EIO-LCA Table for Alto Adige – Süd Tirol Extended to Energy Consumption, Air Emissions and Waste Treatment

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Company profile

LCA of economic systems, from entreprise to regional scale

Sustainable Energy Management

Watershed Scale Models

EU Fund raising & project management

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Summary

1.a. – System Boundaries

Spatial Boundaries	Bolzano Province, 7.400 km²
Temporal Boundaries	Year 2005 (data availability, *baseline*)
Scope	Connection between **economic demand structure**, economic **flows** and **environmental impacts**.

1.b. – Objectives, Materials and Methods

Main Objectives

Obtain ***Benchmarks*** of environmental impacts of the economic activities related to different impact drivers → **Extended EIO-LCA model**.

Model

Economic Input/Output Analysis combined with the **Life Cycle Impacts Assessment**.

→ To analyse the **intersectoral economic flows** (EIO) and put them in relation with Environmental Impacts (LCA).

Data

- **Provincial Input/Output Table** [**ASTAT**]
- National/regional Emissions Account **NAMEA** [ISTAT]
- Province scale emissions inventory (**INEMAR**)
- Provincial Electricity Consumption per economic sector **[TERNA**]
- Province scale Natural Gas Consumption [**SNAM**] and Municipal NG/electricity Consumption [En. Comp. **Azienda Energetica** Meranese]
- Munic. scale Waste Register – Production and Treatment of «special» waste per economic activities [BZ **Chamber of Commerce** CCIAA]

Standardisation

NACE/ATECO 2002 Classification and aggregation in **22 economic sectors** (as in *NAMEA table*)

NACE: *Nomenclature statistique des Activités économiques dans la Communauté Européenne*

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1.c. – Issues & Assumptions

Difficulties

1. (Meta)**Data availability**
2. Different **aggregation and classification** under different data sources
3. Define a **method to estimate the errors** associated with figures produced

Assumptions

Province-level **NG consumptions** with same pattern as at Municipal scale

Province-level **Waste production and management** per economic sector with same pattern as in Municipal Waste management

<u>Tourism sector Expenses: internal or external demand ?</u>

2.a. – Economic Input/Output Model

The Input/Output theory was developed (50s) by Wassily Leontief, who defined the relation $\mathbf{x_{ij} = a_{ij} * x_j}$, assuming

- the existence of **technical coefficients** ($a_{ij} = x_{ij}/x_j$) representing the amount of output of the sector *i* acquired by the sector *j* per unit of output of sector *j*;
- The **invariability of the ratio** ($\mathbf{a_{ij}}$) between x_{ij} and x_j with respect to the variation of the production.

Initial Equation → $X = (A*X) + Y$

The **final production** (X) is employed to satisfy the **direct demand** (Y) and **the indirect one** (A*X) necessary to ensure the **sector reproducibility**.

$X - (A*X) = Y$

$X*(I-A) = Y$

Final Formula → $\mathbf{X = (I-A)^{-1} * Y}$

Leontief Formula: the **final production** is given by the **product between the demand and a coefficient** (**Leontief Coefficient or Multiplicator, $(I-A)^{-1}$**).
It gives a numerical estimate of the **impact on production** resulting from **a unit change in final demand**.

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The matrices required for (economic) calculations are derived from the **original Input/Output table**. This table describes the **flows of goods and services** between the various sectors of an economy to **satisfy the final demand**. At a first glance, **two blocks** can be identified:

Block 1 -> intersectoral flows, value added, available resources;

Block 2 -> final demand distribution.

Xij

	A+B	C	D	E	F	G	H	I	J	K	L	M	N	O-P-Q	Totale consumi intermedi	Spesa delle famiglie	Spesa dei turisti	Consumi della P.A.	Consumi delle istituzioni	Investimenti fissi lordi	Variazioni delle scorte	Esportazioni interreg.	Esportazioni estere	Totale impieghi	IMPIEGHI FINALI
Agricoltura, caccia e silvicoltura; Pesca, piscicoltura e servizi connessi	81.8	0.0	336.3	0.1	0.6	35.4	69.9	1.4	0.1	3.0	0.5	0.8	4.2	0.3	**534.4**	103.0	89.5	8.1	0.9	-5.3	1.5	40.9	308.6	**547.3**	1,081.7
Estrazione di minerali	0.1	2.6	29.4	114.6	23.9	6.9	0.7	0.5	0.1	2.1	0.4	0.1	0.3	0.3	**181.9**	0.1	0.1	0.1	-	-	0.1	19.6	9.4	**29.4**	211.3
Attività manifatturiere	90.3	7.7	1,715.4	69.7	720.8	364.8	521.2	73.7	5.8	84.0	83.2	7.1	120.8	20.1	**3,884.6**	1,715.6	599.3	84.3	1.3	1,060.1	-7.1	1,436.9	1,997.4	**6,887.8**	10,772.4
Produzione e distribuzione di energia elettrica, gas e acqua	12.1	2.0	69.6	109.3	15.9	26.4	52.3	5.9	2.0	23.2	24.1	16.4	13.3	3.2	**375.6**	125.5	1.9	1.3	-	-	-	213.6	-	**342.3**	**717.8**
Costruzioni	2.4	0.3	28.6	8.1	252.7	38.7	18.4	6.9	2.1	52.5	31.4	1.7	11.5	3.7	**458.9**	16.3	0.2	2.5	0.0	2,576.8	-	-	-	**2,595.8**	**3,054.8**
Commercio; riparazione di autoveicoli, motocicli e di beni personali per la casa	22.9	3.6	525.9	19.9	258.6	580.8	166.7	204.1	18.5	88.9	44.4	5.3	62.2	11.6	**2,013.3**	877.2	211.8	57.7	0.4	327.9	-	409.5	348.9	**2,233.5**	**4,246.8**
Beherbergungsbetriebe und Gaststätten Alberghi, ristoranti, bar	1.1	0.3	47.8	3.1	49.0	79.9	39.2	37.0	4.7	38.6	7.6	41.8	18.0	3.0	**371.0**	983.0	1,373.0	21.3	0.5	-	-	-	-	**2,377.9**	**2,748.9**
Trasporti, magazzinaggio e comunicazioni	16.9	2.7	305.6	19.0	205.2	322.8	71.7	265.4	30.9	125.3	57.4	8.9	22.3	5.2	**1,459.1**	346.5	62.3	55.7	-	40.1	-	635.5	210.3	**1,350.3**	**2,809.4**
Attività finanziarie	12.7	0.7	91.1	3.2	106.5	179.1	42.2	31.4	224.5	137.8	34.6	31.0	19.5	6.6	**920.9**	148.8	16.4	0.7	0.1	-	-	53.6	122.7	**342.2**	**1,263.1**
Attività immobiliari, noleggio, informatica, ricerca, servizi alle imprese	4.7	2.7	232.7	17.2	235.5	507.1	165.0	373.9	47.7	366.2	79.5	121.5	58.9	44.7	**2,257.5**	1,140.9	84.0	26.2	2.5	193.5	-	352.5	74.6	**1,874.3**	4,131.8
Amministrazione pubblica	0.1	0.0	1.4	0.1	0.7	0.7	0.3	0.1	0.1	0.5	0.2	0.1	0.1	0.1	**4.6**	6.4	0.6	1,491.0	0.3	-	-	18.8	-	**1,517.1**	**1,521.7**
Istruzione	-	0.0	8.9	1.2	18.5	17.7	1.7	19.6	4.4	32.3	10.2	213.2	3.2	0.6	**331.3**	50.1	-	708.8	9.2	-	-	-	-	**768.1**	**1,099.5**
Sanità e assistenza sociale	1.4	0.0	3.5	0.2	3.9	2.7	1.7	0.5	0.4	1.5	1.3	0.1	95.2	0.2	**112.5**	84.7	41.4	1,036.0	47.0	-	-	-	-	**1,209.2**	**1,321.7**
Organizzazioni ed organismi extraterritoriali	1.8	0.3	49.4	3.7	18.8	89.4	16.9	1.4	0.7	13.8	30.5	4.9	9.5	53.3	**294.3**	175.1	62.2	103.1	76.2	4.6	-	4.7	2.3	**428.3**	**722.6**
Totale Costi Intermedi	**248.3**	**22.9**	**3,445.4**	**369.3**	**1,910.6**	**2,252.4**	**1,167.9**	**1,021.6**	**341.9**	**969.5**	**405.3**	**453.0**	**438.8**	**152.9**	**13,199.8**	**5,773.3**	**2,542.7**	**3,597.0**	**138.5**	**4,197.8**	**-5.5**	**3,185.7**	**3,074.1**	**22,503.5**	**35,703.3**
Valore aggiunto ai prezzi di base	577.7	24.1	1,631.7	316.1	1,119.6	1,688.0	1,573.5	767.4	652.8	2,421.3	1,055.7	626.0	840.6	239.9	**13,534.3**										
Imposte indirette nette	4.4	0.9	25.0	32.4	24.6	39.9	7.1	19.0	19.3	23.9	60.7	20.5	42.2	8.0	**327.8**	604.9	190.0	-	-	285.1	-0.2	128.6	139.1	**1,347.5**	**1,675.4**
Importazioni Interregionali	127.6	21.2	3,066.0	-	-	161.3	0.2	844.1	110.0	608.8	-	-	-	205.2	**5,144.3**										
Importazioni Estere	123.8	142.2	2,604.3	-	-	105.1	0.1	157.3	139.2	108.4	-	-	-	116.7	**3,497.1**										
RISORSE	**1,081.7**	**211.3**	**10,772.5**	**717.8**	**3,054.8**	**4,246.8**	**2,748.8**	**2,809.4**	**1,263.1**	**4,131.8**	**1,521.7**	**1,099.5**	**1,321.7**	**722.7**	**35,703.5**	**6,378.2**	**2,732.7**	**3,597.0**	**138.5**	**4,482.9**	**-5.7**	**3,314.3**	**3,213.2**	**23,851.0**	**37,378.7**

i

j

Xj

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From the **BLOCK 1**, by applying the equation $a_{ij} = x_{ij}/x_j$, the **STRUCTURAL MATRIX ("A") OF TECHNICAL COEFFICIENTS** is obtained **.**

In this matrix, every element (a_{ij}) expresses **the amount of intermediate production demand of sector *i* absorbed from the sector j** **per unit of production** of sector *j*.

	A	B	CA	CB	DA	DB	DC	DD	DE	DF	DG	DH	DI	DJ	DK	DL	DM	DN	E	F	G	H	I	J	K	L	M	N	O-P-Q
A	0.0635	0.0000	0.0000	0.0003	0.1659	0.0070	0.0015	0.0203	0.0018	0.0000	0.0007	0.0036	0.0002	0.0008	0.0003	0.0007	0.0001	0.0016	0.0001	0.0002	0.0089	0.0203	0.0011	0.0002	0.0008	0.0002	0.0001	0.0029	0.0004
B	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0002	0.0022	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0350	0.0000	0.0000	0.0009	0.0000	0.0000	0.0000	0.0000	0.0000	0.1135	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CB	0.0001	0.0000	0.0000	0.0362	0.0003	0.0001	0.0000	0.0004	0.0004	0.0000	0.0007	0.0004	0.0270	0.0005	0.0002	0.0004	0.0002	0.0009	0.0012	0.0072	0.0012	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001
DA	0.0434	0.0013	0.0000	0.0017	0.1093	0.0008	0.0187	0.0008	0.0019	0.0001	0.0066	0.0033	0.0011	0.0007	0.0008	0.0007	0.0007	0.0010	0.0004	0.0009	0.0129	0.1620	0.0010	0.0002	0.0006	0.0011	0.0006	0.0112	0.0011
DB	0.0004	0.0005	0.0000	0.0001	0.0002	0.0654	0.0053	0.0016	0.0007	0.0001	0.0014	0.0047	0.0007	0.0007	0.0003	0.0003	0.0024	0.0035	0.0002	0.0006	0.0050	0.0007	0.0005	0.0000	0.0005	0.0005	0.0002	0.0023	0.0009
DC	0.0002	0.0000	0.0000	0.0000	0.0000	0.0006	0.0153	0.0005	0.0001	0.0000	0.0001	0.0003	0.0002	0.0001	0.0001	0.0001	0.0012	0.0014	0.0001	0.0002	0.0013	0.0000	0.0001	0.0000	0.0000	0.0002	0.0000	0.0001	0.0001
DD	0.0010	0.0001	0.0000	0.0047	0.0037	0.0010	0.0008	0.2312	0.0026	0.0001	0.0048	0.0089	0.0058	0.0045	0.0027	0.0017	0.0027	0.0703	0.0012	0.0206	0.0028	0.0010	0.0015	0.0003	0.0008	0.0016	0.0002	0.0038	0.0013
DE	0.0	0000	0.0000	0.0015	0.0046	0.0014	0.0011	0.0032	0.0550	0.0001	0.0033	0.0039	0.0024	0.0018	0.0023	0.0019	0.0013	0.0046	0.0014	0.0031	0.0136	0.0042	0.0109	0.0034	0.0047	0.0070	0.0003	0.0021	0.0040
DF	0.0	0009	0.0000	0.0099	0.0004	0.0007	0.0003	0.0020	0.0007	0.0025	0.0028	0.0009	0.0052	0.0011	0.0008	0.0006	0.0004	0.0008	0.0206	0.0049	0.0071	0.0034	0.0114	0.0007	0.0019	0.0030	0.0018	0.0011	0.0017
DG	0.0	001	0.0000	0.0100	0.0084	0.0117	0.0031	0.0086	0.0119	0.0010	0.0648	0.0776	0.0128	0.0042	0.0036	0.0068	0.0046	0.0087	0.0043	0.0048	0.0053	0.0027	0.0011	0.0003	0.0015	0.0029	0.0002	0.0445	0.0046
DH	0.0	0001	0.0000	0.0060	0.0062	0.0027	0.0083	0.0037	0.0040	0.0002	0.0072	0.0543	0.0047	0.0046	0.0128	0.0086	0.0213	0.0082	0.0028	0.0138	0.0072	0.0021	0.0102	0.0007	0.0022	0.0010	0.0001	0.0021	0.0021
DI	0.0015	0.0001	0.0000	0.0469	0.0072	0.0004	0.0008	0.0045	0.0003	0.0001	0.0047	0.0022	0.0555	0.0030	0.0028	0.0031	0.0043	0.0023	0.0027	0.0819	0.0025	0.0024	0.0004	0.0001	0.0006	0.0005	0.0001	0.0006	0.0014
DJ	0.0013	0.0005	0.0000	0.0054	0.0044	0.0019	0.0018	0.0200	0.0028	0.0001	0.0043	0.0137	0.0088	0.0935	0.0839	0.0250	0.0638	0.0382	0.0074	0.0564	0.0080	0.0012	0.0038	0.0008	0.0016	0.0041	0.0003	0.0023	0.0019
DK	0.0003	0.0000	0.0000	0.0184	0.0044	0.0031	0.0014	0.0048	0.0034	0.0002	0.0024	0.0073	0.0059	0.0095	0.0508	0.0070	0.0200	0.0069	0.0088	0.0112	0.0080	0.0025	0.0073	0.0009	0.0019	0.0068	0.0005	0.0022	0.0038
DL	0.0002	0.0002	0.0000	0.0019	0.0008	0.0005	0.0006	0.0017	0.0013	0.0004	0.0027	0.0043	0.0016	0.0053	0.0157	0.0400	0.0167	0.0029	0.0064	0.0170	0.0056	0.0018	0.0104	0.0010	0.0022	0.0018	0.0002	0.0193	0.0012
DM	0.0013	0.0002	0.0000	0.0022	0.0004	0.0002	0.0004	0.0008	0.0003	0.0000	0.0006	0.0045	0.0008	0.0022	0.0040	0.0015	0.0667	0.0007	0.0005	0.0021	0.0098	0.0006	0.0103	0.0003	0.0007	0.0051	0.0000	0.0002	0.0037
DN	0.0001	0.0001	0.0000	0.0008	0.0008	0.0011	0.0009	0.0020	0.0018	0.0000	0.0007	0.0016	0.0023	0.0031	0.0025	0.0028	0.0019	0.0253	0.0023	0.0048	0.0042	0.0013	0.0016	0.0009	0.0009	0.0018	0.0001	0.0019	0.0012
E	0.0105	0.0010	0.0000	0.0288	0.0176	0.0109	0.0021	0.0151	0.0077	0.0010	0.0098	0.0202	0.0352	0.0079	0.0059	0.0067	0.0089	0.0062	0.1112	0.0040	0.0056	0.0211	0.0083	0.0045	0.0040	0.0150	0.0212	0.0126	0.0057
F	0.0023	0.0000	0.0000	0.0049	0.0043	0.0024	0.0010	0.0033	0.0081	0.0001	0.0018	0.0041	0.0048	0.0038	0.0038	0.0022	0.0025	0.0028	0.0092	0.0735	0.0155	0.0086	0.0285	0.0066	0.0167	0.0212	0.0064	0.0113	0.0091
G	0.0226	0.0015	0.0000	0.0548	0.0637	0.0565	0.0790	0.0539	0.0813	0.0014	0.0275	0.0505	0.0495	0.0476	0.0455	0.0383	0.0454	0.0545	0.0183	0.0637	0.1056	0.0511	0.0538	0.0136	0.0179	0.0256	0.0039	0.0369	0.0185
H	0.0016	0.0001	0.0000	0.0047	0.0049	0.0021	0.0015	0.0086	0.0041	0.0002	0.0020	0.0052	0.0041	0.0051	0.0075	0.0057	0.0037	0.0039	0.0036	0.0139	0.0137	0.0126	0.0163	0.0037	0.0077	0.0044	0.0078	0.0132	0.0042
I	0.0049	0.0008	0.0000	0.0291	0.0221	0.0073	0.0075	0.0176	0.0166	0.0011	0.0083	0.0164	0.0161	0.0138	0.0147	0.0138	0.0156	0.0126	0.0143	0.0403	0.0645	0.0191	0.1178	0.0341	0.0276	0.0349	0.0016	0.0178	0.0211
J	0.0100	0.0008	0.0000	0.0081	0.0045	0.0042	0.0041	0.0088	0.0055	0.0005	0.0022	0.0054	0.0047	0.0100	0.0087	0.0048	0.0052	0.0097	0.0060	0.0196	0.0251	0.0111	0.0126	0.1692	0.0225	0.0151	0.0179	0.0089	0.0081
K	0.0040	0.0002	0.0000	0.0366	0.0235	0.0131	0.0093	0.0240	0.0366	0.0010	0.0130	0.0279	0.0235	0.0267	0.0262	0.0195	0.0227	0.0184	0.0150	0.0630	0.1231	0.0610	0.0780	0.0624	0.0827	0.0437	0.1452	0.0445	0.0643
L	0.0001	0.0000	0.0000	0.0002	0.0003	0.0001	0.0003	0.0002	0.0003	0.0000	0.0003	0.0008	0.0002	0.0002	0.0003	0.0004	0.0004	0.0003	0.0003	0.0005	0.0005	0.0002	0.0006	0.0003	0.0004	0.0003	0.0001	0.0001	0.0006
M	0.0000	0.0000	0.0000	0.0004	0.0007	0.0002	0.0002	0.0004	0.0007	0.0000	0.0004	0.0008	0.0003	0.0004	0.0007	0.0008	0.0008	0.0004	0.0011	0.0028	0.0020	0.0006	0.0030	0.0017	0.0018	0.0032	0.1339	0.0015	0.0010
N	0.0008	0.0000	0.0000	0.0003	0.0004	0.0002	0.0001	0.0003	0.0006	0.0000	0.0002	0.0004	0.0002	0.0003	0.0005	0.0007	0.0004	0.0002	0.0002	0.0011	0.0007	0.0005	0.0006	0.0004	0.0004	0.0007	0.0000	0.0637	0.0003
O-P-Q	0.0012	0.0000	0.0000	0.0035	0.0071	0.0028	0.0016	0.0027	0.0142	0.0004	0.0031	0.0055	0.0027	0.0021	0.0017	0.0015	0.0015	0.0025	0.0035	0.0059	0.0153	0.0049	0.0036	0.0018	0.0043	0.0182	0.0005	0.0046	0.0482

j

i

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From **"A" MATRIX,** the **LEONTIEF MATRIX (I-A)$^{-1}$** is calculated in which every element (z_{ij}) expresses the **production** of the sector *i* absorbed by the sector *j* **per unit of final demand**.

	A	B	CA	CB	DA	DB	DC	DD	DE	DF	DG	DH	DI	DJ	DK	DL	DM	DN	E	F	G	H	I	J	K	L	M	N	O-P-Q
A	1.07783	0.00034	0.00000	0.00252	0.20268	0.00954	0.00711	0.03080	0.00446	0.00007	0.00317	0.00682	0.00218	0.00268	0.00237	0.00228	0.00199	0.00567	0.00114	0.00411	0.01568	0.05666	0.00428	0.00121	0.00219	0.00169	0.00139	0.00782	0.00172
B	0.00006	1.00016	0.00000	0.00004	0.00080	0.00002	0.00005	0.00005	0.00004	0.00000	0.00007	0.00004	0.00003	0.00003	0.00004	0.00003	0.00003	0.00009	0.00002	0.00007	0.00025	0.00237	0.00008	0.00002	0.00003	0.00003	0.00003	0.00010	0.00006
CA	0.00203	0.00018	1.00000	0.00486	0.[illegible]	[illegible]	0.00059	0.00308	0.00143	0.03521	0.00170	0.00325	0.00637	0.00149	0.00127	0.00121	0.00170	0.00139	0.12876	0.00199	0.00173	0.00373	0.00214	0.00097	0.00088	0.00236	0.00346	0.00224	0.00108
CB	0.00033	0.00001	0.00000	1.03931	0.[illegible]	[illegible]	0.00029	0.00103	0.00082	0.00002	0.00109	0.00083	0.03005	0.00088	0.00064	0.00074	0.00062	0.00136	0.00172	0.01112	0.00195	0.00069	0.00078	0.00027	0.00048	0.00050	0.00031	0.00056	0.00042
DA	0.05379	0.00152	0.00000	0.00519	1.[illegible]	[illegible]	0.02399	0.00693	0.00573	0.00018	0.00944	0.00774	0.00413	0.00364	0.00437	0.00347	0.00362	0.00435	0.00225	0.00722	0.02154	0.18928	0.00718	0.00221	0.00341	0.00356	0.00340	0.01841	0.00327
DB	0.00068	0.00054	0.00000	0.00076	0.00105	1.[illegible]	0.00641	0.00287	0.00155	0.00014	0.00192	0.00602	0.00141	0.00140	0.00102	0.00075	0.00341	0.00462	0.00054	0.00172	0.00653	0.00140	0.00131	0.00032	0.00082	0.00092	0.00041	0.00323	0.00132
DC	0.00025	0.00002	0.00000	0.00019	0.00021	0.00082	1.01570	0.00078	0.00023	0.00001	0.00014	0.00045	0.00030	0.00024	0.00025	0.00019	0.00143	0.00159	0.00021	0.00046	0.00153	0.00017	0.00025	0.00006	0.00010	0.00025	0.00005	0.00022	0.00014
DD	0.00219	0.00023	0.00000	0.00815	0.00718	0.00238	0.00213	1.30252	0.00512	0.00016	0.00751	0.01408	0.00960	0.00768	0.00569	0.00362	0.00567	0.09519	0.00287	0.03220	0.00658	0.00381	0.00460	0.00145	0.00230	0.00367	0.00108	0.00705	0.00289
DE	0.00134	0.00010	0.00000	0.00427	0.00814	0.00328	0.00324	0.00688	1.06078	0.00015	0.00490	0.00676	0.00475	0.00400	0.00467	0.00366	0.00370	0.00740	0.00282	0.00751	0.01925	0.00793	0.01568	0.00594	0.00680	0.00933	0.00195	0.00455	0.00594
DF	0.00975	0.00093	0.00000	0.01281	0.00426	0.00201	0.00159	0.00484	0.00250	1.00261	0.00392	0.00304	0.00790	0.00254	0.00228	0.00172	0.00202	0.00245	0.02399	0.00833	0.01043	0.00609	0.01475	0.00216	0.00320	0.00468	0.00343	0.00294	0.00288
DG	0.012[illegible]	[illegible]23	0.00000	0.01390	0.01450	0.01463	0.00546	0.01445	0.01541	0.00112	1.07093	0.08953	0.01672	0.00663	0.00699	0.00943	0.00913	0.01266	0.00637	0.01097	0.00939	0.00705	0.00441	0.00131	0.00285	0.00459	0.00112	0.05262	0.00627
DH	0.002[illegible]	[illegible]20	0.00000	0.00910	0.00972	0.00430	0.01045	0.00735	0.00651	0.00028	0.00909	1.05997	0.00721	0.00701	0.01644	0.01090	0.02644	0.01114	0.00461	0.01963	0.01174	0.00556	0.01485	0.00236	0.00385	0.00313	0.00123	0.00464	0.00379
DI	0.[illegible]	[illegible]	0.00000	0.05324	0.01057	0.00143	0.00190	0.00789	0.00220	0.00016	0.00607	0.00437	1.06171	0.00476	0.00480	0.00444	0.00642	0.00430	0.00479	0.09603	0.00625	0.00608	0.00479	0.00154	0.00299	0.00334	0.00163	0.00315	0.00311
DJ	0.005[illegible]	[illegible]91	0.00000	0.01177	0.00933	0.00437	0.00420	0.03224	0.00671	0.00026	0.00697	0.02033	0.01402	1.10682	0.10088	0.03140	0.08065	0.04835	0.01227	0.07414	0.01585	0.00583	0.01145	0.00317	0.00470	0.00888	0.00238	0.00661	0.00498
DK	0.00145	0.00011	0.00000	0.02260	0.00752	0.00475	0.00300	0.00887	0.00580	0.00032	0.00379	0.01035	0.00915	0.01258	1.05628	0.00921	0.02510	0.00998	0.01160	0.01704	0.01233	0.00559	0.01129	0.00235	0.00345	0.00908	0.00179	0.00445	0.00549
DL	0.00103	0.00023	0.00000	0.00435	0.00294	0.00163	0.00183	0.00433	0.00321	0.00049	0.00386	0.00678	0.00359	0.00758	0.01922	1.04301	0.02083	0.00494	0.00865	0.02225	0.00942	0.00399	0.01474	0.00259	0.00378	0.00383	0.00146	0.02313	0.00268
DM	0.00212	0.00023	0.00000	0.00421	0.00253	0.00136	0.00182	0.00286	0.00209	0.00006	0.00146	0.00654	0.00225	0.00384	0.00599	0.00272	1.07310	0.00232	0.00136	0.00495	0.01357	0.00243	0.01401	0.00141	0.00181	0.00670	0.00059	0.00155	0.00498
DN	0.00047	0.00016	0.00000	0.00183	0.00178	0.00175	0.00160	0.00354	0.00273	0.00007	0.00120	0.00260	0.00329	0.00411	0.00367	0.00351	0.00303	1.02689	0.00312	0.00685	0.00580	0.00230	0.00293	0.00156	0.00146	0.00257	0.00057	0.00279	0.00180
E	0.01483	0.00129	0.00000	0.03846	0.02784	0.01485	0.00472	0.02556	0.01177	0.00123	0.01355	0.02762	0.04523	0.01201	0.01038	0.01004	0.01430	0.01147	1.12681	0.01419	0.01201	0.03095	0.01427	0.00786	0.00674	0.01933	0.02943	0.01863	0.00861
F	0.00462	0.00017	0.00000	0.01061	0.01057	0.00559	0.00435	0.00946	0.01392	0.00025	0.00417	0.00888	0.00952	0.00799	0.00838	0.00545	0.00697	0.00725	0.01338	1.08725	0.02670	0.01551	0.04000	0.01274	0.02234	0.02723	0.01273	0.01717	0.01387
G	0.03469	0.00215	0.00000	0.07772	0.09607	0.07293	0.09659	0.09059	0.10497	0.00195	0.03898	0.07294	0.06972	0.06676	0.06768	0.05276	0.06888	0.07871	0.03009	0.10339	1.14068	0.08258	0.08295	0.02677	0.02992	0.04010	0.01338	0.05686	0.02991
H	0.00309	0.00021	0.00000	0.00842	0.00911	0.00421	0.00392	0.01453	0.00758	0.00032	0.00368	0.00847	0.00719	0.00806	0.01098	0.00808	0.00714	0.00756	0.00573	0.02061	0.02020	1.01699	0.02241	0.00689	0.01041	0.00729	0.01156	0.01718	0.00663
I	0.01192	0.00125	0.00000	0.04649	0.04156	0.01694	0.01878	0.03825	0.03259	0.00155	0.01565	0.03078	0.03006	0.02634	0.02857	0.02378	0.02982	0.02694	0.02372	0.06858	0.09555	0.03924	1.14905	0.05306	0.04021	0.04871	0.01198	0.03221	0.03234
J	0.01536	0.00111	0.00000	0.01664	0.01480	0.00940	0.00978	0.02047	0.01362	0.00083	0.00574	0.01268	0.01150	0.01804	0.01712	0.01007	0.01278	0.01838	0.01124	0.03597	0.04319	0.02204	0.02565	1.20858	0.03257	0.02358	0.03154	0.01722	0.01490
K	0.01448	0.00087	0.00000	0.06315	0.05230	0.02955	0.02831	0.05634	0.06472	0.00175	0.02499	0.05166	0.04543	0.04811	0.04964	0.03577	0.04612	0.04203	0.02893	0.10839	0.17344	0.09253	0.11941	0.09335	1.10409	0.06534	0.19064	0.06977	0.08460
L	0.00015	0.00001	0.00000	0.00042	0.00054	0.00022	0.00037	0.00046	0.00048	0.00002	0.00036	0.00103	0.00037	0.00032	0.00048	0.00047	0.00054	0.00040	0.00039	0.00078	0.00081	0.00038	0.00084	0.00044	0.00050	1.00040	0.00028	0.00028	0.00072
M	0.00031	0.00002	0.00000	0.00116	0.00158	0.00062	0.00070	0.00119	0.00153	0.00004	0.00075	0.00162	0.00088	0.00101	0.00135	0.00133	0.00152	0.00101	0.00171	0.00450	0.00365	0.00158	0.00479	0.00284	0.00266	0.00433	1.15517	0.00243	0.00175
N	0.00102	0.00001	0.00000	0.00055	0.00081	0.00034	0.00027	0.00065	0.00083	0.00003	0.00032	0.00063	0.00041	0.00053	0.00076	0.00094	0.00065	0.00045	0.00032	0.00154	0.00110	0.00083	0.00102	0.00069	0.00055	0.00088	0.00017	1.06827	0.00042
O-P-Q	0.00272	0.00009	0.00000	0.00631	0.01131	0.00481	0.00393	0.00620	0.01831	0.00046	0.00465	0.00853	0.00518	0.00429	0.00405	0.00317	0.00391	0.00508	0.00519	0.01043	0.02065	0.00916	0.00727	0.00368	0.00608	0.02082	0.00215	0.00731	1.05202

j

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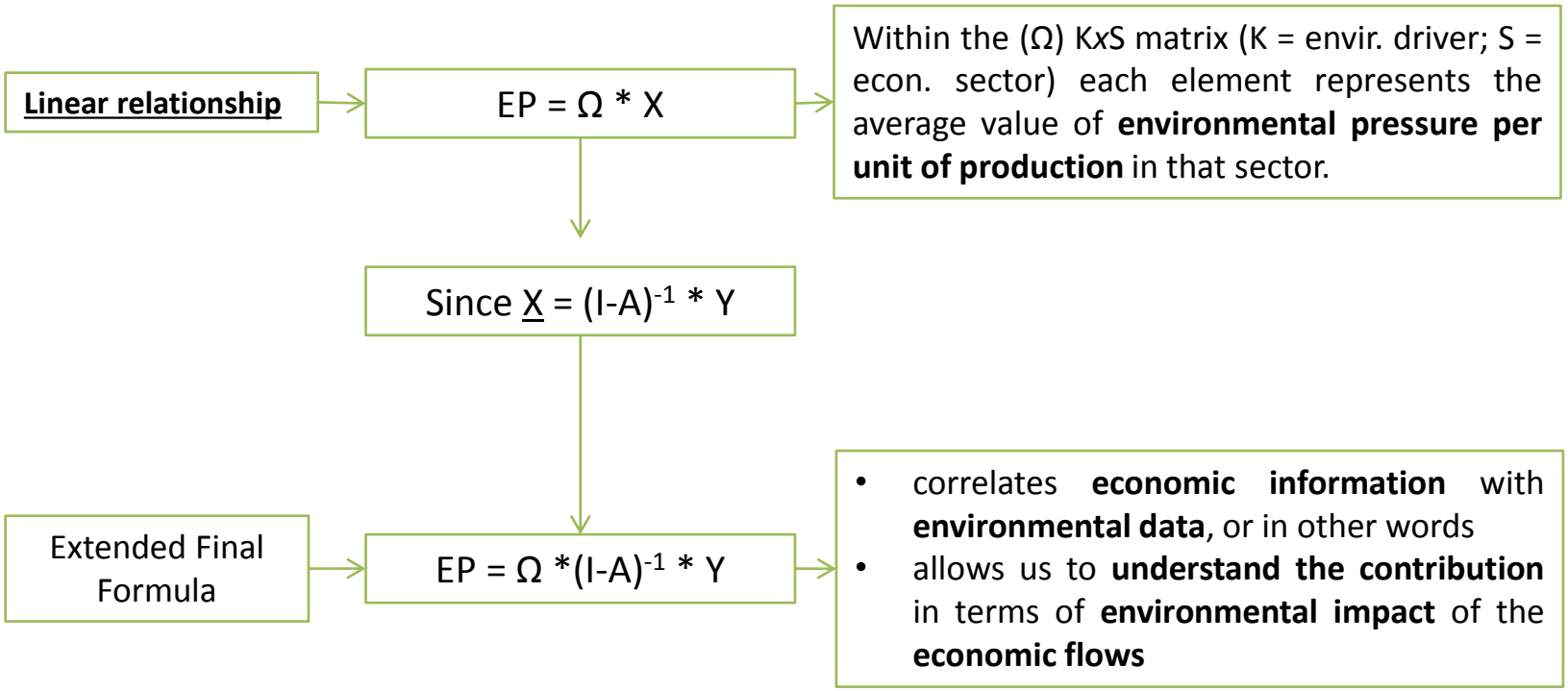
The **DEMAND MATRIX (Y)** is derived from the **BLOCK 2** of the Input/Output table by **diagonalizing the two vectors** of internal and external demand

	Spesa delle famiglie	Spesa dei turisti	Spesa della pubblica amministrazione	DOMANDA INTERNA	Export interregionale	Export estero	DOMANDA ESTERNA
A	73.00	44.87	7.32	125.19	316.04	307.40	623.44
C	1.36	0.19	0.19	1.74	22.67	9.24	31.90
DA	253.96	173.89	4.93	432.78	553.02	323.48	876.49
DB	118.40	46.51	0.55	165.46	22.41	27.30	49.71
DC	16.32	6.18	0.00	22.50	0.67	1.62	2.29
DD	69.28	4.55	7.93	81.76	440.41	99.36	539.77
DE	50.13	1.43	0.24	51.81	103.26	35.90	139.16
DF	130.10	31.50	0.07	161.67	1.44	1.08	2.52
DG	107.31	12.53	93.77	213.60	21.99	58.45	80.45
DH	38.84	10.19	1.83	50.86	128.41	88.29	216.70
DI	30.30	1.51	0.99	32.80	134.37	34.85	169.22
DJ	37.73	1.73	0.73	40.20	301.18	242.30	543.48
DK	63.43	1.39	5.34	70.16	260.40	337.50	597.90
DL	44.40	2.03	5.35	51.77	69.24	88.04	157.28
DM	262.93	1.05	10.80	274.78	112.75	25.63	138.39
DN	159.39	3.01	0.25	162.65	43.94	75.58	119.52
E	82.13	10.26	1.36	93.74	102.83	3.16	105.99
F	39.32	3.38	5.39	48.08	9.49	6.66	16.16
G	1045.00	313.08	47.72	1405.80	1269.75	703.80	1973.54
H	717.92	1561.47	11.69	2291.07	268.33	18.99	287.32
I	429.17	191.21	53.29	673.67	458.42	80.16	538.59
J	223.42	5.62	2.60	231.64	172.36	18.17	190.53
K	1224.66	73.82	39.65	1338.13	44.43	72.09	116.52
L	11.27	2.53	1487.56	1501.36	0.94	0.67	1.61
M	51.90	1.69	710.29	763.87	64.06	1.05	65.11
N	104.20	3.25	1064.40	1171.85	24.04	1.89	25.93
O-P-Q	157.91	99.19	176.26	433.35	4.04	3.39	7.44

Input/Output Extension to Environmental Sphere (EIO-LCA)

- Also environmental data has to be contained in matrices (Ω) expressing the **environmental pressures per unit of production of each sector**
- **A linear relationship is assumed between environmental pressure (EP) and production of goods or services (X)**.



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More in detail: about the linear relation between environmental pressure (EP) and production of goods or services (X).

The I/O method includes two models: **physical and monetary**.
It is necessary to assume the existence of a **relation between the two flows**.
Different approaches have been developed, based on different types of relation.

The basic model, used in this study, assumes as a relation **the linear one**.

Although widely used, **the linear relationship isn't** always **the best** one for three reasons:

1. Through its application, **the quantitative (physical) model loses effectiveness** as physical flows are expressed in monetary units;
2. The **value added** considered **doesn't have a physical counterpart**;
3. A **NON-linear relationship** could better represent and analyse more complex real phenomena.

Future applications from our side are supposed **to go in this direction** and, starting from the obtained results, apply different approaches (not simply linear relationships) and try to analyse the scenario in a more realistic way.

2.b. – *LCA Life Cycle Assessment*

Modelling Platform	***EASEWASTE*** (*DTU ENV* Copenhagen)
Method for estimating the potential environmental impacts	**EDIP**
Impact Categories	- **NON TOXIC**: Global Warming 100 Years; Acidification; Nutrient Enrichment; Photochemical Ozone Formation (high and low NO_x); Stratospheric Ozone Depletion. - **TOXIC**: Human Toxicity via Air; Human Toxicity via Water; Human Toxicity via Soil, Stored Ecotoxicity via Water; Ecotoxicity via Water, Chronic; Spoiled Groundwater Resources; Stored Ecotoxicity in Soil, Ecotoxicity via Soil.
Method for calculating impacts	**CHARACTERISATION FACTORS** putting into relation the elemental flows with impact categories to which they may give rise.
Method for comparing impacts under different categories	**NORMALISATION** with regard to the **environmental impact** of an **average European Inhabitant** during **one year** (*Person Equivalent - PE*).

3.a. – EIO-LCA Application

Data: **air emissions (*NAMEA*)**; **Nat. Gas (*SNAM*)** and **electricity (*TERNA*)** consumption.

tonnellate -> / *settore*	CH4	CO	CO2	N2O	NH3	COVNM	NOx	Pb	PM10	SOx
A	15,710.7	3,500.6	87,730.0	887.1	5,675.6	383.8	1,074.5	0.0	391.9	2.1
C	0.4	29.6	6,420.0	2.2	0.0	9.1	59.0	0.0	5.8	0.2
DA	707.6	151.4	48,760.0	12.9	0.1	297.3	318.4	0.0	31.1	5.6
DB	0.3	6.4	1,970.0	0.5	0.0	1.9	13.5	0.0	1.3	0.3
DC	1.3	2.1	800.0	0.2	0.0	127.2	4.2	0.0	0.4	0.2
DD-DH-DN	6.0	94.3	37,680.0	6.5	0.1	418.2	208.2	0.0	20.1	10.4
DE	2.8	70.0	19,770.0	5.4	0.0	318.5	147.4	0.0	14.3	4.2
DF-DG	20.9	50.5	16,270.0	3.4	0.1	18.6	91.7	0.0	13.1	2.2
DI	3.6	94.0	90,510.0	7.4	0.1	26.4	235.5	0.5	40.8	99.0
DJ	11.9	214.3	49,650.0	8.2	0.1	249.6	215.6	0.4	47.1	24.4
DK-DL-DM	12.5	119.3	44,280.0	8.8	0.1	201.5	289.7	0.0	28.9	28.0
E	1,276.8	39.8	9,780.0	0.9	0.3	171.1	41.9	0.0	4.0	0.3
F	2.5	158.7	48,980.0	10.0	0.2	296.9	318.4	0.0	67.4	1.5
G	16.8	375.2	193,310.0	16.8	0.9	316.5	843.3	0.0	78.9	12.9
H	25.5	143.4	82,060.0	7.0	0.3	40.7	391.5	0.0	27.1	8.4
I	11.5	434.0	211,530.0	19.5	0.9	127.1	968.3	0.0	90.7	15.0
J	1.2	18.3	10,650.0	0.8	0.0	5.3	41.8	0.0	3.6	2.0
K	6.0	118.8	62,070.0	5.3	0.3	34.7	264.4	0.0	24.3	10.6
L	14.8	528.3	44,880.0	4.1	0.1	34.9	219.9	0.0	17.9	32.0
M	2.9	10.3	11,160.0	0.5	0.0	2.5	30.9	0.0	1.7	6.9
N	5.3	23.9	17,100.0	19.4	0.0	6.6	68.4	0.0	4.7	12.9
O	2,106.7	30.7	40,840.0	59.7	18.5	113.7	151.6	0.2	8.9	35.0

energia -> / *settore*	metano mln m3	elettrica mln KWh
A	0.27	150.0
C	0.00	11.9
DA	8.08	176.9
DB	0.50	4.0
DC	0.00	0.4
DD DH DN	2.41	119.9
DE	3.74	21.6
DF DG	0.20	267.5
DI	0.24	31.6
DJ	16.38	121.6
DK DL DM	6.42	142.6
E	47.91	0.0
F	9.71	30.5
G	13.55	178.2
H	39.27	369.1
I	0.73	153.2
J	0.86	21.7
K	2.59	150.0
L	0.00	0.0
M	0.30	0.0
N	11.50	0.0
O	13.06	130.5

From original data → matrix Ω by **dividing every single** cell of "environmental" tables **by the total production of the relative sector** (contained in the IO table) to obtain **pressures per unit of production**.

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By applying the model ($EP = \Omega^*(I-A)^{-1}*Y$) → air emissions and energy consumption (electricity and NG) **per demand component** and **per economic sector**

The I/O 22 sectors were aggregated in three main macro sectors: primary, secondary and tertiary.

EMISSIONI - DOMANDA INTERNA (tonnellate)	CH4	CO	CO2	N2O	NH3	COVNM	NOx	Pb	PM10	SOx
PRIMARIO	2526	567	17584	142	904	72	190	0.0	65	1
SECONDARIO	5108	1656	303432	278	1416	1485	1800	0.4	280	86
TERZIARIO	10271	3245	759653	516	2107	1601	3795	0.6	468	209

ENERGIA - DOMANDA INTERNA	metano mln m3	elettrica mln KWh
PRIMARIO	0.7	38.2
SECONDARIO	42.5	1209.3
TERZIARIO	119.3	1639.8

EMISSIONI - DOMANDA ESTERNA (tonnellate)	CH4	CO	CO2	N2O	NH3	COVNM	NOx	Pb	PM10	SOx
PRIMARIO	13586	3048	92665	764	4868	383	1014	0.0	346	6
SECONDARIO	9815	3139	569083	539	2842	2447	3120	1.3	521	226
TERZIARIO	2642	1182	371011	156	657	813	1815	0.2	215	60

ENERGIA - DOMANDA ESTERNA	metano mln m3	elettrica mln KWh
PRIMARIO	3.2	192.0
SECONDARIO	87.8	1654.8
TERZIARIO	33.9	601.3

This data is then processed through the ***EASEWASTE*** *LCA* software to estimate the potential impacts. So it is possible to **quantify the contribution of each macro-sector** to the impact categories with respect to:

- **Demand Component** (domestic and/or external);
- **Pressure source** (air emission, energy consumption).

NON – TOX CATEGORIES: Normalized Impacts

ENVIRONMENTAL PRESSURE	DEMAND	MACRO SECTOR	Resource Depletion - Aggregated	Global Warming 100 Years	Stratospheric Ozone Depletion	Acidification	Photochemical Ozone Formation, High NOx	Nutrient Enrichment	Photochemical Ozone Formation, Low NOx	SECTOR TOTAL
AIR EMISSION	DOMESTIC	1	-	15,377.94	-	33,474.89	4,749.80	77,307.66	4,387.3[illegible]	135,29[illegible]
		2	-	65,542.02	-	73,141.25	50,704.90	165,253.44	44,051.04	398,695
		3	-	149,418.98	-	124,581.88	60,426.37	278,720.74	53,301.20	666,452
	EXTERNAL	1	-	82,472.17	-	180,052.11	25,358.83	415,835.77	23,436.01	727,156
		2	-	124,267.04	-	141,471.58	85,203.39	317,138.67	74,247.[illegible]2	742,331
		3	-	62,137.36	-	46,822.67	28,287.21	105,475.11	24,738.32	267,46[illegible]
ELECTRICITY CONSUMPTION	DOMESTIC	1	482.58	2,479.53	1.25	782.90	34.17	1,640.57	29.63	5,452
		2	15,267.56	78,445.86	39.48	24,769.04	1,081.01	51,903.57	937.52	172,446
		3	20,702.20	106,369.47	53.53	33,585.83	1,465.80	70,379.18	1,271.24	233,830
	EXTERNAL	1	2,423.47	12,451.96	6.27	3,931.67	171.59	8,238.82	148.82	27,374
		2	20,892.06	107,344.93	54.02	33,893.83	1,479.24	71,024.60	1,282.90	235,974
		3	7,591.56	39,005.98	19.63	12,316.02	537.51	25,808.24	466.17	85,748
METHANE CONSUMPTION	DOMESTIC	1	61.84	400.78	15.27	128.16	41.60	273.37	40.93	963
		2	2,674.01	17,727.29	390.65	4,272.87	1,314.41	9,025.34	1,270.16	36,677
		3	10,959.18	71,021.62	2,706.36	22,710.70	7,372.66	48,443.19	7,252.59	170,469
	EXTERNAL	1	295.19	1,912.99	72.90	611.72	198.59	1,304.84	195.35	4,593
		2	5,003.62	33,415.67	565.59	7,217.55	2,162.42	15,174.48	2,070.45	65,612
		3	3,110.46	20,157.53	768.13	6,445.81	2,092.53	13,749.27	2,058.45	48,385
CATEGORY TOTAL			**89,463.73**	**989,949.13**	**4,693.06**	**750,210.45**	**272,682.04**	**1,676,696.86**	**241,186.03**	

	DOMESTIC	EXTERNAL
1	141,713	759,122
2	607,817	1,043,916
3	1,070,752	401,597

Total impacts for **macro sector** and **demand**, the major **contributions are from** :

- **Tertiary /domestic demand**
- **Secondary / external demand**

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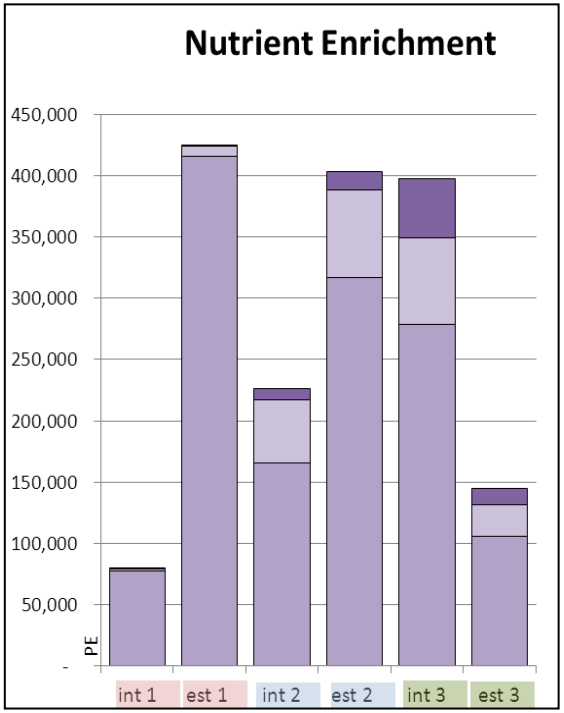
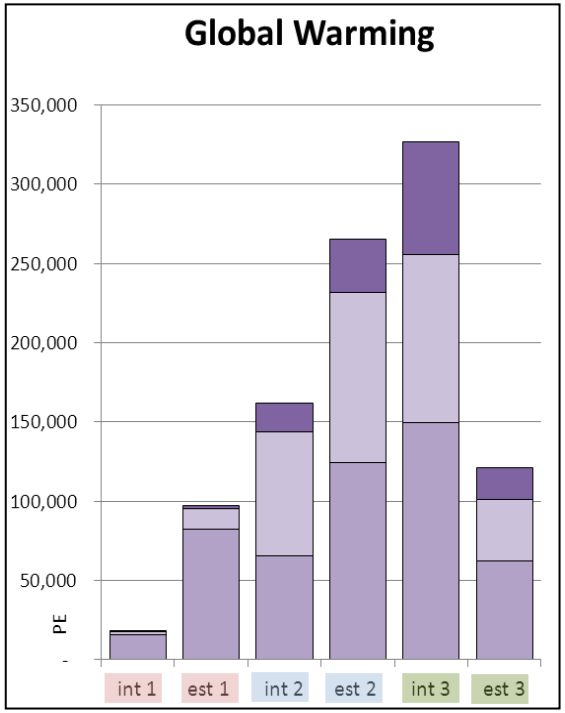




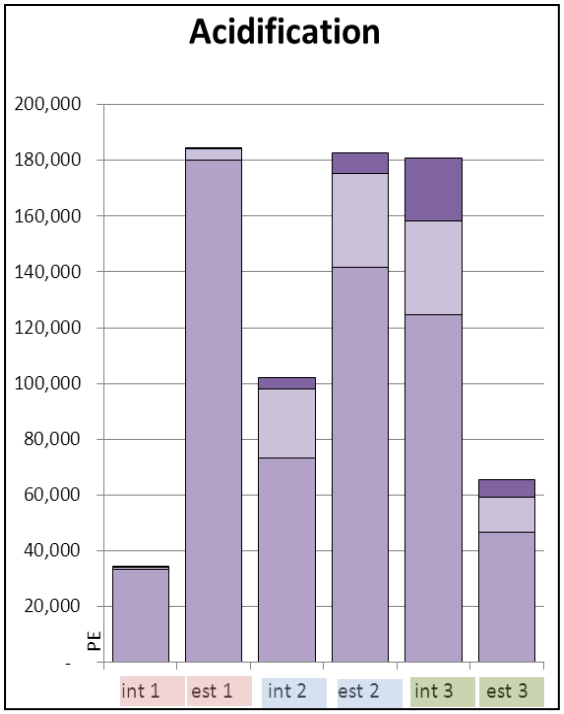
<u>Nutrient Enrichment</u>: <u>PRIMARY</u>

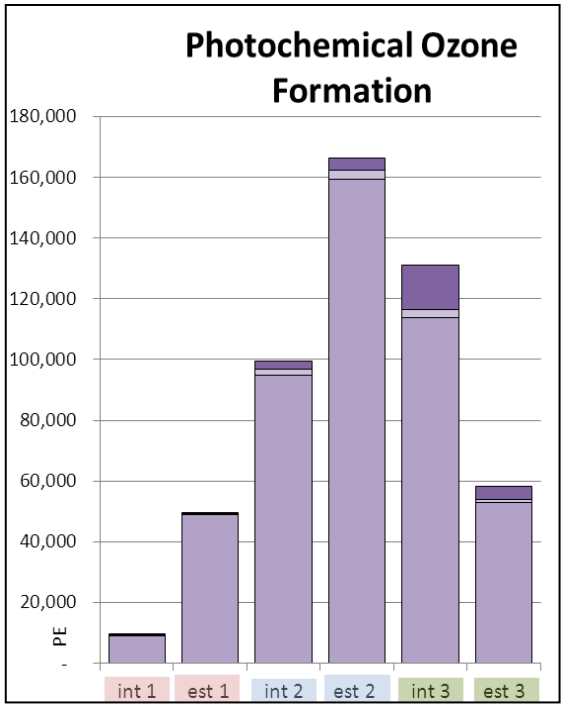
<u>Global Warming</u>: TERTIARY (IN) + 2ary (OUT)

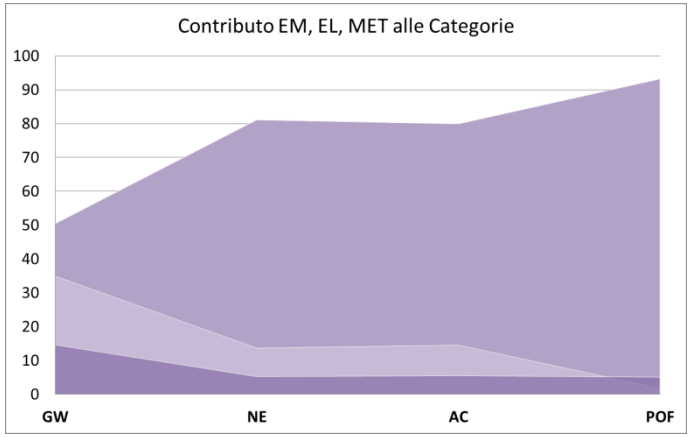
<u>Acidification</u>: PRIMARY + SECONDARY (external) + TERTIARY (domestic)

<u>Photochem. Ozone Formation</u>: SECONDARY

MAJOR PRESSURE: **<u>Air Emissions</u>**







TOXIC CATEGORIES: Normalized Impacts

ENVIRONMENTAL PRESSURE	DEMAND	MACRO SECTOR	Human Toxicity via Water	Spoiled Groundwater Resources	Ecotoxicity in Soil	Human Toxicity via Air	Stored Ecotoxicity in Water	Human Toxicity via Soil	Stored Ecotoxicity in Soil	Ecotoxicity in Water, Chronic	SECTOR TOTAL
AIR EMISSION	DOMESTIC	1	4.52	-	0.00	114.26	-	0.04	-	5.41	125
		2	395.32	-	0.02	1,630.11	-	3.61	-	475.68	2,507
		3	655.99	-	0.03	2,918.32	-	5.99	-	789.19	4,373
	EXTERNAL	1	19.24	-	0.00	598.99	-	0.17	-	22.97	642
		2	1,463.91	-	0.06	4,796.12	-	13.38	-	1,762.16	8,038
		3	215.76	-	0.01	1,131.75	-	1.97	-	259.46	1,612
ELECTRICITY CONSUMPTION	DOMESTIC	1	94.72	-	0.37	15.19	-	0.39	-	46.63	158
		2	2,996.79	-	11.73	480.49	-	12.20	-	1,475.39	4,979
		3	4,063.52	-	15.90	651.52	-	16.54	-	2,000.58	6,751
	EXTERNAL	1	475.69	-	1.86	76.27	-	1.94	-	234.19	791
		2	4,100.79	-	16.05	657.50	-	16.69	-	2,018.92	6,812
		3	1,490.11	-	5.83	238.92	-	6.06	-	733.62	2,478
METHANE CONSUMPTION	DOMESTIC	1	4.01	-	0.62	2.89	-	0.75	-	2.83	12
		2	113.98	-	16.27	101.24	-	19.63	-	413.96	667
		3	709.81	-	109.41	511.54	-	133.12	-	501.24	1,968
	EXTERNAL	1	19.12	-	2.95	13.78	-	3.59	-	13.50	54
		2	176.96	-	24.05	174.98	-	28.85	-	953.45	1,360
		3	201.40	-	31.05	145.13	-	37.78	-	142.20	561
CATEGORY TOTAL			**17,201.70**	**-**	**236.22**	**14,259.05**	**-**	**302.71**	**-**	**11,851.44**	

	DOMESTIC	EXTERNAL
1	296	1,487
2	8,152	16,210
3	13,092	4,650

Total impacts for **macro sector** e **demand**, the major **contributes are from** :

- **Secondary / external demand**
- **Tertiary /domestic demand**

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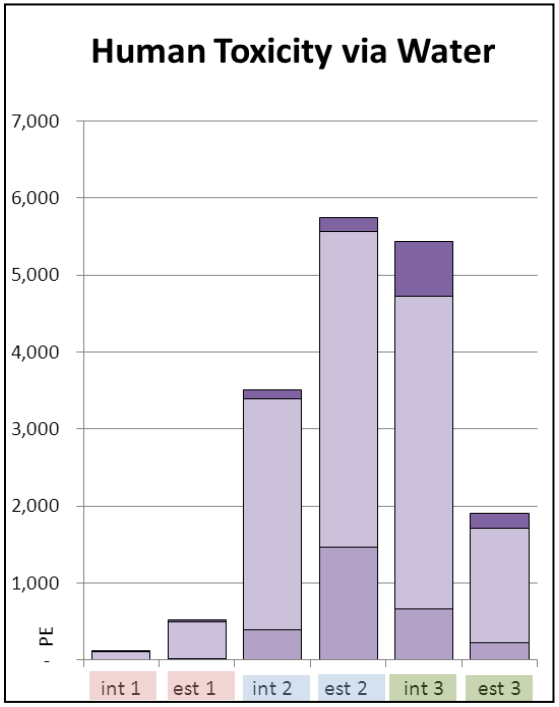
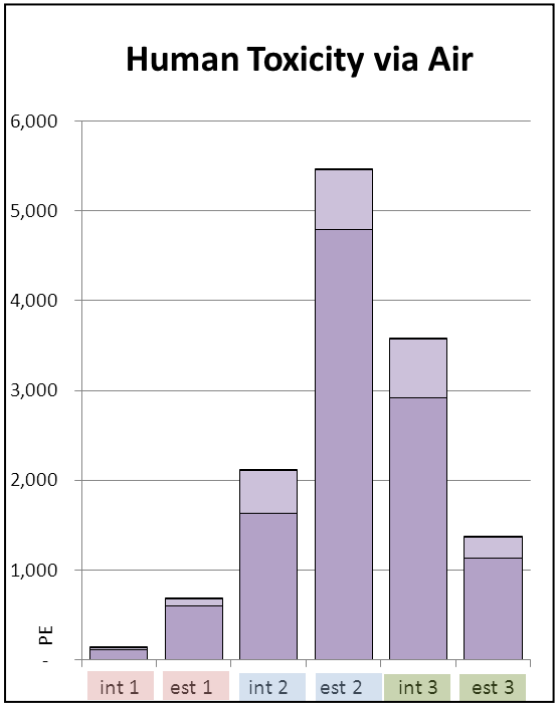
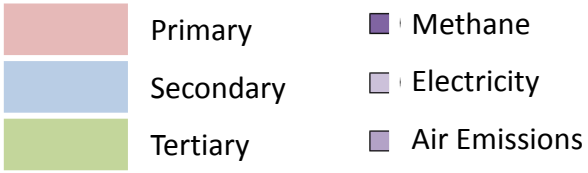






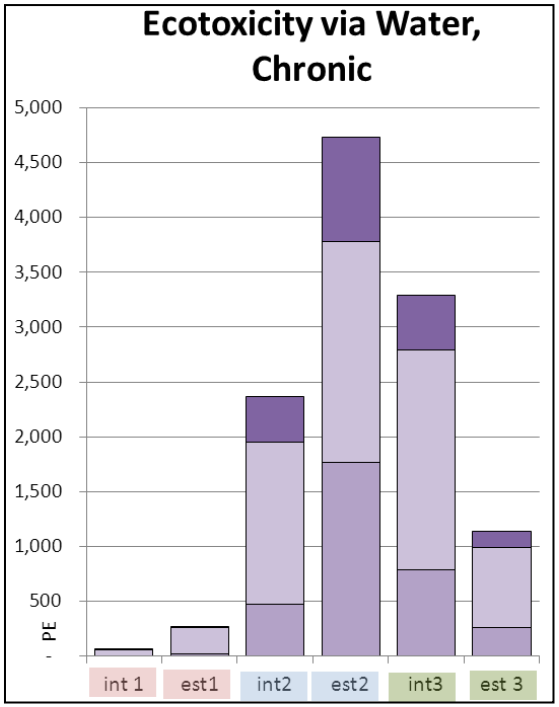
<u>Human Toxicity via Water: SECONDARY</u>

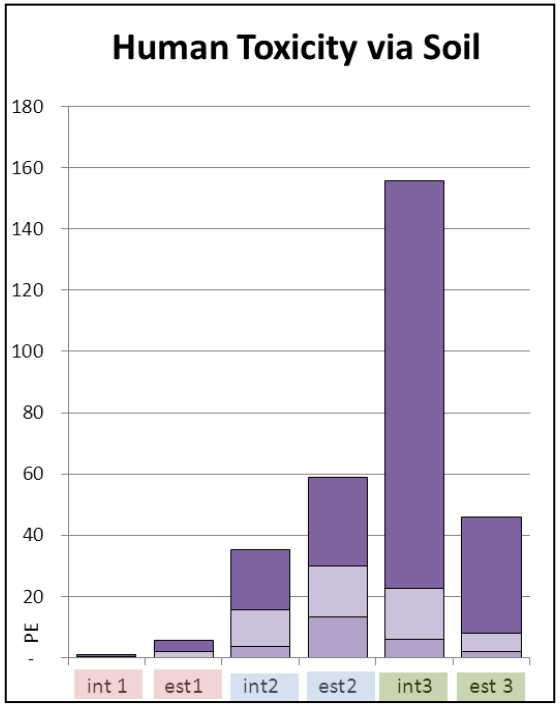
Human Toxicity via Air: Secondary

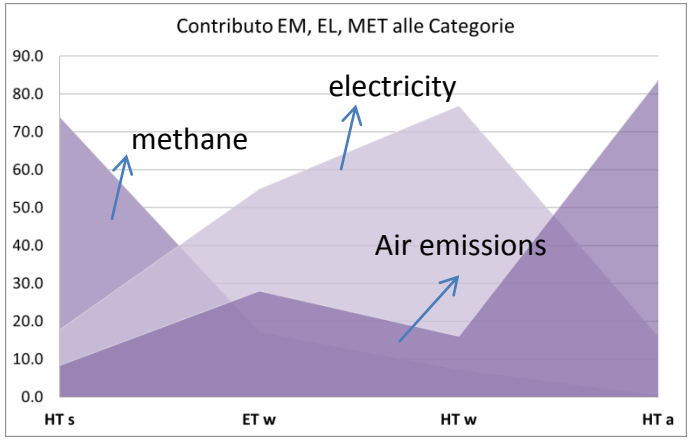
Ecotoxicity via Water: Secondary + Tertiary

Human Toxicity in Soil: Tertiary

<u>MAJOR PRESSURE</u>: **every category has a specific pressure.**







3.b. – WASTE Pot. Impacts of **a sample of Economic Sectors**

Concerning **waste production data** → the **principal (4) economic activities** were considered (DA – food industry; F – construction; G – trade; K – marketable services) [54% Municipality; 47% Province]

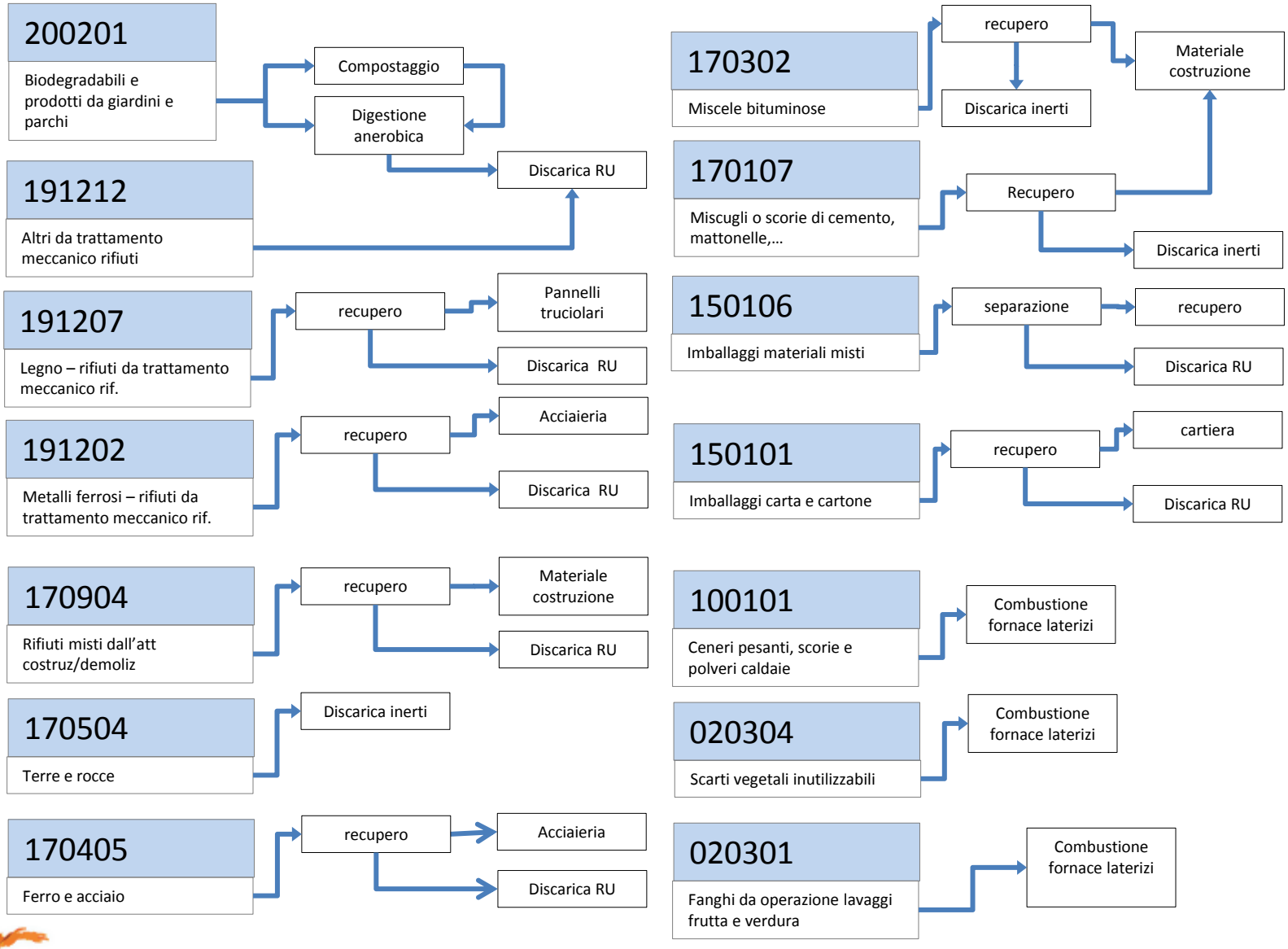
Within the 4, **14 EWC typologies** considered (**90 % of total waste produced**), the follow. were modelled:

- Waste fractions/composition
- Technologies of Treatment/Recovery/Disposal

→ Scenarios & impact calculation

Code CER	Description CER	DA (ton)	F (ton)	G (ton)	K (ton)	EASEWASTE fraction	EASEWASTE treatment
200201	biodegradable waste - from gardens and parks	-	38,051	-	-	yard waste	Compost Plant
191212	other wastes from mechanical treatment	-	288,695	-	-	other non combustibles	Landfill
191207	wood - wastes from the mechanical treatment	-	881,659	-	-	wood	Recovery
191202	ferrous metals - wastes from the mechanical treatment	-	106,681	-	-	other metals	Recovery
170904	construction and demolition mixed waste	661	44,643	-	-	new1	Recovery
170504	soil and stones	-	716,746	-	-	stone and soil	Landfill
170405	iron and steel	-	46,635	-	-	other metals	Recovery
170302	bituminous mixtures	-	132,833	-	-	bitume	Recovery
170107	mixtures of concrete, bricks, tiles and ceramics	-	30,314	-	-	cement	Recovery
150106	mixed packaging	4,369	2,697	7,448	33,286	new2	Recovery and Landfill
150101	papers and cardboards	-	29,180	1,531	-	paper and cardboard	Recovery
100101	bottom ash, slag and dust	8,273	-	-	-	ash	Landfill
020304	materials unsuitable for consumption or processing - wastes from the preparation and processing of fruits, vegetables, …	40,627	-	-	-	vegetable food waste	Biomass Plant
020301	sludges from washing, cleaning, peeling, centrifuging and separation components - from the preparation and processing of fruit, vegetables, cereals, …	13,870	-	-	-	vegetable food waste	Biomass Plant

Treatment processes: indust., commer., demol. waste



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The **EWC codes** have been **associated** with one or more **waste fractions available** through EW.

EWC code	DESCRIZIONE	FRAZIONI	EaseWaste fraction
200201	rifiuti biodegradabili - rifiuti prodotti da giardini e parchi	rifiuto verde	yard waste, flowers
191212	altri rifiuti prodotti dal trattamento meccanico dei rifiuti	altro/ residuo	other non combustibles
191207	legno - rifiuti prodotti dal trattamento meccanico dei rifiuti	legno	wood
191202	metalli ferrosi - rifiuti prodotti dal trattamento meccanico dei rifiuti	metalli	other metals
170904	rifiuti misti dell'attività di costruzione e demolizione	plastica, metalli, legno, inerti	hard plastic (50%), other metals (10%), wood (5%), ceramic and cement (15%), bitume (10%), soil and stone (10%)
170504	terra e rocce	suolo e rocce	soil (70%), stone (30%)
170405	ferro e acciaio	metalli	other metals
170302	miscele bituminose	bitume	bitume
170107	miscugli o scorie di cemento, mattoni, mattonelle e ceramiche	cemento e ceramiche	ceramic (50%), cement (50%)
150106	imballaggi in materiali misti	carta, plastica, legno	paper and cardboards (49%), soft plastic (43%), wood (8%)
150101	imballaggi in carta e cartone	carta e cartone	paper and cardboards
100101	ceneri pesanti, scorie e polveri di caldaia	cenere	ash
020304	scarti inutilizzabili per il consumo o la trasformazione - rifiuti della preparazione e del trattamento di frutta, verdura, …	rifiuto organico	vegetable food waste
020301	fanghi prodotti da operazioni di lavaggio, pulizia, sbucciatura, centrifugazione e separazione di componenti - rifiuti della preparazione e del trattamento di frutta, verdura, cereali,…	rifiuto organico	vegetable food waste

1. As regards to **waste codes not having a corresponding fraction** within the SW, **new fractions were created** as much similar as possible by **specifying the chemical composition** in question:

composizione del cemento:	
Elemento	%
Ca	45.0
O	36.0
Al	3.1
Fe	2.8
Si	10.3
Mg	1.8
S	0.6
Na	0.2
K	0.3
	100.0

Fonte: Università degli Studi di Milano, Dipartimento di Scienze della Terra, 'Composizione del cemento di Portland'

composizione del bitume:	
Elemento	%
C	80
H	10
S	5
N	3
O	2
	100

Fonte: Università degli Studi di Lecce, Facoltà di Ingegneria, tesi : 'Metodi per la Riduzione delle emissioni tossiche durante la stesa e la lavorazione dell'asfalto'

Concerning **mixed waste codes**, composed of **several waste fractions**, such as **17 09 04** (mixed waste from construction and demolition) and **15 01 06** (waste from mixed packaging), after **contacting the treatment sites**, it has come to determine the following **average composition**:

composizione 17 09 04	
Fraction	%
cement	7.5
ceramics	7.5
bitume	10
hard plastic	50
other metals	10
soil	5
stone	5
wood	5

composizione 15 01 06	
EW fraction	%
wood	7.8
soft plastic	43.2
paper and cardboard	49.0

2) The **second step** is defining the **waste (fractions) composition**, i.e. the distribution of the whole waste amount in the **various fractions**, by calculating **their % relative weight as EWC codes** on the total waste (no longer with reference to NACE-ATECO codes).

Such a percentage, expressed as EWC code, **cannot necessarily be inserted directly** into the **software**, because it **works with fractions not always perfectly overlapping with EWC codes**. It can be necessary to recalculate the percentages to express them as EW fractions:

1. for **waste fractions associated with a unique EWC code**, the percentage remains the same;
2. but in the case of **single fractions associated with more EWCs** (e.g. paper, both in **15 01 06** or **15 01 01**) or
3. **single EWCs associated with more fractions** (e.g. **15 01 06** paper, plastic and wood), we had to **recalculate the percentages distribution** expressed as EWC into Easewaste fractions.

Codice CER	%
200201	1.57
191212	11.89
191207	36.30
191202	4.39
170904	1.87
170504	29.51
170405	1.94
170302	5.47
170107	1.25
150106	1.97
150101	1.26
100101	0.34
020304	1.67
020301	0.57
TOTALE	100.00

FRACTION	%
ash	0.34
bitume	5.66
cement	0.76
ceramics	0.76
Hard plastic	0.93
other metals	6.51
other non combustibles	11.89
paper and cardboards	2.23
soft plastic	0.85
soil	20.75
stone	8.95
vegetable food waste	2.24
wood	36.55
yard waste	1.57
	100.00

3) The third step has been to **create a fictitious waste "hub"** to allocate its waste fractions to every NACE/ATECO code.

FRACTION	DA	DN	F	G	K
ash	100	0	0	0	0
bitume	0.05		99.95		
cement	0.27		99.73		
ceramics	0.27		99.73		
Hard plastic	1.46		98.54		
other metals	0.04	0.21	99.75		
other non combustibles			100		
paper and cardboards	3.95		56.33	9.57	30.15
soft plastic	9.12		5.54	15.5	69.84
soil	0.01		99.99	0	0
stone	0.02		99.98	0	0
vegetable food waste	100				
wood	0.04		99.6	0.06	0.3
yard waste			100		

Thanks to this 'hub' **each NACE/ATECO** code was **associated with the relative amount of EWC** codes attributable.

- To obtain the total amounts per EWC code or per waste fraction, an MRF (**Material Recovery Facility**) was adopted, i.e. a model (within the SW it is a **center for waste collection and separation**) that distinguishes the total waste produced by a sector in the different fractions it is made of.
- **Each NACE/ATECO has its own MRF model** in which each fraction of waste will be associated with a collection (and treatment) category so as to divide the total waste into treatment categories without further preliminary selection.

Percentage of sorting in the various fractions of the total waste production per NACE/ATECO activity code.

	170904			170904+ 150106	150106		100101	20304	20301	170904+ 150106	
DA_mrf	**inert**	**plastic**	**metal**	**wood**	**paper**	**plastic**	**ash**	**veg. food waste**	**veg. food waste**	**landfill**	**TOTALE**
ash							100				**100**
bitume	80									20	**100**
cement	80									20	**100**
ceramics	80									20	**100**
hard plastic		80								20	**100**
other metals			80							20	**100**
paper and cardboards					40					60	**100**
soft plastic						40				60	**100**
soil	80									20	**100**
stone	80									20	**100**
vegetable food waste								75	25		**100**
wood				70						30	**100**

	150106 + 150101				
G_mrf	**wood**	**plastic**	**landfill**	**paper**	**TOTALE**
paper and cardboards			49.77	50.23	**100**
soft plastic		40.00	60.00		**100**
wood	40.00		60.00		**100**

	200201	191212	191207+ 170904+ 150106	191202+ 170405+ 170904	170904	170504+ 170904	170302+ 170904+ 170107	150106 + 150101		170904+ 150106	
F_mrf	**yard waste**	**other non comb.**	**wood**	**metal**	**plastic**	**soil and stone**	**bitume**	**plastic**	**paper**	**landfill**	**TOTALE**
bitume							99.34			0.66	**100**
cement							96.34			3.66	**100**
ceramics							96.34			3.66	**100**
Hard plastic					80.00					20.00	**100**
other metals				99.43						0.57	**100**
other non combustibles		100.00									**100**
paper and cardboards									97.40	2.60	**100**
soft plastic								40.00		60.00	**100**
soil						99.91				0.09	**100**
stone						99.79				0.21	**100**
wood			99.75							0.25	**100**
yard waste	100.00										**100**

	150106				
K_mrf	**wood**	**plastic**	**landfill**	**paper**	**TOTALE**
paper and cardboards			60	40	**100**
soft plastic		40	60		**100**
wood	40		60		**100**

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Comparison of initial values (Province) obtained by local data estimations (extrapolation) with those calculated by EASEWASTE

CER DA	100101	020304	020301
Valore modello EW	8257	40800	13600
Valore di stima iniziale	**8273**	**40627**	**13870**
Differenza	0.20%	-0.42%	1.95%

CER F	200201	191212	191207	191202+ 170405	170904 plastic	170504	170302	150101
Valore modello EW	38371	288756	881878	156805	17805	720279	171948	29713
Valore di stima iniziale	**38051**	**288695**	**881659**	**153316**	**17857**	**716746**	**163147**	**29180**
Differenza	-0.84%	-0.02%	-0.02%	-2.28%	0.29%	-0.49%	-5.39%	-1.83%

4) As a last step, there is the most important and demanding that is the **attribution of each fraction** / category of waste to one or more **processes of waste storage, treatment, disposal**, etc.
Each process has to be **described in detail** in terms of **energy, resources and materials consumption** but also of **any measured and recorded emissions**. In this way, it is possible to define a full picture and an analysis the most reliable as possible.

residuo da 150106	discarica creata con dati reali
residuo da 170904	
altro da 191212	
cartone da 150101	cartiera - dati reali
cartone da 150106	
legno da 150106	impianto riciclo legno per pannelli - dati reali
legno da 170904	
legno da 191207	
metalli da 170405	acciaieria - dati reali
metalli da 170904	
organico da 020301	combustione in fornace laterizi - dati reali
organico da 020304	
cenere da 100101	
plastica da 150106	impianto di riciclo plastica- dati default
plastica da 170904	
verde da 200201	compostaggio - dati reali
bitume da 170302	recupero degli inerti - dati reali
cemento da 170107	
terra da 170504	

Landfill

Energy input	amount	unit/ton
Fuel Consumption	0.90	L
Electricity Consumption	8.00	Kwh

GENERAL INPUTS	Specific Value	Unit
LANDFILL HEIGHT m	16.667	m
BULK DENSITY IN LANDFILL	0.075	t/m3

Processing of original data.

Elaboration of data from technical sheets.

Gas Collection → Flare (torch)

Gas Generation		
Period	Duration of Period (yrs)	Landfill Gas Potentials Produced (%)
Time Period 1 - Gas Generation	**2**	**13**
Time Period 2 - Gas Generation	8	33
Time Period 3 - Gas Generation	35	42
Time Period 4 - Gas Generation	55	12

Gas Collection			Treatment Technology for Collected Gas			
Period	Duration of Period (yrs)	% of Gas Generation Collected	Flare [%]	CHP [%]	Electricity Generation [%]	Vent [%]
Time Period 1 - Gas Collection	**2**	**0**	**0**	**0**	**0**	100
Time Period 2 - Gas Collection	8	50	100	0	0	0
Time Period 3 - Gas Collection	35	70	100	0	0	0
Time Period 4 - Gas Collection	55	0	0	0	0	100

For gas generation and treatment, default system data were used "**Conventional, Low organic waste, Flaring, 100 years, Generic**" because it is closer to the real situation: the gas produced is not that much and fully sent to the torch (flare).

Default data for gas generation: *Conventional, Low organic waste, Flaring, 100 years, Generic*

Leachate Collection → WWTP (leachate treatment)

Leachate Generation		
Period	Duration of Period [yrs]	Net Infiltration [mm/yr]
Time Period 1 - Leachate Generation	**2**	**450**
Time Period 2 - Leachate Generation	8	450
Time Period 3 - Leachate Generation	35	300
Time Period 4 - Leachate Generation	55	300

Leachate Collection			Treatment and Discharge of Leachate	
Period	Duration of Period [yrs]	% of Leachate Collected	To WWTP [%]	Direct Discharge [%]
Time Period 1 - Leachate Collection	**10**	**95**	**100**	0
Time Period 2 - Leachate Collection	35	90	100	0
Time Period 3 - Leachate Collection	30	80	100	0
Time Period 4 - Leachate Collection	25	80	100	0

URBAN WASTE LANDFILL

Concerning the leachate generation and treatment default plant data "**Conventional, Household waste, Flaring, 100 years, Generic**" were partly used with the necessary **corrections to meet the real dynamic**: the leachate is collected and sent to a treatment section in order to make the wastewater suitable for public sewerage system.

INERT WASTE LANDFILL

Concerning the leachate generation and treatment default plant data "**Landfilling of Ferrox stabilized residues, 100 years, 2006**" were partly used with corrections to meet the real dynamics, that is the **content of Chromium and Molybdenum has been lowered** according to the report "Leaching properties of natural aggregates" of Ekvall, Bahr, Andersson and Akesson (VÄRMEFORSK Service AB, 2006).

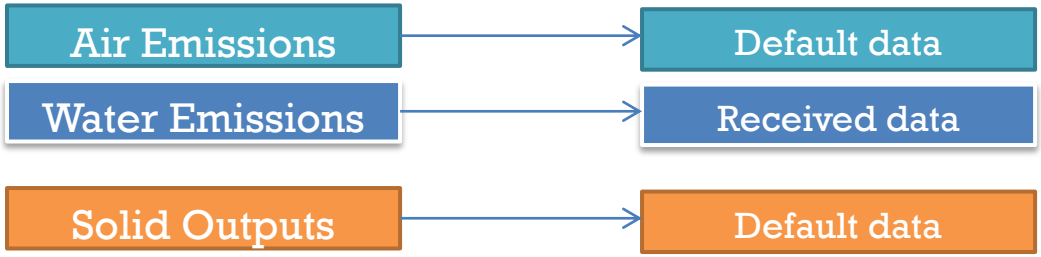
Paper recycling plant

Energy input	amount	unit/ton
Fuel Oil (Light) in Ind. Burner	0.83	L
Natural Gas Consumption	94.34	m3
Electricity Consumption	307.24	Kwh
Water from WaterWorks	13.54	m3

Elaboration of original data

Metarial input	amount	unit/ton
Polymers	*0.535*	*kg*
Acido Fosforico	0.083	kg
Policloruri di Alluminio	3.620	kg
Antischiuma	0.297	kg
Acido (Urea)	0.535	kg
Nutriens	5.221	kg
Amido	3.876	kg
Antischiuma per depurazione	0.086	kg
Antibatterico	0.015	kg

Elaboration of received data, not all substances used by paper recycling plant are present within the Easewaste database and were added under: *Unspecific Resources (Raw Material)*



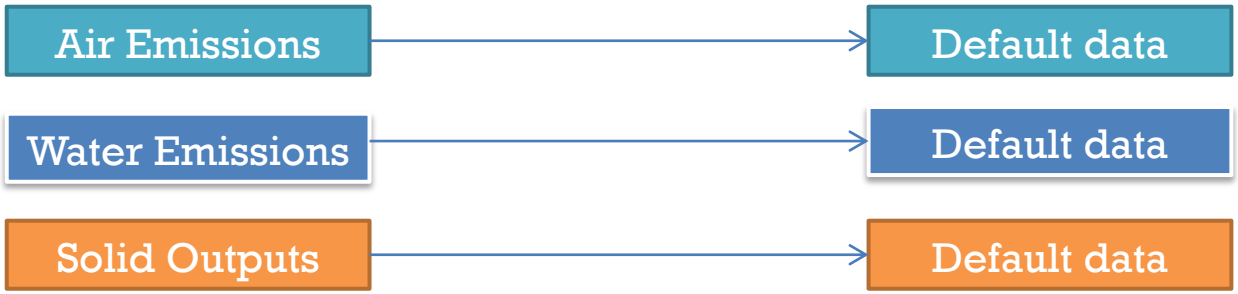
The industrial activity wastewater is treated to decrease the load of pollutants, but it was possible to **only know the emissions to water**: not those to the air and not even the solid ones.

EW data model: *Paper (Different paper and board qualities) to cardboard cores, tubes, liner and paper Skjern Papirfabrik A/S, Dk, 2005*

Metal Recycling Plant

Energy Input	amount	unit/ton
Hard Coal	157.00	kg
Natural Gas	144.00	kg
Fuel Ligh Oil Consumption	70.00	kg
Water for Waterworks	7012.70	kg
Electricity Consumption	987.97	Kwh

Material Input	amount	unit/ton
Gravel	34	kg
CaCO3	105	kg
Mg	40	kg
Mn	20	kg

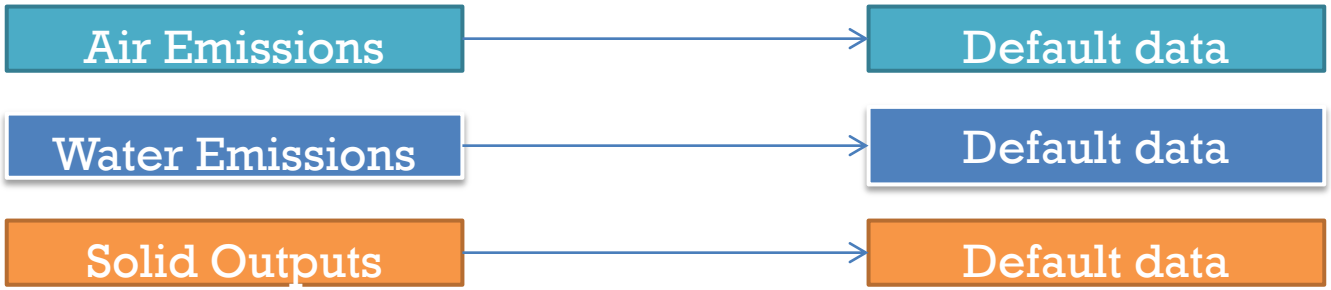


Source data: *article 'Dichiarazione Ambientale di prodotto per tondo in acciaio'*
Default Data: *Steel scrap to steel sheets, Sweden, 2007*

Wood recycling plant

INPUT (energy and material)	Amount	Unit/ton
Electricity Consumption	110	KWh
Natural gas	5.76	Kg
Urea, formaldeide resin	80	Kg
Wood chips	250	kg
Oil	0.042	kg

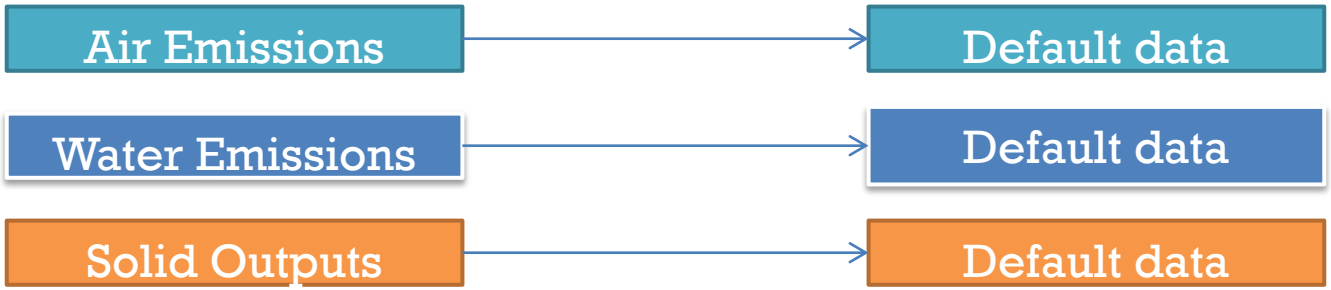
Elaboration of original data.



Bricks Furnace

INPUT (energy and material)	Amount	Unit/ton
Electricity Consumption	1.32	KWh
Natural gas	1570	Kg
Hard Coal	1940	kg
Oil	1020	kg

Original data elaboration.



Composting Plant

Energy input	amount	unit
Electricity Consumption	1.9	Kwh
Water from WaterWorks	89.0	L

Original data elaboration.

NITROGEN EMISSION TO AIR	
Total N loss %	*8*

The remaining is default data, but can be considered sufficiently valid because the default system has many features in common with the real one: waste disposed in heaps, turned periodically and covered with plastic sheets.

DISTRIBUTION OF N LOSS	%
NH3	*83*
N2O	*15*
N2	*2*

AIR EMISSIONS	amount	unit/ton
CO	*0.12*	*kg*
CO2	*86.00*	*kg*
N20	*1.60*	*kg*
CH4	*1.90*	*kg*

Default data: *Composting, Windrows (Garden Waste), Åarhus, DK, 2007*

Inert Waste Recovery

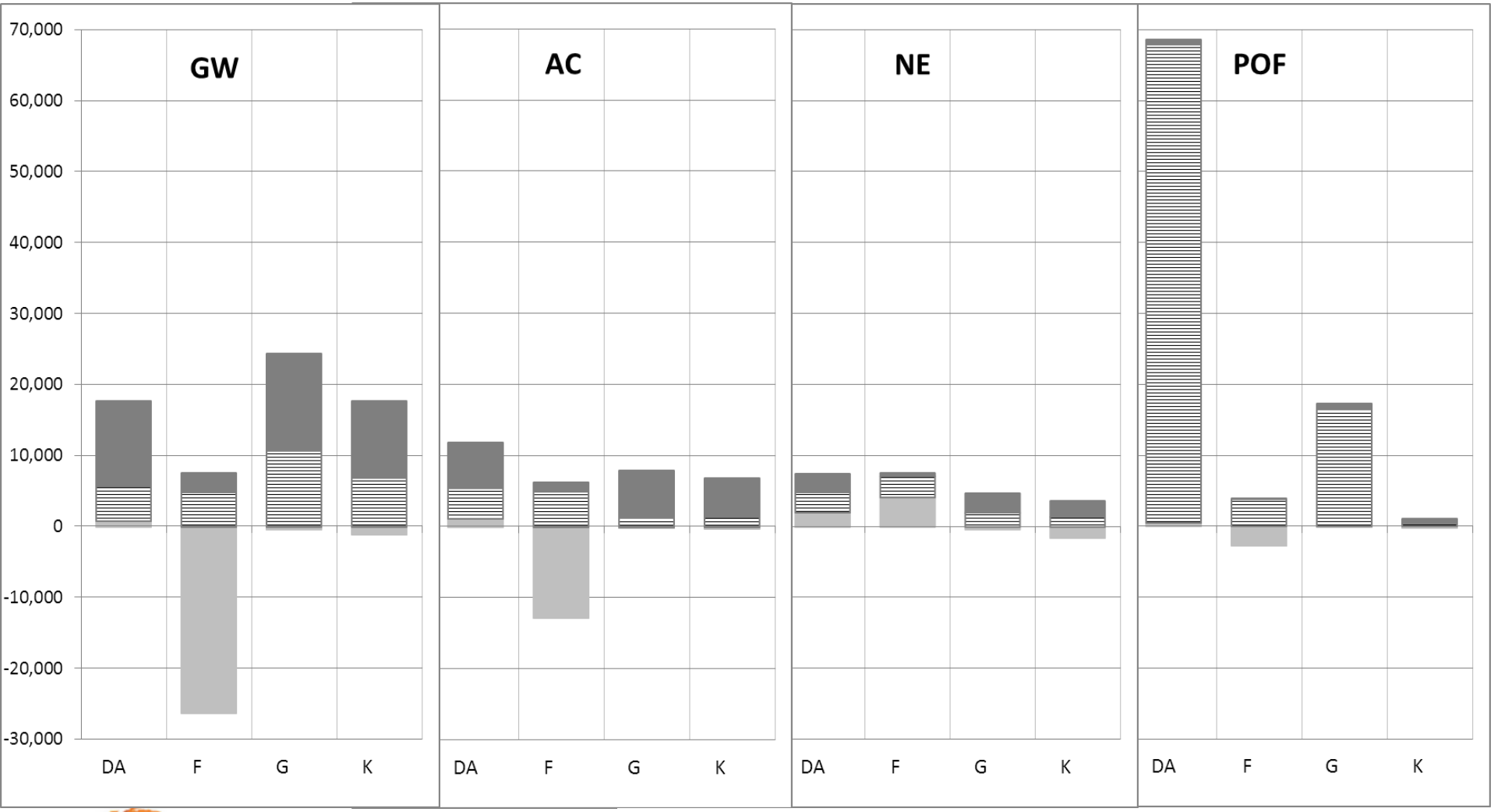
INPUT (energy and material)	Amount	Unit/ton
Electricity Consumption	4.4	KWh
Diesel	0.28	Kg
Water	40	kg

Original data elaboration.

OUTPUT	Amount	Unit/ton
Hazardous Waste	0.013	Kg

Results - WASTE

Normalized Impacts to **non tox categories** for pressures (waste – energy – emissions) and for sectors (DA – **Food Industry**; F – **Construction**; G – **Trade**; K – **Marketable Service**).



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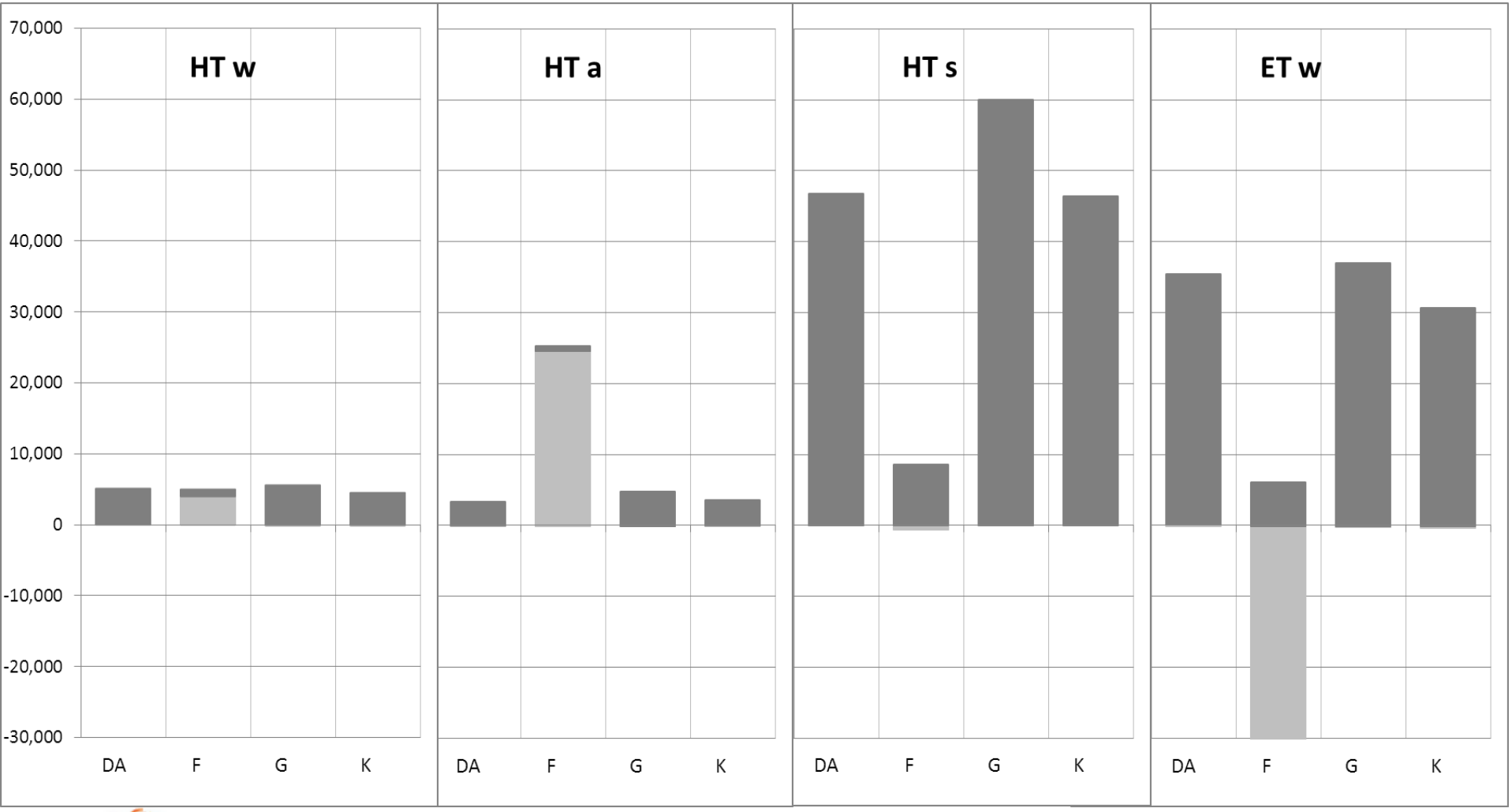
Normalized Impacts to **tox categories** for pressures (waste – energy – emissions) and for sectors (DA – **Food Industry**; F – **Construction**; G – **Trade**; K – **Marketable Service**).



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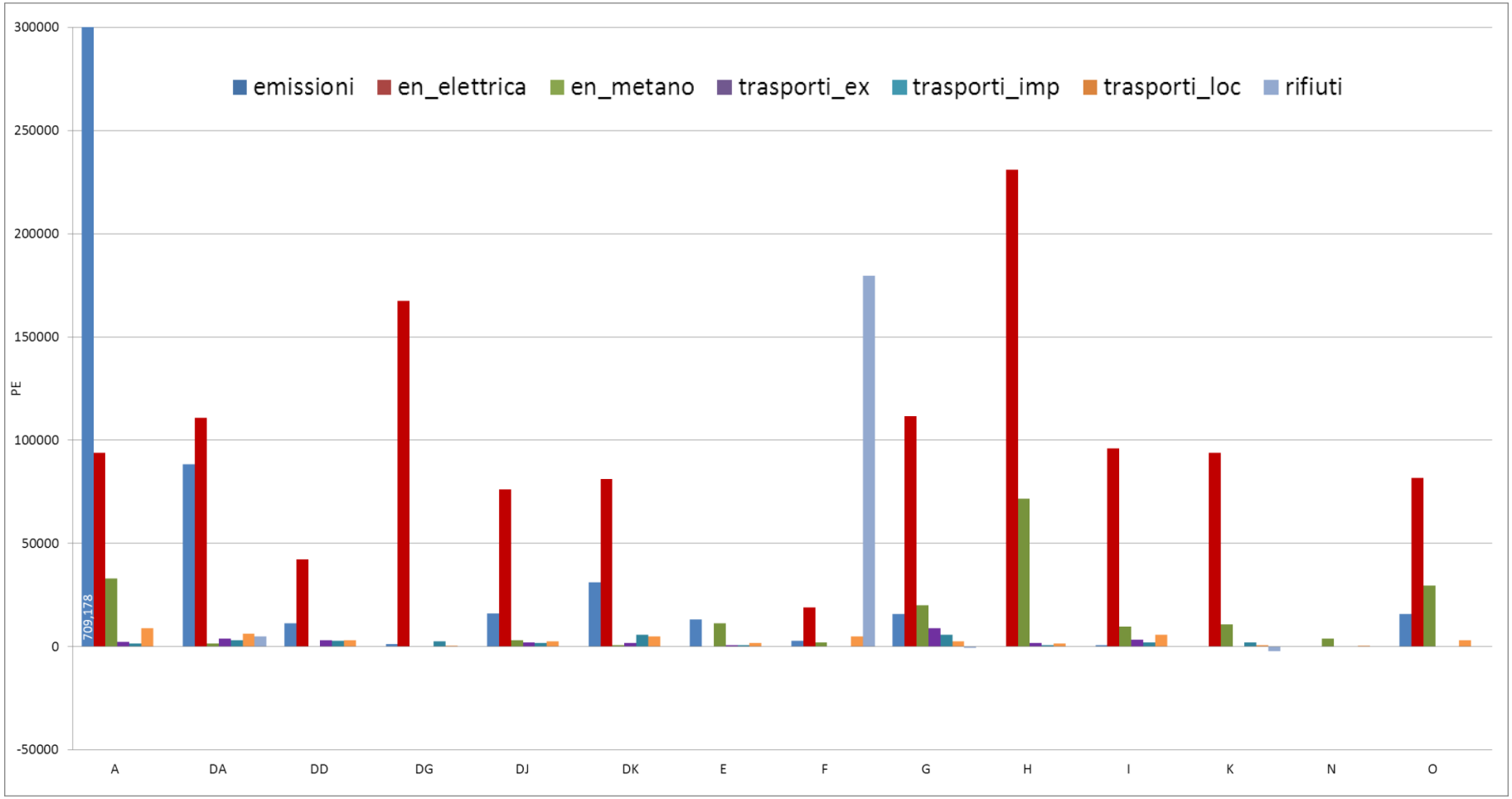
Potential impact Profiles (TOX and NON-TOX): economic activities at the Province scale.



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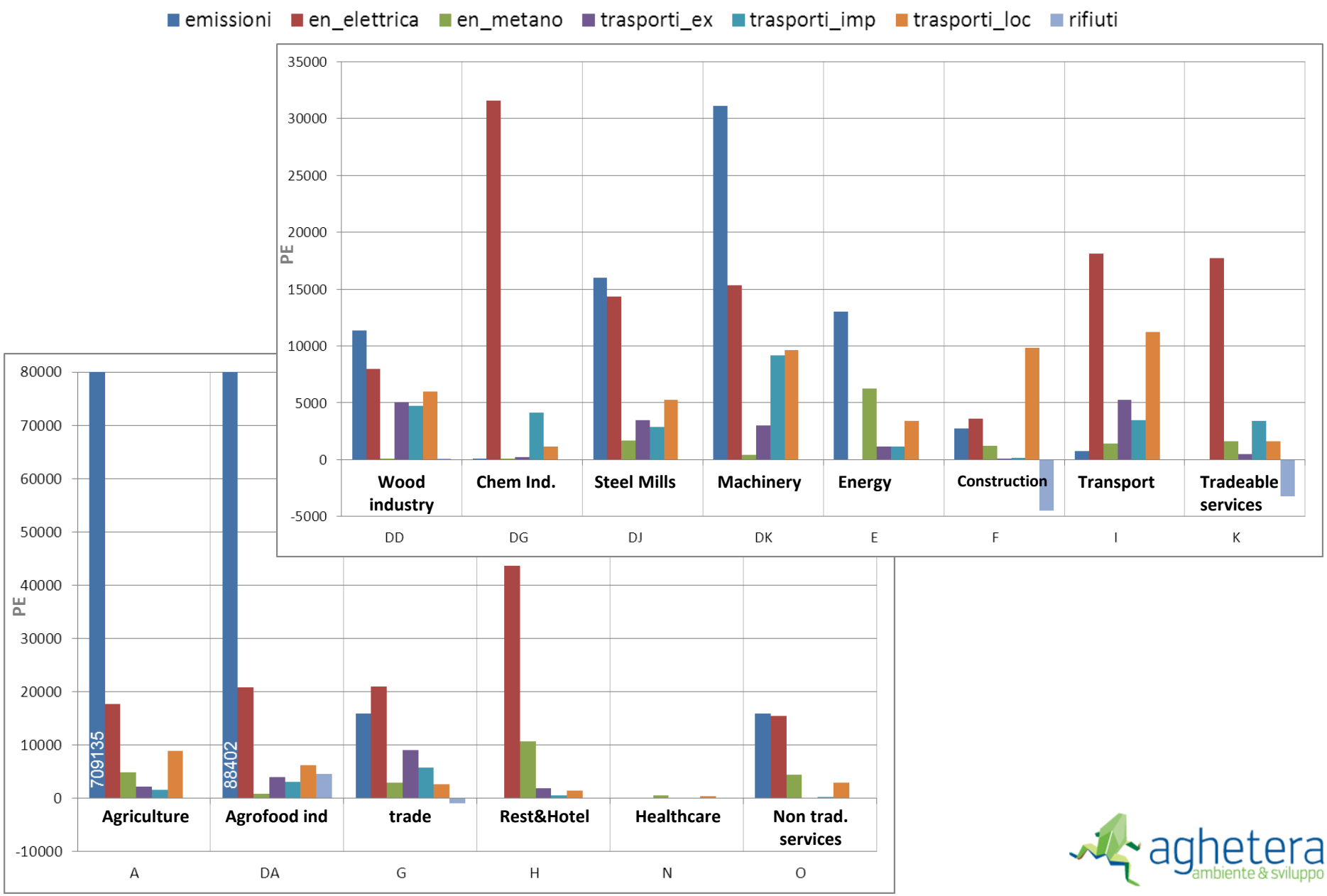
NON TOXIC Impact Categories



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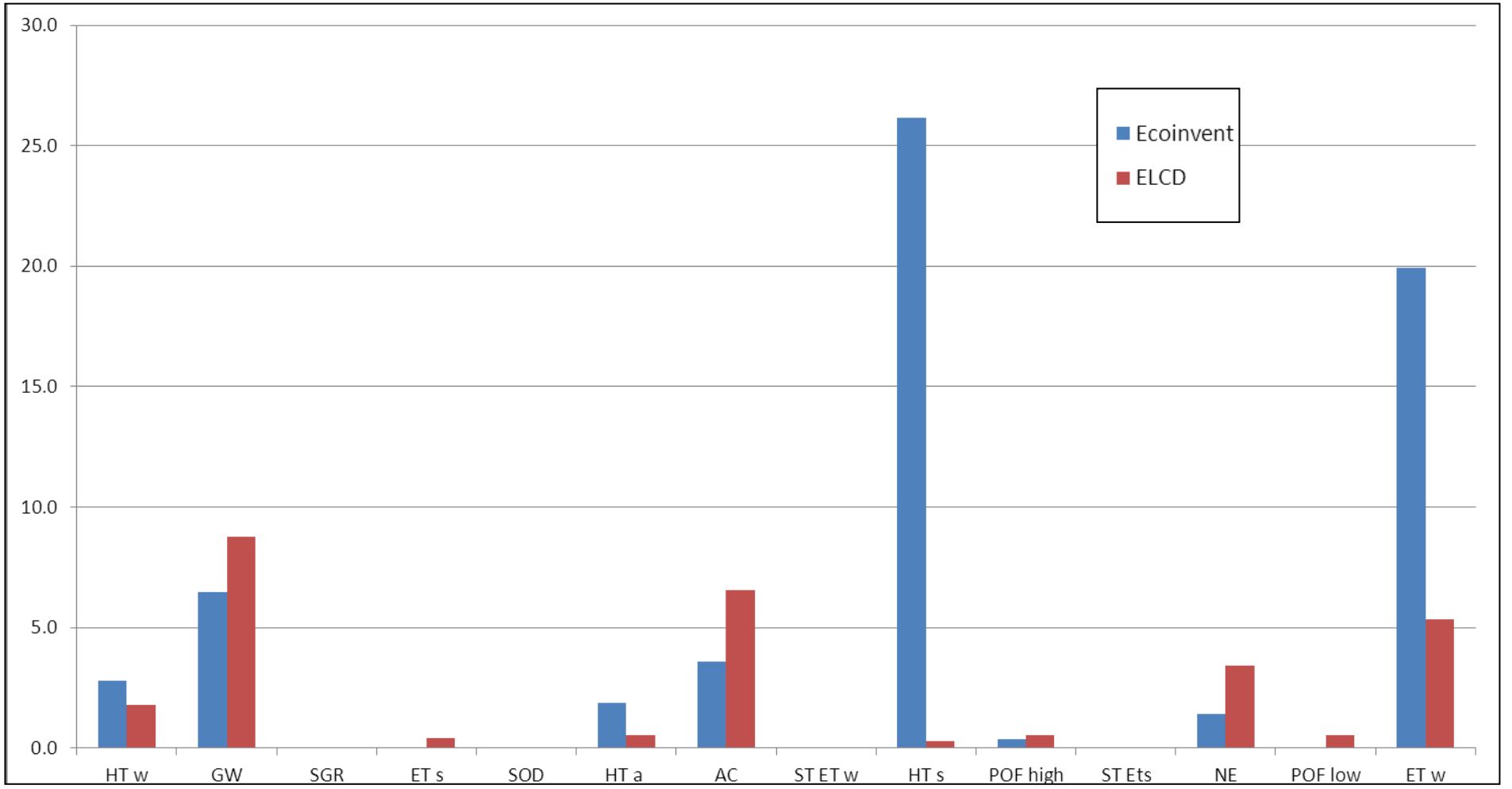
Comparison of diverse energy mixes

- Italy, Grid Mix, AC, Consumption at consumer, 1kV - 60kV, 2002: The process is from the **ELCD database**, and all ownership belongs to the in the text below mentioned source. The data are used in accordance with ELCD database rules. http://lca.jrc.ec.europa.eu/lcainfohub/datasets/elcd/processes/ce82b33c-ea98-4ba2-b7cd-1838deff792d_02.01.000.xml
- **ECOINVENT Electricity mix/IT** kwh: from ecoinvent (SimaPro) database.



CONCLUSIONS

From EIO-LCA analysis:

1. **Exports greatly affect the primary and manufacturing sectors** (also in terms of impacts): compensation could be studied for benefits that "go out" of the Province at the cost of the local environment.

2. The **tertiary/services, almost wholly "turned" inward**; much less "impacting" in specific terms, nevertheless have reached and passed an absolute load in the order of the industrial sector.

3. To **understand the leading sectors** within the three macro-sectors: further analysis with the **data disaggregated** into 22 sectors is required, to provide more useful feedback in view of possible compensation measures for the **export targeted sectors** and other measures for the **internally targeted** economic sectors.

CONCLUSIONS

By **comparing the two analyses**:

1. In the first series of comparisons (process emissions, energy consumption) the **emissions "win"** in terms of environmental impacts generation (NON-TOX).
2. In the next (relative to a sample of sectors that are significant for the provincial economy) we note the **importance of impacts from waste**, and landfill in particular (TOXIC IMPACT CATEGORIES): this might suggest a similar trend for other sectors of the economy.
3. At the same time NON TOXIC impact categories give **important avoided impacts** thanks to materials (and energy(recovery.

EIO-LCA Table for Alto Adige – Süd Tirol Extended to Energy Consumption, Air Emissions and Waste Treatment

Thanks.

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