Next Stop: California

The Benefits of High-Speed Rail Around the World and What's in Store for California

CALPIRG
Education Fund

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June 2010

Acknowledgments

The authors thank Robert Cruickshank, chair of Californians for High-Speed Rail; Gloria Ohland, vice president of communications for Reconnecting America; and Petra Todorovich, director of America 2050, for their thoughtful review of this report. The authors also thank Phineas Baxandall of U.S. PIRG Education Fund and Emily Rusch of CALPIRG Education Fund for their efforts in helping to conceptualize this project and for their editorial review. Finally, the authors thank Ben Davis of Frontier Group for his extensive research assistance, Carolyn Kramer for her editorial assistance, and all the photographers who graciously agreed to allow their work to be reproduced in this report.

CALPIRG Education Fund thanks the Rockefeller Foundation for making this report possible.

The authors bear responsibility for any factual errors. The recommendations are those of CALPIRG Education Fund. The views expressed in this report are those of the authors and do not necessarily reflect the views of our funders or those who provided review.

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Cover photo: German high-speed train, photo by G. Peters
Layout: Harriet Eckstein Graphic Design

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Executive Summary

As California moves toward construction of a new high-speed rail network, the state has much to learn from experiences abroad. High-speed rail lines have operated for more than 45 years in Japan and for three decades in Europe, providing a wealth of information about what California can expect from high-speed rail … and how the state can receive the greatest possible benefits from its investment.

Indeed, the experience of high-speed rail lines abroad suggests that California can expect great benefits from investing in a high-speed passenger rail system, particularly if it makes wise choices in designing the system.

High-speed rail systems in other nations have dramatically reduced air travel and significantly reduced intercity car travel. In California, similar results would ease congestion on the roads and in the skies and reduce the need for expensive new investments in highways and airports. High-speed rail service has virtually eliminated short-haul air service on several corridors in Europe, such as between Paris and Lyon, France, and between Cologne and Frankfurt, Germany.

- The number of air passengers between London and Paris has been cut in half since high-speed rail service was initiated between the two cities through the Channel Tunnel.

- The recent launch of high-speed rail service between Madrid and Barcelona, Spain, has cut air travel on what was once one of the world's busiest passenger air routes by one-third.

- Even in the northeastern U.S., where Amtrak Acela Express service is slow by international standards, rail service accounts for 62 percent of the air/rail market on trips between New York and Washington, D.C., and 47 percent of the air/rail market on trips between Boston and New York.

- High-speed rail service between Madrid and Seville has reduced the share of travel by car between the two cities from 60 percent to 34 percent.

High-speed rail saves energy and protects the environment. In California, high-speed rail could cut our dependence on oil while helping to reduce air pollution and curb global warming.

- *Continual improvement* – Japan's Shinkansen system is estimated to use one quarter the energy of air travel or one-sixth the energy of automobile travel per passenger. The energy efficiency of Shinkansen trains has continually improved over time, such that today's trains use nearly a third less energy, while traveling significantly faster, than the trains introduced in the mid-sixties.

- *More efficient* – On Europe's high-speed lines, a typical Monday morning business trip from London to Paris via high-speed rail uses approximately a third as much energy as a car or plane trip. Similar energy savings are achieved on other European high-speed rail lines.

- *Replacing oil with electricity makes zero emissions possible* – Energy savings translate into reduced emissions of pollutants that cause global warming or respiratory problems – particularly when railroads power their trains with renewable energy. In Sweden, the country's high-speed trains are powered entirely with renewable energy, cutting emissions of global warming pollutants by 99 percent.

High-speed rail is safe and reliable. In California, reliable service via high-speed rail could be an attractive alternative to oft-delayed intercity flights and travel on congested freeways.

- There has never been a fatal accident on Japan's Shinkansen high-speed rail system or during high-speed operation of TGV trains in France, despite carrying billions of passengers over the course of several decades.

- High-speed rail is generally more reliable than air or car travel. The average delay on Japan's Shinkansen system is 36 seconds. Spain's railway operator offers a money-back guarantee if train-related delays exceed five minutes.

High-speed rail can create jobs and boost local economies. California's high-speed rail system could help position the state for economic success in the 21st century while creating short-term jobs in construction.

- Construction of high-speed rail lines creates thousands of temporary jobs. For example, about 8,000 people were involved in construction of the high-speed rail link between London and the Channel Tunnel.

- Well-designed high-speed rail stations located in city centers spark economic development and encourage revitalization of urban areas:

  - A study of the Frankfurt-Cologne high-speed rail line in Germany estimated that areas surrounding two towns with new high-speed rail stations experienced a 2.7 percent increase in overall economic activity compared with the rest of the region.

  - Office space in the vicinity of high-speed rail stations in France and northern Europe generally fetches higher rents than in other parts of the same cities.

  - The city of Lyon experienced a 43 percent increase in the amount of

office space near its high-speed rail station following the completion of a high-speed rail link to Paris.

- Property values near stations on Japan's Shinkansen network have been estimated to be 67 percent higher than property values further away.

- Several cities have used high-speed rail as the catalyst for ambitious urban redevelopment efforts. The city of Lille, France, used its rail station as the core of a multi-use development that now accommodates 6,000 jobs. The new international high-speed rail terminal at London's St. Pancras station is the centerpiece of a major redevelopment project that will add 1,800 residential units, as well as hotels, offices and cultural venues in the heart of London.

- High-speed rail can expand labor markets and increase the potential for face-to-face interactions that create value in the growing "knowledge economy." A British study projects that the construction of the nation's first high-speed rail line will lead to more than $26 billion in net economic benefits over the next 60 years.

High-speed rail lines generally cover their operating costs with fare revenues. In California, a financially sustainable high-speed rail system would deliver on the promise made to voters in Proposition 1A that the system will not require operating subsidies from taxpayers.

- High-speed rail service generates enough operating profit that it can subsidize other, less-profitable intercity rail lines in countries such as France and Spain, as well as in the U.S. Northeast.

- Two high-speed rail lines – the French TGV line between Paris and Lyon and the original Japanese Shinkansen line from Tokyo to Osaka – have covered their initial costs of construction through fares.

Properly planned high-speed rail can encourage sustainable land use and development patterns. In California, focusing new development around high-speed rail stations can reduce pressure to develop in outlying areas, create new centers of commerce and activity, and enable riders to access high-speed rail stations by public transportation, by bike, or on foot.

- Cities throughout Europe have paired the arrival of high-speed rail with expansion of local public transportation options – in some cases, using new high-speed rail lines to bolster local commuter rail service.

- By putting stations in smart locations and providing transit connections, high-speed rail can encourage greater shifts in development patterns and transportation choices.

- Proper land-use policies in areas that receive high-speed rail stations, coupled with effective development of station areas, can ensure that high-speed rail does not fuel new sprawl.

To obtain the economic and transportation benefits experienced by other nations, California should follow through on its decision to invest in high-speed rail, while taking actions to maximize the benefits of that investment. Specifically, California should:

- Follow through on its commitment to build the California high-speed rail system, creating thousands of jobs and positioning the state to meet the economic, transportation, energy and environmental challenges of the next century.

- Use high-speed rail to focus future development by locating stations in city centers, planning for intensive commercial and residential development near stations, and requiring communities receiving high-speed rail stations to adopt land-use and development plans that discourage sprawl.

- Make high-speed rail stations accessible to people using a variety of transportation modes, including automobiles, public transit, bicycling and walking. California should follow the lead of other nations and pair high-speed rail with expansion of local transit networks.

- Integrate high-speed rail with improvements to commuter and freight rail, and provide convenient rail connections to airports, ensuring that the investment California makes in high-speed rail delivers benefits to a wide variety of commuters, travelers and businesses.

- Keep clear lines of accountability by maintaining the independence of the High-Speed Rail Authority, while ensuring strict budget discipline and spending transparency through strong oversight and public disclosure of the authority's expenses.

- Improve lines of communication between the High-Speed Rail Authority and local governments and communities.

- Make high-speed rail green by investing in energy-efficient equipment, powering the system with renewable energy, and designing and building the system in such a way as to maximize environmental benefits.

Introduction

No one ever confused Oakland with London. Or Los Angeles with Tokyo. Or the Inland Empire with the south of France.

So one might wonder what California can learn from the experiences of other nations when it comes to the construction of high-speed rail.

The truth is that California faces many of the same challenges faced by nations throughout Europe and Asia that have adopted high-speed rail: the need to provide the transportation connections that can sustain a 21st century "knowledge economy"; the need to relieve increasingly congested airports and highways; the need to foster the creation of vibrant, sustainable communities; and the need to reduce dependence on oil and protect the environment.

Moreover, California shares many of the geographic and demographic traits of areas served by the world's most successful high-speed rail networks. The vast majority of our 37 million people live in areas that will be served by high-speed rail. In addition, most intercity trips along the state's high-speed rail network are projected to take two to three hours —the "sweet spot" for effective competition between high-speed rail and air travel—or less.

Of course, California does face some unique challenges in making high-speed rail "work." California's sprawling development and our massive freeway network are unmatched in other parts of the world. And our public transportation networks—despite dramatic improvements in cities such as Los Angeles over the past several decades—do not compare with the well-established transit systems of cities such as Paris, Madrid or Berlin.

Yet, even in those areas where California's history and economic geography differ from those of other countries, their experiences still provide us with important lessons about how to maximize the benefits of high-speed rail for California's future. Most importantly, that experience shows that while high-speed rail is a big investment, it has the potential to pay off by addressing our growing transportation challenges, reinvigorating our economy, reshaping development, and building a California that can meet the challenges of the 21st century.

High-Speed Rail: Experiences from Around the World

Nations throughout the developed world (and increasingly, the developing world) have seen the value of high-speed rail in addressing transportation, energy and environmental challenges and boosting economic development. The experience with high-speed rail abroad both underscores the potential benefits of express rail service to California and suggests important lessons that California can learn in the design of its high-speed rail system.

High-Speed Rail Replaces Short-Haul Air Travel

Everywhere high-speed rail lines have been built, they have led to immediate—and often dramatic—declines in air travel between the cities being served, demonstrating the strong demand for clean, fast and efficient travel between metropolitan areas, and freeing up capacity in the aviation system for long-haul and international flights.

California has several reasons to shift in-state travelers from air to rail. Airport congestion contributes to delays that frustrate passengers, waste fuel, and hamper effective travel between cities. In 2008, there were 225,000 passenger flights—an average of 618 per day—between cities that will be served by California's high-speed rail system. [1]

The need to move people between California's cities by air clogs our congested airports and can contribute to delays. The Los Angeles-San Francisco route, for example, is the second most popular air route in the nation, carrying more than 2.8 million passengers between December 2008 and November 2009.[2] It is also one of the most delay-prone: over the same December 2008-November 2009 time period, one out of every four flights from Los Angeles to San Francisco was late, with an average delay on those flights of one hour.[3] Flights in the other direction were only slightly better, with 18 percent delayed and an average delay of slightly less than an hour.[4]

Reducing the number of short-haul flights within California would increase the availability of gates for longer-haul flights, while avoiding the need for expensive airport expansion projects. It would also help

businesses, allowing commercial travelers to get to and from destinations more easily and reliably.

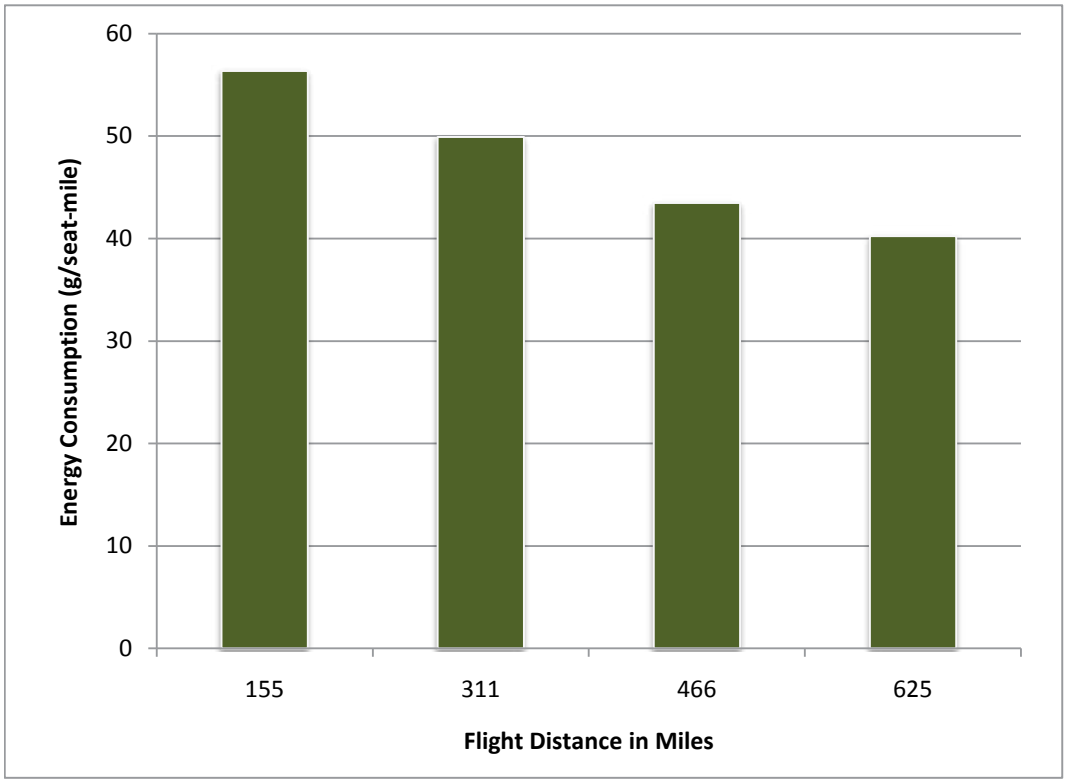
Substituting rail for air trips would also save energy and protect the environment. Short-haul flights are more energy intensive than longer flights, since much of the energy consumed in any air journey is used on take-off. Trips of 155 miles consume approximately 40 more energy per seat-mile than trips of more than 625 miles in the same aircraft.[5] (See Figure 1.) In addition, because high-speed rail does not use oil, it can provide an economical alternative for airline passengers during periods of high jet fuel prices, when airlines often impose ticket surcharges to recover costs from consumers.

High-speed trains around the world effectively replace air travel for precisely the kind of high-frequency, short- to middle-distance trips that would be served by California's high-speed rail network.

The Eurostar: France and England

The Eurostar rail line connects London with Paris and Brussels using the Channel Tunnel, which was completed in late 1994. France inaugurated service on its high-speed TGV-Nord line between the Channel, Paris and the Belgian border shortly before the opening of the Channel Tunnel. But on the English side of the Channel, trains were hampered by the use of aging infrastructure, with average speeds between London and the tunnel of only 62 miles per hour.[9] Then-French President Francois Mitterrand summed up the disparity between the French and British rail systems: "Passengers will race

Figure 1. Airplane Energy Consumption per Seat Mile at Various Flight Distances[6]



at a great pace across the plains of Northern France, rush through the [Channel] Tunnel on a fast track, and then be able to daydream at very low speed, admiring the English countryside."[10]

Even with the slow speeds on the British side, the inauguration of Eurostar service replaced a significant portion of the London-Paris air travel market. Within two years of the service's start, the number of air passengers traveling the route declined from 4 million to less than 3 million.[11]

In recent years, Britain has launched high-speed rail service linking London with the Channel Tunnel, cutting travel times between London and Paris first from 3 hours to 2 hours and 35 minutes, and now, with completion of the final phase of the high-speed line in 2007, to 2 hours and 15 minutes.[12]

Passenger traffic on the Eurostar line picked up significantly as a result, coinciding with another steep drop in London-Paris air travel.[13] The number of air passengers between the two cities has fallen from 2.9 million in 2002 to 1.9 million in 2008—a roughly 50 percent reduction in air travel compared with the years prior to the opening of the Channel Tunnel.[14]

The success of the Eurostar and the High Speed 1 rail line in reducing air traffic has led some Britons to consider whether

High-Speed Rail as a Backup for Air Travel

Redundancy in the transportation system is sometimes thought of as a bad thing. Why invest in improved passenger rail service, for example, if highways and airplanes already make the same trips?

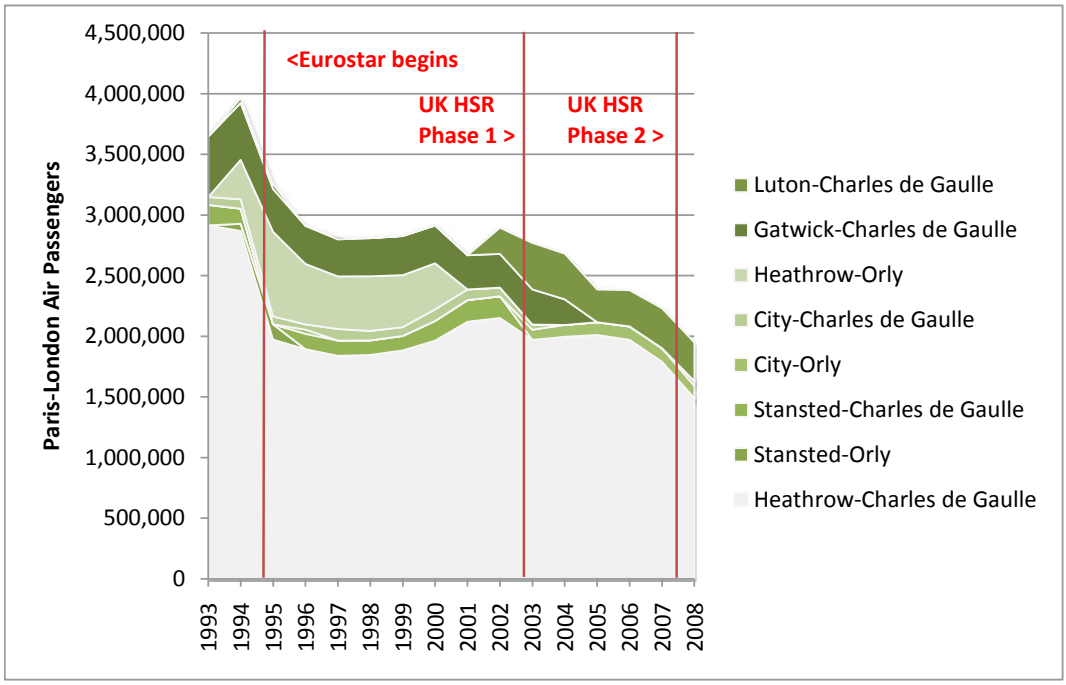
Yet, when one part of the transportation system is shut down unexpectedly, the result can be billions of dollars in economic disruption—disruption that can be greatly reduced when good alternatives are available.

In Europe, high-speed rail proved its value as an alternative to flying during the April 2010 shutdown of air travel following the eruption of a volcano in Iceland. Railroads across the continent mobilized to serve stranded travelers. Swiss Federal Railways increased capacity rapidly, doubling the number of passenger cars on its existing routes.[7] Eurostar added trains to its route between London, Paris and Brussels, carrying 50,000 more passengers than expected, and offered stranded air passengers seating at a special fare. Eurostar reported that it served passengers from as far away as Greece.[8]

While the volcanic eruption remained a major inconvenience for all travelers—particularly those traveling overseas—the existence of an efficient passenger rail system enabled many European passengers to get home hours or days earlier than they otherwise would have, and reduced crowding at airports.

Volcanoes aren't the only potential cause of air system shutdowns. Air traffic control system glitches, extreme weather events, and terrorist attacks (such as those of September 11, 2001) have all hobbled air travel for hours to days at a time. An efficient passenger rail system can provide an important backup to ensure that California's economy keeps running, even when other transportation options stop.

Figure 2. Travel Between London and Paris Airports[15]



new high-speed lines could avert the need for a proposed $15 billion plan to expand Heathrow Airport. Britain's Conservative Party has proposed scrapping the plan for a third runway at Heathrow in exchange for construction of a high-speed rail line linking London with northern England, a move that could reduce the number of short-haul air trips within England.

France

The success of high-speed rail in diverting passengers from planes was demonstrated early on with the completion of the high-speed TGV rail line from Paris to Lyon in 1981. Before completion of the TGV, 31 percent of travelers from Paris to Lyon traveled by airplane. Following completion of the TGV, the air passenger share dwindled to 7 percent.[16]

The TGV has had an even broader impact on the line between Paris and Marseille, which was completed in 2001. Since the completion of the TGV, rail has come to serve a larger share of the air/rail market in the Provence/Alpes/Cote D'Azur region, home to the city of Marseille as well as seaside playgrounds such as Nice

France's TGV system links cities across the country with the capital, Paris, as well as with other European nations. Credit: Kilroy1313 at railpictures.net.

and Cannes. The number of people traveling by air or rail between Paris and the region increased by 25 percent between 1996 and 2003, but the number of air passengers actually declined. All of the travel growth was accommodated via rail travel, which increased its share of the air-rail market from 39 percent before the TGV to 58 percent afterward.[17]

Spain: Madrid-Barcelona

Spain built its first high-speed rail line in 1992, connecting the capital city of Madrid with Seville. Sixteen years later, the nation finally completed a high-speed rail connection between its two largest cities, Madrid and Barcelona.

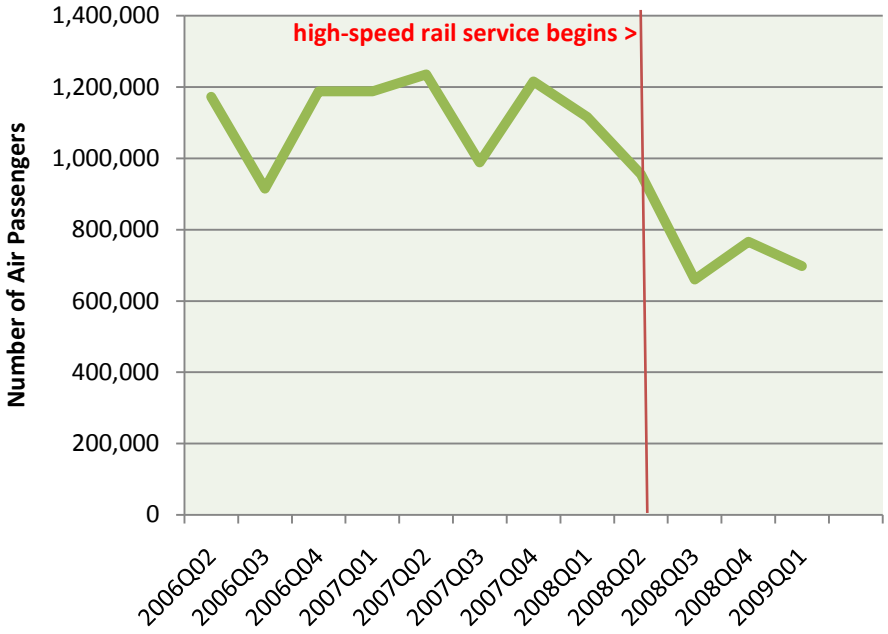
Prior to construction of the high-speed line, flying was by far the preferred option for traveling between Madrid and Barcelona, with 90 percent of travelers choosing air travel.[18] In fact, the Madrid-Barcelona air route was, until recently, the busiest in Europe and one of the busiest in the world, with 4.6 million annual passengers in 2007 on 45,000 flights.[19] Alternatives to flying were arduous: the trip took 7 hours by conventional rail and nearly 6 hours by car.[20]

The arrival of high-speed rail has made travel between the cities much faster and more convenient, providing competition for airlines and an alternative for consumers. Since the introduction of high-speed rail service in early 2008, the number of air travelers between the two cities has fallen by more than one-third, reducing the number of air passengers by 1.5 million in its first full year in service.[21] By early 2010, the number of train travelers between the two cities exceeded the number of air travelers.[22]

Germany

Germany's high-speed rail system serves a network of cities across the country. The Cologne-Frankfurt high-speed rail line, opened in 2002, connects the two cities, which are approximately 110 miles apart, in one hour. Even before the introduction

Figure 3. Air Travel Between Madrid and Barcelona Before and After High-Speed Rail[23]



of high-speed rail, conventional rail service carried most travelers between the two cities. Since the arrival of high-speed rail, however, rail has come to account for 97 percent of the air/rail market share between the two cities, with virtually all the passengers continuing to travel by air making connecting flights. [24]

Similar reductions in domestic air service have occurred in other corridors within Germany that have received high-speed rail service.[25]

Japan

Japan began building its high-speed rail network in the mid-1960s, well before the commercialization of mass air travel in the 1970s and 1980s. Even though domestic air travel has increased in Japan over the years, high-speed rail remains the dominant mode for intercity travel, particularly for trips that can be completed via rail in under three hours.

Japan's Shinkansen high-speed rail line draws more than three times as many passengers per year as air travel.[26] (See Figure 4.) For trips of less than 500 miles, the Shinkansen holds a dominant share of the market. (See Table 1, next page.)

The distances covered by Shinkansen trains are similar to those that would be traveled by California's high-speed rail network. The longest possible trip on the California system—from San Diego to Sacramento—would be 588 miles (to be traveled in 3 hours and 35 minutes), a trip length at which rail and air travel would be expected to have a relatively even split of the travel market. The trip from Los Angeles to San Francisco is 382 miles, a length at which high-speed rail systems in Japan and elsewhere in the world dominate the travel marketplace.

U.S. East Coast

Amtrak's Acela Express service along the East Coast still succeeds in replacing air travel, despite travel speeds that are slow by international standards.

The experience of the Acela confirms

Figure 4. Passengers Traveling via Air and Rail, Japan[27]

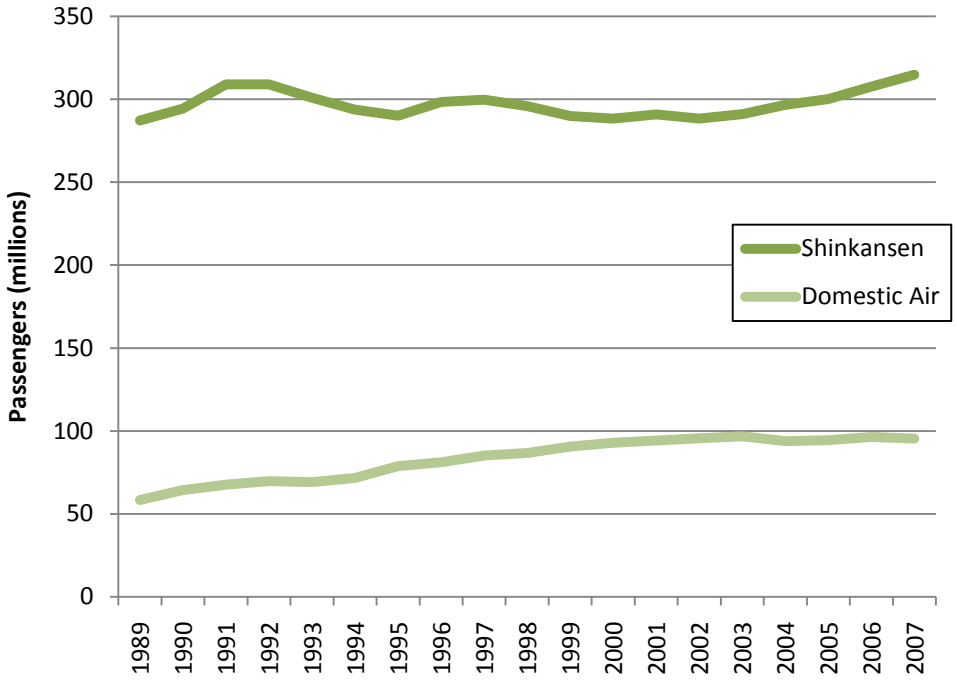


Table 1. Rail-Air Mode Splits for Trips of Various Distances, Japan[28]

	Distance (Miles)	Rail %	Air %
Tokyo-Nagoya	227	100%	0%
Tokyo-Osaka	343	86%	14%
Tokyo-Okayama	455	82%	18%
Tokyo-Hiroshima	555	56%	44%
Tokyo-Fukuoka	733	12%	88%

that train journeys of two to three hours are the "sweet spot" for high-speed rail, where it is most capable of competing effectively with air travel. Currently, the Acela Express makes the journey from New York to Washington, D.C., in 2 hours and 55 minutes, and the journey from Boston to New York in 3 hours and 34 minutes.[29] By contrast, the trip from London to Paris on the Eurostar—which covers a greater distance by rail than either the New York-to-D.C. or Boston-to-New York trips—takes as little as 2 hours and 15 minutes.

Nonetheless, rail service on the Northeast Corridor—particularly following the introduction of near-high-speed Acela Express service in 2001—has captured a growing share of the air/rail market. Amtrak now serves 62 percent of the air/rail market between New York and Washington, D.C., and 47 percent of the air/rail market between New York and Boston.[30]

High-Speed Rail Replaces Car Travel

California's highway traffic congestion is legendary—in 2007, congestion in California's major metropolitan areas cost Californians more than 732 million hours

Locating high-speed rail stations at airports can enable airlines to replace energy-inefficient connecting flights that clog up gate space. The Intercity Express rail station at the airport in Cologne, Germany (above), provides direct access to the high-speed rail network connecting Germany and other nations in northern Europe, enabling travelers flying into Cologne to reach their final destination elsewhere in the country more quickly and conveniently. Credit: Gregorius Mundus

Maximizing the Benefits of High-Speed Rail for Relieving Air Congestion

High-speed rail competes well with air and car travel for trips of the length that will be served by California's high-speed rail network. However, there are several ways that California can learn from the examples of other high-speed rail networks to make the state's rail system both an effective competitor with—and complement to—air travel.

Even with a high-speed rail network, Californians will still rely on air travel for out-of-state trips. Providing convenient air-rail connections can have several benefits: providing air travelers with an alternative to short-haul flights for the last legs of their journeys, enabling Californians to choose from a wider variety of airports, and reducing the need to drive to the airport (thereby reducing congestion and saving air travelers money for parking and taxis).

Many European high-speed rail lines have direct connections with major airports.[31] In France, the high-speed rail connection with Paris Charles de Gaulle airport serves 1.3 million passengers per year.[32] In Germany, Lufthansa Chairman Heinz Ruhnaw predicts that within 10 years, "no German airport will be without a railway station beneath the terminal. By the end of the decade, airports will not require feeder services by regional aircraft—all will be operated by rail."[33] Railroads and airlines can make the most of those connections through codesharing (in which passengers can book their entire air-rail trip at the same time) and, where security permits, with through-checking of baggage, as occurs in Switzerland.[34]

On the U.S. East Coast, some Amtrak trains stop at Newark Liberty Airport and Baltimore-Washington Airport, serving 100,000 and 600,000 passengers per year, respectively.[35] Continental Airlines also provides codesharing with Acela Express trains servicing several northeastern cities via Newark Liberty Airport.

California's proposed high-speed rail system will have direct connections to San Francisco International Airport and Ontario Airport.

of wasted time—the equivalent of 350,000 person-years of work.[36] Evidence from around the world suggests that high-speed rail can reduce automobile travel between cities, possibly contributing to reductions in congestion.

High-speed rail's impact on car travel and congestion in other nations has been much less dramatic than its impact on air travel. Most automobile journeys are local or within a given region, meaning that high-speed rail can only avert a small proportion of total traffic. Moreover, long-distance intercity drivers often have chosen to drive rather than fly for reasons that would also make them unlikely to use high-speed rail, such as the need to carry cargo or concerns about cost.

Still, the experience of other nations with high-speed rail systems suggests that high-speed rail can deliver measurable reductions in intercity automobile traffic—reductions that, while small in absolute terms, can have a significant

impact on reducing traffic congestion. In addition, there are some examples from overseas in which high-speed rail has made a bigger impact in reducing vehicle travel by providing an alternative for long-distance commuters. California, which has many long-distance commuters, could experience greater reductions in vehicle travel than other nations—provided that development around high-speed rail stations occurs in ways that do not promote sprawling development that requires the use of an automobile for local trips. (See page 31.) Diverting travel from highways to high-speed rail could also reduce pressure for costly expansions of the state's existing freeway network.

Spain: Madrid to Seville

The introduction of high-speed rail service between Madrid and Seville led to significant replacement of travel via cars and buses. Prior to the opening of the line, car travel accounted for 60 percent of the trips between the two cities (which are approximately 330 miles apart), with conventional rail service accounting for 14 percent. After the introduction of high-speed rail, rail transportation came to serve 54 percent of the market, with car travel reduced to 34 percent of all trips.[37]

Despite operating over aging infrastructure, Amtrak's Acela Express near-high-speed rail service on the East Coast competes effectively with air travel. Credit: Kyle Gradinger

France: Paris to Lyon

The initiation of France's first high-speed rail service between Paris and Lyon (which are separated by a distance of approximately 240 miles) in 1981 led to a significant decrease in car travel between the two cities. Between 1981 and 1984, the percentage of trips between the cities made by car declined from 29 percent to 21 percent.[38]

Sweden

In contrast to other European countries that have used high-speed rail to supplant air service, Sweden used the initiation of its high-speed rail service to better connect residents of outlying towns less than two hours away with the nation's capital and primary economic engine, Stockholm. By so doing, Sweden provided an appealing new option to commuters, reducing the share of commuting by car. In 1993, prior to the initiation of high-speed "tilting train" service on the Stockholm–Eskilstuna line, 91 percent of travelers in the corridor went by private vehicle; by 2000, the percentage had declined to 65 percent, with the other 35 percent of travelers using high-speed rail.[39] The switch from car to rail was greatest among those living near the stations, and resulted in more residents in those areas choosing not to own cars.

High-Speed Rail Saves Energy and Protects the Environment

California's transportation system is heavily dependent on oil and is a major contributor to both global warming and the state's persistent air pollution problems.

Korea's KTX high-speed rail system reduces congestion on the nation's crowded highway network. Credit: Haniel Francesca

California annually emits more carbon dioxide than all but 18 nations in the world.[41] Meanwhile, despite decades of improvement in the quality of our air, California still has the four smoggiest cities in the country, with levels of air pollution that put millions of residents at risk of reduced lung function and even premature death.[42]

High-speed rail has the potential to curb transportation energy use and pollution. Other nations are realizing that potential, benefiting from the energy savings and emission reductions that result from their investment in advanced rail systems.

High-speed rail delivers energy savings by replacing trips that would have been taken by car or airplane. High-speed rail may also have secondary energy-saving impacts by encouraging patterns of development—including greater concentration of residential or business activity near high-speed rail stations—that reduce the distance of trips made in day-to-day travel.

Rail travel—particularly on electric trains—has some inherent energy-saving advantages compared with cars or airplanes. Both cars and airplanes are, at the moment, completely reliant on oil, whereas trains can be powered by electricity generated from a variety of fuels, including renewable energy. Electric motors are also inherently more energy efficient than the internal combustion engines used in cars and trucks, which dissipate much of the energy in their fuel as heat. High-speed rail also competes favorably in terms of energy consumption with short-haul aircraft, which expend much of their energy on takeoff. (See page 7.)

Assessing the energy savings delivered by high-speed rail is challenging, and

Future High-Speed Rail Improvements in Europe Will Reduce Car Travel

As Europe's high-speed rail network grows, a sizeable share of the new trips taken are expected to be by former car drivers. A study conducted for the International Union of Railways estimated that proposed extensions of Western Europe's high-speed rail network would accommodate 57 billion additional passenger-miles of travel in 2020. Of that amount, 18 billion passenger-miles (or 32 percent) would have been traveled by car if expanded high-speed rail service were not available.[40] Europe expects that high-speed rail will play an important role in reducing travel—and congestion—on the continent's highways.

researchers come to different conclusions. The degree of energy savings depends on a complex interaction of speed, ridership, the source of energy used, and many other factors—as well as the emissions assumed to come from competing modes of travel. For example, a train that moves at high speeds might consume more energy per *seat* than a slower train. But if the higher speeds mean that the service is more attractive and more of the seats on the train are filled, the faster train may be more energy efficient on a *per-passenger* basis and may deliver a larger total energy savings.

Construction of high-speed rail is expected to play a role in helping the state to meet its goal of reducing global warming pollution to 1990 levels by 2020.[43] The experience of nations with high-speed rail lines suggests that high-speed rail can make a meaningful contribution to achieving that goal, while also saving energy and reducing dependence on oil.

Energy Savings on European High-Speed Rail Lines

Europe's high-speed rail lines deliver significant energy savings when compared to flying or driving. Passengers traveling on high-speed trains for a typical Monday morning trip from London to Paris use one-third as much energy as traveling by automobile and 30 percent as much energy as flying (see Figure 5). Passengers traveling high speed trains between Madrid and Barcelona use 28 percent as much energy traveling by automobile and 30 percent as much energy as flying. (See Figure 5.)[44]

Energy Savings in Japan

Even greater energy savings are achieved in Japan, whose Shinkansen system is estimated to consume one-quarter the energy of air transportation and one-sixth the energy of automobiles on a per-passenger basis.[46] Japan has continually improved the energy efficiency of the Shinkansen, with the latest, most energy-efficient trains consuming 32 percent less energy than the original Shinkansen trains, even though they are capable of traveling 43 miles per hour faster.[47]

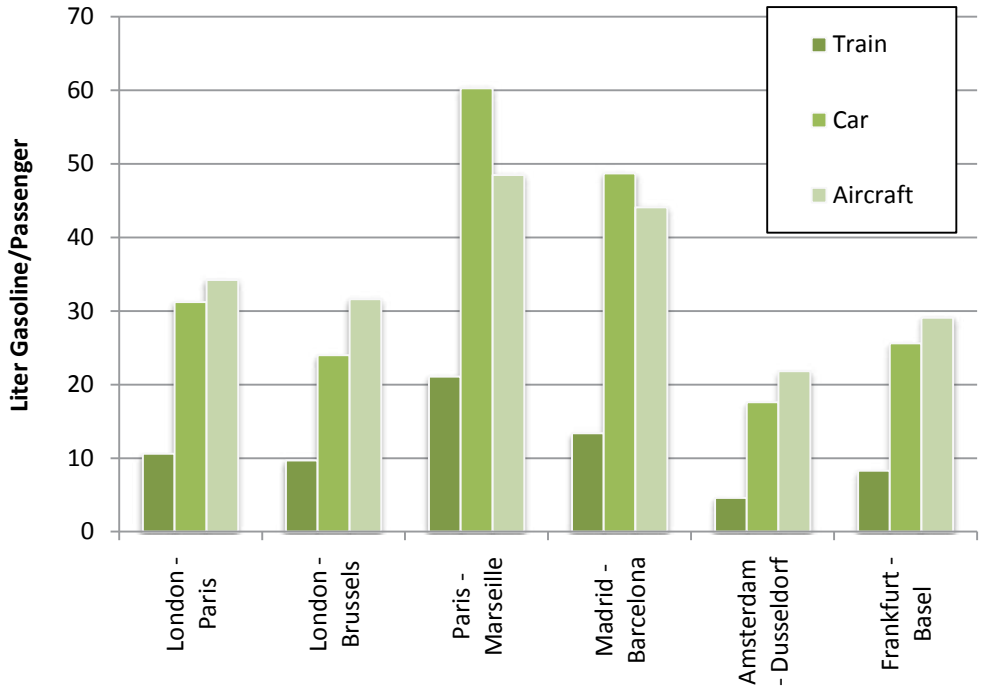
Emission Reductions from High-Speed Rail in Europe and Japan

High-speed rail systems around the world also reduce emissions of harmful pollutants compared to other forms of travel. Because high-speed rail is more energy efficient and can use electricity generated from less-polluting forms of energy, it often delivers large reductions in air pollutant emissions.

High-speed rail lines in Europe produce dramatic reductions in emissions of carbon dioxide—the leading contributor to global warming—compared to other forms of travel. For a typical Monday morning business trip, emission reductions compared with air travel range from 77 percent for a trip between Frankfurt and Basel, Switzerland, to 96 percent for a trip from Paris to Marseille. (See Figure 6, next page.)

The carbon dioxide emission reductions from high-speed rail can add up quickly. Spain's national railway estimates that the Madrid-Barcelona high-speed rail line averted a quarter-million metric tons of carbon dioxide in its first year of operation,

Figure 5: Energy Consumption of Trains, Cars, and Aircraft Traveling Between European Cities, Monday Morning Trip[45]

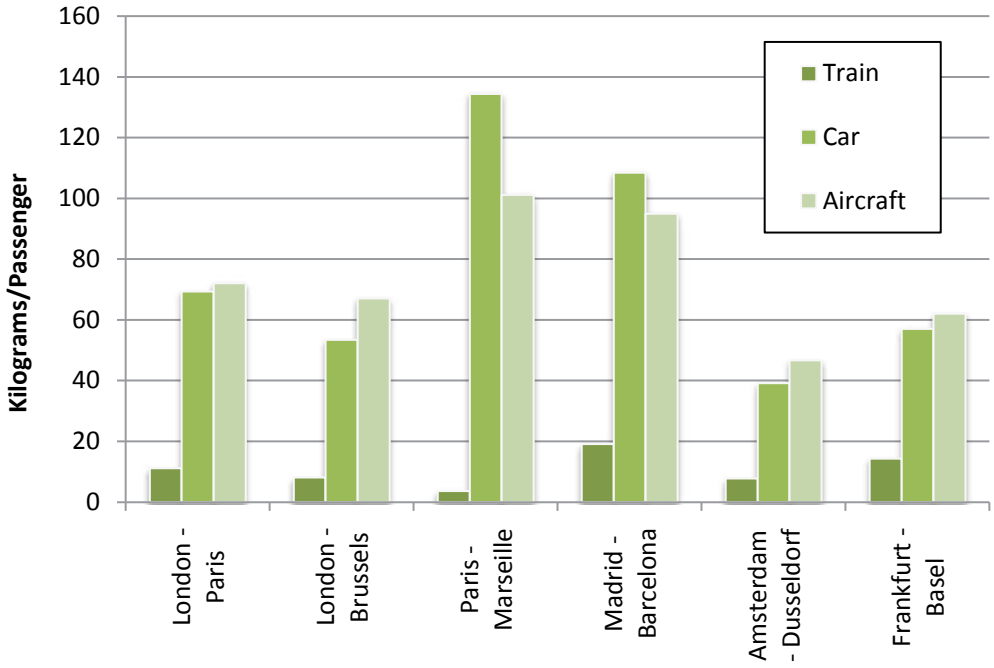


Reducing Oil Dependence with High-Speed Rail

California's transportation system is highly dependent on oil. Fully 99 percent of the energy used to power California's transportation system comes from petroleum.[48] That dependence on oil—not only for cars but also for airplanes, trucks and trains—leaves California residents and businesses at the mercy of volatile world oil markets, erodes our energy independence, and hurts our economy.

High-speed rail lines generally operate on electricity, which can be generated from a variety of sources. By building high-speed rail, California will reduce its dependence on oil for transportation—a sound, long-term investment in the state's economic future.

Figure 6: Carbon Dioxide Emissions of Trains, Cars, and Aircraft Traveling Between European Cities[49]



the equivalent of taking more than 45,000 of today's American cars off the road.[50]

High-speed rail also curbs emissions of air pollutants that contribute to the formation of smog and cause human health problems. Factoring in emissions from generation of the electricity used to power the trains, the train between Frankfurt and Basel emits approximately 18.1 times less particulate matter per passenger than automobiles and 6.5 times less particulate matter per passenger than aircraft. (See Figure 7.) France's high-speed TGV between Paris and Marseille emits approximately 46.2 times fewer nitrogen oxides per passenger than automobiles and 31.9 fewer nitrogen oxides per passenger than aircraft. (See Figure 8.)

It is important to note that emissions from high-speed rail service depend critically on the mix of energy sources used to generate the electricity that powers the trains. France and Japan, for example, have electricity systems that are heavily dependent on nuclear power, which produces no direct emissions of global warming pollution or conventional air pollutants, thereby magnifying the emission reductions delivered by high-speed rail. Other nations, however, are reducing the environmental impact of high-speed rail through the use of renewable energy—a much smarter long-term energy solution than nuclear power—and California can follow suit. (See "Powering High-Speed Rail with Renewable Energy," page 20.)

High-Speed Rail Is Safe and Reliable

As California's population increases, more and more people will demand safe and reliable transportation. While air travel

Figure 7: Particulate Matter Emissions of Trains, Cars, and Aircraft Traveling Between European Cities, Monday Morning Journey[51]

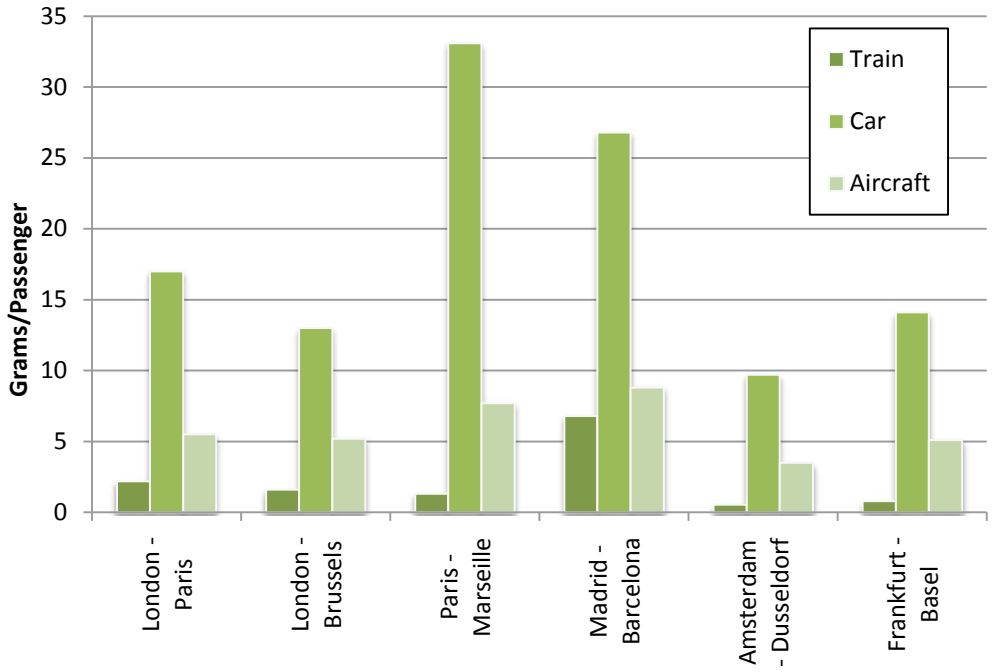
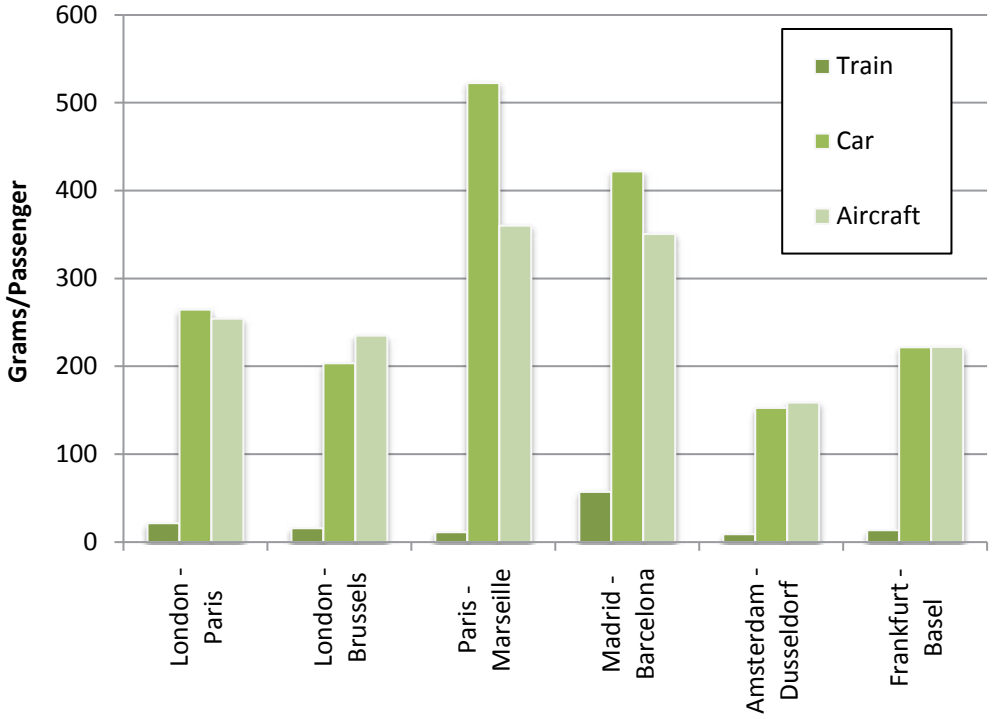


Figure 8: Nitrogen Oxide Emissions of Trains, Cars, and Aircraft Traveling Between European Cities, Monday Morning Journey[52]



in America is relatively safe, save for rare disasters, car travel is a major killer in California and elsewhere. In 2008, more than 3,400 people died on California's highways—a big improvement over previous years, but still shockingly high.[57]

Meanwhile, delays plague many forms of transportation, such as cars and planes. As noted earlier (see page 6), air travel at major airports such as those in San Francisco and Los Angeles is extremely prone to delays, while the prospect of freeway congestion can force drivers to either allocate extra time to their trips or risk having to change their schedules, cancel appointments, or miss important meetings.

High-speed rail can provide Californians with a safe and reliable way to reach their destinations in other cities on time.

Rail Safety in France and Japan

High-speed rail systems can be engineered to be extraordinarily safe. Accidents on high-speed rail systems are possible and have occurred—the most notorious of which was the derailment of an Intercity Express train in Eschede, Germany, in 1998 that killed 101 people. But the world's two oldest and most well-traveled high-speed rail lines—the Japanese Shinkansen and French TGV—have posted impressive safety records.

In Japan, **no** passenger has ever been injured or killed due to an accident, such as derailment or collision, on the Shinkansen during its 46 years of service, despite carrying more than 340 million passengers per year.[58] The Shinkansen employs automatic train control, which will automatically decelerate or halt the train based on the conditions of the route ahead and distance to preceding trains.[59] Of particular importance to Californians, the Shinkansen system is also equipped with a rapid earthquake alarm system that automatically brings trains to a rapid halt when seismic activity is detected.

Similarly, in France, no passenger has ever been killed due to an accident caused by the TGV in high-speed operation

Powering High-Speed Rail with Renewable Energy

California can maximize the environmental benefits of high-speed rail by powering the system with renewable energy. The California High-Speed Rail Authority has set a goal of supplying 100 percent of the energy for the system from renewable sources such as wind and solar power, with the energy either generated on site or purchased from utilities. A 2008 report estimated that the additional cost of an entirely renewable rail system would be as little as 86 cents per ticket, and could be even lower if recent trends of declining prices for wind and solar power continue.[53]

High-speed rail systems in other parts of the world are also increasing their reliance on renewable energy. Swedish Rail now purchases 100 percent of its electricity from renewable sources such as hydroelectric and wind power, a step that has reduced the per-mile carbon impact of its rail system by 99 percent.[54]

As of 2005, Spain obtained 18.4 percent of the electricity for its railways and Italy obtained 14.7 percent from renewable energy.[55] By 2008, Spain's national railway was obtaining 23 percent of its rail traction energy from renewable sources, largely due to an increase in the amount of renewable energy on the Spanish grid.[56]

during its 29 years of service, despite ridership of 48 million passengers per year.[60] In France, TGV railcars are designed such that adjacent TGV cars rest atop a shared two-axle connector, which decreases weight and increases speed, but also prevents the cars from dangerously jack-knifing during a collision as would a conventional train.

Reliability in Europe and Japan

High-speed rail lines also have fewer and shorter delays due in part to the ability to travel in poor visibility conditions and most weather.

Car travel and air travel are notoriously unreliable. Automobile travel can be delayed or made impossible by bad weather, and more often (at least in California) by heavy traffic congestion. Air travel faces similar problems. Airplanes neither depart nor land in airports that have poor visibility or weather conditions, causing flights to depart after their scheduled time, circle the airport upon arrival waiting for weather to clear, or temporarily land at another airport. Because America's air transportation system is integrated, flights in California can be delayed by weather conditions or airport congestion half a continent away.

High-speed rail systems have delivered impressive records of reliability. In Japan, the average train delay on the Tokaido Shinkansen from Tokyo to Osaka—by far the busiest high-speed rail route in the nation—is 36 seconds.[61] This includes delays caused by rain, typhoons or snowfall.

Trains traveling between London and Paris arrive within 15 minutes of their scheduled arrival more than 90 percent of the time, compared with 70 percent of the time for airplanes.[62]

The high speed rail between Madrid and Seville is so reliable that the operator company Renfe refunds the entire cost of the ticket if the train is responsible for arriving more than five minutes late; less than 0.3 percent of tickets are refunded.[63]

High-Speed Rail Boosts the Economy

The arrival of high-speed rail alters the economic geography of a region. Places that had once been difficult to reach –due to distance, congestion or lack of an efficient transportation link—suddenly become easily accessible. The calculus behind countless individual and business decisions—where to locate, how to travel, when to travel—is changed dramatically. As a result, high-speed rail has broad, and often difficult to quantify, economic impacts.

To begin to understand the impact of high-speed rail on the economy, it is best to start from the center and work outwards, beginning with job creation in construction of the line, then addressing economic growth in areas with stations, and looking finally at the broader economy.

Construction Jobs in England, France, Hong Kong and Spain

High-speed rail systems require vast amounts of labor to create—from the professional services required to plan, design and finance the system right down to the work of pouring the concrete and lay the rails. Perhaps the biggest source of job creation is in the actual construction of the system.

Surprisingly little information exists about the number of short-term construction jobs created in previous high-speed rail projects around the world. What is known is that rail construction is more labor-intensive than highway construction, meaning that investments in rail can create more jobs than investment in highways.[65] The limited information available suggests that construction of a high-speed rail line creates thousands of short-term jobs.

- At the peak of construction, the Channel Tunnel employed more than 10,000 workers on the English side.[66]

High-Speed Rail Investment in China

The idea that investment in high-speed rail can spur job creation and reinvigorate the economy is not limited to the United States. China, driven by concerns about factory unemployment during the recent global recession, has embarked on the world's most ambitious program of high-speed rail construction—creating jobs today while laying the groundwork for future economic growth.

The Chinese plan includes the construction of 42 high-speed rail lines. When the recession hit, China accelerated the timetable for finishing the system from 2020 to 2012, dedicating $100 billion to the project. More than 100,000 workers are involved in construction of the line connecting China's two largest cities, Beijing and Shanghai.[64]

China's rapidly accumulating experience with high-speed rail also makes it a leading candidate to export rail technology to other countries.

The scale and speed of China's high-speed rail effort would be impossible to match in the United States, and may not even be advisable. But it does show that high-speed rail has potential to create large numbers of construction jobs, and to do so quickly.

About 8,000 people were involved in construction of the Channel Tunnel Rail Link.[67]

- Hong Kong's high-speed rail line is projected to create 5,000 jobs during construction and another 10,000 during operation.[68]

- The planned expansion of Spain's AVE high-speed rail system is expected to create 30,000 construction jobs.[69]

In addition to the creation of short-term construction jobs, high-speed rail investments can spark the development of companies to manufacture rail cars and other equipment. Countries that made early investments in high-speed rail—including Japan, France, Spain and Germany—also happen to be countries with companies that are leaders in manufacturing of high-speed trains and equipment. Germany-based Siemens, for example, is a major producer of high-speed rail equipment. The company also owns a manufacturing facility in Sacramento, which produces light rail transit cars, and has purchased land adjacent to the plant in hopes of possibly manufacturing high-speed rail systems there.[70] Another manufacturer of high-speed rail equipment, Alstom, also has a California presence, operating a facility on Mare Island to refurbish Amtrak trains.[71]

High-Speed Rail Creates New Opportunities for Development Near Stations

High-speed rail stations bring with them the potential for economic development, serving as an attractive location for stores and offices and increasing land values in the near vicinity. The success of development near high-speed rail stations, however, depends on where the stations are located and the quality of planning for station-area development. A high-speed rail line built in a lightly traveled corridor, or with stations

far away from existing centers of development, for example, is going to have less of an economic impact than a well-designed line with busy, accessible stations in the midst of bustling, economically vibrant cities.

California would benefit from more intensive development in many center city areas—particularly in cities that have experienced dramatic growth in recent decades, such as San Jose, Riverside and Bakersfield. Focusing new commercial development in existing downtowns would reduce the pressure to accommodate growing populations in sprawling developments and would create centers of activity that could be served by a mix of transportation options, including public transit.

Extensive study of the experience with high-speed rail in Europe and Japan leads to several conclusions. First, high-speed rail can act as a powerful magnet, drawing economic activity toward areas with access to the high-speed rail network—generally helping to focus development in city centers rather than in exurban areas.[72] Second, well-planned high-speed rail stations can serve as a major catalyst for economic growth in an area. Finally, high-speed rail can contribute to a vibrant tourism economy.

Japan

With Japan's massive rail ridership, development opportunities around Shinkansen stations have abounded. Studies have shown that population growth and employment in several industries increased faster in cities with high-speed rail stations than in those without. Property values near high-speed rail stations increased by 67 percent.[73] Many high-speed rail stations have become city centers, with intensive mixed-use development and strong connections to local transit networks.[74]

Construction of high-speed rail lines in other countries has created thousands of jobs. Here, construction is underway on a bridge as part of Spain's efforts to extend its high-speed rail network. Credit: Xosema, used under Creative Commons license

High-speed rail stations have the potential to attract many forms of development, including offices, hotels, retail stores and entertainment venues. Above, the 50-story-plus JR Towers rise above Tokyo's Nagoya rail station. Credit: Steve Boland, Nelson/Nygaard Consulting Associates

High-speed rail stations have proven to be such drivers of economic activity that the railroads themselves have sought to get in the act by intensively developing their rail stations. Central Japan Railway has built a complex with two 50-story high-rises above Tokyo's Nagoya Station, including a 780-room hotel, department store, offices and Japan's largest indoor garden.[75] The Tokyo example shows that the revenues brought in by development of high-speed rail station areas can be an important part of the business model for making high-speed rail an economically self-sustaining enterprise.

France

France has had mixed experience with generating economic development near high-speed rail stations, depending chiefly on whether it invested the necessary funds to bring high-speed rail into city centers or placed stations far from city centers to save money. Some of these more remote stations, known colloquially as "beet field" stations, because they were built in agricultural areas, have failed to draw significant numbers of travelers or spark significant economic development.

In other locations, the arrival of high-speed rail service has sparked dramatic development near rail stations:

- The city of Lille along the France-Belgium border used its location at a junction of high-speed rail lines linking London, Brussels and Paris as a basis for economic revitalization. The Lille-Europe high-speed rail station is at the core of a multi-use development including a shopping mall, residences, office buildings and entertainment venues. Office rents in the station area are higher than in other parts of the city, and its location along the high-speed rail line has led to an increase in tourist visits to the city.[76]

- Lyon, which was connected with Paris via the first TGV line in 1981, has experienced dramatic growth around its TGV station, which was newly built specifically for high-speed rail. By 1990, the area surrounding Lyon Part Dieu station was attracting 60 percent of new development projects in the city.[77] The amount of office space in the area increased by 43 percent.[78] Currently, the area surrounding Part Dieu station hosts 5.3 million square feet of office space, 1,000 hotel rooms and 20,000 jobs.[79]

- Cities with more recent access to high-speed rail have experienced similar development. Office space near high-speed rail stations in cities such as Le Mans, Nantes and Vendome

attracts a 20 percent rent premium compared to areas farther away.[80] In Le Mans, the new high-speed rail station was integrated into a business center development that now hosts 80 companies and 2,500 jobs.[81]

- Strasbourg will soon be at the center of a high-speed rail connection linking France to Germany and Eastern Europe, and the city is looking to capitalize on its position by redeveloping several areas of the city, planning to add at least 6,000 housing units as well as commercial development.[82]

Spain

The city of Lleida, between Madrid and Barcelona, has succeeded in attracting new business and tourism since completion of the high-speed rail link between the two major cities during the mid-2000s. Lleida has experienced a 15 percent increase in tourism and has used its proximity to high-speed rail to lure investment from Microsoft and other high-tech companies.[83]

Ciudad Real, a small city about an hour outside of Madrid by high-speed rail, has experienced growth as it has developed into a long-distance commuter town and regional business and university center. Recently, the city has seen the opening of a new airport linked directly to the high-speed rail line.

Italy

Anecdotal evidence suggests that the opening of a new rail station leads to a 30 to 40 percent increase in property values in the immediate area.[84]

Great Britain

The recent initiation of high-speed rail service between London and the English Channel creates new opportunities for development. By 2020, for example, it is estimated that 60 million passengers per year will pass through the area of London's St. Pancras International high-speed rail station and the adjacent King's Cross station, which provides regional rail service.[85] The area is currently the focus of a massive redevelopment effort, which includes as many as 2,500 new homes, hotels, offices and cultural venues, with the area eventually accommodating 30,000 jobs.[86]

Meanwhile, outlying stations are also being targeted for mixed-use development. Ebbsfleet station, for example, is the anchor for development that is anticipated to add as many as 10,000 units of housing and 25,000 new jobs over the next several decades.[87]

The city of Lille, France, has used its strategic position at the intersection of high-speed rail lines serving London, Paris and Brussels as a catalyst for new development. Above, a public art installation sits in front of an office tower built directly above the Lille Europe high-speed rail station. Credit: Simon Schoeters

The high-speed rail station in Stratford will be a main entry point for visitors to the nearby Olympic Park when London hosts the summer Olympic Games in 2012. High-speed trains will whisk 25,000 visitors every hour from central London to Stratford in approximately 7 minutes.[88] After the games, the athletes' Olympic Village will be converted into permanent housing as part of a massive redevelopment project designed to take advantage of the area's transportation connections, including its proximity to central London via high-speed rail.

High-Speed Rail Has Broader Economic Benefits

High-speed rail can spark development around train stations, but what about California's economy as a whole? Traditional economic analyses of high-speed rail investments, including many analyses of high-speed rail lines abroad, focus solely on *transportation* benefits—for example, the amount of time and money saved by traveling via rail versus other modes. But recent research suggests that the non-transportation economic benefits of high-speed rail investments may be just as important.

London's rebuilt St. Pancras International Station (above) serves as the departure point for international Eurostar trains to Paris and Brussels, and is also a core element of an urban redevelopment effort that will create thousands of residential units and tens of thousands of jobs. Credit: Matt Buck, matttbuck.irongalaxy.com

High-speed rail and other transportation investments put more people and businesses in closer connection to one another, with potentially significant gains in productivity. Economists have long studied the benefits of "agglomeration"—the gains in productivity that result from concentrations of industries or people. Economic research shows that industries benefit in many ways from locating near other, similar businesses—a phenomenon that explains the dominance of the film industry in Hollywood or high-tech industry in Silicon Valley.[89] Similarly, some economists believe that large metropolitan areas with diverse economies are more productive than smaller cities. Studies have estimated that doubling the size of a city increases economic productivity by 3 to 8 percent.[90]

High-speed rail in California would ease connections between people and businesses across the state. With a California high-speed rail network, for example, downtown areas of cities such as Riverside, Anaheim and Irvine will be extremely close, travel time-wise, to downtown Los Angeles (and to one another). If the areas around transit stations are developed in such a way as to attract business development, these cities could benefit economically without adding to problems such as sprawl or traffic congestion.

Unfortunately, it is difficult to measure the degree to which high-speed rail—as opposed to other factors—has made regions or nations more economically competitive. A few studies have determined that high-speed rail can lead to broader economic benefits in a given region or country, while more anecdotal evidence finds that high-speed rail has forged new connections among people and businesses—connections that can help spur economic growth in today's "knowledge economy."

Germany

The completion of a new high-speed rail line between Frankfurt and Cologne provided new service to intermediate stations in the towns of Limburg and Montabaur, which had previously been difficult to reach. Researchers have estimated that the counties surrounding those two towns experienced a 2.7 percent increase in their gross domestic product as a result of the increased access to markets provided by high-speed rail. Interestingly, the economic growth associated with high-speed rail came *before* the line entered into service, as businesses and individuals changed their economic behavior in anticipation of the arrival of high-speed rail. Based on their results, the researchers project that every 1 percent increase in market access delivered by high-speed rail will result in a 0.25 percent increase in economic activity in a region.[91]

England

In England, construction of the nation's first high-speed rail line, completed in 2007, is projected to lead to $26 billion in net economic benefits over a 60-year span. Among the benefits identified in the study were "regeneration" benefits (benefits resulting from development spurred by the high-speed line), as well as agglomeration effects and changes in the labor market.[92]

Japan and Korea

One way to get a sense of the economic impact of high-speed rail is to look at who is riding it. If a high-speed rail line is only being used by people who had previously made the same trip via other modes of transportation, its economic impact will be very limited. However, when new travelers start to use high-speed rail for business trips, tourism or commuting, it is a good signal that high-speed rail is spurring broader changes in the economy.

Korea Train eXpress (KTX) began service in 2004, linking the capital of Seoul with the coastal cities of Busan and Mokpo, and providing an alternative to travel on increasingly congested highways. The number of one-day business trips in Korea has increased as a result of high-speed rail.[93] Evidence in Japan suggests that high-speed rail has promoted the centralization of certain service industries in large cities such as Tokyo and Osaka and encouraged business trips.[94]

France

In France, travel along the Paris-Lyon corridor jumped dramatically following the introduction of high-speed rail service. [95] Nearly half of all travel between Paris and Lyon was estimated to be trips that had not occurred prior to the introduction of high-speed rail service.[96] Overall travel between various outlying cities and Paris increased significantly following connection to the TGV network, with business travel increasing on some corridors as well.[97]

High-Speed Rail Is Often Economically Self Sufficient

As California moves toward the creation of a high-speed rail network at a time of extreme economic difficulty, one worry is that a high-speed rail network would be a financial albatross, requiring continuing economic subsidy from taxpayers.

The experience of high-speed rail lines around the world has good news and cautionary news for California. The cautionary news is that high-speed rail infrastructure rarely "pays for itself" directly, in the sense that fare revenue is sufficient to pay for the initial costs of construction. Much like other government infrastructure investments—from highways to airports to water systems—the purpose of investment in high-speed rail isn't to make a profit, but rather to lay the foundation for a vigorous economy and a high quality of life.

The good news, however, is that well-designed high-speed rail lines around the world frequently turn an *operating* profit, meaning that they make enough money in fares to pay for their ongoing operation. In the very best cases, high-speed rail lines have been able to completely pay off the initial cost of construction through fare revenue. And in many cases, profits from high-speed rail operations can subsidize other important, if less profitable, forms of rail service.

The experience abroad suggests that California can expect high-speed service to pay for its ongoing cost of operation, though it may take a few years for the line to achieve its full ridership potential.

France—TGV Paris-Lyon

France's first high-speed rail line, the TGV service from Paris to Lyon, proved itself to be a financial success. The line turned an operating profit shortly after it was launched and paid back the cost of construction within 12 years.[102] In France, profitable high-speed rail service is often used to subsidize money-losing regional service, preserving broad access to passenger rail. In 2008, amidst record ridership during the worldwide spike in oil prices, the French state-owned rail company, SNCF, performed so well that it paid a dividend of $190 million to French taxpayers.[103]

Despite more recent setbacks, including

High-Speed Rail and Tourism

High-speed rail has been shown to have a positive impact on tourism in several nations.

- In France, the city of Nantes saw a large increase in tourism investment, with a 43 percent increase in hotel rooms in the central part of the city in the years following opening of the TGV.[98] Other cities and regions in France have experienced similar effects, with new hotel developments around high-speed rail stations.[99]
- In England, completion of the Channel Tunnel has been shown to increase tourism to London.[100]
- In Japan, the arrival of high-speed rail has been linked to hotel development. In the city of Kakegawa, the opening of a new station along an existing high-speed rail line contributed to the opening of five new hotels and boosted the local economy.[101]

Some analysts suggest that the number of visitors isn't the only thing that changes when high-speed rail reaches a tourist destination—the type of travelers changes as well. Some research suggests that a greater share of visits are "day trips," since getting to and from tourist destinations is much easier. This may result in increased tourism visits, but fewer nights spent in hotels. A similar effect has been observed for business travel.

the economic crisis and higher track-use fees charged by the infrastructure company that owns the tracks over which the TGV must run, 80 percent of TGV services continue to break even or make money.[104]

Japan

The original Tokaido Shinkansen line, linking Tokyo and Osaka, has been highly profitable, paying back its construction costs within approximately a decade.[105] The Sanyo Shinkansen line from Osaka to Fukuoka, which opened between 1972 and 1975, delivers an operating profit to the line's owner, West Japan Railway, which has steadily been retiring debt from its acquisition of the line in 1997.[106]

U.S. East Coast

Depending on the method of accounting used, Amtrak's Northeast Corridor trains run at an operating profit.[107] According to a recent analysis, Amtrak's Acela Express service on the Northeast Corridor turned an operating profit of $41 per passenger, or $220 million in 2008.[108] The Acela Express succeeds financially because it provides an attractive, comfortable and fast travel experience in a densely populated corridor, where Amtrak can charge fares that are comparable to those charged for air travel. As is the case in France and other nations, highly profitable high-speed rail service generates revenue to subsidize less-profitable routes elsewhere.

Spain

According to Spain's national railway, the high-speed AVE network turns an operating profit.[109] In both France and Spain, the high-speed lines are the only parts of the national railway system that recover their operating costs, since the high-speed trains can carry large numbers of passengers at prices that compete with airline fares, particularly for first-class or business class seating.[110]

High-Speed Rail, Transit and Land Use

California faces important decisions about its future growth. It can continue to encourage sprawling forms of development that take up vast amounts of open space and commit residents to dependence on the automobile for most daily trips. Or it can build compact communities where most travel can be done on foot or by public transportation, reducing our dependence on oil and our contribution to global warming.

High-speed rail, in and of itself, cannot change California's land-use patterns. In fact, high-speed rail is better understood as putting an exclamation point on whatever vision of future development the state otherwise promotes. As one study of development around French TGV stations put it: "The TGV accelerates or amplifies what are already favorable or unfavorable factors. It does not create them from nothing."[111]

If California opts to pursue a future of automobile dependence and sprawl, it can design a high-speed rail system that accelerates that vision—locating stations in undeveloped areas, with access only by automobile, and surrounding those stations with low-density bedroom neighborhoods. (Even then, high-speed rail would be a better alternative than expanding highways, which generate sprawl along their entire length, rather than only at stations located many miles apart.)

But, high-speed rail can also be used to accelerate more sustainable forms of development, creating vibrant new centers of activity and commerce, and anchoring well-planned new neighborhoods that include a walkable mix of residential and commercial uses that are well-connected to the rest of the region via public transportation.

The question of how to integrate high-speed rail into the transportation and land-use vision of a region has been

important everywhere that high-speed rail lines have been built. But it is absolutely critical in California. The competitive success of high-speed rail depends on the easy accessibility of high-speed rail stations via both automobile and transit. And high-speed rail's value as an economic development tool depends on stations being well integrated into the fabric of their cities. As California builds high-speed rail, it is important that it does so in ways that forward a vision of a more livable and sustainable state.

High-Speed Rail and Local Transit

High-speed rail's ability to compete against automobile and rail travel depends upon the accessibility of stations to a wide variety of travelers, both those arriving at the station via public transportation and those arriving by car. A study conducted of airport choice in the London metropolitan area found that airport accessibility is the number one factor affecting airport choice—that is, that people are more likely to fly out of the airport that is most accessible to them.[112] The same dynamic is likely to hold true in California as residents consider whether to travel between cities by air, rail or car. If it is easier and faster for Los Angeles travelers to get to LAX than the high-speed rail station, and fares are similar, many will choose to fly rather than ride, minimizing the benefits resulting from California's investment in high-speed rail.

Japan is one of several countries that have built high-speed rail stations in city centers, magnifying the potential of high-speed rail to promote compact, sustainable development. Above, a Japanese Shinkansen high-speed train travels through the Ginza District of Tokyo, the city's exclusive shopping district. Credit: Steve Boland, Nelson/Nygaard Consulting Associates

Nations have used a variety of tools to provide accessible high-speed rail service to the broadest possible range of travels. Many of the principal cities in those nations—cities such as Paris, London and Tokyo—already had extensive transit systems prior to the introduction of high-speed rail. But other cities have used the arrival of high-speed rail to expand access to their transit systems and to leverage improvements in transit service. According to one study of high-speed rail in Europe: "Across mainland Europe, there is evidence of very careful integration of local/regional transport networks with high-speed rail, which means that the high-speed station should form a major interchange point."[113]

France: Expanding Trams and Regional Rail

France has seen a dramatic expansion in the number of local light rail systems, even in relatively small cities. As of 2009, France had 20 city tram systems (similar to light rail or streetcars) in cities outside of Paris, nearly all of them built since 1985, and most in cities with TGV connections.[114]

French cities have used the arrival of the TGV to reorganize and improve transportation connections. The city of Le Mans, for example, was linked to the TGV system in 1989. The city built a new tram line in 2007, which links the TGV station with destinations within the city. Now, Le Mans is redeveloping the rail station into a multi-modal transportation hub, relocating the city's bus station to the rail hub,

expanding automobile parking at the station, installing bike racks, and building a new pedestrian square.[115] Research in France suggests that the degree of integration of a station into local public transportation networks has a direct, and sometimes dramatic, influence on the choices individuals make for how to access those stations, with better-integrated stations drawing a larger share of travelers to the stations via public transportation or on foot.[116]

In addition to providing improved local transit service, France has also invested in improved regional rail service to bring fast, efficient rail service within the reach of a greater share of the population.[117]

Great Britain: Using High-Speed Rail to Improve Regional Service

High-speed rail lines can also be used to improve the quality of regional commuter rail service, which plays a vital role in reducing congestion in metropolitan areas. High-speed rail investments can do this in two ways: by diverting traffic from existing rail lines, enabling them to operate more efficiently, or by creating new high-speed infrastructure that is shared by both local and intercity service.

High-speed rail systems around the world have taken both approaches—some by creating dedicated rail lines used only by high-speed trains and others by enabling the improved infrastructure of high-speed rail lines to be used by both local and regional service.

Great Britain, which saw the opening of its high-speed rail link between London and the Channel Tunnel in 2007, is using its investment in high-speed rail to improve both commuter and freight service to the southeastern portion of the country. In late 2009, high-speed regional rail service was inaugurated in southeast England, providing 200 trains per day linking 21 stations with London's St. Pancras International station.[118] Early results from "preview" service offered prior to the launch of full-fledged high-speed rail suggest that the new service will displace numerous car commutes. During the preview period, 8 percent of high-speed rail riders switched from driving.[119]

Lyon is one of many French cities that have build new tram (streetcar) lines to connect residents of the city and provide improved access to TGV high-speed rail stations. The tram above carries passengers to Lyon's Perrache TGV station. Credit: Marcel Marchon

The new service will dramatically reduce travel times for commuters to London. The new line is also likely to be opened to freight traffic, reducing congestion on existing rail lines.

High-Speed Rail, Commuting and Land Use

One significant concern about high-speed rail in California is that it could contribute to further suburban sprawl, which consumes vast amounts of land and leads to increased automobile use and oil consumption. In the worst-case scenario, high-speed rail stations would be located in undeveloped areas, accessed primarily by car, and surrounded by low-density development.

In some ways, the experience abroad is reassuring. While there are some examples (see below) of outlying cities becoming "commuter towns" for major metropolitan

Britain's new High Speed 1 line not only provides rapid intercity connections between London and Paris, but it also accommodates high-speed commuter trains serving southeastern England (above). Credit: Matt Buck, matttbuck.irongalaxy.com

areas, there is little evidence that high-speed rail has contributed to sprawl.[120]

In addition, high-speed rail has some characteristics that make it less likely to produce sprawl than alternative transportation options such as freeways. First, unlike freeways, which have multiple exits, often spaced a few miles apart, there will be very few access points for California's high-speed rail network. While there are nearly 6,000 freeway exits in California, there will be only 26 proposed stations on the state's high-speed rail network.[121] As a result, any new development sparked by high-speed rail is likely to be more concentrated than that created by new freeway construction. Second, depending on the pricing policy followed, commuting via high-speed rail could be expensive, and therefore out of the reach of many would-be commuters.

Indeed, to the extent that high-speed rail attracts existing long-distance commuters, it may actually help to address some of the problems associated with sprawl. California has many existing long-distance commuters who could potentially switch to high-speed rail for at least part of their journeys. For example, in 2000, there were 7,500 residents of Stockton and 300 residents of Merced who commuted to the Bay Area for their jobs.[122]

Evidence from around the world suggests that high-speed rail can facilitate commuting, but that commuters make up a small share of high-speed rail travelers. Since travel between many of the city pairs that would be served by the California high-speed rail network—particularly within the Bay Area and Southern California—will be possible within an hour or less, it will be vital for California communities and land-use planners to ensure that the arrival of high-speed rail is accompanied by land-use policies that ensure sustainable

development in communities with new stations.

Korea and Japan

Korea and Japan have both taken steps to encourage commuters to use high-speed rail via the sale of discounted passes. In Korea, regular users of commuter passes account for 2.4 percent of total ridership on the KTX system, but for some sections of the line, the share of commuters is as high as 37 percent.[123]

In Japan, an estimated 47,000 business people and students commute using the Shinkansen high-speed rail.[124] While commuters make up less than 10 percent of the ridership on the Shinkansen system, the number of commuters has increased steadily over time, and the railway has added double-decker cars to accommodate demand during rush hours.[125]

France and Spain

In France, the existence of the TGV has led to an increase in the number of people commuting from formerly distant provincial cities and towns to the capital, Paris. In some cases, as with the cities of Le Mans and Tours, which are about an hour away from Paris by TGV, the overall number of commuters has not changed, but the nature of commuting has: whereas business commuters once would travel to Paris on Monday morning and return home on Friday, these commuters are now able to travel back and forth to their jobs daily.[126]

In Spain, high-speed rail has led to the growth of towns such as Ciudad Real, which was brought to within an hour of Madrid by the new rail line, and which has experienced both business growth and an increase in the number of people commuting from the city to Madrid.[127] Formerly a relatively isolated town in an area of 200,000 people, Ciudad Real now serves as many high-speed rail passengers as the city of Cordoba, which is five times larger.[128] Ciudad Real has experienced a population increase of 15 percent over the course of the past decade, with an average of 1,000 new homes built in the city each year.[129] Commuters between Ciudad Real and Madrid make up one in four high-speed rail travelers between the two cities, while reverse commuters from Madrid to Ciudad Real now make up one in five passengers in that direction.[130]

Great Britain

In England, the construction of the high-speed rail link between London and the Channel Tunnel will open up new opportunities for rapid travel between the towns of southeastern England and the capital city. Because the new high-speed rail line will accommodate both international traffic and local commuter service, the potential for development near outlying stations is great.

Local and regional governments have anticipated the arrival of high-speed rail by developing detailed plans to focus growth around new rail stations, and to do so in ways that promote environmental sustainability. For example, the principles for new development near Ebbsfleet station—which is eventually expected to create 10,000 new homes and business development with 20,000 new jobs—include an emphasis on redevelopment of previously used land, expansion of public transportation, provision of open space and community facilities, and compact, mixed-use development patterns that "offer the opportunity to live and work within close proximity, reducing travel and improving quality of life."[131]

Creation of high-speed rail service in California could lead more Californians to embrace long-distance commuting, bringing new development pressures to bear on more remote areas of the state. The state should work to ensure that proper plans are in place to ensure balanced, sustainable development of cities with high-speed rail stations, rather than the creation of new, low-density residential suburbs.

Conclusion and Recommendations

The experiences of nations around the world show that California has much to gain from its investment in high-speed rail, but also that the impact of high-speed rail depends upon the many decisions that will be made in upcoming months and years regarding the location of stations, the construction of local transit networks, policies to guide development around those stations, and other issues.

To maximize the benefits of high-speed rail, California should:

Build it – Countries around the world that have invested in high-speed rail have not regretted the decision, as the continued and accelerating construction of high-speed rail lines around the world demonstrates. Following through on California's commitment to high-speed rail can create thousands of jobs in the near term while positioning the state to meet the economic, transportation, energy and environmental challenges of the 21st century. The cost of inaction is great—committing California to more expensive airport expansions, greater reliance on expensive, foreign oil, and dirtier air.

Use high-speed rail to focus future development, not create sprawl – Locating high-speed rail stations in city centers, as opposed to outlying areas, and planning for intensive commercial and residential development near stations are the best ways to ensure that high-speed rail delivers on its promise of reducing automobile congestion, curbing sprawl and enhancing California's economy and quality of life. Communities receiving high-speed rail stations have the obligation to adopt land-use and economic development plans that contribute to a future of sustainable development for California.

Make high-speed rail accessible to Californians – California should ensure that high-speed rail stations are accessible via a variety of transportation modes, including automobile, public transit, bicycling and walking. While automobile accessibility is important, California should follow the lead of other nations by expanding public transportation services, enabling more residents of and visitors to California cities to get around effectively without a car.

Integrate high-speed rail with improvements to commuter and freight rail – Many nations with high-speed rail systems are using those investments to drive simultaneous improvements in regional or commuter rail and in freight transportation. For example, high-speed rail-driven improvements to the Caltrain corridor between San Francisco and San Jose also have the potential to benefit commuter rail passengers, much as investment in high-speed rail in southeastern England has resulted in the expansion of high-speed commuting options. The California High-Speed Rail Authority should continue working with commuter rail providers to ensure that the new service complements, rather than duplicates, commuter rail service. In addition, California should examine the possibility of allowing freight service on high-speed rail lines at night, as is the practice in some other nations with high-speed rail.

Keep clear lines of accountability – The California High-Speed Rail Authority is solely focused on the creation of a high-speed rail network for the state, and it should stay that way. Folding the authority into Caltrans or another agency, as some have proposed, would leave high-speed rail competing with other modes of transportation for funds and attention, which, along with the disruption involved in bureaucratic reshuffling, would threaten the schedule for the project. Around the world, high-speed rail projects have primarily been undertaken by national railroads, state-owned infrastructure firms, or concessionaires dedicated to the specific task of building the lines. To ensure that the authority has the ability to do its work, it should be adequately staffed and funded. Adequate staffing is particularly important since the authority must quickly ramp up its activities to meet its schedule for initiating service.

Use private participation responsibly – California's Proposition 1A mandated that a third of investment in high-speed rail should come from the private sector. The state must not, however, treat private investors as if it is desperate for their participation. Private contracts must make sense for the long-term public interest, not just act as a way to generate short-term infusions of cash. The state must retain the right to make decisions about fares and operations. Private companies should be subject to at least the same level of public disclosure as would a state agency.

Improve lines of communication – While maintaining the High-Speed Rail Authority as a separate entity is important, the authority must also take steps to improve communication with government agencies and citizens—particularly at the local level. The authority must coordinate with the state Department of Transportation, regional transit authorities, regional councils of governments, metropolitan planning organizations, mayors and groups representing local businesses and citizens to ensure that the state's investment in high-speed rail is matched by the adoption of transportation and land-use plans that can maximize the benefits of that investment. In addition, the authority should conduct regularly scheduled public meetings in cities that will receive high-speed rail stations to provide a forum for public input and a way for the authority to keep the public informed about the progress of the project.

Maintain budget discipline and spending transparency – "Megaprojects" such as the California high-speed rail system are notoriously difficult to keep on track and on budget. Doing so requires budget accountability and transparency at every level. The California High-Speed Rail Authority is already subjected to bud-

get oversight from the executive and legislative branches, as well as its own board (and, in the wake of the project's receipt of funding under the American Recovery and Reinvestment Act, some federal oversight as well). In addition to preserving these layers of oversight, the authority should continue to provide searchable access to details of the contracts it issues to consultants and suppliers through the state's Reporting Transparency in Government Web site.

Make it green – To ensure that high-speed rail delivers the maximum environmental benefits, California should ensure that trains used on the line are as energy efficient as possible and move forward with plans to power the system with renewable energy. As California builds the high-speed rail system, it should also seek to minimize global warming pollution associated with construction, as well as other construction-related environmental impacts.

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