April 16, 2021

Code Advisory Commission, CALGreen
Building Standards Commission
2525 Natomas Park Drive, Suite 130
Sacramento, California 95833-2936
Via Email: cbsc@dgs.ca.gov.

Re: Residential CALGreen 2022, Electric Vehicle Infrastructure, Cost and Economic/Environmental Benefits, Draft Report

Dear Members of the Code Advisory Commission,

Sven Thesen & Associates is submitting for your review this draft cost and economic/ environmental benefit analysis of two compliance pathways for the CALGreen 2022 mandatory residential Electric Vehicle (EV) infrastructure code update. This review, focused solely on multi-family dwellings (MFDs), compares the Department of Housing and Community Development (HCD) compliance pathway provided to the public on April 12, 2021, to an alternative compliance pathway, based on a low power approach, ***EV Charging Access for All*** proposal recently put forth in February 2021 by a coalition of over 700 organizations, companies, faith communities and individuals.

This analysis has determined that including the refined ***EV Charging Access for All*** proposal as an alternative compliance pathway within CALGreen 2022 will offer building developers a choice: one that will lower EV compliance costs, serve more EV drivers, support California's clean air and climate change goals and more. With a choice of pathways, developers can determine for their project which approach is best for them.

Based on the following analysis, the coalition's low power level 2 (LPL2) approach will provide significant economic and environmental benefits, including approximately 3% lower initial construction costs as compared to the HCD compliance pathway. In essence, ***adopting the LPL2 approach as an alternative compliance pathway will save residents of the estimated 150,000 multi-family dwellings (MFDs) to be built during the 2022-25 code cycle an additional $384M in vehicle associated costs, while avoiding an additional 1.5M tons of greenhouse gas emissions over and above the HCD pathway. Further, by providing access to charging for each unit at the time of construction, the LPL2 approach avoids $756M in future utility provided retrofits.*** Finally, by providing power to every unit with access to parking, the LPL2 approach levels the EV playing field between MFDs and single family homes, for whom CALGreen code has mandated access to power since mid 2015.

Figure 1 summarizes the above benefits, accrued over the three-year cycle in which the code will be in effect.

Figure 1. Statewide Impacts, Low Power Level 2 (LPL2) and the HCD April 2021 Compliance Pathways

LPL2 & HCD 12 April 2021 Compliance Pathways, CA Housing, Code Cycle 2023-2025, 150k MFD Units				
Item	**150k LPL2 MFDs**	**150k HCD MFDs**	**Delta**	**Notes**
$M, EV Savings by Residents:	$1,091	$707	$384	$M, Additional Savings by Residents
Avoided Emissions, M Tons CO2:	4.2	2.7	1.5	M tons CO2 Additional Avoided
$M, Initial Construction Costs:	$202	$209	$7	$M, Reduction in Builder Costs
$/ Port, EV Ready:	$1,493	$2,575	$1,083	$/Port, Saving
Port Count, Day 1:	150,000	81,000	69,000	Additional Ports
$M, HCD, EV Capable to Ready:	n/a	$8	$8	$M, Paid by Residents/ MFD Owners
$M, Remainder, Utility Retrofitting: (Retrofitting, $18k/port, PG&E Charge Now program)	n/a	$756	$756	$M, Paid by Utility Ratepayers
$M Total Cost, 100% EV Ready (Retrofitting, $18k/port, PG&E Charge Now program)	$202	$972	$771	$M, Additional Costs by Society

Please note, this report is considered draft until it has been reviewed by HCD and California Air Resources Board (CARB) staff and their comments integrated into the report.

BACKGROUND AND METHODOLOGY:

In 2019, Peninsula Clean Energy (PCE) and Silicon Valley Clean Energy (SVCE) developed a reach code addressing new residential and nonresidential EV infrastructure. This code has already been implemented - in whole or in part - by more than ten cities in the Bay Area and was based on prior reach codes developed by a number of municipalities across California. Within the residential section of the reach code, the most important component provides every unit that has access to a parking space access to power. In addition, to keep costs as low as possible while providing the majority of EV drivers within the PCE/SVCE service territory with a reasonable amount of daily range, the minimum base power at the receptacle or electric vehicle supply equipment (EVSE) was set at 1.4kW. The final critical component of the reach code requires appropriate signage at each "electrified" parking space.

To address all of California – including rural and low-income drivers who may have differing driving patterns plus those with long commutes – a coalition of over 850 organizations, companies, faith communities and individuals is advocating that the state adopt in the form of an alternative compliance pathway a modified version of the PCE/SVCE reach code, increasing the base power at the charging port to 3.3kW[1]. Note, the most important components of the coalition's alternative compliance pathway remain: providing access to power to every MFD unit that has access to parking, with appropriate signage. Figure 3 provides a summary of the April 2021 HCD compliance pathway and the refined *EV Charging Access for All coalition* low power Level 2 alternative compliance

[1] This is based on 208v and 20amp breaker (3.3kW = 208*20*80%).

pathway. Please note the power listed in Table 2 references the power at either the EVSE or receptacle and is based on a 208v circuit multiplied by 80% of the rated circuit breaker.

Figure 2. HCD 12 April 2021 and the Low Power Level 2 February 2021 Compliance Pathways

HCD, Multi-Family Dwellings	***Low Power Level 2, Multi-Family Dwellings***
● 10% of parking spaces are Level 2 (~6.7kW) EV Capable ● 25% of parking spaces are low power Level 2 (~3.3kW) EV Ready ● 5% of parking spaces are Level 2 (~6.7kW) with an EVSE	● 3.3 kW average across all units with access to a parking space ● Signage

EV Infrastructure Construction Cost Comparison

This comparison is based on the report, *Electric Vehicle Infrastructure Cost Analysis Report for Peninsula Clean Energy (PCE) & Silicon Valley Clean Energy (SVCE)*[2], completed by Energy Solutions in November 2019. In this report, as shown by Figure 3 (Table 12 in the Energy Solutions Report), Energy Solutions evaluated the costs to install the EV infrastructure as required by the PCE/SVCE reach code at the time of initial construction and compared that with the cost of a later date retrofit. In 2019, the PCE/SVCE reach code essentially required 25% Level 2, EV Ready ("plug & play" including completed 208/240v 40a circuits), and 75% Level 1, EV Ready ("plug & play" including completed 120v 20a circuits), terminating at a receptacle for every dwelling unit that has a parking space. In one of the report's use cases, a 60-unit MFD has 54 units with their own parking spaces, so the PCE/SVCE 2019 reach code requirement is to install 9 Level 2 EV Ready receptacles (ports) and 45 Level 1 EV Ready receptacles (ports).

[2] https://peninsulareachcodes.org/wp-content/uploads/2020/03/PCE_SCVE-EV-Infrastructure-Report-2019.11.05.pdf

Figure 3. Estimated Cost of Installing EV Infrastructure, PCE/SVCE 2019 Reach Code

Table 12. Estimated Incremental Cost of Installing EV Infrastructure: 60-Unit MUD

	60-Unit MUD			
Retrofit	Market Rate [NC]	Market Rate [Retrofit]	Affordable Housing [NC]	Affordable Housing [Retrofit]
Level 2 Ports Added	9	9	0	0
Level 1 Ports Added	45	45	54	54
Electrical panel	$15,960	$26,008	$9,289	$13,004
Main electrical room, excluding transformer	$13,609	$43,911	$14,055	$35,193
Transformer (480V -> 208V)	$14,164	$12,743	$1,081	$10,897
Raceway / In-slab conduit	$18,059	$77,247	$18,059	$77,247
Electrical components (wire, receptacle)	$11,366	$20,131	$11,307	$20,049
Trenching for installation of conduit	$0	$0	$0	$0
Demolition of equipment	$0	$31,940	$0	$30,918
Pavings (asphalt & concrete)	$0	$7,889	$0	$7,889
Permitting & inspection fees	$2,435	$15,592	$2,435	$15,592
Construction management	$549	$4,449	$403	$4,264
TOTAL	$76,142	$239,909	$56,629	$215,051
TOTAL (Price per Port)	$1,410	$4,443	$1,049	$3,982

As detailed in Figure 4, it is important to note that the majority of the EV infrastructure cost comes from bringing in and managing the power (Electrical Feed and Management), especially as compared to installing raceway and electrical components (Electrical Distribution).

Figure 4. Cost Distribution of PCE/SVCE's 2019 Reach Code, New Construction

Cost	Item
$15,960	Electrical Panel
$13,609	Main electrical room, excluding transformer
$14,164	Transformer(480v->208v)
$43,733	"Electrical Feed and Management"
$18,059	Raceway / In-slab conduit
$11,366	Electrical components (wire, receptacle)
$29,425	"Electrical Distribution"
$2,435	Permitting & Inspection Fee
$549	Construction Management
$2,984	Soft Costs

The low power Level 2 alternative compliance pathway requires each MFD unit with parking to have access to low power Level 2 charging, with 3.3kW as base power plus appropriate signage. Hence, in the low power Level 2 use case, 54 spaces or ports (one port per unit with parking) will each have access to at a minimum of 3.3kW of power.

As noted in Figure 2, HCD's April 2021 compliance pathway requires 10% of the overall parking spaces to be full power Level 2, EV Capable (essentially everything but the wiring and the receptacle); 25% of the overall parking spaces to be LPL2 plus 5% of the overall parking spaces to terminate in a full power L2 EVSE. Per CARB, the subject matter expert agency, overall parking space count is approximately equal to 1.8 times the number of units; in this case, 1.8*60=108 and the cost of the EVSE is $1,500. Note, while this represents 40% of the facility's parking spaces, it does not guarantee that 40% of the units will have access to power.

Using the Energy Solution's 60-unit MFD as the basis, Figure 5 compares the EV infrastructure power requirements of the three: the PCE/SVCE 2019 reach code, the low power Level 2 alternative compliance pathway, and the April HCD compliance pathway.

Figures 5. Power Requirements: PCE/SVCE 2019 Reach Code, Low Power Level 2 and HCD April 2021 pathways

60 unit MUD PCE/SVCE November 2019 Reach Code

Total kW, EV-I	Charging Spaces	# Spaces	kW/ Space	kW	% Spaces	Specifics
89.9	13.5	54	1.7	6.7	25%	Required kW, L2
77.8	40.5	54	1.4	1.9	75%	Required kW, L1
167.6	***54***	***Total Power & Charging Spaces***				

Low Power L2, 3.3 kW at the EV per unit with parking

Total kW, EV-I	*Charging Spaces*	*# Spaces*	*kW/ Space*	*kW*	*% Spaces*	*Specifics*
179.7	54	54	*3.3*	*3.3*	100%	***EV Ready, LPL2***
179.7	**54**	***Total Power & Charging Spaces***				
107%	***Equal***	***% More power & equal number of charging spaces compared to PCE/SVCE Nov 2019 proposal***				

HCD 12 April 2021 Proposal

Total kW, EV-I	Charging Spaces	# Spaces	kW/ Space	kW	% Spaces	Specifics
71.9	10.8	108	*0.7*	6.7	10%	EV Capable, L2
89.9	27	108	*0.8*	3.3	25%	EV Ready, LPL2
35.9	5.4	108	*0.3*	6.7	5%	EV Ready, L2 EVSE
197.7	***43.2***	***Total Power & Charging Spaces***				
118%	***80%***	***% More power & % charging spaces compared to PCE/SVCE Nov 2019 proposal***				

As illustrated in Figure 5, the low power Level 2 alternative compliance pathway requires approximately 7% more power than the PCE/SVCE 2019 reach code while the HCD pathway requires approximately 118% more power.

Based on the above, Figure 6 calculates and compares the costs of the two pathways based on the costs of the PCE/SVCE 2020 reach code (as referenced in Figure 3 above and determined by Energy Solutions). For example, as the low power Level 2 pathway requires ~7% more power, the low power Level 2 costs associated with those items is 7% more than that of the PCE/SVCE 2019 reach code. This same protocol is used to determine the cost of the HCD pathway; for both power (118%) and raceway and electrical components. To fully compare the cost of ports under each set of codes, Figure 6 also calculates the cost to bring the EV-Capable ports in the HCD pathway to EV Ready status.

Figure 6. Cost Comparison: PCE/SVCE 2019 Reach Code, Low Power Level 2 Pathway and HCD April 2021 Pathway

PCE/SVCE	% LPL2	$ LPL2	% HCD	$ HCD	Item
$15,960	107%	$17,112	118%	$18,823	Electrical Panel
$13,609	107%	$14,591	118%	$16,050	Main electrical room, excluding transformer
$14,164	107%	$15,186	118%	$16,705	Transformer(480v->208v)
$18,059	107%	$19,362	80%	$14,447	Raceway / In-slab conduit
$11,366	100%	$11,366	60%	$6,820	Electrical components (wire, receptacle)
$2,435	100%	$2,435	80%	$1,948	Permitting & Inspection Fee
$549	100%	$549	100%	$549	Construction Management
n/a		n/a		$8,100.00	HCD, EVSE, $1500/ EVSE
$76,142		***$80,601***		***$83,442***	***Proposal Construction Costs***
54		**54**		**32**	Ports, EV Ready+EVSE
0		**0**		**11**	Ports, EV Capable
$1,410		***$1,493***		***$2,575***	***$/ Port, Day 1, Operational***
Converting the HCD EV Capable Ports to EV Ready Ports					
n/a		n/a		$2,273	EV Ready: Run wire, breakers, receptacles 20%
n/a		n/a		$731	EV Ready:Permitting, 30%
n/a		n/a		$55	EV Ready: Construction Management, 10%
n/a		***n/a***		***$3,059***	***Delta to go to EV Ready***
$76,142		***$80,601***		***$86,500***	***EV Ready Cost Comparison***
54		***54***		***43***	***Ports, EV Ready+EVSE***
$1,410		***$1,493***		***$2,002***	***$/ port EV Ready+EVSE***
100%		***100%***		***80%***	***% Units, EV Ready or EVSE***

From Figure 6, for this building scenario, initial construction costs for the low power Level 2 pathway are approximately 3.5% less than the HCD pathway. Further, the day one, per port, EV Ready cost, for the low power Level 2 pathway is 48% less than the HCD pathway. Most importantly, the low power Level 2 alternative pathway provides access to power for every unit; the HCD pathway provides power to only 32 units, (assuming the 32 are all designated for differing units) with potentially no capability to serve residents of the final 9 units once the EV Capable spaces are converted to EV Ready.

Figure 7 compares the costs of the low power Level 2 pathway and the HCD pathway to other common building components (HVAC systems and windows), based on typical construction costs for a $30M, 60-unit MFD[3].

[3] $30M, 60 unit MFD cost provided by Katie Ackerly (katieackerly@dbarchitect.com); Windows and HVAC cost provided by Sean Armstrong (RedwoodEnergy.net)

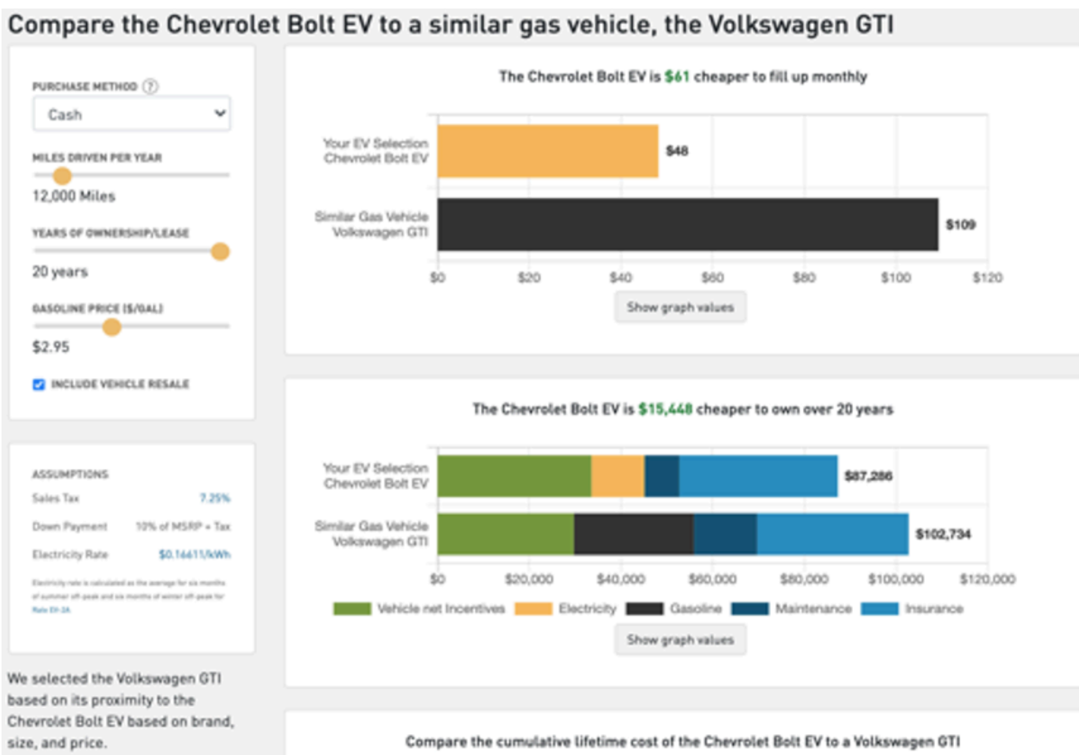
Figure 7. Percentage of total Construction Costs, 60 Unit MFD

0.27%	Low Power Level 2
0.28%	HCD, Day 1
0.29%	HCD, All EV Ready, EVSE
1.0%	Windows ($5k/unit)
3.0%	HVAC ($15k/unit)

EV Infrastructure Economic and Environmental Impacts

The same 60-unit, 54 parking space MFD scenario was used to evaluate the relative economic and environmental impacts of the low power Level 2 and HCD pathways. As noted by Figure 8, Pacific Gas and Electric's (PG&E) online EV Saving Calculator tool[4] was used to compare the costs of an internal combustion engine (ICE) car to those of an all electric vehicle. For the example shown in Figure 8, the ICE car was the Volkswagen GTI and the EV was the Chevrolet Bolt. Figure 8 also shows the total cost of ownership for each vehicle over twenty years, and from this the annual cost by vehicle is calculated.

Figure 8. PG&E's EV Saving Calculator, Chevrolet Bolt versus Volkswagen GTI



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[4] https://ev.pge.com/vehicles/Chevrolet_Bolt__BEV_2020

Figure 9, uses an EV adoption percentage[5] by year, from 2025 to 2045, and calculates the annual costs and fuel use partitioned between the EV and the ICE vehicles by year for the low power Level 2 and HCD pathways plus a 100% ICE vehicle as the base case.

[5] The adoption percentage is based on best engineering judgement, integrating California's EV adoption and climate goals, national and sub-national EV adoption requirements and goals, OEM EV expenditures, etc.

Figure 9. Total 20-Year Economic and Environmental Benefits: LPL2 and HCD Pathways

60-Unit MFD Scenario from Energy Solutions

ENVIRONMENTAL ANALYSIS		
LPL2 Emitted Tons CO2 1,707	HCD Emitted Tons CO2 2,304	Emitted Tons, 100% ICE 3402
LPL2 Avoided Tons CO2 1,695	HCD Avoided Tons CO2 1098	Avoided Tons CO2 0
ECONOMIC ANALYSIS		
LPL2 $ Savings, Compared to 100% ICE $436,282	HCD $ Savings, Compared to 100% ICE $282,776	$ Savings, 100% ICE $0
$ Spend EV+ICE $5,388,735	$ Spend EV+ICE $5,542,242	100% ICE $5,825,018
$ Spend EV: $2,465,131 $ Spend ICE: $2,923,604	$ Spend EV: $1,597,770 $ Spend ICE: $3,944,472	

BASIS, (By Year, EV Adoption Rate Charging Rate, Vehicle Type $ Spend Rate & Gasoline Use

Year, EV Adoption, # Max EVs			LPL2 EVs Charging, $ Spend by EV & ICE + Gasoline Use				HCD EVs Charging, $ Spend by EV & ICE + Gasoline Use				100% ICE, $ & Gasoline Use	
Year	% Adoption	# EVs, Max	LPL2-EVs	$/Year EV	$/Year ICE	Gal/year	HCD-EVs	$/Year EV	$/Year ICE	Gal/year	$/Yr-100%ICE	Gal/Yr-100%ICE
2025	10%	5.4	5.4	$23,567	$249,644	14,580	5.4	$23,567	$249,644	14,580	$277,381.80	16,200
2026	13%	7.0	7.0	$30,637	$241,322	14,094	7.0	$30,637	$241,322	14,094	$277,381.80	16,200
2027	16%	8.6	8.6	$37,708	$233,001	13,608	8.6	$37,708	$233,001	13,608	$277,381.80	16,200
2028	19%	10.3	10.3	$44,778	$224,679	13,122	10.3	$44,778	$224,679	13,122	$277,381.80	16,200
2029	22%	11.9	11.9	$51,848	$216,358	12,636	11.9	$51,848	$216,358	12,636	$277,381.80	16,200
2030	25%	13.5	13.5	$58,918	$208,036	12,150	13.5	$58,918	$208,036	12,150	$277,381.80	16,200
2031	28%	15.1	15.1	$65,988	$199,715	11,664	15.1	$65,988	$199,715	11,664	$277,381.80	16,200
2032	32%	17.3	17.3	$75,415	$188,620	11,016	17.3	$75,415	$188,620	11,016	$277,381.80	16,200
2033	36%	19.4	19.4	$84,842	$177,524	10,368	19.0	$82,922	$179,785	10,500	$277,381.80	16,200
2034	40%	21.6	21.6	$94,269	$166,429	9,720	19.0	$82,922	$179,785	10,500	$277,381.80	16,200
2035	45%	24.3	24.3	$106,052	$152,560	8,910	19.0	$82,922	$179,785	10,500	$277,381.80	16,200
2036	50%	27.0	27.0	$117,836	$138,691	8,100	22	$96,015	$164,374	9,600	$277,381.80	16,200
2037	55%	29.7	29.7	$129,620	$124,822	7,290	22	$96,015	$164,374	9,600	$277,381.80	16,200
2038	60%	32.4	32.4	$141,403	$110,953	6,480	22	$96,015	$164,374	9,600	$277,381.80	16,200
2039	65%	35.1	35.1	$153,187	$97,084	5,670	22	$96,015	$164,374	9,600	$277,381.80	16,200
2040	72%	38.9	38.9	$169,684	$77,667	4,536	22	$96,015	$164,374	9,600	$277,381.80	16,200
2041	79%	42.7	42.7	$186,181	$58,250	3,402	22	$96,015	$164,374	9,600	$277,381.80	16,200
2042	86%	46.4	46.4	$202,678	$38,833	2,268	22	$96,015	$164,374	9,600	$277,381.80	16,200
2043	93%	50.2	50.2	$219,175	$19,417	1,134	22	$96,015	$164,374	9,600	$277,381.80	16,200
2044	100%	54.0	54.0	$235,672	$0	0	22	$96,015	$164,374	9,600	$277,381.80	16,200
2045	100%	54.0	54.0	$235,672	$0	0	22	$96,015	$164,374	9,600	$277,381.80	16,200

As calculated in Figure 9, over the 20 year period, the low power Level 2 alternative compliance pathway provides the 60-unit MFD residents the largest savings ($436,282) and the lowest carbon footprint (1,707 tons CO2). This is compared to the HCD pathway which provides a smaller estimated savings ($282,776) and a larger carbon footprint (2,304 tons CO2).

To calculate the statewide impacts over the three years that the code will be in effect (2023-2025) the number of new MFD units is first projected. As noted in Figure 10, this is based on historic data of the single family and MFD units built in California since 2004 as provided by Robert Raymer, California Building Industry Association. From Figure 10, it is estimated that there will be approximately 50,000 MFD units built per year resulting in a total of 150,000 new MFD units over the three-year code cycle.

Figure 10. Single Family and MFD Units Built in California since 2004

Year	*Single-Family*	*Multi-Family*	*Total*
2004	151,417	61,543	212,960
2005	155,322	53,650	208,972
2006	108,021	56,259	164,280
2007	68,409	44,625	113,034
2008	33,050	31,912	64,962
2009	25,454	10,967	36,421
2010	25,526	19,236	44,762
2011	21,641	25,702	47,343
2012	27,560	31,665	59,225
2013	36,991	48,481	85,472
2014	37,089	48,755	85,844
2015	44,896	53,337	98,233
2016	49,208	51,753	100,961
2017	55,827	59,843	115,670
2018	59,049	58,843	117,892
2019	58,052	53,232	111,284
2020*	53,592	56,765	110,357

*Projected

Scaling the savings and avoided emissions from the 60-unit MFD data contained in Figure 9, the statewide impact of the low power Level 2 pathway results in a savings of $1.09 billion over the status quo and avoids 4.2M tons of CO2. This is compared to the HCD pathway which would save an estimated $707M and avoid 2.7M tons of CO2.

Sven Thesen & Associates appreciates the opportunity to present this draft analysis. We look forward to both HCD and CARB comments.

Sincerely,

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