SOUTH FLORIDA EAST COAST CORRIDOR STUDY

SOUTH FLORIDA EAST COAST (FEC) ALTERNATIVES ANALYSIS

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Phase 2 Energy Technical Memorandum

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MEMORANDUM

To: Scott Seeburger

From: Robert McMullen

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Subject: South Florida East Coast Corridor Transit Analysis (SFECCTA) Study: Energy Technical Memorandum

INTRODUCTION

Purpose

The purpose of this technical memorandum is to provide an overview of the use of energy associated with operation and construction of the proposed transit improvements of the SFECCTA study. The study of energy as part of the environmental screening process complies with the Unites States Department of Transportation Federal Highway Administration Guidance for Preparing and Processing Environmental and Section 4(F) which states that NEPA documentation should discuss in general terms the construction and operational energy requirements and conservation potential of various alternatives under consideration. Energy use is presented in two forms: transportation energy as petroleum based fuels (i.e., gasoline, diesel, and liquid natural gas) and electrical energy, which is delivered by the regional power grid and is generated by a number of methods (i.e., nuclear, liquid natural gas, oil). The consumption and conservation of both types of energy is incorporated into a screening of the various modal technologies and into the screening of the four build alternatives.

Project Description

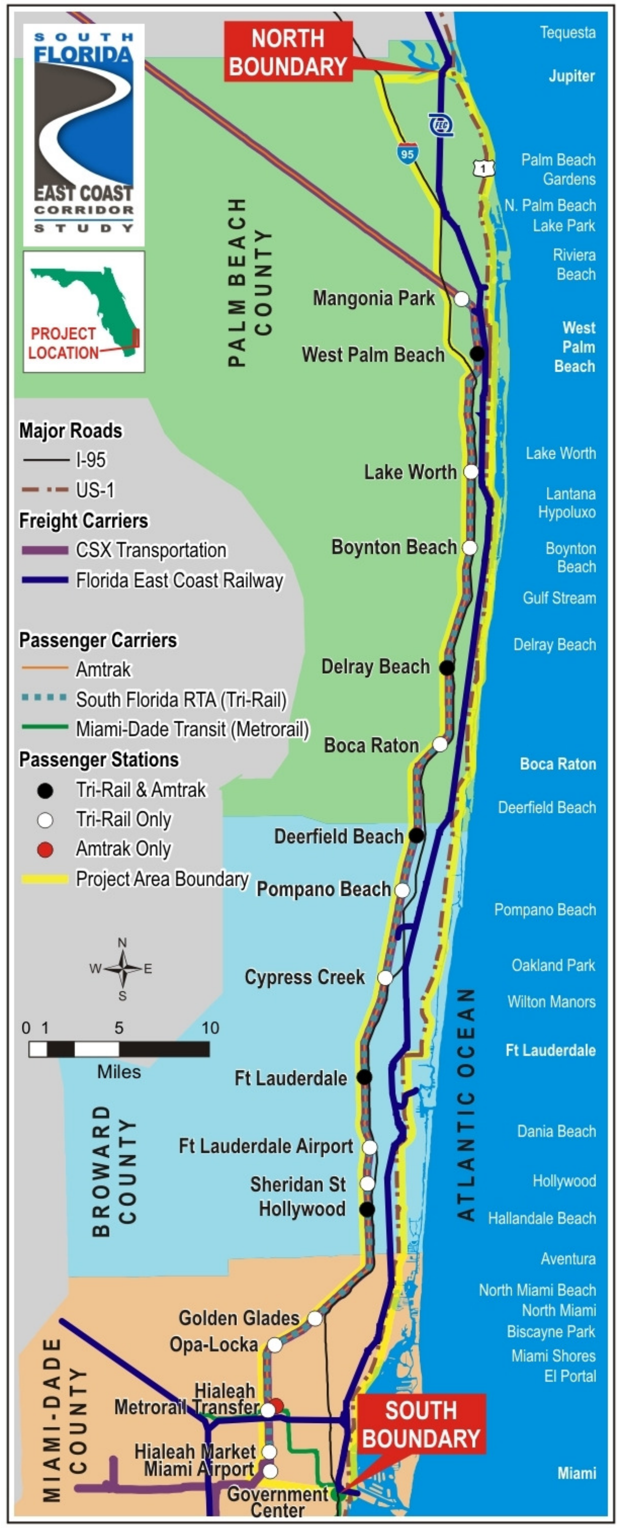
The FDOT initiated the multi-phased South Florida East Coast Corridor Transit Analysis (SFECCTA) study in December 2005 recognizing that the Florida East Coast (FEC) Railway was and is a unique transportation asset that should be evaluated and developed in the context of regional transportation issues, priorities and needs. The SFECCTA study is designed to evaluate the reintroduction of passenger service along a portion of the FEC Railway corridor from Miami to Jupiter. In its second phase, the SFECCTA study continued the Alternative Analysis (AA) – Early Scoping process that was initiated in Phase 1. A discussion of the Phase 1 AA may be found in the Phase 1 Conceptual Alternatives Analysis/Environmental Screening Report (AA/ESR) on the project website (http://www.sfeccstudy.com/).

Phase 2 of the SFECCTA was initiated in January 2009 and was designed to build upon the Phase 1 AA to refine and further develop through an iterative process the alternatives identified at the conclusion of the first phase. The primary focus of Phase 2 was to identify a locally preferred alternative (LPA) within the study area, in accordance with Federal Transit Administration (FTA) and FDOT project development processes, that could ultimately be submitted to FTA for federal assistance in the form of New Starts funding. A Phase 2 Draft Detailed Environmental Screening Report (ESR) has been prepared to describe the detailed environmental screening approach conducted as part of the Phase 2 AA and is supported by a series of technical memoranda and reports such as the one presented here.

Project Area

The SFECCTA study project area, illustrated on the Project Location Map (**Figure 1**), is bounded on the south by Flagler Street, just south of the Miami-Dade Government Center, in the City of Miami and on the north by the southern shoreline of the Loxahatchee River in the Town of Jupiter. The western boundary of the project area runs parallel to and 0.5-miles west of the South Florida Rail Corridor (SFRC)/Tri-Rail corridor from the Miami Intermodal Center (MIC) north to Mangonia Park then continues in a northwesterly direction parallel to and 0.5-mile west of I-95 to the southern shoreline of Southwest Fork of the Loxahatchee River (C-18). The eastern boundary of the project area runs parallel to and 0.5-miles east of Highway US-1 from the Central Business District (CBD) of the City of Miami north to the southern shoreline of the Loxahatchee River in Jupiter.

Figure 1: Project Location Map



Within the SFECCTA project area are several unique *study areas* that were developed specifically to define the affected environment and screen/evaluate the various project alternatives. Generally, the affected environment is a Geographic Information System (GIS) inventory of environmental, social, and cultural resources that could be affected by the proposed improvements. The affected environment and screening process are defined and documented in the Phase 2 Draft ESR.

The primary study area, where most of the improvements are expected to occur, is the FEC Railway corridor that extends from the CBD of the City of Miami north to the Town of Jupiter in Palm Beach County (a linear distance of approximately 83 miles). A detailed description of the study areas and environmental screening methodology is provided in Chapter 3 and Appendix A, respectively, of the Draft ESR.

Energy

Energy availability is limited by factors on both a macro and micro scale. The macro scale considers global fuel production, its availability, its ability to be brought to a market, and its consumption by difference interests; all factors that can influence energy availability. The micro scale takes into consideration fuel availability at the state and regional levels, affected by the transport, storage, and consumption of available fuel. At a macro level the environmental consequence of a project can be considered insignificant, but at the micro level there is potential for a quantifiable impact to occur.

A project can have a negative environmental consequence on energy resources by increasing the consumption of energy and therefore its scarcity. A project can also have a positive environmental consequence on energy resources by reducing the regional consumption of energy, both electrical and transportation fuels, and conserving this finite resource.

Electricity producing facilities feeding into the South Florida regional power grid utilize oil, liquid natural gas, nuclear, or "renewables" (solar) as their source of energy, the majority of which are non-renewable. The Florida Power and Light Company (FPL) is the primary producer of electricity in the SFECCTA study project area. **Table 1** is a breakdown of the different fuel sources utilized at their generating facilities. Liquid natural gas (LNG) and nuclear fuels produce the majority of electricity in the project area (77%).

There is a limited volume of transportation energy present in the form of petroleum-based liquid fuels such as gasoline, diesel, and kerosene (jet fuel). Global and domestic refining capacity is expected to increase in the future, but population and demand is also expected to increase. In the state of Florida demand for transportation services (and, therefore, petroleum/gasoline consumption) will increase as the population increases.

Energy production is the largest emitter of GHG in the United States of America (USA). This is because the majority of the power plants are fueled by fossil fuels such as coal (23.9 percent), natural gas (21.2 percent), and crude oil (10.5 percent). Of all the available energy in the USA roughly 48 percent is consumed by buildings and homes, as opposed to transportation and industry which consume roughly 27 and 25 percent respectively. Significant reductions in energy consumption and GHG emissions can be attained by designing and operating inhabitable structures to be more efficient and use fewer resources. Buildings such as train stations and O&M facilities can be designed and operated to meet new energy efficiency standards. Since such transit related structures are designed for a 40-50 year operational life-span, the potential savings in energy through proper design and operation can be quite significant.

Potential Impacts on Energy Consumption

The SFECCTA is anticipated to have an impact to the regional energy demand through operations (direct impacts), construction (temporary impacts), and secondary facilities (indirect impacts). Operational impacts are related to the energy needed to power/fuel the modal technology and the operation of built facilities such as transit stations and operations and maintenance facilities (O&M). Construction impacts are associated with the fuel consumption of heavy-duty, motorized equipment used during the building process. Indirect impacts are a result of fabricating and transporting materials and/or resources for its use in the SFECCA project.

Table 1. FPL's 2009 Fuel Mix based on Kwh Produced

Florid Power & Light 2009 Fuel Mix	
Fuel Type	**Percentage of kWh Produced**
Natural Gas	56%
Nuclear	21%
Purchased Power	13%
Coal	6%
Oil	4%

Direct Impacts

Modal technologies are fundamentally powered by electricity or fuel. **Table 2** includes the list of the types of modal technologies being considered for the SFEECTA study. Technologies like Electric Multiple Unit (EMU) cars or electrified third-rail trains derive power from the regional electric grid. Utilization of this technology type will have a potential impact to the electricity demand. Technologies that utilize petroleum-based fuels, such as diesel, LNG, and gasoline will consume significant volumes of fuel, relative to personal automobiles, in order to sustain daily service along the entire SFECCTA project corridor. An inventory and greenhouse gas screening of modal technologies based on energy consumption can be found in the *Phase 2 Air Quality Technical Memorandum.*

The operation of transit stations, a location where passengers can board or alight an operating transit vehicle, and O&M facilities, a location used to operate, maintain, and store the transit vehicles of the system, will also have a potential direct impact to the electricity demand in the project area. Transit stations consume energy primarily through lighting needs and operation of electrical equipment such as elevators, escalators, and ticketing devices. Several station types have been proposed for the SFECCTA study, see the *Station Design Guidelines Report*, each differentiated by several factors. The largest station type will be located in major urban areas and will have a significant area of floor space under

Table 2. Modal Technology Energy Consumption Screening

Modal Technology Energy Consumption Screening					
Transit Mode & Sub-Mode			**Modal Technology**	**Consumption / Mile**	**BTU / Mile**
Regional Rail Transit (RGR)	FRA Compliant RGR	Push Pull Locomotive and Coaches	Diesel Locomotive (DPP)	2.18 gal	302746
			Overhead Electric Locomotive (EPP)	7.36 kWh	25113
			Dual Power Diesel-Electric Locomotive (DEPP)	N/A	N/A
		Self Propelled Multiple Units	Diesel Multiple Unit (Type 1 DMU)	0.5 - 0.67 gal	83324
			Overhead Electric Multiple Unit (Type 1 EMU)	4kWh	13649
	Non FRA Compliant RGR		Diesel Multiple Unit (Type 2 DMU)	0.5 - 0.55 gal	7291
			Overhead Electric Multiple Unit (Type 2 EMU)	3.5kWh	11942
Light Rail Transit (LRT)	Diesel Multiple Unit (Type 3 DMU)			0.5 - 0.55 gal	72909
	Overhead Electric Multiple Unit (Type 3 EMU)			3.5kWh	11942
Rail Rapid Transit (RRT)	Electrified Third Rail			2.3kWh	7848
Bus Rapid Transit (BRT)	Clean Diesel			0.36 gal	49995
	Hybrid			0.2 gal	27775
	Alternative Fuels			0.45 gal	42975
Personal Vehicle Miles (Light & Medium Utility Vehicles)				0.05 gal	6244

N/A – Not Available
1 gallon of automotive gasoline = 124,884.378 BTU
1 gallon of diesel fuel oil = 138,874.158 BTU
1 gallon of LPG = 95,500 BTU
1 kilowatt hour = 3,412.141 BTU

heating, ventilation, and air conditioning (HVAC). The other two types of stations will be primarily outdoor venues with little or no floor space under HVAC. In the South Florida environment, exemplified by long, hot and humid summers, electricity consumption used for powering HVAC equipment is significant. The operation of O&M facilities is also energy intensive due to the lighting requirements (O&M facilities are most active in the evening when transit operations cease) and the powering of industrial typed equipment needed to service and maintain the transit vehicle fleet. O&M facilities usually have a large floor plan, necessary to accommodate transit vehicle under a single roof, and do not have HVAC equipment. However, numerous ancillary facilities such as offices and common areas where staff employees will generate electricity demand due primarily to HVAC equipment. The electricity demands for the operation of a regional transit system such as the SFECCTA can be determined due to the high number of similar systems currently operating within the United States of America. A more in-depth, analysis should be conducted during subsequent phase National Environmental Policy Act (NEPA) level studies when a preferred alternative has been selected and undergoes further analysis.

It is anticipated that energy and environmental sustainability initiatives will be incorporated into the design, construction, and operation of transit facilities and buildings to take place in subsequent phases of the study. The implementation of such initiatives will reduce the potential impact to electricity demand within the project area. The following is a partial list of the initiatives that are being considered:

Design Measures to Minimize Energy Consumption:

- Provide proper grouping of buildings
- Minimize amount of required indoor space
- Obtain energy from renewable sources (solar, wind, etc.) on site if possible
- Utilize native trees and shrubs to provide shade and shelter
- Provide natural ventilation with demand fan assist
- Provide “green” or “eco-roofs”
- Provide light-colored, high reflectance, and low-emissivity roofing
- Provide high value building insulation, window/door glazing and/or high-performance glass
- Provide operable windows
- Provide strategic window placement (most windows and doors on north and south face) and skylights, clerestories, or retractable ceilings with monitors to maximize use of day/sunlight while minimizing potential heat gains
- Provide high-performance lighting (such as LEDs), dimming and occupancy controls, and timers
- Provide light shelves, fins, overhangs and diffused glass for sun control
- Provide power control system(s)
- Provide shading over windows and doors
- Provide high-efficiency HVAC systems and appliances (Energy Star Rated)
- Provide non-CFC based refrigerants
- Utilize light-colored materials and paints where it is desirable to reduce the heat island effect

Screening of Build Alternatives

Utilizing the results of the energy inventory of modal technologies an energy screening was conducted (the results of the screening are presented in **Table 8**). The screening compares the four build alternatives and the no-build alternative based on the amount of energy that will be consumed in order to deliver the anticipated daily volume of passengers. The two main differentiating factors between the four build alternatives are the type of modal technology utilized and the alignment of the corridors. A complete description of the different build alternatives, including the proposed modal technologies and corridor alignments, is presented in Chapter 2 of the *ESR*. The consumption of energy was calculated using the following equation:

$$\mathbf{X} \times \mathbf{N_1} \times \mathbf{N_2} \times \mathbf{N_3} \times \mathbf{N_4} = \mathbf{Z}$$

Where,

X = volume of fuel consumed (gallon) per vehicle mile traveled.

- Per transit vehicle.

$\mathbf{N_1}$ = Fuel Energy Equivalent in British Thermal Units per gallon.

- 1 gallon of automotive gasoline = 124,884.378 BTU
- 1 gallon of diesel fuel oil = 138,874.158 BTU

$\mathbf{N_2}$ = Number of units per consist (a consist being a group of rail vehicles that make up a train).

$\mathbf{N_3}$ = approximate distance of the proposed transitway length (miles).

- Estimate of distance between probable corridor termini and does include east/west connections for the DMU and DPP alternatives but not for the BRT and TSM alternatives.
- Important to note that number is only an estimate and will likely change in subsequent phases of the project.

$\mathbf{N_4}$ = number of consists traversing the corridor daily.

- Based on an 18 hour weekday operational schedule with 6 hours of peak headway and 12 hours of off-peak headway.
- Based on both northbound and southbound movement.

Z = British Thermal Units consumed per day.

Table 8. Daily Energy Consumption Screening of Build Alternatives

Alternative	Unit Type	Number of Units	Energy Consumption (BTU/mile)	Distance Traveled	Daily Headway	Daily Energy Consumption (MMBTU)
1. Integrated Rail - Diesel Multiple Unit (DMU)						
FEC Local	DMU	4	83324	69	96	2,208
Flagler Flyer	DMU	4	83324	85	96	2,720
Seaboard Flyer	Diesel Locomotive (push-pull)	1	302746	84	24	610
Airport Flyer	Diesel Locomotive (push-pull)	1	302746	35	96	1,017
					Total:	**6,555**
2. Integrated Rail - Diesel Push-Pull (DPP)						
FEC Local	Diesel Locomotive (push-pull)	1	302746	69	96	2,005
Flagler Flyer	Diesel Locomotive (push-pull)	1	302746	85	96	2,470
Seaboard Flyer	Diesel Locomotive (push-pull)	1	302746	84	24	610
Airport Flyer	Diesel Locomotive (push-pull)	1	302746	35	96	1,017
					Total:	**6,103**
3. Bus Rapid Transit (BRT)						
Route 1	Diesel-Hybrid Bus	1	27775	17.3	48	23.1
Route 2	Diesel-Hybrid Bus	1	27775	30.3	48	40.4
Route 3	Diesel-Hybrid Bus	1	27775	23.7	48	31.6
Route 4	Diesel-Hybrid Bus	1	27775	26.56	48	35.4
Route 5	Diesel Bus	1	49995	40.86	24	49.0
Route 6	Diesel Bus	1	49995	26.56	24	31.9
					Total:	**211**
4. Transportation System Management (TSM)						
Route 1	Diesel-Hybrid Bus	1	27775	17.3	48	23.1
Route 2	Diesel-Hybrid Bus	1	27775	31.25	48	41.7
Route 3	Diesel-Hybrid Bus	1	27775	23.93	48	31.9
Route 4	Diesel-Hybrid Bus	1	27775	14.37	48	19.2
Route 5	Diesel-Hybrid Bus	1	27775	14.6	48	19.5
Route 6	Diesel Bus	1	49995	45.3	24	54.4
Route 7	Diesel Bus	1	49995	29	24	34.8
Route 8	Diesel Bus	1	49995	14.1	24	16.9
					Total:	**241**
No-Build Alternative						
Personal Vehicle	Light & Medium Utility Vehicles	NA	6244	278,608*	NA	1,740
					Total:	**1,740**

Table 9. Energy Consumption Screening of Build Alternatives Summary

Annual Energy Consumption Screening of Build Alternatives		
Alternative	Daily Enegy Consumption (MMBTU)	Annual Energy Consumption (MMBTU)
1. Integrated Rail - DMU	6,555	1,931,324
2. Integrated Rail - DPP	6,103	1,798,243
3. BRT	211	62,274
4. TSM	241	71,101
No Build	1,740	512,585

Table 8 & Table 9 Assumptions:
1 gallon of automotive gasoline = 124,884.378 BTU
1 gallon of diesel fuel oil = 138,874.158 BTU
Annual calculations include typical work days (Monday - Friday) and weekends (Saturday & Sunday)
Weekend service is calculated as 33% of typical work day service.
* Based on the reduction of daily vehicle miles traveled, compared between the no-build and preferred alternative.

The screening results for the four build alternative and No-Build alternative indicate that alternatives one and two consume a significantly greater amount of energy than the others. This is because alternatives one and two utilize DPP Locomotives and DMUs which consume a greater volume of fuel/energy than other transit technologies, but are able to carry a much greater load of passengers than buses or personal vehicles.

For the SFECCTA study, a DPP would be in a consist with three 150 passenger carriages providing total capacity for 450 passengers (seated). The DMUs would be in groups of three to four, depending on demand, and consume close to the same volume of fuel as a DPP locomotive while providing equivalent passenger volume.

The BRT and TSM alternatives utilize buses as preferred modal technology. Buses are much more fuel efficient than both DPP locomotives and DMU, but they carry fewer passengers (about an eighth) so more units must be operated in order to handle the daily passenger load. Even with this greater volume of units operating daily, the TSM and BRT alternatives emit a significantly lesser amount CO_2 than alternative one or two.

Modeling indicates that an increase of 278,608 VMTs will occur if a preferred build alternative is not implemented. This equals 0.17% of the expected daily total (161,407,700 VMTs) which is an insignificant value when compared to the total, but it is equal to roughly 130 short tons of daily CO_2 emissions. The no-build alternative emissions value of 130 short tons represents a greater potential impact of increased CO_2 emissions when compared to either the BRT and TSM alternatives.

Modeling indicates that reduction of 278,608 VMT will be reduced will occur if a preferred build alternative is not implemented. This equals 0.17% of the expected daily total (161,407,700 VMTs) which is an insignificant value when compared to the total, but it is equal to a reduction in energy consumption by roughly 1,740 MMBTU daily, which is more than is consumed by both the BRT and TSM alternatives.

Temporary and Indirect Impacts

Temporary impacts to energy demand are associated with construction-related activities. Heavy, industrial equipment used in the construction of the project will consume a significant volume of fuel in the form of diesel. Energy intensive construction activities include earth moving, transportation of materials, providing on-demand lighting, and lying tracks. Construction-related energy consumption factors for the LPA, as developed further in subsequent study phases, can be compiled and presented accurately because of the plethora of available examples from which to draw data.

Indirect impacts are the result of manufacturing and transporting materials/good to the project site. For example, a significant amount of energy will go into the manufacturing, assembly and delivery of a modal technology to the project site. Also, factories that produce construction materials and machinery that would be used in the construction and maintenance structures and attendant facilities should also be considered. A more in-depth, NEPA level, analysis will be conducted during subsequent phases when a LPA is selected.

Biodiesel

Many transit systems today have considered the incorporation of alternative (renewable) fuels into their fleet operations. Therefore, an assessment of on one such renewable fuel, Biodiesel, is warranted due to its current and future use as a viable alternative fuel. Biodiesel is a type of diesel fuel that is derived from natural, renewable sources such as plants (vegetable oils) and animal sources (meat processing renderings). Biodiesel can also be derived from waste cooking oil, once it undergoes processing. Biodiesel is intended to be used in standard diesel engines either alone or as a blend with traditional, petroleum-based diesel. Biodiesel fuel typically costs more than petroleum-based diesel (10 to 20 cents per gallon more) except where local governments provide a subsidy. The majority of global biodiesel production, 85%, occurs in Europe but American production has increased during the past decade providing U.S. consumers with access to domestically produced biodiesel.

The available energy output for biodiesel and petroleum based diesel varies fractionally. In comparison, pure biodiesel (B100) produces roughly 130,000 BTUs per gallon of fuel while regular diesel produces roughly 140,000 BTUs per gallon of fuel. This represents a minor difference, roughly 1%, in available resources. Currently the South Florida Regional Transportation Authority has mandated the use of biodiesel in the operations of their Tri-Rail locomotives; following Florida Governor Charlie Crist's executive orders aimed at reducing GHG emissions and conserving energy (which went into effect July, 2007).

Summary

An analysis of potential direct impact to energy resources indicates that alternative one (DMU) and two (DPP) consume significantly more energy than both alternative three (BRT) and four (TSM). This difference is due to the difference in modal technology types and total distance traveled under each alternative. The DMU and DPP alternatives utilize heavy, energy intensive technologies powered by large engines while the BRT and TSM alternatives utilize smaller, lighter buses with significantly smaller engine sizes. Also, the DMU and DPP alternative both travel over 20,00 miles daily (based on routes and headway) while the BRT and TSM alternatives travel roughly 6,300 and 7,000 miles daily, respectively (about three times greater). A larger engine size and the greater mileage traveled by the DMU and DPP alternatives are the primary factors contributing to their significantly larger volume of energy consumed, as compared to the other alternatives.

Potential impact related to indirect activities includes: energy consumed during the design and construction phase of the various alternatives; the energy consumed in the operation of transit facilities like stations and O&M facilities; and energy consumed in the production and transportation of operating equipment proposed by the various alternatives. Analyzing indirect impacts are an important part of a comprehensive, NEPA level study, which will be conducted during subsequent phases of the study, when the selected LPA has been selected.

References

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