5 MODEL LAYOUT

The GREET model, developed as a multi-dimensional spreadsheet model in Microsoft Excel 5.0, consists of 12 sheets: *Emn_Factors, Fuel_Specs, Petroleum, NG, Landfill_Gas, Biomass, Coal, Uranium, Electricity, Vehicles, Results, and Graphs*. Figure 2 shows the information flow diagram of the GREET model. Upstream emissions and energy use are calculated in *Petroleum, NG, Landfill_Gas, Biomass, Coal, Uranium,* and *Electricity* by using data contained in *Emn_Factors* and *Fuel_Specs*. Emissions and energy use during vehicle operations are calculated in *Vehicles*; fuel-cycle emissions and energy use are calculated in *Results*; and graphic presentations of calculated fuel-cycle emissions and energy use are shown in *Graphs.*

Emn-Factors contains emission factors of fuel combustion in $g/10^6$ Btu of fuel burned for 38 combinations of combustion technologies and fuels. Emission factors are presented for combustion technologies that burn NG, residual oil, diesel, gasoline, crude, LPG, coal, and woody biomass. These emission factors are used in other sheets to calculate emissions associated with fuel combustion in various fuel-cycle stages. For each technology/fuel combination, emission factors for each of eight pollutants (VOCs, CO, NO_x, PM_{10}, SO_x, CH_4, N_2O, and CO_2) are presented. Emission factors contained in the sheet have been developed primarily from EPA's AP-42 document (EPA 1995). Other sources used for the development of emission factors are presented in the sheet. Emission factors for CO_2 are calculated in the GREET model from carbon contained in a given fuel minus carbon contained in VOCs, CO, and CH_4 emitted during combustion of the fuel. For the CO_2 emission calculation, the sheet lists the carbon ratios of VOCs, CO, and CH_4. The emission factors of SO_x for combustion of NG, gasoline, crude, and LPG are calculated in the model by assuming that all sulfur contained in these fuels is converted to SO_2.

The *Fuel_Specs* sheet contains the following specifications: low heat value, high heat value, fuel density, sulfur content, and carbon content for the fuels included in the GREET model (crude, conventional gasoline, RFG, LSD, residual oil, methanol, ethanol, LPG, liquid hydrogen, MTBE, ETBE, NG liquids, NG, gaseous hydrogen, coal, woody biomass, and herbaceous biomass). The sheet contains GWPs for the GHGs used in the GREET model; the GWPs are used to combine emissions of GHGs together to calculate CO_2-equivalent GHG emissions. On the basis of the IPCC report (IPCC 1995), the GWPs are assumed to be 1 for CO_2, 21 for CH_4, and 310 for N_2O.

The seven upstream emissions and energy sheets (*Petroleum, NG, Landfill_Gas, Biomass, Coal, Uranium,* and *Electricity*) follow the same calculation logistics described above (Figure 3). For each upstream stage, the model assumes input parameters of fuel combustion technology shares, energy efficiencies, in-basin and out-of-basin emission shares, and energy source shares. Energy consumption (by energy source) is calculated by using assumed energy efficiencies and energy

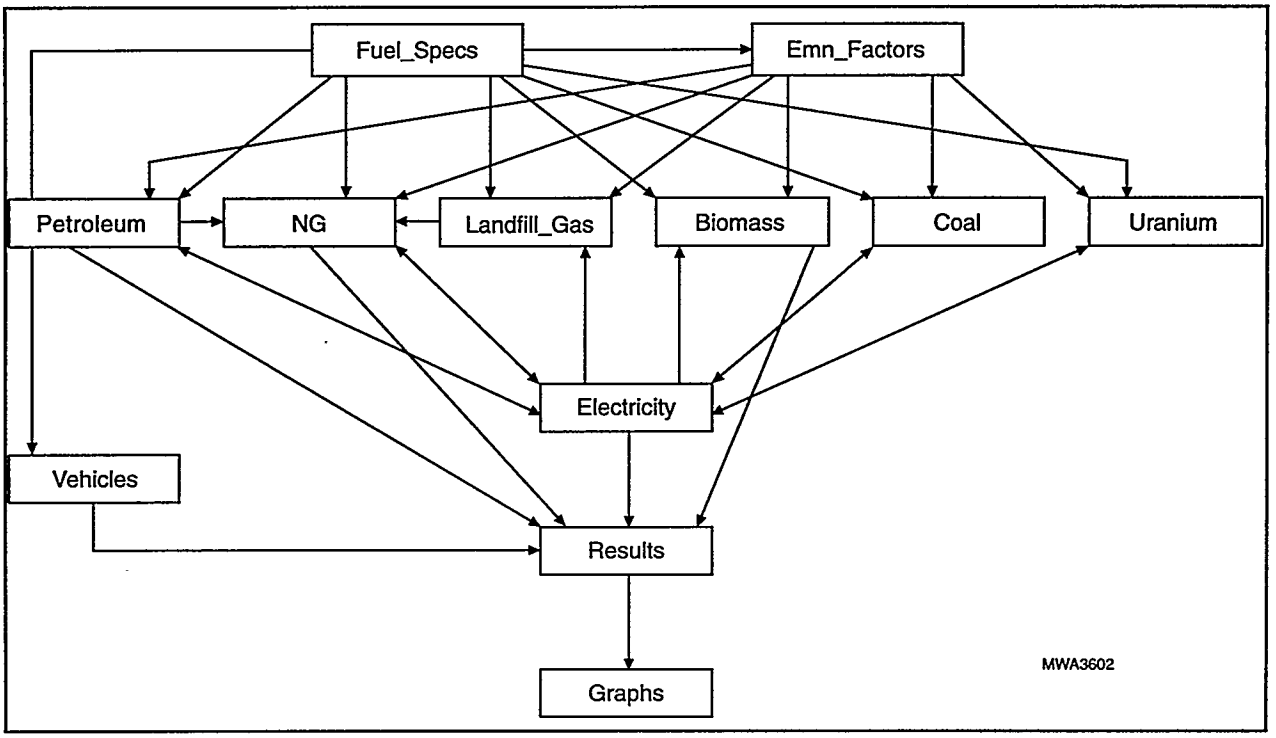

FIGURE 2 Flow Diagram of the GREET Model

source shares. Emissions are calculated from energy consumption (by source), combustion technology shares, and emission factors contained in *Emn-Factors*. Emissions and energy use in all locations are summarized, and in-basin emissions of the five criteria pollutants are calculated by considering in-basin and out-of-basin emission shares.

The *Petroleum* sheet contains four fuel cycles (petroleum to RFG, LSD, and residual oil); the *NG* sheet contains four cycles (NG to CNG, methanol, LPG, and hydrogen); the *Landfill_Gas* sheet contains one cycle (landfill gases to methanol); and the *Biomass* sheet contains three cycles (corn, woody biomass, and herbaceous biomass to ethanol). The *Coal* and *Uranium* sheets calculate emissions from coal mining to coal at power plants and from uranium mining to uranium at power plants. The *Electricity* spreadsheet calculates energy use and emissions generated during electricity production for a given electric generation mix and accounts for energy use and emissions during upstream stages of production for residual oil, NG, coal, and uranium.

The *Vehicles* sheet calculates energy use and emissions of vehicle operations. The *Results sheet* calculates Btu/mi energy use and g/mi emissions for the whole fuel cycle — from primary energy recovery to vehicle operations. Reductions of per-mile energy use and emissions by various vehicle types are calculated relative to baseline GVs. The sheet also presents the allocation of fuel-cycle energy use and emissions among primary energy production, fuel production, and vehicle operations. The *Graphs* sheet graphically presents the allocation of energy use and emissions among primary energy production, fuel production, and vehicle operations and the reductions in energy use and emissions by various vehicle technologies.

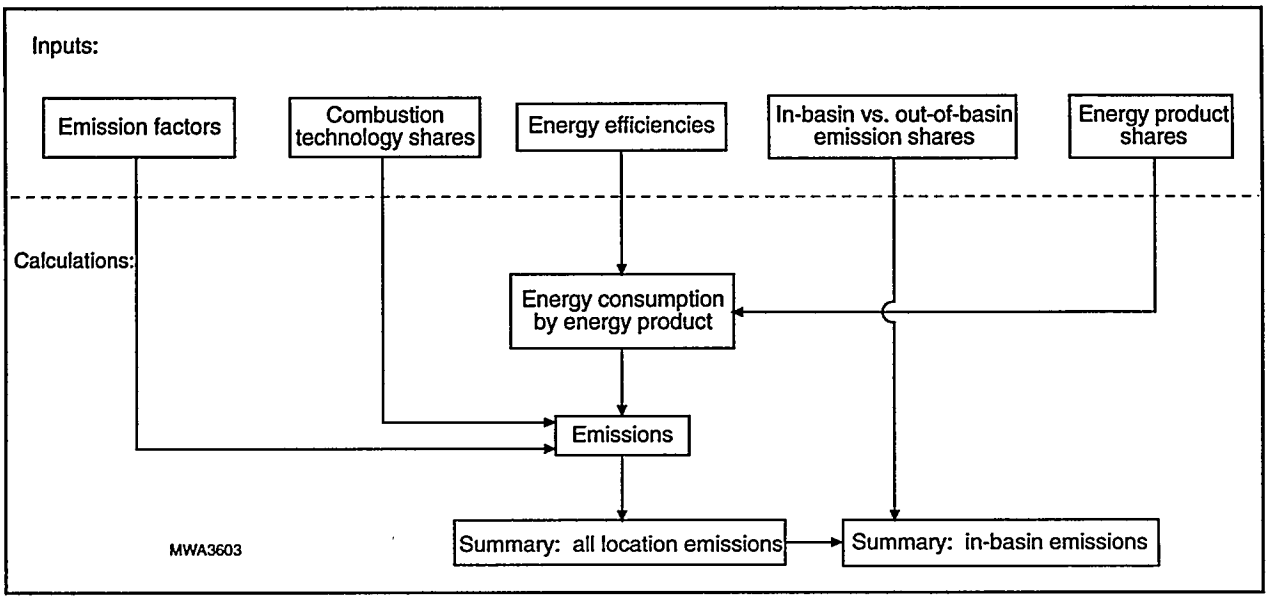

FIGURE 3 Calculation Logic of Upstream Emissions and Energy Use in the GREET Model

Within the GREET model, some cells present default assumptions used for fuel-cycle energy and emission calculations, while others are logic calculations. Users have the option to change any of the default assumptions. The cells that contain critical assumptions are shaded so that users can easily distinguish the critical assumptions from logic calculations.