POLICY CONSIDERATIONS FOR TRANSITIONING TO ZERO EMISSION TECHNOLOGIES TO ACHIEVE IPCC GHG REDUCTION TARGETS IN TRANSPORT SECTOR

By

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Elders Climate Action for U.S. Climate Action

Objective: Preventing More Serious Climate Disasters and Avoiding A Runaway Climate Crisis Beyond Human Intervention.

The National Academy of Sciences (August 2018) issued strong warnings that swift action is needed to avoid a runaway climate crisis that will be beyond human intervention if irreversible tipping points are crossed, including among others 1) the release of methane from frozen tundra as the permafrost thaws, 2) uncontrollable firestorms that convert carbon stored in forests into CO2, and 3) the end of carbon sequestration as carbonate in the marine web of life from ocean acidification.

The latest IPCC report (October 2018) explains that net zero emissions of CO2 must be achieved by 2050, with half of those reductions by 2030, to avoid the more severe climate consequences that will occur if global temperature rises 1.5 C above pre-industrial levels.

The U.S. National Climate Assessment (December 2018) warns that damages and injuries caused by climate disasters will likely cost the U.S. economy $500 billion annually as damaging storms become more frequent and the magnitude of flooding, droughts and firestorms increase, and coastal inundation destroys the productive use of land as sea levels continue to rise.

Transport Emits 35% of U.S. GHG Emissions; Future Emissions Expected to Grow.

The IPCC emission targets cannot be reached without eliminating the use of petroleum fuels in the transport sector. International Energy Agency (IEA) data show that petroleum fuels account for nearly half of global GHG emissions, and that 60% of GHG emissions from petroleum fuels are emitted from powering the transport sector.[1] The International Transportation Outlook published by the Organization for Economic Development estimates that

> CO2 emissions from transport could increase 60% by 2050, despite the significant technology progress assumed in the Outlook's baseline scenario. If no additional measures are taken, CO2 emissions from global freight could increase by 160%, passenger air traffic could grow between 3% and 6% annually, [and] [m]otorised

[1] Global crude oil production is approaching 100 million barrels/day (mm bbl/d). Approximately half (50 mm bbl/d) is refined into fuels combusted to power on-road vehicles, trains, ships and aircraft to transport people and goods; 35% (35 mm bbl/d) is combusted to provide energy for industry and commercial/residential space heating; 15% is not used as a fuel but as feedstock for chemicals and plastics, or as lubricants. Fifty million of every 85 million barrels of crude burned every day (60%) is used to power transport.

mobility in cities is set to double between 2015 and 2050, rising 41% to 2030 and 94% by 2050 in the Outlook's baseline scenario."[2]

This magnitude of economic development cannot be accommodated within the climate system unless GHG emissions from transport are eliminated.

In the U.S. the Energy Information Administration (EIA) reports that 92% of the energy used to power transport is obtained from petroleum fuels. The remaining 8% is obtained from natural gas, ethanol, hydrogen and electricity. With the decommissioning of some coal plants and annual growth in petroleum fuel use by on-road vehicles and aviation, transportation has become the largest source of U.S. GHG emissions (35.9%).[3]

Light duty gasoline vehicles account for the largest share of GHG emissions from the transport sector.[4] The US currently has about 275,000,000 light duty vehicles. US policies governing the production and sale of motor vehicles will directly affect sales in Canada and Mexico. Together N. America accounts for roughly 25% of the 1.3 billion global light duty vehicle fleet.

New vehicle sales in the US have recently averaged 16 million units annually, with 2018 sales peaking at 17.5 mm units. Of this total, zero emission vehicles (ZEVs) accounted for 1% of sales prior to 2018, and reached 2% during 2018. In 2018 17.2 million new internal combustion engines (ICEs) were added to the US fleet, and 0.3 million ZEVs. Unless the ZEV market share rapidly changes, over the next 10 years the U.S. will add about 175 million new vehicles, only 3 million of which will be zero emitting. When replacement rates and scrappage are accounted for, the total U.S. fleet of ICEs will increase to roughly 300 million vehicles by 2030. Since 2011, emissions from the transport sector have increased 2-3% annually and are expected to continue to grow at this rate despite federal standards requiring improved fuel efficiency for petroleum fueled vehicles.

Assuming annual new vehicle sales continue at 16 to 17 million between 2030 and 2050, then 320-340 million new vehicles will be produced during these two decades. Currently, 90% of each model year are replaced within 15 years. Assuming this replacement rate remains constant, and growth in the vehicle fleet associated with population growth is taken into account, this production rate will be barely enough to allow the U.S. 2030 fleet of 300 million ICEs in to be replaced by 2050. To achieve the IPCC 2050 target of net zero emissions from the transport sector without using mandates to shift market trends and traditional consumer behavior, all new vehicles must be ZEVs no later than 2030 if every owner of an ICE in 2030 willingly parts with their vehicle by 2050. If ICEs are any significant share of new vehicles sold after 2030, zero

[2] International Transport Forum, Transport Outlook (OECD 2017), available at: https://www.oecd-ilibrary.org/docserver/e979b24d-en.pdf?expires=1548796341&id=id&accname=guest&checksum=1C79106261143806F5CBDFC76FC2574B.

[3] EIA Monthly Energy Report (Jan. 2019). CO2 emissions from transportation fuels (1,842 million metric tons) as share of total U.S. CO2 emissions (5,131 million metric tons) in 2017 (full year 2018 data not available).

[4] EIA data show gasoline vehicles account for roughly 4/7 (58%) of total CO2 emissions from transport in the US, diesel fueled transport emits 2/7 (28%), and aviation fuels emit 1/7 (14%). Gasoline powers most light duty vehicles. Diesel and bunker fuels are burned in medium and heavy duty trucks, railroad locomotives and marine transport.

emissions by 2050 is not feasible by relying upon replacement rates that are achieved by the planned obsolescence of new vehicles produced today.

To achieve any significant reduction in CO2 emissions before 2030, the market share of ZEV sales must be greater than 50% of total sales (i.e., more ZEVs sold than ICES) as soon as possible. The IPCC's 2030 deadline for cutting CO2 emissions by half from on-road vehicles could only be achieved by requiring at least half of new vehicles to achieve zero emissions beginning in 2026, or by limiting the operation of existing ICE vehicles rather than waiting for normal market trends to achieve their ultimate replacement with ZEVs.

Strategies for Eliminating On-Road CO2 Emissions.

The IPCC targets for preventing a major climate crisis demands that we end the use of fossil fuels in all economic sectors, including transportation. Technological developments during the last decade have produced commercially available zero emission technologies that make possible the accelerated replacement of fossil fueled (FF) ICEs throughout the transport sector. Electric and hydrogen powered vehicles emit no GHGs from the vehicle. Zero emissions are achieved if the electricity or hydrogen are generated using renewable sources of energy.

The recent development of battery technologies has resulted in commercially available vehicles powered by zero emission electric motors. Battery powered vehicles are commercially available as sedans, SUVs, vans, transit and school buses, passenger and freight rail. New electric pick-up truck and 18 wheeler models were commercially introduced in 2018 and Tesla will release a long-haul truck by 2020. Hydrogen fuel-cell vehicles are also in use in California, Europe and Asia. Technology forcing to develop zero emission power sources may be necessary for other transport modes, including marine transport and aviation.

To date only Norway has adopted policies designed to eliminate petroleum fuels for powering on-road vehicles. In 2018 Norway achieved an important benchmark: more battery EVs were sold than ICEs and hybrid EVs combined. China and California officially recognize the need to transform transport to zero emission technologies, but neither has yet adopted policies to achieve this result. In 2018 China adopted a new policy designed to achieve 4% market share for ZEVs by 2020. Reported actual EV sales reached 7%. California's current ZEV mandate requires manufacturers to achieve 3% of sales.[5] CARB reports that ZEVs and EV hybrids were roughly 10% of 2018 sales.

The approach taken by the US in the 2011 Obama fuel efficiency standards will not even come close to achieving zero emissions in the on-road transport sector. Reducing per mile fuel consumption in internal combustion engines (ICEs) is a dead end for the planet because global

[5] The California rule is being attacked by the Trump EPA which has proposed to abandon the Obama fuel efficiency standards for the 2022-2025 model years. To implement an agreement with automakers who sought a uniform national standard, federal fuel efficiency and CO2 emission standards match the California standards except for California's ZEV mandate. Eight other states have adopted the California ZEV mandate. Together they represent about 30% of the U.S. vehicle market. The proposed rollback by the Trump EPA would create less protective standards. To eliminate the possibility of two sets of standards, the Trump EPA has proposed to withdraw California's authority under the Clean Air Act to set more protective standards.

emissions will continue to grow as more people acquire more petroleum fueled vehicles and efficiency gains are overwhelmed by increased vehicle miles travelled. Fuel efficiency standards now in effect through the 2025 model year have slowed the growth in petroleum fuel consumption, but have not reversed the growth trend. The most rigorous limits on CO2 emissions must be retained until a new zero emission standard is adopted. But fuel efficiency standards for ICEs must be a transition to a transport system built on ZEV technologies to achieve the IPCC zero emission target. No matter how efficient petrol fueled vehicles become, burning oil is not a strategy for reducing CO2 emissions to zero.

Public Policies Needed to Achieve Net Zero Emissions by 2050.

Norway is modeling for the world how a successful transition from fossil fuels can be accomplished. The centerpiece of their policy is a ban on the sale of new ICEs beginning in 2025. This is the most aggressive national policy of its kind in the world. Norway has backed up this deadline with strong economic incentives and operational policies (i.e., preferred access to HOV lanes, reserved parking, free public charging stations, and ICE exclusion zones) to encourage current new car purchases of EVs, and an extensive investment in creating charging networks to ensure access to charging stations wherever needed to overcome public resistance linked to range anxiety. These policies achieved 50% market penetration for EVs in 2018 which far exceeds any other nation. By comparison, 2018 EV sales reached 2% in the US, and 7% in China.

The U.S. must enact a zero emission standard for new vehicles to ensure that full conversion to zero CO2 emissions will be achieved by 2050. The average replacement rate for each model year is roughly 90% in 15 years. With an estimated 300 million on-road ICE vehicles in 2030 that must be replaced with ZEVs by 2050, petroleum fuel use can be phased out by relying on traditional replacement rates only if new ICE vehicles are not available after 2030.

A deadline for meeting a zero emission standard will establish a level playing field for all manufacturers to make the conversion, provide strong incentives for the industry to achieve economies of scale that have yet to be achieved in the production of EVs, and to reduce prices as quickly as possible to remain competitive.

Capital costs of new EVs are dropping rapidly as advances in battery technology reduce their cost and weight. Bloomberg estimates battery EVs will achieve costs comparable to new ICEs by 2023-25; California ARB staff estimates comparable costs by 2030. Tesla has shown the way with its new Model 3 priced under $40,000. Sales exploded since the first units became available in September 2018. December sales topped 25,000 units which is 400,000 annually, compared to a few thousand sold by all EV manufacturers in December 2017. Tesla is now on the path to joining the ranks of the major manufacturers and is challenging their market dominance. GM announced in December it is closing plants to facilitate a broad conversion to ZEV technologies. Nissan is committed to ramping up its production of EVs in the US. Ford joined VW in announcing a partnership to develop advanced ZEV technologies. But not all manufacturers are committed to developing ZEV technologies to compete for the still small ZEV market.

Despite these automaker initiatives, all major producers have been reluctant to make the large investment required to convert full production to ZEVs. In public forums Toyota, Chrysler, Ford and VW have all explained that they are reluctant to plan for complete conversion because they are not assured that the market will reward their investment. They need assurance that the market will support their investment. A statutory deadline for meeting a zero emission standard will put all automakers on the same footing, and guarantee a market for ZEVs.

Setting a deadline is also essential for achieving equity benefits and other policy goals. The industry will not achieve economies of scale in the production of ZEVs until ZEVs become the primary, or exclusive, source of sales and revenues. Currently ZEVs are produced to meet regulatory minima under the California ZEV mandate, or to serve a specialty market segment. As long as ZEVs remain a minimal segment of the market, automakers have no incentive to achieve economies of scale in production, reduce prices, or devote marketing budgets to promote ZEV sales. A future deadline to meet a zero emission standard will shift the marketing strategy and production cost planning of every manufacturer. At that point, the cost premium for purchasing a new ZEV compared to an ICE will disappear, and the equity equation will shift in favor of ZEVs for all prospective buyers.

China has become the world's largest auto market with sales exceeding 25 million units annually. The nation that first achieves ZEV cost reductions from economies of scale will have a substantial market advantage for possibly a decade or more. U.S. manufacturers risk losing global market share to Chinese automakers if U.S. producers fail to achieve leadership in lowering the cost of ZEVs below the cost of ICEs.

The need for lead time for the industry to convert production will be greater than in Norway which is an importer rather than a vehicle producer. The U.S. is home to production facilities for seven major auto manufacturers (GM, Ford, Chrysler-Fiat, Nissan, Honda, Toyota, BMW) whose businesses and employees are dependent on ICE sales. Norway's 2025 target (4 years from enactment assuming a favorable political environment for legislation after the 2020 election) is not a feasible deadline for the industry to convert 100% of production to EVs or other non-fossil fuel technologies. A 2026 deadline for every manufacturer to achieve partial ZEV sales, and a 2030 deadline for full conversion of U.S. light duty production to ZEVs is likely doable. This timeline would allow the industry eight model years after 2021 to plan, design and re-tool production lines, and four years beginning in 2026 to develop marketing strategies and refine designs.

Whether medium and heavy duty trucks can meet this deadline will depend on the performance of electric or hydrogen fuel cell trucks now becoming commercially available.

A 2030 ZEV deadline will also provide sufficient opportunity for States and local governments to implement land use, zoning and building codes that facilitate and promote the installation of ubiquitous charging networks. Federal transportation funding can be made available as zero-interest loans to support the initial capital investments needed to create charging networks and fueling stations, with repayment derived from future energy sales.

After the US market is closed to ICEs, it is highly likely Canada and Mexico will be forced to follow our lead as contributors to the U.S. market. The EU and China will likely adopt similar policies to ensure that their producers remain competitive in a global market where the cost advantage shifts to ZEV producers who achieve economies of scale.

Legislation Enacting a Zero Emission Standard.

Senator Merkley (OR) introduced a bill amending the Clean Air Act to require that 50% of new vehicles meet a zero emission standard in 2030, with 100% ZEVs by 2040. The Merkley bill would not get us to zero CO2 emissions by 2050. By requiring only half of all vehicles sold beginning in 2030 to be ZEVs, with a 5% annual increase in ZEV sales until zero internal combustion engine (ICE) sales would be allowed in 2040, nearly 80 million ICEs would remain on the road in 2045.

Assuming U.S. vehicle sales remain above 17 mm units annually, by 2030 the U.S. registered vehicle population will approach 300 million. If expected increases in ZEV market demand are achieved, about 20 million of those 300 million (6.5%) will be ZEVs. If the current vehicle replacement rate (90%/ 15 years) continues after 2030 and 100% ZEV sales are required beginning 2030, 28 million 15 year-old or older ICEs will remain on the road in 2045. To achieve zero emissions by 2050, the registration and use of these remaining ICEs will need to be banned and owners may need to be compensated under the Fifth Amendment. But the market value of these vehicles should be minimal since they will be at least 20 years old by 2050. Under the Merkley bill, another 50+ million new ICEs will be sold during the 2030s, with most of them still in use by 2045. Roughly 80 million vehicles, which is 30% of the current US vehicle population, would be ICEs that need to be replaced between 2045 and 2050 instead of 28 million (11% of the current US vehicle population).

In turn total CO2 emissions from U.S. on-road vehicles during the period 2030 – 2045 would be nearly three times greater than if the 2030 ZEV deadline were enacted. Globally total emissions from transport would likely be comparably greater since we cannot expect Asian or European nations to reduce their ICE fleet numbers faster than the U.S. In addition, the Merkley bill contains no program such as a partial ICE ban beginning in 2026, or a cash-for-clunkers program designed to accelerate the voluntary replacement of ICEs during the 2020s before the ICE ban takes effect in 2030.

As a result the Merkley bill will not come close to achieving the IPCC GHG reduction targets for either 2030 or 2050.

Public Policies to Accelerate Transition to ZEVs Before 2030.

The two major obstacles to a market transition to ZEV technologies are 1) the incremental capital cost of purchasing new vehicles, and 2) the lack of ubiquitous access to electricity for re-charging batteries or re-fueling with hydrogen. These barriers can be overcome during the period when automakers are converting the industry to 100% ZEV production.

Providing a Voluntary Consumer Incentive Before 2030.

During some portion of the decade before a 100% zero emission standard would apply, a cost premium for a ZEV will continue to be a barrier to increasing ZEV market share. The current cost premium for new ZEVs will be temporary if a deadline is set for automakers to convert production to 100% ZEVs, but it will remain a significant barrier to consumer interest in purchasing a ZEV for at least the first five years after enactment of a deadline. The cash-for-clunkers program enacted in 2009 provides an example of an effective strategy for accelerating the ZEV market share before 2030 by offering cash rebates equal to or greater than the blue book value of the vehicle to ICE owners who willingly offer an ICE to be scrapped. This program would provide cash to ICE owners to ensure that they are not stuck with a wasting asset in the unlikely event that the used car market for ICEs declines, and provide cash to offset the initial price premium for the purchase of a ZEV replacement vehicle or to pay for transit as an alternative to vehicle ownership.

Assuring Convenient Access to Charging Facilities.

Electric vehicle (EV) and hydrogen fuel-cell (HFC) technologies both require large investments in new vehicles and energy delivery systems to make fuels readily available. A significant barrier to ZEV ownership will be the lack of access to convenient charging at locations where EVs are parked for extended periods. For example, renters in multi-family dwellings (40% of all Americans) rarely have access to power outlets even when they have dedicated parking spaces. Public and private investments will be needed to create ubiquitous charging and fueling networks that serve the convenient operation of EVs and HFCs, including fast-charging stations along long-distance routes and access to nighttime charging for renters and homeowners who lack access to powered garage space.

This barrier can be overcome by enacting building codes that require all new dwelling units to make EV charging available to owners and tenants, and enact tax credits for the owners of existing rental units to install EV charging capacity for tenants.

To accelerate the creation of publicly accessible charging networks, Congress could authorize or require state transportation departments and metropolitan planning organizations to invest federal transportation funds for the initial installation of public charging networks. User concerns arising from range anxiety will be largely eliminated if public access to charging facilities is provided along major travel routes and at public venues such as parks, recreation facilities, hospitals, shopping malls and other destinations where cars are frequently parked for long enough periods to accommodate a charge. Federal funds could be treated as investment capital to be repaid from energy sales over the life of the charging facility. Those funds would then be returned to the transportation trust fund for re-investment in future transport facilities and services.

Policies To Achieve Public Health benefits.

Another incentive to encourage ICE owners to more rapidly replace their vehicle with a ZEV would also provide significant public health benefits if the operation of ICEs were prohibited in ozone nonattainment areas on high pollution days. A similar policy has been adopted by some cities in Europe and Asia where diesel vehicles have been banned from high density urban zones, or during high pollution episodes. Since NOx and VOC emissions from ICEs are the primary

source of urban ozone pollution, this program would protect the 120 million Americans who live in ozone nonattainment areas during the decades when the full conversion of the vehicle fleet to ZEV technologies is occurring.

Costs.

Critics of climate policies and corporate interests with stakes in preserving oil industry profits argue that the costs of converting to zero emission energy systems are extreme, often pointing to the cost of replacing motor vehicles as an example. But these critiques fail to acknowledge that the economic foundation of the existing ICE-based auto industry turns on the replacement of every motor vehicle on the road today. The need to replace existing vehicles is the economic generator for profits and jobs in the industry. Policies calling for the replacement of ICEs with ZEVs will not increase the capital cost of replacement unless 1) the manufacturing cost of a ZEV is higher than the cost of an ICE, or 2) policies are adopted that compel a more rapid replacement rate thereby reducing the remaining useful life of the existing vehicle fleet.

Rapidly dropping battery costs and expected economies of scale from expanded ZEV production suggests that the replacement cost for a ZEV will soon be equal to or less than the cost of a new ICE. As long as ICE owners are not compelled to shorten the useful operating life on their existing ICE, the best estimates of the future cost of a ZEV indicate that the economy will benefit from lower capital replacement costs for each new vehicle rather than be burdened with higher capital costs.

The new cost that will be incurred will be the installation of charging networks and/or hydrogen fueling stations to replace current petroleum fueling stations. Creating these new charging and fueling facilities will require an initial infusion of capital, but those costs should be recovered from the lower cost of energy. The savings that flow from the increased energy efficiency of electric motors compared to ICEs (driving 30% to 50% further using the same energy), and the substantially lower cost of producing comparable units of electrical versus petroleum energy, will provide significant cost savings that will repay the initial investment in fueling infrastructure within a reasonable time horizon.

Economic Benefits.

These investments in stabilizing the climate will require commitments of public and private resources, but the US economy will benefit from –

- Avoiding many of the costs of climate disruption described in the National Climate Assessment.
- Replacing the national vehicle fleet will ensure the economic health of the auto industry and secure employment in well-paying jobs for at least the next three decades.
- Establishing and maintaining a ubiquitous charging network for EVs will create a new domestic employment sector that cannot be displaced by off-shore production.
- Shifting production of energy used in transport from fossil fuels to renewable sources will create millions of new U.S. jobs that will exceed the employment lost in oil fields and coal mines.

- Large energy cost savings in the transport sector by using electricity produced from sun, wind and geothermal sources instead of energy derived from petroleum.
- Avoided health system costs caused by urban smog and soot pollution that will be eliminated when fossil fuels combusted in vehicles no longer contribute to urban air pollution.
- Reduced defense costs from no longer having to control and protect foreign sources of energy since all renewable sources will be domestically produced.
- Improved reliability of energy system employment since renewable sources of energy are permanent, and do not involve boom and bust cycles associated with development and depletion of oil and gas fields.

Environmental Benefits.

Once petroleum fuels are no longer needed for transport, there will be no need for new pipelines, off-shore drilling, drilling in the arctic, or backyard fracking.

Urban ozone pollution caused by emissions from ICEs will end. Nearly 80 million Americans are exposed to elevated ozone pollution that exceeds national air quality standards and contributes to severe adverse health conditions.

The impairment of human health caused by exposing 45 million Americans living near major highways to elevated levels of toxic pollutants (fine particle soot, black carbon, nitrogen oxides, polycyclic aromatic hydrocarbons, benzene, 1,3 butadiene, formaldehyde, naphthalene) emitted from vehicles will end. Investments will not be needed to move schools and dwellings away from highways to protect children from asthma or to provide special assistance for children who suffer impaired educational development because of pollution-initiated asthma.

Endangered species and marine ecosystems will no longer need protection from spills caused by oil and gas field development.

All those adverse impacts on human health and the environment will be gone as soon as we replace the ICEs on the planet with ZEVs. New ZEV technologies make it possible to eliminate transport demand for petroleum (except planes) as soon as ICEs are replaced.

As ICEs are replaced with ZEVs, existing oil fields should meet the residual demand for oil used as chemical feed stocks, plastics and lubricants. When transport demand is removed, no new wells will be needed for decades. Oil will be worth $25/bbl or less, and no new wells will be drilled because the cost of new wells will exceed the value of the product. The environmental threats associated with the oil industry will shrink along with the reduced demand for oil.

Global Security and Political Impacts.

Global energy systems will no longer be dependent on the decisions of a few state actors. Energy production based on renewable sources will become regionalized and dispersed around the globe. The political influence of the dominant oil producing states (Saudi Arabia, Iran, Russia, UAE, and Qatar) will be significantly reduced. Political conflicts in the Middle East will no longer be of global political significance. They will remain important for the people directly

affected, but they will no longer affect the stability of the global or U.S. economy. U.S. energy independence will be assured even after domestic production of fossil fuels is depleted and declines again.

CONCLUSION.

The IPCC warns that anthropogenic emissions of CO2 must be reduced to net zero by 2050, with nearly half of that reduction by 2030, to avoid exceeding the 1.5 C limit on global temperature rise, and to avoid a high risk of crossing irreversible tipping points that will trigger a runaway climate disaster beyond human control. The future of the economy, economic development, human health and human civilization on the planet depend on achieving these emission reduction targets for each sector of anthropogenic emissions.

Given the role of transport in the global economy and its large contribution to global emissions, climate stabilization cannot be achieved without zeroing CO2 emissions from transport. Technologies are now available or will soon be available to achieve net zero emissions in all segments of the transport sector except aviation. Public policies are needed to ensure their deployment. The Policies proposed are designed to achieve the IPCC targets.

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