# Energy and carbon embodied in international trade of Iran

# Ahmad khodaverdi,Narges Moradkhani\*

# All goods and services which exported or imported in an economy utilize energy directly and indirectly and consequently associated with CO2 emission, according to usage type of fuel. The aim of this study is quantify the energy and CO2 emission embodied in international trade flow in Iran. This paper applied input-output technique and build a 32-sector hybrid energy input-output table based Which extracted from Input-Output table of the year 2006. Total amount of supply primary energy is 1551.51 mtoe and final energy demand is 1042.01 mtoe in the year 2010.In Iran primary energy supply intensity is 3.04 mtoe per million Rial and final energy demand intensity is 2.04 mtoe per million Rial in year 2010 and total amount of CO2 emission which produced by domestic consumption is 538.5 million tons in the year 2010. The total embodied CO2 emission in export is 120 Million tons and in import is 245 Million tons in the year 2006, while the absolute amount export is bigger than import in the same year.

**Keywords:** hybrid energy input-output table, emission, decomposition analysis

\*Corresponding author.

Email address:nnmoradkhani@yahoo.com

# INTRODUCTION

International trade has major impact on the amount of CO2 emission which produced by a country. In this manner, up to the amount of energy embodied in imported goods.

Iranian economy almost is an open economy. It exports different kinds of goods and its one of the major exporter of crude oil. Therefore, it is necessary to reveal whether or not particular policies and characteristics should be designed to deal with the imports of foreign commerce on natural resources use and sustainable development of a country (Machado et al., 2001).

Final energy demand of Iran’s economy increased over years due to economic and population growth and enhance living standard.

The contribution of this paper is inspection the effects of trade flow of Iran on CO2 emission in sub sectoral level of economy and detailed traded items as well.

An assessment of embodied energy in international trade is a quite complicated cause of two sides of trade input and export. The embodied energy in export side is almost directly computed but in import side requires indirect measurement since there is no specific statistics on energy use associated with importing goods, whereas imported goods come from different countries. To obtain accurate investigation the energy intensity of origin country which imported goods is needed. So in this paper we obtained the average energy intensity coefficients for the goods of the monetary volume imported abroad under each category of goods which is classified by ISIC 3.9 version, on economic sectors, then multiply corresponding energy intensity coefficients by traded item figures to get embodied energy in international trade (Tolmasquim and Machado, 2003).

In the case of imported goods, the energy intensity to be used depends on the purpose of the study, if the idea is to assess real energy flows, it is necessary to use the energy intensity of the good in the country of origin of the imports.

In this paper the energy intensity of goods produced domestically is used as a proxy for the energy intensity of exported products (Tolmasquim and Machado, 2003).

However if the focus is to evaluate how foreign trade affects energy use in the countries under analysis, the average energy intensity of goods produced by the domestic branch should be used (Tolmasquim and Machado, 2003).

In this paper we don’t want focus on differences in energy intensity between import and export but we’d like to compute the emission embodied in traded goods. Accordingly the energy intensity coefficients to be used in assessing the energy embodied in imports are the same for exports (Machado, et al., 2001).

All goods produced in an economy directly or indirectly associated with energy use and according to the type of fuel utilized, with CO2 emission as well.

International trade allows a country to delink partially its domestic economic and ecological system, as some goods can be produced by other national economics systems (Dalay, 1993; Pearce and Warferd, 1993; Andersson et al., 1995; Machado and Schaeffer, 1977; Suri and Chapman, 1998; Proops et al., 1999).

The concept of sustainable development implies the important relationship between economic growth and environmental protection in conducting economic activities and utilizing natural resources to fulfill human needs. The Iranian economy could impact the environment by utilizing huge amount of fossil fuel since fossil fuel highly subsidize in Iran so consumers use it carelessly. Since March of 2011 the government started to remove the energy and non-energy subsidy gradually to achieve different purpose. One of the achievements is save the environment by less usage of fossil fuel and consequently less produce of emissions.

This research aims at quantifying the CO2 emission of various economic sectors of Iran. In order to undertake this aim, this study first will compute the energy intensity of different sectors of economy for this purpose will construct a hybrid energy input-output table for the economy. The study applied the year 2006 Input-Output table of Iran

Table ‎1: CO2 Emission in Iran, Million Tons in years 2005-2011.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Year/Sectors | 2005 | 2006 | 2007 | 2008 | 2009 |
| **Final energy demand**  Household ,Commercial and Public |  |  |  |  |  |
| 108 | 116 | - | 135 | 138 |
| Industry | 68 | 65 | - | 86 | 84 |
| Transportation | 92 | 98 | - | 122 | 133 |
| Agriculture  **Intermediate energy demand**  Refineries  Power plant  **Total** | 10  10  101  390 | 10  12  110  413 | -  -  -  - | 13  19  147  523 | 13  17  150  538 |

Source: National Energy Balance, different years, published by Iran’s Ministry of Energy.

Figure 1 CO2 Emission in Iran in term of sectors

Table 2: The Share of CO2 Emission in Iran, Million Tons in years 2005-2011.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Year/Sectors | 2005 | 2006 | 2007 | 2008 | 2009 |
| **Final energy demand**  Household ,Commercial and Public |  |  |  |  |  |
| 27.8 | 28.1 | - | 25.8 | 25.7 |
| Industry | 17.5 | 15.8 | - | 16.4 | 15.8 |
| Transportation | 23.6 | 23.7 | - | 23.4 | 24.9 |
| Agriculture  **Intermediate energy demand**  Refineries  Power plant  **Total** | 2.5  2.5  26  100 | 2.6  3  26.7  100 | -  -  -  - | 2.5  3.7  28.2  100 | 2.5  3.2  27.9  100 |

Source: National Energy Balance, different years, published by Iran’s Ministry of Energy.

Table 3: CO2 Emission in Iran, in Term of different kinds of fuels, Million Tons

|  |  |  |
| --- | --- | --- |
| Year/Sectors | 2008 | 2009 |
| LPG | 7.1 | 7.9 |
| Petrol | 58.2 | 56 |
| Kerosene | 18 | 16.9 |
| Diesel | 96.2 | 96.9 |
| Furnace Oil | 67.7 | 74 |
| Natural Gas | 260 | 272 |
| Coal | 0.04 | 0.04 |
| Other Fuel | 15.66 | 14.66 |
| Total | 522.9 | 538.4 |

Source: National Energy Balance, different years, published by Iran’s Ministry of Energy.

Table 4: CO2 Emission in Some Group Countries, Million Tons.

|  |  |  |
| --- | --- | --- |
| Year/Group countries | 2007 | 2008 |
| North America  South America  Europe and Eurasia  Middle East  Africa  Asia and Pacific  *China*  **Total world** | 6780.2  1016  6747  1389  882  11126.4 | 6551.1  1068.2  6686.3  1492.3  889.9  11656.6 |
| *6027.9*  **28962.4** | *6508.2*  **29381.43** |

Source: IEA, International Energy Agency, Data Services, [www.iea.org](http://www.iea.org).

Table 5: Total CO2 Emission in Iran in different years, Million Tons

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Year/CO2 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| CO2 Emission | 356 | 382 | 421 | 492 | 523 | 538 |

Source: National Energy Balance, different years, published by Iran’s Ministry of Energy.

Table 6: The Value of Export, Million Rials

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Codes | Sectors/Years | 2006 | 2007 | 2008 | 2009 | 2010 |
| 01 | Agriculture, hunting and related service activities | 20150657 | 27733891 | 26319036 | 8358838 | 15962810 |
| 02 | Forestry, logging and related service activities | 901524 | 2129351 | 263721 | 87981 | 95789 |
| 05 | Fishing, aquaculture and service activities incidental to fishing | 309628 | 26958 | 25110 | 8916 | 25445 |
| 10 | Mining of coal and lignite; extraction of peat | 121952 | 40381 | 421877 | 568921 | 178109 |
| 11 | Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying | 224638 | 15639 | 893 | 10249 | 3337 |
| 12 | Mining of uranium and thorium ores | 0 | 0 | 0 | 0 | 0 |
| 13 | Mining of metal ores | 5383098 | 618241 | 1402716 | 412002 | 1088606 |
| 14 | Other mining and quarrying | 3247745 | 2092120 | 931052 | 554567 | 729379 |
| 15 | Manufacture of food products and beverages | 15195160 | 37533032 | 37112293 | 12637456 | 17464100 |
| 16 | Manufacture of food products and beverages | 147862 | 1576891 | 2925478 | 2604794 | 2284685 |
| 17 | Manufacture of food products and beverages | 19129222 | 3695406 | 4620135 | 2854133 | 3248161 |
| 18 | Manufacture of food products and beverages | 10529407 | 2374887 | 136510 | 117114 | 151197 |
| 19 | Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear | 2223568 | 5713635 | 261272 | 281912 | 179984 |
| 20 | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials | 980203 | 3288839 | 3068215 | 1692478 | 3134077 |
| 21 | Manufacture of paper and paper products | 3903313 | 9543754 | 9686083 | 6091590 | 6149349 |
| 22 | Publishing, printing and reproduction of recorded media | 1578602 | 515765 | 690910 | 377637 | 409977 |
| Codes | **Sectors/Years** | 2006 | 2007 | 2008 | 2009 | 2010 |
| 23 | Manufacture of coke, refined petroleum products and nuclear fuel | 26153513 | 20046041 | 48405024 | 14924324 | 15479511 |
| 24 | Manufacture of chemicals and chemical products | 74662157 | 53623908 | 56708413 | 35158827 | 38699126 |
| 25 | Manufacture of rubber and plastics products | 3898798 | 8490821 | 7186074 | 3760115 | 4668381 |
| 26 | Manufacture of other non-metallic mineral products | 8805336 | 13516037 | 5778308 | 3487994 | 3583061 |
| 27 | Manufacture of basic metals | 28829410 | 55912178 | 80531696 | 46963811 | 48880975 |
| 28 | Manufacture of fabricated metal products, except machinery and equipment | 7359068 | 10362287 | 6933453 | 3725427 | 4797179 |
| 29 | Manufacture of machinery and equipment n.e.c. | 9697288 | 68374223 | 82173491 | 47480882 | 58296936 |
| 30 | Manufacture of office, accounting and computing machinery | 364704 | 5937518 | 7731351 | 4189992 | 5337868 |
| 31 | Manufacture of electrical machinery and apparatus n.e.c. | 2360652 | 12728735 | 13282786 | 7507016 | 8528735 |
| 32 | Manufacture of radio, television and communication equipment and apparatus | 1595750 | 8041688 | 13341118 | 8333124 | 11489737 |
| 33 | Manufacture of medical, precision and optical instruments, watches and clocks | 4841394 | 11897615 | 16002354 | 5861284 | 8245407 |
| 34 | Manufacture of motor vehicles, trailers and semi-trailers | 15623757 | 35019496 | 46499534 | 30047788 | 27733621 |
| 35 | Manufacture of other transport equipment | 3716727 | 7570672 | 7190217 | 6042475 | 4748332 |
| 36 | Manufacture of furniture; manufacturing n.e.c. | 4487567 | 3072787 | 2746620 | 1181493 | 1373766 |
| 37 | Recycling | 0 | 0 | 0 | 0 | 0 |
| 41 | Collection, purification and distribution of water | 0 | 0 | 0 | 0 | 434 |
| Codes | **Sectors/Years** | **2006** | **2007** | **2008** | **2009** | **2010** |
| 51 | Wholesale trade and commission trade, except of motor vehicles and motorcycles | 27990 | 273456 | 157402 | 538 | 925 |
| 72 | Computer and related activities | 421623 | 56252 | 88830 | 45535 | 20142 |
| 74 | Other business activities | 113670 | 9644 | 6755 | 3681 | 11633 |
| 92 | Recreational, cultural and sporting activities | 378682 | 2067 | 2651 | 1600672 | 49353 |
| Total | | **277364662** | **411834213** | **482631379** | **256973565** | **293050127** |

Source: National Accounts, published by Statistical Center of Iran, different Years.

Table 7: The Value of Import, Million Rials

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Codes | Sectors/Years | 2006 | 2007 | 2008 | 2009 | 2010 |
| 01 | 01 - Agriculture, hunting and related service activities | 13191811 | 17381436 | 28692490 | 25275810 | 15773703 |
| 02 | Forestry, logging and related service activities | 620079 | 875249 | 233816 | 128244 | 209529 |
| 05 | Fishing, aquaculture and service activities incidental to fishing | 369060 | 601658 | 22238 | 15142 | 18284 |
| 10 | Mining of coal and lignite; extraction of peat | 198979 | 90018 | 251794 | 366607 | 448819 |
| 11 | Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying | 174669 | 71683 | 4810 | 1221 | 1342 |
| 12 | Mining of uranium and thorium ores | 45 | 0 | 0 | 0 | 0 |
| 13 | Mining of metal ores | 3725534 | 1280000 | 1215928 | 474208 | 753117 |
| 14 | Other mining and quarrying | 3144408 | 3484701 | 867984 | 861582 | 898009 |
| 15 | Manufacture of food products and beverages | 9750425 | 19851784 | 35096568 | 20992267 | 32480566 |
| 16 | Manufacture of food products and beverages | 182045 | 906083 | 2430190 | 3349372 | 2607779 |
| 17 | Manufacture of food products and beverages | 12374755 | 20160076 | 4494326 | 3401491 | 3905511 |
| 18 | Manufacture of food products and beverages | 2379550 | 2725207 | 137033 | 113852 | 134542 |
| 19 | Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear | 1587767 | 2898376 | 274516 | 143711 | 172782 |
| 20 | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials | 1117371 | 3268570 | 3594811 | 2155897 | 2727856 |
| 21 | Manufacture of paper and paper products | 4236584 | 4710666 | 9178730 | 7359125 | 9465746 |
| 22 | Publishing, printing and reproduction of recorded media | 1999027 | 242481 | 347599 | 275742 | 275468 |
| 23 | Manufacture of coke, refined petroleum products and nuclear fuel | 12895214 | 3973964 | 19190151 | 23077806 | 28695046 |
| 24 | Manufacture of chemicals and chemical products | 78248333 | 47373525 | 52013795 | 46431951 | 55078907 |
| 25 | Manufacture of rubber and plastics products | 6889145 | 14188203 | 6656334 | 5036135 | 6382470 |
| 26 | Manufacture of other non-metallic mineral products | 8636325 | 4732008 | 5161871 | 4304908 | 4349455 |
| Codes | Sectors/Years | 2006 | 2007 | 2008 | 2009 | 2010 |
| 27 | Manufacture of basic metals | 15149774 | 46270990 | 71431647 | 55147996 | 66036340 |
| 28 | Manufacture of fabricated metal products, except machinery and equipment | 4109930 | 7010527 | 5767510 | 5489777 | 5985204 |
| 29 | Manufacture of machinery and equipment n.e.c. | 25095007 | 48043489 | 72222413 | 57518634 | 76273377 |
| 30 | Manufacture of office, accounting and computing machinery | 825048 | 4071611 | 7948288 | 6065263 | 6732018 |
| 31 | Manufacture of electrical machinery and apparatus n.e.c. | 17067001 | 6795517 | 11579822 | 9396566 | 10410621 |
| 32 | Manufacture of radio, television and communication equipment and apparatus | 4882386 | 5861724 | 12554785 | 10604726 | 11594744 |
| 33 | Manufacture of medical, precision and optical instruments, watches and clocks | 6128702 | 15657460 | 9849122 | 7618944 | 12921639 |
| 34 | Manufacture of motor vehicles, trailers and semi-trailers | 7429206 | 22711415 | 41680888 | 40978759 | 45716498 |
| 35 | Manufacture of other transport equipment | 3455695 | 3280171 | 6222418 | 5471503 | 5465602 |
| 36 | Manufacture of furniture; manufacturing n.e.c. | 6171759 | 17337904 | 2388311 | 1728155 | 2026040 |
| 37 | Recycling | 82568 | 405 | 0 | 0 | 0 |
| 41 | Collection, purification and distribution of water | 3260 | 0 | 137 | 46 | 0 |
| 51 | Wholesale trade and commission trade, except of motor vehicles and motorcycles | 315149 | 325389 | 79026 | 181 | 164985 |
| 72 | Computer and related activities | 41062 | 7000 | 151573 | 164300 | 93998 |
| 74 | Other business activities | 526183 | 10401 | 379 | 1823 | 5061 |
| 92 | Recreational, cultural and sporting activities | 169774 | 109910 | 1679855 | 2486 | 1636 |
| **Total** | | **253173629** | **326309598** | **413421160** | **343954231** | **407806694** |

Source: National Accounts, published by Statistical Center of Iran, different Years.

**Methodology and Data**

Input-output analysis provides a useful framework for tracing energy use and other activities .In recent years much attention has been focused on extending the Leontief input-output framework to account for such activities. Energy input–output table determines the total energy requirements to produced goods and services. It provides both direct and indirect energy required to industries production process. To give an extensive account of process analysis, we can give explain as follows: A target product is identified either as a good or service, then a list are gathered of goods and services directly required to deliver the product.

We must mention that key issue to build energy IO tables for our purpose (Transaction flow between sectors) and quantification of direct and indirect household energy requirement is, monetary input-output table must be transformed into energy term.

If we don't have uniform prices for energy among different sectors of the economy, then we must get physical energy flows data instead of converting monetary data in the input-output tables by using energy tariffs or use other kind of methods such as weighted prices of different types of energy, using exact energy price of different sectors, etc.

As can be shown in Figure 2, we divided the input-output table into two parts, energy and non-energy sectors. Energy sectors are in physical energy unit (toe) and non-energy sectors are in monetary unit (Malaysian ringgit). In this table we suppose that we have k type of energy and (n-k) type non-energy sectors. This table comprises final demand components and total output which are all in physical unit of energy in energy rows.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Energy sectors | Non-energy sectors | Final demand | Output |
| Energy sectors | TE | | Ey | E |
| Non-energy sectors | TN | | y | X |

Figure 2 Brief separation of hybrid energy input-output matrix

In this way we obtain the energy intensity of almost 32 subsectors of Iranian economy, in fact we induced to aggregate the IO table of Iran from 63 sectors to 32 sectors and aggregate the energy sectors cause of limitation of data as well. In this paper we applied the Input-Output table of the year 2006.

In this paper we obtained the average energy intensity coefficients for the goods of the monetary volume imported abroad under each category of goods which is classified by ISIC 3.9 version, on economic sectors, then multiply corresponding energy intensity coefficients by traded item figures to get embodied energy in international trade. In the case of imported goods, the energy intensity to be used depends on the purpose of the study, if the idea is to assess real energy flows, it is necessary to use the energy intensity of the good in the country of origin of the imports. In this paper the energy intensity of goods produced domestically is used as a proxy for the energy intensity of exported products.

## Barrels of oil consumed

Average heat content of crude oil is 5.81 mmbtu per barrel (EPA 2010). Average carbon coefficient of crude oil is 20.17 kg carbon per mmbtu (EPA 2010). Fraction oxidized is 100 percent (IPCC 2006).

Carbon dioxide emissions per barrel of crude oil were determined by multiplying heat content times the carbon coefficient times the fraction oxidized times the ratio of the molecular weight of carbon dioxide to that of carbon (44/12).

##### Calculation:

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

5.81 mmbtu/barrel \* 20.17 kg C/mmbtu \* 44 g CO2/12 g C \* 1 metric ton/1000 kg = **0.43 metric tons CO2/barrel**

**Results and Discussion**

As explain the above sections and according to presented methodology first we obtain the energy intensity of different sectors then consider them as a proxy for import and export commodities. Then we can estimate the energy embodied in export and import goods, by multiplying by the CO2 emission factors the standardized by IPCC(2006) we get the embodied emission in trade of Iran.

**Table 8: Energy intensity of sectors in term of boe/million Rial, in the year 2006.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Code** | **Sectors** | **Total** | **Direct** |
| 1 | Agriculture, hunting and related service activities | 0.36 | 0.04 |
| 2 | Forestry, logging and related service activities | 0.36 | 0.04 |
| 5 | Fishing, aquaculture and service activities incidental to fishing | 0.36 | 0.04 |
| 10 | Mining of coal and lignite; extraction of peat | 2.44 | 1.35 |
| 11 | Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying | 25.94 | 4.68 |
| 12 | Mining of uranium and thorium ores | 2.44 | 1.35 |
| 13 | Mining of metal ores | 2.44 | 1.35 |
| 14 | Other mining and quarrying | 2.44 | 1.35 |
| 15 | Manufacture of food products and beverages | 0.83 | 0.20 |
| 16 | Manufacture of food products and beverages | 0.83 | 0.20 |
| 17 | Manufacture of food products and beverages | 0.83 | 0.20 |
| 18 | Manufacture of food products and beverages | 0.83 | 0.20 |
| 19 | Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear | 0.71 | 0.11 |
| 20 | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials | 1.50 | 0.44 |
| 21 | Manufacture of paper and paper products | 0.99 | 0.24 |
| 22 | Publishing, printing and reproduction of recorded media | 0.99 | 0.24 |
| 23 | Manufacture of coke, refined petroleum products and nuclear fuel | 0.84 | 0.09 |
| 24 | Manufacture of chemicals and chemical products | 1.06 | 0.40 |
| 25 | Manufacture of rubber and plastics products | 1.48 | 0.45 |
| 26 | Manufacture of other non-metallic mineral products | 2.21 | 0.52 |
| 27 | Manufacture of basic metals | 1.26 | 0.13 |
| 28 | Manufacture of fabricated metal products, except machinery and equipment | 1.12 | 0.16 |
| 29 | Manufacture of machinery and equipment n.e.c. | 0.49 | 0.04 |
| 30 | Manufacture of office, accounting and computing machinery | 0.49 | 0.04 |
| 31 | Manufacture of electrical machinery and apparatus n.e.c. | 0.56 | 0.06 |
| 32 | Manufacture of radio, television and communication equipment and apparatus | 0.57 | 0.05 |
| 33 | Manufacture of medical, precision and optical instruments, watches and clocks | 0.49 | 0.04 |
| 34 | Manufacture of motor vehicles, trailers and semi-trailers | 0.70 | 0.06 |
| 35 | Manufacture of other transport equipment | 0.46 | 0.05 |
| 36 | Manufacture of furniture; manufacturing n.e.c. | 0.99 | 0.24 |
| 37 | Recycling | 0.79 | 0.13 |
| 41 | Collection, purification and distribution of water | 0.79 | 0.13 |
| 51 | Wholesale trade and commission trade, except of motor vehicles and motorcycles | 0.79 | 0.13 |
| 72 | Computer and related activities | 0.79 | 0.13 |
| 74 | Other business activities | 0.79 | 0.13 |
| 92 | Recreational, cultural and sporting activities | 0.79 | 0.13 |

Source: Authors Estimation.

Table 9: Total export and Total energy embodied in the export in the year 2006.

|  |  |  |  |
| --- | --- | --- | --- |
| **Code** | **Sectors** | **Export (Milion Rial)** | **Total Energy embodeid(boe)** |
| 1 | Agriculture, hunting and related service activities | **20,150,657** | **7,342,683** |
| 2 | Forestry, logging and related service activities | **901,524** | **328,506** |
| 5 | Fishing, aquaculture and service activities incidental to fishing | **309,628** | **112,825** |
| 10 | Mining of coal and lignite; extraction of peat | **121,952** | **297,013** |
| 11 | Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying | **224,638** | **5,827,414** |
| 12 | Mining of uranium and thorium ores | **0** | **0** |
| 13 | Mining of metal ores | **5,383,098** | **13,110,500** |
| 14 | Other mining and quarrying | **3,247,745** | **7,909,862** |
| 15 | Manufacture of food products and beverages | **15,195,160** | **12,556,548** |
| 16 | Manufacture of food products and beverages | **147,862** | **122,186** |
| 17 | Manufacture of food products and beverages | **19,129,222** | **15,807,467** |
| 18 | Manufacture of food products and beverages | **10,529,407** | **8,700,994** |
| 19 | Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear | **2,223,568** | **1,571,892** |
| 20 | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials | **980,203** | **1,469,042** |
| 21 | Manufacture of paper and paper products | **3,903,313** | **3,856,538** |
| 22 | Publishing, printing and reproduction of recorded media | **1,578,602** | **1,559,685** |
| 23 | Manufacture of coke, refined petroleum products and nuclear fuel | **26,153,513** | **22,064,617** |
| 24 | Manufacture of chemicals and chemical products | **74,662,157** | **79,500,918** |
| 25 | Manufacture of rubber and plastics products | **3,898,798** | **5,763,956** |
| 26 | Manufacture of other non-metallic mineral products | **8,805,336** | **19,430,374** |
| 27 | Manufacture of basic metals | **28,829,410** | **36,251,539** |
| 28 | Manufacture of fabricated metal products, except machinery and equipment | **7,359,068** | **8,213,097** |
| 29 | Manufacture of machinery and equipment n.e.c. | **9,697,288** | **4,761,627** |
| 30 | Manufacture of office, accounting and computing machinery | **364,704** | **179,079** |
| 31 | Manufacture of electrical machinery and apparatus n.e.c. | **2,360,652** | **1,321,126** |
| 32 | Manufacture of radio, television and communication equipment and apparatus | **1,595,750** | **917,358** |
| 33 | Manufacture of medical, precision and optical instruments, watches and clocks | **4,841,394** | **2,377,254** |
| 34 | Manufacture of motor vehicles, trailers and semi-trailers | **15,623,757** | **11,002,467** |
| 35 | Manufacture of other transport equipment | **3,716,727** | **1,709,824** |
| 36 | Manufacture of furniture; manufacturing n.e.c. | **4,487,567** | **4,433,791** |
| 37 | Recycling | **0** | **0** |
| 41 | Collection, purification and distribution of water | **0** | **0** |
| 51 | Wholesale trade and commission trade, except of motor vehicles and motorcycles | **27,990** | **22,128** |
| 72 | Computer and related activities | **421,623** | **333,329** |
| 74 | Other business activities | **113,670** | **89,866** |
| 92 | Recreational, cultural and sporting activities | **378,682** | **299,380** |

Source: Authors Estimation.

Table 10: Total export and Total energy embodied in the export in the year 2006.

|  |  |  |  |
| --- | --- | --- | --- |
| **Code** | **Sectors** | **Import (Milion Rial)** | **Total Energy embodied(boe)** |
| 1 | Agriculture, hunting and related service activities | **13,191,811** | **4,806,954** |
| 2 | Forestry, logging and related service activities | **620,079** | **225,950** |
| 5 | Fishing, aquaculture and service activities incidental to fishing | **369,060** | **134,481** |
| 10 | Mining of coal and lignite; extraction of peat | **198,979** | **484,612** |
| 11 | Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying | **174,669** | **4,531,150** |
| 12 | Mining of uranium and thorium ores | **45** | **110** |
| 13 | Mining of metal ores | **3,725,534** | **9,073,514** |
| 14 | Other mining and quarrying | **3,144,408** | **7,658,185** |
| 15 | Manufacture of food products and beverages | **9,750,425** | **8,057,281** |
| 16 | Manufacture of food products and beverages | **182,045** | **150,433** |
| 17 | Manufacture of food products and beverages | **12,374,755** | **10,225,901** |
| 18 | Manufacture of food products and beverages | **2,379,550** | **1,966,345** |
| 19 | Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear | **1,587,767** | **1,122,430** |
| 20 | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials | **1,117,371** | **1,674,617** |
| 21 | Manufacture of paper and paper products | **4,236,584** | **4,185,815** |
| 22 | Publishing, printing and reproduction of recorded media | **1,999,027** | **1,975,072** |
| 23 | Manufacture of coke, refined petroleum products and nuclear fuel | **12,895,214** | **10,879,149** |
| 24 | Manufacture of chemicals and chemical products | **78,248,333** | **83,319,510** |
| 25 | Manufacture of rubber and plastics products | **6,889,145** | **10,184,864** |
| 26 | Manufacture of other non-metallic mineral products | **8,636,325** | **19,057,424** |
| 27 | Manufacture of basic metals | **15,149,774** | **19,050,082** |
| 28 | Manufacture of fabricated metal products, except machinery and equipment | **4,109,930** | **4,586,893** |
| 29 | Manufacture of machinery and equipment n.e.c. | **25,095,007** | **12,322,319** |
| 30 | Manufacture of office, accounting and computing machinery | **825,048** | **405,121** |
| 31 | Manufacture of electrical machinery and apparatus n.e.c. | **17,067,001** | **9,551,457** |
| 32 | Manufacture of radio, television and communication equipment and apparatus | **4,882,386** | **2,806,765** |
| 33 | Manufacture of medical, precision and optical instruments, watches and clocks | **6,128,702** | **3,009,356** |
| 34 | Manufacture of motor vehicles, trailers and semi-trailers | **7,429,206** | **5,231,750** |
| 35 | Manufacture of other transport equipment | **3,455,695** | **1,589,740** |
| 36 | Manufacture of furniture; manufacturing n.e.c. | **6,171,759** | **6,097,801** |
| 37 | Recycling | **82,568** | **65,277** |
| 41 | Collection, purification and distribution of water | **3,260** | **2,577** |
| 51 | Wholesale trade and commission trade, except of motor vehicles and motorcycles | **315,149** | **249,152** |
| 72 | Computer and related activities | **41,062** | **32,463** |
| 74 | Other business activities | **526,183** | **415,993** |
| 92 | Recreational, cultural and sporting activities | **169,774** | **134,221** |

Source: Authors Estimations.

Table 11: Total CO2 emission embodied in the trade in term of tone, year 2006

|  |  |  |  |
| --- | --- | --- | --- |
| **Code** | **Sectors** | **Export** | **Import** |
| 1 | Agriculture, hunting and related service activities | **3,157,353** | **4,806,954** |
| 2 | Forestry, logging and related service activities | **141,257** | **225,950** |
| 5 | Fishing, aquaculture and service activities incidental to fishing | **48,515** | **134,481** |
| 10 | Mining of coal and lignite; extraction of peat | **127,716** | **484,612** |
| 11 | Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying | **2,505,788** | **4,531,150** |
| 12 | Mining of uranium and thorium ores | **0** | **110** |
| 13 | Mining of metal ores | **5,637,515** | **9,073,514** |
| 14 | Other mining and quarrying | **3,401,241** | **7,658,185** |
| 15 | Manufacture of food products and beverages | **5,399,316** | **8,057,281** |
| 16 | Manufacture of food products and beverages | **52,540** | **150,433** |
| 17 | Manufacture of food products and beverages | **6,797,211** | **10,225,901** |
| 18 | Manufacture of food products and beverages | **3,741,428** | **1,966,345** |
| 19 | Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear | **675,914** | **1,122,430** |
| 20 | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials | **631,688** | **1,674,617** |
| 21 | Manufacture of paper and paper products | **1,658,311** | **4,185,815** |
| 22 | Publishing, printing and reproduction of recorded media | **670,665** | **1,975,072** |
| 23 | Manufacture of coke, refined petroleum products and nuclear fuel | **9,487,785** | **10,879,149** |
| 24 | Manufacture of chemicals and chemical products | **34,185,395** | **83,319,510** |
| 25 | Manufacture of rubber and plastics products | **2,478,501** | **10,184,864** |
| 26 | Manufacture of other non-metallic mineral products | **8,355,061** | **19,057,424** |
| 27 | Manufacture of basic metals | **15,588,162** | **19,050,082** |
| 28 | Manufacture of fabricated metal products, except machinery and equipment | **3,531,632** | **4,586,893** |
| 29 | Manufacture of machinery and equipment n.e.c. | **2,047,500** | **12,322,319** |
| 30 | Manufacture of office, accounting and computing machinery | **77,004** | **405,121** |
| 31 | Manufacture of electrical machinery and apparatus n.e.c. | **568,084** | **9,551,457** |
| 32 | Manufacture of radio, television and communication equipment and apparatus | **394,464** | **2,806,765** |
| 33 | Manufacture of medical, precision and optical instruments, watches and clocks | **1,022,219** | **3,009,356** |
| 34 | Manufacture of motor vehicles, trailers and semi-trailers | **4,731,061** | **5,231,750** |
| 35 | Manufacture of other transport equipment | **735,224** | **1,589,740** |
| 36 | Manufacture of furniture; manufacturing n.e.c. | **1,906,530** | **6,097,801** |
| 37 | Recycling | **0** | **65,277** |
| 41 | Collection, purification and distribution of water | **0** | **2,577** |
| 51 | Wholesale trade and commission trade, except of motor vehicles and motorcycles | **9,515** | **249,152** |
| 72 | Computer and related activities | **143,331** | **32,463** |
| 74 | Other business activities | **38,642** | **415,993** |
| 92 | Recreational, cultural and sporting activities | **128,734** | **134,221** |
|  | Total | **120,075,301** | **245,264,764** |

Source: Authors Estimations.

**Conclusion**

As we can see the total value amount of export is bigger import, since we applied the same coefficient energy intensity for both import and export of Iran so the results can be comparable. The energy embodied in export is larger than embodied energy in import as well. But total CO2 emission embodied in export is half of import one, in other words the embodied CO2 emission in import is two times bigger than export.

Wearers the absolute amount of export is bigger than import so we can say that the emission embodied in import goods is more than two times bigger than export goods. Finally the balance of CO2 emission in international trade of Iran is beneficiary for Iran.

**References**

Andersson, T., Folke, C., Nystro¨m, S., 1995. Ecology, economics, institutions and policy. Earthscan, London.

Daly, H., 1993. Problems with free trade: neoclassical and steady-state perspectives. In: Zaelke, D., Orbuch, P., Housman, R. (Eds.), Trade and Environment: Law, Economics, and Policy. Island Press, Washington, DC, pp. 147–157.

Department of Statistics of Iran.(DOS).(2008). Input-Output Table of Iran 2006, Department of Statistics, Tehran, Published and Printed by DOS, 2008.

Hong,L., Pei Dong, Z., Chunyu, H. and Gang, W.(2007. Evaluating the effects of embodied energy in international trade on ecological footprint in China.Ecological Economics 62, 136-148.

Institute for international energy studies. (2008).National Energy Balance. Ministry of Petroleum Press, Tehran.

Lenzen, M., 1998. Primary energy and greenhouse gases embodied in Australian final consumption: an input–output analysis. Energy Policy 26, 495–506.

Machado, G., Schaeffer, R., 1997. Patterns of energy use in the Brazilian economy: can the profile of Brazilian exports determine the future energy efficiency of its industry? In: ACEEE. 1997 Summer Study in Industry (proceedings), pp. 173–184.

Machado, G., Schaeffer, R., Worrell, E., 2001. Energy and carbon embodied in the international trade of Brazil: an input–output approach. Ecological Economics 39, 409–424.

Pearce, D., Warford, J., 1993. World without end: economics, environment and sustainable development. The World Bank, Washington, DC; Oxford University Press, New York.

Suri, V., Chapman, D., 1998. Economic growth, trade and energy: implications for the environmental Kuznets curve. Ecological Economics 25, 195–208.

Tolmasquim, M.T., Machado, G., 2003. Energy and carbon embodied in the international trade of Brazil. Mitigation and Adaptation Strategies for Global Change 8, 139–155.