S.B. 1530 Should be Revised to Achieve the IPCC Goal of Net-Zero GHG Emissions by 2050, and to Include Fuels Used by Large Watercraft and Railroad Locomotives

By

Robert E. Yuhnke

On behalf of Elders Climate Action

Executive Summary.

Senate Bill 1530 is out of step with the advances in the science reported by the International Panel on Climate Change (IPCC) in its 2018 report describing the emission targets that must be achieved to avoid the potentially catastrophic effects of exceeding a 1.5 C increase in global temperature. Those targets are net zero emissions by 2050, with roughly half that reduction by 2030. S.B. 1530 will, at best, achieve a 70% reduction in Oregon's emissions, and come nowhere close to a 50% reduction by 2030.

The consequences of ineffective actions can be observed now in Australia where continental temperatures have already increased by 1.5 C. The ensuing extended drought, desiccation of the forests, diminished productivity of grazing lands and massive uncontrollable fire storms have devastated the nation and destabilized the economy. Wildfires have incinerated close to 25,000 square miles of territory (Oregon is 98,466 sq/mi) killed nearly 40 residents this year, destroyed over 2500 homes making nearly 10,000 people homeless, contributed to the loss of 8% of the national dairy herd and 12% of the national sheep flock along with the incineration of an estimated 1 billion wild creatures. Those conditions will be repeated here when we have another dry winter like 2015 and a hot dry summer like 2017.

Elders Climate Action asks that the bill incorporate the latest and best science by setting zero emissions as the target for 2050, and adopting more comprehensive strategies for reducing transportation emissions including measures to accelerate the replacement of fossil fueled internal combustion engines ICEs) with zero emission vehicles (ZEVs), including but not limited to tax strategies and other economic incentives, and access preferences for ZEVs compared to ICEs.

What We Know About How Humans Are Changing the Climate.

Thirty years ago scientists warned that adding CO2 and other heat trapping gases would warm the planet and disrupt the stable climate system that has supported the

development of agriculture and the evolution of human civilization for the last 8000 years.[1] Now changes in the climate system predicted a generation ago are happening: more massive floods, more powerful hurricanes, expanded tornado zones, hotter and longer droughts causing desiccation of crops in the field, die-off of forests, and unstoppable firestorms incinerating both wildlands and urban landscapes, and warming oceans that have bleached nearly one-half of the planet's coral reefs. CO2 is also acidifying the oceans threatening the survival of all shell-dwelling critters, putting the entire marine web of life at risk.

Most of these changes have come much more rapidly with more severe consequences than scientists expected two decades ago. An ice-free Arctic Ocean was not expected for another generation, but it will likely occur this decade. Massive melting of Antarctic glaciers was not expected for a half-century or more, but is happening now. Damage from climate events in the U.S. alone exceeded $300 billion in 2017. The Climate Assessment released by 13 U.S. agencies in December 2018 reports that damages from climate disasters will soon routinely exceed $500 billion annually, contributing to a significant contraction in the national economy.

Many of these effects were not expected to occur until after the global temperature had warmed at least 2 degrees (C) above pre-industrial levels, but climate disasters are happening even though the global average has climbed only 1.1 C. Heeding warnings that allowing the planet to warm 2 C might result in crossing irreversible tipping points that will cause a run-away climate catastrophe beyond human intervention, global leaders meeting in the 2015 Paris Conference asked the International Panel on Climate Change (IPCC) to determine what must be done to limit climate change to 1.5 C.

What Must Be Done to Stop a Run-away Climate Catastrophe?

IPCC reported in October 2018 that because no notable progress has been made in reducing global greenhouse gas emissions, it might be too late to avoid exceeding 1.5 C. But if some of the unknowns work out in our favor, it might be possible to avoid exceeding that limit if –

- CO2 emissions are cut to net zero by 2050;

[1] In 1988 Dr. James Hansen, a NASA scientist focused on planetary climate systems, testified in the first U.S. Senate climate hearing to warn of the potentially disastrous climate effects of adding greenhouse gases to Earth's atmosphere.

- CO2 emissions are cut in half by 2030, *AND*
- a large portion of the land surface that once was forested, but is currently dedicated to pasture for raising beef and other domestic animals, must be reforested to grow the planet's capacity to remove CO2 from the atmosphere.

To achieve these emission targets, almost all energy uses that rely on the combustion of sequestered carbon (fossil and biomass) must be stopped or converted to zero emission technologies by 2050. Half of those reductions must be achieved within the next 11 years to avoid the total atmospheric loadings that will drive temperatures above the 1.5 C target over the next 1000 years while we wait for forests and phytoplankton in the oceans to restore stability to the climate by extracting CO2 from the air.

We Must Achieve Zero GHG Emissions from Transport.

Worldwide over 1.3 billion cars, vans, trucks, buses, tens of thousands of aircraft and many thousand ships at sea and railroad locomotives together combust roughly 50 million barrels of the 100 million barrels of petroleum extracted from the Earth *EVERY DAY*.[2] The petroleum burned to provide the motive power to move people and goods accounts for nearly one-quarter of all CO2 emitted daily into the atmosphere. In the U.S. where coal burned to generate electric power was once the largest source of CO2, emissions from power generation has been reduced during the last decade by switching to natural gas, wind and solar. Transport is now the largest source emitting 35% of U.S. CO2 from a sector of the economy where emissions are growing, not declining. The IPCC global emission targets cannot be achieved without reducing transport emissions to net zero by 2050.

Transport Is the Largest source of U.S. and Oregon GHG Emissions.

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

[2] Global crude oil production exceeded 100 million barrels/day (mm bbl/d) for the first time in 2019. *IEA Global Oil Market Report* (Jan. 2020).

transport sector.[3] 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 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.[4]

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

The global trend described by the OECD Transportation Outlook is occurring 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 GHG emissions (35.9%) in the U.S.[5] Since 2011, emissions from the transport sector have increased 2-3% annually and are expected to continue to grow despite the sale of more fuel efficient petroleum fueled vehicles. If this annual increase in emissions from transport continues, emission growth from transport will cancel out all the gains made by decarbonizing the electric power grid.

Replacing Internal Combustion Engines with Zero Emission Vehicles.

The climate crisis demands that the use of fossil fuels in the transport sector must end. This calls for the accelerated replacement of fossil fueled (FF) internal combustion engines (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

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[3] 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 burned every day (60%) is used to power transport.

[4] 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.

[5] 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).

global and U.S. trend of increasing emissions from transport need not be our destiny.

To date only Norway has adopted policies designed to eliminate petroleum fuels for powering on-road vehicles. China and California recognize the need to transform transport to zero emission technologies, but neither has yet adopted policies to achieve this result. The approach taken by the US in the 2011 Obama fuel efficiency standards will not even come close to 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 emissions will continue to grow as more people acquire more petroleum fueled vehicles and efficiency gains are overwhelmed by increased vehicle miles travelled. No matter how efficient petrol fueled vehicles become, burning oil is not a strategy for reducing CO2 emissions to zero.

Zero Emission Alternatives Are Available.

The recent development of battery technologies and hydrogen fuel cells has resulted in commercially available zero emission vehicles (ZEV) that can replace ICEs to power passenger vehicles, vans, transit and school busses, passenger and freight rail.

Tesla has shown the way with its new Model 3 with a 230 mile range priced under $40,000. Sales exploded since the first units became available in September, 2018. Tesla sales are approaching 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, including an electric pick-up. Chevy has stopped production of the hybrid Volt, and replaced it with the all-electric 230 mile per charge Bolt. Nissan has extended the battery range of the Leaf and is committed to ramping up its production of EVs in the US. Ford joined VW in announcing a partnership to develop advanced ZEV technologies.

New electric pick-up truck and 18 wheeler models were commercially introduced in 2018 and Tesla has announced it will release a long-haul truck in 2020. Hydrogen fuel-cell vehicles are also in use in California, Europe and Asia where hydrogen fueling infrastructure is now operational. With just 50- 60 hydrogen fueling stations strategically located along the interstate system, the hydrogen fuel cell could become the ZEV technology of choice for long haul truckers.

The challenge is how these technologies can be deployed quickly enough to replace over 1.3 billion ICEs globally by 2050.

Public Policies Must Be Adopted to Change the Course of our Future.

Currently more than 60 million new passenger vehicles and a few million new trucks are sold annually worldwide. U.S. sales exceeded 17 million in 2018. In the next 20 years between 1.5 and 2 billion new vehicles will be produced to both replace the existing global fleet and add vehicles to meet growing demand. In the U.S. an estimated 150 million new vehicles will be sold between 2020 and 2040, expanding the national vehicle fleet from 270 million now to 300 million by 2030, and near 330 million by 2040.

The average useful life for a passenger vehicle is 20 years, with 90% replaced every 15 years; 25 years for most trucks. Assuming this replacement rate continues, most vehicles on the road today will be replaced before 2050. If they are replaced with more ICEs, the IPCC CO2 targets cannot be met. As of 2018, less than 1% of global new vehicle sales are ZEVs. But to meet the IPCC zero emission target from the transport sector, within a few years 100% of sales must be ZEVs to replace all ICEs by 2050.

This could be accomplished if every new car buyer insisted on buying a ZEV. Public demand, if consciously guided by the choice needed to protect our planetary home, could transform the world's vehicle population by 2050. But that is not happening, either because people are not making conscious choices or their choices are not guided by planetary consciousness.

Norway is demonstrating another path for how this transformation can be achieved. Last year half of all new vehicle sales were ZEVs, and 40% of miles driven are in ZEVs. How has Norway created broad public demand for ZEVs? By investing in a ubiquitous electric vehicle (EV) charging network where power is often free at hours when there is excess capacity in the grid, by creating tax benefits that offset the incremental purchase price of a new EV, and by setting 2025 as the deadline for ending the import and sale of new ICEs. Norway also limits or bars access by ICEs to urban centers, HOV lanes and some parking facilities. Clearly the public will respond if the price signals are set and a national decision is made to stop using petroleum fuels.

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 estimates comparable costs by 2030. Soon special tax incentives may not be needed to make EVs price competitive, but competitive pricing will shift only some market demand. Not 100%. To achieve the IPCC targets, the sale of all new ICEs must end within the next decade. This can only be accomplished by national legislation that prohibits the production and sale of new ICEs.

Senator Merkley has introduced legislation to require that all new vehicles meet a zero emission standard by 2040. For the reasons explained in the attached Policy Analysis, this deadline must be advanced to 2030 to achieve net zero emissions from on-road vehicles by 2050. However, Elders Climate Action, US Climate Action Network and Elizabeth Warren all support a zero emission standard by 2030. Although Oregon is federally pre-empted from setting a more stringent emission standard than that in effect under the Clean Air Act, it should anticipate that federal law will set a future zero emission standard and prepare for that event.

States Can Make a Major Contribution to Shaping Consumer Choices.

States have a major role to play in creating the market and policy environment that favors ZEV technologies, and the infrastructure needed to support convenient use of EVs and other ZEV technologies. State policies, like Norway's, can be designed to create strong incentives for vehicle owners to replace their ICEs with ZEVs without enacting mandates that require owners to abandon ICEs.

S.B. 1530 focuses primarily on increasing the cost of fuel. Elders Climate Action (ECA) believes that this is an effective strategy when targeted at large industrial companies that can invest in alternatives to reduce or eliminate fuel use, but is NOT an effective strategy when aimed at owners of personal vehicles who are not able to account for fuel costs when making vehicle purchase decisions, and are not financially well-positioned to invest in alternative fueled vehicles. Instead of increasing fuel costs for the owners of personal vehicles, ECA urges the enactment of policies that offer cost reductions for the purchase of ZEVs, fees imposed on the purchase of new ICEs, and advantages for the operation of ZEVs.

California is considering legislation to develop a plan for achieving 100% ZEV sales. *See* AB 40 (2018). Some states are choosing to invest public resources to purchase only zero emission technologies for public fleets. Clunker replacement programs can provide incentives for owners to scrap, rather than sell, gas guzzlers. State building codes can ensure that all new and remodeled dwelling units include charging station access for EVs. This is especially important for multiple dwelling

unit properties where residents do not own or control common spaces outside their unit. Fast charging stations are also important along major intercity traffic corridors and highways that serve rural areas. States also can create strong incentives by –

- adopting the California ZEV mandate requiring auto manufacturers to achieve minimum sales targets;
- providing licensing, fee and sales tax rebates;
- preferential access to HOV lanes and toll exemptions for ZEVs;
- exclusive parking zones for ZEVs in high use areas such as CBDs and airports;
- exclusive access zones for ZEVs in high air pollution zones.

States can also use tax policies to encourage business and industry to invest in ZEV technologies. For example, tax credits for the purchase of new ZEVs can be paired with restricting recognized capital investments to ZEVs for tax purposes, and limiting operating expense deductions for vehicle fuels and maintenance to ZEVs. In addition, publicly funded or licensed transport services that involve high mileage vehicles, such as commercial bus and taxi services, and hail-a-ride services, can be restricted to ZEVs.

State climate legislation, state and local building codes, parking policies and HOV access rules should all be evaluated based on the support they provide for encouraging owners to accelerate the replacement of ICEs with ZEVs.

Oregon S.B. 1530.

A. 80% GHG Reduction Not Sufficient to Prevent Climate Disaster and Not Consistent with IPCC 2018 Report.

The 80% reduction target in H.B. 2020 and this bill is likely a carryover from the 2018 draft of the bill before the latest IPCC report was released in October, 2018. The 2007 IPCC report had called for an 80% reduction by 2050 based on the 2 degree (C) that was subsequently adopted by the Parties at the 2009 Copenhagen conference. The IPCC's 2007 80% target also was linked to avoiding the atmospheric loadings that would be achieved by reducing GHG emissions to 1990 levels by 2020, and that further reductions would be achieved annually thereafter through 2050.

The 2018 IPCC report evaluates the GHG reductions needed to avoid exceeding a 1.5 degree (C) increase in global temperatures. The 1.5 C target is based on observed changes in natural systems that exceed the expected changes at the current stage of climate disruption. The science cannot be certain regarding the magnitude of global temperature increase that will trigger tipping points that cause a runaway climate disaster, such as unstoppable firestorms that release into the atmosphere the carbon currently stored in forests when fires burn continuously through the winters, methane releases from vast reservoirs currently trapped below arctic permafrost that is now thawing more rapidly than previously expected, sudden sea level rise from the melting of massive Antarctic and Greenland glaciers, and the death of plankton populations that are responsible for the greatest sequestration of carbon on the planet. For example, the CO2 emissions from Australia's fires this fire season have crossed a major tipping point by increasing annual global CO2 emissions to 10% compared to the 3% rise in global anthropogenic emissions reported for 2019.[6] Australia's domestic CO2 emissions are only 1.3% of global annual emissions. Thus CO2 emitted from the fires far exceed the total reduction that Australia could achieve by shutting down every anthropogenic source.

To avoid the climate disaster that will occur if tipping points are crossed that trigger a runaway global heating beyond the human capacity to reverse, the IPCC developed its best estimate of the emission reductions needed to keep warming from exceeding 1.5 C.

The IPCC report also noted that global emissions since its 2007 recommendation for achieving the 2 C target failed to achieve any of the recommended reductions. Total atmospheric loadings of CO2 are now significantly greater than is necessary to meet the 2 C target. Thus an 80% reduction by 2050 is no longer considered sufficient to maintain global temperatures within the 2 C target.

An 80% reduction is no longer sufficient to prevent a climate disaster. The bill should be revised to reflect the current state of the science. The 80% emission reduction "goal" declared in section 1(b) is not an enforceable standard for which any public or private entity will be held accountable. It serves primarily as a planning target for developing policies and determining the number of "allowances" to be sold. Given the exemptions for fuels used in aviation, watercraft and railroad locomotives, plus the exemption for a large number of

[6] *See EcoWatch* (https://www.ecowatch.com/2020--rising-heat-2644916059.html?rebelltitem=1#rebelltitem1).

small sources (emitting less than 25,000 metric tons of CO2 equivalent), and the exclusion for emissions related to the sale of energy to users outside Oregon, the percent target omits from regulation a significant share of emissions. Thus the 80% target is misleading. Actual reductions will likely be only 70%.

Section 5 requires that emissions budgets be established for all years between 2022 and 2050. Regulated sources need to be able to rely on those budgets for the purpose of planning investments needed to achieve future budgets. Once the budgets are established it will be difficult for the State to reset the budgets to achieve zero emissions because regulated entities will have completed investments needed to achieve the 80% target that may be wasted if alternative energy systems are later required to achieve zero emissions. It is politically foolhardy to design a system to achieve an 80% reduction when the science and emerging climate disasters in Australia and elsewhere make it clear that zero emissions are absolutely essential to stabilize the climate.

For all these reasons, section 1 of the bill should be revised to establish 100% reduction of regulated emissions as the ultimate "goal" of the legislation.

Section 10 (2)(d): Exclusion from "regulated emissions" fuels used in watercraft or railroad locomotives.

Watercraft. Commenters object to the permanent exclusion of emissions from these sources. Large watercraft using Oregon ports are significant users of bunker and diesel fuels. New zero emission technologies are being developed for powering watercraft including vertical wind vanes that drive generators to produce electric power on board, and hydrogen fuel cells that power engines without GHG emissions. Emissions from large watercraft fueled in Oregon should not be permanently excluded from regulated emissions.

Alternative options include either a time limited exclusion which will allow the shipping industry additional time beyond 2022 to adopt and install lower or zero emission technologies, or adopt a fuel volume exclusion that allows smaller craft such as coastal fishing craft with few affordable alternatives to be excluded from treatment as regulated entities or users of included fuels.

Pre-emption provisions of the Clean Air Act do not apply to the inclusion or exclusion of fuels from "regulated emissions" for two reasons. First the bill does not establish a standard limiting the emissions of GHGs from a vessel. Rather it affects the price the vessel must pay to acquire the fuel instead of establishing

measurable limits on vessel emissions of GHGs. Second the bill regulates the conduct of the person producing or transporting the fuel into the state rather than the conduct of the person owning the vessel. Thus federal pre-emption in § 209 of the CAA does not bar inclusion of fuels used by watercraft when determining whether the person selling the fuel has an allowance that authorizes the lawful sale of the fuel.

Railroad Locomotives. The same objection applies to the permanent exclusion of fuels used by railroad locomotives. Railroads have the option to use diesel fuel to power the electric motors that drive locomotives or use electricity from the grid through the installation of catenary systems that deliver electric power to the engine through overhead lines. Throughout most of Europe, the railroads have been electrified and diesel emissions eliminated. Railroads in Oregon have the same opportunity to exempt themselves from the effects of including their fuels within the scope of "regulated emissions." Their fuels should be included to create an incentive for railroads to eliminate GHG emissions from their operations.

CONCLUSION.

Elders Climate Action supports passage of S.B. 1530 with changes designed to assure that the result of the legislation is to achieve reductions in GHG emissions to the net zero objective defined by the latest IPCC report as necessary to prevent a runaway climate catastrophe.

Respectfully submitted on behalf of Elders Climate Action

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Robert E. Yuhnke, Yale Law School ('72), is a former Assistant Attorney General who served as legal counsel to the Pennsylvania Department of Environmental Resources with responsibility for litigation and rulemaking to achieve steel industry compliance with the Clean Air Act. Later at Environmental Defense Fund he created the clean air program focused on stopping acid rain, and the transportation program. Working with key members of Congress, he played a major role in enacting provisions of the 1990 Clean Air Act Amendments. After EDF ended its transportation program, he created the transportation program for the Southwest Energy Efficiency Project (SWEEP) where he worked with legislators in six states to enact electric vehicle legislation, and with metropolitan planning organizations to reduce regional VMT growth and congestion. Last year he co-chaired the U.S.

Climate Action Network policy committee to develop proposed strategies for reducing CO2 from the transportation sector to achieve the IPCC CO2 goals for 2030 and 2050.

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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