GA 815002

Deliverable number:	D1.1
Deliverable title	Technology and Vehicle Taxonomy

Document ID:	uCARe-D1.1-v1.0
Dissemination level:	Public
Main authors:	Peter Mock, Sandra Wappelhorst, Uwe Tietge, Jan Dornoff, Georg Bieker
Issue date:	2019-11-25

EUROPEAN COMMISSION HORIZON2020 – Research and Innovation Action

Disclaimer and acknowledgements

uCARe
You Can Always Reduce Emissions
because you care

This project has received funding from the European Union's Horizon 2020 Programme Research and Innovation action under grant agreement No 815002

Consortium partners

TNO
LAT LABORATORY OF APPLIED THERMODYNAMICS ARISTOTLE UNIVERSITY THESSALONIKI
ivl
vti
icct THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION
TU Graz
Empa Materials Science and Technology
mobi
INFRAS
UNIVERSITY OF LEEDS
HSDAC

Document information

Additional contributing partners

Authors	Organisation
René van Gijlswijk	TNO

Changes and distribution

Version	Date	Change	Distribution
V0.1	31/10/19	Draft final	Graz participants
V1.0	25/11/19	Final	EC

Verification and approval

Check by	Name	Date
WP leader	Norbert Ligterink	
Coordinator	Paul Tilanus	

Executive Summary

The technology and vehicle taxonomy serves two purposes. First, controlled vocabularies are developed that will be used to describe passenger cars in the European market. Harmonizing the vocabulary across multiple EU-funded projects facilitates integrating datasets within the uCARe project and allows uCARe data to be combined with results from other projects. Second, vehicle groups are defined in order to pool measurements of individual vehicles into vehicle groups with similar emission characteristics.

Purpose and structure of the document

Purpose

This document describes the controlled vocabulary and vehicle grouping developed as part of the technology and vehicle taxonomy.

Structure

- Introduction
- Vehicle taxonomy
- Vehicle grouping
- Conclusion

Deviations from the original DoW

Description in the DoW
This deliverable is the result of Task 1.1. This taxonomy will be used in the tools to provide information to individual car owners, once the car's place in the taxonomy is determined.

Time deviations from original DoW
A shared taxonomy for multiple projects was deemed to be more useful than a taxonomy per project. The harmonisation of a taxonomy over multiple projects would require 3 more months, ant it was agreed with the PO that this would be time well-spent.

Content deviations from original DoW
Though the taxonomy was harmonised with CARES, TRUE initiative and MILE21, the purpose as described in the DoW for uCARe was not changed.

Introduction

Process, related projects, and benefits

Introduction

Objective: Standardize how we describe passenger cars so that we can join datasets across different EU projects.

Process:

1. Define key variables that describe vehicle market structures and/or affect emissions performance.
2. Define domains—the set or range of values that each variable may take on.
3. Describe passenger cars sold in the EU in terms of key variables.
4. Apply resulting taxonomy to a variety of EU projects.

Related projects

- TRUE Initiative: aims to independently monitor and report real-world vehicle emissions in cities
- MILE21: LIFE project that helps consumers choose fuel-efficient cars
- CARES: Horizon 2020 project that provides regional and national authorities tools to monitor and detect emissions from road vehicles

Definitions of vehicle groups in various projects

MILE21
battery capacity
drive type

uCARe vehicle family
transmission type

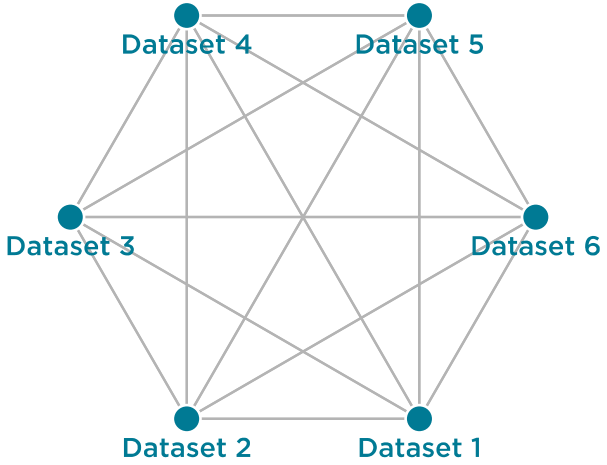
EEA CO□monitoring data
make
model

uCARe engine family
engine power

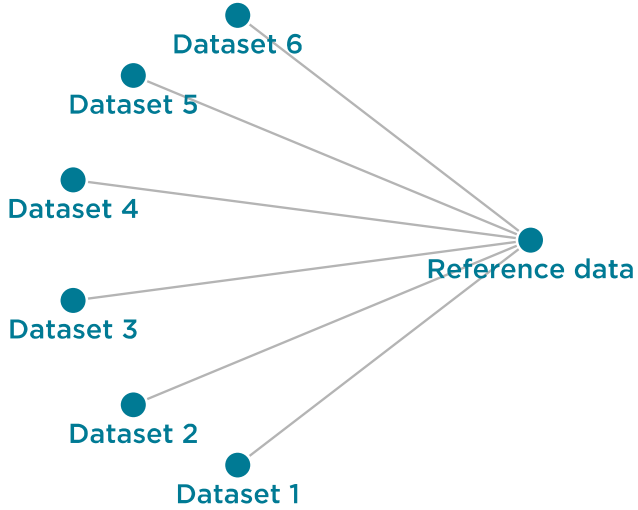
TRUE Initiative
manufacturer
powertrain/fuel type
emission standard
engine displacement

Benefits of a shared taxonomy

Worst case: $\frac{N(N-1)}{2}$



With reference data: N



Vehicle taxonomy

Controlled vocabulary for describing vehicles

Variables and domains to define

Variable	Definition	Type	Domain	Unit	Source
make	Vehicle make as defined by ADAC, without stylization (e.g., "Kia", not "KIA")	varchar	makes		ADAC
model	Defined as model series in ADAC, translated to German and stylization removed	varchar	models		ADAC
manufacturer alliance	Code of the manufacturer alliance, used to group engine families	varchar	alliances		TNO
powertrain type	Powertrain architecture relative to energy storage, energy source, and energy converter	varchar	powertrains		(EU) 2017/1151
fuel type	Externally supplied energy carrier	varchar	fuels		
emission standard	Emission standard vehicle was type-approved to	varchar	emission_standards		
engine displacement	Engine displacement	integer	positive integer	cm3	
engine power	Rated power of internal combustion engine	integer	positive integer	kW	
transmission type	Trigger of gear change	varchar	transmissions		
AWD capable	Flag if vehicle is capable of 4-wheel drive	boolean			
battery capacity	Battery capacity of electrified powertrains	numeric		kWh	

Domain: Makes

Motivation for inclusion: Essential vehicle characteristic shown to co-determine CO_2 and pollutant emissions. [1, 2, 3] Relevant for consumers and regulatory enforcement.

Domain: Abarth, Alfa Romeo, Alpina, Alpine, Aston Martin, Audi, Bentley, BMW, Borgward, Bugatti, Cadillac, Chevrolet, Citroen, Cupra, Dacia, Daihatsu, Dodge, Donkervoort, DS Automobiles, Ego Mobile, Ferrari, Fiat, Ford, Gumpert, Honda, Hyundai, Infiniti, Isuzu, Jaguar, Jeep, Kia, Koenigsegg, KTM, Lada, Lamborghini, Lancia, Land Rover, Lexus, Lotus, Maserati, Maybach, Mazda, McLaren, Mercedes, …

Domain: Models

Motivation for inclusion: Essential information for consumers.

Domain: 540 unique vehicle models. Illustrative examples include:

- 3-Series (not 320d)
- C-Class (not C200)
- Up (not Up!)

Domain: Powertrain types

Motivation for inclusion: Essential vehicle characteristic shown to affect CO_2 and pollutant emissions.[1, 2, 3]

Domain:

- ICEV: internal combustion engine vehicles including mild hybrids (vehicles that require combustion engines for propulsion)
- OVC-HEV: off-vehicle charging HEVs (PHEVs, REEVs)
- NOVC-HEV: non-off-vehicle charging HEVs
- OVC-FCHV: off-vehicle charging fuel cell hybrid vehicles
- NOVC-FCHV: non-off-vehicle charging fuel cell hybrid vehicles
- PEV: pure electric vehicle (BEVs)

Domain: Fuel types

Motivation for inclusion: Essential vehicle characteristic shown to affect CO_2 and pollutant emissions. [1, 2, 3]

Domain:

- diesel (up to and including 20/80 diesel/biodiesel blends)
- petrol (up to and including 20/80 petrol/ethanol blends)
- electricity
- ethanol (down to 80/20 ethanol/petrol blends)
- CNG
- LPG
- hydrogen
- biodiesel

Domain: Emission standards

Motivation for inclusion: Basis for type approval of pollutant emissions and relevant for regulatory compliance and enforcement. Euro 6d-TEMP and Euro 6d are significantly different from Euro 6a–c in type approval procedure and emissions performance to warrant separate entries.

Domain:

- Euro 0 (no Euro standard; vehicles before 1992)
- Euro 1–6
- Euro 6d-TEMP
- Euro 6d
- Optional: Euro 6a, Euro 6b, Euro 6c

Transmission types

Motivation for inclusion: Shown to affect CO_2 emissions.[2]

Domain:

- Automatic (includes torque converter, double-clutch, and continuously variable transmissions)
- Manual

Four-wheel drive capable

Motivation for inclusion: Shown to affect CO_2 emissions (source: ongoing MILE21 work).

Domain:

- TRUE
- FALSE

Battery capacity

Motivation for inclusion: Essential characteristic of electrified vehicles. Important determinant of fuel/electricity consumption and electric range.

Domain:

- Positive numeric
- Ranges
  - OVC-HEV: typically 4–27 kWh
  - PEV: typically 14–100 kWh

Examples of vehicles

make	model	powertrain_type	fuel_type	euro_standard	eng_disp	eng_power	trans_type	awd_capable	battery_cap
VW	Crafter	ICEV	Diesel	Euro 5	1968	100	Manual	FALSE	
SEAT	Exeo	ICEV	Petrol	Euro 5	1798	118	Manual	FALSE	
BMW	3-Series	ICEV	Petrol	Euro 6	1997	135	Automatic	TRUE	
Mercedes	E-Class	ICEV	Diesel	Euro 6	2143	150	Automatic	FALSE	
Audi	Q3	ICEV	Diesel	Euro 6	1968	110	Manual	FALSE	
Citroen	Spacetourer	ICEV	Diesel	Euro 6	1997	130	Automatic	FALSE	
Renault	Espace	ICEV	Diesel	Euro 6d-TEMP	1997	147	Automatic	FALSE	
VW	Transporter	ICEV	Diesel	Euro 6d-TEMP	1968	110	Automatic	FALSE	

Vehicle grouping

Pooling measurements of similar vehicles

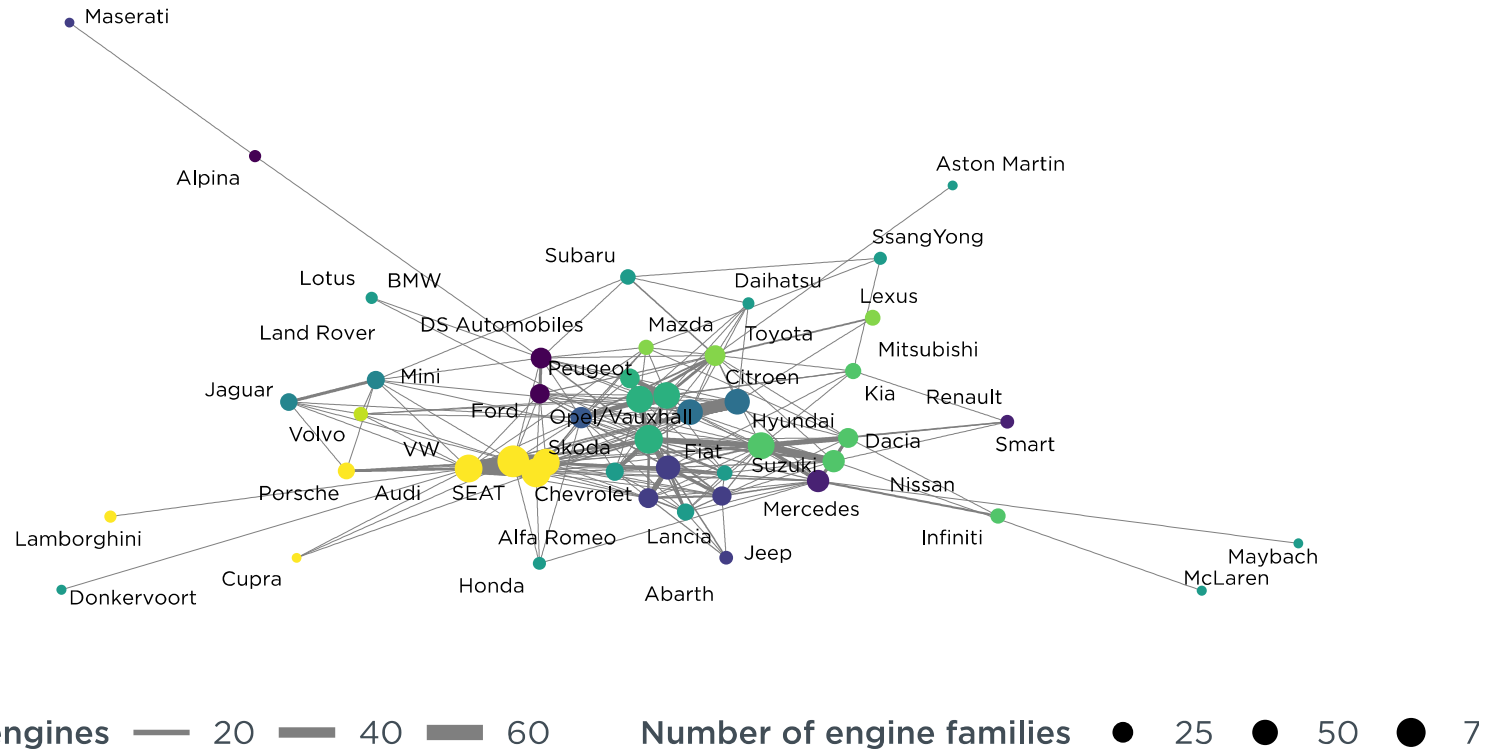
Engine families: Approaches

- Objective: Group engines in order to identify engines that are shared across different makes.
- Hypothesis: Engines have similar emissions performance across makes.
- Approach #1 (TRUE Initiative)
  - Engine family: unique combination of powertrain type, fuel type, emission standard, engine displacement, engine power, *and vehicle manufacturer alliance*
- Approach #2 (TNO)
  - Same as approach #1, but remove the vehicle manufacturer alliance
  - Instead: engine block disambiguation

Engine families: Approach #1

- Next slide:
  - Network of makes sharing engine families
  - Marker size represents number of engine families per make
  - Edge width represents number of shared engine families
  - Color of marker represents manual categorization of manufacturer alliances

Engine families: Approach #1



Engine families: Approach #2

Table used to disambiguate engines that have the same high-level specifications but are not technically identical:

Table 1

Engine block disambiguation

Specs are the same, but the engines are physically different.

P_1598_77_E4	P_1390_55_E4	P_998_51_E5	P_1598_85_E4	D_1598_77_E5	P_1598_81_E4	P_1997_100_E3	D_1598_88_E6	P_1587_80_E3
FCA	RNM	HYUN	TRIT	FCA	RNM	PSA	VAG	VOLV
VAG	VAG	DAIH	VAG	VAG	TOYO	MITS	FCA	PSA
GM			GM		VAG			
RNM								
MAZD								

P_1598_74_E4	P_1598_88_E4	P_999_55_E6	P_999_66_E6	P_999_85_E6	D_1598_81_E6	P_998_48_E6	P_998_48_E5
RNM	PSA4	VAG	VAG	VAG	VAG	FORD	FORD
GM	ALFA	GM	GM	GM	GM	HYUN	HYUN
							GM

If the engine code of a vehicle is listed in table 1, the alliance of manufacturers determines which engine it is.

The alliance code (“FCA”, “VAG”) is found by looking up the vehicle manufacturer in table 2, but only among the entries listed under the engine code in table 1.

Table 2

Alliances / OEM groups

ALFA	ALFA ROMEO					
BMW	BMW	MINI				
DAIH	DAIHATSU	TOYOTA	CITROEN	PEUGEOT		
FCA	FIAT	ALFA ROMEO	LANCIA	JEEP	CHRYSLER	
FCA2	FIAT	ALFA ROMEO	LANCIA	JEEP	CHRYSLER	SUZUKI
FCA3	FIAT	FORD	LANCIA			
FCA4	FIAT	ALFA ROMEO	OPEL	CHEVROLET	CADILLAC	SAAB
FORD	FORD					
GM	OPEL	CHEVROLET				
HYUN	HYUNDAI	KIA				
HYUN2	KIA	MAZDA	HYUNDAI			
MAZD	MAZDA					
MERC	MERCEDES-BENZ					

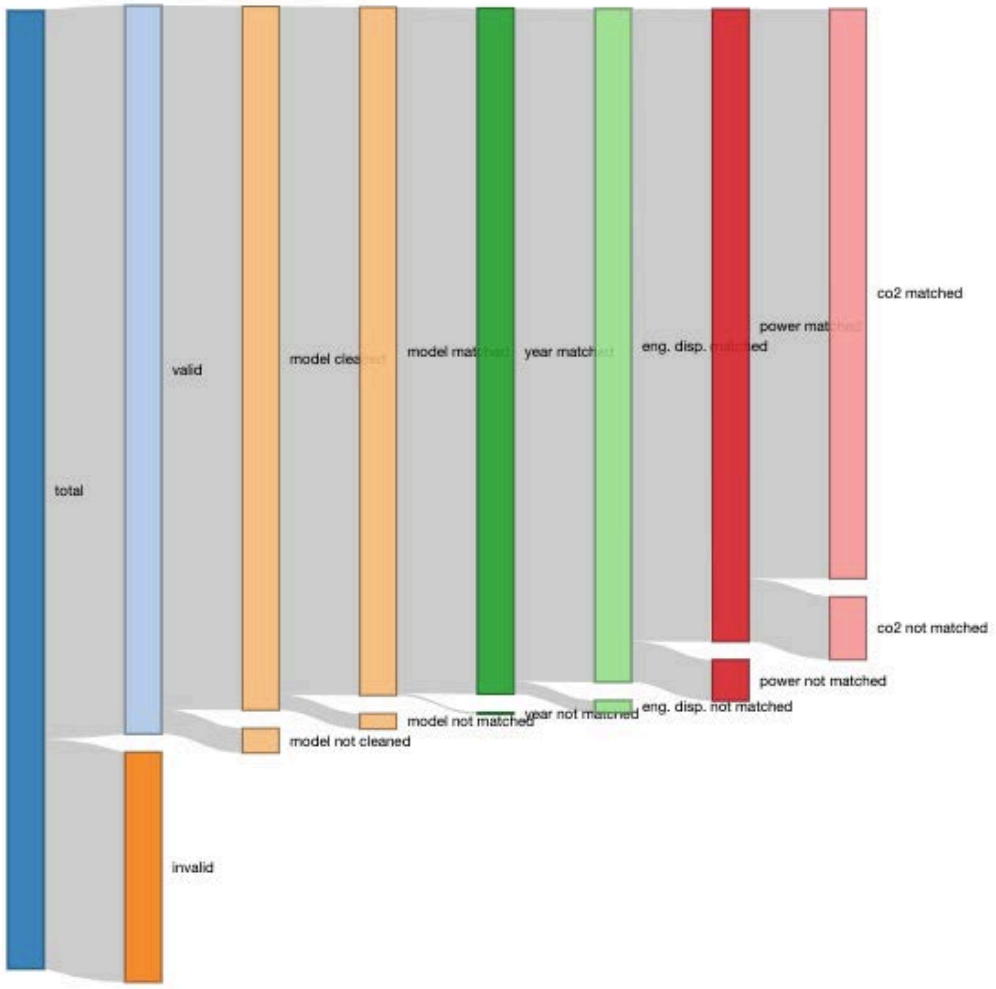
Engine families: Takeaways

- Approach #1
  - Prone to false negatives (assuming that an engine is not shared across manufacturers when it is).
  - Maintenance requires tracking manufacturer alliances over time
- Approach #2: Grouping generally works, but some dubious matches must be checked and manually disambiguated.
  - Prone to false positives (assuming that an engine is shared across manufacturers when it is not).
  - Maintenance requires investigating dubious matches every time the data is updated.
- Approach #2 will be used. Engine families will be disambiguated by TNO.

Market coverage (1)

- Next slide:
  - Market coverage of the described grouping
  - Sales from EEA CO2 monitoring data
  - Market coverage: approximately 80%, but difficult to measure precisely due to poor data quality in the CO2 monitoring data

Market coverage (2)



Conclusion

- Controlled vocabularies for ten vehicle characteristics were developed.
  - More domains can be added as needed.
- Two approaches for defining vehicle groups were explored.
- Controlled vocabulary covers approximately 80% of EU 2013–2018 new passenger car sales.

List of references

[1] Tietge, U., Díaz, S., Mock, P., Bandivadekar, A., Dornoff, J., & Ligterink, N. (2019). *From laboratory to road: A 2018 update of official and "real-world" fuel consumption and CO2 values for passenger cars in Europe* (p. 56). Retrieved from ICCT website: https://www.theicct.org/publications/laboratory-road-2018-update

[2] Tietge, U. (2019). *CO2 emissions from new passenger cars in the EU: Car manufacturers' performance in 2018* (p. 11). Retrieved from ICCT website: https://theicct.org/publications/CO2-emissions-PVs-Europe-2018

[3] Bernard, Y., Tietge, U., German, J., & Muncrief, R. (2018). *Determination of real-world emissions from passenger vehicles using remote sensing data* (p. 31). Retrieved from TRUE Initiative website: https://www.theicct.org/publications/real-world-emissions-using-remote-sensing-data

[4] Allgemeine Deutsche Automobil-Club. (2019). ADAC Autodatenbank. Retrieved November 18, 2019, from ADAC website: https://www.adac.de/infotestrat/autodatenbank/autokatalog/default.aspx

Changes

This is a maintained document.

The most recent version can always be obtained from the Taxonomy Excel files on:

https://www.project-ucare.eu/project-results/

Variable	Definition	Type	Domain	Unit	Source
make	Vehicle make as defined by ADAC, without stylization (e.g., "Kia", not "KIA")	varchar	makes		ADAC
model	Defined as model series in ADAC, translated to German and stylization removed	varchar	models		ADAC
manufacturer alliance	Code of the manufacturer alliance, used to group engine families	varchar	alliances		TNO
powertrain type	Powertrain architecture relative to energy storage, energy source, and energy converter	varchar	powertrains		(EU) 2017/1151
fuel type	Externally supplied energy carrier	varchar	fuels		
emission standard	Emission standard vehicle was type-approved to	varchar	emission_standards		
engine displacement	Engine displacement	integer	positive integer	cm3	
engine power	Rated power of internal combustion engine	integer	positive integer	kW	
transmission type	Trigger of gear change	varchar	transmissions		
AWD capable	Flag if vehicle is capable of 4-wheel drive	boolean			
battery capacity	Battery capacity of electrified powertrains	numeric		kWh	

makes

value	description
Abarth	
Alfa Romeo	
Alpina	
Alpine	
Aston Martin	
Audi	
Bentley	
BMW	
Borgward	
Bugatti	

List aborted due to copyright reasons.
Please contact the author of the Deliverable 1.1 for more information

models

make	value	description
Abarth	124	
Abarth	500	
Abarth	Punto	
Alfa Romeo	4C	
Alfa Romeo	Giulia	
Alfa Romeo	Giulietta	
Alfa Romeo	MiTo	
Alfa Romeo	Stelvio	
Alpina	3-Series	
Alpina	4-Series	

List aborted due to copyright reasons.
Please contact the author of the Deliverable 1.1 for more information

powertrain_types

value	description
ICEV	internal combustion engine vehicles including mild hybrids
OVC-HEV	off-vehicle charging HEVs (PHEVs, REEVs)
NOVC-HEV	non-off-vehicle charging HEVs
OVC-FCHV	off-vehicle charging fuel cell hybrid vehicles
NOVC-FCHV	non-off-vehicle charging fuel cell hybrid vehicles
PEV	pure electric vehicle (BEVs)

fuel_types

value	description
diesel	includes up to 80/20 diesel/biodiesel blends
petrol	includes up to 80/20 petrol/ethanol blends
electricity	
ethanol	ethanol/petrol blends higher than 20/80
CNG	
LPG	
hydrogen	
biodiesel	biodiesel/diesel blends higher than 20/80

euro_standards

value	description	optional
Euro 0	no Euro standard, vehicles before 1992	FALSE
Euro 1–6		FALSE
Euro 6d-TEMP	includes all possible suffixes (EVAP, ISC)	FALSE
Euro 6d	includes all possible suffixes (ISC, FCM)	FALSE
Euro 6a–c		TRUE

transmission_types

value	description
automatic	includes torque converter, double-clutch, and continuously variable transmissions
manual	

AWD_capable

value	description
TRUE	four-wheel drive capable (4WD/AWD)
FALSE	

OEM_alliances

Engine manufacturers / manufacturer alliances. Back to Euro 4, only for engines of which >15000 are still running in the Netherlands.

Alliances / OEM groups

ALFA	ALFA ROMEO					
BMW	BMW	MINI				
DAIH	DAIHATSU	TOYOTA	CITROEN	PEUGEOT		
FCA	FIAT	ALFA ROMEO	LANCIA	JEEP	CHRYSLER	
FCA2	FIAT	ALFA ROMEO	LANCIA	JEEP	CHRYSLER	SUZUKI
FCA3	FIAT	FORD	LANCIA			
FCA4	FIAT	ALFA ROMEO	OPEL	CHEVROLET	CADILLAC	SAAB
FORD	FORD					
GM	OPEL	CHEVROLET				
HYUN	HYUNDAI	KIA				
HYUN2	KIA	MAZDA	HYUNDAI			
MAZD	MAZDA					
MERC	MERCEDES-BENZ					
MERC2	MERCEDES-BENZ	INFINITI				
MITS	MITSUBISHI	KIA	HYUNDAI			
MITS2	MITSUBISHI	SMART				
PAG	FORD	VOLVO	JAGUAR LAND RO'	MAZDA		
PAG2	FORD	VOLVO	JAGUAR LAND RO'	MAZDA	BMW	
PSA	PEUGEOT	CITROEN	DS			
PSA2	PEUGEOT	CITROEN	DS	OPEL		
PSA3	PEUGEOT	CITROEN	VOLVO			
PSA4	PEUGEOT	CITROEN	DS	MINI		
PSAF	PEUGEOT	CITROEN	FORD	MINI	VOLVO	MAZDA
RNM	RENAULT	NISSAN	MITSUBISHI	DACIA		
RNM2	RENAULT	NISSAN	MERCEDES	DACIA		
RNM3	RENAULT	NISSAN	DACIA	SMART		
SUZU	SUZUKI					
SUZU2	SUZUKI	NISSAN	OPEL			
TOYO	TOYOTA	DAIHATSU	LEXUS	SUBARU		

TRIT	CHRYSLER	MINI					
VAG	VOLKSWAGEN	AUDI	SEAT	SKODA			
VAG2	VOLKSWAGEN	AUDI	SEAT	SKODA	JEEP	DODGE	MITSUBISHI
VOLV	VOLVO						

Engine block disambiguation

Specs are the same, but the engines are physically different.

P_1598_77_E4	P_1390_55_E4	P_998_51_E5	P_1598_85_E4	D_1598_77_E5	P_1598_81_E4	P_1997_100_E3	D_1598_88_E6	P_1587_80_E3
FCA	RNM	HYUN	TRIT	FCA	RNM	PSA	VAG	VOLV
VAG	VAG	DAIH	VAG	VAG	TOYO	MITS	FCA	PSA
GM			GM		VAG			
RNM								
MAZD								

P_1598_74_E4	P_1598_88_E4	P_999_55_E6	P_999_66_E6	P_999_85_E6	D_1598_81_E6	P_998_48_E6	P_998_48_E5
RNM	PSA4	VAG	VAG	VAG	VAG	FORD	FORD
GM	ALFA	GM	GM	GM	GM	HYUN	HYUN
							GM