent past, what would have been a high-risk proposition for both cities and renewable energy developers is now easily within reach.

11.3.2.2 Promoting Distributed Generation (DG) Through Community Solar Projects

The regulation of payments made or received by distributed generation customers is in the jurisdiction of state regulators and even the Federal Energy Regulatory Commission. In many places, net metering is limited to very small rooftop solar systems, preventing the participation of larger systems like those from schools, businesses, and local governments. In places where net metering covers community solar projects, cities are promoting the deployment of distributed generation by installing solar gardens to power up public housing buildings. In addition to the benefits of clean power supply, these projects create jobs and training.

As part of New York City's 100% renewable commitment, the city installed 25 megawatts of solar panels atop the city's public housing buildings, which were leased to community solar projects (Gilpin, 2017). Denver's housing authority also plans to have its own community solar garden. This project is expected to power up to 700 public housing units and low-income homes, while cutting energy bills by about 20 percent, offsetting over 54,000 tons of carbon emissions (U.S. Department of Transportation, 2017), and providing job training. St. Paul, Minnesota's public housing is building solar gardens for 10 of its public housing high-rises. The solar gardens are expected to save the housing agency $130,000 a year. Community solar is only possible with sophisticated tracking and metering of distributed generation and consumption by members of the participating community. The challenges faced by community solar, and the outdated regulations banning it in some states, will be increasingly addressed as data collection, smart metering, and real-time pricing structures are deployed more widely.

11.3.2.3 Building or Facilitating Solar and Storage Microgrids

In addition to generating clean energy, solar and storage microgrids can operate in isolation of the grid and bring resilience to the city in instances where there are major power disruptions. They can also facilitate the management of smart grids, as they can work as aggregators of small systems. Many cities have built microgrids to improve resilience after a major disaster. In Hartford, Connecticut, after Hurricane Irene in 2011 and a major snowstorm left 750,000 homes without power for 10 days, the city built a fuel cell-powered microgrid that began operating in March 2017 (Gies, 2017). More recently, cities in California are building solar and storage microgrids after experiencing long power cuts due to the deadly wildfires.

11.3.3 Electrification

Even after the decarbonization of all existing electricity demand, heating and transportation in cities would still contribute to global carbon emissions and jeopardize emissions targets. Leveraging emerging technologies to help shift heating and vehicle demand onto the electricity sector will be a critical strategy for system-wide decarbonization, especially in cities where density allows for a number of innovative strategies in transforming this existing use of distributed fuel.

When it comes to decarbonizing transportation, cities still lack a great deal of governance power. They do not, for example, have the authority to set gasoline taxes or establish fuel efficiency regulations for automakers. Those regulations fall under state and federal jurisdiction. However, when it comes to the electrification of transportation, cities can exercise a great deal of control by leveraging density and investing in emerging technologies.

11.3.3.1 Improving Transit

Efficient urban transit systems could be the best alternative to car use and could simultaneously achieve climate reduction goals. Yet transit ridership is significant in only a few U.S. cities. Before the pandemic, improving, modernizing, and electrifying transit systems and integrating micro-mobility were at the backbone of urban mobility strategies to increase ridership while tackling climate change and improving city livability. With the pandemic, this progress has been seriously delayed. Transit agencies are facing massive operating budget shortfalls as federal funding they received from initial relief packages is running out and funding from local taxes has plunged (Calvert, 2020). The financial hardship has forced drastic service cuts (Goldbaum & Wright, 2020) and the delay of capital projects. Transit system recovery will require a combined effort of federal, state, and local authorities.

11.3.3.2 Vehicle Electrification

Electrification, or the use of alternative fuels for the transportation sector, could be the fastest way to reduce emissions from vehicles, especially since scaling up centralized transit systems has been severely delayed. For cities, the decision to promote and support the adoption of electric vehicles is not always easy. The first consideration is the fuel mix: vehicle electrification may not result in an immediate reduction of emissions if the electricity or alternative fuel is produced from fossil fuels. In this case, vehicle electrification would only shift emissions from the city to the electricity producing region. Second, electric vehicles remain expensive and unaffordable for middle- and low-income populations (Breetz & Salon, 2018). EV promotion could be a regressive policy, primarily benefiting wealthier city dwellers. Third, even if vehicles are electric or powered by alternative and clean fuels, these cars can still pose additional congestion risk.

In the United States, apart from California, the adoption of electric vehicles remains minimal. Cities do not have the jurisdiction to license vehicles nor can they ban the registration of regular gasoline vehicles, which is the most effective policy to ensure EV adoption. Cities can build or support charging infrastructure in public premises; they can electrify their municipal fleet, including transit buses and school buses; and they can provide preferential parking for EVs. These measures certainly help boost EV adoption but are not enough to achieve complete electrification. A study in the United Kingdom, a country which also has a low penetration of EVs, analyzed the impact of local EV policies and found that many of the factors that influence EV adoption are beyond city control. They concluded that investing in charging infrastructure, however, may be the most effective policy, as the short range of EVs is perceived as the main limiting factor for EV purchases (Heidrich et al., 2017).

EVs technological progress and the increasing decarbonization of the grid will facilitate the adoption of EV policies at the local level.

11.3.4 Alternatives for Hard-to-Electrify Sectors

11.3.4.1 Hydrogen Cities

Hydrogen is starting to be considered a clean alternative fuel source, thanks to the technological progress in electrolyzers and fuel cells and the massive reduction in renewable energy generation costs. Although the cost of green hydrogen (produced with water and renewable energy) remains high compared to hydrogen produced with coal or natural gas, many countries have set ambitious green hydrogen adoption targets. Among these countries, South Korea's plan is focused on urban areas. Three initial pilot projects in the cities of Ansan, Ulsan, and Wanju will fuel cooling, heating, electricity, and transportation systems with green hydrogen, with an aim to transform 10% of urban areas to hydrogen power by 2030 and 30% by 2040. Each city will receive USD 24 million from the Korean government to support the development of infrastructure, while a fourth city will be a hydrogen R&D hub (FuelCellsWorks, 2020). While this is an initiative of the national level, it is expected that with further technological developments (costs reductions for hydrogen production, storage technology improvements, reduction in conversion costs of gas boilers), more cities will follow this transformation to achieve climate targets while creating green jobs.

11.3.4.2 Carbon Capture, Utilization, and Storage

Very few cities have implemented carbon capture, utilization, and storage (CCUS) solutions to fight climate change. Most operational CCUS projects capture carbon from power stations and use the carbon for enhanced oil recovery. Therefore, they are located in proximity to oil fields and not in urban environments. While the number of CCUS operational facilities has increased in the last several years, their cost remains a barrier for large-scale implementation in hard-to-decarbonize industries. But the urgency to reduce emissions has made the implementation of these technologies desirable and necessary, especially for cities with ambitious climate targets. In response to this perceived need for urban CCUS solutions, Amsterdam, Copenhagen, Helsinki, Oslo, and Stockholm have created the Carbon Neutral City Alliance to jointly review CCUS solutions. According to a report written by the Bellona Foundation in collaboration with these cities, some CCUS projects are in the process of being implemented (Bellona Foundation, 2020): Amsterdam, for example, plans to expand an existing CO_2 pipeline from Rotterdam to Amsterdam to procure CO_2 from industrial zones and dispatch it to greenhouses. The Netherlands also plans to build a connection pipeline from both the Rotterdam and Amsterdam industrial areas toward gas fields in the North Sea for storage. Oslo is considering a carbon capture and storage (CCS) facility for two of its waste incineration plants. Equinor would build a dedicated pipeline to transport the carbon to a storage site southeast in the North Sea. For cities without access to storage sites, the implementation of CCS is more challenging.

Copenhagen is currently collaborating with the local waste incineration plant on a carbon capture solution but still needs to prove the technical and legal option to do underground CO_2 storage. In Helsinki and Stockholm, the option of bio-energy with carbon capture and storage (BECCS) has been considered to reduce emissions from combined heat and power (CHP) plants. Since 2019, a test facility to capture carbon from bio-cogeneration became operational in Stockholm. The storage infrastructure for this facility will be located in Norway and won't be ready until 2024, as Sweden lacks adequate storage capacity.

11.4 Conclusion

In this chapter, we have offered a sampling of the many climate policy initiatives that cities are taking that either actively leverage or are indirectly supported by recent technological innovations in electricity generation, access, monitoring, alternative fuel synthesis, transportation, and building materials. These technology advancements are allowing cities to respond to global energy challenges with a level of autonomy and power that has not been possible since the regionalization of power grids and fuel supply. Cities are increasingly positioned to become leaders in climate change, not just because of local political realities but also because of universal technological realities.

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