

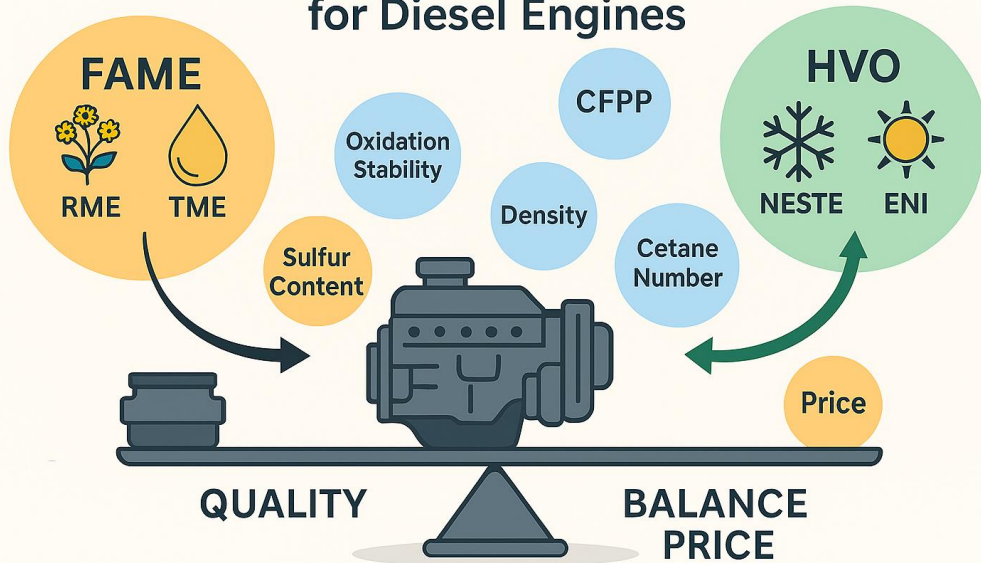
DIESEL



FAME UTILISATION IN HVO
BALANCING AN OPTIMUM 100% RENEWABLE DIESEL

INTRODUCTION AND CONTEXT

Optimizing Renewable Fuel Blends for Diesel Engines



FAME PRICES – Oct25

RME: 1 211 EUR/t

UCOME: 1 283 EUR/t

TME: 1 261 EUR/t

(Argus Media)

HVO PRICES - Oct25

HVOI (RSO): 2 035 EUR/t

HVOII (UCO): 2 256 EUR/t

HVO III (AF): 2 112 EUR/t

HVO price is CZK 13 – 16 / litre higher compared to FAME

GOAL: TO FIND AN OPTIMUM BLEND OF FAME AND HVO AS A 100% RENEWABLE DIESEL FUEL

FAME is substantially limited in its use because of its quality properties (low temperature performance, oxidation stability, sulphur content, contaminants).

However, individual types of FAME substantially differ in their limits. TME and RME comparison is a good example as these stand at the very opposite ends of the qualitative spectrum of various FAME types.

- TME (FAME from animal fats): low contaminants (glycerides, etc.), good oxidation stability, poor CFPP, high sulphur
- RME (FAME from rapeseed oil): high contaminants (glycerides, etc.), poor oxidation stability, good CFPP, low sulphur

HVO represents unlimited renewable diesel in its use but is significantly more expensive than FAME.

Substantially higher price compare to FAME is a main disadvantage:

- Actual HVO prices are higher by € 606-731 / t (i.e. € 0.53-0.64 / litre, CZK13-16 / litre) compared to FAME while adjusted to density and GHG emissions parity. This price difference is very likely to widen further with the onset of demand for SAF (as a premium market for HVO producers).

Low density and poor lubricity represent minor quality disadvantages of HVO.

WHY IS HVO LIKELY TO REMAIN SIGNIFICANTLY MORE EXPENSIVE TO FAME

- HVO processing cost are € 500 / t higher compared to FAME (including variable costs, fixed costs, maintenance CapEx, and minimum return on initial CapEx) on top of higher-quality feedstock (approx. € 30-100 / t higher cost)
- Alongside the REDIII GHG reduction trajectory, HVO is likely to become the main instrument among renewable transport fuels, expected to absorb short- to mid-term demand exceeding supply, resulting in an additional price premium:
 - HVO has no blending wall (unlike bioethanol, FAME)
 - HVO has no infrastructure bottlenecks and incompatibility with the existing vehicle fleet (unlike electromobility and biomethane)
- Moreover, SAF is the only available renewable fuel for aviation, and its increasing demand will further draw on HVO production capacity, reducing supply for road transport.
- The price difference between HVO and FAME is likely to be even greater in inland EU regions such as the Czech Republic compared to coastal regions such as the ARA area, as the most efficient large-scale HVO production relies on access to global feedstock supply chains.

WHY CO-EXISTENCE OF FAME AND HVO BROADENS ELIGIBLE FEEDSTOCK RANGE AND LOWERS OVERALL COST OF RENEWABLE DIESEL

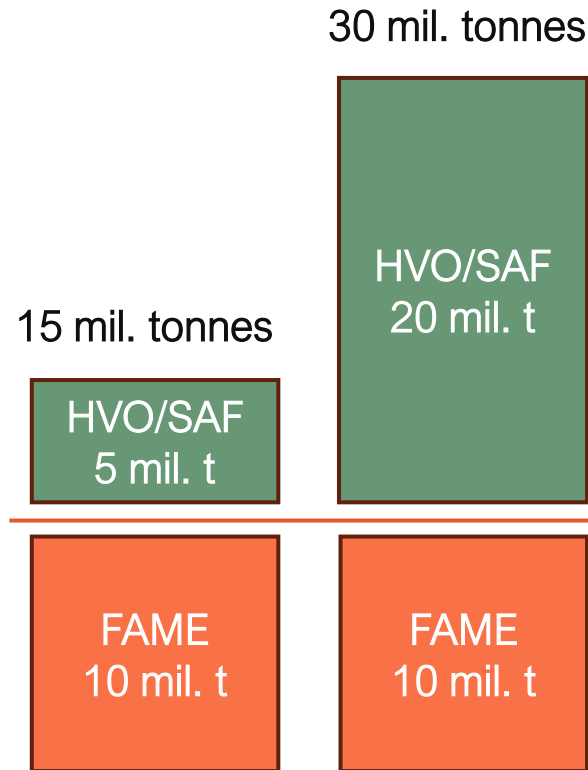
EU production capacities 2025 and 2030+

HVO/SAF - economics

- Production margins **need** to attract new investments

FAME - economics

- Production margins **do not need** to attract new investments



HVO/SAF – production and feedstock attributes

- Larger scale production units more centralized
- More sensitive to impurities
- Sensitive mainly to metals (phosphorus, sodium, etc.) rather than fats acidity

FAME – production and feedstock attributes

- Lower scale production units more distributed
- Less sensitive to impurities
- Sensitive mainly to acidity of fats rather than metals (phosphorus, sodium, etc.)

TEST RESULTS

FAME BLENDING POTENTIAL IS LIMITED MAINLY BY OXIDATION STABILITY (WITH RESPECT TO RME) AND BY COLD FLOW PROPERTIES AND SULPHUR (WITH RESPECT TO TME)

FAME and HVO blend		7 RME NESTE	30 RME NESTE	50 RME NESTE	7 RME ENI	30 RME ENI	50 RME ENI	7 TME NESTE	30 TME NESTE	50 TME NESTE	7 TME ENI	30 TME ENI	50 TME ENI	15940 Limits	
PARAMETER	Unit	26261	26262	26263	26264	26265	26266	26267	26268	26269	26270	26271	26272	Min	Max
Sulphur	mg/kg	<3,0	<3,0	<3,0	<3,0	<3,0	<3,0	4,1	10,0	15,0	<3,0	8,8	14,1		5
Water (Karl Fischer)	% m/m	0,006	0,014	0,022	0,006	0,015	0,022	0,005	0,009	0,011	0,005	0,008	0,010		0,02
Paraffin precipitation temperature	°C	-23	-17	-13	-11	-11	-11	-14	-1	4	-6	0	5		
Total impurities	mg/kg	<12,0	<12,0	12,9	<12,0	12,4	21,1	<12,0	<12,0	<12,0	<12,0	21,2	24,6		24
Distilled volume at 250°C	% V/V	2,7	1,5	0,1	11,6	6,3	3,2	2,8	1,7	0,1	10,4	6,2	3,3		65
Distilled volume at 350°C		*	97,1	95	*	*	96,2	*	*	*	*	*	*	85	
95% distills at temperature	°C	317,8	340,7	350,2	313,7	341,6	345,4	312,9	334,2	342	316,6	337,1	341,4		360
		W	W	W	TP	TP	TP	TP	S		TP	S			
Cold Filter Plugging Point (CFPP)	°C	-27	-26	-24	-13	-13	-15	-16	-2	2	-10	-2	3		B(0) D(-10) F(-20)
Fatty Acid Methyl Esters (FAME)	% V/V	6,9	29,5	49,2	6,8	29,2	49,1	7,2	30,3	51,1	7,1	30,4	50,8		7
Oxidation stability Rancimat (110°C)	h	>48,0	22,6	16,4	>48,0	21,7	16,0	>48,0	>48,0	40,1	>48,0	>48,0	36,4	20	
Density at 15°C	kg/m³	787,4	809,2	829,1	785,7	809,1	829,9	788,8	809,1	827,9	786,1	806,9	826,2	765/780	800/810
Insoluble residues	g/m³	1	2	3	1	2	2	1	1	1	1	1	1		25
Oxidation stability PetroOxy	min.	110,16	55,68	41,24	107,44	57,64	41,83	86,67	66,88	55,75	80,93	63,41	54,80	60	
Cetane number		74,1	69,5	62,8	72,9	67,9	65,8	72,3	71,5	70,9	>74,7	72,7	70,0	70/51	
Acid number	mg KOH/g	0,10	0,29	0,42	0,18	0,30	0,43	0,05	0,18	0,24	0,11	0,19	0,27		"0,2"
Kinematic viscosity	mm²/s	3,103	3,310	3,557	2,794	3,067	3,371	3,109	3,344	3,631	2,809	3,105	3,497		
ARAL test			Yes	Yes		Yes	Yes		No	No		No	No		
Separation temperature after 16h			-10	-10		-10	-10		5	5		5	5		
PP temperature from 20% (V/V) sediment			-18	-14		-11	-11		19	23		23	28		
CFPP from 20% (V/V) sediment			-27	-26		-14	-15		10	10		13	13		

QUALITATIVE BLENDING LIMIT OF FAME IN HVO:

UP TO 30%, ON AVERAGE 25%

MAXIMUM FAME BLEND IS ACHIEVABLE THROUGH COMBINING TME AND RME IN DIFFERENT PROPORTIONS DEPENDING ON SEASONALITY AND HVO TYPE

FAME use in HVO is safe up to 30% share, on average reaching 25% throughout the year (as per CR climate requirements)

Maximum FAME share in total through TME and RME blend when applying EN 15940 quality requirements adjusted for: - Sulphur max 10ppm (as per EN 590) - Acid number max 0.2 to protect fuel stability (as an additional parameter to EN 15940) - ARAL test limitation is reflected to protect cold flow properties (as an additional parameter to EN 15940)	<u>EN 15940 ADJUSTED</u> <i>(sulphur max 10ppm, acid number max 0.2, ARAL test)</i>	FAME maximum share in total through RME and TME blend	TME proportion maximizing total FAME use	RME proportion maximizing total FAME use
	Winter			
	NESTE	22	7	16
	Transition period			
	NESTE	28	20	8
	ENI	18	8	10
	Summer			
	NESTE	30	25	5
	ENI	28	23	5

CONCLUSION AND NEXT STEP

ANALYSIS SUGGESTS AN **OPTIMUM FAME SHARE IN HVO AT 25% ON AVERAGE** SO TO MINIMIZE TOTAL FUEL COSTS WHILE NOT THREATENING FUEL QUALITY

BENEFITS

- Substantial costs reduction of a blended 100% renewable diesel fuel in the extent of around 25% of price difference between HVO and FAME which represents € 13-16 / litre (CZK 3-4 / litre) savings
- Enhancement of combustion process efficiency through increased fuel density and lubricity

POSSIBLE ARRANGEMENT: „EN 15940 Grade B Adjustment“

Amendment of EN 15940 norm for Grade B:

- To enable higher FAME proportion (FAME blending wall extension, sulphur limit extension, density parameters adjustment)
- A need for additional quality parameters is to be considered so to protect fuel quality with higher FAME concentrations (e.g. acid number, Aral test)

Amendment of EN 14214 norm to enable all possible FAME blending variants with respect to amended EN 15940 quality requirements