

7-7-08 TABLE 1. TOOLS TO CALCULATE FUEL CONSUMPTION AND GHG EMISSION RATES jmw 7-7-08)

EMISSION SOURCE	GHG EMISSION CALCULATION METHOD	Advantages	Disadvantages	Policy Considerations
<b>Category of SEPA Proposal: Land Use Plans (Regional, County, and City Level)</b>				
Regional-level, County-level, City-level GHG emissions from land use and transportation sources	Currently-available ICLEI CACP Package  ICLEI – Local Governments for Sustainability  CACP – Clean Air and Climate Protection software	Widely used and respected.	Fuel-based inventory, not based on land use types. Must use external sources as inputs to compile regional fuel usage, VMT, and electrical usage.	
	I-PLACE3S <a href="http://www.energy.ca.gov/places/index.html">www.energy.ca.gov/places/index.html</a>	Designed for regional community planning. Evaluates a range of VMT reduction measures and energy conservation measures.	Uses California factors only. Fuel-based inventory, not based on land use types. Must use external sources as inputs to compile regional fuel usage, VMT, and electrical usage.	
	Sustainable Communities Model (SCM)  <a href="http://www.ctg-net.com/energetics/documents/doc_SCM_070731.pdf">http://www.ctg-net.com/energetics/documents/doc_SCM_070731.pdf</a>	Designed for regional community planning. Evaluates a range of VMT reduction measures and energy conservation measures.	Uses California factors only. Fuel-based inventory, not based on land use types. Must use external sources as inputs to compile regional fuel usage, VMT, and electrical usage.	

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	Upcoming ICLEI CACP Mitigation Package	Automatically evaluates mitigation measures for VMT reduction and energy efficiency.	<p>Not yet distributed (expected late summer 2008).</p> <p>Fuel-based inventory, not based on land use types. Must use external sources to compile regional fuel usage, VMT, and electrical usage.</p> <p>Current CACP model does not automatically evaluate VMT reduction measures or energy conservation measures.</p>	
Subarea-level, by land use type and size	King County Residential /Commercial spreadsheet	Simple to use. Life-cycle GHG emission for any given building type and size. Includes embodied emissions (i.e., emissions from upstream manufacture of building materials used for the project).	<p>Uses state-wide averages for input parameters. Does not forecast downstream vehicle travel.</p> <p>Does not forecast mitigation efficiency.</p> <p>Does not account for new CAFÉ fuel economy standards.</p>	
	URBEMIS 2007. <a href="http://www.urbemis.com/">http://www.urbemis.com/</a>	<p>Simple to use. Includes construction, operation, and downstream vehicle traffic emissions.</p> <p>Offers default values for trip generation and VMT by land use category, with flexibility</p>	<p>- Uses California factors only.</p> <p>Does not account for new CAFÉ fuel economy standards.</p>	

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		<p>to adjust defaults.</p> <p>Calculates mitigation efficiency.</p>		
	Sustainable Communities Model (SCM)	Vendor literature says this regional model is adaptable to subarea and project level analyses. Automatically evaluates a wide range of mitigation measures.	- Uses California factors only. Appears to be very data-intensive, requiring the user to explore external data sources for input to the model (trip generation, VMT, fuel use).	
<b>Category of SEPA Proposal: Transportation Plans</b>				
Modeling of regional VMT, speed, congestion	Regional models (e.g., PSRC Regional Transportation Model)	- Best available models for regional GHG emissions. Forecasts localized traffic smoothing provided by transportation improvement projects.	Very difficult to use. Not useful for project level calculations	
GHG emission factors for individual vehicles.	EPA MOVES/PERE, after EPA releases the "Fixed version" late 2008.	- Use EPA's most recent version of MOVES (not yet publicly distributed). Will fix the speed calculation efforts and deficiencies currently in Mobile6.2 and demo version of MOVES. Emission factors can be	<p>- Corrected version of MOVES/PERE is currently available only upon special request to EPA.</p> <p>- Does not currently account for the new CAFÉ standards</p>	

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		manually adjusted for estimated new CAFÉ fuel standards external to the model.		
GHG emission factors or fuel economy for individual vehicle classes	US EPA MOVES Demonstration Model (the only version of MOVES available at this time)	- Calculates tailpipe emissions of CO2 for various vehicle types based on energy consumption data.	<ul style="list-style-type: none"> <li>- Fatally Flawed (at this time). Current demo version gives erroneous emission factors.</li> <li>- Does not accurately account for changes in vehicle speeds.</li> <li>- Does not account for the new CAFÉ standards.</li> </ul>	
	California EMFAC	Easy to use to generate GHG emission factors in California.	California emission factors only. Does not account for the new CAFÉ standards.	
	MOBILE 6.2 (EPA tailpipe emission factor model)	None at this time.	Fatally Flawed: <ul style="list-style-type: none"> <li>- Emission numbers produced by the model are flawed because the model does not account for speed.</li> <li>- Gives artificial sense of accuracy when that accuracy doesn't exist. Better off calculating GHG emissions from energy report.</li> </ul>	
	Combo Mobile6.2 and EMFAC speed curves (Under	To be determined	To be determined	

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	development by WSDOT )			
Fuel economy for individual vehicles.	Comprehensive Modal Emissions Model (CMEM)	Most accurate fuel economy model available. Can be used to manually adjust MOVES/PERE factors because it considers vehicle operational history effects (i.e., how the last second of operations affect fuel consumption/emissions).	Difficult to use, requires considerable research into second-by-second vehicle speed profiles.	
Regional Tons/year from regional roadway system, refined method accounting for localized congestion improvements	Use regional transportation model to forecast VMT, speed, congestion on each roadway segment in the region (1000s of segments in the region).  Then, for each segment apply the speed-specific GHG emission factors from MOVES/PERE/CMEM Lookup Tables.	Uses best available VMT forecasting tool. Can simulate localized traffic smoothing provided by local and regional improvement projects. Uses best available GHG emission factors, accounting for localized congestion along each roadway segment.	Regional transportation model is very difficult to use. Does not automatically account for new CAFÉ standards, unless MOVES emission factors are manually adjusted.	
Regional tons/year, screening method not accounting for localized congestion.	Use regional transportation model to indicate total regional VMT and regional-average speed. Estimate regional-average fuel economy based on published EPA data. Calculate regional fuel consumption and	<ul style="list-style-type: none"> <li>- Straight forward and easy to understand</li> <li>- Can help create apples to apples comparison across different mode choices (e.g., transit/rail and on-</li> </ul>	<ul style="list-style-type: none"> <li>- Covers only aggregate transportation activities for which ball-park fuel consumption data can be collected or assumed.</li> <li>- Does not account for speed differences on transportation</li> </ul>	

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	regional GHG emissions.	road)	projects - Does not account for smoother flowing traffic on transportation projects - Does not account for congestion and reduced delay relief on transportation projects. - Does not account for land use and microscale traffic changes. - Does not provide detail on differences between on-road bus use and single vehicles unless energy study pulls out that data.	
Upcoming models	WSDOT internal modeling spreadsheet (Under development)?	Don't know yet	Don't know yet	
	Argonne National Labs, GREET model (Under development)	To be determined	To be determined	
	Other EPA, US DOE Calculators	To be determined	To be determined	
<b>Category of SEPA Proposal: Commercial, Retail, Office, and Residential Development</b>				
Project-level, by land use	King County Residential	Simple to use. Life-cycle	Uses state-wide averages for input	

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type and size	/Commercial spreadsheet	GHG emission for any given building type and size. Includes embodied emissions (i.e., emissions from upstream manufacture of building materials used for the project)	parameters. Does not forecast downstream vehicle travel.  Does not forecast mitigation efficiency.  Does not account for new CAFÉ fuel economy standards.	
Project level, by land use type and size	URBEMIS 2007.	Simple to use. Includes construction, operation, and downstream vehicle traffic.  Offers default values for space heating fuel usage.  Offers default values for trip generation and VMT by land use category, with flexibility to adjust defaults.  Calculates mitigation efficiency.	- Uses California factors.  - Does not account for new CAFÉ fuel economy standards.	
Project level, by land use type and size	Sustainable Communities Model (SCM)	Automatically evaluates a wide range of mitigation measures.	- Uses California factors. Appears to be very data-intensive, requiring the user to explore external data sources for input to the model.	
Individual commercial,	World Business Council/WRI	Based on EPA and California	Requires the user to access model	

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retail building space heating and electricity usage.	Reporting Protocol <a href="http://www.ghgprotocol.org/calculation-tools/all-tools">http://www.ghgprotocol.org/calculation-tools/all-tools</a>	Air Resources Board (CARB) reporting protocols for “boundaries”	input factors from other public websites and databases.	
	CCAR General Protocol <a href="http://www.climateregistry.org/tools/protocols/general-reporting-protocol.html">http://www.climateregistry.org/tools/protocols/general-reporting-protocol.html</a> CARROT emission calculation software <a href="http://www.climateregistry.org/CARROT/login.aspx">http://www.climateregistry.org/CARROT/login.aspx</a>			
Individual commercial building space heating and electricity usage	EIA CBECs Energy Intensity Tables <a href="http://www.eia.doe.gov/emeu/cbecs/">http://www.eia.doe.gov/emeu/cbecs/</a>  EERE Buildings Energy Databook, converts space heating fuel usage to GHG emissions.  EIA E-GRID database for GHG emissions from purchased electricity.	Detailed listing of data sources, sorted by geography, land use type, and climatic zone.	Does not calculate GHG emissions, simply provides a source of energy usage factors (e.g., BTU/sq. ft.)	
Residential building space heating and electrical usage.	EIA RECS Energy Intensity Tables <a href="http://www.eia.doe.gov/emeu/">http://www.eia.doe.gov/emeu/</a>	Detailed listing of data sources, sorted by geography, land use type,	Does not calculate GHG emissions, simply provides a source of energy usage factors (e.g., BTU/sq. ft.)	

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	<p><u>recs/</u></p> <p>EERE Buildings Energy Databook</p> <p>EIA E-GRID database for GHG emissions from purchased electricity.</p>	and climatic zone.		
Commercial or residential building space heating and electricity usage	<p>EnergyStar Target Finder</p> <p><a href="http://www.energystar.gov/index.cfm?c=new_bldg_design.bus_target_finder">http://www.energystar.gov/index.cfm?c=new_bldg_design.bus_target_finder</a></p>	<p>Estimates space heating and electricity consumption by location and building type.</p> <p>Estimates mitigation efficiency.</p>	Does not document sources of data.	
VMT (downstream) generated by residential or commercial development	URBEMIS 2007.	<p>Simple to use. Calculates tons/yr CO2 emissions from downstream VMT</p> <p>Offers default ITE values for trip generation and VMT by land use category, with flexibility to adjust defaults.</p> <p>Calculates mitigation efficiency.</p>	<p>Uses California factors only.</p> <p>Does not account for new CAFÉ fuel economy standards.</p>	
Energy conservation mitigation efficiency for project-level facilities and individual buildings.	EnergyStar Target Finder	<p>Estimates space heating and electricity consumption by location and building type.</p> <p>Estimates mitigation</p>	Does not document sources of data.	

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		efficiency.		
<b>SEPA Proposal Category: Municipal Infrastructure</b>				
Street lights and traffic lights	Project engineer must forecast kW-hrs electrical usage. After that, use EIA E-GRID database to calculate GHG emissions.	Conversion from kw-hrs to tons of GHG is easy.	Not easy to forecast. Requires a specification on electricity usage.	
Electricity for water supply and sewerage	Project engineer must forecast kW-hrs electrical usage. After that, use EIA E-GRID database to calculate GHG emissions.	Conversion from kw-hrs to tons of GHG is easy.	Not easy to forecast. Requires a specification on electricity usage.	
<b>SEPA Proposal Category: Waste Handling</b>				
Landfill gas for any given landfill of specified capacity	EPA LANDGEM Model	Very detailed GHG emission estimates based on refuse acceptance rates.	User must specify time series of long term annual acceptance rates.	
Landfills	WRI/WBC GHG emission Protocol	Easy to use. General emission factors (tons GHG per ton of refuse)	None	
	ICLEI CACP Package SCM Model		Complicated software designed for regional land use planning. User must specify data on the landfill.	

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	PLACE3S Model			
Wastewater treatment	IPCC Emission Calculation Guidelines  CCAR Protocol	General emission factors (tons of GHG per million gallons of wastewater.	Data are not specific to any given treatment plant.	
Electricity and emissions from sewers and water supply	Plant engineer forecasts electricity usage (kw-hrs/year). Use EIA E-GRID database to convert kw-hrs to GHG emissions.	Estimate is as precise as the engineer's estimate of electricity purchases.	Not a forecasting tool. Requires an engineering estimate of electricity usage.	
<b>SEPA Proposal Category: Construction Emissions</b>				
Construction Equipment fuel factor (gal/hour each equipment item)	EPA NONROAD Model or California OFFROAD Model	EPA model gives fuel consumption rate (gallons/hp-hr) for each type of equipment. California model gives the relative fuel usage for various pieces of equipment.	Not a forecasting tool. User must specify type, number, and usage of equipment. OFFROAD model is currently being modified to reconcile the emission estimates with fuel usage which is what the GHG emissions are based on.	
Total GHG emissions by land use type and size	URBEMIS 2007. Calculates tons CO2 emission to construct specified land use type and size.	Forecasting tool, with default assumptions for equipment usage by each user-specified land use category and project size.	Uses California tailpipe emission data for construction equipment.	

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Highway construction	CALTRANS 1973 highway Construction Manual	Simple to use. Estimates BTU of construction energy per million dollars of highway construction cost, for a variety of roadway types.	1973 data.	
Highway construction	2008 Sightline Report	Provides estimate of GHG emissions per mile of freeway construction.	Does not apply to all types of roadways.	
<b>General Topic: Agriculture, Silviculture (Tree Related), and Land Clearing (Reduction of Natural Sequestration)</b>				
Agriculture	IPCC Emission Calculation Guidelines	Detailed evaluation of operational GHG emissions by location and crop type.	IPCC emission estimation procedures are worldwide in scope, maybe too broad for project level or Washington state estimates.	
Forest practices	IPCC Emission Calculation Guidelines	Detailed evaluation of operational GHG emissions by location and forest type.	IPCC emission estimation procedures are worldwide in scope	
Sequestration by undeveloped land	IPCC Emission Calculation Guidelines	Detailed evaluation of carbon sequestration by land cover type.	IPCC emission estimation procedures are worldwide in scope	
<b>General topic: Manufacturing Processes</b>				

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Industrial Facilities	WRI/WBC GHG Protocol	Gives emission factors for limited number of industries with the highest GHG intensity (e.g., cement manufacture)	Does not cover all industries.	
	EPA AP-42	Widely used for criteria air pollutant sources. In some cases provides direct CO2 emission factors. In other cases, provides data to estimate fuel consumption.	Does not cover all industries.	
	IPCC Emission Guidelines <a href="http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html">www.ipcc-nggip.iges.or.jp/public/2006gl/index.html</a>	Gives emission factors for limited number of industries with the highest GHG intensity (e.g., cement manufacture)	Does not cover all industries.	
	California CCAR GHG Protocol	Gives emission factors for limited number of industries with the highest GHG intensity (e.g., cement manufacture)	Does not cover all industries.	
Indirect GHG emissions from purchased electricity	Federal EIA E-Grid Database	Converts kw-Hr/year to GHG emissions per year.	Not a forecasting tool, requires the user to specify kw-hrs/year of electricity purchases.	

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<b>SEPA Proposal Category: Nonroad Transportation Ships, Planes, Trains</b>				
Near-shore, harborcraft, and recreational Marine Vessels	EPA NONROAD	Gives information for a variety of vessel types.	Gives fuel consumption only, user must convert fuel usage to GHG emissions.  Emission factors only (gal/hp-hr). User must specify number, type, size and usage of equipment.	
	California OFFROAD model	Gives information for a variety of vessel types.  Gives CO2 emissions.	Emission factors only (gal/hp-hr). User must specify number, type, size and usage of equipment.	
Commercial Marine Vessels	EPA 2000. Analysis of Commercial Marine Vessel Emissions and Fuel Consumption Data	Easy to use tool to estimate gallons/hour fuel usage from typical vessel types.	Fuel consumption only, user must convert fuel usage to GHG emissions.	
Locomotives	EPA Documentation for Tier-2 and Tier-3 for Locomotives. Estimates fuel usage factors (gallons/hour)	Lots of data on types of locomotives, their duty cycles, and fuel consumption.	Fuel consumption only, user must convert fuel usage to GHG emissions.	
Off-shore Marine Vessels	EPA documentation for Category-3 Emission Controls for Marine Vessels. Estimates fuel usage factors	Lots of data on types of large marine vessels, their duty cycles, and fuel consumption.	Fuel consumption only, user must convert fuel usage to GHG emissions.	

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	(gallons/hour)			
Airports, Aircraft, Ground Support Equipment	ICPP Emission Protocol. Sea-Tac Airport GHG Report. Upcoming TRB GHG Protocol.	Gives data for variety of aircraft.	Not an easy forecasting tool, user must specify the number and type of aircraft. Fuel consumption only, user must convert fuel usage to GHG emissions.	