Analysis of GHG Reductions from High-Speed Rail In the AB 32 Proposed Scoping Plan

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Background

The California Global Warming Solutions Act of 2006 (AB 32; Stats. 2006, chapter 488) requires California to reduce its greenhouse gas (GHG) emissions to 1990 levels by 2020. The goal is an ambitious one, requiring that 2020 GHG emissions be 9% lower than actual 2002-2004 emissions, and 28% lower than Business as Usual (BAU) projections for 2020.

In October 2008 the California Air Resources Board (CARB) released its Proposed Scoping Plan, which outlines a policy framework for achieving the 2020 target specified by AB 32. The Proposed Scoping Plan is a revision of the June 2008 Draft Scoping Plan and addresses some of the concerns that were raised regarding the Draft Plan.

The 2020 GHG targets represent a first step toward California's long-term goal of reducing GHG emissions 80% between now and 2050. Some of the measures called for in the Proposed Plan have relatively modest impacts in 2020, but are nevertheless important because they put California on a path toward the 2050 goal.

Table 1 summarizes California's sources of GHGs. Transportation accounts for the largest share of California's GHG emissions, with a 38% share in both 2002-2004 and in the 2020 BAU projections. GHGs are measured, both in the Proposed Scoping Plan and in this paper, in millions of metric tons of carbon dioxide equivalent (MMTCO_2E).

Table 1
California Greenhouse Gas Sources
2002-2004 Average and 2020 BAU Projection
(MMTCO_2E)

SECTOR	2002-2004 AVERAGE	2020 BAU PROJECTION
Transportation	179.3	225.4
Electricity	109.0	139.2
Commercial and Residential	41.0	46.7
Industry	95.9	100.5
Recycling and Waste	5.6	7.7
High Global Warming Potential	14.8	46.9
Agriculture	27.7	29.8
Forest Net Emissions	-4.7	0
Emissions Total	469	596

Source: CARB Proposed Scoping Plan, Table 1

AB 32 requires that CO_2E emissions in 2020 be 169 MMT lower than BAU levels. Table 2 summarizes the 2020 reductions from BAU levels that are outlined in the Proposed Scoping Plan.

Table 2
2020 GHG Reductions from Recommended Measures
(MMT CO_2E)

TOTAL	174
Transportation	62
Electricity	50
High Global Warming Potential	20
Other sectors	8
Cap and Trade	34

Source: CARB Proposed Scoping Plan, Table 2 and author's calculations

Specific regulatory measures provide most of the reductions, with 62 MMT of the regulatory reductions coming from the transportation sector. The final 34 $MMTCO_2E$ come from a broad cap-and-trade program which has been recommended as an adjunct to the sector-specific measures.

This paper analyzes CARB's GHG reduction estimates from one of the recommended transportation measures, high-speed rail (HSR). The proposed HSR system would connect southern California, the Central Valley, and the Bay Area by electric-powered passenger trains. On November 4, 2008, California voters approved Proposition 1A, providing authority for the state to issue nearly $10 billion in bonds to construct the high-speed rail system.

CARB estimates that HSR will reduce GHG emissions in 2020 by 1.1 $MMTCO_2E$, mostly by diverting passengers from air and auto travel to rail. In addition, it is likely that HSR would affect GHG emissions by changing land use patterns. Neither CARB nor this paper addresses these land use changes or their effects on GHG emissions.

The analysis presented here suggests that CARB has underestimated the GHG reductions that would result from HSR. Revised estimates indicate that HSR could reduce GHGs by at least twice as much as CARB projects. Nevertheless, GHG reductions due to HSR represent only a small proportion of the 2020 GHG reductions required by AB 32.

Analyzing CARB's GHG estimates

CARB's analysis uses 2020 GHG reductions compared with BAU as its primary metric; this construction allows direct comparisons of outcomes with and without specific policy measures. This paper's analysis follows the same overall structure. However, ultimately it is the level of GHGs that is important, and not the reduction from BAU.

In fact, projecting GHG emissions under a BAU scenario presents some thorny conceptual issues. One such issue is oil prices. Most analysis of energy and transportation issues relies on energy price forecasts produced by state or federal energy agencies; these forecasts are low relative to current and recent market prices.

In addition, there are policy reasons to expect that fuel prices will be higher in 2020 than they are today. The cap-and-trade program outlined in CARB's Proposed Scoping Plan is just one of many such proposals currently under discussion at the state, regional, and federal levels. Carbon taxes are also under consideration by various governmental agencies. Both cap-and-trade and a carbon tax would tend to increase fuel prices.

If transportation fuels are significantly more expensive in 2020 than currently projected, fuel consumption and GHG emissions in 2020 would be lower than the BAU projections even in the absence of specific measures aimed at reducing transportation-related GHGs.

More generally, the many market conditions and policies that affect consumers' transportation decisions interact with each other, and these interactions can be significant. Stand-alone analysis of one policy proposal cannot capture these interactions. For example, most of the GHG benefits of HSR derive from the reduction in auto and air trips that HSR would make possible. To the extent that other policies reduce travel more generally, or reduce the carbon intensity of air and/or auto travel, HSR would have a smaller effect on GHG emissions than would be estimated based on HSR as an isolated policy measure.

High-Speed Rail

The Proposed Scoping Plan addresses GHG emissions in 2020, which is expected to be the first year of operation for the high-speed rail system. Because high-speed rail will just be starting operation in 2020, GHG reductions expected in 2020 would be smaller than the reductions expected in later years.

CARB's estimated GHG reductions attributable to HSR are based on a ridership study prepared by Cambridge Systematics, Inc. (CS), which generated projections of HSR ridership in 2030. To calculate 2020 estimates using CS's 2030 projections, CARB assumed that the number of riders in 2020 would be 40% of the number estimated for 2030, that the mix of riders (between air and auto displacement) would be the same in 2020 as in 2030, and that 2020 energy use by HSR would be 50% of the 2030 energy use. Table 3 shows CARB's estimates for 2020, CARB's ratios for HSR ridership and energy use, and the author's calculations of 2030 emissions based on information and assumptions from CS and CARB.

Table 3
CARB Estimates, 2020 and 2030
GHG Effects of High-Speed Rail
($MMTCO_2E$)

	2030	2020	ratio 2020 to 2030
High-Speed Rail	1.01	.50	.5
Air Travel Displaced	-.83	-.33	.4
Vehicle Travel Displaced	-3.16	-1.27	.4
Other Travel Displaced	-.10	-.04	.4
NET EFFECT OF HSR	-3.08	-1.14	

Source: CARB, Proposed Scoping Plan, Appendix I, p. I-21, and author's calculations

The next step in the analysis is to examine in greater detail the data and assumptions CARB used in its calculations. To this end, Table 4 presents calculations for 2030 using CS's ridership projections and the parameters CARB used to calculate GHG reductions using CS's ridership projections.

Table 4
GHG Reductions due to HSR, 2030
CARB Methodology

High-Speed Rail Travel		Data Source
Electricity to power HSR (million MWh)	2.3	CARB
Metric tons CO_2E per MWh	0.437	CARB
Total High-Speed Rail GHG emissions	*1.01 MMT CO_2E*	
Air Travel Displaced		
Number of Air Passengers displaced (millions)	10.5	CS
Miles per trip	350	CARB
Pounds of CO_2E per air passenger mile	0.5	CARB
Air travel GHG emissions avoided	*-0.83 MMT CO_2E*	
Vehicle Travel Displaced		
Number of vehicle passengers (millions)	46.7	CS
Number of passengers per vehicle	1.5	CS
Number of miles per trip	250	CARB
Average miles per gallon	22	CARB
Metric tons of CO_2E per gallon of gas	.00894	CARB
Vehicle travel GHG emissions avoided	*-3.16 MMT CO_2E*	
Other Travel Displaced		
Number of passengers (millions)	4.3	CS
Energy use/mile compared with vehicles	0.33	CARB
Other Travel GHG emissions avoided	*-0.10 MMT CO_2E*	
NET GHG REDUCTION DUE TO HSR	***-3.08 MMT CO_2E***	

Source: CARB, Proposed Scoping Plan, Appendix I, p. I-21, and author's calculations

The detail in Table 4 allows us to examine the assumptions that were made in translating the ridership numbers into changes in GHG emissions. Three of the parameters in Table 4 are open to question.

Metric Tons of CO_2E per MWh. CARB used the same CO_2E emissions per MWh of 0.437 metric tons in its calculation of the GHG benefits off the Renewable Portfolio Standard (RPS). However, CARB estimated emissions at 0.437 metric tons per MWh without the RPS, and the RPS specifies that 33% of California's electricity in 2020 must come from renewable sources. According to CARB's analysis of the RPS, the RPS would reduce electricity-related emissions by one third in 2020. Therefore with the RPS CO_2E emissions per MWh would be two thirds of 0.437 MT, or 0.291 MT CO_2E per MWh.

Pounds of CO_2E per air passenger mile. CARB uses a figure of 0.5 pounds per air passenger mile, which is lower than many other analysts use. CO_2E emissions from air travel are difficult to quantify, but they tend to be higher per mile for shorter trips and there are significant climate change effects that are not captured by CO_2 emissions alone. Among online carbon calculators Carbon Counter uses 1.3068 pounds per passenger mile. Native Energy uses 1.28 pounds per passenger mile for short-haul flights, calculated by taking the CO_2 emissions of 0.64 pounds per passenger-mile and doubling the CO_2 emissions to get the total climate change impact. Both of these figures are based on information provided by the International Panel on Climate Change. Given the available information 1.3 pounds per passenger mile is a reasonable figure to use for short-haul, intrastate flights.

Average miles per gallon. Currently, in 2008, the fleetwide average mileage is about 20 miles per gallon. Many energy forecasts estimate 2020 fleet mileage at 22 miles per gallon. However, with the Pavley standards in California and expectations of higher fuel prices in the future this estimate seems low. The California Energy Commission projects 2020 average mileage at 24.84 MPG under its "base fuel price with GHG standards" scenario, which seems somewhat more realistic as a projection for 2020.

A final issue with CARB's projections is that the CS ridership study was conducted using standard assumptions for future gasoline prices, which as mentioned earlier tend to be quite low. The base case automobile operating cost used in the CS study was $0.20 per mile (in 2005 dollars). CS assumes that the non-gas operating cost is 60% of the gasoline cost per mile. Therefore an operating cost of $0.20 per mile would be associated with a gasoline price of $2.74 per gallon.

CS ran various sensitivity analyses, including a scenario in which air and auto costs were 50% higher than the base case scenario. To get a sense of how plausible this "high cost" scenario is, consider auto operating costs that are 50% higher than the base case, or $0.30 per mile. Corresponding gasoline prices would be in the $4 to $5 range. (The exact gasoline price associated with $0.30 per mile operating cost depends on assumptions about the relationship between gasoline and non-gasoline operating costs.) Looking ahead 10 to 20 years a gasoline price in the $4 to $5 per gallon range would seem rather more plausible than does a price of less than $3 per gallon. The sensitivity analysis in the CS study found that a 50% increase in air and auto costs would increase HSR ridership by 46%.

Table 5 presents alternative calculations of GHG reductions in 2030. Ridership and electricity use are 46% higher than CARB's calculations, reflecting the "high air/auto cost" scenario generated in the CS ridership study. The entries that are different from those in Table 4 due to the higher fuel cost assumption are marked with stars in Table 5.

In addition, the calculations in Table 5 use parameters for metric tons of CO_2 per MWh, pounds of CO_2E per air passenger mile, and auto miles per gallon that have been revised from the CARB values to address the issues discussed above. These parameters are marked with asterisks in Table 5.

Table 5
Calculation of GHG Reductions due to HSR, 2030
Author's Calculations

High-Speed Rail Travel		**Data Source**
✭Electricity to power HSR (million MWh)	3.36	CARB + 46%
*Metric tons CO_2E per MWh	0.291	author
Total High-Speed Rail GHG emissions	*0.98 MMT CO_2E*	
Air Travel Displaced		
✭Number of air passengers displaced (millions)	15.33	CS + 46%
Miles per trip	350	CARB
*Pounds of CO_2 per air passenger mile	1.3	author
Air travel GHG emissions avoided	*-3.16 MMT CO_2E*	
Vehicle Travel Displaced		
✭Number of vehicle passengers displaced (millions)	68.18	CS + 46%
Number of passengers per vehicle	1.5	CS
Number of miles per trip	250	CARB
*Average miles per gallon	24.84	CEC
Metric tons of CO_2 per gallon of gas	.00894	CARB
Vehicle travel GHG emissions avoided	*-4.09 MMT CO_2E*	
Other Travel Displaced		
✭Number of other passengers displaced (millions)	6.28	CS + 46%
Energy use/mile compared with vehicles	0.33	CARB
Other Travel GHG emissions avoided	*-0.12 MMT CO_2E*	
NET GHG REDUCTION DUE TO HSR	**-6.39 MMT CO_2E**	

✭Ridership numbers are higher than those in Table 4 due to higher fuel costs
*Parameters that differ from those in Table 4
Sources: CARB, Proposed Scoping Plan, Appendix I, p. I-21; CS report p. 7-1; and author's calculations

Changing the parameters and the expected costs of air and auto travel more than doubles the GHG reductions anticipated from HSR in 2030. HSR generates a 2030 GHG reduction of 6.4 MMT CO_2E using the revised data, compared with a GHG reduction of 3.1 MMT CO_2E using CARB's data and assumptions.

The next step in the analysis is to bring the calculations back to 2020, which is the target year for CARB's analysis. To do so, I use CARB's assumptions, which are that electricity use in 2020 is 50% of 2030 electricity use, and that ridership in 2020 is 40% of 2030 ridership. (2020 is expected to be the first year of operation for the HSR system.) Table 6 presents the 2030 calculations from Table 5 as well as the associated 2020 results.

Table 6
GHG Reductions due to HSR, 2020 and 2030
Author's Calculations
($MMTCO_2E$)

	2030	2020	ratio 2020 to 2030
High-Speed Rail	0.98	0.49	.5
Air Travel Displaced	-3.16	-1.26	.4
Vehicle Travel Displaced	-4.09	-1.64	.4
Other Travel Displaced	-0.12	-.05	.4
NET EFFECT OF HSR	-6.39	-2.46	

Source: CARB, Proposed Scoping Plan, Appendix I, p. I-21, and author's calculations

To conclude the HSR analysis, we compare 2020 estimates of GHG reductions calculated by CARB and calculated by the author. These comparisons are shown in Table 7.

Table 7
Sources of Differences Between CARB and Author Estimates, 2020
GHG Effects of High-Speed Rail
($MMTCO_2E$)

	CARB estimate	chg due to parameters	chg due to fuel price	author's estimate
High-Speed Rail	+0.50	-0.17	+0.16	+0.49
Air Travel Displaced	-0.33	-0.53	-0.40	-1.26
Vehicle Travel Displaced	-1.27	+0.14	-0.51	-1.64
Other Travel Displaced	-0.04	+0.01	-0.02	-0.05
NET EFFECT OF HSR	-1.14	-0.55	-0.77	-2.46

Source: CARB, Proposed Scoping Plan, Appendix I, p. I-21, and author's calculations

The revised estimates show GHG reductions associated with HSR that are more than twice as large as CARB's estimates. The most important sources of the differences between the two estimates are the parameter for GHG emissions per mile of air travel and the higher fuel price.

Air travel is a major contributor to climate change, and shifting travelers from air to rail travel provides a significant part of the GHG benefits from HSR. In addition, higher fuel prices increase the ridership of the HSR system, as higher air fares and higher gasoline prices cause travelers to reevaluate their transportation options. Since the benefits of HSR derive from the vehicle and air trips displaced, increasing HSR ridership increases the GHG reductions generated by HSR.

Conclusions

This paper has examined CARB's estimates of GHG reductions from high-speed rail. This analysis indicates that, under reasonable assumptions about parameters and future fuel prices, GHG reductions from high-speed rail could be more than twice as large as CARB projects. Alternative estimates suggest that in 2020 GHG reductions would be 2.5 MMT CO_2E, significantly more than CARB's estimate of 1.1 MMT CO_2E. As CARB points out, GHG reductions due to HSR would be higher after the introductory year of 2020. Analysis suggests that HSR could generate GHG reductions in 2030 of 6.4 MMT CO_2E, significantly higher than CARB's 2030 estimate of 3.1 MMT CO_2E.

Nevertheless, compared with AB 32's ambitious goal, estimated GHG reductions from HSR are modest. Table 8 presents the Proposed Scoping Plan's estimates of GHG reductions from most of the recommended transportation measures, along with the author's estimate of GHG reductions due to HSR.

Table 8
2020 GHG Reductions from Recommended Transportation Measures
(MMT CO_2E)

Light-Duty Vehicle Standards	31.7
Low-Carbon Fuel Standard	15.0
Regional land-use	5.0
Vehicle efficiency measures	4.5
Goods movement	3.7
Medium-duty vehicles	1.4
High-speed rail	2.5

Sources: CARB Proposed Scoping Plan, Table 2, and, for high-speed rail, author's calculations

By way of comparison, CARB is targeting total GHG reductions of 174 MMT CO_2E in 2020, with 62 MMT from the transportation sector.

In evaluating the potential GHG reductions due to high-speed rail, there are important potential effects that these calculations do not capture. First, the high-speed rail system would be very new in 2020, and its contribution to GHG reductions would probably be larger in both absolute and relative terms in later years as the high-speed rail system is completed and expanded.

Second, land-use policies that promote denser development are key to California's plans for a low-carbon future. To the extent that high-speed rail can stimulate denser, more transit-friendly development, it could play a significant role in California's future. The effects of land-use decisions made during the next ten years will just be starting to bear fruit in terms of reduced vehicle miles traveled in 2020, so the time frame for measuring the GHG reductions due to AB 32 would tend to underestimate the longer-term impacts of land-use decisions as well.

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