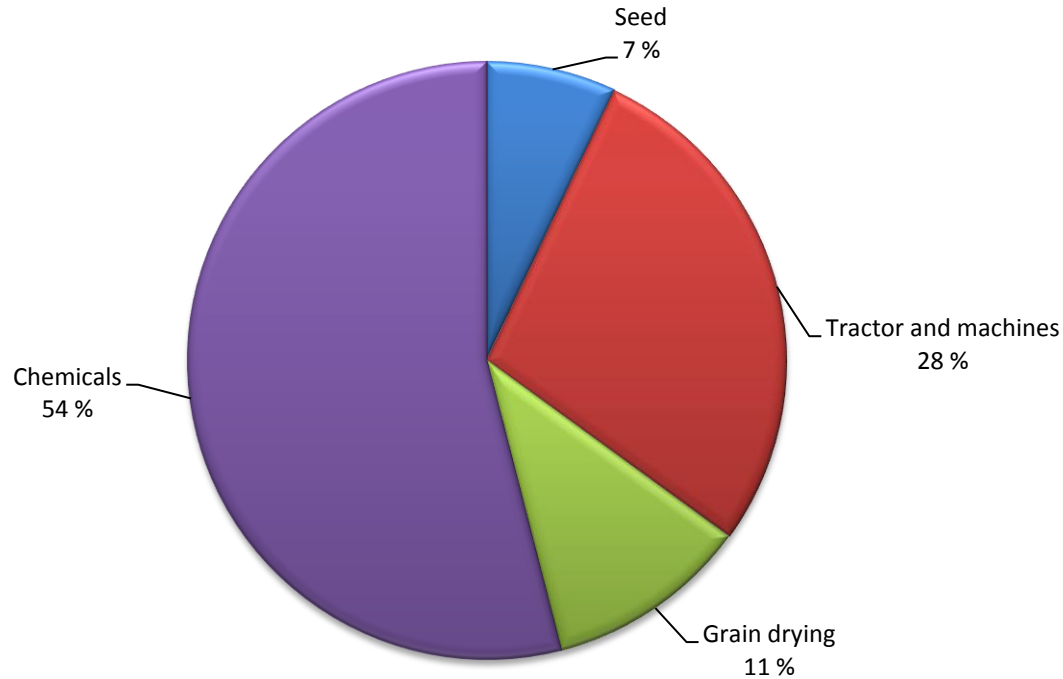


Monitoring energy use on farms,  
measurements, bookkeeping forms,  
inventories

J.Ahokas

# Plant production

Energy consumption in Barley production 11,6 GJ/ha



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)			
time	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 <sub>2</sub> O 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 <sup>-1</sup>	8
Phosphorous as P <sub>2</sub> O <sub>5</sub>	15.5	MJ kg <sup>-1</sup>	8
Potassium as K <sub>2</sub> O	9.7	MJ kg <sup>-1</sup>	8
Pesticide	273.6	MJ kg <sup>-1</sup>	8
Lime	1.3	MJ kg <sup>-1</sup>	9

# Example of direct energy consumption



+



+



+



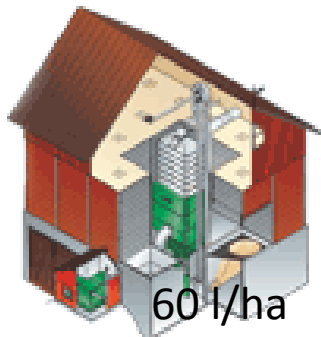
+



+



+



**= 116 l/ha**

# Energy flows

## Fuels

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

## Electricity

- illumination
- engines
- heaters

## Feed material

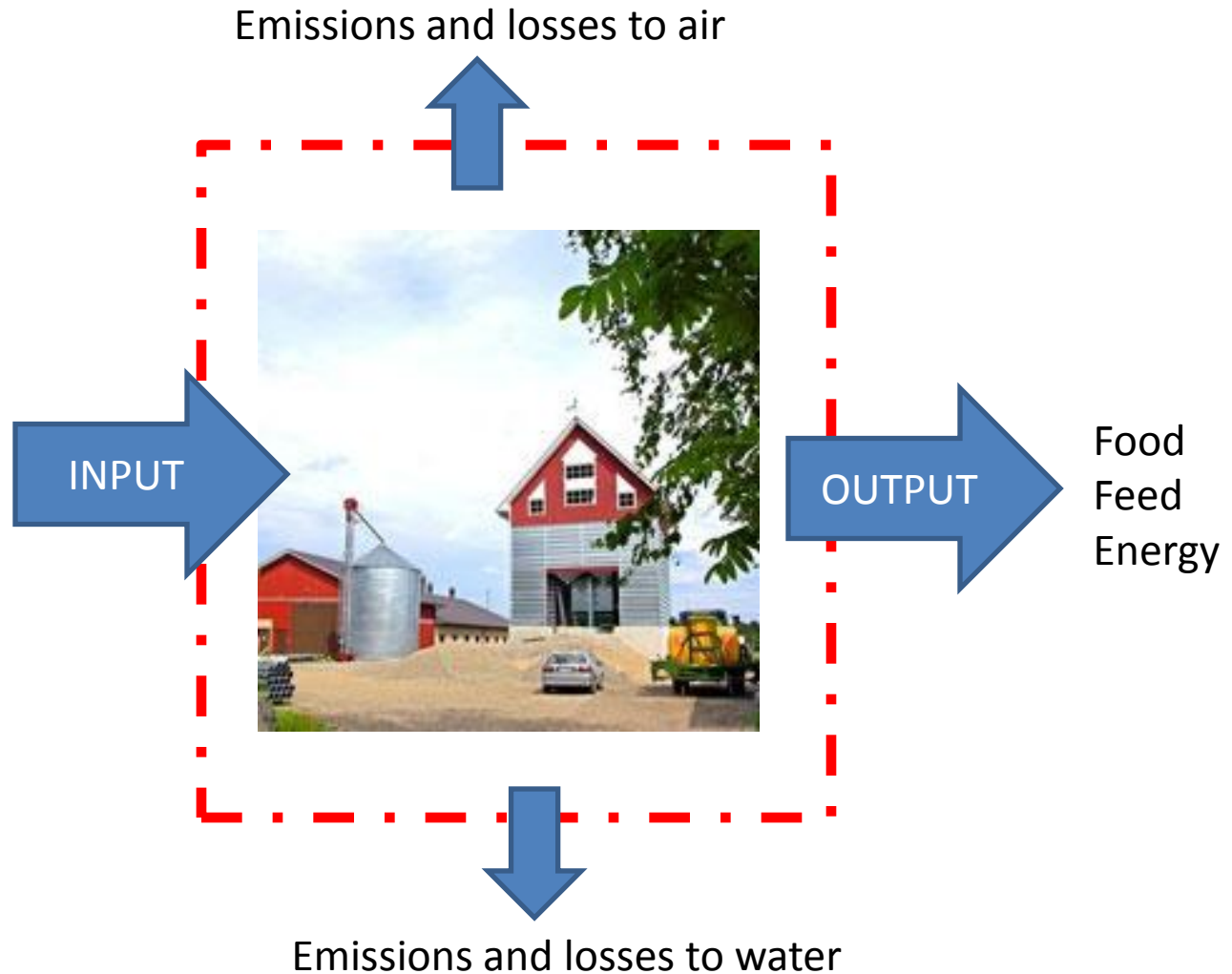
- concentrates

## Nurients

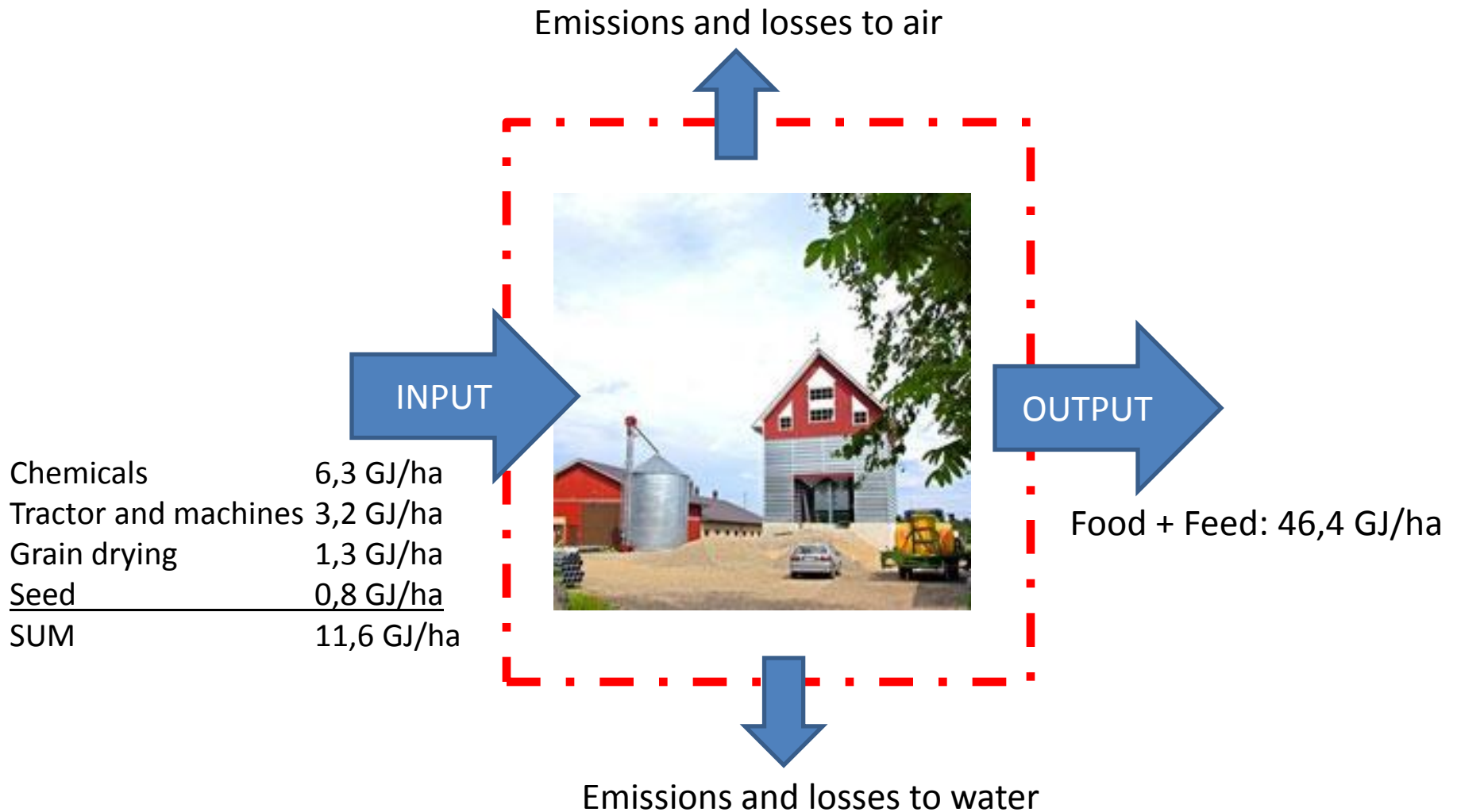
- Fertilizers

## Pesticides

- Radiation (sun)



# Energy flows



# Inputs

- Energy flows in and out of the farm must be recorded
- The largest flows are the most important 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

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

$q_A$  = work rate [ha/h]

$v$  = driving speed [km/h]

$b$  = working width [m]

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

$f_A$  = fuel consumption [l/ha]

$f_e$  = fuel consumption [l/h]

$f_e$  = 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]

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

$N_s$  = specific fuel consumption [l/kg]

$f_A$  = fuel consumption [l/ha]

$y_A$  = yield [kg/ha]

For the l/ha calculations we need:

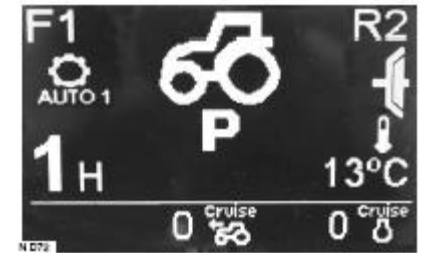
- driving speed
- working width
- fuel consumption

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

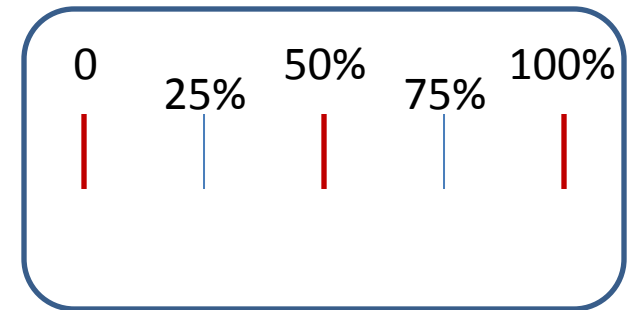
- yield

# 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



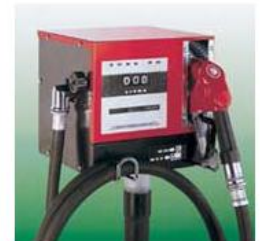
Iso ajonäyttö tulee näytölle.



## Polttoainepumput

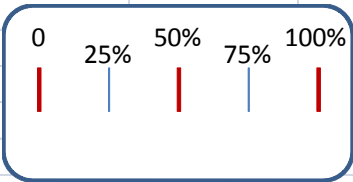
### Tankkauskaappi

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



637.51 €

# Form

<b>Tractor</b>		<i>Belarus MTZ 820</i>								
<b>Register number</b>		<i>uin-123</i>								
										
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

Introducing

## The Flash GPS Reporter

The Most Accurate GPS Tracking Logger Available

For complete historical reporting using GPS tracking technology. Find out exactly where your employees & assets have been.



- Months of continuous logging on full charge
- Rechargeable & swappable battery
- Over 240,000 detailed locates, latitude, longitude and altitude
- Simply charge, deploy, recover & review
- Photo Geo-tagging



From data the following items can be read:

- coordinates
- route
- driving speed => work rate

Add these recommended accessories:

Lowest Price Available For A Logger

Mini  
Magnetic Case



Wall Charger  
Fast Charge



1800 Ma  
Extended Battery



1800 Ma  
Battery Cover



# 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 dried volume can be calculated from the dryer volume.
- Grain dryer fuel consumption is expressed as g oil/evaporated kg H<sub>2</sub>O or MJ/evaporated kg H<sub>2</sub>O



# Grain dryer energy consumption

## 1. Grain mass

$$M = V_D \cdot \rho$$

$M$  = mass  
 $V_D$  = dryer volume  
 $\rho$  = bulk density of grain

## 2. Evaporated water amount

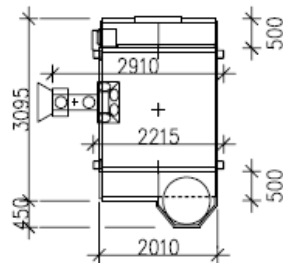
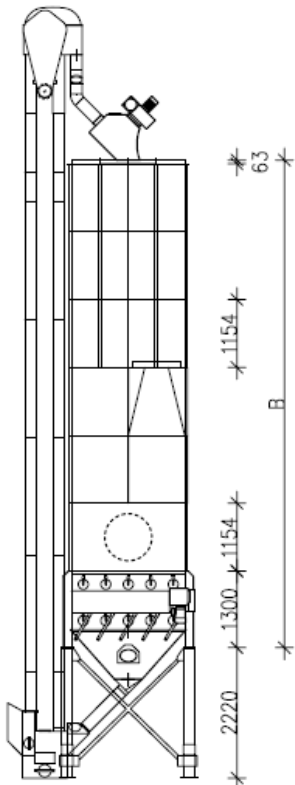
$$M_{RW} = M \frac{w_h - w_d}{1 - w_h}$$

$M_{RW}$  = mass of evaporated water  
 $M$  = mass of the dried grain  
 $w_h$  = moisture content of harvested grain (wb)  
 $w_d$  = moisture content of dried 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



Agrosec MF2 / A-elev / A-160

Ilmapäädtyt 0,5m

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

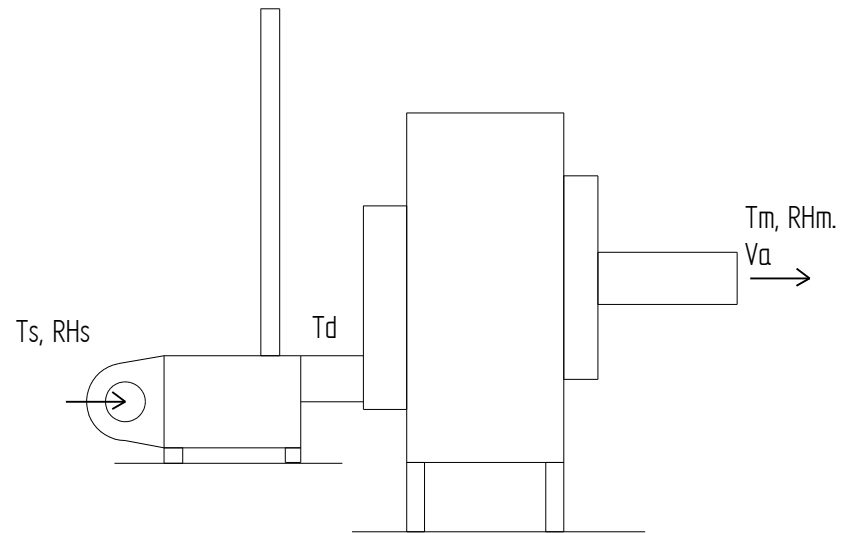




# More accurate grain dryer energy consumption measurement

Continuous measurements, the following measurement system is needed

- The input or ambient air state ( $T_s$  temperature,  $RH_s$  relative humidity), heated air temperature ( $T_d$ )
- Output moisture air state ( $T_m$  temperature,  $RH_m$  relative humidity) must be measured continuously during drying.
- The air flow ( $V_a$ ) 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)

