

# FeMIR - MIR Spectral predictions for feed and energy efficiency - Practical Application

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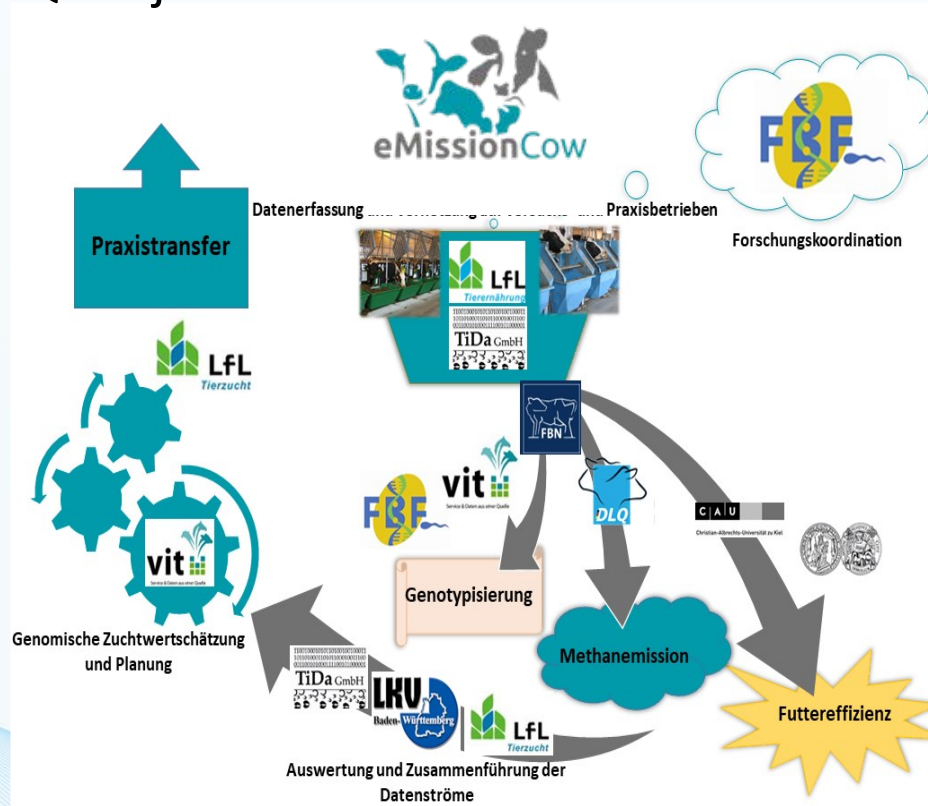
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# LKV BW – MIR - Spectral Data - Projects

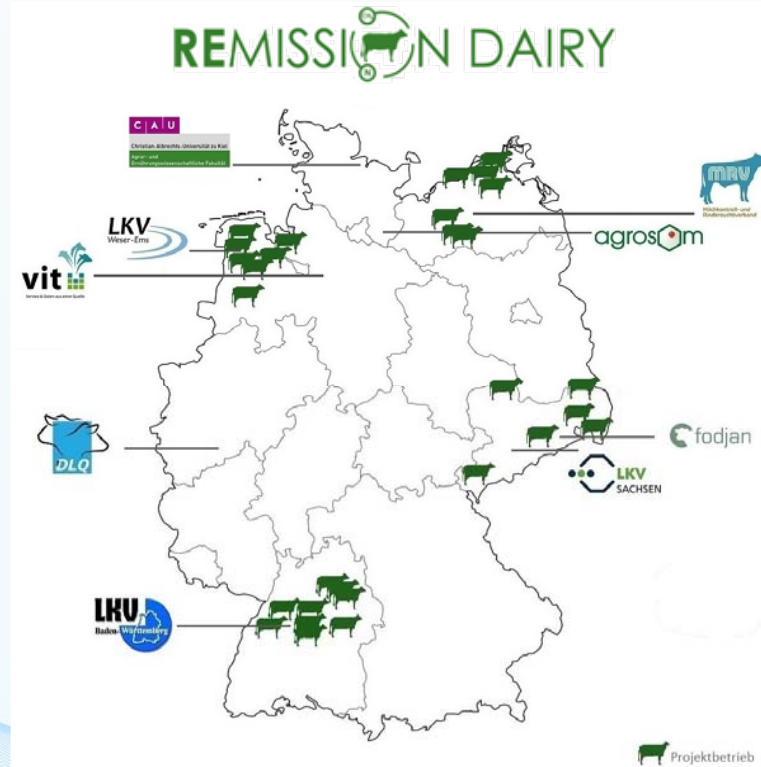
## DLQ-Project



Methane emission and feed efficiency at individual animal level

# LKV BW – MIR - Spectral Data - Projects

## DLQ-Project



Methane emission and feed efficiency in feeding advice



# Milk analysis using mid-infrared spectra (MIR)



Fig.1: Milk Sample



Fig.2: Bentley FTS-Milk Analysis Instrument  
(Source: Bentley-Instruments)

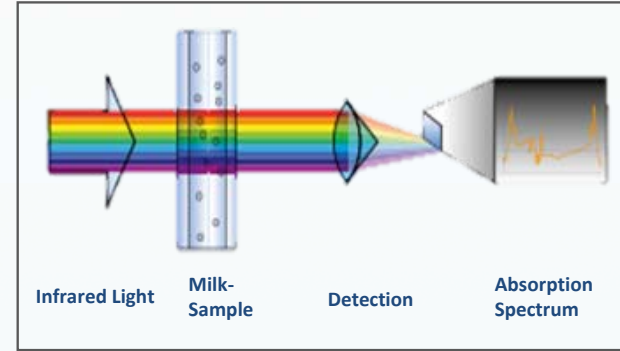


Fig.3: Infrared analysis of milk Scheme  
(Photo: Bentley-Instruments)

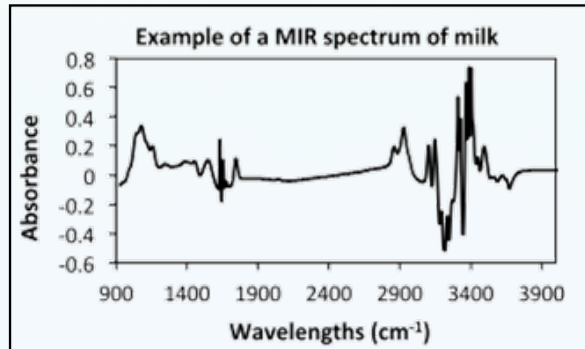


Fig.4: Typical Milk MIR- Absorption Spectrum (Source: OptiMIR)

## Main components:

Fat, protein, lactose, urea ...

## Fine components:

Fatty acids, minerals, Lactoferrin, BHB, acetone ...

## Complex components:

Energy Deficit / Ketosis, Mastitis, CH<sub>4</sub>, Pregnancy ...

## Milk-MIR-Models:

### Energy Balance – Feed/Energy Efficiency - Methan-Emission

Energy Balance (EB): optiKuh/DLQ - (L. Dale 2019)

Milk Biomarker	Unit	#LV	$\phi$	SD	SEC	R <sup>2</sup> c	SECV	R <sup>2</sup> cv	RPDcv	Use
EB – NEL*	[MJ/d]	12	2.47	17.29	8.27	0.75	8.27	0.75	2.001	0
EB – ME**	[MJ/d]	12	0.08	23.54	8.99	0.85	8.94	0.85	2.580	0

\* GfE (2001), \*\* Susenbeth (2018)

Feed/Energy Efficiency (FE) (EE): optiKuh/eMissionCow/DLQ - (L. Dale 2021)

Milch Biomarker	Unit	#LV	$\phi$	SD	SEC	R <sup>2</sup> c	SECV	R <sup>2</sup> cv	RPDcv	Use
EE – NEL*	[MJ/ECM]	7	4.69	0.62	0.27	0.81	0.28	0.81	2.271	0
EE – ME**	[MJ/ECM]	7	7.67	1.03	0.39	0.86	0.39	0.91	2.669	0
FE	[ECM/DM kg]	10	1.55	0.25	0.09	0.90	0.08	0.89	3.131	+

\* GfE (2001), \*\* Susenbeth (2018)

Methane Emission: eMissionCow/DLQ - (Vanlierde A. et al. 2019. L. Dale)

Phenotypes	Unit	#LV	$\phi$	SD	SEC	R <sup>2</sup> c	SECV	R <sup>2</sup> cv	RPDcv	Use
Methane Emission	[g/d]	10	1089	102	58	0.68	61	0.64	1.7	-
GLMNET- Methane Emission	[g/d]	12	1266	97	50	0.73	54	0.69	1.8	-



# New applications for the farmer and consultant

## Feed/Energy Efficiency - Report

FeMIR

Feed Efficiency

Energie Efficiency

Fatty acids

Energie Balance

N - Efficiency

Methane



# New applications for the farmer and consultant

## Feed/Energy Efficiency - Report

### FE-MIR - Mittelwerte Berateransicht

Betrieb:

EB: Energiebilanz-NEL [MJ]

KM (KetoMIR): Anteile der Ketosis-Gefährdungsklassen (KM2) = gefährdet < 20% (KM3) = stark gefährdet < 5%

Table 2: Herdendurchschnitte der MIR-Inhaltstoffe und -Parameter

Abschn.	Status	Anz. Tiere	Anz. Lakt.	L-Tage	Mkg	ECM	F%	E%	H	L%	ZZ	FEQ	F-DN	F-PF	NE	EB	EE	EA	FE	CH4-ECM	KM2 %	KM3 %
1-120	F	10	1	66	25.2	26.0	4.32	3.34	19	5.00	73	1.30	22	40	34	5	0.230	113	1.75	16	10	0
121-240	F	9	1	197	24.7	26.5	4.41	3.80	18	4.84	125	1.16	24	35	29	9	0.190	142	1.33	16		
>240	F	14	1	286	21.3	22.8	4.45	3.80	16	4.92	115	1.17	23	38	29	6	0.190	120	1.36	19		
1-120	K	21	4	58	34.1	35.1	4.30	3.28	17	4.90	192	1.32	21	44	36	-9	0.240	146	1.86	12	28.6	4.8
121-240	K	20	3	181	29.2	31.0	4.41	3.69	18	4.74	419	1.20	24	36	30	11	0.200	159	1.42	16		
>240	K	18	4	297	21.8	23.2	4.50	3.94	15	4.47	278	1.14	22	41	31	23	0.180	128	1.41	21		
alle	F	33	1	195	23.4	24.8	4.40	3.66	17	4.92	105	1.21	23	38	30	6	0.200	124	1.47	17	10	0
alle	K	59	3	173	28.7	30.1	4.40	3.62	17	4.71	295	1.22	22	40	32	8	0.210	145	1.58	16	28.6	4.8
alle	alle	92	3	181	26.8	28.2	4.40	3.64	17	4.79	227	1.22	23	40	31	7	0.210	137	1.54	16	22.6	3.2



# Field test phase FeMIR -report (paper) \*

January - December 2022: 3 consultants, 4 field workers, 9 farms





## Results of the field test

- ✓ In addition to the handling and use of the report, the limits of each parameter were determined and established to be able to define an optimal framework in which a farm should be.
- ✓ At this step, the respective physical constitution of the animals, as found on site, confirmed the experts' expectations, which they had derived from the efficiency and energy parameters in the report.
- ✓ On all farms this assessment could be found, which is why the FeMIR report was also rated by all participants as a valuable and suitable management tool for feeding and monitoring the animals' metabolism.

# Online tool for monitoring the animals in the herd manager

**Systematic monitoring of animal metabolism via MIR spectral data**

↓

**Improved feed management**

↓

**Methane emission reduction**

FE-MIR - Mittelwerte Berateransicht

Betrieb:

ED: Energiebilanz-NEL [MJ]

KM (KetoMIR): Anteile der Ketosis-Gefährdungsklassen (KM2) = gefährdet < 20% (KM3) = stark gefährdet < 5%

Table 2: Herdendurchschnitte der MIR-Inhaltsstoffe und -Parameter

Abschn.	Status	Anz. Tiere	Anz. Lakt.	L-Fuge	Mkg	ECM1	FE	ES	H	L%	ZZ	FEQ	F-DN	F-PF	NE	EB	EE	EA	FE	CH4-ECM	KM2 %	KM3 %
1-120	F	10	1	66	25.2	26.0	4.32	3.34	19	3.00	73	1.30	22	40	34	5	0.200	113	1.75	16	10	0
121-240	F	9	1	197	24.7	26.3	4.41	3.80	18	4.84	125	1.16	24	33	29	9	0.190	142	1.33	16		
>240	F	14	1	286	21.3	22.8	4.43	3.80	16	4.92	115	1.17	23	38	29	6	0.190	120	1.36	19		
1-120	K	21	4	38	34.1	35.1	4.30	3.28	17	4.90	102	1.32	21	44	36	9	0.210	146	1.86	12	28.6	4.8
121-240	K	20	4	184	29.2	31.0	4.31	3.69	18	4.74	419	1.20	24	36	30	11	0.200	159	1.32	16		
>240	K	18	4	297	24.8	23.2	4.50	3.94	15	4.47	278	1.14	22	41	31	23	0.180	128	1.41	21		
alle	F	31	1	195	23.3	24.8	4.30	3.66	17	4.92	105	1.21	23	38	30	6	0.200	124	1.47	17	10	0
alle	K	59	3	173	28.7	30.4	4.36	3.62	17	4.71	295	1.22	22	40	32	8	0.210	145	1.58	16	28.6	4.8
alle	alle	92	3	184	26.8	28.2	4.36	3.64	17	4.79	227	1.22	23	40	31	7	0.210	137	1.51	16	22.6	3.2

**LKVBW  
Herd Manager  
Online System**



# FeMIR - MIR Spectral predictions in the LKV Herd Manager

## Stoffwechsel

KetoMIR

Energie- u. Nährstoffversorgung Herde

Diagnoseentwicklung 1

Diagnosenvergleich Herde/Population

Stoffwechselbedingte Abgänge

**Effizienz**

Probemelkungen

» Übersicht

» Einzeltier

Historie

» Grafiken

★ ? ↗

☆ Favorit 🖨️ Drucken 📄 CSV

PM-Datum: 29.04.2024

- Probemelkungen
- Tierlisten
- Tiere
- Dateneingabe
- Aktionenlisten
- Auswertungen
- Q Check
- Eutergesundheit
- Fruchtbarkeit
- Stoffwechsel**
- KetoMIR
- Energie- u. Nährstoffversorgung Herde
- Diagnoseentwicklung 1
- Diagnosenvergleich Herde/Population
- Stoffwechselbedingte Abgänge
- Effizienz
  - » Übersicht
  - » Einzeltier
- Historie
  - » Grafiken
- Kälbergesundheit
- Klauengesundheit
- Diagnosen

												PM-Datum										
Abschn.	Status	Anz. Tiere	Anz. Lakt	L-Tage	MKg	F%	E%	L%	H	Anteil KM2	Anteil KM3	Energiebilanz [MJ]	ECM [kg]	FS neugebildet [%]	FS Körperfettabbau [%]	Futtereffizienz [kg ECM/kg TM]	Energieaufnahme [MJ NEL]	TM-Aufnahme [kg TM]	Energieeffizienz [kg ECM/MJ NEL]	Stickstoffeffizienz [%]	CH4/ECM [g/Tag/kg]	CH4 [g/Tag]
1-120	F	8	1	105	25,9	3,79	3,03	4,97	31	0,0	0,0	5	24,6	23	36	1,60	108	15	0,23	32	21	493
121-240	F	14	1	198	22,7	4,32	3,18	4,93	31	0,0	0,0	-0	23,2	23	35	1,45	110	16	0,21	28	21	472
>240	F	6	1	375	20,9	4,10	3,19	5,02	27	0,0	0,0	1	20,7	22	36	1,25	98	17	0,21	25	21	427
1-120	K	19	4	87	30,1	3,95	3,04	4,90	29	21,1	0,0	2	29,2	23	36	1,67	124	18	0,24	33	18	521
121-240	K	33	4	174	25,8	4,43	3,18	4,89	27	0,0	0,0	3	26,5	24	34	1,54	120	17	0,22	30	20	512
>240	K	25	5	340	18,9	4,47	3,36	4,76	26	0,0	0,0	9	19,9	22	38	1,28	98	16	0,20	26	23	437
alle	F	28	1	209	23,4	4,12	3,14	4,96	30	0,0	0,0	2	23,2	23	35	1,46	107	16	0,22	29	21	470
alle	K	77	4	207	25,3	4,30	3,18	4,86	27	5,2	0,0	4	25,6	23	36	1,51	116	17	0,22	30	20	496
alle	alle	105	3	207	24,9	4,25	3,17	4,88	28	3,8	0,0	3	25,0	23	35	1,50	114	17	0,22	30	20	489

# FeMIR - MIR Spectral predictions in the LKV Herd Manager

Table 1: Optimal Framework values for herd management

Parameter	Low Value	High Value
EB NEL [MJ]	< -30	> 40
FA Denovo [%]	< 20	
FA Preform [%]		> 50
FE [kg ECM/kg DM]	< 1.2	> 1.8
EI [MJ NEL]	< 80	> 180
DMI [kg DM]	< 5	> 25
EE [kg ECM/MJ NEL]	< 0.12	> 0.36
NE [%]	< 30	
CH4/ECM [g/Tag/kg]	< 10	

\* The LKV herd manager is developed within the RDV cooperation and is in use at every RDV partner - FeMIR could be used for all RDV cows (approx. 2.3 mio.)



# FeMIR - MIR Spectral predictions in the LKV Herd Manager

Stoffwechsel > Effizienz > Probemelkungen > Übersicht

PM-Datum: 29.04.2024

Energiebilanz [MJ]		< -30	> 40
FS neugebildet [%]	Info	< 20	
FS Körperfettabbau [%]	Info	> 50	
Futtermehrfizienz [kg ECM/kg TM]	Info	< 1.2	> 1.8
Energieaufnahme [MJ NEL]		< 80	> 180
TM-Aufnahme [kg TM]		< 5	> 25
Energieeffizienz [kg ECM/MJ NEL]	Info	< 0.12	> 0.36
Stickstoffeffizienz [%]	Info	< 30	
CH4/ECM [g/Tag/kg]	Info	< 10	

Abschn.	Status	Anz. Tiere	Anz. Lakt.	L-Tage	MKg	F%	E%	L%	H	Anteil KM2
1-120	F	8	1	105	25,9	3,79	3,03	4,97	31	0,0
121-240	F	14	1	198	22,7	4,32	3,18	4,93	31	0,0
> 240	F	6	1	375	20,9	4,10	3,19	5,02	27	0,0
1-120	K	19	4	87	30,1	3,95	3,04	4,90	29	21,1
121-240	K	33	4	174	25,8	4,43	3,18	4,89	27	0,0
> 240	K	25	5	340	18,9	4,47	3,36	4,76	26	0,0
alle	F	28	1	209	23,4	4,12	3,14	4,96	30	0,0
alle	K	77	4	207	25,3	4,30	3,18	4,86	27	5,2
alle	alle	105	3	207	24,9	4,25	3,17	4,88	28	3,8

Group	Status	N. Anim.	N. Lact.	DIM	Milk Yield	Fat %	Protein %	Lactose %	Urea	KM2 %	KM3 %
1-120	Primipar	8	1	105	25,9	3,79	3,03	4,97	31	0,0	0,0
121-240	Primipar	14	1	198	22,7	4,32	3,18	4,93	31		
> 240	Primipar	6	1	375	20,9	4,10	3,19	5,02	27		
1-120	Multipar	19	4	87	30,1	3,95	3,04	4,90	29	21,1	0,0
121-240	Multipar	33	4	174	25,8	4,43	3,18	4,89	27		
> 240	Multipar	25	5	340	18,9	4,47	3,36	4,76	26		
alle	Primipar	28	1	209	23,4	4,12	3,14	4,96	30	0,0	0,0
alle	Multipar	77	4	207	25,3	4,30	3,18	4,86	27	5,2	0,0
alle	alle	105	3	207	24,9	4,25	3,17	4,88	28	3,8	0,0



# FeMIR - MIR Spectral predictions in the LKV Herd Manager

Stoffwechsel

- KetoMIR
- Energie- u. Nährstoffversorgung Herde
- Diagnoseentwicklung 1
- Diagnosenvergleich Herde/Population
- Stoffwechselbedingte Abgänge
- Effizienz**
- Probemelkungen
  - » Übersicht
  - » Einzeltier
- Historie
  - » Grafiken

Group	Status	N. Anim.	N. Lact.	DIM	EB [MJ NEL]	ECM [kg]	FA Denovo [%]	FA Preform [%]	FE [kg ECM/kg DM]	EI [MJ NEL]	DMI [kg DM]	EE [kg ECM/MJ NEL]
1-120	Primipar	8	1	105	5	24,6	23	36	1,60	108	15	0,23
121-240	Primipar	14	1	198	0	23,2	23	35	1,45	110	16	0,21
> 240	Primipar	6	1	375	1	20,7	22	36	1,25	98	17	0,21
1-120	Multipar	19	4	87	2	29,2	23	36	1,67	124	18	0,24
121-240	Multipar	33	4	174	3	26,5	24	34	1,54	120	17	0,22
> 240	Multipar	25	5	340	9	19,9	22	38	1,28	98	16	0,20
alle	Primipar	28	1	209	2	23,2	23	35	1,46	107	16	0,22
alle	Multipar	77	4	207	4	25,6	23	36	1,51	116	17	0,22
alle	alle	105	3	207	3	25,0	23	35	1,50	114	17	0,22



## FE – Feed Efficiency - in the LKV Herd Manager

- Is the ratio of the amount of milk produced (kg ECM) to the amount of feed consumed (kg DM, GfE2001 method).
- Provides information on the conversion of the ingested feed quantity into ECM
- Method to calculate the FE:  $FE = \frac{\text{ECM kg cow/day}}{\text{kg DMI cow/day}}$

**kg DMI cow/day**

- Warning values: < 1,2 to > 1,8 (kg ECM/kg DMI)



Estimated from milk spectral data, allows for group-level interpretation to finer screening



# FE – Feed Efficiency - in the LKV Herd Manager

Stoffwechsel > Effizienz > Historie > Übersicht

Parameter Futtereffizienz [kg ECM/kg TM]

Futtereffizienz [kg ECM/kg TM] Info < 1.2 > 1.8

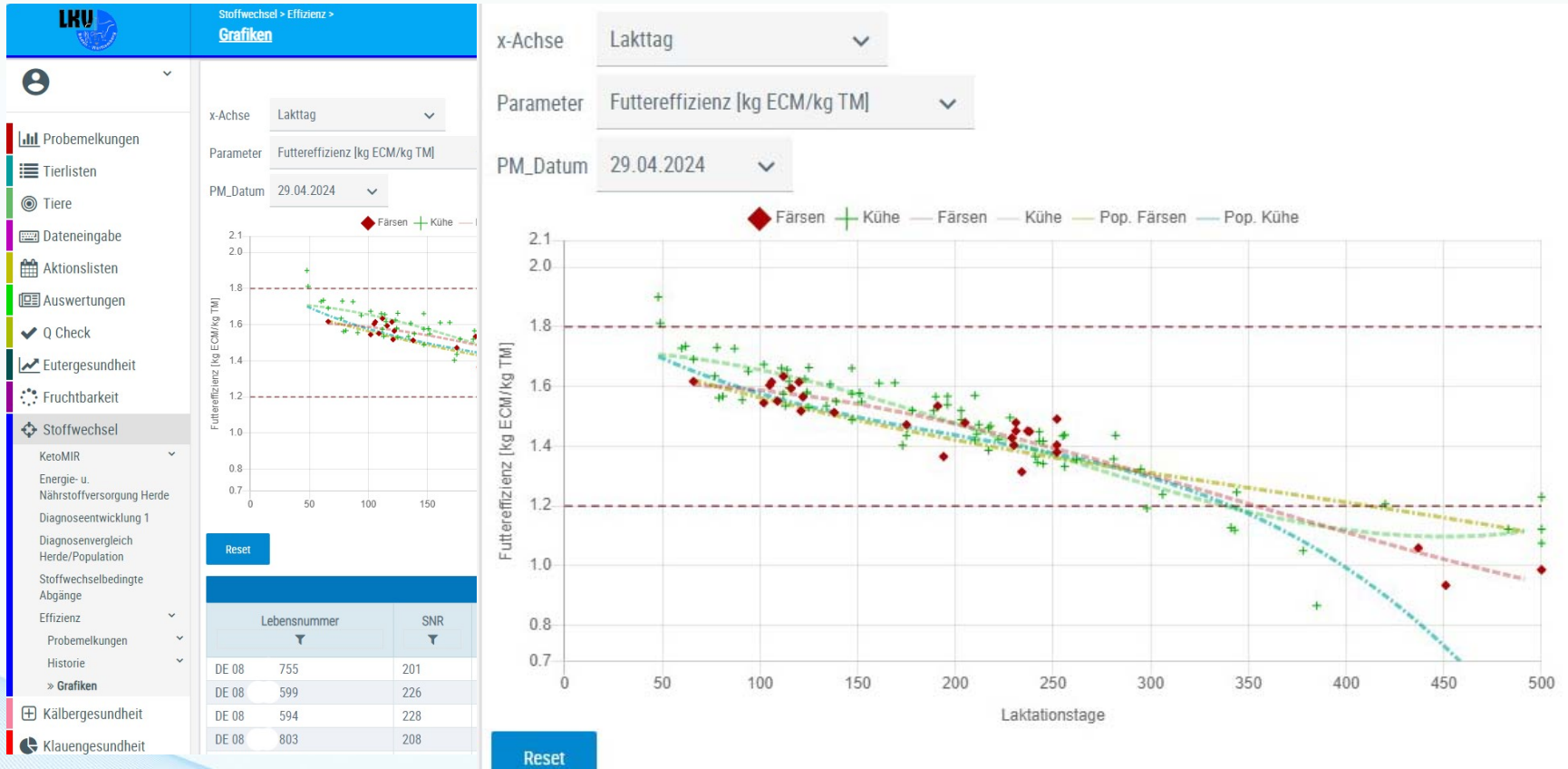
Abschn.	Status	Anz. Tiere	Anz. Lakt	L-Tage	MKg	ECM	F%	E%	L%	H	Anteil KM2	Anteil KM3	Futtereffizienz [kg ECM/kg TM]								
													29.04.24	26.03.24	27.02.24	25.01.24	18.12.23	19.11.23	19.10.23	18.09.23	24.07.23
1-120	F	11	1	81	24,8	23	3,89	3,11	4,95	30	0,0	9,1	1,60	1,60	1,82	1,99			2,21		
121-240	F	14	1	198	22,7	22	4,32	3,18	4,93	31	0,0	0,0	1,45	1,50	1,50	1,59	1,56	1,57	1,93	2,44	
> 240	F	10	1	365	19,5	19	4,19	3,33	4,91	29	0,0	0,0	1,25	1,27	1,28	1,41	1,28	1,41	1,48	1,73	1,46
1-120	K	26	4	81	29,8	28	3,91	3,03	4,86	29	23,1	7,7	1,67	1,75	1,89	2,03	1,08	1,19	1,35	1,45	1,50
121-240	K	37	4	179	25,5	25	4,42	3,21	4,85	27	0,0	0,0	1,54	1,54	1,63	1,73	1,72	1,52	1,50	1,33	1,38
> 240	K	43	4	364	17,9	17	4,37	3,44	4,69	26	0,0	0,0	1,28	1,35	1,36	1,49	1,39	1,43	1,58	1,75	1,63
alle	F	35	1	209	22,6	22	4,14	3,19	4,93	30	0,0	2,9	1,46	1,47	1,53	1,67	1,45	1,50	1,72	1,97	1,46
alle	K	106	4	230	24,4	23	4,25	3,23	4,81	27	5,7	1,9	1,51	1,55	1,60	1,69	1,48	1,39	1,49	1,53	1,48
alle	alle	141	4	225	24,0	22	4,22	3,22	4,84	28	4,3	2,1	1,50	1,53	1,58	1,68	1,47	1,42	1,53	1,59	1,48



## FE – Feed Efficiency - in the LKV Herd Manager

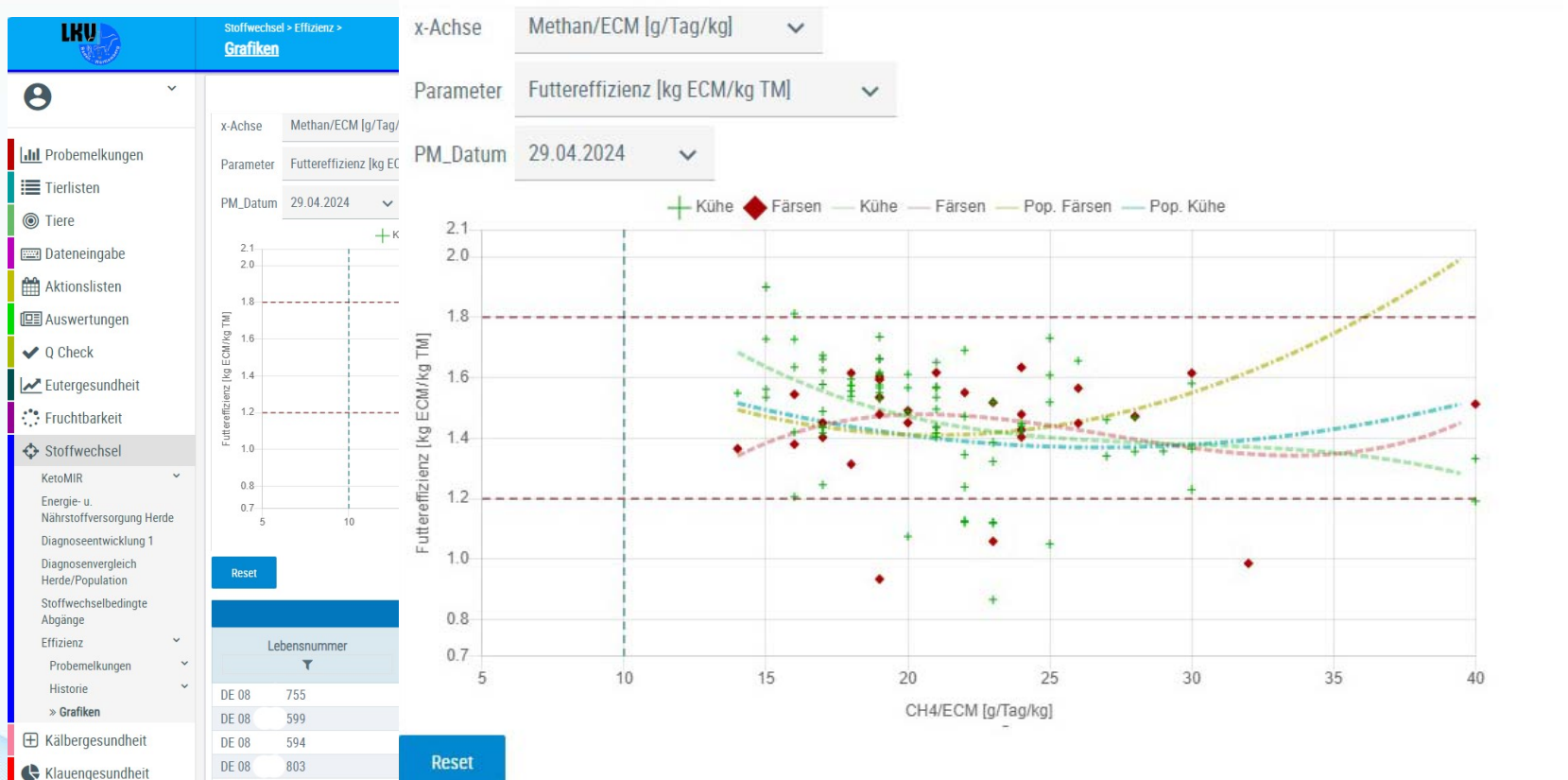
- Low values when cows do not sufficiently convert the feed they consume into milk.
  - ✓ Consequence: fatty degeneration of the cow or alternative use of energy in the body.
- High values, when cows take in too little feed and break down body substance.
  - ✓ Consequence: Weight loss of the cow or alternative use of energy in the body.
- Factors influencing too low / too high energy efficiency
  - ✓ Milk quantity
  - ✓ Persistence
  - ✓ No optimal feed intake:
    - i. feed table condition
    - ii. animal feeding ratio
    - iii. feed availability
    - iv. feed quality

# FE – Feed Efficiency - in the LKV Herd Manager





# FE – Feed Efficiency - in the LKV Herd Manager



# Energy Balance - in the LKV Herd Manager



Warning value:

< -30 to > 40 (MJ NEL/day)

Energy Balance = Energy Intake –

(energy required for body maintenance + production and gestation)



# DeNovo FA - in the LKV Herd Manager

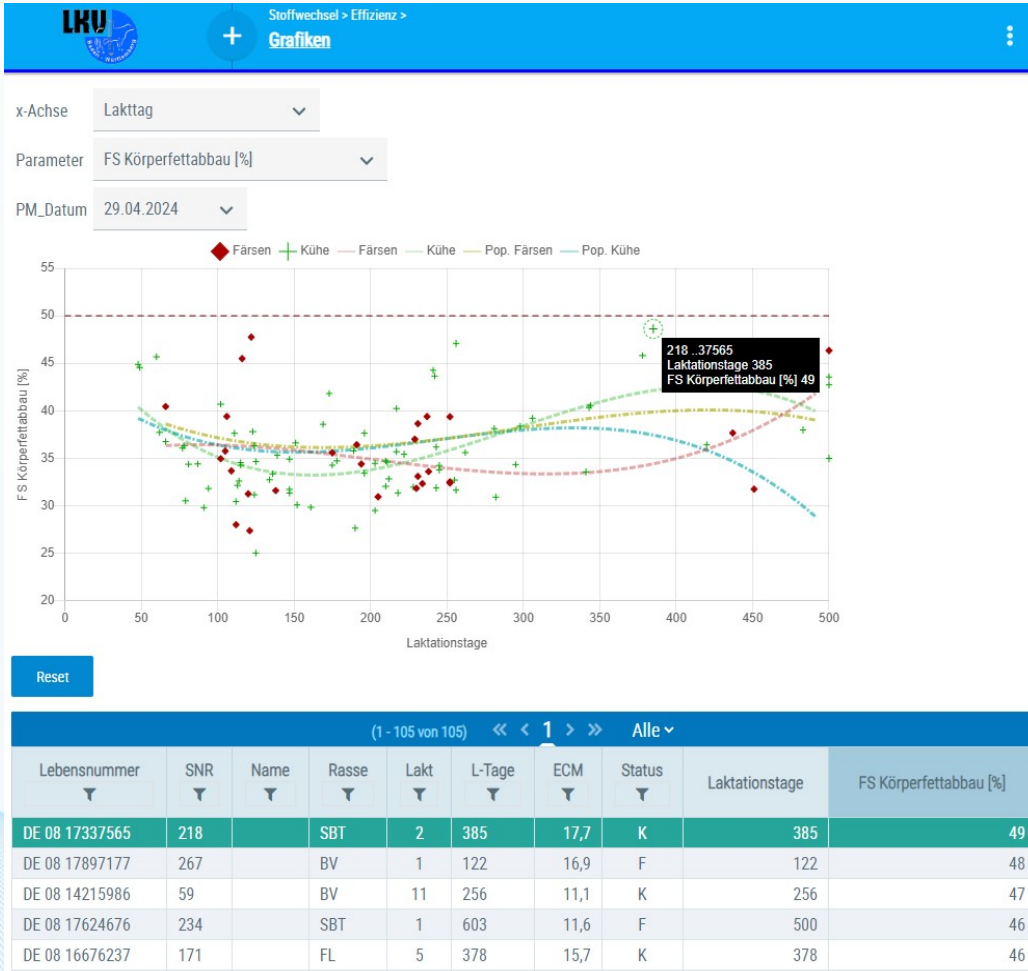


Warning value: < 20 (%)

- Are directly related to the functionality of the rumen
- Low values indicate low feed intake, excessive crude fat content, low cell wall digestibility or insufficient rumen fermentation\*

\*Barbano et al, 2015; New milk mid-FTIR metrics for dairy cattle management

# Preform FA - in the LKV Herd Manager



Warning value: > 50 (%)

- high values indicate high degradation of endogenous pre-formed (long chain) fatty acids
- Preformed Fatty acids are given in the report as a percentage of total fat (100%) (not in relation to the content in milk)\*

\* Barbano et al, 2015; New milk mid-FTIR metrics for dairy cattle management

# FeMIR - MIR Spectral predictions in the LKV Herd Manager

Stoffwechsel > Effizienz > Problemerkungen > Übersicht

PM-Datum 29.04.2024

Energiebilanz [MJ]	< -30	> 40
FS neugebildet [%]	< 20	
FS Körperfettabbau [%]	> 50	
Futtereffizienz [kg ECM/kg TM]	< 1.2	> 1.8
Energieaufnahme [MJ NEL]	< 80	> 180
TM-Aufnahme [kg TM]	< 5	> 25
Energieeffizienz [kg ECM/MJ NEL]	< 0.12	> 0.36
Stickstoffeffizienz [%]	< 30	
CH4/ECM [g/Tag/kg]	< 10	

Abschn.	Status	Anz. Tiere	Anz. Lakt.	L- Tage	MKg	F%	E%	L%	H	Anteil KM2	Anteil KM3	Energie [MJ]
1-120	F	8	1	105	25,9	3,79	3,03	4,97	31	0,0	0,0	
121-240	F	14	1	198	22,7	4,32	3,18	4,93	31	0,0	0,0	
> 240	F	6	1	375	20,9	4,10	3,19	5,02	27	0,0	0,0	
1-120	K	19	4	87	30,1	3,95	3,04	4,90	29	21,1	0,0	
121-240	K	33	4	174	25,8	4,43	3,18	4,89	27	0,0	0,0	
> 240	K	25	5	340	18,9	4,47	3,36	4,76	26	0,0	0,0	
alle	F	28	1	209	23,4	4,12	3,14	4,96	30	0,0	0,0	
alle	K	77	4	207	25,3	4,30	3,18	4,86	27	5,2	0,0	
alle	alle	105	3	207	24,9	4,25	3,17	4,88	28	3,8	0,0	

Group	Status	N. Anim.	N. Lact.	DIM	EB [MJ NEL]	ECM [kg]	NE [%]	CH4/ECM [g/day/kg]	CH4 [g/day]
1-120	Primipar	8	1	105	5	24,6	32	21	493
121-240	Primipar	14	1	198	0	23,2	28	21	472
> 240	Primipar	6	1	375	1	20,7	25	21	427
1-120	Multipar	19	4	87	2	29,2	33	18	521
121-240	Multipar	33	4	174	3	26,5	30	20	512
> 240	Multipar	25	5	340	9	19,9	26	23	437
alle	Primipar	28	1	209	2	23,2	29	21	470
alle	Multipar	77	4	207	4	25,6	30	20	496
alle	alle	105	3	207	3	25,0	30	20	489





# Methane/ECM - in the LKV Herd Manager\*



Methane Equation: based on MIR spectral model from CRA-W it is obtained  
 $g \text{ CH}_4 / \text{ day as daily mean}$

Methane Intensity =  
 $\frac{g \text{ CH}_4 / \text{ day as daily mean}}{\text{kg ECM cow/day}}$

Methane emission enables the use and monitoring of reduction measures

# Conclusions

Physical condition of the animals observed confirmed the experts' expectations derived from the parameters in the report.

While the feed efficiency can only be used together with the values of the energy balance, the latter is informative enough on its own.

On animal level, the report has still to be improved.

But all participants agree, on herd level the FeMIR report is a valuable and effective tool for managing feed and monitoring of animal health.

# Next Steps

Further research is needed on animal level and to investigate the impact of **heat stress** on **efficiency indicators** to assess how **climate change** and **heat stress** affect cows **feeding systems**.



**Thank you for your attention!**  
**Vielen Dank für Ihre Aufmerksamkeit!**

