

Appendix F

Energy Supporting Information

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Appendix F1

Construction Energy Fuel Consumption Calculations – Annual 2022

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UCR Long Range Development Plan Project - Construction Energy Calculations_2022

Last Updated: 6/8/2021

*Based on CalEEMod labeled "2022 Scenario Combined" located here: L:\EPS\Riverside Co\UCR\19-07846 Lng Rng Dev Pln EIR\Other\AQ\CalEEMod\2022 Scenario\2_Second Runs (gsf)

Compression-Ignition Engine Brake-Specific Fuel Consumption (BSFC) Factors [1]:

HP: 0 to 100	0.0588	HP: Greater than 100	0.0529
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Values above are expressed in gallons per horsepower-hour/BSFC.

CONSTRUCTION EQUIPMENT

Construction Equipment	#	Hours per		Horsepower	Load Factor	Construction Phase	Fuel Used (gallons)
		Day					
Concrete/Industrial Saws	1	8		81	0.73	Demolition	555.96
Excavators	3	8		158	0.38	Demolition	1,523.35
Rubber Tired Dozer	2	8		247	0.40	Demolition	1,671.19
Tractors/Loaders/Backhoes	4	8		97	0.37	Site Prep	674.90
Rubber Tired Dozer	3	8		247	0.40	Site Prep	1,253.39
Graders	1	8		187	0.41	Grading	1,134.76
Tractors/Loaders/Backhoes	2	8		97	0.37	Grading	1,181.07
Excavators	2	8		158	0.38	Grading	1,777.25
Scrapers	2	8		367	0.48	Grading	5,214.52
Rubber Tired Dozer	1	8		247	0.40	Grading	1,462.29
Cranes	1	7		231	0.29	Building Construction	3,842.01
Forklifts	3	8		89	0.20	Building Construction	3,891.13
Generator Sets	1	8		84	0.74	Building Construction	4,529.45
Tractors/Loaders/Backhoes	3	7		97	0.37	Building Construction	6,864.95
Welders	1	8		46	0.45	Building Construction	1,508.36
Pavers	2	8		130	0.42	Paving	923.55
Paving Equipment	2	8		132	0.36	Paving	803.80
Rollers	2	8		80	0.38	Paving	571.66
Air Compressors	1	6		78	0.48	Architectural Coating	264.02
Total Diesel Fuel Used							39,647.60

(Gallons)

Construction Phase	Days of Operation
Demolition	20
Site Preparation Phase	10
Grading Phase	35
Building Construction Phase	155
Paving Phase	20
Architectural Coating Phase	20
Total Days	260

WORKER TRIPS

Construction Phase	MPG [2]	Trips	Trip Length (miles)	Fuel Used (gallons)
Demolition Phase	24.0	15	14.7	91.88
Site Prep Phase	24.0	18	14.7	385.88
Grading Phase	24.0	20	14.7	428.75
Building Construction Phase	24.0	398	14.7	37785.13
Paving Phase	24.0	15	14.7	183.75
Architectural Coating Phase	24.0	80	14.7	980.00
Total Fuel Used				39,855.38

HAULING AND VENDOR TRIPS

Trip Class	MPG [2]	Trips	Trip Length (miles)	Fuel Used (gallons)
HAULING TRIPS				
Demolition Phase	7.4	515	20.0	1391.89
Site Prep Phase	7.4	0	20.0	0.00
Grading Phase	7.4	12817	20.0	34640.54
Building Construction Phase	7.4	0	20.0	0.00
Paving Phase	7.4	0	20.0	0.00
Architectural Coating Phase	7.4	0	20.0	0.00
Total Fuel Used				34,640.54
VENDOR TRIPS				
Demolition Phase	7.4	0	6.9	0.00
Site Prep Phase	7.4	0	6.9	0.00

Grading Phase	7.4	0	6.9	0.00
Building Construction Phase	7.4	90	6.9	13007.43
Paving Phase	7.4	0	6.9	0.00
Architectural Coating Phase	7.4	0	6.9	0.00
Total Fuel Used				13,007.43

Total Gasoline Consumption (gallons)	39,855.38
Total Diesel Consumption (gallons)	87,295.57

Sources:

- [1] United States Environmental Protection Agency. 2018. *Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES2014b*. July 2018. Available at: <https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100UXEN.pdf>.
- [2] United States Department of Transportation, Bureau of Transportation Statistics. 2018. *National Transportation Statistics 2018*. Available at: <https://www.bts.gov/sites/bts.dot.gov/files/docs/browse-statistical-products-and-data/national-transportation-statistics/223001/ntsntire2018q4.pdf>.

Appendix F2

Construction Energy Fuel Consumption Calculations – 2023 through 2035

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UCR Long Range Development Plan Project - Construction Energy Calculations_2023-2035

Last Updated: 6/8/2021

*Based on CalEEMod Labeled "2023-2035 Scenario Combined" located here: L:\EPS\Riverside Co\UCR\19-07846 Lng Rng Dev Pln EIR\Other\AQ\CalEEMod\2023-2035 Scenario\2_Second Runs (gsf)

Compression-Ignition Engine Brake-Specific Fuel Consumption (BSFC) Factors [1]:

HP: 0 to 100	0.0588	HP: Greater than 100	0.0529
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Values above are expressed in gallons per horsepower-hour/BSFC.

CONSTRUCTION EQUIPMENT

Construction Equipment	#	Hours per Day	Horsepower	Load Factor	Construction Phase	Fuel Used (gallons)
Concrete/Industrial Saws	1	8	81		0.73 Demolition	555.96
Excavators	3	8	158		0.38 Demolition	1,523.35
Rubber Tired Dozer	2	8	247	0.40	Demolition	1,671.19
Tractors/Loaders/Backhoes	4	8	97	0.37	Site Prep	674.90
Rubber Tired Dozer	3	8	247	0.40	Site Prep	1,253.39
Graders	1	8	187	0.41	Grading	1,134.76
Tractors/Loaders/Backhoes	2	8	97	0.37	Grading	1,181.07
Excavators	2	8	158	0.38	Grading	1,777.25
Scrapers	2	8	367	0.48	Grading	5,214.52
Rubber Tired Dozer	1	8	247	0.40	Grading	1,462.29
Cranes	1	7	231	0.29	Building Construction	3,842.01
Forklifts	3	8	89	0.20	Building Construction	3,891.13
Generator Sets	1	8	84	0.74	Building Construction	4,529.45
Tractors/Loaders/Backhoes	3	7	97	0.37	Building Construction	6,864.95
Welders	1	8	46	0.45	Building Construction	1,508.36
Pavers	2	8	130	0.42	Paving	923.55
Paving Equipment	2	8	132	0.36	Paving	803.80
Rollers	2	8	80	0.38	Paving	571.66
Air Compressors	1	8	78	0.48	Architectural Coating	352.02
Total Fuel Used						39,735.60

(Gallons)

Construction Phase	Days of Operation
Demolition	20
Site Preparation Phase	10
Grading Phase	35
Building Construction Phase	155
Paving Phase	20
Architectural Coating Phase	20
Total Days	260

WORKER TRIPS

Construction Phase	MPG [2]	Trips	Trip Length (miles)	Fuel Used (gallons)
Demolition Phase	24.0	15	14.7	91.88
Site Prep Phase	24.0	18	14.7	385.88
Grading Phase	24.0	20	14.7	428.75
Building Construction Phase	24.0	184	14.7	17468.50
Paving Phase	24.0	15	14.7	183.75
Architectural Coating Phase	24.0	37	14.7	453.25
Total Fuel Used				19,012.00

HAULING AND VENDOR TRIPS

Trip Class	MPG [2]	Trips	Trip Length (miles)	Fuel Used (gallons)
HAULING TRIPS				
Demolition Phase	7.4	270	20.0	729.73
Site Prep Phase	7.4	0	20.0	0.00
Grading Phase	7.4	6725	20.0	18175.68
Building Construction Phase	7.4	0	20.0	0.00
Paving Phase	7.4	0	20.0	0.00
Architectural Coating Phase	7.4	0	20.0	0.00
Total Fuel Used				18,905.41

VENDOR TRIPS

Demoliton Phase	7.4	0	6.9	0.00
Site Prep Phase	7.4	0	6.9	0.00
Grading Phase	7.4	0	6.9	0.00
Building Constrcution Phase	7.4	43	6.9	6214.66
Paving Phase	7.4	0	6.9	0.00
Architectural Coating Phase	7.4	0	6.9	0.00
			Total Fuel Used	6,214.66

Total Gasoline Consumption (gallons)	19,012.00
Total Diesel Consumption (gallons)	64,855.67

Sources:

[1] United States Environmental Protection Agency. 2018. *Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES2014b*. July 2018. Available at: <https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100UXEN.pdf>.

[2] United States Department of Transportation, Bureau of Transportation Statistics. 2018. *National Transportation Statistics 2018*. Available at: <https://www.bts.gov/sites/bts.dot.gov/files/docs/browse-statistical-products-and-data/national-transportation-statistics/223001/ntsntire2018q4.pdf>.

Appendix F3

Operational Energy Consumption

Appendix F4

Operational Energy Consumption Summary

Operational Energy Calculations Summary

Year	1990	2018	2020	2025	2030	2035
Growth Factors						
Campus Population						
Student Population (SP)		23,922	25225	28484	31742	35,000
Faculty/Staff Population (FSP)		4,739	5069	5894	6720	7,545
Campus Population Total (CP)		28,661	30294	34378	38461	42,545
Campus Space (GSF)						
Academics & Research		1,220,283	1376871	1768339	2159808	2,551,277
Academic Support		1,458,975	1702955	2312906	2922856	3,532,806
Student Life		1,875,963	2396174	3696701	4997228	6,297,756
Other		248,279	262884	299395	335907	372,419
Campus LRDP Program Space Total		4,803,500	5738883	8077341	10415800	12,754,258

Energy Use

	Existing Conditions				
Building Electricity Use					
Leg Adj Consumption (kWh)	118,960,675	142,125,831	212,988,450	289,609,592	365,059,169
Building Natural Gas Use					
Leg Adj Consumption (Therms)	3,466,942	4,142,058	6,125,127	8,108,197	10,113,046
Other Stationary Combustion Fuels					
Diesel Consumption (gallons)	8,003	9,561	13,457	17,354	21,250
UCR Fleet Fuel Use					
Unleaded Gasoline Usage (gallons)	135,192	142,897	162,158	181,419	200,681
Diesel Usage (gallons)	7,306	7,722	8,763	9,804	10,845
CNG Usage (gallon equivalents)	4,321	4,567	5,183	5,799	6,414
On-Campus Transportation Fuel Use (campus commuters, commercial vendors, etc)					
Total Gasoline Fuel Consumption (gallons)	2,100,859	2251021.02	2626426.18	3001831.34	3377236.51
Total Diesel Fuel Consumption (gallons)	247,811	232669.27	194815.68	156962.09	119108.50
Total Electricity Consumption (kwh)	75,551	200980.15	514553.66	828127.17	1141700.68
Air Travel Fuel Use (Attributed to UCR use)					
UCR Attributed Aviation Gasoline Fuel Use (gallons)	182,979	195,724	227,586	259,449	291,311
Public Transit Fuel Use (Attributed to UCR use)					
UCR Attributed Bus Fuel Use (gallon equivalents)	125,126	132,257	150,085	167,912	185,739
SUM by Fuel Type					
Total diesel (gallons)	263,120	249,953	217,036	184,120	151,203
Total natural gas (Therms)	3,466,942	4,142,058	6,125,127	8,108,197	10,113,046
Total gasoline (gallons)	2,419,030	2,589,641	3,016,170	3,442,699	3,869,228
Total CNG (GGE)	129,447	136,825	155,267	173,710	192,153
Total electricity (kwh)	119,036,226	142,326,811	213,503,004	290,437,719	366,200,870

Energy Use Sum (2022-2035)	Annualized Energy Use*	Per capita annual energy consumption (LRDP)	Per capita annual energy consumption (Existing Conditions)
3,724,603,983	266,043,142	6,253	4,151
105,251,203	7,517,943	177	121
226,586	16,185	0.38	0.28
2,458,971	175,641	4.13	4.72
132,887	9,492	0.22	0.25
78,594	5,614	0.13	0.15
40,448,937	2,889,210	68	73
2,356,454	168,318	4	9
10,276,772	734,055	17	3
3,498,459	249,890	6	6
2,275,891	162,564	4	4

Notes:

*divided by 14 years (because 14 years of LRDP between 2022 and 2035)

Appendix F5

Mitigation Impacts

Operational Energy Reductions associated with Mitigation

Mitigation Measure: EN-3

All newly constructed building projects, other than wet lab research laboratories, shall be designed, constructed, and commissioned to outperform the California Building Code (Title 24 portion of the California Code of Regulations) energy efficiency standards by at least 20 percent

Energy Consumption for new construction reduced by 20% after title 24 adjustments

	2025	2030	2035	2045
Electricity				
Adjusted Electricity from New Construction (kWh)	23,295,210	46,590,420	69,885,630	69,885,630
Electricity from new construction exceed Title 24 (kWh)	18,636,168	37,272,336	55,908,504	55,908,504
Electricity Reductions (kWh)	4,659,042	9,318,084	13,977,126	13,977,126
Natural Gas				
Adjusted NG from New Construction (therms)	458,373	916,745	1,375,118	1,375,118
NG from new construction exceed Title 24 (therms)	366,698	733,396	1,100,094	1,100,094
Natural Gas Reductions (therms)	91,675	183,349	275,024	275,024

Mitigation Measure: EN-5A

Identify aging equipment throughout the Campus such as equipment associated with the Central Steam Plant, electrical distribution system, and building HVAC systems.....The schedule and upgrade strategy must cumulatively meet a 2% energy efficiency improvement annually through 2035

Assumed 2% reduction in both electricity and natural gas annually in energy consumption in existing starting in 2022 buildings

	2022	2025	2030	2035	2045
Electricity					
Electricity from Existing Buildings (kWh)	165,290,986	165,290,986	165,290,986	165,290,986	165,290,986
Electricity after 2% reductions (kWh)	165,290,986	155,570,554	140,623,459	127,112,469	103,860,142
Electricity Reductions (kWh)	0	9,720,432	24,667,527	38,178,517	61,430,844
Natural Gas					
Natural Gas from Existing Buildings (therm)	3,466,942	3,466,942	3,466,942	3,466,942	3,466,942
Natural Gas after 2% reductions (therm)	3,466,942	3,263,058	2,949,546	2,666,156	2,178,443
Natural Gas Reductions (therms)		203,884	517,396	800,786	1,288,498

Mitigation Measure: EN-5B

Require all new buildings to incorporate occupancy sensors and controls such that lighting of shared spaces is on occupancy sensors, building temperature set points are widened and aligned with occupancy schedules, and ventilation systems are converted from constant volume to variable so that ventilation rates are occupancy-base

Assume energy efficiency is gained in natural gas, and that the majority of natural gas consumption is used for heating and cooling

Assume 20% of energy use is used for lighting

	2025	2030	2035	2045
Electricity				
Electricity Consumption in New Buildings exceeding Title 24 (kWh)	18,636,168	37,272,336	55,908,504	55,908,504
Portion of electricity used for lighting [1]	20%	20%	20%	20%
Electricity consumption in new buildings used for lighting (kWh)	3,727,234	7,454,467	11,181,701	11,181,701
Efficiency Increase from Occupancy-Based Sensors [1]	5.30%	5.30%	5.30%	5.30%
Electricity Consumption Reduced (kWh)	197,543	395,087	592,630	592,630
Natural Gas				
Natural Gas Consumption in New Buildings exceeding Title 24 (therms)	366,698	733,396	1,100,094	1,100,094
Efficiency Increase from Occupancy-Based Sensors [1]	5.30%	5.30%	5.30%	5.30%
Natural Gas Consumption Reduced (therms)	19,435	38,870	58,305	58,305

Table 11. Energy savings for 2007 using occupancy sensors

Building Name	Year	Electricity (kWh)	Natural Gas (therms)	CO2 (metric tons)	Cost (\$)
Building A	2007	100,000	100,000	100,000	100,000
	2008	95,000	95,000	95,000	95,000
Building B	2007	200,000	200,000	200,000	200,000
	2008	190,000	190,000	190,000	190,000
Building C	2007	300,000	300,000	300,000	300,000
	2008	285,000	285,000	285,000	285,000

1. https://www.pnnl.gov/main/publications/external/technical_reports/pnnl-22072.pdf