Deriving a Climate-Stabilizing Solution Set of Fleet-Efficiency and Driving-Level Requirements, for Light-Duty Vehicles in California

AWMA Paper 796315

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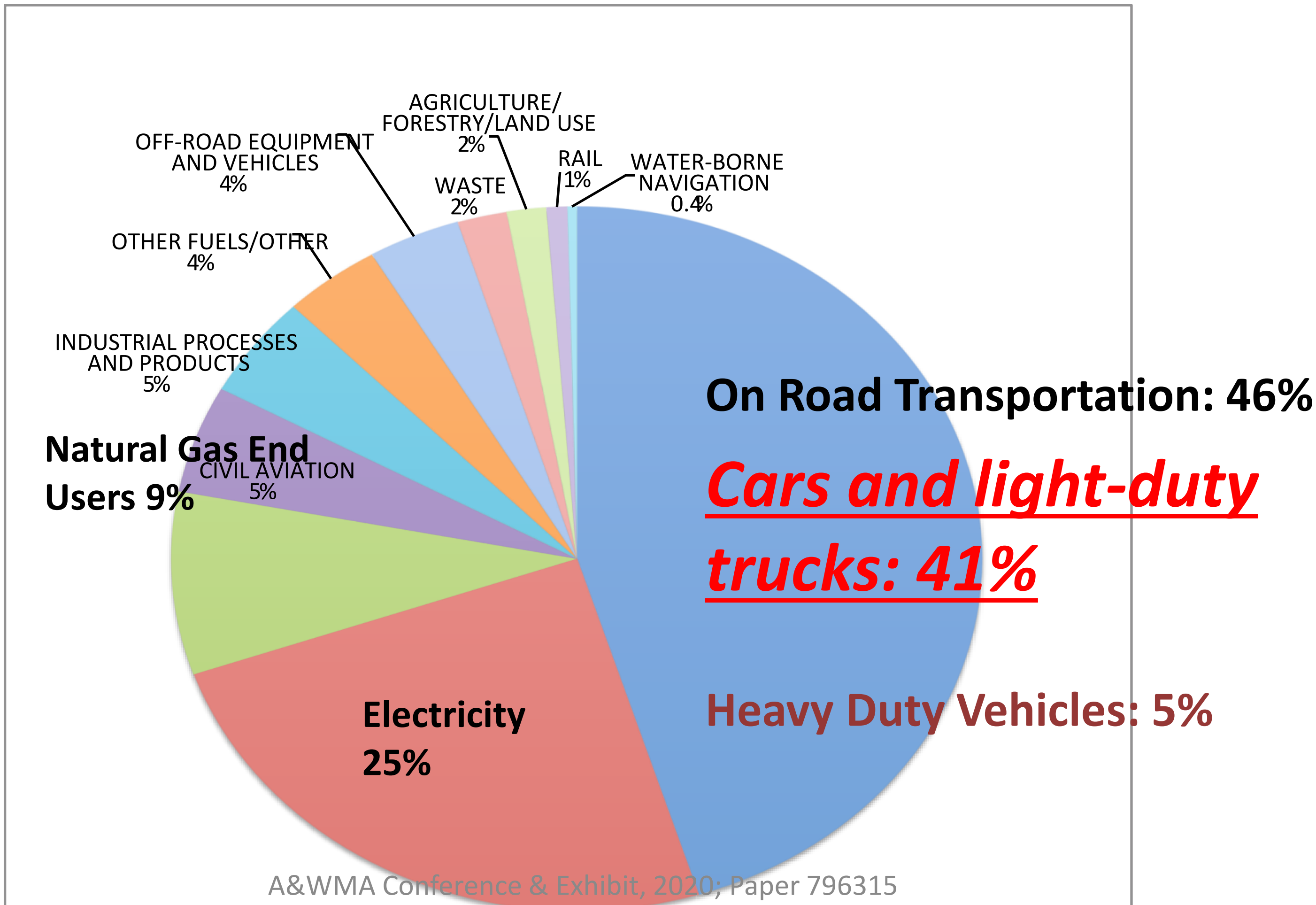
Why pick on cars?

Greenhouse Gas (GHG) Emissions, SD County

Source: Energy Policy Initiatives Center (EPIC, USD)

http://www.sandiego.edu/EPIC/ghginventory/GHG-On-Road1.pdf.pdf



Why is there a Climate Problem?

Any Earth Science text book*
contains the following facts:

- **Atmospheric CO_2 traps heat**
  - CO_2 Molecules absorb and then emit, in a random direction, infrared radiation, heat given off by the Earth's surface
  - This effect is significant
- **Combustion of fossil fuels adds great quantities of CO_2 to our Earth's atmosphere**
  - The amount of C02 in the atmosphere is well known
  - Our yearly emissions are well known

*** For example, Page 539 of *Earth Science*, Tarbuck and Lutgens, Tenth Edition, published by Prentice Hall, 2003.**

How Bad Could It Get?

- *Scientific American* June 2008 issue
  - 550 PPM CO2 possible in several decades
  - This could (5% probability) lead to 8 Deg. Celsius of warming
  - 8 Deg. Celsius could lead to "a devastating collapse of the human population, perhaps even to extinction"
- December 24/31 2012 Issue of Nation magazine:

A recent string of reports from impeccable mainstream institutions-the International Energy Agency, the World Bank, the accounting firm of PricewaterhouseCoopers-have warned that the Earth is on a trajectory to warm by at least 4 Degrees Celsius

[4 Degrees Celsius] would be *incompatible with continued human survival*.

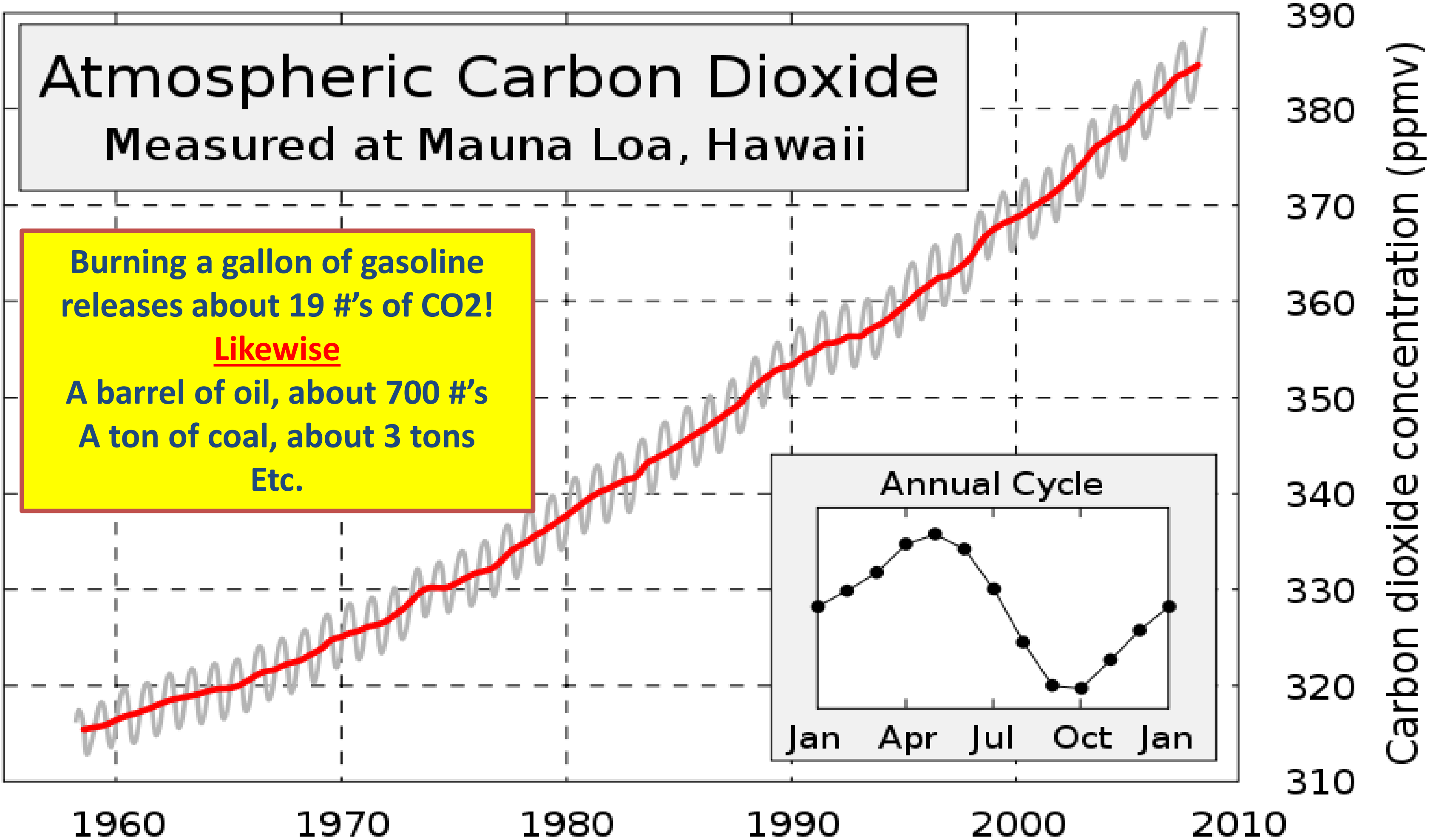
Winter, ***UU World*** magazine (p. 57) " Lags in the replacement of fossil-fuel use by clean energy use have put the world on a pace for 6 degree Celsius by the end of this century. Such a large temperature rise occurred 250 million years ago and extinguished 90 percent of the life on Earth. The current rise is of the same magnitude but is occurring faster. We must reduce or eliminate all uses of fossil fuels.

Climate Data

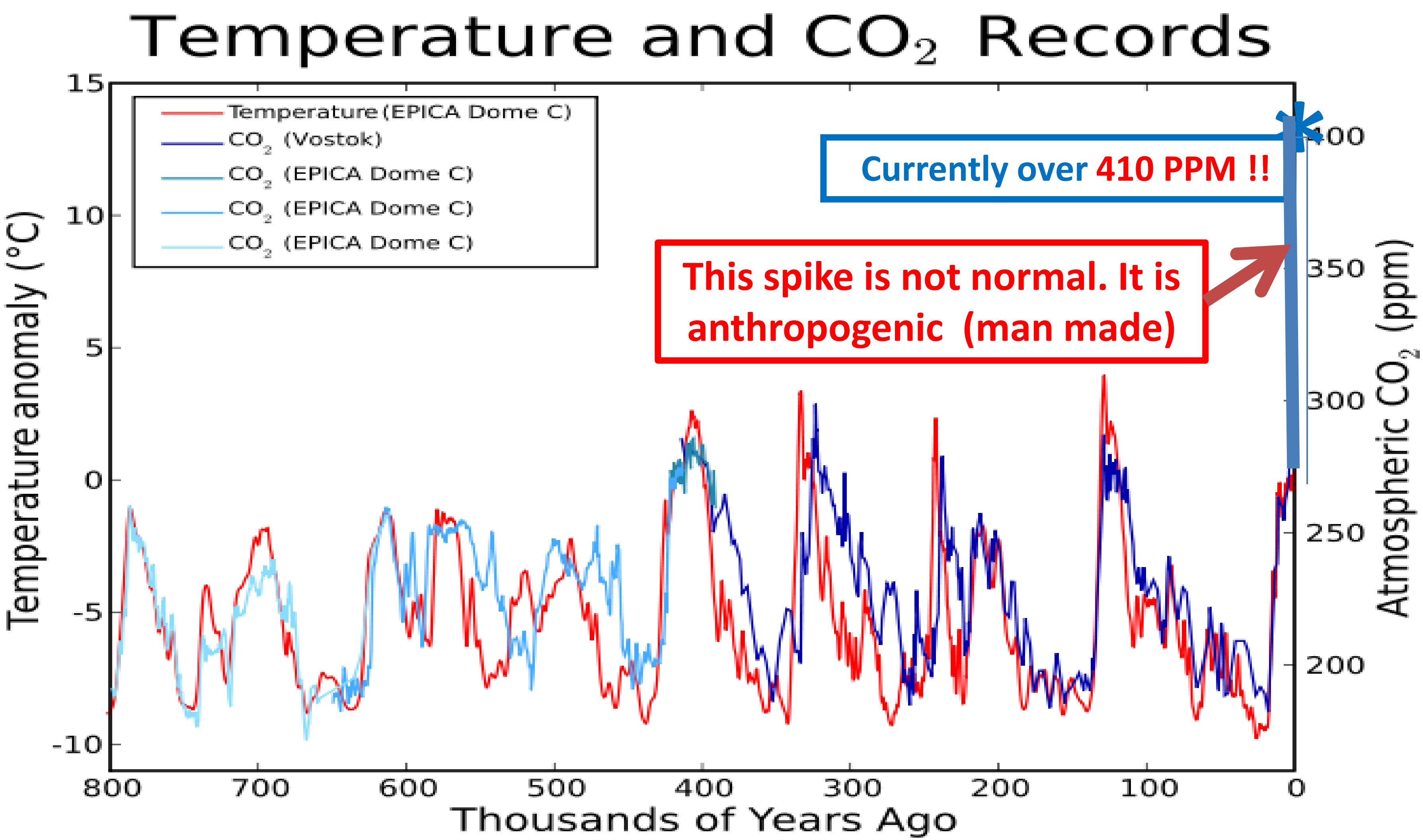
Currently around 415 PPM! *

- Keeling Curve:

http://en.wikipedia.org/wiki/An_Inconvenient_Truth#Scientific_basis



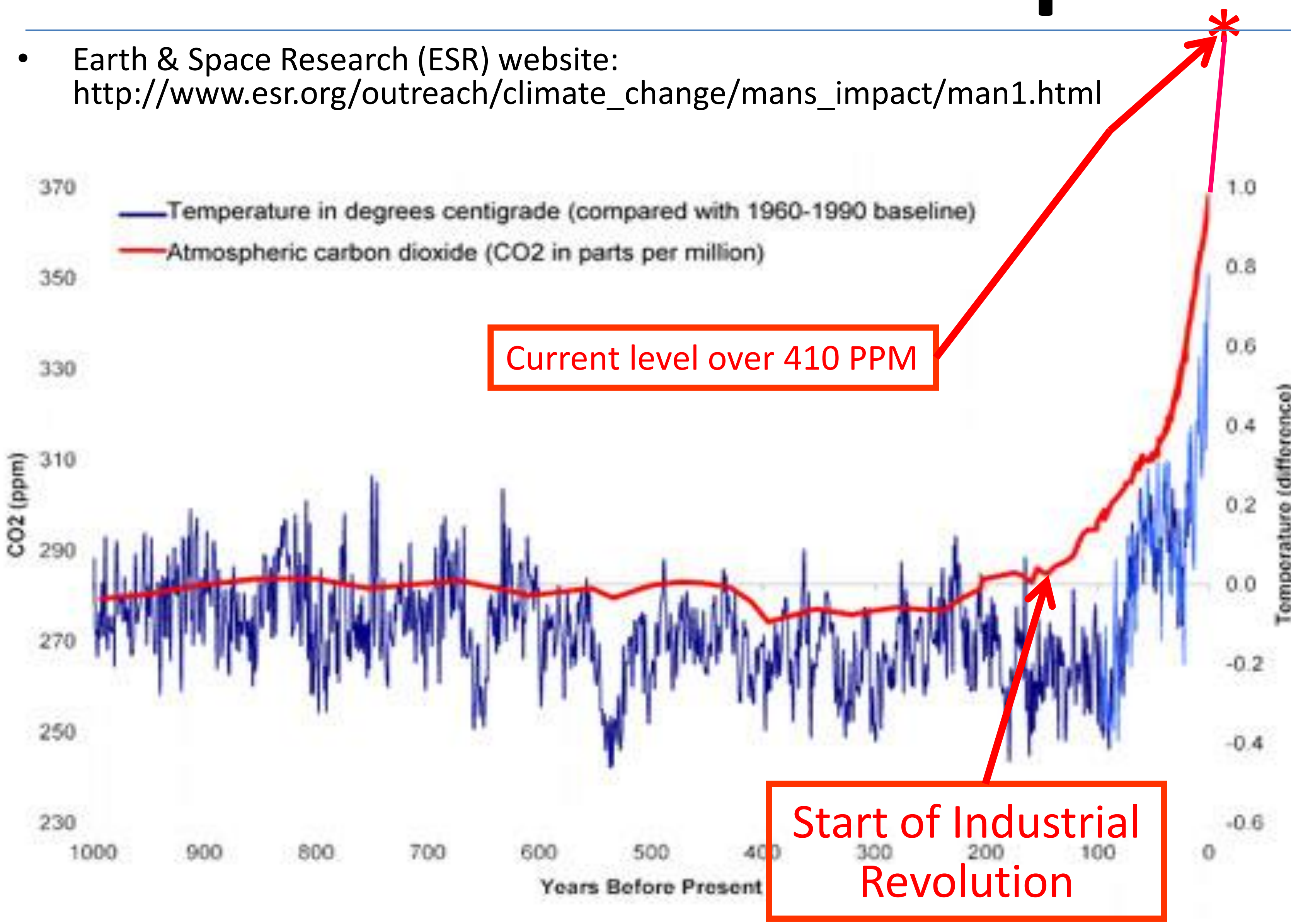
Climate Change, Mostly Normal



A&WMA Conference & Exhibit, 2020; Paper 796315

Let's Zero In on that Spike

- Earth & Space Research (ESR) website: http://www.esr.org/outreach/climate_change/mans_impact/man1.html



Fixing the Problem page 1 of 2

We must stabilize the value of the earth's atmospheric CO2_e

CO2_e Emissions | **Sequestration (Photosynthesis)**

E_N + E_A + E_{WFB} > → **Positive Slope** / = → Zero Slope / < → **Negative Slope** S

Natural: rotting, fire, digestion. respiration

Anthropogenic: combustion of fossil fuel, methane, other

Warming **F**eed **B**ack: such as methane from melting permafrost

Growth of plants on Earth

The Warming Feed Back term, E_{WFB}, is the wild card. It must not become dominant.

Fixing the Problem page 2 of 2

We must stabilize the value of the earth's atmospheric CO2_e. Here is Step 1:

If Anthropogenic emissions were sufficiently low, the slope would be zero, thus capping the value of the Earth's atmospheric CO2_e. To achieve this, industrialized nations must limit their emissions to 80% below their 1990 levels.

Warning: The Warming Feed Back terms must not become dominant.

BRIEF OF SCIENTISTS AMICUS GROUP AS *AMICI CURIAE* IN SUPPORT OF PLAINTIFFS-APPELLANTS SEEKING REVERSAL

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USCA Case #13-5192 Document #1465822 Filed: 11/12/2013

A. Parties and *Amici*. Except for the following, all parties, intervenors, and *amici* appearing before the district court and in this Court are listed in the Brief for Plaintiffs-Appellants. **James Hansen**, David Beerling, Paul J. Hearty, Ove Hoegh-Guldberg, Pushker Kharecha, Valérie Masson-Delmotte, Camille Parmesan, Eelco Rohling, Makiko Sato, Pete Smith, and Lise Van Susteren are *amici curiae* in this appeal (referred to hereinafter as "Amici Scientists.").

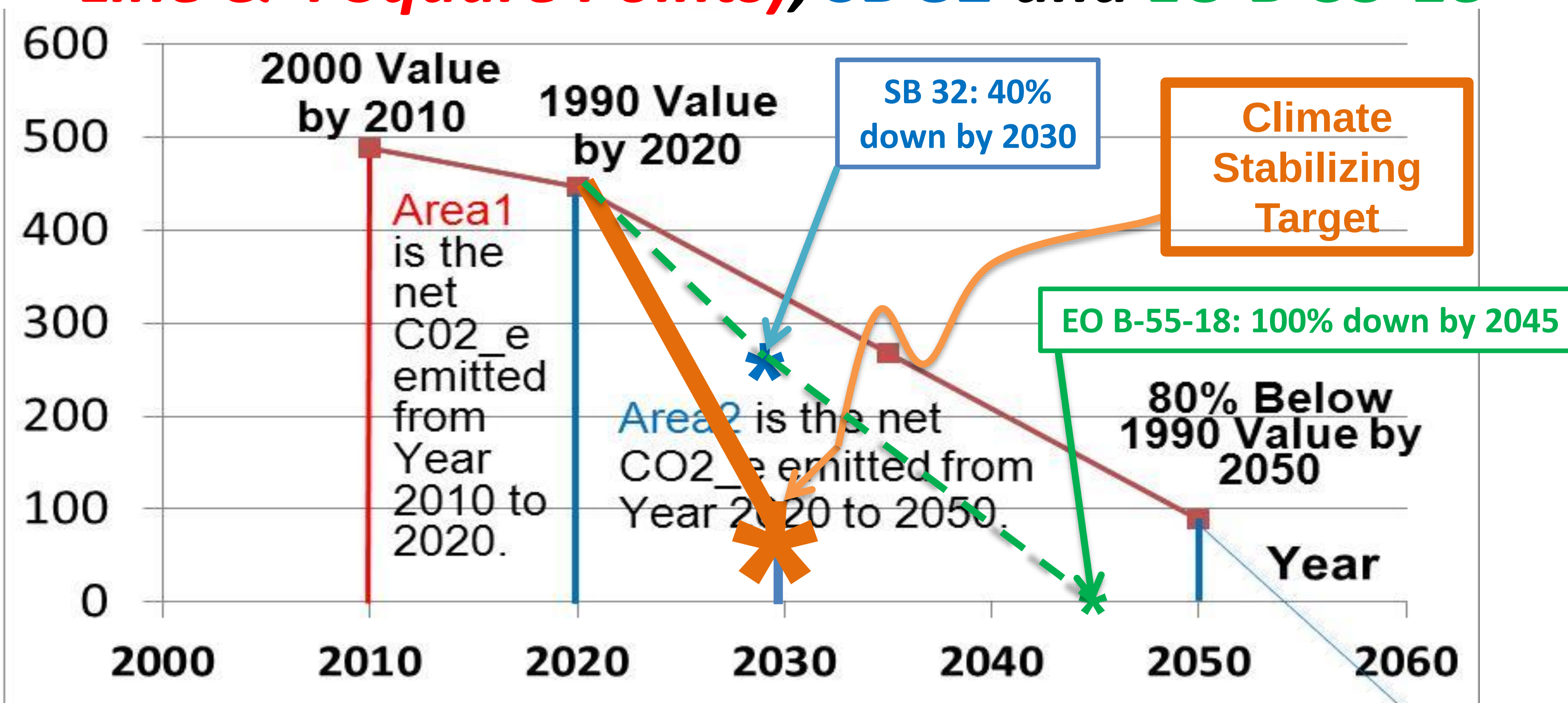
From the Climate Scientists

From Page 21: . . . the required rate of emissions reduction would have been about 3.5% per year if reductions had started in 2005, ***while the required rate of reduction, if commenced in 2020, will be approximately 15% per year.***

- My math:
  - 15% means a factor of 0.85, year after year
  - Consider the 10 years from 2020 to 2030
  - $(.85)^{\mathbf{10}}$ = .20, which is 80% down
  - Other articles, describing Hansen's work: "**decarbonization by 2030**"

New Climate-Stabilization Prescription

Shown with 3 California Mandates: EO S-3-05 (Red Line & 4 Square Points), SB 32 and EO B-55-18



How, for LDVs:

Deriving a Climate-Stabilizing Solution Set of Fleet-Efficiency and Driving-Level Requirements, for Light-Duty Vehicles in California

We have the climate scientist’s target. We must now derive the LDV Requirements.

Notes on Methods

- Base year 2005
- Intermediate year 2015
- Car Efficiency Factor from 2005 to 2015
  - Steve Winkelman's data
  - http://www.nrdc.org/globalWarming/sb375/files/sb375.pdf
- Car Efficiency Factor, 2015 to 2030
  - Derived in paper (and here)
  - Results in car-efficiency requirements
- Cars last 15 years

From a California law (***SB 375***) giving per-capita driving reduction targets to be achieved in Regional Transportation Plans

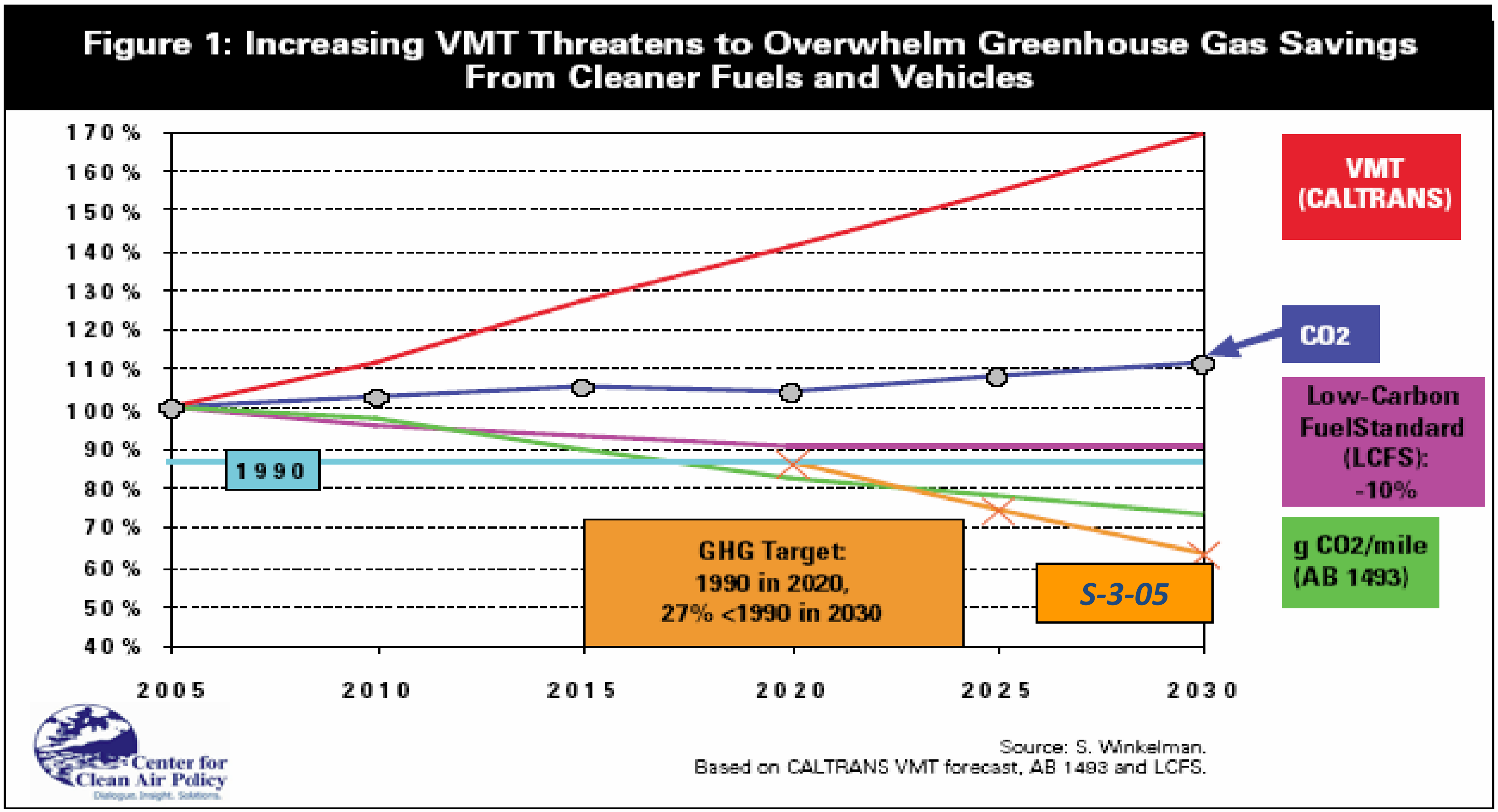
Report on ***SB 375***
See its Table 1.

Cars that survive beyond 2030 are balanced out by those that don't survive to 2030.

Data Relating 1990, 2005, & 2015 Data

Purple (Low carbon fuel), Green (C02/Mile), & Gold (S-3-05)

Figure 1, from: http://www.ecovote.org/sites/default/files/pdf/sb375.pdf



Variables

Definitions	
e_k	LDV Emitted C02, in Year "k"
L_k	Low Carbon Fuel Standard (LCFS) Factor that reduces the Per-Gallon CO2 emissions, in Year "k" (k is denotes Year 2030)
C_k	LDV CO2 emitted per mile driven, average, in Year "k", not accounting for the Low Carbon Fuel Standard (LCFS) Factor
c_k	LDV CO2 emitted per mile driven, average, in Year "k", accounting for the Low Carbon Fuel Standard (LCFS) Factor
p_k	Population, in Year "k"
d_k	Per-capita LDV driving, in Year "k"
D_k	LDV Driving, in Year "k"
M_k	LDV Mileage, miles per gallon, in Year "k"
m_k	LDV Equivalent Mileage, miles per gallon, in Year "k" accounting for the Low Carbon Fuel Standard (LCFS) Factor, so this is M_k/L_k
N	Number of pounds of CO2 per gallon of fuel but not accounting for the Low Carbon Fuel Standard (LCFS) Factor

Fundamental Equations

Future Year k: $\boldsymbol{e_k} = c_k * d_k * p_k$

Base Year i: $\boldsymbol{e_i} = c_i * d_i * p_i$

$$\frac{\boldsymbol{e_k}}{\boldsymbol{e_i}} = \frac{\boldsymbol{c_k}}{\boldsymbol{c_i}} * \frac{\boldsymbol{d_k}}{\boldsymbol{d_i}} * \frac{\boldsymbol{p_k}}{\boldsymbol{p_i}}$$

To work with mileage: $\frac{\boldsymbol{m_i}}{\boldsymbol{m_k}} = \frac{\boldsymbol{c_k}}{\boldsymbol{c_i}}$

Solution Overview

"k" denotes Year 2030
"i" denotes Year 2005

<u>Car Efficiency Factor</u>
From existing mileage requirements and the ***requirements defined herein***

From existing and predicted population

$$\frac{e_k}{e_i} = \frac{m_i}{m_k} * \frac{d_k}{d_i} * \frac{p_k}{p_i}$$

From the known 1990-to-2005 factor and the **Climate-Stabilizing-Target, which is the factor of 2030 emissions to 1990 emissions**

The Independent Variable
It becomes the ***required per-capita driving reduction with respect to 2005 driving***

Solution Using Intermediate Year of 2015

From the **Climate-Stabilizing-Target**, **which is the factor of 2030 emissions to 1990 emissions**

Car Efficiency Factor
From existing mileage requirements and the ***requirements defined herein***

From Winkelman. It is the product of the factor from the green line and the purple line.

From known and predicted populations

$$\frac{e_{2030}}{e_{1990}} * \frac{e_{1990}}{e_{2005}} = \frac{c_{2030}}{c_{2015}} * \frac{c_{2015}}{c_{2005}} * \frac{d_{2030}}{d_{2005}} * \frac{p_{2030}}{p_{2005}}$$

Taken from the Winkelman data: the known 1990-to-2005 factor of emissions (the light blue line)

The Independent Variable
It becomes the ***required 2030 per-capita driving reduction with respect to 2005 driving***

Putting In the Easy-to-Get Values

From the Climate-Stabilizing-Target, **which is the factor of 2030 emissions to 1990 emissions ("80% down")**

Car Efficiency Factor
From existing mileage requirements and the ***requirements defined herein***

From Winkelman. It is the product of the factor from the green line and the purple line. There is less CO2 per mile, thanks to the LCFS

From known and predicted populations

$$0.20 * 0.87 = \frac{c_{2030}}{c_{2015}} * 0.90 * 0.93 * \frac{d_{2030}}{d_{2005}} * 1.17446$$

Taken from the Winkelman data: the known 1990-to-2005 factor of emissions (the light blue line)

This ratio is the Independent Variable.
It is the *required per-capita 2030 driving reduction with respect to 2005 driving*

Combining the Easy-to-Get Values, Solving for the Independent Variable, and Changing the 2015-to-2030 Car Efficiency from CO2-Per-Mile to Equivalent-Miles-Per-Gallon

$$0.17700 = \frac{c_{2030}}{c_{2015}} * \frac{d_{2030}}{d_{2005}}$$

$$\frac{d_{2030}}{d_{2005}} = 0.17700 * \frac{c_{2015}}{c_{2030}}$$

$$\frac{d_{2030}}{d_{2005}} = 0.17700 * \frac{m_{2030}}{m_{2015}}$$

Equivalent Mileage in 2030 is what we make it. **It better be as high as possible, because a large driving reduction will be difficult.**
= "NUMERATOR MILEAGE"

The required per-capita 2030 driving with respect to 2005 driving

2015 Fleet Mileage is computed
= "DENOMINATOR MILEAGE"

Some Requirements Defined to Achieve 2030 Fleet Equivalent-Mileage

- Low-Carbon Fuel Standards (LCFS)
- Corporate Average Fuel Efficiency (CAFÉ) Standards from 2015 to 2030
- Driving Reduction Factors (f_n) for bad-mileage years (Year n)

Both California's existing and extended, "L_k"

Existing, to 2025
Specified to 2030

- For example, 0.75 means 25% less driving
- ***Cash for Gas-guzzlers?***

Three More Requirements

Defined to Achieve 2030 Fleet Equivalent-Mileage

- CAFÉ Standards only apply to Internal Combustion Engine (ICE) LDVs
- New Requirement: Fraction of fleet sold that must be ***Zero Emission Vehicles*** (ZEVs)
- In 2030, only 15%, or (the other case) 10% of electricity is from fossil fuels

Define "*z*" to be the fraction of fleet sold that must be ZEVs

Fleet Mileage for Intermediate Year 2015

LDV Set	Years Old	Model Year	CAFE MPG	LCFS Factor L_{Year}	Factor Driven f	Gallons Used Per f*100 Miles
1	14-15	2001	24.0	1.0	1.0	4.17
2	13-14	2002	24.0	1.0	1.0	4.17
3	12-13	2003	24.0	1.0	1.0	4.17
4	11-12	2004	24.0	1.0	1.0	4.17
5	10-11	2005	25.0	1.0	1.0	4.00
6	9-10	2006	25.7	.9933	1.0	3.87
7	8-9	2007	26.3	.9867	1.0	3.75
8	7-8	2008	27.0	.9800	1.0	3.63
9	6-7	2009	28.0	.9733	1.0	3.48
10	5-6	2010	28.0	.9667	1.0	3.45
11	4-5	2011	29.1	.9600	1.0	3.30
12	3-4	2012	29.8	.9533	1.0	3.20
13	2-3	2013	30.6	.9467	1.0	3.09
14	1-2	2014	31.4	.9400	1.0	2.99
15	0-1	2015	32.6	.9333	1.0	2.86
Sum of Gallons:						54.29
Miles = 100*Sum(f's):						1500
MPG = Miles/(Sum of Gallons):						27.63

Computed DENOMINATOR MILEAGE

ZEV Derivation Variables

Variable	Definition
m_z	ZEV Equivalent mileage (miles per equivalent gallon)
m_{zr}	ZEV Equivalent mileage if the electricity is from 100% renewables
m_{zf}	ZEV Equivalent mileage if the electricity is from 100% fossil fuels
r	fraction of electricity generated from sources not emitting CO2
G	Gallons of equivalent fuel used
D	Arbitrary distance travelled
Num	$m_{zr} \times m_{zf}$
Den	$r \times m_{zf} + (1 - r) \times m_{zr}$

ZEV Derivation

$$G = \frac{r \times D}{m_{zr}} + \frac{(1-r) \times D}{m_{zf}}$$

$$m_z = D/G = D/\left(\frac{r \times D}{m_{zr}} + \frac{(1-r) \times D}{m_{zf}}\right)$$

$$m_z = m_{zr} \times m_{zf}/\left(r \times m_{zf} + (1-r) \times m_{zr}\right)$$

$$m_z = Num/(Den)$$

m_{zr}	m_{zf}	r	1-r	Num	Den	m_z
5000	70	0.80	0.20	350000.00	1056.00	331.44
5000	70	0.85	0.15	350000.00	809.50	432.37
5000	70	0.90	0.10	350000.00	563.00	621.67

Four Variable Definitions & Selecting a Target Numerator Mileage Value

Variable	Definition
D_i	Distance travelled by ICE vehicles
D_z	Distance travelled by ZEV vehicles
G_i	Gallons of equivalent fuel used by ICE vehicles
G_z	Gallons of equivalent fuel used by ZEVs

This previously-derived equation was used.

$$\frac{d_{2030}}{d_{2005}} = 0.17700 * \frac{m_{2030}}{m_{2015}}$$

The driving reduction, $\frac{d_{2030}}{d_{2005}}$, was set to 0.68, corresponding to a 32% reduction in driving.

Then, using the previously-computed $\mathbf{m_{2015}}$ = 27.63 mile per gallon (MPG), the ***Numerator Mileage (m_{2030})*** was computed to be around **106 MPG**.

Finally, the ***z*** values were selected in the following table, by trial and error, to get the ***Numerator Mileage (m_{2030})*** to be close to that **106 MPG** value.

"Balanced_1", 85% Renewable Electricity

			ZevMileage =		432.37		So $G_z = D_z / 432.37$				
	ICE Parameters and Calculations						ZEVs			Yearly Totals		
Year	CAFÉ MPG	LCFS	Eq. MPG	f	D_i	G_i	z	D_z	G_z	Total Miles	Total Gallons	2030 MPG
2016	34.3	0.9267	37.01	0.3	29.4	0.7943	0.02	2	0.005	31.40	0.7989	39.30
2017	35.1	0.9200	38.15	0.4	39.2	1.0275	0.02	2	0.005	41.20	1.0321	39.92
2018	36.1	0.9133	39.53	0.5	48.5	1.2271	0.03	3	0.007	51.50	1.2340	41.73
2019	37.1	0.9067	40.92	0.6	57.6	1.4077	0.04	4	0.009	61.60	1.4169	43.47
2020	38.3	0.9000	42.56	0.7	64.4	1.5133	0.08	8	0.019	72.40	1.5318	47.26
2021	40.3	0.8500	47.41	0.8	64.0	1.3499	0.20	20	0.046	84.00	1.3961	60.17
2022	42.3	0.8000	52.88	0.9	58.5	1.1064	0.35	35	0.081	93.50	1.1873	78.75
2023	44.3	0.8000	55.38	1.0	45.0	0.8126	0.55	55	0.127	100.00	0.9398	106.40
2024	46.5	0.8000	58.13	1.0	20.0	0.3441	0.80	80	0.185	100.00	0.5291	188.99
2025	48.7	0.8000	60.88	1.0	6.0	0.0986	0.94	94	0.217	100.00	0.3160	316.48
2026	51.2	0.8000	64.00	1.0	3.0	0.0469	0.97	97	0.224	100.00	0.2712	368.70
2027	53.7	0.8000	67.13	1.0	2.0	0.0298	0.98	98	0.227	100.00	0.2565	389.93
2028	56.2	0.8000	70.25	1.0	1.0	0.0142	0.99	99	0.229	100.00	0.2432	411.17
2029	58.7	0.8000	73.38	1.0	1.0	0.0136	0.99	99	0.229	100.00	0.2426	412.20
2030	61.2	0.8000	76.50	1.0	1.0	0.0131	0.99	99	0.229	100.00	0.2420	413.15
Sum of Miles and then Gallons of equivalent fuel:										1235.60	11.64	

Equivalent MPG of LDV Fleet in 2030: 106.17

ZEV Miles Driven = 795.0 Fraction of Miles Driven by ZEVs = 64.3%

Computed NUMINATOR MILEAGE

Computing the Ratio of Per-Capita 2030 Driving to Per-Capita 2005 Driving

Equivalent Mileage in 2030 = "**NUMERATOR MILEAGE**"

$$\frac{d_{2030}}{d_{2005}} = .1770 * \frac{106.17}{27.63} = .68$$

2015 Fleet Mileage was computed before **= "DENOMINATOR MILEAGE"**

The factor of 0.68 means there is a 32% reduction in per-capita driving, from 2005 to 2030.

Again, for the next case, the ***z*** values were selected by trial and error, to get the 106 MPG value, corresponding to a 32% decrease in driving.

"Balanced_2", 90% Renewable Electricity

			ZevMileage =	621.67	So $G_z = D_z / 621.67$						
	ICE Parameters and Calculations						ZEVs			Yearly Totals		

Year	CAFÉ MPG	LCFS	Eq. MPG	f	D_i	G_i	z	D_z	G_z	Total Miles	Total Gallons	2030 MPG
2016	34.3	0.927	37.01	0.3	29.4	0.7943	0.02	2	0.003	31.40	0.7975	39.37
2017	35.1	0.920	38.15	0.4	39.2	1.0275	0.02	2	0.003	41.20	1.0307	39.97
2018	36.1	0.913	39.53	0.5	48.5	1.2271	0.03	3	0.005	51.50	1.2319	41.81
2019	37.1	0.907	40.92	0.6	57.6	1.4077	0.04	4	0.006	61.60	1.4141	43.56
2020	38.3	0.900	42.56	0.7	64.4	1.5133	0.08	8	0.013	72.40	1.5262	47.44
2021	40.3	0.850	47.41	0.8	68.0	1.4342	0.15	15	0.024	83.00	1.4584	56.91
2022	42.3	0.800	52.88	0.9	67.5	1.2766	0.25	25	0.040	92.50	1.3168	70.25
2023	44.3	0.800	55.38	1.0	55.0	0.9932	0.45	45	0.072	100.00	1.0656	93.84
2024	46.5	0.800	58.13	1.0	30.0	0.5161	0.70	70	0.113	100.00	0.6287	159.05
2025	48.7	0.800	60.88	1.0	5.0	0.0821	0.95	95	0.153	100.00	0.2349	425.62
2026	51.2	0.800	64.00	1.0	3.0	0.0469	0.97	97	0.156	100.00	0.2029	492.84
2027	53.7	0.800	67.13	1.0	2.0	0.0298	0.98	98	0.158	100.00	0.1874	533.52
2028	56.2	0.800	70.25	1.0	1.0	0.0142	0.99	99	0.159	100.00	0.1735	576.42
2029	58.7	0.800	73.38	1.0	1.0	0.0136	0.99	99	0.159	100.00	0.1729	578.45
2030	61.2	0.800	76.50	1.0	1.0	0.0131	0.99	99	0.159	100.00	0.1723	580.31
Sum of Miles and then Gallons of equivalent fuel:										1233.60	11.61	

Equivalent MPG of LDV Fleet in 2030: 106.22

ZEV Miles Driven = 761.0 Fraction of Miles Driven by ZEVs = 61.7%

Computed NUMINATOR MILEAGE

Selecting a Target Numerator Mileage Value to Get a 0% Reduction in Driving

This previously-derived equation was used.

$$\frac{d_{2030}}{d_{2005}} = 0.17700 * \frac{m_{2030}}{m_{2015}}$$

The driving reduction, $\frac{d_{2030}}{d_{2005}}$, was set to 1.00, corresponding to a 0% reduction in driving.

Then, using the previously-computed $\mathbf{m_{2015}}$ = 27.63 mile per gallon (MPG), the ***Numerator Mileage (m_{2030})*** was computed to be around **156 MPG**.

Finally, the ***z*** values were selected in the following table, by trial and error, to get the ***Numerator Mileage (m_{2030})*** to be close to that **156 MPG** value.

"2005 Driving Case", 90% Renewable Electricity

		Zev mileage	=	621.67	So $G_z = D_z$ / 621.67		

Year	ICE Parameters and Calculations						ZEVs			Yearly Totals		
	CAFÉ MPG	LCFS	Eq. MPG	f	D_i	G_i	z	D_z	G_z	Total Miles	Total Gallons	2030 MPG
2016	34.3	0.9267	37.01	0.3	29.4	0.7943	0.02	2.0	0.003	31.40	0.7975	39.37
2017	35.1	0.9200	38.15	0.4	39.2	1.0275	0.02	2.0	0.003	41.20	1.0307	39.97
2018	36.1	0.9133	39.53	0.5	48.5	1.2271	0.03	3.0	0.005	51.50	1.2319	41.81
2019	37.1	0.9067	40.92	0.6	57.6	1.4077	0.04	4.0	0.006	61.60	1.4141	43.56
2020	38.3	0.9000	42.56	0.7	64.4	1.5133	0.08	8.0	0.013	72.40	1.5262	47.44
2021	40.3	0.8500	47.41	0.8	14.4	0.3037	0.82	82.0	0.132	96.40	0.4356	221.29
2022	42.3	0.8000	52.88	0.9	2.7	0.0511	0.97	97.0	0.156	99.70	0.2071	481.42
2023	44.3	0.8000	55.38	1.0	1.0	0.0181	0.99	99.0	0.159	100.00	0.1773	563.99
2024	46.5	0.8000	58.13	1.0	1.0	0.0172	0.99	99.0	0.159	100.00	0.1765	566.72
2025	48.7	0.8000	60.88	1.0	1.0	0.0164	0.99	99.0	0.159	100.00	0.1757	569.23
2026	51.2	0.8000	64.00	1.0	1.0	0.0156	0.99	99.0	0.159	100.00	0.1749	571.84
2027	53.7	0.8000	67.13	1.0	1.0	0.0149	0.99	99.0	0.159	100.00	0.1741	574.23
2028	56.2	0.8000	70.25	1.0	1.0	0.0142	0.99	99.0	0.159	100.00	0.1735	576.42
2029	58.7	0.8000	73.38	1.0	1.0	0.0136	0.99	99.0	0.159	100.00	0.1729	578.45
2030	61.2	0.8000	76.50	1.0	1.0	0.0131	0.99	99.0	0.159	100.00	0.1723	580.31
Sum of Miles and then Gallons of equivalent fuel:										1254.20	8.04	

Equivalent MPG of LDV Fleet in 2030: 155.99

ZEV Miles Driven = 990.0

Fraction of Miles Driven by ZEVs = 78.9%

Computed NUMINATOR MILEAGE

Computing the Ratio of Per-Capita 2030 Driving to Per-Capita 2005 Driving

Equivalent Mileage in 2030 is what we made it by selecting the "z" values in the previous table. = "**NUMERATOR MILEAGE**"

$$\frac{d_{2030}}{d_{2005}} = .1770 * \frac{155.99}{27.63} = 1.00$$

2015 Fleet Mileage was computed **= "DENOMINATOR MILEAGE"**

For the next case, the ***z*** values were taken from a published article describing values selected by the Chair of the California Air Resources Board, Mary Nichols.

“Mary Nichols Case”, 90% Renewable Electricity

		Zev Mileage =			621.67	So $G_z = D_z$ / 621.67					
Year	ICE Parameters and Calculations					ZEVs			Yearly Totals		
	CAFÉ MPG	LCFS	Eq. MPG	f	D_i	G_i	z	D_z	G_z	Total Miles	Total Gallons	2030 MPG
2016	34.3	0.9267	37.01	0.3	29.2	0.7886	0.027	2.7	0.004	31.89	0.7930	40.22
2017	35.1	0.9200	38.15	0.4	38.9	1.0201	0.027	2.7	0.004	41.62	1.0245	40.63
2018	36.1	0.9133	39.53	0.5	47.4	1.2003	0.051	5.1	0.008	52.56	1.2086	43.49
2019	37.1	0.9067	40.92	0.6	55.5	1.3560	0.075	7.5	0.012	63.01	1.3681	46.06
2020	38.3	0.9000	42.56	0.7	63.0	1.4814	0.099	9.9	0.016	72.98	1.4974	48.74
2021	40.3	0.8500	47.41	0.8	70.1	1.4790	0.124	12.4	0.020	82.47	1.4988	55.02
2022	42.3	0.8000	52.88	0.9	76.7	1.4509	0.148	14.8	0.024	91.48	1.4746	62.03
2023	44.3	0.8000	55.38	1.0	82.8	1.4957	0.172	17.2	0.028	100.00	1.5233	65.65
2024	46.5	0.8000	58.13	1.0	80.4	1.3834	0.196	19.6	0.032	100.00	1.4149	70.67
2025	48.7	0.8000	60.88	1.0	78.0	1.2813	0.220	22.0	0.035	100.00	1.3167	75.95
2026	51.2	0.8000	64.00	1.0	62.4	0.9750	0.376	37.6	0.060	100.00	1.0355	96.57
2027	53.7	0.8000	67.13	1.0	46.8	0.6972	0.532	53.2	0.086	100.00	0.7828	127.75
2028	56.2	0.8000	70.25	1.0	31.2	0.4441	0.688	68.8	0.111	100.00	0.5548	180.25
2029	58.7	0.8000	73.38	1.0	15.6	0.2126	0.844	84.4	0.136	100.00	0.3484	287.05
2030	61.2	0.8000	76.50	1.0	0.0	0.0000	1.000	100.0	0.161	100.00	0.1609	621.67
Sum of Miles and then Gallons of equivalent fuel:										1236.00	16.00	

Equivalent MPG of LDV Fleet in 2030: 77.24

ZEV Miles Driven = 457.9 Fraction of Miles Driven by ZEVs = 37.0%

Computed NUMINATOR MILEAGE

Computing the Ratio of Per-Capita 2030 Driving to Per-Capita 2005 Driving

Equivalent Mileage in 2030 is what resulted from the Mary Nichols statement. It is the "**NUMERATOR MILEAGE**"

$$\frac{d_{2030}}{d_{2005}} = .1770 * \frac{77.24}{27.63} = .495$$

2015 Fleet Mileage was computed = "**DENOMINATOR MILEAGE**"

CARB may not understand that the fleet electrification schedule suggested by their Board Chair would require that per-capita driving be about half what it was in 2005, if LDVs are to achieve climate-stabilizing targets.

Net Driving Decrease with Respect to 2005 Driving for the "Balanced" Cases

(Per-Capita Driving Factor) x (Population Factor) = Net Driving Factor

This factor corresponds to the 32% reduction in per-capita driving

(.68) x (1.1744) = .80

Therefore, even though the population will grow 17%, net driving must decrease by 20%.

Therefore, why add highway lanes?

We need enforceable measures to reduce driving so much there will be no more congestion!

4 Cases that Support Climate Stabilization

Note: Purple denotes difficult; red, impossible.

	Case Designations			
	Balanced_1	Balanced_2	2005 Driving	Mary Nichols
% Renewable Electricity	85.0%	90.0%	90.0%	90.00%
% ZEVs, Year 2016	2.0%	2.0%	2.0%	2.70%
% ZEVs, Year 2017	2.0%	2.0%	2.0%	2.70%
% ZEVs, Year 2018	3.0%	3.0%	3.0%	5.11%
% ZEVs, Year 2019	4.0%	4.0%	4.0%	7.53%
% ZEVs, Year 2020	8.0%	8.0%	8.0%	9.94%
% ZEVs, Year 2021	20.0%	15.0%	82.0%	12.35%
% ZEVs, Year 2022	35.0%	25.0%	97.0%	14.76%
% ZEVs, Year 2023	55.0%	45.0%	99.0%	17.18%
% ZEVs, Year 2024	80.0%	70.0%	99.0%	19.59%
% ZEVs, Year 2025	94.0%	95.0%	99.0%	22.00%
% ZEVs, Year 2026	97.0%	97.0%	99.0%	37.60%
% ZEVs, Year 2027	98.0%	98.0%	99.0%	53.20%
% ZEVs, Year 2028	99.0%	99.0%	99.0%	68.80%
% ZEVs, Year 2029	99.0%	99.0%	99.0%	84.40%
% ZEVs, Year 2030	99.0%	99.0%	99.0%	100.00%
% Reduction in Per-Capita Driving With Respect to Year 2005	32.0%	32.0%	0%	50.5%

Enforceable Measures to Reduce 2030 Driving by 32% With Respect to 2005

California designs and implements this → Value-Priced Road Use Charge (RUC)

Local governments do this with a 3rd party vendor → Value-Priced Parking (Unbundling the Cost)

Driving-Reduction Requirments	Per-Cent Reduction	Factor
Legislated (SB 375) Plans to Reduce Driving	12%	0.88
Value-Priced Road Use Charge (RUC)	10%	0.90
Value-Priced Parking (Unbundling the Cost)	8%	0.92
Transfer Highway Expansion Funds to Transit	2%	0.98
Increase Height & Density by Transit Stations	2%	0.98
"Complete Streets", "Road Diet" (walk/bike)	1%	0.99
Pay-to-Graduate Bicycle Traffic-Skills Class	1%	0.99
Bicycle Projects to Improve Access	1%	0.99
Product of Factors		**0.68**
% Reduction		**32%**

These enforceable measures are described in the AWMA paper.

An Important Pricing Strategy

A Road-Usage-Charge (RUC) Pricing & Payout System

THEREFORE, BE IT RESOLVED, that the Democratic Club of Carlsbad and Oceanside (DEMCCO) supports a road-usage charge (RUC) pricing & payout system that would (1) cover all road-use costs, including the environmental & health costs caused by driving; (2) mitigate impacts on low-income users; (3) protect privacy; (4) include congestion pricing; (5) keep the per-mile price incentive to drive energy-efficient cars at least as large as it is with today's fuel excise tax; and (6) send its earnings to all citizens and institutions that are currently losing money by subsidizing road use.

Another Important **Pricing** Strategy

A good car-parking system: value-priced (with congestion pricing), shared, automated, and providing earnings to those losing money because the parking is being provided.

The first such systems should be installed by a third-party vendor (such as **Google, Qualcomm, Uber, or Lime Bicycle)**, selected by a RFP (Request for Proposal) process, for municipal government employees, as part of the government's **Climate Action Plan**. It would be operated for the financial gain of the employees. The RFP would specify that even employees that continue to drive every day would at least break even. The winning third-party vendor would be skilled at monetizing parking, whenever it is not being used by the employees; at monetizing data; and at expanding the system. The system would be automated with a useful phone app to find the best parking at the user-specified price and walk-distance.