

Initial processing of Ricardo vehicle simulation modeling CO₂ data

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1. Introduction

The basic CO₂ data used in the development of the EU cost curves is derived from simulation modeling performed by Ricardo Inc.¹ The referenced report for the simulation modeling project should be consulted for detailed information on the Ricardo work. This paper is intended to summarize how the data developed by Ricardo was processed to provide the CO₂ estimates used as basic inputs in the development of the EU cost curves.

All of the basic CO₂ estimates used for cost curve development were derived from the Ricardo Data Visualization Tool (DVT), which is an interactive database that was produced as an integral component of the referenced simulation modeling work and which allows the user to estimate CO₂ emissions for a selected set of input parameters.² Interested readers should consult the referenced Ricardo simulation modeling report and DVT documentation for more detailed information. Basically the DVT produces CO₂ estimates given user selected definitions for the following parameters:

- Vehicle Class
- Vehicle Architecture³
- Engine Technology

- Transmission Technology
- Engine Displacement
- Final Drive Ratio (FDR)
- Rolling Resistance Characteristics
- Aerodynamic Drag Characteristics (C_d × Vehicle Frontal Area)
- Vehicle Test Weight
- Engine Efficiency
- Electric Drive Motor Size

The basic methodology used to generate CO₂ estimates for the EU cost curves consists of executing the DVT for four distinct modeling scenarios, one of which is used to develop adjustment factors and three of which are used to generate cost curve data points.

Nominal Scenario Unadjusted: The first scenario, denoted as the nominal scenario unadjusted (to distinguish it from a subsequent adjusted version of the scenario), provides a basis for correcting for minor differences between Ricardo's nominal simulation modeling runs and the corresponding estimates produced by the Ricardo DVT. It is important to understand that while the input parameters for the simulation and DVT nominal scenario unadjusted modeling are identical, the resulting estimates are not. This is because the DVT database represents a curve fitting exercise that is designed to generalize simulation modeling results in the aggregate. In effect, while the DVT is based on simulation modeling data points, DVT output is "predicted" using statistical relationships. Since the associated curve fits are not perfect, predicted estimates will deviate marginally from "observed" estimates for the same data point (as is the case with nearly all statistical relations).

1 Ricardo Inc., "Project Report, Analysis of Greenhouse Gas Emission Reduction Potential of Light Duty Vehicle Technologies in the European Union for 2020-2025," Project C000908, Archive RD.12/96201.2, April 13, 2012.

2 Ricardo Inc., "User Guide for Data Visualization Tool," Project C000908, Archive RD.11/478401.2, May 9, 2012.

3 Architecture refers to the basic design of the vehicle powertrain; in the case of the DVT signifying either an internal combustion engine (only) with start-stop capability, a P2 hybrid electric vehicle, or a power split hybrid electric vehicle.

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ABOUT THIS SERIES. The ICCT has compiled detailed data on the CO₂ reduction potential and associated costs of vehicle technologies for the European light-duty vehicle market (passenger cars and light-commercial vehicles). The analysis incorporates extensive vehicle simulation modeling as well as a detailed tear-down cost assessment. Papers in this series summarize the underlying methodology, input data, the results of the project.

The nominal simulation runs were based on modeling parameters developed and simulated by Ricardo and designated as nominal in their previously referenced project report. Input data to the DVT for the nominal scenario unadjusted are identical to those used for the nominal simulation modeling performed by Ricardo, as documented in that same project report, and reflect the “default” data encoded in the DVT. Based on DVT outputs for this baseline nominal scenario, a DVT *normalization factor* is calculated as the ratio of the simulation modeling nominal scenario estimates to the corresponding DVT nominal scenario unadjusted estimates. The DVT normalization factors are designed to allow the less precise DVT estimates to be adjusted to match the simulation modeling estimates exactly (for the nominal scenario input parameters).

Following the development of the DVT normalization factors, three specific scenarios are modeled using the DVT to generate cost curve data points. DVT estimates for each of these three scenarios are adjusted using the DVT normalization factors. As a result, each scenario is referred to as an *adjusted scenario*.

Adjusted Nominal Scenario: The first data point development scenario is denoted as the DVT adjusted nominal scenario. For ICE-only vehicles, the scenario modeling inputs are identical to those for the nominal scenario unadjusted, except that engine displacement is modified as required to maintain constant zero-to-sixty mile per hour (mph) times.⁴ Hybrid electric vehicles (both P2 and power split designs) are subjected to a five percent vehicle weight penalty as well as the same zero-to-sixty mph time displacement adjustments to which ICE-only vehicles are subject.⁵ All adjusted nominal scenario data are based on

4 As allowed by modeling bounds. The range over which engine displacement can be altered in the DVT is limited, so that there are some cases in which adjustments cannot be implemented to fully equilibrate zero-to-sixty mph times. For example, the lowest allowable DVT displacement is 0.675 liters. If zero-to-sixty mph time is still too low at 0.675 liters, then no further adjustment is made and the technology package is allowed to outperform the corresponding baseline technology package. Conversely, if engine displacement has been adjusted to the maximum allowed for a particular vehicle class and zero-to-sixty mph time is still too high, then no further adjustment is made and the technology package is allowed to underperform the corresponding baseline technology package. In the data tables that follow, the limited instances in which such constraints apply are easily identifiable through the tabulated zero-to-sixty mph time data.

5 The five percent weight penalty for hybrid vehicles is based on data developed by the U.S. Environmental Protection Agency the U.S. National Highway Traffic Safety Administration as documented in their “Draft Joint Technical Support Document: Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards,” EPA-420-D-11-901, November 2011.

While it is recognized that there is also a weight differential between petrol and diesel vehicles, cost curves are developed independently for such vehicles in this work. Both petrol and diesel vehicle curves include hybridized technology options, so the hybrid weight effect must be considered explicitly in each. Inherent petrol and diesel weight effects are accounted for implicitly during cost curve development as the curves developed for each are normalized for consistency with current EU petrol and diesel baselines. This normalization process is discussed in more detail in a subsequent paper that describes actual cost curve development.

the current road load parameters (i.e., rolling resistance characteristics, aerodynamic drag characteristics, and vehicle test weight) of each vehicle class – characteristics that are unchanged from those modeled for the nominal scenario unadjusted.

In making vehicle weight adjustments, both for the hybrid vehicles in the adjusted nominal scenario and the alternative road load scenarios that will be discussed below, vehicle test weight is distinguished from vehicle weight. Vehicle test weight includes a vehicle load offset designed to capture the added weight of a standard driver and a standard load. In the U.S., the standard offset is 136.08 kilograms (kg, 300 pounds). In the EU, the standard offset is 100 kg (220.5 pounds). While the cost curves are EU specific, the simulation modeling that underlies the DVT data can be based on either U.S. or EU test weights (depending on what data Ricardo used to validate their modeling). The specific test weight offsets used are as follows:

- U.S. Offset: B Class, C Class Golf, D Class, MPV, and Large N1 Class.
- EU Offset: C Class Focus and Small N1 Class.

In all cases, any vehicle weight adjustments are implemented as follows:

Modeling Weight = ((Unadjusted Weight - Offset) × Adjustment Factor) + Offset

As a result, the net fractional *test weight* changes can (and do) vary marginally from associated fractional *vehicle weight* changes. For example, a vehicle with a 1350 kg test weight and an EU offset subject to a 15 percent vehicle weight reduction would be modeled with a revised test weight of:

$$((1350 - 100) \times 0.85) + 100 = 1162.5 \text{ kg}$$

so that a 15 percent vehicle weight change results (in this case) in a 13.9 percent test weight change (1162.5/1350 - 1). All modeled weight changes are implemented accordingly.

Adjusted Road Load Scenarios: The final two data point scenarios are designed to model the effects of changes in vehicle road load. The scenario denoted as the adjusted 15/10/10 scenario is based on a 15 percent reduction in vehicle weight and a 10 percent reduction in both rolling resistance and aerodynamic drag characteristics. The scenario denoted as the 30/20/20 scenario is based on a 30 percent reduction in vehicle weight and a 20 percent reduction in both rolling resistance and aerodynamic drag characteristics. As with the adjusted nominal scenario, engine displacement data are adjusted as necessary to maintain constant zero-to-sixty mph times and hybrid electric vehicles are subject to a five percent base weight penalty (so that the implemented weight reductions are taken from a higher baseline

weight). Since the DVT does not allow baseline data to be altered, there are no alternative road load estimates for the baseline technology configurations.

Section 2 presents the DVT nominal scenario unadjusted estimates that are used to develop the DVT normalization factors presented in Section 3. Section 4 presents the DVT adjusted nominal scenario estimates, while Sections 5 and 6 present the DVT adjusted 15/10/10 and DVT adjusted 30/20/20 scenario estimates respectively.

2. DVT Nominal Scenario Estimates Unadjusted

As discussed in Section 1, the DVT allows for CO₂ estimation for the same nominal scenario for which precise simulation modeling results are presented in the Ricardo simulation modeling report. Tables 1 through 7 present the nominal scenario unadjusted estimates produced by the DVT.⁶ Differences between the presented estimates and those developed by the precise simulation modeling are presented in Section 3

that follows on DVT normalization factors.

Note that Ricardo performed *baseline* (nominal) simulation modeling for two C class vehicles, one based on the Volkswagen Golf and a second based on the Ford Focus. However, future nominal technology simulations were performed only for the Golf, so all DVT future technology relationships for the C class are based entirely on the Golf data. To model future technology impacts for the C class Focus, the baseline Focus simulation modeling data are combined with C class future technology estimates from the DVT developed using Focus-specific input parameters. As such, there are no specific unadjusted nominal scenario data for the C class Focus. Moreover, since the range of C class parameters that can be modeled using the DVT are based on set ranges developed around the nominal Golf data, the range available for alternative Focus-based modeling is somewhat more restricted than is the case for other modeled vehicles (since developing the adjusted nominal Focus-based data already “consumes” some of the available C class modeling range).

Table 1. B Class Vehicle: DVT Nominal Scenario Estimates Unadjusted⁷

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	44.0	128	9.9	1.5	4.0	0.0094	0.736	1191	0
ICE SS	PSTDI	2020 6AT	55.6	102	9.9	0.7	4.0	0.0094	0.736	1191	0
ICE SS	PSTDI	2020 6DDCT	56.9	99	9.4	0.7	4.0	0.0094	0.736	1191	0
ICE SS	PLBTDI	2020 6AT	56.9	99	9.9	0.7	4.0	0.0094	0.736	1191	0
ICE SS	PLBTDI	2020 6DDCT	58.3	97	9.4	0.7	4.0	0.0094	0.736	1191	0
ICE SS	PEGRTDI	2020 6AT	57.9	97	9.9	0.7	4.0	0.0094	0.736	1191	0
ICE SS	PEGRTDI	2020 6DDCT	59.3	95	9.4	0.7	4.0	0.0094	0.736	1191	0
ICE SS	Diesel Baseline	2010 6AT	57.9	108	12.2	1.2	3.5	0.0094	0.736	1191	0
ICE SS	2020 Diesel	2020 6AT	64.9	97	10.0	1.1	4.0	0.0094	0.736	1191	0
ICE SS	2020 Diesel	2020 6DDCT	64.8	97	10.1	1.1	4.0	0.0094	0.736	1191	0
P2 HEV	Atkinson CPS	2020 6DDCT	63.2	89	10.1	1.7	4.0	0.0094	0.736	1191	14
P2 HEV	Atkinson DVA	2020 6DDCT	64.6	87	10.1	1.7	4.0	0.0094	0.736	1191	14
PS HEV	Atkinson CPS	Power Split	62.9	90	10.4	1.7	4.0	0.0094	0.736	1191	40
PS HEV	Atkinson DVA	Power Split	66.1	85	10.4	1.7	4.0	0.0094	0.736	1191	40

⁶ The term “unadjusted” is used here simply to distinguish the presented nominal scenario data from a subsequent adjusted nominal scenario. See Section 1 for additional descriptive information on the scenario.

⁷ All of the tables presented in this paper include a number of acronyms and abbreviations, each of which are defined in Section 7.

Table 2. C Class Golf: DVT Nominal Scenario Estimates Unadjusted

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	34.3	165	10.0	2.0	3.7	0.0083	0.65	1474	0
ICE SS	PSTDI	2020 8AT	51.5	110	10.0	0.8	3.7	0.0083	0.65	1474	0
ICE SS	PSTDI	2020 8DDCT	52.9	107	10.2	0.8	3.7	0.0083	0.65	1474	0
ICE SS	PLBTDI	2020 8AT	52.8	107	10.0	0.8	3.7	0.0083	0.65	1474	0
ICE SS	PLBTDI	2020 8DDCT	54.0	105	10.2	0.8	3.7	0.0083	0.65	1474	0
ICE SS	PEGRTDI	2020 8AT	54.0	105	10.0	0.8	3.7	0.0083	0.65	1474	0
ICE SS	PEGRTDI	2020 8DDCT	55.1	102	10.2	0.8	3.7	0.0083	0.65	1474	0
ICE SS	Diesel Baseline	2010 6AT	50.5	124	10.0	1.6	3.4	0.0083	0.65	1474	0
ICE SS	2020 Diesel	2020 8AT	60.2	104	10.1	1.3	3.7	0.0083	0.65	1474	0
ICE SS	2020 Diesel	2020 8DDCT	60.5	104	10.2	1.3	3.7	0.0083	0.65	1474	0
P2 HEV	Atkinson CPS	2020 8DDCT	60.7	93	10.2	1.7	3.7	0.0083	0.65	1474	20
P2 HEV	Atkinson DVA	2020 8DDCT	62.1	91	10.2	1.7	3.7	0.0083	0.65	1474	20
PS HEV	Atkinson CPS	Power Split	58.9	96	9.6	1.7	3.7	0.0083	0.65	1474	40
PS HEV	Atkinson DVA	Power Split	62.1	91	9.5	1.7	3.7	0.0083	0.65	1474	40

Table 3. C Class Focus: DVT Nominal Scenario Estimates Unadjusted

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT									
ICE SS	PSTDI	2020 8DDCT									
ICE SS	PLBTDI	2020 8AT									
ICE SS	PLBTDI	2020 8DDCT									
ICE SS	PEGRTDI	2020 8AT									
ICE SS	PEGRTDI	2020 8DDCT									
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT									
ICE SS	2020 Diesel	2020 8DDCT									
P2 HEV	Atkinson CPS	2020 8DDCT									
P2 HEV	Atkinson DVA	2020 8DDCT									
PS HEV	Atkinson CPS	Power Split									
PS HEV	Atkinson DVA	Power Split									

There are no nominal data for the C class Focus in the DVT

Table 4. D Class Vehicle: DVT Nominal Scenario Estimates Unadjusted

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	34.0	166	8.3	2.4	3.2	0.00822	0.69	1644	0
ICE SS	PSTDI	2020 8AT	48.7	116	8.5	1.0	3.2	0.00822	0.69	1644	0
ICE SS	PSTDI	2020 8DDCT	49.9	113	8.6	1.0	3.2	0.00822	0.69	1644	0
ICE SS	PLBTDI	2020 8AT	50.3	112	8.5	1.0	3.2	0.00822	0.69	1644	0
ICE SS	PLBTDI	2020 8DDCT	51.6	109	8.6	1.0	3.2	0.00822	0.69	1644	0
ICE SS	PEGRTDI	2020 8AT	50.7	111	8.5	1.0	3.2	0.00822	0.69	1644	0
ICE SS	PEGRTDI	2020 8DDCT	51.7	109	8.6	1.0	3.2	0.00822	0.69	1644	0
ICE SS	Diesel Baseline	2010 6AT	47.3	133	7.6	2.0	3.3	0.00822	0.69	1644	0
ICE SS	2020 Diesel	2020 8AT	54.0	116	8.3	1.7	3.2	0.00822	0.69	1644	0
ICE SS	2020 Diesel	2020 8DDCT	54.0	116	8.3	1.7	3.2	0.00822	0.69	1644	0
P2 HEV	Atkinson CPS	2020 8DDCT	61.1	92	8.6	2.4	3.2	0.00822	0.69	1644	24
P2 HEV	Atkinson DVA	2020 8DDCT	62.3	91	8.6	2.4	3.2	0.00822	0.69	1644	24
PS HEV	Atkinson CPS	Power Split	55.8	101	8.5	2.4	3.2	0.00822	0.69	1644	80
PS HEV	Atkinson DVA	Power Split	57.5	98	8.5	2.4	3.2	0.00822	0.69	1644	80

Table 5. MPV: DVT Nominal Scenario Estimates Unadjusted

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	30.3	186	9.0	2.4	3.5	0.00691	0.925	1814	0
ICE SS	PSTDI	2020 8AT	41.0	138	8.9	1.1	3.5	0.00691	0.925	1814	0
ICE SS	PSTDI	2020 8DDCT	41.9	135	8.8	1.1	3.5	0.00691	0.925	1814	0
ICE SS	PLBTDI	2020 8AT	42.1	134	8.9	1.1	3.5	0.00691	0.925	1814	0
ICE SS	PLBTDI	2020 8DDCT	43.1	131	8.8	1.1	3.5	0.00691	0.925	1814	0
ICE SS	PEGRTDI	2020 8AT	42.8	132	8.9	1.1	3.5	0.00691	0.925	1814	0
ICE SS	PEGRTDI	2020 8DDCT	43.7	129	8.8	1.1	3.5	0.00691	0.925	1814	0
ICE SS	Diesel Baseline	2010 6AT	41.2	152	8.1	2.2	3.7	0.00691	0.925	1814	0
ICE SS	2020 Diesel	2020 8AT	46.1	136	9.0	1.8	3.5	0.00691	0.925	1814	0
ICE SS	2020 Diesel	2020 8DDCT	46.5	135	9.1	1.8	3.5	0.00691	0.925	1814	0
P2 HEV	Atkinson CPS	2020 8DDCT	48.2	117	9.5	2.6	3.5	0.00691	0.925	1814	20
P2 HEV	Atkinson DVA	2020 8DDCT	49.3	115	9.5	2.6	3.5	0.00691	0.925	1814	20
PS HEV	Atkinson CPS	Power Split	41.9	135	9.5	2.6	3.5	0.00691	0.925	1814	70
PS HEV	Atkinson DVA	Power Split	47.3	119	9.5	2.6	3.5	0.00691	0.925	1814	70

Table 6. Small N1 Class Vehicle: DVT Nominal Scenario Estimates Unadjusted

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	31.1	182	10.2	2.0	3.1	0.0083	1.04	1644	0
ICE SS	PSTDI	2020 8AT	39.6	143	10.2	0.9	3.4	0.0083	1.04	1644	0
ICE SS	PSTDI	2020 8DDCT	40.5	139	10.3	0.9	3.4	0.0083	1.04	1644	0
ICE SS	PLBTDI	2020 8AT	40.7	139	10.2	0.9	3.4	0.0083	1.04	1644	0
ICE SS	PLBTDI	2020 8DDCT	41.9	135	10.3	0.9	3.4	0.0083	1.04	1644	0
ICE SS	PEGRTDI	2020 8AT	41.5	136	10.2	0.9	3.4	0.0083	1.04	1644	0
ICE SS	PEGRTDI	2020 8DDCT	42.5	133	10.4	0.9	3.4	0.0083	1.04	1644	0
ICE SS	Diesel Baseline	2010 6AT	43.0	146	13.7	1.8	3.6	0.0083	1.04	1644	0
ICE SS	2020 Diesel	2020 8AT	50.0	126	13.8	1.1	3.4	0.0083	1.04	1644	0
ICE SS	2020 Diesel	2020 8DDCT	50.6	124	13.6	1.1	3.4	0.0083	1.04	1644	0
P2 HEV	Atkinson CPS	2020 8DDCT	47.8	118	9.8	2.1	3.4	0.0083	1.04	1644	22
P2 HEV	Atkinson DVA	2020 8DDCT	49.4	114	9.8	2.1	3.4	0.0083	1.04	1644	22
PS HEV	Atkinson CPS	Power Split	45.9	123	9.6	2.1	3.4	0.0083	1.04	1644	85
PS HEV	Atkinson DVA	Power Split	48.1	117	9.6	2.1	3.4	0.0083	1.04	1644	85

Table 7. Large N1 Class Vehicle: DVT Nominal Scenario Estimates Unadjusted

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	24.5	230	8.6	3.8	3.2	0.00721	0.952	2041	0
ICE SS	PSTDI	2020 8AT	37.0	153	8.6	1.3	3.2	0.00721	0.952	2041	0
ICE SS	PSTDI	2020 8WDCT	38.0	149	8.9	1.3	3.2	0.00721	0.952	2041	0
ICE SS	PLBTDI	2020 8AT	37.9	149	8.6	1.3	3.2	0.00721	0.952	2041	0
ICE SS	PLBTDI	2020 8WDCT	39.0	145	8.9	1.3	3.2	0.00721	0.952	2041	0
ICE SS	PEGRTDI	2020 8AT	38.7	146	8.6	1.3	3.2	0.00721	0.952	2041	0
ICE SS	PEGRTDI	2020 8WDCT	39.8	142	8.9	1.3	3.2	0.00721	0.952	2041	0
ICE SS	Diesel Baseline	2010 6AT	37.8	166	10.3	2.2	3.7	0.00721	0.952	2041	0
ICE SS	2020 Diesel	2020 8AT	42.8	147	8.7	2.0	3.2	0.00721	0.952	2041	0
ICE SS	2020 Diesel	2020 8WDCT	42.7	147	8.6	2.0	3.2	0.00721	0.952	2041	0
P2 HEV	Atkinson CPS	2020 8WDCT	44.1	128	8.9	3.2	3.2	0.00721	0.952	2041	25
P2 HEV	Atkinson DVA	2020 8WDCT	45.1	125	8.9	3.2	3.2	0.00721	0.952	2041	25
PS HEV	Atkinson CPS	Power Split	40.4	140	8.8	3.2	3.2	0.00721	0.952	2041	90
PS HEV	Atkinson DVA	Power Split	42.2	134	8.8	3.2	3.2	0.00721	0.952	2041	90

3. DVT Normalization Factors (Comparison of DVT to Nominal Simulation Results)

Although, as discussed in Section 1, the DVT allows for CO₂ estimation for the same nominal scenarios for which precise simulation modeling results are presented in the Ricardo simulation modeling report, the estimates differ marginally from those produced by the simulation modeling. To avoid confusion between DVT output and published Ricardo estimates for a given nominal modeling scenario, a normalization routine was developed wherein all DVT estimates are adjusted by a normalization factor, defined as the ratio of nominal scenario simulation

modeling results to DVT estimates for those same nominal scenarios. Normalization factors are developed for each combination of vehicle class, vehicle architecture, engine technology, and transmission technology. Tables 8 through 14 present the developed normalization factors.

As discussed in Section 2, there are no specific nominal scenario DVT data for the C class Focus, and therefore no distinct normalization factors for the vehicle. Since all Focus-based modeling is performed using the Golf-derived C class relations, the Golf-based normalization factors are used without change for both Golf-based and Focus-based C class modeling.

Table 8. B Class Vehicle: DVT Normalization Factors

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph	Disp	FDR	RR	AD	Weight	EM Size
ICE SS	Petrol Baseline	2010 6AT	1.00026	0.99974	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PSTDI	2020 6AT	0.95624	1.04576	1.00569	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PSTDI	2020 6DDCT	0.95762	1.04425	1.00590	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PLBTDI	2020 6AT	0.96848	1.03255	1.00570	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PLBTDI	2020 6DDCT	0.97216	1.02864	1.00590	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PEGRTDI	2020 6AT	0.95506	1.04706	1.00569	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PEGRTDI	2020 6DDCT	0.95584	1.04620	1.00660	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	Diesel Baseline	2010 6AT	1.00040	0.99960	1.00141	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	2020 Diesel	2020 6AT	0.99766	1.00234	0.99932	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	2020 Diesel	2020 6DDCT	1.02740	0.97334	0.98449	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
P2 HEV	Atkinson CPS	2020 6DDCT	0.99146	1.00862	0.99332	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
P2 HEV	Atkinson DVA	2020 6DDCT	0.99346	1.00658	0.99311	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
PS HEV	Atkinson CPS	Power Split	1.01910	0.98126	0.94670	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
PS HEV	Atkinson DVA	Power Split	1.00694	0.99311	0.94541	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

Table 9. C Class Golf: DVT Normalization Factors

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph	Disp	FDR	RR	AD	Weight	EM Size
ICE SS	Petrol Baseline	2010 6AT	1.00041	0.99959	0.99700	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PSTDI	2020 8AT	0.97169	1.02913	0.99988	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	PSTDI	2020 8DDCT	0.97023	1.03068	1.00189	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	PLBTDI	2020 8AT	0.98247	1.01785	1.00041	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	PLBTDI	2020 8DDCT	0.98176	1.01858	1.00241	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	PEGRTDI	2020 8AT	0.97238	1.02841	1.00050	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	PEGRTDI	2020 8DDCT	0.97334	1.02739	1.00037	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	Diesel Baseline	2010 6AT	0.99960	1.00040	0.99700	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	2020 Diesel	2020 8AT	1.00827	0.99180	0.99557	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	2020 Diesel	2020 8DDCT	1.01700	0.98328	0.98406	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
P2 HEV	Atkinson CPS	2020 8DDCT	1.03889	0.96257	1.00930	0.99713	0.99729	1.00000	1.00000	1.00000	1.00000
P2 HEV	Atkinson DVA	2020 8DDCT	1.02828	0.97250	1.00964	0.99713	0.99729	1.00000	1.00000	1.00000	1.00000
PS HEV	Atkinson CPS	Power Split	0.99520	1.00482	1.00342	0.99713	0.99729	1.00000	1.00000	1.00000	1.00000
PS HEV	Atkinson DVA	Power Split	1.00242	0.99758	1.00622	0.99713	0.99729	1.00000	1.00000	1.00000	1.00000

Table 10. C Class Focus: DVT Normalization Factors

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph	Disp	FDR	RR	AD	Weight	EM Size
ICE SS	Petrol Baseline	2010 6AT	1.00041	0.99959	0.99700	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PSTDI	2020 8AT	0.97169	1.02913	0.99988	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	PSTDI	2020 8DDCT	0.97023	1.03068	1.00189	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	PLBTDI	2020 8AT	0.98247	1.01785	1.00041	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	PLBTDI	2020 8DDCT	0.98176	1.01858	1.00241	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	PEGRTDI	2020 8AT	0.97238	1.02841	1.00050	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	PEGRTDI	2020 8DDCT	0.97334	1.02739	1.00037	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	Diesel Baseline	2010 6AT	0.99960	1.00040	0.99700	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	2020 Diesel	2020 8AT	1.00827	0.99180	0.99557	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
ICE SS	2020 Diesel	2020 8DDCT	1.01700	0.98328	0.98406	1.00000	0.99729	1.00000	1.00000	1.00000	1.00000
P2 HEV	Atkinson CPS	2020 8DDCT	1.03889	0.96257	1.00930	0.99713	0.99729	1.00000	1.00000	1.00000	1.00000
P2 HEV	Atkinson DVA	2020 8DDCT	1.02828	0.97250	1.00964	0.99713	0.99729	1.00000	1.00000	1.00000	1.00000
PS HEV	Atkinson CPS	Power Split	0.99520	1.00482	1.00342	0.99713	0.99729	1.00000	1.00000	1.00000	1.00000
PS HEV	Atkinson DVA	Power Split	1.00242	0.99758	1.00622	0.99713	0.99729	1.00000	1.00000	1.00000	1.00000

Table 11. D Class Vehicle: DVT Normalization Factors

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph	Disp	FDR	RR	AD	Weight	EM Size
ICE SS	Petrol Baseline	2010 6AT	1.00118	0.99882	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PSTDI	2020 8AT	0.96922	1.03176	0.99915	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PSTDI	2020 8DDCT	0.96789	1.03317	1.00101	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PLBTDI	2020 8AT	0.98186	1.01848	0.99914	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PLBTDI	2020 8DDCT	0.98290	1.01739	1.00098	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PEGRTDI	2020 8AT	0.96044	1.04119	0.99908	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PEGRTDI	2020 8DDCT	0.96754	1.03355	1.00096	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	Diesel Baseline	2010 6AT	1.00071	0.99929	1.00355	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	2020 Diesel	2020 8AT	0.99935	1.00065	0.99979	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	2020 Diesel	2020 8DDCT	1.00589	0.99415	0.99505	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
P2 HEV	Atkinson CPS	2020 8DDCT	1.00729	0.99276	0.99725	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
P2 HEV	Atkinson DVA	2020 8DDCT	1.00615	0.99389	0.99793	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
PS HEV	Atkinson CPS	Power Split	0.99362	1.00642	0.93593	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
PS HEV	Atkinson DVA	Power Split	1.00275	0.99726	0.93626	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

Table 12. MPV: DVT Normalization Factors

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph	Disp	FDR	RR	AD	Weight	EM Size
ICE SS	Petrol Baseline	2010 6AT	0.99924	1.00076	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PSTDI	2020 8AT	0.96538	1.03587	0.99645	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PSTDI	2020 8DDCT	0.96923	1.03174	0.99622	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PLBTDI	2020 8AT	0.97782	1.02268	0.99644	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PLBTDI	2020 8DDCT	0.97301	1.02774	0.99623	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PEGRTDI	2020 8AT	0.95962	1.04208	0.99645	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PEGRTDI	2020 8DDCT	0.96229	1.03918	0.99650	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	Diesel Baseline	2010 6AT	1.00002	0.99998	0.99514	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	2020 Diesel	2020 8AT	1.00824	0.99182	1.00857	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	2020 Diesel	2020 8DDCT	1.00693	0.99311	1.00443	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
P2 HEV	Atkinson CPS	2020 8DDCT	1.03540	0.96581	0.97805	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
P2 HEV	Atkinson DVA	2020 8DDCT	1.03365	0.96744	0.97843	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
PS HEV	Atkinson CPS	Power Split	1.01430	0.98590	0.95715	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
PS HEV	Atkinson DVA	Power Split	1.02238	0.97811	0.95810	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

Table 13. Small N1 Class Vehicle: DVT Normalization Factors

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph	Disp	FDR	RR	AD	Weight	EM Size
ICE SS	Petrol Baseline	2010 6AT	1.00096	0.99904	1.00196	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
ICE SS	PSTDI	2020 8AT	1.00567	0.99436	0.99696	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
ICE SS	PSTDI	2020 8DDCT	1.00352	0.99649	1.00653	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
ICE SS	PLBTDI	2020 8AT	1.00666	0.99338	0.99651	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
ICE SS	PLBTDI	2020 8DDCT	1.00027	0.99973	1.00659	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
ICE SS	PEGRTDI	2020 8AT	1.00559	0.99445	0.99654	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
ICE SS	PEGRTDI	2020 8DDCT	1.00355	0.99646	1.00378	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
ICE SS	Diesel Baseline	2010 6AT	0.99930	1.00070	0.99708	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
ICE SS	2020 Diesel	2020 8AT	1.00323	0.99678	0.99732	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
ICE SS	2020 Diesel	2020 8DDCT	1.00733	0.99273	0.99943	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
P2 HEV	Atkinson CPS	2020 8DDCT	1.02114	0.97930	1.00536	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
P2 HEV	Atkinson DVA	2020 8DDCT	1.04073	0.96087	1.00639	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
PS HEV	Atkinson CPS	Power Split	1.00741	0.99265	1.00285	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000
PS HEV	Atkinson DVA	Power Split	1.00552	0.99451	1.00346	1.00000	1.00000	1.00000	1.00000	1.00017	1.00000

Table 14. Large N1 Class Vehicle: DVT Normalization Factors

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph	Disp	FDR	RR	AD	Weight	EM Size
ICE SS	Petrol Baseline	2010 6AT	0.99947	1.00053	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PSTDI	2020 8AT	0.96864	1.03238	0.99759	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PSTDI	2020 8WDCT	0.96052	1.04111	0.99868	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PLBTDI	2020 8AT	0.98417	1.01609	0.99752	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PLBTDI	2020 8WDCT	0.97916	1.02128	0.99864	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PEGRTDI	2020 8AT	0.96560	1.03563	0.99743	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	PEGRTDI	2020 8WDCT	0.96296	1.03847	0.99875	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	Diesel Baseline	2010 6AT	0.99935	1.00065	1.00466	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	2020 Diesel	2020 8AT	0.99395	1.00609	0.99181	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
ICE SS	2020 Diesel	2020 8WDCT	1.00569	0.99434	1.01755	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
P2 HEV	Atkinson CPS	2020 8WDCT	1.04019	0.96136	0.99310	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
P2 HEV	Atkinson DVA	2020 8WDCT	1.04148	0.96017	0.99283	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
PS HEV	Atkinson CPS	Power Split	1.00308	0.99693	1.00049	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
PS HEV	Atkinson DVA	Power Split	1.00204	0.99797	1.00074	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

4. DVT Adjusted Nominal Scenario Estimates

All cost curve data points are based on adjusted DVT estimates. The most fundamental adjustment consists of multiplying unadjusted DVT estimates by the corresponding DVT normalization factors, as presented in Section 3 above, in an effort to “standardize” DVT output with associated simulation modeling results. Since the adjusted nominal scenario estimates are designed to predict CO₂ impacts using current road load parameters (i.e., rolling

resistance characteristics, aerodynamic drag characteristics, and vehicle test weight), initial DVT modeling inputs are set at values identical to the unadjusted nominal scenario discussed above in Section 2. The primary exception is that engine displacement is varied as required to maintain constant zero-to-sixty mph times. Hybrid electric vehicles (both P2 and power split designs) are also subjected to a five percent vehicle weight penalty as discussed in more detail in Section 1 above. Tables 15 through 21 present the developed adjusted nominal scenario estimates.

Table 15. B Class Vehicle: DVT Adjusted Nominal Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	44.0	128	9.9	1.5	4.0	0.0094	0.736	1191	0
ICE SS	PSTDI	2020 6AT	53.1	106	9.9	0.8	4.0	0.0094	0.736	1191	0
ICE SS	PSTDI	2020 6DDCT	54.6	103	9.9	0.7	4.0	0.0094	0.736	1191	0
ICE SS	PLBTDI	2020 6AT	55.1	102	9.9	0.8	4.0	0.0094	0.736	1191	0
ICE SS	PLBTDI	2020 6DDCT	56.6	100	9.9	0.7	4.0	0.0094	0.736	1191	0
ICE SS	PEGRTDI	2020 6AT	55.3	102	9.9	0.8	4.0	0.0094	0.736	1191	0
ICE SS	PEGRTDI	2020 6DDCT	56.9	99	9.9	0.7	4.0	0.0094	0.736	1191	0
ICE SS	Diesel Baseline	2010 6AT	57.9	108	12.2	1.2	3.5	0.0094	0.736	1191	0
ICE SS	2020 Diesel	2020 6AT	64.6	97	9.9	1.1	4.0	0.0094	0.736	1191	0
ICE SS	2020 Diesel	2020 6DDCT	66.6	94	9.9	1.1	4.0	0.0094	0.736	1191	0
P2 HEV	Atkinson CPS	2020 6DDCT	61.6	92	9.9	1.8	4.0	0.0094	0.736	1238	14
P2 HEV	Atkinson DVA	2020 6DDCT	62.9	90	9.9	1.8	4.0	0.0094	0.736	1238	14
PS HEV	Atkinson CPS	Power Split	62.2	91	9.9	1.8	4.0	0.0094	0.736	1238	40
PS HEV	Atkinson DVA	Power Split	65.0	87	9.9	1.8	4.0	0.0094	0.736	1238	40

Table 16. C Class Golf: DVT Adjusted Nominal Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	34.3	165	10.0	2.0	3.7	0.0083	0.65	1474	0
ICE SS	PSTDI	2020 8AT	50.1	113	10.0	0.8	3.7	0.0083	0.65	1474	0
ICE SS	PSTDI	2020 8DDCT	51.3	110	10.0	0.8	3.7	0.0083	0.65	1474	0
ICE SS	PLBTDI	2020 8AT	51.9	109	10.0	0.8	3.7	0.0083	0.65	1474	0
ICE SS	PLBTDI	2020 8DDCT	53.1	106	10.0	0.8	3.7	0.0083	0.65	1474	0
ICE SS	PEGRTDI	2020 8AT	52.5	108	10.0	0.8	3.7	0.0083	0.65	1474	0
ICE SS	PEGRTDI	2020 8DDCT	53.7	105	10.0	0.8	3.7	0.0083	0.65	1474	0
ICE SS	Diesel Baseline	2010 6AT	50.5	124	10.0	1.6	3.4	0.0083	0.65	1474	0
ICE SS	2020 Diesel	2020 8AT	60.5	104	9.9	1.3	3.7	0.0083	0.65	1474	0
ICE SS	2020 Diesel	2020 8DDCT	61.5	102	9.9	1.3	3.7	0.0083	0.65	1474	0
P2 HEV	Atkinson CPS	2020 8DDCT	60.7	93	10.0	1.9	3.7	0.0083	0.65	1548	20
P2 HEV	Atkinson DVA	2020 8DDCT	61.5	92	10.0	1.9	3.7	0.0083	0.65	1548	20
PS HEV	Atkinson CPS	Power Split	57.3	99	9.9	1.8	3.7	0.0083	0.65	1548	40
PS HEV	Atkinson DVA	Power Split	60.9	93	9.9	1.8	3.7	0.0083	0.65	1548	40

Table 17. C Class Focus: DVT Adjusted Nominal Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	40.7	139	9.1	1.6	3.8	0.0079	0.65	1312	0
ICE SS	PSTDI	2020 8AT	54.1	104	9.1	0.8	3.8	0.0079	0.65	1312	0
ICE SS	PSTDI	2020 8DDCT	55.3	102	9.1	0.8	3.8	0.0079	0.65	1312	0
ICE SS	PLBTDI	2020 8AT	56.2	101	9.1	0.8	3.8	0.0079	0.65	1312	0
ICE SS	PLBTDI	2020 8DDCT	57.5	98	9.1	0.8	3.8	0.0079	0.65	1312	0
ICE SS	PEGRTDI	2020 8AT	56.6	100	9.1	0.8	3.8	0.0079	0.65	1312	0
ICE SS	PEGRTDI	2020 8DDCT	57.9	98	9.1	0.8	3.8	0.0079	0.65	1312	0
ICE SS	Diesel Baseline	2010 6AT	51.6	122		1.6	3.8	0.0079	0.65	1312	0
ICE SS	2020 Diesel	2020 8AT	64.4	97	9.0	1.3	3.8	0.0079	0.65	1312	0
ICE SS	2020 Diesel	2020 8DDCT	65.5	96	9.1	1.3	3.8	0.0079	0.65	1312	0
P2 HEV	Atkinson CPS	2020 8DDCT	64.9	87	9.1	1.9	3.8	0.0079	0.65	1386	20
P2 HEV	Atkinson DVA	2020 8DDCT	65.6	86	9.1	1.9	3.8	0.0079	0.65	1386	20
PS HEV	Atkinson CPS	Power Split	60.3	94	9.0	1.7	3.8	0.0079	0.65	1386	40
PS HEV	Atkinson DVA	Power Split	64.4	88	9.0	1.7	3.8	0.0079	0.65	1386	40

Table 18. D Class Vehicle: Adjusted Nominal Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	34.0	166	8.3	2.4	3.2	0.00822	0.69	1644	0
ICE SS	PSTDI	2020 8AT	47.2	120	8.3	1.1	3.2	0.00822	0.69	1644	0
ICE SS	PSTDI	2020 8DDCT	48.3	117	8.3	1.1	3.2	0.00822	0.69	1644	0
ICE SS	PLBTDI	2020 8AT	49.5	114	8.3	1.1	3.2	0.00822	0.69	1644	0
ICE SS	PLBTDI	2020 8DDCT	50.8	111	8.3	1.1	3.2	0.00822	0.69	1644	0
ICE SS	PEGRTDI	2020 8AT	48.7	116	8.3	1.1	3.2	0.00822	0.69	1644	0
ICE SS	PEGRTDI	2020 8DDCT	50.0	113	8.3	1.1	3.2	0.00822	0.69	1644	0
ICE SS	Diesel Baseline	2010 6AT	47.3	133	7.6	2.0	3.3	0.00822	0.69	1644	0
ICE SS	2020 Diesel	2020 8AT	54.0	116	8.3	1.7	3.2	0.00822	0.69	1644	0
ICE SS	2020 Diesel	2020 8DDCT	54.2	116	8.2	1.7	3.2	0.00822	0.69	1644	0
P2 HEV	Atkinson CPS	2020 8DDCT	59.4	95	8.2	2.7	3.2	0.00822	0.69	1726	24
P2 HEV	Atkinson DVA	2020 8DDCT	59.9	94	8.2	2.7	3.2	0.00822	0.69	1726	24
PS HEV	Atkinson CPS	Power Split	54.6	103	8.3	2.4	3.2	0.00822	0.69	1726	80
PS HEV	Atkinson DVA	Power Split	56.8	99	8.3	2.4	3.2	0.00822	0.69	1726	80

Table 19. MPV: DVT Adjusted Nominal Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	30.3	186	9.0	2.4	3.5	0.00691	0.925	1814	0
ICE SS	PSTDI	2020 8AT	39.6	143	9.0	1.1	3.5	0.00691	0.925	1814	0
ICE SS	PSTDI	2020 8DDCT	40.6	139	9.0	1.1	3.5	0.00691	0.925	1814	0
ICE SS	PLBTDI	2020 8AT	41.1	137	9.0	1.1	3.5	0.00691	0.925	1814	0
ICE SS	PLBTDI	2020 8DDCT	41.8	135	9.0	1.1	3.5	0.00691	0.925	1814	0
ICE SS	PEGRTDI	2020 8AT	41.0	138	9.0	1.1	3.5	0.00691	0.925	1814	0
ICE SS	PEGRTDI	2020 8DDCT	42.1	134	9.0	1.1	3.5	0.00691	0.925	1814	0
ICE SS	Diesel Baseline	2010 6AT	41.2	152	8.1	2.2	3.7	0.00691	0.925	1814	0
ICE SS	2020 Diesel	2020 8AT	46.4	135	9.0	1.8	3.5	0.00691	0.925	1814	0
ICE SS	2020 Diesel	2020 8DDCT	46.8	134	9.0	1.8	3.5	0.00691	0.925	1814	0
P2 HEV	Atkinson CPS	2020 8DDCT	47.7	118	9.0	2.9	3.5	0.00691	0.925	1905	20
P2 HEV	Atkinson DVA	2020 8DDCT	48.5	116	9.0	2.9	3.5	0.00691	0.925	1905	20
PS HEV	Atkinson CPS	Power Split	41.2	137	9.0	2.9	3.5	0.00691	0.925	1905	70
PS HEV	Atkinson DVA	Power Split	47.2	120	9.0	2.9	3.5	0.00691	0.925	1905	70

Table 20. Small N1 Class Vehicle: DVT Adjusted Nominal Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d *m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	31.1	181	10.2	2.0	3.1	0.0083	1.04	1644	0
ICE SS	PSTDI	2020 8AT	39.8	142	10.2	0.9	3.4	0.0083	1.04	1644	0
ICE SS	PSTDI	2020 8DDCT	40.8	138	10.3	0.9	3.4	0.0083	1.04	1644	0
ICE SS	PLBTDI	2020 8AT	41.0	138	10.2	0.9	3.4	0.0083	1.04	1644	0
ICE SS	PLBTDI	2020 8DDCT	41.9	135	10.3	0.9	3.4	0.0083	1.04	1644	0
ICE SS	PEGRTDI	2020 8AT	41.8	135	10.2	0.9	3.4	0.0083	1.04	1644	0
ICE SS	PEGRTDI	2020 8DDCT	42.7	132	10.3	0.9	3.4	0.0083	1.04	1644	0
ICE SS	Diesel Baseline	2010 6AT	43.0	146	13.7	1.8	3.6	0.0083	1.04	1644	0
ICE SS	2020 Diesel	2020 8AT	48.4	130	10.9	1.4	3.4	0.0083	1.04	1644	0
ICE SS	2020 Diesel	2020 8DDCT	49.5	127	10.6	1.4	3.4	0.0083	1.04	1644	0
P2 HEV	Atkinson CPS	2020 8DDCT	47.6	119	10.2	2.1	3.4	0.0083	1.04	1726	22
P2 HEV	Atkinson DVA	2020 8DDCT	50.2	112	10.2	2.1	3.4	0.0083	1.04	1726	22
PS HEV	Atkinson CPS	Power Split	46.1	123	10.2	2.0	3.4	0.0083	1.04	1726	85
PS HEV	Atkinson DVA	Power Split	48.4	117	10.2	2.0	3.4	0.0083	1.04	1726	85

Table 21. Large N1 Class Vehicle: DVT Adjusted Nominal Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d *m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT	24.5	231	8.6	3.8	3.2	0.00721	0.952	2041	0
ICE SS	PSTDI	2020 8AT	35.9	157	8.6	1.3	3.2	0.00721	0.952	2041	0
ICE SS	PSTDI	2020 8WDCT	36.5	155	8.5	1.4	3.2	0.00721	0.952	2041	0
ICE SS	PLBTDI	2020 8AT	37.3	151	8.6	1.3	3.2	0.00721	0.952	2041	0
ICE SS	PLBTDI	2020 8WDCT	38.3	147	8.5	1.4	3.2	0.00721	0.952	2041	0
ICE SS	PEGRTDI	2020 8AT	37.3	151	8.6	1.3	3.2	0.00721	0.952	2041	0
ICE SS	PEGRTDI	2020 8WDCT	38.3	147	8.5	1.4	3.2	0.00721	0.952	2041	0
ICE SS	Diesel Baseline	2010 6AT	37.8	166	10.3	2.2	3.7	0.00721	0.952	2041	0
ICE SS	2020 Diesel	2020 8AT	42.5	147	8.6	2.0	3.2	0.00721	0.952	2041	0
ICE SS	2020 Diesel	2020 8WDCT	42.7	147	8.6	2.1	3.2	0.00721	0.952	2041	0
P2 HEV	Atkinson CPS	2020 8WDCT	44.6	127	8.7	3.4	3.2	0.00721	0.952	2143	25
P2 HEV	Atkinson DVA	2020 8WDCT	45.5	124	8.7	3.4	3.2	0.00721	0.952	2143	25
PS HEV	Atkinson CPS	Power Split	39.2	144	8.6	3.6	3.2	0.00721	0.952	2143	90
PS HEV	Atkinson DVA	Power Split	41.1	137	8.6	3.6	3.2	0.00721	0.952	2143	90

5. DVT Adjusted 15/10/10 Scenario Estimates

Adjusted 15/10/10 scenario estimates are designed to predict CO₂ impacts under reduced road loads, specifically a 15 percent reduction in vehicle weight and a 10 percent reduction in both rolling resistance and aerodynamic drag characteristics. Other DVT modeling inputs are set at values identical to the unadjusted nominal scenario discussed above in Section 2, with the exception that engine displacement is varied as required to maintain constant zero-to-sixty mph times

and hybrid electric vehicle (both P2 and power split designs) weight reductions are subject to a five percent base weight penalty (so that the implemented weight reductions are taken from a higher baseline weight). Since the DVT does not allow baseline data to be altered, there are no alternative road load impact estimates for the baseline technology configurations. All weight reductions are performed in accordance with the methodology presented in Section 1 above. Tables 22 through 28 present the resulting adjusted 15/10/10 scenario estimates.

Table 22. B Class Vehicle: DVT Adjusted 15/10/10 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 6AT	60.4	93	9.7	0.7	4.0	0.0085	0.662	1036	0
ICE SS	PSTDI	2020 6DDCT	61.9	91	9.2	0.7	4.0	0.0085	0.662	1036	0
ICE SS	PLBTDI	2020 6AT	62.8	90	9.7	0.7	4.0	0.0085	0.662	1036	0
ICE SS	PLBTDI	2020 6DDCT	64.6	87	9.2	0.7	4.0	0.0085	0.662	1036	0
ICE SS	PEGRTDI	2020 6AT	62.9	90	9.7	0.7	4.0	0.0085	0.662	1036	0
ICE SS	PEGRTDI	2020 6DDCT	64.5	88	9.2	0.7	4.0	0.0085	0.662	1036	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 6AT	73.7	85	9.9	1.0	4.0	0.0085	0.662	1036	0
ICE SS	2020 Diesel	2020 6DDCT	75.6	83	9.9	1.0	4.0	0.0085	0.662	1036	0
P2 HEV	Atkinson CPS	2020 6DDCT	69.6	81	9.9	1.5	4.0	0.0085	0.662	1072	14
P2 HEV	Atkinson DVA	2020 6DDCT	72.1	78	9.9	1.5	4.0	0.0085	0.662	1072	14
PS HEV	Atkinson CPS	Power Split	74.8	75	9.9	1.3	4.0	0.0085	0.662	1072	40
PS HEV	Atkinson DVA	Power Split	76.4	74	9.9	1.3	4.0	0.0085	0.662	1072	40

Table 23. C Class Golf: DVT Adjusted 15/10/10 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT	57.4	98	10.0	0.7	3.7	0.0075	0.585	1268	0
ICE SS	PSTDI	2020 8DDCT	58.7	96	10.0	0.7	3.7	0.0075	0.585	1268	0
ICE SS	PLBTDI	2020 8AT	59.2	95	10.0	0.7	3.7	0.0075	0.585	1268	0
ICE SS	PLBTDI	2020 8DDCT	60.7	93	10.0	0.7	3.7	0.0075	0.585	1268	0
ICE SS	PEGRTDI	2020 8AT	60.1	94	10.0	0.7	3.7	0.0075	0.585	1268	0
ICE SS	PEGRTDI	2020 8DDCT	61.5	92	10.0	0.7	3.7	0.0075	0.585	1268	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT	69.3	91	10.0	1.1	3.7	0.0075	0.585	1268	0
ICE SS	2020 Diesel	2020 8DDCT	70.3	89	9.9	1.1	3.7	0.0075	0.585	1268	0
P2 HEV	Atkinson CPS	2020 8DDCT	71.6	79	10.0	1.6	3.7	0.0075	0.585	1327	20
P2 HEV	Atkinson DVA	2020 8DDCT	72.4	78	10.0	1.6	3.7	0.0075	0.585	1327	20
PS HEV	Atkinson CPS	Power Split	67.4	84	10.0	1.3	3.7	0.0075	0.585	1327	40
PS HEV	Atkinson DVA	Power Split	71.0	80	10.0	1.3	3.7	0.0075	0.585	1327	40

Table 24. C Class Focus: DVT Adjusted 15/10/10 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT	61.5	92	9.1	0.7	3.8	0.0071	0.585	1135	0
ICE SS	PSTDI	2020 8DDCT	62.8	90	9.1	0.7	3.8	0.0071	0.585	1135	0
ICE SS	PLBTDI	2020 8AT	63.6	89	9.1	0.7	3.8	0.0071	0.585	1135	0
ICE SS	PLBTDI	2020 8DDCT	65.1	87	9.1	0.7	3.8	0.0071	0.585	1135	0
ICE SS	PEGRTDI	2020 8AT	64.3	88	9.1	0.7	3.8	0.0071	0.585	1135	0
ICE SS	PEGRTDI	2020 8DDCT	65.7	86	9.1	0.7	3.8	0.0071	0.585	1135	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT	73.4	85	9.1	1.1	3.8	0.0071	0.585	1135	0
ICE SS	2020 Diesel	2020 8DDCT	74.4	84	9.0	1.1	3.8	0.0071	0.585	1135	0
P2 HEV	Atkinson CPS	2020 8DDCT	75.1	75	9.1	1.6	3.8	0.0071	0.585	1194	20
P2 HEV	Atkinson DVA	2020 8DDCT	75.8	75	9.1	1.6	3.8	0.0071	0.585	1194	20
PS HEV	Atkinson CPS	Power Split	70.3	80	9.0	1.3	3.8	0.0071	0.585	1194	40
PS HEV	Atkinson DVA	Power Split	74.5	76	9.0	1.3	3.8	0.0071	0.585	1194	40

Table 25. D Class Vehicle: Adjusted 15/10/10 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT	54.0	105	8.3	0.9	3.2	0.0074	0.621	1414	0
ICE SS	PSTDI	2020 8DDCT	55.2	102	8.3	0.9	3.2	0.0074	0.621	1414	0
ICE SS	PLBTDI	2020 8AT	56.6	100	8.3	0.9	3.2	0.0074	0.621	1414	0
ICE SS	PLBTDI	2020 8DDCT	58.1	97	8.3	0.9	3.2	0.0074	0.621	1414	0
ICE SS	PEGRTDI	2020 8AT	55.8	101	8.3	0.9	3.2	0.0074	0.621	1414	0
ICE SS	PEGRTDI	2020 8DDCT	57.2	99	8.3	0.9	3.2	0.0074	0.621	1414	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT	61.7	102	8.3	1.5	3.2	0.0074	0.621	1414	0
ICE SS	2020 Diesel	2020 8DDCT	62.2	101	8.2	1.5	3.2	0.0074	0.621	1414	0
P2 HEV	Atkinson CPS	2020 8DDCT	69.3	81	8.3	2.2	3.2	0.0074	0.621	1480	24
P2 HEV	Atkinson DVA	2020 8DDCT	70.8	80	8.3	2.2	3.2	0.0074	0.621	1480	24
PS HEV	Atkinson CPS	Power Split	62.4	91	8.3	1.8	3.2	0.0074	0.621	1480	80
PS HEV	Atkinson DVA	Power Split	65.3	86	8.3	1.8	3.2	0.0074	0.621	1480	80

Table 26. MPV: DVT Adjusted 15/10/10 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT	44.5	127	9.0	1.0	3.5	0.0062	0.832	1560	0
ICE SS	PSTDI	2020 8DDCT	45.8	123	8.9	1.0	3.5	0.0062	0.832	1560	0
ICE SS	PLBTDI	2020 8AT	46.3	122	9.0	1.0	3.5	0.0062	0.832	1560	0
ICE SS	PLBTDI	2020 8DDCT	47.1	120	8.9	1.0	3.5	0.0062	0.832	1560	0
ICE SS	PEGRTDI	2020 8AT	46.2	122	9.0	1.0	3.5	0.0062	0.832	1560	0
ICE SS	PEGRTDI	2020 8DDCT	47.5	119	8.9	1.0	3.5	0.0062	0.832	1560	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT	52.8	119	9.0	1.6	3.5	0.0062	0.832	1560	0
ICE SS	2020 Diesel	2020 8DDCT	53.1	118	9.0	1.6	3.5	0.0062	0.832	1560	0
P2 HEV	Atkinson CPS	2020 8DDCT	56.2	101	9.0	2.4	3.5	0.0062	0.832	1633	20
P2 HEV	Atkinson DVA	2020 8DDCT	57.3	98	9.0	2.4	3.5	0.0062	0.832	1633	20
PS HEV	Atkinson CPS	Power Split	47.7	118	9.0	2.2	3.5	0.0062	0.832	1633	70
PS HEV	Atkinson DVA	Power Split	53.8	105	9.0	2.2	3.5	0.0062	0.832	1633	70

Table 27. Small N1 Class Vehicle: DVT Adjusted 15/10/10 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d *m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT	45.5	124	10.2	0.8	3.4	0.0075	0.936	1414	0
ICE SS	PSTDI	2020 8DDCT	46.2	122	10.1	0.8	3.4	0.0075	0.936	1414	0
ICE SS	PLBTDI	2020 8AT	46.8	121	10.2	0.8	3.4	0.0075	0.936	1414	0
ICE SS	PLBTDI	2020 8DDCT	47.4	119	10.1	0.8	3.4	0.0075	0.936	1414	0
ICE SS	PEGRTDI	2020 8AT	47.7	118	10.2	0.8	3.4	0.0075	0.936	1414	0
ICE SS	PEGRTDI	2020 8DDCT	48.4	117	10.1	0.8	3.4	0.0075	0.936	1414	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT	54.8	115	10.2	1.3	3.4	0.0075	0.936	1414	0
ICE SS	2020 Diesel	2020 8DDCT	56.0	112	10.2	1.3	3.4	0.0075	0.936	1414	0
P2 HEV	Atkinson CPS	2020 8DDCT	54.9	103	10.2	1.7	3.4	0.0075	0.936	1480	22
P2 HEV	Atkinson DVA	2020 8DDCT	57.6	98	10.2	1.7	3.4	0.0075	0.936	1480	22
PS HEV	Atkinson CPS	Power Split	53.4	106	10.3	1.5	3.4	0.0075	0.936	1480	85
PS HEV	Atkinson DVA	Power Split	55.1	102	10.3	1.5	3.4	0.0075	0.936	1480	85

Table 28. Large N1 Class Vehicle: DVT Adjusted 15/10/10 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d *m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT	40.8	138	8.6	1.1	3.2	0.0065	0.857	1755	0
ICE SS	PSTDI	2020 8WDCT	41.4	136	8.6	1.2	3.2	0.0065	0.857	1755	0
ICE SS	PLBTDI	2020 8AT	42.5	133	8.6	1.1	3.2	0.0065	0.857	1755	0
ICE SS	PLBTDI	2020 8WDCT	43.4	130	8.6	1.2	3.2	0.0065	0.857	1755	0
ICE SS	PEGRTDI	2020 8AT	42.6	133	8.6	1.1	3.2	0.0065	0.857	1755	0
ICE SS	PEGRTDI	2020 8WDCT	43.4	130	8.6	1.2	3.2	0.0065	0.857	1755	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT	48.3	130	8.6	1.8	3.2	0.0065	0.857	1755	0
ICE SS	2020 Diesel	2020 8WDCT	48.7	129	8.6	1.8	3.2	0.0065	0.857	1755	0
P2 HEV	Atkinson CPS	2020 8WDCT	51.0	111	8.6	2.8	3.2	0.0065	0.857	1837	25
P2 HEV	Atkinson DVA	2020 8WDCT	52.5	108	8.6	2.8	3.2	0.0065	0.857	1837	25
PS HEV	Atkinson CPS	Power Split	44.8	126	8.6	2.7	3.2	0.0065	0.857	1837	90
PS HEV	Atkinson DVA	Power Split	46.7	121	8.6	2.7	3.2	0.0065	0.857	1837	90

6. DVT Adjusted 30/20/20 Scenario Estimates

Adjusted 30/20/20 scenario estimates, designed to predict CO₂ impacts under reduced road loads, are developed in the same manner as described in Section

5 above for the adjusted 15/10/10 scenario, except that they represent a 30 percent reduction in vehicle weight and a 20 percent reduction in both rolling resistance and aerodynamic drag characteristics. Tables 29 through 35 present the adjusted 30/20/20 scenario estimates.

Table 29. B Class Vehicle: DVT Adjusted 30/20/20 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 6AT	69.1	82	9.0	0.7	4.0	0.0075	0.589	869	0
ICE SS	PSTDI	2020 6DDCT	70.8	80	8.5	0.7	4.0	0.0075	0.589	869	0
ICE SS	PLBTDI	2020 6AT	72.8	78	9.0	0.7	4.0	0.0075	0.589	869	0
ICE SS	PLBTDI	2020 6DDCT	74.8	75	8.5	0.7	4.0	0.0075	0.589	869	0
ICE SS	PEGRTDI	2020 6AT	72.0	78	9.0	0.7	4.0	0.0075	0.589	869	0
ICE SS	PEGRTDI	2020 6DDCT	73.7	77	8.5	0.7	4.0	0.0075	0.589	869	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 6AT	85.1	74	9.9	0.9	4.0	0.0075	0.589	869	0
ICE SS	2020 Diesel	2020 6DDCT	87.9	71	9.9	0.8	4.0	0.0075	0.589	869	0
P2 HEV	Atkinson CPS	2020 6DDCT	78.8	72	9.9	1.2	4.0	0.0075	0.589	917	14
P2 HEV	Atkinson DVA	2020 6DDCT	83.4	68	9.9	1.2	4.0	0.0075	0.589	917	14
PS HEV	Atkinson CPS	Power Split	85.3	66	9.9	0.9	4.0	0.0075	0.589	917	40
PS HEV	Atkinson DVA	Power Split	86.3	65	9.9	0.9	4.0	0.0075	0.589	917	40

Table 30. C Class Golf: DVT Adjusted 30/20/20 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT	66.0	86	8.6	0.7	3.7	0.0066	0.52	1076	0
ICE SS	PSTDI	2020 8DDCT	67.5	84	8.8	0.7	3.7	0.0066	0.52	1076	0
ICE SS	PLBTDI	2020 8AT	68.6	82	8.6	0.7	3.7	0.0066	0.52	1076	0
ICE SS	PLBTDI	2020 8DDCT	70.3	80	8.8	0.7	3.7	0.0066	0.52	1076	0
ICE SS	PEGRTDI	2020 8AT	69.1	82	8.6	0.7	3.7	0.0066	0.52	1076	0
ICE SS	PEGRTDI	2020 8DDCT	70.6	80	8.8	0.7	3.7	0.0066	0.52	1076	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT	80.2	78	9.9	1.0	3.7	0.0066	0.52	1076	0
ICE SS	2020 Diesel	2020 8DDCT	81.0	77	10.0	1.0	3.7	0.0066	0.52	1076	0
P2 HEV	Atkinson CPS	2020 8DDCT	81.6	69	10.0	1.2	3.7	0.0066	0.52	1120	20
P2 HEV	Atkinson DVA	2020 8DDCT	82.5	68	10.0	1.2	3.7	0.0066	0.52	1120	20
PS HEV	Atkinson CPS	Power Split	78.8	72	10.0	1.0	3.7	0.0066	0.52	1120	40
PS HEV	Atkinson DVA	Power Split	82.3	69	10.0	1.0	3.7	0.0066	0.52	1120	40

Table 31. C Class Focus: DVT Adjusted 30/20/20 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT	70.4	80	7.9	0.7	3.8	0.0063	0.52	958	0
ICE SS	PSTDI	2020 8DDCT	71.8	79	7.9	0.7	3.8	0.0063	0.52	958	0
ICE SS	PLBTDI	2020 8AT	73.3	77	7.9	0.7	3.8	0.0063	0.52	958	0
ICE SS	PLBTDI	2020 8DDCT	75.1	75	7.9	0.7	3.8	0.0063	0.52	958	0
ICE SS	PEGRTDI	2020 8AT	73.6	77	7.9	0.7	3.8	0.0063	0.52	958	0
ICE SS	PEGRTDI	2020 8DDCT	75.1	75	7.9	0.7	3.8	0.0063	0.52	958	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT	84.8	74	9.1	1.0	3.8	0.0063	0.52	958	0
ICE SS	2020 Diesel	2020 8DDCT	85.4	73	9.0	1.0	3.8	0.0063	0.52	958	0
P2 HEV	Atkinson CPS	2020 8DDCT	85.0	66	9.1	1.2	3.8	0.0063	0.52	1002	20
P2 HEV	Atkinson DVA	2020 8DDCT	85.8	66	9.1	1.2	3.8	0.0063	0.52	1002	20
PS HEV	Atkinson CPS	Power Split	81.7	69	9.0	0.9	3.8	0.0063	0.52	1002	40
PS HEV	Atkinson DVA	Power Split	85.4	66	9.0	0.9	3.8	0.0063	0.52	1002	40

Table 32. D Class Vehicle: Adjusted 30/20/20 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT	62.7	90	8.2	0.8	3.2	0.0066	0.552	1184	0
ICE SS	PSTDI	2020 8DDCT	64.1	88	8.3	0.8	3.2	0.0066	0.552	1184	0
ICE SS	PLBTDI	2020 8AT	65.9	86	8.2	0.8	3.2	0.0066	0.552	1184	0
ICE SS	PLBTDI	2020 8DDCT	67.7	83	8.3	0.8	3.2	0.0066	0.552	1184	0
ICE SS	PEGRTDI	2020 8AT	64.9	87	8.2	0.8	3.2	0.0066	0.552	1184	0
ICE SS	PEGRTDI	2020 8DDCT	66.6	85	8.3	0.8	3.2	0.0066	0.552	1184	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT	71.8	87	8.3	1.3	3.2	0.0066	0.552	1184	0
ICE SS	2020 Diesel	2020 8DDCT	72.7	86	8.3	1.3	3.2	0.0066	0.552	1184	0
P2 HEV	Atkinson CPS	2020 8DDCT	79.4	71	8.3	1.7	3.2	0.0066	0.552	1250	24
P2 HEV	Atkinson DVA	2020 8DDCT	81.8	69	8.3	1.7	3.2	0.0066	0.552	1250	24
PS HEV	Atkinson CPS	Power Split	72.1	78	8.3	1.4	3.2	0.0066	0.552	1250	80
PS HEV	Atkinson DVA	Power Split	75.1	75	8.3	1.4	3.2	0.0066	0.552	1250	80

Table 33. MPV: DVT Adjusted 30/20/20 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d ×m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT	50.8	111	8.9	0.8	3.5	0.0055	0.74	1306	0
ICE SS	PSTDI	2020 8DDCT	52.3	108	8.9	0.8	3.5	0.0055	0.74	1306	0
ICE SS	PLBTDI	2020 8AT	52.7	107	8.9	0.8	3.5	0.0055	0.74	1306	0
ICE SS	PLBTDI	2020 8DDCT	53.8	105	8.9	0.8	3.5	0.0055	0.74	1306	0
ICE SS	PEGRTDI	2020 8AT	52.8	107	8.9	0.8	3.5	0.0055	0.74	1306	0
ICE SS	PEGRTDI	2020 8DDCT	54.3	104	8.9	0.8	3.5	0.0055	0.74	1306	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT	60.7	103	9.0	1.3	3.5	0.0055	0.74	1306	0
ICE SS	2020 Diesel	2020 8DDCT	61.1	103	9.0	1.3	3.5	0.0055	0.74	1306	0
P2 HEV	Atkinson CPS	2020 8DDCT	62.9	90	9.0	1.9	3.5	0.0055	0.74	1361	20
P2 HEV	Atkinson DVA	2020 8DDCT	65.0	87	9.0	1.9	3.5	0.0055	0.74	1361	20
PS HEV	Atkinson CPS	Power Split	53.3	106	9.0	1.6	3.5	0.0055	0.74	1361	70
PS HEV	Atkinson DVA	Power Split	60.8	93	9.0	1.6	3.5	0.0055	0.74	1361	70

Table 34. Small N1 Class Vehicle: DVT Adjusted 30/20/20 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d *m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT	52.7	107	9.9	0.7	3.4	0.0066	0.832	1184	0
ICE SS	PSTDI	2020 8DDCT	53.3	106	10.1	0.7	3.4	0.0066	0.832	1184	0
ICE SS	PLBTDI	2020 8AT	54.4	104	9.9	0.7	3.4	0.0066	0.832	1184	0
ICE SS	PLBTDI	2020 8DDCT	54.6	103	10.1	0.7	3.4	0.0066	0.832	1184	0
ICE SS	PEGRTDI	2020 8AT	55.3	102	9.9	0.7	3.4	0.0066	0.832	1184	0
ICE SS	PEGRTDI	2020 8DDCT	55.7	101	10.1	0.7	3.4	0.0066	0.832	1184	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT	63.4	99	10.2	1.1	3.4	0.0066	0.832	1184	0
ICE SS	2020 Diesel	2020 8DDCT	64.5	97	10.2	1.1	3.4	0.0066	0.832	1184	0
P2 HEV	Atkinson CPS	2020 8DDCT	62.8	90	10.2	1.3	3.4	0.0066	0.832	1233	22
P2 HEV	Atkinson DVA	2020 8DDCT	66.0	86	10.2	1.3	3.4	0.0066	0.832	1233	22
PS HEV	Atkinson CPS	Power Split	56.2	101	10.2	1.0	3.4	0.0066	0.832	1233	85
PS HEV	Atkinson DVA	Power Split	57.8	98	10.2	1.0	3.4	0.0066	0.832	1233	85

Table 35. Large N1 Class Vehicle: DVT Adjusted 30/20/20 Scenario Estimates

Architecture	Engine Type	Transmission	NEDC mpg	NEDC gCO ₂ /km	0-60 mph seconds	Disp liters	FDR	RR	AD C _d *m ²	Weight kg	EM Size kW
ICE SS	Petrol Baseline	2010 6AT									
ICE SS	PSTDI	2020 8AT	47.1	120	8.5	1.0	3.2	0.0058	0.762	1470	0
ICE SS	PSTDI	2020 8WDCT	47.7	118	8.6	1.0	3.2	0.0058	0.762	1470	0
ICE SS	PLBTDI	2020 8AT	49.0	115	8.5	1.0	3.2	0.0058	0.762	1470	0
ICE SS	PLBTDI	2020 8WDCT	50.0	113	8.6	1.0	3.2	0.0058	0.762	1470	0
ICE SS	PEGRTDI	2020 8AT	49.2	115	8.5	1.0	3.2	0.0058	0.762	1470	0
ICE SS	PEGRTDI	2020 8WDCT	50.0	113	8.6	1.0	3.2	0.0058	0.762	1470	0
ICE SS	Diesel Baseline	2010 6AT									
ICE SS	2020 Diesel	2020 8AT	55.6	113	8.6	1.5	3.2	0.0058	0.762	1470	0
ICE SS	2020 Diesel	2020 8WDCT	56.0	112	8.7	1.5	3.2	0.0058	0.762	1470	0
P2 HEV	Atkinson CPS	2020 8WDCT	58.9	96	8.6	2.2	3.2	0.0058	0.762	1531	25
P2 HEV	Atkinson DVA	2020 8WDCT	60.9	93	8.6	2.2	3.2	0.0058	0.762	1531	25
PS HEV	Atkinson CPS	Power Split	51.6	109	8.6	2.0	3.2	0.0058	0.762	1531	90
PS HEV	Atkinson DVA	Power Split	53.5	106	8.6	2.0	3.2	0.0058	0.762	1531	90

Abbreviations and Acronyms

AD	Aerodynamic Drag Parameter ($C_d \times$ Vehicle Frontal Area)
Atkinson CPS	Atkinson Cycle Internal Combustion Engine with Cam Phase Switching
Atkinson DVA	Atkinson Cycle Internal Combustion Engine with Digital Valve Actuation
C_d	Coefficient of Drag
CO ₂	Carbon Dioxide
Disp	Displacement
DVT	Ricardo Data Visualization Tool
EM	Electric Drive Motor
EU	European Union
FDR	Final Drive Ratio
gCO ₂ /km	Grams CO ₂ per Kilometer
ICE SS	Internal Combustion Engine Only (i.e., Non-Hybrid) with Start-Stop Technology
kg	Kilogram(s)
km	Kilometer(s)
kW	Kilowatt(s)
mph	Miles per Hour
MPV	Multi-Purpose Vehicle
m ²	Square Meters (of Vehicle Frontal Area)
NEDC	New European Driving Cycle
PEGRTDI	Petrol Stoichiometric Turbocharged Direct Injection with Dual-Loop Cooled Exhaust Gas Recirculation
PLBTDI	Petrol Lean Burn Turbocharged Direct Injection
PSTD	Petrol Stoichiometric Turbocharged Direct Injection
PS HEV	Power Split Design Hybrid Electric Vehicle
P2 HEV	P2 Design Hybrid Electric Vehicle
RR	Rolling Resistance Parameter
U.S.	United States
6AT	Six Speed Automatic Transmission
6DDCT	Six Speed Dry Dual-Clutch Automated Manual Transmission
8AT	Eight Speed Automatic Transmission
8DDCT	Eight Speed Dry Dual-Clutch Automated Manual Transmission
8WDCT	Eight Speed Wet Dual-Clutch Automated Manual Transmission