DIPARTIMENTO DI ECONOMIA
UNIVERSITÀ DEGLI STUDI DI PARMA
Via J. F. Kennedy, 6 – 43100 Parma – Italia

P. FABBRI – A. NINNI

ENVIRONMENTAL PROBLEMS AND DEVELOPMENT POLICIES FOR RENEWABLE ENERGY IN BRIC COUNTRIES

WORKING PAPER EP02/2015

Environmental Problems and Development Policies for Renewable Energy in BRIC Countries

by **Paolo Fabbri** [1]– **Augusto Ninni**[2]

1. The sustainability issue at the BRICS[3] summits and within official declarations

One of the most relevant and compelling issues faced by the BRIC countries (i.e. Brazil, Russia, India and China) in the current economic climate, concerns the environmental and energy fields, especially in the face of the present economic stagnation.

The VI BRICS Summit[4] was devoted mainly to social inclusion and sustainable development. The debate was based on the slogan "Inclusive growth: sustainable solutions". During the summit, an Agreement on the New Development Bank was signed in order to address the "…significant financing constraints to address infrastructure gaps and sustainable development needs"[5].

One of the many commitments of New Development Bank (NDB) is:

"DESIROUS to contribute to an international financial system conducive to economic and social development respectful of the global environment;"[6]

while the Final Declaration of Fortaleza states that:

#54. "The agenda should integrate the economic, social and environmental dimensions of sustainable development in a balanced and comprehensive manner with concise, implementable and measurable goals,…"

#55. "We reiterate our commitment to the UN General Assembly Open Working Group on Sustainable Development Goals (SDGs) …"[7]

At the UNFCCC meeting in Bonn (June 2014), the BRICS group established a financial instrument (NDB) for future challenges in a world that is just coming out of a crisis; many interested contributors from both developed and developing countries have indicated that they will be making financial pledges to the Green Climate Fund (GCF).

The Fund, established during the 2010 Conference of UNFCCC (United Nations Framework Climate Change Convention) States Parties (held in Cancun), was designated as an operating entity of the financial mechanism of the Convention. It will aim to make a significant and ambitious contribution to the efforts towards attaining agreed international goals on fighting against climate change, including a shift towards low-emission and climate-resilient development pathways by providing support to developing countries.

The Initial Mobilization Resource should be around US$ 10billion, according to the latest decisions of the GCF Board.

So there are various financial instruments devoted to dealing with future challenges in sustainable development. These instruments have an impact on main environmental indicators. But, what about

1 Parma University, Department of Economics; paolo.fabbri@unipr.it
2 Parma University, Department of Economics; augusto.ninni@unipr.it
3 Our analysis does not include South Africa
4 Fortaleza and Brasilia 2014, 6th Summit of Heads of State and of Government of BRICS.
5 Fortaleza, 2014, Agreement on the New Development Bank
6 Fortaleza, 2014, Agreement on the NDB, Annex 1
7 Fortaleza 2014 Declaration

situation and trend of environmental main indicators? GHG emission and removal are important elements amidst efforts to achieve the objective of "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system"[8]

After COP 18 in Warsaw (Poland), in 2013, where trends were updated, the contribution of BRIC countries towards the objective of stabilization is now clear.

2. The environment trend in the BRIC countries

First of all, we must analyze the recent trends of GHG emission in BRIC, based on the UNFCCC database. [9] Unfortunately, only Annex I Parties provide "projection data", made available for 2020 and 2030 under the 'with measures', 'with additional measures' and 'without measures' scenarios[10].

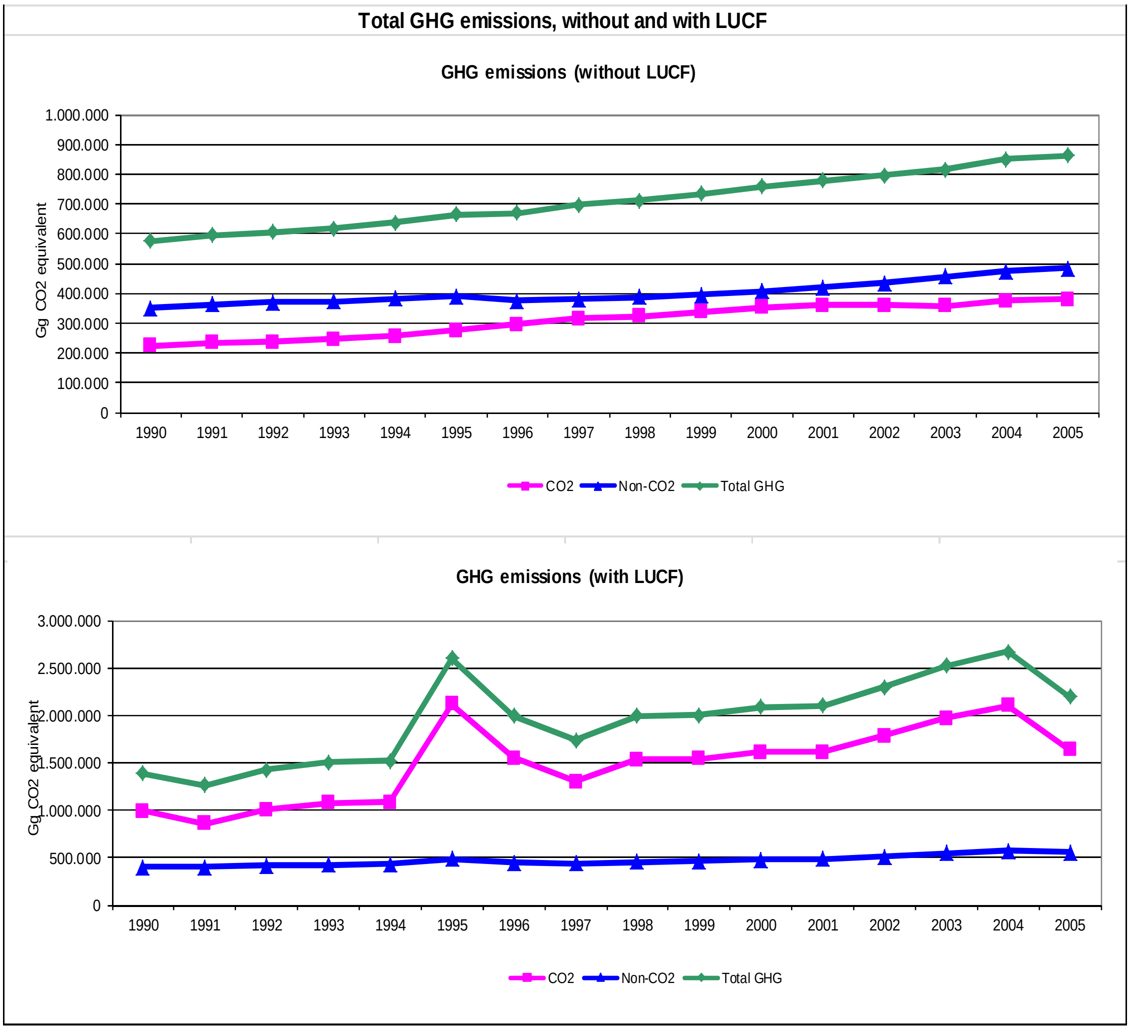
The main data are represented with or without LUCF and LULUCF (Land-use and Land-use and change forestry). Following the definition of UNFCCC, the rate of the increase of CO_2 in the atmosphere can be reduced thanks to the fact that atmospheric CO_2 can accumulate as carbon in vegetation and soils in terrestrial ecosystems (namely, "sink"). Human activities impact terrestrial "sinks" through land use, land-use change and forestry (LULUCF) activities. As a consequence, the exchange of CO_2 (carbon cycle) between the terrestrial biosphere system and the atmosphere is altered. The role of LULUCF activities in the mitigation of climate change has long been recognized. Mitigation can be achieved through activities in the LULUCF sector that increase the removal of greenhouse gases (GHGs) from the atmosphere or decrease emissions by sources leading to an accumulation of carbon stocks. An important feature of LULUCF activities in this context is their potential reversibility and thus non-permanence of the accumulated carbon stocks.

The BRIC data demonstrate the impact and role of LULUCF activities in measuring emission trends/removal. Country case studies will be analyzed as follows.

BRAZIL

Graph 1. Emission trends, Brazil.

[8] Here is the ultimate objective of UNFCCC.
[9] GHG Data Interface are updated to the latest GHG data received by the secretariat as of **28 May 2014**, which includes the 2014 national GHG inventory submissions.
[10] GHG Data Interface by UNFCCC.



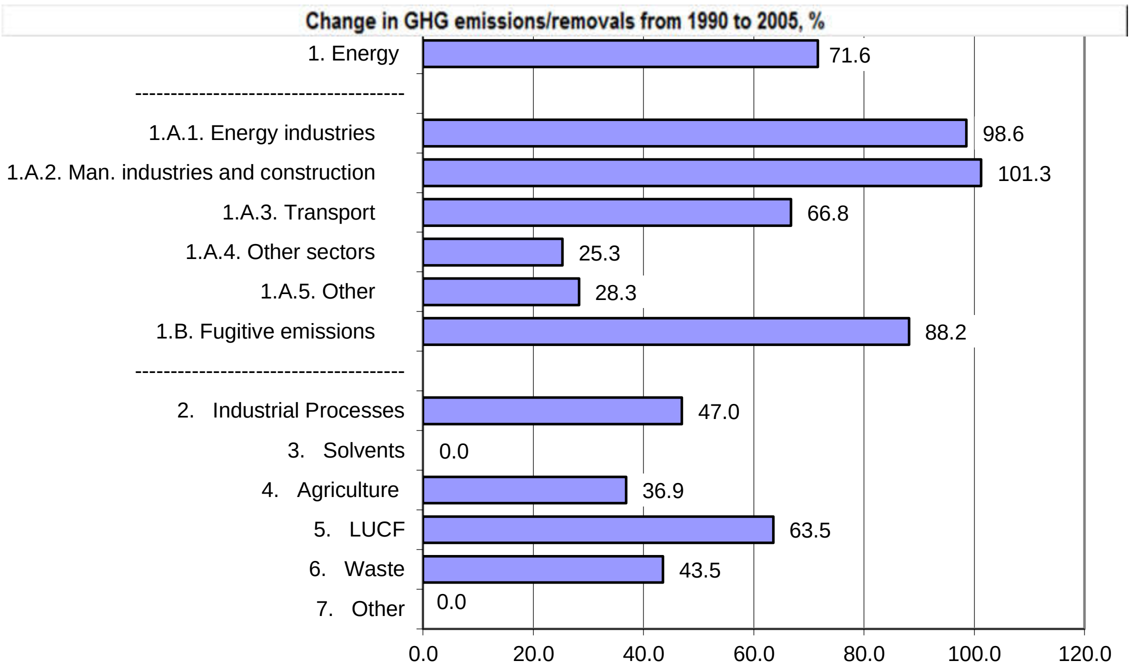
Source: UNFCCC, GHG Inventory Data.

Net GHGs emission peaked in 1995 (Graph 1) following new policies on car fuel, and subsequently decreased. According to latest data from the Observadorio do Clima[1], the decreasing trend of GHG emission reached its minimum low in 2012 since 1992 (1,48 Gigatons in 2012, 1,43Gt. in 1992).

During the same period (1990-2005) change in GHGs removals is shown in Graph 2:

[1] Tasso Rezende de Azevedo and Carlos Rittl, 2014.

Graph 2. Brazil, Total change in emissions/removals.

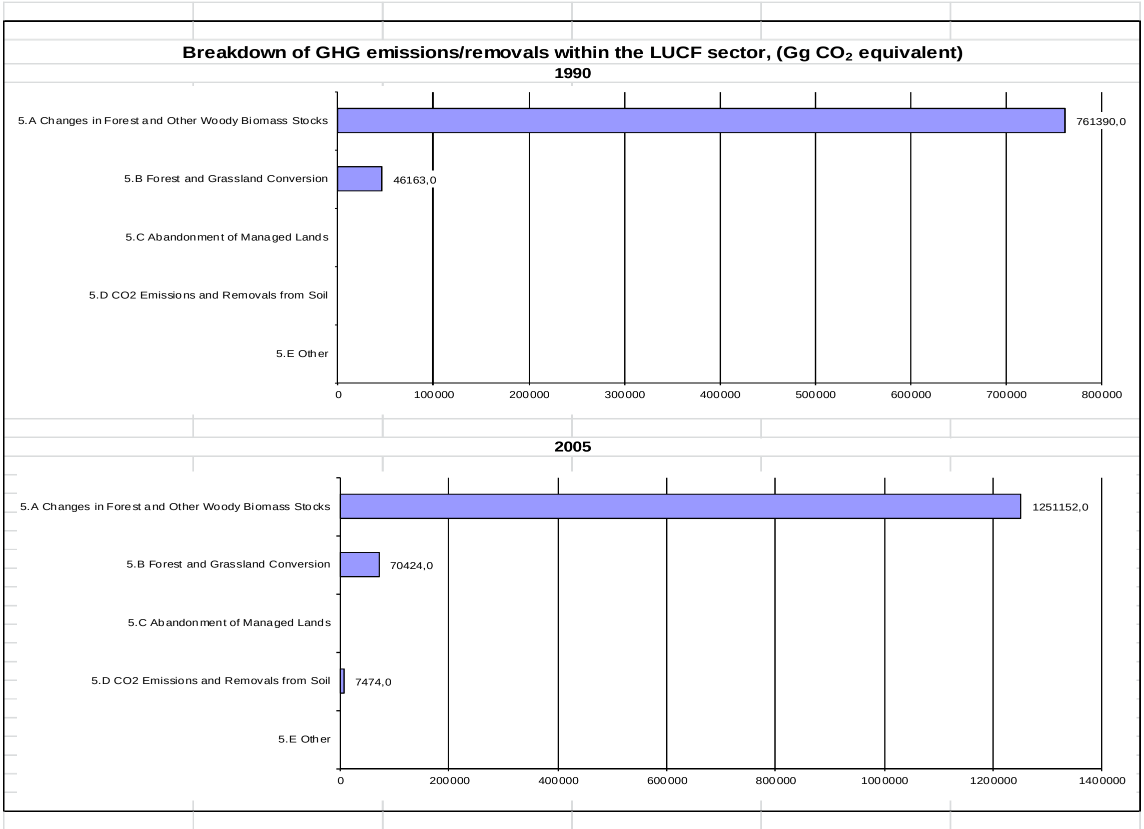


Source: UNFCCC, GHG Inventory Data.

Graph 2 shows that the energy sector (see total and disaggregates %) was more relevant than industry and other sectors.

The relevance of LUCF is given by the breakdown of GHGs emissions/removals in graph 3:

Graph 3. Brazil, Change in emissions/removals within LUCF sector.



Source: UNFCCC, GHG Inventory Data.

RUSSIA

The Russian Federation shows a longer time series compared to Brazil, as well as LULUCF decreasing from the '90s onwards, due to different policies of Land-use and forestry management.

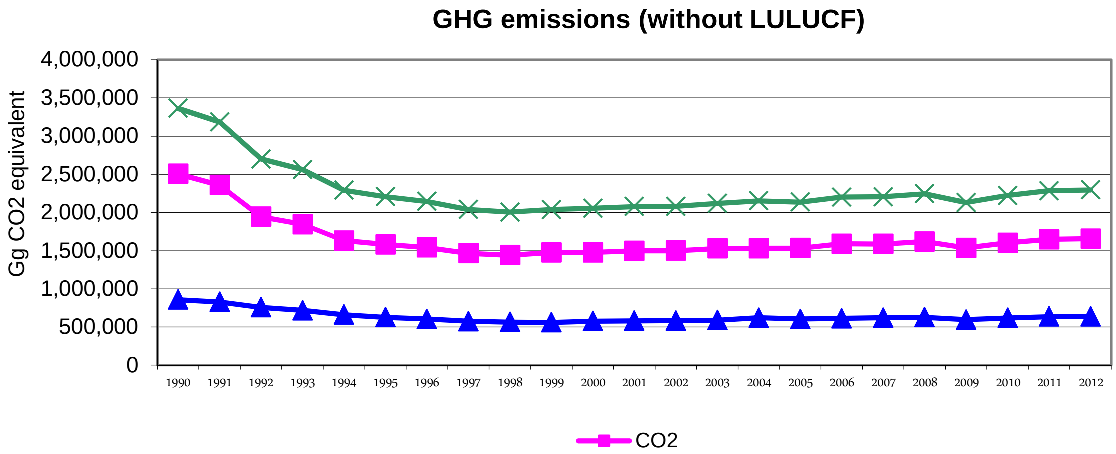
Activities and programs devoted to "sinks" had their impact before 2000 (see the greater decreasing trend of LULUCF data until 2000 in Graph 4).

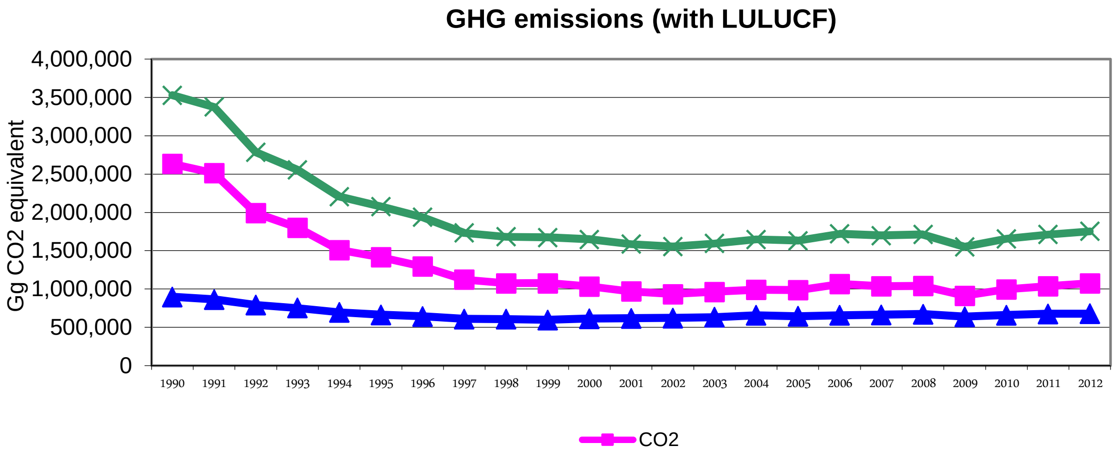
Main concerns are about LULUCF, as "According to recent scientific analyses, net CO2 sinks by Russia's managed forests (the term used by the UNFCCC) will dramatically decrease. If forest management continues its wide commercial cutting of primary forest, this net sink will reach zero by 2040"[12].

The total emissions are shown in Graph 4, from 1990 to 2012.

[12] Kokorin, Korppoo, 2014.

Graph 4. Emission trends: Russian Federation.

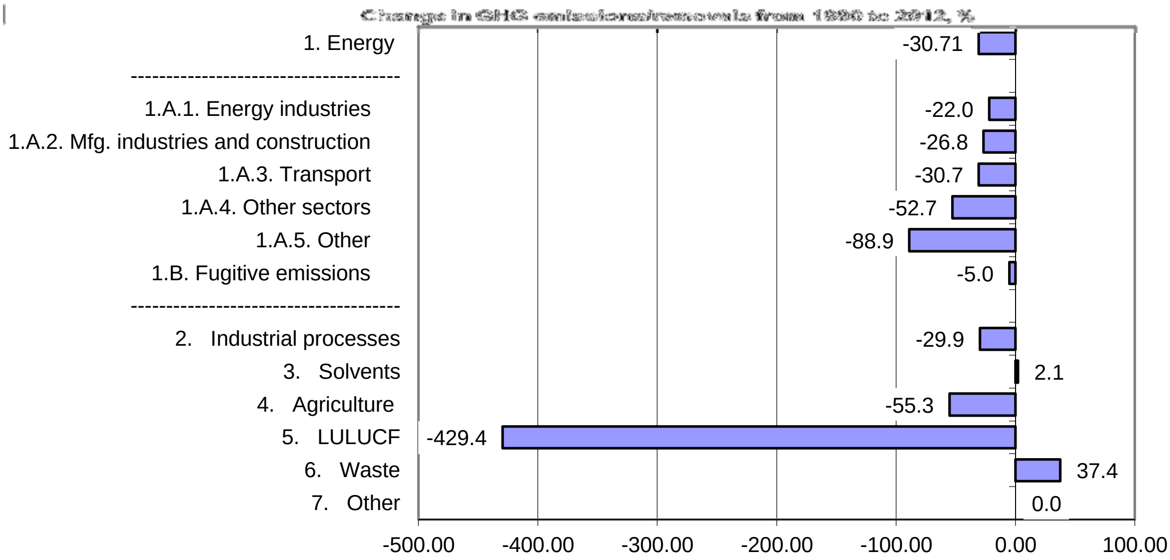




Source: UNFCCC, GHG Inventory Data.

Graph 5 underlines the relevance of Land Use and Forest Management in Russian Federation.

Graph 5. Russian Federation, Total change in emissions/removals.

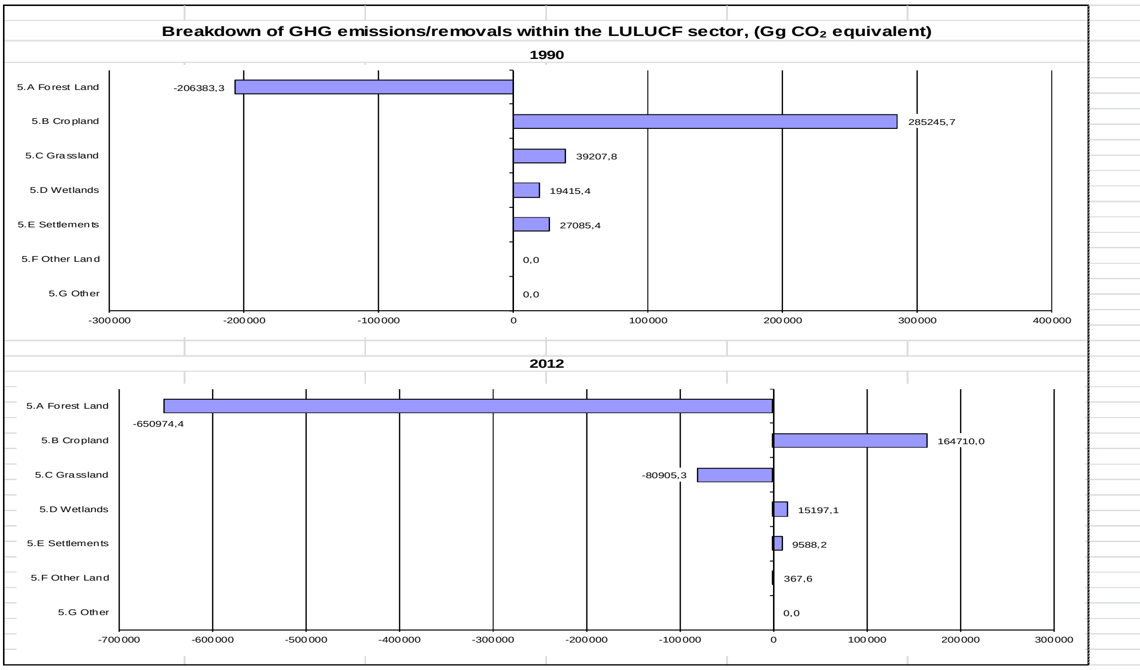


Source: UNFCCC, GHG Inventory Data

The LULUCF sector outweighs all other economic sectors, and only "waste" shows a net positive trend.

In a certain way, the Russian LULUCF course presents a trend which runs counter to other BRIC countries. Graph 6 illustrates the concerns about needs of new forest management, due to increasing negative data.

Graph 6. Russian Federation, Change in emissions/removals within LULUCF sector

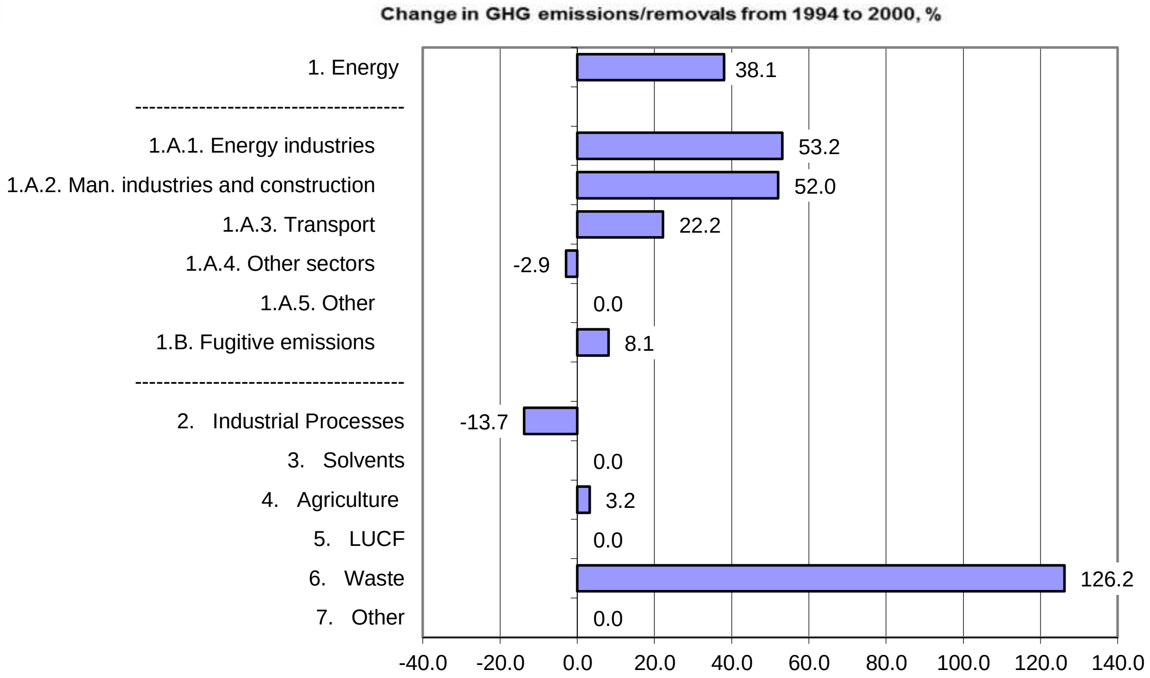


Source: UNFCCC, GHG Inventory Data

INDIA

Data in India are not as readily available as in previous countries. It has not been presented by time series for the last 20 years, but only for 1994 and 2000; this is due to specific problems related to their national statistic system (harmonization of statistical techniques is an objective of UNFCCC).

Graph 7. India, Total change in emissions/removals.



Source: UNFCCC, GHG Inventory Data

In Graph 7 we can appreciate total change of emissions/removals, with a major impact of waste sector.

Original figures (Table 1) help us to show the limited impact of LULUCF policies on net trend, which highlights the need for more accurate statistics to analyze India's trend.

Table 1. India, Emission Summary

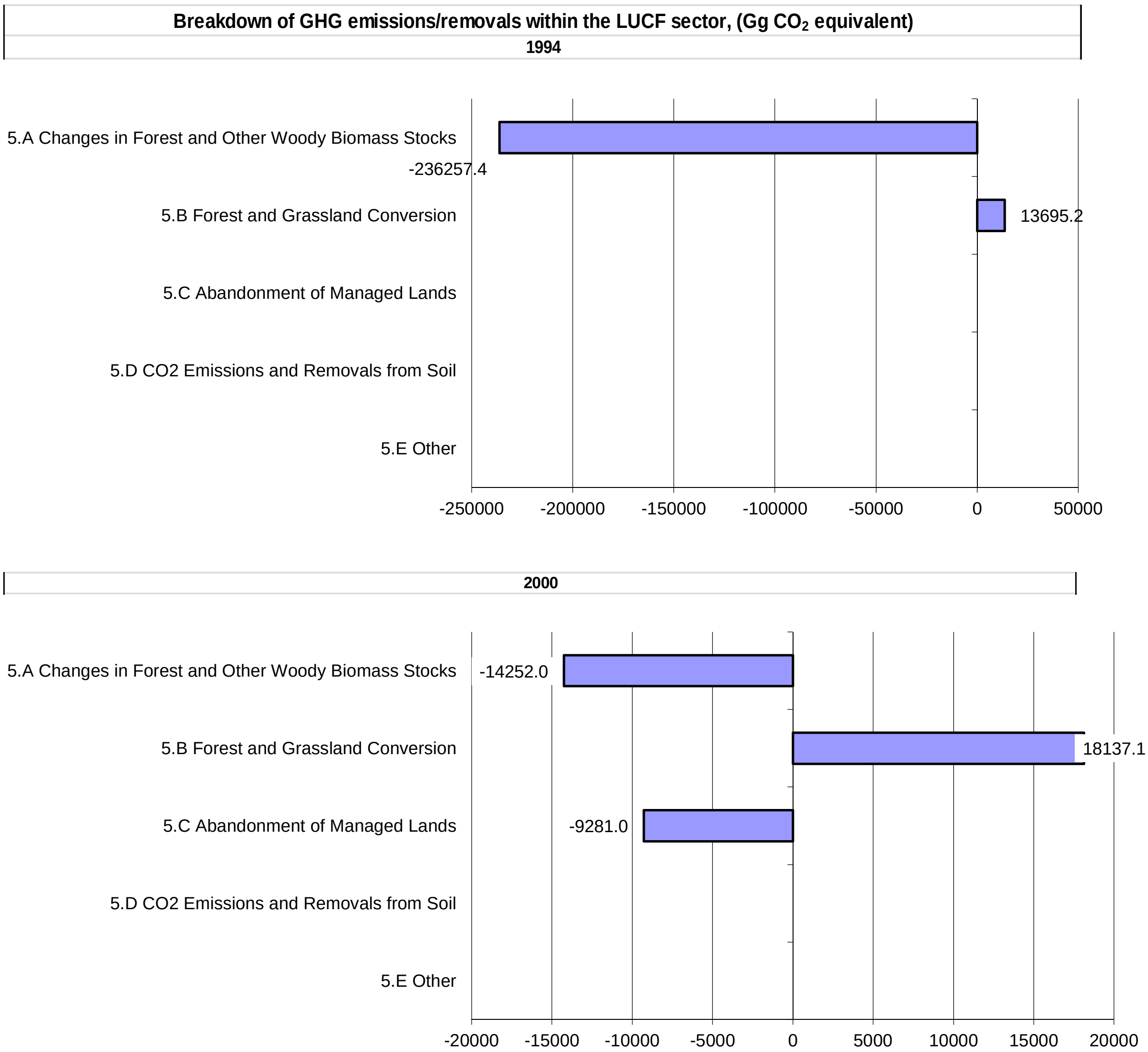
	Emissions, in Gg CO_2 equivalent		
	1994	2000	Latest available year (2000)
CO2 emissions without LUCF	779.348,0	1.024.772,9	1.024.772,9
CO2 net emissions/removals by LUCF	14.142,0	-236.257,4	-236.257,4
CO2 net emissions/removals with LUCF	793.490,0	788.515,4	788.515,4
GHG emissions without LUCF	1.214.248,0	1.523.766,6	1.523.766,6
GHG net emissions/removals by LUCF	14.292,1	-222.562,2	-222.562,2
GHG net emissions/removals with LUCF	1.228.540,1	1.301.204,3	1.301.204,3

Source: UNFCCC, GHG Inventory Data

Data show the great negative net amount of forest and other biomass stock, as well as abandonment of managed lands in 2000. On the other hand, the impact of Forest and grassland conversion presented a positive trend in the same year.

In Graph 8 we find the decreasing trend of negative LUCF sector towards a net zero value. Best practices and policy commitment were effective during this interval.

Graph 8. India, Breakdown of GHG emissions/removals within LUCF sector.



Source: UNFCCC, GHG Inventory Data

CHINA

As in the case of India, China's official statistics to UNFCCC do not include an annual trend, but only data in 1994 and 2005.

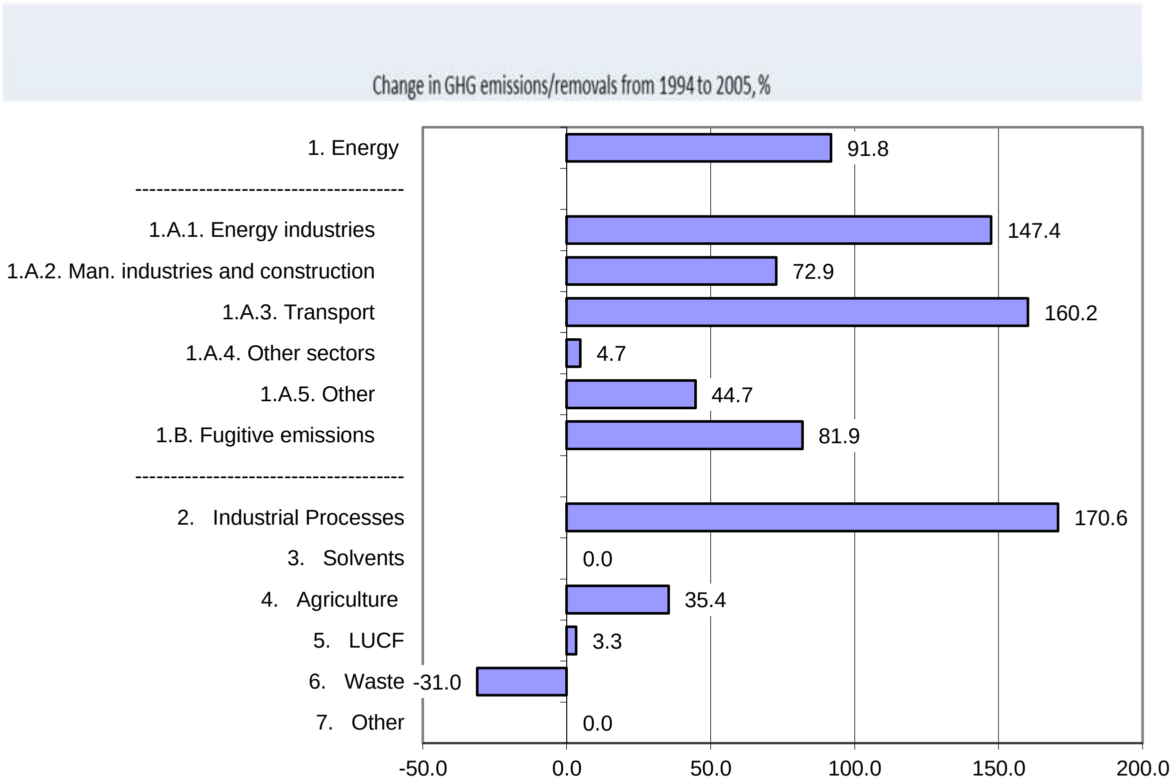
Table 2. China, Emission Summary.

	Emissions, in Gg CO_2 equivalent		
	1994	2005	Latest available year (2005)
CO2 emissions without LUCF	3.073.470,0	5.975.568,0	5.975.568,0
CO2 net emissions/removals by LUCF	-407.479,0	-421.530,0	-421.530,0
CO2 net emissions/removals with LUCF	2.665.991,0	5.554.038,0	5.554.038,0
GHG emissions without LUCF	4.057.617,0	7.465.861,7	7.465.861,7
GHG net emissions/removals by LUCF	-407.479,0	-420.817,0	-420.817,0
GHG net emissions/removals with LUCF	3.650.138,0	7.045.044,7	7.045.044,7

Source: UNFCCC, GHG Inventory Data

Table 2 shows the negligible impact of LULUCF activities from 1994 to 2005, but at the same time it is important to observe that the net emission has doubled in 15 years (+93%), increasing at an annual rate of +6,2%.

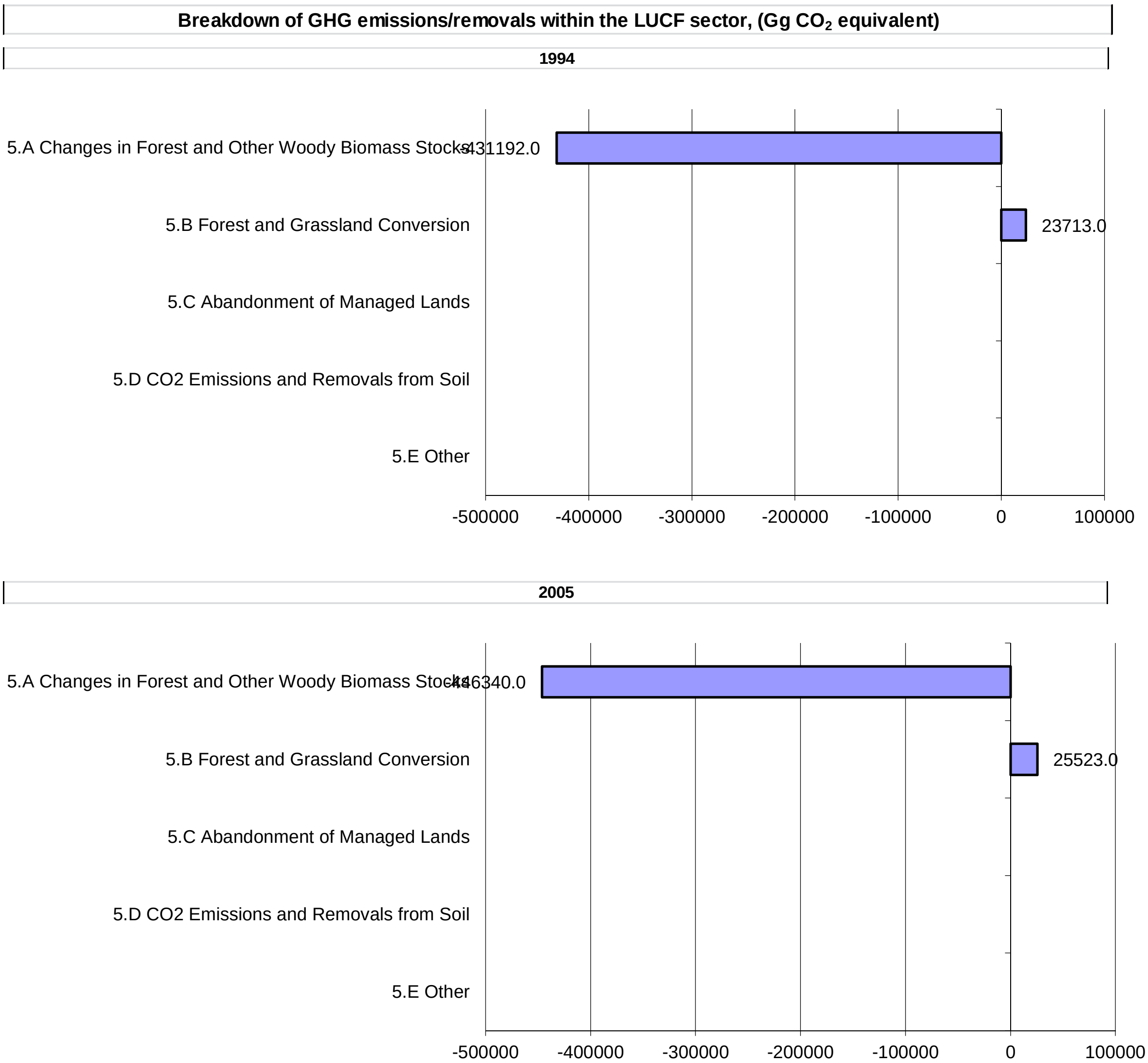
Graph 9. China, Total change in emissions/removals.



Source: UNFCCC, GHG Inventory Data.

Change in total emission (Graph 9) depends on industrial and energy sector, with negative impact of waste.

Graph 10. China, Breakdown of GHG within LUCF sector.



Source: UNFCCC, GHG Inventory Data.

There is no relevant variation in activities and policies during the considered years: Graph 9 shows the great LUCF negative impact on emissions.

As for the Global Environment Outlook[13] and OECD forecast[14], the first challenge for BRIC countries is the decoupling of energy inputs to production, in relative or absolute terms.

This effect is not evident in BRIC countries, partly because of the displacement effect and the delocalization of firms and sectors to emerging countries.

Thus, carbon and energy productivity, as well as resource productivity, are the most important factors responsible of total GHGs emission.

[13] UNEP, 2013.
[14] OECD, 2014.

The interdependence of the economic system means that stabilization of emissions is a global objective, and a deep analysis of emissions related to international trade is a necessary instrument not only for analysis, but also for policy action.

For BRIC countries in particular, production-based productivity (GDP per unit of GHGs emitted) and demand-based productivity (real income per unit of GHGs emitted, equal to production-based plus imports embodied emission, minus exports embodied emission) is the best way of monitoring progress with the aim to "stabilize the concentration of emission of GHGs in the atmosphere at a level that would limit their adverse effect on climate system".

The consequence is that the evaluation of the impact for policy actions (environmental regulation, energy incentives/taxation) is an important element in order to guarantee the best course of action as well as feasible international agreements.

A significant comparative study[15] applied to the situation in China shows how great and significant the consequences of a weak and strong regulation framework on total-factor energy efficiency (indirectly on emission trend) are. Regional and short vs long run differences in China demonstrate that the BRIC emission trend and environmental policies must be "tailored" according to the potential increase of green technology, but also to potential environmental stress to industrial sectors.

The latest commitments of BRIC countries, as declared until COP18, show the difficulties of a general agreement. In the face of a weak pledge on final objectives, there are recommendations on the next steps that should be taken, in particular[16]:

- Brazil: reduction by at least 36.1% of greenhouse gas emissions compared to projected emissions by 2020, SUBJECT TO condition "if…" [17]
- Russia: reduction of GHGs by 15-25% by 2020, (starting point 1990), SUBJECT TO condition "if…"[18]
- India: reduce the emission intensity of GDP by 20-25% by 2020, on 2005 levels (emissions from the agriculture sector not included).[19]
- China: set the target to reduce its CO2 emissions per unit of GDP by 40–45 % by 2020 compared with the 2005 level. Moreover, The National People's Congress approved the

[15] Z. Wang, C. Feng, 2014.

[16] Official communication of Parties to COP 18 and subsequent UNFCCC meetings.

[17] " Brazil has already achieved very positive results in terms of mitigation, and calls on all countries, most notably developed country Parties, to demonstrate this kind of ambitious engagement. Brazil's NAMAs (National Appropriate Mitigation Actions) are to cut emissions by 2020 between 36.1% and 38.9% in relation to BAU (Business As Usual scenario), and we will make it. The reduction in greenhouse gas emissions achieved by Brazil in 2010, in comparison with its 1995 levels, outnumbers the results in emissions reduction achieved by all Annex I countries […] this years' rate is the second lowest since such registration begun, twenty five years ago. We are closely examining the reasons for this. It is clear, nevertheless, that beyond vigorous command and control measures, we should set in place effective economic instruments to valuate environmental assets, such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation)." COP19, 2013.

[18] The range of the GHG emission reductions will depend on the following conditions:
- Appropriate accounting of the potential of Russia's forestry in frame of contribution in meeting the obligations of the anthropogenic emissions reduction;
- Undertaking by all major emitters the legally binding obligations to reduce anthropogenic GHG emissions.
Russian Federation indicated that it does not intend to assume a quantitative emission target, at COP18.
Nonetheless, a Presidential Decree 2013, No. 752, declare "greenhouse gas emissions to be cut by 2020 to the level not more than 75 per cent of such emissions in 1990".

[19] The options considered suggest that with determined efforts, India can bring down the emission intensity of its GDP by 23–25% over the 2005 levels, and with aggressive efforts, the emission intensity can be brought down by as much as 33–35% over the 2005 level. India, 2012, p. 31.

Outline of the 12th Five-Year Plan, which clearly mentions that China will establish statistical and verification systems for GHGs emissions.[20]

3. Energy dynamics in the BRIC countries

As energy production and distribution usually account for around 60-70% % of the emissions of CO2, to focus on the only energy issues can be both useful and worthwhile.

As it is known, the growth of the energy utilization associated with the growth of GDP is what explains the common fear that the high GDP growth rates of the BRIC countries – starting from a low level - should lead to high energy consumption with all its consequences, including high emissions: according to the 2007 edition of the IEA World Energy Outlook 45% of the expected increase of world energy consumption in the period 2005-2050 should come from China and India alone. What was however unknown at the time was the capability of the BRIC countries in lowering their energy intensity, more swiftly and more broadly than expected.

In recent years the energy intensity of the BRIC countries[21] dropped heavily: in the period 2000-2013 it fell more in China, India or Russia more than in some Western countries (Graph 1): - 25 % for China[22] and India, - 33 % for Russia, where however energy intensity was still affected by the kind of economic growth - depleting natural resources - of the communist period[23]

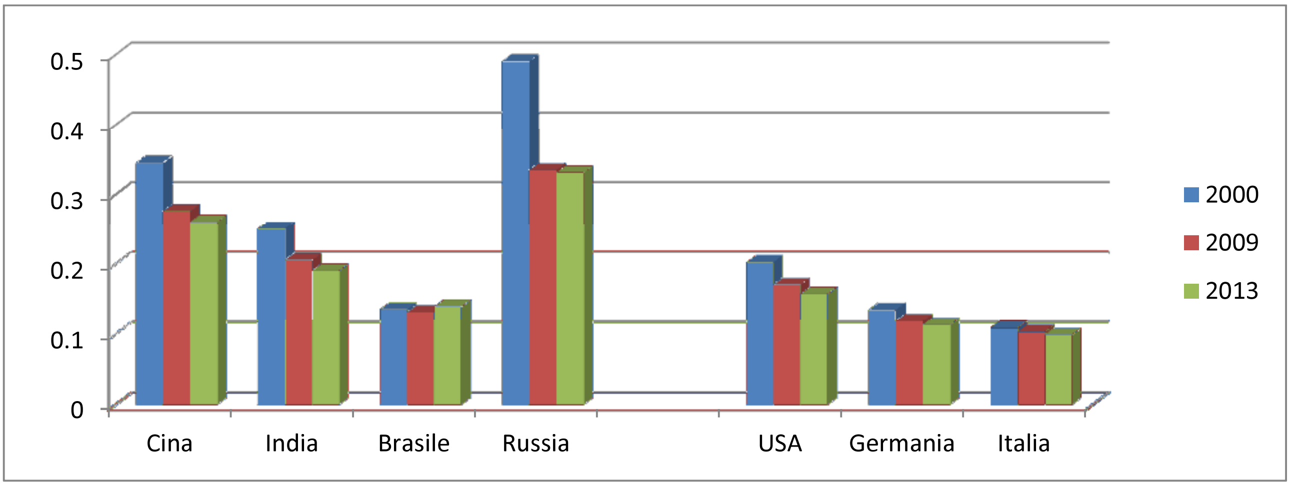
Graph 11. Overall energy intensity (2000, 2009, 2013) - Unit: koe/$2005p (**constant purchasing power parities).**

[20] China will endeavor to lower its carbon dioxide emissions per unit of GDP by 40-45% by 2020 compared to the 2005 level, increase the share of non-fossil fuels in primary energy consumption to around 15% by 2020 and increase forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic meters by 2020 from the 2005
Levels. Communication to UNFCCC, 2010.

[21] An interesting analysis of the evolution of energy intensity in many countries and in many sectors is in Voigt et alli (2014)

[22] For the Chinese case, see Zeng (2014)

[23] On the contrary, the most recent economic growth of Brazil is characterized by a quite constant path of energy intensity.



Source: Enerdata.

Energy intensity fell more heavily at the beginning of the century than in the last years: it dropped also in China (Zhang, 2014), while the only BRIC country where the rate of decrease of energy intensity was quite constant in all the period was India.

It is common way to focus more deeply on the industry. This approach can be accepted for two main reasons: 1) the level of detail that can be reached is high; 2) the industrial users are more likely to pay attention to the role of the price, so that they are expected to adopt any economically convenient policy to rationalize energy consumption. Furthermore, the share of total energy consumption coming from industry is still higher than that coming from other sources, as it is typical of growing economies[24]: see tab. 3.

Table 3. Main items of final energy consumption in BRIC's countries, 2010 (%).

	Industry	Transport	Residential	Commerc.	Agriculture	Fishing	Non-specified	Non-Energy use
Brazil	37,7	33,2	11,2	4,9	4,7	0,0	0,2	8,0
China	47,1	12,1	23,5	3,8	2,1	0,0	2,8	8,7
India	33,2	12,1	37,7	3,4	3,1	0,0	2,2	8,3
Russia	29,5	21,6	25,0	8,3	1,8	0,2	0,0	13,6

Source: International Energy Agency, Balances of Non OECD countries

As we can see by tab. 4, the adoption of energy saving technologies was the rule in all the Chinese industry sectors except two. It was also a diffused practice in many Indian sectors (10 out of 16), while it was rather uncommon in the Brazilian industry. Finally this energy saving practice was also pursued by the half of the Russian industry, but in other sectors the increase of the energy intensity has been astonishing.

Table 4. Dynamics of the energy intensity by industry sectors, 2009 vs 2000.

	China	India	Brazil	Russia
AGRICULTURE, HUNTING, FORESTRY AND FISHING	91,4	115,2	86,1	75,8
MINING AND QUARRYING	75,5	145,1	115,2	66,2
FOOD , BEVERAGES AND TOBACCO	70,0	103,7	131,7	58,2

[24] So this explains also the relatively low incidence of industry in the Russian final energy consumption

TEXTILES	102,9	50,2	117,8	87,9
LEATHER AND FOOTWEAR	80,4	68,5	124,7	61,5
WOOD AND MANUFACTURES OF WOOD AND CORK	94,2	169,2	163,9	19,7
PULP, PAPER, PRINTING AND PUBLISHING	99,5	76,8	127,7	194,5
COKE, REFINED PETROLEUM AND NUCLEAR FUEL	72,2	83,4	98,0	152,8
CHEMICALS AND CHEMICAL	64,8	52,8	78,3	114,0
RUBBER AND PLASTICS	79,6	115,6	139,4	175,9
OTHER NON-METALLIC MINERAL	122,6	78,3	97,3	122,6
BASIC METALS AND FABRICATED METAL	84,7	109,4	99,2	83,9
MACHINERY, NEC	79,6	93,9	120,7	30,8
ELECTRICAL AND OPTICAL EQUIPMENT	88,2	83,1	103,2	44,6
TRANSPORT EQUIPMENT	66,5	82,4	104,2	926,7
MANUFACTURING NEC; RECYCLING	45,3	42,4	119,9	233,6

Notes: for each sector the number represents the ratio between the dynamics of the sectoral energy use and the dynamics of the value added at constant prices (2000=100).

Sources: WIOD analysis, 7th Program Framework, EU.

The sharp reduction of energy intensity in many industrial sectors in the BRIC countries seems to reduce the importance of the common idea that Western industry has delocalized in that area (China above all) the most energy intensive and ecologically "dirtiest" steps of its production.

Together with the increasing role of energy efficiency in the sectors more open to the international competition, another explanation of the reduction of the emission intensity in the BRIC area comes of course from the diffusion of the renewable energy sources.

The diffusion of renewable energy sources has been maybe more than expected in China and India (table 5), while it has decreased in Russia and Brazil[25].

Table 5. Incidence of renewables in the electricity generation, %

	2012	2000	2012	2000
	renewables		renewables excluding hydro	
Oecd	20,3	16,1	6,9	1,6
China	20,0	16,6	2,7	0,2
India	15,6	13,6	4,4	0,5
Russia	15,7	18,8	0,0	0,0
Brazil	82,5	89,5	7,3	2,2

Sources: IEA database.

According to the 2012 IEA figures, the current share of renewable energy sources in the generation of electrical energy is now in China definitively similar to that reached in the group of the Oecd countries (more than 20%), and the 2000-2012 rate of penetration is well comparable (i.e. four percentage points).

[25] We are referring only to the renewables for the generation of electrical energy

Around 15 % of the electricity generation in India and Russia is made by renewable sources of energy[26], while in Brazil the renewable share is more than 80%[27] : as it is known, it is mainly the effect of the role and of the size of its huge hydroelectricity supply.

But if we exclude hydroelectricity from the analysis, the scenario changes in a deep way. The contribution of the renewables to electricity generation in China is now more than half of that provided in the Oecd countries; Russia disappears by the analysis because there is no "renewable" contribution other than that provided by hydroelectricity; now the effort made by India to develop renewable energy seems higher than that provided by China; finally, excluding hydroelectricity from the calculation strongly downsizes the contribution of the renewables to the Brazilian generation of electricity, but their weight remains higher than in the Oecd average (because of the utilization of biomass).

However, not considering hydroelectricity when GHG emissions are considered is highly questionable, so that it is of course more correct to consider even them in the analysis. Furthermore, the increase of the utilization of the other renewable sources of electrical energy, different by large hydroelectricity, is a very recent phenomenon (see tab 6), occurring only very recently and only in two countries, India and above all China[28].

Table 6. Renewable electric power capacity addition, 2013 vs 2012 (GW).

	World	China	India	Russia	Brazil	Top country in the world
Hydropower	40	28.7	0.8	0.7	1.5	China
Solar PV	39	12.9				China
Wind	35	16.1	1.7			China

Source: REN.

Table 6 says that:

- In 2013 China is the most important market in the world for each quoted renewable source of electrical energy, not only for hydroelectricity, in terms of addition of new capacity (including solar PV);
- Chinese performance accounts for between one half and one third of the new world capacity additions;
- The cumulate sum of Chinese solar PV and wind capacity additions is (more than) equal to the addition of Chinese hydropower (in terms of GW added);
- The increase of wind capacity is large also for India, which is becoming the 4th market in the world.

As in many other countries in the BRIC group the diffusion of renewable energy sources is driven through formal targets of overall penetration in the generation of electricity sector (table 7), also focussing on capacity targets for different kinds of renewable sources.

Table 7. Renewable energy targets adopted by BRIC governments.

	Brazil	China	India	Russia

26 The incidence in Russia however decreased after the beginning of the century
27 It decreased even more sharply than in Russia
28 Electric generation by biomass is important in Brazil as well

SHARE OF PRIMARY OR FINAL ENERGY		On final energy consumption: 9,5 % in 2015, established in 2012		
SHARE OF ELECTRICITY GENERATION	Only specific capacity targets (see below)	Only specific capacity targets (see below)	9% in 2018 by renewables (excluding hydroelectricity installations larger than 25 MW), established in 2012;	2.5% by 2015 , 4.5% by 2020 , (excluding hydroelectricity installations larger than 25 MW), established in 2009
OTHER	Bio-power 19.3 GW by 2021 Hydropower (small-scale) 7.8 GW by 2021 Wind 15.6 GW by 2021	Bio-power 13 GW by 2015 Hydropower 290 GW by 2015 Solar PV 10 GW added in 2014; 35 GW by 2015 (including 20 GW distributed generation) CSP 1 GW by 2015; 3 GW by 2020 Wind 100 GW grid-connected by 2015; 200 GW by 2020	Electricity 4.3 GW added in 2014 Electricity 30 GW added 2012–2017 Bio-power 2.7 GW added 2012–2017 Hydropower (small-scale) 2.1 GW added 2012–2017 Solar PV and CSP 10 GW added 2012–2017; 20 GW grid-connected added 2010–2022; 2 GW off-grid added 2010–2020; 20 million solar lighting systems added 2010–2022 Wind 15 GW added 2012–2017	Hydropower (small-scale), solar PV, wind 6 GW combined by 2020

Sources: REN21, Renewables 2014, Global Status Report; IEA/IRENA Joint Policies and Measures Database for Global Renewable Energy.

In the large hydroelectricity plants[29] the addition of capacity is directly driven by the Governments, and the generated electric energy is competitive. On the contrary, electrical energy provided by the other renewable sources is usually[30] not competitive with the one generated by fossil fuels and nuclear[31], so that everywhere renewable sources of energy need incentives. The array of incentives deployed[32] by the BRIC countries is shown in the Table 8.

[29] In India e in Russia plants over 25 MW are not subject to the special provisions referring to renewable energy (see table 7)

[30] The most recent official analysis of the costs of generating electricity is still IEA, 2010.

[31] Different factors affect the relative competitiveness of the renewable sources. Maybe the most important is location. It is especially important for wind farms, where location affects wind yield, construction costs and repair and maintenance costs. Offshore wind enables the size of the plant to be increased relative to onshore locations, but capital and operating costs increase substantially. Hydro is of course dependent on site conditions and the local situation as regards water supply, and biomass costs are strictly dependent on location. Furthermore, economies of scale are less important for renewables than for fossil fuels: adding more generators gives rise to only modest savings in shared infrastructure. Economies of scale at the plant level could potentially be important for biomass, but the weight of transport costs is so large that they more than balance any cost savings.

[32] Of course there are many works analysing the experience for the single country (Boute, 2012; Johnson, 2013; Vieira, 2011; Wang-Zeng, 2014)

Table 8. Regulatory policies and instruments adopted by BRIC governments to boost the use of renewable energies.

	Brazil	China	India	Russia
FIT Tariffs (incl. premium payments)		R	o	
Renewable Portfolio Standards/ Quota obligation with tradable green certificates		o	o	
Net metering	o		*	
Tendering	R	o	R	*
Heat obligation /mandate	+	o	*	
Biofuel obligation/mandate	R	o	R	

Notes:
o: existing policy, at a national level;
+: existing policy, at a sub-national level;
*: new policy
R: revised policy

Source: REN21, Renewables 2014, Global Status Report

As is known, there are some differences among the instruments as well. According to the experience of the EU countries and considering only on the most important ones, which affect the generation of electrical energy, we have:

Feed-in tariffs: they give renewable producers that are eligible a guaranteed price for the power they feed into the grid. The preferential and technology-specific tariffs are regulated by governments and are normally guaranteed for a period of 10 - 20 years. The electricity produced is delivered to the grid, where the system operator takes care of its distribution. Renewable producers, therefore, face a relatively secure and stable demand for their output. Feed-in tariffs accordingly reduce both prices and market risk and create certainty for investors as regards rates of return.

Feed-in premiums: they give renewable producers a guaranteed additional amount over and above the existing current price for electricity. The preferential and technology-specific premiums concerned are still determined by Governments and the producer still benefits from secure demand. However, in this case, the prices for renewable producers fluctuate according to changes in the market price of electricity.

Green certificates: they are normally based on quota obligations. The government imposes an obligation on consumers or suppliers to obtain a certain proportion of electricity from renewables. The authorities issue certificates to producers corresponding to their production of renewable energy, which are sold separately from electricity. Quota obligations on electricity suppliers ensure that there is a demand for certificates, since suppliers need to buy these in order to fulfill their quotas. The main advantage of this system is that it allows competition between renewable producers, since the price of certificates depends on their demand and supply.

It is difficult to establish a hierarchy among the different instruments to promote renewable energy [33], even if FIT Tariff seem to become the most utilized one in the world. As a matter of fact, in the group of the BRIC countries they are utilized only by China and India. More generally, these two countries seem to be able to utilize a large deployment of specific tools.

The fact that only China and India were able to exploit the advantages coming from renewable sources of energy, which are still more expensive than fossil fuels, so that need to use incentives, can be explained in different ways. First of all, strategic reasons suggest to minimize dependence from abroad for very important "basic needs" like fuels: Russia is a net exporter of gas and oil, and holds among the highest R/P ratios in the world for coal (BP, 2014); even Brazil is a net energy exporter, is strongly investing in oil offshore reserves (OECD, 2011) and its hydroelectricity capacity is so large that its future dependence from abroad is very questionable. Second, classical import substitution reasons foster the development of domestic energy sources as PV and wind in China and India, while are not felt in Russia and Brazil. Third and most important issue: to develop PV and wind energy industry is an objective of industrial policy, more than to be an objective of energy policy.

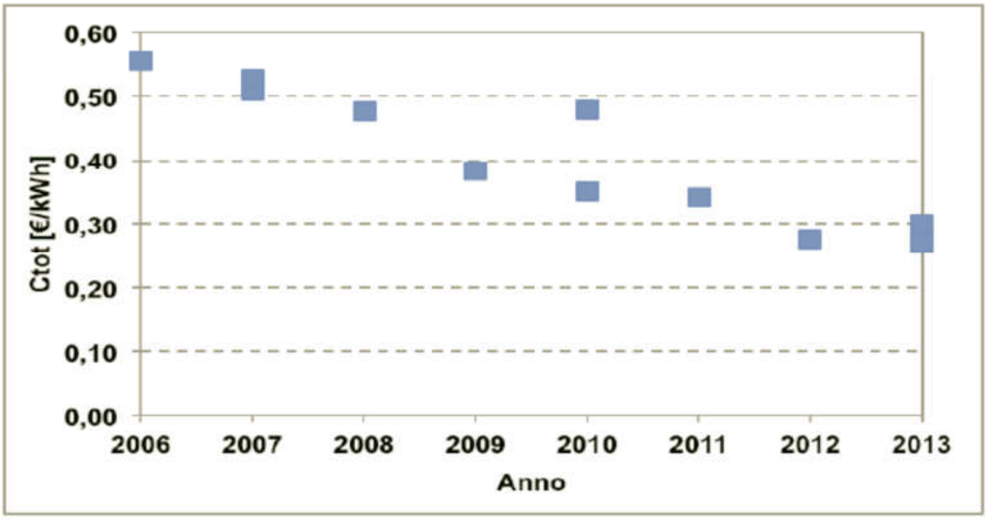
As a matter of fact all the four BRIC countries adopted an interventionist policy, where some sectors were considered as major targets of policy interventions. However only China and India included PV and wind energy as "strategic sectors" (Cao-Groba, 2013; Gosens-Yu, 2014; Johnson, 2013; Lizuka, 2014; OECD, 2011; Sargsyan et alii, 2013; Simachev et alii, 2013; Vieira, 2011) adopting a "green industrial policy" approach (Hallegatte et alii, 2013; Rodrik, 2013), while these sectors were not mentioned by the other two countries, Brazil and Russia[34].

The result of this is twofold:

- to be able to utilize equipment for renewable goods produced in (relatively) low wage countries, but provided with an acceptable quality level strongly eased the transition to renewable energies in Western countries. The graph no. 12 shows the sharp reduction of the kWh cost of the PV equipment in Italy, mainly due to reduction in the cost of PV equipment provided by Chinese producers, in place of that achieved in Western countries.

[33] In the EU case, see Canton G., Linden A.J., 2010; Ecofys 2011
[34] The Russian case is very interesting: see the evaluations in IFC, 2011 and the proposals in IFC, 2012

Graph 12. Cost of the kWh produced through PV technology, in Italy (2006-2013).



Source: Politecnico di Milano, 2013, p. 51.

- the economic difficulties of the Western countries in the last years, and above all in 2012-2013, indirectly promoted the growth of the domestic market for PV and wind technologies in China and in India (also aiming at reducing the excess of supply of equipment inside those firms, previously producing mainly for exports), so making easier the transition even in those two countries towards renewable sources others than hydro power.

4. Conclusions: world benefits of nationalistic industrial policies

Sometimes industrial policy has been criticized because it could strengthen one country at other's expense: according to this idea it is a "zero-sum game" where a "beggar-my-neighbour policy" [35] is implemented, even without being a protectionistic policy (that cannot occur, given the WTO rules). In this case, agreeing with Dani Rodrik, nationalistic industrial policies pursued in two very large countries benefitted one of the most important public goods at the world level, environment, so contributing to reduce emissions and energy intensity in the planet.

Bibliography

Agreement on the New Development Bank,2014, http://brics6.itamaraty.gov.br/media2/press-releases/219-agreement-on-the-new-development-bank-fortaleza-july-15

Boute A., 2012, "Promoting renewable energy through capacity markets: an analysis of the Russian support scheme", Energy Policy 46 (2012), pp 68-77.

BP, 2014, "Statistical Review of the World Energy", British Petroleum.

Canton G., Linden A.J., 2010, "Support schemes for renewable electricity in the EU", EU Economic Papers 408, April.

Cao J., Groba F., 2013, "Chinese renewable energy technology exports: the role of policy, innovation and markets", DIW Berlin Discussion Papers n. 1263.

[35] Not "beggar-thy-neighbour", according to the classical definition of Joan Robinson.

Dai J., Kesternich M., Loeschel A., Ziegler A., 2014, "Do Chinese individuals believe in global climate change and why ? An econometric analysis", MAGKS Joint Discussion Paper Series in Economics, No. 28-2014.

Ecofys 2011, "Financing Renewable Energy in the European Energy Market", report for the European Commission, DG TREN
http://ec.europa.eu/energy/renewables/studies/doc/renewables/2011_financing_renewable.pdf

FAO, Global Forest Resources Assessment 2010. Main Report, *Fao Forestry paper* 163, Rome.

Fortaleza Declaration, http://brics6.itamaraty.gov.br/media2/press-releases/214-sixth-brics-summit-fortaleza-declaration

Gosens J., lu Y., 2014, "Prospects for global market expansion of China's wind turbine manufacturing industry, Energy Policy 67 (2014), pp. 301-318.

Hallegatte S., Fay M., Vogt-Schilb A., 2013, "Green industrial policies: when and how", World Bank Policy Research Working Paper, WPS6677.

IEA, 2010, "Projected costs of generating electricity", Paris.

IEA/IRENA, 2014, Joint Policies and Measures Database for Global Renewable Energy, http://www.iea.org/policiesandmeasures/renewableenergy/

IFC, 2011, "Renewable energy policy in Russia: waking the green giant".

IFC, 2012, "Financing renewable energy investments in Russia: legal challenges and opportunities" (under the supervision of Anatole Boule).

India, 2012, *Second National Communication to the United Nations Framework Convention on Climate Change*, Ministry of Environment and Forests, New Delhi.

IPCC, 2014, *Fifth Assessment Report: Climate Change 2013*, Cambridge University Press, New York.

Johnson O., 2013, "Exploring the competitiveness of local content requirements in promoting solar PV manufacturing in India", German Development Institute, Discussion Paper n. 11.

Kokorin Alexey, Korppoo Anna, 2014, *Russia's Greenhouse Gas Target 2020, Projections, Trends, and Risks*, Friedrich-Ebert-Stiftung, Berlin.

Lizuka M., 2014, "Diverse and uneven paths towards transition to low carbon development: The case of diffusion of solar PV technology in China", UNU-Merit Working Paper Series, 2014-002.

OECD 2011, "Brazil", OECD Economic Surveys.

OECD, 2014, *OECD Environmental Outlook to 2050. The Consequence of Inaction*. OECD Green Growth Indicators 2014.

Politecnico di Milano, , 2013, "Costi di produzione di energia elettrica da fonti rinnovabili", Dipartimento di Energia (on request by AEEG, the Italian Authority for Electrical Energy and Gas).

Presidential Decree of the Russian Federation, 2013, No. 752 *On Greenhouse Gas Emission Reduction,* Moscow.

REN21, Renewables. Global Futures Report 2013 (E. Martinot edt.), Paris.

REN21, 2014, "Renewables. Global Status Report".

Rodrik D., 2013, "Green industrial policy", paper https://www.sss.ias.edu/files/pdfs/Rodrik/Research/Green-Industrial-Policy.pdf

Sargsyan G., Bhatia M., Banerjee S.G., Raghunathan K., Soni R,, 2011, "Unleashing the potential of renewable energy in India", A World Bank Study.

Simachev Y., Kuzyk M., Kuznetsov B., Pogrebniak B., 2013, "Industrial policy in Russia 2000-2013: institutional features and key lessons", in Gaidar Institute for Economic Policy, "Russian Economy in 2013: trends and outlooks".

Tasso Rezende de Azevedo and Carlos Rittl (edt.), 2014, *Análise Da Evolução Das Emissões De Gee No Brasil (1990-2012). Documento Síntese*. Brasilia
UNFCCC, 2013, *GHG Data*, (updated), http://unfccc.int/ghg_data/items/3800.php

UNEP, 2013, Annual Report, http://www.unep.org/annualreport/2013/docs/hr_ar2013.pdf

UNFCCC, 2014, GHG Data Interface, http://unfccc.int/ghg_data/items/3800.php

Vieira D, 2011, "Policies to encourage the sustainable development of Brazilian electricity system with distributed generation", thesis, University of Cambridge.

Voigt, Sebastian & De Cian, Enrica & Schymura, Michael & Verdolini, Elena, 2014. "**Energy intensity developments in 40 major economies: Structural change or technology improvement?**," Energy Economics, Elsevier, vol. 41(C), pages 47-62.

Wang Z., C. Feng: The impact and economic cost of environmental regulation on energy utilization in China, *Applied Economics*, 2014, no. 27, pp. 3362.3376.

WIOD database: http://www.wiod.org/new_site/database/eas.htm

Zeng L., Xu M., Liang S., Zeng S., Zhang T., 2014, "Revisiting drivers of energy intensity in China during 1997-2007: a structural decomposition analysis", Energy Policy 67 (2014), pp. 640-647.

Zhang S., Andrews-Speed P., Ji M. 2014, "The erratic path of low-carbon transition in China", Energy Policy, (67), pp. 903-912.