# UCC2
# ICE optimization peak thermal efficiency towards 50%

LONGRUN SC F2F

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FEV

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- Outlook (M42-M48)

# Status Roadmap

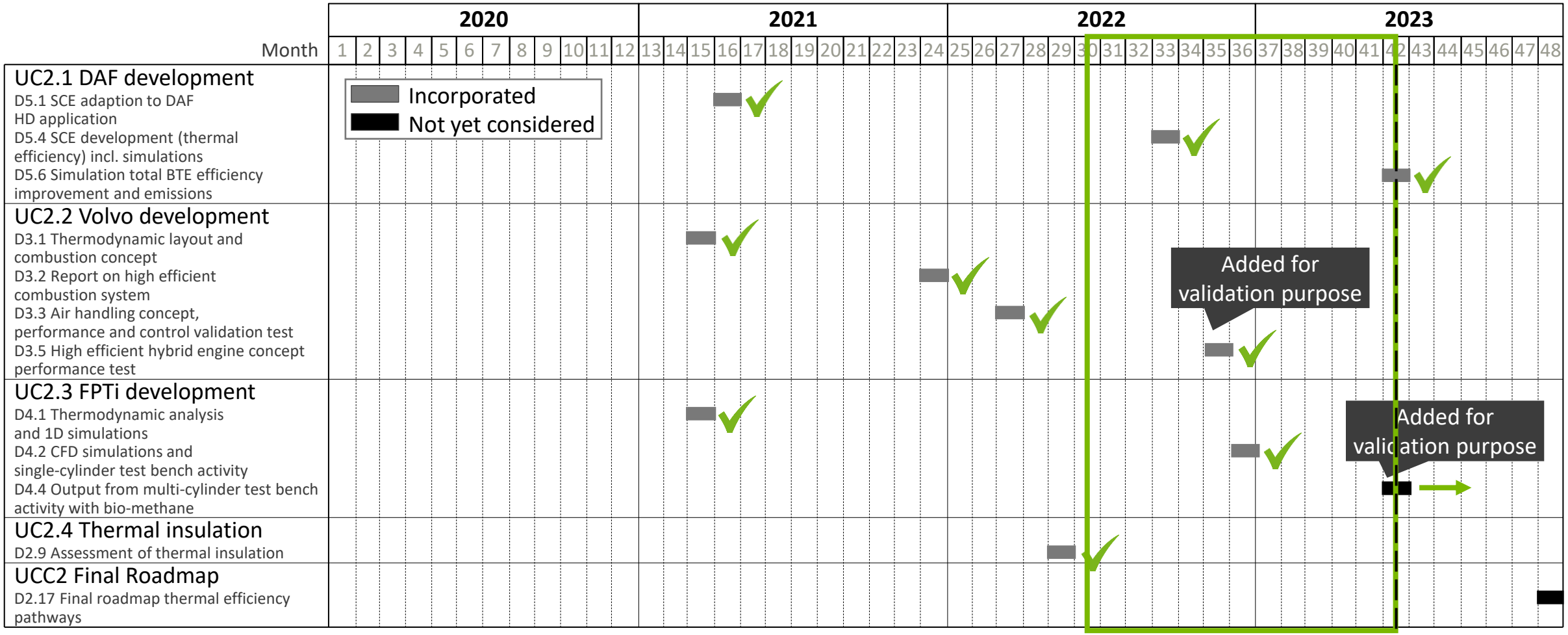
# Objectives

| | Engine upgrade | Combustion improvement, incl. heat transfer reduction | Mechanical improvement | Air handling | BTE Target |
|---|---|---|---|---|---|
| UC2.1 DAF development | 1.0 % | 1.3 % | 0.7 % | 1.0 % | 50.0 % |
| UC2.2 VOLVO development | | 2.0 % | 1.0 % | 2.0 % | 50.0 % |
| UC2.3 FPTi development | | 3.0 % | 1.0 % | 3.0 % | 46.0 % |
| UC2.4 Coatings | | 0.5 % | | | 0.5 % |

# UCC 2

# Status of deliverables input

» STATUS M42




» More than 90 % received of required results on the way to final roadmap

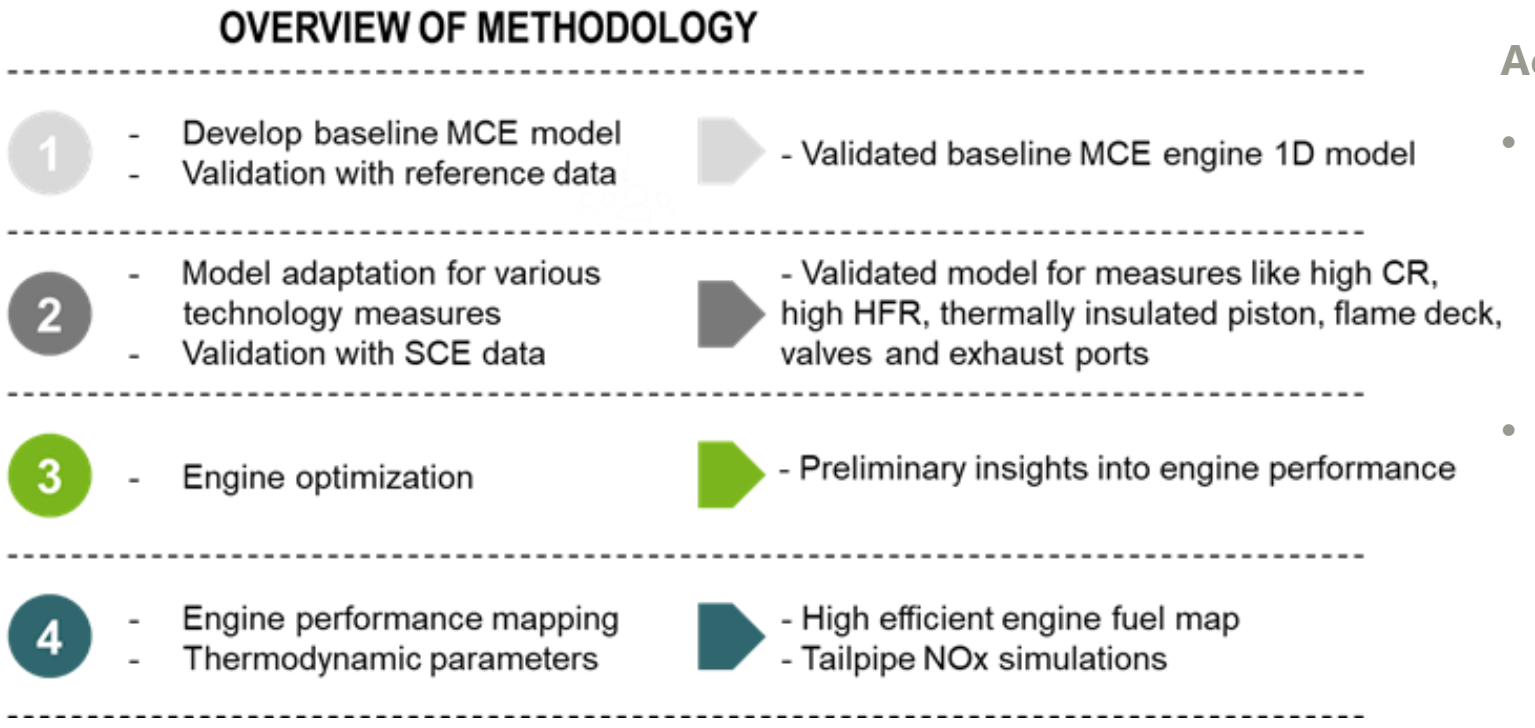
# Results & Outcome

# Task 5.6 Simulation total BTE efficiency improvement and tail-pipe emissions

**Task 5.6 Simulation total BTE efficiency improvement and tail-pipe emissions (TL: RWTH; FEV, DAF) [M30-M36]**
**ST5.6.1 Simulation on BTE (TL: RWTH; Partners: FEV, DAF)**
Demonstration will be in simulation only (consolidation task for FEV with RWTH support) which includes results from all (horizontal and vertical) tasks (thermal barrier-coating/alternative stroke-bore-ratio/alternative fuels/etc.).
**ST5.6.2 Simulation / prediction tail-pipe out NOx (TL: RWTH; FEV, DAF)**
Since the aftertreatment performance is highly depending on exhaust gas temperature and because not all technologies will be present in the full engine the exhaust gas temperature used for determining aftertreatment conversion efficiency need to be corrected as well (using a model from the aftertreatment system in the horizontal WP) and the NOx-conversion will be simulated (and with that the tailpipe-out NOx). The (FEV)-aftertreatment model need to be tuned on the DAF engine. The simulation will be a task for RWTH.

# ST5.6.1 Simulation on BTE

ENGINE MODEL DEVELOPMENT AND GENETIC ALGORITHM BASED OPTIMIZATION - OVERVIEW

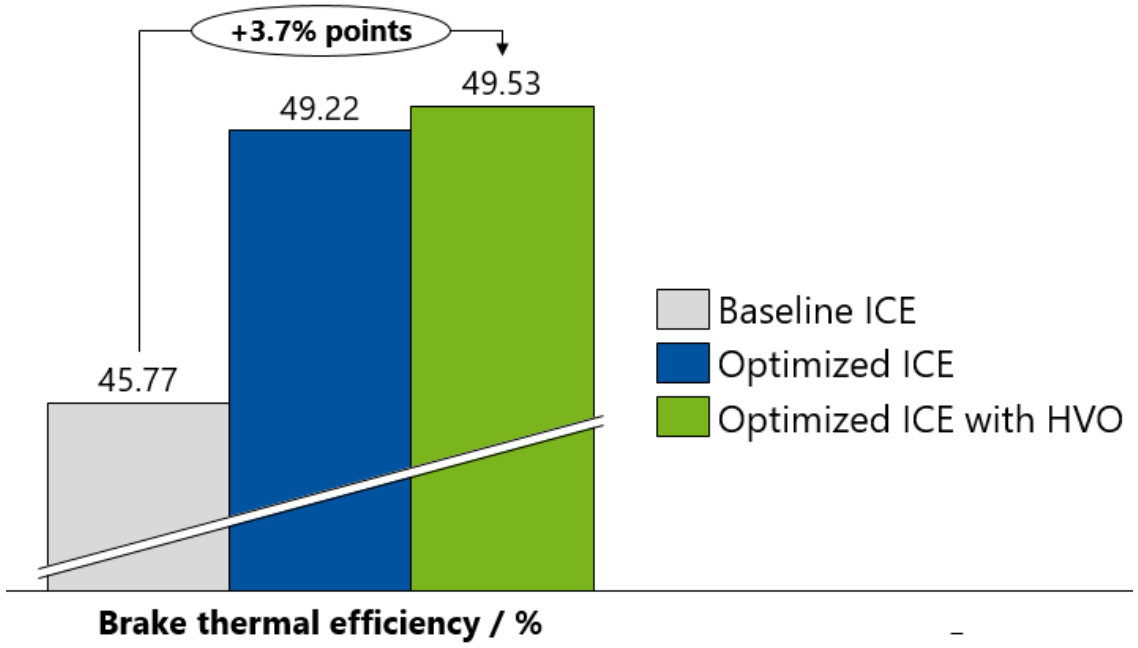



**Activities**

- Development and consolidation of 1D engine models for capturing the influence of individual thermal efficiency improvement measures including exhaust energy recovery by E-turbo
- Genetic algorithm-based optimization of engine parameters

# ST5.6.1 Simulation on BTE

ADDITIONAL IMPROVEMENT IN BTE WITH HVO FUEL –PERFORMANCE AT BEST EFFICIENCY POINT




- The brake thermal efficiency improves by ~3.5% points with reference to the baseline. This can be attributed to the combined effect of improved high pressure cycle efficiency, reduced friction, reduced pumping losses and a marginal amount of exhaust energy recuperation.
- The final consolidated optimized ICE leads to a 49.22% points BTE with Diesel and 49.53% with hydrogenated vegetable oil as fuel.
- This final simulated value is slightly lower than the SCE test result but it considers all the interactions of the investigated technologies.

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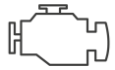
# ST5.6.2 simulation / prediction tail-pipe out $NO_x$

VIRTUAL CERTIFICATION APPROACH OF THE GT-OPTIMIZED ICE ACCORDING TO THE EURO VIC STANDARDS – POWERTRAIN SIMULATION STRATEGY

## 1 Cycle Selection

WHTC



Selection of the relevant regulatory cycle for the Euro VIc regulation

## 2 Powertrain Configuration


Simulation of an ICE and EATS model only (no vehicle)

- ICE model calibration: GT model developed in ST5.6.1
- EATS model calibration: RWTH library

## 3 Simulation Approach

WHTC hot (WF=0.86)

WHTC cold (WF=0.14)

**Note**: The cold-start ICE behavior (i.e. engine-out NOx and T4 until the SCR reaches light-off temperature) is corrected based on RWTH/FEV internal experience.

## 4 Simulation Target

Virtual certification of the GT optimized ICE according to the **Euro VIc** standards:

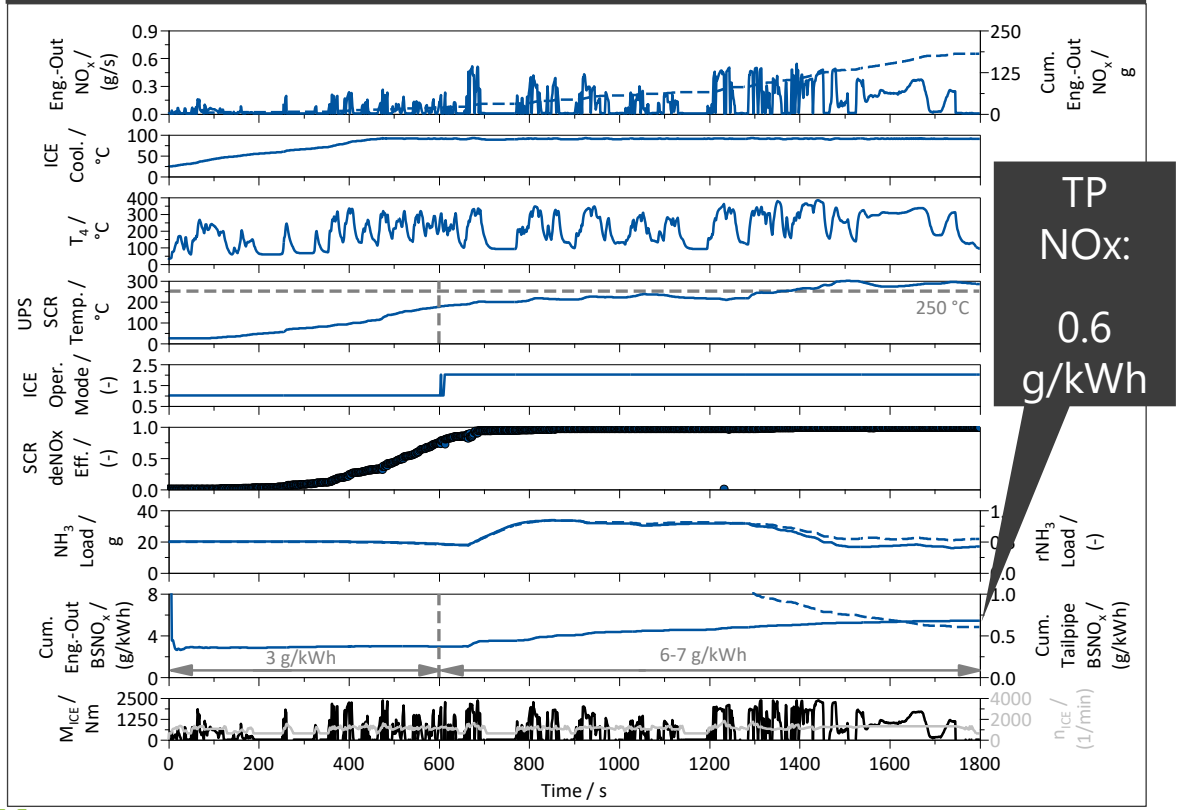
- Identify the necessary EATS updates to meet the standards **in case of non-compliance**

# ST5.6.2 simulation / prediction tail-pipe out $NO_x$

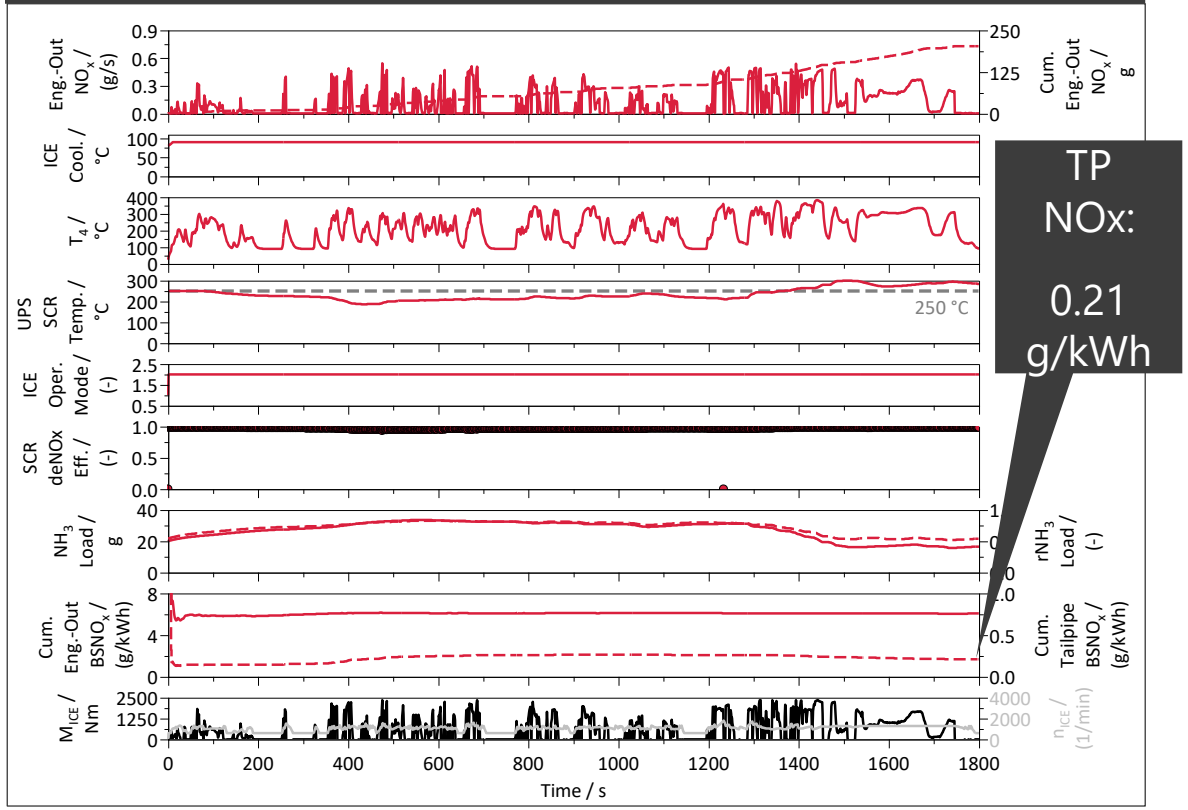
VIRTUAL ENGINE CERTIFICATION

**Remarks**: 1) Engine model: GT-optimized engine model based on the DAF MX13 engine
2) Exhausts aftertreatment system model: Validated Euro VIc layout on a valid ISC route

## WHTC Simulation - Cold Start




## WHTC Simulation - Warm Start

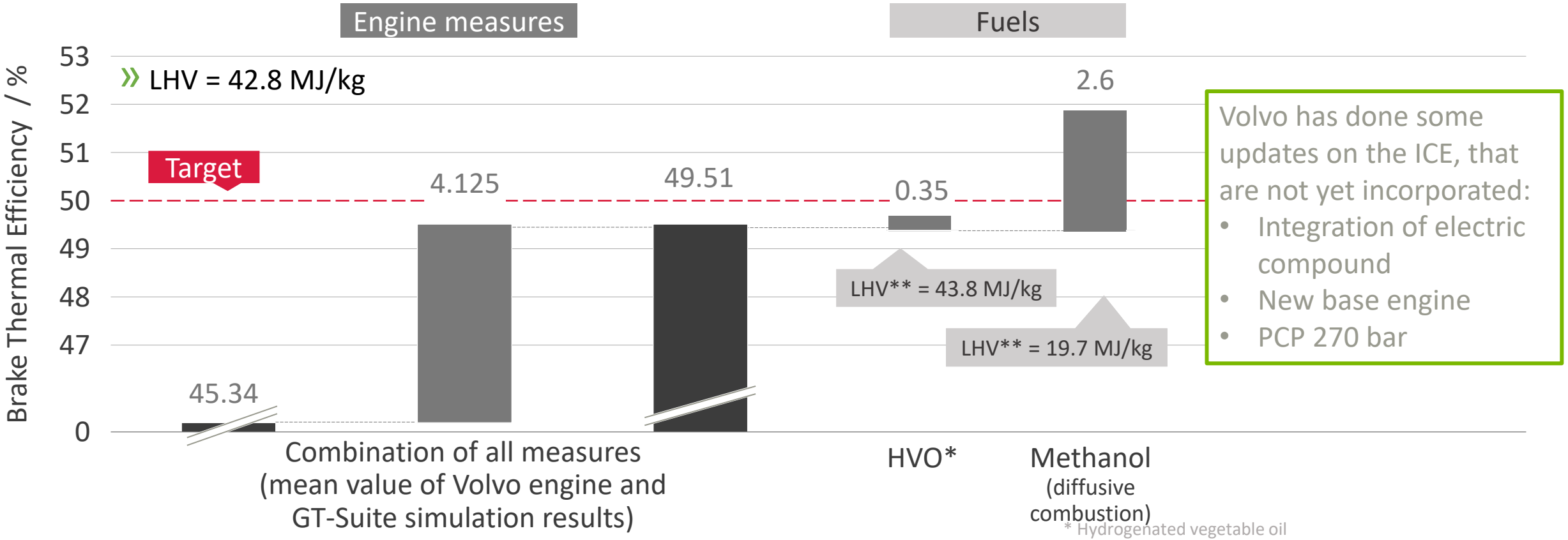



The ICE with future technology can stay below the 0.46 g/kWh NOx emission limit in WHTC – Weighted Tailpipe NOx emissions: 0.265 g/kWh

# CI diesel ICE improvements Summary

» STATUS M42

Best efficiency point
n = 1300 $min^{-1}$, IMEP ca. 19 bar, $BSNO_X$ = 6 g/kWh




Volvo has done some updates on the ICE, that are not yet incorporated:
- Integration of electric compound
- New base engine
- PCP 270 bar

* Hydrogenated vegetable oil
** Lower heating value (LHV) considered for BTE evaluation

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# SI natural gas ICE improvements Summary

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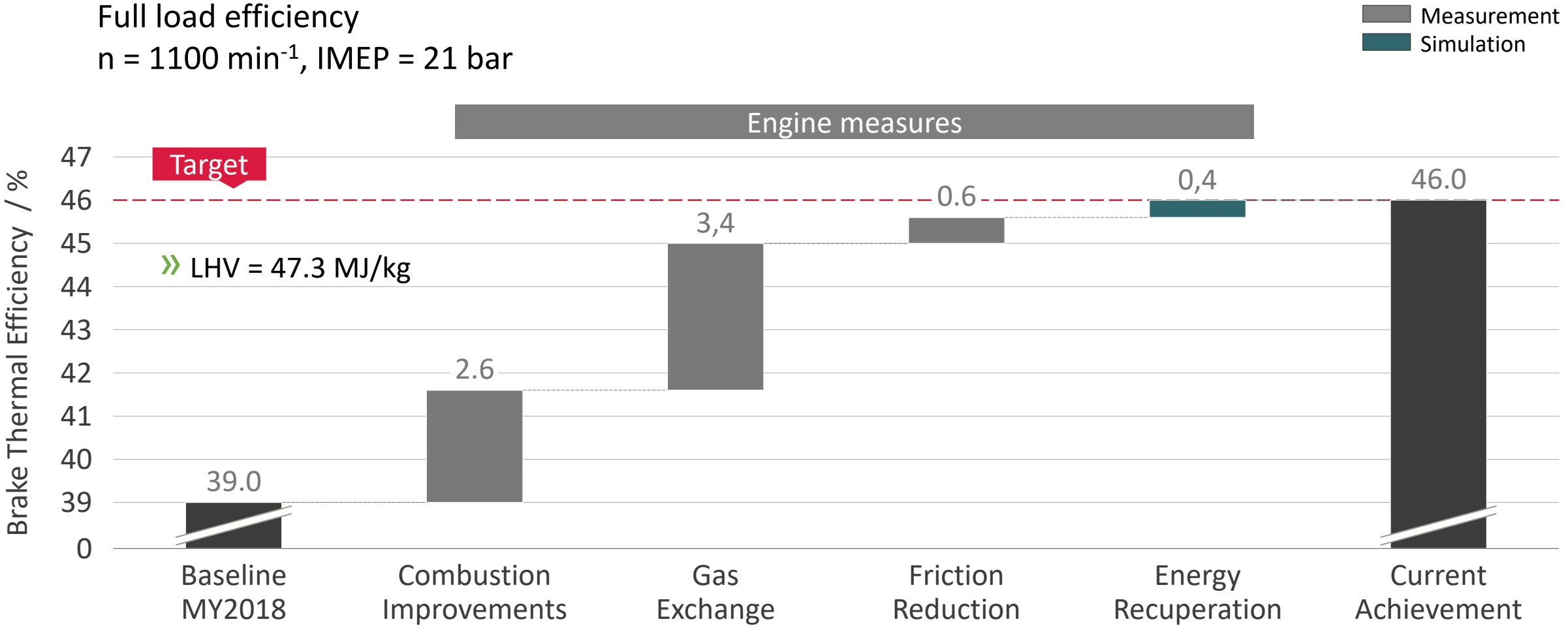
Full load efficiency
n = 1100 min$^{-1}$, IMEP = 21 bar



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# SI – Combustion improvements
# Charge motion: Swumble™

» STATUS M42

## DESCRIPTION

- Innovative concept of in-cylinder aerodynamics for high efficiency spark ignited systems of combustion
- High production of Turbulent Kinetic Energy at TDC
- Compatible with a 4 valve, pent roof architecture of the cylinder head
- Applicable to all gaseous and liquid fuels spark ignited

## ADVANTAGES

- Improved efficiency by reduction of thermal losses, unburnt losses and combustion duration
- Enabler for further efficiency improvement approaches : increased compression ratio, Miller, EGR dilution, lean burn

## RISKS / CHALLENGES

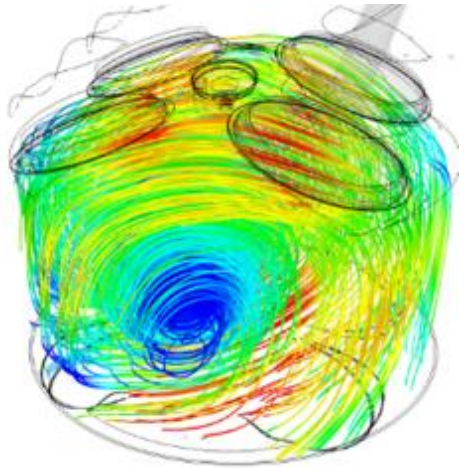
- Requires a “gasoline like” architecture of the cylinder head

⇒ Not directly compatible with an existing “Diesel like” system of combustion of the current HD gas engines

## ASSESSMENT

| | |
|---|---|
| BTE impact | Around 2.6 %-point BTE improvements |
| Invest | Moderate invest expected |
| Maturity 2025-2030 | Medium/high maturity level |

Impact: low — medium — high

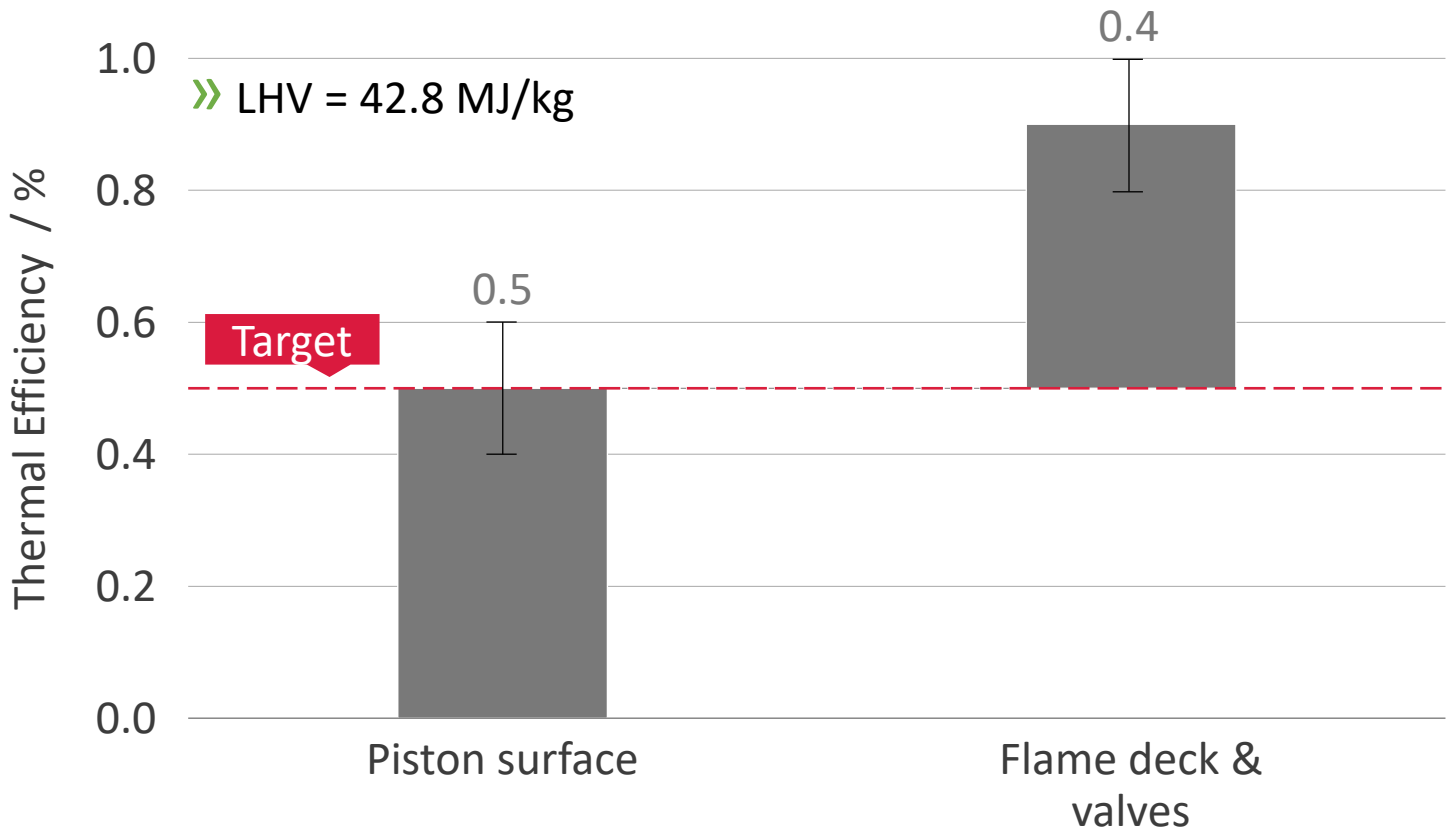


# ICE improvements by coatings Summary



Best efficiency point

n = 1200 $min^{-1}$, IMEP ca. 21 bar, $BSNO_X$ = 8-10 g/kWh



# UCC2 Outlook M42-M48

# Outlook – next 6 month

| Use case | Action |
|---|---|
| 1 DAF development | • Completed for UCC2<br>• Multi cylinder engine<br>  • High efficiency eTurbo ➔ results will only be used to validate the simulation results (no deliverable and UCC2 contribution connected to these measurements) |
| 2 Volvo development | • Completed (deliverable 3.7 contains some updates on the engine; their effect on BTE still has to be quantified) |
| 3 FPTi development | • Analysis of energy recovery system e.g. eTurbo ➔ shifted to project end |
| 4 Coatings | • Completed |
| 5 Final roadmap | • Continuous update of working document |

# Thank you

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