

Agricultural working posture and work load assessment by use of the energy consumption method

Hermann Auernhammer

Technical University of Munich, Weihenstephan
Germany

International Agricultural Engineering Conference

Bangkok, Thailand

December 6 - 9, 2005

Nostalgic agricultural work (The Harvesters, Bruegel 1565)

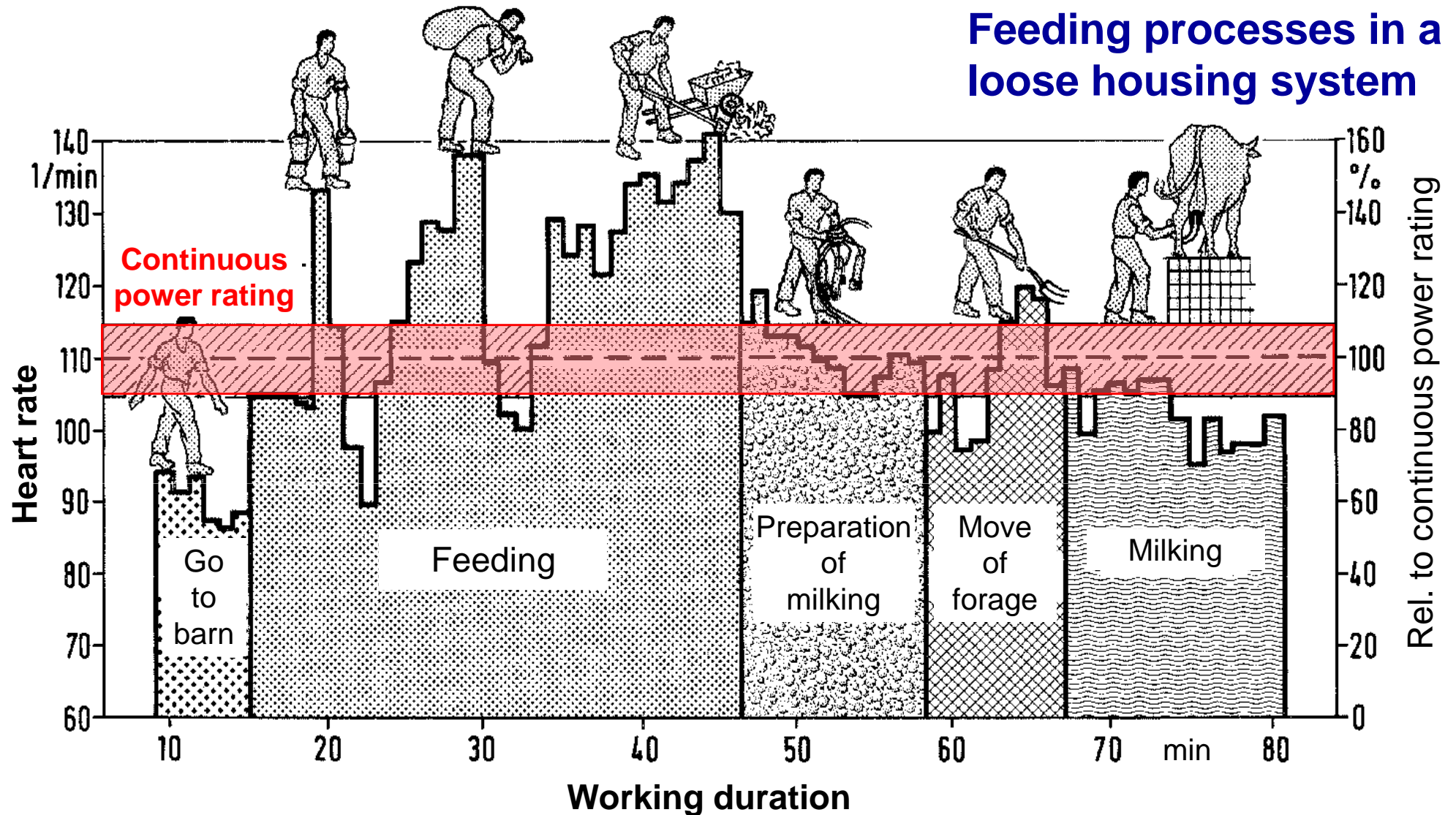


Methods and Materials

Still some manual work in agriculture forces a high work load

Measurement can be done with the heart rate method and others

Feeding processes in a loose housing system



Methods and Materials

Still some manual work in agriculture forces a high work load

Measurement can be done under real conditions with the heart rate method and others

But for planning purposes we need an evaluation method

- to improve the work process at all
- to reduce the work load above the continuous power rating
- to detect the work sequences with a too high work load
- to substitute those sequences with alternative technologies

Energy consumption of working postures and types of work

Working posture	kJ/min		
Sitting	1.0		
Kneeing	3.0		
Croching	5.0		
Standing	2.5		
Ducked standing	4.0		
Walking	7.0		
Moving up/down	3,0 per meter		
Type of Work	kJ/min		
Simple handwork	1.0	1.8	2.5
Medium handwork	2.5	3.3	4.0
Haevy handwork	4.0	4.8	5.5
Simple one arm work	2.5	3.8	5.0
Medium one arm work	5.0	6.3	7.5
Haevy one arm work	7.5	8.8	10.0
Simple two arm work	6.0	7.3	8.5
Medium two arm work	8.5	9.8	11.0
Haevy two arm work	11.0	12.3	13.5
Simple body work	11.0	14.0	17.0
Medium body work	17.0	21.0	25.0
Haevy body work	25.0	30.0	35.0
Very haevy body work	35.0	42.5	50.0

Reasonable energy consumption across a working day

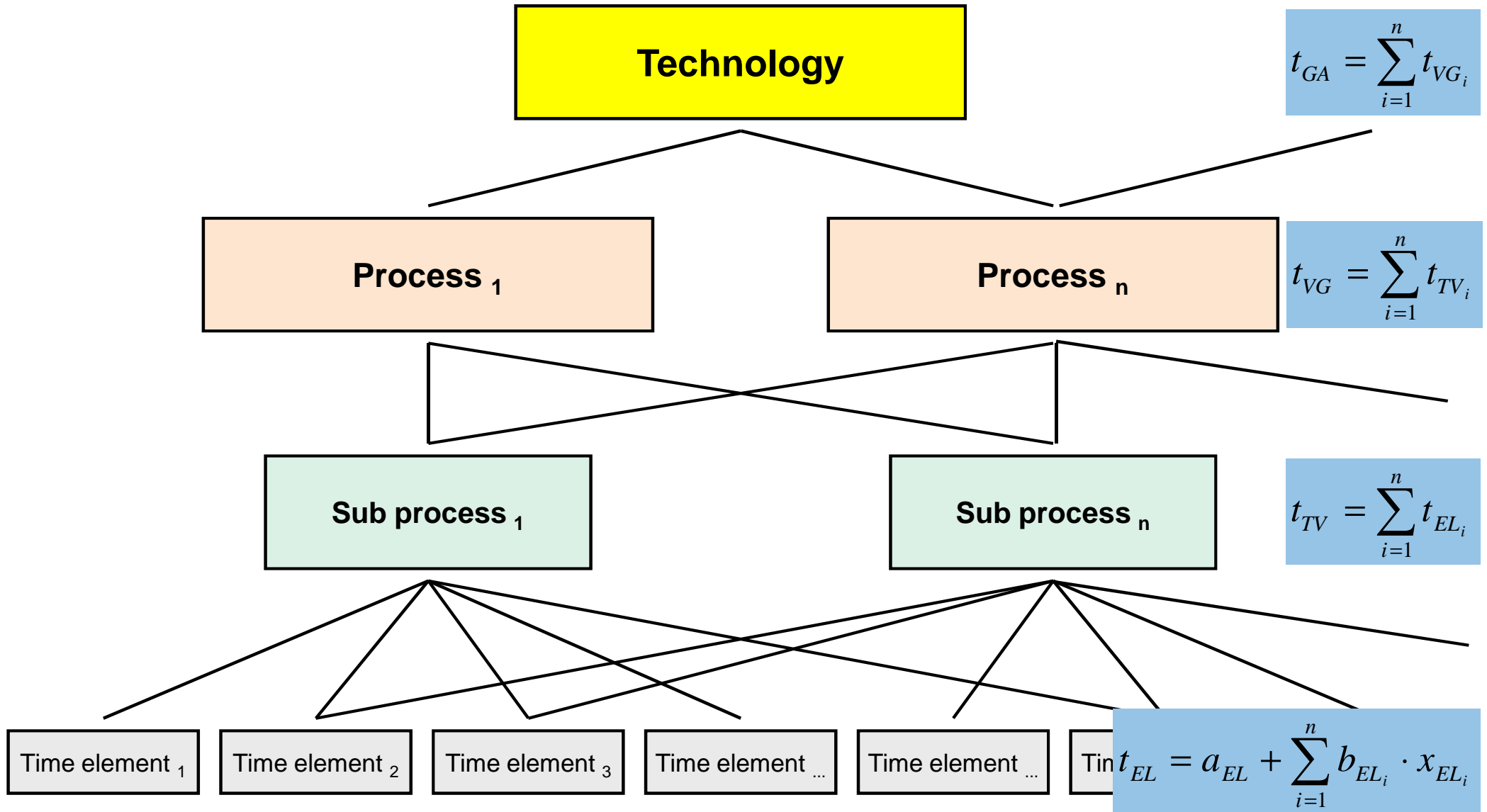
Male 8.500 kJ/8h = **17.3 kJ/min**

Female 5.500 kJ/8h = **11.4 kJ/min**

Source: Hettinger und Spitzer, 1982

Basic model structure for “Work Time Calculation” in LISL

(LISL = Landwirtschaftliches Informations-System Landtechnik)



Document structure in LISL

Part 1 **Title**

Measurement points
Author(s)
Modifications

Part 2 **Work content**

Work flow
Restrictions

Part 3 **Parameters**

Number of parameters
Parameter definition
Default value of parameters
Dimension

Part 6 **Work element with statistics / Sub model concatenation**

either **Mean / Regression**

*with: Distribution
Probability
Test values
Transformations (log)*

or **Concatenation rules**

*with: Calculated parameters
Number of sub models
Parameters of sub model*

Part 7: Energy consumption with

- Working posture (partly)
- Working type (partly)
- Energy consumption



Document of process element „walking without load“ in LISL

Dokument-Inn 100900 11. 7.05 12 0 0 0

PL 100900 Walking without load (load < 20kg)

Beginning: Lift foot for first step

End: Hit the ground with foot after last step

Created: 01.06.77 by H.Auernhammer, J.Reinholz, H.Zaeh

----- end of section -----

Content...

Walking with loads of max. 20kg.

----- end of section -----

Changeable variables = 2

- | | | |
|---------------------|------|-------|
| 1. Frequency | 1.0 | |
| 2. Walking distance | 20.0 | Meter |

----- end of section -----

Data acquisition scheme for 1 mandatory and 0 exploratory variables

- | | | | | | |
|-----------------|-------|-------|---|---|------|
| 1. Walking dist | Meter | 25-29 | 1 | 0 | 1.00 |
|-----------------|-------|-------|---|---|------|

----- end of section -----

Function 2652 measured values with 1 factors.; supplement = .90%

B = .928 average-Y = 29.0 S = .700 F=3433.0
 Distance 19.900 1.3113 .0060 225.863 .975 .000

----- End of section -----

Work load function

Energy- Posture 0.0 0.0 0.0 0.0 0.0 0.0 1.0 0.0
 Energy- Work type 0.0 0.0 0.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

----- End of document -----

Working posture

Sitting
 Kneeing
 Croching
 Standing
 Ducked standing
 Walking
 Moving up/down

Type of Work

Simple handwork
 Medium handwork
 Haevy handwork
 Simple one arm work
 Medium one arm work
 Haevy one arm work
 Simple two arm work
 Medium two arm work
 Haevy two arm work
 Simple body work
 Medium body work
 Haevy body work
 Very haevy body work

$$e_{EL} = \sum_{i=1}^n r_{EL_i} \cdot c_{EL_i} \cdot t_{EL_i}$$

Work time calculation in LISL

Final model results (milking with a pipeline milking system)

Result of calculation for a stock size of	15	animals
Time consumption per animal an day	7.9 Mmin*	= 0.13 Mh**
Time consumption per day and stock size	119.0 Mmin	= 1.98 Mh
Working duration per day	119.0 Mmin	= 1.98 Mh
Rearing period of	365	days
Time consumption per animal and period	48.3	Mh
Time consumption for full stock and period	723.8	Mh
Average work load from energy consumption	15.9	kJ/min
Rel. work load "female" (11.4 kJ/min)	139.8	%
Rel. work load "male" (17.3 kJ/min)	92.1	%

* Mmin = Man minutes

** Mh = Man hours

Example of a work load file in LISL

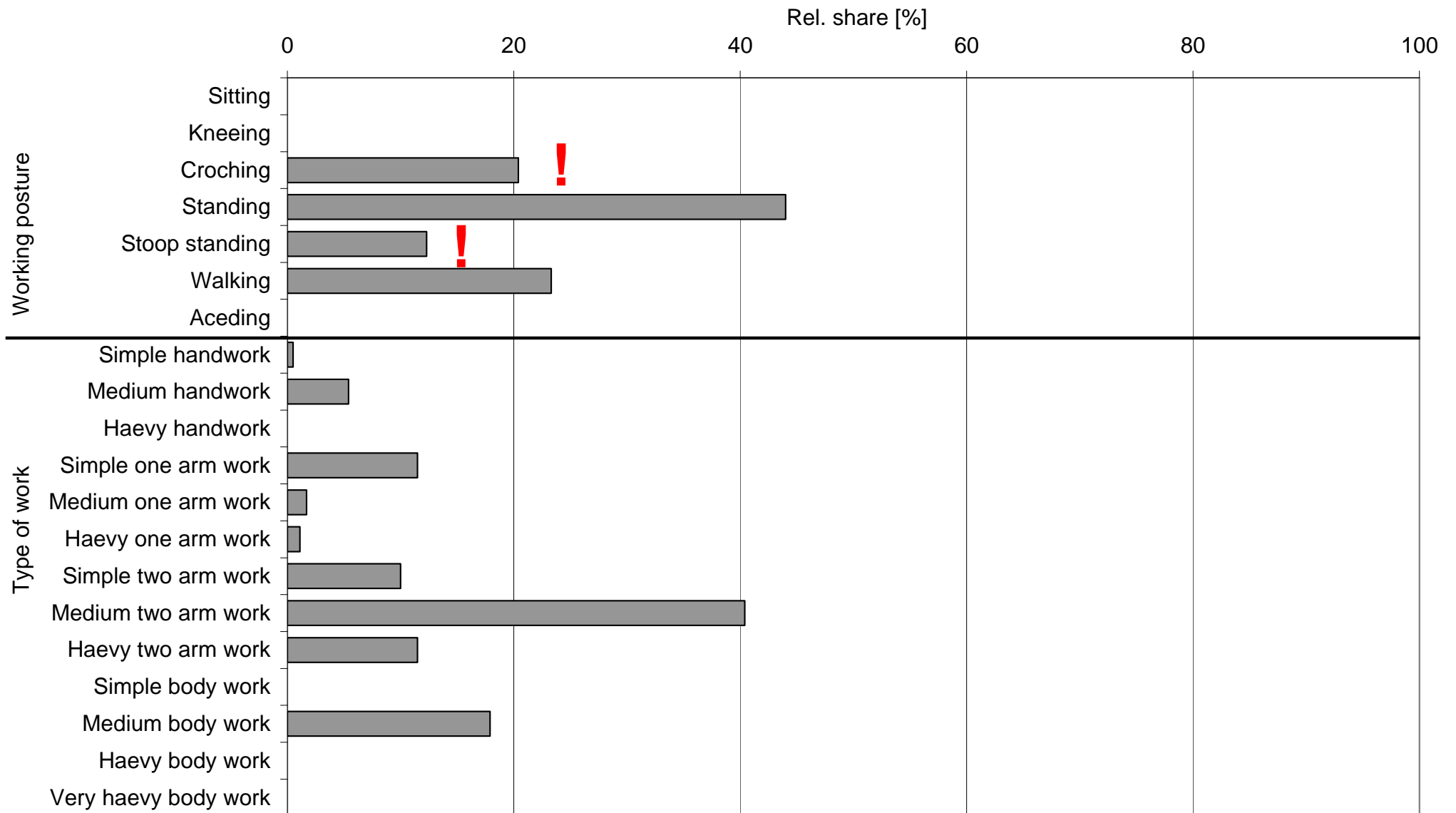
Model: VG 207 Milking in a tied-up stall with bucket milking system																							
TV 2070 General preparation work for milking																							
		0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.132	
		0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.125	
		0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.090	
		0.0	0.0	0.0	0.2	0.0	0.8	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.166	
		0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.4	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.357	
TV 2071 preparation work for milking in a tied-up stall																							
		0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	2.000	
...																							
		0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.000	
		0.0	0.0	0.0	0.0	0.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.383	
TV 2072 Milking in a tied-up stall with bucket milking system																							
		0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.190	
		0.0	0.0	0.0	0.3	0.0	0.7	0.0	0.0	0.6	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.760	
...																							
		0.0	0.0	0.0	0.0	0.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	4.109	
		0.0	0.0	0.0	0.3	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	10.656	
		0.0	0.0	0.0	0.0	0.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.370	
TV 2073 Finishing work after milking in a tied-up stall																							
		0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.090	
		0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.277	
...																							
Rel. share		0.0	0.0	20.4	44.0	12.3	23.3	0.0	0.5	5.4	0.0	11.5	1.7	1.1	10.0	4.0	0.0	0.0	0.0	0.0	0.0	9.500	
100%																100%							
Working posture																Type of work						total time	

- Working posture**
- Sitting
 - Kneeing
 - Croching
 - Standing
 - Ducked standing
 - Walking
 - Moving up/down

- Type of Work**
- Simple handwork
 - Medium handwork
 - Haevy handwork
 - Simple one arm work
 - Medium one arm work
 - Haevy one arm work
 - Simple two arm work
 - Medium two arm work
 - Haevy two arm work
 - Simple body work
 - Medium body work
 - Haevy body work
 - Very haevy body work

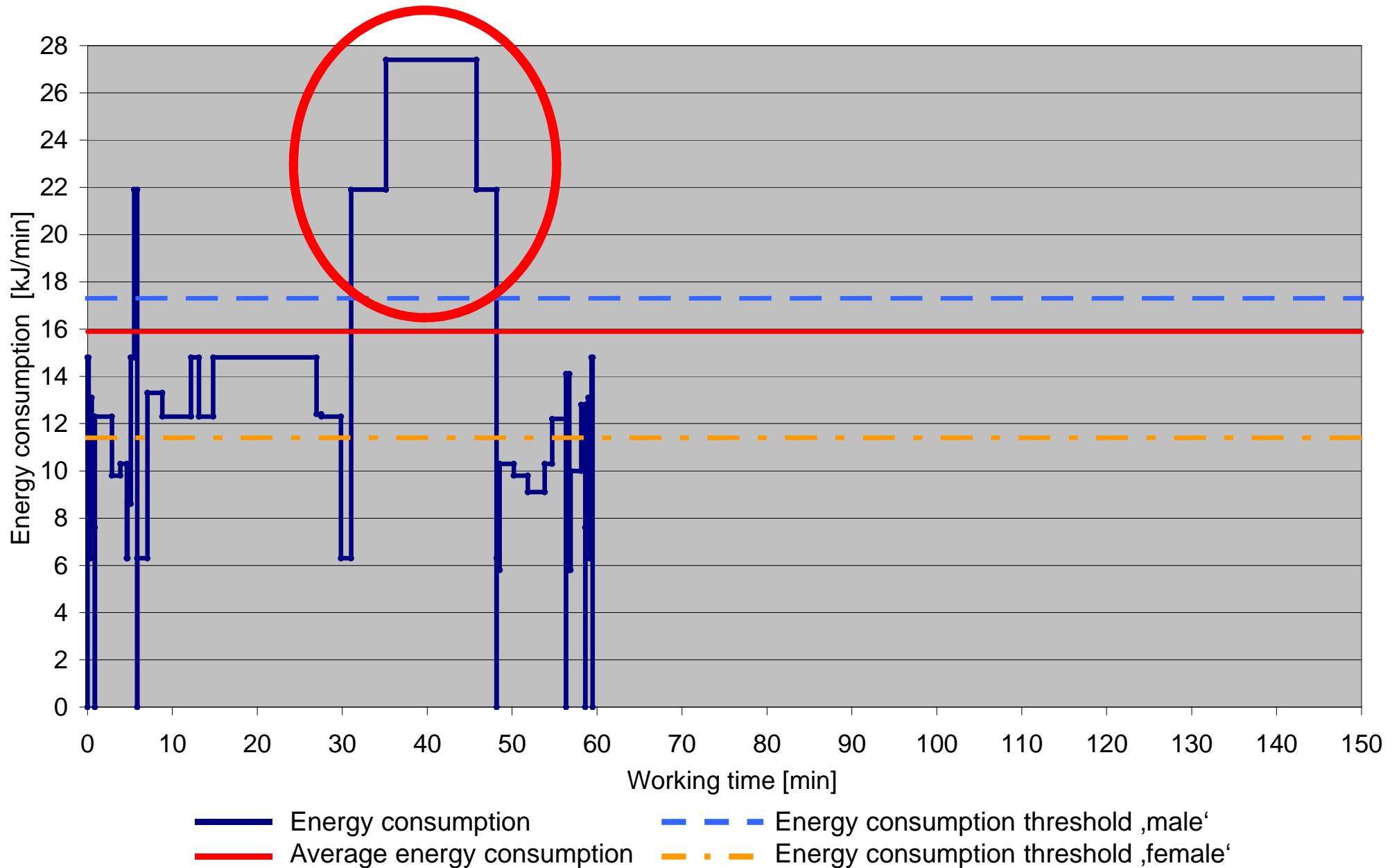
Rel. shares of working postures and types of work

Bucket milking system



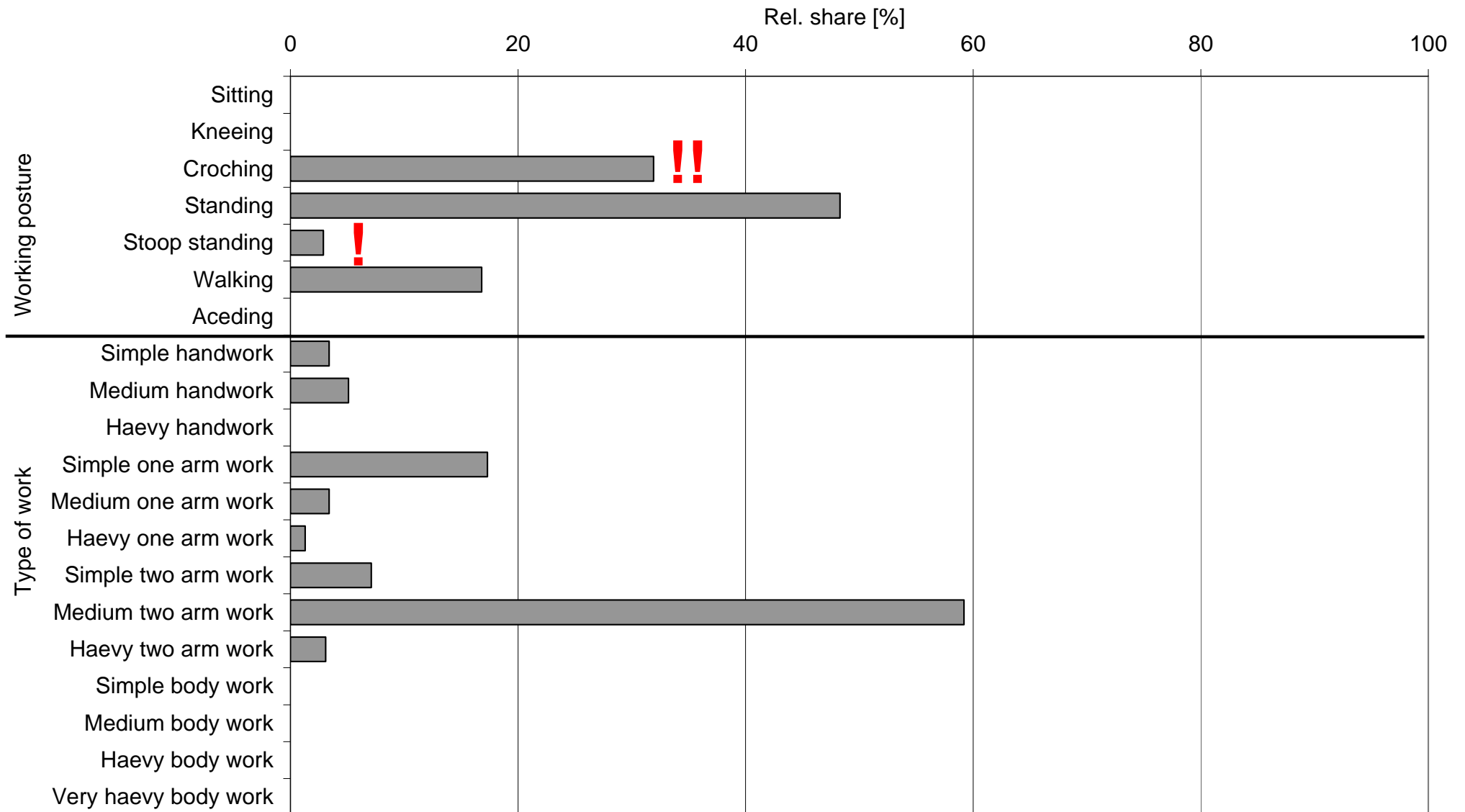
Distinguished energy consumption profile

Bucket milking system



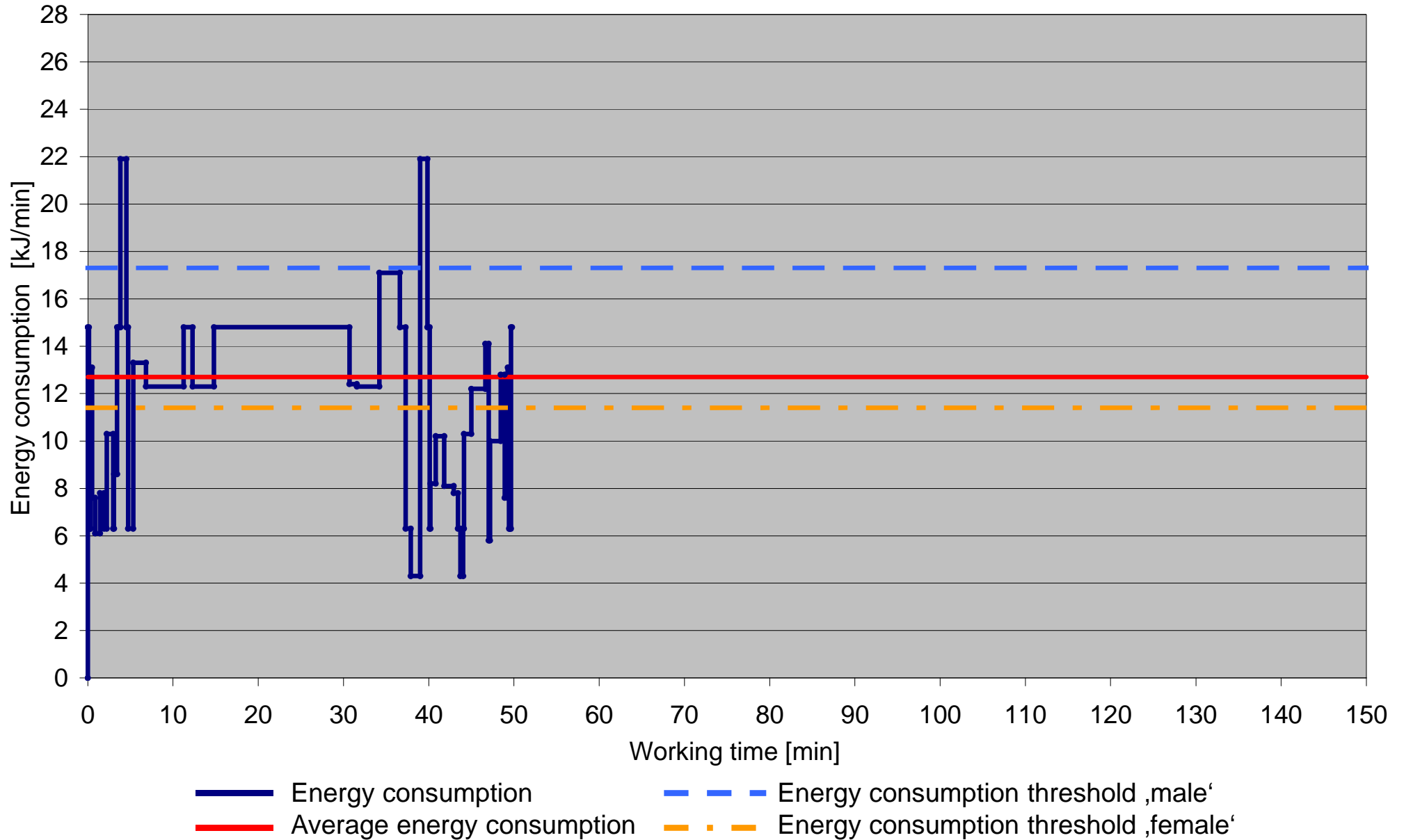
Rel. shares of working postures and types of work

Pipeline milking system



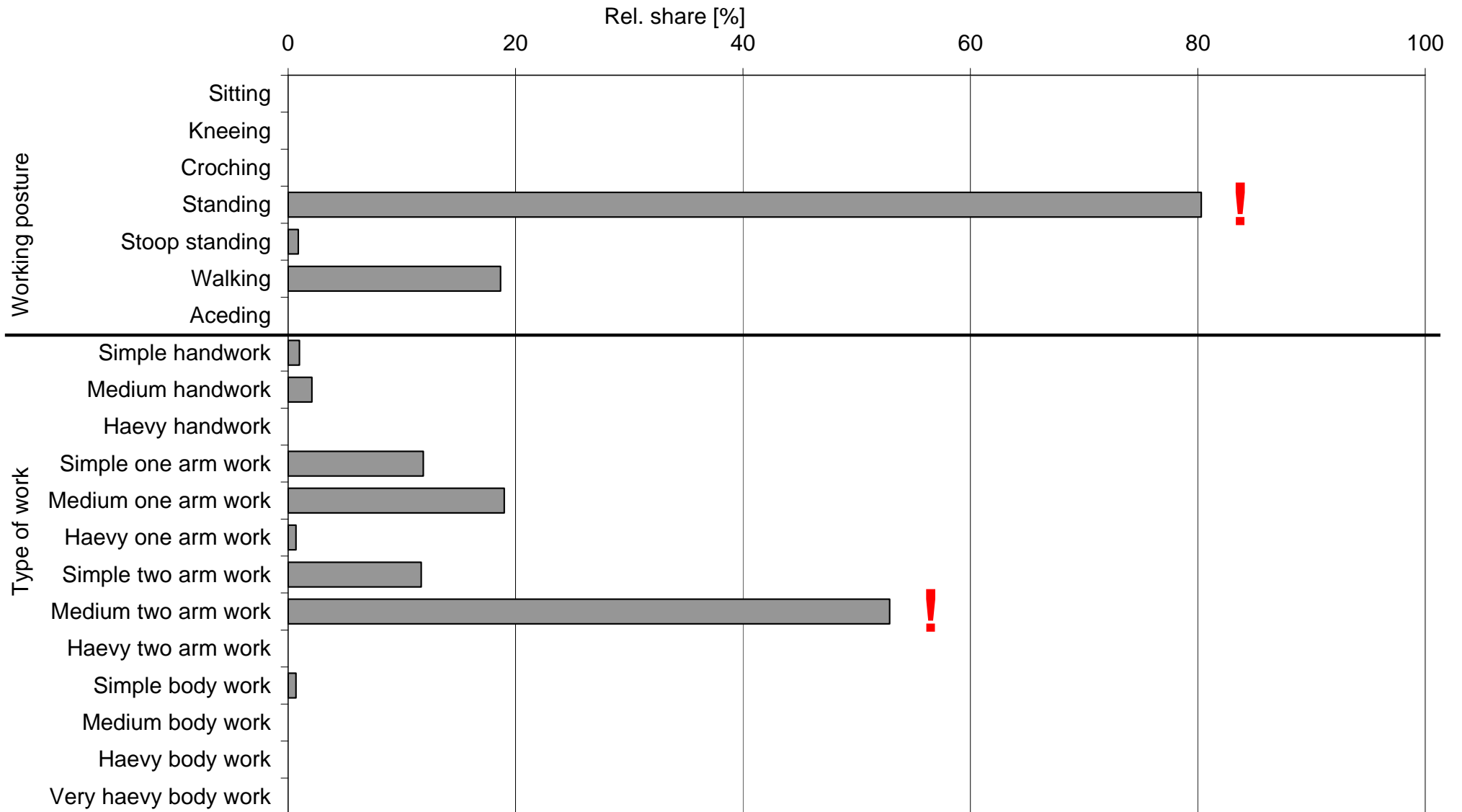
Distinguished energy consumption profile

Pipeline milking system



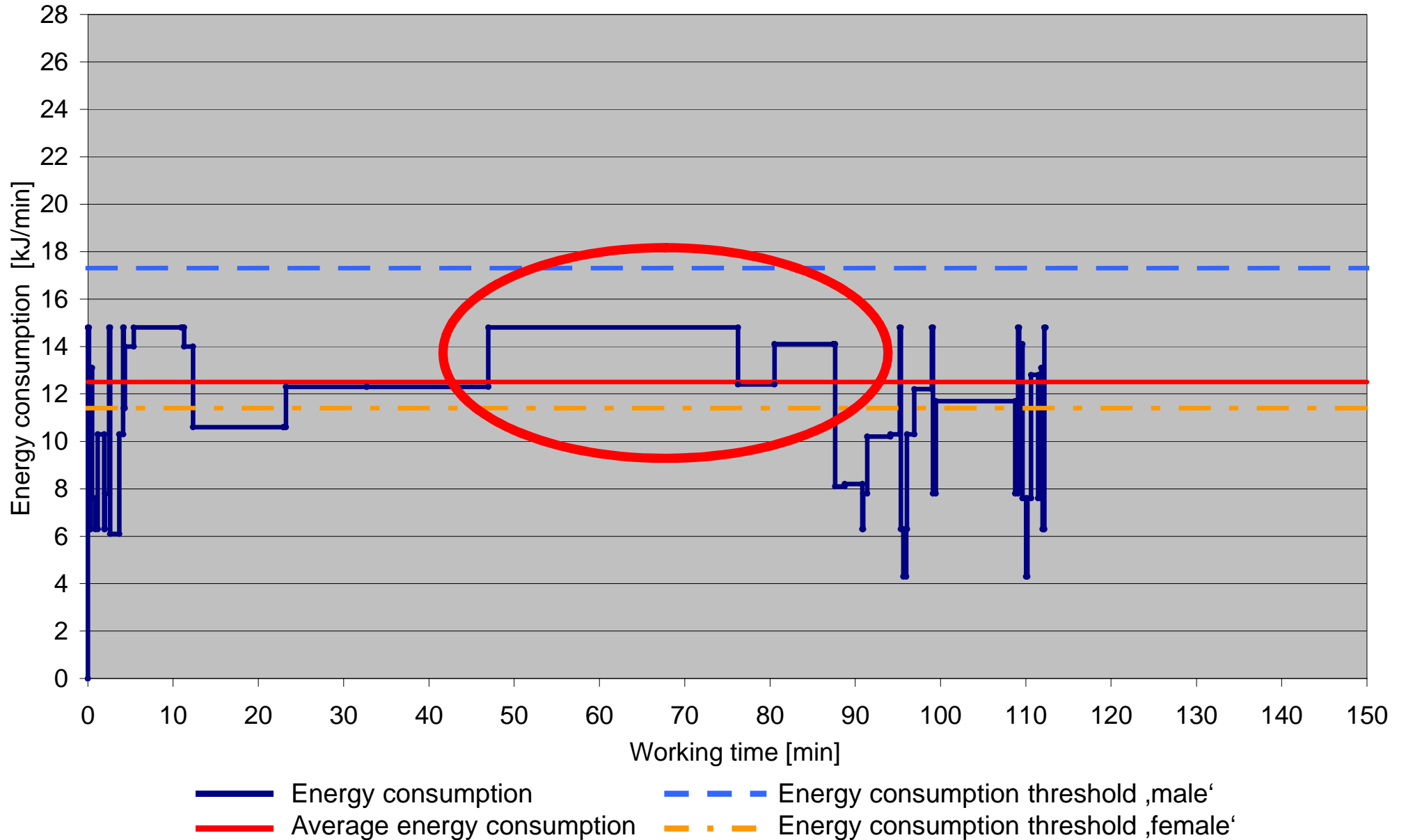
Rel. shares of working postures and types of work

Herringbone milking parlour



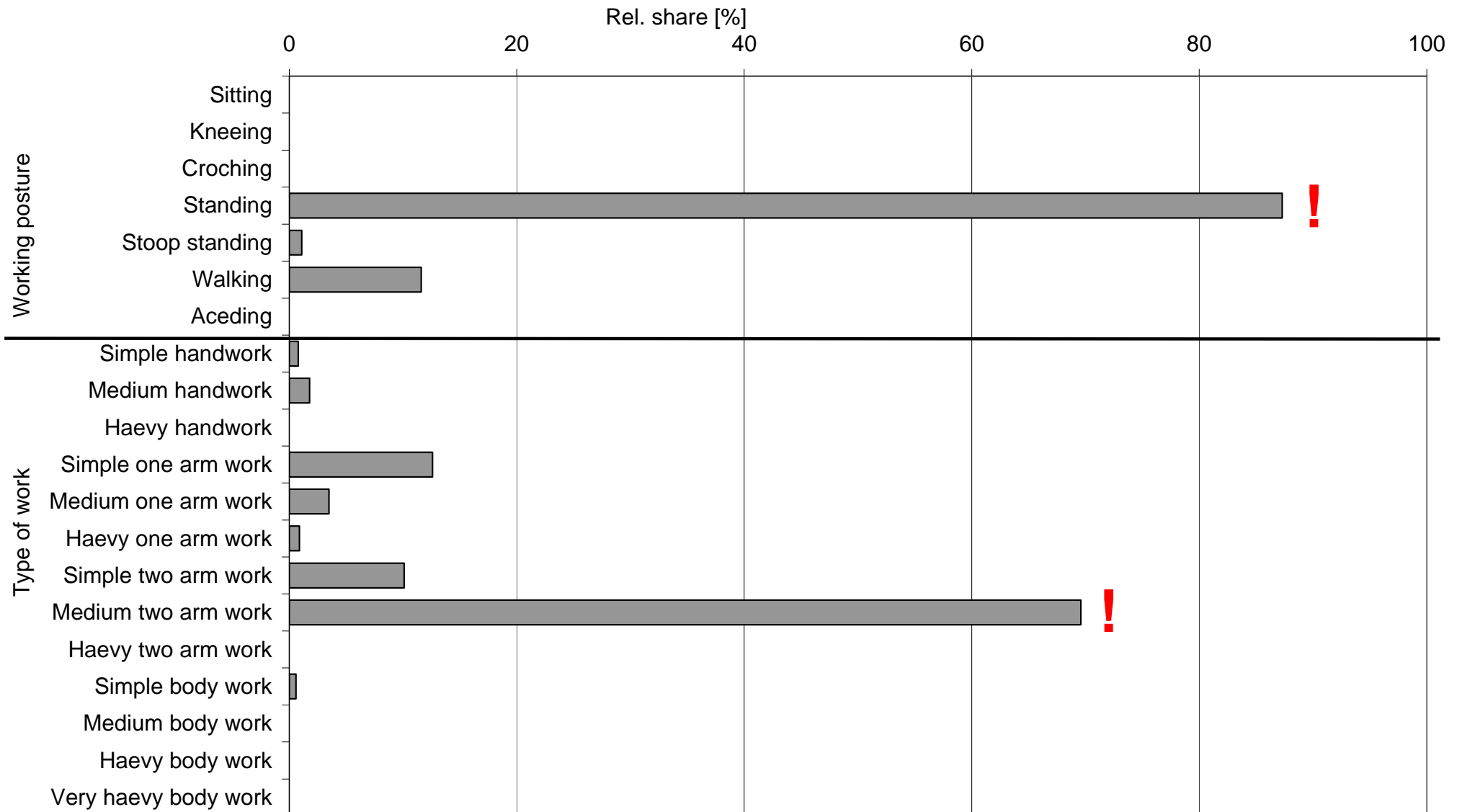
Distinguished energy consumption profile

Herringbone milking parlour



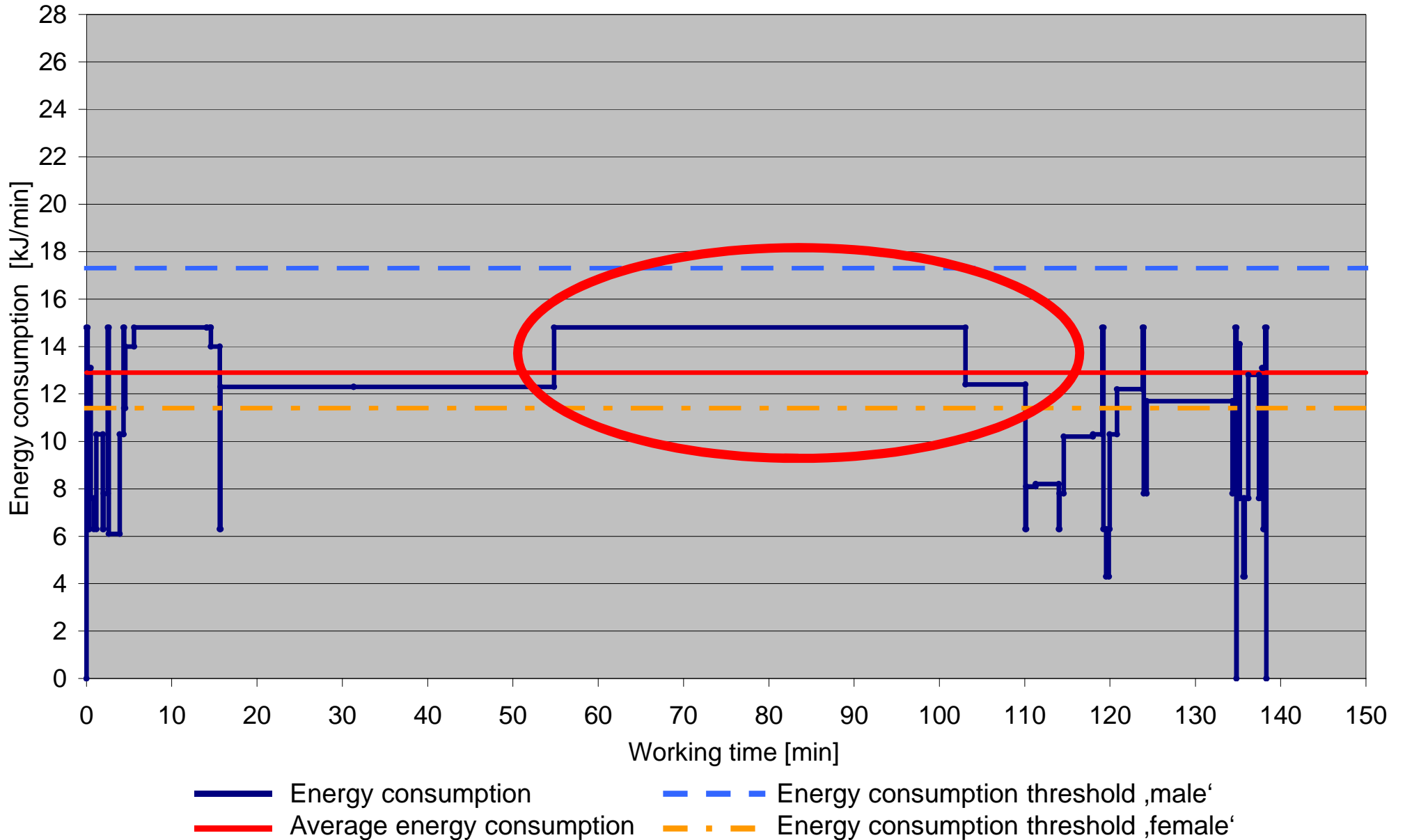
Rel. shares of working postures and types of work

Rotary milking parlour



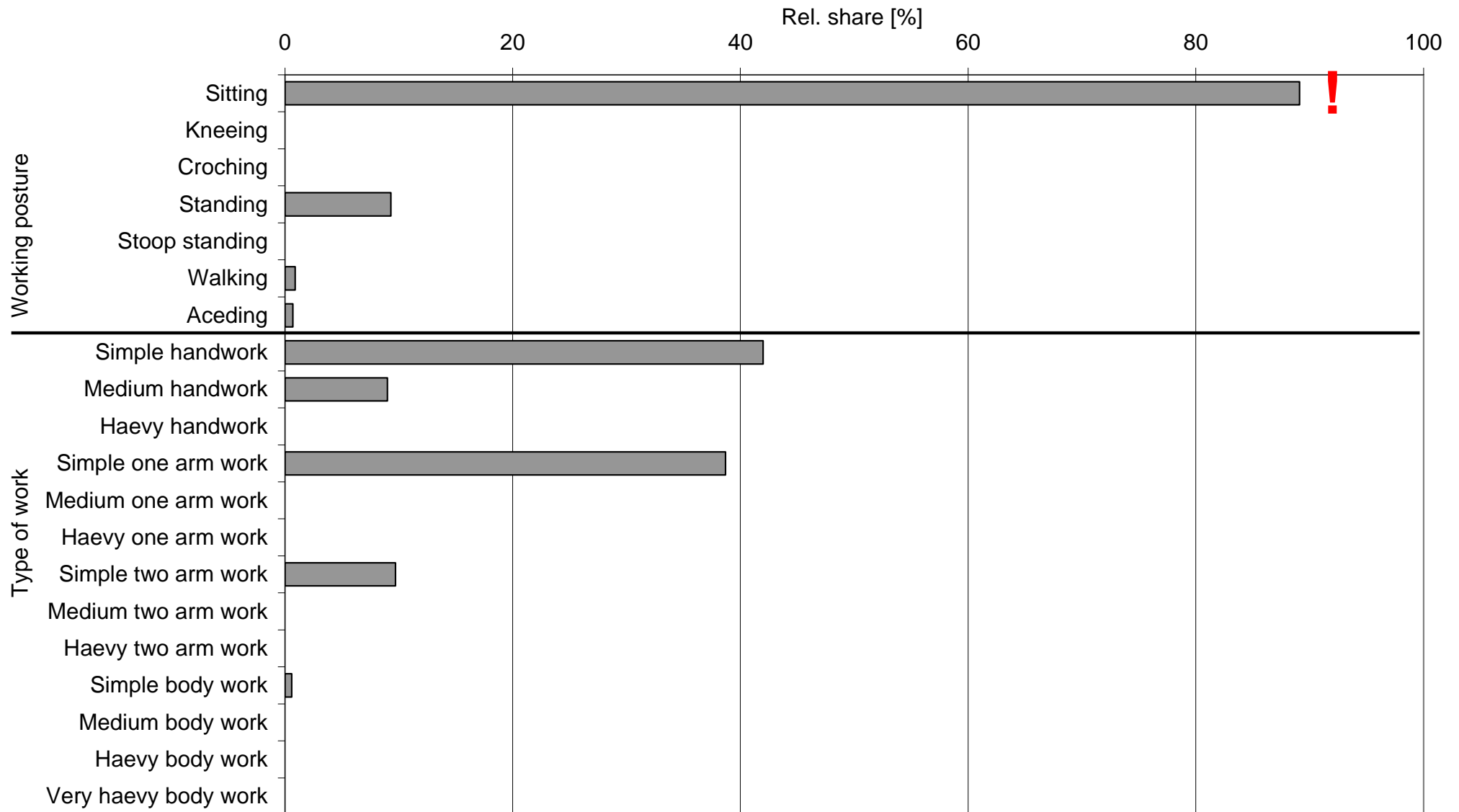
Distinguished energy consumption profile

Rotary milking parlour



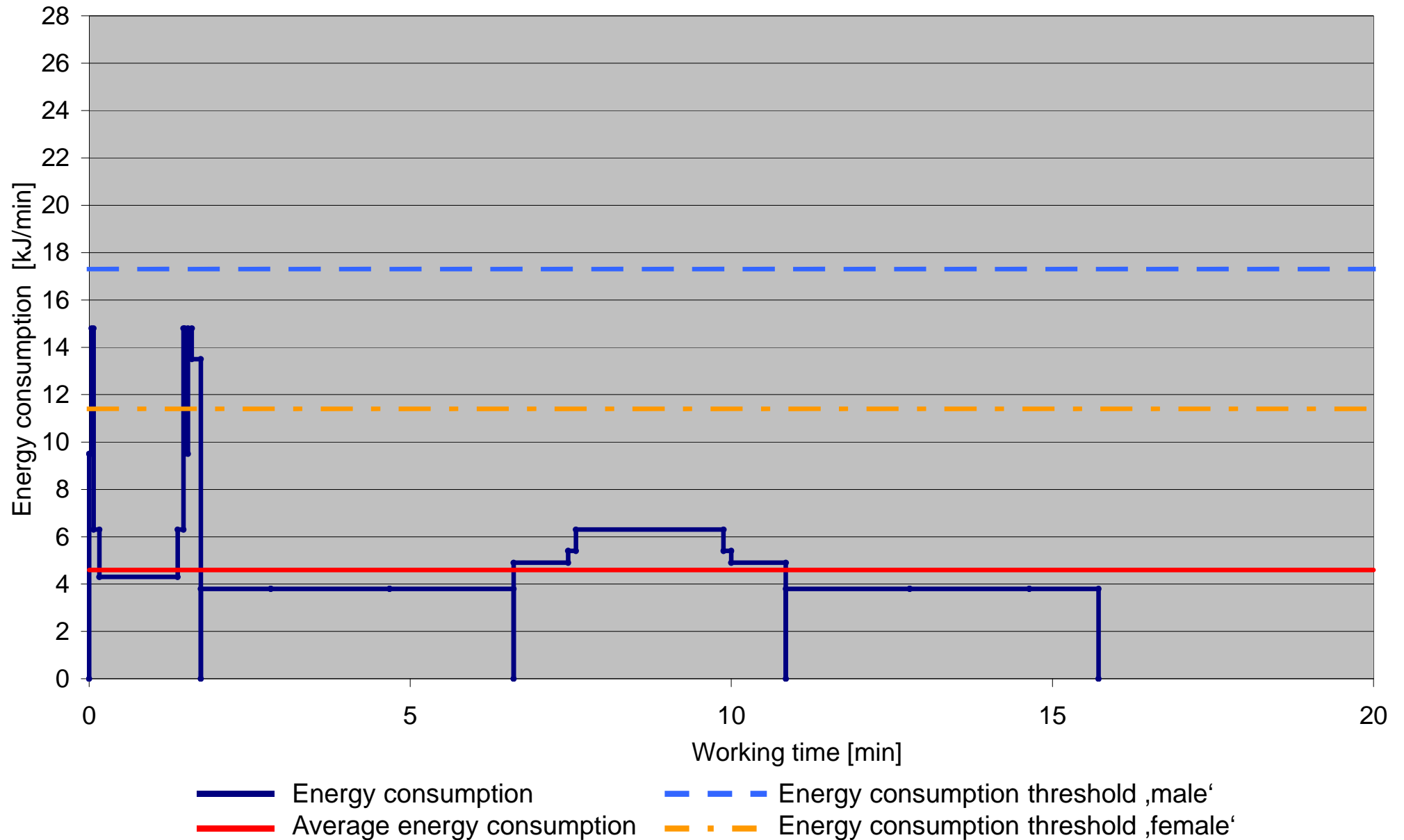
Rel. shares of working postures and types of work

Slurry spreading



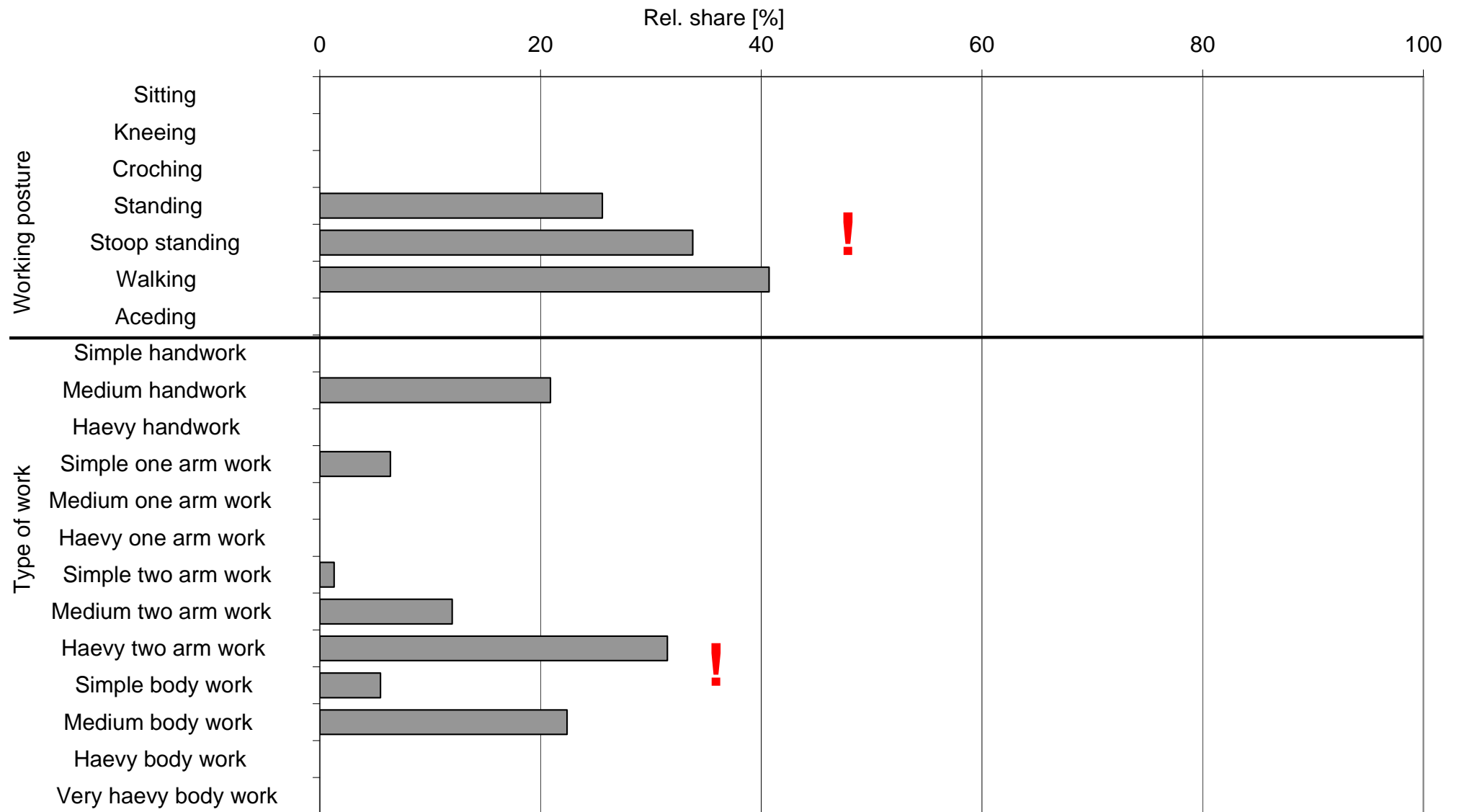
Distinguished energy consumption profile

Slurry spreading



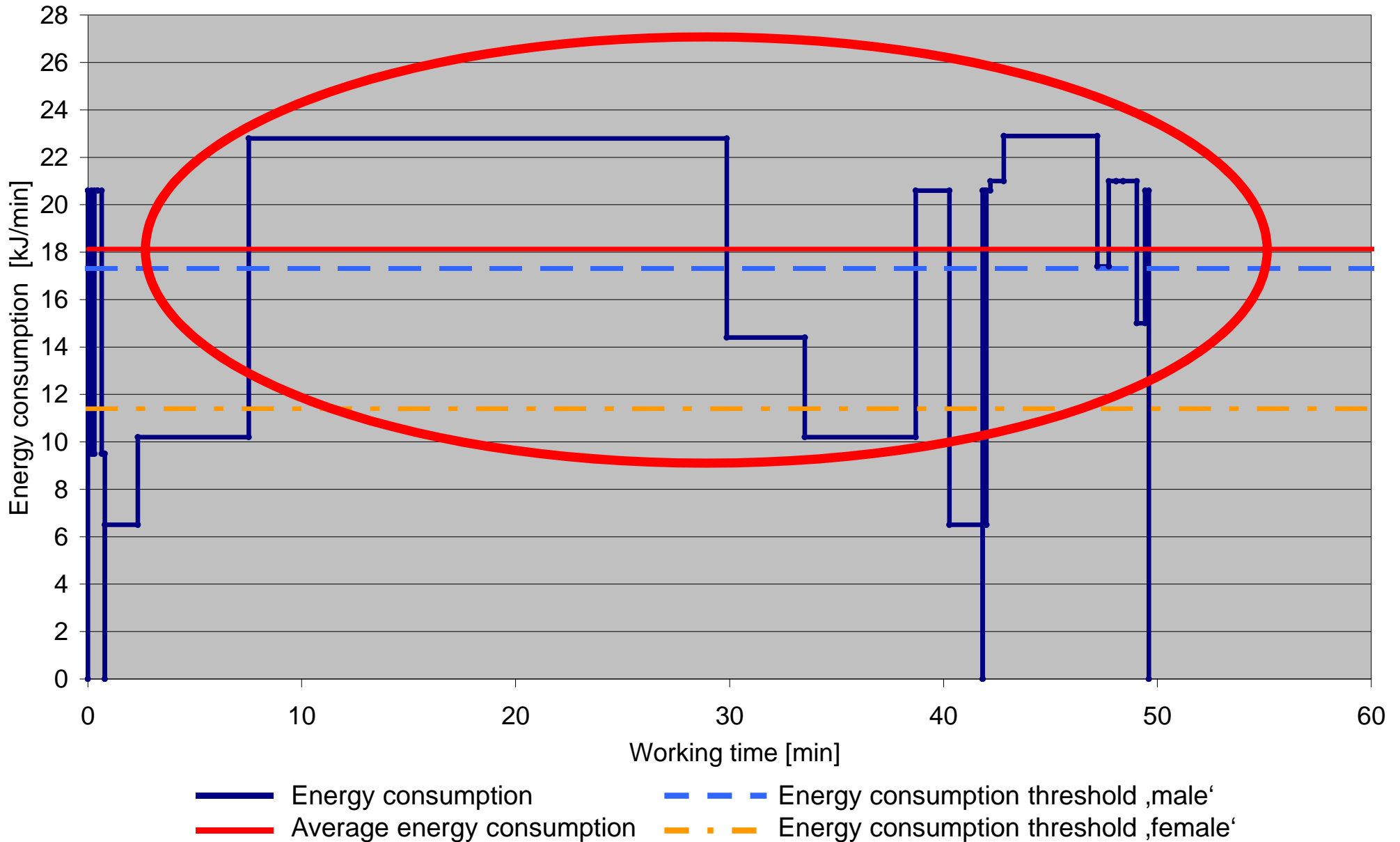
Rel. shares of working postures and types of work

Muck out in pig farming



Distinguished energy consumption profile

Muck out in pig farming



Rel. shares in different milking systems

Unfavourable working postures and energy consumption above thresholds

	Milking system				Pig farming
	Bucket	Pipeline	Herringbone	Rotary	Muck out
	15 dairy cows	20 dairy cows	60 dairy cows	100 dairy cows	30 sows
	2 milking units	3 milking units	2x5 milking units	13 milking units	Litter
Unfavourable working posture [%]	32.8	34.9	27.0	36.0	33.8
Unfavourable type of work [%]	12.6	4.4	0.7	0.9	31.5
Over female energy consumption threshold [%]	77.0	75.3	76.7	87.7	72.1
Over male energy consumption threshold [%]	29.5	3.1	0.0	0.0	64.0

Conclusions

1. Several working procedures in agriculture cause a **high or even to high work load**
2. With the energy consumption model from **HETTINGER & SPITZER working postures, types of work** and the **consumption of energy** can be analyzed
3. Based on a **detailed work time calculation** system like LISL working postures, types of work and energy consumption profiles along the working duration can be predicted
4. For **different milking systems** these method shows **impressive results**
5. The use of this method in extension as well as in the education of students gives an **additional benefit of work time calculations** and it opens the eyes for **labour improvements**