NEW POLICY FOR AN ERA OF ENERGY DIGITALIZATION:

TRANSPORTATION

JULY 2018

EC-MAP

ENERGY CONSUMER MARKET ALIGNMENT PROJECT

ABOUT EC-MAP

The Energy Consumer Market Alignment Project (EC-MAP) is a Washington, DC non-profit operating in collaboration with the Keystone Policy Center, an independent nonprofit founded in 1975 to drive actionable, shared solutions to contentious policy issues. We envision an energy future where digital technologies drive greater transparency, fair competition, and consumer choice—and where policy enables innovation instead of creating market barriers.

EC-MAP seeks to work with stakeholders to advance knowledge and associated policy mechanisms to accelerate the era of energy digitalization. Our goal is to enable a critical dialogue around identification of policy barriers and the future role of government to promote free and fair market competition and build policy consensus that benefits energy consumers, the economy, and the environment.

ACKNOWLEDGEMENT

EC-MAP would like to acknowledge Alisa Ferguson for her significant contributions towards the development of this report. EC-MAP would also like to recognize the contributions of Christina Stanton and Sean McGinnis in preparing this report.

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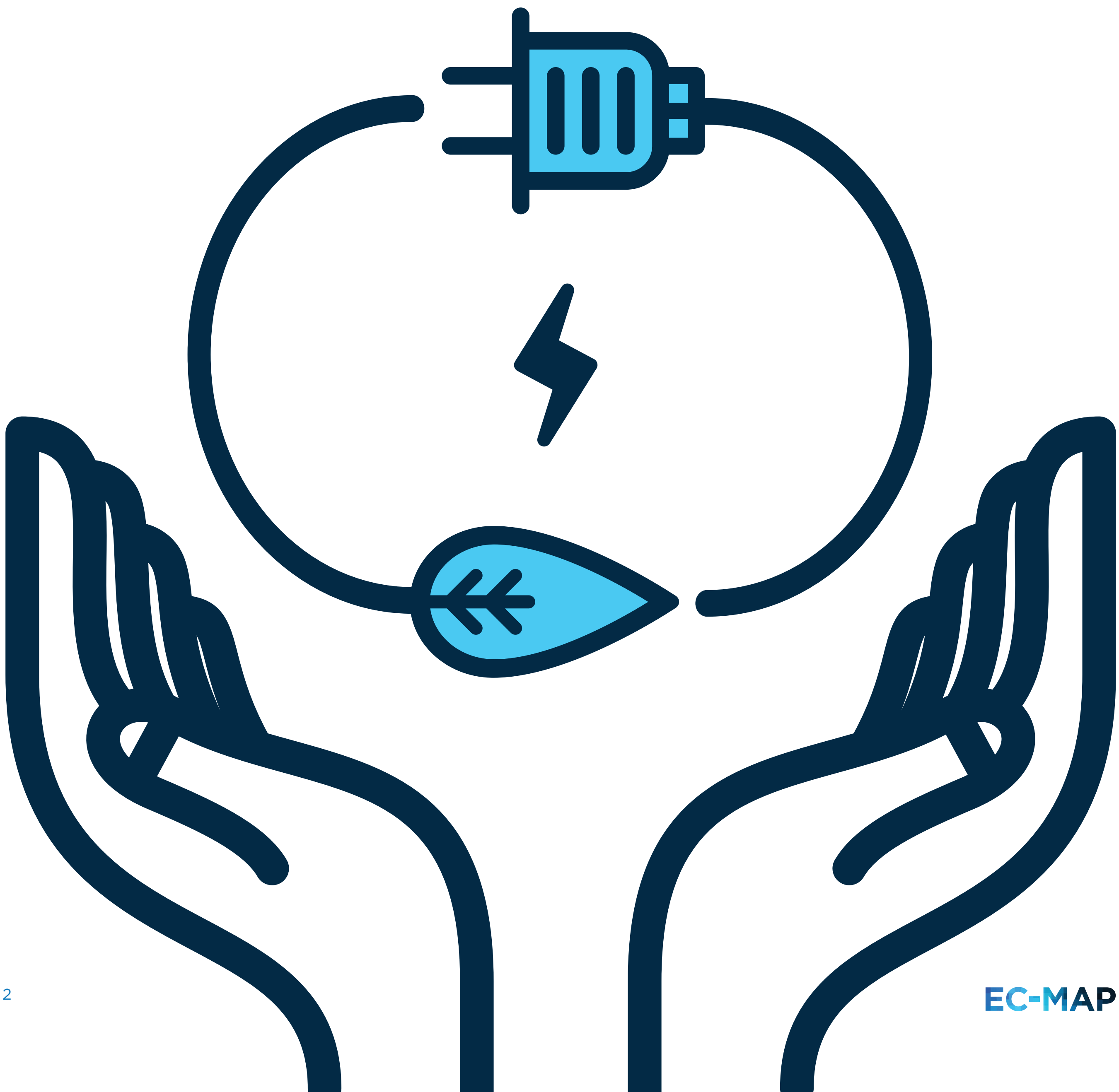
EXECUTIVE SUMMARY



Throughout history, the energy system has gone through revolutions driven by technology and innovation. Today, change is being driven by three trends: decentralization, connectivity, and automation. Economies of scale for clean energy generation are rapidly transforming the grid and opportunities to connect electric vehicles to it, while advances in energy production technologies are giving regions of the country new fueling and infrastructure options. Real-time access to the internet, broadband, and mobile devices is driving consumer demand for transparency, empowering sustainable data management, and circumventing traditional limits to choice. Advances in computing and machine learning have enabled automation and advanced functionality to be embedded within vehicles, transportation infrastructure, and energy delivery systems and distribution networks.

Together these trends are enabling a new era of energy digitalization. This era will be dominated by crosscutting digital tools and platforms—including artificial intelligence, blockchain, crowdsourcing, the internet of things, and software that enables new business models—that can be applied to the energy system in myriad ways. This era is also one where change will be driven from the bottom-up—in other words, one where consumers play a much more significant role in meeting their energy needs and driving goals around cost, sustainability, and efficiency.

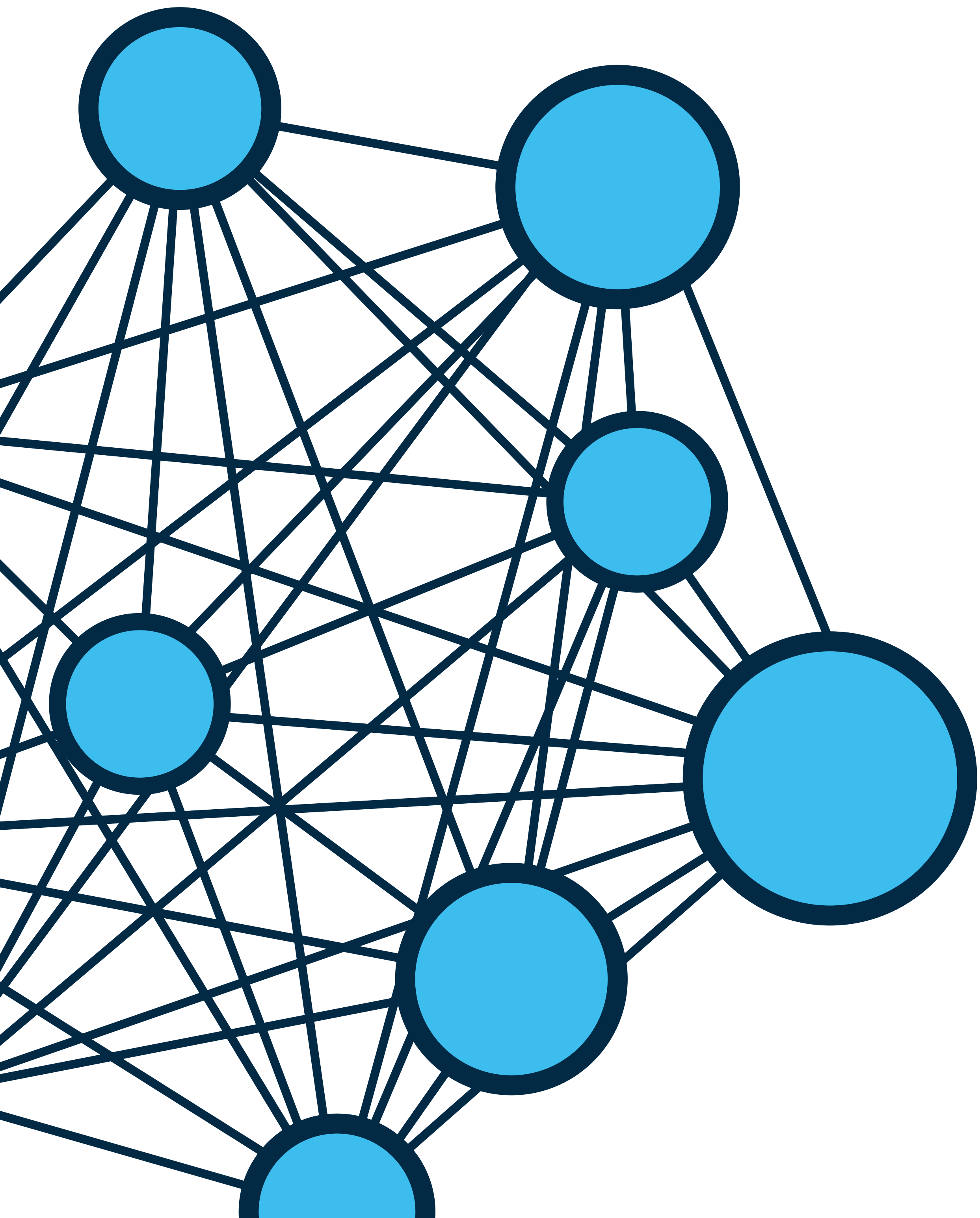
The era of energy digitalization requires policymakers and regulators to embrace a new way of thinking about energy governance. The energy system of the past required intermediation—i.e. establishing regulation and incentives to protect the public interest and to promote specific resources and technologies deemed superior or desirable. The era of energy digitalization, in contrast, requires disintermediation—i.e. removing barriers to facilitate new markets, enable new forms of transactions, and empower consumers.

Today, there are increasing tensions between digital innovations well positioned to deliver what consumers want and policy that creates barriers to their adoption. Electricity markets that could enable consumer choice and participation of electric vehicles and energy storage are often stymied by outdated approaches to governance. Federal mandates for fuels and vehicles have sometimes not effectively achieved their goals. And the need for transportation infrastructure investment dwarfs the funding available through existing taxes and budgets. Specifically, statutes such as Corporate Average Fuel Economy Standards (CAFE); the Renewable Fuel Standard (RFS); the Federal Power Act; approaches to highway and infrastructure finance; and state and local regulation of auto dealers and taxicabs are increasingly not aligned with emerging digital innovations.

EC-MAP is challenging stakeholders to consider a different future—one where digital innovations enable consumers to express preferences that drive markets—and where policy plays a more limited and nuanced role. This future does not require significant new R&D, and it is not one that is decades away. This future is already emerging, and policy change will need to accelerate to keep up.

EC-MAP and our partners believe the era of energy digitalization is inevitable; the only question is whether government will accelerate or impede its benefits. EC-MAP plans to work with incumbent stakeholders, new stakeholders, policymakers—and you—to build a roadmap to align policy with a digital energy future.

I. OUR CHANGING ENERGY SYSTEM



TECHNOLOGY DRIVES CHANGE

Throughout history, the energy system has gone through several revolutions driven by technology and innovation. Before the Industrial Revolution, agriculture was central to energy, with wood used for heat and horses for transportation. In the 19th Century, the invention and development of modern drilling techniques, the use of kerosene for lighting, and finally the development of the internal combustion engine, all helped unleash an era dominated by fossil fuels. Although the 1973 oil embargo ushered in a new focus on domestic energy production and resource diversity, including investment in renewable fuels and more efficient vehicles, oil has remained dominant in the transportation sector. However, the rise of the internet, which has democratized access to information and enabled new ways to communicate, is poised to once again transform how consumers interact with fuels, vehicles, and transportation infrastructure.

Today three significant trends are driving change in the energy and transportation systems: decentralization, connectivity, and automation.

- **Decentralization.** Economies of scale for clean energy generation are rapidly transforming the grid. Renewable generation technologies (in particular solar PV) are increasingly economic both at large utility scale and at smaller scales appropriate to buildings and vehicles. This is driving opportunities for unprecedented convergence between the electric grid and transportation infrastructure.
- **Connectivity.** Access to the internet, broadband, and mobile devices has grown dramatically. Global internet traffic continues to increase exponentially (see Figure 1), and in the U.S., smartphone adoption has surpassed 80 percent.[1] A car is increasingly more like an iPhone than a Model T, with integrated technology and connectivity that is often overtaken by more advanced features within a few years. In response, consumers are demanding more flexible financing and ownership options; the volume of car leases grew from 1.4 million vehicles in 2009 to 4.3 million vehicles in 2016,[2] and new business models such as car subscriptions are already emerging.[3]
- **Automation.** Advances in computing, machine learning, and artificial intelligence (AI) have enabled significantly increased automation embedded within vehicles and infrastructure. Currently, every major automaker is pursuing some kind of self-driving technology, and most believe a future with autonomous vehicles is no longer a matter of if, but when. One study by Intel and research firm Strategy Analytics projected that in the U.S. alone, autonomous cars could be a $2 trillion industry by 2050.[4] McKinsey & Company has predicted that storing, organizing, and analyzing data from cars will be a $750 million market by 2030.[5]

Together these trends are driving change from the bottom-up, with consumers playing a much more significant role in meeting their energy and transportation needs and driving goals around cost, sustainability, and efficiency.

Figure 1
Growth in Global Internet Traffic

Source: International Energy Agency

THE ACCELERATING PACE OF DIGITALIZATION

Information and communications technologies are increasingly dominant in the economy as a whole.

Information and communications technologies are increasingly dominant in the economy as a whole. As recently as the early 2000s, the world's largest companies represented a diversity of industries; however today, all are companies focused on information and communications technology (see Figure 2).

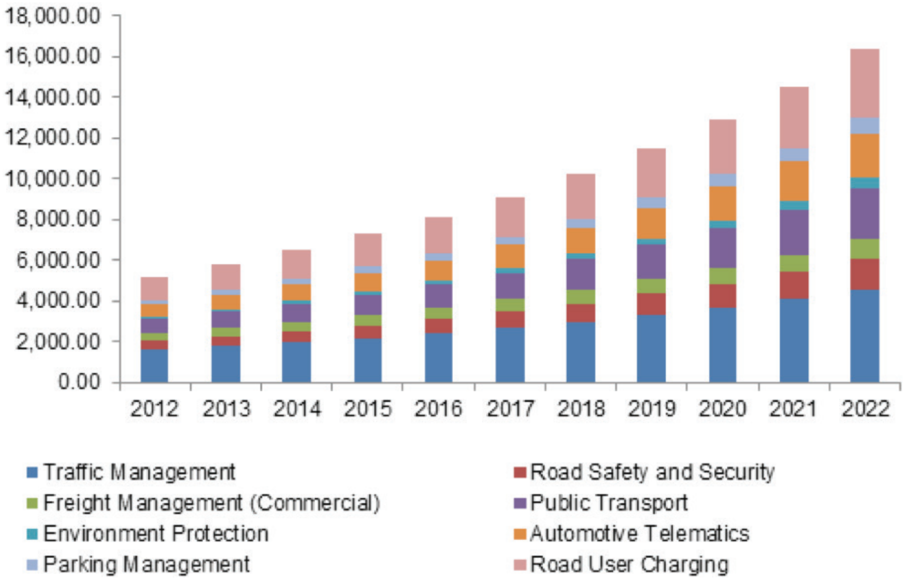
Information and communications technologies are intersecting with the transportation system in a variety of ways, including through data-collecting sensors; advanced analytics; communications systems that enable remote control; infrastructure that connects vehicles and the electric grid; and other intelligent transportation systems designed to lower costs and improve safety, operational efficiency, and customer service.[6] Although the intersection of information technology and energy is far from new, the pace of adoption is accelerating dramatically. The market for intelligent transportation systems in the U.S. nearly doubled between 2012 and 2017 and is on pace to more than triple by 2022 (see Figure 3).[7] Overall, investment in digital technologies by energy companies grew by more than 20 percent between 2014 and 2016 (see Figure 4). Accelerated adoption of smart, two-way communications technologies is also already driving increased engagement by utilities and similar organizations around the appropriate and necessary allocation of broadband spectrum to accommodate them.[8]

Figure 2
Largest Companies by Market Capitalization

Source: International Energy Agency

Figure 3

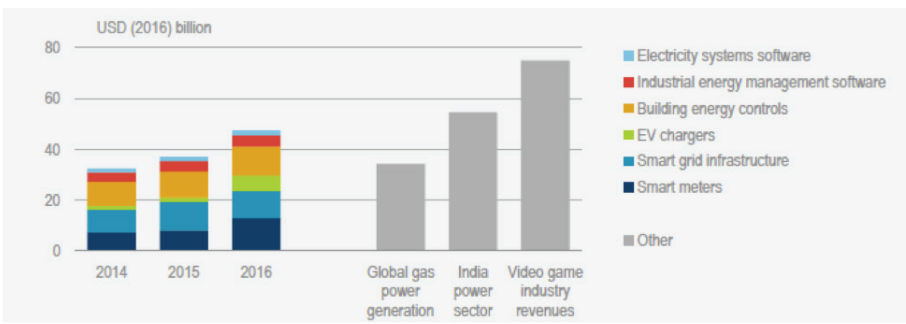
U.S. Intelligent Transportation System Market by Application, 2012-2022 (USD Million)



Source: Global Market Insights

Figure 4

Recent Growth Trends in Digital Energy Infrastructure Invesment



Source: International Energy Agency

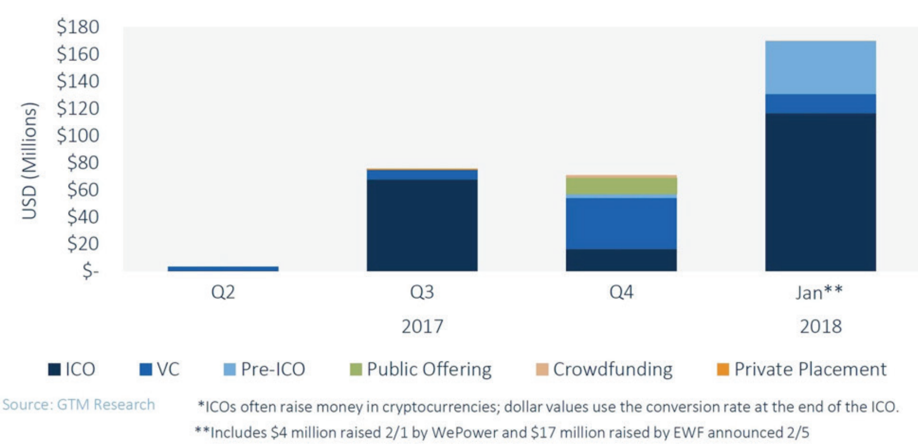
Unlike many innovations of past decades, emerging digital innovations are not technologies that serve a single purpose. Rather, most are crosscutting digital tools and platforms that can be applied to the energy system in myriad ways. They include:

- Artificial intelligence and machine learning that enable increased automation;
- Blockchain technologies that enable secure, decentralized, peer-to-peer transactions;
- Crowdsourcing platforms that enable creative finance mechanisms and expose consumer preferences;
- The internet of things, which connects smart appliances, electronics, mobile devices, and sensors and enables them to communicate across a network; and
- Software and systems that enable new business models for energy services.

These digital tools and platforms create new data streams that have significant potential to enhance measurement, reporting, and verification (MRV) related to carbon and other emissions reporting, sustainability attributes of alternative fuels, and renewable energy and distributed energy resources transactions. Digital MRV can improve the speed and accuracy of reporting, lower reporting and verification costs, and increase scalability and security of MRV systems.[9] It can also enable new approaches to policy design, more effective enforcement of regulations, and better oversight of policy effectiveness.

Investment in these areas is growing rapidly. Investment in blockchain by energy organizations, for example, has gone from nearly nonexistent a year ago to approximately $170 million in January 2018 (see Figure 5).

Figure 5
Investments in Blockchain by Energy Organizations



Source: GTM Research

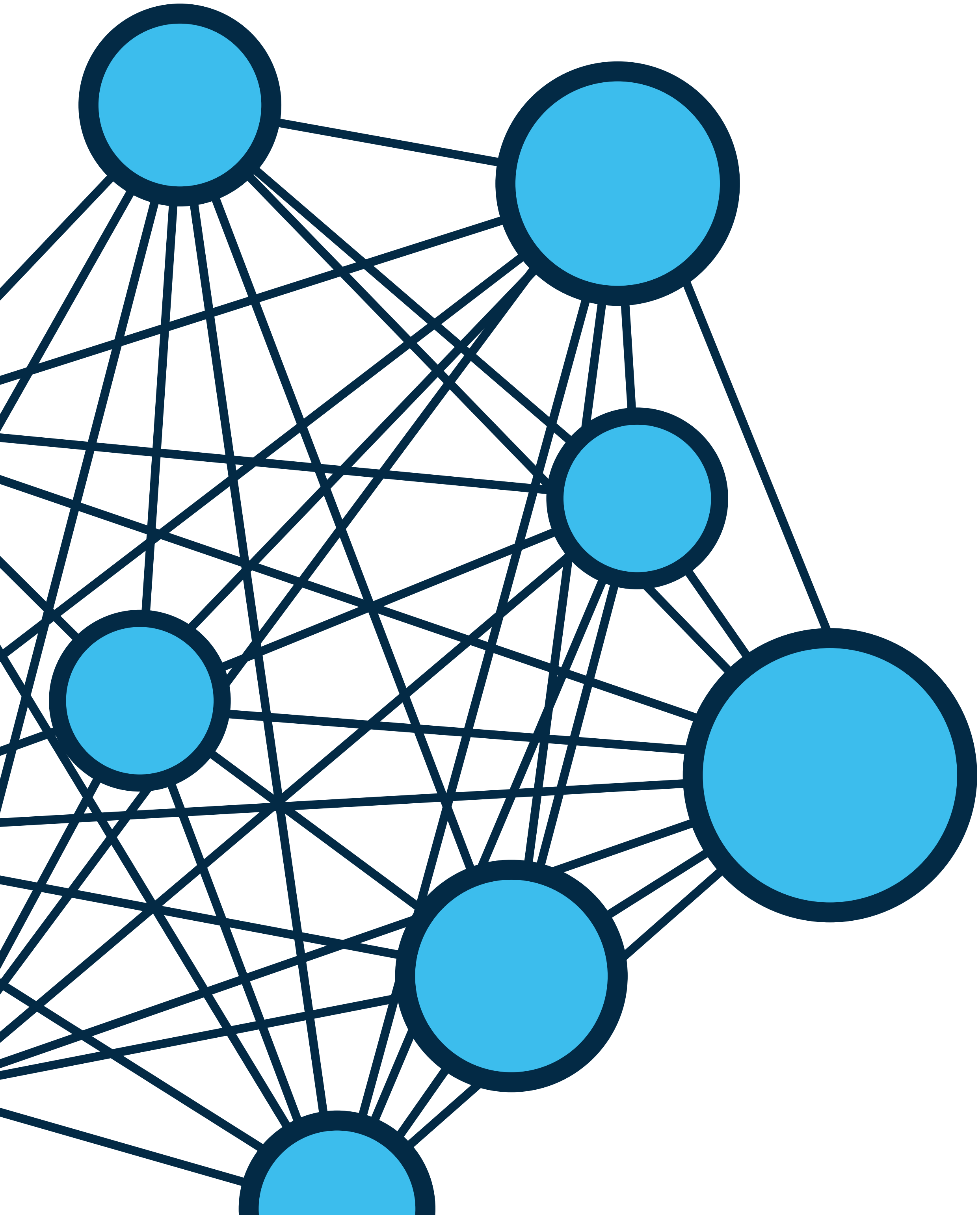
A NEW ROLE FOR GOVERNMENT

Government plays a fundamental role in the energy system. However, as an institution, government is not designed to move quickly. The era of energy digitalization requires policymakers and regulators to embrace a new way of thinking about energy governance. Historically, government intervention was designed around the concept of intermediation—i.e. establishing regulation and incentives to protect the public interest and to promote specific resources and technologies deemed superior or desirable by policymakers. The era of energy digitalization, in contrast, requires intervention designed around the concept of disintermediation—i.e. removing barriers to facilitate new markets, enable new forms of transactions, and empower consumers.

The era of energy digitalization does not require that all policy and regulation be abolished; but neither should policymakers reflexively assume that existing policy and regulatory architectures are still relevant or necessary. If government is to remain relevant, policymakers and regulators must align energy policy to enable markets that are designed to accelerate innovations and optimize benefits to consumers. Section II reviews how existing policy and regulation create barriers in our changing energy system; Sections III and IV outline a framework for developing new policy approaches that are better aligned with the era of energy digitalization. EC-MAP and our partners believe the era of energy digitalization is inevitable; the only question is whether government will accelerate or impede its benefits.

The era of energy digitalization requires policymakers and regulators to embrace a new way of thinking about energy governance.

II. HOW EXISTING POLICY AND REGULATION CREATE BARRIERS TO CHANGE



No policy or regulation is perfect; most energy and transportation policies were initiated with good intentions—to spur economic growth, boost national security, keep consumers safe, and protect the environment. However, too often as the energy and transportation systems evolve, policy remains stagnant. In today's world of accelerating change, policy and regulation based on old ways of thinking have the potential to—intentionally or unintentionally—block the very innovations necessary to achieve policy goals.

Already, much of today's policy architecture is no longer aligned with the realities of the energy and transportation systems. Some policies designed decades ago have been extended over and over again as a matter of course without conscious reassessment of fundamental goals and impact; others have not been altered significantly in that same timeframe. Incumbent stakeholders naturally seek to protect the status quo (in which they have often invested significant resources) while blocking changes that would disrupt their interests or incentivize alternative solutions.

Much of today's policy architecture is no longer aligned with the realities of the energy and transportation systems.

Below are four current issues that illustrate tensions between status quo policy approaches and a future where digital innovations enable markets to respond directly to consumers and enable consumers to express preferences that drive markets. At the end of Section II, Table 1 inventories a broader selection of existing policy and regulatory architectures and how they create barriers to emerging innovation, market efficiency, and consumer choice.

A GROWING GAS TAX GAP

The first Federal gasoline tax was instituted in 1932; it was made permanent in 1941. In 1956, the gas tax became tied to a new Highway Trust Fund that would ensure gas tax revenues were used to fund the interstate highway system and other highway projects. The tax was increased again in 1961, 1982, and 1990; it was last increased 25 years ago, to 18.4 cents per gallon in 1993.[10]

Since that time, the value of the gas tax has eroded dramatically. Inflation alone has reduced its purchasing power by 40 percent.[11] Increased fuel efficiency combined with greater numbers of hybrid and electric vehicles—which use much less or no gasoline but still use road infrastructure—are further reducing its effectiveness. The results have been dramatic. According to the 2017 American Society of Civil Engineers infrastructure report card, one out of every five miles of highway pavement is in poor condition and the maintenance backlog due to chronic underfunding totals more than $800 billion.[12] In cities with the worst roads, individual drivers are estimated to incur between $500 and $1,000 in additional maintenance and fuel costs annually.[13]

In recent years, Congress has kept the Highway Trust Fund from insolvency by appropriating supplemental funding. However, no consensus has yet emerged around a longer-term fix. Industry groups and lawmakers have proposed solutions such as indexing the gas tax to inflation and considering other types of user fees. States are considering a variety of fixes around the margins of the problem: raising state gasoline taxes; seeking private sources of financing; instituting new toll roads; enacting fees on alternative fuel vehicles; and exploring user charges based on miles driven rather than gasoline consumed. However, capturing the benefits from the growing shift toward digitalization requires a more fundamental reckoning.

How can policymakers consider approaches to financing infrastructure that accommodate a variety of vehicles, fuels, and technologies in different regions of the country, rather than a single type for all?

THE CAFE GAME

Corporate Average Fuel Economy (CAFE) standards were originally enacted in 1975 in response to the 1973 oil embargo and reflected a desire to reduce energy consumption and bolster U.S. independence from foreign oil.[14,15] Authority over CAFE is shared by two Federal agencies, the National Highway Traffic Safety Administration (NHTSA), which sets and enforces standards and the Environmental Protection Agency (EPA), which calculates fuel efficiency and regulates compliance with related greenhouse gas emissions standards. In 1990, California instituted a separate Zero Emission Vehicle (ZEV) program intended to incentivize the deployment of vehicles with zero or near-zero emissions. The ZEV standard has since been adopted by thirteen additional states.[16] Updates to CAFE in 2012 were intended to harmonize standards and create "One National Program" across NHTSA, EPA, and California; however, automakers have challenged that the rules remain inconsistent, raising the cost and complexity of compliance.[17]

Policymakers, automakers, environmental groups, and consumer advocates have battled over the structure and details of CAFE.

Over the last several decades, policymakers, automakers, environmental groups, and consumer advocates have battled over the structure and details of CAFE. Most recently, the Trump Administration has indicated its intention to freeze standards beginning in 2020 and potentially revoke a waiver that allows California to set higher emissions standards than the Federal government. The moves are not necessarily supported by the auto industry and are likely to be challenged in the courts.[18] The result is continued uncertainty for a regulation that already is dizzyingly complex and fails to optimize benefits for consumers.

Auto manufacturers have naturally sought to minimize the cost and impact of compliance with standards; in many cases they have done so by exploiting the complexity of CAFE without necessarily embracing new innovations. Differences between how passenger cars and light trucks are treated under the rules has led to reclassification of cars built on truck platforms (including the "invention" of sport utility vehicles)[19] and sizing of vehicle footprints to game fuel efficiency requirements.[20] Perhaps most egregiously, the flex-fuel vehicle loophole allowed manufacturers for many years to get (and bank) credits for producing vehicles that could run on E85 fuel; the rule was based on market assumptions that 50 percent of vehicles would actually use the fuel (despite the fact it was only sold at 2 percent of gas stations)[21] and environmental assumptions that E85 had zero emissions (despite the fact that ethanol has been shown to have an emissions profile only marginally less carbon-intensive than gasoline).[22] Banking and trading of credits (including Federal CAFE credits and state ZEV credits) have also enabled Tesla to make more money selling credits ($622 million, between 2011 and 2015) than selling cars.[23]

Some benefits of CAFE have been eroded by a variety of unintended consequences. One is the "rebound effect," whereby drivers of more fuel-efficient cars take advantage of lower costs by driving approximately 10 percent more miles.[24] One analysis has estimated that CAFE (in spite of gaming to meet its requirements) has added at least $3,800 to the price of a new car. This in turn has resulted in people keeping or seeking lower-priced (and relatively less fuel efficient) used cars and for longer periods of time, and the phenomenon is estimated to reduce emissions benefits by 15 percent.[26] EPA calculations have also been criticized as relying on indoor tests that do not accurately model real-world driving, resulting in, for example, a 54.5 mpg projection that results in only 37 to 40 mpg in the real world.[27] Overall, researchers have estimated that costs associated with CAFE are more than 8X higher than the environmental benefits.[28]

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Real-world consumers use vehicles in different ways depending on where they live, what they do for work, the needs of family members, and how they enjoy spending leisure time. In an era where data can drive more informed consumer choice, is CAFE still relevant? How can policymakers better align national policy goals with mechanisms that enable price signals and empower consumers to demand vehicles that best suit their individual needs?

ADVANCED BIOFUELS: A FAILED EXPERIMENT?

The Renewable Fuels Standard (RFS), originally enacted in 2005 and updated in 2007, requires transportation fuels to be blended with renewable fuels. The law set the requirement at 4 billion gallons of renewable fuels in 2006, rising to 36 billion gallons in 2022. Within the overall obligation are specific requirements for conventional biofuels (generally corn ethanol) and advanced and cellulosic biofuels (including cellulosic ethanol and advanced drop-in fuels from various feedstocks). Conventional biofuels have consistently met the annual requirement; however, advanced and cellulosic biofuels have remained nearly nonexistent. According to the Congressional Research Service, "[g]oing forward, it is unlikely that the United States will meet the total renewable fuel target as outlined in statute."[29]

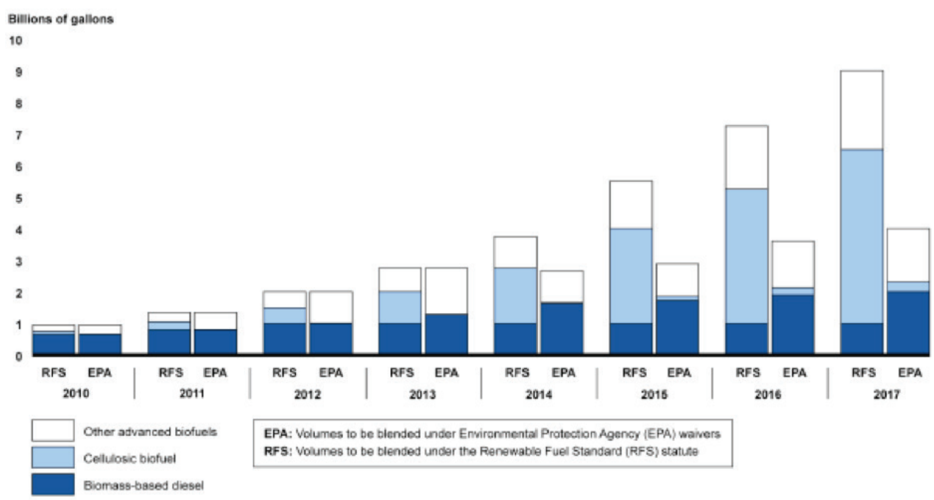
In the mid-to-late 2000s, an advanced biofuels "bubble" emerged, with entrepreneurs, VCs, and the media alike making huge predictions about gallons and dollars associated with biofuels from algae and other non-food, cellulosic feedstocks.[30] However, these aspirations have never become a reality. In 2015, the RFS target for cellulosic biofuels was 3 billion gallons; that year, 142 million gallons of cellulosic biofuels were produced—2 million gallons of cellulosic ethanol and 140 million gallons of renewable natural gas—representing less than 5 percent of the statutory target.[31] This trend has continued in subsequent years as EPA has issued waivers that seek to align the requirements with actual gallons projected to be produced (see Figure 6). As a result, in 2017 the Government Accountability Office (GAO) concluded there is limited potential for expanded production of cellulosic ethanol over the next five years.[32] Many advanced biofuels companies that still exist have shifted their business models toward niche but high value markets such as bio-based chemicals and cosmetics. Still, policy debates rage each year over whether EPA should ratchet down the statutory requirements to realistic levels and whether biofuels tax credits (most currently expired) should be extended another year.[33]

Further, while flex-fuel vehicle models have proliferated (thanks in large part to preferential treatment under CAFE, see above), other infrastructure necessary to deploy biofuels, in particular ethanol, has also failed to materialize. Many environmental groups, automakers, and utilities seem to instead be doubling down on transportation electrification as a preferred solution, at least for passenger cars. At the same time, some lawmakers and fuels industry groups have suggested shifting to a "high octane fuel standard" that would marry the intentions of the RFS and CAFE.[34] While biofuels maintain valuable potential in some regions and for some applications, the blunt instrument of a national renewable fuels standard has not been successful in helping realize it.

How can policymakers leverage digital tools to better enable consumers and markets to drive winners amongst alternative fuels, instead of continuing to debate inflexible and unrealistic mandates?

Figure 6

Volumes of Advanced Biofuels to Be Blended into Domestic Transportation Fuel



Source: Government Accountability Office

WHEN GRID MODERNIZATION MEETS MOBILITY

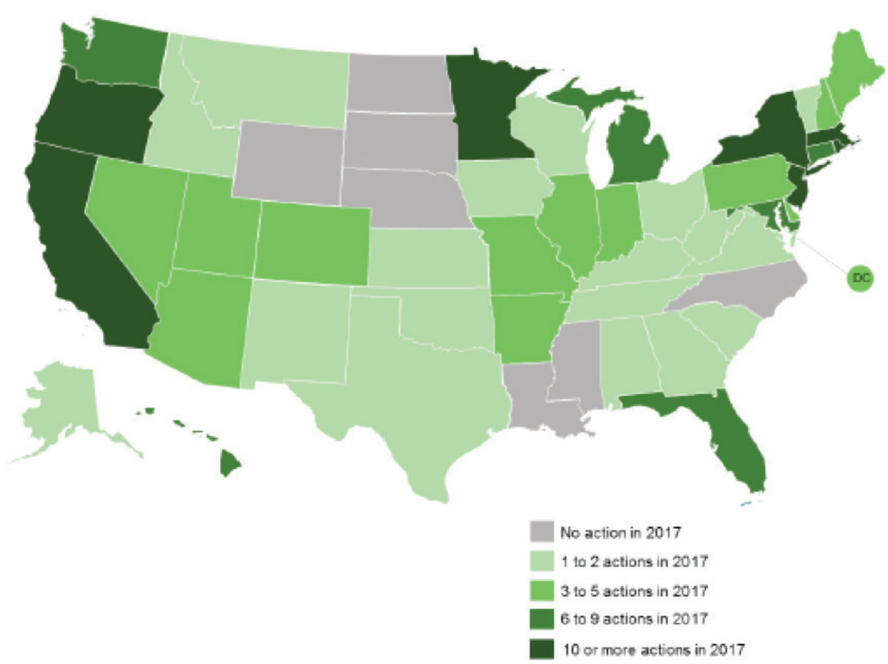
Historically, the transportation sector has operated largely independent of the power sector.[35] The Federal Power Act and state electricity regulation has generally not contemplated a future where power generation, delivery, storage, and consumption is more decentralized—in homes, commercial buildings, and vehicles. That has begun to change as the deployment of electric vehicles (EVs) grows.

In 2017, nearly 200,000 plug-in EVs were sold in the U.S., and just over 50 percent were pure EVs. Although this represents only 1.2 percent of all vehicle sales, adoption of EVs is projected to double in 2018 and continue an exponential trajectory in the coming years.[36] EVs have been forecasted to reach 65 percent of new light-duty vehicle sales in the U.S. by 2050.[37] Auto manufacturers, moreover, are driving rather than resisting the trend. Volvo announced it would make only hybrid or electric vehicles after 2019,[38] and Volkswagen and BMW have set goals to sell hundreds of thousands of EVs in the next few years.[39,40] Ford has committed to produce six EV models by 2022 (as well as hybrid versions of high performance vehicles like the F150 and Mustang); GM has announced it will eventually make only electric vehicles, with the exact schedule to vary among markets and regions.[41]

Electricity regulators, in turn, have begun to recognize the role of EVs in electricity markets—both as electricity consumers as well as electricity storage assets. In 2017, all but seven states took some policy action related to electric vehicles; more than a dozen states took six or more policy actions (see Figure 7). The most popular actions were related to: fees to supplement or replace the gas tax; EV rebate programs; EV electricity rate tariffs; various studies; and fast charging station deployment.[42] New rules regarding how aggregated distributed energy resources (DERs) can participate in power markets were considered at an April 2018 Federal Energy Regulatory Commission (FERC) technical conference, and follow-on regulatory action is expected in the near future.[43]

How can policymakers break through the inherent structures that silo electricity and transportation policy and consider how digital innovations and electricity markets can drive benefits to consumers that desire transportation electrification?

Figure 7
Number of State Actions on Electric Vehicles



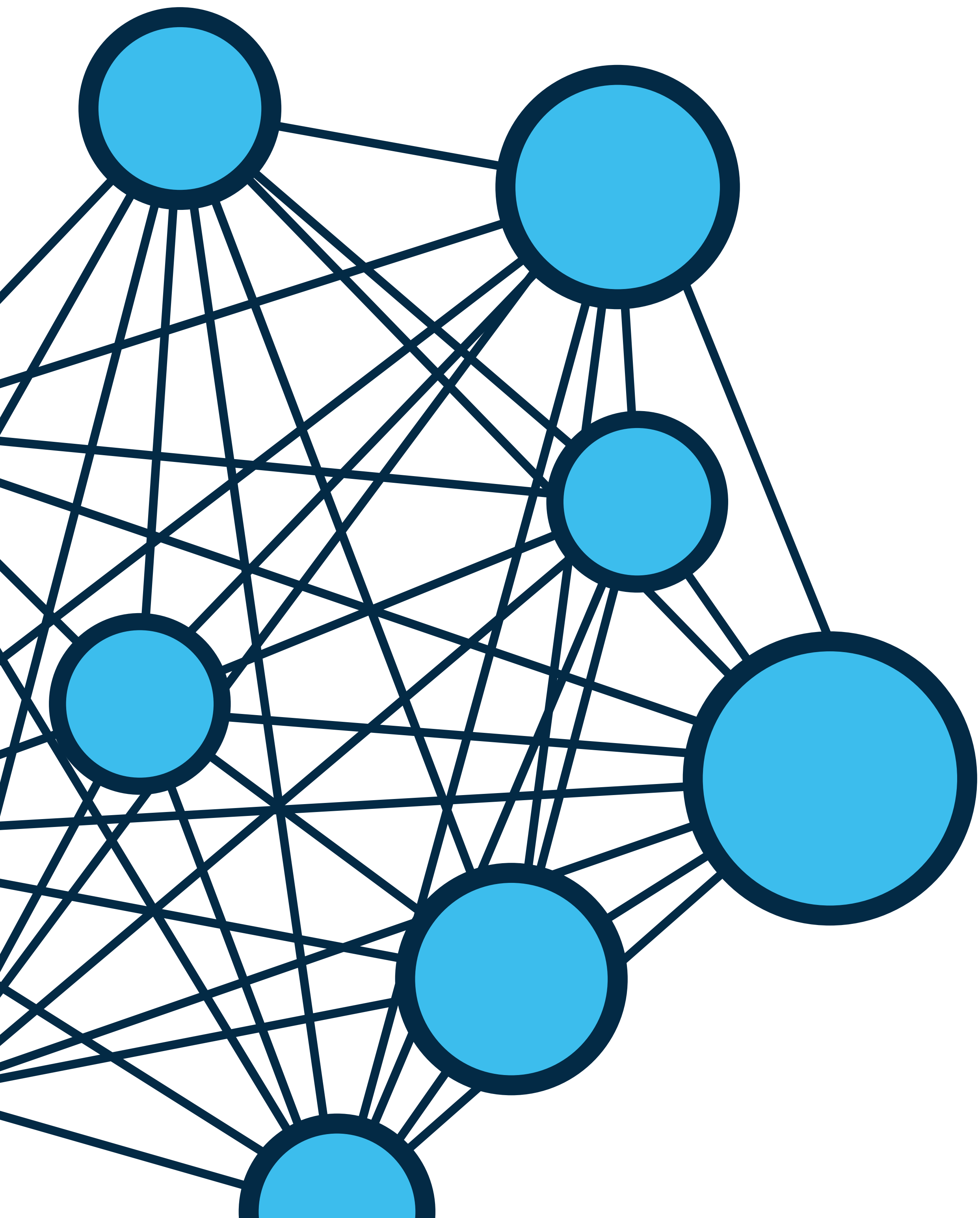
Source: North Carolina Clean Energy Technology Center

TABLE 1: POLICY AND REGULATORY ARCHITECTURES NO LONGER ALIGNED WITH A CHANGING ENERGY SYSTEM

Existing Policy	Historical Overview	Barriers to Emerging Innovations, Market Efficiency, and Consumer Choice
		Federal Policy
Corporate Average Fuel Economy (CAFE)	• 1975: Originally enacted for Model Year (MY)1978-85 • 1980s through early 2000s: Fuel efficiency requirements remain essentially flat • 2007: Energy Independence and Security Act (EISA) drives new "national" fuel economy/ greenhouse gas emissions standards through MY2020	• Complexity of standards incentivizes gaming by industry rather than innovation around intended goals • Beneficial impact of the standards has been partially reduced by consumer behavior • Fuel economy assumptions and calculations are not transparent to consumers • Standards are not fundamentally aligned with promoting fuel neutrality and technology neutrality in achieving efficiency • Standards sometimes incentivize vehicles contrary to what consumers desire
Renewable Fuel Standard (RFS)	• 2005: Originally established in Energy Policy Act to replace Methyl Tertiary Butyl Ether (MTBE) and promote fuel diversity • 2007: EISA expands volumes and categories of renewable fuels	• Required volumes do not reflect market realities for advanced and cellulosic biofuels • Ethanol blended above 10 percent requires new and different infrastructure to reach wide deployment • Consumers have little access to data regarding fuel attributes
Highway Trust Fund (HTF)	• 1956: Created to leverage gasoline tax revenue exclusively for highway projects • 1991 ISTEA /1998 TEA-21/ 2005 SAFETA-LU/ 2012 MAP21: Reauthorized and expanded diversity of surface transportation programs and projects • 2008: HTF becomes insolvent for the first time; Congress has transferred $143 billion to fund projects through 2020	• Dependent on a financing source (gasoline tax) tied to a single fuel source (oil) • Reauthorization legislation has not prioritized development and deployment of diverse, flexible infrastructure or enabled broad deployment of existing and emerging intelligent transportation systems
Federal Power Act	• 1920: Originally enacted to regulate development of Federal hydropower • 1935: Established FERC authority over interstate electricity • 1992/2005: Expanded FERC authority over transmission access, reliability, cybersecurity, market manipulation, and interstate transmission siting	• Degrees of restructuring at wholesale and retail levels vary unevenly across regions • There is little to no market incentive for utilities outside of competitive markets to innovate or prioritize customer choice • There are few incentives or requirements for utilities to share electricity data necessary to reveal true value of DERs (including EVs) and emerging digital innovations • Barriers to entry create hurdles to market participation of DERs (including EVs) and third-party energy services providers • Rules and modeling for considering and valuing non-wires alternatives are nascent[44]

Existing Policy	Historical Overview	Barriers to Emerging Innovations, Market Efficiency, and Consumer Choice
		State and Local Policy
State franchise laws	• 1950s: States first enacted laws protecting independent franchise auto dealers from competition • 25 states currently prohibit or restrict car manufacturers from selling directly to consumers[45]	• Many existing state laws insulate car dealers from competition, stifling innovation and consumer choice[46] • Narrow opening of laws have limited benefit a single auto manufacturer and a single alternative business model—Tesla[47]
State retail electricity competition	• 1990s/2000s: 13 states and the District of Columbia restructure their retail electricity markets • Currently 15 states have some level of retail electricity competition[48]	• There are few incentives or requirements for utilities to share electricity data necessary to reveal true value of DERs (including EVs) and emerging digital innovations • State regulators often do not have access to data and information related to pilot and demonstration of new technologies • The level to which consumers understand and take advantage of competition varies dramatically across states and depends significantly on how the market is structured[49]
City taxicab regulations	• 1930s: Concerns about "ruinous competitive" led government to tightly control prices and restrict supply of taxi services[50] • A medallion system remains in effect in most major cities today	• Existing regulations do not generally require or incentivize adoption of new innovations by incumbent taxi services • Existing regulations purport to protect consumers, but do not necessarily take into account consumer desires

III. A DIGITAL ENERGY FUTURE



A wide variety of stakeholders have already imagined the future of transportation through frameworks and concepts such as smart cities, intelligent transportation systems, and grid modernization. Most of these futures share common attributes; stakeholders generally seek a transportation system that is:

- Affordable and accessible to a wide range of consumers, with more choices in fueling;
- Clean and sustainable, minimizing impacts to the environment and health;
- Convenient and efficient, minimizing congestion and unexpected delays;
- Safe and reliable, protecting passengers from physical harm and financial stress; and
- Secure from growing physical and cybersecurity threats.

Digital innovations are positioned to enable and accelerate these attributes in transformational ways. Artificial intelligence and machine learning has already been integrated into vehicles and are poised in the coming years to enable cars and trucks to be completely autonomous. Blockchain technologies can enable consumers to buy and sell electricity, energy storage, fuels, and mobility services based on preferred attributes. Crowdsourcing platforms can unleash new sources of investment and accelerate deployment of both physical and digital infrastructure. The internet of things can help optimize transportation efficiency and cost effectiveness of both vehicles and smart infrastructure. And software and systems can enable new business models for mobility services that deliver consumer benefits at lower costs. Adoption of these digital tools and platforms remains nascent; however, most do not require additional R&D. Rather, they require policy, regulation, market design, and tools that can enable stakeholders to understand and capture their value.

To help stakeholders imagine a world driven by digital innovations, we have developed five hypothetical scenarios from a not too distant future. These snapshots are optimistic, but based in reality. Below each hypothetical scenario is a description of an actual pilot project operating today. Each of these projects is already leveraging one or more digital tools and platforms to move the energy and transportation systems toward the era of energy digitalization. However, barriers highlighted in Table 2 create hurdles to broader adoption, and a combination of legislative action and agency engagement (by EPA, NHTSA, and FERC, among other Federal agencies) as well as RTOs/ISOs and state regulators will be necessary to scale to a digital energy future.

A VEHICLE-CENTRIC GRID

With EVs reaching 20-25 percent penetration in most metropolitan areas and autonomous transit and delivery fleets becoming ubiquitous, the traditional "virtual power plant" is shifting toward a "vehicle power plant." EVs with solar embedded in carbon fiber bodies charge batteries with power that can be sold back to the grid when they are idle; many office buildings are powered by a mix of vehicles, some still owned by commuters but many shared and available to office tenants for meetings across town or even multi-day trips. Fleet and transit centers have become enormous electricity hubs, powering their own operations and selling excess power to their neighbors—often high tech manufacturing on the outskirts of urban cores. The system works because of intelligent software that automatically coordinates and optimizes hundreds or thousands of distributed "assets" across the system. Back in 2024 and 2025, a few forward-thinking utilities got a head start by funding pilot projects and gathering data on the most lucrative models; several are now expanding outside of their traditional service territories (now allowed by regulators in most states) to compete for new customers. However, they will also be competing with mobility service providers (previously known as traditional auto manufacturers) that are also designing schemes to generate, store, and deliver electricity through EVs. In 2030, the power business has truly gone mobile.

In 2017, software company Nuvve partnered with UC San Diego, San Diego Gas and Electric, and major automotive industry players Nissan, Mitsubishi, and Hitachi to deploy a virtual power plant made up of electric vehicles. The project involves installation of bi-directional vehicle-to-grid (V2G) charging systems on the university campus, which already operates a microgrid.[51] The project is intended to demonstrate that the technology can give utilities the ability to draw on EV batteries to meet energy demands, help grid operators maintain stability, and enable EV owners to get paid for energy storage and backup power.

ZERO CONGESTION ZONES

—"What's on the list of best places to live this year?"

—"You know, the usual—Atlanta, Dallas, Los Angeles, Chicago, New York."

A decade ago, none of these places were likely to make such a list, for a single reason: traffic. However, following several successful pilots and fundamental changes to infrastructure finance at the Federal and state levels, major metropolitan areas across the country began deploying intelligent transportation systems that allow vehicles to communicate with transportation infrastructure and optimize routes, speed, and timing while maintaining convenience and safety. The systems use blockchain to enable instantaneous and secure validation of data transmitted across the network of distributed nodes. New cars are required to have the necessary communications devices installed, but retrofitting older cars is easy. A small plug-and-play, aftermarket device retailing for $9.99 can enable any car to communicate with thousands of sensors and devices deployed in most major cities. Just as important was a database launched in 2022 through a partnership between the National League of Cities and Intelligent

Transportation Society of America. The database consolidated pilot project data and created a matchmaking service for cities seeking financing and financiers seeking low-risk, smart transportation investments. Once thought to be constrained by their infrastructure, today's big cities are increasingly earning the designation of "Zero Congestion Zones."

In 2017, the Florida Department of Transportation and Tampa-Hillsborough Expressway Authority began deployment of technology to enable vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication between 1,600 vehicles (including cars, buses, and streetcars) and infrastructure in more than 40 locations in downtown Tampa.[52] The pilot has been designed to test six use cases for the technologies: morning back-ups, wrong-way entry, pedestrian safety, transit signal priority, streetcar conflicts, and traffic flow optimization.[53] Policymakers expect the project to improve safety, mobility, and environmental impacts from traffic; evaluation of its results began in spring 2018.

EMBRACING BOUTIQUE FUELS

"I remember decades ago when 'boutique fuels' was an ugly word," a fueling station owner recently told Congress. "Now my business is thriving because of them." What an earlier generation once called "gas stations" are now increasingly known as "energy stations" where consumers can power up their vehicles with a variety of fuels including gasoline, bio-based gasoline (chemically indistinguishable from conventional gasoline except through carbon dating), various ethanol blends, compressed natural gas, hydrogen (produced from renewable energy), and of course, electricity. Most energy stations don't have every option, but many have at least two or three. Regional preferences play a big role—in California, EV chargers dominate; in Illinois, locally-produced E50 and E85 are most popular; and CNG has taken a large share of the market in Texas and Oklahoma (still the country's biggest hubs for oil and gas production—not to mention a lot of large pickup trucks that use CNG) and also in New York, where piloting CNG and LNG for transit fleets and heavy trucks translated into insights into how it could benefit the consumer market.

At first, people worried about whether they would be able to find the right fuel on long road trips; but in 2025 the Department of Transportation partnered with major tech firms to map every fuel station nationwide. A free app—EveryFuelStation—provides real-time, crowdsourced pricing information as well as sustainability attributes for different fuels. It has become the go-to resource for anyone who still owns a car and drives. But much more revolutionary has been the decentralization of fueling. According to a recent Gallup poll, 1 in 5 Americans did not visit an energy station in the last month—primarily because they could fuel up at home or work. EV chargers and CNG "stations" are becoming more popular in downtown parking garages and in home garages alike, where existing infrastructure is easy to expand. In its latest move to expand into new sectors, Amazon just announced a new service for rural areas where a month's supply of E85 can be delivered to your doorstep by autonomous delivery truck; the move is expected to boost the market for used flex-fuel vehicles, which were often previously run only on gasoline because E85 was inaccessible. Today it's truly a brave new boutique world.

In 2017, French oil company Total was an early leader in announcing it would add EV charging stations at its network of gasoline stations across France, with an initial 300 stations at locations about 100 miles apart.[54] The news was followed just months later by an announcement by Royal Dutch Shell that it would acquire a major European EV charging company and begin transitioning gas stations to "energy stations."[55] In recent years, Shell has accelerated its efforts to diversify its business; the company has also taken a large stake as an owner/operator of more than 100 U.S.-based solar plants and agreed to provide credit to a California-based smart-home energy management company.[56] In other areas of the country, larger scale natural gas fueling stations continue to open to address the growing fleets of heavy-duty truck drivers needs.[57] A recently released Shell scenario describing a possible future in 2070—one where EVs dominate passenger cars, a new carbon use industry takes off, and hydrogen is a growing fuel source for road transport[58]—demonstrates that this "oil company" is thinking more like an "energy company."

THE RISE OF THE ATTRIBUTE

—"It's a good lookin' truck, but what are the STMs?" The man shopping for a new truck subscription was skeptical.

—The dealer was relaxed, he had heard this question a thousand times. "Do you have the STM-X app? Scan the bar code on the window and you can see the analytics yourself. If they don't look good for you, just can plug in what you'd like to optimize and the app will rank which models are better."

The Federal government had always mandated that information about fuel efficiency and safety be made available to consumers, but the data was often presented in ways that were difficult to comprehend or compare across different vehicles and fuels. Some consumers wanted information that just wasn't available—where the vehicle was manufactured or whether it was optimized for high octane, low-carbon gasoline. That changed when the U.S. Congress overhauled two laws: CAFE and the RFS. Both had grown in complexity over time, creating a patchwork of overlapping requirements that were siloed in ways that no longer reflected the marketplace. Regulators and policymakers argued about whether the regulations were achieving their intended goals; from the data they had, it just wasn't clear anymore. Neither law had been designed to integrate new streams of data into their MRV systems—data that didn't exist when the laws were written but now were ubiquitous and easily accessible from any connected mobile device.

The result was a new law that created "Sustainable Transportations Metrics" (pronounced "stems"). The Federal government defined five basic stems and established an open source platform for the private sector to propose additional metrics. The government also deployed a blockchain application to ensure all data was verifiable and secure. App developers and other third parties could integrate new proposed metrics into their algorithms and let consumer demand drive their popularity and adoption. Today the most popular STM apps allow consumers to compare the five government-defined metrics (fuel efficiency, carbon emissions, lifecycle cost, safety, and cybersecurity rating) as well as a number of other metrics like local economic impact, sustainability rating of major suppliers, and something called "vehicle happiness" —based on real-time user experience and feedback.

The Energy Independence and Security Act of 2007 required EPA to study the potential for allowing EVs powered by renewable sources of electricity to qualify under the RFS. In 2014, EPA issued a rule defining a pathway for biogas-derived electricity and requiring that applicants track and verify that the electricity produced was actually being used for transportation. BTR Energy has proposed leveraging vehicle telematics—communications systems already installed in many cars that can transmit data for GPS, make an emergency call, and optimize electric vehicle charging. Under the company's business model, farmers generate biogas from waste, and BTR tracks and verifies the use of that electricity to charge EVs using data generated by the vehicles. The company has awaited a decision from EPA on the proposal since 2015.[59] Although an increasing array of energy data like these are accessible today, EPA has not yet determined how to put them to use for consumers.

INTELLIGENT LOGISTICS

"We used to worry robots were coming for our jobs. Now we realize they were exactly what we needed to do our jobs better." That statement started off testimony by the American Trucking Association at a recent Congressional hearing on the costs and benefits of autonomous trucking. Only a few years ago many truckers were resistant to testing the new autonomous trucks on long-haul routes. But the results have been overwhelmingly positive: highway accidents involving heavy duty trucks are down by more than 50 percent; hours lost in traffic congestion are down 70 percent; and new trucking jobs have doubled in the last five years alone. Trucking is now the number one career choice for job seekers without a college degree and, truckers are among workers with the highest job satisfaction. The results are no surprise; truckers no longer have to spend days or weeks on the road away from family and friends or work grueling hours, and wages have remained stable. The adoption of autonomous semis has been driven by online retailers seeking to increase speed of delivery to customers without increasing costs; but the Federal government has also played a role by streamlining regulations for autonomous trucking. Once fading communities are thriving again because of jobs at "truck transfer hubs" off the interstates (where long-haul autonomous trucks hand off loads to human truck drivers and at "remote trucking centers" where autonomous trucks are piloted remotely by workers). Some incumbent trucking companies have consolidated but others are thriving, especially those founded on new business models that use machine learning to optimize logistics and "last mile" routes. The trucking life has never been better.

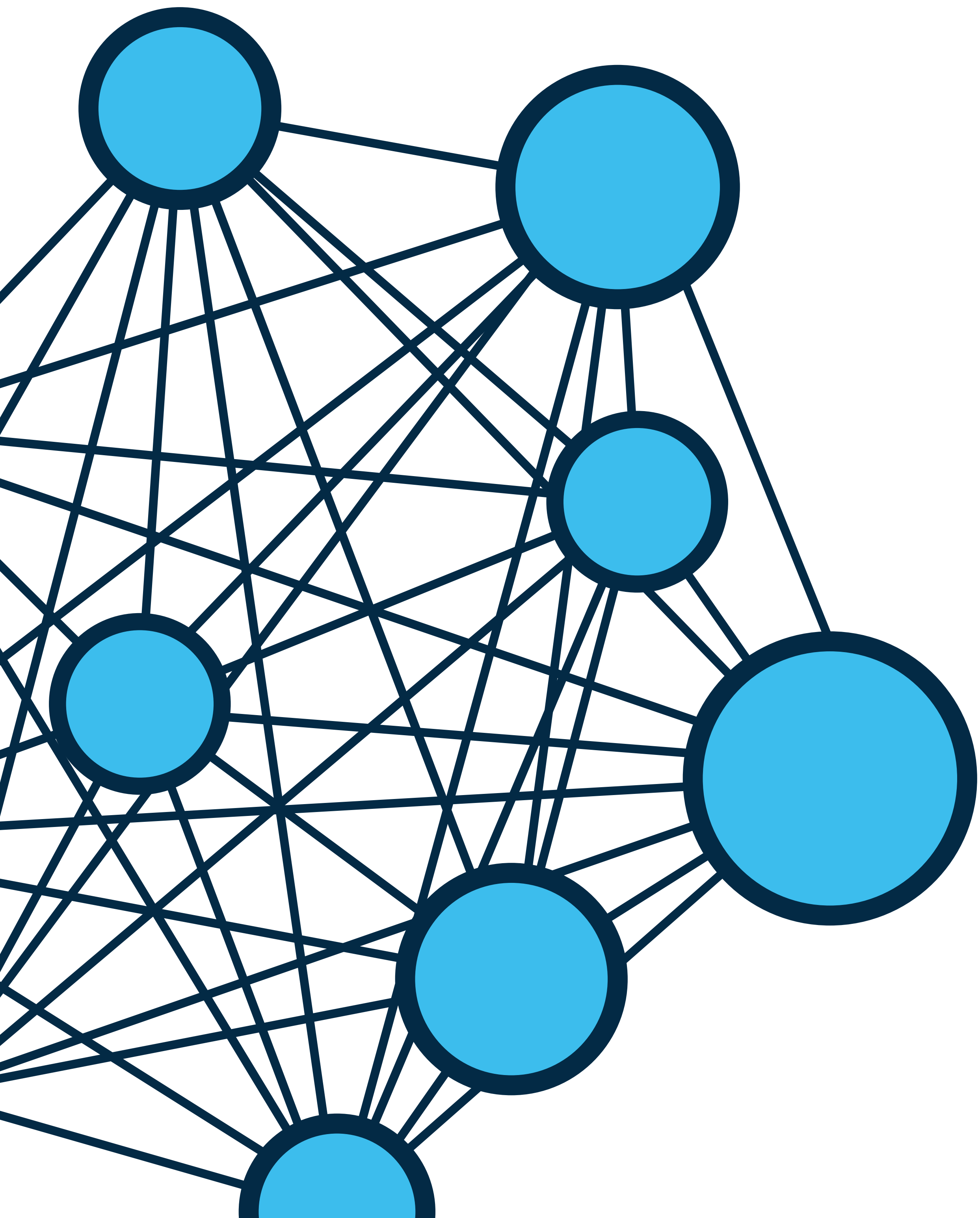
Since 2016, Uber has piloted a transfer hub system at weigh stations off of I-40 in Arizona where autonomous trucks (with a driver behind the wheel, for now) transport cargo over highways and then shift their trailer to human-driven trucks to navigate the final portion of the trip over more complex local roads.[60] The project is built on a foundation of logistics data collected through Uber Freight, a system, like the company's ridesharing app that connects truckers with cargo. Uber's ultimate goal is not just to show off self-driving trucks; they envision a future where every truck is moving cargo and making money, seamlessly and efficiently, 24/7.[61]

TABLE 2: POTENTIAL BARRIERS TO A DIGITAL FUTURE

<table>
<tr><th>Future Scenario</th><th>Policy/ Regulation</th><th>Potential Barriers to This Future</th></tr>
<tr><td rowspan="4">“A Vehicle-Centric Grid”</td><td>Federal Power Act</td><td>• There are few incentives or requirements for utilities to share electricity data necessary to reveal true value of DERs and emerging digital innovations
• Barriers to entry create hurdles to market participation of DERs and third-party energy services providers</td></tr>
<tr><td>CAFE</td><td>• Complexity of standards incentivizes gaming by industry rather than innovation around intended goals
• Standards are not fundamentally aligned with promoting fuel neutrality and technology neutrality in achieving efficiency</td></tr>
<tr><td>Highway Trust Fund</td><td>• Reauthorization legislation has not prioritized development and deployment of diverse, flexible infrastructure or enabled broad deployment of existing and emerging intelligent transportation systems</td></tr>
<tr><td>State retail electricity competition</td><td>• There are few incentives or requirements for utilities to share electricity data necessary to reveal true value of DERs (including EVs) and emerging digital innovations
• State regulators often do not have access to data and information related to pilot and demonstration of new technologies</td></tr>
<tr><td rowspan="2">“Zero Congestion Zones”</td><td>Highway Trust Fund</td><td>• Dependent on a financing source (gasoline tax) tied to a single fuel source (oil)
• Reauthorization legislation has not prioritized development and deployment of diverse, flexible infrastructure or enabled broad deployment of existing and emerging intelligent transportation systems</td></tr>
<tr><td>City taxicab regulations</td><td>• Existing regulations do not generally require or incentivize adoption of new innovations by incumbent taxi services</td></tr>
<tr><td rowspan="3">“Embracing Boutique Fuels”</td><td>RFS</td><td>• Ethanol blended above 10 percent requires new and different infrastructure to reach wide deployment
• Consumers have little access to data regarding fuel attributes</td></tr>
<tr><td>CAFE</td><td>• Standards are not fundamentally aligned with promoting fuel neutrality and technology neutrality in achieving efficiency</td></tr>
<tr><td>Highway Trust Fund</td><td>• Reauthorization legislation has not prioritized development and deployment of diverse, flexible infrastructure or enabled broad deployment of existing and emerging intelligent transportation systems</td></tr>
</table>

Future Scenario	Policy/ Regulation	Potential Barriers to This Future
"The Rise of the Attribute	CAFE	• Fuel economy assumptions and calculations are not transparent to consumers • Standards are not fundamentally aligned with promoting fuel neutrality and technology neutrality in achieving efficiency
	Federal Power Act	• There are few incentives or requirements for utilities to share electricity data necessary to reveal true value of DERs (including EVs) and emerging digital innovations
	RFS	• Consumers have little access to data regarding fuel attributes
	State franchise laws	• Many existing state laws insulate car dealers from competition, stifling innovation and consumer choice
	State retail electricity competition	• There are few incentives or requirements for utilities to share electricity data necessary to reveal true value of DERs (including EVs) and emerging digital innovations
"Intelligent Logistics"	Highway Trust Fund	• Dependent on a financing source (gasoline tax) tied to a single fuel source (oil) • Reauthorization legislation has not prioritized development and deployment of diverse, flexible infrastructure or enabled broad deployment of existing and emerging intelligent transportation systems

IV. HOW DO WE GET THERE



Many organizations are already working to identify and advocate for policy and regulation to enable a future similar to the one imagined here, but efforts are often polarized by debates over climate change and siloed by proponents of different solutions such as transportation electrification, alternative fuels, and emerging issues related to autonomous vehicles and cybersecurity.

EC-MAP and our partners are focused on accelerating these efforts in three ways: 1) by taking a broader view of energy and transportation policy across fuels and vehicle types; 2) by building support among a wider diversity of policymakers from different geographies and political parties; and 3) by developing a roadmap to align policy with a digital energy future—a future where government empowers consumers, supports free and fair markets, and enables innovation.

In the coming months, we plan to engage stakeholders around questions we believe are critical to building the policy and regulatory architectures necessary to unlock the digital technologies, tools, and platforms described here. Some of these questions will be uncomfortable to ask and complicated to answer; but to ignore them will only slow our progress toward a more affordable, clean, efficient, reliable, and resilient future. It is critical to ask questions in at least three areas:

1. How existing policy designed decades ago for a different kind of transportation system creates barriers to innovation, such as:
    - Is CAFE relevant for driving efficiency, value, and choice to consumers? Is there a better approach that would sidestep tensions between the Federal government and states, companies and consumers?
    - Should the RFS be allowed to expire? Are there market mechanisms (enabled by blockchain and other digital technologies) that could better enable clean, domestically produced fuels with the attributes consumers demand?
    - Can wholesale and retail electricity markets leverage the participation of emerging electric vehicle technologies, applications, and services to accelerate emissions reductions better than command and control regulation?
2. How new policy can be designed with the flexibility to enable adoption of emerging technologies today and technologies not yet imagined in the years to come, such as:
    - How can policymakers and the private sector leverage markets, innovation, and consumers to make digital transportation systems resilient to cybersecurity threats?
    - How can policymakers increase access to transparent, verifiable data streams and empower consumers to drive markets for vehicles and mobility services?
    - What policies can incentivize the necessary investment (including by individuals and small communities) in physical and digital infrastructure?

A future where government empowers consumers, supports free and fair markets, and enables innovation.

3. How policy and regulation can ease the transition to an era of energy digitalization, such as:
    - Do consumers still want to own cars? What policies are holding back alternative financing mechanisms and business models for deploying and accessing mobility services?
    - How can fleets be leveraged to pilot emerging technologies? What policy mechanisms would help successful fleet demonstrations scale to other markets?
    - How can new data streams from digital innovations—for example sustainability attributes of fuels verified by a blockchain system—be best integrated with existing measurement, reporting, and verification (MRV) frameworks?

Policy can and should be better aligned with energy consumer preferences and competitive markets.

While questions like these are a starting point, we know that we don't have all the answers. Some barriers are so entrenched they may seem insurmountable, but potential solutions are also advancing at an unprecedented pace. Policy can and should be better aligned with energy consumer preferences and competitive markets; EC-MAP plans to work with incumbent stakeholders, new stakeholders, policymakers—and you—to build a roadmap to get there. We hope you will join us in accelerating the era of energy digitalization.

FURTHER READING

The following is a selection of key resources related to the topics covered in this paper. These sources may be instructive for future EC-MAP discussions and activities.

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