Life Cycle Associates

Draft Carbon Intensity Tables for Washington Clean Fuel Standard

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The following draft table provides the carbon intensity (CI) values for lookup pathways for use under the Washington Clean Fuel Standard (WA CFS) program. The WA-GREET draft model version currently available to public via Washington Department of Ecology website[1] has been used to model all the CI values presented in this table.

The CI values for the clear gasoline and clear diesel fuels are based on combination of OPGEE and WA-GREET modelling. To develop the CI values for the blended gasoline/diesel fuel used in Washington, the blend level data for Washington for the year 2017 was calculated using EIA data.[2] EIA data includes the annual consumption (in volume) in transportation sector for denatured ethanol, gasoline including ethanol, biodiesel, and diesel including biodiesel. EIA reports the ethanol consumption data in its denatured form.

For EtOH and soy BD used for blending with clear gasoline and clear diesel, the direct CI results from the publicly-available WA-GREET draft model have been used. Please refer to the Washington fuel blending calculator for more details on explicit EtOH and soy BD CI inputs and blended CI calculation.

For all the other fuel pathways included in the lookup table, largely, the methodology and assumptions as specified in the CARB's 2018 "CA-GREET3.0 Lookup Table Pathways Technical Support Documentation"[3] were followed. Following CARB's approach, but in contrast to Oregon's approach, a Washington grid average electricity lookup pathway has been added to the lookup pathways table that is based on the 2018 Washington grid electricity CI modelling in WA-GREET and is subject to annual update.

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Table 4
Washington Carbon Intensity Lookup Pathways Table

Fuel	Pathway Code	Pathway Description	Carbon Intensity Values (gCO_2e/MJ)
Gasoline	WAGAS001	Clear gasoline – based on a weighted average of gasoline supplied to Washington	100.37
	WAGAS002	Washington gasoline – blended with corn ethanol as supplied to Washington[4]	98.59

[1] https://ecology.wa.gov/Regulations-Permits/Laws-rules-rulemaking/Rulemaking/WAC-173-424-455
[2] EIA State Energy Data System (SEDS): 1960-2019 (complete), available at https://www.eia.gov/state/seds/seds-data-complete.php?
[3] Available at CARB website https://ww2.arb.ca.gov/resources/documents/lcfs-life-cycle-analysis-models-and-documentation
[4] Based on 2017 WA blending level derived from EIA data, using standard corn ethanol pathway CI from WA-GREET

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Fuel	Pathway Code	Pathway Description	Carbon Intensity Values (gCO_2e/MJ)
Diesel	WAULSD001	Clear diesel – based on a weighted average of diesel fuel supplied to Washington	101.09
	WAULSD002	Washington diesel – blended with soy biodiesel as supplied to Washington[5]	100.02
Compressed natural gas	WACNG	North American natural gas delivered via pipeline; compressed in Washington	77.99
Liquefied natural gas	WALNG	North American natural gas delivered via pipeline; liquefied in Washington	86.76
Liquefied petroleum gas	WALPG	Fossil liquefied petroleum gas from crude oil and natural gas[6]	83.14
Electricity	WAELEC001	Washington average grid electricity used as transportation fuel in Washington	63.76 (subject to annual update)
	WAELEC002	Solar power, produced at or directly connected to the site of the charging station in Washington	0
	WAELEC003	Renewable power deemed to have a carbon intensity of zero	0
Hydrogen	WAHYF	Compressed H_2 produced in Washington from central steam methane reformation of North American fossil-based natural gas	112.69
	WAHYB	Compressed H_2 produced in Washington from central steam methane reformation of biomethane (renewable feedstock) from North American landfills	92.71
	WAHYEG	Compressed H_2 produced in Washington from electrolysis using Washington average grid electricity	94.34

[5] Based on 2017 Washington blending level derived from EIA data, using standard soy biodiesel pathway CI from WA-GREET

[6] Based on CARB estimate of 25% natural gas and 75% petroleum for PADD5

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Fuel	Pathway Code	Pathway Description	Carbon Intensity Values (gCO_2e/MJ)
	WAHYER	Compressed H_2 produced in Washington from electrolysis using solar- or wind-generated electricity[7]	6.52

[7] Assumes WAMX grid electricity is used for compression and dispensing at refueling stations

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Table 6
Washington Energy Densities of Fuels

Fuel (unit)	MJ/unit
Gasoline blendstock (gallon)	122.48 (MJ/gallon)
Washington gasoline (gallon)	117.72 (MJ/gallon)
Diesel fuel (gallon)	134.48 (MJ/gallon)
Compressed natural gas (therm)[8]	105.5 (MJ/therm)
Electricity (kiloWatt hour)	3.60 (MJ/kiloWatt hour)
Denatured ethanol (gallon)	81.51 (MJ/gallon)
Clear biodiesel (gallon)	126.13 (MJ/gallon)
Liquefied natural gas (gallon)	78.83 (MJ/gallon)
Hydrogen (kilogram)	120.00 (MJ/kilogram)
Liquefied petroleum gas (gallon)	89.63 (MJ/gallon)
Renewable hydrocarbon diesel (gallon)	129.65 (MJ/gallon)
Undenatured anhydrous ethanol (gallon)	80.53 (MJ/gallon)
Alternative Jet Fuel (gallon)	126.37 (MJ/gallon)
Renewable naphtha (gallon)	117.66 (MJ/gallon)

[8] If therms are reported on a LHV basis. For therms reported on an HHV basis, this value must be converted to HHV basis.

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Table 7
Washington Energy Economy Ratio Values for Fuels

Light/Medium Duty Applications (fuels used as gasoline replacements)		Heavy-Duty/Off-Road Applications (fuels used as diesel replacements)		Aviation Applications (fuels used as jet fuel replacements)	
Fuel/Vehicle Combination	**EER Value Relative to Gasoline**	**Fuel/Vehicle Combination**	**EER Value Relative to Diesel**	**Fuel/Vehicle Combination**	**EER Value Relative to conventional jet**
Gasoline (including E10) or any other gasoline-ethanol blend	1	Diesel fuel (including B5) or any other blend of diesel and biodiesel or renewable hydrocarbon diesel	1	Alternative Jet Fuel	1
CNG Internal Combustion Engine Vehicle (ICEV)	1	CNG, LNG, or LPG (spark-ignition engines)	0.9	- - -	
Electricity/Battery Electric Vehicle or Plug-In Hybrid Electric Vehicle	3.4	CNG, LNG, or LPG (compression-ignition engines)	1		
Electricity/On-Road Electric Motorcycle	4.4	Electricity/Battery Electric Vehicle or Plug-In Hybrid Electric Vehicle	5		
Propane/Propane Forklift	0.9	Electricity/Battery Electric or Plug-in Hybrid Transit Bus	5		
Hydrogen/Fuel Cell Vehicle	2.5	Electricity/Fixed Guideway Light Rail	3.3		
- - -		Electricity/Fixed Guideway Streetcar	2.1		
		Electricity/Fixed Guideway Aerial Tram	2.6		
		Electricity/Electric Forklift	3.8		

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Light/Medium Duty Applications (fuels used as gasoline replacements)		Heavy-Duty/Off-Road Applications (fuels used as diesel replacements)		Aviation Applications (fuels used as jet fuel replacements)	
Fuel/Vehicle Combination	**EER Value Relative to Gasoline**	**Fuel/Vehicle Combination**	**EER Value Relative to Diesel**	**Fuel/Vehicle Combination**	**EER Value Relative to conventional jet**
		Electricity/Electric TRU (eTRU)	3.4		
		Hydrogen/Fuel Cell Vehicle	1.9		
		Hydrogen/Fuel Cell Forklift	2.1		
		Electricity/Cargo Handling Equipment	2.7		
		Electricity/Ocean Going Vessels	2.6		

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Table 8
Washington Substitute Fuel Pathway Codes

Fuel	Fuel Pathway Code	CI (gCO_2e/MJ)
Substitute CI for ethanol. This pathway may only be used to report transactions that are sales or purchases without obligation, exports, loss of inventory, not for transportation use, and exempt fuel use.	ETH0116	40
Substitute CI for biodiesel. This pathway may only be used to report transactions that are sales or purchases without obligation, exports, loss of inventory, not for transportation use, and exempt fuel use.	BIOD0116	15
Substitute CI for renewable diesel. This pathway may only be used to report transactions that are sales or purchases without obligation, exports, loss of inventory, not for transportation use, and exempt fuel use.	RNWD0116	15
Substitute CI for E10 gasoline. This pathway may only be used to report transactions that are sales or purchases without obligation, exports, loss of inventory, not for transportationuse, and exempt fuel use.	WAGAS0116	96.36 (subject to annual update)
Substitute CI for B5 diesel. This pathway may only be used to report transactions that are sales or purchases without obligation, exports, loss of inventory, not for transportation use, andexempt fuel use.	WAULSD0116	99.08 (subject to annual update)

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Table 9
Washington Temporary Fuel Pathway Codes for Fuels with Indeterminate CIs

Fuel	Feedstock	Process Energy	FPC	CI (g CO_2e/MJ)
Ethanol	Corn	Grid electricity, natural gas, and/or renewables	WAETH100T	90[9]
	Sorghum	Grid electricity, natural gas, and/or renewables	WAETH101T	95[10]
	Sugarcane and molasses	Bagasse and straw only, no grid electricity	WAETH102T	55
	Any starch or sugar feedstock	Any	WAETH103T	Baseline (2017) CI for Washington gasoline
	Corn stover, wheat straw, or sugarcane straw	As specified in WA-GREET	WAETH104T	50
Biodiesel	Any feedstock derived from animal fats, corn oil, or a waste stream	Grid electricity, natural gas, and/or renewables	WABIOD200T	45
	Any feedstock derived from plant oils except for palm-derived oils	Grid electricity, natural gas, and/or renewables	WABIOD201T	65
	Any feedstock	Any	WABIOD202T	Baseline (2017) CI for Washington ULSD

[9] Reflects an iLUC value of 19.8. If iLUC value under WA CFS is modified, this may be adjusted accordingly.

[10] Reflects an iLUC value of 19.8. If iLUC value under WA CFS is modified, this may be adjusted accordingly.

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Fuel	Feedstock	Process Energy	FPC	CI (g CO_2e/MJ)
Renewable Diesel	Any feedstock derived from animal fats, corn oil, or a waste stream	Grid electricity, natural gas, and/or renewables	WARNWD300T	45
	Any feedstock derived from plant oils except for palm-derived oils	Grid electricity, natural gas, and/or renewables	WARNWD301T	65
	Any other feedstock	Any	WARNWD302T	Baseline (2017) CI for WA ULSD
Biomethane CNG	Landfill or digester gas	Grid electricity, natural gas, and/or renewables	WACNG500T	70
	Municipal wastewater sludge, food waste, green waste, or other organic waste	Grid electricity, natural gas, and/or parasitic load	WACNG501T	45
Biomethane LNG	Landfill or digester gas	Grid electricity, natural gas, and/or renewables	WALNG501T	85
	Municipal wastewater sludge, food waste, green waste, or other organic waste	Grid electricity, natural gas, and/or parasitic load	WALNG502T	60
Biomethane L-CNG	Landfill or digester gas	Grid electricity, natural gas, and/or renewables	WALCNG502T	90

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Fuel	Feedstock	Process Energy	FPC	CI (g CO_2e/MJ)
	Municipal wastewater sludge, food waste, green waste, or other organic waste	Grid electricity, natural gas, and/or parasitic load	WALCNG503T	65
Biomethane CNG, LNG,L-CNG	Dairy and swine manure	Grid electricity, natural gas, and/or parasitic load	WALCNG504T	-150
Hydrogen	Centralized SMR of fossil LNG	Grid electricity, natural gas, and/or renewables	WAHYG601T	165
Renewable LPG	Fats, oils, and grease residues	Grid electricity, natural gas, and/or renewables	WARNWP400T	45
	Any feedstock derived from plant oils (excluding palm and palm derivatives)	Grid electricity, natural gas, and/or renewables	WARNWP401T	65
Any gasoline substitute feedstock-fuel combination not included above	Any	Any	WASG800T	Baseline (2017) CI for Washington gasoline
Any diesel substitute feedstock-fuel combination not included above	Any	Any	WASD801T	Baseline (2017) CI for Washington ULSD