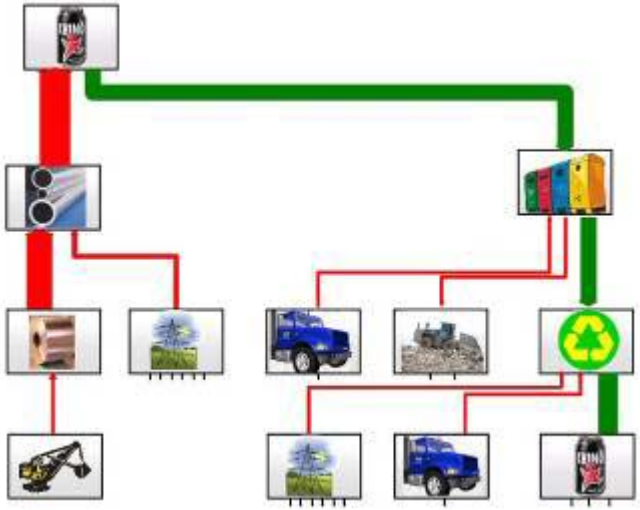
16-17 June 2010, Seville (Spain)

2nd Experts Seminar on

«Optimal recovery of material and energy resources:
The cases of the rest fraction of municipal waste and sewage sludge»

LCA of Integrated Waste Management Systems



Gian Andrea Blengini, PhD.

DISPEA Politecnico di Torino

CNR-IGAG Torino

Two **Life Cycle Assessment** studies in co-operation with:

- Politecnico di Torino
- Waste planning and management authority of Provincia di Torino
- Waste planning and management authority of Provincia di Cuneo

LCA of Integrated Waste Management Systems: application to different scenarios in Torino and Cuneo Districts

~1 200 000 t MSW

2 200 000 inhabitants

~300 000 t MSW

583 000 inhabitants

In both cases, the objective was identifying the scenarios with best energy and environmental performances

Through a SYSTEM APPROACH...

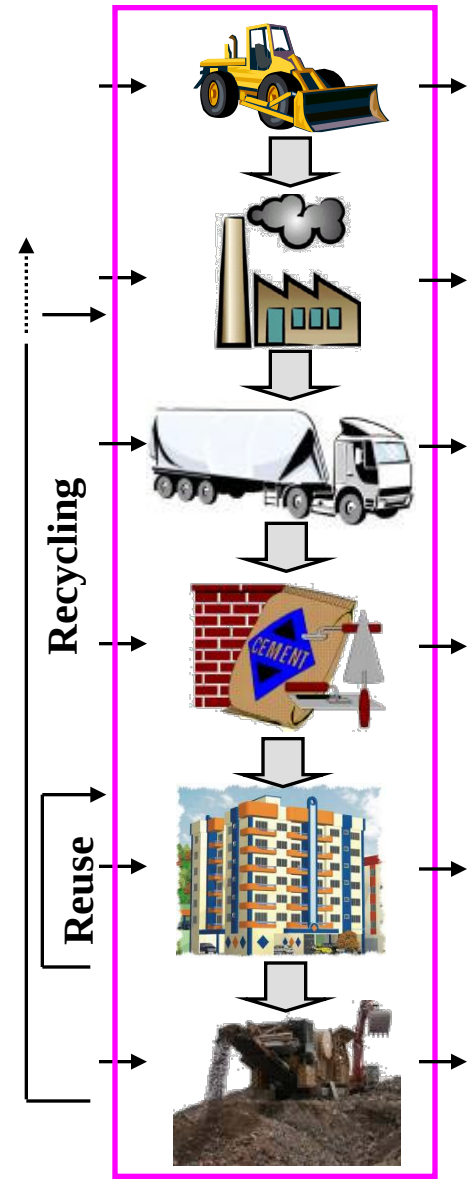
(every single activity has a role in the IWMS)

What is LCA? (Life Cycle Assessment)

LCA **is an** ***objective tool*** **for** ***analyzing*** **and** ***quantifying*** **the** ***environmental consequences*** **of** ***products*** **(services) during all their** ***life-cycle*****, from the extraction of raw materials, through industrial production, including the use phase and the end-of-life disposal**

"from-cradle-to-grave"

Environmental consequences of production/use systems encompass resource conservation issues as well as all kind of emissions harmful to human health and ecosystem quality



LCA identifies and quantifies **energy** and **materials** used, as well as **releases** to the environment and their **potential impacts** throughout the whole life cycle

Study boundary

Methodology (Torino): LCA + participatory approach

A panel of stakeholders/experts, including participants from Politecnico di Torino, Waste management Authorities, Environmentalist NGOs, was set up in order to define the objectives and scope of the LCA research:

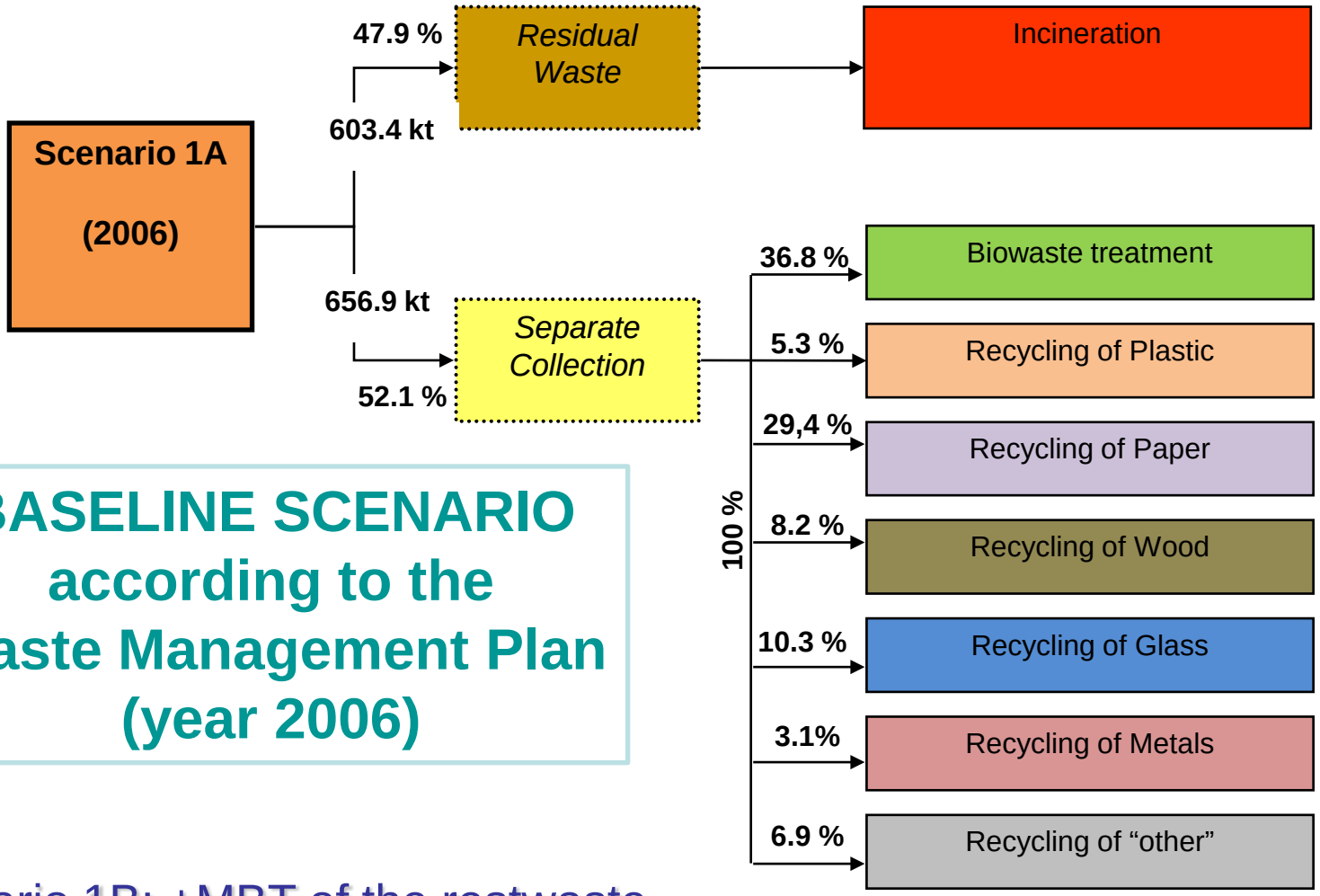
Definition and description of scenarios to be compared:
% of separate collection; alternative treatment options; system boundaries

Data collection:
Data sources, cut off criteria and responsibilities for data quality

Selection of meaningful environmental and energy indicators:
Energy indicators: GER Gross Energy Requirement; NRE Non Renew Energy
Climate Change indicators: GWP_t Global Warming Potential (fossil+ biogenic); GWP_f Global Warming Potential (fossil)

Detailed input data and assumptions relevant to the LCA models are available in the Research Reports (see references)

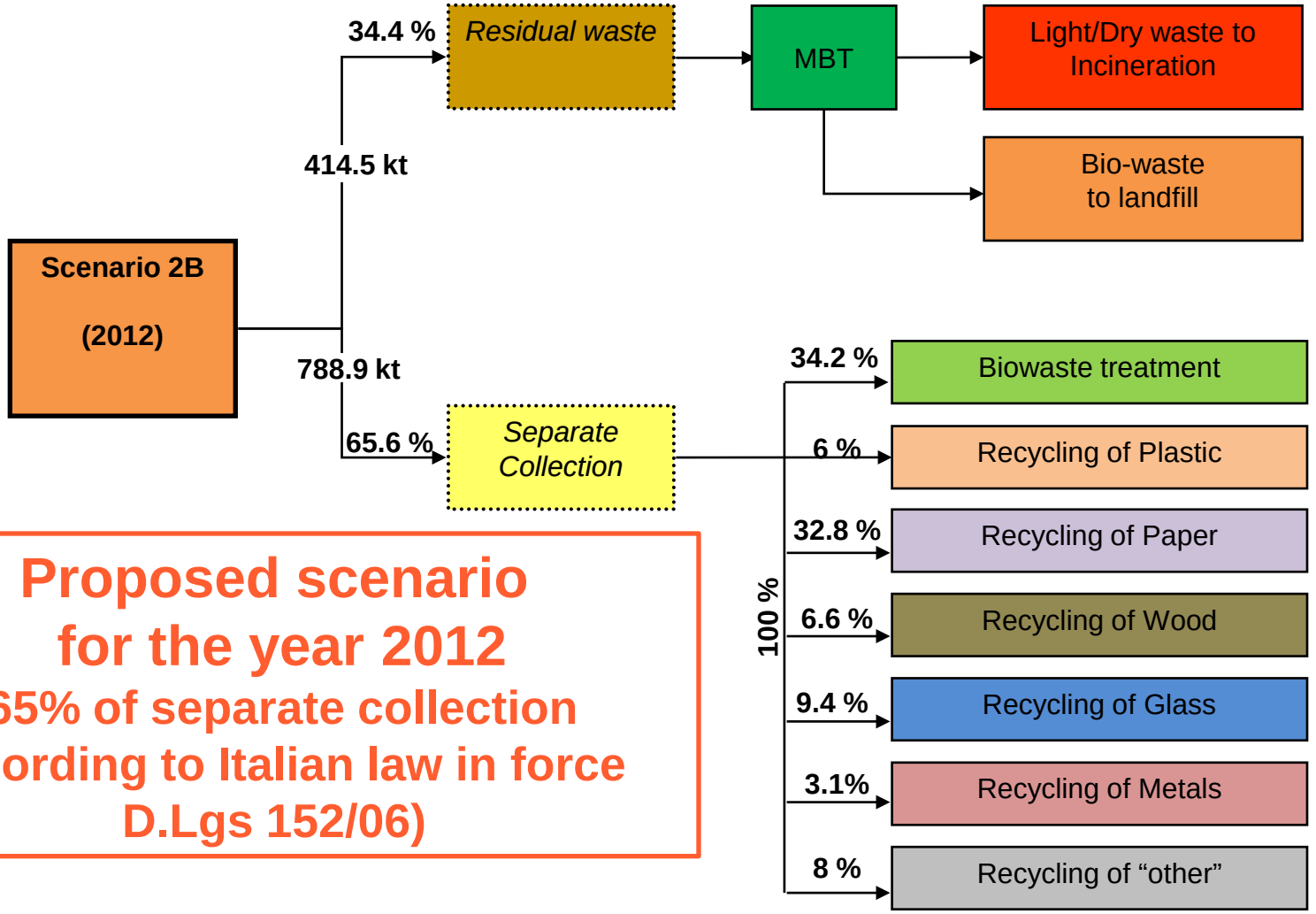
LCA of the IWMS of Torino District: scenarios to compare



BASELINE SCENARIO according to the Waste Management Plan (year 2006)

Scenario 1B: +MBT of the restwaste

LCA of the IWMS of Torino District: scenarios to compare



Proposed scenario for the year 2012
(65% of separate collection according to Italian law in force D.Lgs 152/06)

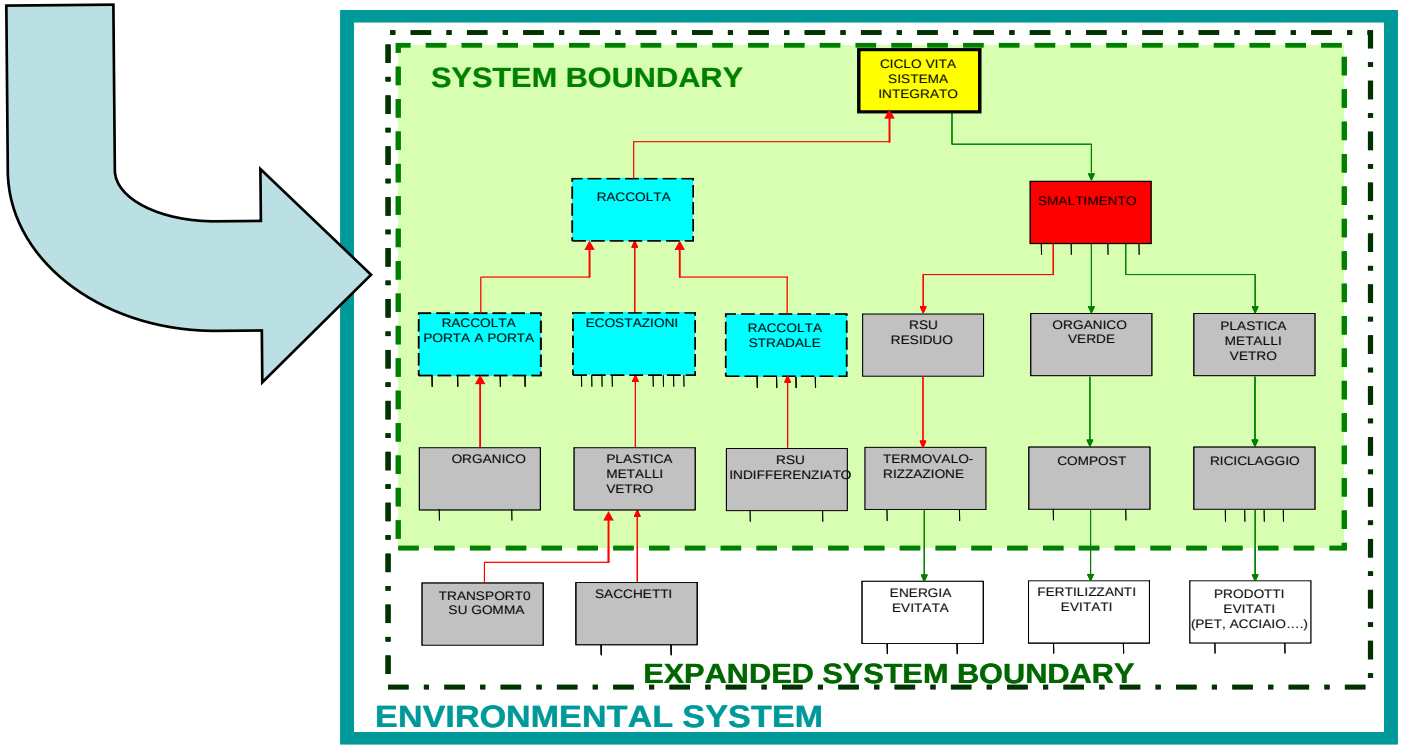
Scenario 2A: excl. MBT of the restwaste

Waste flows in the IWMS of Torino District (2006-2012)

		Scenario 1A/B (2006) RD=52.1%			Scenario 2A/B (2012) RD=65.6%		
		ton x 1000	%	kg/ab/ year	ton x 1000	%	kg/ab/ year
TOTAL WASTE	Foodwaste	346.5	27.5%	154	330.9	27.5%	147
	Green waste	67.0	5.3%	30	63.9	5.3%	28
	Plastic	173.9	13.8%	77	166.1	13.8%	74
	Paper	289.8	23.0%	129	276.7	23.0%	123
	Wood	99.1	7.9%	44	94.6	7.9%	42
	Glass	93.9	7.5%	42	89.7	7.5%	40
	Metal	39.3	3.1%	17	37.5	3.1%	17
	Other	150.8	12.0%	67	144.0	12.0%	64
	TOTAL	**1260.3**	**100%**	**560**	**1203.4**	**100%**	**535**
SEPARATELY COLLECTED WASTE	Foodwaste	190.0	28.9%	84	219.7	27.7%	98
	Green waste	51.7	7.9%	23	51.8	6.5%	23
	Plastic	35.1	5.3%	16	47.4	6.0%	21
	Paper	193.4	29.4%	86	260.0	32.8%	116
	Wood	54.0	8.2%	24	52.3	6.6%	23
	Glass	67.5	10.3%	30	74.2	9.4%	33
	Metal	20.2	3.1%	9	24.7	3.1%	11
	Other	45.0	6.8%	20	63.2	8.0%	28
	TOTAL	**656.9**	**100%**	**292**	**793.4**	**100%**	**353**
RESIDUUAL WASTE (RESTWASTE)	Foodwaste	156.5	25.9%	70	111.1	26.8%	49
	Green waste	15.2	2.5%	7	12.1	2.9%	5
	Plastic	138.9	23.0%	62	118.7	28.6%	53
	Paper	96.4	16.0%	43	16.7	4.0%	7
	Wood	45.1	7.5%	20	42.3	10.2%	19
	Glass	26.4	4.4%	12	15.4	3.7%	7
	Metal	19.0	3.2%	8	17.2	4.2%	8
	Other	105.9	17.5%	47	80.9	19.5%	36
	TOTAL	**603.4**	**100%**	**268**	**414.4**	**100%**	**184**

Assumptions

- "ZERO BURDENS": generated waste holds no environmental burdens*
- Functional Unit: 1 ton input waste
- Biogenic carbon accounted for (but reported separately)
- Expanded boundaries and detailed LCA

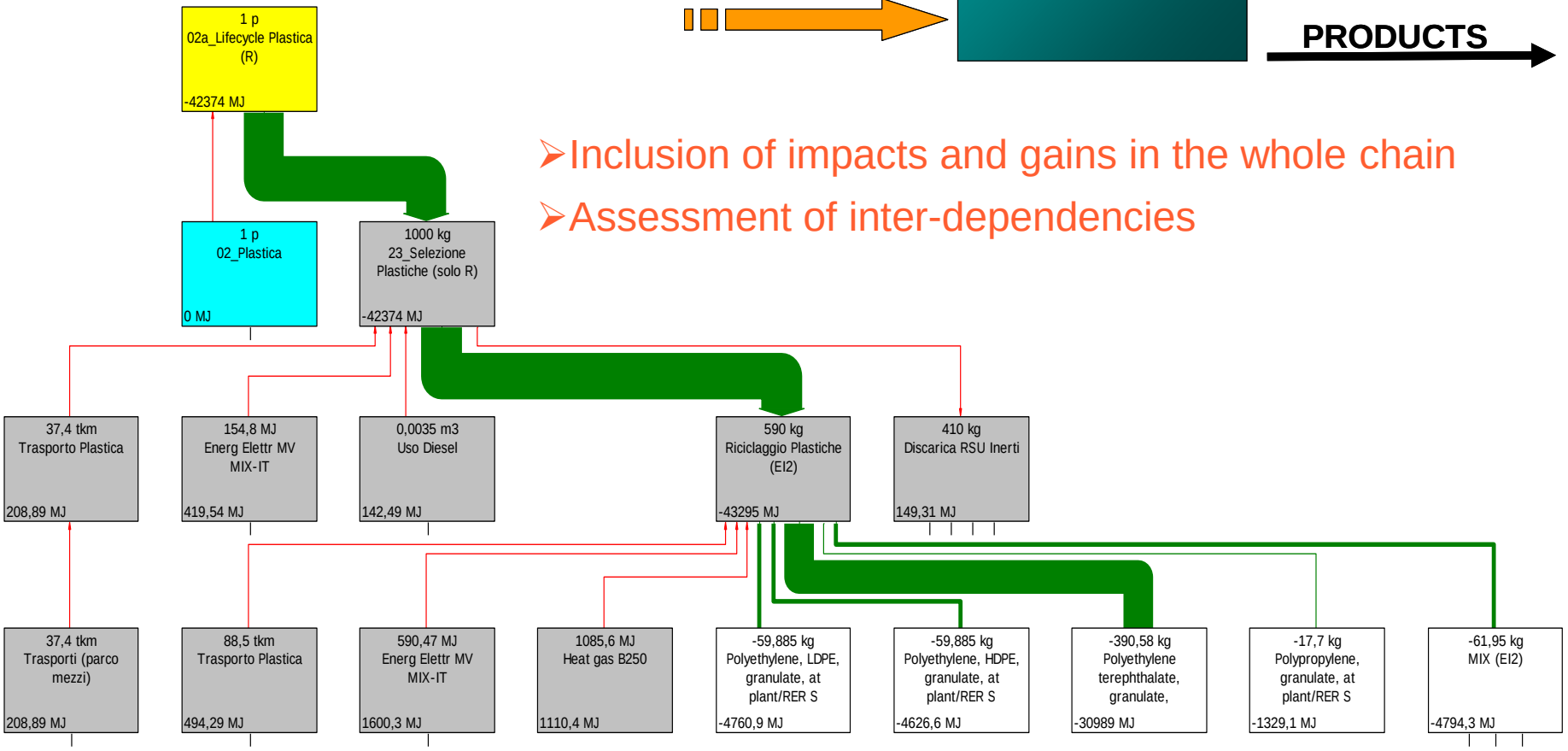


* this assumption doesn't allow assessing the benefits of waste reduction!!!

DATA COLLECTION

- based on site specific data from real waste management chains in Piemonte/Italy

- Inclusion of impacts and gains in the whole chain
- Assessment of inter-dependencies



Inventory analysis

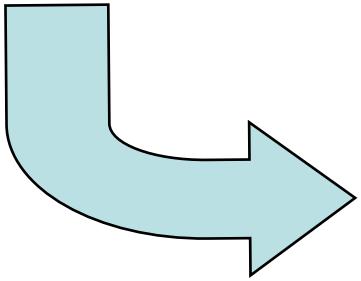
Detailed analysis of "*subsystems*":

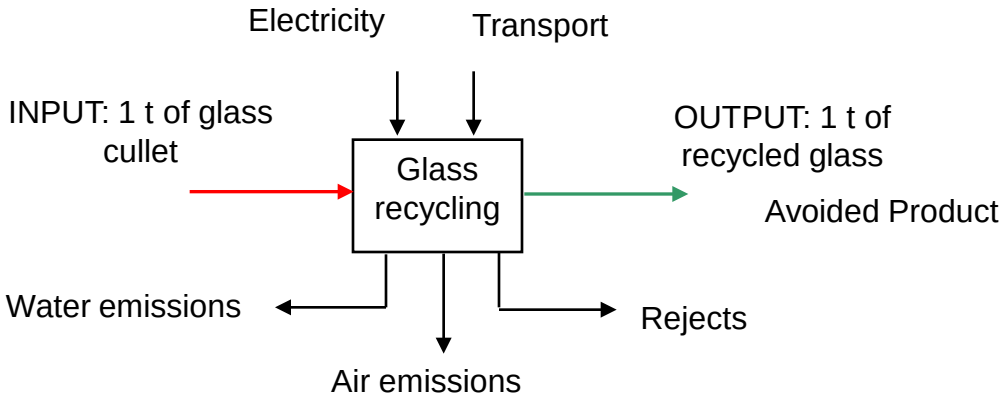
Collection of residual waste

Separate collection

Composting / Anaerobic digestion of biowaste and green waste

Recycling of Plastic, Paper, Wood, Glass, Metals



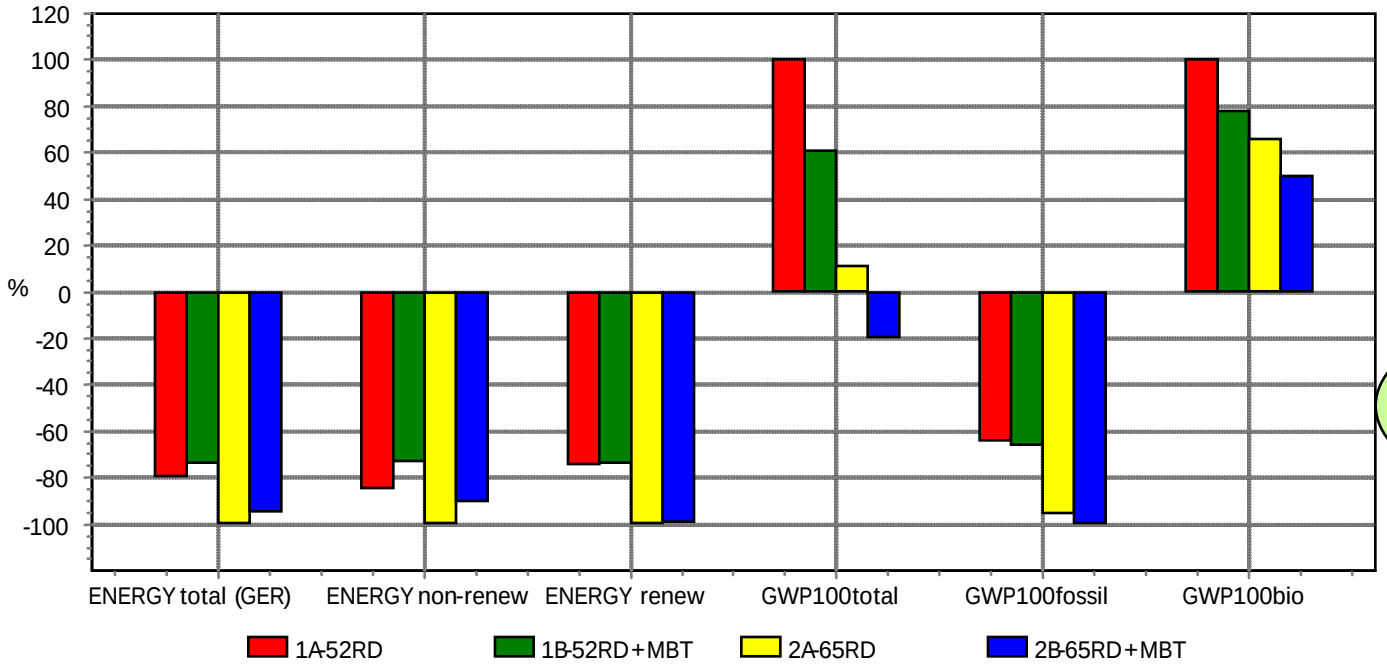


MBT of residual waste (scenarios 1B e 2B)

Incineration

Landfill of residual waste and rejects

Detailed input data and assumptions relevant to the LCA models are available in the Research Reports (see references)



LCA of Torino IWMS

GER - GWP

(1 t total waste)

		1A (52RD)	1B (52RD+MBT)	2A (65RD)	2B (65RD+MBT)
ENERGY (GER)	**MJ/t**	**-13898**	**-12.858**	**-17.362**	**-16.497**
ENERGY non-renew	**MJ/t**	**-7476**	**-6499**	**-8811**	**-8001**
ENERGY renew	**MJ/t**	**-6422**	**-6359**	**-8551**	**-8496**
GWP100total	**kg CO_{2eq}/t**	**233**	**142**	**26**	**-46**
GWP100fossil	**kg CO_{2eq}/t**	**-156**	**-160**	**-230**	**-241**
GWP100bio	**kg CO_{2eq}/t**	**389**	**302**	**256**	**195**

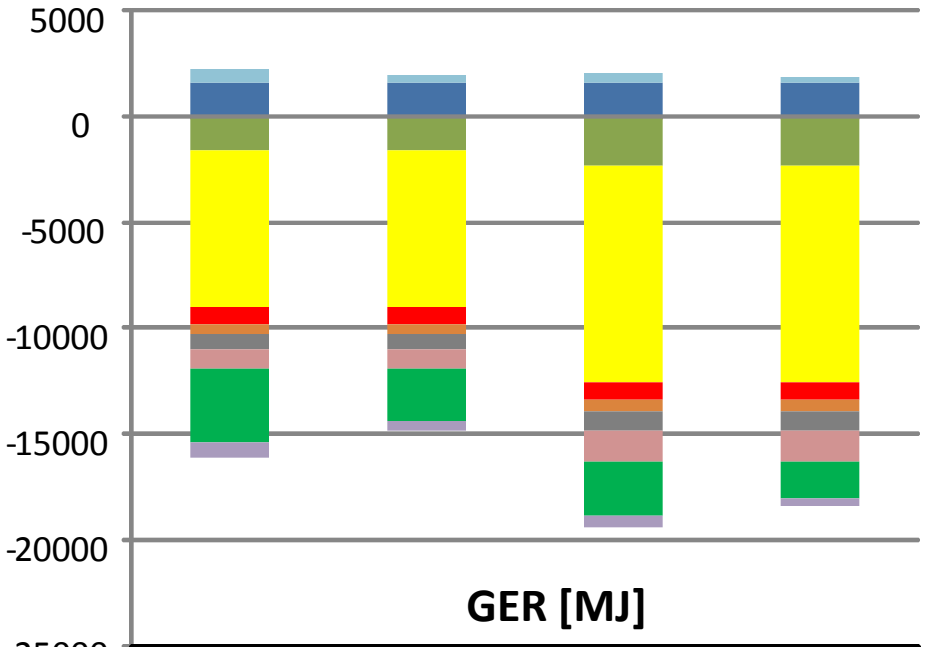
RD = % Separate Collection

Contribution analysis

LCA of Torino IWMS

(1 t total waste)

ENERGY



GER [MJ]

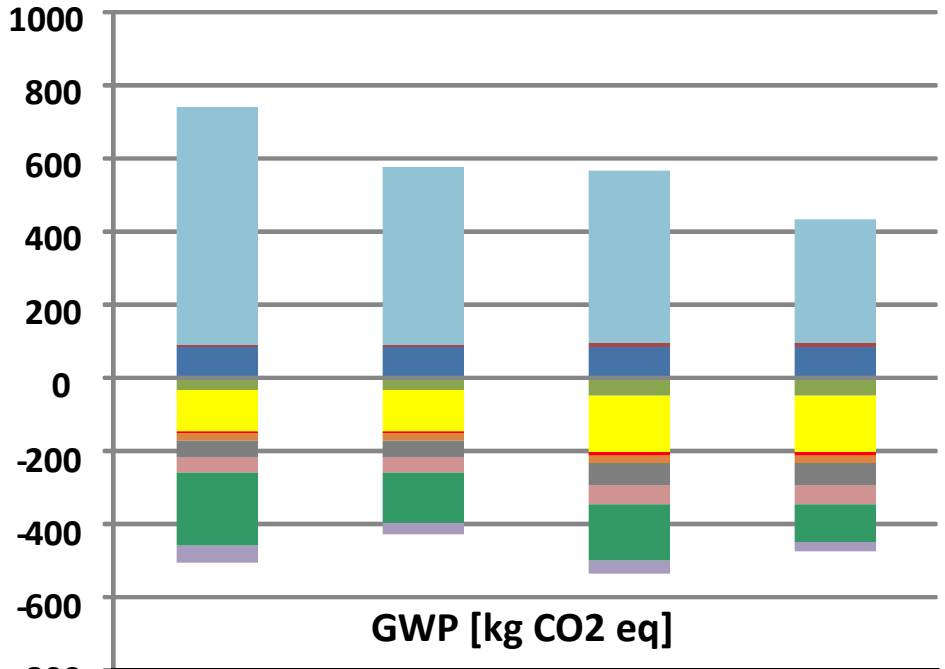
	1A	1B	2A	2B
Incineration process	607,3	367,9	436,3	253,6
Heat from incineration	-726,1	-504,2	-550,4	-366,6
Electricity from inciner.	-3457,5	-2399,9	-2606	-1743
Recycling other	-966,8	-966,8	-1411,3	-1411,3
Recycling metals	-753	-753	-959,4	-959,4
Recycling glass	-456,4	-456,4	-522,6	-522,6
Recycling wood	-796,5	-796,5	-804,4	-804,4
Recycling paper	-7356,4	-7356,4	-10299	-10299
Recycling plastic	-1575,4	-1575,4	-2219	-2219
Treatment of biowaste	-49,8	-49,8	-58,2	-58,2
Collection	1632,5	1632,5	1632,5	1632,5

Contribution analysis

LCA of Torino IWMS

(1 t total waste)

GLOBAL WARMING

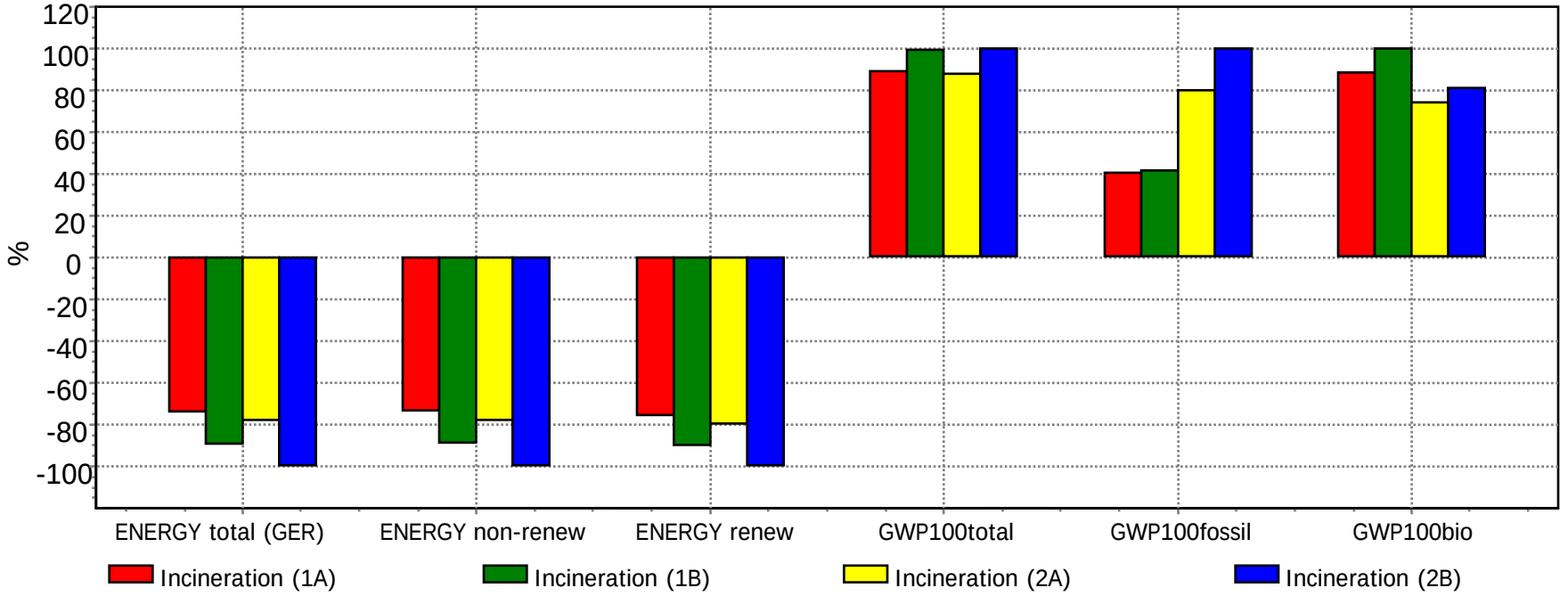


	1A	1B	2A	2B
Incineration process	649	482,8	472,4	338,5
Heat from incineration	-42,4	-29,4	-32,1	-21,4
Electricity from inciner.	-204,4	-141,8	-154	-103
Recycling "other"	-36,3	-36,3	-52,9	-52,9
Recycling metals	-49,4	-49,4	-62,9	-62,9
Recycling glass	-17,8	-17,8	-20,4	-20,4
Recycling wood	-9	-9	-9,1	-9,1
Recycling paper	-109,6	-109,6	-153,5	-153,5
Recycling plastic	-36,9	-36,9	-52	-52
Treatment of biowaste	5,2	5,2	6	6
Collection	84,4	84,4	84,4	84,4

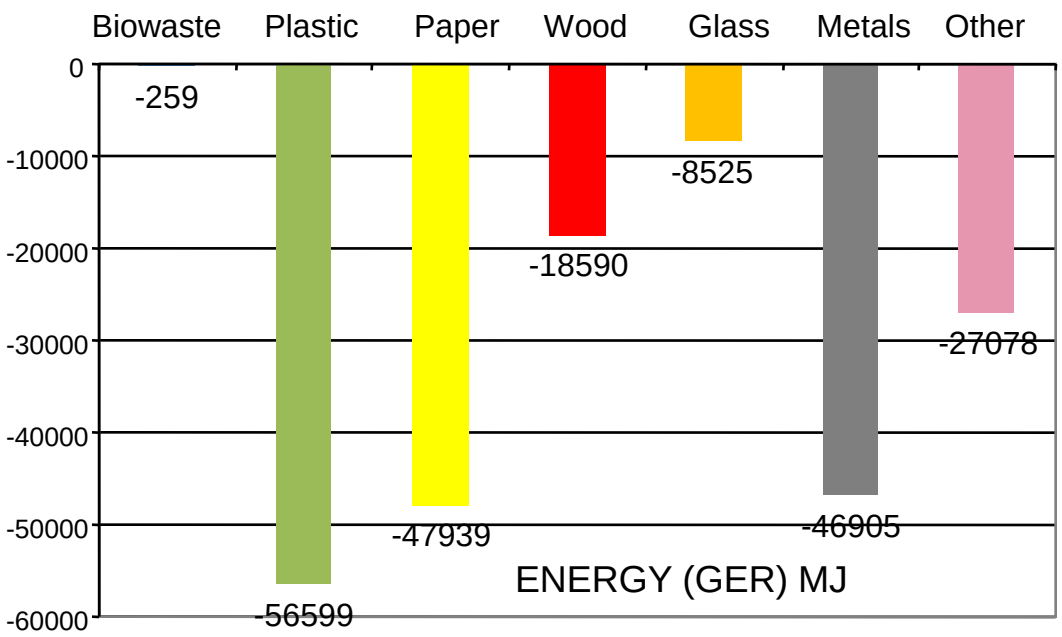
Energy balance and carbon balance of incineration

(1 t residual waste 1A-2A / 1t dry fraction 1B-2B)

Impact category	Unit	Incineration (1A)	Incineration (1B)	Incineration (2A)	Incineration (2B)
ENERGY total (GER)	**MJ**	**-7471**	**-9013**	**-7897**	**-10076**
ENERGY non-renew	MJ	-6903	-8340	-7301	-9331
ENERGY renew	MJ	-565	-670	-594	-743
GWP100total	**kg CO2eq**	**840**	**937**	**831**	**943**
GWP100fossil	kg CO2eq	112	116	221	277
GWP100bio	kg CO2eq	729	822	610	667

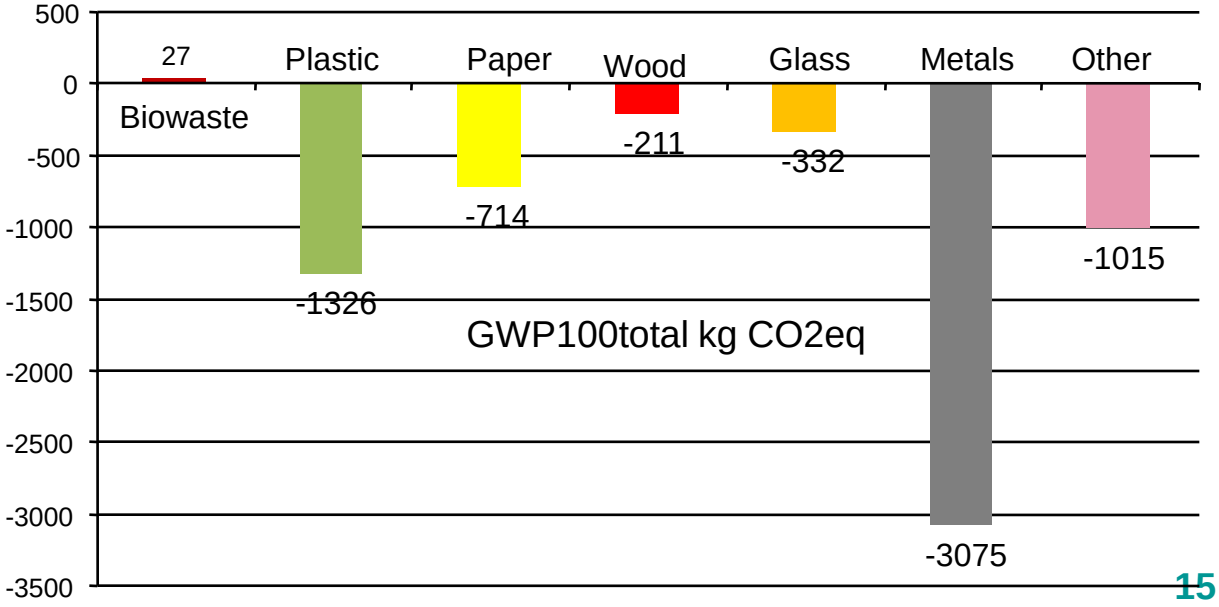


Energy balance and carbon balance of separate collection + recycling



GER

(1 t separately collected waste)

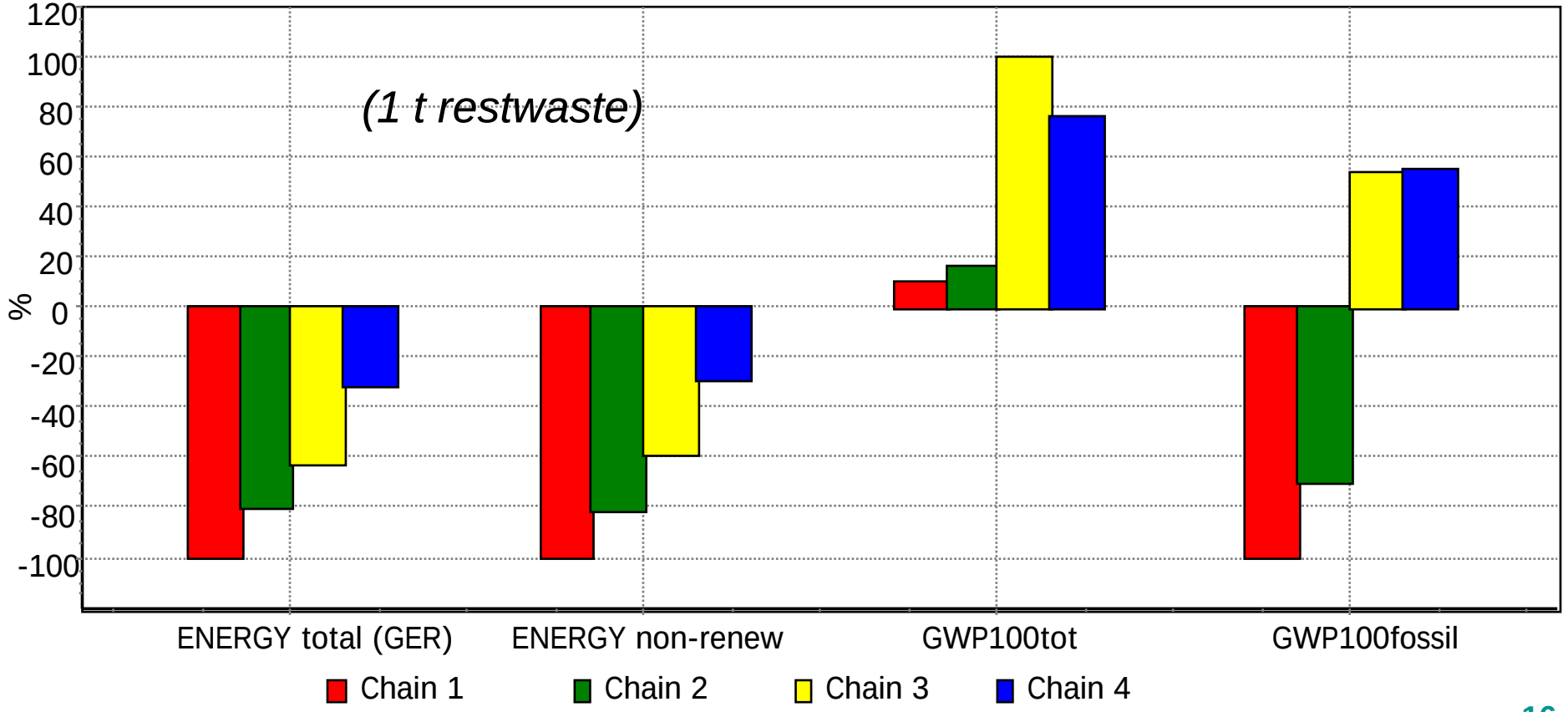


GWP

Energy & carbon balance of alternative energy recovery chains from restwaste

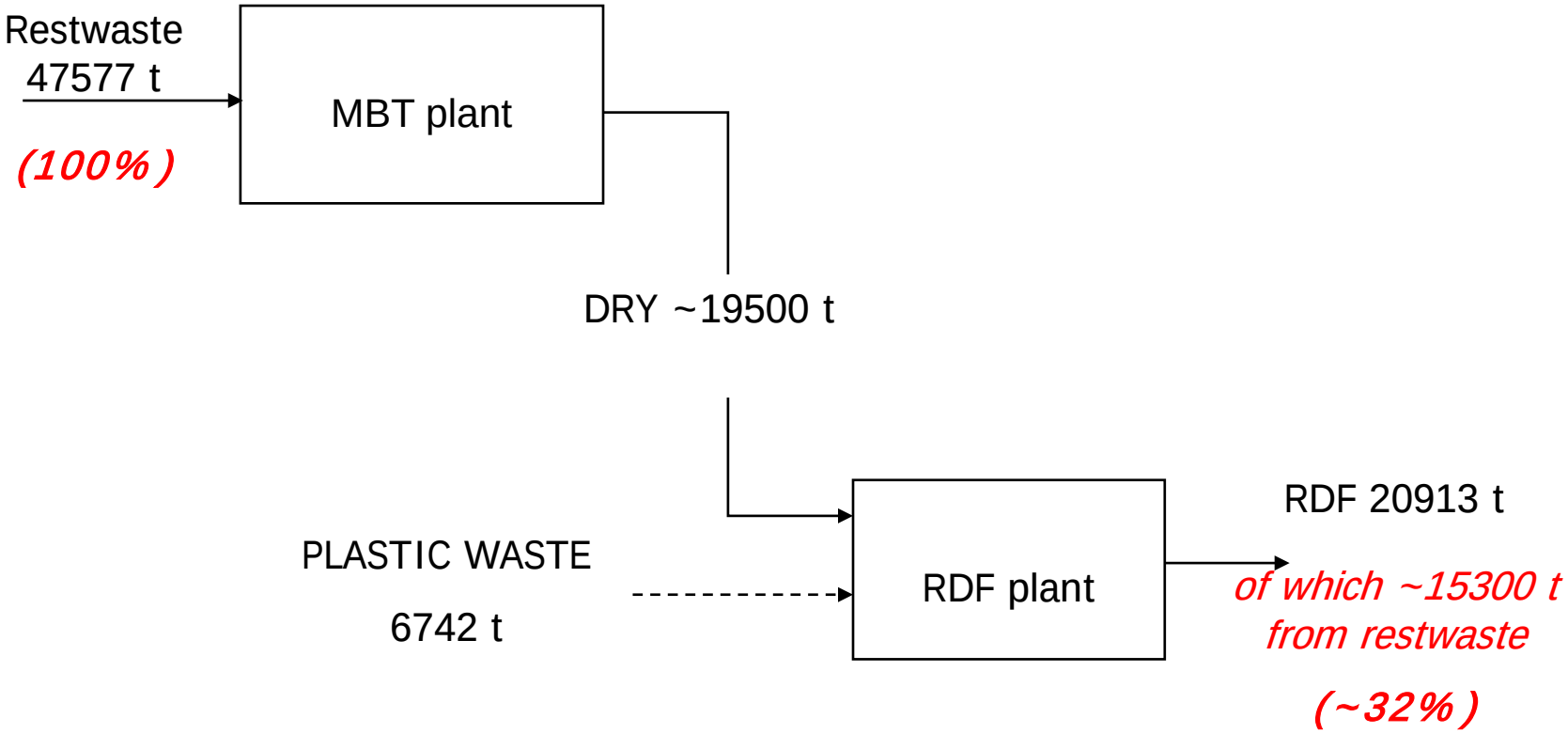
Chain 1: MBT + RDF + co-incineration in cement kiln
Chain 2: Bio-Dry + RDF + co-incineration in cement kiln
Chain 3: Direct incineration (scenario 1A LCA IWMS Torino)
Chain 4: MBT + incineration (scenario 1B LCA IWMS Torino)

LCA of Cuneo IWMS



Inventory of restwaste Chain 1

Production of Residue Derived Fuel (RDF): *mass flow in the restwaste-to-RDF chain*



Detailed input data and assumptions relevant to the LCA models are available in the Research Reports (see references)

CONCLUSIONS (based on the LCAs)

1. Increasing use of LCA in waste management in Italy
2. Use participatory approach to enhance LCA objectivity & acceptance
3. Increase of separate collection/recycl. (highest eco-efficiency)
   - *Improve efficiency of collection-recycling*
4. Strategies for energy recovery from residual waste (lower effic.)
   - *Use preferably existing cement kilns*
   - *Improve RDF chain efficiency*
   - *Further LCA research is needed to better understand the role of MBT*
5. There are other environmental issues beyond climate change!

References

Blengini G.A. (2008) – "Applying LCA to organic waste management in Piedmont-Italy", Management of Environmental Quality, Vol. 19 No. 5. pp. 533-549.

Blengini G.A., Genon G., Fantoni M., (2008) "LCA del sistema integrato di gestione dei rifiuti nella provincia di Torino". Research programme financed by "Servizio Pianificazione Sviluppo Sostenibile e Ciclo Integrato di rifiuti della Provincia di Torino", 50 pp.

Blengini G.A., Genon G., Fantoni M., (2009) LCA del sistema integrato dei RSU nella Provincia di Cuneo. Research programme financed by "ATO-Rifiuti Cuneo - Associazione Ambito Cuneese Ambiente", 47 pp.

Gian Andrea Blengini

Politecnico di Torino

DISPEA – Production Systems and Business Economics Department

Corso Duca degli Abruzzi 24 - 10129 Torino, Italy

blengini@polito.it

tel. +39 011 090 7288