

**COMMUTER RAIL AND AIR QUALITY**  
**ELECTRICATION OF COMMUTER RAIL**

**A STATUS REPORT OF THE**  
**ELECTRIFICATION STUDY FOR THE SOUTHERN CALIFORNIA**  
**REGIONAL RAIL SYSTEM**

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**Rail Transit Conference**  
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**ABSTRACT**

A mandate by the voters of Los Angeles County in November 1990 to finance the building of a 400 mile Commuter Rail network has brought with it increased awareness on the part of the South Coast Air Quality Management District of the contribution made by the region's rail system to the smog problems in the area.

Following a proclamation by the AQMD that 90% of the region's railroads shall be electrified by the year 2010, the Los Angeles County Transportation Commission took the lead role in a study to determine the cost and feasibility of electrifying some 800 route miles of railroad, both freight and Commuter over the next 18 years.

This paper will give an overview of the process by which the Commission and its subsidiary, the Southern California Regional Rail Authority, coordinated the study efforts of over 15 different public agencies, two power companies, and four railroads to reach agreement on the cost and feasibility of carrying out the proposed railroad electrification project.

## Introduction

In November 1990, the voters of California approved three Propositions, 108, 111, and 116, which enabled funding for, among other transportation improvement projects, the genesis of a Commuter Rail operation in Southern California.

The LACTC, in anticipation of the passage of these referenda, moved swiftly to have contracts in place for signature soon after the election in order to speed up the implementation of the Commuter Rail System the region so desperately needs. Accordingly, an order was placed for 17 diesel-electric locomotives from General Motors and 70 coaches from UTDC, all scheduled for delivery in the second quarter of 1992.

Service inauguration over three routes was targeted for October, 1992, in time for a November, 1992 ballot measure that will seek funding for additional Commuter Rail Routes. Ultimately, a total of nine regional rail routes will be operated by the Southern California Regional Rail Authority. The SCRRA was formed as a subsidiary of the LACTC in order to design and construct the network.

Upon learning that the new Commuter Rail system would be diesel-powered, the Air Quality Management Board entered an objection to the plan stating that the dieselized system would add to the regional air pollution problem rather than diminish it.

The SCRRA countered that the enabling transportation funding was earmarked for the mobility of people and a secondary benefit would be a reduction in automobile traffic on the freeways. This would result in reduced air pollution. SCRRA felt that not nearly enough funding would be available to electrify the commuter lines and purchase the requisite rolling stock and necessary fixed facilities.

The agency agreed to investigate the possible use of alternative (to diesel) fuels in its locomotives, but there was no possible way that the routes could be electrified in time for the planned October, 1992 startup. The AQMD threatened to seek withholding of State funding for the rolling stock unless a study were to be made to determine the feasibility and cost of electrification of the system.

A compromise was quickly reached when LACTC agreed to commission an all encompassing study of the regional rail system in Southern California. The Commission, however, rationalized that the only way to truly reduce rail-related air pollution in the basin would be to electrify both the freight and the Commuter Rail operations since, in reality, the freight rail operations represented in excess of 95% of the rail-related emissions.

Thus the task force cataloged some 1300 miles of railroad track and performed a thorough analysis of the cost, feasibility, and time constraints required to electrify. This study required the interaction of upwards of 20 public and private agencies along with numerous engineering consultants, all working under a very limited amount of time to finish.

What resulted was a very comprehensive analysis together with supporting cost data which can be used as the cornerstone of any future planning of an electrified rail system.

### Agencies Participating in the Electrification Study

The list below is intended to show the enormous diversity of the participants in the electrification study. Considering the varied expertise and independent objectives of the group, from regulatory agencies, to for-profit railroads, to citizen activist groups, to Public Utility Companies and beyond, credit is due to all that this all-encompassing report was generated in such a short amount of time.

#### County Agencies

Los Angeles County Transportation Commission  
Southern California Regional Rail Authority  
Orange County Transportation Authority  
North San Diego County Transit Authority  
Riverside Transportation Commission  
Ventura County Transportation Commission  
San Bernardino Area Governments  
San Diego Association of Governments  
Southern California Association of Governments  
Alameda Corridor Transportation Authority  
San Diego Air Pollution Control District

#### State Agencies

California Public Utilities Commission  
California Transportation Commission  
South Coast Air Quality Management District  
California Air Resources Board

#### Federal Agencies

Federal Railroad Administration

#### Railroads

National Railroad Passenger Corp. (Amtrak)  
Union Pacific Railroad  
Southern Pacific Transportation Co.  
Santa Fe Railroad

#### Utilities

Southern California Edison Co.  
Southern California Gas Co.  
Department of Water & Power Co.

#### Citizens' Groups

Coalition for Clean Air

### **Goals of the Electrification Study**

The goals of the electrification task force study were as follows:

- Determine the cost to electrify the region's railroads.
- Determine how quickly the railroads could be electrified.
- Which lines, if electrified, would contribute the most emissions reductions?
- What is the most viable means of obtaining funding?
- What are the air quality impacts of the proposed diesel commuter rail network?
- What legal/legislative/regulatory actions must be undertaken to implement a regional electrification program?
- Will the candidate electrified network achieve the AQMB target of 90% emissions reduction if implemented?
- What will be the contribution of alternative fossil fuels in achieving the 90% reduction by the year 2010?

# REGIONAL RAIL ELECTRIFICATION TASK FORCE



**TASK FORCE CHAIRMAN**  
Bruce Nestande

**PROJECT MANAGER**  
Norm Jesler

**CONSULTANTS**

- Myra Frank & Associates
- De Leuw Calther & Co
- Booz-Allen & Hamilton
- Frederic R. Harris Inc.
- Seelye Stevenson Value & Knecht
- LTK Engineering

**ADMINISTRATION**  
Debbie Sclar

- Agency Coordination
- Progress Reporting
- Invoice Processing
- Agenda Preparation

**TECHNICAL**  
Bob Shipley

**Committees**

**ALTERNATIVE FUELS**  
Jack Smith (SCG)

- Ident. of Alt. Fuels
- Operating Characteristics
- O & M Cost
- Capital Cost
- Technical Development/Timing
- Environmental Impact
- Demonstration Grants

**PLANNING, ENGINEERING, OPERATIONS & MAINTENANCE ANALYSIS**  
Bob Shipley

- Corridor Identification
- Corridor Feasibility
- Track Configuration
- Clearances
- Locomotives
- Overhead Catenary
- Traction Power Sub-Station
- Communications
- Signaling
- Grade Crossings
- Maintenance Facility
- Agreements
- Facility Requirements
- Safety
- Procurement
- Construction
- Cost and Schedules

**ENVIRONMENTAL ASSESSMENT**  
Mike Nazemi-Myra Frank

- Air Quality
- Noise & Vibration
- EMF
- Construction
- Energy/Utilities
- Land Use
- Visual
- Vehicular Traffic

**ADMINISTRATION**  
Sharon Greene

**Committees**

**FUNDING**  
Linda Bohlinger

- AOMD
- Counties
- Local Sales Tax
- Railroads
- State ARB
- Utilities
- CTC
- Federal EPA-DOT

**LEGAL/LEGISLATIVE**  
N. Webster-C. Moody

- EIR Documentation
- Permits
- Institutional Issues
- Legislative Issues

**REGULATORY APPLICATION:**  
De Ann Johnson (PUC)

- PUC
- Project Descripti
- Electrical System
- Project Facilities
- Construction
- O & M
- Cos. Benefit
- Franchise & Per

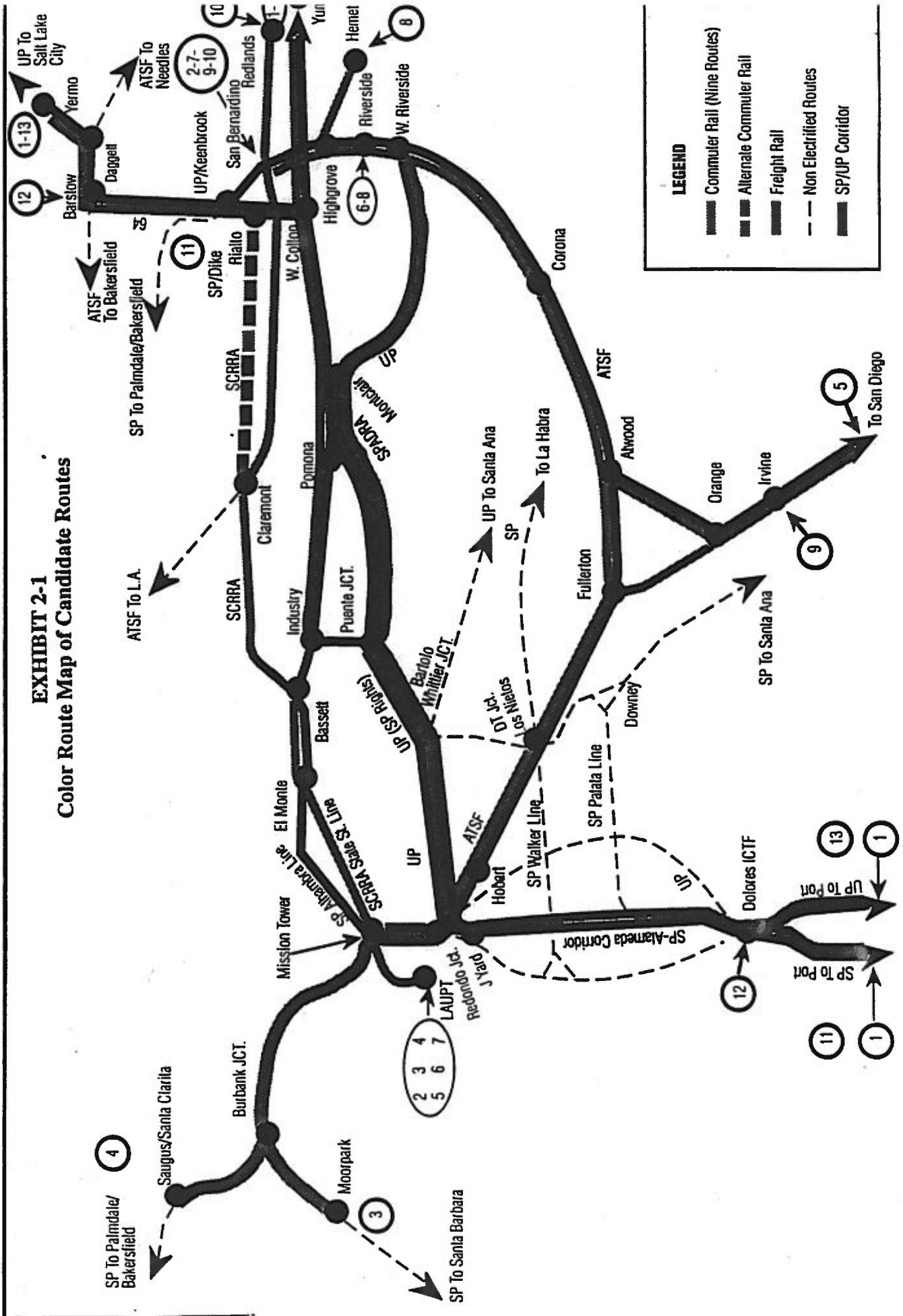
## Chronology of Electrification Task Force

- November 1990** Voters approve Propositions 108, 111, and 116 to fund Commuter Rail System for Southern California.
- November 1990** Southern California Regional Rail Authority is formed by LACTC to design and construct the system. 17 diesel-electric locomotives are ordered from General Motors of Canada and 70 coaches are ordered from Urban Transportation Development Corp. of Canada. Delivery is scheduled for second quarter 1992 and service startup is scheduled for October 1992.
- Spring 1991** Dialogue begins between SCRRRA and South Coast Air Quality Management Board over the potential adverse effects on the environment of adding a fleet of as high as 50 diesel locomotives operating over 9 Commuter Rail Routes in the region.
- August 20, 1991** California Transportation Commission hosts workshop in Los Angeles to discuss these effects. CTC Chairman Leonard raises the issue of weighing the anticipated benefits of electrification of commuter rail services against the impact of delaying the implementation of commuter rail service rather than using diesel locomotives in the interim. LACTC Executive Director, Neil Peterson commits to CTC to form an electrification study task force to make that determination. Mr. Peterson further commits to make the results of the study available to the CTC by January 1992 so as to not jeopardize the planned October, 1992 startup of the rail service.
- Sept. 24, 1991** Kickoff meeting of the Task Force is convened with 24 agencies represented.
- Oct. 30, 1991** The second meeting is held and a comprehensive Work Plan is unveiled and approved.
- Nov. 91-Jan. 92** Numerous committee meetings are held, progress reports given to various agencies and countless hours of analysis, cost data derivation, cataloging of railroad facilities, fact finding, issue resolution, and general knowledge gained.
- Jan. xx, 1992** Preliminary findings are released in a progress meeting of the task force.
- Feb. 10, 1992** First draft of the seven-volume study report is issued for comment. Report concludes that the cost to electrify the regions railroads would be approximately \$4.6 billion. The report gives a proposed construction phasing plan which could be accomplished assuming \$300 million becoming available each year for the next 18 years.
- May 8, 1992** Final report issued.



# ELECTRIFICATION STUDY Thirteen Final Candidate Routes

## EXHIBIT 2-1 Color Route Map of Candidate Routes



LEGEND	
	Commuter Rail (Nine Routes)
	Alternate Commuter Rail
	Freight Rail
	Non Electrified Routes
	SP/UP Corridor

NOT TO SCALE



## Study Methodology

### 1- Selecting the Candidate Routes

The first task was to work with the operating railroads to catalog the railroad physical plant in the Los Angeles Basin. Because the railroads could not practically change locomotives at the entrance or exit to the basin, it was necessary to establish railroad locations outside the basin where it would be economical to begin the electrification and change crews on the trains. These peripheral points were established as Yermo (UP), Barstow (ATSF), San Diego (Amtrak), Yuma (SP), Moorpark (SCRRA), and Santa Clarita (SCRRA). Next it was necessary to determine which routes would not be practical to electrify in any case. These routes, which would require alternate-fuel diesel locomotives, were the SP alternate routes to the Port of Los Angeles, the Santa Ana Branch of the SP, the Anaheim Branch of the UP and the Santa Fe Pasadena Subdivision, which will be purchased by SCRRA and converted to light rail operation in the near future.

Once the physical plant was cataloged into some 1450 track miles, the routes were broken into candidate routes, any one of which could be electrified as a stand-alone route. This resulted in 13 candidate routes. Nine of the thirteen were commuter rail routes, and three were freight-only routes, one for each railroad connecting with the Ports of Long Beach and Los Angeles. The thirteenth route was a combined Union Pacific/Southern Pacific corridor route upon which all three of the freight railroads would share trackage with one another so as to maximize the traffic on a minimum amount of electrified trackage.

The thirteen routes are defined below:

Route #	Description	Railroad	Miles
1	UP/SP Corridor	UP/SP/SF	393
2	Baldwin Park Line	SCRRA	57
3	Moorpark Line	SCRRA/SP	47
4	Santa Clarita Line	SCRRA/SP	35
5	LOSSAN Corridor	AMTRAK/SF	133
6	Riverside via Ontario	UP/SCRRA	59
7	Riverside via Fullerton	ATSF	62
8	Hemet Commuter	SCRRA	39
9	San Bernardino-Irvine	ATSF	53
10	Redlands Commuter	SCRRA	12
11	Southern Pacific to Ports	SP	282
12	Santa Fe to Ports	ATSF	176
13	Union Pacific to Ports	UP	187

## 2- Collecting Unit Cost Data

Working independently of the local railroads, our engineering consultants collected cost data from recent electrification projects around the nation and the world. This was not an easy task since there are few electrification projects ongoing in the western hemisphere. The problem was compounded by the need to determine what line voltages should be costed. The selection of primary voltage at the pantograph hinged upon the clearances which would be required by the railroads above the tracks and upon addition to the available overhead bridge and tunnel clearances in the study area.

A separate team of consultants undertook the task of cataloging all the overpass, bridge, tunnel, and signal mast clearances on the regional railroad network. In order to hurry the decision-making process, cost data were derived for three basic means of supplying electricity to the catenary: 50,000 volts AC, 25,000 volts AC and 50,000 volts AC with auto transformers to step the voltage down to 25,000 volts AC at the pantograph.

Ultimately, a 25,000 volts AC operating system was chosen for the final cost estimation because it is widely accepted as the current international standard. To use 50,000 volts AC, while less expensive for the electrical hardware, would undoubtedly cause many freeway bridges to be raised to clear the catenary, and there is no accurate cost data available to be used in this category.

The huge amount of cost data was then applied to the various components of the railroad, such as a mainline turnout, through a tunnel, under an overpass, mile of single track, mile of double track and so on. The resulting data compendium was enormous.

## 3- Collecting Railroad Operating Data

Probably the most difficult task was that of forecasting how many trains per day will be operating over which tracks, 18 years from the present. For the Commuter operation, this task is relatively easy, but for the freight railroads, forecasting is extremely difficult, since there have been few firm decisions to date on, for example, whether trash will be hauled by train to landfills in the Mojave Desert. In any event, an honest effort was made to determine what the horsepower and tonnage of the freight movements will be in the basin in the year 2010 and what the resulting amount of emissions (assuming the locomotives are still operating on diesel fuel) will be. This was then broken down route by route in order to determine the benefits that could be expected from partial electrification.

## 4- Operational Considerations

Operational analyses were performed to address a variety of aspects of the electrification program.

- Traffic projections were developed using current operating data, several studies and other sources. These data were combined into a microcomputer data base.
- Operating scenarios were developed to assess the operational feasibility of the proposed electrified network and to support the development of facilities improvements and locomotive requirements and related cost estimates. This subtask included performing an operational analysis of the Consolidated Corridor.
- Operating and maintenance costs were identified and, to the extent possible, quantified.

- Other relevant issues were documented.

#### **5- Alternative Fuels Investigated**

Consistent with the 1991 Air Quality Management Plan, the consultant team prepared an analysis of alternative fuel technology that would be applicable to those railroad operations that will not be electrified (local and yard switching operations) and that would also be viable for use in the transition from diesel to electric operation. Technologies addressed were:

- Clean diesel
- Natural gas
- Methanol/Avocet

#### **6- Investigation of Legal and Legislative Issues**

The Legal and Legislative Issues analysis sought to identify all agencies and organizations that would be potential participants in the implementation of Accelerated Rail Electrification. Roles and responsibilities for each potential participant were categorized as planning, funding, regulatory review, and/or implementation.

#### **7- Regulatory Issue Investigation**

A thorough analysis was performed of the regulatory framework within which potentially involved electric utilities must operate. The regulatory analysis consisted of two main steps:

- Identification of the affected utilities and quantification of the proposed mileage of electrified railroad located within each utility's service area.
- Detailed description of the formal processes by which investor-owned utilities, such as Southern California Edison, and the various municipally-owned utilities, such as the Los Angeles Department of Water and Power, would apply for authority to invest in the rail electrification infrastructure and recover their investment through rate treatment. Additionally, information requirements for such regulatory applications were identified in detail.

#### **8- Environmental Analyses**

A three-part environmental analysis was performed as follows:

- Air Quality Impact Analysis
- Electromagnetic Fields Analysis
- Other Environmental Impacts Analysis

The Air Quality Impact Analysis quantified locomotive emissions in the South Coast Air Basin. Estimates were prepared of the potential emissions reduction that might be achieved by electrification. These estimated reductions were then evaluated on the basis of capital cost effectiveness.

Analyses of Electro magnetic Field effects consisted primarily of documenting the evidence that has been assimilated to date regarding the effects of exposure to Electromagnetic Fields.

The remaining Environmental Analyses consisted of a compliance review of project aspects that might bear on the environmental process required for implementation of the electrification program.

### **9- Funding Alternatives Identified**

The Funding Committee investigated a variety of potential financing techniques and funding sources that might be available for implementation of rail electrification. The Funding Analysis devoted substantial effort to evaluating the potential for utility financing by both investor owned (SCE) and municipal utilities (LADWP), as well as by public sector participation at the state, federal, and local levels and by financial participation by the freight railroads.

The Funding Committee prepared three different funding scenarios for detailed analysis. The scenarios in no way reflected any agreements to participate in funding rail electrification. Likewise, the percentage allocated to individual agencies or industries does not represent any agreements by participants as to future levels of financial participation.

The three financing scenarios were applied separately to the electrification of commuter rail operations only and to the electrification of commuter and freight rail operations. The scenarios were based on costs, assuming that construction will proceed according to a preferred sequence that allows the costs to be presented unduplicated. They include the costs of locomotives and other systemwide facilities like a control center. In addition, they are escalated using an inflation factor of 3.46%. They do not include the costs of consolidating the UP/SP/ATSF Consolidated Corridor.

## Key Findings

The major findings of the Electrification Study are presented below in answer to the questions identified previously:

### Cost

The electrification of the 418 miles of commuter rail only is estimated to cost \$1.45 billion in current dollars. The cost to electrify the entire 806 route miles of candidate lines is estimated to cost \$3.26 billion in current dollars. The escalated cost of electrifying the nine commuter rail routes only is estimated to be \$1.85 billion; the escalated cost for the entire candidate network is estimated to be \$4.6 billion. These estimates exclude the cost of the electric locomotives currently projected to cost in the order of \$1.5 billion. In addition, these costs assume minimal vertical clearances and utility relocation at no cost to the SCRRA. Higher vertical clearances, as requested by the railroads, would significantly increase these costs as it would require raising over 20% of the existing structures.

Cost To Electrify		
	Current \$	Escalated \$
Commuter Rail	\$1.45 billion	\$1.86 billion
Commuter and Frt.	\$3.26 billion	\$4.60 billion
Locomotives Commuter	\$160 million	\$200 million
Locomotives Com & Frt.	\$1.0 billion	\$1.5 billion

### Schedule

The time required to electrify the nine individual candidate commuter rail routes is estimated to range between four and seven years. These durations include preliminary engineering, environmental approval process, final design, contract bid process, construction, and testing. The freight railroad main lines and the UP/SP/ATSF Consolidated Corridor are estimated to require between approximately nine and ten years to electrify.

Application of an assumed funding constraint of \$300 million annually to the schedule results in an estimated project duration of eighteen years.

## Priority Candidates

A two-step evaluation process was applied separately to the nine planned commuter rail routes and to all candidate routes, commuter and freight.

The evaluation process resulted in the following prioritization of the candidate routes:

- |     |          |   |
|-----|----------|---|
| 1.  | Route 1  | UP-SP Consolidated Freight Corridor           |
| 2.  | Route 13 | UP Ports to Yermo Freight                     |
| 3.  | Route 6  | Riverside to Los Angeles (UP) Commuter        |
| 4.  | Route 12 | ATSF Ports to Barstow Freight                 |
| 5.  | Route 7  | Riverside-LAUPT via Fullerton (ATSF) Commuter |
| 6.  | Route 11 | SP Ports to Yuma Freight                      |
| 7.  | Route 9  | San Bernardino to Irvine (ATSF) Commuter      |
| 8.  | Route 2  | Baldwin Park Commuter                         |
| 9.  | Route 3  | Moorpark Commuter                             |
| 10. | Route 4  | Santa Clarita Commuter                        |
| 11. | Route 5  | LOSSAN Corridor (ATSF) Commuter/Intercity     |
| 12. | Route 8  | Hemet to Riverside Commuter                   |
| 13. | Route 10 | Redlands Commuter                             |

The highest-scoring commuter rail line, candidate route 6, Riverside- Los Angeles via the Union Pacific, has been suggested by members of the task force as an initial project for preliminary engineering.

## Funding

To the extent that electrification costs are not offset by easily quantified economic benefits, decisions on funding participation levels among various public, private, and commercial entities must attempt to spread the significant costs of rail electrification as widely and as equitably as possible. Rate-based utility financing, if CPUC approval can be obtained, will spread costs to SCE customers, and offer a base to which many other fund sources must be added. Rate treatment of roughly 40% of capital costs would have to be considered. State, federal, and local sources as well as financial participation from the freight railroads, must be utilized in order to successfully accomplish rail electrification in Southern California.



## Air Quality

Current NOx emissions from railroad operations constitute less than 2.6% of the total Nox emissions in the South Coast Air Basin. The SCAQMD projects that by the year 2010, mainline freight operations will constitute almost 72% of the railroad-related NOx emissions in the South Coast Air Basin, with yard, switching, and other local operations contributing 21% of NOx emissions. SCAQMD projects that commuter rail operations will constitute about 5.4% of the total NOx emissions for rail operations in 2010.

Although diesel-powered commuter trains emit less of certain pollutants and less pollutants overall than the equivalent number of automobiles, the Air Quality Analysis conducted by SCAQMD indicates that NOx emissions will increase by 2.04 tons/day and SOx emissions will increase by 0.1 tons/day over the emissions from an equivalent number of automobiles displaced. (This analysis assumes 70% electrification of the automobile fleet and no improvement in diesel locomotive technology by 2010.)

Assuming a \$4.05 million average cost per route mile for commuter and freight services, the cost-per-ton of NOx reduced would range from \$3,900 to over \$10,900 depending on assumptions and calculation methodologies. While this compares favorably with other industries which spend \$25,000 to \$45,000 per ton to reduce emissions, it cannot be accomplished without electrifying all of the railroads in the basin.

Conversely, if only the commuter rail operations were electrified, the 90% emissions reduction would not be met, and the electrification of these routes without freight participation would not be cost-effective. Assuming \$3.47 million capital cost per commuter route mile, the cost-per-ton of NOx reduced for commuter rail electrification would range from \$48,000 to over \$183,000 per ton of NOx reduced.

## Legal/Legislative

Electrification of commuter and freight lines may require compliance with environmental requirements under the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA). Only commuter rail facilities electrified within existing railroad rights-of-way are exempt from such requirements.

While commuter rail lines acquired through fee of easement could be electrified, additional access rights would be required to electrify those lines operated under trackage rights agreements.

Delaying implementation of the planned commuter rail network until electrification takes place could subject the region to federal sanctions for failure to expeditiously implement Transportation Control Measure 2G. Further, these sanctions may include disapproval of the RTIP and withholding of Federal transportation funds for the region and/or state.

## Regulatory

There are 12 separate utilities in the electrification study area. The investor-owned utilities such as Southern California Edison could consider application to the California Public Utilities Commission for rate treatment financing of defined components of the electrified system. The municipally-owned utilities would apply to their respective City Councils.

### **Measure 14 Target**

Electrification of the entire candidate network is estimated to reduce rail-related emissions by 76% by the year 2010. Further study is required to ascertain how additional reductions might be achieved to meet the 90% emissions reduction target.

### **Alternative Fuels**

Several alternative fuel technologies appear to offer a means by which to reduce emissions from rail operations not identified as candidates for electrification and could be used during the transition from diesel to electric operation.



## **Next Steps**

**For the Southern California Accelerated Electrification Program to progress to the implementation stage, eight major steps must be undertaken:**

- 1- Address policy issues**
- 2- Adopt contingent phasing plan for electrification and alternate technologies**
- 3- Proceed with concurrent initial electrification project and alternate technologies demonstrations**
- 4- Perform Preliminary Engineering**
- 5- Obtain environmental clearances**
- 6- Negotiate railroad/utility agreements**
- 7- Develop a full funding plan, and**
- 8- Obtain required regulatory approvals**

## **Planned SCRRA Actions**

**We at the SCRRA plan to take the following course of action in this area:**

- Reaffirm dual commitment to mobility AND air quality objectives.**
- Continue with expeditious implementation of the Metrolink Regional Commuter Rail System under reduced emission diesel operation initially. System design will accommodate future electrification.**
- Commit to achievement of air quality goals.**