NOVEMBER 2021

SUPPORTING GOVERNMENTS WITH 100% ZEV TARGETS

WORKSHOP REPORT

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ACKNOWLEDGMENTS

This work is conducted for the International Zero-Emission Vehicle Alliance and is supported by its members (Baden-Württemberg, British Columbia, California, Canada, Chile, Connecticut, Costa Rica, Germany, Maryland, Massachusetts, the Netherlands, New Jersey, New York, Norway, Oregon, Québec, Rhode Island, the United Kingdom, Vermont, and Washington). Nic Lutsey and Peter Slowik provided critical reviews and key input. Members of the International Zero-Emission Vehicle Alliance and the interactive webinar discussion series participants reviewed an earlier version of the report. Their review does not imply an endorsement, and any errors are the authors' own.

INTRODUCTION

The zero-emission vehicle (ZEV) market has experienced dramatic growth, reaching over 10.5 million sales of passenger ZEVs[1] through 2020, including more than 3 million in 2020 alone. The pace of the ZEV transition continues to accelerate because of an array of government support policies at the local, state or province, and national levels to achieve climate, air quality, industrial policy, and energy security objectives. Auto manufacturers have brought hundreds of ZEV models to market, and vehicle prices continue to fall with lower battery and component costs due to economies of scale and technological innovations.

ZEVs hold significant promise as a solution to decarbonizing the transport sector: Battery electric vehicles, the most common type of ZEV through 2020, emit 40% to 70% less greenhouse gases (GHGs) than a similar combustion engine vehicle over the vehicle's lifetime, a share that will continue to fall as the electricity grid decarbonizes.[2] Despite the dramatic market growth, the current pace of the global ZEV transition is insufficient to achieve decarbonization targets in line with international climate agreements.[3] To that end, governments from the city to the international level are increasingly setting targets for the end of combustion engine vehicle sales and a shift to all zero-emission vehicles.

A commitment to move to all ZEV sales represents a substantial shift in transport, environmental, and industrial policy, and as such requires careful planning and coordination among many stakeholders. Beyond setting targets, governments face additional questions related to creating binding enforcement mechanisms and complementary policies to ensure that targets are met. To investigate these questions and discern emerging best practices from leading governments, the members of the International ZEV Alliance commissioned and hosted four government-only interactive webinars in April–June 2021, each focusing on a different aspect of 100% ZEV targets. This report summarizes the key lessons from the webinar series alongside additional data on the status of 100% ZEV targets and accompanying policies. The paper is organized into chapters based on the topics of the four workshop sessions: the state of 100% ZEV targets, regulations to ensure the ZEV transition, working with cities to achieve ZEV targets, and the economic impacts of the ZEV transition. The expert speakers for each session are listed in the appendix.

1 Unless noted otherwise, ZEVs in this paper include battery electric vehicles, plug-in hybrid electric vehicles, and fuel cell vehicles.

2 Georg Bieker, A Global Comparison of the Life-Cycle Greenhouse Gas Emissions of Combustion Engine and Electric Passenger Cars (ICCT: Washington, DC, July 20, 2021), https://theicct.org/publications/global-LCA-passenger-cars-jul2021.

3 Stephanie Searle, Georg Bieker, and Chelsea Baldino, "Decarbonizing Road Transport by 2050: Zero-Emission Pathways for Passenger Vehicles" (ZEV Transition Council: Washington, D.C., July 20, 2021), https://theicct.org/publications/zevtc-decarbonizing-by-2050-jul2021.

SESSION 1: THE STATE OF 100% ZEV TARGETS GLOBALLY

As of July 2021, at least 15 national governments have set targets for the phaseout of new combustion engine vehicle sales. Figure 1 lists the 100% ZEV targets for countries as well as for California, a major vehicle market within the United States with unique authority over vehicle regulations. Also included is the 2035 proposed phaseout target issued by the European Commission as a part of the "Fit for 55" climate package in mid-2021. This target, which would affect the European Union and European Economic Area markets, will be finalized through 2022 or beyond. The figure also displays the sales shares of new passenger vehicles that were ZEVs from 2010 through 2020 in solid lines,[4] along with a linear trajectory from 2020 to achieve their 100% ZEV targets. The targets range from 2025 in Norway to 2040 in France and Spain. Many cities have also set stronger targets; these will be highlighted in Session 3.

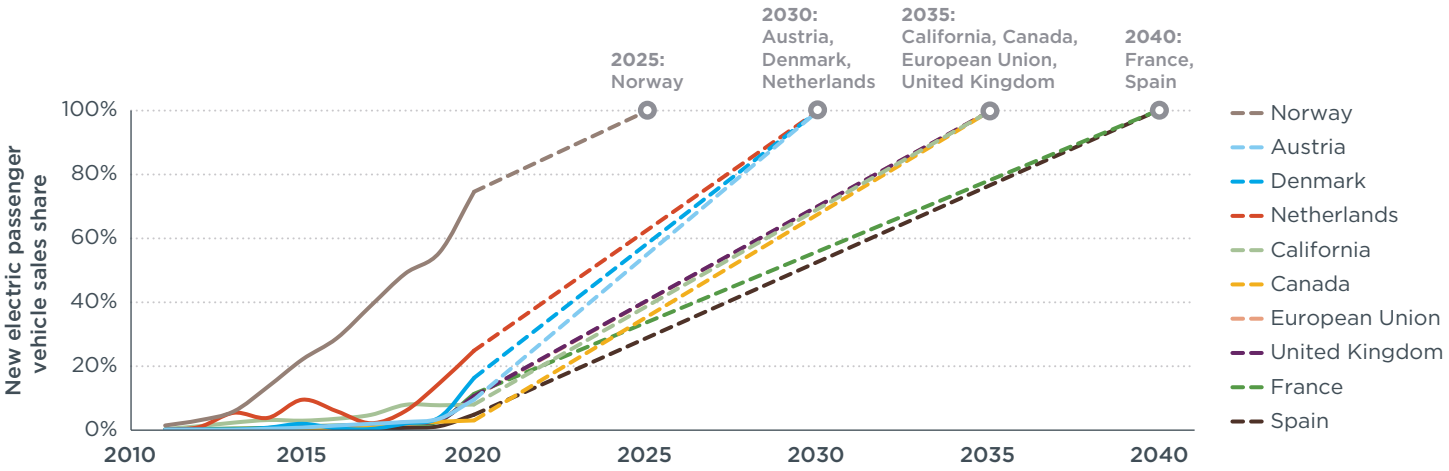

Figure 1. Targets for 100% ZEV sales of new passenger vehicles with 2010–2020 ZEV sales shares.

Figure 1 shows that progress toward meeting targets varies widely among markets that have announced targets. The compound annual growth rate in ZEV sales required to meet the announced target (not shown in the figures) is greatest in Canada (26%) and Denmark (20%). On the other hand, the required annual growth is lowest in Norway (6%), the market with the highest sales shares through 2020. Canada and the United Kingdom have both moved up their targets from 2040 to 2035 to better align with climate targets and market developments. The targets displayed in the figure are generally not legally binding, although some (e.g., France and Spain) are incorporated into national laws and others (e.g., California and the European Union) are being translated into binding regulations. Nonetheless, the targets serve as important guidelines for public and private investments (e.g., fleet procurement, charging infrastructure rollout, ZEV manufacturing capacity) and developing accompanying ZEV support policies.

There are fewer targets set for a full transition to heavy-duty ZEVs, and those that do exist are on a slower pace. Urban buses are the heavy-duty segment where ZEVs are most mature. Consequently, targets here are most common, including the Netherlands, Denmark, and Norway (2025, with biogas also allowed in Norway) and Colombia

4 Data from EV-Volumes (EV Data Center, 2020), http://www.ev-volumes.com/datacenter/.

(2035). Fifteen U.S. states and the Canadian province of Québec have set a target for 100% of new trucks being zero-emission in 2050, with an interim target of 30% in 2030. Other governments have set targets for electric sales shares for the broader heavy-duty fleet, including 50% by 2030 in Norway and 90% by 2040 in Pakistan.

Setting the world's earliest 100% ZEV target. Norway, the world's leading ZEV market, offers a case study in how such targets can be set and their impacts. Norway set its long-term ZEV goals in 2017 after witnessing a slowdown in the ZEV market; in 2016, 15% of Norway's passenger car sales were battery electric vehicles (BEVs), compared to 17% a year earlier. The goals were designed to ensure that transport provided a suitable share of emission reductions toward Norway's objectives under the Paris Agreement. The government decided that no combustion engine cars or light vans would be sold after 2025; by 2030, this would be expanded to heavy vans, as well as all urban goods delivery vehicles, 75% of intercity buses, and 50% of medium- and heavy-duty trucks. As the market has grown, these goals have taken on a greater significance. "We started out with these goals as an indicator in the National Transport Plan, but it seems like it has caught traction, so it has gone from being an indicator to being spoken of as a target, with more and more focus on it," said Sigve Jarl Aasebø of the Norwegian Public Roads Administration. "[The target] has caught more political attention and it has proven to be more solid." Since announcing these targets, the Norwegian government has continued its strong financial incentives for ZEVs (including exemption from 25% value-added tax [VAT]), invested in charging infrastructure in remote regions, and encouraged cities to offer additional supportive measures to ensure that this ZEV uptake goal remains within reach.

Opportunities for international collaboration. Beyond goals established by individual governments, there also are efforts to align targets, share knowledge, and build ambition among different stakeholders to make targets stronger and ensure they can be met. One far-reaching effort is the ZEV Transition Council, which counts 15 countries as well as the European Commission and California as members. The effort was initiated by the United Kingdom as COP26 president to stem the growth in emissions in the transport sector, targeting the largest and most influential vehicle markets. "Just 15 countries make up about 80% of new car sales. If those countries work together, and also with other governments and non-state actors, we can make this transition quicker, cheaper, and easier for all," said Stephanie Edwards, head of sector strategy for international climate change at the United Kingdom Department for Business, Energy, and International Strategy. The ZEV Transition Council will include several high-level meetings on policies related to the ZEV transition leading up to COP26 and will continue its collaboration in 2022 and beyond.

For heavy-duty vehicles, 15 U.S. states and the District of Columbia signed a memorandum of understanding to transition to zero-emission medium- and heavy-duty vehicles with targets of 30% of medium- and heavy-duty vehicles being ZEVs by 2030 and 100% by 2050.[5] Additionally, eight countries, led by the Netherlands and the Drive to Zero program, issued a call for a global memorandum of understanding ahead of COP26 with the core goal of reaching 100% zero-emission medium- and heavy-duty vehicle sales between 2040 and 2050.[6]

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5 "Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding," July 14, 2020, https://www.nescaum.org/documents/multistate-truck-zev-governors-mou-20200714.pdf.

6 "Austria, Canada, Chile, Germany, Greece, Netherlands, Norway, Sweden Call on Leading Nations to Jointly Pursue Global Agreement on Zero-Emission Trucks and Meet Paris Climate Goals," Global Commercial Vehicle Drive to Zero, May 31, 2021, https://globaldrivetozero.org/2021/05/31/cem12announcement-5-31-21/.

SESSION 2: REGULATIONS TO ENSURE THE ZEV TRANSITION

Although long-term ZEV targets are important in sending a market signal and coordinating public and private investments, binding regulations have proven vital in boosting ZEV sales during the early phases of the ZEV transition and will likewise play an important role in advancing the transition. The most widespread binding regulations are CO_2 standards, which set a limit on the fleetwide average of new vehicles (generally cars, light trucks, and vans) for each manufacturer, measured in grams of CO_2 per kilometer or mile. CO_2 standards are present in every country in the world with a ZEV sales share above the global average. These regulations are designed to be technology neutral and allow different automakers to pursue different strategies. ZEVs typically are counted as emitting zero grams of CO_2 per kilometer and sometimes receive "super credits" giving them extra weight when calculating fleetwide averages, making them an attractive compliance option. However, because they are technology neutral, these performance standards cannot guarantee a particular ZEV sales share.

Successes and challenges with the European Union's CO_2 standards. The impact of CO_2 standards on the ZEV market can most clearly be seen in Europe in 2020: When the new CO_2 regulation came into force (roughly 95 g CO_2/km, down from 130 from 2015–2019), the electric vehicle sales share increased from 3% in 2019 to 11% in 2020.[7] Furthermore, the number of models available in at least one city in Europe increased from 115 to 185. The tighter CO_2 regulations also corresponded to growth in manufacturing of both electric vehicles and batteries, illustrating how supply-side regulation can function as industrial policy as well as climate policy. Europe's post-2020 standards include a "benchmark" standard to further incentivize the sale of ZEVs. If at least 15% of a manufacturer's new passenger cars and vans are zero- and low-emission (below 50 grams of CO_2 per kilometer) in 2025, then the company's CO_2 targets are relaxed. The benchmark rises to 35% for cars and 30% for vans in 2030.

Despite the strong electric vehicle growth, the European CO_2 standards also highlight some important considerations for future policy design. First, European CO_2 standards have traditionally only been tightened every 5 years, meaning that automakers could effectively maintain the same EV share between 2021 to 2024. This has resulted in large jumps in EV sales (and declines in fleetwide emissions) when targets come into effect (as in 2020), followed by years of stagnation. A solution to this challenge would be to replace this stepwise approach in previous regulations and in the proposed regulation with linearly decreasing annual standards. Even with the same 2025, 2030, and 2035 CO_2 targets, this change could save an additional 480 million tonnes of CO_2, doubling the reduction.[8] Electric vehicle sales shares would also see faster growth in intervening years if targets were made annual rather than every 5 years, increasing the total number of electric cars on the roads.

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7 Peter Mock, Uwe Tietge, Sandra Wappelhorst, Georg Bieker, and Jan Dornoff, "Market Monitor: European Passenger Car Registrations, January–December 2020" (ICCT: Washington, DC, February 3, 2021), https://theicct.org/publications/market-monitor-eu-jan2021.

8 Joshua Miller and Arijit Sen, "Details Matter: The Outsized Climate Benefits of Setting Annual Targets for New Cars in Europe," ICCT Staff Blog (blog), July 8, 2021, https://theicct.org/blog/staff/details-matter-annual-targets-europe-jul2021.

Second, the real-world benefits of CO_2 standards tend to be substantially less than the targets. "The lesson here is that the nominal target is not as important as the design of the regulation or standard," said Julia Poliscanova, senior director of vehicles and e-mobility at Transport & Environment. A 15% reduction in grams of CO_2 per kilometer within a standard could result in only a 2% real-world reduction due to a number of regulatory flexibilities including mass adjustment, eco-innovations (credits for implementing new technologies, also known as off-cycle credits), and test cycle manipulations.[9] Furthermore, the same provisions that have made CO_2 standards a useful tool to introduce ZEVs into the early market also come with environmental tradeoffs. The super credits, which give ZEVs extra weighting in the fleet average emissions (2.0 in the European Union in 2020, for example), could enable emissions in the combustion vehicle fleet to stagnate or even rise as the ZEV sales share grows above 20%.[10] Additionally, many standards, including Europe's, give substantial benefits for plug-in hybrid electric vehicles (PHEVs) that are not consistent with their real-world benefits. This risk can be mitigated by calculating CO_2 values based on real-world fuel and electricity use and removing multipliers for PHEVs.

ZEV regulations and supporting policy in California. An additional form of regulation that addresses some of these issues is a ZEV regulation, which requires that every manufacturer earn credits from the sale of ZEVs (typically BEVs, PHEVs, and fuel cell electric vehicles), with a requirement based on each automakers' total vehicle sales. These standards are present only in a few markets: California and 12 other U.S. states, China, and the provinces of Québec and British Columbia in Canada; key aspects of these programs are summarized in Table 1. British Columbia's policy is the only ZEV regulation designed for a 100% ZEV sales share, with a date of 2040. These ZEV regulations can be tailored to encourage specific technologies or attributes; for example, China's regulation gives more credits to BEVs with longer range and greater energy efficiency, whereas the other regulations are based on range alone.[11] These markets tend to have far greater sales than nearby jurisdictions: the two Canadian provinces, for example, accounted for 37% of the country's light-duty vehicle sales but 75% of ZEV sales through 2020.[12]

9 "Cars CO_2 Review: Europe's Chance to Win the Emobility Race" (Transport & Environment, January 2021), https://www.transportenvironment.org/publications/car-co2-review-europes-chance-win-e-mobility-race.

10 Nic Lutsey, Modernizing Vehicle Regulations for Electrification (ICCT: Washington, DC, October 21, 2018), https://theicct.org/publications/modernizing-regulations-electrification.

11 Zhinan Chen and Hui He, The Second Phase of China's New Energy Vehicle Mandate Policy for Passenger Cars (ICCT: Washington, DC, May 4, 2021), https://theicct.org/publications/china-new-energy-vehicle-mandate-phase2-may2021.

12 Government of Canada, "New Motor Vehicle Registrations," Statistics Canada, May 26, 2021, https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2010002101.

Table 1. Key characteristics of ZEV standards in place in 2021

Jurisdiction	Credit function	Time period	Credits per vehicle	Credit share 2025	Banking	Credit trading market
California plus 12 other U.S. states	Range	2012–2025	Up to 4	22%	X	X
Québec	Range	2019–2024	Up to 4	22%	X	X
British Columbia	Range	2020–2040	Up to 4	22%		X
China	Range, weight, efficiency	2018–2025	1–6	20%		X

First adopted in 1990, California ramped up the world's first ZEV program in 2012, and recently directed the state's regulatory agency to develop a regulation reaching 100% passenger ZEV sales in 2035, on top of its goal of 5 million cumulative ZEVs by 2030. California has recently adopted or is developing numerous new regulations to accelerate its ZEV transition, summarized in Table 2 according to the vehicle segments targeted, the status, and the key objectives. The regulations and supporting policies, including infrastructure, incentives, and economic development, are coordinated through the California Zero-Emission Vehicle Market Development Strategy released by the Governor's Office of Business and Economic Development.[13]

Table 2. Recently adopted or in-progress regulations to promote ZEVs in California

Policy	Regulated entities	Status	Key objectives
Innovative Clean Transit	Transit bus operators	Adopted in December 2018	• All new bus purchases ZEV by 2029, 100% zero-emission transit bus fleet by 2040 • Low NOx engines required on all new buses
Advanced Clean Trucks	Medium- and heavy-duty truck manufacturers	Adopted in June 2020	• 2035 ZEV sales targets: 25% for Class 2b–3, 75% Class 4–8 straight, 40% tractors
Clean Miles Standard	Transportation network companies (e.g., ride-hailing)	Adopted in May 2021	• 90% eVMT in 2030 (with intermediate targets) • 50% reduction in g CO2/PMT by 2026, 100% reduction by 2030, incentives for active transport and transit
Advanced Clean Fleets	Public and private heavy-duty truck fleets	Scheduled to be adopted by end of 2021	• Public fleets: 50% new trucks ZEVs 2024–2026, 100% 2027 onward • Drayage trucks: New trucks ZEVs by 2023, 100% trucks in use ZEVs by 2035 • ZEV phase-in requirements for large fleets; 100% in 2035–2042 • 100% heavy-duty ZEV sales by 2040
Advanced Clean Cars II	Passenger car and light truck manufacturers	Draft proposal released, scheduled to be adopted in summer 2022	• 100% light-duty ZEV sales in 2035, 57% in 2030 • Increased strictness on PHEVs • Environmental Justice credits for used ZEVs, deploying ZEVs in community programs

NO_x = nitrogen oxides, eVMT = electric vehicle miles traveled, PMT = passenger miles traveled

13 Go-Biz ZEV Team, "California Zero-Emission Vehicle Market Development Strategy" (California Governor's Office of Business and Economic Development, February 2021), https://business.ca.gov/industries/zero-emission-vehicles/zev-strategy/.

Beyond these binding regulations stemming from high-level targets, California is strengthening its portfolio of policies to ensure improved ZEV affordability, convenience, and awareness, with a particular emphasis on disadvantaged communities. "We've long recognized that California cannot simply set sales and fleet requirements for ZEVs and expect them to be successful. We need additional policies," said Analisa Bevan, zero-emission infrastructure specialist at the California Air Resources Board. More than 20 agencies in California's government have submitted action plans to identify how they can contribute to these targets and what additional policies will be needed. The state's 2021–2022 budget includes $3.9 billion in funding for ZEVs and infrastructure, including incentives; infrastructure for light-, medium- and heavy-duty vehicles; and manufacturing support.[14]

14 State of California, "2021-2022 Enacted Budget Summary," June 28, 2021, http://www.ebudget.ca.gov/budget/2021-22EN/#/BudgetSummary.

SESSION 3: WORKING WITH CITIES TO ACHIEVE ZEV TARGETS

Although national governments are increasingly announcing and strengthening commitments to end the sale of new internal combustion engine (ICE) vehicles, the most ambitious targets around zero-emission vehicles and decarbonization more broadly are at the city level. Figure 2 summarizes the key ZEV targets announced at a city level. As indicated by the squares, many cities are setting 100% targets for not only new sales, but for all vehicles being zero-emission in the city. Target dates for 100% ZEV passenger vehicle stock range from 2025 in Oslo to 2050 in Los Angeles, Tokyo, and New York. The smaller circles indicate cities that have set targets for 100% of new sales, similar to the national-level targets described above, such as San Francisco in 2035. As the map makes clear, city ICE phaseout targets are most developed in Europe, but are also being explored in other markets including the United States and Japan. Not included on the map are the dozens of cities that have announced plans for zero-emission or near-zero-emission zones in smaller parts of cities, many of which are being implemented in the 2021–2025 time frame.[15]

	100% new passenger vehicle sales	100% of passenger vehicle stock
2020-2024	●	■
2025-2029	●	■
2030-2034	●	■
2035-2039	●	■
2040-2050	●	■

Figure 2. Major cities targeting 100% ZEV passenger vehicle sales (circle) and stock (square).

15 Hongyang Cui, Pramoda Gode, and Sandra Wappelhorst, A Global Overview of Zero-Emission Zones in Cities and Their Development Progress (ICCT: Washington, DC, 2021), https://theicct.org/publications/global-cities-zez-dev-EN-aug21.

Cities are motivated to show leadership on ZEVs to fulfill ambitious climate pledges as well as mitigate air pollution and associated health impacts. Because cities frequently do not have all of the authority held by national or even state governments, city governments have developed innovative policies to overcome the prevailing barriers of cost, convenience, and awareness alongside regulations to accelerate deployment in key fleets. These commonly include preferential parking and lane access, charging infrastructure support, electric vehicle-ready building codes, fleet regulations, and planning for zero-emission areas. Such policies have helped push cities to the front of the transition to ZEVs: Through the end of 2019, 25 metropolitan areas represented 40% of global electric vehicle sales, and 24 of these exceeded their national averages in electric vehicle sales share.

Seattle Transportation Electrification Blueprint. The city of Seattle, Washington, offers a case study of the constraints that cities face. Seattle has goals of reducing transportation emissions 83% by 2030 and being carbon neutral by 2050. To accomplish these goals, Seattle is heavily focusing on transportation electrification to leverage its clean and inexpensive electricity supply, as outlined in *Seattle's Clean Transportation Electrification Blueprint*.[16] According to Andrea Pratt, Seattle's climate and transportation policy advisor, "Shifting our transportation system off of dirty fossil fuels is critical not only to climate, but also to public health. We have a lot of work to do, but we have a path to get there." In its *Blueprint*, Seattle lays out several targets for 2030, each reflecting an area of the city's authority: 100% of shared mobility electric; 90% of personal trips zero-emission (including active transport, electrified public transport, and ZEVs); 30% of goods delivery zero-emission; 100% of the city's fleet fossil-free (zero-emission or biofuels); and implementing one or more zero-emission zones. Although Seattle has set an aspirational goal of 30% of light-duty vehicles in Seattle being electric by 2030, the city has not set a target for 100% of new vehicle sales or of the vehicle stock to be ZEVs by a particular date, recognizing that these are ultimately outside of city authority. The city's *Blueprint* also discusses how complementary measures can ensure that electric vehicles also improve equity within Seattle; for example, future job training programs around ZEV maintenance and infrastructure will be directed toward underserved neighborhoods and populations.

A primary challenge Seattle faces is that vehicle emission standards and vehicle registration policies are the responsibility of national and state governments, and cities do not have the authority to enact policies like ZEV regulations. Therefore, in addition to enacting a suite of policies and incentives to make the transition smoother, the city encourages Washington State and the U.S. federal government to enact stronger climate policies and provide Seattle with greater city-level authority to implement zero-emission zones. "At the end of the day, we do need state and federal help. Seattle is eager to work with our federal partners to advance some of these goals," said Pratt. In the discussion, national 100% ZEV targets, ZEV regulations for light-duty and heavy-duty vehicles, fleet purchasing requirements, more stringent CO_2 standards, and low-carbon fuel standards were cited as national-level policies that could help cities meet their goals.

Los Angeles's three-pillar approach. Los Angeles, California, the largest metropolitan-level ZEV market in the world outside of China, has similarly crafted a comprehensive

16 City of Seattle Office of Sustainability & Environment, "Transportation Electrification Blueprint" (City of Seattle, March 2021), https://www.seattle.gov/environment/climate-change/transportation-electrification.

ZEV strategy working around thorny issues of authority. Los Angeles has set goals for the share of vehicles on the road that are ZEVs: 25% in 2025, 80% in 2035, and 100% in 2050. However, these are targets over which Los Angeles does not have explicit regulatory control. The city has also set specific sectoral targets in areas where it may have leverage: 100% zero-emission taxis and school buses in 2028 and 100% of urban deliveries zero-emission by 2035 (to be enforced through curb use regulations).

For the broader private vehicle stock, "We have a little less stick and a little more carrot in our toolbox," said Michael Samulon, director of vehicle electrification and city projects at the Los Angeles Mayor's Office of Sustainability. Los Angeles has organized its efforts into three main approaches, as summarized in Figure 3: leading by example, policy development, and stakeholder engagement. For each area, the figure shows two subcategories, further broken down into specific policies and actions. Together, these represent a comprehensive suite of policies undertaken to tackle barriers of cost, convenience, and public awareness within the limits of city authority.

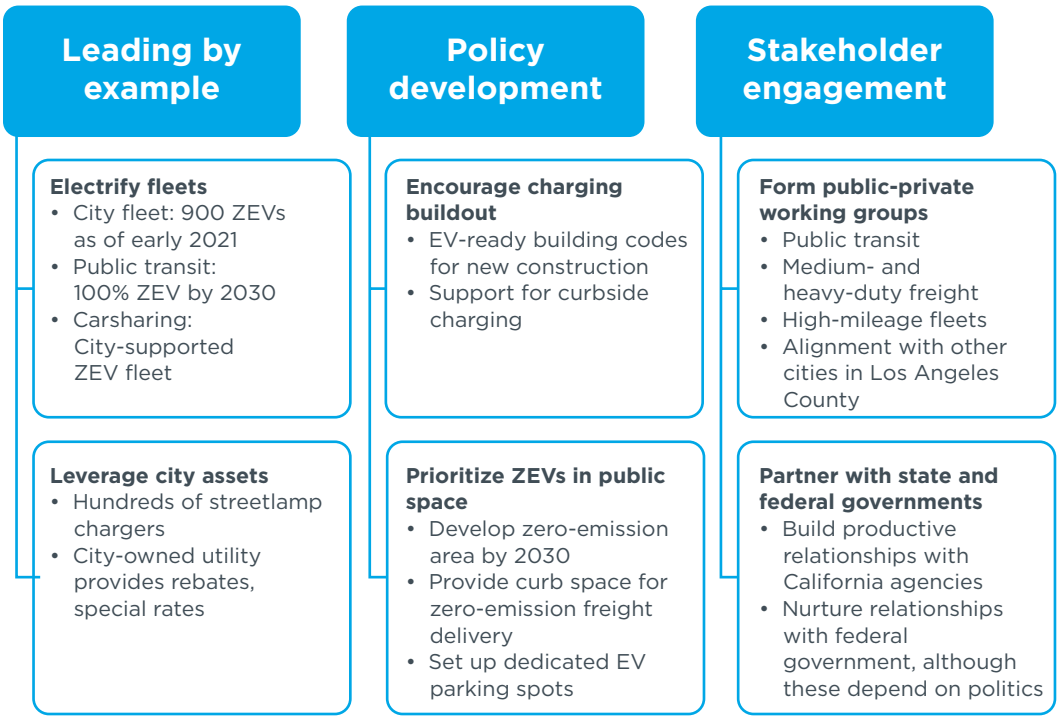

Figure 3. Summary of the Los Angeles city ZEV strategy.

Multilevel collaboration in the Netherlands. In contrast to the challenges identified by Seattle and Los Angeles, the Netherlands offers a framework for collaboration among city and national governments for mutual benefit. This collaboration has been facilitated through Green Deals, agreements among the national government, local governments, and companies to overcome specific barriers and implement innovative projects that promote sustainability and economic growth. Green Deals related to zero-emission mobility in cities include electric carsharing, taxis and special purpose vehicles, zero-emission urban logistics, construction logistics, and inland shipping. The vision for zero-emission mobility in cities, and the support measures from the national

government, were summarized in the national Climate Agreement of 2019, which was created in partnership with more than 100 businesses and knowledge institutions.[17]

The Netherlands was the first country in the world to give cities the freedom to implement zero-emission zones. Between 30 and 40 cities in the Netherlands, including the country's largest cities of Amsterdam, Rotterdam, the Hague, and Utrecht, have committed to adopting zero-emission zones for freight vehicles. In these zones, all new freight and commercial vehicles registered in the zones must be zero-emission beginning in 2025, and all freight vehicles accessing the zones must be zero-emission no later than 2030. To ease this process for cities, the national government created a harmonized framework including vehicle eligibility criteria, reporting, signage, etc.; provides a team of experts to answer research questions; and facilitates knowledge sharing among the cities and international organizations.[18] However, there is still room for customization to reflect local conditions. For example, Amsterdam has integrated the zero-emission freight zone into a broader stepwise plan to phase out all combustion vehicles.[19] By 2030, these zero-emission zones are projected to reduce CO_2 emissions by one million tons, or 15% of the national transport sector reduction target, illustrating how empowering and supporting cities can help national governments to meet climate targets.

17 Government of the Netherlands, "Climate Agreement" (The Hague, June 28, 2019), https://www.government.nl/documents/reports/2019/06/28/climate-agreement.

18 "Zero-Emission Zones: Don't Wait to Start with Freight" (Transportation Decarbonization Alliance, C40, and POLIS, December 3, 2020), https://www.polisnetwork.eu/wp-content/uploads/2020/12/ZEZ-F_How-to-Guide_low.pdf.

19 Hongyang Cui, Pramoda Gode, and Sandra Wappelhorst, A Global Overview of Zero-Emission Zones in Cities and Their Development Progress (ICCT: Washington, D.C., August 30, 2021), https://theicct.org/publications/global-cities-zez-dev-EN-aug21.

SESSION 4: FINANCIAL AND ECONOMIC CONSIDERATIONS FOR THE ZEV TRANSITION

The transition to ZEVs will have significant long-term benefits for health, the climate, and the economy. According to a 2020 white paper conducted for the ZEV Alliance, cumulative benefits of ZEVs through 2050 will outweigh the costs by a factor of 11; for the United States, this could mean annual benefits of $17 billion, with cumulative net benefits approaching $240 billion by 2050.[20] However, particularly in the early stages of the transition, there are significant costs. For governments, this includes financial incentives, foregone taxes, investments in charging infrastructure, and the cost of awareness activities. In the private sector, auto manufacturers, suppliers, and repair companies must pivot to offering new vehicles, requiring investments and potentially challenging traditional business models. Leading governments are implementing innovative solutions to reduce costs, both to the government and the private sector, and to maximize the benefits of the ZEV transition.

ZEV incentives as climate policy in Norway. Norway has had the most success in shifting to ZEVs in large part by offering generous taxation benefits to ZEVs, including exemption from VAT since 2001.[21] These incentives enabled electric vehicles to be equivalent in total cost of ownership for many segments in 2020. The government expects electric vehicles will be less costly for the average car owner by 2022, and for most truck operators around 2025.

These policies have been guided by a comprehensive assessment of the least costly options for reducing greenhouse gas emissions. Norway's modeling shows that electric vehicles require a moderate cost of abatement, which is shown in Figure 4. The figure shows the average abatement costs for passenger cars in blue, light vans in red, and trucks in purple. These values represent the additional cost per electric vehicle over the vehicle's life (without including any taxation benefits) divided by the CO_2 savings over the vehicle life. Values below zero indicate that the vehicles bring economic benefits to society even without considering the climate and air quality benefits.

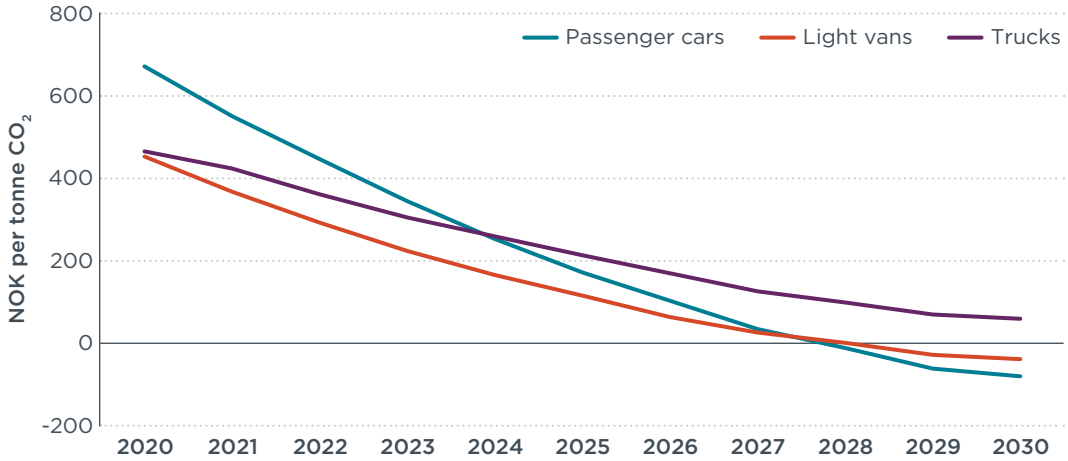

Figure 4. CO_2 abatement costs for electric vehicles in Norway.

20 Peter Slowik, Dale Hall, Mic Lutsey, Michael Nicholas, and Sandra Wappelhorst, Funding the Transition to All Zero-Emission Vehicles (ICCT: Washington, DC, 2019), https://theicct.org/publications/funding-ZEV-transition.

21 "Norwegian EV policy," Norsk elbilforening, 2021, https://elbil.no/english/norwegian-ev-policy/.

The average costs over the 2020–2030 period generally range between $100 per tonne and $200 per tonne for cars, light vans, and trucks. These are considered moderate-cost measures under the Norwegian government's framework. The costs become negative (i.e., offer CO_2 reductions and cost savings) when electric cars and vans reach upfront cost parity around 2027, while also continuing to offer ongoing fuel savings.[22] Although trucks face a greater upfront price premium than cars, the abatement cost is lower in the near term (through 2024) because of the greater fuel savings, and greater emissions reduction, for each truck.

Engagement with industry in Germany. Beyond taxation decisions, however, the shift to ZEVs can also have broader economic and even cultural impacts, particularly in regions where combustion engine vehicles are responsible for many jobs. There are few places where this more true than in Germany, where the diesel engine was invented and around 800,000 people work in the automotive industry. "For Germany, the auto sector is very important in terms of jobs, economic output, and innovation, and therefore it also has a high political importance," said Dr. Fabian Joas, policy advisor for the German Ministry of Finance.

Germany has set a target of a net-zero emission transport sector by 2045. To help meet this target, the government is providing substantial support both to individuals and industry. On the demand side, the government provides a subsidy of up to €6,000 for a new private or company car, which is matched by €3,000 from the vehicle manufacturer. The government is also supporting growth of the charging ecosystem by providing €900 for private chargers, funding fast charging via a tender for the "Deutschlandnetz," and setting standards (e.g., for payment) to improve competition and user experience. In 2020 the German government committed to spend more than €10 billion over the next years to support the ZEV transition and digitalization.

On the industry side, the government is focusing on the specific regions where the auto industry (including vehicle manufacturers as well as suppliers) is located. "In order to manage this transition without major job losses, key players in the auto regions – trade unions, municipalities, companies, and research institutions – come together and develop a strategy based around what they're good at and what this highly trained workforce could do in this new world where electric and fully digitalized cars play the biggest role," Joas said. The federal government assists in retraining programs for workers and also funds research, development, and implementation to ensure that its auto industry remains competitive and also to improve the sustainability of ZEVs in areas such as battery manufacturing and recycling.

Leveraging hydropower and generating new opportunities in Québec. For regions without a deep history of automotive manufacturing, ZEVs present an opportunity to create jobs in a new, fast-growing sector. The province of Québec, Canada, views electric vehicles as both an environmental and industrial policy opportunity, leveraging the province's robust supply of clean hydropower generated by the public utility Hydro-Québec. Imported oil is responsible for 50% of Québec's greenhouse gas emissions and costs $8.5 billion (US$6.8 billion) annually.[23] Switching energy demand, primarily in the transport sector, from oil to electricity will result in emission reductions

22 Miljødirektoratet, "Klimakur 2030: Tiltak og Virkemidler mot 2030" (Government of Norway, February 3, 2030), https://www.miljodirektoratet.no/ansvarsomrader/klima/klimatiltak/klimakur/.

23 Québec government, "2030 Plan for a Green Economy," March 11, 2021, https://www.quebec.ca/en/government/policies-orientations/plan-green-economy/.

as well as significant cost savings and more growth in its local electricity industry. As such, Québec has announced that it would prohibit the sale of new ICE vehicles starting from 2035, thus aiming for 100% ZEV sales by this date.

In addition to its renewable energy production, Québec is home to a diverse and growing electric mobility sector focusing on five key areas: commercial and specialty vehicle companies; raw materials; enabling digital technologies; research laboratories; and storage and charging. The province has encouraged this industry through the "mobilizing projects" approach, in which the government invites companies and research organizations to collaborate to develop a specific technology to the precommercialization stage. These projects have resulted in local companies developing electric buses, delivery trucks, and automated agricultural equipment. The government also focuses on battery production, battery recycling, and zero-emission aerospace.

The growth of electricity sales and the electric mobility industry in Québec begins with local demand. To spur sales within the province, Québec has comprehensive policies to address all barriers to electric vehicle uptake. To increase the supply of vehicle models, Québec implemented a ZEV standard in 2018, the second such standard in the world following California. The province offers incentives of up to $8,000 (US$6,400) for the purchase of a new vehicle, which is is in addition to the federal government incentive of up to $5,000 (US$4,000), and also offers support for purchasing medium- and heavy-duty vehicles. Hydro-Québec has built an extensive public charging network, the Electric Circuit, and the province subsidizes private home and workplace charging. Finally, the province supports a comprehensive consumer awareness program, Running Electric, led by the nonprofit organization Équiterre. These measures have led to Québec having the most electric vehicle sales of any Canadian province and an electric sales share almost twice the national average (6.8% vs 3.4%).[24]

24 StatisticsCanada, "Vehicle Registrations, by Type of Vehicle," Statistics Canada, 2021, https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2010002101.

CONCLUSIONS

To meet climate, air quality, and industrial policy goals, governments are increasingly setting targets to reach 100% ZEVs. However, significant uncertainties remain about how the transition will unfold, including how to ensure these targets are met, how governments at different levels can support each other, and how to maximize economic benefits of ZEVs while keeping government outlays in check. This workshop series for government officials investigated these questions, learning from the experiences of the ZEV Alliance governments and other ZEV leaders. The discussions are distilled and summarized in the following key takeaways:

100% ZEV targets are accelerating, reflecting climate urgency and technical feasibility. At least 15 national governments, as well as the European Commission and numerous U.S. states and Canadian provinces, have set targets for the full phaseout of combustion engine vehicle sales. Some national governments, including Canada and the United Kingdom, have advanced their targets in light of promising market and technology developments and increased urgency to reduce emissions. For Norway, setting the world's earliest 100% goal for 2025 was initially seen as aspirational and uncertain, but has since spurred greater ZEV sales and has served as an important planning target for government, industry, and the public. As more governments set 100% ZEV targets and work together on supporting policies, the transition will continue to accelerate.

Vehicle CO_2 and direct ZEV regulations are critical tools for making targets a reality. The early ZEV market has grown in large part due to vehicle CO_2 standards, present in every major market, and ZEV regulations, present in California, China, British Columbia, and Québec; jurisdictions with strong standards consistently outperform other markets. Strengthened regulations will be similarly crucial for ensuring that the market moves toward 100%, although different regulatory designs may be needed in the late stages of the transition, with more restrictions on use of flexibilities and the inclusion of plug-in hybrids. California offers a blueprint for a long-term transition, with regulations adopted or in development to achieve a full transition to ZEVs for light-duty vehicles, medium- and heavy-duty vehicles, large commercial fleets, transit agencies, and transportation network companies.

Cities have strong ZEV ambitions and innovative policies but would gain from national support. At least a dozen major cities have set targets for fully transitioning to ZEVs, with many, like Oslo, Paris, and San Francisco, setting targets ahead of national or state counterparts. However, the scope of authority varies widely across cities, and most lack the funding or authority to regulate vehicle sales or support a full transition to combustion vehicles. For example, Seattle is concentrating on shared mobility and the city fleet, with an emphasis on disadvantaged communities. Similarly, Los Angeles is also focusing on city assets like the city fleet, transit, and charging supported by the public utility, as well as goods delivery and partnerships with private fleets. Cities also must rely on national vehicle regulations to ensure an increasing supply of ZEV models in far greater volume to reach their goals. The Netherlands exemplifies how a national government can support and empower cities with its project to implement zero-emission zones in 30–40 cities by 2030, as well as its Green Deals and other public-private partnerships.

To realize broad long-term benefits, industrial policies will need to be tailored to each market. Beyond climate mitigation and clean air, the ZEV transition brings direct fuel and maintenance benefits, as well as broader economic benefits and new jobs. Tailored industrial policies that are aligned with national and city-level market development policies will help realize these benefits. Germany and other jurisdictions with a strong automotive industry presence can work in partnership with companies, local governments, and trade unions on unique regional transition strategies and retraining programs. Jurisdictions like Québec are showing the value of integrating their ZEV growth with local low-carbon electricity. Other jurisdictions can similarly use public-private partnerships to support the growing ecosystem of ZEV component suppliers, specialty vehicle manufacturers, and raw material providers. ZEV manufacturing and industry typically locate in areas where ZEV demand is strong, so market support actions also help to realize these accompanying economic benefits.

APPENDIX

The following speakers shared their expertise during the four sessions of the government-only interactive discussion series. This report would not have been possible without their knowledge and help.

Table A1. Speakers and schedule of interactive discussion sessions

Session focus	Date	Speakers and affiliations
The state of 100% ZEV targets globally	April 21, 2021	• Sigve Aasebø, senior advisor, Norwegian Public Roads Administration • Andrea Pratt, climate and transportation policy advisor, City of Seattle, Office of Sustainability & Environment • Stephanie Edwards, head of sector strategy for international climate change, U.K. Department for Business, Energy, and Industrial Strategy
Regulations to ensure the ZEV transition	May 5, 2021	• Analisa Bevan, zero emission infrastructure specialist, California Air Resources Board • Julia Poliscanova, senior director, vehicles and e-mobility, Transport & Environment
Working with cities to achieve ZEV targets	May 19, 2021	• Rosemarie Cramer, advisor international sustainable logistics, Netherlands Ministry of Infrastructure and Water Management • Gerben Passier, senior advisor sustainable mobility, Netherlands Ministry of Infrastructure and Water Management • Michael Samulon, director of vehicle electrification and city projects, Los Angeles Mayor's Office of Sustainability
Financial and economic considerations for the ZEV transition	June 2, 2021	• Christine Maass, senior advisor, Section for Transport and Air Quality, Norwegian Environment Agency • Dr. Fabian Joas, policy advisor, German Ministry for Finance • Mathieu Ferland, director of transportation and sustainable mobility, Québec Ministry of Economy and Innovation