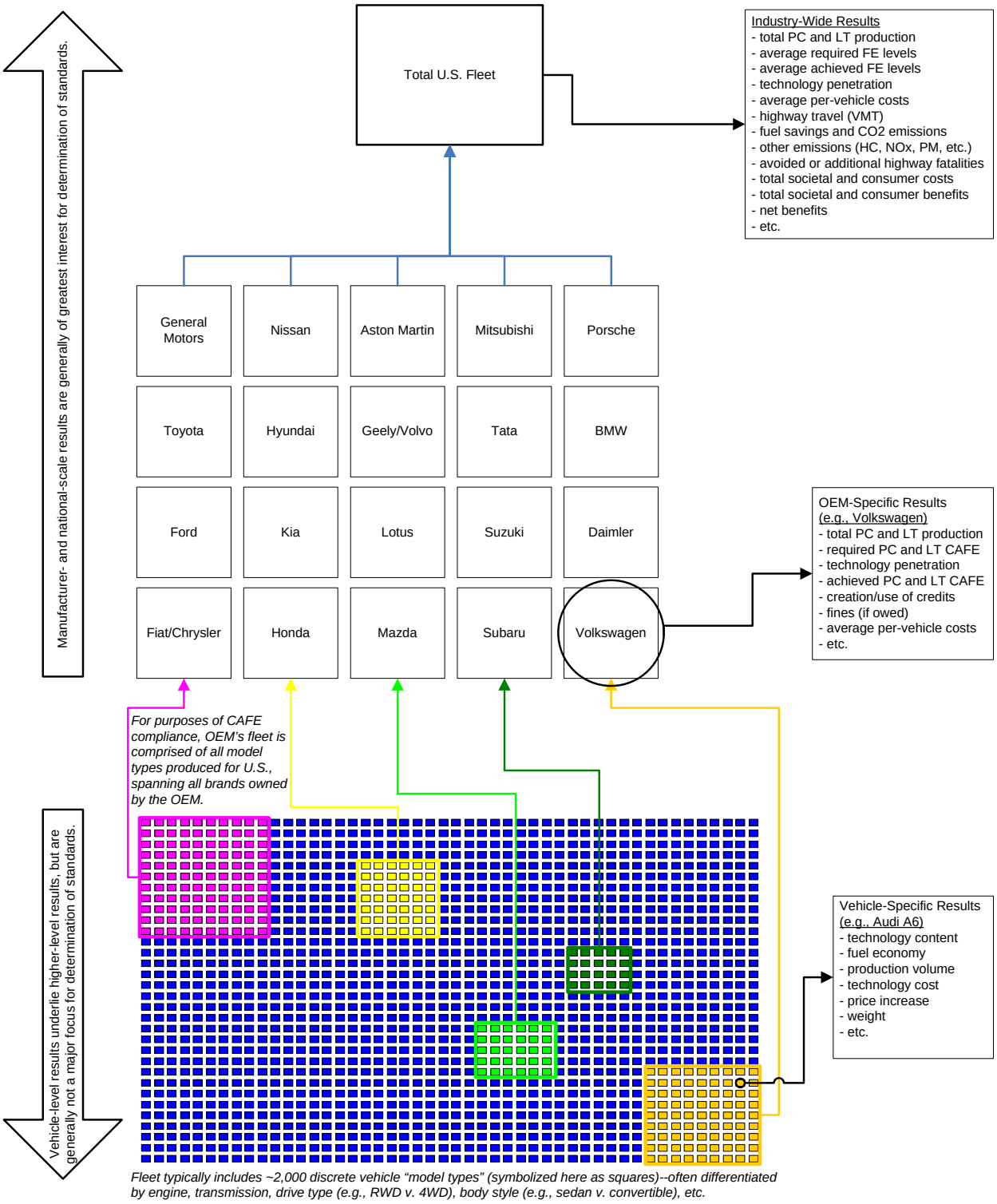
Overview of CAFE Model Inputs, Simulation, and Outputs

The CAFE modeling system estimates the extent to which manufacturers could respond to CAFE standards and other factors (e.g., technology costs, fuel prices, etc.) by adding technology beyond that represented by a market forecast contained in a model input file. In order to analyze the effects of different CAFE standards as required by Executive Order 12866 and OMB Circular A-4, DOT must develop a "baseline," an estimate what the world would look like in the *absence* of new CAFE standards as a basis for comparison. The market forecast provides the initial basis for developing that baseline, which may include additional technology estimated to be added in response to fuel prices and baseline standards.

The model then calculates the impacts of that additional technology, like fuel savings and monetized costs and benefits, all relative to the baseline scenario. When applying technology, the model follows an approach that attempts to minimize the "effective cost" of responding to CAFE standards and other factors. This approach helps DOT to consider the technological feasibility and economic practicability of different regulatory alternatives, providing a basis to select the maximum feasible standards applicable to each fleet in each model year.

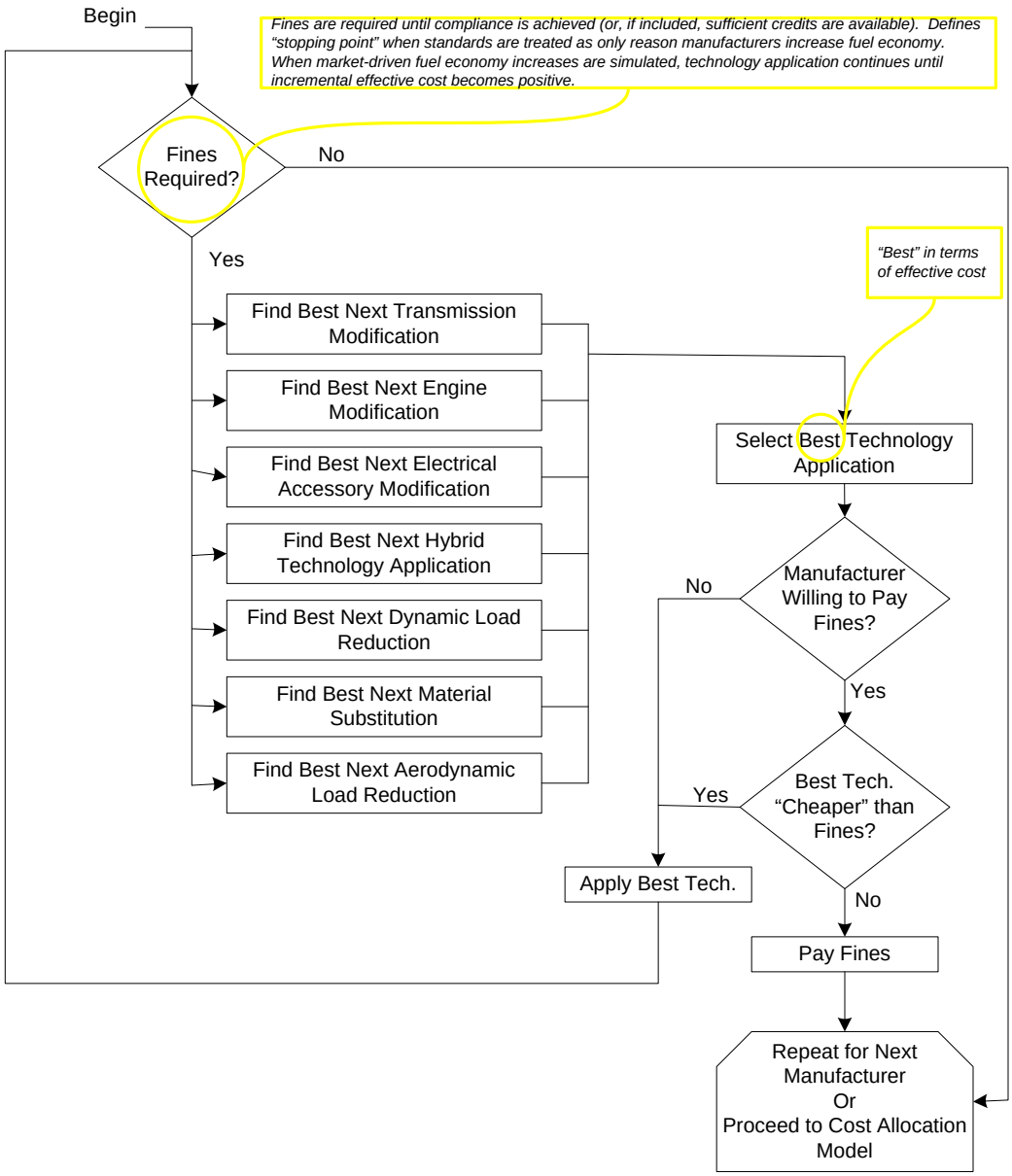
Hierarchy of Model Results

Model results build from (a) detailed results for each included vehicle model to (b) average and total results for each OEM's fleets of passenger cars and light trucks to (c) results for the aggregate fleet.



Overview of Compliance Simulation (Technology Application Algorithm)

The following flow chart provides an overview of the logic applied by the CAFE modeling system when used to estimate manufacturers' potential response to CAFE standards, assuming that manufacturers only increase fuel economy in response to CAFE standards. CAFE fines are used as a test to determine whether compliance has been achieved, and also as a basis for estimating when manufacturers with some history of paying fines might apply some very cost-effective technology, but stop short of achieving compliance with CAFE standards. In either case, multiyear planning (i.e., impacts on future model years) is considered. Though not shown below, the algorithm can also be used to estimate manufacturers' potential addition of technology beyond levels required for compliance, in which case technology is added as long as effective costs are negative, given inputs specifying the payback period to apply as representing the potential that market-driven fuel economy increases could occur.



Effective Cost

Effective Cost: The CAFE model uses "effective cost" ($COST_{eff}$) to select among available opportunities to introduce additional technology. Depending on inputs settings, the model also uses effective cost to determine when to stop adding technology (for OEMs assumed willing to pay fines, or OEMs that have already achieved compliance with CAFE standards). In effect, the model applies technology assuming the manufacturer acts as if the effective cost represents the revenue loss that would be entailed in pricing the vehicle to leave buyers "neutral" regarding the vehicles offered with the additional technology.

$$COST_{eff} = \sum_{i=BaseMY}^{i=PresentMY} \frac{0.77 \times \Delta TECHCOST_i + \Delta FINE_i - (VALUE_{FUEL})_i + WELFARELOSS_i}{(N_j)_i}$$

Multiyear planning evaluates range of model years affected when adding technology to a vehicle (typically at redesign).

Assumes manufacturer acts as if average first owner expects, when reselling, to recover 23% of additional cost.

Term representing value loss to buyer. Could be reduced range (pure EVs). Could be reversed sign for any additional value to buyer.

$$FINE = -k_F \sum_C \mathrm{MIN}(CREDIT_C, 0)$$

Fine calculated based on credit deficit in each regulatory class C.

$$CREDIT_C = N_C\left[\mathrm{STD}_C(\mathbf{N}_C, \mathbf{A}_C) - \mathrm{CAFE}_C(\mathbf{N}_C, \mathbf{FE}_C)\right]$$

Adding technology changes fuel economy of some set of vehicles in regulatory class C.

$$VALUE_{FUEL} = \sum_{i \in j}\left[N_i \times \sum_{FT}\left(\left(\sum_{v=0}^{v=PB} \frac{SURV_v \times MI_v \times VMTGROWTH_{MY+v} \times (PRICE_{FT})_{MY+v}}{(1-GAP_{FT}) \times (1+r)^V}\right) \times \left(\frac{(FS_{FT})_i}{(FE_{FT})_i} - \frac{(FS'_{FT})_i}{(FE'_{FT})_i}\right)\right)\right]$$

Assumes manufacturer acts as if can price based on buyer being "paid back" in within PB years.

Fuel prices for each fuel type.

Accounts for fuel economy and fuel share for each fuel (e.g., for FFVs).

Real-world fuel economy is lower than laboratory fuel economy.

Notation

COSTeff: effective cost
PresentMY: the current modeling year
BaseMY: first year of the potential application of the technology (can be less than or equal to *PresentMY*)
ΔTECHCOST: product of affected sales and the unit cost of the technology
$WELFARELOSS_i$: the loss of value to the consumer (negative for consumer benefit)
Nj: production of affected cohort of vehicles (*j*) for all years involved in the candidate technology application.
$SURV_v$: average probability that a vehicle of that vintage will remain in service
MI_v: average number of miles driven in a year at a given vintage *v*
$VMTGROWTH_{MY+v}$: growth factor to apply to the base miles driven in the current model year *MY* at the given vintage *v*
FT: fuel type the vehicle operates on (gasoline, diesel, or electricity)
$(FE_{FT})_i$ and $(FE'_{FT})_i$: vehicle's fuel economy for a specific fuel type prior to and after the pending application of technology
$(FS_{FT})_i$ and $(FS'_{FT})_i$: vehicle's assumed share of operating on a specific fuel type prior to and after the pending application of technology
GAP_{FT}: relative difference between on-road and laboratory fuel economy for a specific fuel type
N_i: sales volume for model *i* in the current model year *MY*
$(PRICE_{FT})_{MY+v}$: price of the specific fuel type in year *MY+v*
PB: "payback period", or number of years in the future the consumer is assumed to take into account when considering fuel savings.
FINE: change in total CAFE penalties (*i.e.*, accounting for all regulatory classes in the current CAFE scenario and model year)
k_F: fine rate s in dollars per mpg (*e.g.*, $55/mpg)
$\mathbf{A}_C$: vector containing the value of the relevant attribute for each vehicle model in regulatory class *C*
$CAFE_C$: the CAFE level for regulatory class *C* (*e.g.*, if the standard depends on curb weight, $\mathbf{A}_C$ contains each vehicle model's curb weight)
$\mathbf{FE}_C$: vector containing the fuel economy level of each vehicle model in regulatory class *C*, N_C is the total sales volume for regulatory class *C*
$\mathbf{N}_C$: vector containing the sales volume for each vehicle model in regulatory class *C*, and $STD_C(\mathbf{N}_C, \mathbf{A}_C)$: function defining the standard applicable to regulatory class *C*.