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Environmental and Other Co-benefits of Developing a High Speed Rail System in California: A Prospective Vision 2010-2050

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Environmental Impact of High Speed Rail in California

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Overview of the Paper

California is in the process of developing a high speed rail (HSR) system that would run much the length of the state, connecting its urban areas. This paper examines the environmental impacts that such a system could produce.

The paper begins with a brief discussion of the California High Speed Rail Authority's proposed system. The paper then reviews the complex environmental review process that is underway and some of the issues it raises. Since neither the final design nor the environmental assessment for the project is yet complete, a number of gaps remain in the environmental analyses available at this time. However, some of the environmental uncertainties result from questions about the cost estimates and demand forecasts for the project, which in turn raise questions about the operations plans that would be feasible if demand and costs are indeed substantially different from current figures. Furthermore, the future performance of competing modes and future urban development and transport also affect HSR environmental performance and are sources of additional uncertainty. Technology advances, policy changes, and planning interventions all could alter HSR environmental impacts. These factors are discussed in the paper.

The CHSRA Proposal

The California High Speed Rail Authority (CHSRA) has developed a proposal for a two-phase implementation of a system of high speed trains spanning the state (See www.chsra.ca.gov for details.) The system would be developed in phases. The first phase would provide service between San Francisco and Los Angeles with an extension to Anaheim, running on about 500 miles of tracks. Later phases would extend services from San Jose to Oakland, Stockton and Sacramento, and from Los Angeles to San Diego via the Inland Empire, bringing the total length of the system up to about 800 miles of rail lines. Plans call for construction to begin late in 2012, with passenger service on the first phase system by 2020. The decision on the first section for the system will be made shortly. Figure 1 shows the proposed system and stations.

According to the CHSRA, trains will carry up to 1000 passengers each, at speeds up to 220 mph. Up to 24 stations will be built. Headways will be as low as 5 min. in peak periods. Current fares are estimated to be around $100 for San Francisco to Los Angeles, about the same as a plane ticket today.

The CHSRA has estimated that ridership could be "as much as" 100 million or more a year by 2030. (This is about the same as current ridership on the Bay Area Rapid Transit (BART), which serves four counties and 39 stations.) However, CHSRA has also produced lower estimates of ridership in the recent past.

CHSRA's estimate for the cost of the system is about $40 billion (2008). Clearly timing, inflation rates, construction prices, and design details including mitigation could alter the cost figures. To date, about $12 B of the needed funding has been identified. Proposition 1A - dubbed the Safe, Reliable High-Speed Passenger Train Bond Act for the 21st Century - authorized the issuance of 9.95 B in general obligation bonds; it was approved 52.6% to 48.4% in Nov. 2008. However under the current economic climate no bonds have yet been sold. The federal government has

provided an additional $3 billion for CA HSR, with $2.344B made available in January 2010 through the American Recovery and Reinvestment Act (ARRA) and $715 million in additional federal funds announced Oct. 2010. Most of the federal funds are designated for the Central Valley, and current plans would allocate a total of $4.3 billion build the first section of the system there, with ARRA funds matched dollar for dollar with state funds and the Oct. 2010 award matched 30% in state funding.

Figure 1. Proposed CA HSR System

Planning and Environmental Review Process and Objectives

Planning and environmental review for HSR in California has been going on for almost two decades. The current, CHSRA process, which began in 19XX, includes multiple steps:

- **Scoping** – determining the project, alignment and station options
- **Alternatives Analysis** – added by CHSRA (not legally required for HSR)as a way to involve local governments and other stakeholders in the decision process
- **Draft and Final EIR/EISs**:
    - Statewide system-level environmental review (completed 2005)
    - Section by section environmental reviews (underway.)

The section-level environmental reviews are being done for the following nine sections:

- San Francisco - San Jose
- San Jose - Merced
- Merced - Fresno
- Fresno - Bakersfield
- Bakersfield - Palmdale
- Palmdale - Los Angeles
- Los Angeles - Anaheim
- Los Angeles - San Diego
- Sacramento - Merced

In addition, additional environmental work is also being done for the Altamont Corridor, where improvements to existing passenger rail services are proposed.

Preliminary design is taking place and is being refined during these detailed environmental review phases. Once the environmental reviews are approved (the deadline is Sept. 2011), right-of-way acquisition and construction procurement work will be done, followed by the actual construction itself, which is scheduled to begin in 2012. Then a period of testing will take place before the train system is commissioned to operate.

In developing and analyzing alternative routes, the CHSRA considered three major objectives for the project:

- maximize ridership and revenue potential, taking into consideration travel time as well as route length;
- maximize connectivity and accessibility, as measured by intermodal connections; and
- control operations and maintenance costs.

Additional objectives were added as the evaluations proceeded:

- Constructability – make choices that lead to an easily buildable and affordable project

- Minimize disruptions to neighborhoods and communities along the corridor by minimizing right-of-way acquisitions and other negative project design effects
- Avoid and minimize impacts on sensitive environmental and natural resources adjacent to the project corridor
- Support transit-oriented development within a half mile of the stations
- Provide for consistency with regional and local planning documents and proposals

These objectives were what led the project to seek use of existing rail right of way (or properties directly adjacent to rail ROW) and to serve urban downtowns.

The first segment to be implemented was recently (Dec. 2, 2010) selected**.** The Federal Railroad Administration had directed that the federal funding awarded to the project – both the stimulus funding and the Fiscal Year 2010-11 dollars – must be dedicated to a single section of the project in the Central Valley (Szabo, 2010). In response to this mandate, the CHSRA staff recommended and the Authority Board approved a 65 mile segment running from Madera to Corcoran with two stations –downtown Fresno and the other east of Hanford (Figure 2.) The estimated cost of this first segment is $4.15 billion, an amount that leaves enough of the currently available $4.3 billion to connect tracks to existing rail lines if necessary. This is in accordance with the federal government's requirement that a segment must have "independent utility.")

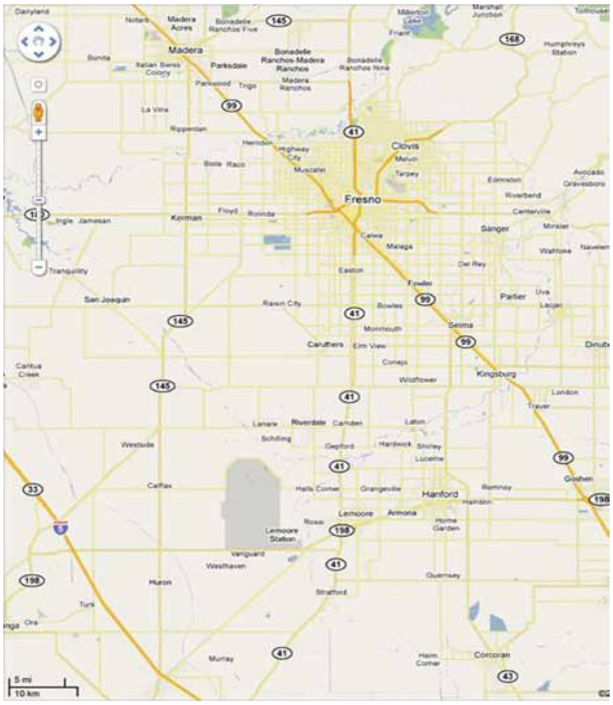


Figure 2. First segment to be built: from Madera in the north to Corcoran in the South, with stations in Fresno and east of Hanford

Environmental Issues Being Addressed

Both federal and California environmental laws must be addressed in the environmental review for the HSR project. The National Environmental Protection Act (NEPA) requires preparation of a statement of the environmental effects that rise to significance, the California Environmental Quality Act goes a step farther by also calling for mitigation of adverse effects. Because of the size and complexity of the projects and the many urban and natural environments it will affect, the series of environmental review documents will cover a full range of potential impacts.

Among the impacts identified as potentially significant are the following:

- Air quality
- Greenhouse gas emissions
- Water quality
- Impacts on wetlands, streams
- Impacts on habitat
- Impact on flora and fauna – endangered and threatened species: takings, other special concerns
- Noise and vibrations – effects on natural environment use and enjoyment (parks, wildlife)
- Disruption to rail and road transport during construction
- Permanent impacts on rail operations due to, e.g., loss or relocation of sidings
- Permanent changes to traffic circulation - increased circuitry and delay due to protection of ROW
- Traffic and parking impacts around stations
- Disruption, relocation of utilities
- New multimodal terminals and feeders services – transit improvements for broad catchment area could be induced or added as traffic mitigation
- Takings of homes and businesses – full and partial
- Loss of access to urban and rural parcels
- Severance of parcels
- Waterways, wetlands and nature preserves or biologically sensitive habitat areas affected
- Parklands lost, trails crossed
- Prime and unique farmland and farmland of statewide or local importance within limits of disturbance
- Encroachment into areas of highly erodible or otherwise sensitive soils
- Visual impacts of elevated structures, sound walls, other elements – can affect property values, enjoyment of open space
- Noise and vibration affects on buildings, roads, utilities
- New opportunities for infill, higher densities around HSR stations
- New businesses to serve travelers.

It should be noted that both short term impacts (including construction impacts) and longer term environmental consequences must be considered. Further, some of the impacts could be beneficial, while others will likely be negative. Comments from the public during scoping

sessions and environmental reviews indicated particular concerns about effects on neighborhoods - noise, visual impact, takings, severance , traffic and circulation changes - as well as potentially harmful impacts on parks and other sensitive land and species. Indeed, litigation over the impacts on the San Francisco Peninsula (Atherton v. CHSRA, 2009) is an indication of how strong concerns about environmental impacts can be.

CHSRA's Anticipated Benefits

Although the impacts of any major construction project are likely to be both positive and negative, the CHSRA's description of the HSR project emphasizes only the positive aspects of the project. Table 1, slightly modified from the CHSRA website, identifies key benefits that the CHSRA anticipates. They include transportation benefits (congestion relief, faster travel) and numerous jobs as well as environmental impacts such as reduced greenhouse gas emissions, improved energy efficiency, revitalized communities and improved safety.

Table 1. Benefits Identified in CHSRA Project Descriptions

Transportation	Employment	Environmental Quality	Urban Vitality
Congestion relief on freeways and at airports	Up to 100,000 construction-related jobs	Improved air quality; Reduced greenhouse gas emissions by 12 billion pounds per year	Revitalized communities, economic development around stations
Faster travel between major metropolitan areas	Up to 450,000 permanent new jobs over 25 yrs created by HSR economic growth	Improved energy efficiency: 1/3 energy use of planes, 1/5 that of cars	Transit- and pedestrian-oriented infill development
Improved movement of people, goods and services		Reduced dependence on foreign oil: 12.7 million barrels less per year	Enhanced public safety due to separation of tracks and highways

Source: http://www.cahighspeedrail.ca.gov/project_vision.aspx

Several analysts have been highly critical of these benefits claims. For example, Enthoven et al. (2010) question the magnitude and basis of employment forecasts. A large number of analysts (Levinson (1996), Levinson and Gillen (1996) , Levinson et al. (1996), van Wee et al. (2003), Kemp (2004) and Morris (2009) - among others) show that when the costs of construction are included, benefits per HSR passenger are considerably lower than when operations alone are considered - a point made decades earlier by Lave (1996). Cox and Vranich (2008) and Reason

Foundation (ND), among others, note that technological improvements in other modes are also likely and would narrow the gap between HSR and air or auto. Still other analysts, while less critical of HSR in general, note that the environmental benefits are likely to be modest and net benefits will depend largely on travel considerations (Kosinski et al, 2010.)

More generally, many analysts have characterized the California HSR project as a "megaproject" - one whose complexity, time frame, large size, and huge cost lead to risks of optimism bias (overconfidence, unduly favorable interpretations of evidence) and strategic misrepresentation (strategic misrepresentation, or lying) (Pickrell, 1992, Flybjerg et al, 2003, Altshuler and Luberoff, 2003.) The increases in costs over time have been one source of concern, but an even bigger source of concern appears to be the major increases in forecast ridership between 2000 and 2007. Forecasts prepared by Charles River Associates in 2007 estimated that the "investment grade" ridership would be about 37.9 million riders a year in 2020; their sensitivity analysis suggested a high ridership of up to 69.1 million riders annually. Forecast prepared seven years later by Cambridge Systematics for 2030 projected a much higher 65.5 million riders in the " base case" and up to 96.5 million riders for the high estimate. CHSRA has cited ridership figures even higher than this latter high estimate and apparently has calculated environmental benefits on the basis of the high estimate. (www.highspeedrail.ca.gov). Reviewers have questioned the methods used in the latter studies, although the consultants and agency dispute the criticisms (www.highspeedrail.ca.gov: Ridership_and_Revenue_Forecasting_Study.)

Why is this the accuracy of costs and forecasts an environmental issue? Largely, this is because some environmental impacts are a function of costs and ridership. For example, if construction cost overruns are severe, funds that might otherwise have been spent on environmental mitigation or amenities may be reduced. Likewise, if ridership falls short, both positive and negative impacts may fall short of those anticipated.

Indeed, in considering environmental impacts, it is useful to distinguish those that result from right of way and design choices, from those that are a function of operations, from those that are a function of demand. Many environmental costs result from building the system, whether or not there is good ridership: takings, severance, circuitry, impacts on parks, farmland, visual impact. Others are a function of the number of trains operating regardless of how many passengers are on it, e.g. noise, vibrations, and a significant portion of energy consumption and emissions. Still other environmental costs are a direct function of ridership. Examples include the traffic levels that will be experienced in station areas, and the potential for business growth related to passenger services.

With some analysts (Levinson, Reason) claiming that ridership could be closer to 20 million a year in 2030 than the currently projected 100 million, worries that forecasts are drastically too high could have significant environmental consequences in addition to the cost consequences. An accurate benefits assessment, including environmental assessment, rests in part on the accuracy of the demand forecasts.

Costs and Benefits Compared to What?

One area of considerable complexity in evaluating the environmental benefits is the comparison to other alternatives. For HSR, comparative environmental costs and savings depend on what is assumed to be happening in air and highway transport (the competition.)

What do we compare? Supply (capacity), technology, and policy are three factors that could affect the forecasts; some options are:

- HSR construction compared to new construction of equivalent capacity for air and highway travel, e.g., widened roadways, more flights, more runways, assumed to be needed to handle growth
- Effects of additional use of air and auto modes with little or no capacity expansion or technological change (and resulting congestion, emissions, etc.)
- Use of technologically advanced air and auto modes in the future, e.g., advanced highway operations, highly efficient motor vehicle technologies, quiet and fuel efficient aircraft, more effective air traffic control
- Continuation of current subsidies and services, e.g., subsidies to minor airports, subsidies to transit services that feed HSR stations
- Continued cuts in subsidies, up to eventual elimination of support for minor airports and for public transit.

Each of these options or a combination of them could be used to forecast how HSR would fare, with widely different results likely. Figuring out "most likely' trajectories is not a simple matter, because existing plans only help a little – for the most part there is not enough detail., and assumptions and time horizons differ. Scenarios thus may be the best way to proceed.

Scenarios also may be a way to address additional questions with environmental consequences - to size up how important the questions are. Some questions that might fall into this category are:

- How use of rail ROW would affect ability to move more freight by rail (only sketchily analyzed to date in publicly available studies)
- Longer term effects of global warming – e.g., flooding, storms affecting CA airports (could change cost functions and performance of airports)
- Induced travel – how many new trips would be made that are not made now? (could be negative from an environmental perspective, though from a mobility perspective it could be a positive outcome)
- Effect of comfort, ability to use time more effectively during travel; affect on mode choice (SP surveys address this in part, but how well do they predict esp. for Californians with limited train experience?)
- How AB32 and SB375 plans will change local investments in higher densities, transit; how they will affect investments in highways and airports.

Addressing such questions could provide useful insights not only for HSR but for other modes as well.

Example: Potential for Land Use Changes

As an example of environmental benefits and costs that might be indirectly associated with HSR, consider the potential for land use changes. The CHSRA has identified transit-oriented development around its stations as one of its objectives, and even though the catchment area for stations will surely be much larger, having TOD around stations could support ridership, especially in downtowns where ,many destinations would be within walking distance of the station and many more might be accessed via rail, bus, shuttle and taxi serving the station.

Figures 3-5 are taken from a study by Deakin et al. (2009) investigating infill development around the potential HSR station in Fresno. (A similar study for two other station areas was done as well; see Deakin et al. 2008). Figure 3 presents an analysis of infill potential, showing that there is a vast amount of un- and under-developed land. Figure 4 is an example of the sort of infill development that might be implemented. Figure 5 shows how bus rapid transit routes (BRT) could be used to improve connections to the downtown and make the station area multimodal. Together, strategies 4 and 5 could make it much easier for employees and visitors to use HSR.

Figure 3. Infill Development Potential – Fresno

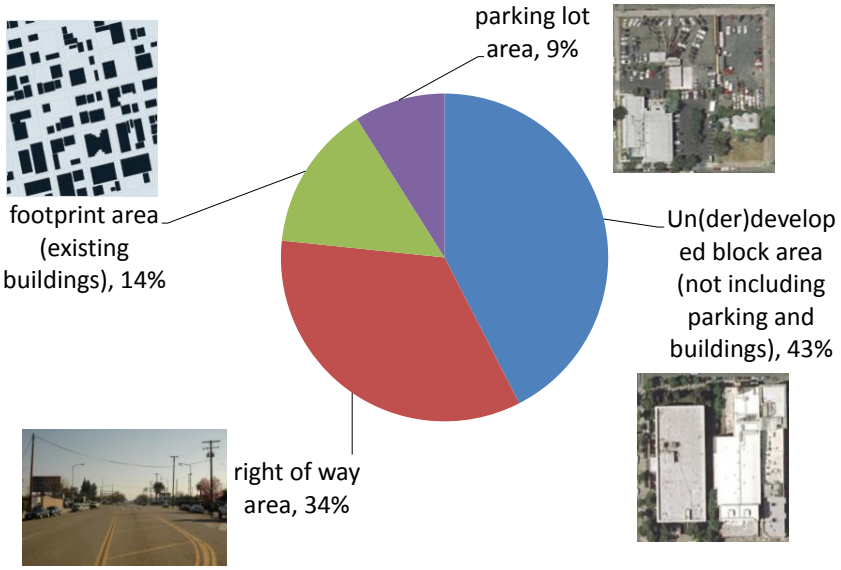
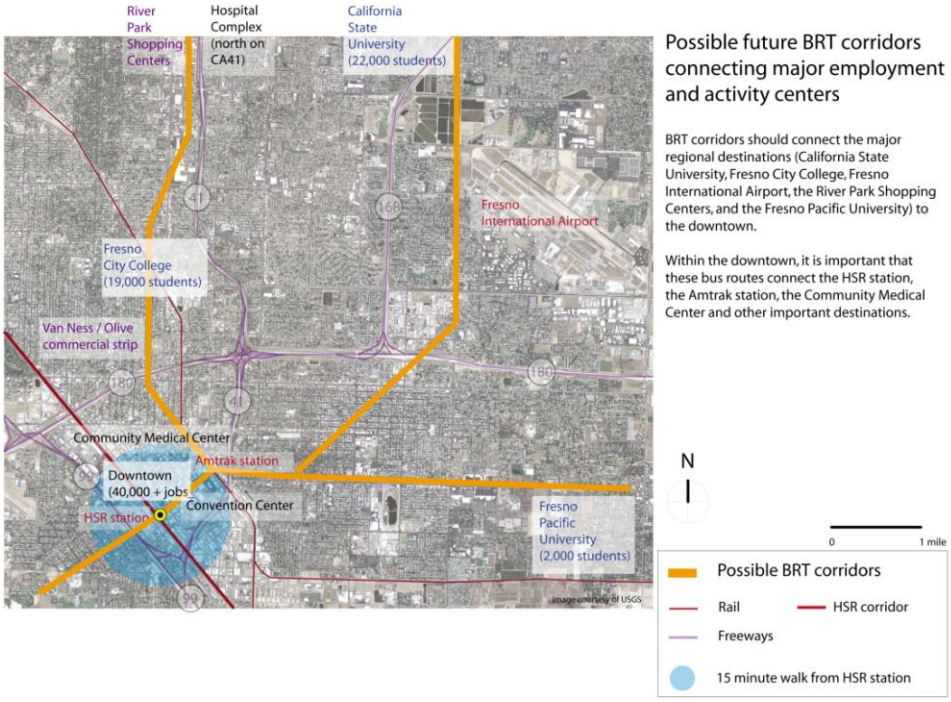


Figure 4. Infill Examples

Figure 5. BRT Complements



But how realistic are such concepts? The designs reflect possibilities for development that have not been checked against market realities. With a high unemployment rate, a flattened real estate market, and heavy current reliance on the automobile for nearly all travel, Fresno is not a particularly god prospect for new infill development any time soon. More generally, rail in such areas tends to be served by park and ride lots and used by travelers who arrive by car from distant locales. Might HSR actually promote more sprawl and long distance travel, especially long distance commuting? This question not only is important if we are to understand the impacts of HSR on California, it is also squarely within the set of questions SB375, the state's law to reduce greenhouse gases by curbing sprawl, must address. SB375 plans ('sustainable community strategies") are to increase infill around transit, and HSR multimodal stations could certainly be hubs for such development. However, it won't happen unless there is a market for it.

Summing Up: Risks, but Potential as Well

To sum up, high speed rail in California will affect the environment in a variety of ways. Both positive and negative impacts on the natural and built environment are likely. Some of the impacts, such as severance of properties, visual impact of structures, and changes in street connections and rail spur availability, will be determined by the choice of right of way and elevation, independent of actual ridership. Other impacts, such noise from trains, will depend on service frequency and speeds. Still other impacts, such as air pollution reduction and GHG emissions avoidance, will depend on how many passengers are attracted to HSR and what share of total passengers would otherwise have traveled by car or train. For the latter set of impact calculations, the future performance of cars, highways, aircraft and airports will also determine the comparative performance, and hence the net environmental benefits, of HSR.

Concerns about ridership forecasts mean that there are also concerns about the ability of California's HSR project to achieve the levels of energy savings, emissions reductions, and GHG avoidance it has claimed. Ridership estimates for the CHSRA have been as high as 100 million passengers a year by 2030; skeptics argue that the figures are likely to be much lower, perhaps as low as one fifth that level. Environmental benefits appear to be calculated based on the high estimates.

Ridership estimates seem to be high because of assumptions about low ticket costs, high speeds, and high frequency of service. On the other hand, the ability to make productive use of time on the train may not have been fully examined, and there appears to be room for further investigation of this and other demand questions, both through California studies and through international comparisons.

HSR's environmental impact also depends on how fast the technology of competing modes improves. HSR performance will look far better if cars in 2030 get 30 mpg than if they achieve 45 or 50 mpg. Likewise, if aircraft become far more fuel efficient (and airlines can afford to use

such aircraft in the California markets) HSR's projected advantage over air travel would be diminished.

Many impacts of HSR will depend on the specific alignment and elevation design decisions being developed now. Mitigation of these impacts will likely add costs to the project. An analysis of HSR's changing impacts over time (including a life cycle analysis)is worth doing, but the comparison to other modes likewise should include life cycle comparisons.

Urban impacts will depend not only on HSR plans but also on state and local actions that shape the context in which HSR will operate. If the next 10-12 million people and their jobs are located mostly in low density developments at the fringe of metropolitan areas, it seems likely that driving will continue to be the best option for many trips in the HSR range. If population and economic growth is accommodated around transit lines through urban infill and densification, HSR may be easily accessible to a higher share of the population and employment centers and therefore more attractive. California's new initiatives to reduce greenhouse gases through regional and local planning under SB375 could spur the latter response.

References

California High Speed Rail Authority website, www.cahighspeedrail.ca.gov - see the following:

--Alternatives Analysis methods and data at 20091223214401_AA Methods Version 2[1].pdf

--Project vision and anticipated benefits at :
http://www.cahighspeedrail.ca.gov/project_vision.aspx

--Project sections and anticipated planning and construction stages at
http://www.cahighspeedrail.ca.gov/planning_construction.aspx

-- Environmental Engineering:
http://www.cahighspeedrail.ca.gov/Project_Level_Environmental_Engineering_Guidelines.aspx

--Ridership forecasts (including ITS review and CHSRA, CSI and ITS comments and responses) at
http://www.cahighspeedrail.ca.gov/Ridership_and_Revenue_Forecasting_Study.aspxttp://www.cahighs

--Station Development Policies at
http://www.cahighspeedrail.ca.gov/highspeedtrain_stationdev_policies.aspx

Cox, Wendell and Joseph Vranich, The California High Speed Rail Proposal, Reason Foundation,
September 2008, reason.org/ps370.pdf; policy summary at
http://reason.org/files/9633e4725acf8bc75c1c4929c43e4ac1.pdf

Deakin, Elizabeth, M. Shirgaokar, N. Duduta et al. Transit Oriented Development for High Speed Rail (HSR) in the Central Valley, California: Design Concepts for Stockton and Merced Report to the California High Speed Rail Authority. Spring 2009.

Deakin, Elizabeth, et al. Transit Oriented Development for High Speed Rail (HSR) in the Central Valley, California: Design Concepts for Fresno. Report to the California High Speed Rail Authority, 2010

Enthoven, Alain C., William C. Grindley, and William H. Warren, The Financial Risks of California's Proposed High-Speed Rail, Oct. 2010. At http://www.cc-hsr.org/assets/pdf/CHSR-Financial_Risks-101210-D.pdf

Flyvbjerg, Bent, Nils Bruzelius, and Werner Rothengatter, Megaprojects and Risk: An Anatomy of Ambition, Cambridge University Press, 2003

Gillen, David, and David Levinson. The Full Cost of Air Travel in the California Corridor. Transportation Research Record: Journal of the Transportation Research Board 1662: 1-9.

Kemp, Roger, Environmental impact of high-speed rail, Institution of Mechanical Engineers, High Speed Rail Developments, 21 April 2004, at http://www.docstoc.com/docs/26717444/Environmental-impact-of-high-speed-rail

Kosinski, Andrew, Lee Schipper and Elizabeth Deakin, Analysis of High-Speed Rail's Potential to
Reduce CO2 Emissions from Transportation in the United States, Working Paper, Global Metropolitan Studies Program, University of California, Berkeley, November 2010.

Lave, Charles. 1976. The Negative Energy Impact of Modern Rail-Transit Systems Science, February 11, 1977. Vol. 195, pp. 595-596..

Levinson, David. 1996. The Full Cost of Intercity Transportation. Access Magazine #9: 21-25.

Levinson, David, Jean-Michel Mathieu, Adib Kanafani , and David Gillen. 1996. *The Full Cost of Intercity Transportation: A Comparison of Air, Highway, and High Speed Rail*. research report UCB-ITS-RR-96-3

Morris, Eric A., High-Speed Rail and CO2, Freakonomics, New York Times, July 24, 2009, at http://freakonomics.blogs.nytimes.com/2009/07/24/high-speed-rail-and-co2/

Pickrell, Don. 1992. A Desire Named Streetcar: Fantasy and Fact in Rail Transit Planning: Journal of the American Planning Association 58:2 158-76

Reason Foundation, California's High Speed Rail Proposal: Exaggerating Effects on California Transportation. Policy Study No. 370,
http://reason.org/files/c469d70dfbe3365acb8309e7f654b294.pdf

Szabo, Joseph, Federal Railroad Administrator, to Roelof van Ark, CEO, California High Speed Rail Authority, letter of November 3, 2010 regarding expenditures of federal funds received in 2010. At http://www.cahighspeedrail.ca.gov/displaycontent.aspx?id=9384

Town of Atherton et al. v. California High Speed Rail Authority, California Superior Court of the County of Sacramento, Case No 34-2008- 80000022. Filed Nov. 26, 2009.

van Wee, Bert, Robert van den Brink, and Hans Nijland, Environmental impacts of high-speed rail links in cost–benefit analyses: a case study of the Dutch Zuider Zee line. Transport Research Part D: 8 (2003) 299–314

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