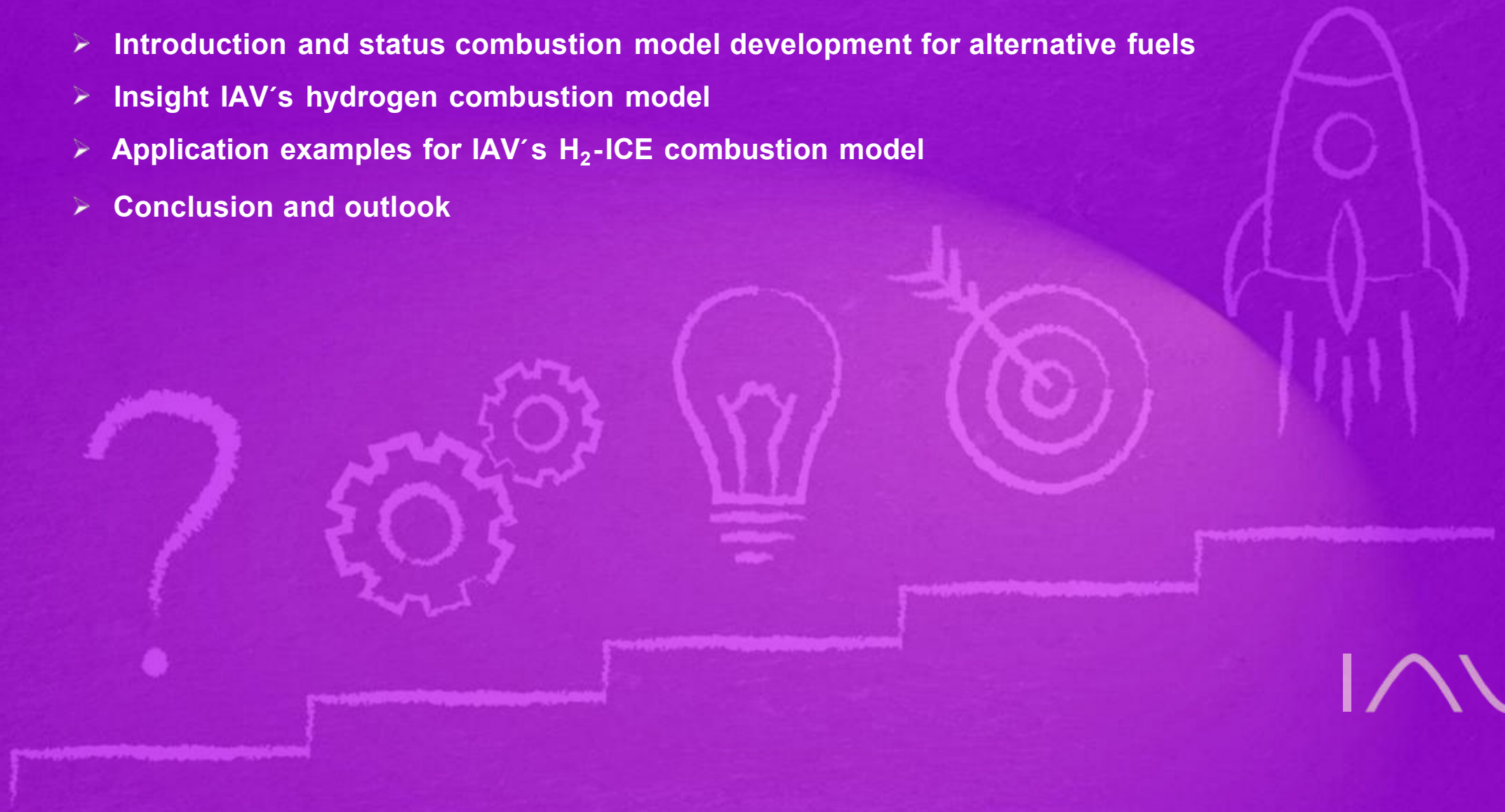
Combustion modelling solutions for alternative fuels

MOBEX Webinar

Michael Rieß, April 2024

Content

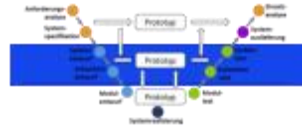
- Introduction and status combustion model development for alternative fuels
- Insight IAV´s hydrogen combustion model
- Application examples for IAV´s H_2-ICE combustion model
- Conclusion and outlook



Introduction and status combustion model development for alternative fuels

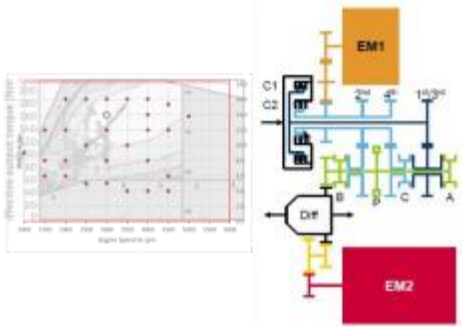
Combustion modelling solutions for alternative fuels

Overarching ICE development process



Pre-Concept Layout | **Detailed Concept Design** | **Concept Evaluation**

Based on Targets and/or output Powertrain Synthesis



Selected configuration	
EM1 (peak) - specifications	150Nm / 60kW / 8400 rpm
EM2 (peak) - specifications	150Nm / 60kW / 13900 rpm
TM ratio series	13.6 / 8.0 / 4.7 / 2.76
EM connection ratio EM1 / EM2	1.4 / 8.5
WLTP cycle consumption	2.54 kg/100km
Constant consump. @ 130 km/h	3.65 kg/100km
Acc. Time 0-100km/h hybrid (peak)	5.40 s
Max. velocity pure ICE	226 km/h
Max. wheel torque pure ICE	3383 Nm

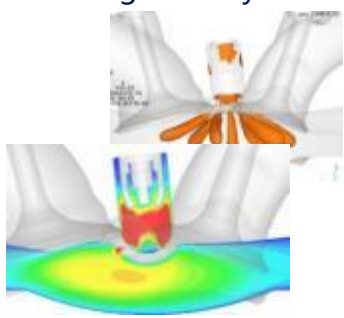
1st Virtual Prototype Layout

Component Level

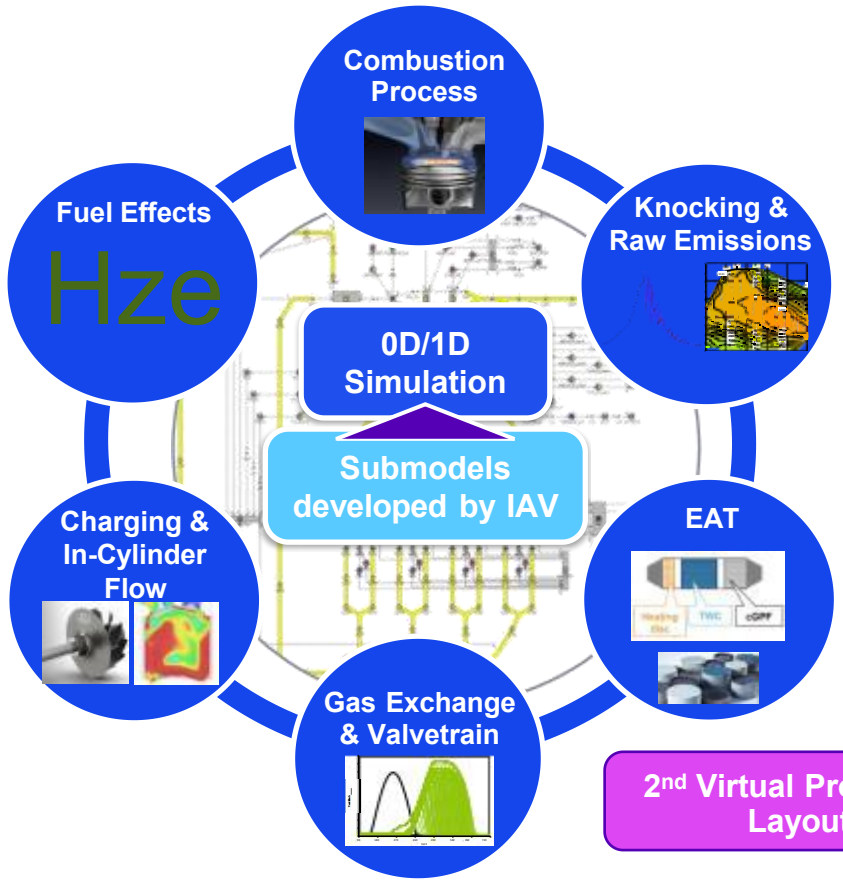
Injector / Port …

Subsystem Level

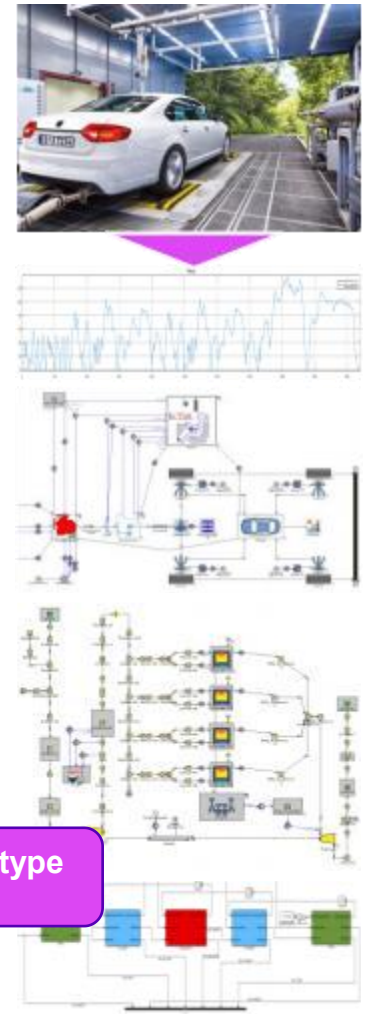
Combustion Design with High Fidelity 3D CFD



System Level



2nd Virtual Prototype Layout



Combustion modelling solutions for alternative fuels

Overview / selected fuels for ICE applications

Property	Unit	e-Hydrogen (H_2)	e-Ammonia (NH_3)	e-Methane (CH_4)	POSYN	DMC + MEFO	FAME ($C_{18.2}H_{35}O_2$)	e-Methanol (CH_3OH)	e-DME (C_2H_6O)	Gasoline ($C_{6.5}H_{12.4}O_{0.2}$)	Diesel ($C_{13}H_{23}$)
Character		CO_2-free		Drop-in capability		Engine adaptations needed				Conventional / fossil fuels	
TTW CO_2	gCO_2/MJ	0	0	55			75	69		73	76
Molar mass	kg/mol	2	17	16		79.5		32	46	94	170
Density (liquid)	kg/m³	71 @ -253°C	682 @ -33°C	324 @ -162°C	725 @15°C	1041 @ 15°C	880 @ 15°C	792 @ 20°C	740 @ -24°C	746 @ 15°C	837 @ 15°C
Density (gas @ 1 bar, 298 K))	kg/m³	0.08	0.77	0.66	-	-	-	-	2.11	-	-
Boiling temperature	°C	-253	-33	-162	45.4…134.1	38…94	300..340	65	-24	30..210	170..360
Ignition temperature	°C	585	630	595			240	460	240	220..450	230
Ignition energy	mJ	0.02	8	0.29			0.2	0.14	0.29	0.23	0.18
Ignition limits in air	Vol-%	4.0..76	15.4..33.6	4.4..16.5				6.7..36	2.8..24.4	1.0..7.6	0.6..5.5
	λ	0.4..7.3	0.6..1.4	0.6..2.1				0.3..1.8	0.3..2.3	0.3..1.9	0.2..1.9
RON / CN	- / -	130 / -	130 / -	120 / -	103 / -	117 / -	- / 56	106..119 / -	- / >55	87..102 / -	- / 48..54
Lower heat value (grav.)	MJ/kg	120	18.8	50	42.84	15.2	37.3	19.9	27.6	41.7	42.8
Lower heat value (vol.)	MJ/dm³	0.011 (1 bar)	12.8 (liquid)	0.033 (1 bar)	31.059	15.8232	32.8 (liquid)	15.8 (liquid)	20.4 (liquid)	31.1 (liquid)	35.5 (liquid)
		4.8 (700 bar)		23 (700)							
Stoich. air requirement	kg/kg	34.3	6.1	17.2	14.49	4.64	12.75	6.483	9.1	14.7	14.5
	kg/MJ	0.29	0.32	0.34	0.34	0.31		0.33	0.33	0.36	0.34
Mixture heat value stoich (grav.)	MJ/kg_{air}	3.5	3.1	2.9	3.0	3.3		3.1	3.0	2.8	2.9
Heat of vaporisation	kJ/kg	0 (g)	1200	0 (g)		459	260	1110		300	270
Laminar flame velocity 1 bar / 298 K	cm/s	250-300	7	35-40				50-60	40-50	40-50	40-50

Proprietary models available (1D)

Development of models ongoing

Using commercial models

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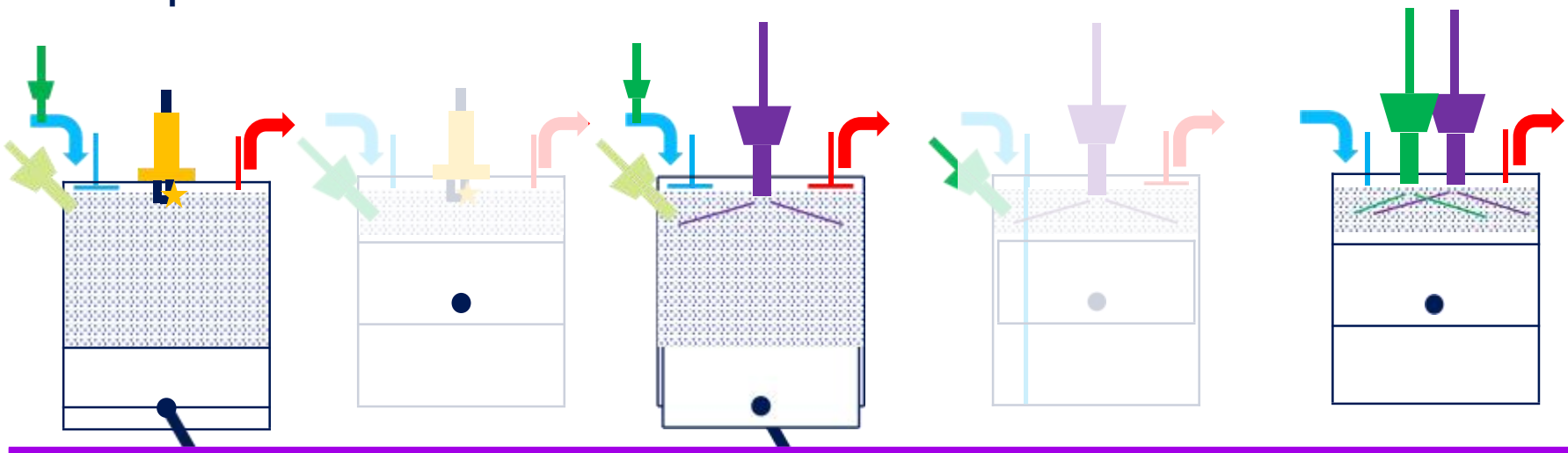
Status and next steps



	SI homogeneous	SI stratified	CI DF homogeneous	CI DF stratified	CI DF double diffusive
H_2	Available / validated	Not yet	Available / validated	Not yet	Not yet
CH_3OH	Available / validation ongoing	Not yet	Work in progress	Not yet	Not yet
NH_3	Work in progress	Not yet	Planned	Not yet	Not yet

Basic Injection System | Advanced Injection System

Ignition System | Pilot fuel injection System