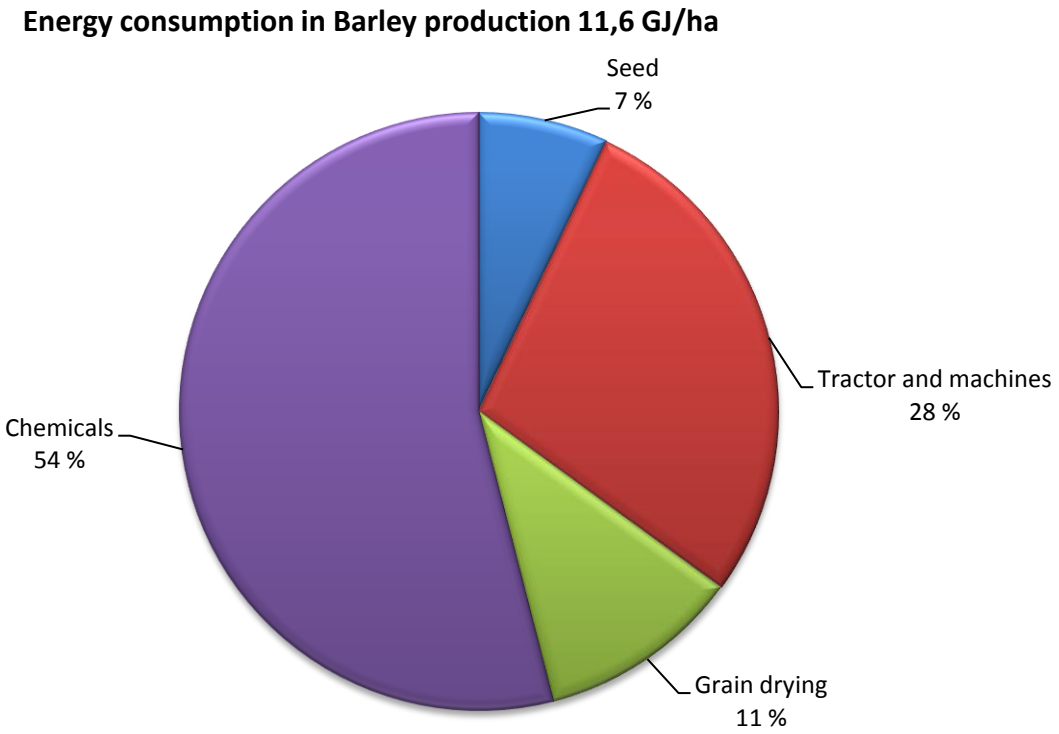
Monitoring energy use on farms, measurements, bookkeeping forms, inventories

J.Ahokas

Plant production



The parts consuming most of the energy are the most important ones!

Energy use on farms

Table 2. The most important starting values of input energy used in the models.

Operation of the production chain or material input	Diesel fuel or energy consumption	Unit	Sources
Primary tillage			
ploughing	25.1	l diesel per ha	1, 2, 3, 4, 7
stubble cultivation (one-pass)			
tine	10.0	l diesel per ha	3
disc	7.2	l diesel per ha	1, 7
Secondary tillage			
levelling of ploughed or stubble cultivated soil	4.5	l diesel per ha	2
harrowing (one-pass)	5.4	l diesel per ha	1, 2, 3, 4
Seeding			
combined seeding and fertilizing	3.7	l diesel per ha	2, 3
direct drilling	7.6	l diesel per ha	1, 3
Fertilizer spreading	2.9	l diesel per ha	1, 4
Spraying	1.8	l diesel per ha	1, 2, 3, 4
Combine harvesting	15.1	l diesel per ha	1, 2, 5
Grain drying	120.0	(g diesel oil) per 1kg H_2O evaporated	6
Mowing	6.0	l diesel per ha	1, 4
Baling (round bales)	0.5	l diesel per bale	1
Field transport	76.0	(g diesel oil) per ton and km	1
Nitrogen	49.2	MJ kg^{-1}	8
Phosphorous as P_2O_5	15.5	MJ kg^{-1}	8
Potassium as K_2O	9.7	MJ kg^{-1}	8
Pesticide	273.6	MJ kg^{-1}	8
Lime	1.3	MJ kg^{-1}	9

Example of direct energy consumption

+

+

+

+

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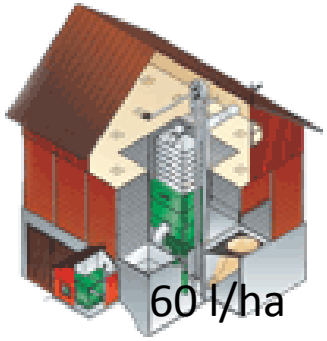


= 116 l/ha

Energy flows

Fuels
- diesel oil
- petrol
- wood
- peat
- straw
- gas

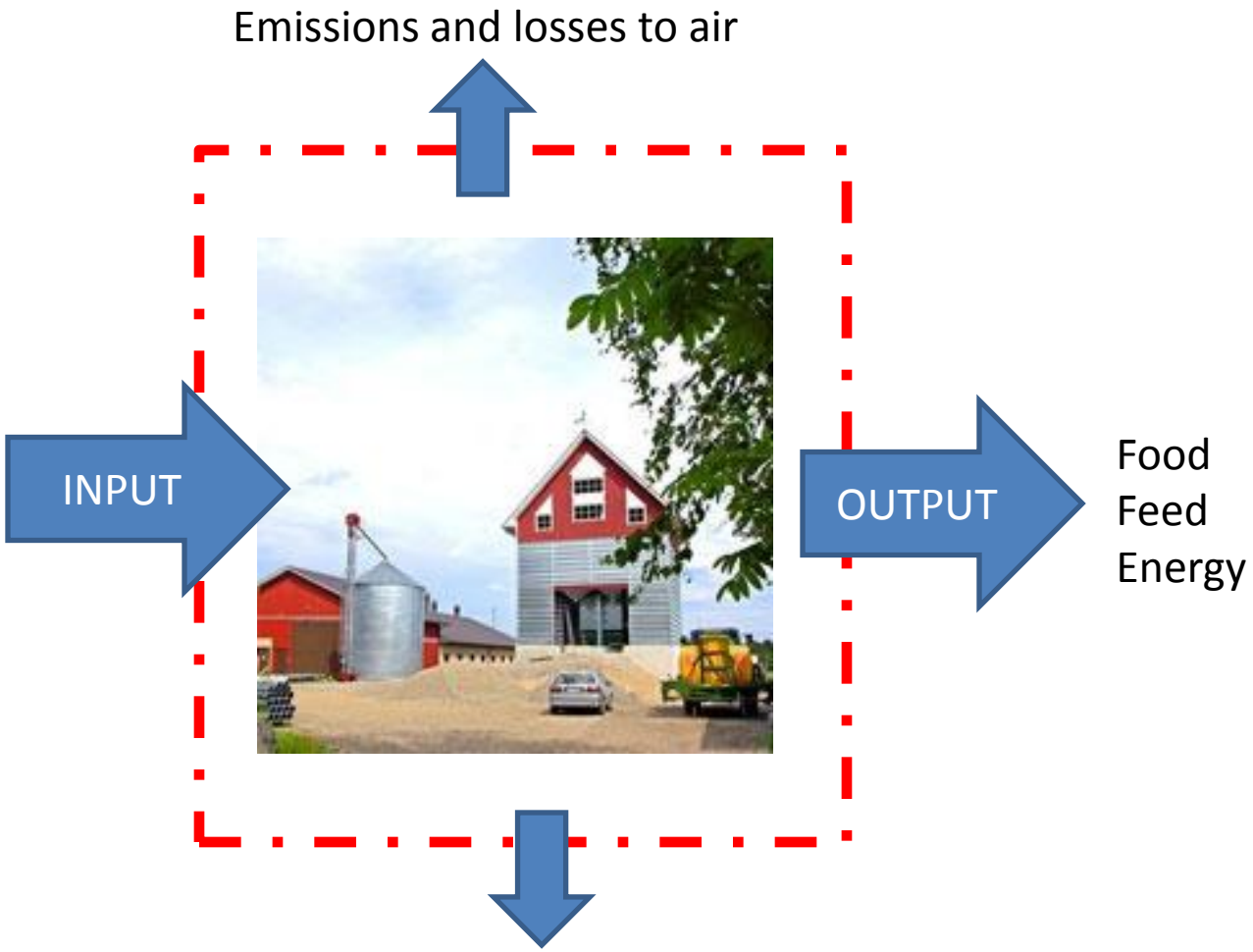
Electricity
- illumination
- engines
- heaters

Feed material
- concentrates

Nurients
- Fertilizers

Pesticides

Radiation (sun)



Energy flows

Emissions and losses to air

INPUT

OUTPUT

Food + Feed: 46,4 GJ/ha

Chemicals	6,3 GJ/ha
Tractor and machines	3,2 GJ/ha
Grain drying	1,3 GJ/ha
Seed	0,8 GJ/ha
SUM	11,6 GJ/ha

Emissions and losses to water

Inputs

- Energy flows in and out of the farm must be recorded
- The largest flows are the most importants but also the most economical ones for the farmers are very important
- Strategy
  - Fertilizers and pesticides
    - Usage is important to record but the decrease is important for the farmer only if some other cheaper nutrients are available or the farmer has overdosed
    - The usage is recorded by doing inventories before and after sowing times
  - Agricultural machines
    - Savings in fuel consumption can happen without investment with good work planning, important for the farmer
    - The usage is recorded in machine/work basis
  - Preservation of biomass
    - Energy savings in drying are important if they are economical
    - Other less energy consuming preservation methods could be used in the future
    - Both fuel and electricity uses are recorded

Tractor and field machinery energy consumption

- Energy consumption is recorded l/ha basis
  - This figure is good when consumptions are compared
  - The 'main' tractor, forage and combine harvester fuel consumption should be get in l/ha basis
  - This means that we have to record fuel consumption l/h and also work rate ha/h
- Energy consumption in l/kg product basis
  - We should get some kind of idea also to this figure
  - This means that we should also record yields
- The scope of the recording should be at least farm level but a plot/field level would be desirable

Diesel fuel consumption, calculations

$$q_A[ha/h] = \frac{v[km/h] \cdot b[m]}{10}$$

q_A = work rate [ha/h]
v = driving speed [km/h]
b = working width [m]

$$f_A[l/ha] = \frac{f_e[l/h]}{q_A[ha/h]}$$

f_A = fuel consumption [l/ha]
f_A = fuel consumption [l/ha]
f_e = average fuel consumption during work [l/h]
q_A = work rate [ha/h]

$$m = q_A \cdot y_A$$

m = mass flow [kg/h]
y_A = yield [kg/ha]
q_A = work rate [ha/h]

$$N_s = \frac{f_A[l/ha]}{y_A[kg/ha]}$$

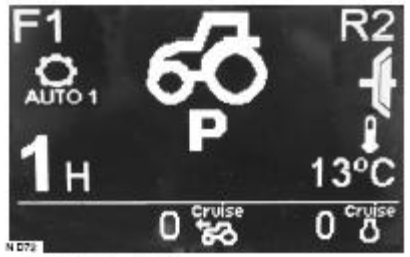
N_s = specific fuel consumption [l/kg]
f_A = fuel consumption [l/ha]
y_A = yield [kg/ha]

For the l/ha calculations we need:
- driving speed
- working width
- fuel consumption

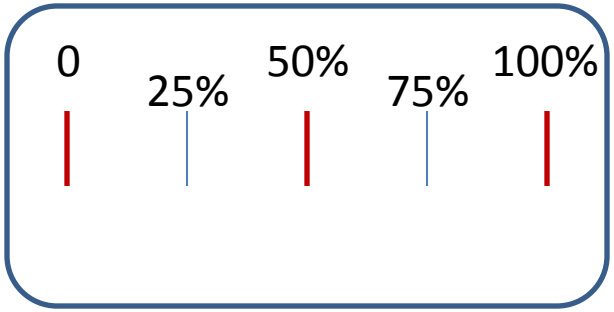
For the specific fuel consumption l/kg we need further:
- yield

Tractors

- Tractors doing the hard work such as tillage, direct drilling, fodder harvest and heavy transport will be equipped with good fuel and work rate following systems
  - Fuel consumption
    - Tractor own information system, if available
    - Recorded fuel filling figures together with tractor hour meter readings
    - The filling stations are equipped with fuel meters
  - Work rate
    - Tractor own information system
    - Vehicle tracking system
    - Registered daily work tasks together with tractor hour meter readings and tractor fuel meter reading
- Tractors whose annual driving time is less than 100 hours will be followed only by bookkeeping



Iso ajoneäyttö tulee näytölle.



Polttoainepumput

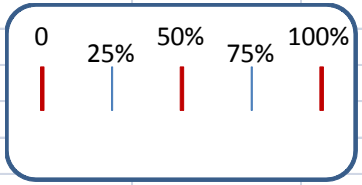
Tankkauskaappi

- tuotto 50 l/min
- automaattipistooli + letku 4 m
- polttoainepumppu 0,37 kW, 230 V
- polttoainemittari
- imupuolen suodatin
- liitin 1"
- sisältää yhdistäjän

637.51 €

Form

	Tractor	*Belarus MTZ 820*									
	Register number	*uin-123*									
	Year	Month	Day	Hour	Hour meter	Fuel meter	Work	Width of imp.	Fuel filled	Maintanance	
	2010	5	1	8:00	5678	75	Harrowing	4	34,5		
				17:00	5683	25					
			1	8:00	5683	100	Harrowing	4	45,2		



Tractor tracking system

From data the following items can be read:

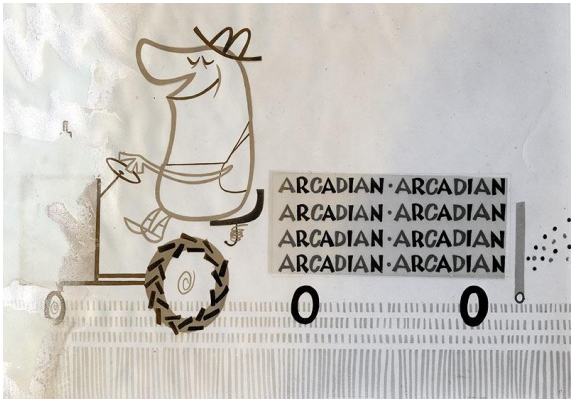
- coordinates
- route
- driving speed => work rate

Combine harvesters and self propelled machinery

- Combine harvesters should be equipped if possible with fuel meters and vehicle tracking systems.
- The yields of different fields should also be recorded in order to be able to calculate the energy consumption per harvested mass
- The follow-up of these machines is otherwise the same as with tractors

Chemicals

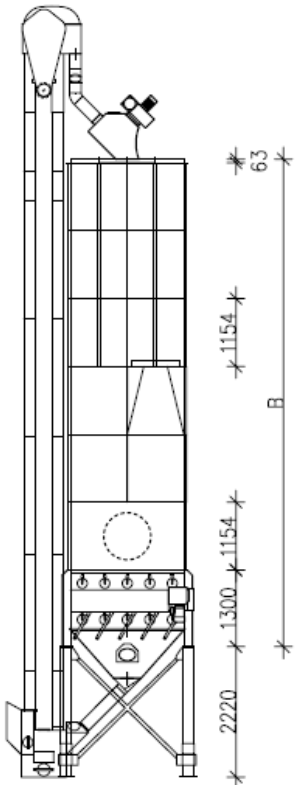
- Fertilizers are the most important items, which usage must be recorded
- Besides fertilizers also other nutrients such as manure should be recorded
- Pesticides and other chemicals have often very small influence on total energy consumption
- Usage is controlled by inventories and bookkeepings

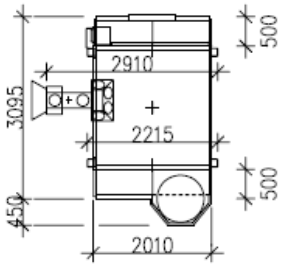


Grain dryer energy consumption

- Grain dryers must be equipped with fuel consumption and grain moisture meters (if the farmer does not have a good one)
- Electricity consumption meters are not obligatory but they could give more information
- The dryers are normally batch dryers and the dryed volume can be calculated from the dryer volume.
- Grain dryer fuel consumption is expressed as g oil/evaporated kg H_2O or MJ/evaporated kg H_2O

Grain dryer energy consumption





Agrosec MF2 / A–elev / A–160

Ilmapäädyt 0,5m

2W	21	22	23	33
m3	12,6	16,9	21,2	24,3
A mm	9600	10600	12100	13100
B mm	4830	5980	7140	8290

1. Grain mass

$$M = V_D \cdot \rho$$

M	=	mass
V_D	=	dryer volume
ρ	=	bulk density of grain

2. Evaporated water amount

$$M_{RW} = M\frac{w_h - w_d}{1 - w_h}$$

M_{RW}	=	mass of evaporated water
M	=	mass of the dryed grain
w_h	=	moisture content of harvested grain (wb)
W_d	=	moisture content of dryed grain (wb)

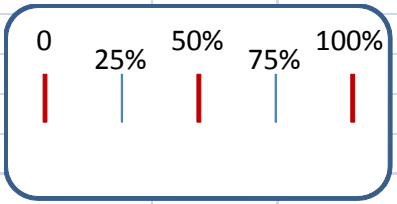
3. Consumed oil amount during the batch

$$q_D = \frac{M_{oil}}{M_{RW}}$$

q_D	=	specific oil consumption in grain dryer
M_{oil}	=	oil consumption in drying
M_{RW}	=	mass of evaporated water

Example

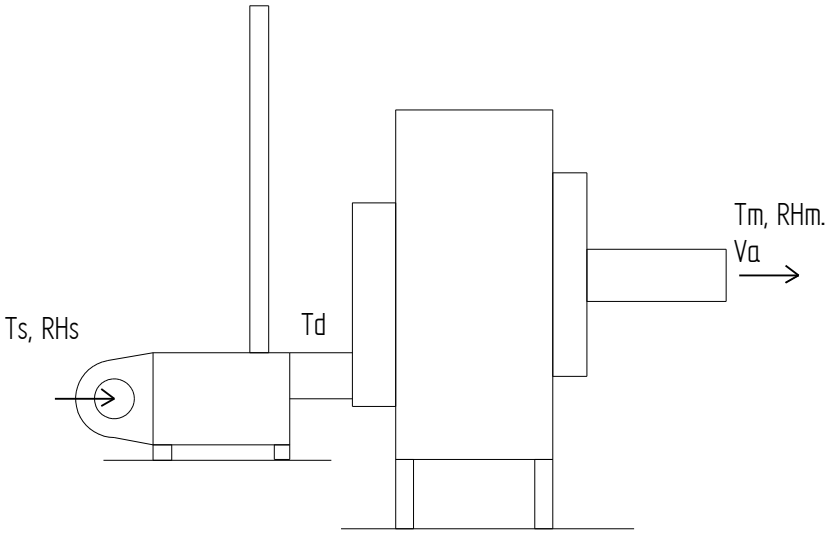
Dryer	*NNNN*												
Volume	*45*	m3											
Furnace													
			Start							**End**			
Year	Month	Day	Hour	Grain	Plot	Storage silo	Moisture	Fuel meter	kWh meter	Hour	Moisture	Fuel meter	kWh meter
2010	8	12	15:00	rye	A1	75	21,3	234,6	2345,33	1:00	13,3	345,6	2456,66



More accurate grain dryer energy consumption measurement

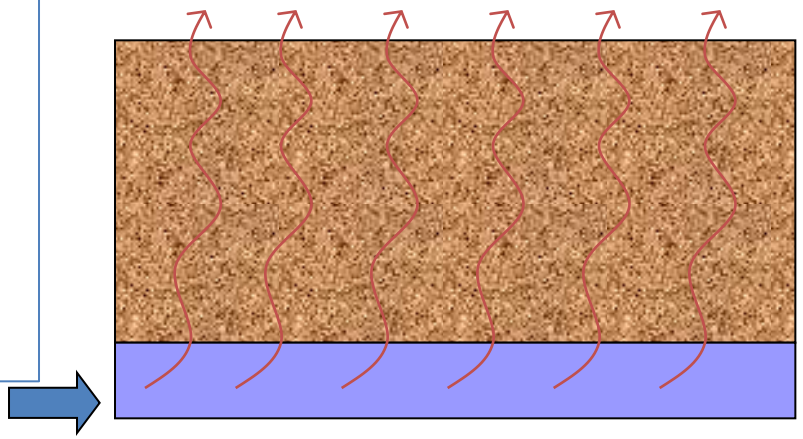
Continuos measurements, the following measurement system is needed

- The input or ambient air state (Ts temperature, RHs relative humidity), heated air temperature (Td)
- Output moisture air state (Tm temperature, RHm relative humidity) must be measured continuously during drying.
- The air flow (Va)is quite constant and it can be measured occasionally.



Cold air dryer

- The farms can have cold air dryers for grain, hay or wood chips
- The same procedure can be used as for hot air dryers
- In these cases the drying air may not be heated or it is heated only a small amount
- The main consumption is electricity consumption (fan)



This material has been produced in ENPOS project. ENPOS is acronym for ***Energy Positive Farm***.

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• University of Helsinki, department of Agricultural Sciences – Agrotechnology
• MTT Agrifood Research Finland - Agricultural Engineering
• Estonian University of Life Sciences

Project home page is at http://enpos.weebly.com/

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