3.16 Energy

3.16.1 What are the concerns related to energy and why are they important to this project?

Energy is used during the construction and operation of transportation facilities. The energy used in the construction of various facilities is inclusive of the manufacture and transport of materials and equipment and operation of construction equipment. Operational energy consumption is the fuel and electricity used to power the vehicles using the transportation facility. This total energy is based on the vehicle mix and vehicle miles of travel for each alternative evaluated.

Traffic volumes and large elevation changes make energy an important issue in the Corridor.

The past several years were tumultuous ones for world energy markets, with oil prices soaring through the first half of 2008 and diving in its second half. The downturn in the world economy had an impact on energy demand, and the near-term future of energy markets is tied to the downturn's uncertain depth and persistence.

Key Global Energy Issues:

- Higher but uncertain world oil prices
- Greenhouse gas emissions
- Increasing renewable fuel use
- Increasing production of unconventional natural gas
- Shift in transportation fleet to more efficient vehicles
- Improved efficiency in end-use appliances

Source: United States Department of Energy, Energy Information Administration - Annual Energy Outlook 2009

3.16.2 What study area and process was used to analyze energy?

The project footprint was used to analyze energy consumption. The common unit of energy measurement, British thermal units (BTU), was used to determine energy consumption for the I-70 Mountain Corridor. Estimating the number of BTU for Corridor construction can be even more complex given the altitude, the steep grades that have to be overcome, and the abbreviated construction seasons that can result in reduced efficiencies. Construction consumption numbers were developed with an accepted technique using data developed by the Engineering News Record and Caltrans (Talaga et al., 1983). Construction energy consumption for all alternatives having a transit component was evaluated in terms of both track mileage and construction costs. Fuel prices were updated for 2009 and were used to determine operational energy impacts. Both construction and operational energy impacts were determined using 2035 traffic projections.

Operational energy consumption by vehicles operating on the roadway is directly proportional to the number of miles driven. Variables considered include vehicle type, speeds, roadway grades, and fuel economy. Average gas mileage for all vehicles in the traffic stream can be used to convert miles driven to a measurement of energy. The United States (U.S.) Department of Energy has data readily available in its *Transportation Energy Data Book* (Davis et al., 2002) that was used to calculate the energy consumption rate per person mile of travel. That document includes a table relating passenger travel and energy use in the U.S. for the year 2000 for various modes of transportation, including automobiles, buses, and rail. Having assimilated information from various sources, and recognizing the empirical nature of this subject and unknown impacts due to other variables, an energy consumption rate of 125,000 BTU per gallon of gasoline and an average gas mileage of 22 miles per gallon (mpg) were used.

Energy consumption for the transit components of each alternative was calculated on various bases. Transit energy usage consists of electrical energy expressed in kilowatt-hours and fuel consumption expressed in gallons of diesel fuel. For the Rail with Intermountain Connection and Advanced Guideway System components, electrical energy consumption was calculated on the basis of RAILSIM 7® Train Performance Calculator simulation output. However, for the Advanced Guideway System Alternative, the

Train Performance Calculator calculated only the propulsion and on-board energy requirements, not the energy required to levitate the trains. That was derived from the Federal Transit Administration (FTA) *Urban Maglev Technology Development Program—Colorado Maglev Project Report* (FTA, 2004) and added to the propulsion energy calculated in this section.

For purposes of determining fuel consumption by the buses (both diesel and dual-mode) off the guideway, a fuel consumption rate of 2.6 mpg was used for the diesel bus and 2.0 mpg for the dual-mode bus. Running time and distance for the segments off the guideway were based on simulations conducted using the VisSim™ software. See the *I-70 Mountain Corridor PEIS Energy Technical Report* (Colorado Department of Transportation [CDOT], March 2011) for more detailed methodology information.

3.16.3 What agencies have CDOT and FHWA coordinated with and what are their relevant issues?

There was no formal coordination with agencies about energy issues in the Corridor. However, as noted in the methodology section, information from the U.S. Department of Energy was used for energy consumption calculations.

Also, guidance from the Environmental Protection Agency is used during the Programmatic Environmental Impact Statement (PEIS) process. The Environmental Protection Agency's Office of Transportation and Air Quality protects public health and the environment by regulating air pollution from motor vehicles, engines, and the fuels used to operate them, and by encouraging travel choices that minimize emissions. The Environmental Protection Agency produced regulations and standards for the following issues:

- Controlling greenhouse gases
- Improving fuel economy for new trucks and cars sold in the United States
- Incorporating more renewable fuels

3.16.4 What are the areas of energy interest identified in the Corridor?

The Corridor stretches from Glenwood Springs to the Denver metropolitan area and serves as the only viable through route for surface transportation. Traffic volumes vary considerably, with the higher concentration east of the Continental Divide, especially east of Empire Junction.

The Corridor, while generally in rural mountainous terrain, passes through several highly developed areas. It includes major changes in elevation from Denver to the Continental Divide affecting energy consumption. Moving a vehicle from less than 6,000 feet to 11,000 feet involves overcoming an elevation change of 1 mile, at grades as high as 7 percent. This impacts energy requirements, and it cannot be concluded that the additional effort to accomplish this can be compensated for by a corresponding decrease in energy needed on the descent, especially as it applies to heavy trucks.

3.16.5 How do the alternatives potentially affect energy?

The alternatives' potential operational and construction energy impacts, as well as impacts in 2050, are discussed below.

This document acknowledges the uncertainty in projecting advances in the following areas:

- Technology
- Worldwide petroleum demand

- Status of the oil supply, fuel costs, future public policy regarding energy use, and environmental controls
- Changing economies and world markets

This document attempts to address these uncertainties by evaluating a range of alternatives to develop its forecasts. See the *I-70 Mountain Corridor PEIS Energy Technical Report* (CDOT, March 2011) and **Chapter 4 , Cumulative Impacts Analysis**, for more information about the Corridor's cumulative impacts on global issues.

How do the Action Alternatives affect operational energy?

Operational energy consumption is the amount of fuel and electricity used to power the vehicles using the transportation facility. Energy use during operations of any alternative is directly related to the gasoline and diesel consumption of automobiles, trucks, and buses, as well as to the propulsion energy generated for powering transit vehicles. The variation in total operational energy consumption among the alternatives, compared to the No Action Alternative, ranges from no difference in the case of Rail with Intermountain Connection and Advanced Guideway System, to 17 percent higher in the case of the Combination Six-Lane Highway with Diesel Bus in Guideway Alternative. The Preferred Alternative is among the lowest of all alternatives, with expected increases ranging between 6 percent and 7 percent over the No Action Alternative by 2035.

Table 3.16-1 summarizes energy consumption for each alternative, broken down by both transit travel and vehicles on the roadway. Roadway vehicles in any alternative represent the great majority of impacts in terms of energy usage. Because energy consumption can be different for each alternative, the 11 standard alternative groupings were further broken out to show differentiating impacts.

How does construction of the Action Alternatives affect energy?

These impacts are the direct result of the operation of construction equipment, as well as delivery of materials to the site. If the No Action Alternative is selected, no changes to the existing Corridor occur and no associated energy usage is consumed. The No Action Alternative therefore acts as an appropriate baseline to compare energy usage of the Action Alternatives. The Minimal Action, Six-Lane Highway (55 or 65 miles per hour [mph]), and Reversible/High Occupancy Vehicle /High Occupancy Toll Lanes Alternatives are anticipated to have the lowest total construction energy consumption. Less overall construction requires fewer materials and, therefore, less energy consumption. The Preferred Alternative (both for the Minimum Program of Improvements and the full implementation of the Maximum Program of Improvements), Advanced Guideway System, Combination Six-Lane Highway with Advanced Guideway System, and Combination Six-Lane Highway with Rail and Intermountain Connection Alternatives are anticipated to have the highest total construction energy consumption. **Table 3.16-2** summarizes the estimated energy consumption for construction of each alternative. Because energy consumption of the Bus in Guideway alternatives varies depending on the technology (dual-mode or diesel), **Table 3.16-2** separates these alternatives to show differentiating impacts.

What are the project effects on energy in 2050?

By 2050, the decreased availability of fossil fuels is likely to affect travel. Potential effects include a change of fuel type resulting in more hybrids and electrically powered vehicles. Reductions in fossil fuel supply could also result in changes in public policy such as a carbon tax or vehicle miles of travel, which could decrease travel overall. Reductions in fossil fuel supply could also result in dramatically increased fuel costs, which could decrease travel overall. Therefore, based on available information about fossil fuel availability, vehicle technology advancements, and the trends from 2035 data related to traffic flow

Table 3.16-1. Daily Operational Energy Consumption – Based on 2035 Travel Demand

Alternative	Total Transit Energy Use per Day (kWh)	Total Transit Energy Use per Day (gallons)	Daily Transit Energy Consumption (Billion BTU)	Daily Vehicle Miles on Roadway[1]	Daily Gasoline Consumption (gallons)	Total Daily Energy Consumption (Billion BTU)	Total Daily Energy Operations Cost[2]	Change in Energy Consumption Relative to No Action	Change in Energy Cost Relative to No Action
No Action	N/A	N/A	N/A	7,937,501	360,796	45.1	$939,872	N/A	N/A
Minimal Action	N/A	10,307	1.43	7,886,351	358,470	46.2	$962,778	3%	2%
Rail with IMC	353,893	5,611	1.99	7,602,796	345,582	45.2	$951,396	0%	1%
AGS	480,505	1,691	1.87	7,577,457	344,430	44.9	$950,042	0%	1%
Dual-Mode Bus in Guideway	419,317	6,084	2.28	7,657,130	348,051	45.8	$965,702	2%	3%
Diesel Bus in Guideway	N/A	43,159	5.99	7,668,452	348,566	49.6	$1,029,291	10%	10%
Six-Lane Highway (55 and 65 mph)	N/A	N/A	N/A	8,906,240	404,829	50.6	$1,054,580	12%	12%
Reversible/HOV/HOT Lanes	N/A	N/A	N/A	8,916,457	405,293	50.7	$1,055,790	12%	12%
Combination Six-Lane Highway with Rail and IMC	382,036	5,907	2.12	8,164,669	371,121	48.5	$1,021,573	8%	9%
Combination Six-Lane Highway with AGS	501,607	1,691	1.95	8,119,072	369,049	48.1	$1,016,284	7%	8%
Combination Six-Lane Highway with Dual-Mode Bus in Guideway	334,464	6,886	2.09	8,132,914	369,678	48.3	$1,015,751	7%	8%
Combination Six-Lane Highway with Diesel Bus in Guideway	N/A	45,913	6.38	8,179,969	371,817	52.9	$1,097,598	17%	17%
Preferred Alternative[3]	501,607 to 501,969	1,690 to 1,691	1.95	8,077,130 to 8,119,072	367,142 to 369,049	47.8 to 48.1	$1,011,351 to $1,016,284	6% to 7%	8%

[1] Average daily vehicle miles traveled based on an average over the year (rather than peak volumes, which are used for other analyses such as air quality).

[2] Electrical energy cost for transit is based on $0.10 per kWh. Diesel energy cost for transit and gasoline cost for cars are based on per gallon costs for the Rocky Mountain Region as posted on the U.S. Department of Energy, Energy Information Administration, website (http://www.eia.doe.gov/oog/info/gdu/gasdiesel.asp), accessed November 2, 2009.

[3]The Preferred Alternative is presented as a range because the adaptive management component allows it to be implemented based on future needs and associated triggers for further action. Section 2.7.2 of this document describes the triggers for implementing components of the Preferred Alternative.

Key to Abbreviations/Acronyms

AGS = Advanced Guideway System
IMC = Intermountain Connection
BTU = British thermal units
kWh = kilowatt-hours
HOT = high-occupancy toll
mph = miles per hour
HOV = high-occupancy vehicle
N/A = not applicable

Table 3.16-2. Construction Energy Consumption – Based on 2035 Travel Demand, in Billion BTU

Alternative	Number of Transit Track Miles	Civil Construction Energy Consumption	Track Construction Energy Consumption	Total Construction Energy Consumption
No Action	N/C	N/C	N/C	N/C
Minimal Action	N/A	12	N/A	12
Rail with IMC	147	26	3	29
AGS	236	43	5	47
Bus in Guideway (Dual-Mode and Diesel)	N/A	36	N/A	36
Six-Lane Highway 55 mph	N/A	19	N/A	19
Six-Lane Highway 65 mph	N/A	22	N/A	22
Reversible/HOV/HOT Lanes	N/A	20	N/A	20
Combination Six-Lane Highway with Rail and IMC	147	48	3	51
Combination Six-Lane Highway with AGS	236	67	5	71
Combination Six-Lane Highway with Bus in Guideway (Dual-Mode and Diesel)	N/A	46	N/A	46
Preferred Alternative[1]	N/A to 236	58 to 67	N/A to 5	58 to 71

[1]The Preferred Alternative is presented as a range because the adaptive management component allows it to be implemented based on future needs and associated triggers for further action. Section 2.7.2 of this document describes the triggers for implementing components of the Preferred Alternative.

Key to Abbreviations/Acronyms

AGS = Advanced Guideway System IMC = Intermountain Connection mph = miles per hour HOV = high-occupancy vehicle
N/A = not applicable N/C = not calculated BTU = British thermal units HOT = high-occupancy toll

improvement from the Action Alternatives, the Preferred Alternative continues to be among the lowest of all alternatives in operational energy consumption. Because construction of the Preferred Alternative occurs over a longer period of time (2050 rather than 2035), energy impacts from construction are more spread out over time.

3.16.6 What will be addressed in Tier 2 processes?

The Colorado Department of Transportation will conduct more detailed analyses of energy impacts during future Tier 2 processes, which will use the most current data and guidance available. Tier 2 processes will include additional analysis of construction and operational impacts based on the specific improvements and mode(s) selected. This document considered fossil fuel as the primary fuel source when calculating energy consumption. Tier 2 processes will have further consideration of power sources and mixes of energy supply types (renewable/alternative energy, fossil fuel, and other future concepts). Tier 2 processes will also include development of specific best management practices for each project.

3.16.7 What are the approaches to programmatic mitigation planning for energy?

Mitigation strategies for energy impacts will be developed and refined in Tier 2 processes in the context of a specific project. However, mitigation strategies that typically apply to construction projects to reduce impacts are addressed below. Construction and operational impacts will be mitigated through implementation of appropriate best management practices.

The following conceptual strategies could be included to reduce energy consumption during construction:

- Limiting the idling of construction equipment
- Encouraging employee carpooling or vanpools for construction workers
- Encouraging the use of the closest material sources (for example, aggregate or concrete)
- Locating construction staging areas close to work sites
- Using cleaner and more fuel-efficient construction vehicles (for example, low sulfur fuel, biodiesel, or hybrid technologies)
- Using alternative fuels and asphalt binders
- Implementing traffic management schemes that minimize motorist delays and vehicle idling

The following conceptual strategies included as non-infrastructure components of the Preferred Alternative could reduce operational energy consumption:

- Carrying out maintenance activities during periods of reduced traffic volumes
- Encouraging greater use of transit through measures such as incentive programs
- Working with chambers of commerce or tourist organizations to encourage resort operators to offer incentives for visitors who use transit or who use low emission or alternative fuel vehicles
- Promoting carpooling for regular facility users