6.0 Application Case Study: Emilia-Romagna

6.1 Context & Objectives

The first pilot project of RAMEA in Emilia-Romagna was carried out by ARPA Emilia-Romagna, the Regional Environment Agency, in close collaboration with IRPET[24] and ISTAT.[25] The main objectives of the study are:

- to link the economic knowledge on production and consumption activities to the air emissions;
- to build a tool useful for reports (in particular, Strategic Environmental Assessment - SEA), studies, scenarios, regional planning;

Two matrices were produced, for year 1995 and 2000, using:

- regional economic data supplied by IRPET for 30 economic sectors plus 3 types of household consumptions, using a multi-sector and multi-regional econometric model with the ability to produce economic accounting matrices, consistent with national accounting matrices, for all Italian regions (Casini Benvenuti & Paniccià, 2003);
- official database of 21 pollutant air emissions at a provincial level produced by the National Environment Agency (APAT, 2004)

The methodology to link the two sets of data was developed in close collaboration with IRPET and is partially based on the previous experiences of regional NAMEA for two Italian regions, Toscana and Lazio (Bertini et al. 2007, ISTAT 2006a-b)[26].

[24] IRPET, Regional Institute for Economic Planning in Tuscany (www.irpet.it).

[25] ISTAT, Italian National Institute of Statistics (www.istat.it).

[26] The methodology mainly deals with the activities carried out to shift from the CORINAIR process-oriented source nomenclature (SNAP 97 codes) to the RAMEA socio-economic nomenclature (which includes economic activities described by NACE codes plus household consumption), and in particular: (i) the analysis of the qualitative link between each SNAP 97 process and RAMEA economic activities and (ii) the quantitative allocation of the emissions of each SNAP 97 process to the related RAMEA activities. Since there is no standard connection between SNAP and NACE categories, the attribution of SNAP-based emission data to NACE-based accounts depends on the economic structure of the region. In addition to that, only emissions from anthropic sources are taken into account, excluding all emissions related to natural phenomena.

RAMEA 2000 was applied to three different kinds of analyses, to explore some of the possibilities that this type of tool offers to regional planning/ reporting:

- monitoring regional air emissions and eco-efficiency;
- comparing regional and national eco-efficiency;
- understanding the indirect effects/responsibilities of the electricity sector.

RAMEA 2000 is illustrated in a simplified version in Table 5, with economic and environmental indicators for each macro-sector calculated as percentage of the total.

As a monitoring and descriptive system, RAMEA facilitates an analysis of the pressures placed on the environment by the activities of the economic sectors and households. In this report we highlight the key sectors for Greenhouse Gas (GHG) emissions, acidification and local air quality, directly linked to the economic performance of those sectors (in terms of production and value added) and developing the associated eco-efficiency indexes (i.e. tonnes of pollutants emitted per millions of euros of production/value added).

The eco-efficiency of Emilia-Romagna can then be readily compared with the same indicators for Italy. A more detailed analysis (Shift-Share analysis) is then carried out to better understand the different GHG emission intensities of regional economic sectors by comparison with those at a national level .

[27]Using Shift-Share analysis, the role of the productive structure as a cause for the average gap between regional and national efficiency can be isolated and quantified, whilst also obtaining, in a complementary way, a measure of the role of the specific efficiency of emissions of productive sectors. The choice of this methodology derives from the search of effects and factors that could explain the relative efficiency of Emilia-Romagna compared to Italy as a whole and could be shown in a more exhaustive way than a descriptive statistic analysis. As a matter of fact the latter can give indications on the relative efficiency of Italy with reference to the whole regional economy (Total Emissions/Total Added Value) or to specific fields, but it cannot measure two important effects: (i) the different sectoral composition of the regional

Table 1 - RAMEA 2000 for Emilia-Romagna Region (%). Source: Arpa Emilia-Romagna

		Current Prices			GHG emissions	Acidification	Local air quality		
NACE (COICOP)	**Sectors**	**Output**	**Gross Value Added**	**Final Consumption**	**CO_2eq**	**H+ eq**	**PM_{10}**	**NMVOC**	**CO**
A, B	Agriculture, hunting and forestry, fishing	2,8	4,0	-	12,2	47,0	24,2	4,6	9,8
C	Mining and quarrying	0,1	0,1	-	0,1	0,1	0,2	0,2	0,0
D	Manufacturing activities	41,2	27,4	-	31,5	21,2	31,3	30,7	2,4
E	Electricity, gas and water supply	1,3	1,3	-	14,3	10,2	4,6	3,2	0,5
F	Construction	5,5	5,0	-	0,2	0,1	2,2	3,9	0,1
G, H	Wholesale and retail trade, hotels and restaurants	14,4	17,8	-	2,0	0,7	0,9	1,7	0,5
I	Transport, storage and communication	6,4	7,1	-	7,0	7,5	13,2	6,9	5,6
J-Q	Other services	28,2	37,1	-	6,2	1,9	2,1	1,3	2,1
07	Private traffic	-	-	3,4	12,3	9,1	13,3	34,1	70,3
04	Heating, cooking, air cond	-	-	2,1	14,1	2,1	8,0	1,9	8,0
-	Other consumptions	-	-	94,6	0,1	0,0		11,4	0,7
	Economic activities	**100,0**	**100,0**	**-**	**73,5**	**88,8**	**78,7**	**52,6**	**21,0**
	Households			**100,0**	**26,5**	**11,2**	**21,3**	**47,4**	**79,0**
	Total	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**

economy compared to that of the national economy; and (ii) the different efficiency of emission of the regional economic sectors compared to the national average. These effects and their combination can be collected and read by a Shift Share analysis that, thanks to the correspondence and coherence between sectoral economic and environmental variables given by RAMEA, allows attribution of the whole observable deviations to the combination of the effects mentioned above, and also quantifies them. Therefore the descriptive comparison between efficiency of every field (Emilia-Romagna/Italy) for GHG generates a deviation matrix between the regional and national average: the application of a Shift-Share analysis allows detailed consideration of such differentials.

6.2 Sectoral Eco-efficiency & Analysis of Electricity Sector

6.2.1 Application of RAMEA

The simplified version of RAMEA 2000 showed in Table 1 highlights the different contribution of economic sectors and households to the economy (output, value-added and final consumption) and the environment (GHG[28], acidification[29], local air quality), facilitating a simple but interesting analysis of the data, which shows that:

- Manufacturing is the sector with the higher contribution to the regional output (41.2%) but also has a high impact on the environment (GHG 31.5%, acidification 21.2% and PM[30] 31.3%);
- The Electricity sector makes a very little contribution to the regional output and value added (1.3% each) but has a significant environmental impact in terms of GHG (14.3%) and acidification (10.2%);
- Agriculture makes little contribution to the regional output (2.8%) and value-added (4.0%), but is relatively important in relation to GHG (12.2%), the highest for acidification (47%) and makes a strong contribution in terms of PM (24.2%);
- Households also have an impact on environment that cannot be overlooked, particularly for emissions such as CO_2 (31%), NO_X (29%), NMVOC (47%) and CO (79%) (See Figure 1).

[28]GHG takes into account the Global Warming Potential (tonnes of CO_2 equivalent) of CO_2, CH_4 and N_2O, with the formula $GHG = CO_2 + 21\ CH_4 + 310\ N_2O$
[29]Acidification takes into account the Potential Acid Equivalent (tonnes of H+ equivalent) of NO_X, SO_X and NH_3, with the formula $H+\ eq = 1/46\ NO_X + 1/32\ SO_2 + 1/17\ NH_3$
[30]Particulate Matter

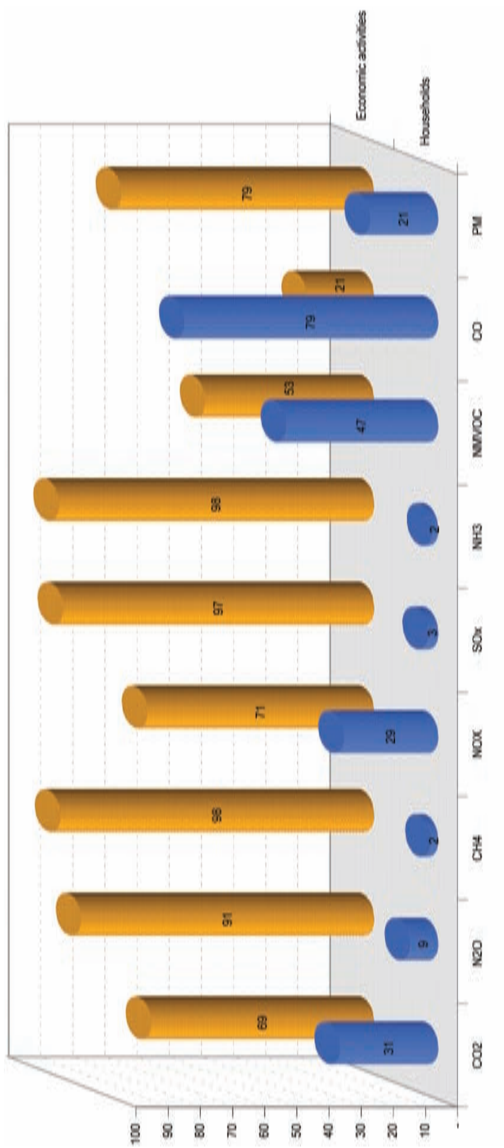

Figure 1
Economic and Household Contribution to Emissions (%)
Source: RAMEA 2000

Monitoring Regional Air Emissions and Eco-efficiency

Disaggregating the manufacturing sector D, analysis of the data in RAMEA 2000 highlights the key sectors in relation to the environmental aspects analysed and their relative contribution to the regional output.

Figure 2 shows the economic output of the industrial sectors in relation to their greenhouse gas emissions. The first three sectors (DI, E and A+B) contribute around 50% of the emissions but only contribute 8.4% of the output. In particular, sector DI, other non- metallic products (in Emilia-Romagna mainly manufacture of ceramic products), makes an overall contribution of 19% to the total of emissions and 4.3% to the output.

It also indicates that households contribute around 26.5% of the total emissions, i.e. the above three sectors plus household consumption total 72% of the total. Looking at the green bars (economic output) it is interesting to note that they are higher for sectors with little or no contribution to GHG emissions.

If we perform the same analysis for acidification, Agriculture has the major contribution (47%): adding sectors DI, E and households' emission we reach a contribution to the total potential acid equivalent of more than 80%, in comparison to an impact on the total output of about 8% (Figure 3).

Taking into account PM emissions for local air quality (Figure 4), Agriculture has again the highest contribution (24.2%), which was not expected, while in sector I "Transport, storage and communication", as well as sector DI (17.4%), has a relevant importance (13.2%). Even in this case the impact of domestic consumption, in comparison with economic activities, is quite important (21.3%).

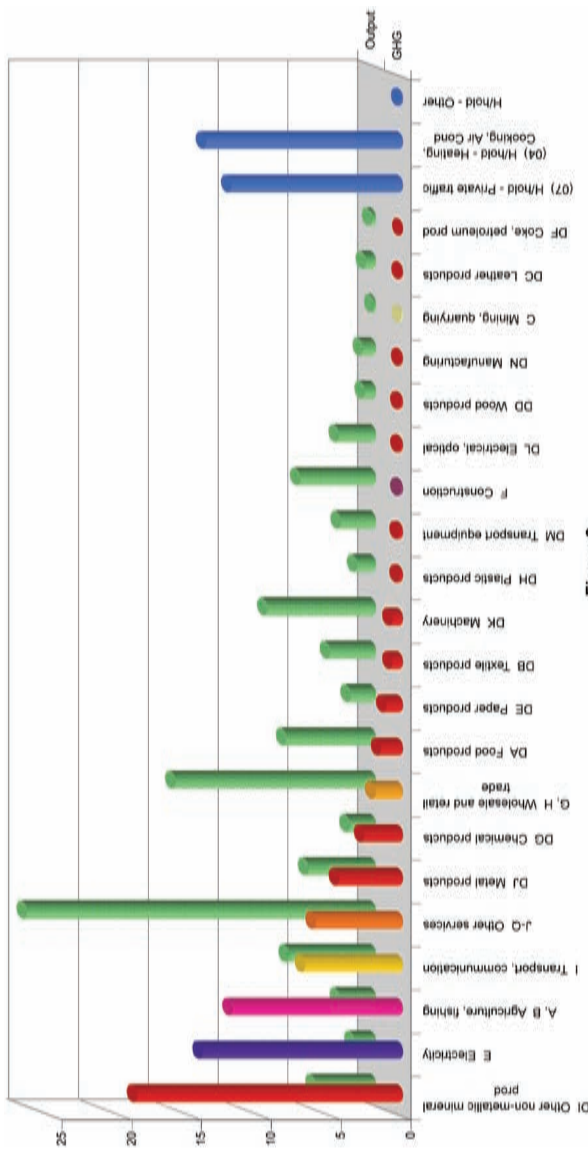

Figure 2
Sectoral Contribution to Greenhouse Gases and Output (%)
Source: RAMEA 2000

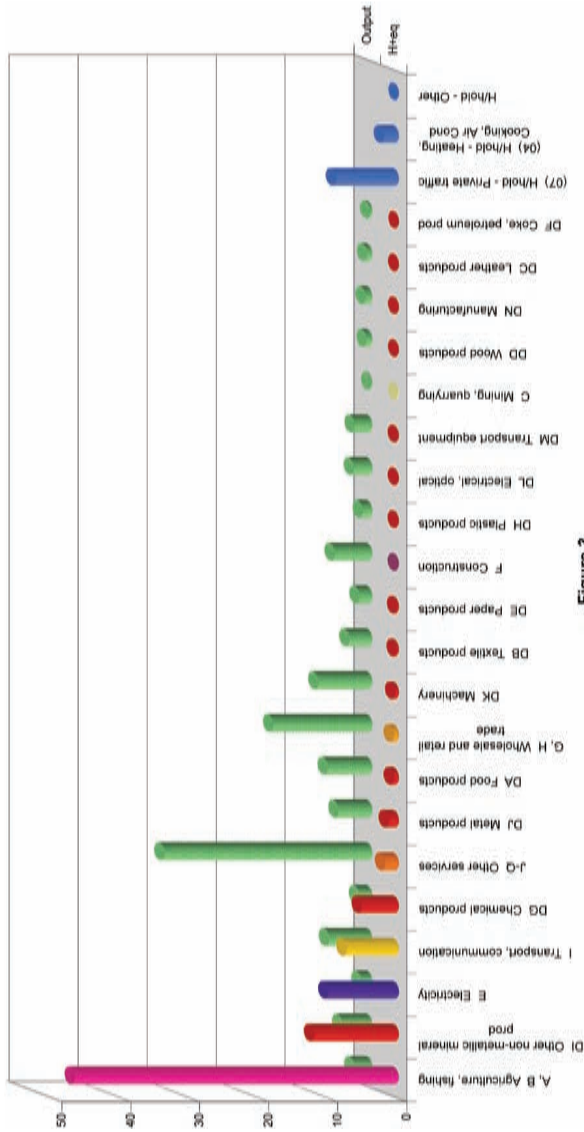

Figure 3
Sectoral Contribution to Acidification and Output (%)
Source: RAMEA 2000

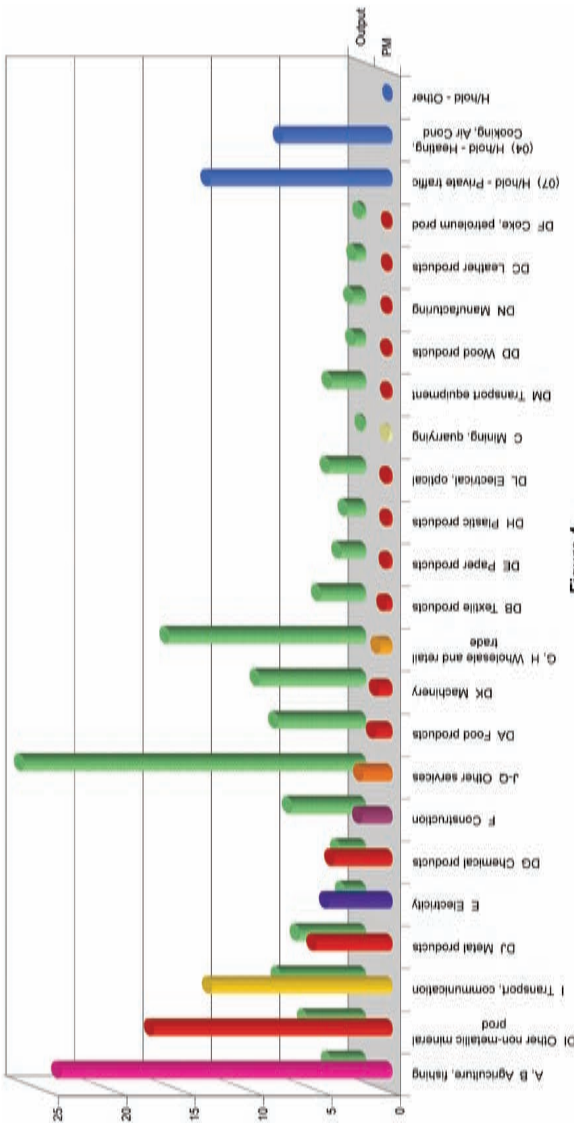

Figure 4
Sectoral Contribution to PM_{10} Emissions and Output (%)
Source: RAMEA 2000

Using the RAMEA data it is also possible to calculate "Emission Intensity" indicators, expressed as the ratio between emissions and production or value added. As explained in Cervigni et al (2005), this ratio can be considered representative, as an inverse index, of the ecological efficiency of a given activity and can form the basis for:

- different time period comparisons regarding an economic activity (a reduction in the ratio over time indicates an increase in ecological efficiency and vice versa);
- comparisons between different activities in the same country;
- comparisons amongst different countries or regions.

Figure 5 shows the emission intensity of GHG by production activity in Emilia-Romagna. In this case, the sector with the highest ratio (i.e. with the highest emission of GHG per unit of output) is the Electricity sector with an index of over 2000 tons of GHG per million euros, about double that of the nearest sectors, DI and A+B. These results are linked to the particular approach of this methodology, which is based on "Producer Responsibility". In the NAMEA/RAMEA framework environmental pressures are allocated directly to the producer, be it economic activity or household, responsible for generating the emissions / environmental impact. Some industries which directly emit large amounts of greenhouse gases, such as power generation, are presented in a bad light under this approach (Bertini et al, 2007:15).

Section 6.2.2: Understanding the Indirect Effects / Responsibilities of Electricity Sector, related to the Electricity sector, illustrates how it is possible to explore the concept of "Consumer Responsibility", using Input-Output analysis.

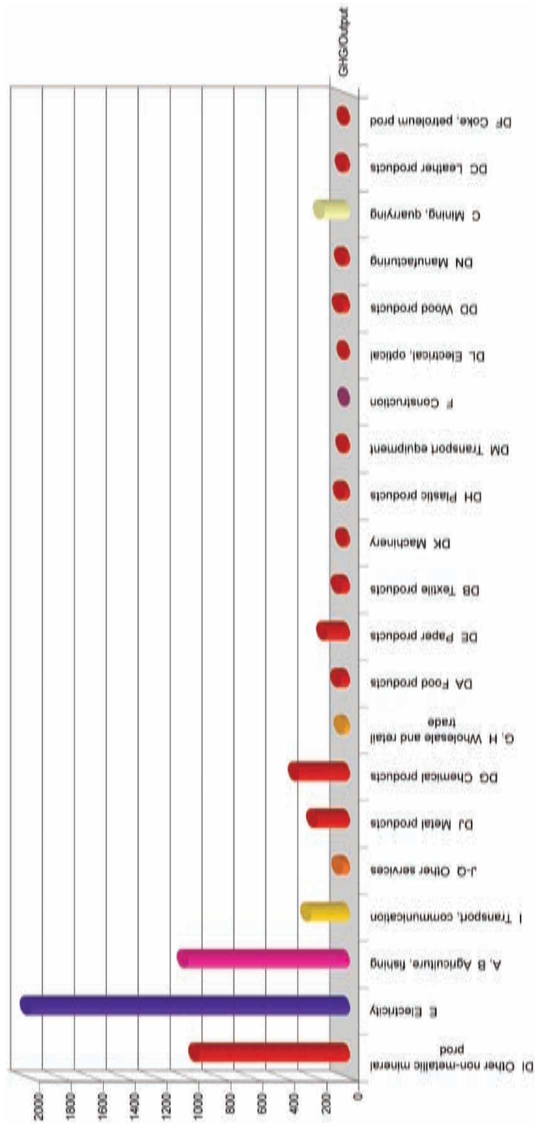

Figure 5
Intensity of Greenhouse Gas Emissions (Mg CO2eq/M Euro)
Source: RAMEA 2000

Comparing Regional and National Eco-efficiency

This section analyses the intensity of GHG emissions for the regional economy in Emilia-Romagna, compared to the national average, for all economic sectors covered by RAMEA 2000 and NAMEA 2000 (ISTAT, 2007). This approach has also been used in literature: see e.g. Zaccomer (2005).

Methodological Approach

The indicator "Emission Intensity", as "Emissions/Added Value", is used in this analysis as a measure of the efficiency in terms of GHG emissions. The regional average Emission Intensity (X_e) for GHG is the summation of the sectoral intensities of emission, weighted in relation to the ratios of the sectors for Total Added Value (P_e). The national average Emission Intensity (X) is defined in the same way.

The region may show a greater or lower Emission Intensity compared to the national average depending on the combination of the three Shift-Share effects:

- Industry mix (or Structural);
- Differential (or National Share);
- Allocative (or Regional Share).

The *Industry Mix Effect* estimates that element of greater/lower Emission Intensity which is due to the sectoral structure of the regional or national economy. This can show that although the Emission Intensity may be similar to the average national for every sector, the economic industrial mix may generate higher or lower indicators for the complete economic system.

The difference between the regional and national average Emission Intensities may depend on differences in the specific intensities of some or of all of the considered fields, marking out the *Differential Effect*.

Finally, the *Allocative Component* adds further analytic information. The covariance between the sectoral structure, assuming parity of efficiency, and the difference between the sectoral Emission Intensity, assuming parity of sectoral structure, indicates whether and how much the system has a productive specialization in the fields within which the comparative advantage of efficiency was assessed.

The total indicator of Emission Intensity shown as Total Emissions per Unit of Added Value is defined as $X = E/VA$ for the national average, and as $X_e = E_e/VA_e$ for E-R. It is important to note that the higher the ratio, the higher the inefficiency and vice versa.

By defining:

$X^s_e = E^s_e/VA^s_e$	the indicator of intensity of emission for every economic field in E-R;
$X^s = E^s/VA^s$	the indicator of intensity of emission for every economic field in Italy;
$P^s_e = VA^s_e/ VA_e$	the ratio of sectoral Added Value for E-R;
$P^s = VA^s/ VA$	the ratio of sectoral Added Value for Italy.

Consider:

$$\sum P^s_e = 1 \qquad \sum P^s = 1 \qquad \text{e} \qquad X = \sum P^s X^s \qquad X_e = \sum P^s_e X^s_e$$

This identifies three effects, provided by the Shift-Share model, which explains the Total Differential of Emission Intensity between E-R and Italy.

(i) The first effect (structural or Industry mix) is given by:

$$m_e = \sum X^s (P^s_e - P^s) \qquad \text{Hp: } X^s_e - X^s = 0 \text{ (parity of intensity of emission)}$$

m_e takes on positive value (algebraically negative) if the region specializes in sectors with a higher environmental efficiency (P^s_e - $P^s < 0$), as every differential of sectoral Added Value ratio is multiplied by X (as if the region were characterized by the national average efficiency). The effect takes on the minimal value if the region is specialized in more efficient fields on average, compared to the national average.

(ii) The second effect (Differential) is given by:

$p_e = \sum P^s (X^s_e - X^s)$ Hp: $P^s_e - P^s = 0$ (parity of sectoral structure)

p_e takes on positive value (algebraically negative) if the region is more efficient in terms of emissions (the shift between regional and national efficiency), as if the sectoral ratios of Added Value were the same for the region and for the national average ($X^s_e - X^s < 0$).

(iii) Finally, the effect of covariance between the two already mentioned, or Allocative component, is given by:

$a_e = \sum (X^s_e - X^s)(P^s_e - P^s)$

The effect is negative if the region is specialized, compared to the national average, in the fields with lower Emission Intensity. It takes on the minimal value, in our case, if the region is specialized in the fields in which it records the higher comparative advantage (low Emission Intensity).
For this it is an indicator of covariance between m_e and p_e. Guarini and Tassinari (2000) gave a theoretical explanation of this statistical notion applied to the economic subject.

The total difference between regional and national average Emission Intensity equals the summation of the three effects:

$X_e - X = p_e + m_e + a_e$

Thus a quantitative assessment can be made of the causes of the differential Emission Intensities between E-R and the national average. This can be due to the sectoral structure, from "the history of development" of the economy, or the average state of production technologies, and the emissions in the region compared to the national average. For example, a higher value of regional Emission Intensity could be due solely to the production structure in areas where an energy-environmental policy cannot have a great influence; whereas it could have greater chance of effect if the relative total regional inefficiency were due to the specific environmental inefficiency of the sectors, due to their process technologies or inefficient public regulation assets.

The higher the Indicator the less efficient the considered system or sector. This is reflected in the interpretation of the differential between E-R and Italy; so if $X_e - X > 0$, E-R is relatively less efficient (e.g. produces more emissions for unit of Added Value than the national average). The same is true for the signs of the three Shift-Share effects. When they are algebraically negative they identify an efficiency advantage for the region E-R. The same methodology was used in a different analysis by Biffignandi and Fabrizi (2006) and by Biffignandi (1993).

Shift-Share Analysis of the Regional Economy[31]

First of all it is essential to observe the trend of the Indicator of efficiency (X_e-X) and (X^s_e-X^s), i.e., the variable object of the Shift-Share factorization. The four variables P_e P, (the relative combination of Added Value), and X_e X (the Total Emission per million Euro of Total Added Value), are the basis of the Shift-Share factorization study according to the described approach.

Figure 6 shows the matrix Sectors/Emissions of the percentage deviation between Indicators X^s_e and X^s, as is $[(X^s_e - X^s)/X^s]$.

However this kind of comprehensive information is insufficient to identify the main drivers of the efficiency gaps and consequently the possible implications for policy makers.

[31]Mazzanti et al. (2006) resolved similar analysis for another Italian region (Lazio), still compared to the national average.

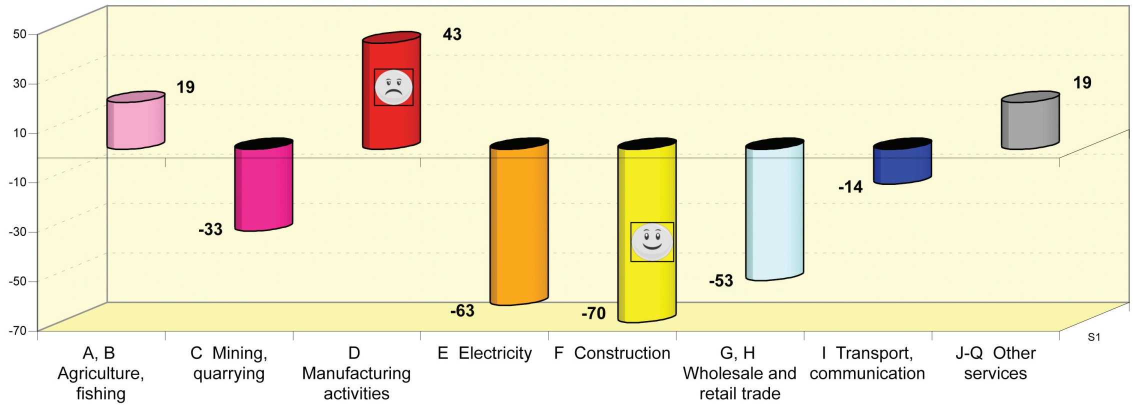

Figure 6

Difference between Key Perfomance Indicators (%): $(X^s_e - X^s)/X_s$

Source: RAMEA 2000

The main results of Shift-Share analysis are shown in Table 2 and Figure 7 in terms of effects/components (*m, p* and *a*) that contribute to explain the differentials (X_e-X), and are here studied for GHG, according to NAMEA.

Table 2 – Shift Share Analysis of the Regional Economy

Total economic activities	$\sum X_e$	$\sum X$	$\sum (X_e\text{-}X)$	$\sum(m_e+p_e+a_e)$	$\sum m_e$	$\sum p_e$	$\sum a_e$
GHG	0,340499	0,412959	-0,0724599	-0,0724599	-0,0248043	-0,0752752	0,0276196
% deviation compared to the national average			-18%				

The results of this first analysis show that the first two effects identified by Shift Share (m, p) are algebraically negative and highlight the fact that a major efficiency of E-R (X_e < X) is due to an efficient industrial sector mix and lower Emissions of GHG per unit of Added Value. It also shows an algebraically positive sign for the third factor (a), the covariance between m and p. This suggests an absence of specialization in E-R in the most efficient sectors, on average. A negative sign for *a* would indicate an effective mix of the first two effects. On the whole, the efficiency advantage of E-R (-18%) would appear to be associated with a factor of greater specific environmental efficiency (p= -0.0752752) rather than to reasons of sectoral specialization (m=-0.0248043), if they exist.

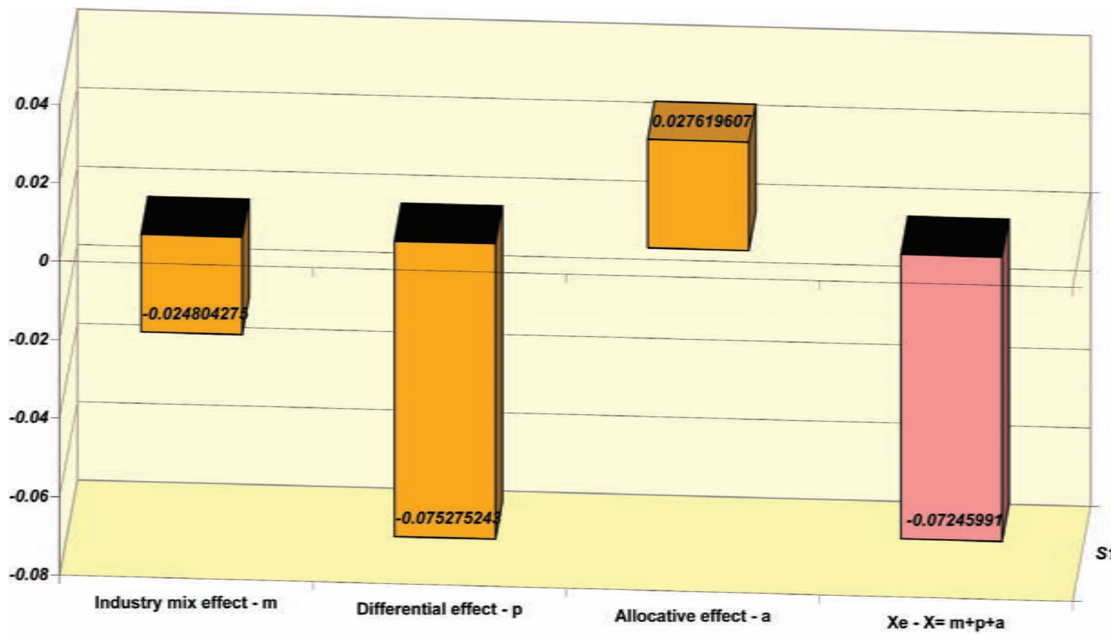

Figure 7
Three effects of Shift-Share Anlaysis of the Full Economy (E-R /Italy) X_e-X= m+p+a
Source: Ramea 2000:

Shift-Share Analysis of Regional Economic Fields (compared to the national average)

A further analysis of all of the economic sectors allows further interpretation within the regional economic system in terms of effects identified by Shift-Share. Mazzanti et al. (2006) also used this approach.

Starting the analysis from the efficiency gaps without distinguishing between the three different drivers (*industry mix, national share, allocative components*), in order to continue with the Shift-Share analysis and with the possible differences compared to the analysis identified in the whole economic system, it is evident that the analysis of the economic sectors does not confirm a huge variation in Emission Intensity across the sectors in E-R. It can then be verified whether or not the efficiency, in terms of Emissions per Unit of Added Value, where it still exists, is lower or higher in the macro-fields compared to the average data (benchmarking between regional and national average economic system), i.e. how much each sector contributes to the average advantage.

Such a comparison shows the cases in which the gap, favourable to the E-R whole economic system, is greater if it is analyzed specifically for the economic sectors. Only one sector (E) gives the relative advantage to the region in terms of Emissions per Unit of Added Value. In fact Figure 8 shows that the differential of efficiency per sector is higher or lower if compared to (X_e - X).

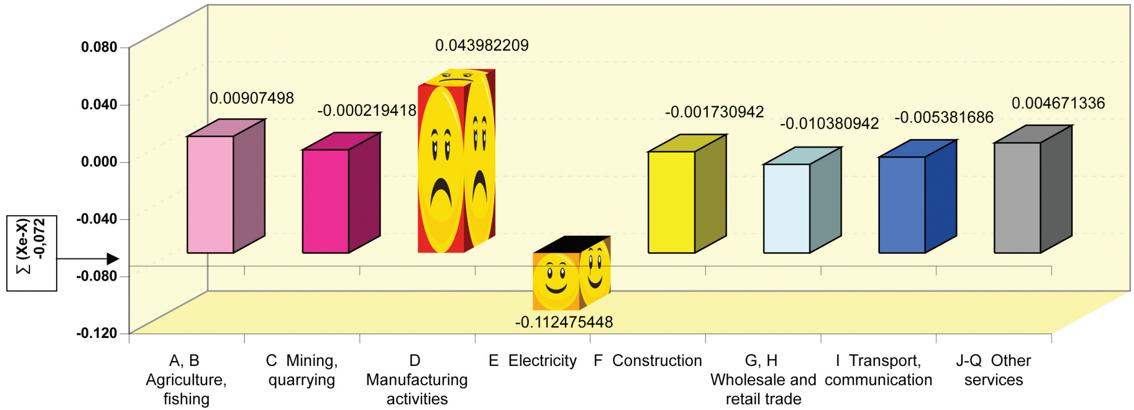

Figure 8

Benchmarking between Sectoral & Average Differential for the Full Economic System $[(X^s_e - X_s)/(X_e - X)]$

Source: RAMEA 2000

The Shift-Share sectoral factorization shown in Figure 9 highlights other interesting aspects in relation to GHG emissions. Such results always relate to the comparison of the efficiency (and the linked drivers) of identified sectors with the national average efficiency. Starting from the result of a lower Emission Intensity in E-R, by comparing the sectors C, E, F, G+H, I to the corresponding sectors in national Italian economy, it is possible to measure and to rank the efficiency of the regional sectors, whilst also referring to their environmental efficiency.

In relation to GHG Emissions, the positive differential (algebraically negative) of E, compared to the efficiency in E-R on average, depends on the greater *industry mix* (m) and *differential* (p) effects, compared to the remaining sectors. Consequentially it would appear that the structure of Added Value is particularly effective in terms of efficiency of emissions (maximum negative value among the *p*) and of sectoral combination (maximum absolute value among the *m*); the positive sign of covariance remains and confirms the previous findings, i.e., the region does not specialize in sub-sectors with high environmental efficiency in terms of GHG Emissions.

In relation to sector D, the reverse is identified, with the maximum negative differential (algebraically positive) compared to efficiency found for E-R on average and compared to the other sector gaps. The greater relative difference derives from the contributions of the sectoral effect (maximum positive value among the *m*) and of specific emissions (maximum positive value among the *p*). The positive sign of the covariance would indicate value in continuing with a Shift-Share analysis of the manufacturing (D) sub-sectors.

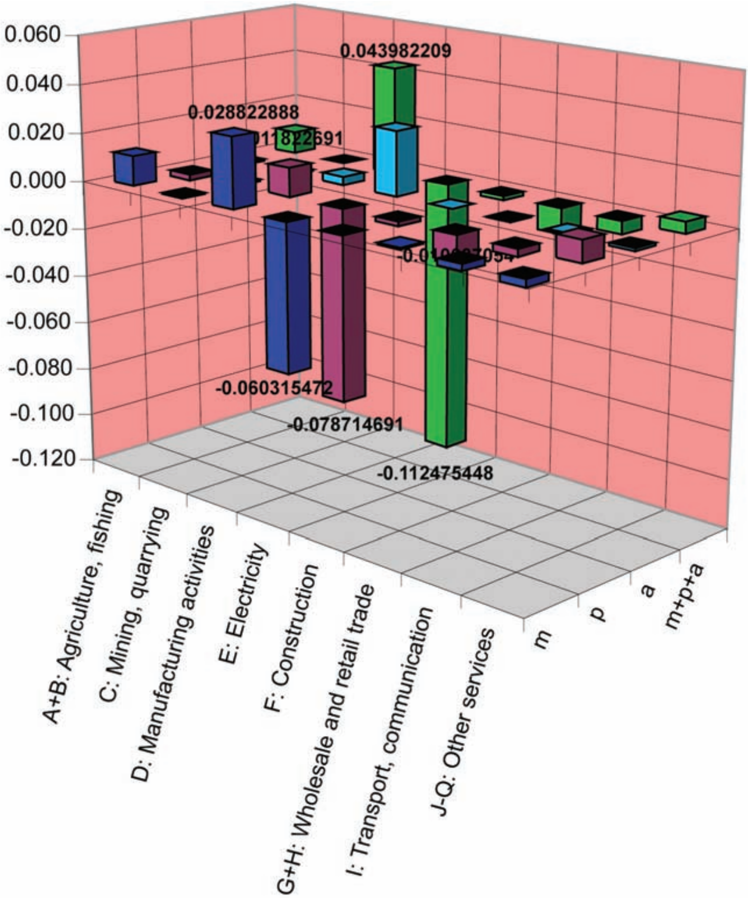

Figure 9
Sectoral Shift-Share Anaysis: Trend of Coefficients
Source: RAMEA 2000

Table 3 - Shift Share matrix

Total economic activities	$\sum X_e$	$\sum X$	$\sum (X_e\text{-}X)$	$\sum(m_e+p_e+a_e)$	$\sum m_e$	$\sum p_e$	$\sum a_e$
GHG	0,3404994	0,4129593	-0,0724599	-0,0724599	-0,0248043	-0,0752752	0,0276196
deviation %			-18%				
A+B: Agriculture, hunting and forestry, fishing	X^s_e	X^s	$(X^s_e{*}P^s_e) - (X^s{*}P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	1,6036195	1,6925946	0,0090750	0,0090750	0,0122109	-0,0024940	-0,0006419
deviation %			19%				
C: Mining and quarrying	X^s_e	X^s	$(X^s_e{*}P^s_e) - (X^s{*}P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	0,2843369	0,1346742	-0,0002194	-0,0002194	-0,0004528	0,0007365	-0,0005032
deviation %			-33%				
D: Manufacturing activities	X^s_e	X^s	$(X^s_e{*}P^s_e) - (X^s{*}P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	0,5483483	0,4914558	0,0439822	0,0439822	0,0288229	0,0118227	0,0033366
deviation %			43%				
E: Electricity, gas and water supply	X^s_e	X^s	$(X^s_e{*}P^s_e) - (X^s{*}P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	5,0695846	9,0570952	-0,1124754	-0,1124754	-0,0603154	-0,0787146	0,0265547
deviation %			-63%				
F: Construction	X^s_e	X^s	$(X^s_e{*}P^s_e) - (X^s{*}P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	0,0149001	0,0491699	-0,0017309	-0,0017309	-0,0000421	-0,0017182	0,0000294
deviation %			-70%				
G+H: Wholesale and retail trade, hotels and restaurants	X^s_e	X^s	$(X^s_e{*}P^s_e) - (X^s{*}P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	0,0531170	0,1169122	-0,0103809	-0,0103809	0,0005637	-0,0106371	-0,0003076
deviation %			-53%				
I: Transport, storage and communication	X^s_e	X^s	$(X^s_e{*}P^s_e) - (X^s{*}P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	0,4763596	0,5165247	-0,0053817	-0,0053817	-0,0026492	-0,0029385	0,0002060
deviation %			-14%				
J-Q: Other services	X^s_e	X^s	$(X^s_e{*}P^s_e) - (X^s{*}P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	0,0730957	0,0538107	0,0046713	0,0046713	-0,0029422	0,0086680	-0,0010545
deviation %			19%				

6.2.2 Analysis of Findings

Shift Share Analysis of the Manufacturing (D) Sub-sectors

A Shift-Share analysis in the macro-sector D highlights those components that contribute positively and negatively to the overall disadvantage of the field and those that confirm a non-efficient regional specialization. Such analysis is suggested by the positive covariance of sector D (a= 0,0033366 the region is not specialized in sub-sectors with greater environmental efficiency in terms of emissions of GHG).

Table 4 - Shift Share coefficients of sub-sector DI

DI Fabrication of non- metallic products	X^s_e	X^s	$(X^s_e*P^s_e) - (X^s*P^s)$	m_s	p_s	a_s
GHG	2,4742436	2,5881831	0,1597444	0,1749735	-0,0075262	-0,0077029
deviation %			93%			

The differential is the maximum positive value (0,1597444) and as a consequence the sector is highlighted as that with the most negative impact. However a good specific environmental efficiency is connected to a non-efficient sectoral composition of the economy (m_s=0,1749735).

Table 5 – Shift-Share Coefficients of Sub-sector DF

DF Coke processing industries and treatment of nuclear fuel	X^s_e	X^s	$(X^s_e*P^s_e) - (X^s*P^s)$	m_s	p_s	a_s
GHG	0,1080430	6,6672333	**-0,0718431**	**-0,0555891**	**-0,0709423**	0,0546883
deviation %			-99%			

Industry mix and *differential* effects are shown by maximum negative values (m_s= -0,0555891 and p_s= -0,0709423) and therefore give the maximum positive impact on the differential of sector D (-0,0718431). Between these two effects, the specific sub-sectoral efficiency prevails.

Shift Share Analysis Outputs

On the whole, therefore, the relative efficiency of E-R compared to Italy is explained more by a lower effective Emission Intensity per unit of Added Value, rather than by an efficient sectoral composition of the economy in terms of emissions produced. The covariance between the two effects (a), that of sectoral mix and of specific efficiency, is positive, which means that E-R is not characterized particularly by a specialization in sectors in which its differential in terms of emissions is greater than the national average. The most efficient sectors are not with those have the greatest impact on the economy.

Continuing with the Shift-Share analysis of single economic sectors produces some further results, indicating that the total differentials of efficiency for GHG do not remain in favour of E-R for every sector (see Figure 10). As far as the observed differential for the regional average is concerned, it can be seen that the macro-sectors contributing the most to the region's positive advantage are, in order of priority, (i) E (ii) G+H (iii) I, (iiii) F, (v) C. The sectors with the greatest negative impact on the regional average are, in increasing order vi)J-Q 7) A+B, 8) D.

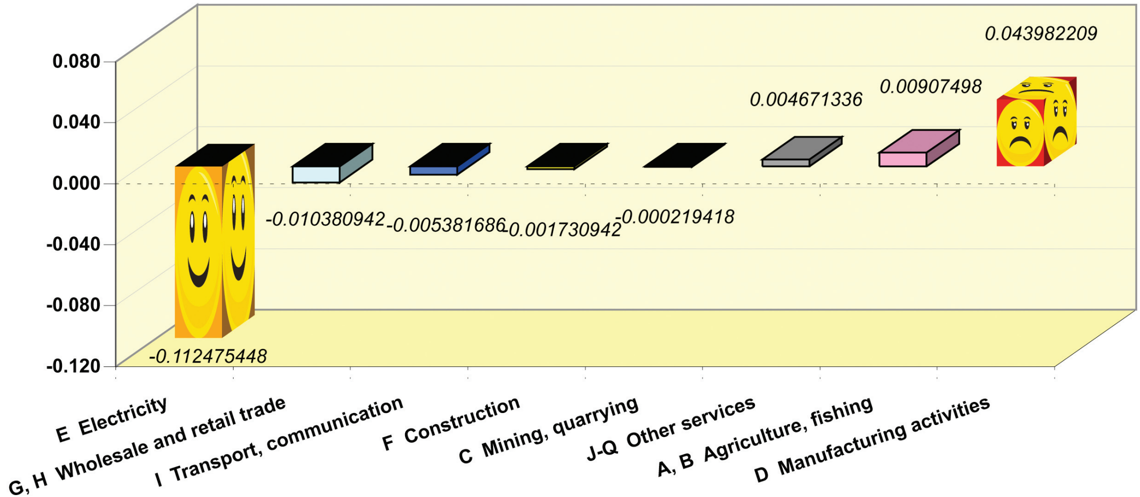

Figure 10
Sectoral Shift-Share Analysis ((E-R/Italy)
Source: RAMEA 2000

We can observe that the sector E contributes more positively than the other sectors to the positive differential efficiency of E-R compared to Italy. The sector E seems to be the main sectoral driver of the relative efficiency of E-R in terms of Emission of GHG (-0,1124754).

The same sector itself turns out to be also more efficient than the others from the point of view of environmental-specific efficiency (p maximum relative value) and from the point of view of industry-mix effect (m maximum value). Instead it is sector D which contributes the most negative effect on the average differential of economy (0,0439822): in particular all the three effects are >0, unlike all the other cases, with maximum values both for the effect *m* and for *p*.

A possible policy strategy to address this could entail a combined mix of regional development and environmental policy in the sector. The positive covariance indicates a non specialization of the macro-sectors with a greater comparative advantage (low Emission Intensity), that is, in the most efficient sectors (positive mix of m and p: m and p<0). Through further analysis in the sub-sectors, the *Ceramics* sector is been identified as having the disadvantageous differential. The relative ranking of the manufacturing sub-sectors (D) is shown in Figure 11.

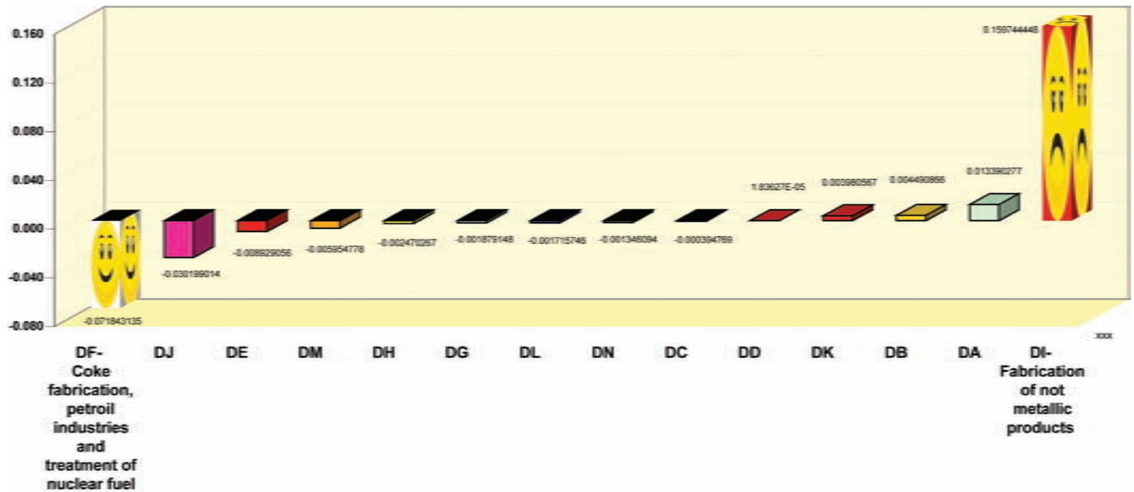

Figure 11
Shift-Share Analysis of Sector D (Emilia-Romagna / Italy) : (Xde*Pde-Xd*Pd)
Source: RAMEA 2000

Considering the sector A+B, which ranks second in relation to the most negative effect on the whole differential of the economy (0,0090750), the industry-mix effect denotes that inside this sector, the Added Value composition is not effective in terms of emission efficiency, even if the negative sign of the effect p remains. A negative covariance could influence regional policy to try and develop those sub-sectors with a lower Emission Intensity in order to make the most of this comparative advantage.

In no sectors is there a positive combination of the three effects (m, p, a<0); however more sectors are characterized by an environmental-specific efficiency (in decreasing order G+H, I, A+B, F). A general approach on how to derive and analyze the Shift-Share signs is explained in Foderà *et al*. (2005). In these sectors where, as a result of an analysis of the total air emissions for the sector, it is possible to verify a covariance <0 corresponding to an effect where m<0, regional strategies could encourage and / or develop sectoral technologies with lower air emissions, whilst increasing the positive effect on the economy. This would connect the impact due to the sectoral specialization (m<0) with a greater efficiency in terms of emission of GHG (in this case: C, J-Q).

Table 6 - Synthesis of the Shift-Share analysis for Sectors D, E, A+B

Sector	Impact	Comments	Notes
D	the most negative impacting ($Xs_e – Xs$ = 0439822)	All the three effects are >0. The factors m and p are the highest. The Industry mix effect quantifies the higher part of Intensity of emission given by the weight of the sector D on the regional economy, compared to the national average.	Shift Share analysis of the sub-sectors
E	the most positive impacting ($Xs_e – Xs$ = -0,1124754)	m and p are <0 and are relatively higher. More sector efficiency compared to the national average deriving both from the economy sectoral composition and from reasons connected to the lower emissions of GHG for unit of Added Value.	
A+B	the second sector for the disadvantage brought to the whole differential of the economic system: $Xs_e – Xs$ = 0,0090750	Effect p<0, good environmental efficiency of emissions of GHG Effect m>0, shows that inside this sector the Added Value structure is not effective in terms of efficiency of emissions compared to the national average, even if the p sign is algebraically negative.	Covariance <0

Understanding the Indirect Effects / Responsibilities of Electricity Sector

As stated above (par. 6.1) the RAMEA (and NAMEA) approach considers the producer directly responsible for direct environmental pressures generated. The use of Input-Output (I/O) tables allows an analysis of the interface between the economy and the environment, based on the model proposed by W. Leontief in the 1970s, to identify not only which sectors directly contribute to production and any related pollution ("Producer Responsibility"), but also the sectoral and household responsibility related to the indirect impacts of consumption ("Consumer Responsibility").
In particular:

"the more an industry uses products of which the production is intensive in terms of pollution, the higher is the pollution indirectly caused by the production necessary to satisfy the final demand of its product"
(Eurostat 2004:71).

With the I/O table available in RAMEA, it is possible to highlight the consumption impacts of the sectors and households through their demand for electricity (Figure 12) and thus understand who is indirectly responsible for the high impact of this sector on the regional air emissions. The chart shows the different contribution to the total purchase from sector E, i.e. electricity demand from whom and by how much. This shows that part of the electricity produced is used to meet the needs of sectors DI (10.3%), E itself (9.9%), and Other Services and Commerce together (15.8%). However the biggest demand is from households, which could be held indirectly accountable for 34% of the emissions from sector E.

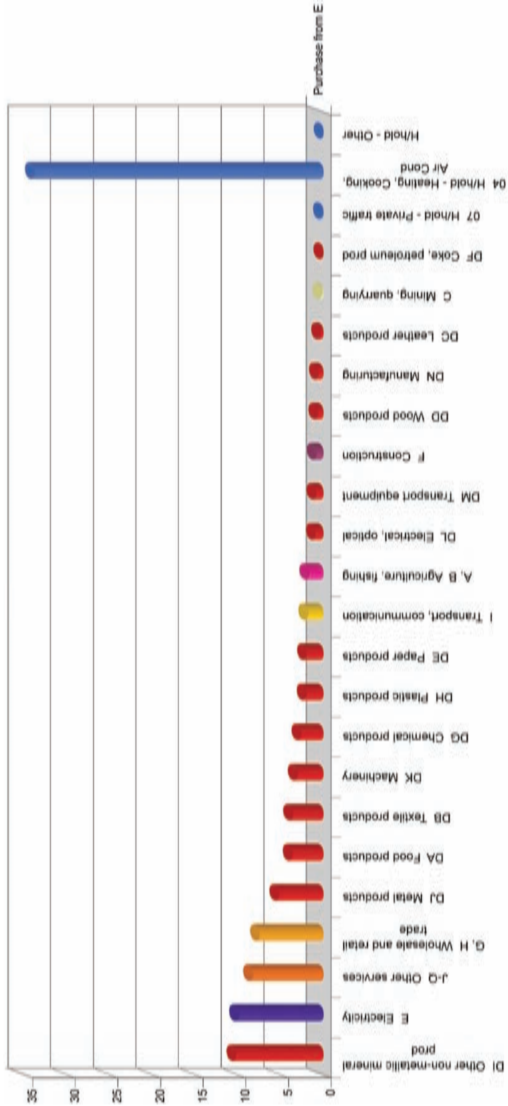

Figure 12
Indirect Sectoral Impact of Consumption from Sector E (Electricity, Gas and Water Supply) (%)
Source: RAMEA 2000

6.2.3 Use of the Findings from RAMEA

It is proposed to apply RAMEA in the Strategic Environmental Assessments (SEAs) of regional plans and programmes to forge a clear link between economy and environment and identify to decision-makers how the region could be developed economically and socially without causing environmental damage. In particular RAMEA can be invaluable in the:

- determination of the environmental issues, objectives and indicators that should be considered within an SEA;
- evaluation of the potential effects of plans and programmes on the environment (together with scenario analysis);
- evaluation of monitoring system for the programming document;
- decision-making on the basis of regional environmental information.

In Emilia-Romagna Region, RAMEA could be useful to assess regional plans and programmes prepared for the development of both the whole territory and of the different sectors (Energy, Agriculture, Industry…). Taking account of the results of the Shift-Share analysis, a prototype Decision Support Matrix (Table 7) has been constructed to support policy makers; after illustrating possible scenarios, depending on the possible combination of Shift-Share effects, a number of possible strategies have been identified for sectoral policy.

RAMEA could also be used help to inform the public about the decision-making process and chosen strategies, with the help of the integrated economic-environmental indicators already available or through the development of a single score indicator, like the ecological footprint or carbon footprint.

Table 7 - Effects of Shift Share Analysis & Possible Scenarios (Decision-Support Matrix)

m Industry mix	p Differential	a Allocative[32]	How may Policy Makers react?
-	-	-	
+	+	+	A combined programme of environmental and sectoral development Policy is advisable.
+	-	-	Sectoral development Policy to boost environmentally-efficient sectors.
+	+	-	
-	-	+	Double advantages of the effects m and p. A further Shift Share analysis of the sub-sectors allows us to look into their relative impacts, not being the mix of the effects m e p yet advantageous e.g. RAMEA E-R sector D (manufacturing).
-	+	+	A further Shift-Share analysis can give us information on the situations of the sub-sectors (a>0). An action aiming at the improvement and reduction of the Intensity of emission of sector would be useful.
-	+	-	An effective Environmental Policy can contribute to the technological development of sector. Besides improving the positive effect on the average economic system, it could combine the weight given by the sectoral specialization (m<0) with a greater efficiency in terms of emissions of GHG.

[32] Covariance

The availability of a more extended set of RAMEA together with analysis of all air, waste and water emissions, would allow this kind of analysis to be extended. In particular, it would be possible to characterize the trend of the three effects identified by Shift-Share analysis, separating out the trend of production structure factors and objectives of regional policy, from the trend of specific efficiencies, connected to the state of technologies and of the regulations and therefore objectives of the environmental policy.

6.3 Monitoring and Upgrading Proposals

RAMEA for Emilia-Romagna Region was built for years 1995 and 2000. An upgrade of the 2000 version for the year 2003 was developed for the benchmarking between RAMEA partners: while the 1995 and 2000 versions are based on robust data, the 2003 version, despite its suitability for the above purpose, should be viewed with lower level of confidence.

A first step in any upgrade should be to improve the 2003 version to the same level of uncertainty / confidence of the others, in order to have a more recent year and consistent time series. This will need considerable effort to gather sufficiently robust environmental data on air emissions which, in comparison to economic data, are usually updated less frequently. On the other hand environmental data are becoming more and more important for planners and, as related to the economic data, are of particular importance for the reduction of GHG emissions through trading schemes and Kyoto project-based mechanisms[33].

Another potential improvement under consideration is the extension of the RAMEA framework to include additional environmental aspects, such as liquid and solid waste, eutrophication, direct and indirect effects of energy, and the inclusion of the social dimension.

[33]see in particular Directive 2003/87/EC "Emissions Trading" and Directive 2004/101/EC "Linking"