BarPLUS - III Meeting

8th – 9th March 2018
University of Lleida – Av. Rovira Roure 191, Lleida, Spain

Session - Life Cycle Assessment (Task 4.3, M13 – M36)

Environmental assessment: preliminary results

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Life Cycle Assessment (LCA; ISO 14040) is a standardised methodology used to quantify the *potential environmental impacts* of a *product*, *process* or *activity*, during its whole life cycle, from the extraction of raw materials to the disposal processes (*"from cradle to grave"*).

The LCA approach is performed by:

1. defining the objective of study;
2. compiling an inventory of relevant/all inputs and outputs of the system (sequence of stages);
3. evaluating the potential environmental impacts associated to these inputs and outputs;
4. interpreting the results of inventory and impact phases, in relation to the study objective.

The LCA enables to:

- ❑ estimate the cumulative impacts results from all the stages of the product life cycle;
- ❑ identify the system hotspots;
- ❑ suggest mitigation strategies;
- ❑ compare alternative solutions.

LCA STRUCTURE (4 PHASES)

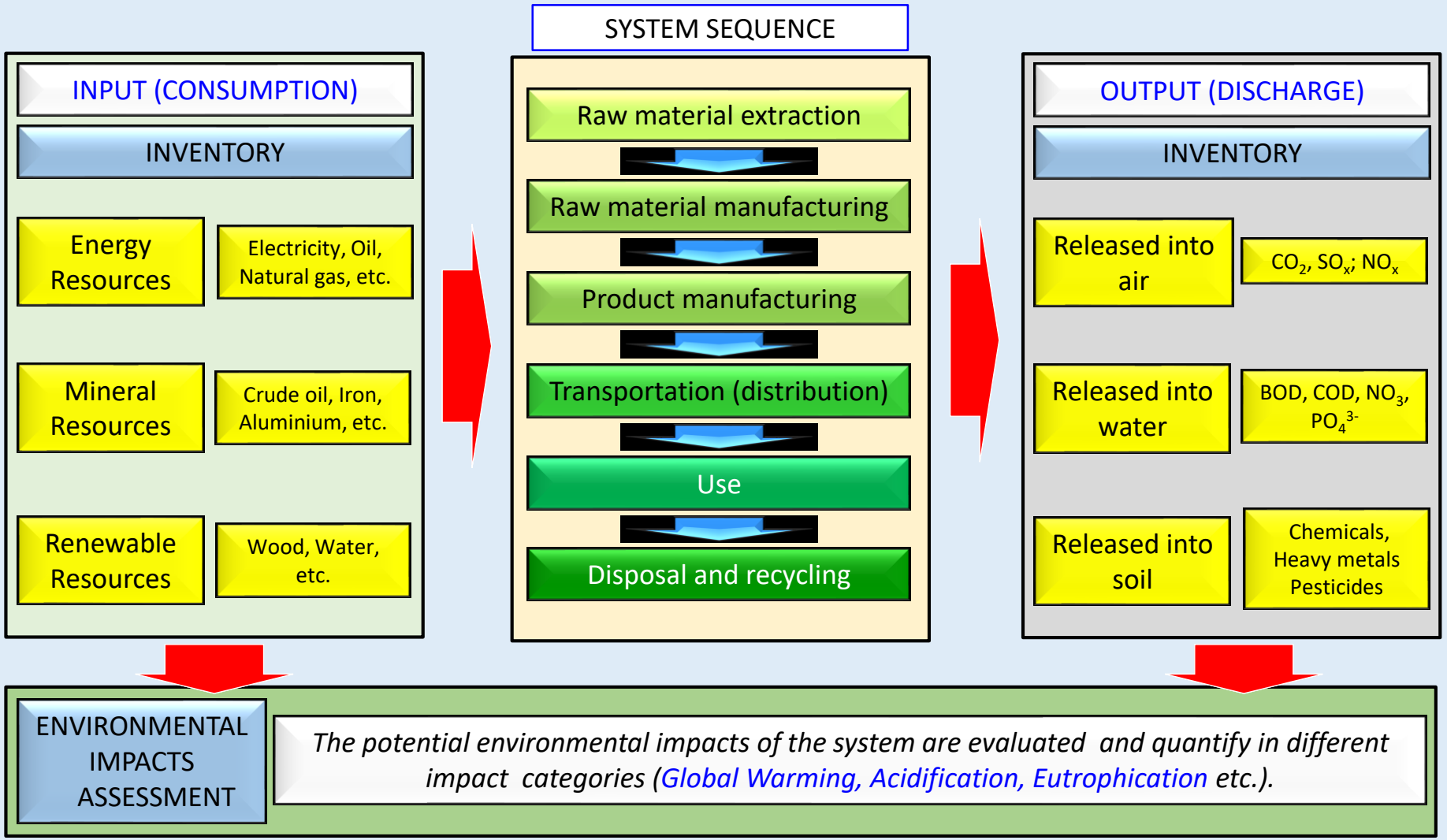
GOAL and SCOPE DEFINITION

LIFE CYCLE INVENTORY ANALYSIS (LCI)
- ❑ Flow chart process
- ❑ Data collection
- ❑ Boundary system definition
- ❑ Emission quantification

LIFE CYCLE INPACT ASSESSMENT (LCIA)
- ❑ Classification
- ❑ Characterization
- ❑ Normalization
- ❑ Weighting

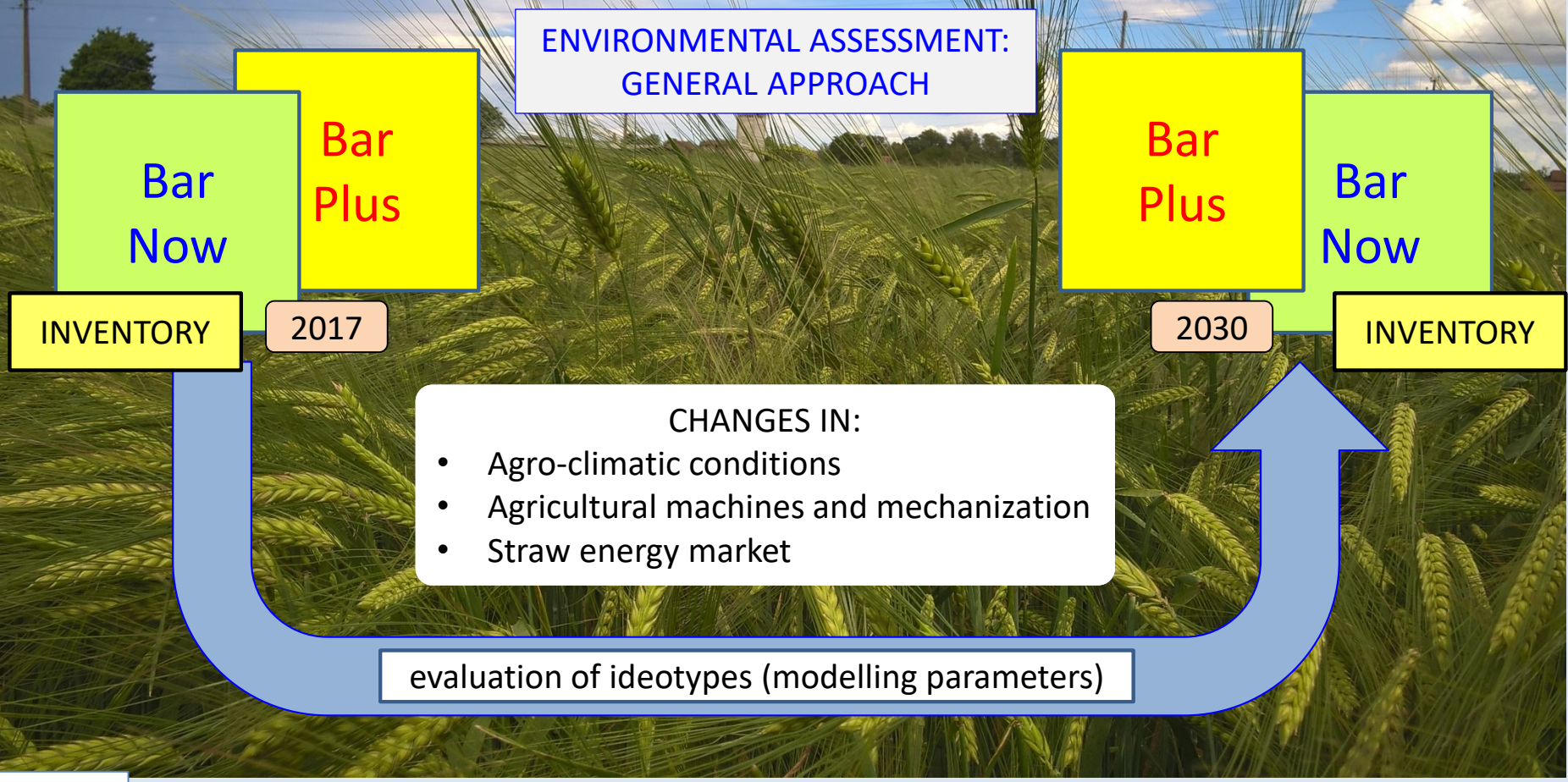
INTERPRETATION OF RESULTS

Among the LCA four phases, Life Cycle Inventory (LCI) is the most complex to accomplish.



GOAL & SCOPE

- LCA methodology is applied to quantify the environmental performance of barley cultivation (2017 and 2030) in four barley districts adopting a cradle-to-farm gate perspective;
- comparison between BarNow (2017) and BarPlus (2030) of environmental performances;
- highlighting benefits arising from the BarPlus higher straw yield (t/ha DM) for energy purposes.



Inventory phase and ENVironmental Inventory of Agricultural Machinery operations model

DIFFICULTIES

To know datails about the production system → barley cropping input and output in 2+2 different situations (in our case)

PRIMARY DATA
by experimantal data

CRITICAL ISSUES
- ❑ *Technical difficulties*
- ❑ *Time consuming*
- ❑ *Expensive*

STRENGHTS
- ❑ *Site/system very specific*

SECONDARY DATA
by commercial databases

STRENGHTS
- ❑ *Easy to find*
- ❑ *Time saving*
- ❑ *Relatively cheap*

CRITICAL ISSUES
- ❑ *Site/System Unspecific*
- ❑ *Few available Dbase*
- ❑ *…*

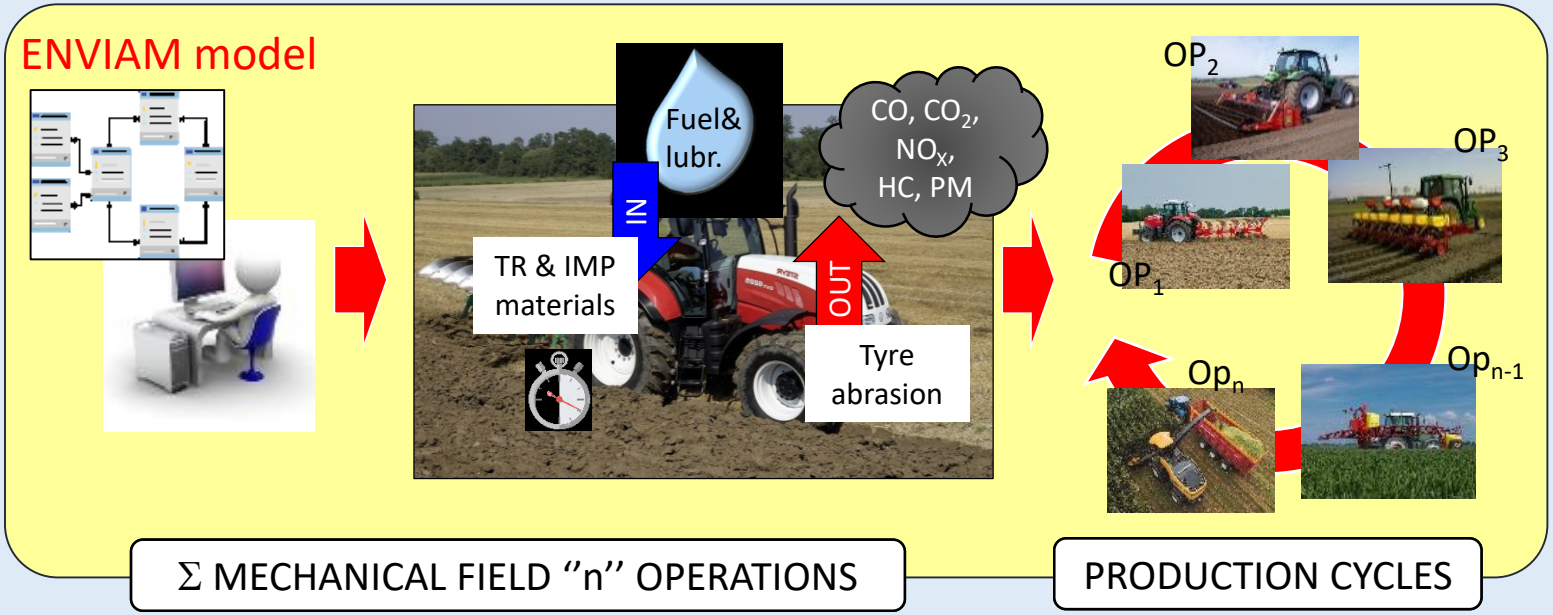
SECONDARY DATA
by specific model

Analyses on agricultural products cycles snow mechanization as a production step with significant environmental impacts

Developed to complete the LCI phase for on field mechanization operations, with the goal to guarantee the availability of local data able to describe the mechanical and operative conditions.

University of Milan - DiSAA
ENVIAM model (v1 and v2)

ENVIAM calculates mechanical power requests, directly consumed inputs (i.e. fuel, lubricant) and materials consumption during the mechanical operations of barley cropping, taking into account soil texture, specific used machinery and coupling solutions (i.e., TR&IMP, defined by the user).
Fuel/lubricant consumption and engine emissions are calculated for each working time (and relative engine load) constituting the field operation. Vice versa, the materials consumption and tyre abrasion are quantified on the basis of the tractor/machine physical lifetime.



The exhaust gases emissions from i.c. engine (CO_2; CO; HC, NO_x and PM) are assessed taking into account the specific tractor (engine) Emission Stage.

Poland
Germany
Spain
Italy

BARLEY DISTRICT and FARM
→ type&sequence of mech. operations; production factors (seeds, fertilizers, pesticides, etc.); yields

INPUT
1. Diesel/lubricant
2. Fertilizers&Pesticides
3. TR & IMP masses

BAR NOW

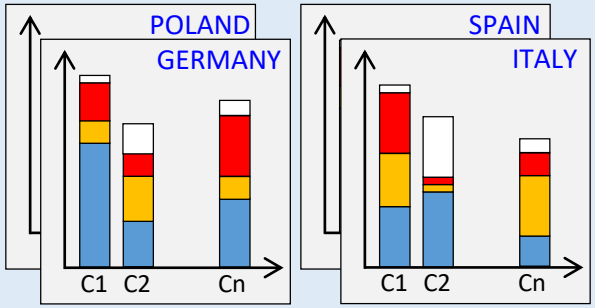
BAR PLUS

OUTPUT
1. Materials consumption
2. Emissions in air (i.c. engines)
3. Emissions in soil

LCIA

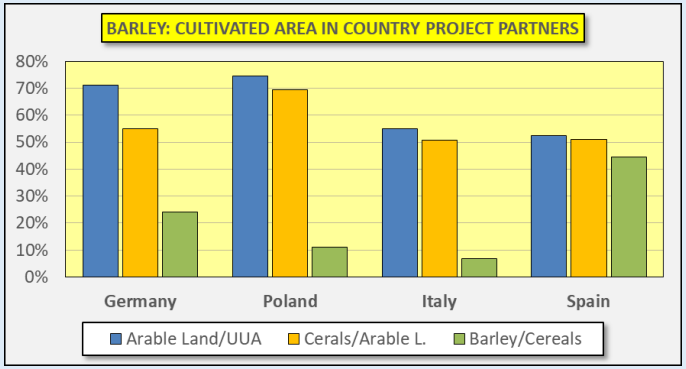
ENVIAM v2

BarNow & BarPlus



Country Project Partners: barley overview (Eurostat, 2017)

BARLEY CULTIVATED AREAS & YIELDS



Country	UAA ha	Arable L. ha	Cereal ha	Barley ha	Arable L. % UUA	Cereal % Arable L	Barley % UUA	Barley % Arable L.	Barley % Cereals	Barley Yield (2010-17) t/ha FM	Barley Yield (2010-17) t/ha DM
Germany	16.699.580	11.875.900	6.533.710	1.570.400	71%	55%	9%	13%	24%	6,6	5,7
Poland	14.409.870	10.759.600	7.479.500	820.000	75%	70%	6%	8%	11%	3,6	3,0
Italy	12.426.000	6.827.000	3.459.870	237.270	55%	51%	2%	3%	7%	3,8	3,3
Spain	23.494.570	12.310.530	6.268.030	2.784.280	52%	51%	12%	23%	44%	2,8	2,6

FARM SIZE vs BARLEY CULTIVATED AREA

Germany

FARM AREA UAA (ha)	Barley area (ha) < 1	1-1.9	2-4.9	5-9.9	10-19.9	20-29.9	30-79.9	> 80	TOTAL (% tot UAA)
< 2	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2-4.9	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
5-9.9	0,1%	0,3%	0,8%	0,1%	0,0%	0,0%	0,0%	0,0%	1,4%
10-19.9	0,1%	0,4%	2,6%	1,7%	0,5%	0,0%	0,0%	0,0%	5,3%
20-29.9	0,0%	0,2%	1,2%	2,1%	0,9%	0,0%	0,0%	0,0%	4,4%
30-49.9	0,0%	0,2%	1,6%	4,3%	3,9%	0,5%	0,1%	0,0%	10,5%
50-99.9	0,0%	0,1%	1,0%	4,3%	10,0%	4,8%	1,8%	0,0%	22,0%
> 100	0,0%	0,0%	0,2%	1,3%	5,3%	6,3%	17,0%	26,1%	56,3%
Total (% tot UUA)	0,2%	1,2%	7,4%	14,0%	20,5%	11,7%	18,9%	26,1%	**100%**

Poland

FARM AREA UAA (ha)	Barley area (ha) < 1	1-1.9	2-4.9	5-9.9	10-19.9	20-29.9	30-79.9	> 80	TOTAL (ha)
< 2	0,0%	1,0%	1,0%	0,0%	0,0%	0,0%	0,0%	0,0%	2,1%
2-4.9	0,0%	2,3%	3,5%	3,3%	0,0%	0,0%	0,0%	0,0%	9,2%
5-9.9	0,0%	1,7%	4,6%	8,5%	1,7%	0,0%	0,0%	0,0%	16,4%
10-19.9	0,0%	0,7%	3,2%	11,8%	5,7%	0,0%	0,0%	0,0%	21,3%
20-29.9	0,0%	0,1%	0,7%	3,9%	4,4%	0,2%	0,0%	0,0%	9,3%
30-49.9	0,0%	0,0%	0,3%	2,3%	4,1%	0,6%	0,1%	0,0%	7,5%
50-99.9	0,0%	0,0%	0,1%	0,8%	1,9%	1,7%	1,1%	0,0%	5,6%
> 100	0,0%	0,0%	0,0%	0,1%	0,4%	1,8%	6,6%	8,6%	17,4%
Total (% tot UUA)	0,0%	5,9%	13,5%	30,7%	18,1%	4,2%	7,8%	8,6%	**89%**

Italy

FARM AREA UAA (ha)	Barley area (ha) < 1	1-1.9	2-4.9	5-9.9	10-19.9	20-29.9	30-79.9	> 80	TOTAL (ha)
< 2	0,7%	1,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	1,8%
2-4.9	1,1%	2,6%	3,4%	0,0%	0,0%	0,0%	0,0%	0,0%	7,1%
5-9.9	0,8%	2,6%	4,5%	3,0%	0,0%	0,0%	0,0%	0,0%	10,9%
10-19.9	0,4%	1,6%	6,3%	6,1%	3,7%	0,0%	0,0%	0,0%	18,2%
20-29.9	0,1%	0,5%	2,9%	4,5%	3,0%	0,8%	0,0%	0,0%	11,8%
30-49.9	0,1%	0,3%	2,4%	4,7%	5,7%	1,2%	1,6%	0,0%	16,0%
50-99.9	0,1%	0,2%	1,3%	3,3%	6,4%	3,9%	2,6%	0,0%	17,7%
> 100	0,0%	0,0%	0,4%	1,1%	3,3%	3,3%	5,9%	2,5%	16,5%
Total (% tot UUA)	3,4%	8,9%	21,2%	22,7%	22,0%	9,2%	10,1%	2,5%	**100%**

Spain

FARM AREA UAA (ha)	Barley area (ha) < 1	1-1.9	2-4.9	5-9.9	10-19.9	20-29.9	30-79.9	> 80	TOTAL (ha)
< 2	0,0%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%
2-4.9	0,1%	0,2%	0,7%	0,0%	0,0%	0,0%	0,0%	0,0%	1,0%
5-9.9	0,0%	0,1%	0,9%	0,9%	0,0%	0,0%	0,0%	0,0%	1,9%
10-19.9	0,0%	0,1%	0,8%	1,8%	2,1%	0,0%	0,0%	0,0%	4,9%
20-29.9	0,0%	0,0%	0,3%	1,2%	2,5%	1,5%	0,0%	0,0%	5,5%
30-49.9	0,0%	0,0%	0,3%	0,8%	3,7%	3,2%	2,5%	0,0%	10,5%
50-99.9	0,0%	0,0%	0,2%	0,7%	2,5%	4,1%	12,0%	0,4%	19,9%
> 100	0,0%	0,0%	0,1%	0,3%	1,3%	2,3%	21,3%	30,9%	56,1%
Total (% tot UUA)	0,2%	0,7%	3,2%	5,7%	12,1%	11,1%	35,8%	31,3%	**100%**

To define the different environmental impacts related to barley cultivation (BarNow-2017 and BarPlus-2030) it is necessary to know with the greatest possible detail the cropping system applied both in the 2 Districts of Central Europe (CE_D → Poland & Germany), and Southern Europe (CE_D → Spain & Italy).

ASK TO THE PARTNERS

CENTRAL EU DISTRICTS (CE_D)

POLAND | GERMANY

SOUTHERN EU DISTRICTS (SE_D)

SPAIN | ITALY

Poland

Germany

Spain

Italy

REPRESENTATIVE DISTRICT and FARM type&sequence of mechan. operations; production factors (seeds, fertilizers, pesticides, etc.); yields

TO DEFINE

(1) the barley area which best represents the barley cultivation in each Country

(2) the barley farm which best represents (size, cropping system, products yield and final use) the selected district

BARLEY DISTRICT DATA

CE_D: Germany, Poland, SE_D: Italy, Spain

DISTRICT NAME: ……..

GENERAL INFORMATION (Table 1)

Country	-	
District name	-	
Coordinates	-	
Total cultivated area	ha	
Total barley cultivated area	ha	

2010-2015 CLIMATE DATA (Table 2)

	Average rainfall	Average temperature	
		min	MAX
	mm	°C	°C
Jan			
Feb			
Mar			
Apr			
May			
Jun			
Jul			
Aug			
Sep			
Oct			
Nov			
Dec			

If not available, please suggest a data link/source: …

BARLEY PRODUCTS & BY-PRODUCTS CURRENT FINAL DESTINATION (Table 3)

		% on total	
GRAIN	Food		
	Feed		
	Fuel		
	Other (…)		
		% on total	
STRAW	**Not collected** and:		
	- incorporated into soil		
	- burned into fields		
	- other use (…)		
	Collected for:		**Avg. distance to final destination** (km)
	- animal bedding		
	- energy use (burner use)		
	- industrial transform. (raw material)		
	- bio-refinery (ethanol)		
	- other use (…)		

BARLEY DISTRICT and FARM SURVEY
OCTOBER 2017

«*2017_Barley_Survey_01.xslx*» has been sent to the Project Partners in order to define the application context of environmental assessment.

REPRESENTATIVE BARLEY FARM DATA

CE_D: Germany, Poland, SE_D: Italy, Spain

FARM CHARACTERISTICS (Table 4)

Total cultivated area	ha	
Total barley cultivated area	ha	
Altitude	m a.s.l.	
Slope	%	
Soil type (silty, clayey, loamy, …)	…	
Soil organic Carbon (pool)	t/ha	
Winter or Spring barley?	W/S	
Farm management based on barley monocropping?	Y/N	
- if NOT previuos crops	year -1	
	year -2	
	year -3	
	year -4	
Avg. distance from barley fields to farm	km	

BARLEY FARM: MECHANICAL OPERATIONS SURVEY

CURRENT BARLEY IDEOTYPE(s) INPUT INVENTORY for FIELD OPERATIONS

REPRESENTATIVE BARLEY FARM: CE_D: Germany, Poland, SE_D: Italy, Spain

DISTRICT NAME: ……

FIELD OPERATIONS and CROP INPUT (Table 5)

	FIELD OPERATION	N. OF OPER/CYCLE	MONTH	MACHINES: Technical characteristic			MACHINES: Operative characteristics and input			NOTES
1	**Organic fertilisation**		Jan	**Implement type**	-		Fertilizer type (manure, slurry, …)	-		
			Feb	**Implement mass**	kg		Dry matter content	%		
			Mar	**Working width**	m		Fertilizer rate	kg/ha		
			Apr	**Trailer useful volume**	m^3		Nitrogen content	%		
			May	Implement other…	…		Phosphate content	%		
			Jun	Implement other…	…		NH4-N (kg NH4-N/ton fertilizer)	%		
			Jul	**Tractor type (wheels or crawled)**	W/C		Incorporation into soil	Y/N		
			Aug	**Tractor engine max power**	kW		Time between application and incorporation or precipitation	days		
			Sep	Tractor (other)	…					
			Oct				Operation (other)	…		
			Nov							
			Dec							
2	**Soil tillage** (primary)	1	Jan	**Implement type**	-		Are crop residues incorporated into soil?	Y/N		
			Feb	**Implement mass**	kg		If **YES**:			
			Mar	**Working width**	m		- which crop residues	…		
			Apr	**Working depth**	cm		- residues amount	t/ha		
			May	Implement (other)	…		Operation (other)	…		
			Jun	Implement (other)	…					
			Jul	**Tractor type (wheels or crawled)**	W/C					
			Aug	**Tractor engine max power**	kW					
			Sep	Tractor (other)	…					
			Oct							
			Nov							
			Dec							
3	**Soil tillage** (secondary) (*harrowing*)		Jan	**Implement type**	-					
			Feb	**Implement mass**	kg					
			Mar	**Working width**	m					
			Apr	**Working depth**	cm					
			May	Implement (other)	…					
			Jun	Implement (other)	…					
			Jul	**Tractor type (wheels or crawled)**	W/C					
			Aug	**Tractor engine max power**	kW					
			Sep	Tractor (other)	…					
			Oct							
			Nov							
			Dec							

MECHANICAL OPERATIONS
Organic fertilisation
Soil tillage (primary)
Soil tillage (secondary
Sowing
Weed Control (mechanical)
Weed Control (herbicide_1)
Weed Control (herbicide_2)
Weed Control (herbicide_n)
Mineral fertilisation (fertilizer_1)
Mineral fertilisation (fertilizer_2)
Mineral fertilisation (fertilizer_3)
Irrigation
Grain harvesting
Grain transportation (field-farm)
Straw collection
Straw transportation (field-farm)

Italian DISTRICT selection

Identification criteria

A **relevant barley production** and dedicated agricultural land in comparison with the national context (see Statistical data) .The Italian Project Partner (CREA) is included within the district.

Localization and size

Localization: Pianura Padana (**Po Valley**).

Regions included: Piemonte, Lombardia, Emilia-Romagna, Veneto

Size: approximately 47.000 km^2

Crop cycle: **from 10-15 October to 10 June** (July, straw collection)

Statistical data: the main source is ISTAT (Italian Institute of Statistics), year 2013.

- ❑ 47.7% of cereal area (including rice and maize) is cultivated in Northern Italy;
- ❑ barley area is approximately even distributed along the County (30.5, 27.8 and 41.7% in North, Central and South Italy, respectively);
- ❑ 42% of total barley grain is produced in Pianura Padana. Emilia-Romagna Region is the top producer in 2013 (107,000 t of barley grain).

Italian FARM selection

Farm type: arable crops farm

Used Agricultural Area (UAA): 120 ha, unified surface.

Fields shape: regular, flat conditions.

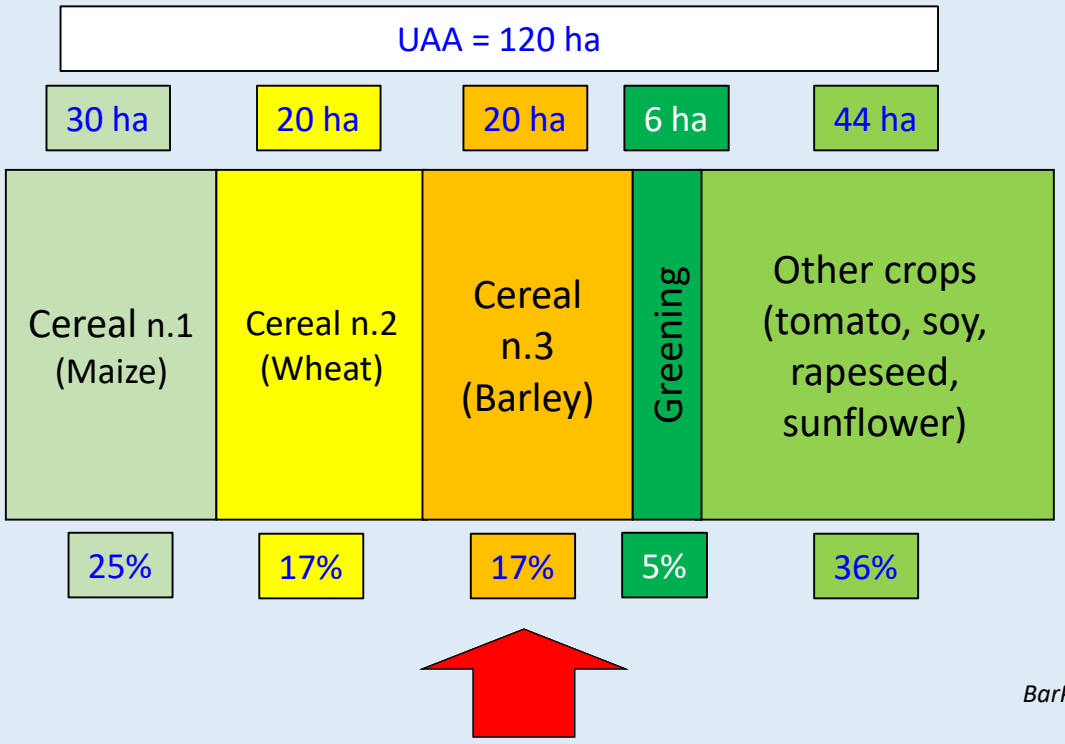
Cultivation system: annual rotation (55-60% cereals; 45-50% other crops, indicatively).

Barley: 15-20% of UAA (20 ha). Not irrigated.

Soil texture: medium.

Cropping system: sowing rate 150 kg/ha; fertilizers (urea): 45+85 kg_N/ha; Herbicide (Axial): 200 dm^3/ha

Yields: grain (6,0 t/ha FM; MC = 13%); straw (6,5 t/ha FM; MC = 12%).



Survey results: Italy farm mechanisation and cropping system (BarNow)

Italian FARM selection

Tractors fleet: n.5 4WD type; n.2 2WD type

Total power instaleld: 530 kW (4.4 kW/ha)

Emission Stage: 3B

TRACTOR TYPE	kW
4WD	150
4WD	120
4WD	100
4WD	80
4WD	50
2WD	30
TOTAL	530
SPECIFIC TRACTOR POWER	kW/ha 4,4

Barley cropping system: Ploughing → Harrowing → Sowing → Chemical Weed Control → Top Fertilization → Grain Harvesting → Grain Transportation (field to farm storage) → Straw Baling → Straw Transportation (from field to farm storage).

Implents fleet: (see the above table)

MACHINE TYPE	MACHINE SIZE		WIDTH	SPEED	WORK CAPACITY	IMPLEMENTS USE ON			TIMES	TOTAL TIME
			b_u	v_a	Co	UAA cereals	UAA PAC	UAA tot		
			m	km/h	ha/h	h/yr				h/yr
Mouldboard plough	Ploughs n°	5	0,40	6,5	1,03	68,0	5,8	116,4	1	100
Rotary harrow	Width (m)	4,0	4,0	7,0	2,20	31,8	2,7	54,5	1	
Mechanical row seeder	Width (m)	4,0	4,0	5,0	1,33	52,7	4,5	57,2	1	53
Mineral fertlizer	Volume (dm^3)	1100	20,0	10,0	4,38	16,0	1,4	27,4	2	45
Pesticides sprayer	Width (m)	18,0	18,0	10,0	5,42	12,9	1,1	22,1	1	
Round baler	Straw row (m)	6,2	6,2	7,0	2,38	16,9	2,5	37,8	1	166
Combine harvester	Width (m)	5,5	5,5	8,0	3,17	12,7	1,9	28,4	1	
Trailer wagon (for grain)	Volume (m^3)	14,0	-	8,0	2,54	15,8	2,4	35,4	3	
Trailer wagon (for straw)	Volume (m^3)	39,3	-	25,0	0,45	89,1	13,3	200,0	1	

SYSTEM BOUNDARIES | FUNCTIONAL UNIT | IMPACTS ALLOCATION

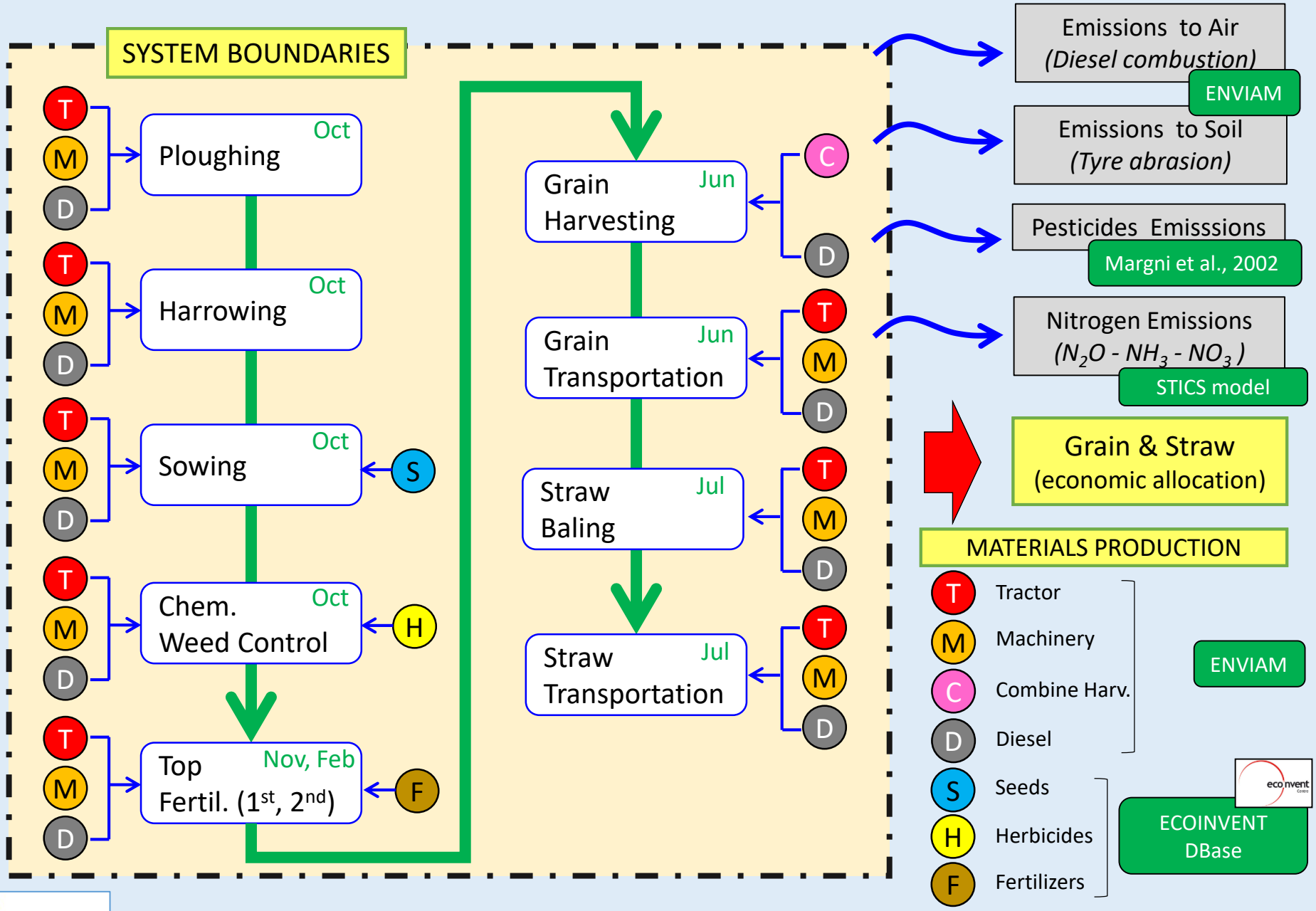
The *System Boundaries* include:

- ❑ agricultural practices at farm level (including consumption and emissions to air and soil);
- ❑ production and maintenance of tractors and agricultural machinery;
- ❑ production of Diesel oil, seeds, herbicides, fertilizers and auxiliary materials;
- ❑ emissions to atmosphere and soil (exhausted engine gases, tyres abrasion, fertilizers and pesticides).

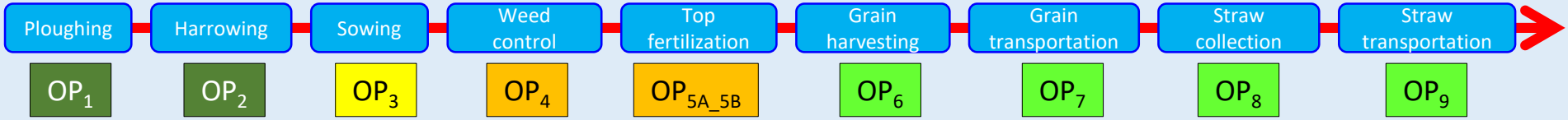
The *Functional Unit* (FU) is → 1 t of barley grain (dry matter, DM) at the farm gate.

To solve the multi-functionality of the system (grain and straw), the environmental impacts are allocated between the two main products adopting an economic-base allocation method (e.g. market prices).

Italian farm: barley operations sequence and environmental input/output (BarNow)



Italian barley farm: ENVIAM v2 results (field operations inventory data - BarNow)



FINAL RESULTS TABLE

BARPLUS IDEOTYPE(S): FIELD OPERATIONS INVENTORY DATA — REPRESENTATIVE BARLEY FARM: ITALY — DISTRICT NAME: PO VALLEY		SYMBOL	UNIT OF MEASURE	FIELD OPERATIONS																	
				PRIMARY SOIL TILLAGE		SECONDARY SOIL TILLAGE		SOWING		WEED CONTROL		MINERAL FERTILIZATION (1st)		MINERAL FERTILIZATION (2nd)		GRAIN HARVESTING	GRAIN TRANSPORTATION		STRAW COLLECTION		STRAW TRANSPORTATION	
				TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE	COMBINE HARVESTER	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE
TECHNICAL PARAMETERS	Numer of tractors/machines required	N°	-	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	1	1	1	1
	Max engine power	Pm_{MAX}	kW	150		80		80		100		50		50		160	50		80		50	
	Mass (machine/tractor only)	m	kg	8920	2600	4417	1450	4417	870	5910	860	3260	200	3260	200	14000	3260	4000	4417	1950	3260	6100
	Tractor/machine driving wheels	WD	-	4		4		4		4		4		4		4	4		4		4	
	Machine type	-	-		traditional plow		rotary harrow		row seeder		pesticides sprayer		fertilizers spreader		fertilizers spreader			trailer wagon		round baler		trailer wagon
	Machine coupling needs	-	-	force		pto		force		pto		pto		pto		self propelled	force		force + pto		force	
	Machine effective working width	b_w	m		2,0		3,9		4,0		17,5		10,0		10,0	5,5				6,0		
	Machine working depth	H	cm		30		15		4													
	Speed (effective time; t_E)	v_s	$km \cdot h^{-1}$	6,5		7,0		5,0		10,0		10,0		10,0		8	8		7,0		25,0	
	Total Mass (machine + product)	m_{MG+P}	kg		2600		1450		1440		2070		1300		1300	19525		15900		2175		12000
	Physical lifetime	PL	ha	12000	2000	12000	2000	12000	1500	12000	1500	12000	1500	12000	1500	3000	12000	3000	12000	2500	12000	6500
	Time of machine preparation on farm	t_{PR1}	s		600		600		600		600		300		300	600		200		600		200
	Time of machine maintenance on field	t_{MN}	% t_E		0,5%		0,5%		1,0%		2,0%		1,0%		1,0%	0,5%		0,5%		1,0%		0,5%
	Time of machine preparation on field	t_{PR2}	s		300		300		600		500		300		300	300		200		600		200
	Operative work capacity	OC	$ha \cdot h^{-1}$	1,03		2,20		1,33		5,42		5,44		4,38		3,17	2,54		2,36		0,45	
EMISSIONS IN ATMOSPHERE	Carbon monoxide	CO	g/ha	210	0	35	0	49	0	15	0	6	0	7	0	73	20	0	22	0	28	0
	Unburnt hydrocarbons	HC	g/ha	54	0	8	0	11	0	3	0	2	0	2	0	19	6	0	5	0	8	0
	Nitrogen oxides	NO_x	g/ha	635	0	159	0	221	0	67	0	19	0	23	0	221	64	0	59	0	86	0
	Particulate	PM	g/ha	10	0	1	0	2	0	1	0	0	0	0	0	3	1	0	1	0	1	0
	Carbon dioxide	CO_2	g/ha	75194	0	20095	0	29954	0	6934	0	3879	0	4712	0	24870	4541	0	13082	0	7881	0
EMISSIONS IN SOIL	Cadmium	Cd	g/ha	0,00010	0,00000	0,00002	0,00000	0,00004	0,00000	0,00001	0,00000	0,00001	0,00000	0,00001	0,00000	0,00003	0,00002	0,00000	0,00002	0,00000	0,00009	0,00000
	Lead	Pb	g/ha	0,00044	0,00000	0,00010	0,00000	0,00017	0,00000	0,00006	0,00000	0,00003	0,00000	0,00004	0,00000	0,00014	0,00007	0,00000	0,00010	0,00000	0,00037	0,00000
	Zinc	Zn	g/ha	0,27333	0,00000	0,06338	0,00000	0,10452	0,00000	0,03443	0,00000	0,01892	0,00000	0,02350	0,00000	0,08467	0,04055	0,00000	0,05913	0,00000	0,22675	0,00000

Italian barley farm: ENVIAM v2 results (field operations inventory data - BarNow)

TR&IMP TECHNICAL PARAMETERS

TR&IMP number
TR max Power, 2WD-4WD
TR mass
Type of IMP
Type of TR&IMP coupling
IMP effective working width
Working depth (tillage only)
Working speed
Polimeric materials&rubber
Tr&IMP lifetime
No-working timing
Work capacity

CONSUMPTION MATERIALS (g/ha)

Fuel
Lubricant
Steel/Iron
Copper
Alluminium
Lead batteries
Glass
Polimeric materials&rubber
Tyres
Fluids, oil, chemicals

EMISSIONS IN AIR (g/ha)

CO - NOx - CO_2
PM
Unburnt hydrocarbons (HC)

EMISSIONS IN SOIL (g/ha)

Cadmium (Cd), Lead (Pb), Zinc (Zn)

BARPLUS IDEOTYPE(S): FIELD OPERATIONS INVENTORY DATA REPRESENTATIVE BARLEY FARM: ITALY DISTRICT NAME: PO VALLEY	SYMBOL	UNIT OF MEASURE	FIELD OPERATIONS					
			PRIMARY SOIL TILLAGE		SECONDARY SOIL TILLAGE		SOWING	
			TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE
Numer of tractors/machines required	N°	-	1	1	1	1	1	1
Max engine power	Pm_{MAX}	kW	150		80		80	
Mass (machine/tractor only)	m	kg	8920	2600	4417	1450	4417	870
Tractor/machine driving wheels	WD	-	4		4		4	
Machine type	-	-		traditional plow		rotary harrow		row seeder
Machine coupling needs	-	-	force		pto		force	
Machine effective working width	b_u	m		2,0		3,9		4,0
Machine working depth	H	cm		30		15		4
Speed (effective time; t_E)	v_a	$km \cdot h^{-1}$	6,5		7,0		5,0	
Total Mass (machine + product)	m_{MO+P}	kg		2600		1450		1440
Physical lifetime	PL	ha	12000	2000	12000	2000	12000	1500
Time of machine preparation on farm	t_{PR1}	s		600		600		600
Time of machine maintenance on field	t_{MN}	% t_E		0,5%		0,5%		1,0%
Time of machine preparation on field	t_{PR2}	s		300		300		600
Operative work capacity	OC	$ha \cdot h^{-1}$	1,03		2,20		1,33	
Fuel	FC	kg/ha	23,87	0,00	6,38	0,00	9,51	0,00
Lubricant	LC	kg/ha	0,12	0,01	0,03	0,02	0,06	0,01
mass	MC	kg/ha	1,17	1,26	0,27	0,33	0,45	0,43
Steel/iron	-	g/ha	668,02	1230,11	154,91	322,92	255,46	406,89
Copper	-	g/ha	17,31	0,00	4,02	0,33	6,62	0,87
Aluminium	-	g/ha	38,96	1,26	9,03	0,33	14,90	0,87
Lead batteries	-	g/ha	28,86	0,00	6,69	0,00	11,04	0,00
Glass	-	g/ha	8,66	0,00	2,01	0,00	3,31	0,00
Polimeric materials and rubber	-	g/ha	28,13	1,26	6,52	1,98	10,76	8,69
Tyres	-	g/ha	213,54	25,23	49,52	0,00	81,66	15,65
Fluids, oil, chemicals	-	g/ha	152,94	3,78	35,47	3,95	58,49	1,74
Other	-	g/ha	12,99	0,00	3,01	0,00	4,97	0,00
Tyres abrasion	TA	g/ha	17,08	0,00	3,96	0,00	6,53	0,00
Carbon monoxide	CO	g/ha	209,59	0,00	35,19	0,00	49,34	0,00
Unburnt hydrocarbons	HC	g/ha	53,98	0,00	8,20	0,00	11,49	0,00
Nitrogen oxides	NO_X	g/ha	635,12	0,00	159,09	0,00	223,06	0,00
Particulate	PM	g/ha	9,53	0,00	1,45	0,00	2,03	0,00
Carbon dioxide	CO_2	g/ha	75194,22	0,00	20094,93	0,00	29953,80	0,00
Cadmium	Cd	g/ha	0,00010	0,00000	0,00002	0,00000	0,00004	0,00000
Lead	Pb	g/ha	0,00044	0,00000	0,00010	0,00000	0,00017	0,00000
Zinc	Zn	g/ha	0,27333	0,00000	0,06338	0,00000	0,10452	0,00000

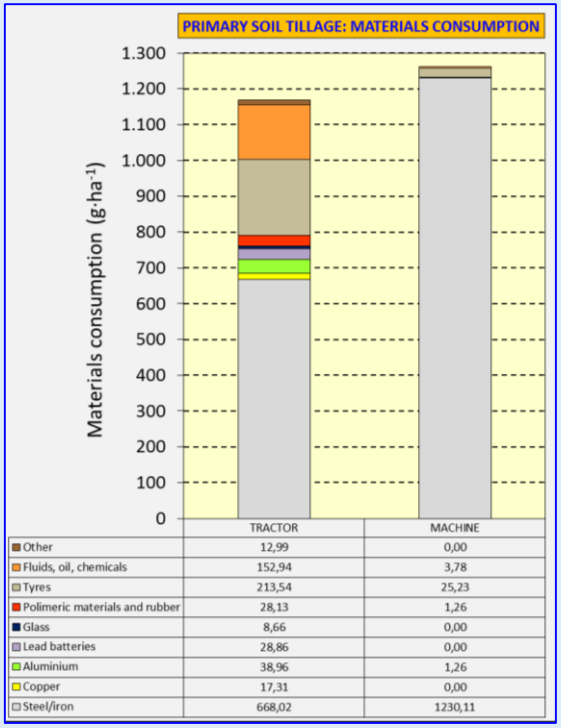
Italian barley farm: ENVIAM v2 results (consumption of materials)

Ploughing → Harrowing → Sowing → Weed control → Top fertilization → Grain harvesting → Grain transportation → Straw collection → Straw transportation

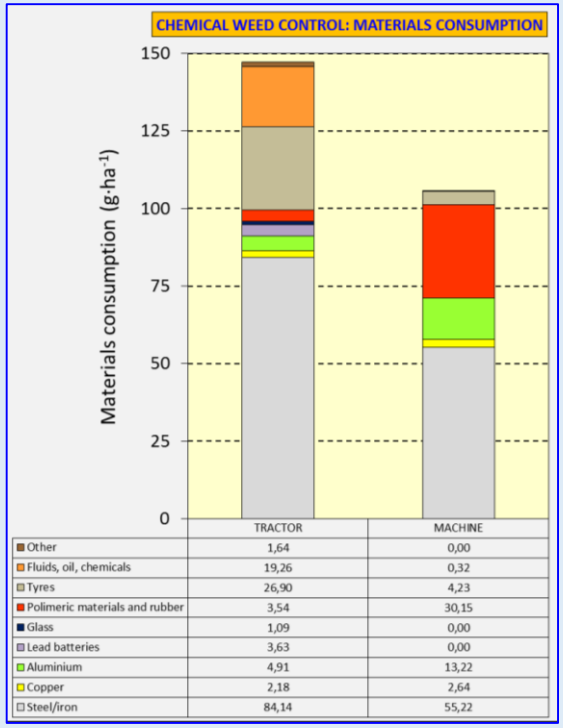
[...]

[...]

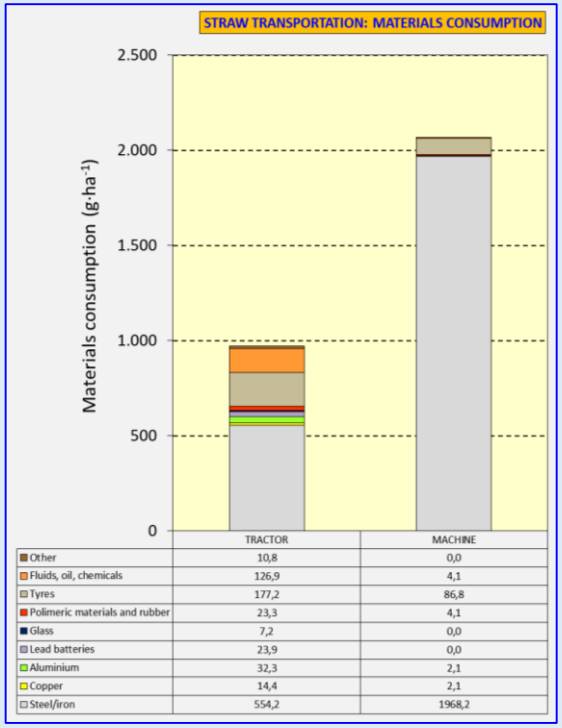
Steel/Iron – Copper – Alluminium - Lead batteries - Glass - Polimeric materials&rubber – Tyres - Fluids, oil, chemicals



	TRACTOR	MACHINE
Other	12,99	0,00
Fluids, oil, chemicals	152,94	3,78
Tyres	213,54	25,23
Polimeric materials and rubber	28,13	1,26
Glass	8,66	0,00
Lead batteries	28,86	0,00
Aluminium	38,96	1,26
Copper	17,31	0,00
Steel/iron	668,02	1230,11



	TRACTOR	MACHINE
Other	1,64	0,00
Fluids, oil, chemicals	19,26	0,32
Tyres	26,90	4,23
Polimeric materials and rubber	3,54	30,15
Glass	1,09	0,00
Lead batteries	3,63	0,00
Aluminium	4,91	13,22
Copper	2,18	2,64
Steel/iron	84,14	55,22



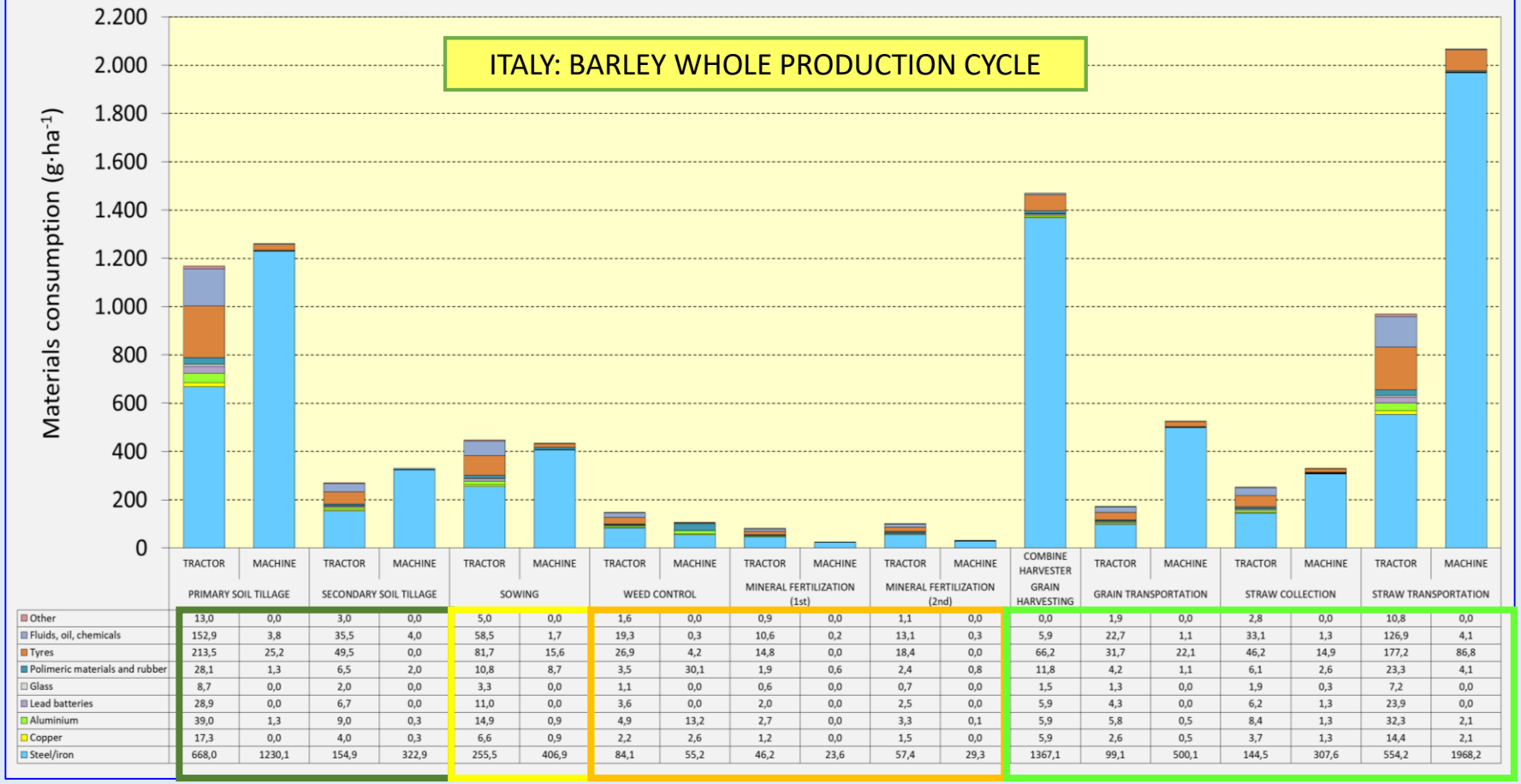
	TRACTOR	MACHINE
Other	10,8	0,0
Fluids, oil, chemicals	126,9	4,1
Tyres	177,2	86,8
Polimeric materials and rubber	23,3	4,1
Glass	7,2	0,0
Lead batteries	23,9	0,0
Aluminium	32,3	2,1
Copper	14,4	2,1
Steel/iron	554,2	1968,2

Italian barley farm: ENVIAM v2 results (consumption of materials)

Ploughing → Harrowing → Sowing → Weed control → Top fertilization → Grain harvesting → Grain transportation → Straw collection → Straw transportation

OP_1 OP_2 OP_3 OP_4 OP_{5A_5B} OP_6 OP_7 OP_8 OP_9

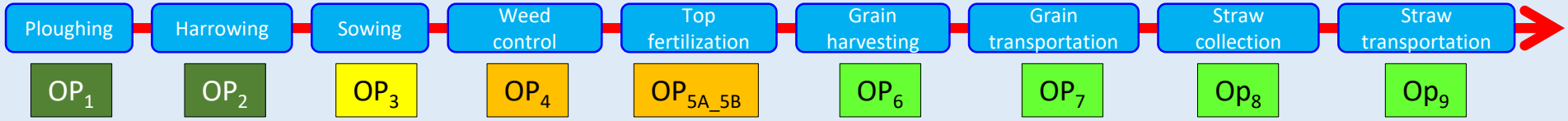
FIELD OPERATIONS: MATERIALS CONSUMPTION



	PRIMARY SOIL TILLAGE		SECONDARY SOIL TILLAGE		SOWING		WEED CONTROL		MINERAL FERTILIZATION (1st)		MINERAL FERTILIZATION (2nd)		COMBINE HARVESTER GRAIN HARVESTING	GRAIN TRANSPORTATION		STRAW COLLECTION		STRAW TRANSPORTATION	
	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE		TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE
Other	13,0	0,0	3,0	0,0	5,0	0,0	1,6	0,0	0,9	0,0	1,1	0,0	0,0	1,9	0,0	2,8	0,0	10,8	0,0
Fluids, oil, chemicals	152,9	3,8	35,5	4,0	58,5	1,7	19,3	0,3	10,6	0,2	13,1	0,3	5,9	22,7	1,1	33,1	1,3	126,9	4,1
Tyres	213,5	25,2	49,5	0,0	81,7	15,6	26,9	4,2	14,8	0,0	18,4	0,0	66,2	31,7	22,1	46,2	14,9	177,2	86,8
Polimeric materials and rubber	28,1	1,3	6,5	2,0	10,8	8,7	3,5	30,1	1,9	0,6	2,4	0,8	11,8	4,2	1,1	6,1	2,6	23,3	4,1
Glass	8,7	0,0	2,0	0,0	3,3	0,0	1,1	0,0	0,6	0,0	0,7	0,0	1,5	1,3	0,0	1,9	0,3	7,2	0,0
Lead batteries	28,9	0,0	6,7	0,0	11,0	0,0	3,6	0,0	2,0	0,0	2,5	0,0	5,9	4,3	0,0	6,2	1,3	23,9	0,0
Aluminium	39,0	1,3	9,0	0,3	14,9	0,9	4,9	13,2	2,7	0,0	3,3	0,1	5,9	5,8	0,5	8,4	1,3	32,3	2,1
Copper	17,3	0,0	4,0	0,3	6,6	0,9	2,2	2,6	1,2	0,0	1,5	0,0	5,9	2,6	0,5	3,7	1,3	14,4	2,1
Steel/iron	668,0	1230,1	154,9	322,9	255,5	406,9	84,1	55,2	46,2	23,6	57,4	29,3	1367,1	99,1	500,1	144,5	307,6	554,2	1968,2

OP_1 OP_2 OP_3 OP_4 OP_{5A} OP_{5B} OP_6 OP_7 Op_8 Op_9

Italian barley farm: ENVIAM v2 results (Totala consumption of materials)



TOTAL MATERIALS CONSUMPTION

	UM	TR	IMP	TOT
Fuel	kg/ha	52,8	7,9	**60,7**
Lubricant		0,5	0,2	**0,7**
mass		3,6	6,6	**10,2**
Steel/iron	g/ha	2064,0	6211,0	**8275,1**
Copper		53,5	13,6	**67,1**
Aluminium		120,4	25,6	**146,0**
Lead batteries		89,2	7,2	**96,4**
Glass		26,7	1,8	**28,5**
Polimeric materials and rubber		86,9	63,0	**150,0**
Tyres		659,8	235,0	**894,8**
Fluids, oil, chemicals		472,5	22,7	**495,3**
Other		40,1	0,0	**40,1**
Tyres abrasion		52,8	5,3	**58,1**

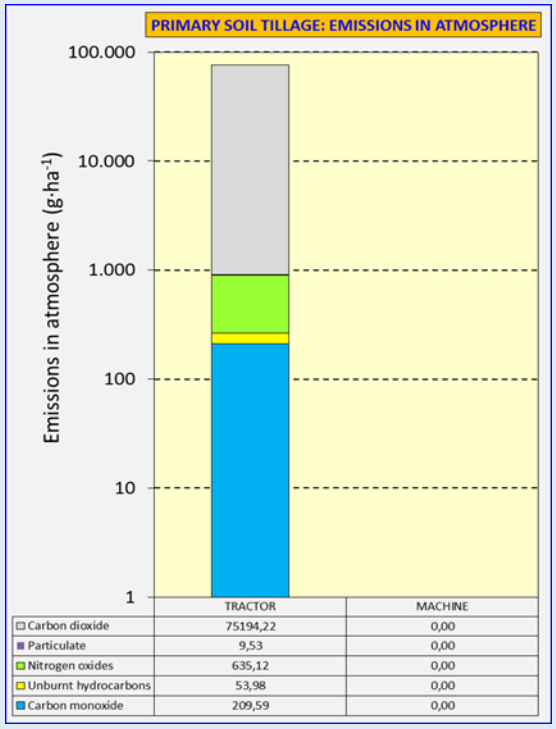
Italian barley farm: ENVIAM v2 results (emissions to air from Diesel engines)

Ploughing | Harrowing | Sowing | Weed control | Top fertilization | Grain harvesting | Grain transportation | Straw collection | Straw transportation

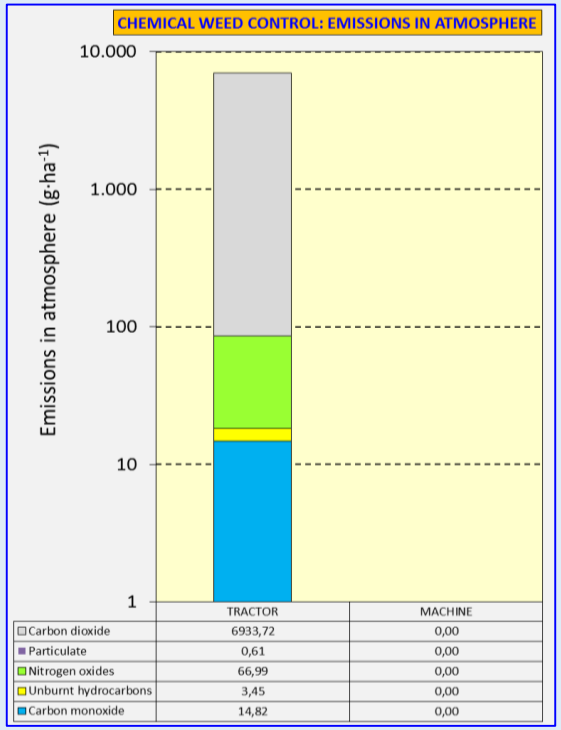
[...]

[...]

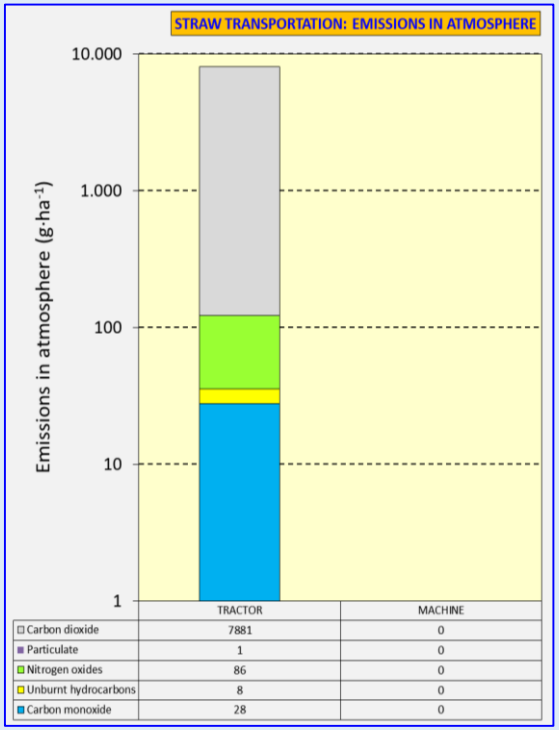
CO - NOx - CO_2 – PM - Unburnt hydrocarbons (HC)



	TRACTOR	MACHINE
Carbon dioxide	75194,22	0,00
Particulate	9,53	0,00
Nitrogen oxides	635,12	0,00
Unburnt hydrocarbons	53,98	0,00
Carbon monoxide	209,59	0,00

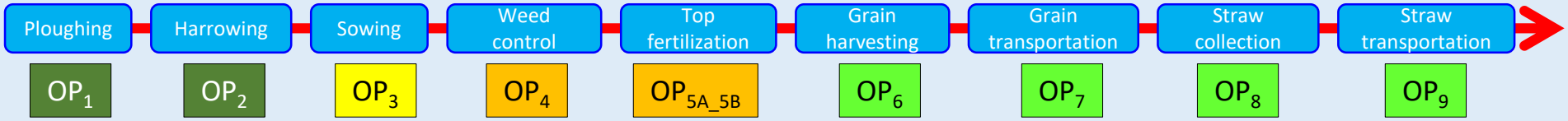


	TRACTOR	MACHINE
Carbon dioxide	6933,72	0,00
Particulate	0,61	0,00
Nitrogen oxides	66,99	0,00
Unburnt hydrocarbons	3,45	0,00
Carbon monoxide	14,82	0,00



	TRACTOR	MACHINE
Carbon dioxide	7881	0
Particulate	1	0
Nitrogen oxides	86	0
Unburnt hydrocarbons	8	0
Carbon monoxide	28	0

Italian barley farm: ENVIAM v2 results (Total emissions)



TOTAL EMISSIONS TO AIR (exhausted gases) and TO SOIL TYRES ABRASION

	UM	TR	IMP	TOT
Carbon monoxide	g/ha	391,8	73,1	**464,9**
Unburnt hydrocarbons		99,3	18,8	**118,1**
Nitrogen oxides		1378,1	221,5	**1599,5**
Particulate		16,0	3,3	**19,4**
Carbon dioxide		166271,3	24869,7	**191141,0**
Cadmium		0,0	0,0	**0,0**
Lead		0,0	0,0	**0,0**
Zinc		0,8	0,1	**0,9**

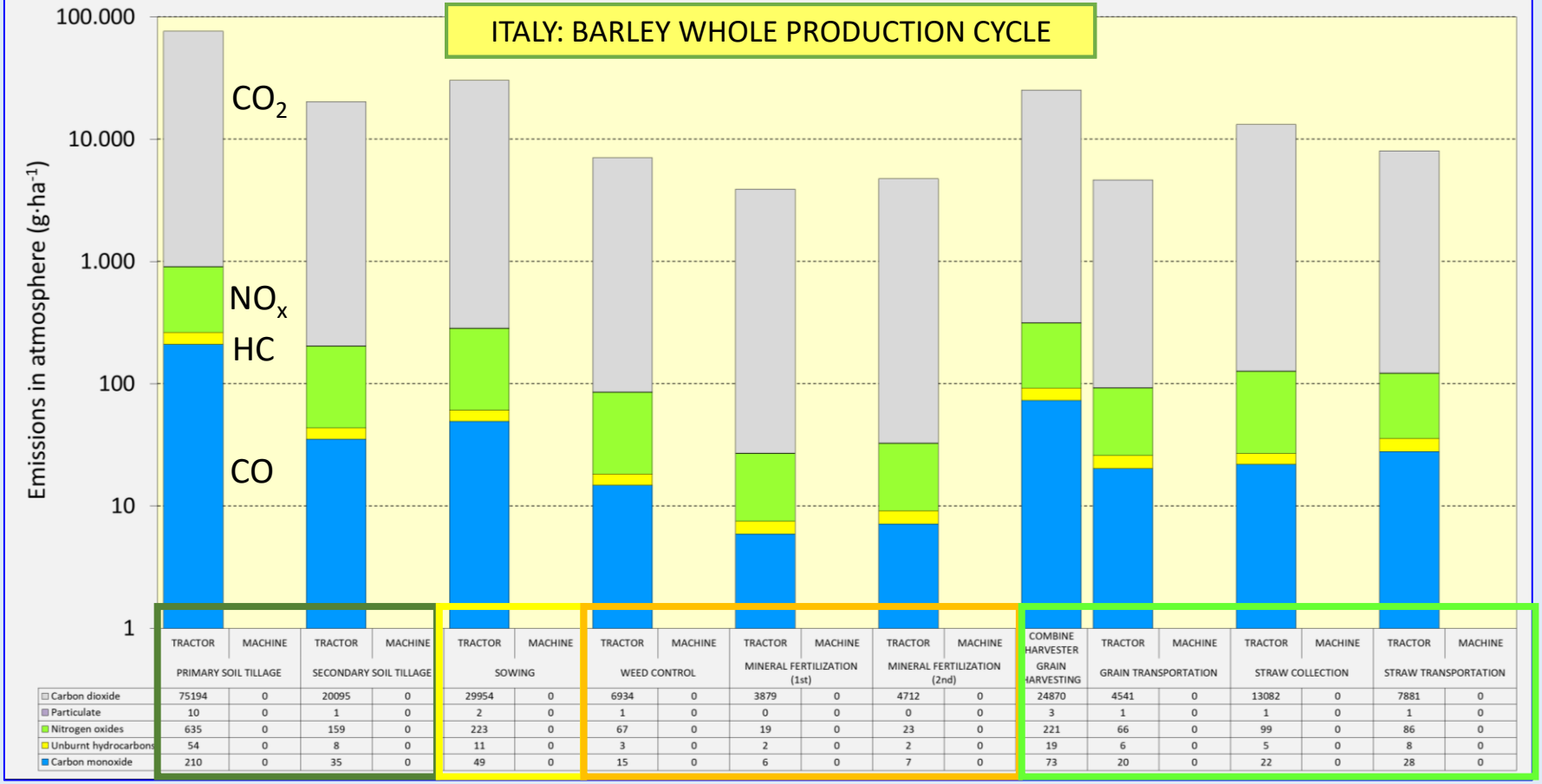
Italian barley farm: ENVIAM v2 results (emissions to air from Diesel engines)

Ploughing → Harrowing → Sowing → Weed control → Top fertilization → Grain harvesting → Grain transportation → Straw collection → Straw transportation

OP_1 OP_2 OP_3 OP_4 OP_{5A_5B} OP_6 OP_7 Op_8 Op_9

FIELD OPERATIONS: GASEOUS EMISSIONS IN ATMOSPHERE

ITALY: BARLEY WHOLE PRODUCTION CYCLE



	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE	COMBINE HARVESTER	TRACTOR	MACHINE	TRACTOR	MACHINE	TRACTOR	MACHINE
	PRIMARY SOIL TILLAGE		SECONDARY SOIL TILLAGE		SOWING		WEED CONTROL		MINERAL FERTILIZATION (1st)		MINERAL FERTILIZATION (2nd)		GRAIN HARVESTING	GRAIN TRANSPORTATION		STRAW COLLECTION		STRAW TRANSPORTATION	
Carbon dioxide	75194	0	20095	0	29954	0	6934	0	3879	0	4712	0	24870	4541	0	13082	0	7881	0
Particulate	10	0	1	0	2	0	1	0	0	0	0	0	3	1	0	1	0	1	0
Nitrogen oxides	635	0	159	0	223	0	67	0	19	0	23	0	221	66	0	99	0	86	0
Unburnt hydrocarbons	54	0	8	0	11	0	3	0	2	0	2	0	19	6	0	5	0	8	0
Carbon monoxide	210	0	35	0	49	0	15	0	6	0	7	0	73	20	0	22	0	28	0

OP_1 OP_2 OP_3 OP_4 OP_{5A} OP_{5B} OP_6 OP_7 Op_8 Op_9

…FUTURE

PRIORITY n.1

for German, Poland and Spain districts

- ❑ complete District, Farm and barley cropping information/data from Project Partners (→ Spain: work in progress; Poland: work just started; Germany: work still to start).

PRIORITY n.2

for all the districts

- ❑ complete the Life Cycle Impact Inventory (LCI) with:
  - Nitrogen emission due to the fertilizers application (STICS model);
  - emissions due to pesticides distribution (Margni et al., 2002);
- ❑ implement all the LCI in SimaPro Software;
- ❑ running Life Cycle Impact Assessment (LCIA) using the ILCD method v 1.09 (Wolf et al., 2012)
- ❑ results interpretation.

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