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An Input-Output Analysis to Estimate Embodied Energy of Goods

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Abstract- This paper proposes a methodology that integrates a growth model with an input-output transaction matrix to analyze the impacts of economic growth on the consumption of energy .This methodology also use to study that how energy intensity in Indian industry change over time. This allows us to verify the pattern of energy consumption of about 130 each sector between the years 1967- 2012.

Energy consumption and greenhouse gas emissions are closely linked. This paper reviews energy efficiency option to reduce energy intensities and energy consumption and their impacts. Energy efficiency and technological changes, energy mix can save energy by demand in household and as a result green house gas emission decrease. It also present a model to calculate energy consumption in households.

The other focus of this work is on presenting the process of data collection and methodology. Results and discussion will be revealed in a later paper.

Index Terms- Energy efficiency, energy intensity, household, Input-output

I. Introduction

Energy is the most important factor in wealth generation and economic and social development. Based on historical data, there is a strong relationship between economic activities and availability of energy resources.

Energy is needed for basic human needs: for cooking, heating, lighting, boiling water and for other household-based activities. Energy is also required to sustain and expand economic processes like agriculture, electricity production, industries, services and transport. It is commonly suggested that energy consumption is closely linked with development and economic well-being.

The economy was dependent largely on the non-commercial sources of energy for meeting the requirements of the households and on animal and human energy in case of agriculture and transport. During the 50 years that followed Independence, the demand for energy, particularly for commercial energy, registered a high rate of growth contributed largely by the changes in the demographic structure brought about through rapid urbanization, need for socio-economic development and the need for attaining and sustaining self reliance in different sectors of the economy. In economic terms, India has a steeply increasing GDP growth and an expanding economy. At the same time, India hosts a large population living below poverty line, namely 35% of its total population in 2003 [1].

Fossil energy resources are limited and its use is associated with a number of negative environmental effects, therefore energy has become a major geo-political and socioeconomic issue. This development puts pressure on all countries around the world. The pressure on developing countries may be even greater, because they are currently in the process of development which requires higher energy resources for achieving higher living standards. High population levels and high fossil fuel reliance increase this pressure even more. To meet energy security, reduce pressure on fossil energy resources and to ensure a higher environmental quality, the share of low-polluting renewable and clean energy should be enhanced.

During the last 25 years, the risk and reality of environmental degradation, worldwide, have become more apparent. There is enough scientific evidence of growing environmental problems due to combination of different factors, such as increased population, energy consumption and industrial activities in the world. At present, most of world's energy is produced and consumed in ways that could not be sustained if technologies remain unchanged.

II. IMPACT OF FOSSILE ENERGY ON THE ENVIORNMENT

The Intergovernmental Panel on Climate Change IPCC (2007a:253) states that―Presently , green house gas produced from fossils fuels and 75% emission including carbon dioxide, methane and some traces of nitrous oxide .It is well documented that global temperature is rising due consumption of fossil fuels .These emissions may increase the global temperature. As per IPCC (2007b), the global mean surface temperature has risen by 0.74°C ± 0.18°C between 1906 and 2005.

Energy use has potentially significant climate impacts, which are assumed to exceed the impacts from other sources like land-use and other industrial activities. It is considered crucial to implement greenhouse gas (GHG) emission reduction technologies for fossil fuel combustion processes, as they are considered the main contributors to global climate change.

In 2003, the average Indian emitted 16.6 times less CO2 per capita than the average US citizen and the average Chinese citizen emitted 6.2 times less CO2 than the average American (see Figure 1) (World Bank, 2008).

Renewable resources are abundant and globally available which comes from renewable resources, such as sun, water and wind, renewable sources does not emit green house gas during energy generation therefore it is stated that it is close to carbon free technologies. They are usually climate-friendly and environment-friendly.

III. CURRENT SENARIO OF INDIAN ENERGY

India is one of the countries where the present level of energy consumption, by world standards, is very low. It has been shown in table 1

Table: 1 Per capita energy consumption
Sources: Indian Energy Scenario Article

Country	KGOE
India	305
Japan	4050
Sout Korea	4275
USA	7850
China	1200

The estimate of annual energy consumption in India is about 330 Million Tones Oil Equivalent (MTOE) for the year 2004. The world average per capita energy consumption is about 1690(KGOE).

The above figures represent that India is far behind in per capita energy consumption and per capita electricity consumption in compare to many countries it as also fact that India behind even the world average of energy consumption. Therefore, to improve the standards of living of Indian it is imperative that energy level is enhanced.

Growth rate of energy production[1] and compound annual growth rate of production of energy in India by primary sources from 1970-2009 has been indicated in snapshot as in figure 1.it indicates that consumption of all energy resources has been increasing exponentially every year.

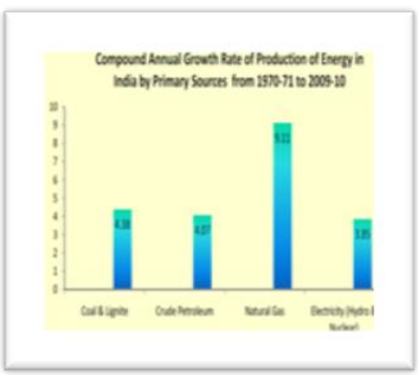
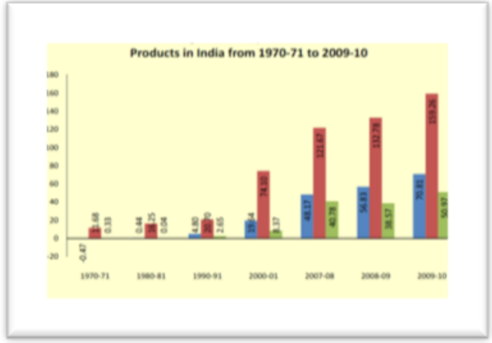


Figure: 1annual growth rate of energy
Sources: Energy Statics -2011

Out of total electricity production, 65.8% comes from thermal power plants, 26.3% from hydro electricity & only 3.1% from nuclear power. Non-conventional, renewable energy sources like solar, wind energy constitute nearly 4.9%. (As per NIC site on Ministry of Power).

At current rate of consumption & production, coal reserves in India would last for about 130 years. Oil would last only for about 20 to 25 years. In commercial energy consumption, coal constitutes 29%, Oil & gas 54% & electricity 17%.

Figure 2 Import of Primary Energy Sources[5]: Energy Statics -2011



The above snapshot in figure 2 indicates that all economic activities use energy. Therefore energy is basically called the engine of the economy. About 90% of world energy use is derived from finite fossil energy.
Combustion of fossil energy involves the emission of carbon dioxide (CO_2). Its caused global warming of the earth which may cause climate changes.

At present, the ratio of energy production to consumption is very low Trend in per capita energy consumption has been shown in table 2.

Today, fossil fuel remains the primary source of energy throughout the world. Oil, Natural gas, and coal have a combined share of 80% of the total energy, and they are the predominant energy sources. Oil and natural gas alone make up 60%of the energy sources, primarily used as fuels, whereas coal is more related to power generation to meet the electricity demand. The increasing amount of fossil fuels combusted is generating increasing amounts of harmful gas emissions .These gases are called green house gases (GHG's)

The inevitable increase in demand and continuing depletion of accessible oil and gas resources during the 21st century will cause greater dependence on energy minerals such as coal, uranium, and unconventional sources of oil and natural gas to satisfy our increasing energy needs.

We need to change course: to switch from an unsustainable fossil fuel-based energy economy to one based on more sustainable resources

The relationship between energy consumption and economic growth is now well established in the literature,

A recent report from the Planning Commission of India mentions that in order to achieve a growth of between 8 and 9%, one of the major challenges is provision of infrastructure and electricity. It aptly points out that universal recognition of shortage of electric power and unreliability of power supply are a drag on the pace of India's development (Planning Commission, 2006).

India's GDP has grown impressively since the mid 1980s and more so since 2003–04. It has not just meant homothetic growth but rather a rapid transformation of the share of different sectors in their contribution to the economy. It is interesting to examine the evolution in the sect oral breakdown of economic growth.

There are two steps to determining the energy demand in each sector. In the first step, the demand is calculated in physical units, it means requirements of fuels for transportation , cooking fuels and lightening , the energy consumption on these sectors are depends on energy intensity and energy efficiency parameters and criteria of users. It is simple criteria to calculate requirements of energy.

The second step is based on the input-output structure of a given sector, the demand for energy in its various forms coal, petroleum products , natural gas, electricity, etc. is determined. It is a very complex criteria to determine and mapping of concerned industry.

This approach integrates an exogenous growth model and an input-output model to analyze energy use and economic growth at an economic sect oral level.

IV. IMPRTANCE OF EMBODIED ENERGY IN HOUSEHOLD SECTOR

Our research papers is based to discuss minimum energy requirements for human being to fulfill their basic needs .that is, requirements of bottom line of total energy demand how much energy will be needed to meet people's satisfaction in eating, housing, clothing, travelling, education and sports entertainment at a higher level of living standard. The energy required for it would increase not only direct energy use but more significantly, indirect use of energy caused by family-using products and services. Usually, households consume more energy in the indirect way [2].

The household is main consumption sector where different income groups consumed different quantity of energy .The Households have many categories of expenditures; they buy products (daily needs product ie footwear, wearing cloths, consumable items, food items etc) and use services (banks, insurances, public transport, etc.).The whole economy is based on energy consumption by industries. The direct energy use of the production sectors can be considered as indirect energy use of the households. Thus households do not only use direct energy, e.g. electricity, motor fuels and natural gas, but also indirect energy by purchasing goods and services

The above literature indicates that80% fossil energy is used as primary energy and for different economic activities. We cannot survive without energy and available energy produce every material requisite necessary

An important aspect is to calculate total energy required for production of economic goods and services. The energy consumed to manufacturing in product is called embodied energy.

The embodied energy of the product is determined according to the convention set by the IFIAS (1974). The embodied energy value is defined here as the amount of energy resources sequestered. The IFIAS (1974) set the boundary limit for calculation of embodied energy.

It is required to calculate the energy required at each step of the production process (embodied energy) for every product that is consumed by the households (Nishimura 1996).The energy requirements depend on pattern of energy consumption. Therefore in order to calculate the energy requirements, it is required to analysis of consumption pattern in different household.

To reveal the relationship between household expenditure and primary energy demand in India a hybrid I –O energy analysis is applied in this paper to forecast the household energy requirements under an assumed expenditure target. However total energy requirements as also depend on export, import, capital goods and investment, government consumption etc which are also taken account to determine sharing of greenhouse gas emission due to all causes.

V. LITERATURE REVIEW

Energy embodied in consumer goods and services purchased by households can be calculated by combining household expenditure data with input–output-based energy intensities. This methodology was developed by Robert Herendeen in the early 1970s, and was first time it was applied to the US economy in 1960–1961 [3], to the Norwegian economy in 1973 [4], and again to the US economy in 1972–1973 [5].

Herendeen also studied various demographic factors influencing household energy requirements such as expenditure (related to income), number of household members, and regional population density. The main results of these early studies were as follows: (1) a substantial part of a household's energy requirements is constituted by non-energy commodities, (2) total energy requirements increase less than proportionally with income, that is, total energy intensity decreases with income, (3) per-capita energy requirements decrease with the number of household members, and (4) urban households exhibit a lower energy intensity than rural households.

In Morioka and Yoshida [6] take an unusual and interesting perspective by assessing actual cohorts through their life stages by analyzing data over four decades. Their result of energy requirements increasing with expenditure is based on an actual time series, instead of the snapshot observations of other studies. Weber and Perrels combine input–output energy analysis with demographic models and behavioral models of car and appliance ownership, in order to determine the likely impact of lifestyles on future energy demand and related emissions [7,8].Jalas [9] presents an interesting conversion of the energy requirements of Finnish households from a commodity to a time-use representation. Three more recent input–output-based studies deal with developing countries [10-12].

The Australian data covers only the largest city, Sydney [13], in order to avoid fixed within-country effects due to the climatic differences across the continent. The Brazilian household expenditure data covers only the urban population of 11 capital cities in Brazil [14]; a survey of the rural population does not exist. Details on the Danish and Indian databases are in Munksgaard et al. [15] .Education is not reported in the Japanese National Survey of Family Income and Expenditure.

In the case of Brazil, direct energy requirements of urban Brazilian households rise with the income.

However, the share of direct energy requirements in total energy requirements is seen to decline with rising income levels of households.

In particular, both direct and indirect energy requirements for transport appear to increase significantly with rising income/expenditure levels of households Previous studies by Parikh et al. [11] and Murthy et al. [12] that examine the energy and carbon emission implications of household consumption in India, make use of only aggregate data from the year 1989–1990, either for the average Indian household or for an average household belonging.

In early studies, Herendeen & Tanaka [16] found that 66% indirect energy is used in rich US households and only 33% in poor households. Similar **about** same fractions of direct and indirect energy use have been studied for rich and poor households in Norway by Herendeen, 1978[17]. In other studies, indirect energy was reported by Vringer & Blok, 1995 [18] to be 54% of the total average energy demand for a Dutch household, 30% for an Australian household reported by Lenzen,1998 [19] and 50% for the average Swedish household by Carlsson-Kanyama et al.,2005[20], while Weber & Perrels [21] reported indirect use to be less than 50% of total energy use for households in France, West Germany and the Netherlands .Reinders et al. [22] matched energy intensities for goods and services in the Netherlands against national household expenditure data from 11 EU countries and found that 36-66% of the energy used was indirect. Similar values have been presented by Pachauri & Spreng [23] for Indian households (50% indirect energy), Park & Heo [24] for households in the Republic of Korea (60% indirect energy) and Cohen et al. [25] for households in Brazil (61% indirect energy)

A number of studies have been carried out in developed countries to analyze overall energy on the basis of input-output method.

Some studies on the basis of input-output method

S.No.	**Description**	**Author**	**Time**	**Country**
1	Energy and infrastructure	Ranjana Mukhopadhyay	1983-84 and 1989-90 input output tables of India	India
2	Energy intensity in India during pre-reform and reform period An Input-Output Analysis	Kakali Mukhopadhyay Fifteenth International Input-Output Conference June 27- July 1, 2005	input output tables (1983-84, 1989-90, 1993-94 and 1998-99)	India
3	Making Input-Output Tables for Environmental Analysis for India: 1993/94 and 1998/99	Koichi Hikita ,Kazushige Shimpo ‡, Megha Shukla,May 2007 2-6 July 2007	Indian I-O tables for the years of 1993/94 and 1998/99.	India
4	Direct and indirect energy requirements of households	Shonali Pachauri , Daniel Spreng (2002)	Input–output 1983–84, 1989–90 and 1993–94.	India
5	Household energy demand for a well-off society by 020	Xing Lua, Shi Leib (2011)	2002 I-O table	China
6	Energy requirements of households in Brazil	Claude Cohena, , (2005)	input–output 1995	Brazil
7	An estimation of energy and GHG emission intensity	Whan-Sam Chung a mApplied Energy 86 (2009)	2000 Korean IO table	Korea
8	Analysis Energy requirements of Sydney households	Manfred Lenzen , (2004)	input–output for1994 and 1999	Australia
9	A scenario analysis of energy-economic in 2030	Eto Ryo , Uchiyama Yohji , and Okajima Keiichi	economic data and an input-output table in 2000	Japan
10	Consumer lifestyle approach to US energy use and the related CO2 emissions	Shui Bina,, Hadi Dowlatabad (2005)	Consumer expenditure Survey (CES) US household in 1997	USA

11	Direct and Indirect Energy demands and CO2 Emissions from production Activities in Jiangsu Province in 2007	Sai Lianga , Tianzhu Zhanga Energy Procedia 00 (2011) 000–0	based on the 2007 MIOT	China
12	An Input–output Analysis of Total Requirements of Energy and Greenhouse Gases for all Industrial Sectors in Thailand	O. F. Kofoworola and S. H. gheewala (2008),	Input-output matrices for the years 2000 and 1998 respectively were utilized.	Thailand
13	Analysis Energy requirements of Sydney households	Manfred Lenzen , (2004)	input–output for1994 and 1999	Australia
14	A scenario analysis of energy-economic in	Eto Ryo , Uchiyama Yohji , and Okajima	economic data and an input-output table in 2000	Japan
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A *Outcome of Literature survey*

Households can be seen as end-users of goods produced and services delivered by economic production sectors. In such an approach, energy used along entire production-consumption chains is attributed to household expenditures. All studies are based on static modeling and, have not considered improvement in energy efficiency in product at consumer end & in manufacturing process. All final demand has been analyzed using constant energy intensity. Output is a linear function of final demand. Detailed household expenditures data in Indian perspective are not considered, which shall be useful to yield comprehensive energy breakdown. Clear correlation should be drawn between per capita income, urbanity, and population growth and consumer behavior.

B *Factors affecting of different household energy use*

There is a positive relation has been found between level of income and total energy use for households in different studied (Herendeen & Tanaka, 1976; Herendeen, 1978; Pachauri& Spreng, 2002; Reinders et al., 2003). This creates problems for countries world-wide as they attempt to lower their energy use while maintaining sustainable economic growth. However, the effect of increasing income varies considerably across countries, even allowing for socioeconomic and demographic variables (Lenzen et al., 2006). An additional variable explaining levels of total energy use is lifestyle, with urban living 10-15% less energy-intensive than rural (nonfarming) living (Herendeen & Tanaka, 1976; Herendeen, 1978). Recent studies of the carbon footprint of UK households (Druckman & Jackson, 2009) and total energy use of Swedish households (Alfredsson, 2002) reached similar conclusions. Local support systems are another possible determinant of household energy use, with the potential for reductions in energy use depending largely on improving such systems, e.g. by improving access to environmentally friendly transportation (Carlsson-Kanyama et al., 2005).

VI. GENERAL TERMINOLOGY

A. Gross energy requirement (GER)

The GER of a product is the sum of all energy sources which are required for the making of the product. The GER is expressed in energy per physical unit of the good or service.

In case of energy per financial unit, often the term energy intensity is used. The energy requirements in terms of energy per unit money value of product. It is defined by IFIAS (1974

B. Primary Energy:

The energy which appears in nature is called primary energy. The types of primary energy can be divided in renewable and nonrenewable energy. Solar energy and wind energy are the example of renewable. Whereas natural gas, coal, crude oil, uranium are the example of non renewable energy.

C. Secondary energy

The form of energy which is available for use, e.g. coke, coal gas, petrol or electricity. The ERE value is always greater than or equal to one, since both numerator and denominator contain the combustion value of the fuel under consideration. The inverse of the ERE value gives the efficiency of the energy conversion.

D. Primary Inputs

The primary inputs consist of imports of goods and services and gross value added.

E. The Gross Value Added:

It comprises depreciation, indirect taxes and subsidies, gross wages and Salaries, charges and profits.

F. Total production **:**

It is the sum of the intermediate deliveries and the final deliveries.

G. Direct Energy

Fuel and electricity used by consumers for heating, lighting and transportation.ie it depends on personal travel and home energy use.(Space heating, water heating, air conditioning, refrigeration, microwave electric press, lightening and other appliances).

H. Indirect Energy:

The energy needed to in the preparation of a product or service ie the consumption of energy before using by consumer is known as indirect energy .The energy which used by industry for producing any product and its delivery up to customer by transportation. In short it is defined as energy embodied in the product is called indirect energy. It depends on housing operation transportation operation and food consumption. The indirect energy use of an economic sector comprises all the energy that is needed for the production and delivery of the goods and services that are used in the production process.

VII. ENERGY REQUIREMENTS IN INDIAN HOUSEHOLDS

Energy analysis provides methods for calculating the energy requirement of households. Main energy analysis methods are process analysis and input-output analysis (IFIAS, 1974).Process analysis is an accurate, but also laborious method and for that reason less appropriate for calculating the household energy requirement. Input-output analysis is a much faster calculation method. Therefore, it is a convenient methodology for the determination of energy use associated with consumption patterns.

A main consumption sector is formed by the households. Households have many categories of expenditures; they buy products (food, clothes, etc.) and use services (insurances, public transport, etc.).

Economic activities depend upon the household expenditure and consumption, Economic activities means production and consumption of products. However economy is also based upon services delivered by industries.

Assuming that production takes place in favor of consumption implies that all energy use in an economy can be allocated to consumption. A main consumption sector is formed by the households. The whole economy is based on this consumption of goods produced by industry, and services delivered by service industry.

All indirect and direct energy which is used in industrial sector embodied in product and is used in household sector as indirect energy.

However, for any country the energy requirements of households is never equal to domestic energy use because some production and services are also imported and exported to and from other country. Forecasting of future household energy requirements on the basis of an estimate of the demand of Consumption items.

In 2001 Parliament adopted a law on energy efficiency, known as the Energy Conservation Act. This law came into force in March 2002. It required large energy consumers to implement specific actions and introduced energy consumption labels and performance standards for electrical appliances. The Bureau of Energy Efficiency was created to implement those provisions.

Production is a transformation process in which two agents of transformation, human labor and manufactured capital transform a flow of materials, energy, and information. The flow of energy, materials and services from natural capital is what is being transformed (the material cause), while manufactured capital effects the transformation (the efficient cause). For example, all machines require energy for their operation and they function by acting on a flow of materials from natural capital.

This study investigates household energy requirements from a physical/technological perspective. For this purpose, the energy analysis methodology is used which has been under study since the early 70s.

Examines household energy requirements in the year 2025 by implementing improvements in energy efficiency and volume changes in household consumption assuming production structure and consumption pattern remain unchanged. Forecasting of future household energy requirements on the basis of an estimate of the demand of consumption items at sector level

VIII. INPUT OUTPUT MODEL

The input-output framework of analysis was developed by Wassily Leontief in the late 1920s and early 1930s. The input-output analysis is a method of systematically quantifying the mutual interrelationships among the various sectors of a complex economic system. The input-output model is based on a fully determined general equilibrium model, where all the intermediate goods were expressed as a set of equations with sales and purchases of the intermediate industries forming the core of the system.

Within the field of input-output analysis exists a technique for measuring the energy use in producing goods and services of an economy using physical (energy) units for all primary and secondary energy sectors in an input-output matrix. Given sufficient data availability the so called full hybrid-unit analysis, which takes into account energy conservation conditions, is suitable to trace the energy needed for production of goods and services for delivery to final demand. The method shows the effect of consumer spending on direct and indirect energy use. For example, say a consumer buys a new car, this will have a direct effect on transactions among industries (manufacturer mainly) as well as an indirect effect (on the steel making industry as well as transport) in the inter industry matrix of the input-output table. The direct and indirect energy coefficients can be used to calculate the energy effects created by such transactions.

Following the energy crisis in the 1970's, hybrid unit models have been used as a tool to give recommendations for appropriate design of energy policies (Wright, 1974, Bullard and Herendeen, 1975). The technique has been broadly applied to evaluate overall efficiency of production systems, to show effects of inter-fuel substitution on energy intensity, to investigate technological change, as well as to estimate different energy use due to changes in final demand.

Different input-output models are specified in order to study the interrelations between economic activities and their impacts on the environment, pollution and natural resources use. Park(1982) puts forward an input-output model to study direct, indirect and induced energy effects of a change in demand and estimates the effects of technical change on energy consumption.

Hawdon and Pearson (1995) constructed an input-output model to study interactions between energy and economic activities for the United Kingdom. Henry 1995) discusses the idea of capacity growth and the impacts on energy in an input-output framework and shows how a forward year by year uniform capacity growth across all sectors can be reached based on a specific annual growth rate.

IX. METHADOLOGY

There are following method of energy analysis

A *Process analysis:*

An energy analysis from a technical perspective is called process analysis. Process analysis is an accurate, but also a laborious method.

B *Input-output energy analysis:*

An energy analysis from an economic perspective is called input output analysis.

Input-output analysis is a much faster calculation method. Therefore, it is a convenient methodology for the determination of energy use associated with consumption patterns. However it is less accurate than process analysis.

In *input–output* analysis the energy requirement is determined using an economic-statistical approach. The transactions between the various sectors of an economy are collected in an input–output matrix (Leontief, 1966). For each combination of two sectors, the input–output matrix contains, in monetary terms, the supply from one sector to the other sector. Certain direct energy requirement can be attributed to each sector in the input–output matrix, for instance, on the basis of energy statistics. Subsequently, by applying several mathematical operations to the matrix, one can calculate the energy requirement associated with the delivery of the final goods to consumers

An input output table of an economy contains the transactions between economic sectors in financial units. With such an input-output table and data on the primary energy use of every sector, the energy intensity of each sector can be calculated. This energy intensity gives the total primary energy that a sector needs for the production of one financial unit of output. Since the data available from input output tables are more aggregated than data received from process studies.

In general, the energy requirement for any product differ from manufacturer to manufacturer Therefore we are not interested to know the energy requirements of a product produced in a particular manufacturer, but we are interesting to know the energy requirements of an average product bought by an household in India. Input output table has been shown in table 3.

B Application of input-output method [27]

For energy analysis, the basic input output model is extended to use for energy analysis. It is considered that the input- output coefficient matrix can be decomposed and expanded to account for energy supply industries.

- Assess how various changes in energy technology might affect the economy in long run.
- Estimate the impact of shortage of fuel.
- Analysis of energy and greenhouse gases emission in economic sectors.

C. Strength of I/O Method

- Input–output (I–O) analysis is an analytical framework for evaluating the interrelations between economic activities.
- Ability to capture indirect effect.

Input-output analysis is a much faster calculation method. Therefore, it is a convenient methodology for the determination of energy use associated with consumption patterns

D Transaction Equations

$$X_{11} + X_{12} + X_{13} + X_{14} + X_{15} + X_{16} + Y_1 = X_1$$
$$X_{21} + X_{22} + X_{23} + X_{24} + X_{25} + X_{26} + Y_2 = X_2$$
$$\vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots$$
$$X_{n1} + X_{n2} + X_{n3} + X_{n4} + X_{n5} + X_{n6} + Y_n = X_n$$

x_{ij} is a sale from sector *i* (rows) to sector *j* (column), *Y* is a sale from sector *i* to final demand, and X_i is the total output of sector *i*.

$$a_{ij} = \frac{x_{ij}}{x_j}$$

It is called technical coefficient this means value of input purchased from all sectors in the economy per economy monetary value.

Where, *I* is the identity matrix, and *B= (I-A)*$^{-1}$ is the Leontief inverse matrix. It represents total output required to produce for unit rupee financial demand by respective sector.

$$X = AX + Y$$

$$X = \begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{pmatrix} A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix} Y = \begin{pmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{pmatrix}$$

Y is the value of private consumer demand.
V is the value of inventory investment demand..
G is the value of government demand.
E is the value of export demand.
M is the value of imports

$$X = Y + V + G + E - M$$

$$\begin{aligned} &a_{11}X_1 + a_{12}X_2 + a_{13}X_3 \ldots\ldots\ldots + a_{1n}X_n + Y_1 = X_1 \\ &a_{21}X_1 + a_{22}X_2 + a_{23}X_3 \ldots\ldots\ldots + a_{2n}X_n + Y_2 = X_2 \\ &\vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \\ &a_{n1}X_1 + a_{n2}X_2 + a_{n3}X_3 \ldots\ldots\ldots + a_{nn}X_n + Y_n = X_n \\ &AX + Y = X \end{aligned}$$

Where, *Y*= vector of final demand
A= matrix of inter-industry coefficients or technological coefficient
X= vector of gross outputs

$$X = (I - A)^{-1} Y$$

E Energy Balance Sector

$\varepsilon_1X_{11} + \varepsilon_2X_{21} + \varepsilon_3X_{31} + \varepsilon_4X_{41}$ +---------+ ε_nX_{n1}+ $E_1 = \varepsilon_1X_1$
$\varepsilon_1X_{12} + \varepsilon_2X_{22} + \varepsilon_3X_{32} + \varepsilon_4X_{43}$ +---------+ ε_nX_{n2} +$E_2 = \varepsilon_jX_2$
$\varepsilon_1X_{13} + \varepsilon_2X_{23} + \varepsilon_3X_{33} + \varepsilon_4X_{43}$ +---------+ ε_nX_{n3} +$E_3 = \varepsilon_jX_3$
$\varepsilon_1X_{14} + \varepsilon_2X_{24} + \varepsilon_3X_{34} + \varepsilon_4X_{44}$ +---------+ ε_nX_{n4} +$E_4 = \varepsilon_jX_4$

$$E_j + \sum_{i=1}^{n} \varepsilon_i X_{ij} = \varepsilon_j X_j$$

Where as

E_j is the direct energy input into sector *j*
ε_i is the embodied energy per unit production of sector *i*
x_{ij} is the goods and services flow from sector i to sector *j*
X_j is the gross production of sector *j*.

Therefore total energy required to produce one unit financial i.e. total energy intensity of product
$E_{out} = \varepsilon_j Y_j = d_j (I - A)^{-1} Y_j = d_j X_j = E_{in}$

This equation provides information for consumption of indirect energy requirements.
Where E *the indirect energy requirement of households.*
d_j matrix with direct energy intensities of economic sectors per unit financial value .

I unit matrix
A Technological matrix and *y* household consumption vector

F Input-Output Analysis – Salient feature

The central advantage of Input-Output analysis is that it tries to estimate these inter-industry transactions and use those figures to estimate the economic impacts of any changes to the economy.

The IO approach estimates how many goods and services from other sectors are needed (*inputs*) to produce each Rs. of *output* for the sector.

G Parameters affected energy consumption

There are following parameters which affect energy saving opportunities.
$E_{out} = \varepsilon_j Y_j = d_j (I - A)^{-1} Y = E_{in}$

- Improvement in Conversion efficiency (r)
- Improvement in technological matrix (A)
- Change of consumption pattern (Y)
- Decreasing in direct energy intensity factor (d)

The combined effect of all individual options determines the over-all effect on the household energy requirement with regard to the given set of options. The combined effect of a set of reduction options may be lower than the sum of the effects of the individual options.

The energy intensity of an economic sector gives the required amount of energy per unit deliveries of that sector.
The energy requirements of specific deliveries

$E = d (I-A)^{-1} y = e\ y = d\ x_h$

Multiplying the energy intensity of each sector with the deliveries to households and summing over all sectors, household energy requirements are calculated.

Since the energy intensities calculated with this method do not include the direct energy deliveries to households, the above relation is concerns the indirect energy requirements of households.

X. Construction of input-output model table for Indian economy

The government of India started the study on input-output accounts in the late 1950's. In 1959, the Central Statistical Organization (CSO) set up a committee and it was involved in the compilation of input –output table. The CSO publishes the transaction tables on regular basis, at the interval of four to six years, with supporting tables (see Table 4). The CSO

Tables have been consisting of 60 sectors in 1968/69 and 115 sectors since the 1973/74 table, but it increased to 130 sectors in the latest 2003/04 table (see Table 4 for sector classifications).

A. Features of India's Input-Output Tables

India's I-O tables have been with the principle of the System of National Account (SNA) that is determined by the United Nations (UN) as an international standard. India's table employs the India's fiscal year as the reference period, i.e. from April through March.

The number of sectors of the India's table Increased from 115 in 1998/99 to 130 in the latest 2003/04 table, in response to the changes of the economic structure. The service sectors account for most of the increase. Specifically, the transportation service increased from only two sectors ("103 Railway transport services" and "104 other transport services") in 1998/99 table to five sectors in 2003/04 table and "114 Other services" in 1998/99 was split into seven sectors in 2003/04. The intermediate transactions are valued at factor costs (producer's price less indirect taxes). The transactions of the India's table are evaluated at factor costs.

Table: 4 Input-Output Tables of India

Ref year	industries	Year published
+1968/69	60	1978
1973/74	115	1981
1978/79	115	1989
1983/84	115	1990
1989/90	115	1997
1993/94	115	2000
1998/99	115	2005
2003/04	130	2007

The final demand and the value added sectors of India's tables have been unchanged since the first CSO table for 1968/69. The final demand of the India' table consists of six items, i.e. (1) Private final consumption expenditure (2) Government final consumption expenditure (3) Gross fixed capital (4) Changes in stocks (CIS), (5) Exports (EXP) and (6) Imports and exports.

XI. Data Sources

The basis of the data of our research is to different input output tables Input-Output tables of the Indian economy for the years 1968-69 , 1973-74 ,1978-79, 1983-84, 1989-90, 1993-94,1998-99 2003-04 - prepared by CSO in 1978,1981,1989,1990,1997,2000,20052007 . Input-Output tables are Commodity by Commodity tables consisting of 60 x 60 sectors. These have been aggregated to 47 sectors on the basis of the nature of commodities. Here we shall convert the monetary units of energy sectors into physical unit from the energy data published by CMIE report. Three energy sectors like coal as million tones, crude petroleum in million tonnes, natural gas in million cubic meter and electricity in T.W.H have been converted into one common unit which is million tones oil equivalent or mtoe. For better presentation of results this mtoe unit has been transformed to thousand tons of oil equivalents.

NSSO surveys provide time-series data of expenditure on food and non-food items in different income groups, residence (rural & urban) and state. Taking into account the cost of food in the corresponding year, NSSO computes and reports household level of consumption of different food items.

The report presents data on both level of consumption measured by the sum of monetary values of goods and services consumed per month by households and pattern of consumption reflected in the composition of total consumption by commodity group. The report also presents distribution of households and persons over different ranges of quantitative consumption level, separately for rural and urban areas of different States of the country.

Average monthly per capita consumer expenditure (average MPCE) in 2005-06 wasRs.625 in rural India and Rs.1171 in urban India at 2005-06 prices [26].

XII. Conclusion

The input output table published by the CSO contains highly aggregate data which have many limitations. This table is used to calculate energy intensity of the product. The embodied energy in the product can be used to calculate energy required domestically or for household. Further total energy consumed by any industry can be exactly equal to energy required for household, because product manufactured by any industry is used for many purposes, some of the part is imported and also export etc.

The first step of our research to evaluate the effects of energy conservation options by using input output analysis and also assess total energy demand caused by Indian household consumption and o predict overall energy demand increment caused by household consumption.

We presented a methodology to describe the option of evaluating technological and demand-side energy Conservation options based on an input-output model for the calculation of the energy requirement of households.

The scope of decline the energy intensity of Indian industries. To examines the factors that influence energy intensity in Indian industries.

The input-output framework enabled an easy investigation of the effects of different options for the household energy requirement. Besides, the use of input-output analysis enables (future) research directed on the effects of these options on several economic parameters the evaluation of individual energy conservation options may result in a ranking of energy conservation options concerning the effect on energy use and economic parameters. The outcome of such considerations clarifies the social significance of separate energy conservation options.

The approach described is generally applicable, but considering the easy access to data, In this analysis we could also calculate The energy requirement does not correspond with energy use in the Indian household but energy use in the economic production sectors, e.g., import, exports and investments capital goods etc.

As the demand pattern in households vary with income level and geographical location (rural/ urban), better results are obtained by disaggregating the demand by income level and rural/ urban areas. The total demand in that case would be sum of demands by all categories and locations.

We combined several data sources and apply them in an integrating modeling in calculating energy requirements .National sample survey organization provides information regarding private consumption and also find out household characteristics in urban and rural area. This methodology will help to calculate green house gas production in every sector. We could also compare the national differences in income and expenditure elasticity of both energy and green house gas emission.

Future prospects show a further increase in economic activities. According to the match between energy use and economic activities, the present energy supply based on fossil fuel is not sustainable. A solution is a switch to renewable energy carriers. Since this switch takes time, a first step is a more saving use of fossil energy carriers.

The feasibility of an integrative approach which considers total energy use in combination with the relations between production processes.

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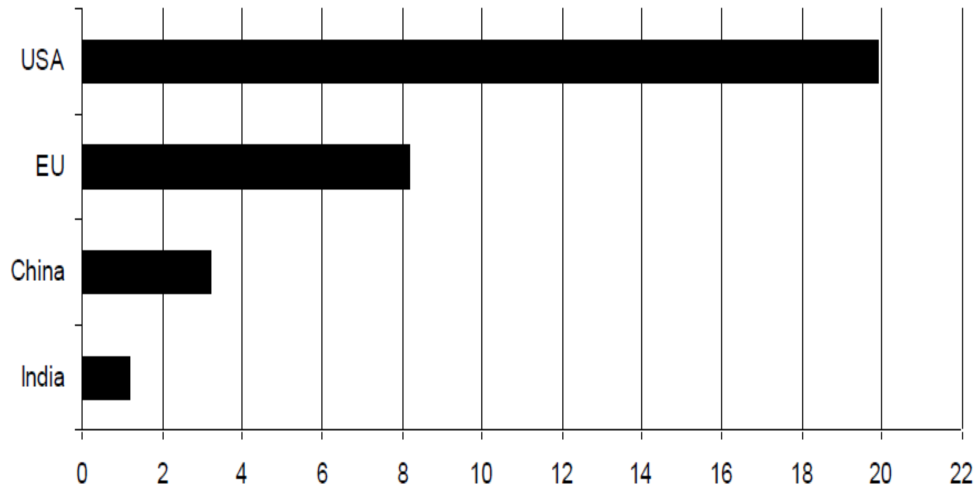

Figure 1: CO_2 emission for USA, EU, China and India [CO_2 emission per capita]
Sources: World Bank, 2008).

Year	Energy consumption in KWH in billion	Midyear population in000 number	GDP (Crore) in 1999)2000 price	Per capita energy consumption (KWh)	Energy Intensity (KWH)* per rupee
1970-71	663.99	5,51,311	517148	1204.39	0.1284
1975-76	840.53	6,17,248	596428	1361.74	0.1409
1980-81	1012.58	688320	695361	1471.09	0.1456
1985-86	1477.50	7,66,135	894041	1928.51	0.1653
1990-91	1902.75	852297	1193650	2232.50	0.1594
1995-96	2436.77	939540	1529453	2593.58	0.1593
2000-01	3154.28	1034931	2030710	3047.81	0.1553
2005-06	3909.37	1117734	2844942	3497.59	0.1374
2006-07	4226.78	1134023	3120029	3727.24	0.1355
2007-08	4508.26	11,47,677	3402716	3928.16	0.1325
2008-09	4808.48	11,61,495	3711016	4139.91	0.1296

Table 2 Trend in per capita energy consumption and energy intensity in India
Sources: Annual report 2010-11, Government of India, ministry of statistics

Table 3. Sectoral growth rates of real GDP (1999-2000 prices) (%)
Source Economic Survey 2007–08,

	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Agriculture	0.02	5.86	5.89	9.29	0.70	5.82	3.95	4.5	2.5
Industry	6.75	2.82	6.89	7.80	10.54	10.63	11.45	8.5	7.5
Service	5.65	7.18	7.47	8.49	9.14	10.34	11.08	10.8	9.6
Total	4.35	5.81	3.84	8.52	7.45	9.40	9.62	9.7	7.7

Table: 4 Input -Out put table

Sectors (i)	**Intermediate demand or intermediate transaction (j)**							**Final demand**	**Total output**
	1	**2**	**3**	**4**	**-**	**-**	**n**	**Y_i**	**x_i**
1	**X_{11}**	**X_{12}**	**X_{13}**	**X_{14}**			**X_{1n}**	**Y_1**	**x_1**
2	**X_{21}**	**X_{22}**	**X_{23}**	**X_{24}**	**-**	**-**	**X_{2n}**	**Y_2**	**x_2**
3	**X_{31}**	**X_{32}**	**X_{33}**	**X_{34}**	**-**	**-**	**X_{3n}**	**Y_3**	**x_3**
4	**X_{41}**	**X_{42}**	**X_{43}**	**X_{44}**	**-**	**-**	**X_{4n}**	**Y_4**	**x_4**
-									
-									
-									
n	**X_{n1}**	**X_{n2}**	**X_{n3}**	**X_{n4}**	**-**	**-**	**X_{nn}**	**Y_n**	**x_n**