# Briefing on EMFAC-HK Update

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# Background

- EPD has adapted the vehicle emission model, EMFAC, developed by California Air Resources Board (CARB) for use in Hong Kong since 2005.
- EMFAC-HK model calculates emission rates[#] from all on-road vehicles.
- For territory-wide emission inventories, emission factors in EMFAC-HK are multiplied by territory-wide vehicle activity data.
- For other vehicle emission assessment like EIA, EMFAC-HK provides fleet average emission factors and the consultants will provide case specific activity data.
- It was agreed to promulgate update every January, if needed, since 2013.

[#]Emission rate = Emission Factor (g/km) x Vehicle activity (km/day)

# Outline

- Application of EMFAC-HK
- Timeline of EMFAC-HK updates
- Changes made in EMFAC-HK update (V4.3)
- Comparison of emissions and fleet average emission factors (FAEF)
- Transitional Arrangement & Meeting Air Quality Objectives

# Application of EMFAC-HK

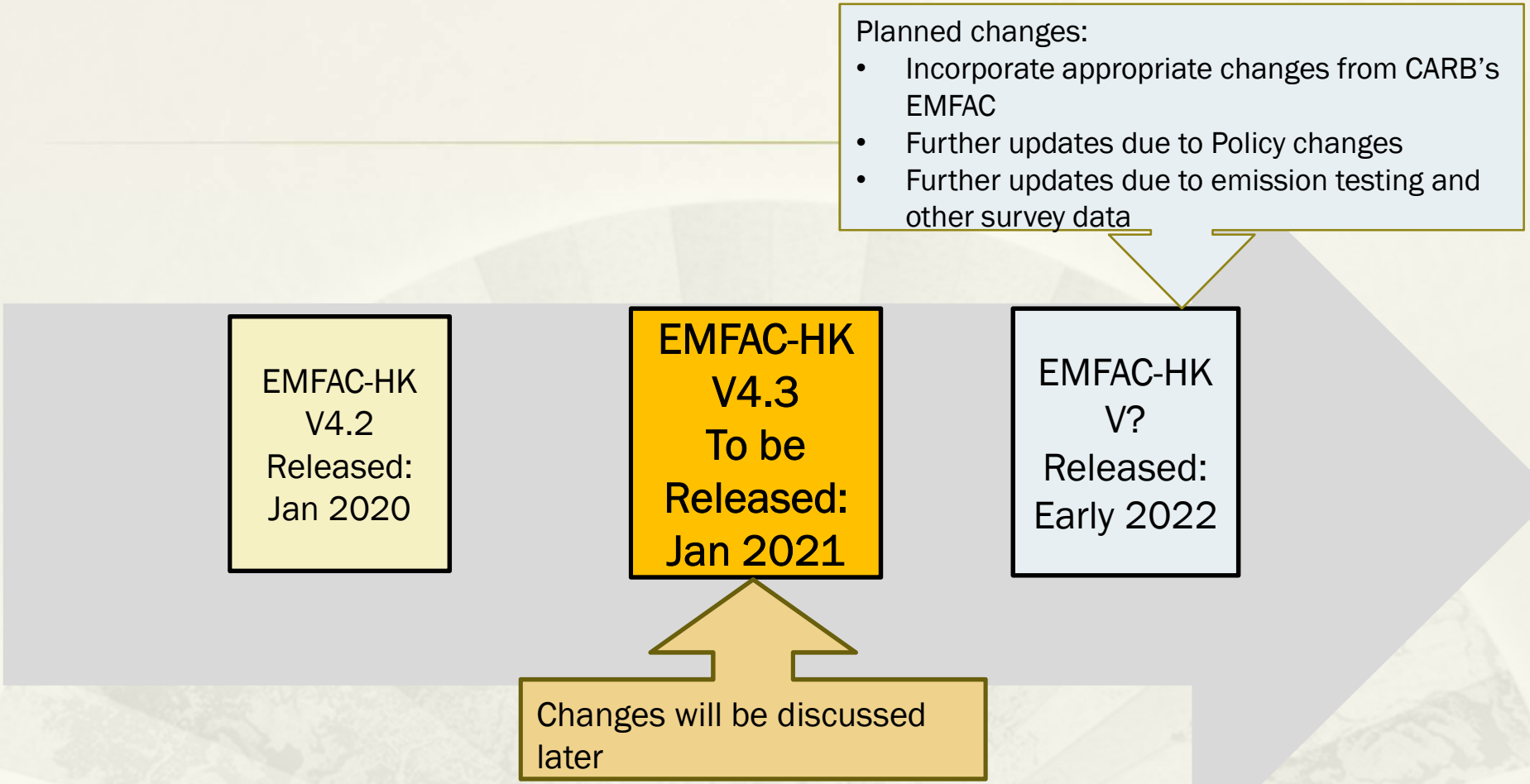
- EMFAC-HK is a tool for estimating vehicle emissions with default vehicle emission factors and assumptions[#].
- Some default data may become outdated over time. Thus, we will issue a new version of EMFAC-HK in early part of the year when necessary.
- When using EMFAC-HK, users can apply other appropriate assumptions in estimating vehicle emissions to suit their projects/purpose.
- The users should judge whether the default values of EMFAC-HK are applicable to their case and how robust their assessments are.

#See Appendix II in https://www.epd.gov.hk/epd/english/environmentinhk/air/guide_ref/emfac-hk.html

# Outline

* Application of EMFAC-HK
* Timeline of EMFAC-HK updates
* Changes made in EMFAC-HK update (V4.2)
* Comparison of emissions and fleet average emission factors (FAEF)
* Transitional Arrangement & Meeting Air Quality Objectives

# Timeline of EMFAC-HK updates



# Outline

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# Comparison of Current EMFAC-HK V4.1 & EMFAC-HK update(V4.2)

## Activity Related

| Current | Update |
|---|---|
| 2016 vehicle population distribution from TD | 2018 vehicle population distribution from TD |
| 2016 VKT from TD | 2018 VKT from TD |
| 2016 survey on vehicle classification on 100 road segments (from 7 a.m. to 11 p.m. from TD | 2018 survey on vehicle classification on 100 road segments (from 7 a.m. to 11 p.m.) from TD |
| EPD conducted surveys in 2012-16 on vehicle classifications to supplement TD's data (from 11 p.m. to 7 a.m.) and 64 additional road segments | EPD conducted surveys in 2014-18 on vehicle classifications to supplement TD's data (from 11 p.m. to 7 a.m.) and 64 additional road segments |
| 2016 speed limits from TD & HyD | 2018 speed limits from TD & HyD |
| 2016 speed surveys from TD | 2018 speed surveys from TD |
| 2016 ambient temperature & relative humidity from HKO | 2018 ambient temperature & relative humidity from HKO |

*Changes highlighted in red.*

# Comparison of Current EMFAC-HK V4.2 & EMFAC-HK update (V4.3)

## Emission Factor Related

| Current | Update |
|---|---|
| Real-world vehicle emission data are used to determine these factors or as references. International emission factors are used using local data as reference if few data are collected in some tech groups. | Updated NOx zero mile emission factors (ZMEF) and deterioration rates (DR) with the same approach but having more real-world vehicle emission data. |
| Estimated occurrence of normal, high and super emitters for petrol cars and LPG taxis based on 2016/17 remote sensing data. | Estimated occurrence of normal, high and super emitters for petrol cars and LPG taxis based on 2018 remote sensing data. |

*Changes highlighted in red.*

# Comparison of Current EMFAC-HK V4.2 & EMFAC-HK update (V4.3)

## Projection Related

| Current | Update |
|---|---|
| Project vehicle emissions up to 2040 | Project vehicle emissions up to 2060 |
| Contains actual population between 2002-2016. The remaining years are backward or forward projected. | Only retain actual 2018 population. The remaining years are backward or forward projected. |

*Changes highlighted in red.*

# Split of Vehicle Classes

Two original classes are split into four classes by its gross vehicle weight

Current

| Vehicle Class Description | Gross Vehicle Weight (tonnes) | Symbol |
|---|---|---|
| Medium & Heavy Goods Vehicles (>15t) | >15t | HGV8 |
| Non-franchised Buses (>15t) | >15t | NFB8 |

Update

| Vehicle Class Description | Gross Vehicle Weight (tonnes) | Symbol |
|---|---|---|
| Medium Goods Vehicles (15-24t) | >15-24t | HGV8 |
| Heavy Goods Vehicles (>24t) | >24t | HGV9 |
| Non-franchised Buses (15-24t) | >15-24t | NFB8 |
| Non-franchised Buses (>24t) | >24t | NFB9 |

New Class Symbols

# Split of Vehicle Classes

Note: New classes are added at the end

| Index | Vehicle Class Description | Fuel | Gross Vehicle Weight (tonnes) | in executables | in csv output file | in INP input file and rtl, bcd & bdn output files |
|---|---|---|---|---|---|---|
| 1 | Private Cars | ALL | ALL | Private Cars (PC) | PC | PC |
| 2 | Taxi | ALL | ALL | Taxi | TAXI | TAXI |
| 3 | Light Goods Vehicles (<=2.5t) | ALL | <=2.5t | Light Goods Vehicles<=2.5t | LGV<=2.5t | LGV3 |
| 4 | Light Goods Vehicles (2.5-3.5t) | ALL | >2.5-3.5t | Lt Goods Vehicles2.5-3.5t | LGV2.5-3.5t | LGV4 |
| 5 | Light Goods Vehicles (3.5-5.5t) | ALL | >3.5-5.5t | Light Goods Vehicles>3.5t | LGV>3.5t | LGV6 |
| 6 | Medium Goods Vehicles (5.5-15t) | ALL | >5.5-15t | Medium Goods Vehicles<=15t | HGV<=15t | HGV7 |
| 7 | Medium Goods Vehicles (15-24t) | ALL | >15-24t | Medium Goods Vehicles15-24t | HGV15-24t | HGV8 |
| 8 | Public Light Buses | ALL | ALL | Public Light Buses | PLB | PLB |
| 9 | Private Light Buses (<=3.5t) | ALL | <=3.5t | Private Light Buses<=3.5t | PrLB<=3.5t | PV4 |
| 10 | Private Light Buses (>3.5t) | ALL | >3.5t | Private Light Buses>3.5t | PrLB>3.5t | PV5 |
| 11 | Non-franchised Buses (<6.4t) | ALL | <=6.36t | Non-franchised Buses<=6.4t | NFB<=6.4t | NFB6 |
| 12 | Non-franchised Buses (6.4-15t) | ALL | >6.36-15t | Non-franchised Buses 6.4-15t | NFB6.4-15t | NFB7 |
| 13 | Non-franchised Buses (15-24t) | ALL | >15-24t | Non-franchised Buses15-24t | NFB15-24t | NFB8 |
| 14 | Single Deck Franchised Buses | ALL | ALL | Franchised Buses(SD) | FBSD | FBSD |
| 15 | Double Deck Franchised Buses | ALL | ALL | Franchised Buses(DD) | FBDD | FBDD |
| 16 | Motor Cycles | ALL | ALL | Motorcycles (MC) | MC | MC |
| 17 | Heavy Goods Vehicles (>24t) | ALL | >24t | Heavy Goods Vehicles>24t | HGV>24t | HGV9 |
| 18 | Non-franchised Buses (>24t) | ALL | >24t | Non-franchised Buses>24t | NFB>24t | NFB9 |
| 19 | Placeholder (P3) | -- | -- | Placeholder (P3) | P3 | P3 |
| 20 | Placeholder (P4) | -- | -- | Placeholder (P4) | P4 | P4 |
| 21 | Placeholder (P5) | -- | -- | Placeholder (P5) | P5 | P5 |

# Re-define of Current Tech Groups and New Tech Groups

Due to splitting of class, these Tech Groups are redefined.

**Diesel Medium Goods Vehicles with GVW 15-24 t (HGV8)**

| Vehicle Emission Standards | Technology Group Index |
|---|---|
| pre-Euro | 153 |
| pre-Euro with DOC Retrofitted | 155 |
| Euro I | 154 |
| Euro II | 157 |
| Euro III | 159 |
| Euro IV | 160 |
| Euro IV - DPF | 163 |
| Euro IV - SCR | 164 |
| Euro V | 161 |
| Euro V - DPF | 165 |
| Euro V - SCR | 166 |
| Euro VI | 162 |

# Re-define of Current Tech Groups and New Tech Groups

Due to splitting of class, these Tech Groups are newly introduced.

**Diesel Heavy Goods Vehicles with GVW >24 t (HGV9)**

| Vehicle Emission Standards | Technology Group Index |
|---|---|
| pre-Euro | 246 |
| pre-Euro with DOC Retrofitted | 248 |
| Euro I | 247 |
| Euro II | 250 |
| Euro III | 252 |
| Euro IV | 253 |
| Euro IV - DPF | 256 |
| Euro IV - SCR | 257 |
| Euro V | 254 |
| Euro V - DPF | 258 |
| Euro V - SCR | 259 |
| Euro VI | 255 |

# Re-define of Current Tech Groups and New Tech Groups

Due to splitting of class, these Tech Groups are redefined.

**Diesel Non-franchised Buses with GVW 15-24 t (NFB8)**

| Vehicle Emission Standards | Technology Group Index |
|---|---|
| pre-Euro | 53 |
| pre-Euro with DOC Retrofitted | 55 |
| Euro I | 54 |
| Euro II | 57 |
| Euro III | 59 |
| Euro IV | 60 |
| Euro IV - DPF | 63 |
| Euro IV - SCR | 64 |
| Euro V | 61 |
| Euro V - DPF | 65 |
| Euro V - SCR | 66 |
| Euro VI | 62 |

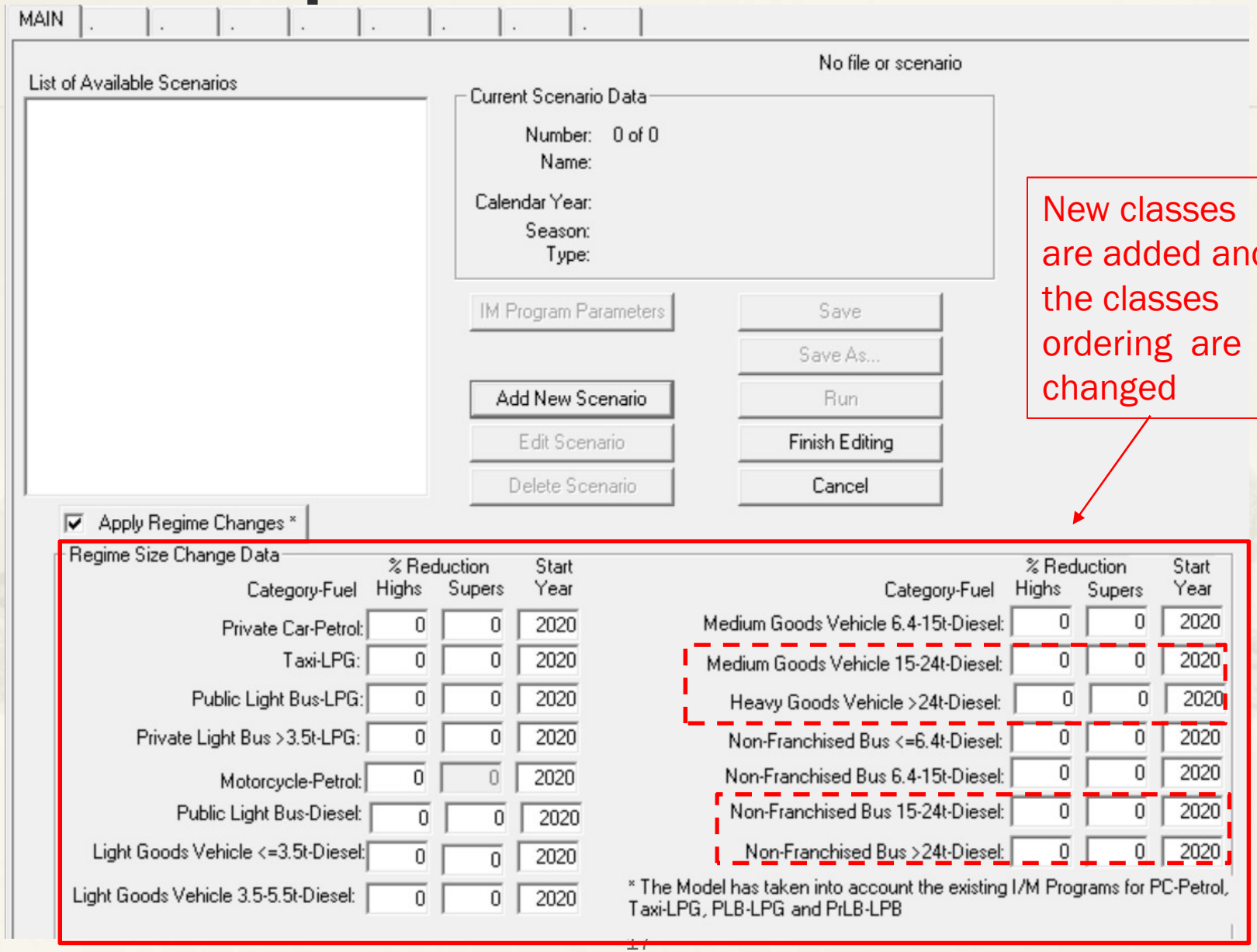
# Re-define of Current Tech Groups and New Tech Groups

Due to splitting of class, these Tech Groups are newly introduced.

**Diesel Non-franchised Buses with GVW >24 t** (NFB9)

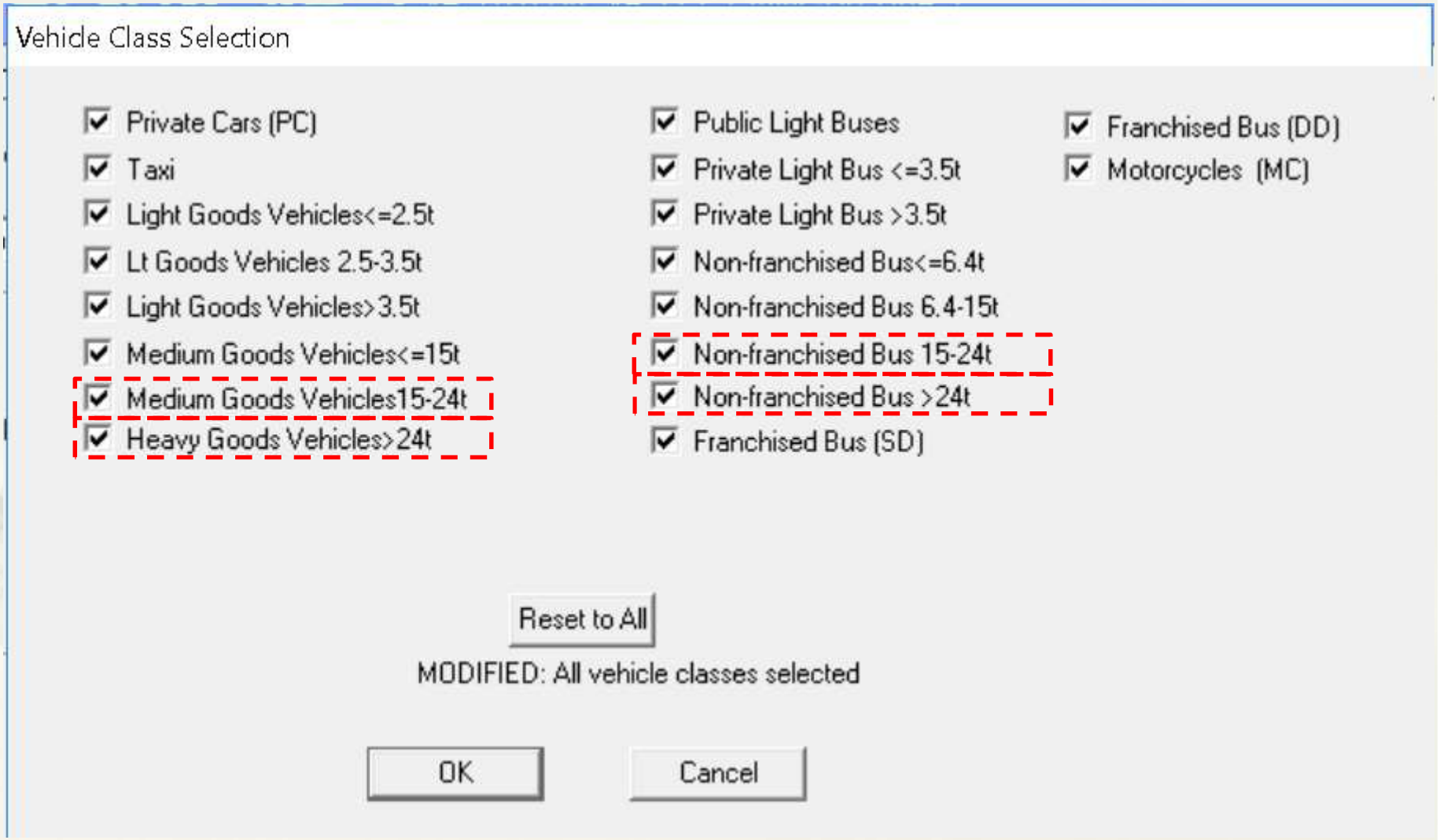
| Vehicle Emission Standards | Technology Group Index |
|---|---|
| pre-Euro | 232 |
| pre-Euro with DOC Retrofitted | 234 |
| Euro I | 233 |
| Euro II | 236 |
| Euro III | 238 |
| Euro IV | 239 |
| Euro IV - DPF | 242 |
| Euro IV - SCR | 243 |
| Euro V | 240 |
| Euro V - DPF | 244 |
| Euro V - SCR | 245 |
| Euro VI | 241 |

# Input Screen Revised




New classes are added and the classes ordering are changed

# Input Screen Revised



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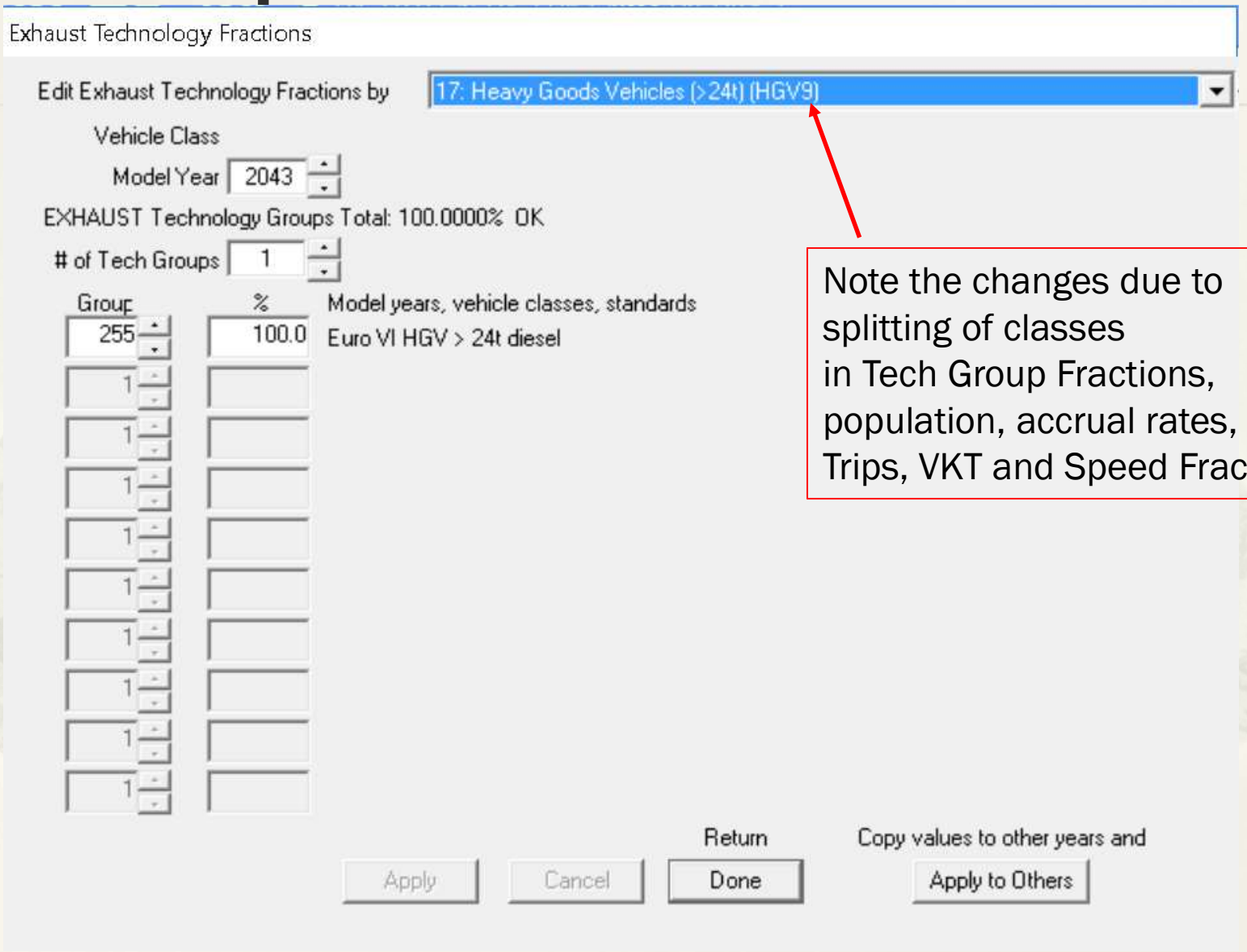


Note the changes due to splitting of classes in Tech Group Fractions, population, accrual rates, Trips, VKT and Speed Fractions

# Input File Revised

```
EmfacHK429-Header
    Version 4 2 99 1
    Scenario-Count 1
    HK-IM Y 0 0 2020 0 0 2020 0 0 2020 0 0 2020 0 0 2020 0 0 2020 0 0 2020 0 0 2020 0 0 2020 0 0 2020 0 0 2020 0 0 2020 0 0 2020 0 0 2020
    HKUNITS Y
End-Header
Begin-Scenario 1
    Title Hong Kong SAR Annual CYr 2030 Default Title
    Program-Mode Burden
    Area-Method One-County
    Area-Type SAR
    Area-Number 38 [Hong Kong SAR]
    HC-Mode VOC
    PM-Mode PM10
    CYr 2030
    BYr -1
    MYr All
    Vehicles PC TAXI LGV3 LGV4 LGV6 HGV7 HGV8 PLB PV4 PV5 NFB6 NFB7 NFB8 FBSD FBDD MC HGV9 NFB9
    Season Annual
    Burden-Reports CSV_Standard Detail_ModelYear Detail_TechGroup
    Burden-Daily
    Burden-Speeds 5
End-Scenario
```

Note that the classes order are changed and more classes are added.

More classes

# Input File Revised

For matric-form data types, e.g. Accrual Rates, Population and Trips,

rows 7, 13, 28, 34, 49 & 55 represent the redefined HGV8 and NFB8.

rows 17, 18, 38, 39, 59 & 60 represent the new classes HGV9 and NFB9,

for the three fuel types.

Data rows for re-defined classes

Data rows for the two new classes

```
Applies-To Area-Type SAR
Applies-To Area-Number 38 [Hong Kong SAR]
Begin-Real-Array
    Dims 45 21 3 1
    Data
     58666.69 58011.15 57815.83 57599.93 57278.
     0 0 0 0 0 0 0 0 0 0 0 0 0 1.186901 0 0 0.5
     2.59859 1.128329 1.277479 1.333094 1.32001
     129.1886 63.06879 66.07736 69.02385 71.216
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     0 0 0 0 0 0 0 0 0 0 0 0 9.929201 9.627542
     0 0 0 0 0 0 0 0 0.1712886 0.6761877 0.662
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     7303.375 6612.848 6358.087 6066.795 5724.
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     1049.438 967.454 859.5019 736.3349 615.001
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     88.35207 38.36319 43.4343 45.32519 44.880
     6498.749 3172.635 3323.979 3472.201 3582.
     2024.887 832.7003 800.4194 841.8478 883.5
     1497.511 506.3909 512.4727 570.3722 617.8
     2935.469 1239.446 1241.87 1362.395 1435.0
     240.8442 213.0932 215.9494 240.3654 287.1
     43.3396 34.94924 33.54574 38.28527 36.576
     394.522 300.0818 318.9268 319.5894 305.08
     202.0217 202.1415 222.0227 235.5645 237.7
     146.4867 127.621 139.2299 155.4885 159.61
     391.4043 342.7589 355.0259 364.7609 354.7
     48.99867 36.00099 45.99639 9.999814 8.000
     280.9893 176.9878 46.99999 45.00243 64.00
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     782.2275 379.8688 394.4093 421.067 423.95
     2.0201683E-02 2.1263627E-02 0.180876 0.33
     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

# Input File Revised

For by-class block data types, e.g. VKT, Speed Fractions and Tech Group Fractions, users are reminded that the classes HGV8 and NFB8 are re-defined and the addition of new classes HGV9 and NFB9

```
Begin-Data-Item
    DataType 40 VKTVehicleFuelHour
    Applies-To CYr 2018
    Applies-To Area-Method One-County
    Applies-To Area-Type SAR
    Applies-To Area-Number 38 [Hong Kong SAR]
    Applies-To Vehicle HGV8
    Applies-To Fuel Diesel
    Begin-Real-Array
        Dims 24 1 1 1
        Data
         24944.09 20380.48 17182.58 16013.73 18385.63 25667.82 54428.
    End-Real-Array
End-Data-Item
```

# Output File Revised

For csv files (Burden mode), new columns are added for the new classes. Also note that meaning of the columns under HGV8 and NFB8 are redefined.

| CB | CC | CD | CE | CF | CG | CH | CI | CJ | CK | CL | CM | CN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

New columns are added for HGV9 and NFB9

| LPG | MC-TOT | HGV>24t-NCAT | HGV>24t-CAT | HGV>24t-DSL | HGV>24t-LPG | HGV>24t-TOT | NFB>24t-NCAT | NFB>24t-CAT | NFB>24t-DSL | NFB>24t-LPG | NFB>24t-TOT | ALL-TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 72695 | 0 | 0 | 6851 | 0 | 6851 | 0 | 0 | 2 | 0 | 2 | 9563 |
| 0 | 1207852 | 0 | 0 | 591441 | 0 | 591441 | 0 | 0 | 239 | 0 | 239 | 434614 |
| 0 | 436127 | 0 | 0 | 27401 | 0 | 27401 | 0 | 0 | 8 | 0 | 8 | 22142 |
| | | | | | | | | | | | | |
| 0 | 0.3888 | 0 | 0 | 0.01823 | 0 | 0.01823 | 0 | 0 | 0.00001 | 0 | 0.00001 | 1.443 |
| 0 | 0.16287 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 |

# Output File Revised

For bdn files (Burden mode), new rows are added for the new classes (and new tech groups). Also note that meaning of the rows of HGV8 and NFB8 are redefined.

New rows are added for HGV9 and NFB9 and the associated new tech groups

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 7 | Vh | 1 | 2030 | Hong Kon | MC | AllMYr | TOT | Day | 72695.09 | 1207852 | 4 |
| 8 | TG | 1 | 2030 | Hong Kon | HGV9 | 2012 | Ex254 | Day | 41.96804 | 3514.928 | 167 |
| 9 | TG | 1 | 2030 | Hong Kon | HGV9 | 2012 | Ex258 | Day | 45.72055 | 3829.209 | 182 |
| 0 | TG | 1 | 2030 | Hong Kon | HGV9 | 2012 | Ex259 | Day | 40.53642 | 3395.026 | 162 |
| 1 | TG | 1 | 2030 | Hong Kon | HGV9 | 2012 | Ev035 | Day | 0 | 0 | |
| 2 | MY | 1 | 2030 | Hong Kon | HGV9 | 2012 | GAS | Day | 0 | 0 | |
| 3 | MY | 1 | 2030 | Hong Kon | HGV9 | 2012 | DSL | Day | 128.225 | 10739.16 | 512 |
| 4 | MY | 1 | 2030 | Hong Kon | HGV9 | 2012 | LPG | Day | 0 | 0 | |
| 5 | MY | 1 | 2030 | Hong Kon | HGV9 | 2012 | TOT | Day | 128.225 | 10739.16 | 512 |
| 6 | TG | 1 | 2030 | Hong Kon | HGV9 | 2013 | Ex254 | Day | 85.62686 | 7179.771 | 342 |

# Output File Revised

Similarly, for rtl files (EMFAC mode), new columns are added for the new classes. Also note that meaning of the columns under HGV8 and NFB8 are redefined.

| CC | CD | CE | CF | CG | CH | CI | CJ | CK | CL | CM | CN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | HGV9 | HGV9 | HGV9 | HGV9 | HGV9 | NFB9 | NFB9 | NFB9 | NFB9 | NFB9 | ALL |
| | NCAT | CAT | DSL | LPG | ALL | NCAT | CAT | DSL | LPG | ALL | NCAT |
| | | | | | | | | | | | |
| .9339 | 0 | 0 | 0.0975 | 0 | 0.0975 | 0 | 0 | 0.0953 | 0 | 0.0953 | 2.654 |
| .5924 | 0 | 0 | 0.0522 | 0 | 0.0522 | 0 | 0 | 0.0512 | 0 | 0.0512 | 1.714 |
| .3956 | 0 | 0 | 0.0375 | 0 | 0.0375 | 0 | 0 | 0.0372 | 0 | 0.0372 | 1.174 |

New columns are added for HGV9 and NFB9

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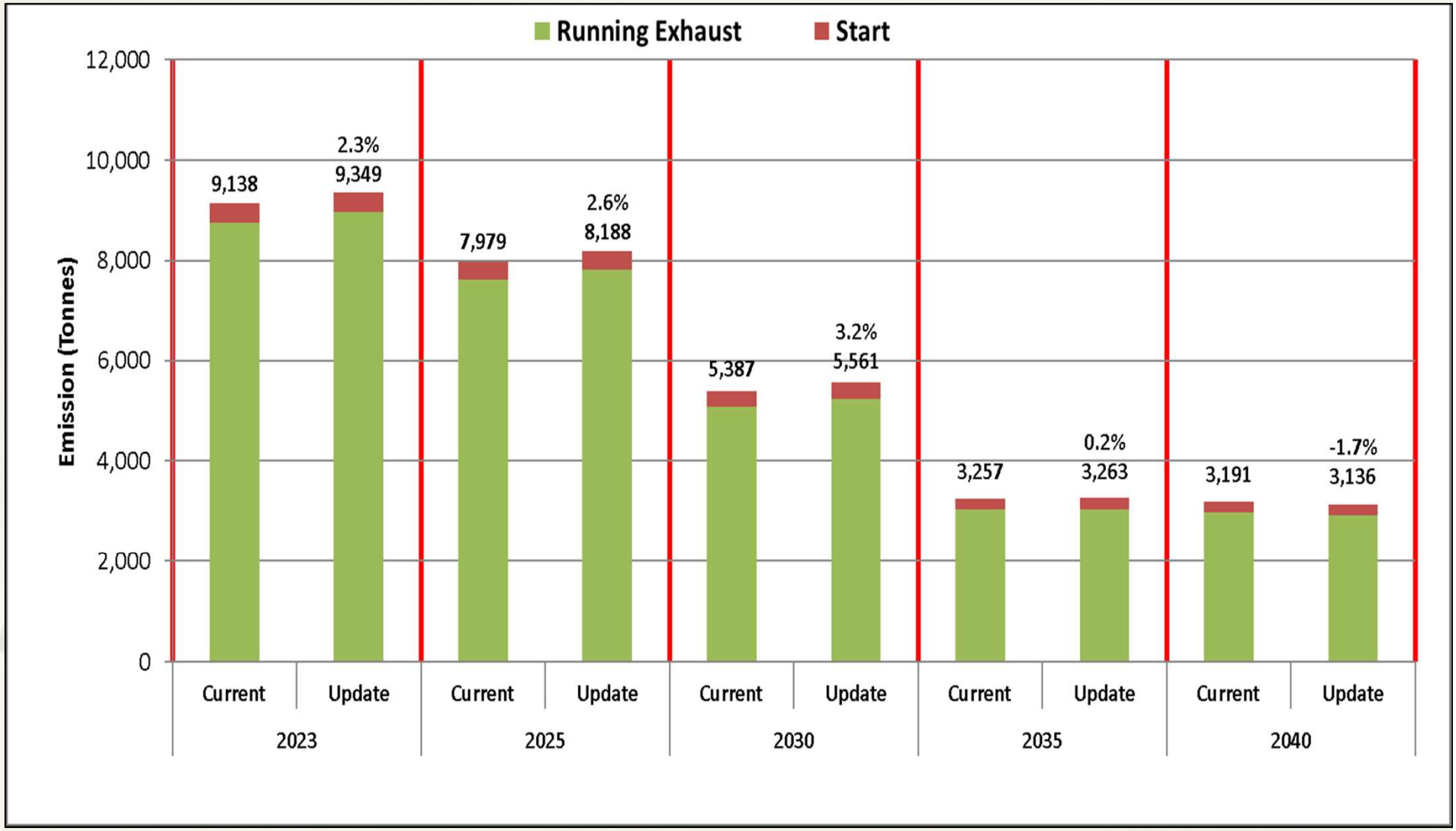
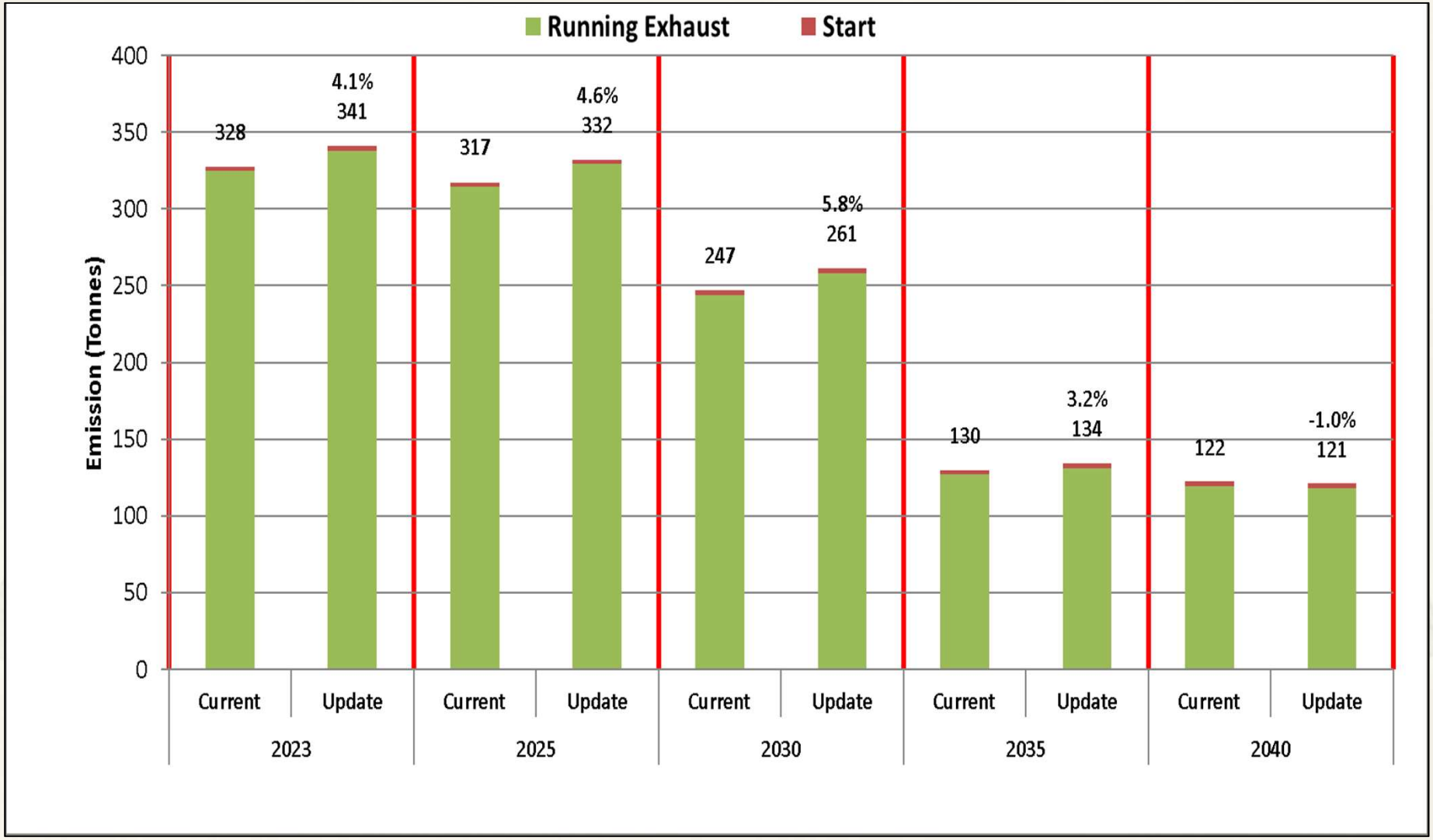
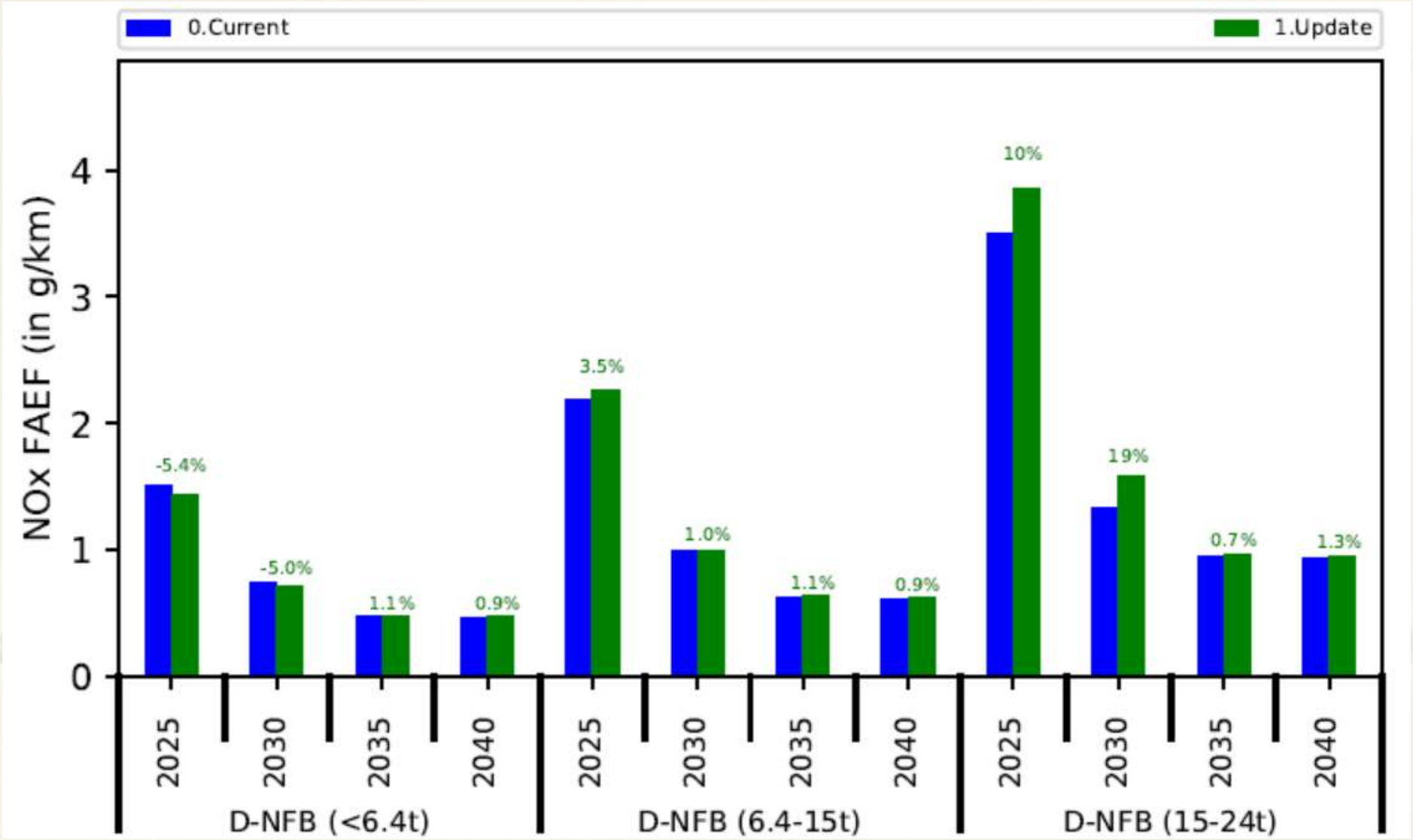
# Comparison of Territory-wide NOx Emissions in Current (V4.2) and EMFAC-HK update (V4.3)



# Comparison of Territory-wide $PM_{10}$ Emissions in Current (V4.2) and EMFAC-HK update (V4.3)

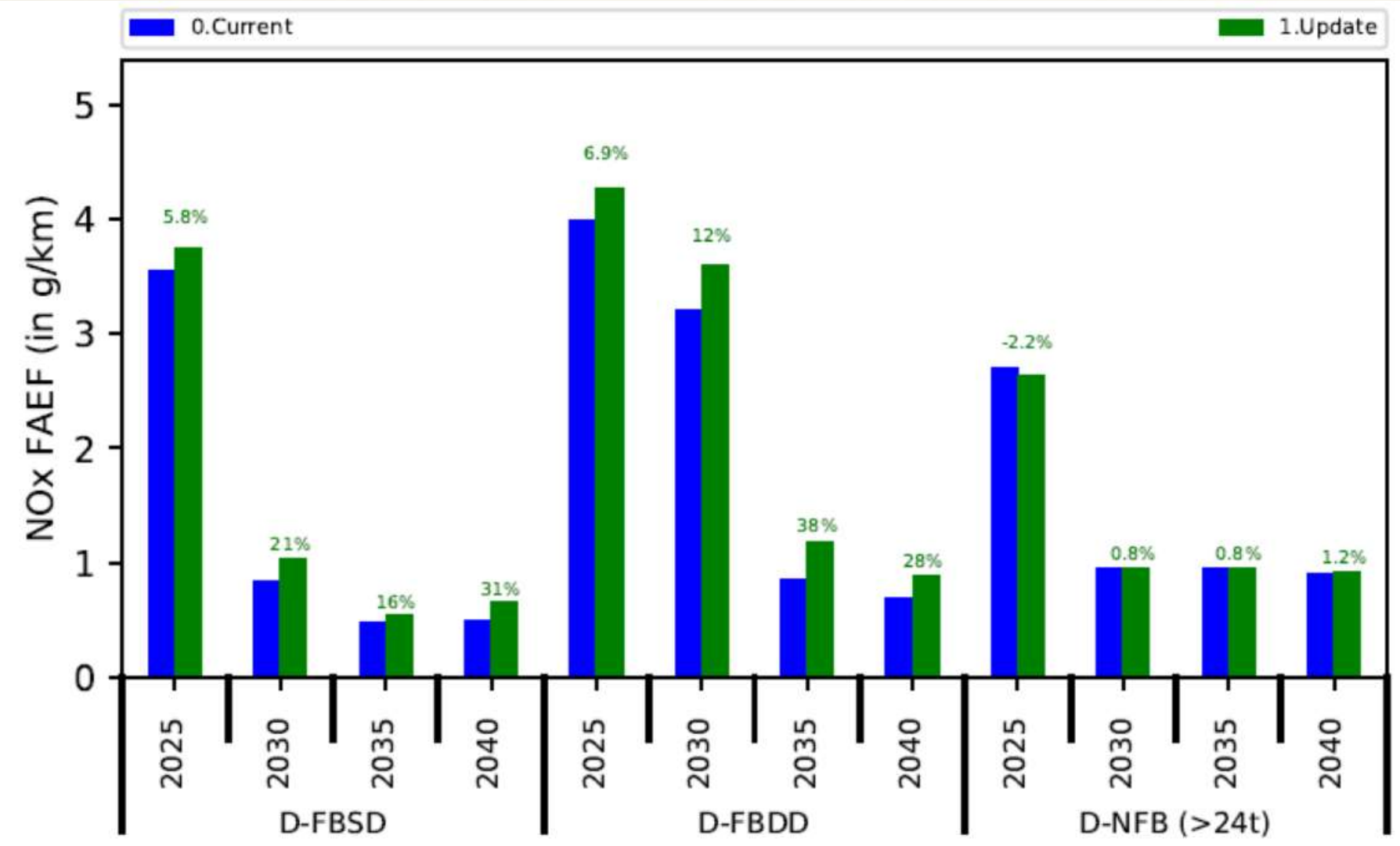


# Comparison of NOx (Running Exhaust) FAEF (at 28km/hr)




Remark: “D-”, “P-”and “L” mean Diesel, Petrol and LPG respectively.

# Comparison of NOx (Running Exhaust) FAEF (at 28km/hr)




Remark: “D-”, “P-”and “L” mean Diesel, Petrol and LPG respectively.

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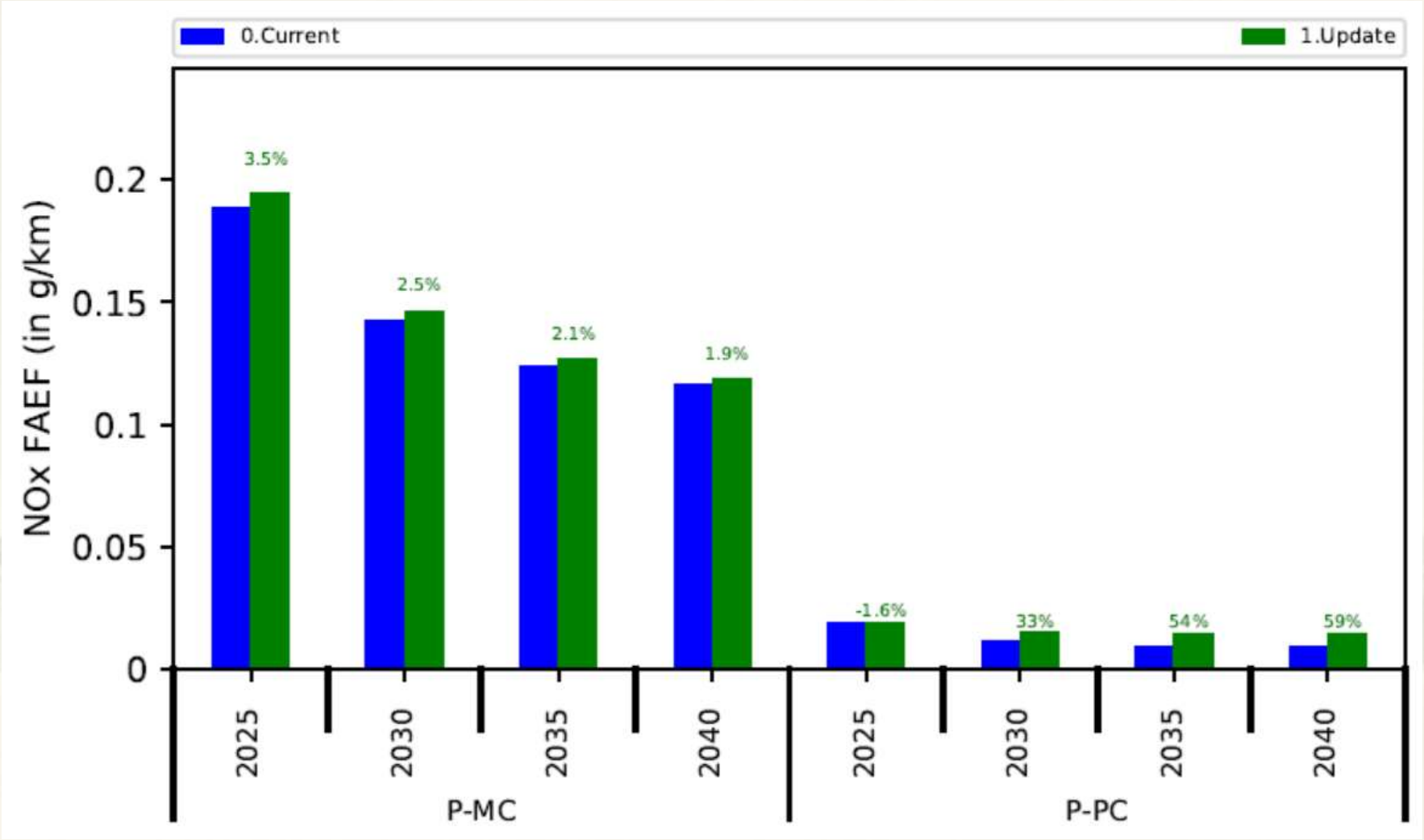


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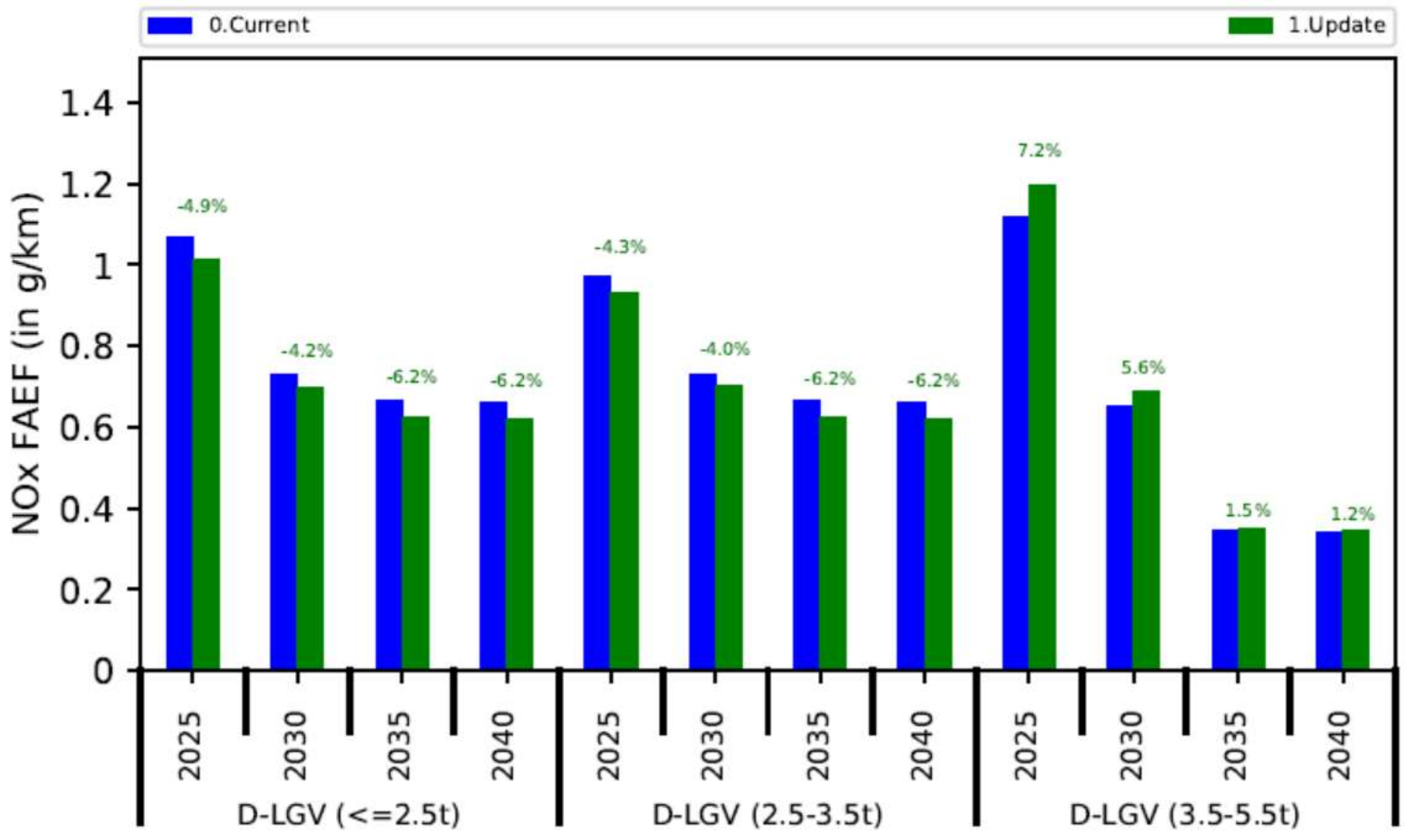
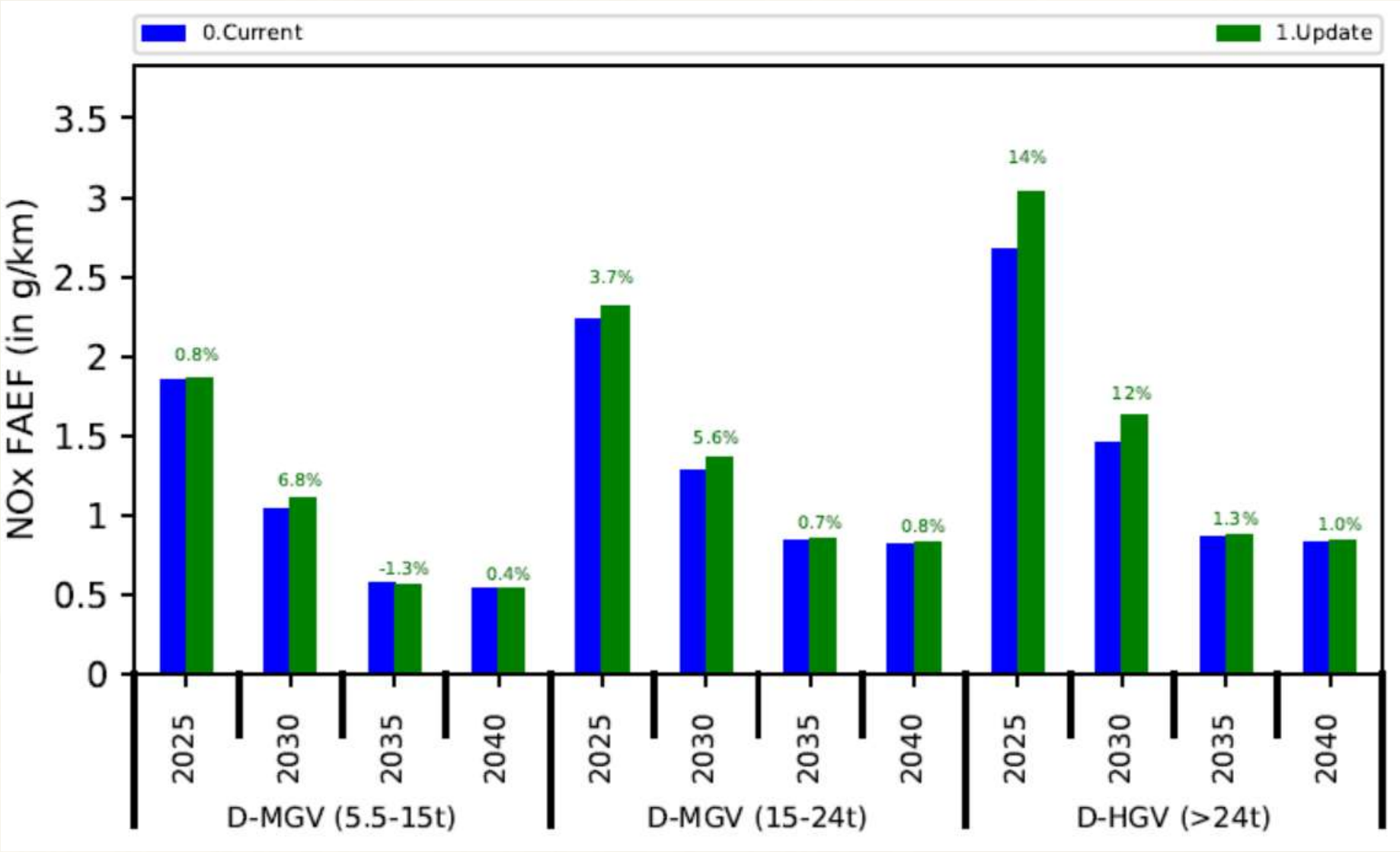
# Comparison of NOx (Running Exhaust) FAEF (at 28km/hr)



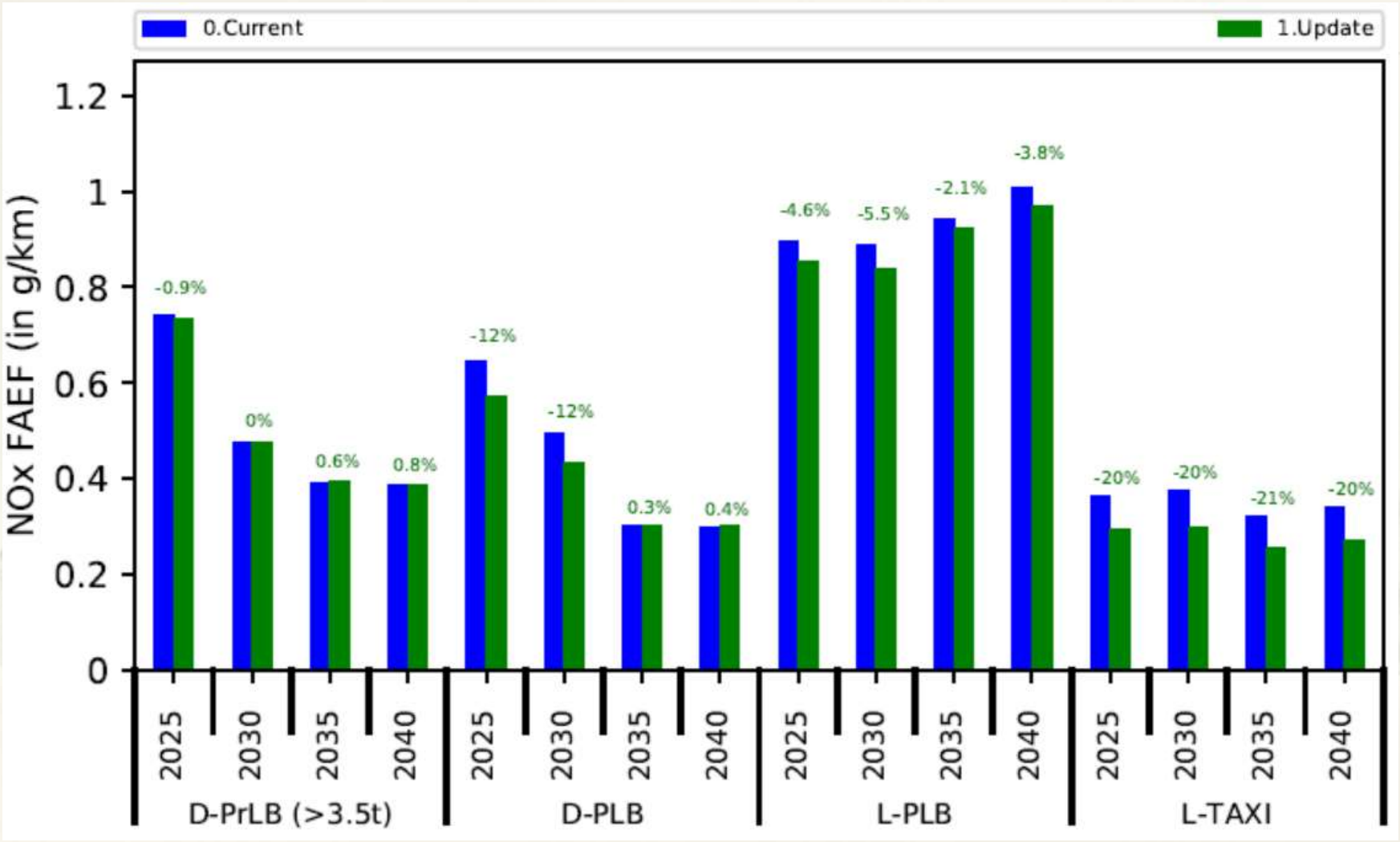

Remark: “D-”, “P-”and “L” mean Diesel, Petrol and LPG respectively.

# Comparison of NOx (Running Exhaust) FAEF (at 28km/hr)




Remark: “D-”, “P-”and “L” mean Diesel, Petrol and LPG respectively.

# Comparison of NOx (Running Exhaust) FAEF (at 28km/hr)

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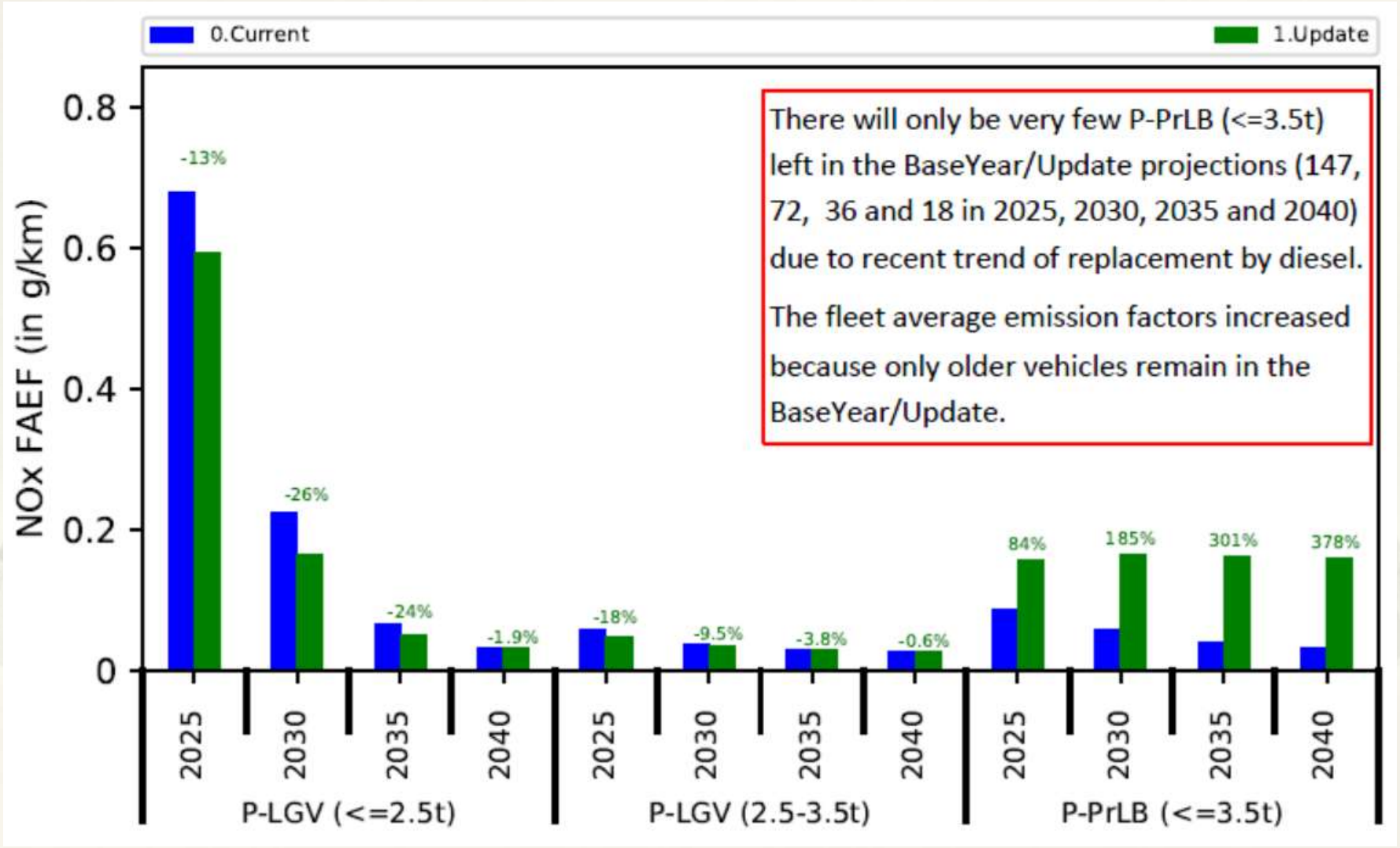
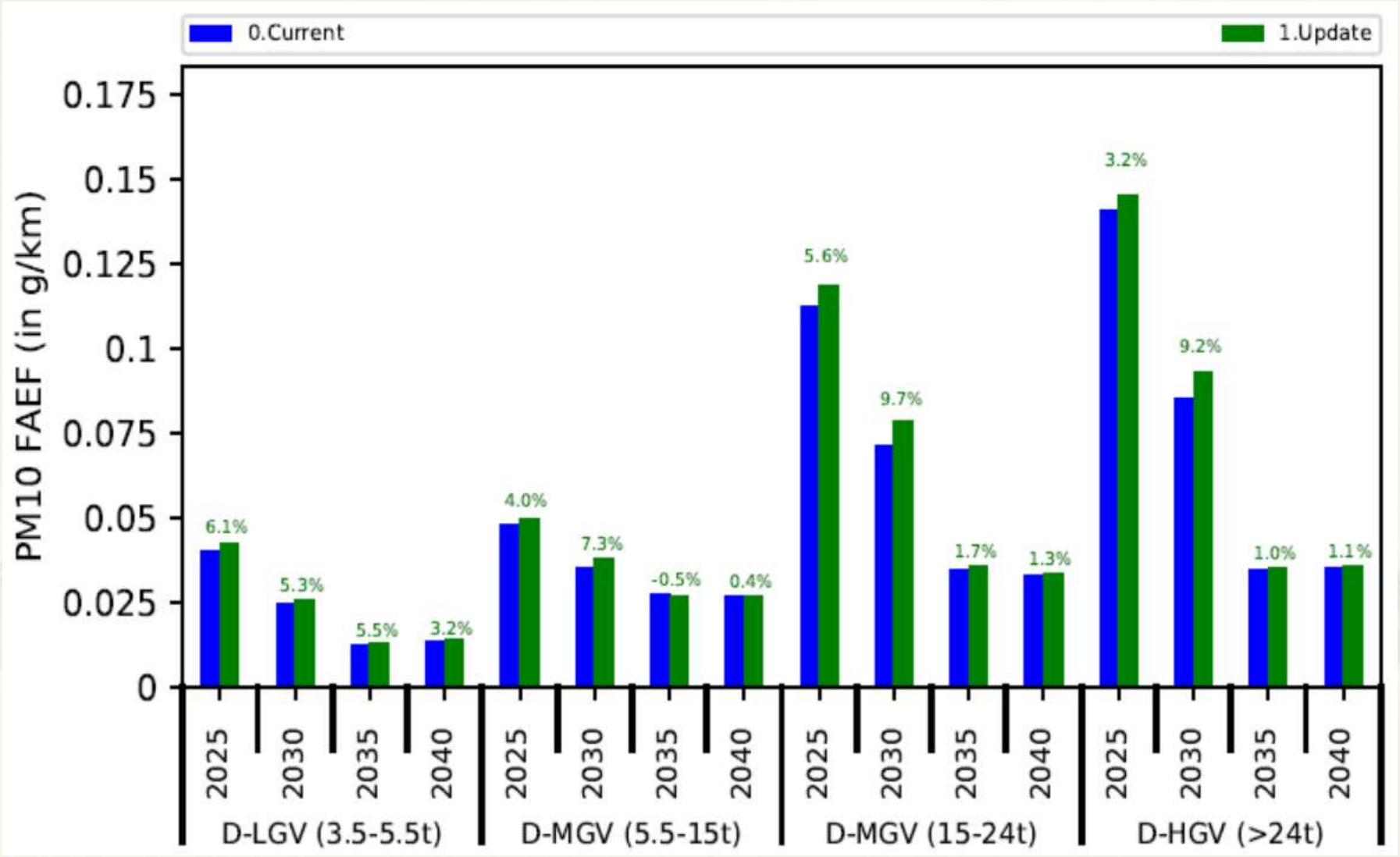


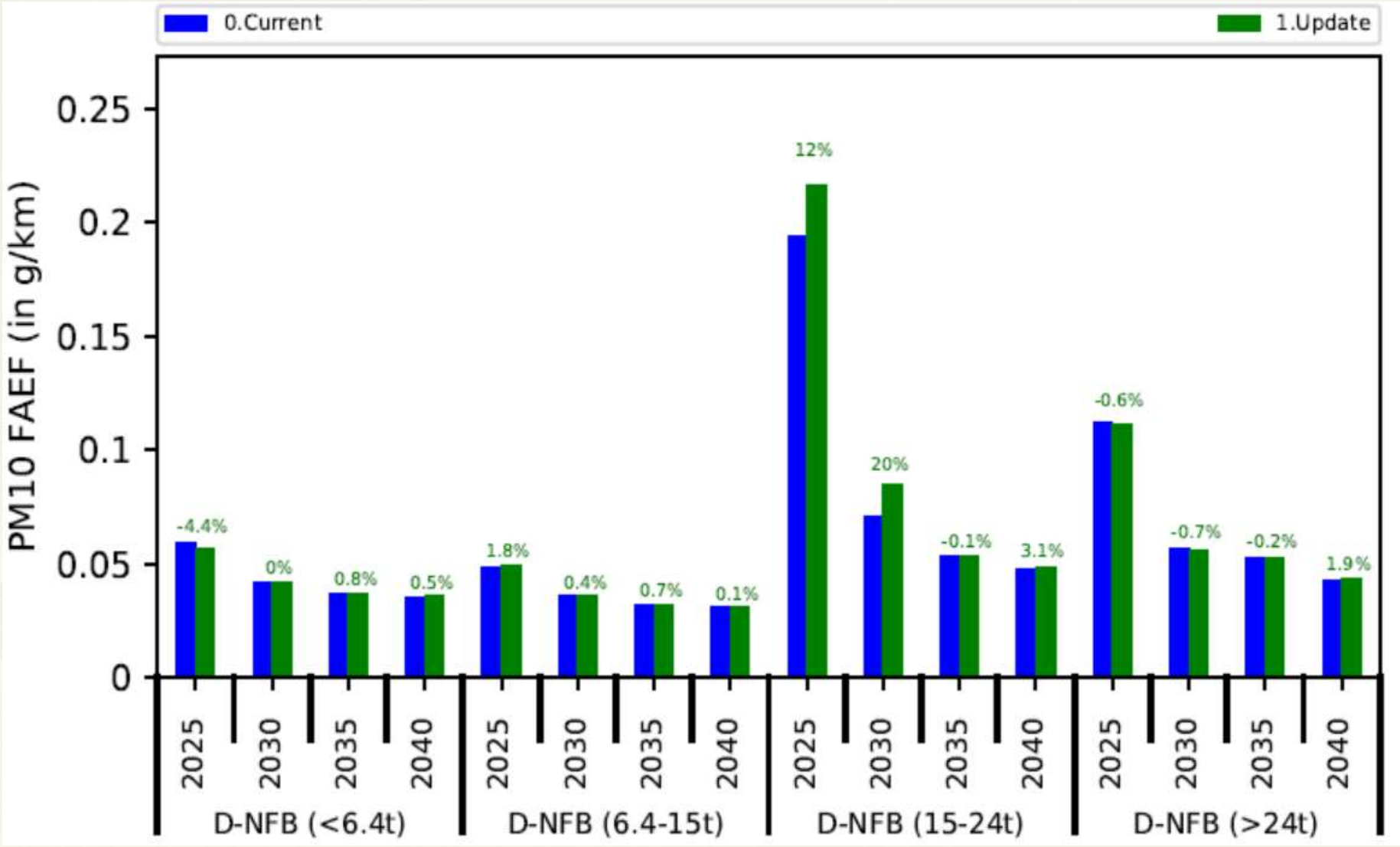

Remark: “D-”, “P-”and “L” mean Diesel, Petrol and LPG respectively.

# Comparison of PM10 (Running Exhaust) FAEF (at 28km/hr)




Remark: “D-”, “P-”and “L” mean Diesel, Petrol and LPG respectively.

# Comparison of PM10 (Running Exhaust) FAEF (at 28km/hr)

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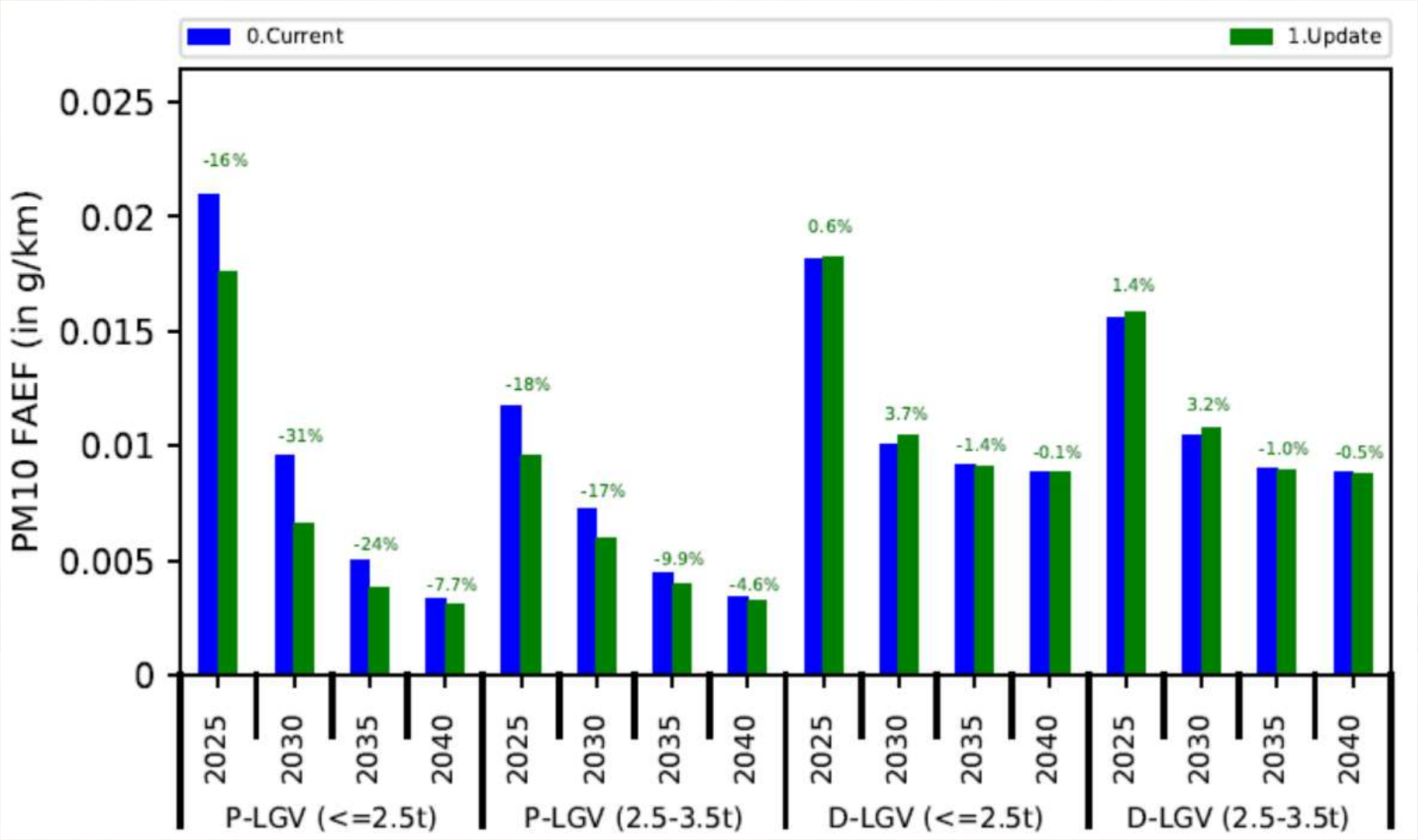


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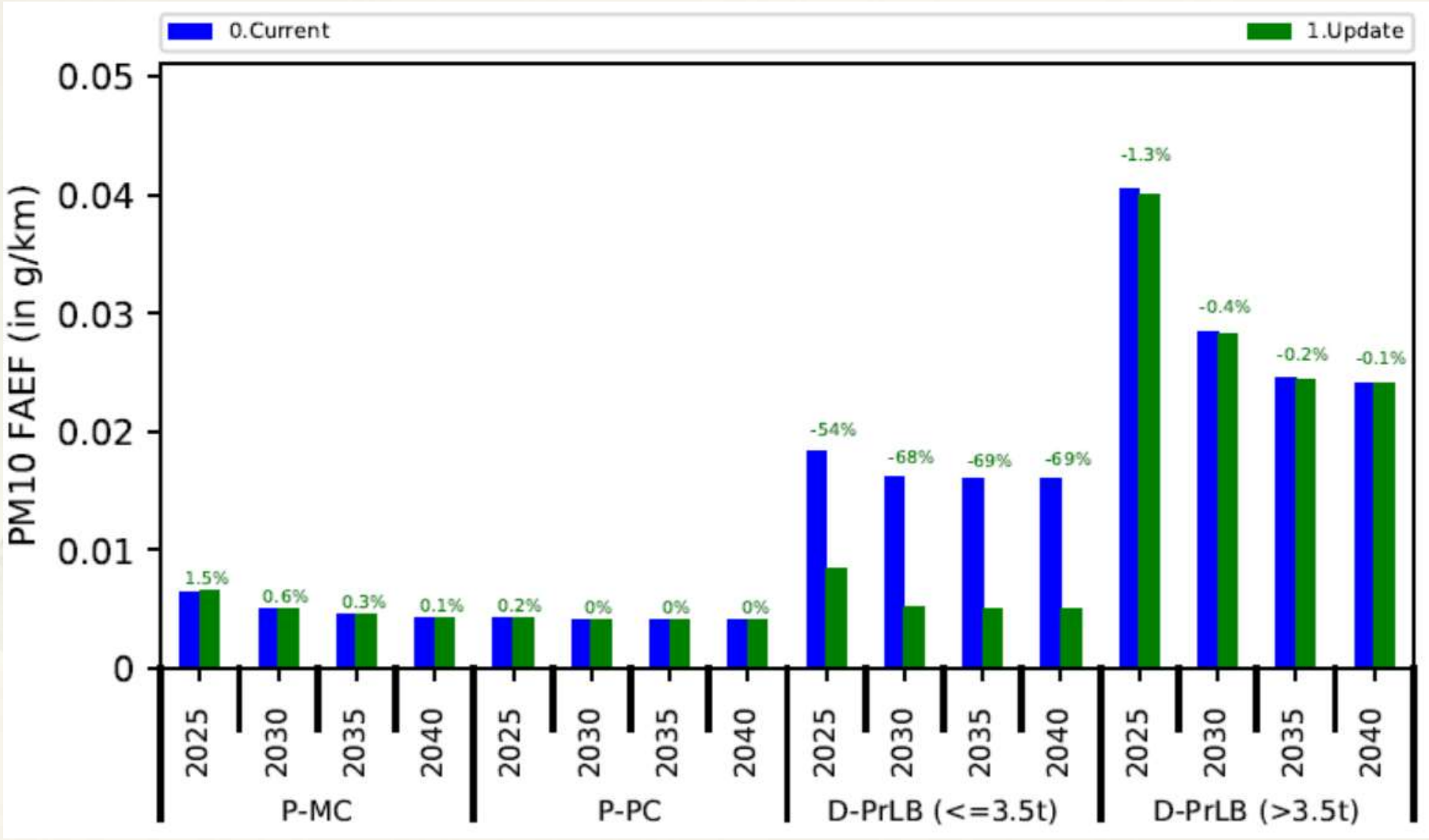


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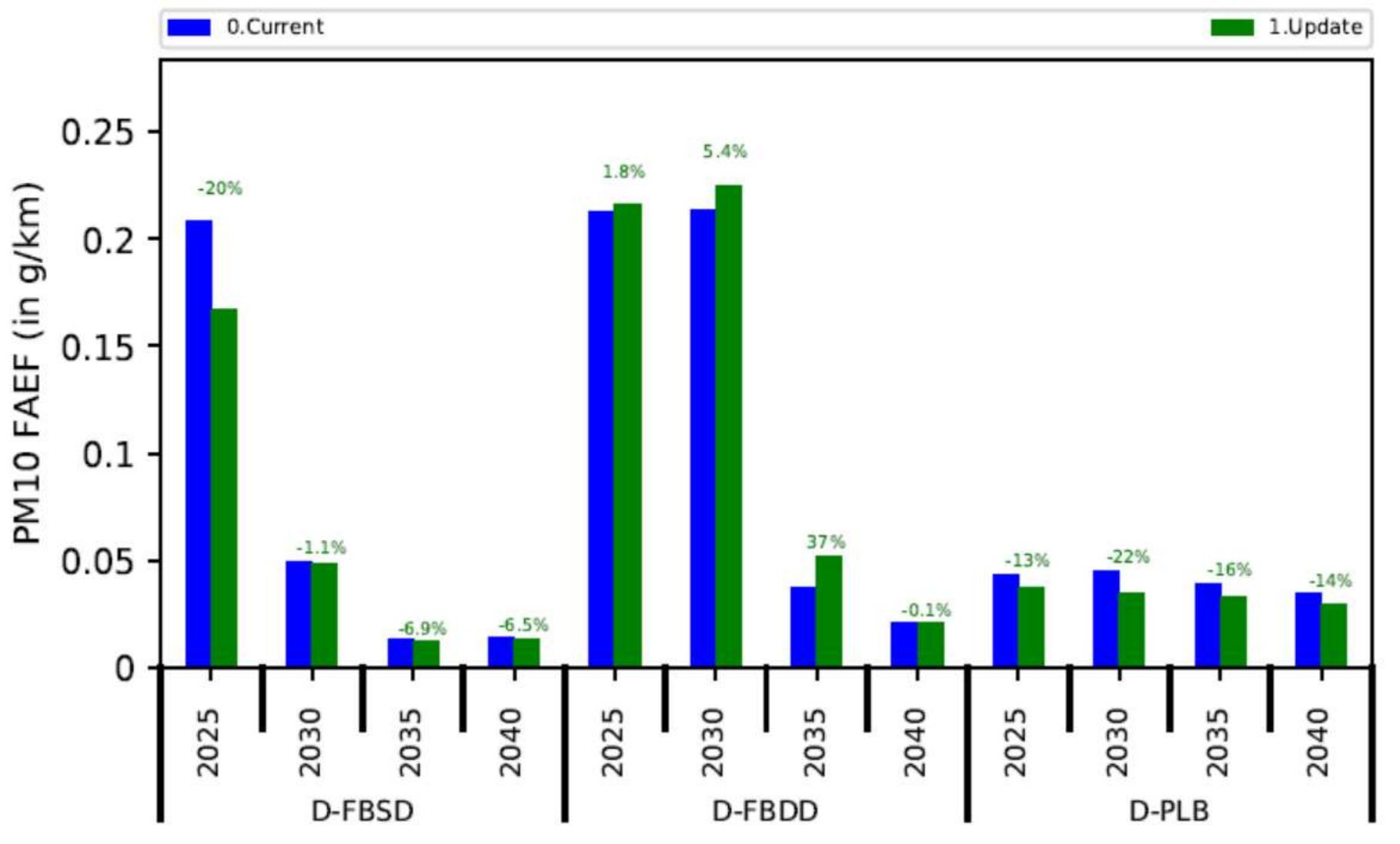


Remark: “D-”, “P-”and “L” mean Diesel, Petrol and LPG respectively.

# Release of EMFAC-HK

* Will release EMFAC-HK V4.3 in January 2021.

# Outline

* Application of EMFAC-HK
* Timeline of EMFAC-HK updates
* Changes made in EMFAC-HK update (V4.3)
* Comparison of emissions and fleet average emission factors (FAEF)
* Transitional Arrangement & Meeting Air Quality Objectives

# Transitional Arrangement for Use of EMFAC-HK in EIA Studies

* Provision of 6-month transition period for EIA studies being conducted for adaption to the new model and reduction of abortive work (same as the current arrangement)

* During the transition period, EIA reports submitted under Section 6 of the EIAO may continue to use the previous old model version for the air quality impact assessment. After the transition period, all EIA report submissions must use the new model version

# Meeting Air Quality Objectives

* **Air Quality Objectives (AQOs) are the principal air quality standards** in determining the acceptability of air quality impacts of development projects

* Annex 4 of the Technical Memorandum on EIA Process (TM) issued under the EIAO sets out the criteria for evaluating air quality impact in EIA studies. The key criterion is that AQOs and other standards established under the Air Pollution Control Ordinance have to be met. The same criterion applies to non-EIAO case.

* Project proponents need to demonstrate that, by means of various mathematical air quality assessment models, upon inclusion of the impacts caused by the project, the **cumulative air pollutant concentration** at identified air sensitive receivers would **comply with the AQOs** during the **construction and operation phases** of the project.

* Meeting the annual concentration standard of NO2, i.e. 40ug/m3, is challenging in urban districts and at the vicinity of trunk roads

* Appropriate **mitigation measures** have to be adopted to **control and prevent non-compliance**, if necessary.

Thank you.
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