November 18, 2017

RailPlan@dot.ca.gov

Subject: Comments on 2018 California State Rail Plan

To Whom it May Concern:

I commend the California State Department of Transportation (Caltrans) for its publication of the draft 2018 California State Rail Plan.

The State Rail Plan properly recognizes that electrification, which will be realized either through traditional catenary-based systems or other zero emission technology, will improve rail system capacity and energy efficiency. The plan also acknowledges the lower operating costs and emissions benefits of electric trains.

I am very pleased that the 2022 Short-Term Plan includes a statewide goal to "…make significant progress in implementing alternative fuels or zero-emission technology on both rail and integrated express bus services", and supports Caltrain's Peninsula Corridor Electrification Program as a high priority for capital funding. The State Rail Plan also support funding of passenger rail electrification projects for the 2027 (Mid-Term) and 2040 (Long-Term) capital investment plans.

It is also laudable that the advancement of zero and near-zero emissions technologies was identified as one of six major areas of need and opportunity identified for freight rail in California. However, the State Rail Plan needs to provide more specific goals and plans for zero-emissions freight locomotives, and propose pilot projects for both conventional catenary and emerging technologies such as battery locomotives. The state needs to develop grant programs and other financial incentives for such pilot projects in collaboration in private railroad companies, even if they are initially resistant to implementing zero-emissions motive power.

The comments below are complimented by the attached white paper "The Need for Freight Rail Electrification in Southern California", which I recently submitted as an attachment to my public comments on the Ports' Clean Air Action Plan. I have also attached another white paper titled "Southern California Freight Railroad Lines and Renewable Energy Transmission", which discusses the use of freight railroad right of ways for renewable energy transmission. It also touches on electric freight railroads hosting utility-scale energy storage, and various benefits possible for electric utilities.

Thank you for this opportunity to provide comment on this important work that Caltrans is doing for the economic and environmental well-being of the State of California.

Sincerely,

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Pg. 7, 1.2.2 Trends and Opportunities – Emerging technologies

Electric traction is listed under 'emerging technologies'. However, it is a very well established technology.

Electrification with overhead catenary wire has been used for well over a century for both passenger and freight rail, and is used today on about one quarter of all railroad tracks in the world. See comment below for "Pg. 168, 5.2.7 Advancement of Zero and Near-Zero Emissions Technologies".

Pg. 26, 1.3.6 Environment

> "Rail investments contribute to reduced impacts on the environment by offering shippers and travelers a cleaner alternative to motor vehicle and air travel. In the Bay Area, the Caltrain corridor alone is responsible for saving over 200 metric tons of GHG emissions per day. Over the course of the year, that equates to 50,000 metric tons of carbon dioxide saved, and over 1 million dollars on the cap-and-trade market, just from mode shift.[48]
>
> Electrification of the Caltrain line will lead to further net air quality benefits in the form of reduced on-board emissions from the switch away from diesel trains."

Similar emissions- reductions calculations should also be done for other passenger and freight rail services within the state.

Pg. 36, 1.4.4 Regional Plans & 1.4.5 Corridor-Level Plans

Electrification of other train services besides HSR, on 'blended' corridors or elsewhere, needs to be recommended for these plans.

California High Speed Rail investments could also aid electrification of freight rail, even if freight trains never use the same tracks as high speed trains. There are opportunities for sharing 25-kV electrification infrastructure on the two corridors which are planned to blend the high speed trains (going at non-high speeds) with other passenger trains: San Francisco to San Jose (Caltrain) and Burbank-Los Angeles-Anaheim (Metrolink and Amtrak). For example, the California High Speed Rail Authority has proposed to upgrade the Los Angeles-Fullerton corridor from the existing three tracks to five: two passenger-only electrified tracks, alongside three freight tracks. High speed trains would share the electrified tracks with other passenger trains, and freight could be kept off the passenger tracks entirely. However, the overhead catenary structures for high-speed rail could be designed to also support catenary wire on adjacent tracks in a shared corridor.

Pg. 37, 1.4.5 Corridor-Level Plans, Southwest Multi-State Rail Planning Study

Southwest Multi-State Rail Planning Study should include analysis of long-distance, interstate electrification, including the routing of electric transmission lines on rail corridor right-of-ways to transmit renewable energy between states.

Pgs. 105-106, 3.1.2, Policy 2: Invest Strategically to Optimize System Performance

> "Electrification and Zero Emission Technology (ZET)
>
> The 2040 Vision recognizes opportunities to electrify or deploy other zero emission vehicle (ZEV) technology on as much of the intercity passenger rail network as possible, which allows the system to be operated in a more efficient, cost-effective, and cleaner manner than is possible with existing diesel-powered locomotive technology.
>
> Electrification for some parts of the statewide rail network will mean traditional catenary-based systems. For other services, this will mean other zero or near-zero emissions technologies.
>
> This definition of electrification provides considerable opportunities to increase system efficiencies and performance, and improve air quality. This means longer trains can be deployed and accelerated faster and the rail network supports the State's efforts to reach its GHG emissions."

It is commendable that the 2040 Vision places a high priority on electrification and zero-emissions technology. In addition to the state's passenger rail network, the electrification of freight rail needs to be studied, because the vast majority of railroad emissions are from freight trains.

> "..Avoiding duplicate investments: The integrated network will not include duplicate or overlapping investments. Where multiple services operate in the same corridor, the mix of services (such as high-speed, express, and local) should address regional and statewide needs, and serve all markets, often using the same corridor."

Co-utilization of electrification infrastructure by high-speed and more conventional passenger trains, along shared 'blended' corridors, needs to be implemented. The sharing of electrified corridors by passenger and freight trains must also be studied.

Pg. 109, 3.1.3, Policy 3: Adapt the Multimodal Transportation System to Reduce Impacts from Climate Change

> "…because the Rail Plan includes significant core infrastructure, especially high speed, that is electrified, additional opportunities to expand electrification on adjoining corridors and on services that share HSR blended infrastructure will be pursued to operate a cleaner rail system. By 2040, Caltrans expects a majority of passenger miles on the rail system to be provided by electric trains. "

Freight rail electrification must also be studied.

Pg. 115, 3.1.6, Policy 3: Integrate Health and Social Equity in Transportation Planning and Decision Making

> "The State supports integrating social equity in the rail planning process. The 2040 Vision plans for many more access points to a transportation network than exist today, or that were envisioned previously, providing economic benefits and opportunities to disadvantaged communities in the state. Implementation actions and investment supported by the 2040 Vision are also associated with discussion and evaluation of improvements to possible community impacts of rail service, including establishment of quiet zones and implementation of grade crossing improvements to make rail corridors good neighbors."

The State Rail Plan must address the pollution impacts of freight rail operations on nearby communities, and ways of reducing emissions from freight locomotives and other vehicles operating within railyards.

Pg. 116, 3.1.7, Policy 3: Reduce GHG Emissions and Other Air Pollutants

> "A 2009 FRA study reported that a double-stack container-trailer-freight rail car moves freight three to five times more fuel-efficiently than a truck.[162] Each freight train carries much more total weight than a single combination truck, so each train movement reduces truck traffic on highways and reduces GHG emissions."

Electric trains are the most energy efficient way to move freight on land, moving a ton with as little as one-tenth the energy used by diesel truck. Electric locomotives are twice as energy efficient as diesel locomotives. The electrification of freight rail in California is the best way to reduce the public health impacts to local communities affected by diesel-powered freight transportation, and reduce greenhouse gas emissions of freight movement.

Switching from a freight rail system that relies on diesel power to one that relies on electric power will have a substantial impact on emissions in California. According a 2016 RailTEC report for the California Air Resources Board, if all line-haul freight rail locomotives in the South Coast Air Basin were all-electric (and all electricity used from zero-emissions sources), compared to using a fleet of 100% Tier 2 diesel locomotives, the annual emissions reductions possible would be as follows[1]:

- 372,000 tons CO_2
- 3,750 tons NOx
- 1,000 tons CO
- 200 tons hydrocarbons (HC)
- 140 tons particulate matter (PM)

The above figures do not include the region's freight yard/switcher or passenger locomotives. However, over 80% of locomotive emissions in the South Coast Air Basin are from line-haul freight trains. In addition to reducing emissions of pollution with local public health impacts, electrifying freight rail will also help meet the state's goals for reducing greenhouse gas (GHG) emissions. If more freight and passenger traffic is shifted from road to rail in the future, the emissions benefits of electric rail would be more significant.

Pg. 116, 3.1.7, Policy 4: Transform to a Clean and Energy Efficient Transportation System

> "…The 2040 Vision intends to accommodate additional demand for trips, and grow the rail network in a manner that incorporates substantial electrification of the state network, with improvements possible on additional corridors where there is support to do so. The statewide HSR network included in the 2040

[1] *Transitioning to a Zero or Near-Zero Emission Line-Haul Freight Rail System in California Operational and Economic Considerations, Final Report.* Prepared for State of California Air Resources Board by University of Illinois at Urbana-Champaign Rail Transportation and Engineering Center (RailTEC), Spring 2016, pg. 52. https://www.arb.ca.gov/railyard/docs/uoi_rpt_06222016.pdf.

> Vision will be powered entirely from renewable energy sources, providing a growing market for clean energy providers."

The benefits of rail electrification to electric utilities and renewable energy producers need to be further explored. Electric utilities must be involved in planning for rail electrification from the outset. It is the electric utilities who will provide the electric energy, build up new substation infrastructure to service electrified track, and construct or upgrade distribution and transmission lines. While there would be a need to construct new electric power infrastructure to serve electrified freight rail lines, electric utilities could see the new loads from freight trains as a business opportunity. In fact, the region's utilities are concerned about losing revenue from more and more customers, particularly large industrial and institutional ones, investing in distributed self-generation projects such as rooftop solar. Utilities also would benefit from being able to transmit or distribute power via rail rights-of-way. Existing transmission and distribution grid infrastructure needed to service electrified track in urban areas of California tends to be in industrial areas and near major rail corridors.

California's largest utilities are also now required to procure progressively larger amounts of energy storage capacity in the years ahead. Energy storage connected to electric rail catenary, and trackside charging systems for locomotives with batteries, could be located at passenger train stations and along freight railroads. A sufficient level of energy storage along a rail line could provide backup power in case of a local or regional power outage. These rail energy storage systems could be a new business opportunity for electric utilities. Under utility control, these distributed energy storage systems could be charged at off-peak hours, provide power to the local distribution grid during periods of peak demand, and provide ancillary services such as voltage and frequency support, reactive power, or aid integration of distributed solar energy systems. California utilities should consult the experience of other countries with both extensive electric rail and high penetration of renewable energy generation, such as Germany and Spain. Both of these nations have populations greater than California's, meet more than one-third of their overall electricity needs from renewable sources (excluding large-scale hydroelectric), and have a rail system electrification rate of at least 60%.

Significant among the benefits of electric locomotives on mountain grades, such as the Cajon Pass north of San Bernardino, is regeneration of power from braking. This recovered power can be used to power other trains nearby on the same line, or be fed back to the power grid via bi-directional substations. There are potential benefits to utilities from electric rail regenerative braking. From a utility perspective, an electric locomotive feeding power back to the grid would basically be serving as distributed generation source.

The routing of new transmission lines along freight railroad rights-of-way in Southern California is a concept worthy of study. This concept could be a new source of revenue for the railroads, increase the amount of renewable energy used in California, and improve power grid reliability. A potential win-win for railroad and electric utility companies, installing overhead power transmission lines along rail lines has long been common around the world for electrified tracks. Such lines have overhead catenary wires used to power trains, along with high-voltage power transmission lines suspended further above the catenary. The use of a rail corridor for power transmission is possible whether or not the tracks themselves are electrified with overhead catenary. For electrified railways, support structures for the catenary wire can be combined with transmission line structures. Route-specific feasibility and design studies are needed to determine what size transmission lines could be safely accommodated on a particular railroad right-of-way. Potential benefits to electric utilities, as well as revenue opportunities for railroads hosting transmission lines and energy storage capacity need to be studied.

2022 Short-Term Plan:

Pgs. 133-134, 4.6.7 Los Angeles Urban Mobility Corridor/4.6.8 Inland Empire

For the 2022 Short-Term Plan, there is no mention of planning for electrification on the Los Angeles Urban Mobility Corridor, like it is mentioned for the Inland Empire (pg. 134). Benefits of passenger rail electrification on this corridor would be similar to those described in section 4.6.3 for the South San Francisco Bay Area (pg. 131).

2027 Mid-Term Plan:

Pg. 141, 4.8.6. North LOSSAN and Antelope Valley,

> “Planning, Analysis, and Project Development:
>
> • Study electrification of corridor segments north of Burbank on the SCRRA Valley Subdivision and west of Burbank on the LOSSAN North Corridor, to leverage the benefits of HSR electrification. Determine appropriate investments both in conjunction with HSR Phase 1 service in the region, and for the 2040 time horizon.
>
> …
>
> • Study to determine the long-term mix of express and local services that can be supported in the corridor, including the extent of electrification that is possible, and the end point for half-hourly services (i.e., Chatsworth, Moorpark, or Ventura). Decisions about electrifying the corridor will influence service patterns and which corridor sections may need peak-only additional service.”

Freight rail electrification on these corridors, co-utilizing passenger rail catenary infrastructure, should also be explored.

Pg. 142-3, 4.8.8 Inland Empire

> “Planning, Analysis, and Project Development:
>
> Determine extent of 2040 electrification on Los Angeles Union Station to Inland Empire lines, and plan for implementation on at least corridors served by express rail service, and potentially also on corridors served by local rail services. “
>
> …Plan for HSR services connecting Los Angeles, Ontario, Riverside, and San Bernardino to each other and to San Diego, using electrified east-west express rail corridors. Include identification of opportunities to further upgrade corridor speeds through phased investment when Coachella Valley and Arizona rail service plans reach their recommendations.”

The Inland Empire is a major nexus for the state’s freight rail network. Freight rail electrification on these corridors between Los Angeles and the Inland Empire, co-utilizing passenger rail catenary infrastructure, should also be explored.

Pg. 143, 4.8.9. LOSSAN South

Electrification should be studied for this corridor, beyond blended HSR corridor to Anaheim/Irvine, all the way to San Diego.

2040 Long-Term Vision – Statewide Goals:

Pg. 144, 4.10.1 Central Valley and Sierra Nevada

Pg. 146, 4.10.2 North San Francisco Bay Area

Pg. 147, 4.10.3 South San Francisco Bay Area

Freight rail electrification on these corridors, co-utilizing passenger rail catenary infrastructure, should also be explored on all the major Northern California passenger rail corridors which will be electrified.

Pg. 160, Exhibit 5.1: Transcontinental Freight Routes

This map does not appear accurate for some rail freight routes. In particular, the freight volume on the BNSF Southern Transcon appears far too light. In reality, the freight volume on this line is greater than the UP Sunset Route, as shown on the map in Exhibit 1.11, "Line-Haul Freight Train Volumes, 2013" (pg. 22).

Pg. 167, 5.2.5 Additional Terminal and Yard Capacity

> "Table 5.4: Examples of Adding Terminal and Yard Capacity and Co-Benefits
> ..-Potential battery assist switcher demonstration in Bay Area yards
> ..-Reduce yard and terminal emissions through implementation of zero emissions technologies (cargo handling and switching).."

Electric battery switcher locomotive demonstrations should also be implemented in Southern California, where there is a far greater amount freight rail traffic and yard activities, as well as more severe regional air pollution problems and public health impacts caused by railyards.

Pg. 168, 5.2.6 Short-Haul Rail Improvements

> "Short-haul rail shuttles connecting ports with inland regions hosting substantial international trade-related distribution activity offer the opportunity to improve the velocity of the flow of goods into and out of the densely populated regions of Southern California and San Francisco Bay Area. With sufficiently high volumes, short-haul rail shuttles transfer the volume of freight truck traffic away from the already congested highways, particularly in and around the major ports. The capital investment in short-haul rail shuttle improvement can be made using the Traffic Congestion Relief Program funds, given a clear analysis of how the rail shuttle can help relieve congestion on roadways. The feasibility of short-haul rail shuttles is highly sensitive to the differential in costs between rail and highway transportation, and would

> require efficient operation to maximize their viability, and to capture a better rate of return on the investment of public funds."

Conventional rail electrification, with overhead catenary wire, should be studied for short-haul freight rail service in California. Electrification of the proposed short-haul rail service between the Ports of LA and Long Beach and the Inland Empire, currently under study, is an opportunity for using electric locomotives though the Alameda Corridor. All-electric locomotives dedicated to the short-haul service could go back and forth along less than 100 miles electrified track between San Pedro Bay and the Inland Empire, while conventional non-electric line-haul freight trains could continue to use the same tracks. Freight car switching on either end of electrified track segments could be performed by zero emissions battery-electric switcher locomotives, which would not require overhead catenary.

Pg. 168, 5.2.7 Advancement of Zero and Near-Zero Emissions Technologies

> "Priority should be given to rail projects that support the deployment of technologies that produce zero or near-zero air emissions. An element of the California Sustainable Freight Action Plan is that zero-emissions equipment should be deployed, where feasible, to reliably and efficiently transport freight; near-zero emission equipment powered by clean, low-carbon renewable fuels should be used everywhere else. The use of less polluting equipment reduces GHGs and other toxic emissions, and ultimately improves air quality. The freight railroads are private companies that operate in national and transcontinental markets, and therefore may be more reluctant to invest in zero and near-zero emissions technologies to meet California-specific standards. However, the State's role in advancing the adoption of this technology is central, from both a regulatory and financial perspective, because it can help advance development of the prerequisite technology; and by providing financial incentives, support its commercialization."

Conventional rail electrification, with overhead catenary wire, should be studied for freight railroads in California. Electrification with overhead catenary wire has been used for over a century for freight rail, and is used today on about one quarter of all railroad tracks in the world. Outside of North America, electric freight trains are very common. Globally, electricity's share of moving trains is increasing, from 17% in 1990 to 36% in 2012. Nations from India to South Africa, China to those of Western Europe, are expanding electrification of heavy freight and passenger lines. A large pool of manufacturers and engineering expertise exists around the world for this technology.

Most urban rail systems in the U.S. run on electricity, but electrification is sparse in the nation's intercity rail network. Amtrak runs electrified passenger service along the 457-mile Northeast corridor from Boston to Washington, and the Keystone Corridor from Philadelphia to Harrisburg, Pennsylvania. While electricity is now a major source of motive power for freight railroads in most advanced economies, the percentage of U.S. rail freight hauled using electricity is close to zero. Three lines totaling about 130 miles carry coal from mines to power plants in Arizona, Utah and New Mexico, while the Iowa Traction Railway runs 18 miles of electric line from Mason City to Clear Lake.

Almost every industrialized country, including nearly all of Europe and Japan, has an extensive network of electrified freight rail. Russia's Trans-Siberian Railway electrification was completed in 2002, at nearly 6,000 miles the world's longest rain line. Switzerland is all electric, except for one tourist line that has steam engines. Over one quarter of India's railways are electrified, and its first two freight-only electric rail lines are under construction in northern India, to carry double-stacked container under the wires.

Nations from Chile to South Africa are investing in expanding or building new electrified rail lines, while China is in the middle of electrifying 20,000 km of existing track. As described by the *Solutionary Rail* book:[2]

> AROUND A QUARTER OF THE WORLD'S RAIL LINES ARE ELECTRIFIED, 186,000 miles out of a total of 808,000. Western Europe leads with 53% of lines propelled by electricity, while North America trails with 1%. The global electrification market "continues to grow dynamically," particularly in Western Europe, Africa and the Middle East, SGI/Verkehr reports. Electricity's share in fueling rail is growing, up from 17% in 1990 to 36% in 2012, while oil has held steady at 58% and coal decreased from 25% to 6%....
>
> However, these figures understate the significance of electrification. Typically it is the more heavily used lines that are electrified. For example, though France is only 52% electrified, 85% of freight and 90% of passengers run on electrified lines.
>
> In Russia the Trans-Siberian, at nearly 6,000 miles the longest continuous rail line in the world, was fully electrified by the end of 2002. This is notable because it runs in one of the world's harshest environments and because reliable operation is critical to Russia's strategic control of its eastern regions. The rail line carries 30% of Russian exports. Overall, electric lines carry 70% of Russian freight, the equivalent in ton-miles of 80% of US rail freight... China's rail electrification has expanded rapidly. Concerted efforts have grown the percentage from only 5% in 1975 to over 40% today.
>
> Smaller economic powerhouse nations have largely electrified rail systems. Sweden grew electrification from 61% in in 1970 to 77% of its system in 2005. The Netherlands has increased its electrified network from 52% in 1970 to 73% in 2005. Switzerland is a global standout with a 100% electrification rate. That nation is in the midst of a major rail line improvement program, a central goal of which to move freight from trucks to electric rail. In 17 European nations the rail network is at least 40% electrified.
>
> Great Britain, which has lagged other European nations with only 33% of its rail network electrified, in 2007 announced a £1.1 billion effort to expand electrification. The Great Western Line linking London with Wales is slated for full electrification by 2017. Liverpool-Manchester, one of the world's oldest rail lines, was electrified in 2015.
>
> Nations around the world that have recently expanded electrified rail or are engaged in significant efforts to do so include Chile, Taiwan, Malaysia, Iran, Israel, Saudi Arabia, Kazakhstan, Uzbekistan, Ethiopia, South Africa, Denmark, Norway, and New Zealand. Electrified rail is working around the world. It can work in the US again.

[2] Bill Moyer, Patrick Mazza and the Solutionary Rail team (http://www.solutionaryrail.org/). *Solutionary Rail: A people-powered campaign to electrify America's railroads and open corridors for a clean energy future,* October 2016, pp.15-17.

Table 1: Railroad electrification around the world (as of 2016)[3]

Country	Miles Electrified (approx.)	Percentage Electrified
Ethiopia/Djibouti	470	100%
Switzerland	3,200	99%
Belgium	1,900	85%
Sweden	7,600	76%
Japan	12,500	75%
Netherlands	1,400	72%
South Korea	1,600	70%
China	50,000	65%
Italy	8,200	65%
Spain	6,300	64%
Poland	7,400	62%
Austria	2,200	61%
Morocco	800	61%
Germany	12,400	60%
Finland	2,000	55%
France	9,400	52%
Russia	27,000	50%
South Africa	5,900	45%
India	14,700	35%
United Kingdom	3,300	33%

Development needed for an all-electric freight locomotive for California will be greatly aided by this deep pool of international experience. An electric locomotive can be designed to match or exceed the performance specifications required by U.S. line-haul freight trains. In fact, the world's most powerful locomotives are all-electric. In China, a single HXD1 two-section, all-electric 19,000 horsepower

3
https://www.cia.gov/library/publications/the-world-factbook/fields/2121.html

http://uic.org/IMG/pdf/synopsis_2015_print_5_.pdf

http://statbel.fgov.be/fr/statistiques/chiffres/circulation_et_transport/transport/ferroviaire/

locomotive set pulls entire 20,000-ton coal trains under a 25 kilovolt (kV) catenary. Transnet Freight Rail of South Africa uses a 50 kV catenary system for hauling iron ore trains in excess of 40,000 tons. More than double the weight of the heaviest U.S. line-haul freight train, these trains are pulled by up to nine all-electric Mitsui Class 15E locomotives in distributed configuration.

For widespread freight rail electrification to work again on a large scale in the U.S., there is a need for a new generation of all-electric locomotives designed specifically for the U.S. freight market. There could be advantages in using an adapted, in production electric locomotive for a small order for the short-haul freight service in the Alameda Corridor, or between the ports and the Inland Empire. Perhaps the Bombardier IORE freight or the Siemens ACS-64 passenger locomotives could be modified for California short-haul freight rail service, pulling lighter and faster trains than an interstate line-haul freight train. It is also possible for an existing line-haul freight locomotive, with its higher weight, tractive effort and six-axle chassis, to be converted to all-electric by replacing the diesel engine with a catenary pantograph and transformer system.

The change out of locomotives on trains would require the construction of new dedicated siding tracks and other facilities to inspect, service, stage, and store both diesel and electric locomotives. The 2012 SCAG report on freight rail electrification concluded the locating the locomotive “switch out” locations at the end of the electrified segment of track, such as Barstow or Indio, would have the least impact on railroad operations[4]. Located in less-populated areas, such sites also have more opportunities and space for future expansion of track and facilities. Further out ‘stateline’ sites such as Needles (California), Yuma (Arizona) and Primm (Nevada) could also serve as ‘switch out’ locations. Possible ways of minimizing locomotive exchange delays need to be studied. Research is needed in collaboration with railroads operating in California, who best understand their operations, as well as bringing international expertise from electrified freight railroads outside the U.S. Potential solutions to the exchange point delay problem, which could be studied, could include:

- Computer simulations to model locomotive change-out, to find electrification strategies that have the least operational impacts.
- Evaluate locomotive change out of dual-mode diesel electric compared to that of all-electric locomotives, and if this would reduce change-out time.
- Electrifying short-haul rail service as first phase of electrification, with later expansion in stages to entire long-haul corridors such as the Southern Transcon or the Sunset Corridor.
- Electric ‘helper’ locomotives carrying freight trains up and down up Cajon Pass, carrying ‘dead’ diesel-electric locomotives. There are different rules for adding ‘helper’ locomotives, as the air brake line is not broken between the locomotives and the cars, and the crew staying the cab of the original locomotive.
- For long-distance trains, the electrification could be phased in using dual-mode locomotives and electric-diesel mixed locomotive trains (discussed below in section 8). The short-haul freight

[4] 2012 SCAG report, pg. 4-28

train service could also begin with dual-mode. When there is a sufficient amount of regional track electrified, commuter passenger rail and short-haul freight services would switch to straight electric, and the dual mode locomotives moved to long-haul freight service. The locomotive types could also be switched where crews are changed, and where diesel-electrics are already refueled and inspected, to reduce costs and delays.

In addition to large line-haul electric locomotives, smaller all-electric locomotives such as medium-sized or small switcher units, could be developed for short-haul and freight yard switching service. All electric versions of small 'switcher' (1,000 to 2,300 hp, 130 to 450 kN tractive effort) and medium-sized (2,300 to 4,300 hp, 350 to 700 kN tractive effort) locomotives could be utilized by short-line railroads and freight railyards in Southern California. While small, switcher-scale prototype battery locomotives have been built such as Norfolk Southern's NS999, battery-electric freight locomotives are expected to become more practical in the years ahead due to improvements in vehicle-scale battery technology. However, like electric automobiles, the current generation of battery locomotives have a limited range and have only a fraction of the power needed to pull a large freight train.

Battery-diesel hybrids are another possibility that could be well suited to medium and small locomotives. In the U.S., the first generation of prototype diesel-battery electric hybrid locomotives proved disappointing to railroads, such as Railpower's Green Goat introduced in 2004, and GE's hybrid locomotive prototype introduced in 2007. Since 2014, more advanced Alstom Prima H3 and Prima H4 battery electric switcher locomotives, including both diesel-battery hybrids and battery-only versions, have been introduced into commercial service in Europe[5].

The Zero Emissions Battery Locomotive (ZEBL) conceptual prototype developed by Rail Propulsion Systems could find application for switcher locomotives, or short-haul freight rail service. A 'hybrid ZEBL', battery electric locomotive with retractable overhead pantograph for receiving power from overhead catenary, could be used in freight yards or an electrified Alameda Corridor or other short-haul freight rail corridors in California.

Pg. 179, 2040 (Long-Term) Infrastructure Investment

> "The 2040 Capital Program is focused on completion of the full build-out of regional networks to integrate the statewide system and High Speed Rail with unified service throughout the state. The program represents the long-term investments needed to achieve the passenger rail service goals described in the 2040 Vision (see Chapter 4). These include incremental projects built to expand and connect previously described services in the 2022 and 2027 programs, wider-scale investments to modernize services through electrification and connectivity improvements at station hubs, and large infrastructure projects like HSR expansion, intermodal hubs, new Transbay tube, and urban rail transit investments.
>
> HSR expansion plays of key importance to the 2040 Capital Program, and includes electrified blended service from Sacramento to Merced and through the Inland Empire, as well as HSR service to San Diego.

[5] http://www.alstom.com/products-services/product-catalogue/rail-systems/trains/products/prima-shunting-and-works-locomotives-/

> Intercity rail improvements for 2040 include electrification of express services in both Northern and Southern California, complementing HSR in network hubs with pulsed service schedules to achieve the 2040 Vision.
>
> This includes wide-scale electrification of intercity services in the San Jose-Oakland-Sacramento corridor, Central Valley from Merced to Sacramento, and Inland Empire, from Los Angeles separately to San Bernardino and Riverside, and on to the Coachella Valley."

The electrification of Southern California corridors need to be made a higher priority, and implemented well before 2040. High speed trains would share the electrified tracks with other Metrolink and Amtrak passenger trains.

Electrification of freight rail, along corridors shared with passenger rail, also needs to be explored.

Pg. 206, Short Haul Program, Public Benefits

> "The primary public benefit to short-haul rail investments is the diversion of freight traffic from highways to rail, which results in reduced highway maintenance costs and related improvements in air quality and congestion. A 2011 report estimated that rail was three times more fuel efficient than trucking per ton-mile.[210] The same report projected 2,020 grams per ton-mile of carbon dioxide (CO_2) emissions of 209 for trucks, and 44 for rail (21 percent of the truck emissions rate); particulate matter 10 microns in diameter or less (PM_{10}) emissions of 0.012 for trucks and 0.010 for rail (83 percent); and nitrogen oxide (NO_x) emissions of 0.79 for trucks and 0.53 for rail (67 percent). Therefore, any diversion of truck traffic to rail could yield significant air quality benefits, especially in the Southern California region, which historically suffers from poor air quality.
>
> The aforementioned University of California Berkeley study found that short-haul rail intermodal service from the San Pedro Bay ports to the Inland Empire could yield a 180 percent reduction in emissions, if marine containers alone shift to rail. The air quality improvements could be even greater if a portion of domestic containers also shifted. In addition to air quality improvements, the study estimated that with a successful short-haul intermodal service, up to 2.6 million drays per year between the ports and the Inland Empire would be removed from busy Southern California's freeways."

The emissions benefits described above would be far greater with zero-emissions locomotives. Electrification of short haul freight rail needs to be studied, see above comment on "Pg. 168, 5.2.6 Short-Haul Rail Improvements".

Pgs. 209-211, Emissions Analysis

The reduced rail emissions should also be calculated to include the benefits of zero-emissions freight rail electrification. The vast majority of railroad emissions in the state are from freight locomotives. See comment above on "Pg. 116, 3.1.7, Policy 3: Reduce GHG Emissions and Other Air Pollutants".

Pgs. 212, Future Planning Studies

The Rail Plan should recommend a statewide study on freight rail electrification. Zero-emissions freight locomotives would help the state achieve the emissions-reductions goals laid out in AB 32, SB 375, and SB 391.

Recommended Next Steps for Freight Rail Electrification in California-

1. A comprehensive feasibility study on electrifying a short freight corridor such as the Alameda Corridor, along with short-haul rail service from the Ports of Los Angeles and Long Beach to an 'Inland Port' or other types of intermodal facilities in the Inland Empire. This comprehensive study would include:

    - Preliminary design and cost estimation
    - Cost/benefit analysis: what lines are the best candidates for electrification?
    - Viable strategies for funding the high upfront costs of electrification.
    - Environmental and social impact assessment of possible electrification alternatives.
    - Cost assessment of modifying/replacing existing infrastructure such as bridges and tunnels for overhead catenaries, impacts on rail operations and safety, impacts to regional power grids.
    - Operational impacts to existing freight and passenger rail service.
    - Carefully assess present and future patterns of truck and rail traffic from the Ports to the Inland Empire.
    - Evaluation of Inland Port sites, in the Inland Empire, or further inland sites in the Victorville and Barstow areas.
    - Legal/legislative/regulatory actions needed to support rail electrification.
    - Further questions that must be addressed by such a study:
        - Match the electrified-Inland Port model with regional objectives
        - Best ways for more freight to be shifted from truck to rail, and to reduce truck VMT and highway congestion
        - Environmental impact of short-haul freight rail and related intermodal freight facilities
        - Economic development opportunities of short-haul freight rail
        - Identify effective project "champions"

2. Increased research and development on all types of low-emissions or zero-emissions freight rail and truck technology, for railroad yards, intermodal shipping facilities, and ports. To compliment and build upon existing efforts in the state, a research program or center in California should be established, dedicated to electric rail technology. Such a research program would partner with organizations such as the American Association of Railroad's Transportation Technology Center in Colorado, the University of Illinois at Urbana-Champaign Rail Transportation and Engineering Center (RailTEC), and other research centers located in other countries experienced with electric heavy freight rail.

3. Construction in California of a short, test track of overhead catenary at a freight rail yard or short-line freight railroad. This demonstration site could serve as a test bed to evaluate an all-electric locomotive such as modified Siemens ACS-64, a converted freight rail locomotive, a dual-mode locomotive such as a modified Bombardier ALP-45DP, a smaller all-electric switcher (yard) locomotive, or catenary hybrid/ battery tender/ZEBL technology (discussed below in section 6). If at first such a test site could not be built in California, new electric freight rail locomotives could be tested on the existing electric rail test tracks of the Transportation Technology Center near Pueblo, Colorado.

4. Selection of an initial freight rail corridor in California to electrify.

5. Demonstration site, at a freight yard or passenger train station/yard, with charging infrastructure for battery electric and hybrid locomotives, including emerging technologies such as wireless power transfer.

6. Explore co-deployment of electrification along corridors shared with passenger service trains of Caltrain, California High Speed Rail Metrolink, or Amtrak.

7. Phasing-in of all-electric operations with existing fleet of diesel-electric locomotives, and opportunities for dual-power, or 'mixed-unit' trains pulled by both all-electric and diesel electric power.

8. Negotiated agreements between railroads and electric utility companies, and thorough analysis of the economic value and benefits to electric utilities from railroad-hosted transmission line routes and energy storage capacity.

In addition, there is a need to build a broad base of support in the region for rail electrification from community organizations, environmental and public health public advocacy groups, along with local businesses, labor unions, trade associations and community activists. Local engineering, construction, and transit agency experience with electric rail transit could be applied to electrifying freight rail. Global and national experts in electric rail should also be invited to Southern California. A regional rail electrification task force was created in the early 1990s for the 1992 *Southern California Accelerated Rail Electrification Program* study, with committees for planning, engineering, analysis, operations & maintenance, environmental analysis, legal/legislative funding, alternative fuels, and regulatory applications[6]. Such a task force should be created again for California in the 21st century.

[6] *Southern California Accelerated Rail Electrification Program, Draft Executive Summary.* Prepared for Southern California Regional Rail Authority, February 10, 1992, pgs. ES-1, ES-2: http://libraryarchives.metro.net/DPGTL/Metrolink/1992-ExecSummary-SoCal-Accelerated-Rail-Electrification.pdf