Ph. D. Dissertation in Engineering

Empirical Analysis of Effect of Demand Structure on the East African Electricity Power Market

수요구조가 동아프리카 전력시장에 미치는 영향에 관한 실증연구

August 2014

Graduate School of Seoul National University

Technology Management, Economics, and Policy Program

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이 논문을 공학박사학위 논문으로 제출함
2014 년 8 월

서울대학교 대학원
협동과정 기술경영경제정책 전공

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Ephrem Hassen Gossoma 의 공학박사학위 논문을 인준함
2014 년 8 월

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Abstract

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The Sub Saharan Africa (SSA) electrification coverage was 32% while the African average was 43% (IEA, 2012). The figure for SSA ranks it at a lower profile in terms of electrification. Despite very low level of electrification in the SSA, many countries in this region are undertaking ambitious economic development programs.

To balance the gap between the demand and supply, Electricity market integration was considered as one of the means. As electricity market integration allows transaction of electricity between countries, there need to be strict precautions for every country in deciding to involve in the market. Many

inputs are required in planning the electricity market integration process. Exporting countries need to account for their remaining balance of electricity for local use. On the other side, Importing countries need to justify the volume of electricity they claim to get from the market. No denial that quantity and price are important in trade and market. The quantity and price are performed based on behavior of economic sectors.

Based on this idea, this research was looking at how electricity need is accounted for economic sectors based on the lowest possible determinant variable of use. This research used Index Decomposition Analysis (IDA) method to identify the factors of electricity consumption in six selected East African Countries: DRC, Egypt, Ethiopia, Kenya, Sudan and Tanzania. In this study, electricity consumption was decomposed in two effects, which are structure effect and intensity effect.

Analyses were done in two models; 1) for each country consisting of four economic sectors namely, Agriculture-Forestry-&-others, Industry, Commercial & Public Services, and Residential Sectors, and 2) at economic sector level across the six countries. From these two types of analysis models, one can realize that sector level estimation of electricity consumption and using factors of consumption gives better picture of actual demand for electricity than the aggregate level estimation. Time period in both analyses is from 1990 to 2010, but it varies among countries due to each country's data availability.

For the first case, the outputs from decomposition of each country's aggregate electricity were set of four structure and intensity effects. The first analysis was to show how electricity consumption was affected by change in mix of sectors and change in intensity of use by each sector with in a country. The first analysis gave significant result in differentiating the sector of importance in electricity use within a country.

In case of DRC, intensity effect dominated during the 1991-1999 and structure effect dominated during the 2000-2010. The intensity effect dominated for the whole study period. During 1991-1999, Industry and Residential sectors push the intensity effect. The important sectors in the case of DRC were Industrial and the Residential sector. The Result of Index decomposition analysis for Egypt in 1996-2010 shows that intensity effect was increased bigger than structure effect. And in Egypt, the Industrial sector and Agriculture-forestry-&-others sectors take the dominant role in the electricity use in this period. The result from Index decomposition analysis in Ethiopia shows that the increasing of structure effect is half size of increasing of intensity effect. The relevant sectors were the Industrial sector and Commercial & Public Service sector in structure effect, and Residential sector and Commercial & Public Service sector in intensity effect.

In Kenya, the analysis was performed for three time periods: 1991-1994, 1995-2007, 2008-2010, due to data availability of sectors. In Kenya, the analysis result showed that increased of structure effect is small compared with the intensity effect during periods. The dominant sector in affecting the change in electricity consumption varies in this analysis. The result of decomposition analysis for Sudan shows that intensity effect increased in big figure. This was mainly attributed to the low figure of Residential sector consumption expenditure compared to the electricity volume it uses. Based on Index decomposition analysis for Tanzania, structure effect was smaller than intensity effect. The trend that Intensity effect dominated in most part in the study period repeated in Tanzania. The trend that Intensity effect dominated in most part in the study period repeated in Tanzania. For Tanzania, the Industrial and Residential sectors were dominant.

The second analysis was to show how electricity consumption of each sector was affected by change in countries' share. In this case, the result was more refined. Each country was compared with the remaining five and it was relatively easy to tell the fate of each country based on the proportion of its intensity of electricity consumption volume for that specific sector. For instance, Agriculture-forestry-&-others sector's aggregate electricity intensity was decomposed.

Index decomposition analysis of aggregate electricity intensity in Agriculture-Forestry-&-others sector for 1991 to 1994 showed increased structure and intensity effects. Most of the countries did not use electricity in the agriculture sector during 1995-1999. But they produced economic output through conventional methods without using much electricity for productive purpose in the sector. The electricity intensity has increased in the sector in 2000 to 2007 due to increase of intensity effect. Analysis results of Industry sector for 1991 to 2010 show that structure effect has decreased while the intensity effect has increased. Though intensity effect was slightly bigger, the effect of change in activity mixes dominated because of reduced share of Egypt and DRC.

Index decomposition analysis of Commercial and Public Services sector was classified in to two parts due to data availability. The results for 1991 to 1999 show that structure effect has decreased while the intensity effect has increased dramatically. The result for 2000 to 2010 shows that both structure effect and intensity effects have increased. Structure effect showed decrease in electricity used to produce an economic output in a year, but intensity effect shows big change in volume of electricity used to produce an economic output in a year.

Index decomposition analysis of Residential sector for 1991 to 2010 shows that structure effect has decreased while the intensity effect has increased. Since intensity effect was slightly bigger, the effect of change in activity mixes was dominated because share of Egypt, Sudan, and DRC was decreased and also

Kenya’s share remaining constant. Decreased share of Egypt shows reduction of output growth rate leading to less electricity use even though the volume of production increased. In this sector, the intensity change was important in identifying the country that dominated in the electricity use in the Residential sector for this specific period.

Countries need to be harmonized in the market and also be well organized in both regional and national electricity plans. Based on this idea, this research was looking at how electricity need is accounted for economic sectors based on the lowest possible determinant variable of use. The results of this research, considering economic sectors at first taking their lowest possible category of consumption variable, can be used to minimize mismatch and consequent negative repercussion on the sectors electricity access and on the overall economy of any participating country.

Electricity use in the six east African countries was increasing mainly due to positive change in the electricity use for economic value added on annual basis. This analysis identified the most strategic sector among others that caused such change in each country. This helped to identify strategic sectors among others for planners, decision makers and executing bodies of respective countries. The structure effect and intensity effect have been direct determining variables for the change in the size of electricity used in the economic sectors;

hence these factors were used frequently in describing the policy implications in the six countries.

For Ethiopia, based on the result of the IDA it was possible to identify the following policy implications. The Commercial and Public Services Sector dominated in both effects in contributing to the change. This implies that the economic sectors or even countries would hold dominant role if their contribution dominates in terms of activity mix effect and intensity effect. In this study, the Commercial and Public services sector can be considered strategically important sector in planning for electricity demand.

Keywords: : Ethiopia's Electricity intensity, Demand structure, Index Decomposition Analysis, Intensity effect, Structure effect, East African Electricity Power Market

Student Number: 2011-30799

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Chapter 1 Introduction

1.1 Background

Electricity shortage and consequent interruption are main features of energy sector in most part of Africa. According to the World Energy Outlook 2013 of the IEA, the global electrification level was 81.9% while it was 43% for Africa in 2011. Within Africa, the Sub Saharan Africa electrification coverage was below African level. Despite very low level of electrification, many countries in this region are undertaking ambitious economic development programs. To support these programs, the countries need corresponding level of infrastructure development including electricity generation and supply. Hence they are compelled to execute both infrastructure and economic development programs side by side though huge finance and accompanying resources are needed.

In Africa, countries with relatively good resource potential have been trying to curb this problem through construction of additional power generation facilities. But achieving sustainable solution at individual country level was hindered by many factors. The most important factors include limited finance, uneven distribution of the energy resources, and limited technical capacity. For instance, Ethiopia, DRC, Uganda, Sudan, and Rwanda are countries rich with resources mainly hydro (SNC_LAVALIN INRENATIONAL INC &

BRINCKERHOFF PASONS, 2011). According to the electricity Master plan of East African Power Pool (EAPP), these countries were identified as potentially having excess amount of electricity for sale in international market within the region. But to convert these resources to useable form, most of them depend on external financial sources except the recent effort by Ethiopia to finance a big hydro power project.

There are other countries in the sub region which lack both the energy resource and sufficient finance. Moreover, the technical capacity in most of the counties is not yet matured to handle such large scale electricity power generation facility and their local manufacturing capacity has not yet developed. Therefore, the countries remain partly handicapped to lead their vigorous economic development programs unless they find out alternative means for meeting the big demand for electric energy.

Nevertheless, the current global trend in power market blinked a dawn of hope that electricity supply problems can be solved through interconnection of national grid systems. A number of western developed countries Like Norway, Denmark, England, and USA handled electricity supply problem through electricity market integration though some of them have their own planning issues. It has been a good remedy for balancing power supply in time of shortage or seasonal variation.

For instance, the fluctuation of wind power in Denmark could be balanced by excess hydro from Norway in the Nordic Pool. During dry season, Norway does the same from the wind resource based power in Denmark and other potential member countries in the Nord Pool (Bach.Paul-Frederik, 2011). Though the purpose of interconnection in the developed countries was not strictly for solving shortage of finance, the model was found effective in solving financial and technical capacity problems too. The Interconnection could also be a very good remedy for countries with insufficient energy resource to meet local demand. It also could be a way out for those with limited affording capacity to build new power plants locally.

Power market in Africa started in the form of bilateral trade. The first bilateral trade was begun between Democratic Republic of Congo (DRC) and Zambia in 1950 (Kambanda,C., 2014). Enlarging the network and transition to integrated markets at sub-regional level was considered as one of the best measure in addressing the electricity problem in Africa. With this initiative South African Power Pool was established as pioneer in 1995 in the continent. Three more Power Pools and one association of utilities where North African countries are incorporated were established, East African Power Pool comprising of 10 countries being the latest. Since the initiative for creating this market was to enable affordable and reliable electricity in the market for the sub region, knowledge and frequent follow up of the behavior of consumption in all the countries requires special attention as the market progresses.

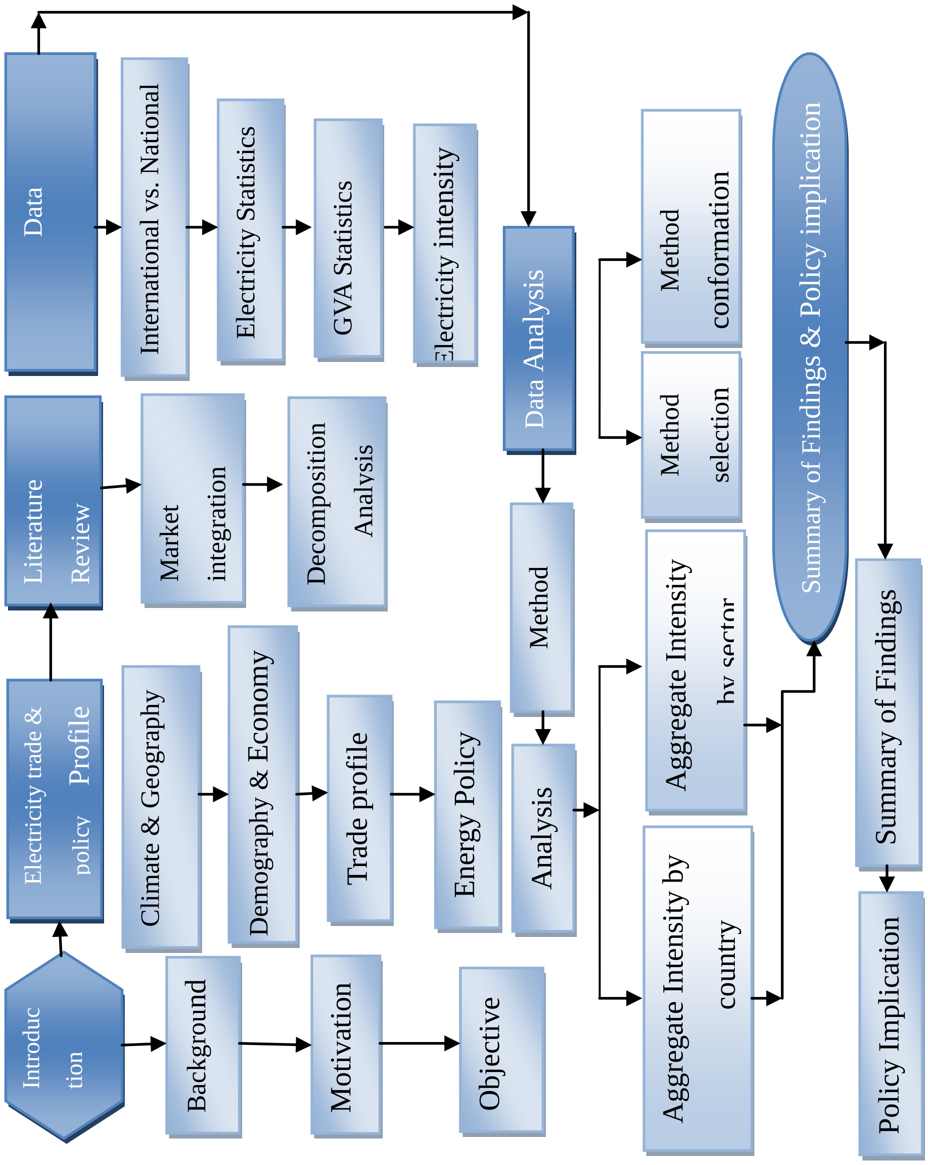

Fig.1-1 Flow of Research Process

1.1 Research Motivation

As power pool is a market model for transaction of electricity between countries, there need to be strict precautions for every country in deciding to involve in the market. Exporting countries need to account for their remaining balance of electricity for local use. Importing countries also need to justify the volume of electricity they claim to get from the market. Here, no denial that quantity and price are important, but this research was looking at how electricity need is accounted on behalf of economic sectors or consumers. The approach, considering economic sectors or consumers at first, is believed to minimize mismatch and consequent negative repercussion on the sectors electricity access and on the overall economy of any participating country.

Countries in the EAPP have developed common master plan for facilitating implementation of the integration process. One of the main components of the master plan was demand estimation and forecasting. It was developed through review of existing national master plans. The models adopted and variables used for developing these master plans varied somehow. After establishing the EAPP, New master plan[1] was developed using different model

[1] In general, the regional master plan was prepared with due care. The model used was Regression Analysis Load Forecast (RALF). Depending on data availability, major input variables considered in clude historical data on population, GDP by economic activity sectors and their forecasts. Historical sales, consumer number, and tariff by consumer category, generation sent, and system peak were incl

and variables from those reported by the countries. This document is considered as common reference for execution and monitoring of the sub regional integrated electricity market.

Compared with National level master plans, the regional master plan has considered consistent variables across the countries where data availability permitted. The common variables included in estimating demand were demographic, national income, sector level electricity use among others. The model used was its own Regression Analysis Load Forecasting (RALF). The result of such estimation was aggregate[2] demand in which future direction of change was presented in this aggregate for each of the countries. But the way electricity use by economic sectors accounted in the demand can be further refined.

Identifying real estimates for the electricity demand and its forecast is essential base for planning relatively stable electricity market. To make it more

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uded. Detailed input assumptions considered including Energy sales (GWh), Tariff (cost/kWh), Numbe r of consumers, and Specific consumption (kWh/consumer) by consumer categories. But in cases whe re there are data gaps and reliability problem, combination of growth rate analysis, electrification ass umption, population data and specific consumption assumptions were used to derive independent dem and forecast.

[2] Further detailing of variables in to their components where possible in terms of data availability a nd reliability would contribute in substantiating the causes of change in the demand for electricity at national level. This would further ensure users security for access when a country involves in such type of market.

robust, the input variables used in the estimation process have to reflect reality as much as possible. Therefore, these variables have to be split into their lowest components where possible. Thriving to reach at demand segments or structures reflecting customers' reality has to be given as much attention by planners and decision makers as possible.

This contributes for better review of the demand and the forecasts for the regional electricity market. Failure to review factors and their proportion in the estimates & forecasts of the electricity demand may contribute to failure of investment in big power generation facilities, poor performance of the market, and finally failure to achieve the main objective which is sustainable supply of electricity in the sub region. This concern was based on observed facts in the country level planning exercises in the east African sub region.

There was a case where demand has been forecasted based on an assumption of change in system wide specific consumption (BRINCKERHOFF, SNC_LAVALIN INRENATIONAL INC & PASONS, 2011). System wide specific consumption was defined in the master plan as an amount of electricity used regardless of the type of consumer. The result indicated low level of change in the national electricity demand throughout the study period of the national master plan. This was because the assumption allowed even distribution of specific electricity consumption regardless of difference in the size of electricity used in each of the sectors, apart from the small size of users.

It has hidden the difference in share and underemphasized respective impact sectors might have on determining the future demand for the electricity. Also, it concealed the fact that the decrease or increase of a demand for electricity could vary from sector to sector. If this approach continues to be pursued in the planning process, it makes every sector strategically important which can rarely happen in reality. Also a country trying to join the integrated market with such a plan easily fails to cope in the system since facts about electricity demand in such a country do not represent reality. It has to be clearly understood that the aggregate demand value tells what volume of electricity is needed. But it is difficult to depend on this value and do investment planning for stabilizing supply problem since it does not have any connection with its causes.

Electricity demand is dependent on other sectors development plan. Also since it is aggregate value, it shows only the need of an economy or a country at gross level. This gross level need for power in a country is retained as refined or a net from the individual components of sector level needs. The sector level needs may change in different direction depending on the change in energy intensity of electricity end use facilities at users' premises or due to change in the number of users of such facilities.

Hence there could be chance of diversion from forecasted value depending on the dominant type of change and its direction. This occurs because some of the changes in the consumer's premises might lead to a decrease in demand for electricity than past time. To know potential sources of such changes and accommodate potential drivers of such change, it would be necessary to do short and medium term review to check if such change has happened.

Another incidence of interest was that the regional master plan estimates & forecasts of electricity need were often lower compared to the national level forecasts of individual countries in EAPP. The difference was observed due to different input variables they considered and models they used for estimation and forecasting of the demand. If these countries want to involve in the integrated market, they need to adopt either of the two. But which one to adopt is challenge because each of them considered assumptions that sounded reasonable in their context. Also comparison of the two master plans with the aim of selecting one by itself seems illogical since they were based on different variables and did the analysis using different models.

Hence, accepting either the local estimates or the new estimates for the regional master plan does not give full confidence to decision makers. If the national master plans are to be pursued to implement the market integration, the need for investment would be relatively high. But if the assumed variables and their values are found to be wrong, then it implies unnecessary loss of resources. Conversely, if the new master plan is to be adopted and execution of plan follows accordingly, then the investment requirement could be relatively cheap compared with the previous. But, in case the master plan fails to show the proper demand, then it would lead to under investment. This implies that the gap in electricity supply still may remain unfulfilled. Therefore, there has to be some sort of common variable to plan and monitor the actual implementation of the program. This might be resolved through revision of national level forecasts in the short to medium term before and even during actual market operation process.

The researcher believes that the more disaggregated the variables in estimating electricity demand, the more visible would be the impact of change by such variables than that of aggregate level variable change. In this particular case, the variable assumptions are defined as the descriptions about the way social or economic determinants of actual volume of electricity need are structured. For example GDP is known to be economic variable determining the volume of electricity. How the relationship between GDP and volume of electricity behaves could be learnt by reviewing the interaction between the two in further detail.

The change in gross value added could come from adding more facilities or by improving the input efficiency of existing facilities or by improving processes in a particular economic sector. It could even happen because of combination of either of the above. Similar fashion of change in electricity demand would be observed depicting the relationship between change in the economic sector and the volume of electricity needed. The causal relation can be highlighted following the approach in this research.

The total demand by such economic sector or even a country could either be reported as one figure or as sum total of the demand aggravated by changes in these factors. Both cases tell planners that a change in demand is needed. But, the latter case gives more information telling why the change has occurred and what volume of change due to each case. It gives some clue to both planners and decision makers on possible measures to be taken. This contributes for a work of deriving and understanding the impact of these changes in the electricity consumption trend of the countries. It provides additional information for planners while reviewing estimates and forecasts for electricity demand at national level.

Furthermore, aggregation of such information minimizes risk of over planning and doubt about the change in the size of demand. It also contributes for better monitoring and revision of plans at country or even region level thereby minimizing compromises between priorities in the planning of electricity utilization. Through this approach, planners and decision makers in the sub-region would get valuable insight about major determinants of electricity consumption in East African integrated electricity market.

Hence, the bottom-line in this study is not to disqualify the past or current demand estimation methods. Rather it is to equip planers with additional tool for better way of representing changes in input variables in estimating electricity demand. In addition, it helps to demarcate and compare results from different studies leading to relatively representative estimate and forecast of real demand situation. Therefore, National master plans can be reviewed and monitored in the short to medium term using this approach before & during actual market operation process.

Decomposition Analysis was used for the empirical work in this study. It helps to quantify the contribution of various factors to a change in certain outcome (Fortin N., Lemieux T., Firpo S., 2010). In the case of this research, the possible outcomes include an increase or a decrease in electricity intensity due to structure or intensity effects. Secondly, this author further stated that decomposition helps to identify factors that are quantitatively important among those included in the analysis. This alerts planners or decision makers to give special attention for such values. For instance, if intensity effect as one of the factors shows a need for large value for electricity in sectors of respective countries repeatedly, it may signal review of electricity efficiency condition.

Thirdly, Decomposition Analysis through identifying dominant sector and country in terms of electricity intensity would trigger further detailed study to understand the reason of such unique value in that country or sector. In such a manner, Decomposition Analysis would help planners in the electricity sector through provision of information for planning of effective electricity use.

Also Fortin N., et-al (2010), stated that the decomposition analysis shows the quantitative importance of an empirical estimate in an economy. For instance, certain result may tell us that specific estimate is very important due to its large contribution in the electricity use of a sector in a country. But that sector might not consume large size of electricity compared with sectors in that country. Getting such classified information could be possible relatively in easier fashion by applying Decomposition Analysis.

Since same type of information need to be determined for this research, Decomposition Analysis is useful. It can be used for determining factors of change in electricity intensity and facilitates comparison between countries and sectors in easy way. Using Decomposition Analysis, relative weight of changes in size of electricity intensity at sector or national level would be determined and its implication would be understood.

Another reason that magnifies the importance of Decomposition Analysis in this study was shortage of data which limited use of other analytical methods for producing the required outputs. Decomposition Analysis, especially Index Decomposition Analysis (IDA), was found to be suitable for this study because it possess the required analytical quality in a data constrained environment.

The research was designed to show the relative change in aggregate electricity consumption and factors behind the change using sector level information. Change in electricity consumption relative to change in economic variable in a situation of limited data availability can be better handled by decomposition analysis. According to Ang B.W. (2004), Index Decomposition Analysis helps to study the impact of changes in product mix in an industry (Structure effect), and impact of change in sectors electricity intensity (Intensity effect) on trend of electricity use in an economic sector. This scholar substantiated that IDA was used as an analytical tool in many energy related policy studies in the past. Therefore, IDA was adopted in this study because it helps us to derive change in aggregate electricity intensity both at sector level and economy wide. Especially its unique attributes of flexibility in handling data shortage issue and in addressing the required level of empirical analysis made IDA useful in this research.

1.2 Objective of the research

The overall objective of this study was to forward set of assertions about the importance of using the embedded effects of electricity consumption instead of the aggregate quantity in demand estimation for electricity Market. These embedded effects in the context of this research are the structure and intensity effects of electricity consumption. It helps to understand the direction and size of change in electricity consumption pattern aggravated by the change in economic value added of these countries. But in broader sense, the study would help to see how the knowledge about the behavior of sectoral energy consumption pattern in relation to economic determinants is important for any country that joins integrated electricity market.

Hence, in this study it was aimed at decomposition analysis of electricity demand in six East African countries to help the countries carefully plan their involvement in the regional market. Specifically it was:

- to identify factors influencing the electricity demand[3] & understand their behavior at sector and country level
- to discuss the interaction between the factors and show how the dominant factor would influence the prevailing market model or participation of countries
- to recommend policy direction

1.3 **Dissertation Structure**

This paper was organized as follows. Chapter 1 discusses a few stylized facts about the reason why the research was necessary. Special attention given on the way demand was determined and used in estimating the required

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[3] Please note that here demand is to mean consumption.

electricity for the regional electricity market. Chapter 2 deals with general profile of these countries. Electricity trade, energy policies pursued, and overall demographic and socio-economic condition of the countries was discussed. Chapter 3 reviewed major literature on global and African level evolution of electricity market. Advantage and some drawback of electricity market integration were discussed here. Also how decomposition analysis could be used in assessing electricity use at sector, country and regional level was discussed. Chapter 4 presents date description in relation with data sources and behavior of each country's data. Chapter 5 is about the main empirical analysis including method selection. Chapter 6 consists of summary of main findings and policy implication.

Chapter2 Electricity Trade&Policy of Six East African Countries

2.1 General Introduction on why Six Countries only

The electricity access issue in Africa, especially the East African Region has been strategic for the region as a whole. The economy of the sub region is dominated by traditional agriculture system and industries need radical change in terms of process improvement and size escalation. Many FDI influxes are getting in to these countries, but infrastructure development like road network, ICT, and electricity developments are very much constrained. Though most of the countries in the region have ambitious economic and social development programs, access for these infrastructures has been a great challenge.

Electricity development as one of the basic infrastructure was given special emphasis due to the fast truck development agendas of these countries of the east African region. It was with this understanding that the governments of the 10 east African countries agreed to establish an integrated electricity market for east African countries with a name East African Power Pool (EAPP) in 2005. As this research was an initiative for addressing issues of planning for electricity development in these countries in totality, the research was intended to consider all the countries. But mainly problem of access for sufficient and complete data forced the researcher to select only six countries among all. Especially accessing electricity use data at the level of economic sector was major bottleneck.

2.2 Profile of the Six African countries

This study was supposed to incorporate the 10 countries of East African Power Pool. But only 6 of them were considered for further detailed study. It was not intentional, but lack of complete data set on electricity consumption compelled the researcher to exclude the four countries (Figure2-1).

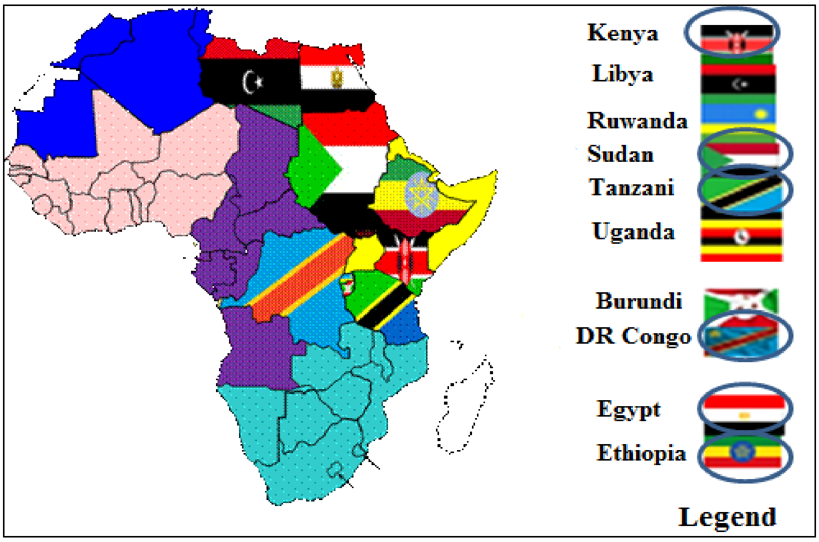

Fig. 2 1Countries in the research domain
(Source: Eastern Africa Power Pool, Addis Ababa, Ethiopia[4]. Copyright © 2013)

[4]Source for the East African Power Pool member countries location map. http://www.eappool.org/members-of-eapp.html

The countries excluded were Uganda, Burundi, Djibouti, and Rwanda as seen in figure 2-1. They have a total potential electric power of 4.6giggawatt. This figure represents 0.92% of the estimated import potential and 10.1% of export potential for the planning period of the master plan. Among the 6 countries considered for this study, 3 are potential suppliers and 3 of them are potential importers. They represent a total potential electric power of 107giggawat. Out of the total power available for the market from the six countries, 70.37% was estimated as import potential and 29.63% as export potential within the planning period of the master plan.

The main reason for exclusion of the four countries was data shortage. The basic data for this study were electricity consumption in GWH and Gross value added of main energy consuming sectors, namely, Agriculture, Industry, Commercial & Public Services, and the Household Sectors. The electricity consumption data for the four could not be obtained in respective countries and in the database of energy affiliated international organizations like the World Bank, International Energy Agency, and even in the US Energy Information Administration for the study period. Also the corresponding GDP values were incomplete. It could have been possible to forecast the GDP data using extrapolation method, but electricity data could not be obtained for these countries.

Attempt was made to get these data from statistics of respective countries, but was not easily accessible. There were factors like confidentiality, time constraints for collecting and re-organizing data within the time frame of the research. In addition, many gaps were observed between the data from International sources compared with the national sources. Just to put the study in same level and minimize bias data from official sources were considered and when necessary local data were used to fill gaps but with very rare instances. The data collected for the six countries covers the years 1991 through 2010. The final year was the latest common year for which data on electricity consumption and Gross value added for the sectors in each country could be obtained.

The countries are characterized by different demographic, economic, and geophysical characteristics (Table 1-1). Of all the characteristics, the variation in climatic condition within one country seems interesting. There are chances of heavy rain in one part of a country and dry in another but with heavy wind and sunny weather. Sectoral GDP contribution is also another whereby level contribution in DRC, Ethiopia, and Sudan depend more on agriculture. Whereas, Tanzania, Kenya, and Egypt depend on Commercial and Public services sectors. The latter case might have certain level of connection with income from tourism. Tanzania & Kenya own the largest National parks for Tourist attraction in Africa. Also Egypt is one of the sources of ancient civilization. From the remaining countries, Ethiopia also has significant tourist attractions. But, due to relatively more comparative advantage of vast arable land and agricultural crops Agriculture overweighed the other sectors. This will continue for some times in the future with introduction of more productive techniques and innovations in the area.

Table 2- 1 Profile of the six East African Power Pool countries as of 2014

Country	Climate	Geography	Population	Per Capita GDP US$	GDP share (%) as of 2014 Agri.	Industry	Commercial & Public service
DRC	tropical; hot and humid in equatorial river basin; cooler and drier in southern highlands; cooler and wetter in eastern highlands; north of Equator - wet season (April to October), dry season (December to February); south of Equator - wet season (November to March), dry season (April to October)	Largest in SSA, dense tropical rain forest in central river basin and eastern highlands, the only outlet to Atlantic ocean, total area: 2,344,858 sq km	77.4	400.00	44.3	21.7	34
Egypt	desert; hot, dry summers with moderate winters	controls Sinai Peninsula, only land bridge between Africa and remainder of Eastern Hemisphere; controls Suez Canal, a sea link between Indian Ocean and Mediterranean Sea; dependence on upstream neighbors; total area: 1,001,450 sq km	86.9	6,600.00	14.5	37.5	48
Ethiopia	tropical monsoon with wide topographic-induced variation	the most populous landlocked country in the world with total: 1,104,300 sq km. Origin for coffee, grain sorghum, and castor bean. Origin for Blue Nile (Northwest highlands)	96.6	1,300.00	47	10.8	42.2
Kenya	varies from tropical along coast to arid in interior	One of the countries with most successful highland agricultural production in Africa; glaciers on Mount Kenya, Africa's second highest peak; abundant and varied wildlife of scientific and economic value. Kenya's total size: 580,367 sq km.	45	1,800.00	29.3	17.4	53.3
Sudan	hot and dry; arid desert; rainy season varies by region (April to November)	dominated by the Nile and its tributaries. Sudan total area: 1,861,484 sq km	35.5	2,600.00	80	7	13
Tanzania	varies from tropical along coast to temperate in highlands	Kilimanjaro, highest peak in Africa. It has glaciers; bordered by Lake Victoria (the world's second-largest freshwater lake) in the north, Lake Tanganyika (the world's second deepest) in the west, and Lake Nyasa (Lake Malawi) in the southwestTanzania total area: 947,300 sq km	49.6	1,700.00	27.6	25	47.4

Source: Central Intelligence Agency (US)

https://www.cia.gov/library/publications/the-world-factbook/geos/print/country/countrypdf_et.pdf

DRC was affected by protracted socio-political instability beginning from around 90's (US CIA, 2014). Though this nation was endowed with vest natural resources, developing these resources was a big challenge. The corruption which begun at the end of colonial era and conflicts of mid-90s have contributed to the reduction of GDP and increase of external debt (US CIA, 2014). According to this source, positive changes in the economy begun to manifest in the urban settlements. The mining sector which could have contributed to the economic growth remained under the influence of the informal sector for long time. However, the mining sector started to bring good amount of foreign currency to the country.

Though the global recession hit economic growth in 2009 down to below half its 2008 level, 7% per year growth was registered in 2010-12 (US CIA, 2014). The entrenched issue transparency in the Mining sub-sector affected recent financial deal of the country with IMF. But the country took appropriate measure by updating its business laws in accordance with the Organization for the Harmonization of Business Law in Africa (OHADA) in 2012. The economy of DRC is getting stable with positive growth for more than ten years in the past.

Egypt is one of the oldest civilizations in history. The uninterrupted flow of Nile River and construction of the Suez Canal in 1869 as important world transportation hub gave exclusive opportunity of prosperity for Egypt. After long term colonization by many foreign countries, the country got full libration beginning from 1952 (US CIA, 2014). Then completion of the Aswan High Dam in 1971 gave another opportunity of development for Egypt (ib-id).

Construction of Aswan High dam resulted in Lake Nasser that helped Egypt to succeed in agriculture. However, imbalance between resources and population growth was stressful making living in Egypt expensive. How hard subsequent governments straggled to do economic reforms and fulfill basic infrastructure, the need of the people could not be addressed as expected. The economy of Egypt slowed significantly, Tourism, manufacturing, and construction contributing less to the growth of the national income compared to past.

Ethiopia has begun a unique development strategy since 2010. The purpose was concentrating on the potential in resources the country has and the opportunity that globalization created for development. Eradicating poverty and reaching the level of middle of income countries by 2023 is the target (MOFED, 2010). From outset, the plan seems overambitious. But, it depends on the level of commitment and effectiveness of every resource put into the execution off the program.

Agriculture used to be the dominant sector and will continue being the base for development in Ethiopia. But use of input, level of skill, and speed of resource mobilization need complete overhauling. So, this and the urge to maximize return from this huge sector led the government to promote diversification. The Growth and Transformation plan (GTP) is not the starting point for diversification in Ethiopia, but rather a sign of increased level of awareness by the decision maker about the importance in the value of the diversification.

The current focus on manufacturing, textiles, and energy generation needed huge financial resource. But promotion of Foreign Direct Investment was considered to give certain relief. Except restriction of the banking, insurance, telecommunications, and micro-credit industries to domestic investors, the country has attracted significant foreign investment in textiles, leather, commercial agriculture and manufacturing. However, proper handling and fast response in a speed that the customer except to be treated is a key for success of the FDI. Moreover, transparency needs to continue to govern throughout irrespective of the change in leadership in a system. Modern infrastructure like ICT and energy need to be part of the commitment apart from the existing incentive mechanism in attracting more FDI.

The GTP has forced the government to focus on infrastructure expansion leading it to the extent of constructing large scale Hydro power plants. The current Grand Renaissance Dam on the Nile could be a good example especially due to risk taking decision of constructing with own finance. The project was estimated to cost five billion dollar and the electricity from this project is intended for domestic consumption and export.

Kenya has been performing well in the 2000s, though external shocks and public sector inefficiency were evident (African Development Bank, 2010). The private sector has contributed through development of business on horticulture and ICT fields in economy. But the government gave more emphasis on public-private partnerships as way to achieve the long term vision and infrastructure projects to take Kenya into a middle income economy.

The country's economy has been the largest in East Africa though low priced primary goods and corruption dominated for the long period. According to US CIA, (2014), Low investment on infrastructure was also another threat. According to same source, the issue of corruption was evident to the World Bank and IMF in 2006. The country has been experiencing, chronic budget deficits, inflationary pressures, and sharp currency depreciation due to increasing food and fuel import prices. Kenya discovered oil in 2012 which would be an opportunity to remedy the problem of trade deficit on condition that the oil gets good international market from its export.

In Sudan, military based government was dominant and two long lasted civil wars persisted between Southern and Northern Sudanese people in most of 20th century (US CIA, 2014). The reason for such a protracted conflict was economic, social, and Political dominance of the later over the former. This ended in 2011 with referendum that allowed the existence of South Sudan as an independent country. The two countries have signed security and economic agreements on September 27, 2012 to normalize relationship. The conflict continued in the south with devastative effect on the economy and the life of millions making millions homeless and refugees. The conflict in Sudan has sporadic effect on the neighboring countries in the form of refugee influx.

The division of Sudan in to two led North Sudan to serious economic shocks. The major one was missing the oil revenue which was over half of government revenues and 95% of exports (The WB Group, 2014). This was followed by drop in economic growth rates, increase in consumer price inflation and increased fuel prices. Internal conflict emerged in 2013 due to the inconvenience of living condition. Also the most important issues were that due to failure to use bonus from the oil, diversification of the economy was hindered. The country lacks adequate infrastructure services like transport and electricity, access to finance and taxation policies. The government of North Sudan has devised Agriculture and Livestock development as a means for emergency economic recovery program committing 20% of public expenditure for modernizing these subsectors (Ibid).

Tanzania was emerged as one country after colonialism from the merger of Tanganyika and Zanzibar in 1964 (UA CIS, 2014). According to this source, the country was one of the poorest economies with lowest Per capita income, but significant level of gold production and tourism led it to exhibit sizable change. Market liberalization was effective except for telecommunications, banking, energy, and mining sub sectors. The CIA reported that the World Bank, the IMF, and bilateral donors have helped the country to rehabilitate aging rail and port infrastructure to help facilitate trade links for inland countries.

Recently the financial sector in Tanzania has expanded incorporating foreign-owned banks accounting for about 48% of the banking industry's total assets (US CIA, 2014). Efficiency and quality of financial services improved but with interest rates still being relatively high. According to US CIA, the country received the world's largest Millennium Challenge Compact grant, worth $698 million in 2008, and it was re-selected in December 2012 for a second Compact. GDP growth in 2009-13 was 6-7% mainly attributed to high gold prices and increased production (US CIA, 2014)

Table 2- 2 common items traded and major economic shock in the six EAPP countries5

Country	Trade		Major Economic Shocks
	Import	Export	
DRC	foodstuffs, mining and other machinery, transport equipment, fuels	diamonds, copper, gold, cobalt, wood products, crude oil, coffee	2009 recession reduced export to less than half of 2008 level
Egypt	machinery and equipment, foodstuffs, chemicals, wood products, fuels	crude oil and petroleum products, cotton, textiles, metal products, chemicals, processed food	2011 due to internal political unrest
Ethiopia	food and live animals, petroleum and petroleum products, chemicals, machinery, motor vehicles, cereals, textiles	coffee, khat, gold, leather products, live animals, oilseeds, flower	1974 due to new command-based economic system, 1984 due to famine and 1992 due tointroduction of market economy
Kenya	machinery and transportation equipment, petroleum products, motor vehicles, iron and steel, resins and plastics	tea, horticultural products, coffee, petroleum products, fish, cement	the 1974 change of policy in favour of a command-based economic system, the 1984
Sudan	foodstuffs, manufactured goods, refinery and transport equipment, medicines and chemicals, textiles, wheat	gold; oil and petroleum products; cotton, sesame, livestock, groundnuts, gum Arabic, sugar	famine and the 1992 change of policy that introduced a market economy.
Tanzania	consumer goods, machinery and transportation equipment, industrial raw materials, crude oil	gold, coffee, cashew nuts, manufactures, cotton	Oil crisis of 1970s, droght in 1996/97 and El Niño floods1997/98

The types of products made available in the international market and the once imported to each of the countries tell something about the potential for development and relevance for the growth in the demand for energy. Most often, the types of products exported do not appear to need much processing. Hence, at this stage the demand for energy might not be promising to think of expanding the generation capacity of the power sector. But the development programs of most of the countries give a signal that large size electricity generation is a matter of urgency (Table 2-2).

[5] The Oil crisis of 1970s was common to all of the countries

Section 1.01 East African Electricity Trade

Electricity Trade in the Sub Saharan Africa existed for about half a century. The search for a more reliable and secure electricity supply has been the main reason of building these power systems interconnections (UNECA, 2014). According to UNECA, hydropower was the main source though the extent and volume of the trade was not as such magnificent. The commonly known trading utilities among Sub-Saharan Africa were, the Owen Falls hydropower station of Uganda in 1950s, the Karina North hydropower station of the Zambia-Zimbabwe Border in 1960s, Inga I hydropower Station of the Democratic Republic of Congo (DRC) in 1972, the Akosombo hydroelectric dam of Ghana in 1960s and the Chora Bassa hydro electric dam of Mozambique in 1974.

According to Ranganathan R., Foster V., (2011) the power situation in east African Countries is worst compared with the rest of the regions in the continent. This was justified by the author mentioning the smallest generation capacity compared with all other sub regions, which is less by fivefold from the WAPP and by 13 fold from SAPP.

However, individual utility performance in terms of system losses is reported to be the lowest compared to others except southern Africa. In this sub region, there was very small and less spread bilateral trade especially among the member countries of the EAPP.

Table 2- 3 Electricity Trade by Six EAPP Countries (TWH) as of 2010

Country	Production	Consumption	Trade		
			Export	Import	Balance
DRC	7.8	6.2	0.92	0.16	0.76
Egypt	138.7	122.4	1.6	0.16	1.44
Ethiopia	4.93	4.45	-	-	-
Kenya	7.33	6.15	0.03	0.03	-
Sudan	7.19	5.67	-	-	-
Tanzania	4.3	3.4	-	0.05-	-0.05
Total	**170.26**	**148.26**	**0.03**	**0.05**	-0.05

The volume of transaction between countries can be seen on table 1-2 which depicts how insignificant it was in terms of size. But it gave some sort of experience on the how of electricity trade among countries. So, it can be concluded that some experience was secured among the countries though the trade volume was small. Since the initial stage of the market integration in the EAPP is going to be bi-lateral level, the preparatory work will be less costly than new beginning. But, the size of the trade tells that the electricity trade in the region is still in early stage of development. In this trade the government utilities of respective countries are the main actors.

Section 1.02 Electricity Policy of the Six African countries

Electricity as an infrastructure was given much attention by East African Countries very recently. This can be realized from the level of development of the energy resources and the time it begun to considered as strategic issue in the national agenda. Most of energy policies in east Africa were connected with the oil crisis of 1970s. These countries learnt to consider alternative sources of energy to scatter risk of energy crisis.

But, due to the low level of economic development and mostly agriculture based, the focus of energy for development was not as such hot issue. If it was, mainly to address the biomass energy related problem of inefficiency in use and related effect on deforestation and land degradation. Especially, electricity subsector development was stagnant due to its connection with urban center development.

In the recent past, when energy concerns were raised, the first strategic energy issue was securing access for petroleum fuel. This has been because petroleum fuel has been used for many purposes in African energy, mainly for eastern region. It has been source of power generation, used in factories to run different small and a few medium sized engines, also main source of transport fuel for all sorts of automated locomotives, and also for cooking for households. But, as environment concern came into picture, the focus for use of petroleum fuel for power generation begun to be loosen with the concern related to environmental protection. Though environmental pollution was not a mandatory concern, the different kinds of benefit packages invented by the western developed countries partly attracted the attention of the poor developing nations of Africa, East Africa being the target due to its renewable energy resource potential.

Apart from actual facts, the genuine concern of some of the east African leaders for the coming generation convinced these poor nations to divert to environment friendly energy resources development. So, some of the countries excluded petroleum fuel based power generation facilities to hydro based in areas where the resource is abundant. Apart from Hydro based, most of electricity generated using renewable energy sources like solar and wind is not affordable within the context of current technological level of those renewables. Also the energy to be generated is intermittent and seasonal.

But very recent economic shift and introduction of FDI for boosting economic development necessitated the expansion of infrastructure mainly, ICT, road network, and electricity. Therefore, in countries where there is political stability, the development of electricity and other infrastructures is given equal footing, sometimes the energy sector competing in sharing the government budget allocation. This is mainly because most of power generation activities are dominated by government utilities tough there is some level of movement to liberalize the power sector.

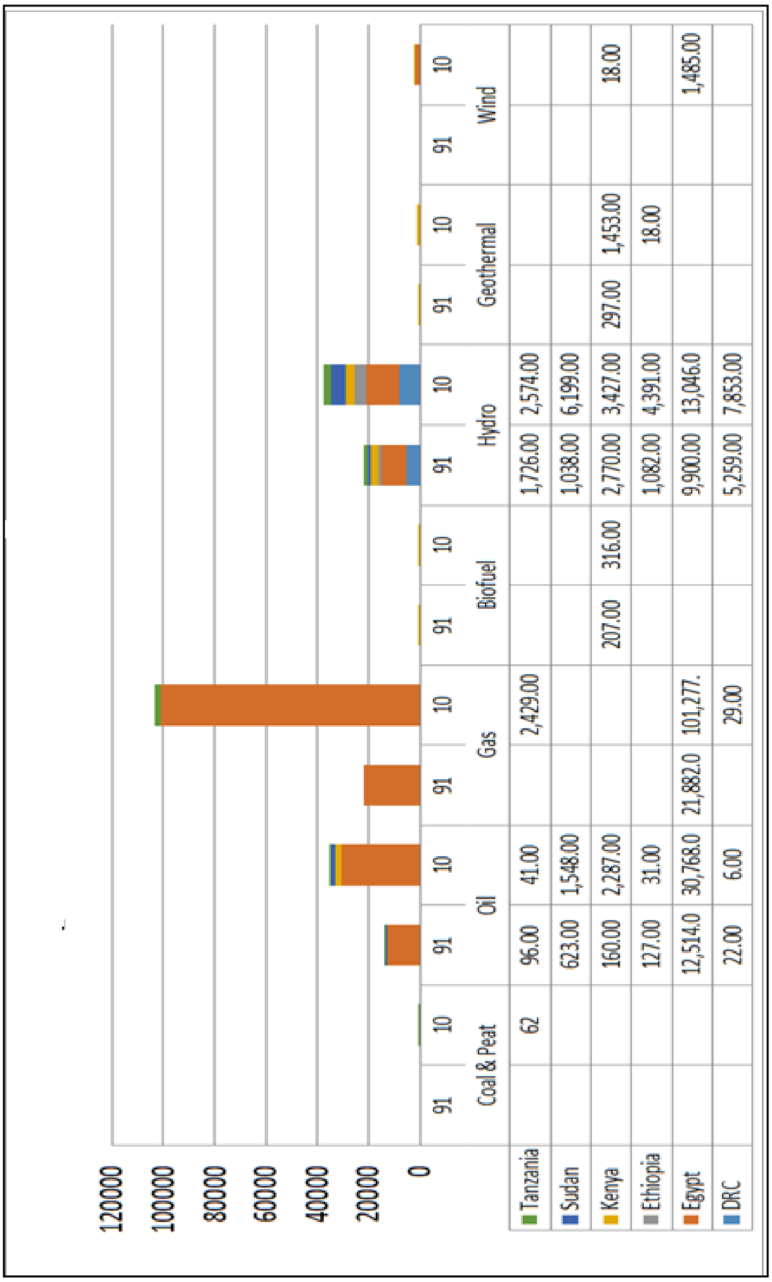

Fig. 2 2 Electricity Generation by Source in the Six EAPP Countries (1991 & 2010)

In general the volume of energy used to generate electricity from each sources including oil has increased (Figure2-1). This might be due to large number of vehicle influx in these countries dominantly used in the country of origin. In terms volume of consumption all of the sources increased. But renewable including hydro has increased relatively in higher proportion compared to the conventional sources with respective value of 81% and 77%. Among the fuels, still the order of importance was gas oil, and hydro in descending hierarchy by volume. The slow development of hydro was mainly attributed to the large investment requirement and limited financial resources.

By volume of generation resource, Egypt dominated due to large size of Gas and oil resource. But in terms of using diversified generation sources Kenya took the lead position and Egypt and Tanzania ranked second with equal level. Oil and hydro were the most frequently used electricity generation sources in these countries. Among the six countries, Ethiopia, Tanzania, and DRC have opted for using more Renewable Energy. But generally, promoting renewable energy is most focused strategy in all the countries, though the figure concealed the fact. Furthermore, the energy policies of these countries highly encourage development & use of indigenous resources.

Chapter 3 Literature Review

3.1 Electricity Market integration

a. Global market

Early in the history of electricity market, demand in the process of electricity transaction was incubated by suppliers. For instance, in 1870s Independent Power Producers (IPPs) in USA had to do door to door campaign to initiate demand for their electricity (Joskow, 2005). Those early days, the determinant for the success of electricity market was not manipulation of the interaction between Price and quantity. Rather it was IPPs strong ability to convince the likely users through advertizing about the electricity more than anything else. Price and Quantity did not determine the volume of the electricity trade since the market was not yet matured.

Gellings, Grasty, & Jacobso, (1990) in his work described about those early times in the history of electricity market as a time of coincidence between creating market & maximizing sales. According to the author, suppliers used to tag price for services like illumination, heating, and ironing on daily or weekly basis since there was no metering facility[6]. Also, since there were few small

[6] In the late 1880s, development of a meter that could measure electricity use sparked another

producers and the demand was not well developed, electricity was not known as commodity in the market. Competition had been yet to emerge and the utility/supplier used to set the price.

Gradually as the market got well established, monopolies emerged. According to Gellings et-al (1990), metering electricity has been introduced and electricity had been sold as service. Through such relatively long evolution, electricity utility has emerged as industry in 1982 (Ibid). As the size of customers went on increasing, the scale of the electricity industry grew up to the level where big power generation utilities emerged and got more recognition. According to the author, these utilities began to scale up their size to meet relatively growing demand and get better income by selling more electricity. From there on electricity became commodity deserving a status of an investment venture. The author describes that utilities were comfortable to increase the size of their generation to benefit from economies of scale by monopolizing on the whole utility system ranging from Generation to distribution[7].

Hence, according to Gelling et-al., (1990) up to 1970's the electricity

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controversy within the industry: how to price its product. In 1879, when an inventor named Charles Brush began the California Electric Light Company in San Francisco, he sold "illumination," not electricity. Brush's arc-lamps were unmetered; he simply charged customers 10 per week per lamp.

[7] The electricity system is a relay which starts with generating power using different types of f uels and consists of three major uninterrupted steps, namely Generation, Transmission and Distribution until it reaches the customer's premises where it adds value as derived demand

utility companies had been comfortably trading electricity to their customers at prices which fetch them higher margin and there was no mention about shortage or reliability problem. They expected to continue getting more profit as far as they produce sufficient power with less cost. Since there was no information disclosure demanded from the utilities about their cost, these utilities could maximize profit as they wish. But Customers awareness about the nature of electricity system went on improving and they begun to understand that there had been manipulation of the market by the suppliers. Then, when their bills pile up due to an increase in tariff, these customers started to look for options though difficult to get because of few numbers of suppliers (Ibid).

Since utilities do not reveal clear information about how prices were set, electricity tariff used to be manipulated by utilities to generate more income in those early times. Real market mechanism also did not function. Therefore, customers even though tried to look for alternative sources, fail to succeed due to similarity of existing suppliers' strategy. Also since responding to the prices change means either to quit the service or to have isolated generation facility. This was hard to implement and hence even when it was evident that the prices were manipulated, customers had to follow the suppliers' strategy.

Governments have been implementing different mechanisms to ease the tension of high cost of electricity in general. Though it does not have direct link with the act of utilities, implementation of incentives was one of such measures and still exists in different forms in the world. For instance USA implemented subsidy in the electricity sector for about 60 years in the past (Management Information Services, Inc (MISI), 2011).According to this study, the largest beneficiaries of federal energy incentives in USA have been oil & gas, receiving more than 50% provided since 1950.

The incentives were in the form of tax concessions to the companies which construct and supply energy leading to relatively lower utility tariff. Other developed countries also have been using incentives to support the power sector development. For instance, France have applied subsidy for their nuclear plants development in the period 1970 to 200. UK provided subsidy in the form of fossil-fuel levy charged on thermal generation to Nuclear Electric between 1990 and 1996 (Kitson L., Wooders P., Moerenhout T., 2011). But, according to the author, subsidy in the power sector of developing countries is directly targeted on ultimately reducing tariff to make energy affordable and accessible to all users.

Use of subsidy in developing countries, gave relief to customers but did not address the problem of shortage as power demand increased, hence failed to be attractive mainly to African countries. As an additional means, market integration at regional level was used as best means to solve the problem of electricity sustainability, and transparent transaction between customers and suppliers.

For instance, the Electricity pool of Wales was considered helpful in maintaining quality and security of supply (Trade & Regional Integration Division (TRID), 2009). But according to TRID, (2009) there had been a sort of manipulation by large generators in price determination. This led the government of Wales to the extent of changing the power system from Pool to New Electricity Trading Arrangement (NETA). The report revealed that the government preferred contract based and power exchange in Wales from there onwards. But the reduction of market power of vertically integrated utility was one of the main purposes of having Power pools which could not materialize in this specific instance.

USA had also introduced power pool market following the black out of 1965 (TRID, 2009). The power pools in USA were classified as Tight Power Polls (TPP) and Loose Power Pools (LPP). The former was tighter where by planning used to be central, with restrictive procedures demanding decision based on majorities agreement. Highly interconnected and centrally planned.

Despite some controversial issues in those electricity markets, there had been success stories where by NORD Pool could be considered as a model for such a success. The success areas were all rounded including physical delivery market trade which is related to physical contractual agreement, financial market trade, and clear-in (NorDREG, 2010). The experience in the developed world serves a very good benchmark for African electricity Market integration. Genuine search for such information requires full commitment.

b. African Market

Electricity was introduced to Africa in 1880s and 1890s through colonial system (Showers, 2011). Technically it begun as small-scale privately owned generation facility intended to supply private farms, industries and municipalities with the energy for lighting and running engines (Ibid). According to Shower, (2011) through electrification in Africa was initially used by colonials as a show-case about their level of advancement to their African colonies, it end up benefiting the continent's economic and social sectors development significantly.

Among economic sectors, Mining industries were the first beneficiaries of electrification in Africa. Later it became a stimulus for industrial development in the continent at country level. Initially, western world brought electrification for their own ends though it became an infrastructure to meet the demand of different native customer groups and facilitate socio-economic change. Gradually, with its full structure of vertical integration from generation to distribution, the electricity sector remained under government strict control for long time in history and the way it has been handled and the economic condition of the countries did attract private sectors involvement (WengerLucia, 2005). This resulted in slow development of the she electricity infrastructure.

The genuine reason for the government to manage power sector business was to allow fair and least cost access of every citizen to electricity service. This was so because of low economic condition of the African majority. At the same time it was to keep the electricity business in operation. Especially the major concern was to protect low income customers through provision of subsidy. That seems reasonable, but since the subsidy does not differentiate between customer categories, it rather benefited high and medium income groups more due to their high consumption volume (Alleyne T. et-al., 2013).

But, removing the subsidy by itself also does not guarantee relief for the low income group from high cost of energy due to relatively significant share of energy cost within the expenditure list of the low income society. To check if this assertion holds and to come up with the best solution for the problem, some sort of analytical mechanism needs to be devised for detailing what purpose takes more of the energy used in the household. Such a mechanism will open chances for considering other ways of helping these households than using the subsidy. Or even it helps to lead the subsidy to the more productive direction, like incentivizing the introduction and institution of efficiency measures. This in turn leads to minimizing subsidy and even quitting it at all at some definite point in time.

It is important to keep in mind that the efficiency of end use equipments varies between high or middle income households and low income households. Often, the latter category owns relatively poor quality end use equipments which make them venerable to inefficient energy consumption resulting in cost escalation. This deprives them of the opportunity of benefiting from the subsidy even if it reaches to their premises.

Since removing subsidy from electricity supply process also affects the low income group, the latter third option can be applied side by side with subsidy removal. That means provision of targeted incentive for households to change inefficient end use facility or consumption pattern after evaluation of main causes of the change on the overall electricity consumption pattern in the household. This contributes to solve the issue of market distortion due to the subsidy. At the same time it also fixes the African governments worry of high tariff effect that hindered private sector business in the whole electricity business.

Furthermore, it would be possible to maximize government income by promote more private sectors' involvement and securing more revenue from their business than retaining the electricity business under government and letting sluggish growth continue into the future. But once private investment begins and their number increases, obviously competition begins to sprout and the low of market will gradually steps in and stabilizes the market. But facilitating legal basis and allowing fair play in the electricity market remains always essential. Enacting regulatory mechanisms ensures genuine functioning of every stakeholder in the electricity market. The regulator needs to watch if distortions get injected amidst normal flow of the market operation. This maximizes the chance of expansion of generation capacity and also adds momentum for producing and supplying the electricity for local use and for the international market.

As economies of African Countries are on the eve of upward growth trend, the local level electricity supply only could not suffice to meet the demand in some of the countries. On the other side, there are countries with excess potential resources which could be converted into useable form of energy and exported to others. However, limited finance and technical capacity hindered the realization of such benefit (Trade & Regional Integeration Division, 2009). The opportunity created by regionalization of economic activities like creation of Southern African Democratic Community (SADC), the Economic Community of West African States (ECOWAS), and East African Community (EAC) opened the way for sharing of electricity through market integration in Africa (Trade & Regional Integeration Division, 2009). According to the author, within the short time span, electricity market integration has been getting wider coverage in Africa.

Both resource rich and those with limited resource secured some sort of benefits. For instance, South Africa since it joined the integrated power market could minimize risk of power oversupply because more number of customers were connected to the system than used to be. On the other hand, countries with limited or unreliable capacity could benefit from sufficient power without constructing new generation facilities. Moreover, possibility created for purchase of bulk power and distribution to local users at cheap price compared to the locally generated using imported conventional fuel. Also flexibility achieved in managing demand due to minimized incidence of Peaks and shortages.

In Africa, networking of the electricity grid have occurred both on an informal basis between two countries and also on formal basis. The formal could be represented by the Southern African Power Pool (SAPP)[8], where member countries get power at regulated prices (Trade & Regional Integeration Division, 2009). According to the Trade & Regional Integration Division (2009), South Africa, Ghana and Zambia take lion's share of power export in Africa.

African countries who involved in informal electricity market did not use restructuring as a getaway to market integration in the power sector (Bacon & esant-Jones, 2001). Rather they got in to the bilateral deal at vertically integrated utility level. But due to economic and Technical capacity problem, the utilities were not in a position to expand their generation capacity in response to the size of the demand. They could not either expand or contribute for improvement of per-capita consumption (IEA, 2013). According to the authors, some countries tried to restructure, though the initiative was poorly designed and did not lead to

[8]Countries linked through the SAPP network are: South Africa, Mozambique, Zimbabwe, Zambia, Namibia, Botswana, the Democratic Republic of Congo, Swaziland, Tanzania, Lesotho and Malaw i. Kenya and Tanzania have recently been discussing a connection to the Zambian power grid, w hich would bring Kenya into the SAPP.

market integration. Rather, foreign power companies were involved on concession basis (Bacon & Besant-Jones, 2001). This has shown some success though effort to privatize had poor outcome like the case in Ghana where the government intervened to set price for private sectors operation (William & Ghanadan, 2006). So, the bilateral model continued but most often with long term contractual agreements with little amendment. It still exists as one of marketing mechanism in the integrated market of Southern Africa.

Gradually, the current regional power pools came into picture. Conceptually, power pools are designed to ensure availability of adequate generation capacity, adequate volume of supply and sufficient transmission capacity (Trade & Regional Integeration Division, 2009). There are five regional power pools in the continent which include, Central African Power Pool (CAPP), the Comité Maghrébin de l'Electricité (COMELEC), the Eastern African Power Pool (EAPP), the Southern African Power Pool (SAPP), and the West African Power Pool (WAPP). Their total installed capacity was 125,762MW among which the SAPP stands first with 39.7% and the EAPP second with 22.6% contribution to the power supply in the continent as of 2010 (ICA, 2011). Each of the Power pools has its own coordination body.

The SAPP pioneered in establishing regional electric power market in 1995 (SADC, 1997) and comprised of 12 countries (Leary, Charpentier, &

MIinogue, 1998). Initially, the SAPP begun electricity transaction on the basis of long term bilateral contract through interconnection bewtween vertically integrated utilities in each of these countries (WEC, 2005). The major supplier and consumer of power in the Pool was South Africa because of the size of its economy (ICA, 2011). This might have certain implication in the market though it could not be instilled due to supply limitation at the moment.

The SAPP has gone significant distance in the implementation of the electricity market integration. Utilities of member countries use own cost of supply methodologies for determining electricity tariffs to the pool market (SAPP, 2013). The Tariff differed between countries and by customer type in the SAPP (ICA, 2011). This variation was the basis for the competitive power market.

It is clear that customers prefer low price and reliable supply. So, countries within the pool with lower price and excess supply were expected to fetch good income, contribute for overall price reduction within the pool and also for system stability based on the size of energy they supply. But, the market at the time of this research had issues of imbalance between supply and demand where transmission constraint considered as main cause (SAPP, 2013). According to SAPP (2013), general power deficit in the region and mismatch of buyers and sellers price quotation on the market were also identified as additional causes for the problem. This signals wider perspective of planning and monitoring where by each country takes part in reviewing its local need and spare volume of electricity available for the market. In so doing, planning at micro level in individual countries would help to detect the direction of demand growth and revise forecasts accordingly.

The east African Integrated electricity market was initiated by seven East African Countries[9] in 2005 (EAPP, 2013). According to EAPP (2013), Tanzania, Libya, Uganda, and Egypt joined the group and the total number of member countries grew to 10 in 2010-2012.

The EAPP is aimed at managing electricity market at bilateral and multilateral level in an optimized manner to ensure affordable, sustainable and reliable supply in the region[10].

Countries in this sub region use water as the major resource for power generation next to gas. Gas consumption dominated due to high consumption volume in Egypt. Hydro power was relatively stable compared to other renewable energy sources like wind and solar. This may be advantageous to stabilize supply in the short term and can be a power balancing tool in the future too.

The case of Demark where the intermittence of the electricity generated from wind power could be balanced through connection to Norway where vast power is

[9]Burundi, Democratic Republic of Congo (DRC), Egypt, Ethiopia, Kenya, Rwanda and Sudan

Source:-http://www.water-energy-food.org/en/news/view__1049/the-eastern-africa-power-pool-and-the-water-energy-food-security-nexus-in-africa.html generated from hydro can give a good lesson (Försund & Hjalmarsson, 2010).

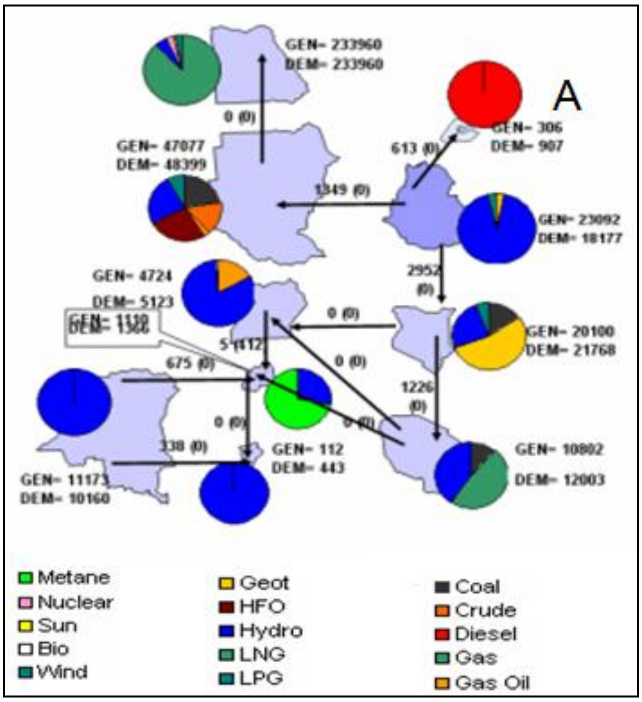


Fig. 3-1Electricity Generation potential in EAPP countries by source
(Source: Regional Power System Master Plan & Grid Code
Study, Final Master Plan Report, EAPP 2013)

The other advantage in this sub region is that the season for wind blow is complementary with the season where water resource is in plenty. So, where the resources are available integrated planning of wind and hydro generation helps to maintain balance of operation of Hydro power plants (MATEVOSYAN, 2004). There are others like geothermal and to certain extent biomass as potential sources for electricity power generation for the sub-region. Power generated from all these sources have to be exploited in such a way that wastage is minimized and reliability is secured. This market is at early stage of implementation as integrated market. However, from what was observed in other integrated market including SAPP, putting emphasis on the pattern of electricity consumption and related demand in each country from the very beginning would be an advantage.

3.2 Decomposition Analysis

(a) a. Global level

Energy consumption can be decomposed to quantify the real trend hidden in terms of the effects. If these effects rather than the aggregate used in planning, relatively proper measures would be identified to tackle the energy problem (du Can, Hasanbeigi, & Sathaye, 2013). The most common effects identified by scholars in decomposing energy use are activity, structure, and intensity factors. According to these scholars, change in energy use occurs mainly due to one of these three effects. Among these, Energy intensity is assumed be important since it relates energy use with the reason of its use in ratio terms. Often such connected indicators to energy or electricity can be economic indicators like GDP or Gross value added or even environmental factors. Obviously this research considered Gross Domestic product. The volume and direction of change of these factors either increasing or decreasing is believed to determine the nature of planning in the energy sector.

Similar cases were addressed through decomposition analysis of electricity consumption (Inglesi-Lotz & Blignaut, 2011). According to the authors, decomposing electricity consumption revealed significant level of increase in the consumption of electricity in this particular case. The reason was found to be an increase in the volume of economic output, known in decomposition analysis as activity effect. One could easily understand that results from decomposition analysis give better information than the original data for planners and allow them suggest relatively better policy design.

If energy intensity or electricity intensity was decomposed instead of direct energy consumption, the resulting information will be more meaningful in the context of this research. This would further help to describe the change in electricity use per unit change of economic or related determinant. In this case, planning will be further clear to the extent of telling the effect per unit change of such indicator. The ratio may guide to do further assessment to evaluate the type of end use facility in a particular sector. It would be possible to detect the level and significance of environmental factors in connection with the change. Mulder & de Groot, (2011) have justified such assertion by revealing that decreasing energy intensity may mean reduced GHG emission given the type of fuel used in the economy and the end use facility are known. In this study, energy intensity has served as indicator for the effect of energy on environment.

Likewise, decomposing the aggregate electricity use per unit of gross value added or the aggregate electricity intensity and reviewing the resulting pattern would help to trace the main reasons for the decrease or increase of electricity in a particular economic sector or country. Given collection of proper information about the structure of economic sectors, it would be relatively easy to foresee the future direction of electricity use at sector level or at country level. This would lead to identify sector which deserve much focus whenever electricity supply is concerned. In turn, it may minimize risk of export or import within the context of integrated electricity market.

For instance, right from the oil crisis of 1973's, the energy intensity of developed countries has been increasing in more proportion than their GDP and the trend of both has been in the same direction (PARK, DISSMANN, & NAM, 1993). The authors state further that with a passage of time, the intensity in the developed world started to decline while that of developing increasing. From outset it was so difficult to give any explanation. If at all the explanations were given, they could be guess work or judgment from experience.

But after applying decomposition analysis the decoupling of energy intensity from GDP was known to be attributed to the change in structure of industrial sector and technical efficiency in the process flow in the industries of developed world. Similar trend was seen in a number of East Asian countries. It prevails in other part of developing countries too. For instance in china from 1998 to 2002 the demand for electricity was very high (Steenhof, 2006). According to the author, the major factor was the high energy intensity due to positive structural effect represented by booming industry in the country.

The electricity demand may depend mainly on economic, technological, and environmental transformation. Use of intensity analysis gives better picture about the relationship than direct decomposition of the demand. For instance when efficiency effect show significant decreases in the electricity consumption, the result triggers the need to check the sector's end use system or the production processes to evaluate how far such change continue. Then relatively better idea would be obtained for further planning. But the decrease in the aggregate value of electricity demand does not reveal this fact. Hence, the possible action could be to reduce the supply and wait for another incidence of change. Even when the aggregate value is used for the search of cause, it would take long way and vague to know the reason and to plan the future.

Application of electricity decomposition analysis in china helped to identify causes for the change of trends in electricity use and helped them to plan and be effective in their actions (Steenhof, 2006). According to Steenhof, (2006), the government of china evaluated the trend of industrial development and learned whether the installed electricity suffices or further increase in generation capacity needed to meet the demand by the economy. Furthermore, they could get a good guidance to audit the efficiency of the industrial sector's electricity use and take necessary measures using the result of same study. Due to such informed intervention, the country could take necessary measure on the energy intensity which kept the energy intensity in 2001 very low at 28% compared with 1980 (Steenhof, 2006). Such a study helped China to save significant volume of fuel or equivalent amount of currency.

From the perspective of using decomposition analysis on regional electricity market situation many cases would have been reviewed. But the case about India was found to be well addressed. In the work of Mukherjee, (2008) the research was to decompose electricity consumption in 18 major Indian states to see the respective role of scale, structural and intensity effects. The second objective was to rank the effects according to their contribution to the changes. The scholar applied the Laspeyres based parametric and Simple Average Parametric Divisia Methods (Mukherjee, 2008). In his study, he applied both the Consumption and Intensity decomposition analysis methods and as a result all the effects, namely Production, Structure, and intensity were determined.

As scholars work showed, the consumption method considers actual values as opposed to the intensity method that considers percentages or ratios. Mukherjee, 2(000) mentioned that in each of both approached they used Laspeyer Based Parametric Divisia and Simple average Parametric Divisia methods. The choice between the two was dependent on the growth pattern, whether exponential or linear. The researcher decided the base year for the Laspeyer's based method while the other method is based on the average of the base and final year values (Mukherjee, 2008).

Finally, percentage value of the three effects relating to the total change in electricity consumption was used to rank the 18 different States of India. The researcher advices using the Divisia index than simple add up methods as an analytical tool for similar cases from his observation in the study (ib-id). The author stated that secondary cross section data, on sector level electricity consumption and output, was utilized for all the states in each category of years 1990-91, 1995-96, and 2000-01 (Mukherjee, 2008). The economic sectors covered in the study include, commercial, Agriculture, Industry, and Transport. The Last sector was included because of electricity use for rail-way service. They have identified varying results for each period, especially between early 1990 and later.

The value of effects indicated the nature of relationship between electricity use and output growth, either positive or negative. The empirical result is all about major disaggregated effects and how the trends are using production or intensity approaches. The author reminds in the study that sometimes the value of the residuals may mean in the system that there are other effects than the three mentioned earlier.

The authors disaggregated effects on the overall change of demand for electricity of the states using decomposition analysis. According to Mukherjee, (2008), the basis for choosing among the four parametric divisia methods for this analysis has to be the growth pattern of outputs & electricity. Choice of parameter values depends on the assumption related to the choose values that can best meet to the objectives of the study (ib-id). The scholar’s work concluded that the size of electricity to be supplied can be determined by the states based on the volume of the most critical effects of the aggregate demand rather than all the effects for the specific period of time. So, decomposition analysis helped to pinpoint those effects and contributed for recommending reasonable policy initiative for Indian regional electricity market.

b. African Level

The researcher did not come across such a similar regional level studies in this aspect in Africa. But a number of studies were found specially on South Africa. One of such study was Decomposition analysis of South Africa’s sector level electricity consumption. Data availability and quality in the energy field was considered as basic issues in this study. As rightly mentioned, this problem holds true for all of African countries. The Authors wanted to use data from their energy balance to minimize discrepancy in data availability, and therefore fixed the study period in accordance with the period when such data could be obtained, i.e., 1993 to 2006 (Inglesi L. & Blignaut, 2011).

According to Inglesi L., et-al (2011), data type collected include sector level data on electricity consumption and real output. Sector disaggregation was limited to primary and secondary sectors and agriculture, mining and industry were the three sectors considered for the analysis. This study excluded government organizations assuming the output from this sector as expenditure at national level. In similar fashion, household sector was also excluded for there is not a specific indicator to be considered in the GDP (Ibid).

In this study, the change in electricity use between 1993 and 2006 was decomposed with the aim to determine the main drivers for this change (Inglesi-Lotz & Blignaut, 2011). According to the author, the general trend of energy and economy in South Africa was in the same direction since 2004. But they were interested to know the details about causes for such trend through decomposing the demand for electricity.

The authors, like other scholars, discussed about appropriate decomposition method in which they compared SDA & IDA. They clearly understood the fact that IDA is used to reflect the first round or direct effects of the final demand while SD explains the indirect effects as well. But they were attracted by the simplicity of IDA and due to data limitation in the country; they decided to use IDA in this study with further identification of the appropriate index decomposition methods among the many.

The IDA method selected for the empirical analysis was the Log Mean Divisia method consisting of both additive and multiplicative method. Common to most of the researchers who preferred to use the LMDI method, these authors stated that their reason for selecting it were adaptability; ease of use and result interpretation; perfect decomposition without residual; its consistency in aggregation; possibility of concluding same results using additive or multiplicative method (Inglesi L. & Blignaut, 2011).

Results from the empirical work of Inglesi-Lotz & Blignaut, (2011) indicate an electricity use increased to 131,024 GWh in South Africa at the end of the study period. According to the authors, this change was mainly due to increase in sector level activity effect by 116%. It was attributed to quantitative and qualitative factors such as the upward political, social and economic change that led to an increase in country's economic activity. The structural change was found to be the second contributor with 64%. The efficiency effect contributed to the decline in the total electricity use but had less impact (Inglesi L. & Blignaut, 2011). The demand for electricity in its aggregation could not tell such detailed implications as rightly stated by the analyst. Policy decisions could be relatively more vivid under these levels of disaggregation.

This study was aimed at identifying the effects of change in the electricity use in an economy within the country. But, comparative analysis at regional electricity market level has not been yet done in the continent. So, it is possible to provide tool for countries to decide what volume of electricity to import or export based on the pattern and value of the effects. This could mean widening the scale a case which is not yet done in Africa. Also regional level implication of using such effects as indicators in planning and monitoring could also be additional for the Africa and specifically to east African regional market.

Chapter 4 Data

4.1 Data at International Agency versus Country Level

The researcher learnt that national level data availability depends on level of development of the energy sector, status of ICT in data acquisition, way data made ready for use, awareness and value given to data acquisition. Most of developed countries which have good ICT network have fully fledged, detailed, and interactive statistics on the electricity. For instance, most of the OECD countries data are more detailed and data gap is not an issue any time. Conversely, in the case of most part of developing world including Africa, the poor level of economic development and high cost of distribution for ICT infrastructure have resulted in low level of data organization in the past.

In many instances of developing countries, devoting appropriate bodies in each organization for handling energy databases and to ease access for internal use or external customers was a very recent phenomenon. Especially in Africa up to very recent years, data handling was considered as less important work and with no tangible outcome. Conversely, in countries where data importance got recognition, database security seems given more focus than providing access to the service.

Sometimes it seem like protecting users from reaching the data base than protecting the data from illegal or destructive use and securing the access for legitimate users. For instance, data on energy from the utilities were considered confidential by many concerned organizations. Apart from these, very limited updates and poor network speed are common. So, databases may remain inaccessible for long time without serving the purpose for which they were designed. This does not appear intentional, except limited exposure of those who manage the database and fear of loss of the database if exposed to the public.

There are communication gaps between international agencies and local organizations concerning their energy statistics. In the researcher's opinion, these gaps are because of lack direct communication between appropriate organizations within countries and the representatives of the international organizations. These gaps partly could be due to lack of trust by these international organizations on the way data were collected and processed by countries. Due to its international coverage, the researcher could identify such data discrepancy issues during the course of this research. However, governments of respective countries are making concerted effort to ease access for data.

Statistics from international agencies are very well organized and most often interactive in nature. And also, they are organized and managed in especially devoted World Wide Web address where any problem or change could easily be detected. Moreover, the international sources do data updating in relatively reasonable speed. This would enable to consider relatively latest level of developments while dealing with the sector. So, the researcher has determined to use the international sources throughout the study period and incorporate national level data when obtained from trusted sources only. But the data from international sources were not without deficiency.

International database were found incompatible with national level data in terms of volume reported. Especially, economic data like GDP, Gross Value Added and GDP growth rate differed between countries and international organizations. The discrepancy was observed even on the electricity data of the countries considered in the study and international organizations. For instance, there was mismatch in reporting between IMF and the Government of Ethiopia about the growth rate of the economy. Same way, the data reported on electricity consumption varies between the Ethiopian government report and the World Bank data source. Most often data reported on development related indicators from these international sources are lower than each country's. This could be attributed to the assumption considered by both sources. Even the meaning for some of the indicator terminologies vary between countries and International organizations. For instance, electricity access is reported as rate of electrification by the International Energy Agency (IEA, 2012). World Bank also treats the same way (The IBRD, 2009). Whereas, the term rate shows the ratio value of an indicator reported against certain time variable like year.

Data gap is another problem which even international source like the World Bank and IEA experienced. The indicators where such data gap observed include aggregate level of electricity supply, sectoral Gross Value added, and mostly sectoral electricity consumption for the whole study period. As the data requirement goes one step to the detailed level, data gap became more. A few cases were found where some sectors lack reported data for the whole study period. This does not mean that these sectors lack the data. But since the data could not be obtained from these sources, the study would be compelled to exclude such sectors or countries. Excluding these sectors or countries from the list does not give same result compared with inclusion of the same. But, excluding a sector with deficient data was preferred to minimize the complication of analysis and interpretation.

Trying to fill data gap needed considerable time and effort. It need to be handled as separate research and demanded large investment and actual visit to the study areas or countries. Planning primary data acquisition mechanism was not attempted owing to longer time and large resource it requires. So, the means with relative cost effectiveness in terms of time and other resources was to cling on existing data from relatively trusted International sources. The researcher knows that the data of international sources are in slight disagreement in volume with some of the national data. But it was relatively easier to get almost all data from International sources compared to the local ones. Therefore, the data from international sources are preferred to secure relative consistency.

But even then, there have been big data gaps, because of which covering all the countries in the EAPP was impossible. Only six out of the ten countries were considered for this research. These countries are Democratic Republic of Congo (DRC), Egypt Arab Republic (Egypt), Federal Democratic Republic of Ethiopia (Ethiopia), Republic of Kenya (Kenya), Republic of Sudan (Sudan) and Republic of Tanzania (Tanzania). Details about the type of data and its preparation for the subsequent analyses are presented below for each country.

4.2 Democratic Republic of Congo

a. Electricity Statistics

The electricity consumption data in DRC hindered fully fledged electricity intensity analysis because of missing data in two sectors. Firstly, there was no data for Commercial & Public Services sectors electricity use for the period 1991 to 1999 (Table 4-1). Similarly, there was no data on Agriculture-Forestry-&-others sector for the period 2000 to 2010 (table 4-1). The electricity consumption volume varied from sector to sector throughout the given time interval. One can easily see how one sector is important from the other by looking at the volume of electricity used in each sector and the trend it shows within the period.

Table 4-1 Electricity Consumption in DRC Million Kwh (1991-1999)

Sector	91	92	93	94	95	96	97	98	99
Agriculture1	15	15	12	10	10	15	15	15	16
Industry	1054	1072	1194	938	1003	1008	1008	1010	1061
Residential	1176	1309	1514	1052	1054	1010	1012	1015	1066
Final Consumption	2245	2396	2720	2000	2067	2033	2035	2040	2143

(Source: IEA Energy Balance 2011)

T

he table clearly shows that residential sector uses relatively large volume of electricity followed by the industrial sector. The direction of the change was similar but the residential sector decreased in 1999. Furthermore the trend can be visualized more in Figure 4-1. The 1991 to 1993 household electricity use grown fast and the industrial use also has shown same pattern but with relatively lesser rate. Beginning from the years 1994 the values for both sectors went below the values in previous years and then continued to converge to close values. On the contrary, the agriculture sector electricity use remained almost stagnant with very small variation.

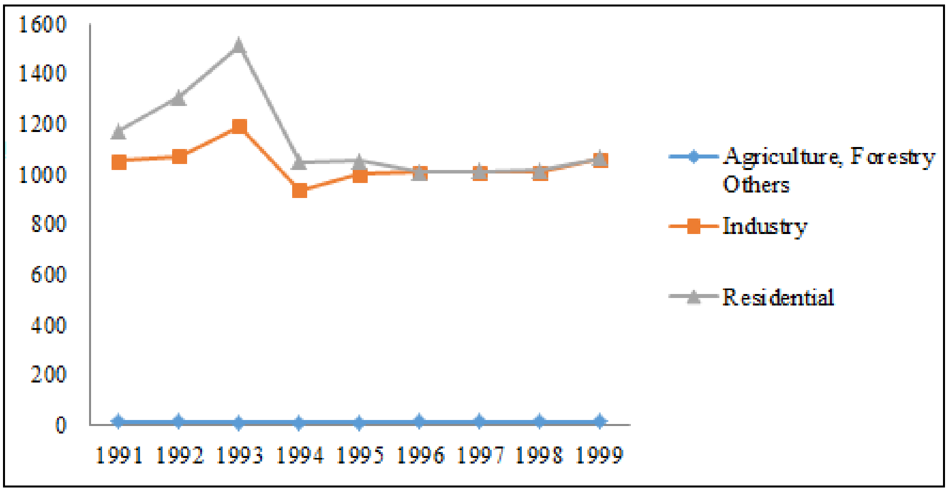


Fig. 4- 1 Sectors Electricity use in DRC in million Kwh (1991-1999)

The second part of the data for electricity consumption covered the periods 2000 to 2010. In this case the Agriculture sector was excluded from the sectors list due to lack of data on electricity use by this sector Table 4-.2. The volume of electricity use found recorded in the first part of the data put an impression that agriculture sector is not in a position of using much electricity in these years.

Table 4-2 Electricity consumption in DRC in Million Kwh (2000-2010)

•Sector	00	01	02	03	04	05	06	07	08	09	10
Industry	1.9	2.0	2.8	3.0	2.9	3.1	2.9	3.9	3.9	4.2	4.0
Commercial & Public services	1.4	1.4	0.5	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Residential	1.2	1.2	1.2	1.3	1.5	1.6	2.6	2.1	2.0	2.2	2.1
Final Use	4.5	4.6	4.5	4.6	4.7	4.9	5.7	6.1	6.1	6.7	6.3

Surprisingly, in the second part of the study period agriculture data completely disappears. But this might not necessarily indicate absence of electricity use in this sector in this period (figure 4-2). As seen on table 4-2, the electricity consumption has continued in the pattern of previous year's irregularity in the volume of electricity used by similar sectors in this period.

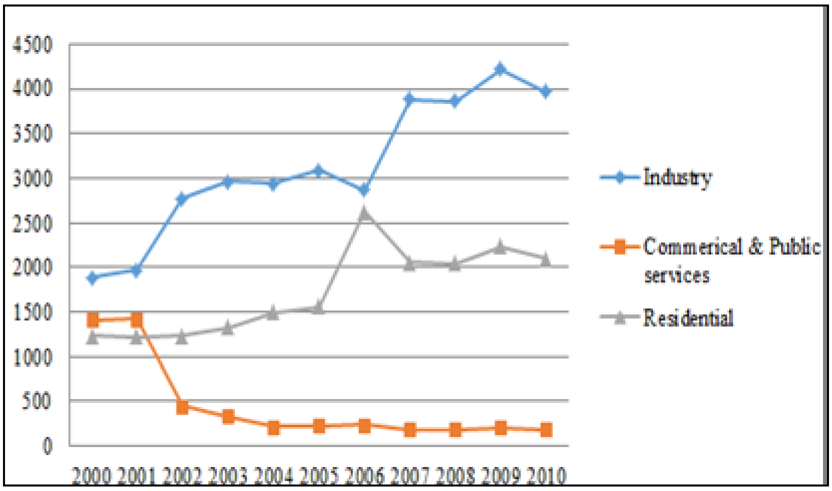


Fig. 4- 2 Electricity use in DRC in Million Kwh (2000-2010)

The order of magnitude gives more weight to the Industry than commercial sector. But the commercial sector's electricity use showed dramatic fall after 2004 up to the end of the study period. Whereas, the increment in the household sector continued like it was in the industrial sector. However the volume of change varied, Industrial sector taking the dominant position. This might have significant implication in terms of competition for accessing electricity among sectors and also countries.

b. Statistics on Sectors Gross Value added

The economic value added by respective sectors was one of the required data for the decomposition analysis. Some problem was encountered in using this data. The electricity sector as main focus of this study lacks complete data set for all sectors. This limited use of the data on gross value added in almost four out of the six countries included in this research. So, inclusion of the Gross value added data and the sectors for further sector by country level analysis was highly dependent on the availability of electricity consumption data for those sectors.

For DRC there are two sectors with no report about data for their electricity use. So, the whole data for the period 1991 to 2010 was split into two parts. The portion of the data which included Agriculture-Forestry-and-others, Industry and Household sectors for the period 1991-1999 was treated in one category. When the behavior of the data is reviewed, one can see some sort of variation among the sectors within the period under consideration.

Sector	91	92	93	94	95	96	96	98	99
Agriculture-Forestry-&-Others	3.3	3.4	3.4	3.4	3.8	3.9	3.8	3.7	3.8
Industry	2.1	1.4	1.2	1.2	1.1	1.1	0.9	0.9	1.0
Household	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 4- 3 Gross value added at factor cost in DRC in Billion UD$ (1911-1999)

In terms of size, agriculture sector dominated and continued on increasing though the rate was not that big. Among the remaining two, the Industrial sector's share was declining up to the year 1997 and seems reviving again. But the household sector consumption expenditure remained with slight variation throughout the period (Figure 4-3). The Services & commercial sector was excluded from the study for this period in DRC due to absence of data for the electricity sector.

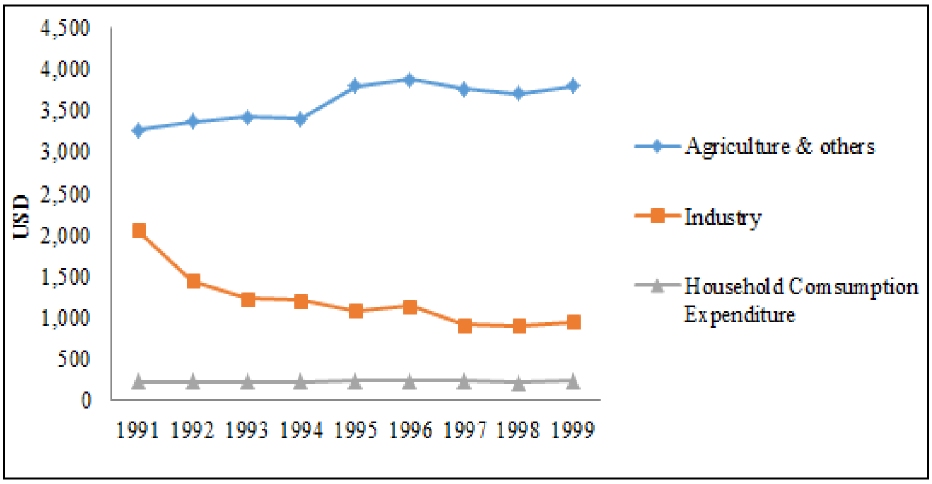


Fig. 4- 3Sectors Gross Value Added at factor cost for DRC in Million US$ (1991-1999)

This picture might be somehow different had this sector been included. The second part of the data which extends from 2000 to 2010 excluded agriculture for similar reason of data absence and kept the remaining three sectors in the analysis (table 4-4).

Table 4- 4Gross Value added at factor cost for DRC in constant 2005 US$ for (2000-2010)

Sector	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agriculture & others	3,347.23	3,215.68	3,230.67	3,270.10	3,291.28	3,385.74	3,495.67	3,609.28	3,717.91	3,829.82	3,945.10
Industry	965.73	949.41	1,038.18	1,164.81	1,378.22	1,579.52	1,650.82	1,613.39	1,720.34	1,753.57	2,089.46
Services	1,575.32	1,556.36	1,612.66	1,749.94	1,864.17	2,026.12	2,208.43	2,565.75	2,787.00	2,865.43	2,947.10
Household Comsumption Expenditure	216.57	213.39	197.78	205.43	217.15	233.05	252.81	270.06	298.58	314.36	318.00
Total	6,104.85	5,934.84	6,079.29	6,390.28	6,750.83	7,224.43	7,607.73	8,058.48	8,523.84	8,763.18	9,299.66

In this study period also certain variability of the gross value added is observed among the three sectors. Almost all the three exhibited growth in same direction though the magnitude varied. In terms of size, The Services sector dominated and beginning from year 2006 it goes on increasing throughout the remaining time.

Among the remaining two, the Industrial sector's share has increased somehow in higher rate up to 2005. From 2005 to 2009, the change was positive but it shoots up beginning from 2009. This trend may continue in the future too because of the positive interest by current government policy on the pattern of development in this sector in most of African countries. The household sector's consumption expenditure was increasing but in slow rate slightly better than the period 1991-1999 (Figure 4-4).

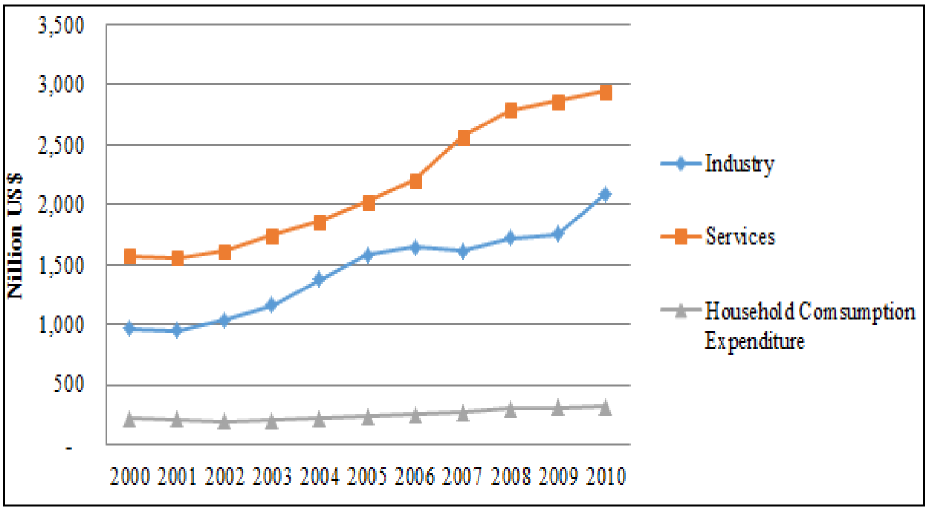


Fig. 4- 4Sectors Gross Value Added at factor cost for DRC in Million US$ (2000-2010)11

The Agriculture sector was excluded from the study for this period in DRC due to absence of data for the electricity sector. The figure above could have been somehow different had the data on electricity use been available for this sector.

[11] Please note that all Gross Value Added figures are in Constant 2005US$.

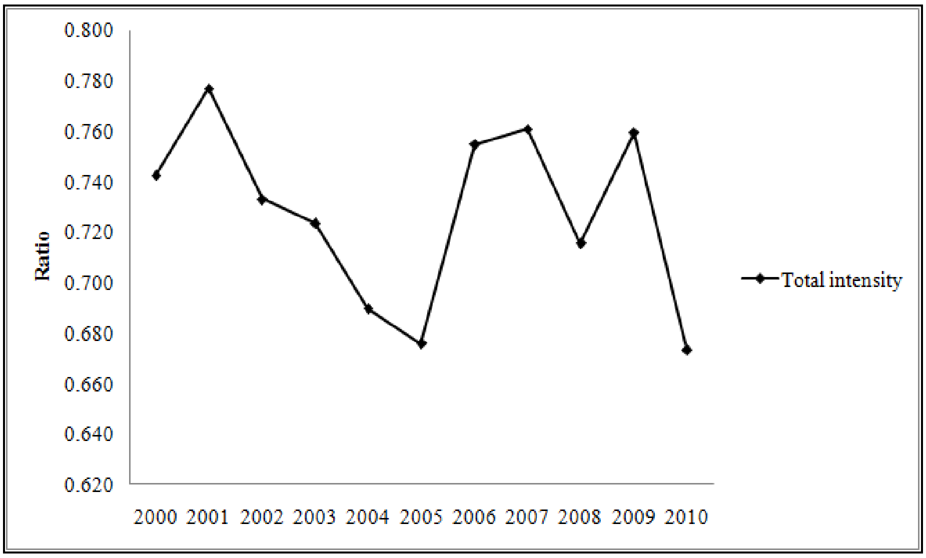


Fig. 4- 5 Aggregate Electricity Intensity-DRC in kwh/US$ for 1991-1999

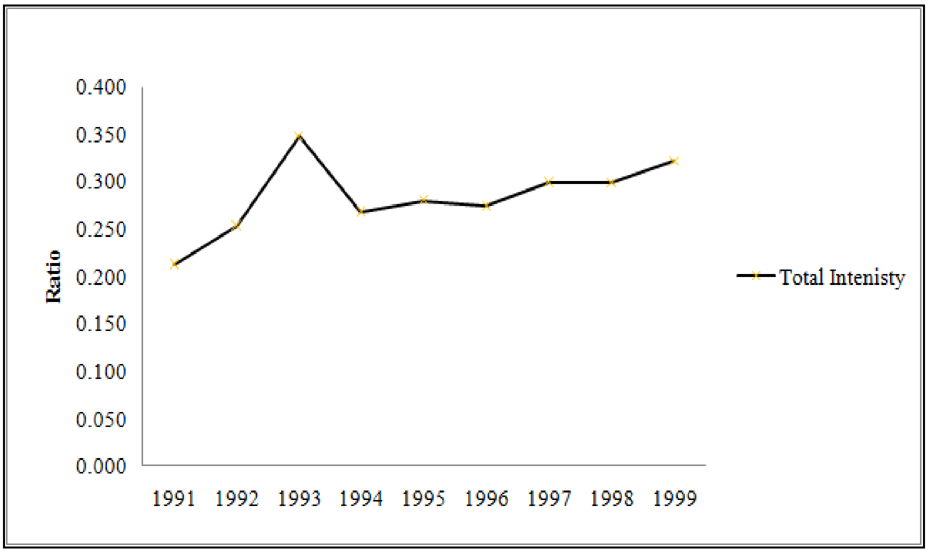


Fig. 4- 6 Aggregate Electricity Intensity-DRC in kwh/US$ for 2000-2010

The gross electricity Intensity value which simply means the ratio of electricity used to the Gross value added will be the final aggregate data for the main decomposition analysis are shown in Figure 4-5. As seen from the figure, the aggregate intensity for the second period fluctuated sporadically.

4.3 Egypt Arab Republic

a. Electricity Statistics

The electricity consumption data in Egypt Arab Republic (Egypt) also exhibited the same problem with DRC for similar reason. Firstly, there was no data for *Commercial & Services sectors* electricity use for the period 1991 to 1995 (Table 4-5). Except that, the years 1996 through 2010 have complete data (Figure4-8). The electricity consumption volume varied from sector to sector throughout the two time periods. One can easily see how one sector is important from the other by looking at the volume of electricity used in each sector and the trend it shows within the period.

Sector	91	92	93	94	95
Agriculture-Forestry-&-Others	6.3	6.5	6.8	7.1	7.5
Industry	17.5	18.1	18.8	19.5	20.2
Residential	14.1	14.4	15.2	15.9	16.8
Final Consumption	38.0	39.0	40.8	42.6	44.6

Table 4-5 Electricity consumption in Egypt in Gwh for 1991-1995

Table 4-5 clearly shows that all the three sector show similar trend of increment for the first 3 years. But the years 1995 to 2010, residential and Industrial sectors use relatively large volume of electricity. In 2001 the Agriculture and commercial sectors exchange position and later in 2010 each of them return to their position again, where the agriculture sector continued to increase more than the commercial sector in the use of electricity (Figure 4-8).

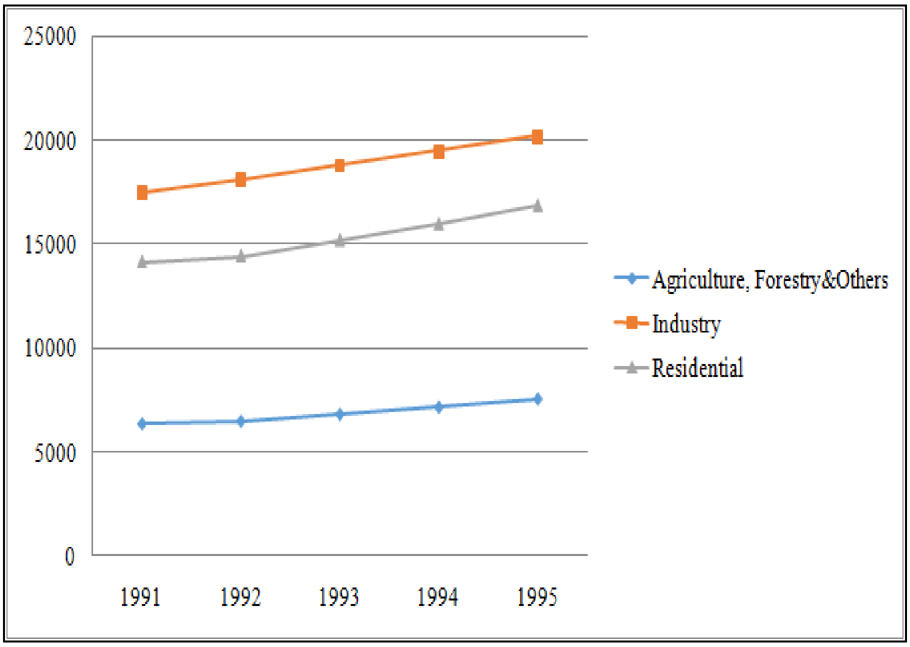


Fig. 4-7Sectors Electricity Consumption in Egypt in million Kwh (1991-1995)

In Egypt, Agriculture-forest-and-others sector exceeded from the industrial sector beginning from 2001, the only country where relatively large volume of electricity was utilized for agriculture sector. There was relatively high rate of increase in the use of electricity in the agriculture sector since 2006. Roughly, it could be said that all the sectors exhibited some sort of increase in the utilization of electricity in Egypt (see figure 4-7 and Figure 4-8). The commercial sector electricity use seems declining from 2010 onwards, but difficult to give reasonable comment.

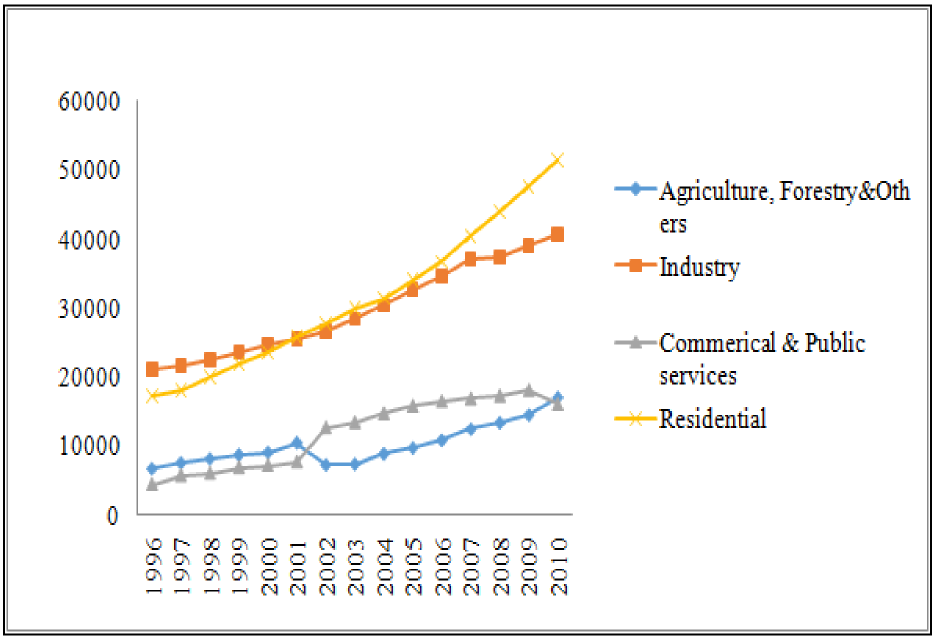


Fig. 4- 8 Sectors Electricity Consumption for Egypt in Million kwh (1996-2010)

As observed in figure 4-8, electricity use in the household, Industry, and Agriculture sectors was found increasing. Also the Household and Industry sectors dominate in the use of electricity compared to the remaining two Sectors.

b. Statistics on Sector Gross Value added

The economic value added by respective sectors was increasing smoothly in three sectors (Figure 4-9A). As the figure depicts, the household sector consumption expenditure seems somehow too slow in changing. As the electricity use condition in these sectors was the leading factor for inclusion or rejection of the sector from study, all of the sectors use electricity except in the period 1991-1995, Gross value added data for the Commercial & Public Services sector was excluded from first five years in the study period because of lack of data on electricity use in the sector.

Seen from the adjacent figures in Figure 4-9 below however, the path of change seems relayed from the first period to the second for sectors which survived data shortage problem during the second period. Obviously, the data for sectors reported in both periods was same and the split into two parts does not change in these values.

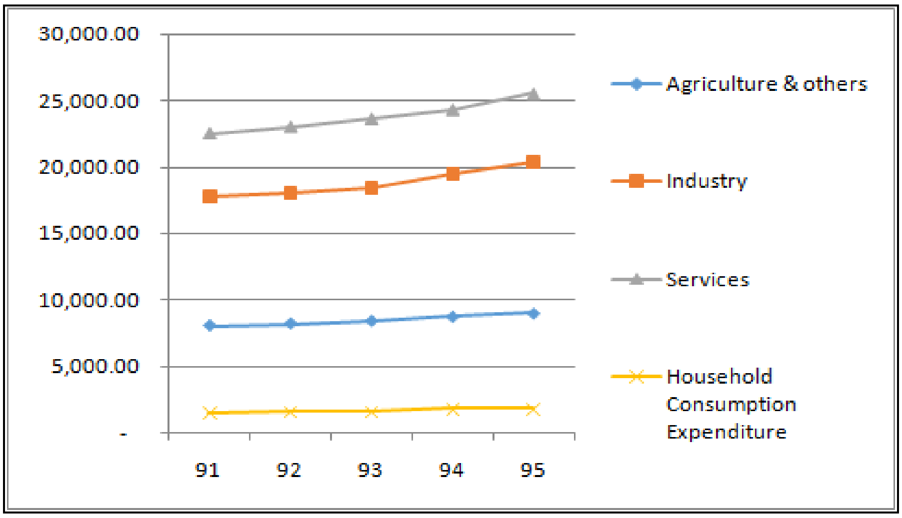


Fig. 4- 9 GVA[12] Million US$ for Egypt at factor Cost for Egypt (Constant 2005US$)

[12] GVA represents Gross Value Added

In Egypt the Services and Industry sectors have been bringing considerable income for 1991 through 1994. The chane in the Agriculture-forestry-&-others sector was not that much attractive. But it was increasing anyhow.

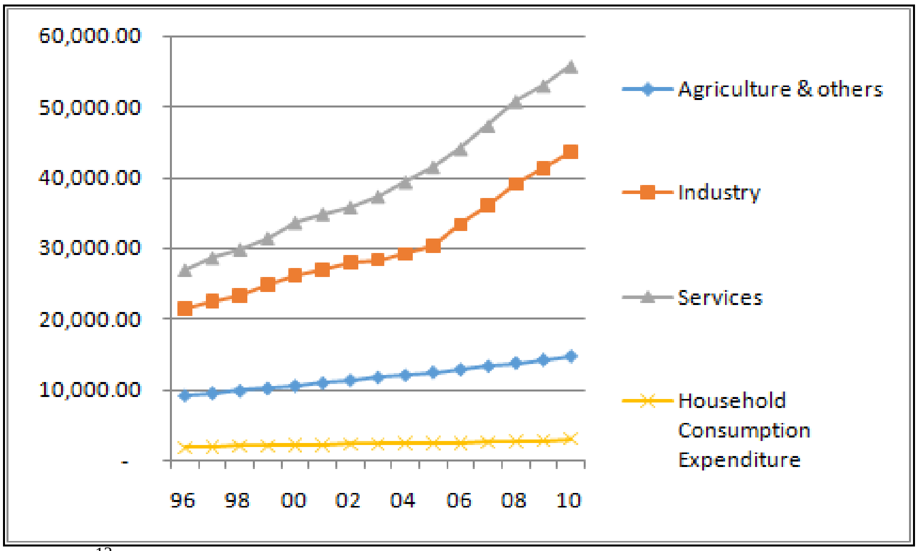


Fig. 4- 10 GVA[13]Million US$ Egypt at factor Cost (Constant 2005US$) in 1996-2010

Country level comparison would be possible if only the three sectors apart from agriculture are taken. But the volume of electricity used in the Egyptian agriculture is relatively large. In terms of size, agriculture dominates and increased continuously at a relatively high rate. Industrial sector value added also exhibited same fashion with the Agriculture. No significant downward drift seen in this data set (see second part of Figure 4). Tables 4-6 and 4-7 respectively contain the data for Egypt sector level gross value added for the two consecutive

[13] GVA represents Gross Value Added

periods.

Table 4- 6 GVA at factor cost Egypt in Million US$ (Constant 2005 US$)

Sector	**1991**	**1992**	**1993**	**1994**	**1995**
Agriculture,Forestry-&-)thers	8,054	8,212	8,416	8,739	8,992
Industry	17,781	18,048	18,450	19,450	20,431
Residential	1,489	1,610	1,598	1,777	1,823
Total	27,324	27,870	28,464	29,972	31,246

The only reason for splitting these two tables was the absence of data for *Commercial & Public Services sector* in the first period. The other sector's data continues from the year 1991 through 2010. Excluding the agriculture sector in the context of Egypt's electricity use in the sector would result in significant loss of information. Hence, splitting the Intensity data tables in to two was preferred following the pattern in the country's electricity.

Table 4- 7 Sector GVA at factor cost Egypt Billion US$ (Constant 2005US$)

Sector	96	97	98	99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	10
Agriculture & others	9.27	9.59	9.93	10.28	10.63	11.02	11.42	11.82	12.14	12.54	12.95	13.42	13.87	14.31	14.81
Industry	21.43	22.42	23.31	24.85	26.17	26.99	27.96	28.31	29.14	30.3	33.28	35.93	38.98	41.22	43.52
Services	26.96	28.67	29.88	31.46	33.67	34.86	35.85	37.35	39.4	41.52	44.07	47.33	50.81	53.01	55.75
Household Consumption Expenditure	1.83	1.87	1.99	2.04	2.12	2.22	2.31	2.36	2.4	2.41	2.5	2.63	2.76	2.83	3.06
Total	59.49	62.55	65.12	68.63	72.59	75.1	77.54	79.84	83.08	86.77	92.81	99.31	106.4	111.4	117.2

One can imagine how the two figures follow some sort of similarity in pattern. This is simple to understand that they originate from same source data. The reason for their difference was only removal of the services sector as repeatedly mentioned.

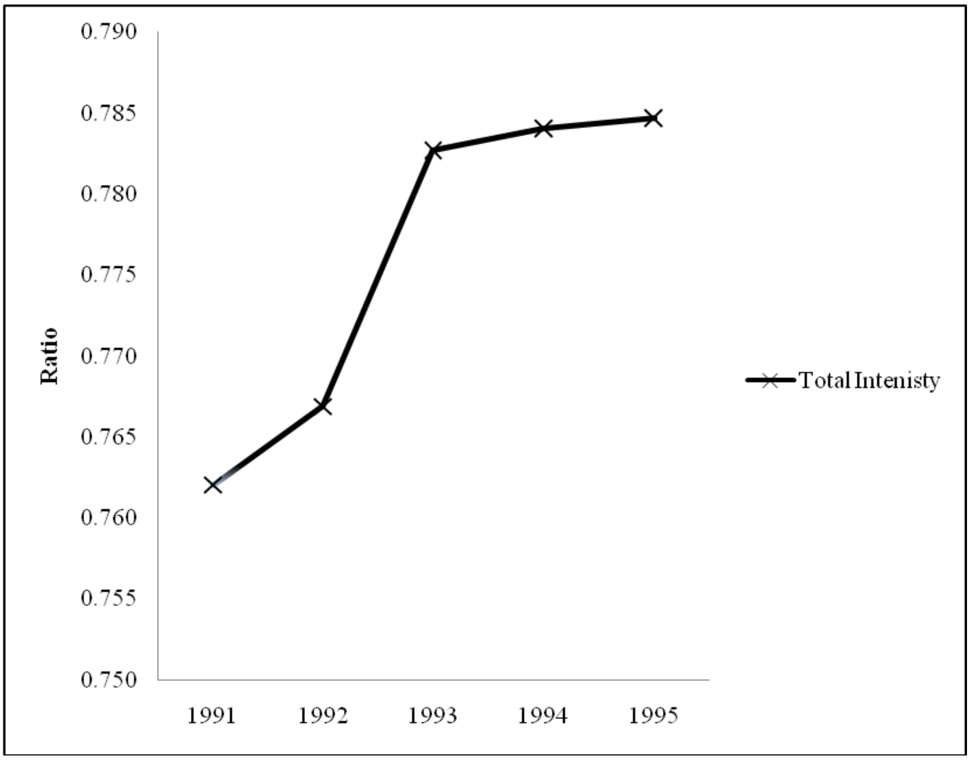


Fig. 4- 11Electricity Intensity for Egypt in Kwh/US$ in 1991-2010

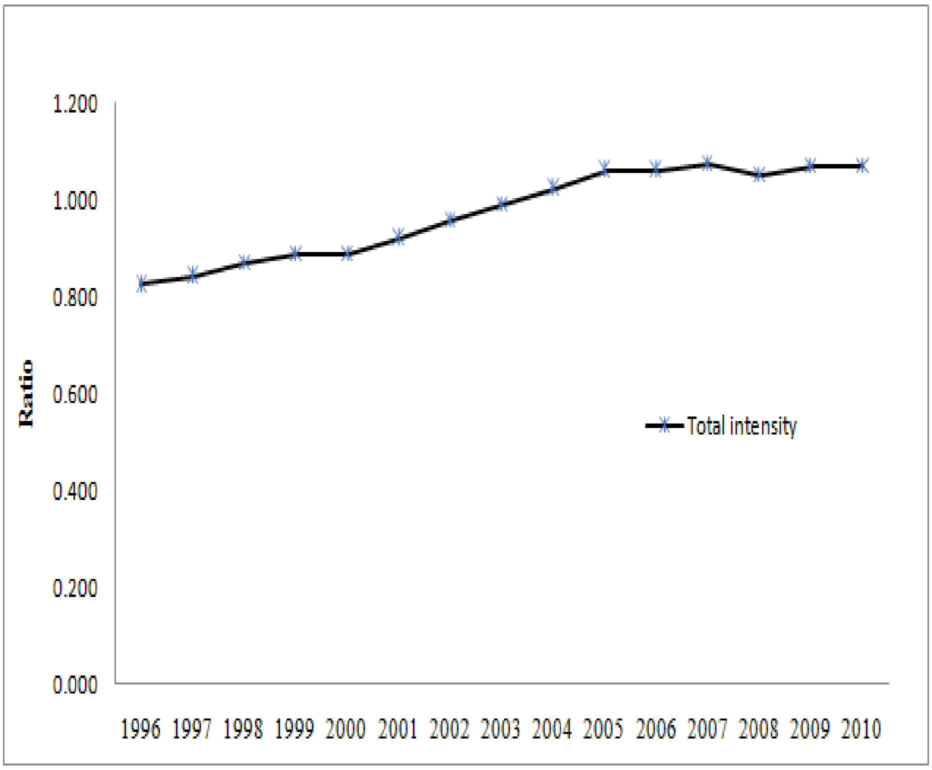


Fig. 4- 122Electricity Intensity for Egypt in Kwh/US$ in 1996-2010

Beginning from 2000, the electricity Intensity in Agypt have shown smooth increment up to 2005. Then after, it was increasing but in much slower rate.. Towards the end of the study period, the value tends to decrease. This behaviou is directly related with the sectors economic performance in the country. But at this point, it is difficult to tell exactly which sector contributed for what change. After performing the Decomposition Analysis, good amount of information were obtained.

5 Ethiopia

c. Electricity Statistics

The electricity consumption data in Ethiopia does not have any breakdowns. But electricity consumption volume is dominated by the industry and household sector, the later taking the lead up until 2008. One can easily see how one sector is important from the other just by looking at the volume of electricity used in each sector and the trend it shows within the period.

Table 4- 7 Electricity Consumption in Ethiopia Million kwh 1991-2010

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agriculture, Forestry & others	15	17	10	8	8	8	8	9	10	12	14	19	23	32	35	53	46	23	26	30
Industry	441	441	499	521	546	564	563	559	534	549	653	692	718	796	945	897	973	1,188	1,223	1,395
Commerical & Public services	114	119	123	133	144	168	185	274	304	338	387	396	449	512	585	640	694	737	813	940
Residential	365	405	437	481	530	558	569	516	497	520	395	591	644	711	769	977	1,060	1,178	1,191	1,472
Final Consumption	935	982	1,069	1,143	1,228	1,298	1,325	1,358	1,345	1,419	1,449	1,698	1,834	2,051	2,334	2,567	2,773	3,126	3,253	3,837

Table 4-8 and figure 4-12 are used for convenience of description. The Industrial and Services sectors use relatively large volume of electricity throughout the study period. The two sectors seem competing for electricity. From 1991 to 1996, the industrial sector was leading. After one year, in 1998 through 2005 the Industrial sector continued to lead in the consumption of electricity. In years 2006 and 2007 the residential sector was leading in the consumption and after two years in 2010 it again took back the lead in electricity consumption. This might be a good sign of how economies are changing abruptly in the countries of East Africa these days.

The direction of change was similar for all of the sectors except the agriculture in the study period. This could be more clearly visualized in Figure 4-12. As seen in the figure, the agriculture sector electricity use remained almost stagnant up to around 2003 and went back again in 2008 through the end of the study period.

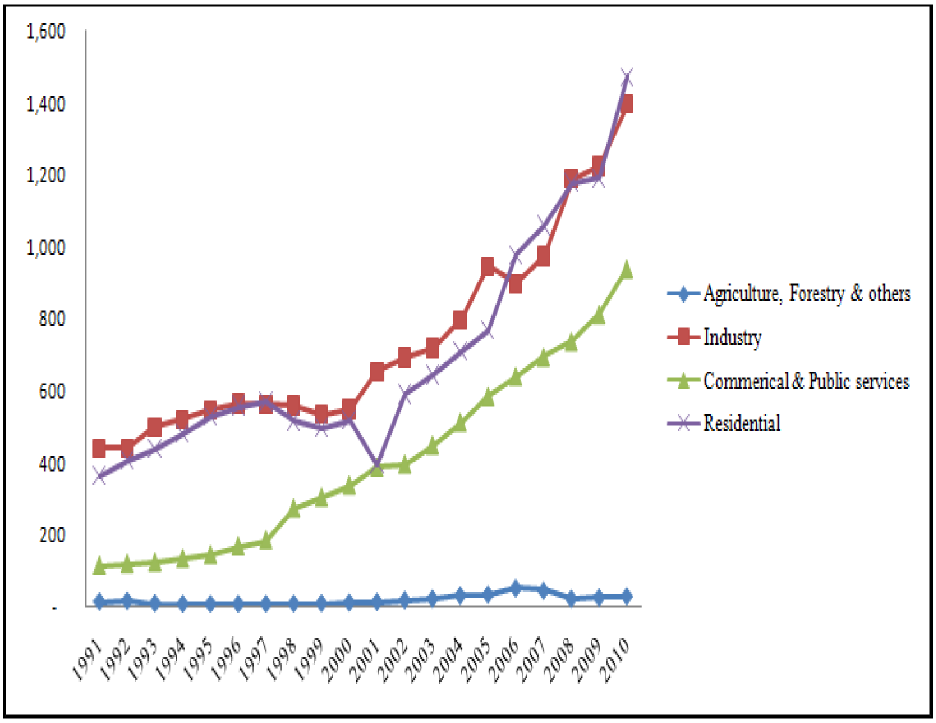


Fig. 4- 13 Sectors Electricity Consumption for Ethiopia in Million kwh (1991-2010)

Since the volume of electricity used in the agriculture sector is small and the variation throughout the study period was not that visible, the impact of this sector on the overall analysis might not be important for the time being. In Ethiopian Context, the Residential/household, Industry, and services sectors play significant role in the electricity market.

d. Statistics on Sector Gross Value added

The data of economic value added by respective sectors was treated in the same way for all the countries. The main economic sectors discussed here include the Agriculture, Industry, commercial & Public Services, and the Household sector. There is no guarantee for the Gross value added by each sectors to follow the trend observed on the electricity consumption statistics of same sectors. Luckily, Ethiopia was one of those countries for which relatively good volume of data was obtained on Gross Value Added for all the sectors. This was seen on the electricity use data set and the same situation was observed here too.

For Ethiopia, there was no need to split the data set and the whole data for the period 1991 to 2010 was treated at the same time (Figure 4-13). When the behavior of the data was reviewed, some sort of variation observed among the sectors within the period under consideration. The Details on the sector level Gross value added data show that Agriculture and services sectors exhibit significant contribution compared to the others.

The trend of all the sectors is increasing though the above two sectors hold the dominant position. Agriculture remained dominant for most of the study period, though its growth was irregular up to 2003. But surprisingly, beginning from year 2008, the services sector took the leading position.

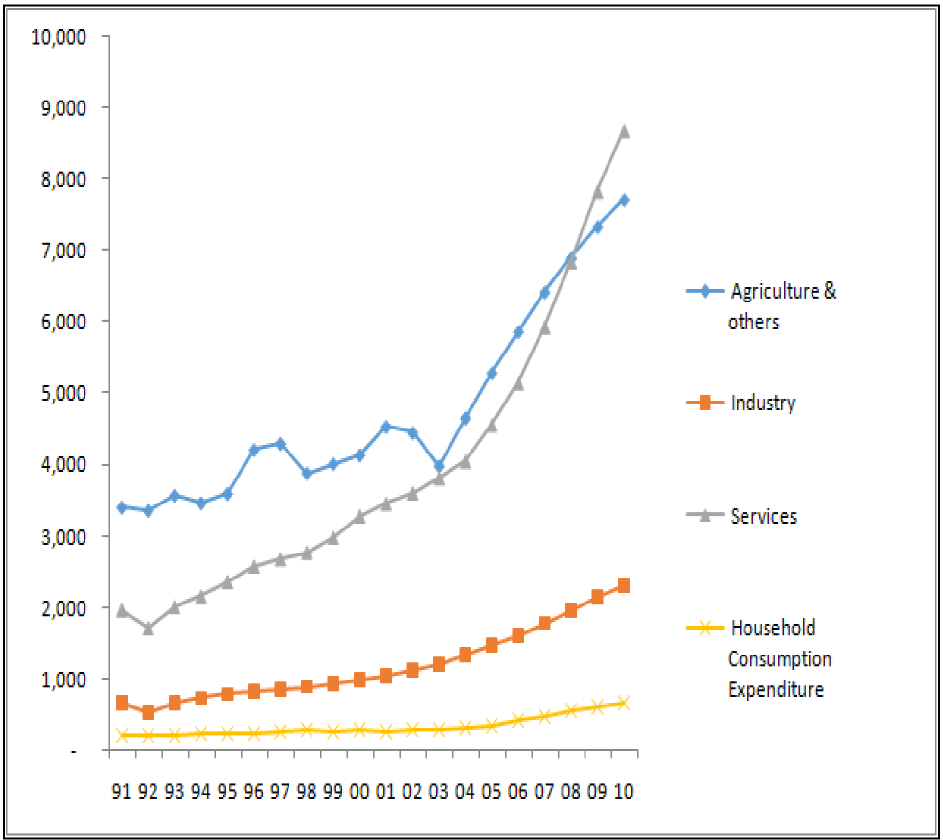


Figure 4- 14 Sectors Gross Value added at factor cost for Ethiopia (1991-2010)

It seems that Agriculture and services sectors are paired and at the same time the Industry and Household sectors also paired. The rate of increase by the former two is larger while for the later ones it is slower. These variations in the sectors economic contribution have significant implication in terms of electricity requirement in the past, present and future.

The purpose of describing the electricity use and the Gross value added data was to get aggregate electricity intensity. The aggregate electricity intensity of Ethiopia was determined using the data on electricity use by the four sectors and applying it on the gross value added by the same four sectors. Figure (4-12) depicts this ratio and the pattern of its change throughout the study period can easily be seen right below.

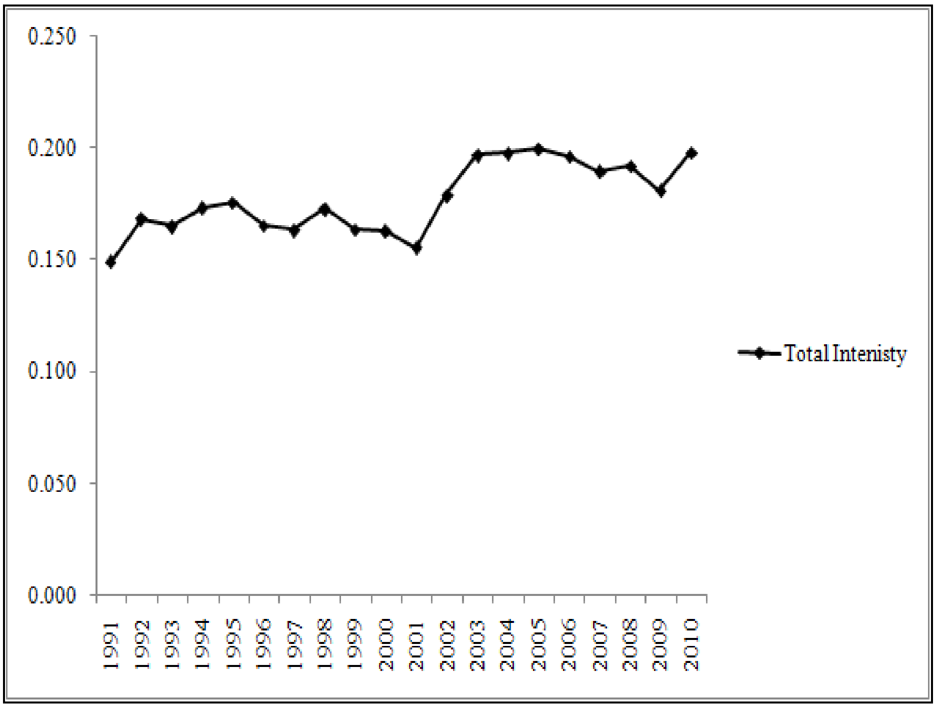


Fig. 4- 15 Electricity Intensity for Ethiopia in kwh/US$ (1991-2010)

There seems that the intensity was increasing in the overall and there were variations at different points in the course of change in time. The Aggregate Electricity Intensity value for Ethiopia will also be used for the main decomposition analysis to show the role of sector level demand structure in the market aggregation process.

6 Kenya

e. Electricity Statistics

The electricity consumption data obtained for Kenya hindered fully fledged electricity intensity analysis in same manner as it was for DRC. Electricity use in the Agriculture sector could not be obtained for the years 1991-1994 and also for the later years 2008-2010. Therefore, Figure 4-13 respectively are constructed based on three sectors as shown. The electricity consumption volume seems followed the same trend in these two different time period data.

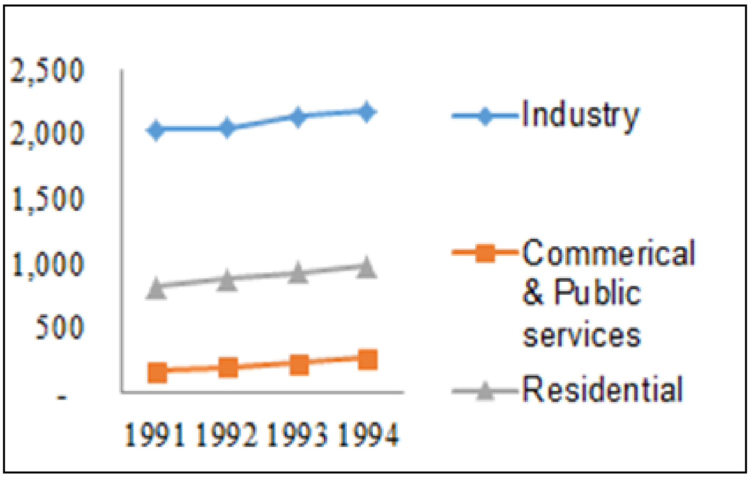


Fig. 4- 16 Sectors Electricity Consumption in Kenya in Million Kwh in 1991-1994

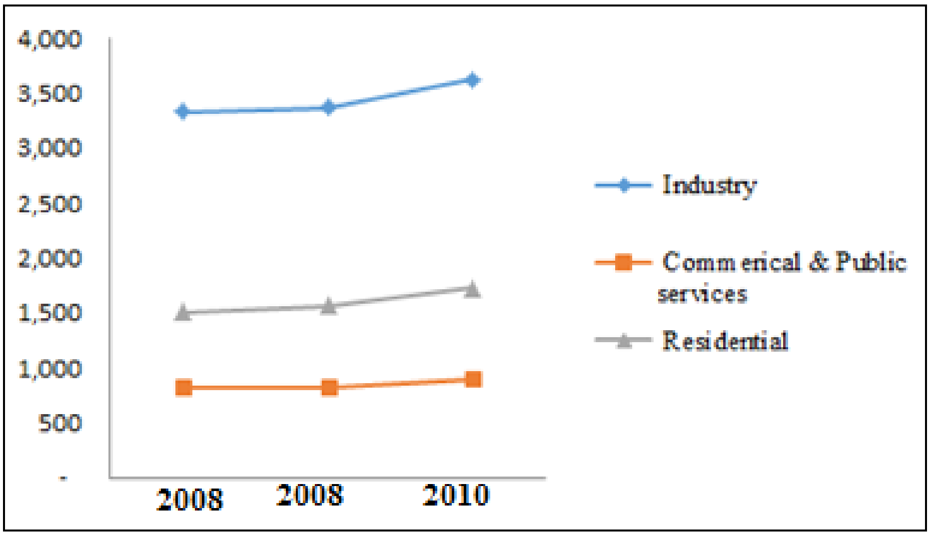


Fig. 4- 17 Sectors Electricity Consumption in Kenya in Million Kwh in 1991-1994

The years in the middle ranging from 1995 to 2007 are grouped under same category in terms of data for electricity consumption (Figure 4-14). The industrial and residential sectors consume relatively large volume of electricity in the Kenyan economy. Industrial sector plays the leading role compared to others. Services sector is also increasing but it has its own trend. The agriculture sector's electricity consumption volume is very minimal and remained slow in terms of changes in electricity use.

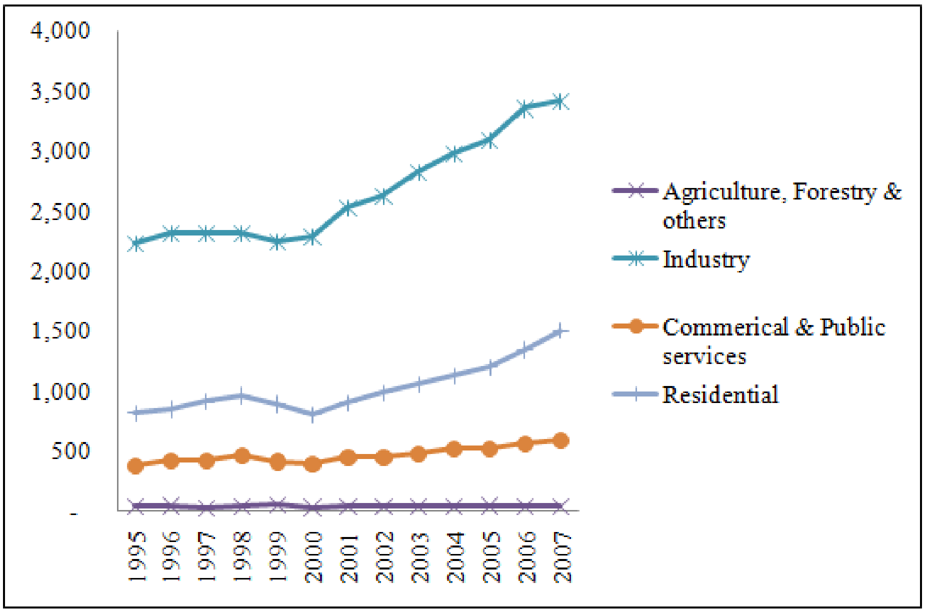


Fig. 4- 18 **Sectors Electricity Consumption for Kenya in Million Kwh (1996-2007)**

In the years from 1995 to 2007, the Industrial and residential sectors show increasing trend in electricity use. However, commercial & Public services sector remain slow in growth though there is some change throughout. Agriculture sector seem stagnant in growth of electricity use throughout the period. There was observed some sort of coupling among the sector level electricity use in Kenya. Industry and residential sectors exhibit same growth trend. While the Agriculture and Commercial and Public services sectors show somehow similar trend but the former has slight difference in the pattern of electricity use. This could be clearly seen from Table 4- 9, 4-10, and 4-11 respectively.

Table 4-8 Electricity consumption in Kenya in Million kwh for 1991-1994

Sector	1991	1992	1993	1994
Industry	2,039	2,049	2,135	2,175
Commercial & Public services	166	202	232	**273**
Residential	823	877	927	977
Final Consumption	**3,028**	**3,128**	**3,294**	**3,425**

One can easily see how one sector is important from the other by looking at the volume of electricity used in each sector and the trend it shows within the period.

Table 4- 9 Electricity Consumption in Kenya in Million Kwh (1995 – 2007)

Sectors	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Agriculture, Forestry & others	44	47	27	45	54	33	36	38	38	38	47	42	37
Industry	2231	2315	2313	2315	2244	2286	2525	2621	2818	2977	3085	3351	3411
Commerical & Public services	375	418	414	466	410	385	446	450	476	522	522	558	590
Residential	812	847	907	957	886	800	899	981	1050	1120	1193	1334	1495
Final Consumption	3462	3627	3661	3783	3594	3504	3906	4090	4382	4657	4847	5285	5533

The volume of electricity use in the industrial sector in Kenya was relatively large. The residential sector also went on increasing more from years 2003 to 2007. The table for the remaining three years confirms how the change in the three sectors resembled with the first group of years, 199-1994.

Table 4- 10 Electricity Consumption in Kenya in Million kwh for 2008-2010

Sector	2008	2009	2010
Industry	3,332	3,370	3,630
Commercial & Public services	823	823	904
Residential	1,504	1,569	1,731
Total	**5,659**	**5,762**	**6,265**

The electricity use in Kenya could be summarized in such a way that in the whole study period the industrial electricity use dominated compared among the four sectors. Residential and commercial sector follow in the order they are seen (see fig. 4-13, and 4-14)

f. Statistics on Sector Gross Value added

The sectors covered in this study for determining the contribution of the electricity sector as an input to the economic value added followed the style in the electricity sector. That means the in first four years, 1991 to 1994 and in the last three years, 2008 to 2010 only the three sectors namely the Industry, Commercial & Public services, and the residential sectors were included. Agriculture was excluded since there was no reported data indicating the use of electricity in this sector. In similar manner with the case discussed for the DRC, the data for Kenya also does not allow fully fledged study about the demand structure for the whole period continuously.

For Kenya, the agriculture sector has missing data for the years 1991 to 1994 and for 2008 to 2010. So, the whole data for the period 1991 to 2010 was split into three parts. Each of them including the period 1996-2007 which has full set of data were treated in a category. When the behavior of the data is reviewed, one can see some sort of variability among the sectors within the period under consideration.

As observed form review of the gross value added in the sectors covered, the trend seen in the electricity consumption volume does not repeat itself in Gross value added. As shown in figure 4-15, the most important sector in terms of gross value added was Commercial & public Services sectors and the Industry sector comes in the second position.

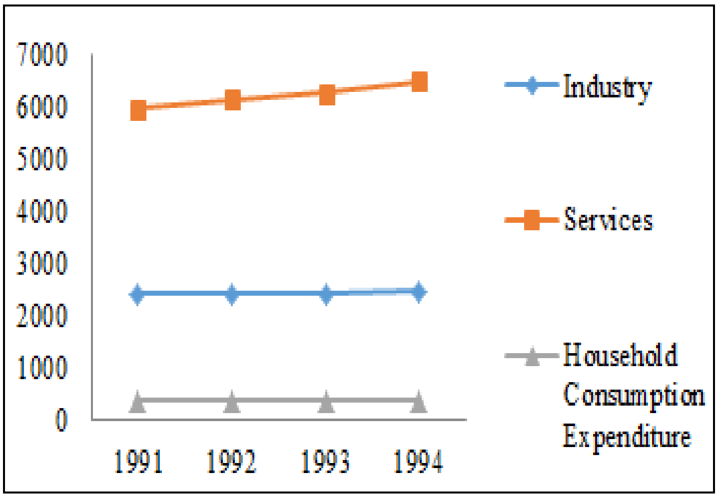


Fig. 4- 19 Gross Value Added at Factor Cost for Kenya in Million US$ (1991-1994)

For years 2008 to 2010 also the same trend continues. The Industrial and services sectors exhibited some sort of similarity in upward movement for the two periods, though the interval for these periods was only four and three years respectively. In both cases, the household sector consumption expenditure remained with slight variation (Figure 4-15 and 4-16).

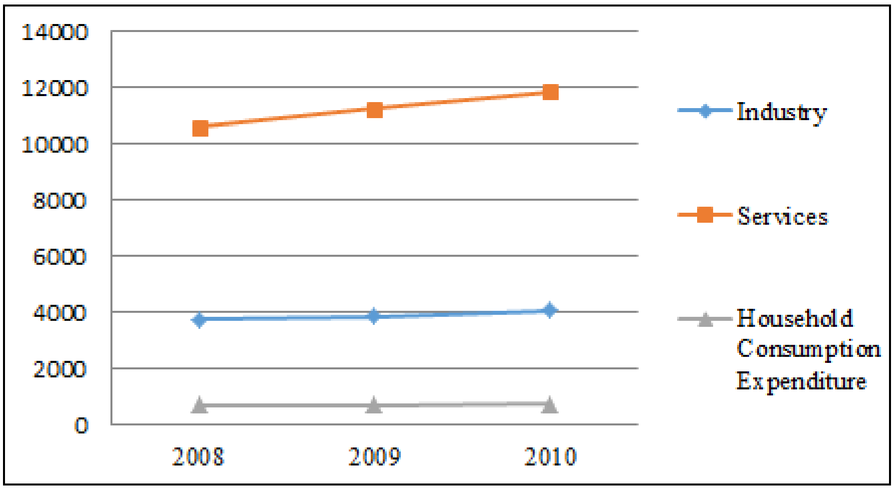


Fig. 4- 20 Gross Value Added at Factor Cost for Kenya in Million US$ (2008-2010)

The Gross value added data for the years 1995 to 2007 included agriculture. This has somehow changed the picture of the volume of Gross value added from each sector. It is always logical for income from agriculture to be relatively more compared to other sectors. But the commercial & Public services sector maintained its position as dominant contributor for the Gross value added and agriculture remained second (figure 4-17).

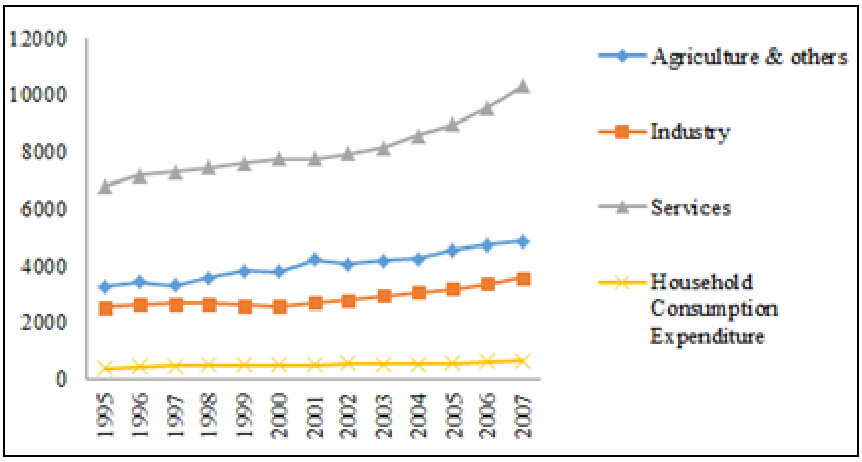


Fig. 4- 21 GVA at Factor Cost for Kenya in Million US$ (1995-2007)

The trend with the rest of the sectors continued as usual. For quantitative view of the figurative description, the data for each of the periods, i.e., 1991-1994, 1995-2007, and 2008-2010 are presented consecutively on table 4-12, table 4-13 and table4-14 as follows.

Table 4- 11 Gross Value Added at factor Cost for Kenya in Million US$ (1991-1994)

Sector	**1991**	**1992**	**1993**	**1994**
Industry	2,411	2,410	2,415	2,461
Services	5,952	6,126	6,260	6,476
Household Consumption Expenditure	376	380	378	365
Total	11,969	12,038	12,074	12,415

The services sector contributed more than double that of the industrial sector throughout the four years.

Table 4- 12 GVAd at factor Cost for Kenya in Million US$ (1995-2007)

Sector	95	96	97	98	99	00	01	02	03	04	05	06	07
Agriculture-Forestry-&-others	3,262.53	3,408.40	3,303.93	3,577.81	3,831.56	3,782.62	4,223.61	4,075.93	4,175.00	4,247.99	4,541.37	4,744.65	4,855.09
Industry	2,547.68	2,634.19	2,665.58	2,671.86	2,608.71	2,560.92	2,701.70	2,765.10	2,934.30	3,053.81	3,187.81	3,346.06	3,582.64
Services	6,819.81	7,172.87	7,294.56	7,458.55	7,614.20	7,757.02	7,745.88	7,955.09	8,156.45	8,574.25	8,967.84	9,554.61	10,331.37
Household Consumption Expenditure	375.60	436.12	444.19	475.06	487.98	499.67	496.52	537.97	529.01	520.29	551.22	597.17	655.40
Total	13,005.61	13,651.58	13,708.27	14,183.29	14,542.46	14,600.23	15,167.70	15,334.09	15,794.75	16,396.33	17,248.23	18,242.49	19,424.50

The large volume of gross value added by the services sector remained dominant. The order of magnitude has still increased throughout the study period. The last part of the data which covers 2008-2010 also shows similar trend in volume of contribution (Table 4-14).

Table 4- 13 Gross Value Added at Factor Cost for Kenya in Million US$ (2008-2010)

Sector	**2008**	**2009**	**2010**
Industry	3,750	3,855	4,062
Commercial & Public services	10,607	11,223	11,843
Household Consumption Expenditure	704	703	746
Total	**19,709**	**20,232**	**21,386**

It is easy to conclude based on the data and the figures that among the sectors identified in the economy of Kenya, the Commercial and public services sector plays significant role in the Gross Value added. The aggregate electricity Intensity for Kenya was also split into three parts due to the nature of the source data (Figure 4-18).

As already known, the aggregate electricity intensity data for Kenya was determined as the ratio of the total Electricity consumption to the total value of the Gross value added. In this case it would be enough to show the figure, since the details are discussed in the analysis part. But, it might help to know that the commercial & Public services sector electricity intensity within the aggregate was very small. On the contrary, the residential sector's electricity intensity was extremely large value. These might have guided the whole course of change in the aggregate electricity intensity.

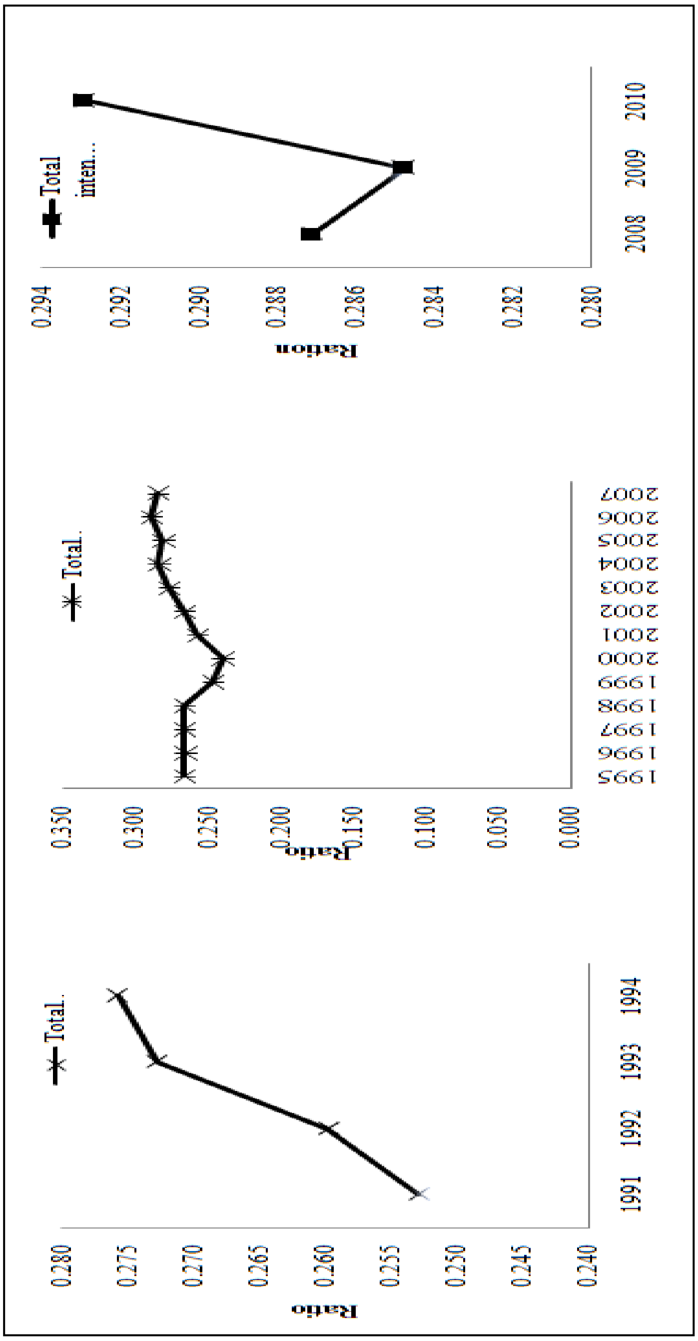


Figure 4- 22 Electricity intensity for Kenya Kwh/US$ in 1991-2010

These gross electricity intensity values for the three periods will be decomposed separately. There would be certain common feature that would be exhibited by the factors within each of them. The result of the analysis may have some sort of logical flow though there is data missed for the Agriculture sector for comparatively extended period of time.

7 Sudan

g. Electricity Statistics

The electricity consumption data in Sudan does not have any breakdowns. But electricity consumption volume is dominated by the residential sector. As can be seen on figure 4-19, the Industry sector and the commercial and public services sectors were taking the lead interchangeably. All the sectors showed an increasing electricity consumption tendency. But the residential and the commercial & public services sectors are increased sharply beginning from 2007. In the years 1999 and 2000 the electricity consumption in the Commercial and public sector has increased relatively in a unique fashion. This might introduce some bias later in the analysis.

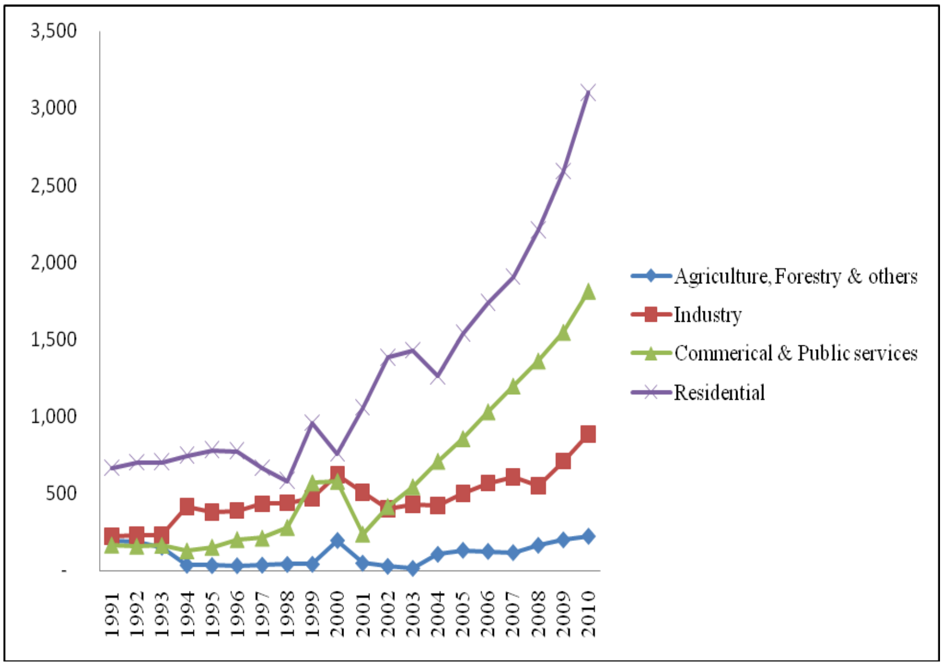


Figure 4- 23 Sectors Electricity Consumption in Sudan Million Kwh (1991-2010)

The years 1999, 2000, and 2002 are the years in which somehow unexpected increase and decrease was observed in the electricity use in the Residential sector of Sudan. Especially, year 2000 was common to all the sectors where the consumption in the residential sector decreased and in the remaining three sectors increased. Here the main explanation could be its coincidence with beginning of oil marketing and high oil production in Sudan. Since 2002 within the study period, the commercial sectors have been consuming more oil every year in Sudan. The situation of electricity use in Sudan can be quantified using Table 4-15 within the limit of the available data. But looking at the volume of electricity used in each sector and the trend it shows within the period only does not give clear understanding of the cause of such a change in the use of electricity.

Sector	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
Industry	221	231	231	416	378	388	433	438	468	619	508	398	427	419	497	566	605	547	709	884
Agriculture,Forestry, & Others	191	183	151	35	33	32	36	40	41	194	48	28	15	105	131	124	116	163	198	221
Industry	221	231	231	416	378	388	433	438	468	619	508	398	427	419	497	566	605	547	709	884
Commerical & Public services	166	159	164	128	152	202	211	280	570	580	237	416	544	710	857	1031	1198	1361	1547	1814
Residential	665	701	704	747	780	774	664	580	958	761	1057	1383	1428	1262	1539	1737	1907	2210	2593	3105
Final Consumption	1243	1274	1250	1326	1343	1396	1344	1338	2037	2154	1850	2225	2414	2496	3024	3458	3826	4281	5047	6024

Table 4- 14 Sectors Electricity Consumption in Sudan in Million Kwh (1991-2010)

For this purpose, considering data on the size of the economic value added by sectors which used electricity as one of the inputs in their production process was emphasized. Here also, the volume of electricity used in the agriculture sector is small though the variation throughout the study period was somehow better than other countries except Egypt. Hence, the impact of this sector in the overall analysis might not be so important within this study period. But certainly, the future trend would change dramatically judged from the practice of the countries in Africa, especially Eastern sub region. In the Context of Sudan, the Residential and the Commercial & Public services sectors dominate in the volume of electricity use. The Industry sector stands in the third position in the study period.

h. Statistics on Sector Gross Value added

In Sudan, the Gross value added data was obtained for all the main economic sectors. The sectors included were, the Agriculture, Industry, Commercial & Public Services &, and the Household sectors. Hence, there was no need to split the data set and the whole data for the period 1991 to 2010 was treated at the same time (Figure4-16). Based on the data, there was mixed response to amount of electricity use by each of the sectors. The services sector uniquely responded positive to the use of the electricity. Other sectors also have some sort of parallel, but difficult to give detailed explanation right away.

When the historical flow of the data is reviewed, some sort of irregularity was observed among the sectors within the period under consideration. The Details on the sector level Gross value added show that Agriculture and services sectors contributed significantly compared to the others. The trend of all the sectors was increasing though Agriculture and services sectors hold the dominant position. Services sector remained dominant for most of the study period, though its growth was irregular up to 2003. Beginning from year 2006, the Industry sector was in next position in contributing to the Gross value added in Sudan.

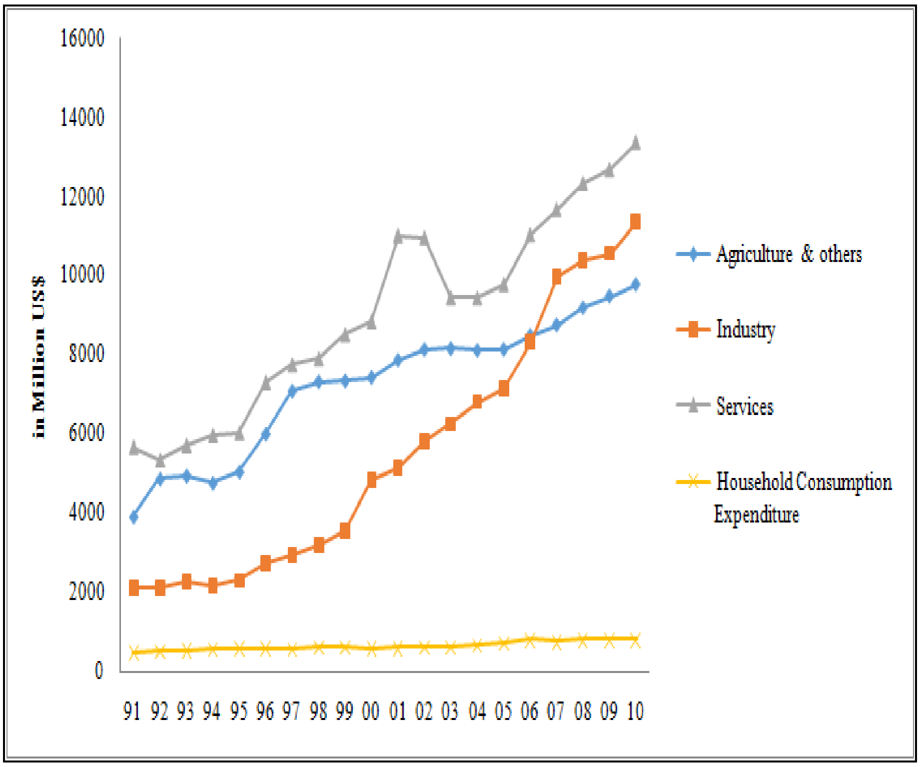
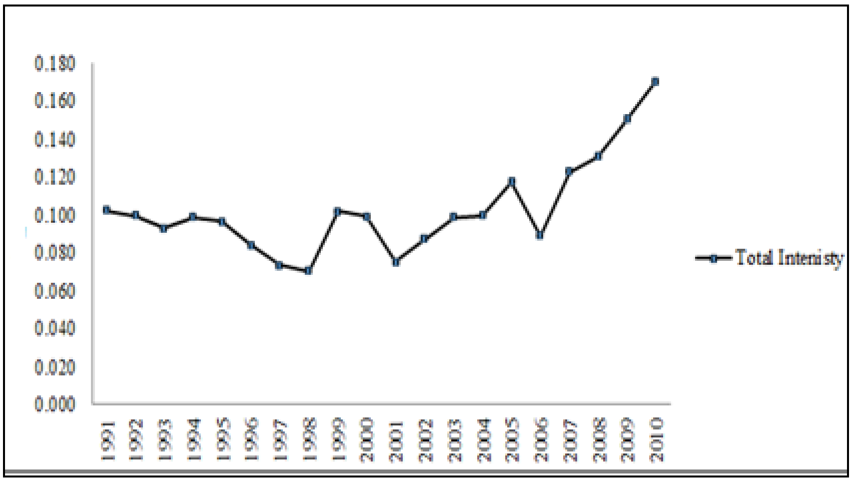


Figure 4- 24 Gross Value Added at Factor Cost for Sudan in Million US$ (1991-2010)

Agriculture and services sectors are paired up to the end of the study period while the Industry and Household sectors also paired up to 1995. Later on, the Industry sector went on increasing continuously up to the end of study period. The rate of increase by the former two sectors is larger while it remained very low with only slight change for the household sector. Whereas, the Industrial sector's Gross value added increased in increasing rate up to 2007 and somehow followed the trend of the Commercial and Public Services and Agriculture[14] sectors pattern. These variations in the sectors economic contribution have significant implication in terms of electricity requirement in the past, present and future.

But, here also the case with the agriculture sector is quite different because its energy consumption volume was low compared with other sectors. As it was common to majority of countries in Africa, the existing agricultural practices and level technical sophistication were not in a position to accommodate the use of large volume of electricity in the sector.

The aggregate electricity intensity for Sudan was determined as a ratio of the total electricity used by the four sectors divided by the total gross value added by the same four sectors. Figure 4-21 depicts this ratio and the pattern of its change throughout the study period can easily be seen right below.



[14] "Agriculture" is considered in this study as "Agriculture, Forestry and others Sector".

Figure 4- 25 Aggregate Electricity Intensity for Sudan in Kwh/US$ (1991-2010)

Generally the electricity intensity was increasing in Sudan. However, it exhibited significant irregularities within the period 1998 through 2006. This figure is an input for the decomposition analysis at aggregate level for the country. It was suspected that these irregularities can be explained more by conducting sector level decomposition.

8 Tanzania

i. Electricity Statistics

The electricity consumption data in Tanzania excluded the commercial and public services sector among the sectors considered in this research mainly because of lack of data. The commercial and public services sector had influential role in countries like Sudan, Ethiopia, and DRC. However, absence of the Commercial and Public Services sector in the data for Tanzania changed the pattern of sector level electricity use from that was seen in these countries. Based on the data, the Industry and Residential sectors took the lead in electricity consumption interchangeably (Figure 4-22). The consumption volume by these two sectors showed irregularity beginning from 1991 through 2007.

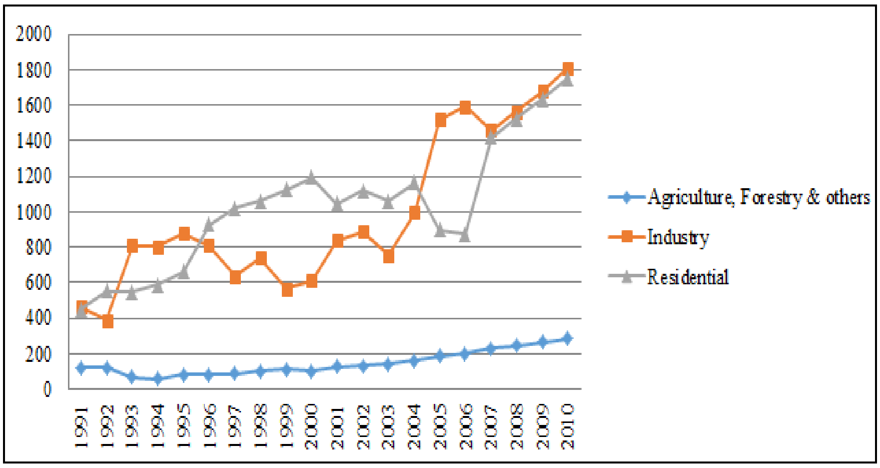


Figure 4- 26 Sectors Electricity Consumption in Tanzania in Million Kwh (1991-2010)

Especially, the irregularity is more magnified in the industrial sector's electricity use almost in the whole study period. In the case of the Residential sector the irregularity is observed more between 2000 and 2007. No clear reason identified for this irregularity yet. The agriculture sector electricity use was smooth except that it declined at 1992 and recovered around 2000. Then after, it has shown linear increment within the study period.

Table4-15 shows the data on electricity use by the three sectors beginning from 1991 through 2010. The volume electricity consumed varied within sectors from year to year throughout the given time interval. Moreover, one can easily see quantitatively how one sector is important from the other by looking at the volume of electricity used in each sector and the trend it shows within the period.

Sector	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
Agriculture & others	2455	2485	2563	2617	2769	2876	2947	3003	3125	3264	3425	3598	3714	3933	4107	4266	4439	4642	4791	4985
Industry	1382	1383	1330	1351	1325	1414	1508	1664	1776	1856	1978	2164	2400	2662	2938	3187	3489	3789	4054	4387
Household Consumption Expenditure	200	196	198	216	213	224	236	257	294	307	312	322	340	349	371	412	446	472	496	525
Total	4038	4065	4090	4184	4308	4514	4691	4924	5194	5427	5715	6083	6454	6944	7415	7866	8373	8903	9340	9898

Table 4- 15 Sectors Electricity Consumption in Tanzania in Million Kwh (1991-2010)

The values in the table clearly substantiate the description given on Figure 4-22. The data on this table will be combined with the Gross value added data of each sector to give us the Aggregate Electricity Intensity to be shown in the later part of this section. As repeatedly mentioned the Industrial and residential sectors are the two most important sectors in the case of Tanzania. It is to be recalled that where there was the commercial and public services sectors, the residential sector had been taking the third position in terms of volume contributed to the national account. Beginning at 2007, the residential and industrial sectors increased their contribution in almost with same volume. The Agriculture sector followed the two sectors with a volume way below though it was increasing towards the end of the study period.

j. Statistics on Sector Gross Value added

The economic value added in Tanzania by respective sectors was smooth with all sectors exhibiting an increase in volume of contribution to the Gross value added. The general direction of change observed in the electricity use by the Industrial sector was repeated in this section as well (Compare Figure 2-23 & Figure 2-24). But in this case the change was smooth. The agriculture and Industry sectors taking dominant position while the agriculture leading.

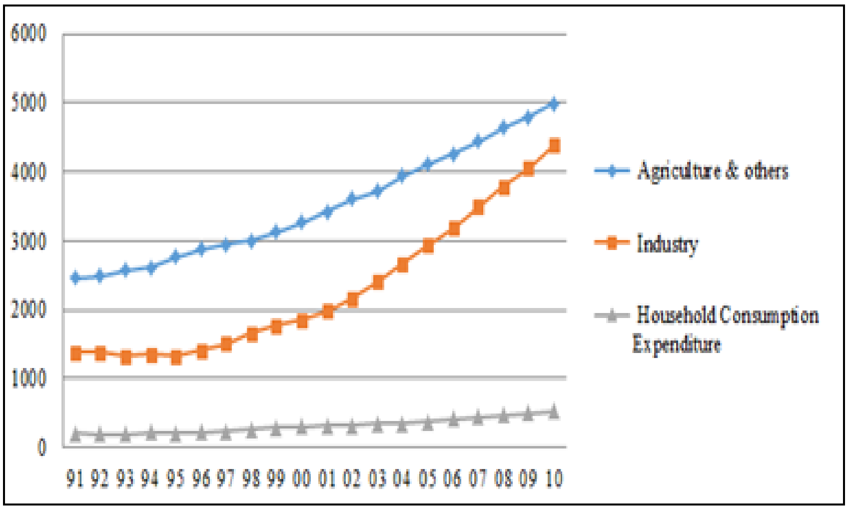


Fig. 4- 27 Gross Value Added at Factor Cost for Tanzania in Million US$ (1991-2010)

The household consumption expenditure was slow but increasing towards the end of the study period. The corresponding table for the above figure shows that the Agriculture sector was leading in the contribution of economic value added to the national account. However, the Industrial sector grew faster and almost approached the Agriculture sector (Figure 4-23 and Table 4-17).

Table 4- 16 GVA at Factor Cost for Tanzania in Million US$ (1991-2010)

Sector	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
Agriculture & others	124	123	71	59	84	86	89	104	115	105	127	133	145	161	185	204	231	248	266	285
Industry	465	391	811	806	876	809	635	740	566	614	836	889	755	996	1519	1593	1459	1565	1679	1810
Residential	448	553	545	585	660	927	1023	1059	1126	1192	1048	1120	1058	1163	900	871	1420	1523	1634	1753
Final Consumption	1037	1067	1427	1450	1620	1822	1747	1903	1807	1911	2011	2142	1958	2320	2604	2668	3110	3336	3579	3848

Smooth flow of the Gross value added does not guarantee the same pattern in the aggregate Electricity Intensity for Tanzania. Rather the effect of the trend in electricity use was different and the intensity data exhibited significant variability throughout the study period.

The aggregate Electricity intensity for Tanzania seems the opposite with the pattern for Sudan. This might be due to the type of electricity use data for the sectors of the two countries. It has connotation when reviewed from the regional integration point of view.

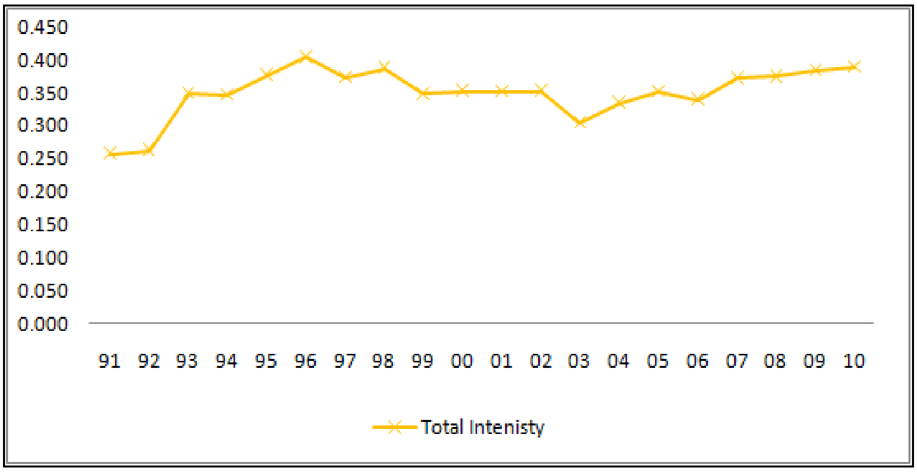


Table 4- 17 Electricity Intensity for Tanzania kwh/US$ (1991-2010)

This table depicts the data for aggregate electricity intensity on annual basis for the country as a basis for decomposing in to respective factors. The Electricity Intensity data can be used to check for the values of each sector within the country. Obviously, the main decomposition analysis begun from the more general to the detailed level based on data availability. Firstly the six countries aggregate electricity intensity was decomposed and the result discussed. Secondly, country level Electricity intensity was decomposed and results were discussed. Then both values are compared roughly because of data inconsistency due to lack of some sector data in all the countries. Finally, the result discussed in detail in chapter 5.

Chapter5. Decomposition Analysis of Electricity Use in Six EAPP Countries

5.1 Decomposition Analysis

Decomposition analysis, in the context of this study, is a method to understand causative factors of changes in aggregate energy or electricity demand (Bhattacharyya, 2011). According to Sadoulet & de Janvry (1995) decomposition analysis was initially designed for factoring economic growth in to price & Volume effects. Blok (2007) and other scholars who applied this method confirmed the idea that the approach is applicable on energy too. He stated that decomposition helps us to know energy use factored into volume, Structure, and energy efficiency or specific energy use.

Historically, the study of electricity demand structure or decomposition analysis has evolved from energy decomposition analysis during the 1973/74 world oil crisis (Ang, 1995), and (Ang & Zhang, 2000). According to these authors, the challenge to have better knowledge about causes of changes in industrial energy use led scholars to study whether decomposition analysis could be applied in electricity too. They found out that this tool was initially used to understand the nature of prevailing demand and future trend in the industrial economic sectors. The approach was expanded to include other sectors than industry at national as well as regional level. For instance Zhang, Mu, Ning, & Son (2009) studied about the use of decomposition analysis in the Green House Gas emission from energy.

The result from decomposition analysis helped planners to identify the root cause of the change in the energy demand. It facilitated relatively proper attribution of such change either with product mix or structural effect of the sector (Ang & Zhang, 2000). Based on clear and detailed evidences on the breakdown of the aggregate energy demand into its causative factors, decision makers had implemented the different intervention measures to curb the energy crisis in the past.

Two major techniques, known as Index Decomposition Analysis (IDA) and Structural Decomposition Analysis (SDA) are popular to assess the influence posed by economic growth, structural and technology changes on different environmental and socio-economic indicators (Hoekstraa, J.M., & Bergha, 2003). According to the authors, these two techniques are used for understanding the effect of driving forces on indicator changes in a given socio-economic or environmental contexts. The common indicators whose changes are analyzed often using the IDA and SDA method include energy use, CO2-emissions, labor demand and value added.

5.2 Structural & Index Decomposition Analyses

The renowned economist Dr. W. W. Leontief had developed Input-Output technique to show the effect of a change in one economic sector on a change in others. This work enabled the inventor to win the Nobel laureate award (Wahid, 2002). According to Wahid, the model is commendable achievement since it enables planners to address economic problems in detail and help decision makers take sensible measures to these problems.

Input–output model is a basis for SDA (Heostraa et-al, 2003). SDA is used to account all possible input-output relationships in the product value chain/process using this model. SDA enables to do more detailed level of s ector classification than IDA (ib-id). It can be used to represent induced eff ects of inter-industry interaction which the IDA cannot (Miller & Blair, 200 9). The general formula for SDA is adapted as follows from static monetary input-output model to fit the context of this research:

$$X = Ax + Y \qquad (5.1)$$

Where,

1. "X" represents a hybrid unit total-output-vector (nx1). In here, the electricity sector output is measured in million KWH. Whereas, the

outputs of the economic sectors (non electricity) are measures in Million US$.

2. "Y" is a hybrid unit final-demand-vector (nx1). Here also, the final electricity demand is measured in million KWH and the final demand for the output of economic sectors (non-electricity) is measured in Million US$.

3. "A" is a hybrid unit technical-coefficient-matrix (nxn), in which:

   - input coefficients of electricity sector over electricity sector are measured in million KWH /million KWH.

   - input coefficients of electricity sector over the economic sectors is measured in Million KWH / million US$,

   - input coefficients of non electricity sectors over electricity sectors is measured million US$ / Million KWH;

   - input coefficients of non-electricity sectors over non-electricity sectors is measured in Million US$ / Million US$.

   - an identity matrix (nxn) is represented by "I".

The general energy I-O model,

$$F_k = \sum_j F_{kj} + F_{kd} = \sum_j e_{kj} X_j + F_{kd} \quad (5.2)$$

Where:

- F_k is total electricity use
- F_{kj} is total electricity use in sector *j*
- F_{kd} is total electricity use in final demand sector
- e_{kj} the direct electricity input coefficient of sector *j*
- X_i is the Gross output of sector *j*

Re-written equation(5.2) will give: $F = EX + F = E(I - A)^{-1}Y + F_d$, ignoring F_d the equation w ill be:

$$EX = ETY \quad (5.3)$$

$where,$

- E stands for électricité intensité,
- T is a matrix of total input requirement in a given sector or economy. This value represents Leontief technology matrix. It is replaced by.$(1 - A)^{-1}$ and,
- Y stands for a vector of final demand.

SDA approach can be used to analyze electricity consumption change in an economy between any two years (year 0 and year t) (Dietzenbacher and Los, 1998). SDA is a technique to study sources of change in economic structure by analyzing changes in major parameters in Input-Output table. This change in economic structure can be decomposed into these major factors using equation (5.3) shown above by inserting the values for the different variables between the initial year and the final year. According to Dietzenbacher and Los (1998), this equation can be determined in various ways. Assigning different values for the weight will lead to difference in results depicting the value of the change, which otherwise could have been same. To avoid this problem, the authors suggested use of the average of the two SDA decomposition forms shown right below. One of these SDA forms is equation (5.4a) in which the base year for the analysis is assumed to be final year or year "*t*".

$$\Delta EX = \Delta ET_tY_t + E_0 \Delta TY_t + E_0T_0 \Delta Y \qquad (5.4a)$$

The second SDA form is equation (4-2) the case where the initial year i s considered as a base (year-0).

$$\Delta EX = \Delta ET_0Y_0 + E_t \Delta T Y_0 + E_tT_t \Delta Y \qquad (5.4b)$$

Averaging the equations (4-1) and (4-2) is assumed to reduce the variance in the outcome of decomposition analysis compared to the variance in the result of original result data (Haan, 2001) and(Boer, 2008).Then the resulting final SDA model which is the average of the terms in equations (4-1) and (4-2) is as follows.

$$1/2[\Delta ET_t Y_t + \Delta ET_0\, Y_0] + \ 1/2[E_0 \Delta T Y_t + E_t\, \Delta T Y_0] + 1/2[E_0 T_0 \Delta Y + E_t T_t \Delta \mathrm{Y}]$$

(5.5).

Where,

- First bracket reflects change in total electricity consumption per unit of output consumption or change due to the shift of electricity intensity in various industries, given other variables constant during study period.
- Second bracket reflects change in electricity consumption due to direct or intermediate stage changes in producing technology while other things kept constant. Here, the change depicts input development in either more or less electricity intensive direction.
- Third bracket reflects change in electricity consumption due to the change in final economic demand (Structure & volume).

Historically, apart from Input output table's indices have been used to show the relationship between prices & volume and later on it was related to decomposition (Heostraa et-al, 2003). According to Fisher (1922), an index is a certain weight that is assigned to a determinant. Ir. Fisher contributed to the development of index number theory through intensive research on the behavior of many indices (Heostraa et-al, 2003). Research showed that there have not been single perfect index identified. So, the approach for identifying relatively the best index method was comparing existing indices based on the desired property and taking the most appropriate one among existing alternatives developing new. Hence, as stated by Hoestra, et-al, (2003) scholars have been proposing various index approaches and therefore numerous Index Decomposition Analysis (IDA) models have been developed.

Index Decomposition Analysis allows inter-country comparison whereby style of comparison varies from intra-country level study. According to Ang, (2004), similar factors used in intra-country level study can be used for inter-country level except that comparision for the later case becomes between countries on same year instead of considering change between two different years. So, when sector level electricity demand is compared, the structure effect reflects the impact arising from differences in sector product mix between countries. The same way, the intensity effect gives the impact arising from differences in sector level electricity intensities between countries.

The general formula for Energy Intensity (I)[15] can be described as follows:

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[15] The 'I' in this study will represent the electricity intensity as the focus of the research is only on electricity use.

$$I = \frac{E}{Y} = \sum_i \frac{E_i}{Y_i}\frac{Y_i}{Y} = \sum_i I_i S_i \qquad (5.6)$$

In this simple algorithm,

I = electricity intensity (sector or National level),

E= electricity consumption measured in energy units (mostly kWh)

Y= Gross Value added measured in USD.

E_i = electricity consumption in sector "i",

Y_i =Gross value added in sector"i",

I_i= Electricity Intensity effect in sector"i",

S_i =Electricity Structural effect in sector"i",

Here, the subscript "i" denote electricity consuming sector, the sector contributed for the Gross value added, and the effects either intensity or structure from each of the sectors. According to Ang, (2004), the expression applies for sector or aggregate level data.

Hence the general formula for decomposing the change in electricity intensity can be decomposed using either Multiplicative or Additive form and the essence of each is described in section 5.2.1 or 5.2.2 respectively.

But from past research works by different scholars, use of both forms is not a must as far as clear indication is observed from the result of analysis using either of them.

SDA and IDA are used for analyzing the influence of changes in economy, industry structure and technology on the environmental and energy indicators (Hoekstraa et-al, 2003). But one method differs from the other method in the level of disaggregation and focus of analysis. According to statement of these authors the main difference between these two methods is attributed to the following points:

- SDA is known to use the input–output framework while IDA uses only aggregate sector information. IDA accommodates less detailed level and direct effects compared to SDA. The analysis is modeled differently among the two methods.

- IDA captures long term changes through time series and country based studies at aggregate level. However, the SDA lacks this quality (Hoekstraa, et-al; 2003) and fails to be used for analyzing long term data.

- The authors described three forms of indicators namely absolute, intensity, and elasticity. At this stage in time, IDA can accommodate analysis that addresses all the three indicator types while the SDA uses only the absolute indicator (Hoekstraa, et-al; 2003). So, IDA is more flexible compared to SDA.

- The analysis in this research considers intensity indicators, and this limits the use of SDA. Intensity indicator is required mainly to facilitate comparision between countries and also to pave way for further research in the line of demand side management (for instance measures like energy efficicny and demand response measures). Use of intensity indicator is believed to give infomration about condition of electricity use as well as efficiency related informations.

Using IDA method, problems related with aggregate electricity intensity within sectors or countries can also be addressed easily and comparison made possible. However, SDA does not facilitate such work. Hence, the entire points listed above make the Index Decomposition Analysis more preferable than the SDA in this research.

5.3 Multiplicative and Additive Form Analyses

As this study is used to decompose the change in the aggregate electricity intensity, it can be presented using one or both of the two most common forms of decomposition measures, namely Additive and/or multiplicative forms (Bhattacharyya, 2011). The algorithms for both forms of measures are different though the result might sometimes be close to each other depicting the possibility of using them interchangeably. The data used for the additive form is known to be level or actual data and for the multiplicative form it is ratio data. The detail of the Algorithm for both forms is presented here. The general formula for multiplicative index Decomposition of Intensity:

$$D_{tot} = \frac{I^0}{I^T}$$

$$D_{tot} = D_{str} D_{int} D_{res} \qquad (5.7)$$

This algorithm represents the functional relationship between the aggregate electricity intensity and the effects when decomposing the electricity intensity where,

- I^0 = Electricity Intensity value of the base year,

- I^T = Electricity intensity value of the final year

- "D_{tot}" = aggregate value of electricity intensity change,

- "D_{str}" = structure effect of the aggregate electricity intensity change,

- "D_{int}" = intensity effect the aggregate electricity intensity change, and

"D_{res}" = the residual value, known by scholars as residual effect which is obtained at the end of analysis (Ang B., 2004).

The higher the residual value implies poor representation of the factors while using particular decomposition method. It is taken as one of the criteria in method selection later in this research based on the scholar's recommendation. The general formula for additive index Decomposition of Aggregate Intensity:

$$\Delta I_T = I^T - I^0$$

$$\Delta I_{tot} = \Delta I_{Str} + \Delta I_{int} + \Delta I_{Res} \qquad (5.8)$$

The additive form of decomposition is used while determining direct effects like change in demand for electricity in actual value terms. Also the algorithm represents the functional relationship between the aggregate electricity intensity and the effects while decomposing the aggregate electricity intensity. The explanation used for the expressions of the terms for multiplicative form applies for this algorithm as well despite difference in values. The residual value, in the case of additive form, can be determined simply by taking the sum of structural effect and intensity effect and later subtracting from the aggregate value (Ang B., 2004).

According to Hoestra, et-al, (2003), use of Multiplicative or additive forms is left to the researcher. Using one of them is assumed just as a matter of presentation. In this research, the multiplicative form of decomposition analysis is preferred just to minimize the problem of difference in units of measurements and currency values thereby to facilitate easy comparison between countries. Checking its performance against the multiplicative form will further gives confidence. Therefore, as discussed in the theoretical discussion, this decision is validated by looking at the result of actual application of both methods in the research data for identification of the appropriate method of index decomposition.

In the use of the energy consumption approach, the causative factors for change in total electricity consumption need to be determined directly. The approach is to single out one factor's contribution to the change while keeping other possible factors constant. The change in these factors can either be calculated simply by direct subtraction of the original values between two years, while considering one of them as base year. The Algorithm[16] to represent the decomposition of the electricity consumption is adopted and presented following the way it was presented in Bhattacharyya's book of energy economics. The researcher found it easy to understand for any reader and coneys the required message at the same time.

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[16] It is similar with equation (3.4) of the energy consumption decomposition analysis shown in PP 58 – 59 Bhattacharyya's book of energy economics, Published by Springer – verlag Lo ndon Limitted in 2011. Moreover, the whole set of algorithm for energy consumption appro ach is adapted from the same source.

$$E = Q * EI = Q * \sum\left(\frac{E_i}{Q_i}\frac{Q_i}{Q}\right) = Q\sum_i E_i S_i \qquad (5.9)$$

Where,

$E =$ Electricity consumption in the sector or country,

$Q =$ Overall economic activity of sector, country or region,

$Q_i =$ Activity of sector, or country *i*

$S_i =$Economic structure "*i*" of a sector in a country or a country in a region. It represents the share of sector or country economic activity "*i*" relative to overall economic activity in a country or region respectively.

$EI_i =$ Electricity Intensity "*i*" of a sector in a country or a country in a region. It represents the ratio of sector or country economic activity "*i*" relative to overall economic activity in a country or region respectively.

For facilitating calculation of the value of contributing factors for electricity use, two separat years are used, which are year "*t*"as a final year and year "*0*"as a base year. The electricity use for the two times is calculated as:

$$E^t = Q^t \sum E_i^t S_i^t, \qquad (5.10)$$

$where\ "E^t"\ representing\ the\ electricity\ consumption\ in\ the\ final\ year.$

$$E^0 = Q^0 \sum E_i^0 S_i^0 \qquad (5.11)$$

Where ,“E^0” representing the electricity consumption in the initial year. The change in electricity consumption can be determined by subtracting the increase or decrease in electricity consumption from year ‘0’ to year ‘1’. The general formla could either be in Multipicative or additive form as represented by the following consecutive algorithms.

Multiplicative:

$$D = D_{act} * D_{str} * D_{Int} * D_{\mathrm{Re}\,sid} \text{ and} \qquad (5.12)$$

Additive:

$$\Delta E = (\Delta E_{act} + \Delta E_{str} + \Delta E_{\mathrm{int}}) - \Delta E_{res}. \qquad (5.13)$$

As seen on different scholar’s work, the additive and multiplicative approaches may appear on the same decompostion method.

Energy intensity can be defined as the ratio of energy consumption over economic out per unit of time most likely per annum (Mulder & L.F. Degroot, 2011). It is treated as an approach for addressing ratio indicator since it relates two quantity indicators (AORAN, 2012).

In the context of this research, instead of energy intensity, the focus is on electricity intensity which will have similar definition except the term “energy” is replaced by specific fuel, "electricity". The causative factors for change in aggregate electricity intensity are determined relative to the size of output instead of simply indicating change in total electricity directly. Studies indicate that intensity approach helps to find out the contribution of change in energy in general or electricity use to certain fixed unit change in economic output in a sector, economy as a whole or a country within a region. This may be considered in other direction too, the effect of change in the economic output on the change in the energy or electricity use in a sector or a country in general.

The electricity intensity approach differs from electricity consumption approach since it shows the volume of electricity used in a certain sector or country relative to their respective output. Furthermore, research work by different scholars show that the effects considered in electricity intensity analysis are structure and intensity effects only. Identifying quantity for demand analysis using these building blocks of quantity would most probably lead to proper demand estimation, given other factors constant. More importantly, the market we are concerned in this research was designed to benefit importers through sufficient access for electricity and suppliers through sale of excess electricity without compromising local demand. So, estimating real volume of electricity needed through assessment of economic sector's consumption pattern in terms of efficiency change or structure change in both supplier's and consumer's premises is essential

Studying the economic sector's consumption patter means identifying the real cause for change in the electricity need since it is attached with economic sectors in the form of aggregate electricity. It would give some idea to know which aspects are more influential to describe the ups and downs in the process of the change in the volume of electricity consumption in the economy over time. And also it helps to get information for planning more realistic ways to handle the electricity demand and supply in such a market.

The general algorithm[17] to represent the analysis of the electricity intensity is adopted and presented following the approach in Bhattacharyya's book of energy economics. The researcher found it simple to convey the required massage and relatively easy for any reader to understand.

$$EI = \frac{E}{Q} = \sum\left(\frac{E_i Q_i}{Q_i Q}\right) = \sum_i EI_i S_i, \qquad (5.14)$$

Where,

$EI = Aggregate\ Electricity\ Intensity\ in\ the\ sector\ or\ country,$

$E =$ Electricity consumption in the sector or country,

$Q =$ Overall economic activity of sector or country,

$Q_i =$ Activity of sector, or country "*i*"

[17] It is adapted from the basic equation of energy intensity (3.10) on pp 62 of Bhattacharyya's book of energy economics, Published by Springer – verlag London Limitted in 2011. The o nly change is the fuel type from energy to electricity.

S_i =Economic structure "*i*" of a sector in a country or a country in a region. It represents the share of sector or country economic activity "*i*" relative to overall economic activity in a country or region respectively.

EI_i = represents electricity intensity "*i*" of a sector in a country or a country in a region.

For facilitating calculation of the value of contributing factors for change in electricity intensity, two reference times were used which include the final year, year "*t*" and the first year represented by "*0*". The first year is often considered as a base year. The order may change based on the type of decomposition method to be used. The change in electricity intensity between the two reference time is decomposed in to two effects in the context of this research, namely "Structure" and "Intensity" effects.

In decomposition studies conducted in the past, both the energy cosumption and energy intensity approaches are used frequently. Use of either energy consumption approach or Intensity approach depends entirely on the nature of research, the intended result of the research, and data availability. Acoording to B. W. Ang, (1994), the intensity approach can be applied using both periodwise and time series decomposition analysis.

In the context of this study aggregate electricity intensity is taken as an overall electricity performance indicator in the electricity demand analysis. Though it is possible to do electricity indicator analysis using either electricity consumption approach or electricity intensity approach, the later is selected with a concern for fruther work on energy conservation which is not well addressed in the sub-region.

Since Intensity approach deals with ratio indicators, it is more convenient to deal with relations as it reveals these relations more meaningfully than quantity indicators do. As already discussed, since this research considers the energy or electricity intensity approach, then the ratio of aggregate electricity to Gross value added is decomposed in to structural effects and intensity effects. The decomposition method for this research is determined based on scholars' recommendation supported by own analysis for validation of those recommended methods.

5.4 Time consideration in the Analysis

Studies in the past reveal that there are two time considerations in the decomposition analysis. They are known to have different terminologies, like time serious vs. period-wise, fixed base year vs. rolling base, and Non-chaining vs. chaining decomposition which were adopted by scholars though the meaning is one and same respectively. Non chaining method as one among them representing fixed base year decomposition analysis will be adhered in this research just for the sake of convenience (AORAN, 2012). The works of the scholars reviewed as sited by AORAN (2012) show that some of these scholars used the Chaining approach while others followed the non-chaining approach.

B.W. Ang(1994) in his study reveal that Energy Intensity approach accomodates both Chaning and non-chaining time consideration. He and AORAN, (2012) identified that energy consumption approach can be conveniently handled using the non-chaining time consideration. But use of non-chaining approach may hide some of important information due to the nature of analysis. Whereas, chaining approach makes presentation of results more descriptive than the periodwise. Also, if a study is intended to do detailed comparision between sectors or countries, then the chaining approach remains the most prefered since it allows more argument and reasoning.

So, though there is no hard and fast rule that recommends the use of only one of the two time considerations, research work and intuition tells us that selection of one of them is dependent on data availability and quality, nature of study, and researcher’s interest. If detailed data are available and the researcher has intention to conduct deeper research, obviously use of chaining approach is preferred. But currently, data limitations lead the researcher to cling to the fixed base year method.

5.5 Index Decomposition Model

5.5.1. Index Decomposition Approach in Energy

Index decomposition as analytical tool in this study is used to determine causes for the change in the aggregate electricity demand through application of index number approach. According to Ang and Liu (2001), it can be defined as a method for decomposing aggregate value of an indicator in to factors causing the change in the aggregate in such a way that their relative share is manifested. As deduced from the expression of Bhattacharyya, (2011), the main causes for change in aggregate energy consumption or energy intensity are changes in economic activity, change in electricity use efficiency of a given technology or electricity use per an economic value added in a certain currency unit (usually US$), and a change in structure of an economic activity.

As clearly described by Bhattacharyya, (2011), these changes can be represneted as either the difference in values between two time intervals of direct electricity use or the ratio of values between two time intervals represented as electricity intensity in a sector, a country, or a region. As it is known, electricity intnensity in this study is the ratio of the volume of electricity in KWH to the gross value added, measured in local currency or in US$, in an economy within a given year.

Many researchers identified that the index decomposition analysis is used to determine the relative change of indicator overtime. In this regard, various index decomposition analysis models are applied to identify the factors of change in aggregate energy intensity at regional level (SZÉP, 2013). Many index methods are known to be used at sector and subsector level. According to Ang & Zhang (2000), 124 studies were conducted at different times using index decomposition analysis focused on different indicators.

Latest study by Xu & Ang (2013) found out that cases studied with Index decomposition analysis have increased to about 496. The types & number of fields assessed and purpose of decomposition are growing over the past years. Obviously, the number will grow more since the approach is being used and developed further. It also signals how this method is useful in the energy and academic world in general. So, IDA is adopted in this research for analyzing the electricity demand structure and its effect on the regional electricity market in EAPP. Among existing IDA methods, identifying one that best meets and suitable for the expected performance level was a challenge.

5.5.2. Index Method

The starting point for searching an appropriate IDA method was review of scholarly work. The best method was selected out of existing scholarly work through practical examination and using existing criteria identified during past research. The contingency plan, in case such approach fails, was developing new method. Luckily, there were bunch of IDA methods already developed and practically proven. So, the researcher decided to utilize the one among scholars' recommendations after selecting six IDA methods. The decision to choose one among the six was based on the validation of their robustness through application on the aggregate level data and comparing the result thereof. Though time consuming and demands to understand the different algorithms, inclusion of this approach helped to build more confidence and trust on the model used for this study. It also gave boldness in doing and interpreting the empirical analysis.

Comparison of these six methods was done by analyzing the data for this research using each of them and evaluating the behavior of each of these candidates against the criteria including, Residual test, Time reversal, Factor reversal, circular test, Proportionality, Availability of Additive & Multiplicative form, and Relation between additive & Multiplicative approaches. Determining residual from the result of the analytical work was the first steps among the criteria suggested by Ang B., (2004), Granel, (2003), and others. The final model was selected among these six IDA methods based on these six criteria. The first part of this work was reviewing the recommendations by the scholars'. Then data collected by the research was analyzed using these recommended approaches. Finally the most robust IDA method was determined by a combined result as shown on table 5-9.

k. Laspeyer's index method

In the Laspeyer's Index (LI) method, the contribution of each of the effects to electricity intensity in major economic sectors of a country or overall economy of the each country among the six EAPP member countries can be determined based on the following general algorithm of *LI* method. Decomposition of the electricity intensity using multiplicative *LI* method

$$EI = \frac{E}{Q} = \sum_i \left(\frac{E_i Q_i}{Q_i Q}\right) = \sum_i (EI_i S_i) = \qquad (5.15)$$

Where, *"EI"* stands for the electricity intensity effect,

"E" stands for electricity use in Million Kilowatt-hour,

"Q" Stands for Gross value added at factor cost (constant 2005 US$),

"E_i" Sector or Country level Electricity consumption,

"Q_i" Sector or Country level Gross Value added,

The change in Electricity intensity represented by the two effects known as Structure and Intensity effect will be determined using the following algorithm. Intensity effect at sector or country level is calculated using the following algorithm

$$D_{\text{int}} = \frac{EI_i^T S_i^0}{EI_i^0 S_i^0} \qquad (5.16)$$

Where, D_{int} stands for the intensity effect of aggregate electricity Intensity in country "*i*" and

$$D_{Str} = \sum\left(\frac{E_i Q_i}{Q_i Q}\right) = \sum\left(EI_i S_i\right) \qquad (5.17)$$

Where, D_{str} stands for the structure effect of aggregate electricity intensity in country "*i*".

The total change in electricity Intensity in the six countries is determined can be decomposed as

$$D_{tot} = D_{str} D_{\text{int}} \qquad (5.18)$$

But, due to the residual value from the decomposition analysis equation (5.15) will change after considering the residual effect which is represented as

$$D_{res} = \left(D_{act} / (D_{str} D_{\text{int}})\right) \qquad (5.19)$$

Where "D_{res}" stands for residual effect and "D_{act}" representing actual electricity intensity in country "*i*". Hence, the final algorithm for decomposing electricity intensity using multiplicative method is

$$D_{tot} = D_{act} / (D_{str} D_{\text{int}})) D_{str} D_{\text{int}} = D_{str} D_{\text{int}} D_{res} \qquad (5.20)$$

The same way, the additive method of laspeyer's index is presented as follows

$$\Delta EI_{str} = S_i^T I_i^0 - S_i^o I_i^0 \qquad (5.21)$$

Where, S_i^T stands for the gross value added in the economic structure in year "t" in country *"i"*, S_i^0 stands for the gross value added in the economic Structure in year "0" in country *"i"*

I_i^T representing the electricity intensity in year "t" in country *"i"*,

I_i^0 representing the electricity intensity in year 0 in country *"i"*

ΔE_{str} representing the Change in Electricity Intensity due to Structure effect

$$\Delta E_{\text{int}} = S_i^0 I_i^T - S_i^0 I_i^0 \qquad (5.22)$$

Where, ΔEI_{int} representing the change in electricity intensity due to intensity effect. The total change in electricity intensity can be determined as

$$\Delta EI_{tot} = \Delta EI_{str} + \Delta EI_{\text{int}} + \Delta EI_{res} \qquad (5.23)$$

Where, ΔEI_{res} representing the residual which is determined by subtracting the calculated electricity intensity (ΔEI_{tot}) from the actual electricity intensity observed in the original data.

l. Log Mean Divisia Index I (LMDI I)

Assuming that "EI" is aggregate electricity intensity, the variables contributing the change in this aggregate value could be $x_1, x_2 \ldots\ldots x_n$. Log mean

Divisia Index I (LMDI I) as one of the Index decomposition analysis method can be represented by general formulae as shown in the next equations. The effect of the Structure and Intensity respectively is determined either additively or multiplicatively as presented in equation (5.25) and (5.26) respectively.

$$D_{xk} = \exp\left(\sum_i \frac{L(V_i^T V_i^0)}{L(V^T V^0)} \ln\left(\frac{x_k^T}{x_i^0}\right) \right) \qquad (5.24)$$

Where,

D_{xk} represents the Intensity or Structure effects of aggregate electricity intensity. The subscripts "x" represents the variables and "k" represents the sub categories. The expression '$\sum_i \frac{L(V_i^T V_i^0)}{L(V^T V^0)}$' represent the weight for LMDI I, and the expression '$\frac{x_k^T}{x_k^0}$' represent the Intensity or structure effect values. The multiplicative form of the equation (5.21) will be:

$$D_{xk} = \exp\left(\sum_i \frac{(V_i^T - V_i^0)/(\ln V_i^T - \ln V_i^0)}{(V^T - V^0)/(\ln V^T - \ln V^0)} \ln\left(\frac{x_k^T}{x_i^0}\right) \text{ and,} \qquad (5.25).$$

The additive form will be:

$$EI_{xk} = L(EI_i^T, EI_i^o) \ln\left(\frac{x_k^T}{x_k^0}\right), \qquad (5.26).$$

Where, the final algorithm for the additive form:

$$\Delta EI_{xk} = \sum \frac{(EI_i^T - EI_i^0)}{\ln EI_i^T - \ln EI_i^0} \ln(\frac{x_k^T}{x_i^0}) \qquad (5.27).$$

In general, the following relation applies in the equation (5.25) and (5.26): The weights are determined based on the relationship stated by Ang (2005), as $L(a,b) = (a-b)/(\ln a - \ln b)$. The ‘EI’ and “V” in the equations (5.24) through (5.27) are interchangeable or replace one another.

m. Arithmetic Mean Divisia Index (AMDI)

Arithmetic mean Divisia index method (AMDI) is the same in functional appearance with LMDI, but it’s weighting schemes differs (Ang, 2004). The formulae for determining the effects of the individual factors multiplicatively (5.28) or additively (5.29) can be written respectively:

$$D_{xk} = \exp(\sum_i W_i^* \ln(\frac{x_k^T}{x_i^0})) \qquad (5.28)$$

Where,

D_{xk} stands for the k_{th} effect of intensity (D_{int}) or Structure (D_{Str}) factor based on nature of case in consideration.

W_i^* Stand for t2he weight for the multiplicative AMDI and represented by $W_i^* = \frac{\left(\frac{V_i^T}{V^T} + \frac{V_i^0}{V^0}\right)}{2}$.

$$D_{xk} = \sum_i W_i^{'} \ln(\frac{x_k^T}{x_k^0}) \qquad (5.29)$$

W_i^r Stand for the weight for the additive AMDI and represented by $W_i^* = \left(\frac{V^T}{V^0}\right)/2$. This method does not give perfect decomposition but may be applicable with relatively lower residual value compared to traditional Lapeyer's method (B.W. Ang, 2007). In this study also due to ease of calculation and depending on the size of the residual value in other studies, it was considered candidate to qualify for this research. B.W.Ang, (2004) cited research cases like Wade (2002), ODYSSEE (2005), and Tedesco and Thorpe (2003) in which the AMDI is used as an analytical tool.

n. Paasche index

The Paasche Index method is the reverse of the Laspeyer's index method (LIM) in that the base year in the case of LIM decomposition analysis is considered to be the final year when treated in the Passche Index method. So, the change in Electricity intensity represented by the two effects known as Structure and Intensity effect will be determined using the following algorithm for the Paasche method. Intensity effect in country or Sector level

$$D_{\text{int}} = \frac{EI_i^T S_i^T}{EI_i^0 S_i^T} \qquad (5.30)$$

Where, D_{int} stands for the intensity effect of aggregate electricity Intensity in country "*i*" and

$$D_{str} = \frac{EI_i^T S_i^T}{EI_i^0 S_i^T} \tag{5.31}$$

Where, "D_{str}" stands for the structure effect of aggregate electricity intensity in country "*i*". The total change in electricity Intensity in the six countries without considering the residual value can be decomposed as:

$$D_{tot} = D_{str} D_{\text{int}} \tag{5.32}$$

But due to the residual value from the decomposition analysis, equation (5.15) will change. The residual effect is represented as

$$D_{res} = D_{act} \div D_{tot} \tag{5.33}$$

Where "D_{res}" stands for residual effect and "D_{act}" representing actual electricity intensity in country "*i*". Hence, the final algorithm for decomposing electricity intensity using multiplicative method is

$$D_{tot} = (D_{act} \div D_{tot}) D_{str} D_{\text{int}} \tag{5.34}$$

The same way, the additive method of laspeyer's index is presented as follows

$$\Delta ET_{str} = S_i^T I_i^T - S_i^T I_i^0 \tag{5.35}$$

Where,

S_i^T stands for the gross value added in the economic structure in year "t" in country ., I_i^T stands for the electricity intensity in year "t" in country "*i*. I_i^T stands for the electricity intensity in year "0" in country *"i"*. ΔEI_{str} stands for the Change in Electricity Intensity due to Structure effect

$$EI_{\text{int}} = S_i^0 I_i^T - S_i^0 I_i^0 \qquad (5.36)$$

Where, ΔEI_{int} representing the change in electricity intensity due to intensity effect. The total change in electricity intensity can be determined as

$$EI_{tot} = \Delta EI_{str} + \Delta EI_{\text{int}} + \Delta EI_{res} \qquad (5.37)$$

Where, ΔEI_{res} representing the residual which is determined by subtracting the calculated electricity intensity ((ΔEI_{tot}) from the actual electricity intensity observed in the original data.

(ii)

(iii)

o. Fisher Ideal Index

Fisher Ideal Index is determined by calculating the geometric mean of the separate result of Laspeyer's Index Method (FIIM) and the Paasche Index Method (Liu et al., 2003). The Algorithm for the Fisher Ideal Index Method is presented as shown right below. The Structure effect is represented by:

$$F_{Str} = \sqrt[2]{L_{Str} P_{Str}} \qquad (5.38)$$

Where,

F_{Str} Stands for Structure effect of aggregate electricity intensity using Fisher Ideal Index (FII) method which in turn is represented by the squared root of Laspeyer's Structure effect (L_{Str}) multiplied by Paasche Structure effect (P_{Str}). Each of the effects is determined as shown in equation (5.37A) and equation (5.37B) respectively. The difference between the two methods lies in the consideration of base year. The base year for laspeyer's method is initial year where as for the Paasche method the base year is the final year as shown below.

$$L_{Str} = \sum_i S_i^T I_i^0 / \sum S_i^0 I_i^0 \qquad (5.37A)$$

$$P_{Str} = \sum_i S_i^T I_i^T / \sum_i S_i^0 I_0^T \qquad (5.37B)$$

The Intensity effect is represented by:

$$F_{Int} = \sqrt[2]{L_{Int} P_{Int}} \qquad (5.38)$$

Where,

F_{Int} Stands for Intensity effect of aggregate electricity intensity using Fisher Ideal Index method which in turn is represented by the squared root of Laspeyer's Intensity effect (L_{int}) times Paasche Intensity effect (P_{int}). Each of the effects is determined as shown in equation (5.38A) and equation (5.38B) respectively.

$$L_{Int} = \sum_i S_i^0 I_i^T / \sum_i S_i^0 I_i^0 \qquad (5.38A)$$

$$P_{Int} = \sum_i S_i^T I_i^T / \sum_i S_i^T I_i^0 \qquad (5.38B)$$

Then the aggregate electricity intensity can be calculated using the following formula:

$$F_{Tot} = \sqrt[2]{\{(L_{Str} P_{Str})(L_{int} P_{Int})\}} \qquad (5.39)$$

$$or$$

$$= \sqrt[2]{\left\{ \left(\frac{\sum_i S_i^T I_i^0}{\sum_i S_i^0 I_i^0} \frac{\sum_i S_i^T I_T^T}{\sum_i S_i^0 I_i^T} \right) \left(\frac{\sum_i S_i^0 I_i^T}{\sum_i S_i^0 I_i^0} \frac{\sum_i S_i^T I_i^T}{\sum_i S_i^T I_i^0} \right) \right\}}$$

This approach was originally derived from I. Fisher’s formula which was considered as "ideal" because it could be determined by the geometric mean between two ratios of aggregates (Persons, 1921). According to this author, the main reason for using FII method and labeling it “ideal” was its capacity to meet most of the requirements and having the residual term of value “1” which implied decomposition result without residual value. Further, the author recommends use of Fisher's formula on non-chaining decomposition approach. It also mean the same that Fisher's "ideal" index gives better result when applying constant weights than Chain Index (Persons, 1921).

p. Drobisch Index

This index is the weighted arithmetic average of the Paasche and Laspeyres index and identified as Drobisch (1871) index ID. The general algorithm for this Index:

$$I_D = \left(\frac{I_L + I_P}{2}\right) \times 100. \qquad (5.40)$$

Where,

I_D stands for aggregate electricity intensity determined by Drobish Index method,

I_L Stands for Laspeyers Index for aggregate electricity intensity

I_P Stands for Paasche Index for aggregate electricity intensity;

The detailed algorithm for the Drobish Index method for decomposing electricity intensity will be:

$$I_{Dtot} = \left(\frac{\left(\frac{L_{S_i^0} L_{I_i^0}}{L_{S_i^T} L_{I_i^0}} * \frac{L_{S_i^0} L_{I_i^0}}{L_{S_i^0} L_{I_i^T}} \right)\left(\frac{P_{S_i^T} P_{I_i^T}}{P_{S_i^0} P_{I_i^T}} * \frac{P_{S_i^T} P_{I_i^T}}{P_{S_i^T} P_{I_i^0}} \right)}{2} \right) * 100 . \qquad (5.41)$$

Where,

The expression "$\frac{L_{S_i^0} L_{I_i^0}}{L_{S_i^T} L_{I_i^0}}$"represents the Structure effect determined by laspeyer's index method,

The expression "$\frac{L_{S_i^0} L_{I_i^0}}{L_{S_i^0} L_{I_i^T}}$" represents the intensity effect determined by laspeyer's index method,

The expression "$\frac{P_{S_i^T} P_{I_i^T}}{P_{S_i^0} P_{I_i^T}}$" represents the Structure effect determined by Paasche index method, and

The expression "$\frac{P_{S_i^T} P_{I_i^T}}{P_{S_i^T} P_{I_i^0}}$" represents the intensity effect determined by Paasche index method. For additive method of decomposition the Paasche Index method is not applicable.

q. Scholarly Recommendations

According to Ang B., (2004), the Divisia and Laspeyers Decomposition Methods are the most popular. This author listed about eight research works of different scholars who compared these methods for about ten years beginning from 1991 (ib-id). He commented that none of these scholars came up with specific method perfectly acceptable to all. Also he indicated about some of the researchers who thought that there is no other method than the one they know because of their limited exposure to the information.

Generally, Ang B., (2004) mentioned that methods based on laspeyer's approach are easy to understand compared to the divisia approach. Also he points out that contrary to its good quality like ease of use; the laspeyer's approach produces more residual compared to the divisia approach. However, refined models of both approaches are developed and listed among preferred ones (FENGLING, 2004).

All the eight decomposition methods are identified by Ang. B., (2004) as suitable for energy/electricity analysis. He recommends consideration of, at least their theoretical foundation, adaptability, ease of use, and ease of result interpretation as criteria for selecting relatively most suitable method among them. Many scholars follow the recommendation by Ang B. (2004). For instance Granel., (2003) used the approach to compare index decomposition methods and found out five methods which fulfill the criteria relatively better than others. Moreover, different scholars including FENGLING, (2004), DE WAZIERS, (2005), Kesicki., (2012) undertook comparative studies and came up with potentially preferred methods namely Marshall-Edgeworth, Fisher, LMDI 1, LMDI 2, RLI, Shapley and MRCI. Among these, LMDI I is identified by these scholars as consistent in aggregation and as giving perfect result without residual.

However, LMDI was identified failing to accommodate data with negative value easily. Whereas, Modified Fisher ideal index method (MFII) is reported to be effective in most data condition, like accommodating negative data, values with no residual after decomposition (FENGLING, 2004). So, the author further recommended these two and four more methods, all with IDA origin, as perfect in decomposition. The list of methods in this research is relatively different from other scholar’s recommendation as it included the index methods from all kinds, recommended as well as conventional.

5.5.3. Verification test for candidate IDA Methods

The approach in this research was considering mixture of both the less frequent and the frequently recommended methods and running the test. This was opted just to provide additional evidence if they behave according to the scholars statement. And to see if incase they succeed in meeting the required level of perfection in my work. This may confirm the fact that no method is perfect fit all analysis works. From the test result, the behavior of each of the method is checked against previously set criteria. Researchers did different types of tests which include Residual test, Factor Reversal test, Time Reversal test, Circular test, and many more. Each of them has their own value in determining the quality of the IDA method.

Generally, scholars show us that the similarity between the purpose of IDA methods and Index numbers analysis in Economics makes the former to qualify for evaluation and comparison through application of similar tests used for evaluating the desirable properties of index numbers (B.W. Ang and F. Z., 2000). Hence, this research considered these qualities as criteria to select the best IDA method among the list applicable for the main analysis. As can be observed, all the names for the index decomposition analysis emanted from respective economic index studies and therefore using the criteria for diferentiating the best fit method seems reasonable (ib-id). According to B.W. Ang and F.Z. Zhang, (2000) three tests were recommended by Fisher which include , time reversal test, factor reversal test, and circular test. The six index decomposition methods presented as candidates for the impirical analysis in this research are checked for their robustness to fit the main analysis using these tests as shown below.

a. Residual test

This test is the easiest among recommended tests since it can be observed within the analysis result without need for further analysis. Any method that gives minimal or no residual value is highly desirable. As previously mentioned by many scholars, the most important aspect of decomposition analysis is complete representation of the effect of factors which contribute to the aggregate value. As stated by B.W. Ang (2004), if a method gives a residual value of "0"during additive decomposition or a residual value of 1 during Multiplicative decomposition, then it is considered passed residual test.

The IDA methods described in section (5.5.2) were used to run the total decomposition analysis and the result was observed to determine the index method that is robust in terms of not having any residual value among the six methods is shown as follows. This analysis, besides being part of the main work, contributed for the screening test in identifying the best applicable method among the six listed through estimation of the residual value. Table 5-1 depicts the values for residual and respective ranking.

Table5- 1Residual for Multiplicative Index Decomposition of Electricity use in 6 African Countries

Index Method	**91-95**	**96-20**	**01-05**	**06-10**	**Remark**
Ideal Value	1.0000	1.0000	1.0000	1.0000	No
Laspeyers	0.9947	0.9985	0.9982	0.9999	Yes
AMDI	1.0000	1.0000	1.0088	1.0000	Yes
LMDI I	0.9988	1.0008	1.0113	1.0025	Yes
Paashe Index	1.0018	1.0101	1.0018	1.0000	Yes
Fisher Ideal index	1.0000	1.0000	1.0000	1.0000	No
Drobidh Index	1.0293	0.9978	1.0000	0.9961	Yes

Based on the result for decomposition of aggregate electricity intensity using the multiplicative index decomposition methods, “AMDI” are found to have relatively less residual value compared to others for the non-chaining decomposition method (Table 5-1 and Table 5-2).

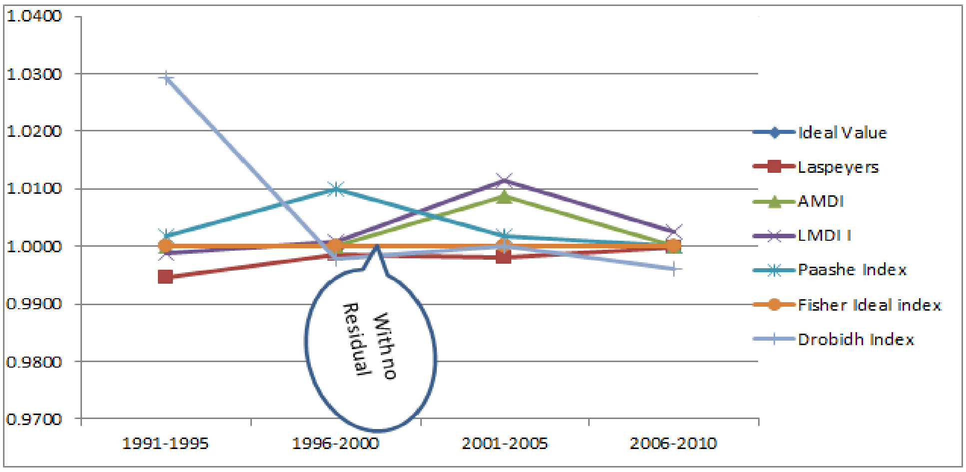


Fig. 5- 1Comparision of six IDA methods for residual value

But, the residual value for the "Fisher Ideal index" method is same as the expected or ideal value "1" for all of the analysis periods. It is also possible to check using the chaining decomposition method.

In the case of additive decomposition, four out of the six methods are compared. Since ''Fisher Ideal index'' and ''Drobish Index'' do not have the additive version in the index decomposition analysis, they are excluded from comparison for evaluating their residual value. These two methods lack the quality of compatibility for additive approach of index method.

Table5- 2 Residual for additive IDA of electricity Intensity of 6 EAPP countries

Mehtod	1991-1995	1996-2000	2001-2005	2006-2010
Laspeyers	0.00206	-0.00803	-0.00077	-0.00014
AMDI	-0.00002	-0.0006	-0.00022	-0.00006
LMDI I	0.0006	0.02661	0.01875	0.00176
Paashe Index	-0.00001	0.00805	0.08178	0.00002
Fisher Ideal index	N	N	N	N
Drobidh Index	N	N	N	N

Based on comparison between the four index methods, the "AMDI" followed by the laspeyer's method takes the first position (Table 5-2). This can be clearly seen from the highlight using arrow and star signs to help viewers differentiate between the two methods (Figure 5-2[18]).

[18] The use of star and arrow signs is just to show the histograms for the AMDI and Lapeyer's method.

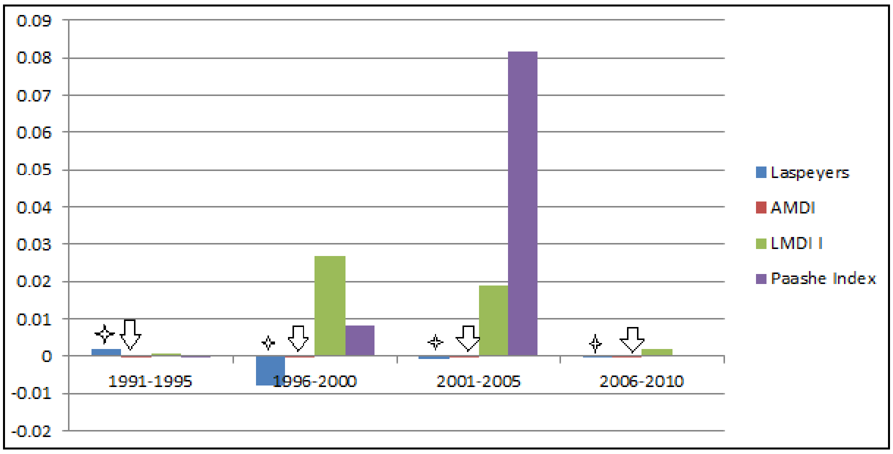


Fig. 5- 2 Residual for the Additive Index Decomposition of six Decomposition methods using research data

It is obvious that the residual value is very important but not the only criteria to identify the most preferable Index method for performing the decomposition analysis.

b. Time Reversal Test

According to B.W. Ang and F. Z., (2000), Fisher designed this test to show that the result of analysis after changing the base year, denoted by "0" from the frist year to the final is the resiprocal of the result obtained by keeping the first year in the interval as base year. With this understanding, the six candidate index methods for this study are evaluated and the result is presented on table 5-4 as follows. As already stated by scholars, this analysis reminds us that any method in the index decomposition analysis should show same result with its resiprocal.

The general approach can be shown as an example using Laspeyer's index method on the first interval. Before application of time reversal, the general formula for determining one of the factors will be $D_{\text{int}} = \dfrac{S_i^0 EI_i^T}{S_i^0 EI_i^0}$. As it is common, this case represent when the base year "0" is kept to be the initial year. The result for the analysis is presented on table 5-3. But the analysis was conducted by reversing the base year "0" from first year to last year. The result as seen on table-5-3 is different from the original decomposition results. The next step is multiplying the two values which hold same cell before and after factor reversal. The result must be equal to one for the method to pass the time reversal test.

Table5- 3Decomposition Result using initial year as base

Country Name	D_s	D_{int}	D_{tot}	D_{act}	D_{res}
Congo, Dem. Rep.	0.64221	1.33183	0.85531	1.33183	1.55712
Egypt, Arab Rep.	1.05603	1.03211	1.08993	1.03211	0.94695
Ethiopia	1.03968	1.17351	1.22008	1.17351	0.96183
Kenya	1.01207	1.04945	1.06212	1.04945	0.98807
Sudan	1.06074	0.94623	1.00370	0.94623	0.94274
Tanzania	0.98516	1.07626	1.06029	1.07626	1.01506
Total	1.03100	1.04948	1.08201	1.07630	0.99472

The formula for determining the factor value after changing the base year is represeted by $D_{\text{int}} = \dfrac{S_i^T EI_i^0}{S_i^T EI_i^T}$. Here the bsae year is considered to be year “t”. When the results of the the first equation reported in table 5-3 are multipied by the result of Second equation reproted in Table 5-4, the final result has to give a value “1” and this is in agreement with the statement that recognizes the applicability of time reversal in a candidate method. According ot such notion the Laspeyer’s Index method was tested for its applicability.

For instance, the result for the time reversal test of ‘D_{str}’ in the Laspeyer’s index method can be $D_{s(before\ time\ reversal)}$ *$D_{s(after\ time\ reversal)}$ which is 0.97508x1.03100. The result was equals to 1.00530 slightly higher than ideal value “1”.

Table5- 4 Decomposition Result considering the Final year as Base

Country Name	D_s	D_{int}	D_{tot}	D_{act}	D_{res}
Congo, Dem. Re	1.55712	1.33183	2.07381	1.33183	0.64221
Egypt, Arab Rep.	0.94695	1.03211	0.97735	1.03211	1.05603
Ethiopia	0.96183	1.17351	1.12873	1.17351	1.03968
Kenya	0.98807	1.04945	1.03693	1.04945	1.01207
Sudan	0.94274	0.94623	0.89205	0.94623	1.06074
Tanzania	1.01506	1.07626	1.09247	1.07626	0.98516
Total	0.97508	1.04948	1.02333	1.07630	1.05176

Similar way, the time reversal test was conducted for each of the remaining five methods and the result for all of them is summarized in table 5-6 below. Before presenting the summary result, the algoriths for time reversal analysis of the six IDA methods together with the original formulae was shown in table 5-5 for comparision. Subsequently, respective analysis were conducted using these algorithms in this table.

Table5- 5 List of candidate methods tested for time reversal

Name	Algorithm for time reversal	
	Original	Modified
Laspeyer's Index	$D_{xk} = \frac{S_i^0 I_i^0}{S_i^T I_i^0}$	$D_{xk} = \frac{S_i^T I_i^T}{S_i^0 I_i^T}$
AMDI	$D_{xk} = Exp\left(\frac{\frac{V_i^0}{V^T}+\frac{V_i^T}{V^T}}{2}\right) Ln\left(\frac{x_i^0}{x_i^T}\right)$ where "x" represents Sturcture or Intensity effects.	$D_{xk} = Exp\left(\frac{\frac{V_i^0}{V^T}+\frac{V_i^T}{V^T}}{2}\right) Ln\left(\frac{x_i^T}{x_i^0}\right)$
LMDI 1	$D_{xk} = Exp\left(\frac{L(V_i^T, V_i^0)}{L(V^T V^0)}\right) Ln\left(\frac{x_i^T}{x_i^0}\right)$	$D_{xk} = Exp\left(\frac{L(V_i^T, V_i^0)}{L(V^T V^0)}\right) Ln\left(\frac{x_i^0}{x_i^T}\right)$
Paasche Index	$D_{xk} = \frac{S_i^0 I_i^T}{S_i^T I_i^T}$	$D_{xk} = \frac{S_i^0 I_i^0}{S_i^T I_i^0}$
Fisher Ideal Index	$D_{xk} = \sqrt[2]{\frac{\sum S_i^T I_i^0 \sum S_i^T I_i^T}{\sum S_i^0 I_i^0 \sum S_i^0 I_i^T}}$	$D_{xk} = \sqrt[2]{\frac{\sum S_i^0 I_i^T \sum S_i^T I_i^T}{\sum S_i^T I_i^T \sum S_i^0 I_i^T}}$
Drobish Index	$D_{xk} = \frac{\left(\frac{S_i^0 I_i^0}{S_i^T I_i^0} + \frac{S_i^0 I_i^T}{S_i^T I_i^T}\right)}{2}$	$D_{xk} = \frac{\left(\frac{S_i^T I_i^T}{S_i^0 I_i^T} + \frac{S_i^0 I_i^0}{S_i^T I_i^0}\right)}{2}$

The result from time reversal test show that three of the six methods which include Laspeyer’s Index, Paasche Index, and Drobisch index fail to meet the requirement of the test. When the products of the values for the result from the decomposition analysis after and before time reversal are seen, the laspeyer’s Index is 5.3% more from expected value “1”. Whereas, Paasche Index and Dorbisch index exhibit 1.61% and 0.53% less than the expected standard.

Table5- 6 Summary of time reversal Tests

Method	Normal value	Modified value	Product	Remark
Laspeyer's	1.03100	0.97508	1.00530	No
AMDI	0.97231	1.02848	1.00000	yes
LMDI I	1.00118	0.99882	1.00000	Yes
Paasche	1.00000	0.98395	0.98395	No
Fisher Ideal	1.01539	0.98484	1.00000	Yes
Drobish	1.01550	0.97952	0.99470	No

Based on the results for the six index methods, The AMDI Index, LMDI, and Fisher Ideal Index methods conform to the requirement of the time reversal test. So, this result makes these three Index methods to be candidate for the main analysis in this study.

c. Factor Reversal Test

This test is simply to show that the aggregate value is perfectly decomposed in to factors which effected its occurrence. It means that the change in the structural effect times the change in the intensity effect should give the change in the aggregate electricity intensity in the context of this research. The Index method by which the product of structure effect and intensity effect results in same value with the aggregate electricity intensity value is considered perfect fit for the main analysis (R.A. Fisher, 1921).

Six of the methods are analysed for factor reversal test and summary of the result is presented on table 5-7. In each of these methods, the change in Aggregate Electricity intensity is compared with the product of the change in Structural effect represented by D_{str} and the change in the Intensity effect represented by D_{Int}. If any one of the methods gives same result, then that index method having same result with the aggregate value passes the factor reversal test in this study.

The general algorithm for factor reversal test of Index decomposition is $D_{tot} = D_{str} D_{\text{int}} = \dfrac{\sum S_i^T I_i^T}{\sum S_i^0 I_i^0}$ where, variables 'S' and 'I' representing the structure effect and Electricity Intensity effect respectively. Simple analysis was made using data obtained for the 1991 – 1995 on six countries to identify a method that meets the requirement. Treating the 1991 as year “0” and the later as final year “t”, The values of product of structure effect and intensity effect are compared with the aggregate value using respective formulas of the six methods.

Table5- 7 Summary result for Factor Reversal Test

Method	$\sum(S^T_i I^T_i)/\sum(S^0_i I^0_i)$	Dstr	D_{int}	D_{tot}	Remark
Laspeyer's Index	1.07630	1.03100	1.07630	1.10966	No
AMDI Index	1.07630	0.97231	0.95561	0.92915	No
LMDI I	1.07630	0.97231	0.95561	0.92915	No
Paasche Index	1.14574	1.00000	1.14574	1.14574	yes
Fisher Ideal index	1.14574	1.01539	1.12838	1.14574	Yes
Drobish Index	1.14574	1.01550	1.11102	1.12824	No

Based on the analysis result for the year 1991-1995, two Index methods pass the test and the remaining three did not fulfill the required standard. The summary is presented in table5-7. As can be seen in the table, the the change in the aggregate electricity intensity is same as the product of the the intensity effect and the structure effect. For both Paasche and Fisher Ideal index methods. This result is in conformation with Fisher’s conclusion for the Fisher Ideal Index.

d. Circular Test

According to R.A. Fisher, (1921), this test extends from the time reversal test. It requires the index method to show this behavior of circularity. The General Algorithm, as refered from the work of the same scholar , will be:

$$D_{01} * D_{12} * D_{21} = 1$$

The decomposition analysis in this research uses non chaning method. So, the years are grouped in to 1991-1995, 1996-2000, 2001-2005, 2006 – 2010. Hence, to demonstrate this test the data for the first, second and last intervals are considered. On this basis, the $"D_{01}"$ is the result from the decomposition analysis by considering 1991 as a base year denoted by ‘0’ and 1995 as the final year denoted by ‘1’. $"D_{12}"$ also represents the decomposition analysis for the year 1996 -2000 where by 1996 was considered as the base year, denoted by ‘1’ and 2000 considered as final year, denoted by ‘2’. Then the last interval which is 2010 – 1995 closes the circle. In this case year 2010 is taken as a base year, denoted by ‘2’ and year 1995 is considered as final year, denoted by ‘1’.

This process is applied on the six candidate index decomposition methods for this study and the summary of the result can be seen on table 5-8. As can be seen from the table from the six methods diagnosed for their fitnes for the main analysis of this study, only Fisher Ideal Index Method shows relatively better result by passing the factor reversal, time reversal tests and ofcourse the residual value test.

Table5-8 Summary Result for Circular Test

Method	1991-1995(D_{01})	1996-2000 (D_{12})	2010-1991(D_{20})	D_{01}*D_{12}*D_{20}	Remark
Laspeyer's	1.10966	1.12800	1.01884	1.27528	No
AMDI	0.92915	0.73119	0.52341	0.35560	No
LMDI I	1.07757	1.11117	0.78936	0.94516	No
Paasche	1.14574	1.10092	0.72514	0.91467	No
Fisher Ideal	1.14574	1.11438	0.70412	0.89901	No
Drobish	1.12824	1.11442	0.77947	0.98005	No

But it failed the circular test and this is also seen in another scholarly studies. Nevertheless, the most important qualities are factor reversal and time reversal tests and Fisher Ideal index performed well in these two tests.

5.5.4. Confirmed Model for Empirical Analysis

According to Ang., B.W. (2004), researchers compared different Index methods to be used for energy demand or energy intensity decomposition and identified criteria for gauging the desirability of an Index method. These criteria include theoretical foundation, adaptability, ease of use, and result interpretation. He also identified from his review that the energy demand decomposition using Index decomposition method has direct link with Index number theory and this have been used by Ang., et-al. (2002).

Hence, Ang suggested that the same testing approach used for identifying appropriate method in the Index Number theory be applied in selecting the best index decomposition method too. Hence, the tests seen in this document section 5.1 considered the four criteria suggested by the Scholar which include factor-reversal, time-reversal, proportionality, and aggregation tests. Of tests recommended by scholars, the factor-reversal test is the most important and once a decomposition method passed this test, it was always considered highly desirable by analysts (Ang. B.W., 2004).

In addition to these criteria which already been tested by the researcher, B. W. Ang., (2004) recommended use of a direct and simple association between additive and multiplicative decomposition as additional criteria for adopting certain Index method since adaptability to both might be considered as one of the needed qualities. This is mentioned as an advantage because it allows either time series analysis and/or cross country comparison with little technical modification (ib-id). The author's recommendation is considered but still getting the indexing method that gives little or no residual value is given more priority.

Summary of the selection results for the best Index decomposition method for this study based on recommendations by researchers & scholars, the result from actual test run, and result from decomposition analysis at aggregate level are presented in table 5.9. The name & general algorithms of each of the candidate method, and list of the six selection criteria with their respective weights and rankings were presented in this summary.

Table5-9Test result summary Candidate IDA methods, their respective Algorithms, and selection criteria

Method	Algorithm	Selection criteria					
		Time reversal test.	Factor reversal Test.	Circular Test.	Additive & Multiplicative method.	Relation between add. & Mult. approaches.	ce of Resid ual Value.
Laspeyer's Index.	$D_{xk} = \frac{S_i^0 I_i^0}{S_i^T I_i^0}$	N.	N.	N.	Y.	N.	N.
AMDI.	$D_{xk} = Exp\left(\frac{\frac{v_i^0}{V^T}+\frac{v_i^T}{V^T}}{2}\right) Ln\left(\frac{x_i^0}{x_i^T}\right)$ where "x" represents Sturcture or Intensity effects.	Y.	N.	N.	N.	N.	N.
LMDI 1.	$D_{xk} = Exp\left(\frac{L(V_i^T, V_i^0)}{L(V^T V^0)}\right) Ln\left(\frac{x_i^T}{x_i^0}\right)$	Y.	N.	N.	Y.	Y.	N.
Paasche Index.	$D_{xk} = \frac{S_i^0 I_i^T}{S_i^T I_i^T}$	N.	Y.	N.	Y.	Y.	N.
Fisger Ideal Index.	$D_{xk} = \sqrt[2]{\frac{\sum S_i^T I_i^0 \sum S_i^T I_i^T}{\sum S_i^0 I_i^0 \sum S_i^0 I_i^T}}$	Y.	Y.	N.	N.	N.	Y.
Drobish Index.	$D_{xk} = \frac{\left(\frac{S_i^0 I_i^0}{S_i^T I_i^0} + \frac{S_i^0 I_i^T}{S_i^T I_i^T}\right)}{2}$	N.	N.	N.	N.	N.	N.

Different scholars gave their opinion based on their experimental results and their practical experience. In addition to the opinion of scholars, the result from the confirmation tests done on the data for this research helped the researcher to come up with single Index Method for performing the main decomposition analysis in the study.

The overall result as seen on table 5-9 shows three potential methods having equal number of points assuming equal weight but for different criteria. From the scholarly recommendation and from intuition, residual free decomposition is most important. Here it is only Fisher Ideal Index Method and LMDI I which have residual free decomposition result among the three.

Hence, using this result and recommendation of the scholars, Fisher Ideal Index method is found to be relatively robust and most preferred method. Therefore, this method is preferred for running the main decomposition analysis for this research.

The Model for the data analysis will have the following form:

$V_i = \sum S_i I_i$, Representing IDA general formula for the aggregate electricity Intensity. Then, the general method for determining the change of intensity will be

$D = \frac{V^T}{V^0} =$ $D_{str}D_{int}$ Where,

D stands for aggregate electricity intensity,

V^T stands for value of aggregate at the final year or ‘t’,

V^0 stands for value of aggregate at the initial year or ‘0’,

D_{str} stands for value of Structure effect

D_{int} stands for value of Intensity effect.

The algorithm for determining D_{Str} and D_{Int} are presented as:

$$D_{Str} = \sqrt[2]{\frac{\sum S_i^T I_i^0 \sum S_i^T I_i^T}{\sum S_i^0 I_i^0 \sum S_i^0 I_i^T}} \text{, and } D_{Int} = \sqrt[2]{\frac{\sum S_i^0 I_i^T \sum S_i^T I_i^T}{\sum S_i^0 I_i^0 \sum S_i^T I_i^0}}$$

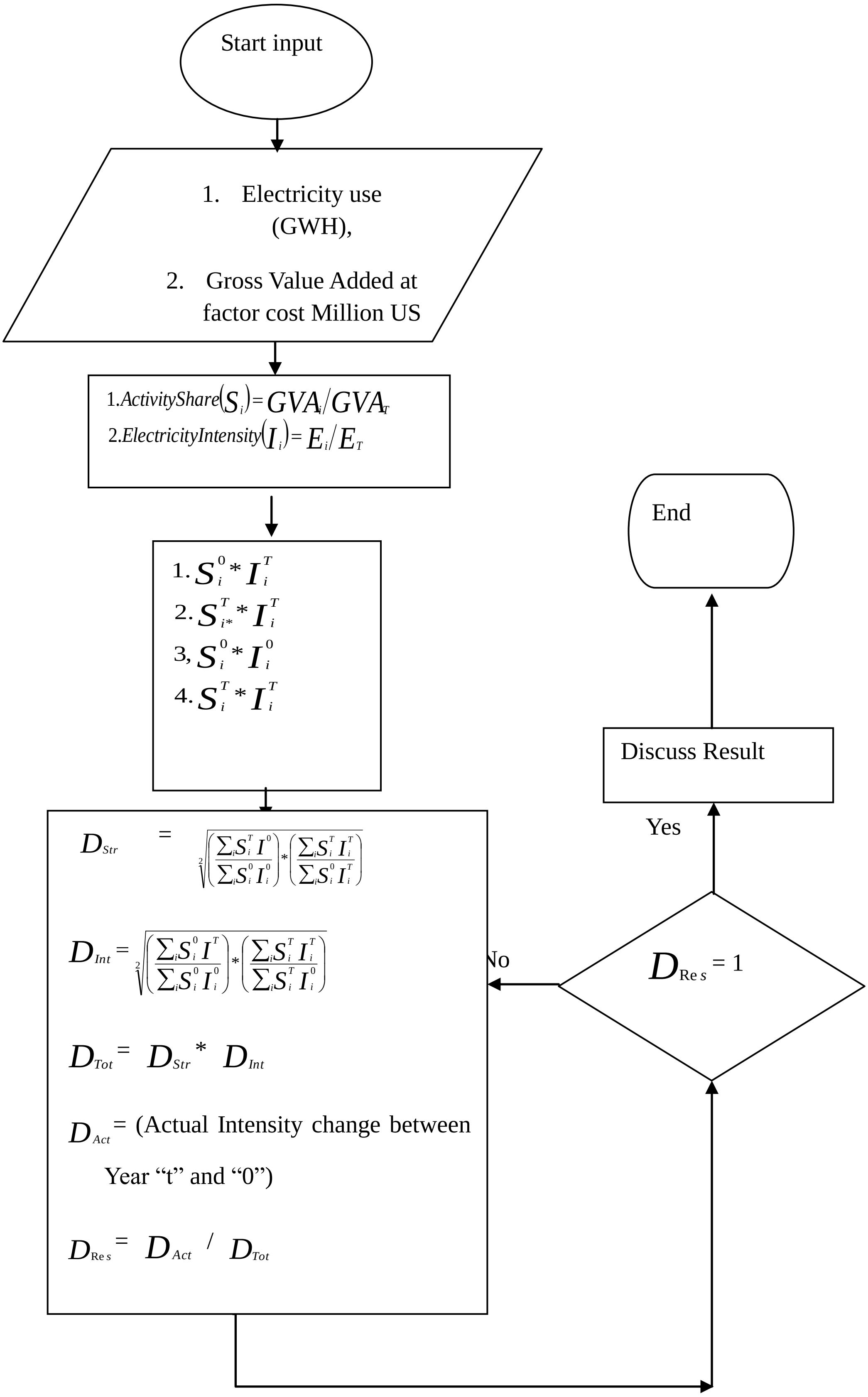
$\frac{\sum S_i^T I_i^0}{\sum S_i^0 I_i^0}$, laspeyer’s Index for determining the structure effect ,

$\frac{\sum S_i^0 I_i^T}{\sum S_i^0 I_i^0}$, Laspeyer’s Index for determining the intensity effect, and

$\frac{\sum S_i^T I_i^T}{\sum S_i^0 I_i^T}$, Paasche Index for determining the structure effect.

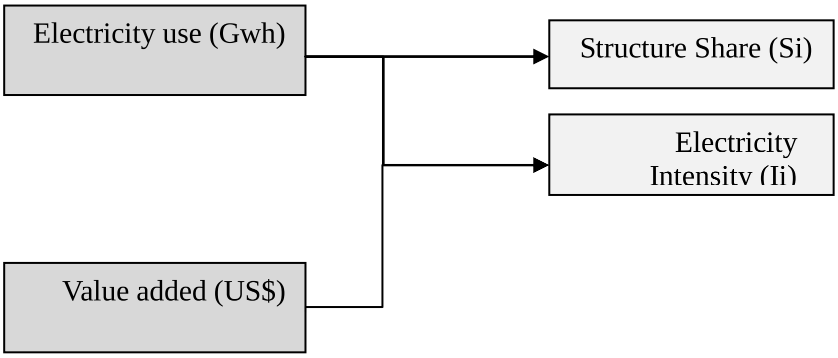
$\frac{\sum S_i^T I_i^T}{\sum S_i^T I_i^0}$, represent the Passche Index for determining the Intensity effect.

Based on scholars work & Test result the “FII” is same as the square root of the Laspeyer’s and Passche Index.


Start input
1. Electricity use (GWH),
2. Gross Value Added at factor cost Million US
1. $ActivityShare(S_i) = GVA_i / GVA_T$
2. $ElectricityIntensity(I_i) = E_i / E_T$
1. $S_i^0 * I_i^T$
2. $S_{i*}^T * I_i^T$
3, $S_i^0 * I_i^0$
4. $S_i^T * I_i^T$
$D_{Str} = \sqrt[2]{\left(\frac{\sum_i S_i^T I_i^0}{\sum_i S_i^0 I_i^0}\right) * \left(\frac{\sum_i S_i^T I_i^T}{\sum_i S_i^0 I_i^T}\right)}$
$D_{Int} = \sqrt[2]{\left(\frac{\sum_i S_i^0 I_i^T}{\sum_i S_i^0 I_i^0}\right) * \left(\frac{\sum_i S_i^T I_i^T}{\sum_i S_i^T I_i^0}\right)}$
$D_{Tot} = D_{Str} * D_{Int}$
D_{Act} = (Actual Intensity change between Year "t" and "0")
$D_{Res} = D_{Act} / D_{Tot}$
$D_{Res} = 1$
No
Yes
Discuss Result
End

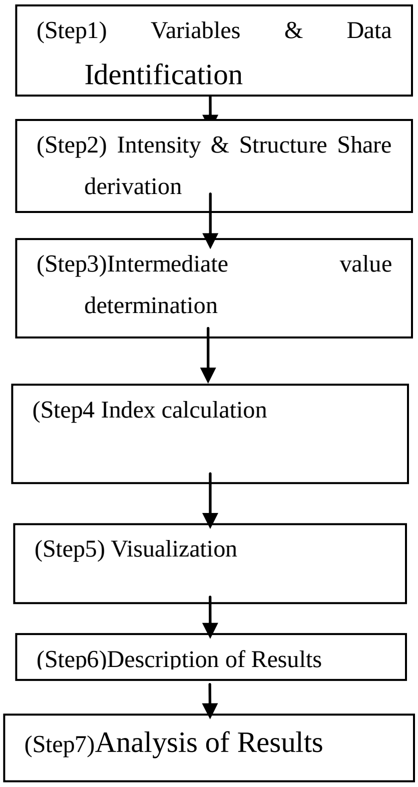
Description of Major steps

Step1 & 2: Input Variables and Data Identification



Also, to identify the influence of each sector on the change of electricity intensity, the output share of each sector has to be determined. The sectors to be covered in this analysis include Agriculture-Forestry-&-Others, Industry, Commercial & Public Services Sector, and Residential Sector. In the context of this research, determining Electricity Intensity (EI) needed two variables.

1) The Electricity consumption in GWH (Million KWH) for the years 1991-2010 in each of the four economic sectors in each country. 2) The Gross value added at factor cost in Million US$ (constant 2005 US$) by each of the four economic sectors.



Step-1: Electricity Consumption (GWH), Gross Value Added (at factor cost in Million US$ constant 2005 US$) total data for the six countries

Step-2 [19] : determine Structure share (Country GVA /Total GVA)and the Electricity Intensity (GWH/US$)

Step-3[20]:
1. $S_i^0 * I_i^T$
2. $S_{i*}^T * I_i^T$
3, $S_i^0 * I_i^0$
4. $S_i^T * I_i^T$

Step-4: The structure effects,

$$D_{Str} = \sqrt[2]{\left(\frac{\sum_i S_i^T I^0}{\sum_i S_i^0 I_i^0}\right) * \left(\frac{\sum_i S_i^T I_i^T}{\sum_i S_i^0 I_i^T}\right)}$$

Intensity effects,

$$D_{Int} = \sqrt[2]{\left(\frac{\sum_i S_i^0 I^T}{\sum_i S_i^0 I_i^0}\right) * \left(\frac{\sum_i S_i^T I_i^T}{\sum_i S_i^T I_i^0}\right)}$$

(D_{tot}) Total effects is simply "Structure effect" x Intensity Effect

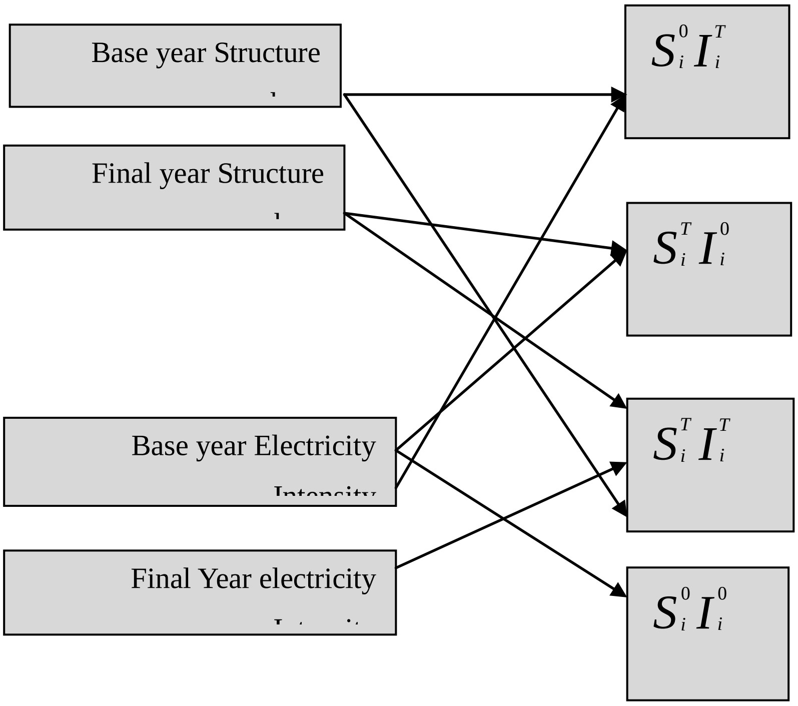
(Dres)Residual Value is determined. Dact/Dtot

Fig. 5- 3 Flow Chart for Data Analysis Model

[19] GVA stands for Gross Value Added.

[20] $S_i^0 I_i^0$ is structure share times electricity Intensity of country (i) in the base year ; $S_i^T I_i^T$ is Structure share structure share times electricity Intensity of Country (i) in the final Year; $S_i^0 I_i^T$ is Structure share in base year times Electricity Intensity in the final year; $S_i^T I_i^0$ is Structure share in the final year times Electricity Intensity in the base year. The first half of the algorithm for determining structure effect stands for Laspeyers Structure effect and the second half of the same algorithm stands for the Passche Index Structure effect. The multiplicative result of the square root of the Laspeyer's structure effect and Paashe's Structure effect gave us Fisher Ideal Index Structure effect. Same way the Intensity effect was calculated.

Step3: Intermediate process

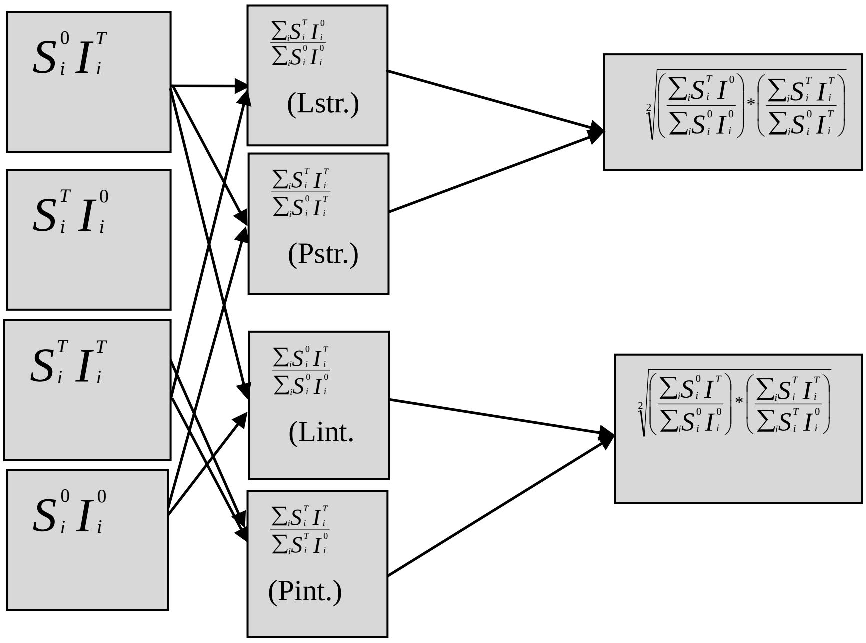


In this step, the intermediate values to be used for determining the indices are calculated. These are simply results of sector's share multiplied by Intensity in same sector. In this analysis the super script 0 indicate the base year and T indicate final year. Also the "i" indicates sector. In this research the value of "i" is 1 to 4.

Step-4: Index Calculation

This is the Index decomposition analysis output part where four results are determined. These include, the Structure effect D (Str.), Intensity effect (D

(Int.), Total effect D (Tot.), and Residual effect D (Res.).



As noted earlier, to decompose electricity intensity in the sectors using the Fisher Ideal index: 1) the result of step-3 is used as an input. 2) Structure effects for Laspeyer's and Paasche Indices respectively are calculated 3) then structure effect by Laspeyer's index multiplied by structure effect by Paasche's Index then the square root of the multiplication result will give the Fisher Ideal Index Structure effect. The same steps are followed to give the result for the Fisher Ideal Index intensity effect.

In this step, the total effects are determined by multiplying the Structure effect by Intensity effect of Fisher Ideal index (D(tot) = D(str.) *D(int.)). Then the value is compared with the Actual figure of electricity intensity change.

This is done by dividing the actual electricity intensity by the total electricity intensity. Since Fisher Ideal index is a perfect Index Decomposition Method the result has to be 1. The figure is the residual effect (D(res)).

Step5: Visualization

This and subsequent steps are common for all empirical analyses. The visualization was done using Tables, bar chart or line graph. But Bar chart is preferred to see how the change in electricity intensity was influenced by wither Intensity effect or Structure effect.

Step6: Description of the results

This is where the results were described referring the graph. But the implications are not stated here.

Step7: Discussion of results

In this section, the meaning and the implication of figures in the tables, bar or line charts on electricity use in the sectors or countries were presented based on the cases. This approach was applied for both electricity Intensity decomposition analyses by country level and by sector level. The main difference between the two was the definition for structure effect. For the case of IDA of electricity intensity by country level, the structure effect is represented as the influence of sectors' share of Gross value added in each country. For the case of

IDA by Sectors level, the structure effect is represented by the influence of share of countries within the context of a sector under consideration.

5.6. Index Decomposition Analysis of Aggregate Electricity Intensity by country

The six countries for which Index Decomposition Analysis of aggregate electricity conducted include Democratic Republic of Congo (DRC), Arab Republic of Egypt (Egypt), The People's Democratic republic of Ethiopia (Ethiopia), the Republic of Kenya (Kenya), the Republic of Sudan[21] and The United Republic of Tanzania (Tanzania). The sectors electricity consumption data obtained from the IEA Energy Balance report. Some countries have incomplete sector level electricity consumption data in the study period. Attempt to get the same data either from respective countries or from other international sources was not successful. So, it was decided to use the available

[21] In this research, the data obtained from the international sources, does not differentiate between S outh and North Sudan. So, all the data and interpretations are considered accordingly. But the r esearcher highly regards & understands the current countries as South and North Sudan. In the future, as data permits, the content of the study may change to accommodate such differences.

data as much as possible by dividing the analysis in parts based on years that have registered data (Table-).

Table 5- 10 Summary Description about country level data problem

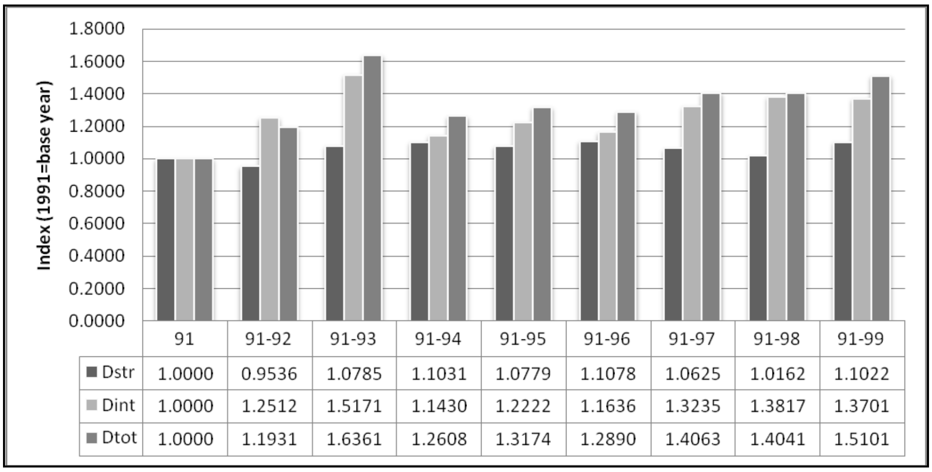
Country	Division of data period
DRC	1991–1999 (3Sectors): Agriculture-forestry-&-Others, Industry, Residential. 2) 2000–2010 (3 Sectors):Industry, Commercial & Public Services, and Residential.
Egypt	1)1991-1995 (3 Sectors) Agriculture-Forestry-&-Others, Industry, and Residential 2) 1996-2010 (4 Sectors) Agriculture-Forestry-&-Others, Industry, Commercial & Public Services Sectors and Residential.
Ethiopia	1991-2010 (4 sectors) Agriculture-Forestry-&-Others, Industry, Commercial & Public Services Sectors and Residential.
Kenya	1)1991-1994 (3 Sectors) Industry, Commercial & Public Services, and Residential 2)1995-2007 (4 sectors) Agriculture-Forestry-&-Others, Industry, Commercial & Public Services Sectors and Residential. 3) 2008-2010 Industry, Commercial & Public Services, and Residential
Sudan	1)1991-2010(4 sectors) Agriculture-Forestry-&-Others, Industry, Commercial & Public Services Sectors and Residential
Tanzania	1)1991-2010 (4 sectors) Agriculture-Forestry-&-Others, Industry, Commercial & Public Services Sectors and Residential

In this section, the main interest was to see which sector in a given country dominated in electricity use among sectors considered in the analysis. Then knowing factors contributed for such incidence, either structure or intensity. Based on the result, a sector with high electricity requirement has to be strategic for the country while planning for participating in the electricity market. Based on this information, countries might be able to gauge their merits and demerits in the market ahead of their decision. The main factors considered in this analysis were the Structure and intensity effects. In the following sections, Index Decomposition Analysis of aggregate electricity intensity was done for the economic sectors in each country level.

5.6.1. Congo Democratic Republic

a. Index Decomposition Analysis (1991-1999):

The aggregate electricity intensity in DRC was between 0.406watt-hours/US$ and 0.431watt-hours/US$ for the period 1991 to 1999. In the DRC, the Share of Agriculture-Forestry-&-Others sector and Residential sectors' increased in the activity mix at the end of 1999. The electricity intensity share of the Residential and Industry sectors increased. The industrial sector electricity intensity increased because of large reduction by the sector in the share of activity mix in 1999 though the electricity consumption has shown relatively small decrease. This doubled the electricity intensity of Industry sector compared to the base year value. But the household electricity intensity decreased compared to the base year because of less activity share in 1999 compared to the base year while the electricity consumption decreased very slightly.



	91	91-92	91-93	91-94	91-95	91-96	91-97	91-98	91-99
Dstr	1.0000	0.9536	1.0785	1.1031	1.0779	1.1078	1.0625	1.0162	1.1022
Dint	1.0000	1.2512	1.5171	1.1430	1.2222	1.1636	1.3235	1.3817	1.3701
Dtot	1.0000	1.1931	1.6361	1.2608	1.3174	1.2890	1.4063	1.4041	1.5101

Fig. 5- 4 Decomposition Result for DRC (1991-1999)

Based on Index the decomposition analysis result, the structure effect was 10.22% increase in the aggregate electricity intensity from its based year value. Also the intensity effect led to an increase of 37.01% in the aggregate electricity in 1999 from the base year value. The net effect was 51.01%. (Fig.5-3) The Intensity effect dominated because industrial sector exhibited big increase in the electricity intensity value in 1999 compared to the base year value.

b. Index Decomposition Analysis for DRC (2000-2010)

The aggregate electricity intensity in DRC was between 0.743watt-hours/US$ and 0.673watt-hours/US$ for the period 2000 to 2010. During this period, the share of Industry sector increased in the activity mix. The electricity intensity share of the industrial sector decreased more than the increase in its share in the activity mix. But the scale effect has contribution for the industrial sector to remain important in this country for this period. Its influence on the electricity use was because of the size of economic value added by the sector. Based on the index decomposition analysis result, the structure effect resulted in the increase of electricity intensity by 22%. On the contrary, the intensity effect led to a decrease in the value of aggregate electricity intensity by 27% from the 2000 level. So, the net effect was a decrease in the aggregate electricity intensity by 10% from the 2000 value (Fig. 5-4). In this analysis the structure effect dominated.

The security problem in 1990s tightened and gradually the first Congo war erupted in 1996 resulted in the destruction of infrastructures including the electricity sector and also hindered further investment. The Hindrances of further expansion was believed to contribute to significant decrease in the activity mix of the industry sector. Further, during second Congo war towards the end of 1998 electricity infrastructure and the mining facilities were damaged. But After 1999, the intensity effect showed positive value with a big leap.

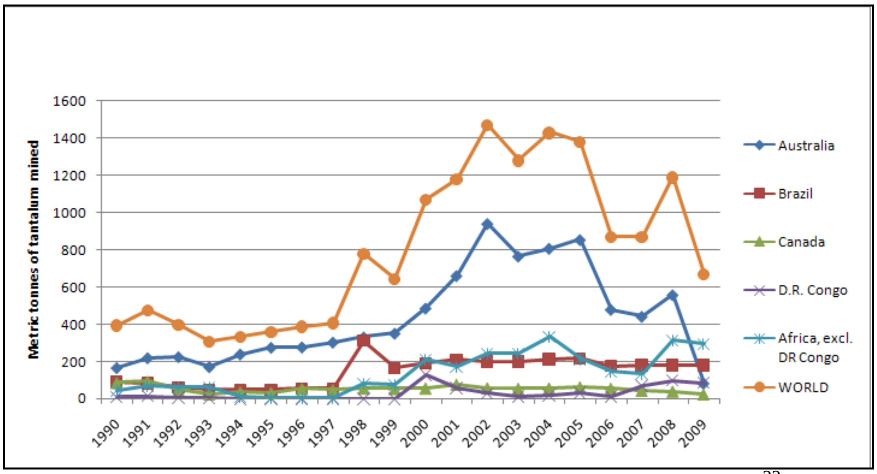


Fig. 5- 5 Global Mined Tantalum Production, 1990-2009[22]

This was mainly because of mining sectors relieve and production boom and establishment of urban centers around the sites resulted in an increase for consumption of electricity. Especially an increase in Tantalum production 1990-2009 matched with dominance in the proportion of the intensity effect (The Hague Center for Strategic Studies (HCSS) et-al, 2013).

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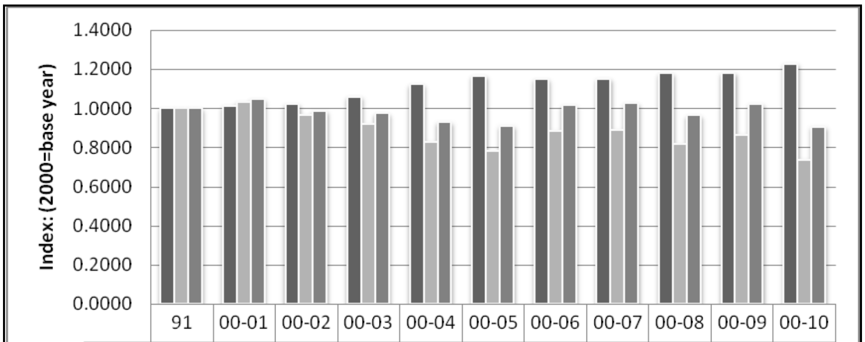
[22] This data was originally estimate of US Geological Survey



	91	00-01	00-02	00-03	00-04	00-05	00-06	00-07	00-08	00-09	00-10
Dstr	1.00	1.01	1.02	1.06	1.12	1.16	1.14	1.15	1.17	1.18	1.22
Dint	1.00	1.03	0.96	0.91	0.82	0.78	0.88	0.88	0.81	0.86	0.73
Dtot	1.00	1.04	0.98	0.97	0.92	0.91	1.01	1.02	0.96	1.02	0.90

Fig. 5- 6 Decomposition result for DRC (2000-2010)

An increase in the electricity intensity to 0.74 watt-hours/US$ during the second time interval was assumed to be attributed to the growth of the copper industry and related urbanization around the mining areas which resulted in more electricity demand.

The Index decomposition analysis of the Aggregate Electricity intensity in DRC in both time intervals showed that the Intensity effect dominated throughout the study period. It was positive for 1991 to 1999 with big leap on end of this period. In the second part of the analysis, the intensity effect dominated but led to reduction of the aggregate electricity intensity.

The aggregate electricity intensity of 2010 for DRC was large figure compared to the value in 1991. Practically, the economic change in DRC since 2002 was more related to the mining industry (usaid, 2014). Large mining companies which have been involved in the production of different minerals, like cobalt, diamond, and copper have contributed to the increased use of electricity in the industrial sector of the country.

5.6.2. Egypt Arab Republic

The Aggregate Electricity intensity in Egypt was analyzed in two parts. The first was for 1991 to 1995 and the second was for 1996 2010.

a. Index Decomposition Analysis for Egypt (1991-1995).

The aggregate electricity intensity in Egypt was 0.kwh/US$ in 1991 and increased to 0.782kwh/US$ at the end of study 1995. The total Gross Value increased, but the structure share (Activity Mix) in 1995 remained the same with the 1991 proportion. However, the aggregate electricity intensity in the economy has increased by 13% from its value in 1991. In Egypt the Industrial sector and Agriculture-forestry-&-others sectors take the dominant role in the electricity use. Because their relative share of the two sectors in the activity mix was bigger in the order they are though it did not change from the base value.

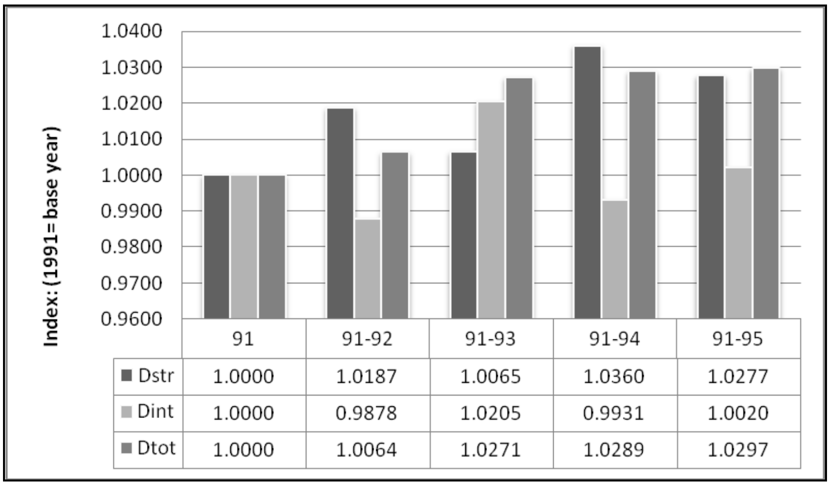
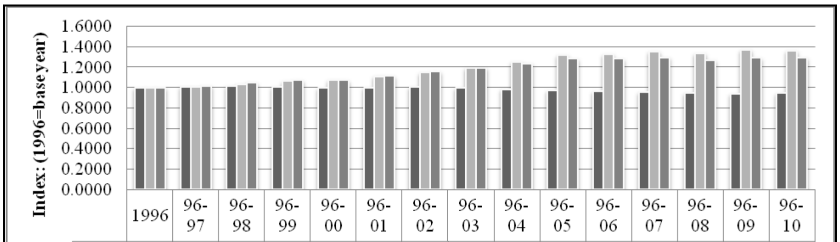


Fig. 5- 7 The Index Decomposition result for Egypt (1991-1995)

The result of decomposition analysis of aggregate electricity intensity for the period 1991 to 1995 shows that the structure effect resulted in an increase of the intensity by 3% from the value it had in 1991. The intensity effect has brought about the change in the electricity intensity, but the change was very small compared to the former. So, the net effect reminded 3% for the period under consideration. The structure effect in this case represents the change in the scale of the output from the industry and agriculture sector. But the overall change in this time interval was relatively small.

b.**Index Decomposition Analysis for Egypt (1996-2010)**

The aggregate electricity intensity in the study period has increased from 0.826kwh/US$ in 1996 to 1.0684kwh/US$ in 2010. The scale of the economy has almost doubled in 2010 compared to 1996. The largest contributors have been Commercial and Public Services and industrial sector. In the activity mix, the proportion of commercial & Public services, industry and Agriculture-Forestry-&-others sectors have increased from the base year value.



	1996	96-97	96-98	96-99	96-00	96-01	96-02	96-03	96-04	96-05	96-06	96-07	96-08	96-09	96-10
Dstr	1.00	1.01	1.01	1.00	0.99	1.00	1.00	1.00	0.98	0.97	0.96	0.95	0.94	0.94	0.94
Dint	1.00	1.00	1.03	1.06	1.07	1.11	1.14	1.19	1.25	1.32	1.32	1.35	1.33	1.37	1.36
Dtot	1.00	1.01	1.05	1.07	1.07	1.11	1.15	1.19	1.23	1.28	1.28	1.29	1.27	1.29	1.29

Fig. 5- 8 Index decomposition result for Egypt (1996-2010)

The Result of Index decomposition analysis shows a net increase in the aggregate electricity intensity by 29% in 2010 from the value in 1996. The dominant factor for this change was intensity effect which led for an increase of the aggregate electricity intensity from the base year value by 36%. Increase of household sector electricity intensity has contributed for such change. In addition, the commercial and Public services sector and Agriculture sector have also good amount of contribution though share of agriculture in the economy has decreased in 1996 compared to 2010.

In Egypt the aggregate electricity consumption has increased in 1996 to 2010. This was believed to be related with the structural reform of 1991-2007 that was enforced by international institutions (Khorshid M., et-al, 2011). According to the same source, this reform was supplemented by fiscal and monetary policies and hence market oriented economy was created in the country up to 2007. This led to the influx of foreign investment and shift of government owned business to private sector ownership and management except sectors that were considered strategic.

In 1996-2007, the GDP have been growing relatively smooth and Industries including Automobile manufacture, Textile, Petroleum and Gas have grown significantly. But as time passed, this wealth obtained from such development could not be distributed evenly and employment problem, food price rise, and related problems begun to erupt since 2008. As could be concluded from this study, Egypt has been progressing very well until 2008. Because, the economic sectors in the country including Agriculture have shown significant positive change. Due to the dominance by the Industry, Services, agriculture sector within the economy of Egypt, the need for electricity had to increase relatively in a good proportion.

The argument concerning the increase in volume of electricity use in Egypt's economy applies only until 2007. It was substantiated by the size of Egypt's economy, the favorable legal condition, and the nature of most of the businesses. But, global economic crisis of 2008 had indirect impact on the halt of the economic condition of Egypt's citizens beginning from 2008 (Khorshid M., et-al, 2011). This may affect the country as potential importer in the East African electricity market network.

5.6.3. Ethiopia

The aggregate electricity intensity in Ethiopia was 0.149kwh/US$ in 1991 and increased to 0.198kwh/US$ at the end of study period, 2010. The change in aggregate electricity intensity of Ethiopia was intermittent periodically forming a small trough on 2001, repeating another in 2009, and increasing up to the end of the study period. The intensity value in 2010 was 33% compared with the base year.

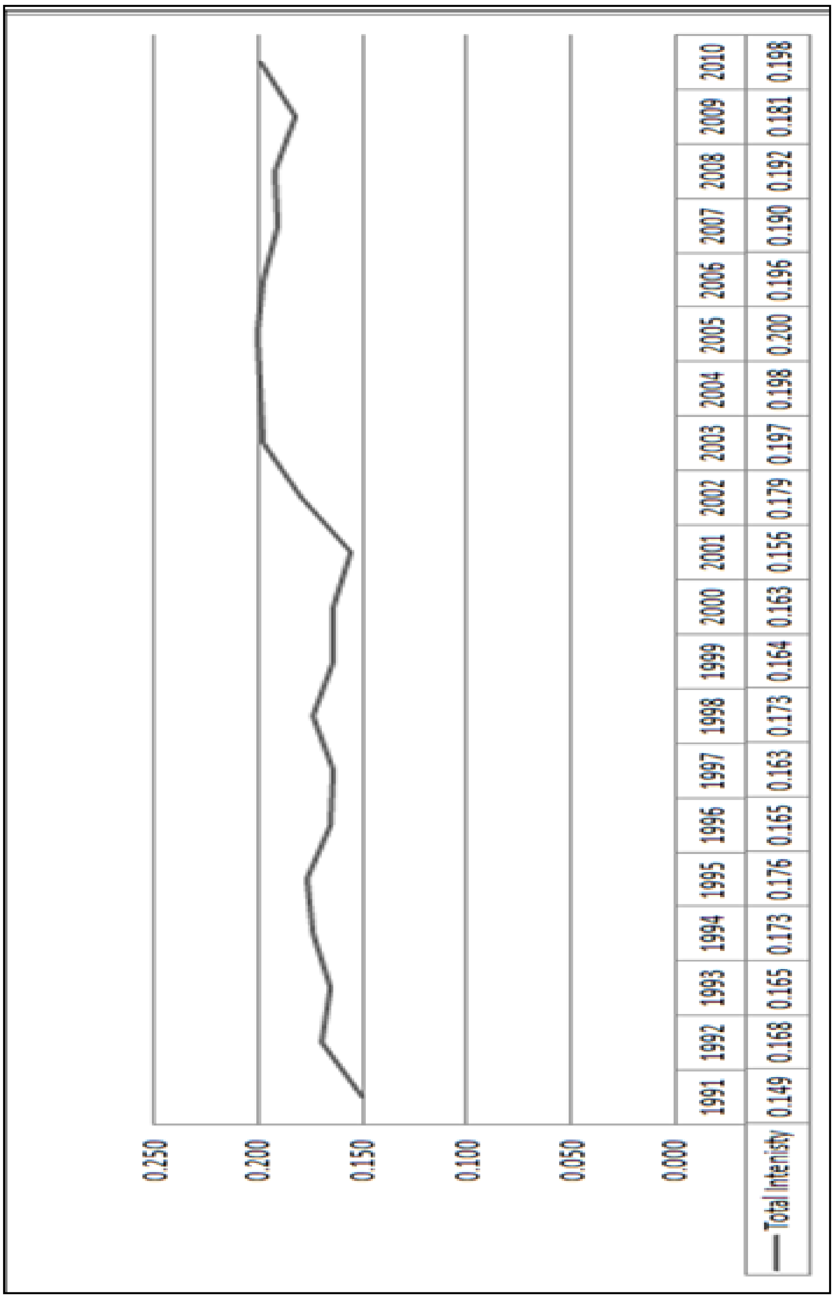
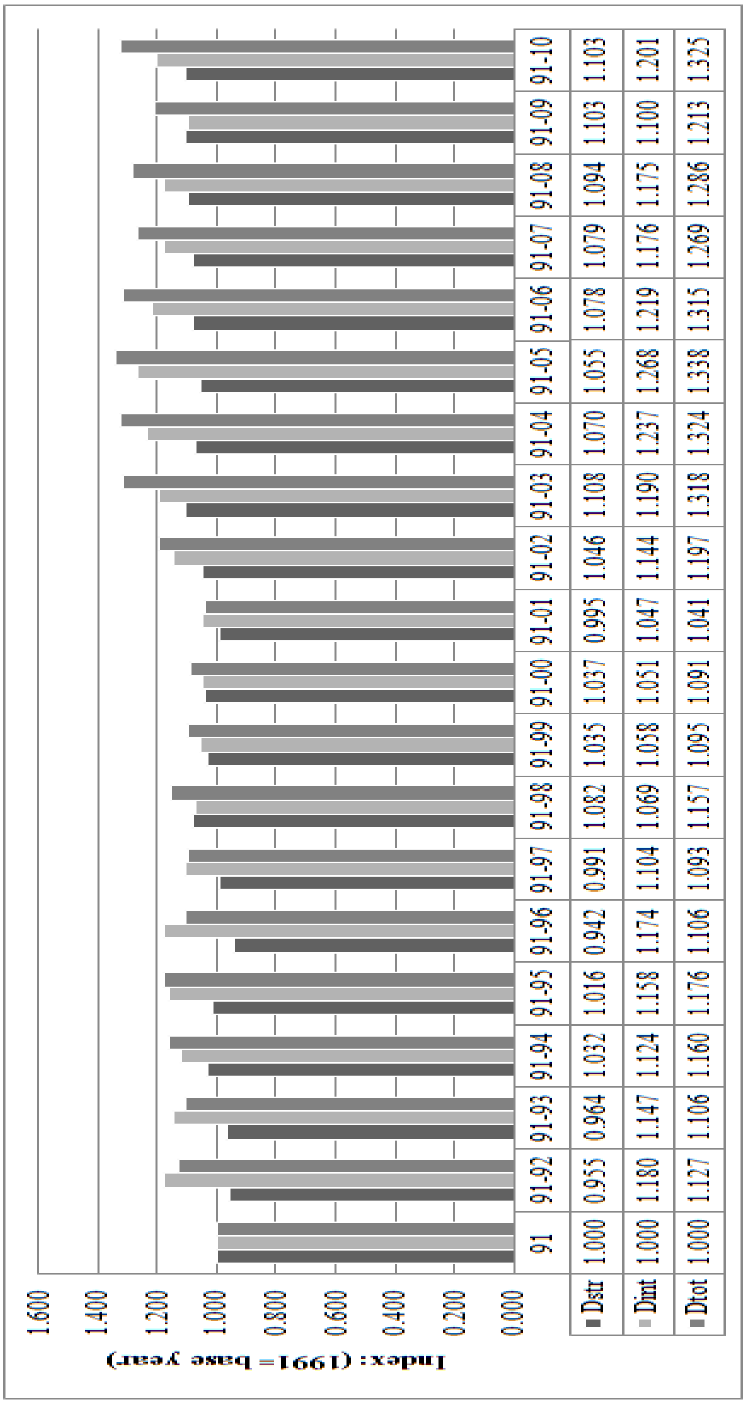


Fig. 5- 9Total Electricity intensity for Ethiopia in Kwh/US$ (1991-2010)

Electricity consumption has been growing slow beginning from the base year until 2001. But after 2001 the rate has increased, because the access to power was relatively better due to an increase in power supply between 2001 and 2004 compared to the previous years (Ministry of Finance and Economic Development (MoFED), 2007). The increment in the intensity was relatively in larger rate beginning from 2003 for the whole period. The electricity consumption compared with the Gross value added was relatively slow. This has connection mainly with the relative dominance of Agriculture in the GDP. As can be seen from the small electricity consumption size in this sector, the impact of electricity use on the agriculture value added was less magnificent.

The change in the Gross value added was sharply increasing after 2003 until end of study period. The rate of change in gross value added has been exhibiting similar trend every 5 year beginning from 1991 up to 2010. The major factor for such fluctuation was the fluctuation in the agriculture sector GDP. In 2002/2003, the Agriculture sector performed very poor. Main factors were drought incidence and border conflict. Due to these reasons, the household/residential sector expenditure decreased. In Ethiopia income of majority of households is secured from the Agriculture sector. The Gross value added increased nearly threefold at the end of the study period compared to the base year.

But, its contribution to the change in the electricity intensity was not seen on the activity mix, but indirectly on the intensity change in the household sector.



	91	91-92	91-93	91-94	91-95	91-96	91-97	91-98	91-99	91-00	91-01	91-02	91-03	91-04	91-05	91-06	91-07	91-08	91-09	91-10
Dstr	1.000	0.955	0.964	1.032	1.016	0.942	0.991	1.082	1.035	1.037	0.995	1.046	1.108	1.070	1.055	1.078	1.079	1.094	1.103	1.103
Dint	1.000	1.180	1.147	1.124	1.158	1.174	1.104	1.069	1.058	1.051	1.047	1.144	1.190	1.237	1.268	1.219	1.176	1.175	1.100	1.201
Dtot	1.000	1.127	1.106	1.160	1.176	1.106	1.093	1.157	1.095	1.091	1.041	1.197	1.318	1.324	1.338	1.315	1.269	1.286	1.213	1.325

Fig. 5- 10 Decomposition result for Ethiopia (1991-2010)

The Index decomposition analysis of the Aggregate Electricity Intensity in Ethiopia shows that the structure effect increased by 10.3% and intensity effect by 20.1% in 2010. The Intensity effect dominated throughout the study period except in 2009, the year at which modest decline in the GDP observed (MOFED, 2010). The GDP growth was large between 11.5 and 12.6 in the interval 2002/3 to 2007/08 for five consecutive years (Dorosh and Schmidt 2010), and (ChamberlinJordan & SchmidtEmily, 2011).

In Ethiopia, Agriculture-forestry-&-others sector besides its large contribution to the economy did not use much electricity compared to the other two. Hence its electricity intensity value for Ethiopia was relatively insignificant. But for the industry and commercial services, the growth of GDP has direct connection. The government has implemented special self help initiative to assist wide scale establishment of Small and Medium Enterprises within these periods. This initiative consisted of businesses related with commercial services and also small scale cottage industries. These have contributed to an increase in the use of electricity in the commercial & public services Sector and industrial sector[23]. The total effect in 2010 was 32.5% compared to the base year. The trend of dominance

[23] The researcher assumed that electricity intensity in the commercial services sector is relatively less compared to the economic value added by the sector due to the nature of the business activity

by intensity effect in other countries in the study period was also repeated in Ethiopia.

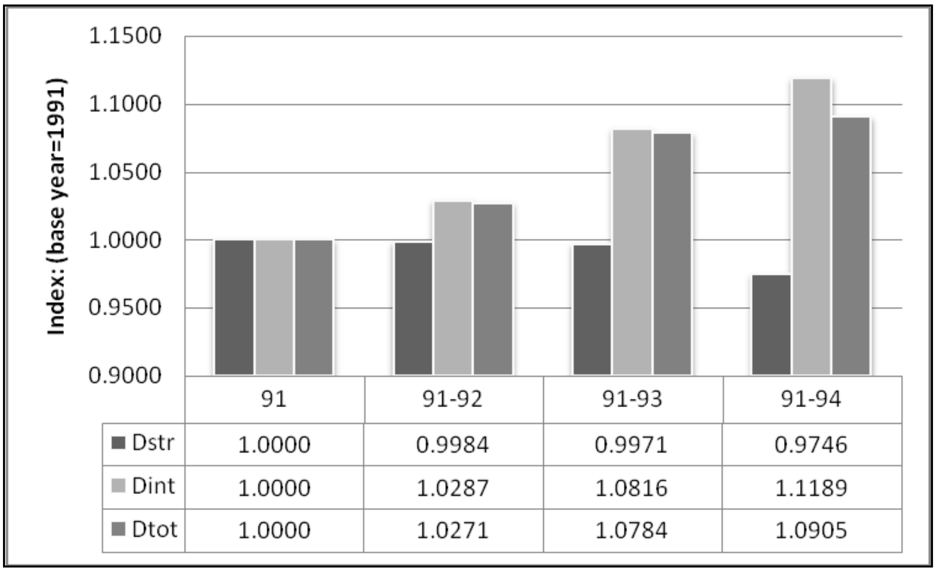
5.6.4. Kenya

The country level analysis for Kenya was split in to three parts because of early mentioned data problem.

a. Kenya (1991 to 1994):

The aggregate electricity intensity in Kenya was 0.253kwh/US$ in 1991 and increased to 0.276kwh/US$ at the end of 1994. The change in aggregate electricity intensity of Kenya was only 9.1% in 1994 compared to the base year. The share of gross value added has increased for the residential sector while the agriculture sector remained same. The Structure share of Commercial and Public Services sectors has increased by small amount while Residential and Industry sectors share decreased in 1994 compared to the base year. The intensity share of all the sectors has increased but the residential sector’s contribution was relatively large followed by industry sector. The change in aggregate electricity intensity of Kenya in 1991-1994 has increased owing to the dominance of the increase by the residential sector’s electricity intensity.

The total electricity intensity for this period has increased significantly. Based on the result of decomposition analysis, structure effect resulted in a 3% decrease in total electricity intensity. But Intensity effect has 11.9% increases in the electricity intensity in 2010.



	91	91-92	91-93	91-94
Dstr	1.0000	0.9984	0.9971	0.9746
Dint	1.0000	1.0287	1.0816	1.1189
Dtot	1.0000	1.0271	1.0784	1.0905

Fig. 5- 11 Decomposition result for Kenya (1991-1994)

The total change during this period was 9.1% mainly due to all the sectors. But, the share of Residential and Commercial & Public services sectors was relatively bigger.

b. Kenya (1995 to 2007)

The aggregate electricity intensity in Kenya for the period 1995 to 2007 was 0.226kwh/US$ and 0.285kwh/US$ respectively. The change in aggregate electricity intensity of Kenya was only 2% in 2007 compared to the base year. Though all sectors Gross value increased, only the share of the commercial and Public services sector has increased. The agriculture, forestry & others and residential sectors share remained the same with the base ear. However, the Industrial sectors share has decreased.

The Structure share of Commercial and Public Services sectors and the Household sector has increased while the Industry and Agriculture sectors structure share has decreased in 2007 compared to the base year. The intensity share of agriculture was very insignificant. The share of remaining three sectors, namely Residential, Commercial and Public Services, and Agriculture sectors have increased but the Residential, and industrial sector's share was relatively large followed by industry sector. Therefore, the change in aggregate electricity intensity of Kenya in 1995-2007 has increased mainly owing to the dominance of the increase by the residential sector and then that of Industrial Sector intensity share. Availability of electricity was affected 1998 and declined up to 2000 by shortage of rain as Kenya has been 57% dependant on Hydropower electricity (Mwangi M., 2005). The total electricity intensity for this period has increased slightly. Based on the result of decomposition analysis, structure effect resulted in a 0.2% increase in total electricity intensity. The Intensity effect has led to a 7% increases in the electricity intensity in 2007.

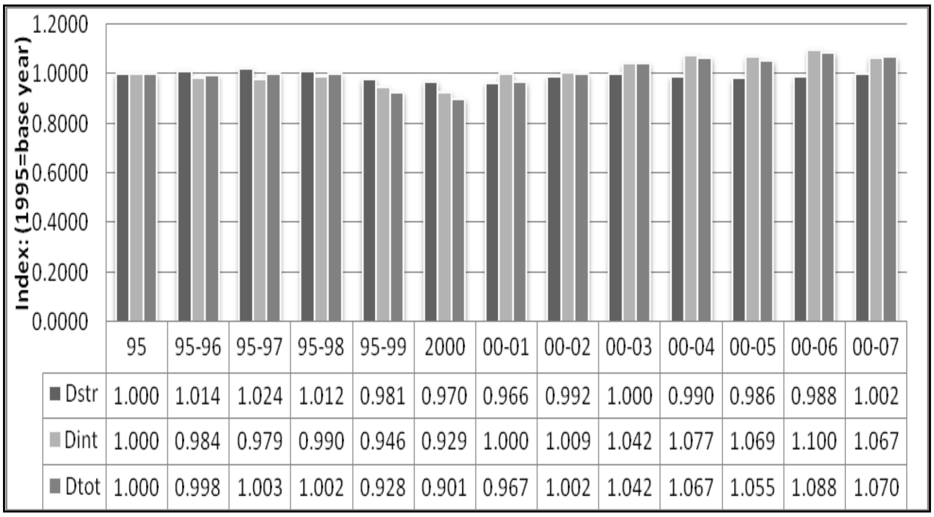


Fig. 5- 12 Decomposition result for Kenya (1995-2007)

Both effects contributed for the increase in the Aggregate electricity intensity in 2007. But the size of Intensity effect was relatively more. The trend that Intensity effect dominated in most part in the study period included Kenya within this time interval. Both the effects show positive change at the end of second period, 2007. The multiplication of the Intensity effect with the Structure effect resulted in an increase of aggregate electricity intensity effect in the study period. But the change was relatively small (Figure 5-9).

c. Kenya (2008-2010)

The aggregate electricity intensity in Kenya for the period 1995 to 2007 was 0.287kwh/US$ and 0.293kwh/US$ respectively. The change in aggregate electricity intensity of Kenya was also 2% in 2010 compared to the 2008. The structure share of Residential and Commercial and Public Services sector has decreased. But the Industrial sectors share remained the same. The intensity share of the residential and industrial sectors increased while that of commercial and Public services sector decreased. But in the intensity share the Industrial sector and Residential sectors intensity effect increased. But since the structure share of residential decreased, the increase in electricity intensity is affected more by the industrial sector in 2008-2010. The dominant sector in affecting the change in electricity intensity in Kenya was Residential sector followed by industrial sector for the period 2008-2010.

Therefore, the change in aggregate electricity intensity of Kenya in 2008 to 2010 has increased mainly owing to the dominance of the increase by the Residential sectors intensity share.

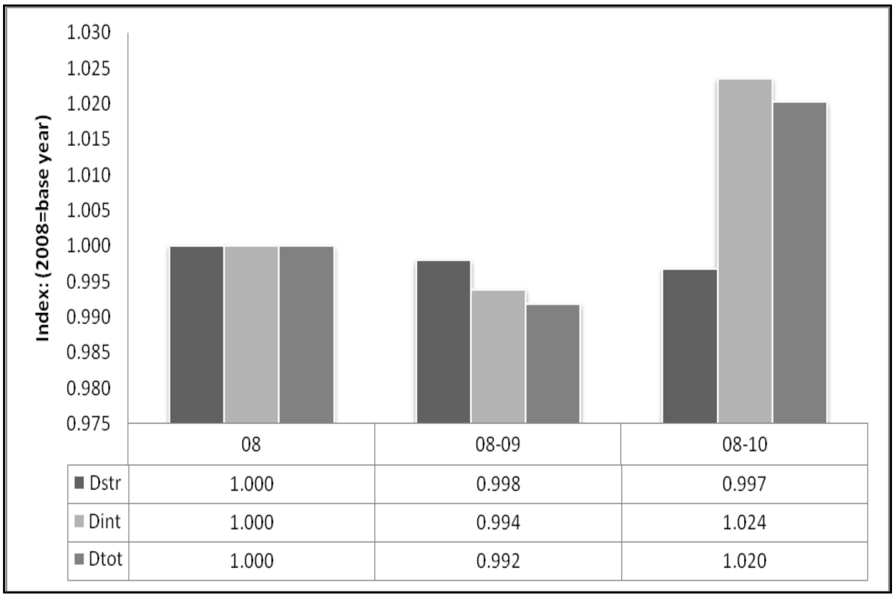


Fig. 5- 13 Decomposition result for Kenya (2008-2010)

Based on the result of decomposition analysis, structure effect resulted in a 0.3% decrease in total electricity intensity. The Intensity effect has led to a 2.4% increases in the electricity intensity in 2010 compared to 2008. The intensity effect dominated and the total change in electricity intensity was 2% in 2010 (Fig.5-10). In Kenya, throughout the whole study period the dominant sector in contributing to the change in Electricity intensity was the residential sector.

5.6.5. Sudan

Aggregate electricity intensity in Sudan has exhibited unique change beginning from 1998 to 2000. It has shown major decrease in 1998 as low as

0.073 kwh/US$ below the original value. But beginning from 2001, has increased up to the final year of the study period. It was 0.102kwh in 1991 and increased to 0.175kwh/US$ at the end of study period, 2010. The change in aggregate electricity intensity for Sudan was intermittent and somehow periodical. Compared to the base year, the change for the whole study period was very insignificant amount, 0.073kwh/US$ or 69% of the base year value.

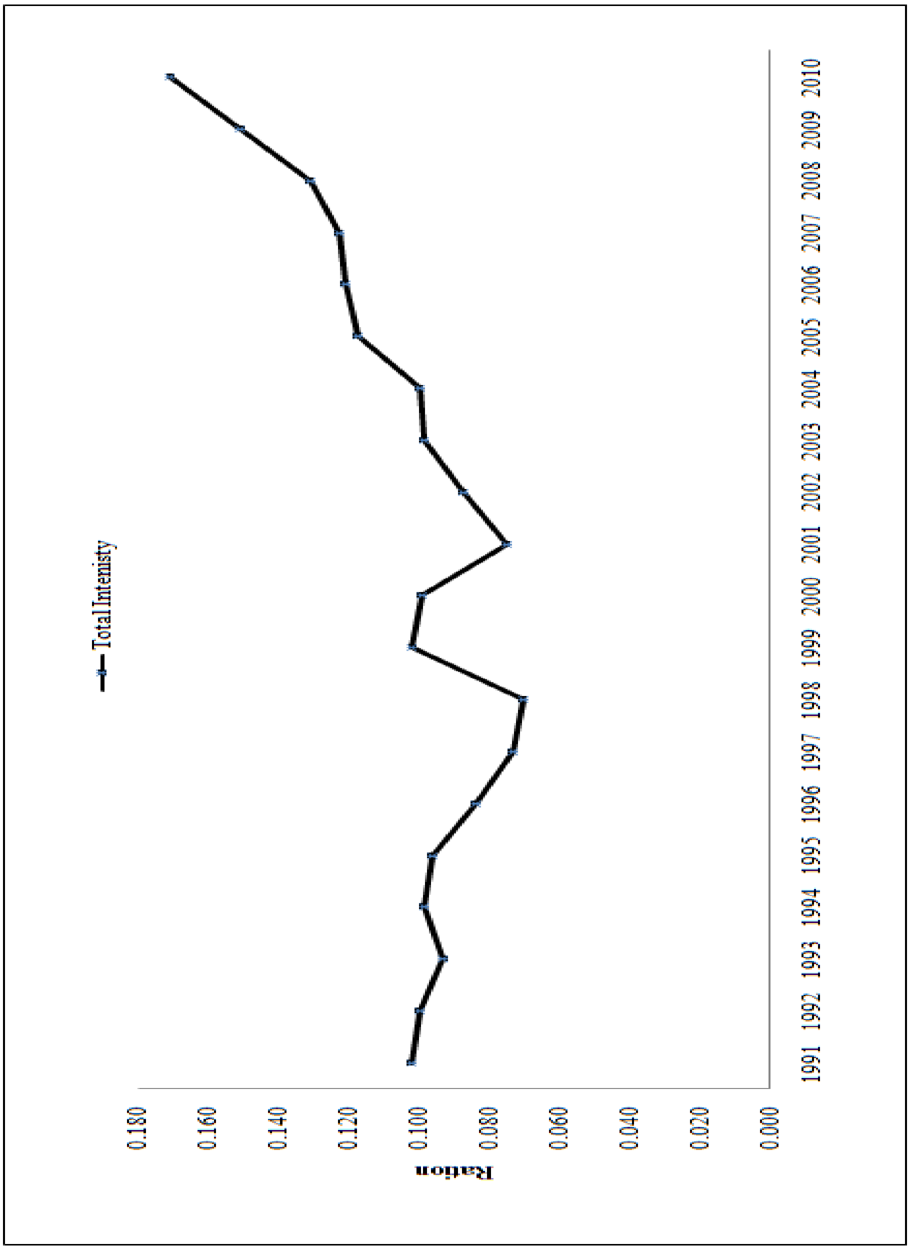


Fig. 5- 14Aggregate Electricity Intensity for Sudan (1991-2010)

The unique value in Sudan's aggregate electricity intensity between 1998 and

2001 was probably attributed to the beginning of oil exportation where the income of the people increased to connect to the grid and also to use more appliances in their premises. Moreover, there has been large number of Migrants flowing to the country due to job opportunity created due to the new oil business (HCENR[24], 2013).

The electricity use on the aggregate level has been growing up to the end of the study period except between 1998 and 2001. It was growing faster and smooth within the range of these three years. The electricity consumption compared with the Gross value added was relatively slow. The share in Gross value added of Industrial sector increased in 2010 while the other sector's share decreased.

[24] Higher Council for Environment and Natural Resources (HCENR)

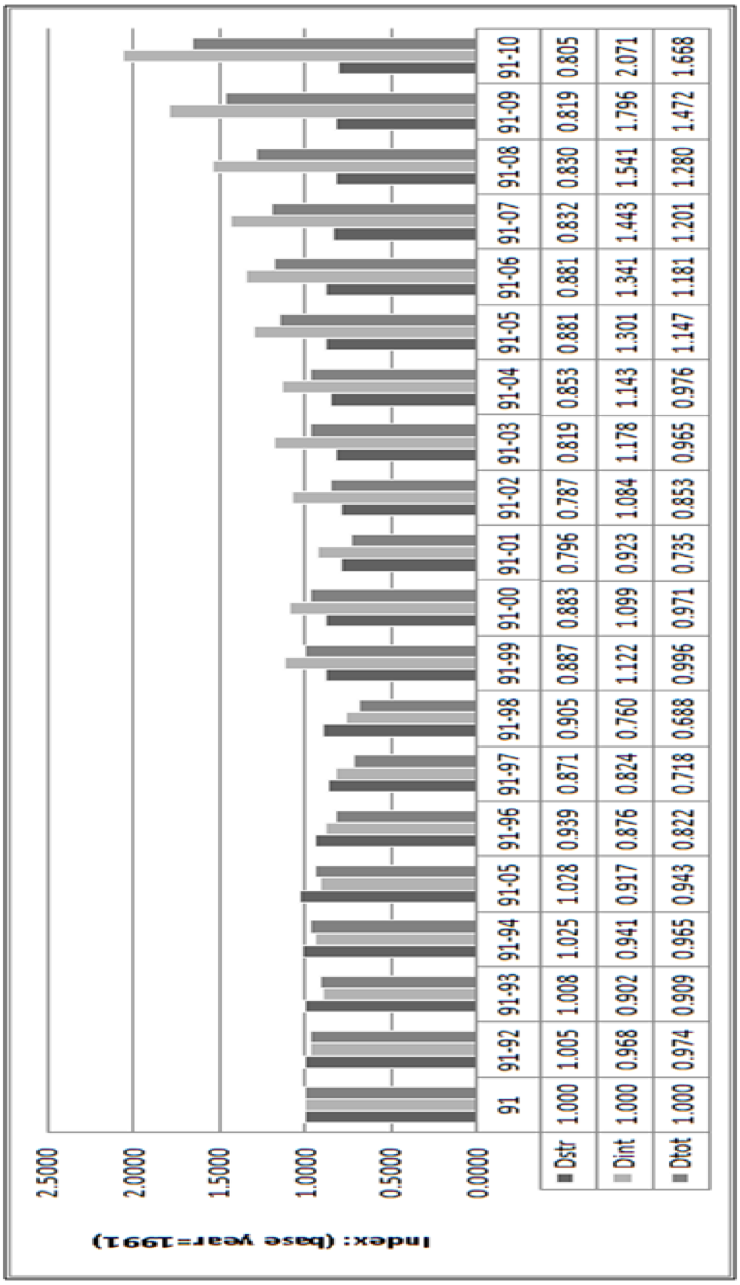


Fig. 5- 15 Decomposition Result for Sudan (1991-2010)

The result of decomposition analysis of the Aggregate Electricity intensity in Sudan shows that Intensity effects have increased by 107% compared to the base year. But the structure effect decreased by 20% only. The net effect of both was that the aggregate electricity intensity has increased from the 1991 by 66.8% in 2010. But when reviewed in detail, the Structure effect was relatively larger than the intensity effect until 1998. Further, the two effects change slowly in their respective direction with slight difference till at 1995. After this, the intensity effect starts to decrease while the Structure effect increases small dimension compared with the former trend. Beginning at 1999 intensity effect continuously took the dominant position.

The overall trend in Sudan was that Intensity effect dominated most cases. Both effects exhibited opposite direction of change. The volume of electricity used for producing a Gross value added of 1US$ worth in 1991 was 66.9% less compared to the current year (Figure 1-13). Sudan became the third country in which the Intensity effect contributed to more to the overall change compared to the Structure effect. So, it took the lead with a significant contribution like in the case of DRC, Egypt, and Ethiopia. The probable cause of the large electricity intensity value was the economic change due to the oil production in the country.

5.6.6. Tanzania

The aggregate electricity intensity in Tanzania was 0.257kwh/US$ worth in 1991 and has increased to the level of 0.389kwh/US$ at the end of study period, 2010. The change in aggregate electricity intensity of Tanzania was very intermittent increasing up to 1996 (Figure 5-13). This kind of fluctuation continued with decreasing direction up to 1999 and then followed very small change up to 2002. Intensity value increased beginning in 2003 and continued up to the end of study period.

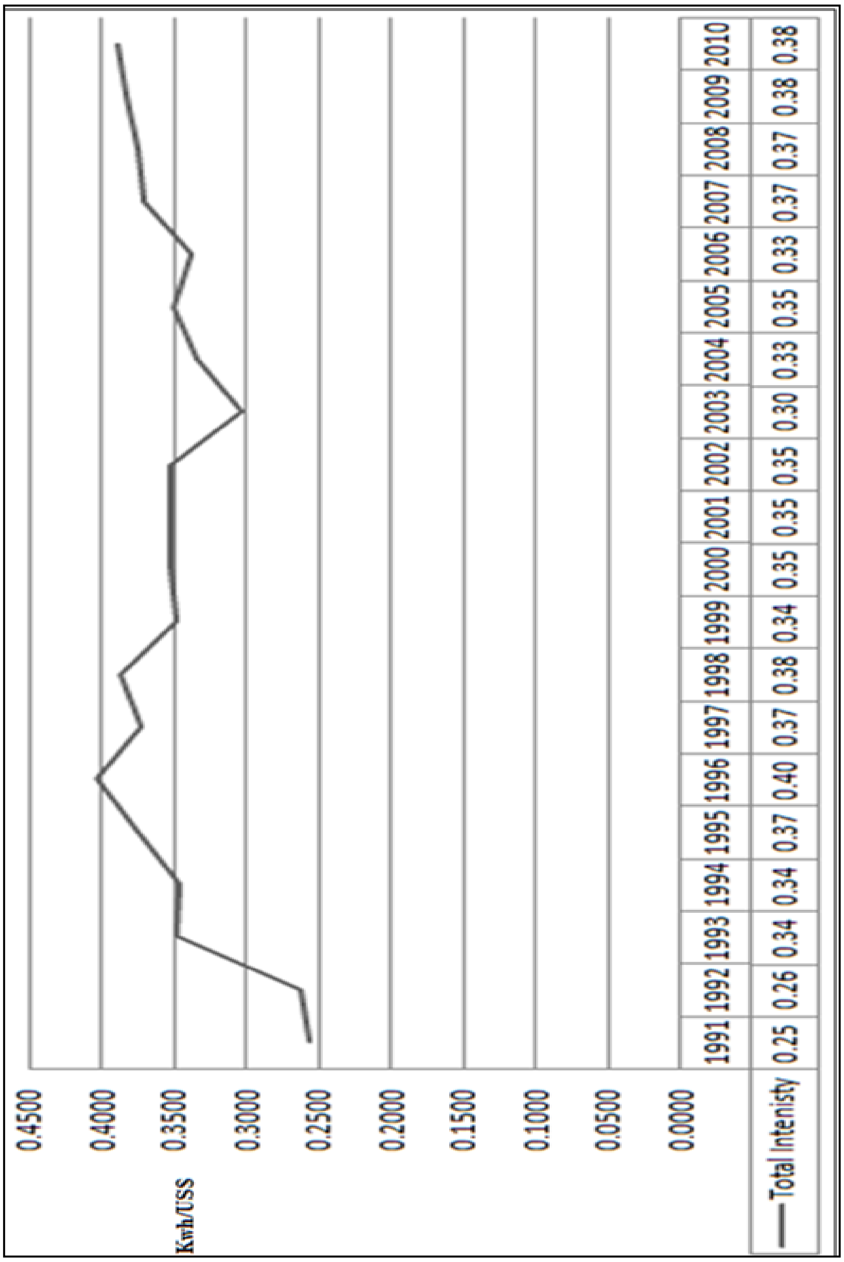


Fig. 5- 16 Aggregate Electricity intensity for Tanzania 1991-2010

Compared to the base year, the electricity intensity for Tanzania has increased by 51% in 2010. In terms of Activity share no change for residential sector. But for it increased for the industrial sector and decreased for the Agriculture forestry and others sector. Structure share of Residential & Industry sector increased but for agriculture it decreased. The case of dominance of industrial sector can be argued by using the following evidence.

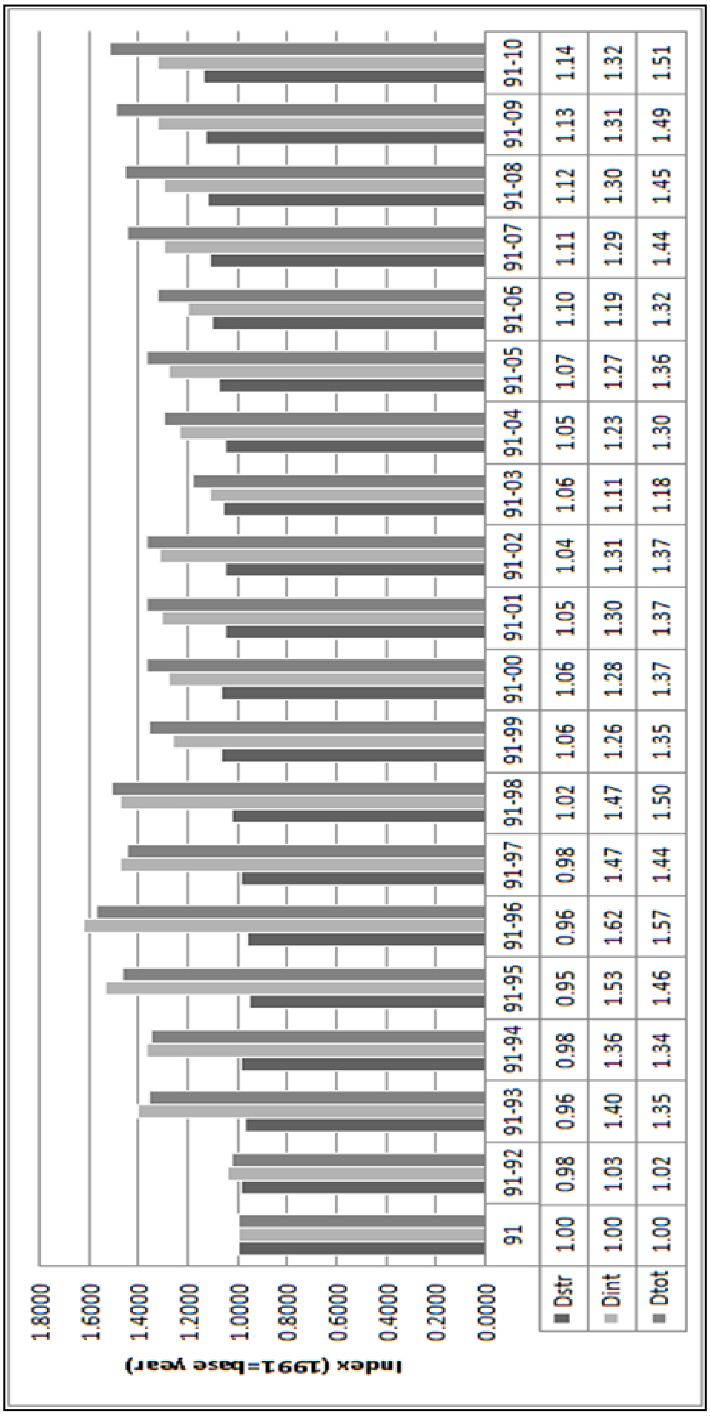
In Tanzania, the late 1990s and early 2000s were known to be periods of major increase and diversification of output and exports respectively (PapageorgiouChris & SpatafiraNikola, 2012). According to the Authors, Tanzania experienced strong growth in the mining, manufacturing, construction and services sectors due to market oriented economic reform. Papageorgiou Chris & Spatafira Nikola (2012) stated that the main reason for the growth of the economy was diversification.

The export items & Services in this period in Tanzania were found to be mainly tourism, manufacturing, minerals, and traditional exports while the share of traditional agriculture decreased. Among these the Manufacturing sector and partly mining sectors are the most likely candidates for using electricity as an input in their production process.

The manufacturing value added in Tanzania has shown significant growth between 2000 and 2010 (Ministry of Industry and Trade of the United Republic of (MIT) & UNIDO, 2012). According to MIT & UNIDO (2010)

Manufactured trade begun to increase in Tanzania beginning from 2005 and continued upward till the end of 2010. Tanzania's performance in manufacturing value added was significant between 2000 and 2010 and it was reflected on the steady GDP growth.

Based on the Index decomposition analysis of the Aggregate Electricity intensity for Tanzania, the Intensity and Structure effects changed in same direction. The trend that Intensity effect dominated in most part in the study period repeated in Tanzania. Compared with the base year, the total intensity effect was 51% of the value in 1991 (Figure 5-14). The structure effect was 14% which is by far less than the intensity effect. But both are on the same direction.



	91	91-92	91-93	91-94	91-95	91-96	91-97	91-98	91-99	91-00	91-01	91-02	91-03	91-04	91-05	91-06	91-07	91-08	91-09	91-10
Dstr	1.00	0.98	0.96	0.98	0.95	0.96	0.98	1.02	1.06	1.06	1.05	1.04	1.06	1.05	1.07	1.10	1.11	1.12	1.13	1.14
Dint	1.00	1.03	1.40	1.36	1.53	1.62	1.47	1.47	1.26	1.28	1.30	1.31	1.11	1.23	1.27	1.19	1.29	1.30	1.31	1.32
Dtot	1.00	1.02	1.35	1.34	1.46	1.57	1.44	1.50	1.35	1.37	1.37	1.37	1.18	1.30	1.36	1.32	1.44	1.45	1.49	1.51

Fig. 5- 17 Decomposition Result for Tanzania (1991-2010)

Hence, the net effect shows us that in Tanzania the volume of electricity used for producing a Gross value added of 1US$ worth was 22.6% in 1991 less compared to the current year (Figure 5-14). The decomposition analysis in this section helped to identify the factors for the pattern and changes occurred in the electricity intensity using the context of each country at aggregate level. The analysis under 5.4.2 to 5.4.7 has brought us one step closer to the knowledge about how electricity use evolved in each country. Also what probable patter will it follow in the short term, since end-use facilities at user's premises do not change overnight. But within the constraint of data limitation, further analysis of sector level use has been attempted in what follows.

5.6 Index Decomposition Analysis of Electricity Intensity by Economic Sector

Electricity consumption data for Economic sectors of the six countries presented in Chapter 4 section 4.2 through 4.7 was found incomplete. Despite data problem, four sectors namely, Agriculture-Forestry-&-others, Industry, Commercial and Public Services, and Residential Sectors were covered in the study.

The major data problem was missing electricity consumption data in some years from some sectors and occurrence of outlier with some data type. Due to these reasons, data were cleared and grouped in parts for the Agriculture-Forestry-&-others and Commercial & Public Services sectors (see Table 5-26). Whereas, only the Industry and Residential Sectors' electricity consumption data were found relatively in a good condition for running the analysis at the six countries level if need arises. Also, in terms of the volume of Electricity Consumption, Industry and Residential sectors take higher share compared to the Agriculture-Forestry-&-Others and commercial & Public Services Sectors. Due to the above reasons, i., e., because there was difference in data availability among countries for two of the sectors, running decomposition analysis using aggregation data of the six countries was not possible. Hence, the analysis continued with the sectors electricity intensity across the six countries, as specified in the table 5-11 below using the algorithm in the flow chart (Fig. 5-18).

(Step-1) Variables & Data Identification ↓ (Step-2) Intensity & Structure Share derivation ↓ (Step-3)Intermediate value determination ↓ (Step-4 Index calculation ↓ (Step-5) Visualization ↓ (Step-6)Description of Results ↓ (Step-7)Analysis of Results	<u>Step-1</u>: Electricity Consumption (GWH), Gross Value Added (at factor cost in Million US$ constant 2005 US$) total data for the six countries <u>Step-2</u>[25]: determine Structure share (Sector GVA /Total GVA across six countries) and the Electricity Intensity (GWH/US$) <u>Step-3</u>[26]: 1. $S_i^0 * I_i^T$ 2. $S_i^T * I_i^T$ 3. $S_i^0 * I_i^0$ 4. $S_i^T * I_i^T$ Step-4: The structure effects, $D_{Str} = \sqrt[2]{\left(\frac{\sum_i S_i^T I^0}{\sum_i S_i^0 I_i^0}\right) * \left(\frac{\sum_i S_i^T I_i^T}{\sum_i S_i^0 I_i^T}\right)}$ Intensity effects, $D_{Int} = \sqrt[2]{\left(\frac{\sum_i S_i^0 I^T}{\sum_i S_i^0 I_i^0}\right) * \left(\frac{\sum_i S_i^T I_i^T}{\sum_i S_i^T I_i^0}\right)}$ (D_{tot}) Total effects is simply "Structure effect" x Intensity Effect (D_{res})Residual Value is determined. Dact/D_{tot}

Fig. 5- 18 Flow Chart for IDA by total consumption of six EAPP countries

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25 GVA stands for Gross Value Added.

26 $S_i^0 I_i^0$ is base year structure share times electricity Intensity of country (i); $S_i^T I_i^T$ is final Year Structure share structure share times electricity Intensity of Country (i); $S_i^0 I_i^T$ is final year Structure share in base year times Electricity Intensity in the; $S_i^T I_i^0$ is Structure share in the final year times Electricity Intensity in the base year. The first half of the algorithm for determining structure effect stands for Laspeyers Structure effect and the second half of the same algorithm stands for the Passche Index Structure effect. The multiplicative result of the square root of the Laspeyer's structure effect and Paashe's Structure effect gave us Fisher Ideal Index Structure effect. Same way the Intensity effect was calculated.

Table5-9 summary description about Sector Level Data problem

Sector	Division of data period
Agriculture-Forestry-&-others Sector	1) 1991–1994 (5 countries): DRC, Egypt, Ethiopia, Sudan, Tanzania 2) 1995–1999 (6 countries): DRC, Egypt, Ethiopia, Kenya, Sudan, Tanzania 3) 2000–2007 (5 countries): Egypt, Ethiopia, Kenya, Sudan, Tanzania 4) 2008–2010 (4 countries): Egypt, Ethiopia, Sudan, Tanzania
Industry Sector	1991-2010 (all 6 countries) DRC, Egypt, Ethiopia, Kenya, Sudan, Tanzania
Commercial & Public Services Sector	1)1991-1999 (4 countries) Egypt, Ethiopia, Kenya, and Sudan. 2) 2000-2010 (5 countries) DRC, Egypt, Ethiopia, Kenya, and Sudan
Household Sector	1991-2010 (all 6 countries) DRC, Egypt, Ethiopia, Kenya, Sudan, Tanzania

In this section, the aggregate electricity intensity of each sector across the six countries was decomposed in to Structure and Intensity effects. First, the two effects on the sector's electricity intensity were compared between each other across the board and the net effect was determined[27]. Based on the net effect in each of the sectors, it was possible to tell the required change in the volume of

[27] Had it been that the entire sectors have complete data set, it would have been possible to do the comparison across sectors. But it was not reasonable to do such comparison at the moment be cause of data deficiency.

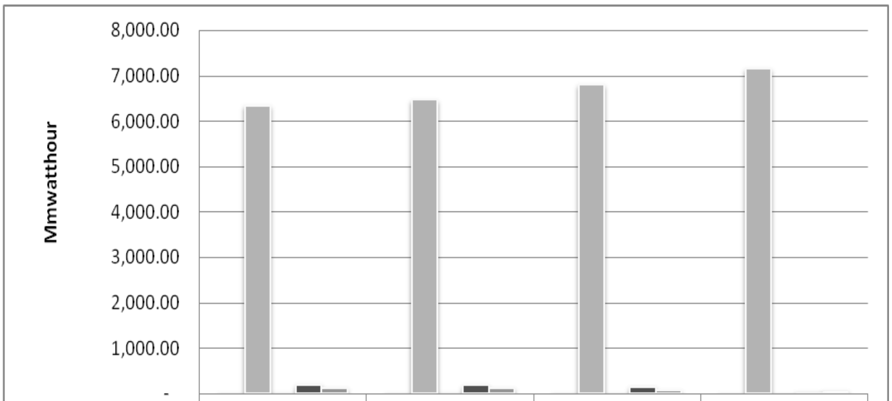
electricity intensity or the amount of electricity needed per unit of economic value added in this specific sector in each country.

For instance, assume Agriculture was the dominant economic activity in a particular country in a group of countries. Also let the net effect of decomposition analysis of the aggregate electricity intensity of agriculture across all the countries was dominated by increasing structure effect. Then, the volume of electricity used in the agriculture sector of that country increases in proportion to the intensity share of the country compared with the remaining countries.

If the sector is the larger consumer of electricity in that specific country, then the volume of electricity required will be relatively higher. At the same time, if the intensity effect dominated and the change was positive, still the need for electricity by this country will be greater because existing businesses increased the ratio of their electricity use per US $ equivalent of the economic value added. If the country used relatively small size of electricity for the sector, then whatever the change in direction and dimension of the effect would be, the impact remains insignificant.

5.7.1. Agriculture, Forestry, & others Sector

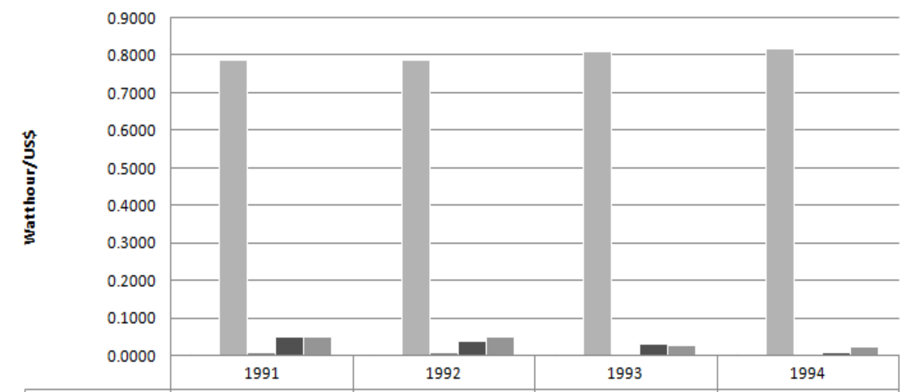
The electricity consumption of the agriculture sector in the five countries in these three years shows that Egypt took the dominant share. Also the consumption volume for the country increased throughout the four years. Among the remaining four countries, Tanzania follows Sudan in terms of volume of consumption. Then, Ethiopia and DRC were almost consuming closely similar volume of electricity (Figure 5-15).



	1991	1992	1993	1994
Congo, Dem. Rep.	15.00	15.00	12.00	10.00
Egypt, Arab Rep.	6,341.00	6,464.00	6,803.00	7,149.00
Ethiopia	15.00	17.00	10.00	8.00
Sudan	191.00	183.00	151.00	35.00
Tanzania	124.00	123.00	71.00	59.00

Fig. 5- 19 Agriculture Sector Electricity Consumption in Five EAPP Countries (1991-1994)

The Electricity Intensity also followed the trend in the Gross Value added. In terms of electricity intensity also, Egypt dominated. But the rate of increase was slow compared with that of consumption. Next to Egypt in terms of electricity intensity, Tanzania and Sudan followed. This case was the reverse of the Electricity consumption case. DRC and Ethiopia still stayed almost paired.

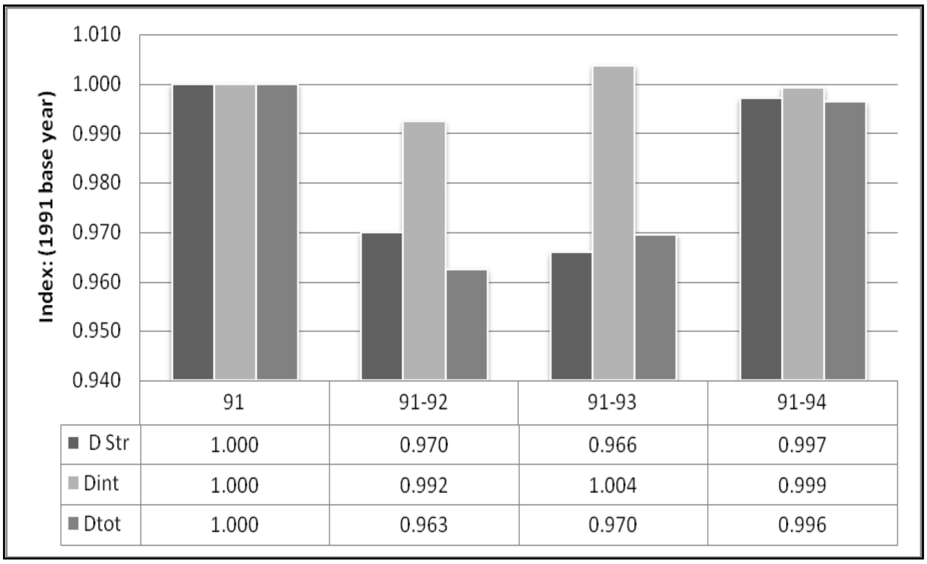


	1991	1992	1993	1994
D.R.C.	0.0046	0.0045	0.0035	0.0029
Egypt, Arab Rep.	0.7873	0.7872	0.8083	0.8181
Ethiopia	0.0044	0.0051	0.0028	0.0023
Sudan	0.0491	0.0378	0.0307	0.0074
Tanzania	0.0505	0.0495	0.0277	0.0225

Fig. 5- 20 Electricity Intensity for Agriculture Sector (1991-1994)

Except for Egypt, the Intensity values decreased from the base year level. Especially, the value for Sudan exhibited relatively significant decrease. It was 0.0491Kwhr/US$ in 1991 and decreased to 0.0074kwhr/US$ in 1994. Relatively large change was observed from 1993 to 1994.

The Index decomposition analysis of Agriculture-Forestry-&-others sector for 1991 to 1994 shows that both Intensity and Structure effects of Aggregate electricity intensity decreased. The Structure effect was 0.3% whereas Intensity effect was 0.1% less than the base year value. Here the decrease was dominantly by the Structure effect (Figure 5-29). As could be deduced from the figure, the Structure effect in the Agriculture sector resulted in decrease in electricity for 1 US $ equivalent of value added by the sector 0.3% in 1994 compared with the 1991 amount. At the same time the Intensity effect has also led to a decrease in the volume of electricity use in the agriculture sector though the volume was very small.

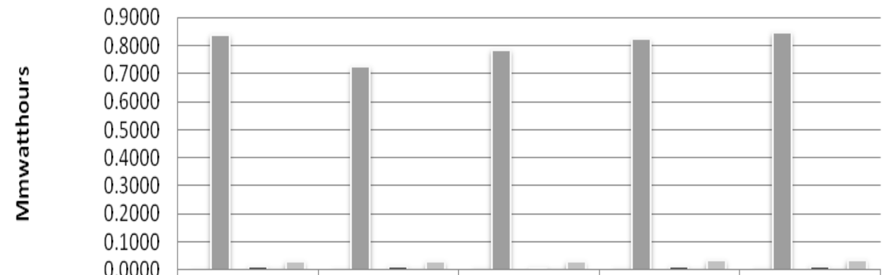


	91	91-92	91-93	91-94
D Str	1.000	0.970	0.966	0.997
Dint	1.000	0.992	1.004	0.999
Dtot	1.000	0.963	0.970	0.996

Fig. 5- 21 Agriculture-Forestry-&-Others Sector Decomposition Result (1991-1994)

The net effect was a decrease in aggregate electricity intensity by 0.4% compared to the base year, 1991. In this analysis the change in the aggregate electricity consumption affects mainly Egypt compare to others. Even though the value is same for all of the countries, the share of intensity for Egypt is greater. Tanzania and Sudan follow in their respective order.

Part two of the Agriculture Sector analysis Covers the years 1995 to 1999. All of the six countries were included in the analysis. This part could be possible candidate for comparing across sectors because of full data availability (Figure 5-30).

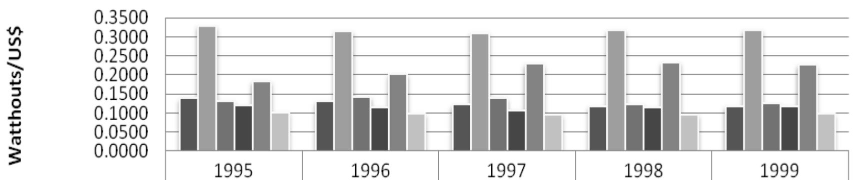


	1995	1996	1997	1998	1999
D.R.C.	0.0026	0.0039	0.0040	0.0040	0.0042
Egypt, Arab Rep.	0.8392	0.7237	0.7857	0.8217	0.8472
Ethiopia	0.0022	0.0019	0.0019	0.0023	0.0025
Kenya	0.0135	0.0138	0.0082	0.0126	0.0141
Sudan	0.0066	0.0054	0.0051	0.0055	0.0056
Tanzania	0.0303	0.0299	0.0302	0.0346	0.0368

Fig. 5- 22Electricity Consumption in Agriculture (1995-1999)

The dominant country in Electricity use was Egypt. It remains always the dominant in this study mainly because of the size of its total consumption. Tanzania was the second but with comparatively low level compared with Egypt. Then Kenya and Sudan follow in the order of importance. DRC and Ethiopia used relatively small amount of electricity among all.

The electricity intensity trend was also almost similar with the consumption trend, Egypt taking the leading position with highest electricity intensity. The other five countries also remained in the same position as it was with their electricity consumption level.



	1995	1996	1997	1998	1999
D.R.C.	0.1380	0.1306	0.1215	0.1180	0.1171
Egypt, Arab Rep.	0.3279	0.3131	0.3097	0.3163	0.3176
Ethiopia	0.1310	0.1422	0.1388	0.1236	0.1240
Kenya	0.1190	0.1151	0.1067	0.1139	0.1184
Sudan	0.1831	0.2018	0.2282	0.2324	0.2262
Tanzania	0.1010	0.0972	0.0952	0.0956	0.0966

Fig. 5- 23 Electricity Intensity for Agriculture Sector (1995-1999)

The electricity intensity values in 1999 have decreased a little compared to the value in 1995 except in Sudan where it shown slight increase. (Figure 5-31)

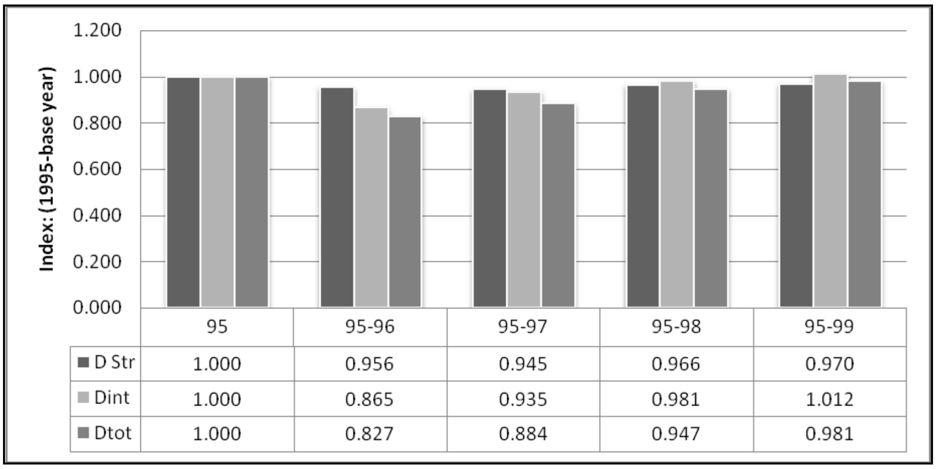
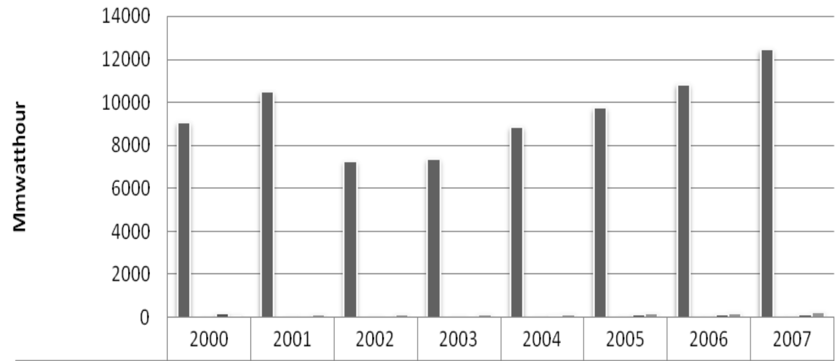


Fig. 5- 24 Decomposition result for Agriculture (1995-1999)

Decomposition result of the aggregate intensity shows a net reduction of 1.9%. This value shows that the amount of electricity needed for 1 US$ worth of gross value added has decreased by 1.9%. The Structure effect in 1999 was 3% less from its 1995 value. On the other hand, the Intensity effect was higher by 1.2% compared to the value in 1991. In the Agriculture sector the Structure effect was dominant in this period (Figure 5-32).

Part three of Agriculture Sector analysis covers the years 2000 to 2007. The dominant country in Electricity use in here also continued to be Egypt (Figure 5-34). Even the trend of the total electricity use was guided most by the value for Egypt than any other country in the domain.

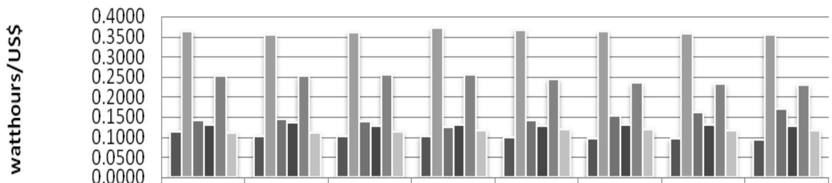


	2000	2001	2002	2003	2004	2005	2006	2007
Egypt, Arab Rep.	9057	10472	7247	7361	8853	9735	10,835.	12,449.
Ethiopia	12	14	19	23	32	35	53.00	46.00
Kenya	33	36	38	38	38	47	42.00	37.00
Sudan	194	48	28	15	105	131	124.00	116.00
Tanzania	105	127	133	145	161	185	204.00	231.00

Fig. 5- 25 Electricity Consumption in Agriculture Sector (2000-2007)

Though the figures were small, the ranking among the countries in terms of volume of electricity use has shifted compared with part two. Tanzania remained second, as usual at a low level compared with Egypt at the end of this period. Sudan, Ethiopia, and Kenya follow in respective order of the size of consumption. Ethiopia and Kenya used relatively small amount of electricity among all for the agricultural sector (see table 5-33).

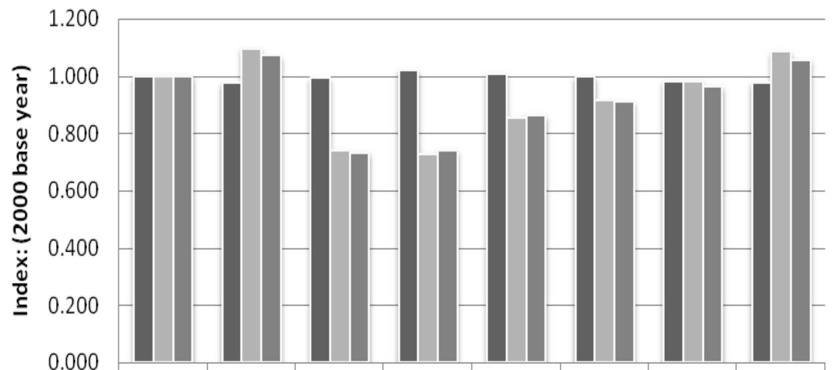
The electricity intensity trend has shown some change compared with the consumption trend, Egypt remaining as leader with highest electricity intensity. Among other five countries, Sudan took second position while the remaining order being Ethiopia, Kenya, Tanzania, and DRC. The electricity intensity values have increased except in Sudan and Kenya (see fig. 5-22).



	2000	2001	2002	2003	2004	2005	2006	2007
D.R.C.	0.1145	0.1036	0.1021	0.1028	0.0995	0.0979	0.0963	0.0953
Egypt, Arab Rep.	0.3637	0.3550	0.3608	0.3713	0.3672	0.3625	0.3567	0.3544
Ethiopia	0.1416	0.1460	0.1406	0.1252	0.1408	0.1529	0.1616	0.1695
Kenya	0.1294	0.1360	0.1288	0.1312	0.1284	0.1313	0.1307	0.1282
Sudan	0.2536	0.2527	0.2562	0.2556	0.2446	0.2346	0.2334	0.2307
Tanzania	0.1117	0.1103	0.1137	0.1167	0.1189	0.1187	0.1175	0.1172

Fig. 5- 26 Electricity intensity for Agriculture for Agriculture (2000-2007)

Decomposition of the aggregate electricity intensity shows a net increment by 6% in 2007 compared with 2000. The Structure effect was 3% less in 2007 from its 2000 value (Figure- 5-23). However, the Intensity effect was higher by 8% in 2007 compared to its value in 2000. The net effect was guided by the Intensity effect resulting in an increase of the final aggregate intensity during this period.

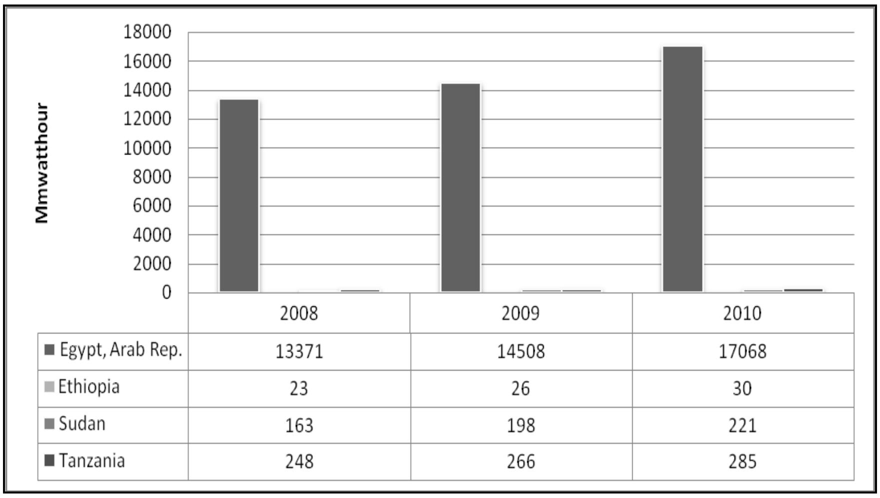


	2000	2001	2002	2003	2004	2005	2006	2007
D Str	1.000	0.977	0.992	1.021	1.009	0.997	0.981	0.975
Dint	1.000	1.096	0.739	0.726	0.856	0.914	0.983	1.084
Dtot	1.000	1.071	0.733	0.741	0.864	0.911	0.964	1.057

Fig. 5- 27 Decomposition result for Agriculture (2000-2007)

The volume of electricity needed for 1 US $ worth of Gross Value Added has increased by 6% in 2007 compared to the value in 2000. In the Agriculture sector, the Intensity effect was dominant in this period (Figure 5-23). The structure effect shows a decrease by 2.5 % in the volume of electricity needed for a US $ worth of gross value added in 2007. The intensity effect shows 8.4% increase in the volume of electricity needed per 1 UD$ worth of gross value added

Part four of Agriculture Sector analysis Covers the years 2008 to 2010. This section of the analysis is relatively short. However, there were two options, either to include or exclude it from the analysis. Excluding was not considered an option since it leads to a loss of some valuable data.

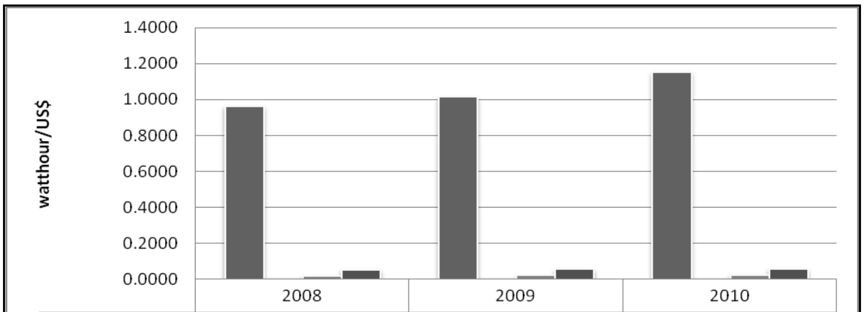


	2008	2009	2010
Egypt, Arab Rep.	13371	14508	17068
Ethiopia	23	26	30
Sudan	163	198	221
Tanzania	248	266	285

Fig. 5- 28 Electricity consumption in Agriculture-Forestry-&-Others Sector (2008-2010)

The electricity consumption in the Agriculture sector during these three years increased in all the countries. Here as well Egypt and Tanzania were leading in the annual size of electricity consumption. Sudan and Ethiopia followed, though with large difference from each other (Figure5-25). The growth trend for Agriculture was unique in that it was continuously up ward slopping more than all other countries. Here also the total electricity consumption of this sector was guided by the electricity use in Egypt. Though the figures were small, the ranking order in these countries on the basis consumption size has shifted compared with the second part. Tanzania remained second, as usual at a low level compared with Egypt at the end of this period. Sudan was in third position followed by Ethiopia. Moreover, the difference in electricity consumption between Sudan & Ethiopia was relatively large.

The electricity intensity trend in Part four of Agriculture sector was almost similar with the consumption trend in part four and even the intensity trend in part three. Egypt and Tanzania continue pairing in electricity intensity. Sudan and Ethiopia also remained in their previous respective position (Figure 5-25).



	2008	2009	2010
Egypt, Arab Rep.	0.9638	1.0137	1.1525
Ethiopia	0.0033	0.0035	0.0039
Sudan	0.0178	0.0209	0.0227
Tanzania	0.0534	0.0555	0.0572

Fig. 5- 29 Electricity Intensity for Agriculture-Forestry-&-Others Sector (2008-2010)

The electricity intensity values have increased in the four countries though the rate of increase was very large in Egypt. The rate of change in the remaining three countries, especially in Ethiopia and Tanzania was very slow. The actual intensity value by itself was very small in Ethiopia compared with other four.

Decomposition of the aggregate electricity intensity in Part four shows a net increment by 18% in 2010 compared with 2008. The Structure effect was less by 1% in 2010 from its 2008 value. However, the Intensity effect was higher by 19% in 2010 compared to its value in 2008. The net effect was guided by the Intensity effect resulting in an increase of the final aggregate intensity by 18 % at the end of this period.

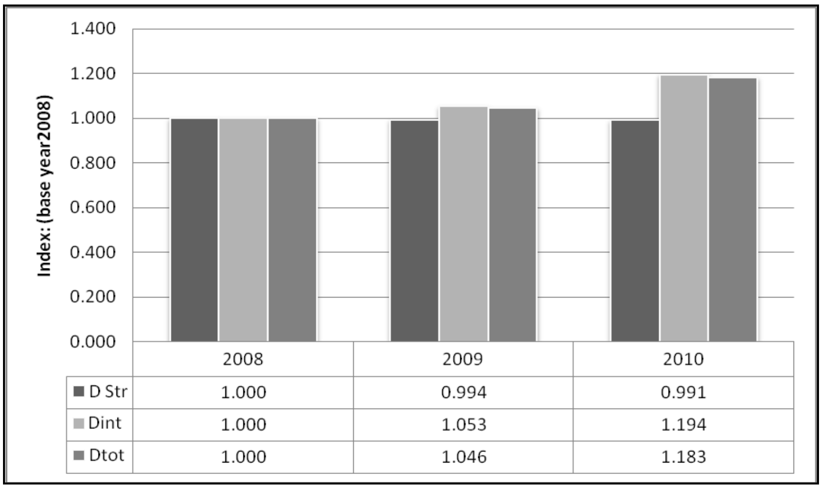


Fig. 5- 30 Agriculture-Forestry-&-Others Sector Electricity intensity Decomposition Result (2008-2010)

The amount of electricity needed for 1 US $ worth of Gross Value Added has been more by 18% in 2010 compared to the value in 2008. In Part four of Agriculture sector electricity Intensity decomposition, the Intensity effect was still dominant (Figure 5-27).

5.7.2. Industry Sector

The analysis for this sector comprised of all the six countries. Intuitively, the industrial sector could be assumed the most important in terms of electricity consumption. But the reader is expected to consider the level of industrialization in these countries. So, all the discussion in this document was in the context of developing sub Saharan African countries. Luckily, there was complete set of data for the industrial sector of each country. Electricity consumption in the industrial sector was dominated by Egypt as it was seen in the Agriculture sector. But the second larger consumer was DRC though its size electricity consumption was not comparable with Egypt. Kenya and Tanzania were the third and fourth level electricity users in the industrial sector in terms of annual volume of consumption (Figure 5-28).

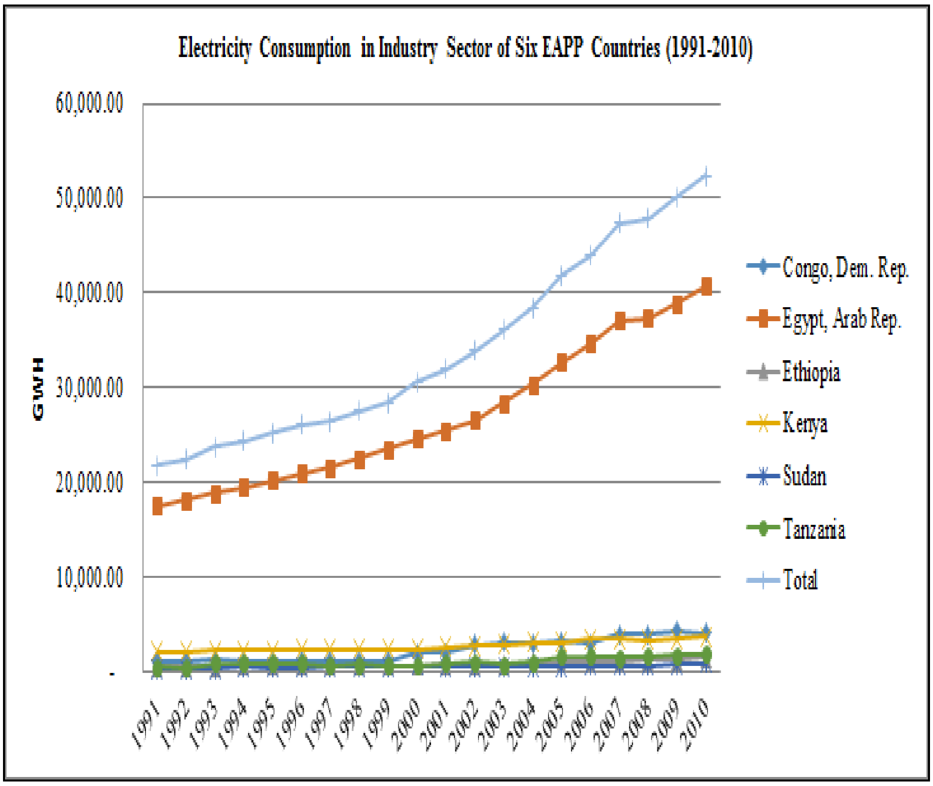
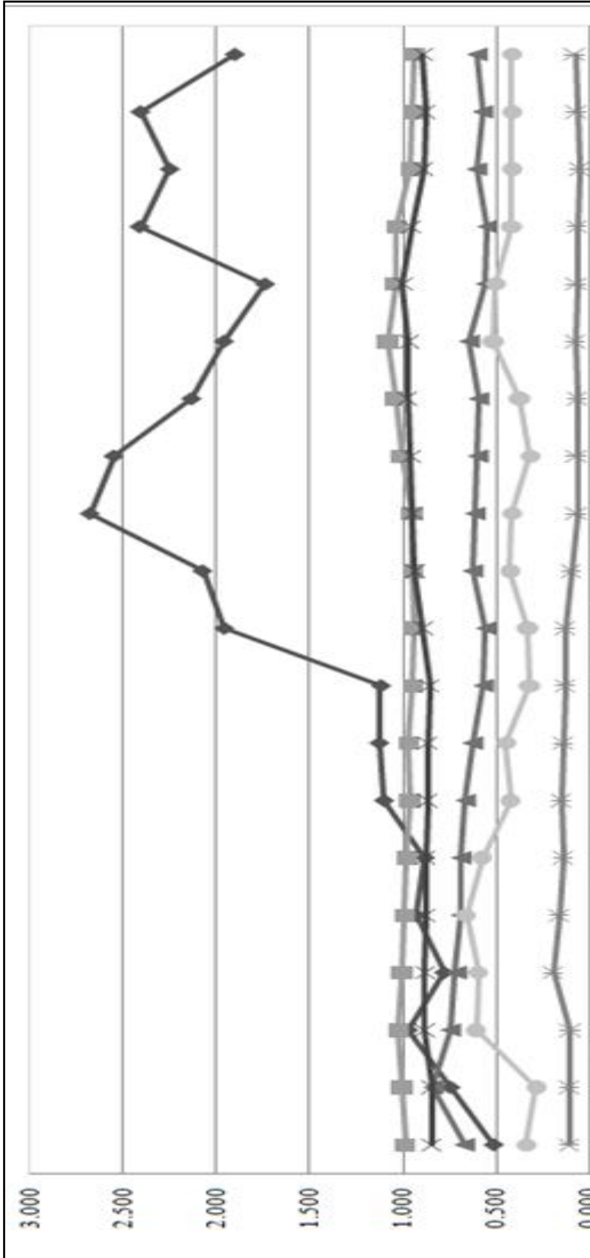


Fig. 5- 31 Electricity Consumption in the Industry Sector of Six EAPP Countries (1991-2010)

There seemed coupling between countries in terms of the size of annual electricity consumption. The size of electricity used in DRC was close to that of Kenya. Same way, the size for Ethiopia was close to the amount in Tanzania. Sudan remains the least consumer of electricity in its industry sector. Kenya compared with DRC has been leading up to 2002. But DRC took the lead up to the end of the study period. DRC exhibited dramatic change beginning from 1999 and at the end of the study period took the leading position next to Egypt.

Unlike the case with the most part of Agriculture sector, the trend of the intensity did not follow the trend of consumption in the Industry sector. The electricity intensity in the Industry sector of these six countries was mostly below 1kwh/US$. But the case with DRC was somewhat odd. It leaped out beginning from 1996 and exceeded the 1 kwh/US$. The fluctuation of the annual increments in DRC was very large between 1999 and 2010. DRC's annual Intensity value reached its climax on 2002. This has some connection with the expansion of the mining sector in DRC around these years. The least intensity value was observed in Sudan and further decreased towards the end of the study period.



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
D.R.C.	0.514	0.746	0.972	0.780	0.930	0.883	1.101	1.126	1.117	1.957	2.073	2.676	2.548	2.132	1.959	1.738	2.409	2.248	2.405	1.900
Egypt, Arab Rep.	0.984	1.004	1.018	1.001	0.988	0.977	0.959	0.964	0.943	0.938	0.941	0.949	1.003	1.039	1.079	1.039	1.031	0.956	0.944	0.935
Ethiopia	0.669	0.837	0.745	0.713	0.690	0.688	0.664	0.627	0.567	0.554	0.627	0.613	0.597	0.593	0.644	0.554	0.546	0.604	0.571	0.602
Kenya	0.846	0.850	0.884	0.884	0.876	0.879	0.868	0.866	0.860	0.893	0.935	0.948	0.960	0.975	0.968	1.001	0.952	0.888	0.874	0.894
Sudan	0.104	0.110	0.102	0.193	0.165	0.143	0.149	0.138	0.132	0.128	0.099	0.069	0.068	0.062	0.070	0.068	0.061	0.053	0.067	0.078
Tanzania	0.336	0.283	0.610	0.597	0.661	0.572	0.421	0.445	0.319	0.331	0.423	0.411	0.315	0.374	0.517	0.500	0.418	0.413	0.414	0.413

Fig. 5- 32 Electricity intensity In the industry Sector (1991-2010)

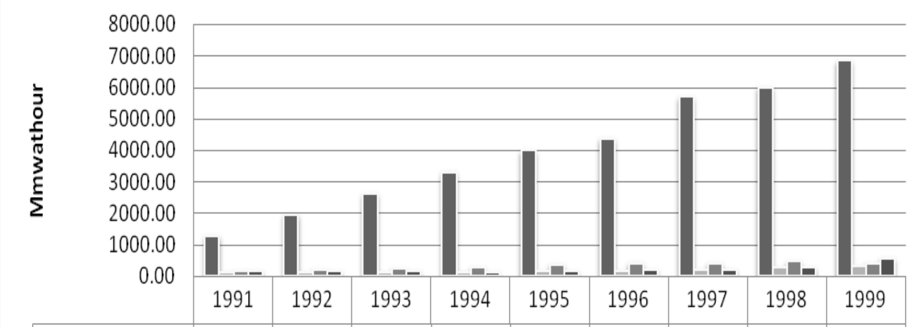
The total electricity intensity value was also below 1kwh/US$ and decreased a little at the end of the study period. DRC, Egypt and Kenya exhibited an intensity value greater than the total while the others below the total value. Towards the end of the study period there seems a sort of grouping between Egypt & Kenya and Between Ethiopia and Tanzania in terms of the intensity value only. DRC and Sudan remained between the two extremes (Figure 5-40). The trend of total electricity intensity was guided by the majority of the countries though the DRC exhibited extreme values. The actual values on electricity intensity can be referred from Appendix -1.

Decomposition of the aggregate electricity intensity in the Industry sector shows a net decrease by 6% in 2010 compared with 1991. The Structure effect was less by 33% in 2010 from its 2000 value. However, the Intensity effect was higher by 40% for the same study period. The decrease in the structure effect was due to decreased share of value added the in industrial sector of Egypt.

In this figure, both Structure and intensity effects brunched out in opposite direction beginning from 1996. The net effect was negative in that the amount of electricity needed in 2010 for 1 US $ worth of Gross Value Added has been less by 6% compared to the value in 1991. In the Industry sector, the Intensity effect was dominant in most of the study period. But towards the last three years the Structure effect dominated (AppendixA-3).

5.7.3. Commercial & Public Services Sector

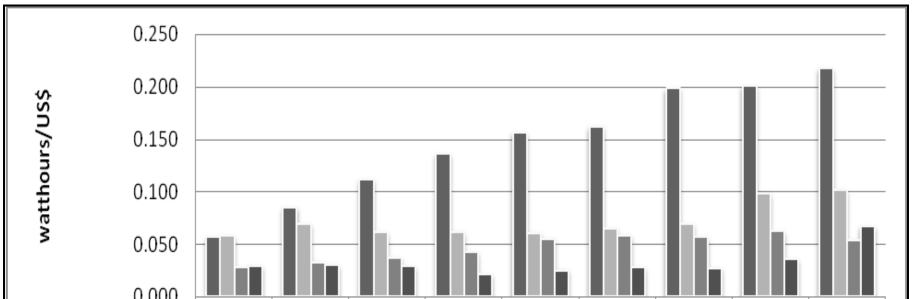
The analysis has two parts. In part one, the electricity consumption in the Commercial and Public Services sector was dominated by Egypt as it was seen in the previous two sectors. But the second larger consumer was Kenya and finally Sudan in 1999(Figure 5-31). The consumption size for Kenya, Sudan, and Ethiopia was closely clustered.



	1991	1992	1993	1994	1995	1996	1997	1998	1999
Egypt, Arab Rep.	1280.80	1957.00	2633.20	3309.40	3985.60	4371.00	5685.00	6001.00	6839.00
Ethiopia	114.00	119.00	123.00	133.00	144.00	168.00	185.00	274.00	304.00
Kenya	166.00	202.00	232.00	273.00	375.00	418.00	414.00	466.00	410.00
Sudan	166.00	159.00	164.00	128.00	152.00	202.00	211.00	280.00	570.00

Fig. 5- 33 Electricity use Commercial & Public Services Sector (1991-1999)

The difference in the size of electricity consumption between these countries and Egypt was very large. Here also, the total electricity consumption was dominated by Egypt's electricity consumption. In this case, all the countries exhibited increasing trend in the electricity intensity in the commercial and Public services sector for 1991-1999. Egypt was dominant in the value of annual electricity use foe economic value added or intensity size as usual. Here Ethiopia was second important in this respect. Sudan and Kenya followed after the two, but Sudan exceeded since 1999. Kenya’s electricity intensity was decreasing starting from 1999. The remaining part of this study revealed the actual result. The intensity value showed large leap for Ethiopia in 1997.



	1991	1992	1993	1994	1995	1996	1997	1998	1999
Egypt, Arab Rep.	0.057	0.085	0.112	0.136	0.156	0.162	0.198	0.201	0.217
Ethiopia	0.058	0.069	0.061	0.061	0.061	0.065	0.069	0.099	0.102
Kenya	0.028	0.033	0.037	0.042	0.055	0.058	0.057	0.062	0.054
Sudan	0.029	0.030	0.029	0.021	0.025	0.028	0.027	0.035	0.067

Fig. 5- 34 Electricity Intensity in the Commercial and Public Services Sector (1991-2010)

Except for an increase in size, the trend of the intensity did not follow the trend of consumption in the commercial and Public services sector. Electricity intensity for the Commercial & public Services sector in these four countries was mostly below 0.1kwh/US$ in except for Egypt and Ethiopia (Figure 5-32). In 1998 the intensity value for Ethiopia stepped on an intensity value of 1. Beginning from late 1992 the value exceeded for Egypt. The remaining two countries stayed below this value. The total electricity intensity value was also way below 0.25kwh/US$ and decreased a little at the end of the study period.

Only Egypt exhibited an intensity value greater than the total value. At the beginning, there was a sort of grouping between Ethiopia & Egypt and between Sudan and Kenya. But as it time passed the grouping started to disappear.

Decomposition of the aggregate electricity intensity in the Commercial and Public Services sector shows very large value for a net increase of 236% in 1999 compared with 1991. This value seems strange and needs further investigation. But probably the intensity value of Egypt might have some contribution. The dominant cause for such increment in the net electricity intensity was the intensity effect with 258% increase in 1999 from its 1991 value. However, the structure effect led to a decrease by only 6% for the same study period. When the Figure is observed the Structure decreased very slightly up to the end of this period. However, the intensity effect brunched upward to the end of 1999. The increment in intensity effect was significant except small fluctuation between 1995 and 1997. The net effect was very big and positive with an increment of the electricity needed in 1999 for 1 US $ worth of Gross Value Added by more than two fold compared to the value in 1991. As discussed earlier, the Intensity effect was highly dominant in most of the study period with bigger effect on the electricity use in the sector. The country which contributed for such change was not yet identified, but the intensity of all the countries have increased significantly. The decomposition result visualized using chart would look like the following (Figure 5-46).

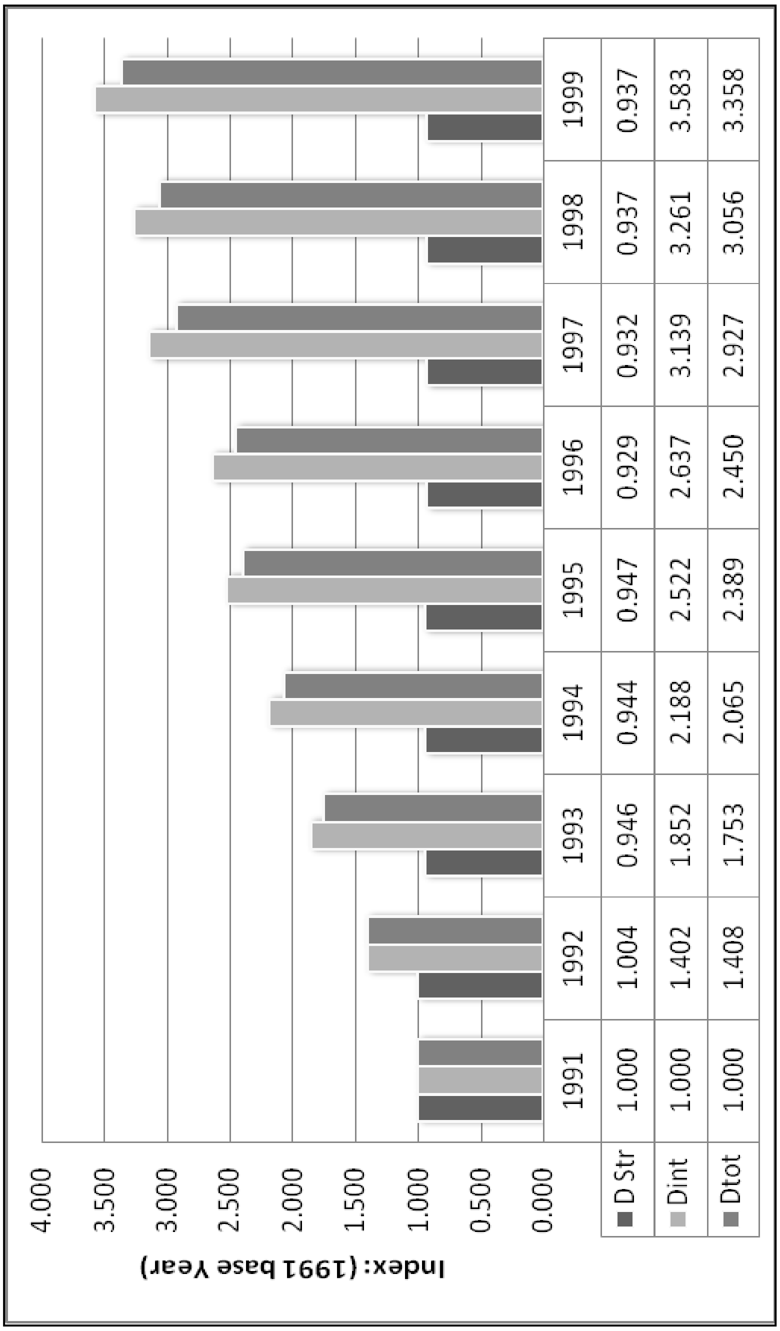
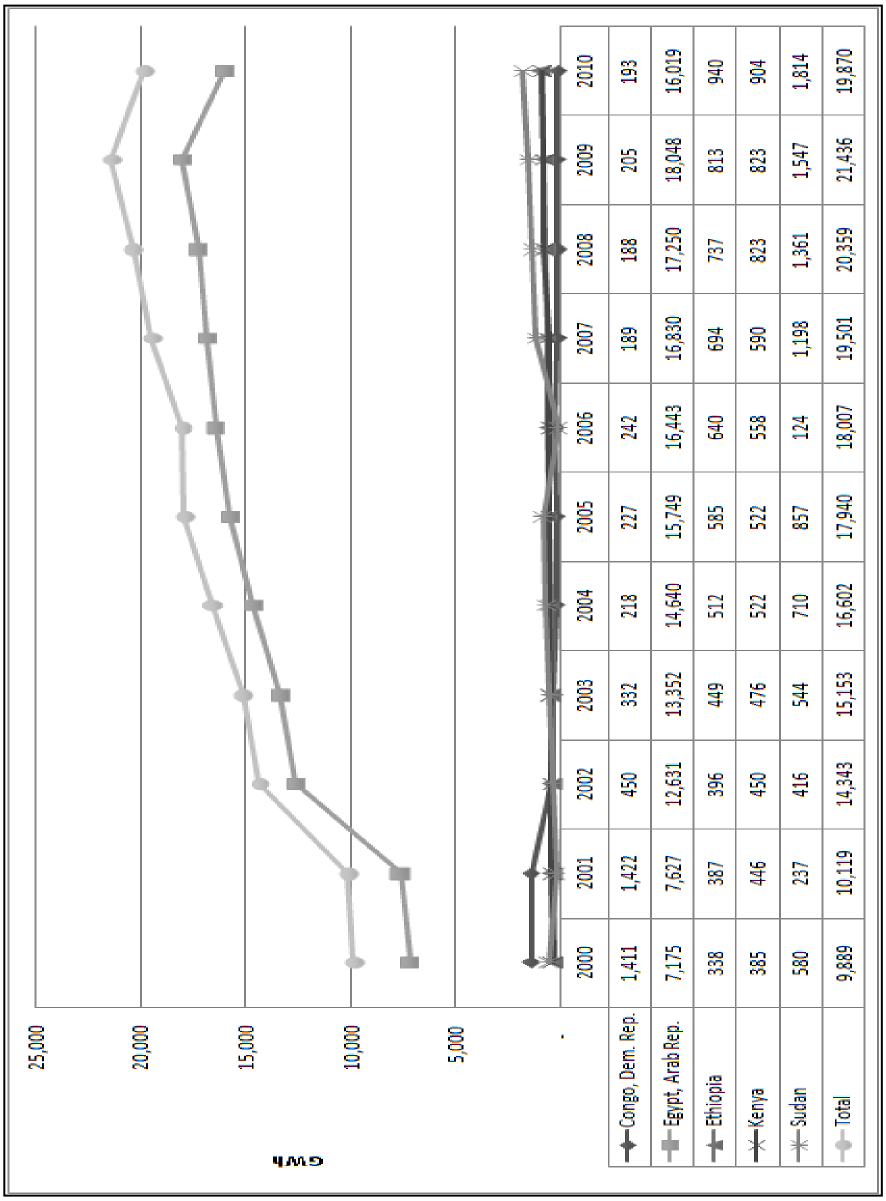


Fig. 5- 35 Decomposition Result for commercial and Public Services Sector (1991-1999)

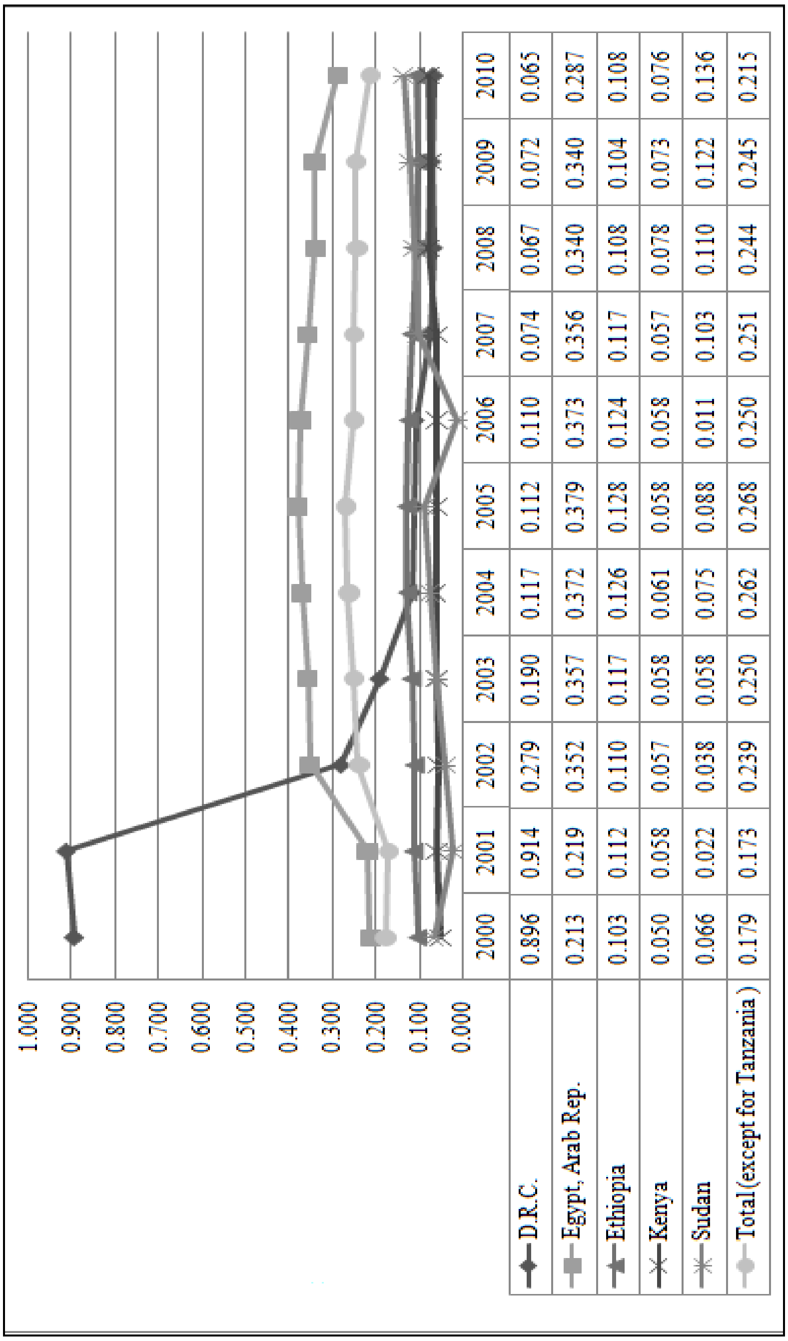
In part two, the electricity consumption in the Commercial and Public Services sector was still dominated by Egypt as it was seen in the previous two sectors and in the first part of the commercial and public services sector. But the second larger consumer was Sudan beginning at 2002 and except 2006 (Figure 5-31). The consumption values for Kenya, Sudan, and Ethiopia was closely clustered. Especially, Ethiopia and Kenya were very close in the electricity consumption pattern from the beginning to the end of the period. At the end, the order goes with Egypt, Sudan, Ethiopia, Kenya, and DRC. But the difference in the size of electricity consumption between these clusters and Egypt was very large as it was observed in the previous sectors.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Congo, Dem. Rep.	1,411	1,422	450	332	218	227	242	189	188	205	193
Egypt, Arab Rep.	7,175	7,627	12,631	13,352	14,640	15,749	16,443	16,830	17,250	18,048	16,019
Ethiopia	338	387	396	449	512	585	640	694	737	813	940
Kenya	385	446	450	476	522	522	558	590	823	823	904
Sudan	580	237	416	544	710	857	124	1,198	1,361	1,547	1,814
Total	9,889	10,119	14,343	15,153	16,602	17,940	18,007	19,501	20,359	21,436	19,870

Fig. 5- 36 Electricity Consumption in Commercial & Public Services Sector (2000-2010)

The trend in total electricity consumption was dominated as it was common by the size of Egypt’s electricity consumption. Except DRC, the remaining countries exhibited increasing trend in the electricity consumption of the commercial and Public services sector for the year 2000-2010. The electricity intensity value in this category has clustered all the countries relatively close to each other. But at the beginning, the value for DRC was very large as recorded by the IEA energy balances report. Starting at 1993 the value decreased by about three fourth compared to the values of the previous two years (Figure 5-46). While this change in the electricity consumption has happened the trend in the Gross value added did not change immediately with the way the electricity use decreased, the intensity value exhibited such a big drop beginning from 2003 onwards.



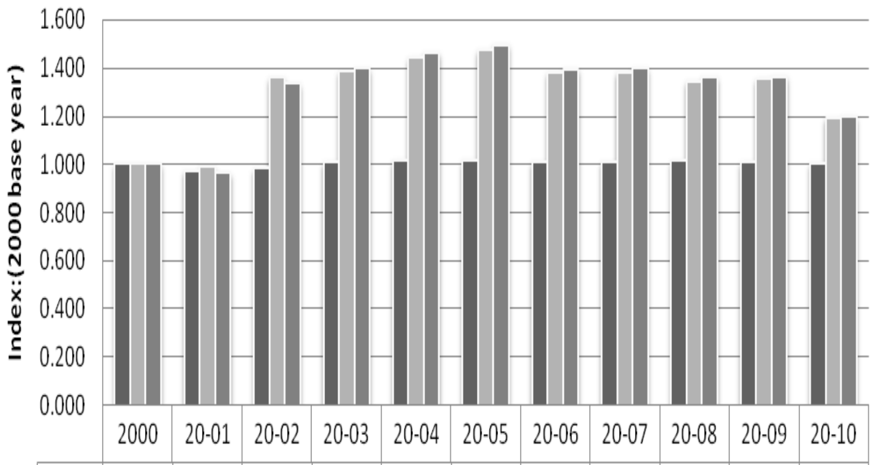
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
D.R.C.	0.896	0.914	0.279	0.190	0.117	0.112	0.110	0.074	0.067	0.072	0.065
Egypt, Arab Rep.	0.213	0.219	0.352	0.357	0.372	0.379	0.373	0.356	0.340	0.340	0.287
Ethiopia	0.103	0.112	0.110	0.117	0.126	0.128	0.124	0.117	0.108	0.104	0.108
Kenya	0.050	0.058	0.057	0.058	0.061	0.058	0.058	0.057	0.078	0.073	0.076
Sudan	0.066	0.022	0.038	0.058	0.075	0.088	0.011	0.103	0.110	0.122	0.136
Total (except for Tanzania)	0.179	0.173	0.239	0.250	0.262	0.268	0.250	0.251	0.244	0.245	0.215

Fig. 5- 37 Electricity Intensity in the Commercial & Public Services Sector (1991-2010)

Final intensity value of DRC was the least among the five countries.

Egypt still remained leader in intensity value. Sudan, Ethiopia, Kenya and DRC exhibited a value in descending order. Kenya and DRC looked paired in an intensity value towards the end of the study period. The total intensity value was 0.215kwh/USD and it was less than the value for Egypt. Here also, the trend in the intensity did not follow the trend of consumption. The electricity intensity for Commercial & public Services sector of these four countries was mostly between 0.066 to 0.213kwh/US$ in the base year and 0.076 to 0.287kwh/US$ at the end of the study period except for the DRC at the beginning. (Figure 5-46).

Decomposition of the aggregate electricity intensity in the Commercial and Public Services sector shows a net increase of 19.6% in 2010 compared with 2000. The increment in the intensity effect was 19.2% while the value for the Structure effect was only 0.4% (Figure). The intensity effect might have affected the net result at the end of the study period. When the Figures are observed in detail, Both Intensity and Structure effects have been more than one most often. But the structure effect has been dominating by the size of annual value. The electricity needed in 2010 for 1 US $ worth of Gross Value Added increased significantly compared to the value in 1991.



	2000	20-01	20-02	20-03	20-04	20-05	20-06	20-07	20-08	20-09	20-10
D Str	1.000	0.974	0.982	1.008	1.015	1.016	1.010	1.011	1.013	1.008	1.004
Dint	1.000	0.988	1.358	1.384	1.441	1.472	1.380	1.382	1.344	1.353	1.192
Dtot	1.000	0.962	1.333	1.396	1.461	1.496	1.394	1.397	1.361	1.364	1.196

Fig. 5- 38 Commercial & Public Services Sector Decomposition Result for the six EAPP countries (2000-2010)

In this category also, Intensity effect was highly dominant in most of the study period with relatively large value on the electricity use in the sector. The influence by Structure effect was not as significant as the intensity effect (Figure 5-47). The influence of the Intensity effect was significant since 2002 and went on slightly declining at the end of the study period.

5.7.4. Residential Sector

The electricity consumption in the Residential sector was still dominated by Egypt as it was seen in the previous sectors. Here also Sudan was second important consumer beginning at 2007 (Figure 5-35). Kenya & Tanzania were somewhat closely clustered. But Sudan DRC and Ethiopia have significant difference in between, the record for Ethiopia being relatively the lowest. This figure might not tell exactly about the future, except how consumption changed through time. So, countries with bigger consumption figure might be exceeded by those who recorded low.

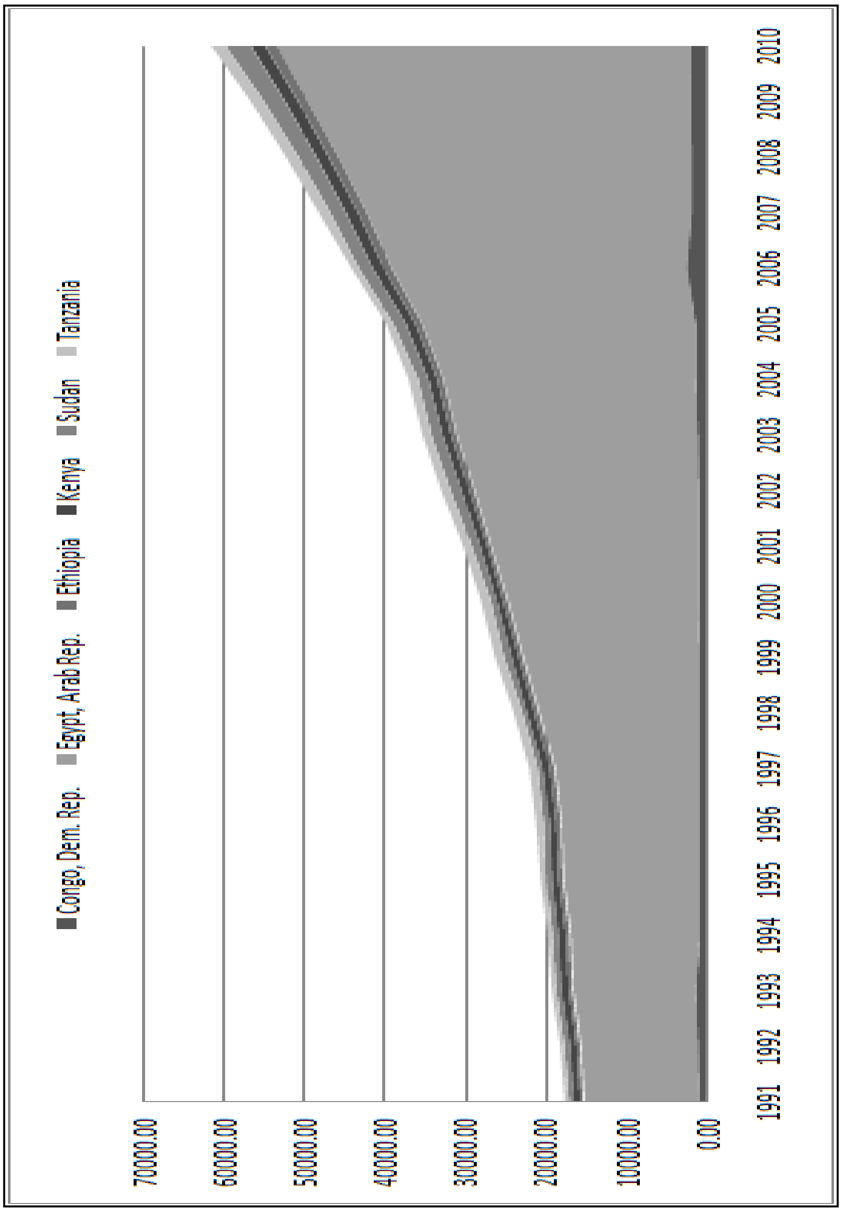
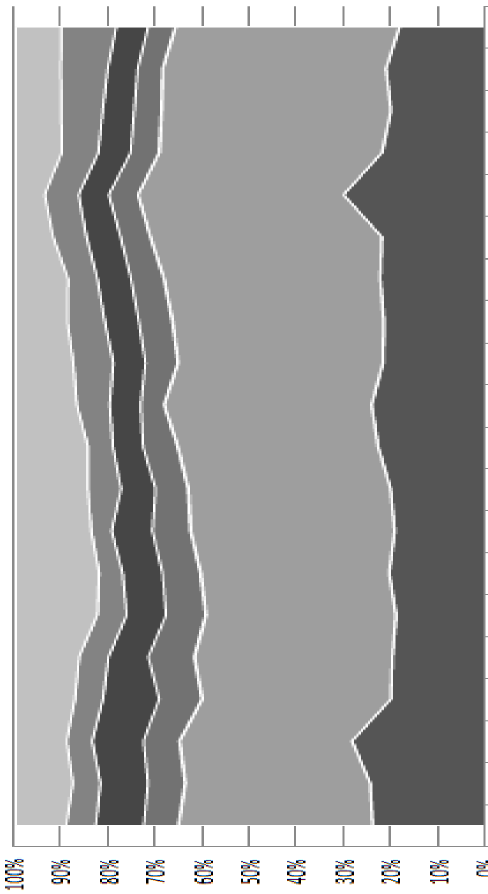


Fig. 5- 39 Electricity Consumption in the Residential Sector (1991-2010)

The trend in total electricity consumption was guided by the size of Egypt's electricity consumption. Almost all of the countries exhibited certain level of increment in electricity consumption. But the trend was slow in the five countries compared to Egypt for the years 2000-2010.



	91	92	93	94	95	96	97	98	99	20	01	02	03	04	05	06	07	08	09	10
Tanzania	2.28	2.79	2.52	2.74	2.94	3.92	3.97	3.61	3.67	3.82	3.26	3.29	3.03	3.14	2.18	1.95	3.01	3.07	3.11	3.22
Sudan	1.34	1.34	1.27	1.30	1.35	1.40	1.09	0.96	1.66	1.29	1.74	2.27	2.19	1.76	1.96	2.32	2.38	2.79	3.24	3.84
Kenya	2.17	2.32	2.54	2.60	1.86	1.91	1.91	1.96	1.77	1.61	1.67	1.85	2.02	2.03	2.00	2.04	2.12	2.14	2.10	2.28
Ethiopia	1.62	1.88	1.84	2.05	2.19	1.99	1.89	1.88	1.72	1.90	1.30	1.93	2.04	2.03	1.77	2.01	1.91	1.90	1.79	2.01
Egypt, Arab Rep.	8.78	9.02	8.54	8.75	9.19	9.15	8.98	9.75	10.29	10.59	11.09	11.74	12.43	13.00	13.55	13.92	14.57	15.49	15.48	15.83
Congo, Dem. Rep.	5.19	5.73	6.71	4.47	4.40	4.39	4.68	4.42	4.92	5.77	6.17	5.98	6.09	6.43	6.18	9.74	6.88	6.51	7.02	6.19

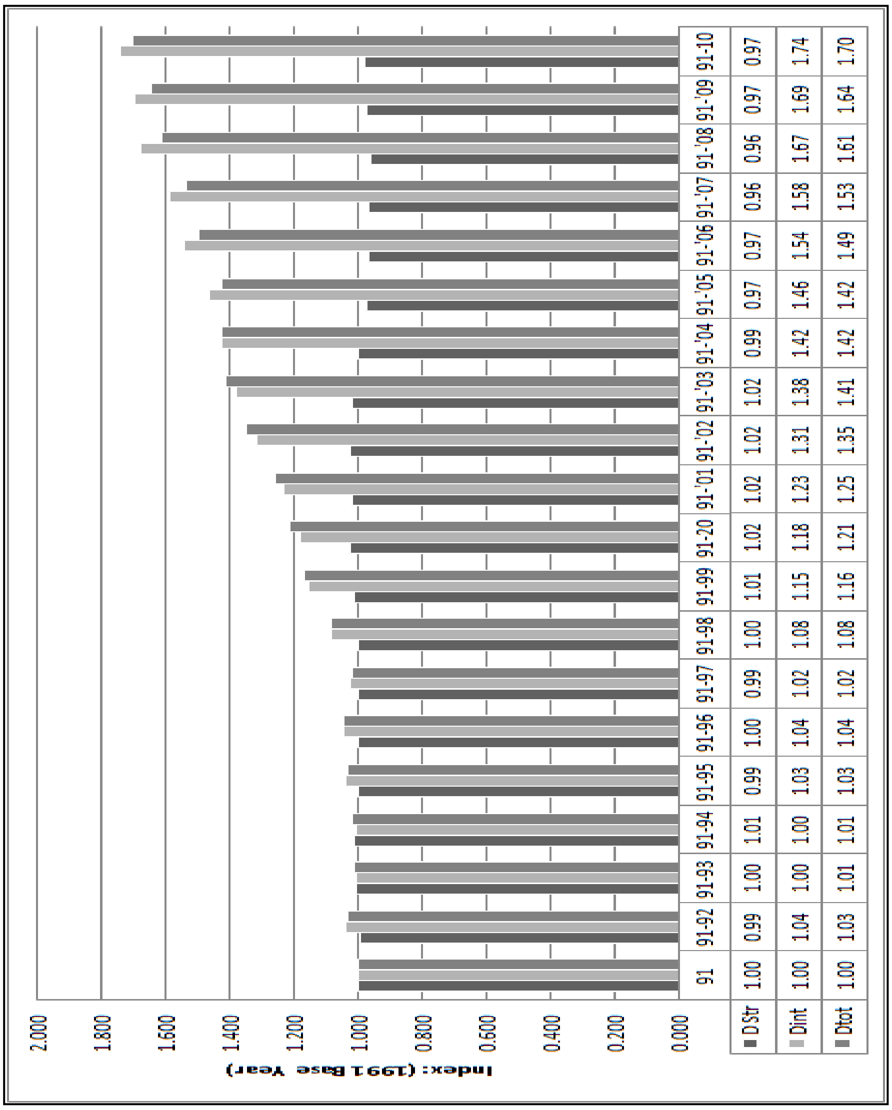
Fig. 5- 40 Electricity Intensity in the Residential Sector in watt-hours/US$ (1991-2010)

The electricity intensity value in the Residential Sector was almost close to the trend in the consumption. But the intensity has shown relative distinction between countries. Sudan had an intensity value below all the six countries in 1991 and end up with higher than all except Egypt and DRC. DRC exhibited sharp change in 1993 and 2006. Ethiopia and Kenya continued closely parried for longer years but at the beginning for the first four years Kenya was pared with Tanzania. From 1999-2006, Ethiopia, Kenya, and Tanzania were paired. Especially in 2005 and 2006 except Egypt and DRC, the four countries have been exhibiting very close intensity values (Figure 5-49). Egypt still remained leader in intensity value. The total intensity value for the six countries was 5.62 watt-hours/US$ in 1991 and it increased as high as 9.57 kwh/USD. Still the total intensity value was less than the value for Egypt.

This sector was the second to the industrial sector having full data for all the countries among the four sectors. In the context of the sub-region, these two sectors could be considered as taking the majority share in terms of electricity consumption. Therefore, if need be comparing the two may give interesting insight about impact of change by sector against by country... The electricity intensity for Residential sector of the sub-region was mostly between 1.34 to 2.01kwh/US$ in the base year and 8.78 to 15.83kwh/US$ at the end of the study period except (Figure 5-49).

Decomposition of the aggregate electricity intensity in the Residential sector shows a net increase by 70% of the amount of electricity used per 1 US$ gross value added in the sector in 2010 compared with 2000. The increment in the intensity effect was 74% while the value for the

Structure effect was a decrease by only 2% (table 5-28).



	91	91-92	91-93	91-94	91-95	91-96	91-97	91-98	91-99	91-20	91-'01	91-'02	91-'03	91-'04	91-'05	91-'06	91-'07	91-'08	91-'09	91-10
DStr	1.00	0.99	1.00	1.01	0.99	1.00	0.99	1.00	1.01	1.02	1.02	1.02	1.02	0.99	0.97	0.97	0.96	0.96	0.97	0.97
Dint	1.00	1.04	1.00	1.00	1.03	1.04	1.02	1.08	1.15	1.18	1.23	1.31	1.38	1.42	1.46	1.54	1.58	1.67	1.69	1.74
Dtot	1.00	1.03	1.01	1.01	1.03	1.04	1.02	1.08	1.16	1.21	1.25	1.35	1.41	1.42	1.42	1.49	1.53	1.61	1.64	1.70

Fig. 5- 41 Household Sector Decomposition result for the Six EAPP Countries (2000-2010)

The intensity effect might have affected the net result at the end of the study period here as well. From the base year up to 1997, the influence of both effects was not that visible. But beginning from there, the intensity effect was guiding the rate of increase and direction of change in the total intensity value of the sector. However, the structure effect remained almost flat throughout the study period (Figure 5-37).

Chapter 6 Summary of results & Policy implication

6.1 Summary of Results

The Sub Saharan Africa (SSA) is a very important area in terms of its lack of electricity. In 2012, SSA electrification coverage was 32% while the average of while Africa was 43% (IEA, 2012). To balance the gap between the demand and supply, Electricity market integration was considered as one of the means. Many inputs are required in planning the electricity market integration process. This research was designed to contribute in this process through identification of factors affecting the change in the pattern of electricity use within and among countries. Based on these factors, identification of important sectors in each country and across all countries was performed. This research used Index Decomposition Analysis (IDA) to identify the factors of electricity consumption in six selected East African Countries: DRC, Egypt, Ethiopia, Kenya, Sudan and Tanzania.

The Index Decomposition Analysis (IDA) was run at two levels; first for aggregate electricity intensity at country level and the second at sector level. Target countries are six selected East African Countries. Economic sectors in analysis are classified in to four, which include Agriculture-forestry-&-others

sector, Industry sector, Commercial & Public Services sector, and Residential sector. Time period of data in analysis is from 1990 to 2010, but it varies among countries because of data availability. The results from these two different levels of decomposition analyses were summarized in the subsequent paragraphs as follows.

Result of Decomposition Analysis by Country

First, the results for the DRC were analyzed in two consecutive time periods, 1991-1999 and 2000-2010. The results of Index Decomposition Analysis for 1991-1999 show that the total electricity intensity has increased from its base level by 51%. The dominant factor was intensity effect. Change in structure mix or structure effect has resulted in 10.22% increase in the aggregate electricity intensity from its base year value. Also the intensity effect was an increase of 37.01% in the aggregate electricity in 1999 from the base year value.

Industry and Residential sectors were responsible for this change. The Residential sector structure share was very low though its electricity intensity value larger than the industrial sector. The industrial sector share in the structure mix has decreased from the value in 1991. Because of large change in electricity intensity value of Residential sector, it dominated in terms of energy consumption.

For 2000 to 2010 in DRC, the structure mix effect was 22%. But the large decrease in intensity of the Residential sector compared to other sectors resulted in decrease of aggregate electricity intensity by 27% from the 2000. Electricity intensity share of Industrial sector decreased more though the share of Industry sector increased in the structure mix. Due to high scale effect, the industrial sector dominated in the use of electricity for this period.

Second, Index Decomposition Analysis was done in Egypt in two time periods: The first period covers 1991-1995 and second from 1996-2010. The Index Decomposition Result 1991 to 1995 in Egypt shows that the structure effect[28] resulted in an increase of aggregate electricity intensity by 3% from the value it had in 1991. The size of change due to intensity effect was very small. The total Gross Value added increased by 14%, but the structure share in 1995 remained the same with the 1991 proportion. In Egypt, Industrial and Agriculture-forestry-&-others sectors played dominant role in using electricity in this period. Because the relative share of the two sectors in the structure mix was bigger in respective order.

[28] The structure effect in this case related with change in the scale of the output from th e industry and agriculture sector while their share remained constant and their intensit y improved.

The Result of Index Decomposition Analysis for Egypt in 1996-2010 shows a net increase in the aggregate electricity intensity by 29% in 2010 from the value in 1996. The dominant factor for this change was intensity effect which resulted in an increase of the aggregate electricity intensity from the base year value by 36%. Generally Index decomposition analysis of the aggregate electricity intensity in Egypt for the whole period shows dominance of structure effect from 1991-1995 and intensity effect from 1996-2010.

Third, the result from Index decomposition analysis of the aggregate electricity intensity in Ethiopia shows that the structure effect increased by 10.3% and intensity effect by 20.1% in 2010. The overall intensity increased by 33% compared to the base year. The Intensity effect dominated throughout the study period except in 2009, the year at which modest decline in the GDP observed (MOFED, 2010).

The relevant sectors for the change in the electricity intensity were Commercial and Public services sector and Industrial sector due to their relative increase in the structure share. Among the lists of sectors identified, the Commercial and Public Services sector has been influential due to increased share in the Gross Value Added and at the same time due to increased electricity intensity.

Fourth, based on the results of Index Decomposition Analysis of Kenya, structure effect resulted in a 3% decrease in total electricity intensity. Intensity effect has 11.9% increases in the electricity intensity in 2010. The share of gross value added of the economy has increased for the Residential sector while the Agriculture-forestry-&-others sector remained same. The increase in structure share of Commercial and Public Services sectors has been small while the share of Residential and industry sectors decreased in 1994 compared to the base year. The intensity share of all the sectors has increased but the Residential sector's contribution was relatively large followed by industry sector. The increase in aggregate electricity intensity of Kenya in 1991-1994 was due to relative dominance of the residential and Commercial and Public Services sector's electricity intensity

Based on result of decomposition analysis for 1995-2007, structure effect showed a 0.2% increase in total electricity intensity. The intensity effect has led to a 7% increases in the electricity intensity in 2007. The share of the Commercial and Public services sector has increased compared to all the sectors in the economy. Among the remaining sectors, the Industrial sectors share has decreased. The intensity share of Agriculture-forestry-&-others was insignificant while the share of remaining three sectors, namely Residential, Commercial and Public Services, and Industrial sectors have increased. The change in aggregate electricity intensity of Kenya in 1995-2007 was mainly due to the dominance of the increase by the following three sectors in order of importance.

Based on the result of decomposition analysis for 2008-2010, structure effect resulted in a 0.3% decrease in total electricity intensity. The Intensity effect has led to a 2.4% increases in the electricity intensity in 2010 compared to 2008. The structure share of Residential and Commercial and Public Services sector have decreased. Industrial sectors share remained the same. Whereas, intensity share of the Residential and Industrial sectors increased while that of Commercial and Public services sector decreased. The dominant sector in affecting the change in electricity intensity in Kenya was industrial sector followed by Residential sector for the period 2008-2010.

Fifth, for Sudan, the results of decomposition analysis of the Aggregate Electricity intensity show that intensity effect has increased by 107% compared to the base year. This was mainly attributed to the low figure of Residential sector's electricity consumption. In the meanwhile, the structure effect decreased by 20% compared to the value of the base year.

Sudan experienced unique increase in aggregate electricity intensity between 1998 and 2001. The reason was that the time coincided with the beginning of oil exportation. The income of the people improved by the business opportunities created and also number of Migrants entering the country due to job opportunity created due to the new oil business (HCENR[29], 2013). The electricity consumption has been growing faster and was smooth within the range of these three years. The share in Gross value added of Industrial sector increased in 2010 while the other sector's share decreased. The overall trend in Sudan was that Intensity effect dominated most cases.

The share of the industrial sector increased from 15.4% in 1990 to 23.9% in 2010 in the agriculture dominated economy of Sudan. The main industry to generate foreign income was the oil industry. Moreover, Agriculture-forestry-&-others sector also increased. All together up lifted Sudan to a lower medium income countries category. It has to be noted that during these days, the growth of the industrial sector also contributed to better welfare of the residents. Hence the electricity use level at Residential also begun to increase.

Sixth and last, based on Index Decomposition Analysis of the aggregate electricity intensity, Tanzania's structure effect was 14% compared to the base year. The intensity effect was also 32% compared to the base year. But both are on the same direction. The trend that intensity effect dominated in most part in the study period repeated in Tanzania. In terms of structure share no change for residential sector. But the structure share increased for the industrial sector and

[29] Higher Council for Environment and Natural Resources (HCENR)

decreased for the Agriculture-forestry-&-others sector. For Tanzania, the Industrial and Residential sectors were dominant in determining amount of electricity use. Because, the Industry sector share has increased and at the same time its intensity share has also increased. But the Residential sector's share did not change from the base year value.

Result of Decomposition Analysis by Sector

In this analysis, we have 4 main sectors (Agriculture-forestry-&-Others, Industry, Commercial and Public Services, and the Residential) across for all six countries.

First, results from Index decomposition Analysis of aggregate electricity intensity in Agriculture-Forestry-&-others sector for 1991 to 1994 showed increased structure and intensity effects[30]. The values were -0.3% for structure effect whereas -0.1% for intensity effect in 1994 compared with the base year value. For 1995 to 1999, structure effect decreased and intensity effect increased. The values were -3% for structure effect whereas 1.2% for intensity

[30] Structure effect is understood as a change in the aggregate electricity intensity from the base year due to change in the mix of output from the six countries.

effect in 1994 compared with the base year value. For 2000 to 2007, intensity effect increased and dominated. The values were -3% for structure effect whereas 8% for intensity effect in 1994 compared with the base year value. For 2008 to 2010, structure effect decreased and intensity effect increased and dominated. The values were -1% for Structure effect whereas 19% for Intensity effect in 1994 compared with the base year value.

Results from The Index Decomposition Analysis revealed that the amount of electricity used in this economic sector per output in monetary value in 1994 was small compared to 1991. Though both effects show decrease in electricity intensity, the effect of change in structure mix was dominant. Most of the countries did not use electricity in the agriculture sector during 1995-1999. They produced economic output through conventional methods without using much electricity for productive purpose in the sector. The electricity intensity has increased in the sector in 2000 to 2007. For 2008 to 2010 also the intensity effect was dominant in determining size of electricity used in the agriculture sector.

In the Agriculture-forestry-&-others sector, countries ranking on the basis of change in volume of electricity use changed from 1991 to 2010 across the whole study period because of change in the list of countries included in the study. In 1991-1994, the order of ranking was Egypt, Tanzania and Sudan. But the amount of electricity used was small. For the period 1995 to 1999, in terms of electricity intensity Egypt ranked first. Then Tanzania, Kenya, Sudan, DRC and Ethiopia are ranked in descending order. For 2000 to 2007, the rank shifted and the order was Egypt, Sudan, Ethiopia, Kenya, Tanzania, and DRC.

Secondly, Index decomposition analysis of Industry sector for 1991 to 2010 shows that structure effect has decreased while the intensity effect has increased. The values were -33% for Structure effect whereas 40% for Intensity effect in 2010 compared with the base year value.

The Index Decomposition Analysis result revealed that the amount of electricity used in this economic sector per output in monetary value in 2010 was small compared to 1991. Though intensity effect was slightly bigger, the effect of change in structure mixes dominated because of reduced share of Egypt and DRC. Reduced share of Egypt shows reduction of electricity use even though the volume of production increased. Also reduced share of DRC means reduced volume of electricity since DRC used large electricity per output in 2010 compared to 1991. So, the structure mix was dominant cause of decrease in the electricity intensity in 2010 from its level in 1991.

In the Industry sector, Countries' ranking on the basis of change in volume of electricity use between 1991 and 2010 puts DRC in the first position. This means that even though the volume of electricity consumed in the industrial sector of DRC was relatively low, the size used per 1US$ worth income in the industry sector was larger than all the countries including Egypt on the same year. Since the structure share and volume of output of Congo was relatively very small, the figure does not represent an equivalent change in the consumption of electricity. This implied that the industrial sector have been strategic in terms of electricity use for DRC in the study period. Ethiopia moved one step high in the case of ranking using intensity. During the study period, the structural change representing share of countries in a sector and respective volume of electricity use were important in identifying the country that dominated in the electricity use in the industrial sector for this specific period.

Thirdly, Index Decomposition Analysis of Commercial and Public Services sector was classified in to two parts due to data availability. The result for 1991 to 1999 shows that structure effect has decreased while the intensity effect has increased dramatically. The values were -6% for Structure effect whereas 258% for intensity effect in 2010 compared with the base year value. The result for 2000 to 2010 shows that both structure effect and intensity effects have increased. The values were 4% for Structure effect whereas 19.2% for Intensity effect in 2010 compared with the base year value.

The Index Decomposition Analysis result revealed that the amount of electricity used in this economic sector per output in monetary value in 1999 was large compared to 1991. Structure effect showed decrease in electricity used to produce an economic output in a year, but intensity effect shows big change in volume of electricity used to produce an economic output in a year. This was mainly due to same proportion of structure share while the output and electricity intensity value changed dramatically.

In the Commercial and Services sector, countries' ranking on the basis of change in volume of electricity use between 1991 and 1999 puts Egypt in the first position. For the Commercial and Public services sector, the change in electricity intensity value was important factor for the change in the volume of electricity use.

Fourthly and finally, Index decomposition analysis of Residential sector for 1991 to 2010 shows that structure effect has decreased while the intensity effect has increased. The values were -2% for structure effect whereas 74% for intensity effect in 2010 compared with the base year value.

The Index Decomposition Analysis result revealed that the amount of electricity used in this economic sector per output in monetary value in 2010 was relatively large compared to 1991. Since intensity effect was slightly bigger, the effect of change in structure mixes was dominated because share of Egypt, Sudan, and DRC was decreased and also Kenya's share remaining constant. Decreased share of Egypt shows reduction of output growth rate leading to less electricity use even though the volume of production increased. Also unchanged share of

Kenya means reduced rate in the volume of electricity in 2010 compared to 1991.

In the Residential sector, countries' ranking on the basis of change in volume of electricity use between 1991 and 2010 puts Sudan in the first position. This means that even though the share of Egypt in the structure mix was less in 2010 than 1991, the electricity intensity in the Residential sector of Egypt was relatively high. This was due to the larger size of electricity used per US dollar worth income in the Residential sector in Egypt and elsewhere on the same year. In this sector, the intensity change was important in identifying the country that dominated in the electricity use in the Residential sector for this specific period.

6.2 Policy implications

Electricity use in the six east African countries was increasing mainly due to positive change in the electricity use towards more economic value added activities on annual basis. Identifying these strategic sectors among others seems worth taking as electricity supply in the region is scarce. Using, Index Decomposition Analysis (IDA), the structure effect and Intensity effect show direct determining variables for the change in the electricity consumption used in the economic sectors; hence these factors were used frequently in describing the policy implications in the six countries. Here, by countries, Ethiopia at the end with more focus on implications, are the main results and policy implications from this study.

Firstly, For DRC, it was found from the IDA results that value addition in the industrial sector needed more electricity compared with other sectors. The residential sector also used more electricity among other sectors. The increase in the household consumption expenditure compared to the increase in the electricity use was lower. The probable reason could be existence of subsidy on electricity price. From sector analysis result also, it was understood that DRC has recorded higher electricity intensity change compared to the other five countries. So, DRC should focus on the dominant sector in electricity use: Industrial sector.

For Egypt, activity mix was found to be remained stable for all the sectors. But when the change in the size of electricity used for a yearly gross value added by sectors was compared, the Agriculture share takes prior position and industrial sector is second. Also the country level IDA result revealed that Residential sector was also dominant sector due to its large size of increase in expenditure for electricity among annual consumption expenditure by households compared with other countries in 2010 compared to the base year.

For Kenya, it was found from the IDA that Industrial and Residential sectors demanded more electricity for yearly additional value added compared with other sectors. According to the result of sector analysis, Kenya faces more competition for use of electricity to the Industrial sector than the Residential sector. This was understood from the fact that in the priority list sector both the Industrial and Residential sector result.

Fourthly, for Sudan, it was found from the IDA that Commercial and Public services sector demanded more electricity for yearly additional value added compared with other sectors. Residential Sector also has been important for Sudan in terms of demand for electricity with second position. Sudan held second position for both the Commercial and Public Services and Residential sectors' electricity demand among the six countries. During this period the country was only concerned with Egypt's consumption growth since it was the dominant user among others. The size of the economy of others was also not that much worrisome.

For Tanzania, Industrial and Residential sectors are found to demand more electricity for yearly additional value added compared with other sectors. Tanzania held fourth position for Residential sector's electricity demand among the six countries. During this period the country has three competitors including Egypt. The other countries were Sudan and DR respectively. But for the

Commercial and Public Services sector it did not have any competition.

For Ethiopia, based on the analyses results, it was possible to identify the following policy implications. Firstly, both activity mix and Intensity effect as factors have contributed to an increase in the use of electricity in 2010 compared with 1991. The later dominated in effecting the change in consumption of electricity. But there was variation between sectors in the proportion of electricity change required in 2010. This implies 1) only the need by Residential, and Commercial and Public Services sectors have constituted the result of change in the intensity effect. 2) Only Commercial and Public Services and Industrial sectors have constituted the result of change in the Activity Mix. So, having both factors positive does not imply that all sector were positively affected.

Secondly, Commercial and Public Services sector dominated in both effects in contributing to the change. This implies that the economic sectors, or even governments, would hold dominant role if their contribution dominates in terms of activity mix effect and intensity effect. For Ethiopia, the Commercial and Public services sector can be considered strategically important sector in planning for electricity demand.

Thirdly Residential sector was having largest electricity intensity value compared to other sectors. But the change in the activity mix due to the residential sector had decreasing effect on the volume of electricity required by the sector. And the large positive intensity effect also did not result from more demand for electricity. But the increase in the electricity consumption was not because of change in output in the household sector. This also implies having large intensity value of Activity mix value by itself does not show an increase for need of additional electricity.

Finally, Ethiopia ranked fourth in the commercial and Public services electricity consumption and Fifth in Residential sector's electricity consumption in the sector analysis. This tells us that the residential sector's electricity access level was lower compared to other countries.

This study lacks in several key areas. First and foremost is the data availability. As SSA countries lacks good database for sound analyses, this research can only reach as far as data allow us to go. Data problem also restrict this study to expand its research areas to analyses on electricity consumption and production functions as well as economy-related or Co_2 emission related analyses of SSA countries. Also, Structural Decomposition Analysis (SDA) in addition to IDA cannot be accomplished.

There are also further research areas that need to be done. For example, one area would be to analyze the impact of implementing different policy tools their cost for governments. The other area which can improve the current study is finding the equilibrium investment portfolio among SSA countries.

Analysis results from these could provide policy-makers with better policy recommendations to set their future electricity as well as economic development plans.

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Appendix

Appendix A-1 Gross Value added country level at factor cost Million US$ (Constant 2005 US$)

Gross Value added											
Agricultur	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
DRC	3255.51	3357.14	3420.22	3392.18	3785.83	3865.34	3760.19	3705.51	3790.73	3347.23	3215.68
Egypt	8054.22	8211.71	8416.24	8738.96	8992.35	9268.48	9586.64	9932.50	10279.74	10629.49	11023.65
Ethiopia	3402.62	3358.85	3569.41	3464.79	3593.27	4210.15	4296.49	3882.30	4014.21	4136.77	4534.90
Kenya	3229.97	3122.55	3020.38	3113.33	3262.53	3408.40	3303.93	3577.81	3831.56	3782.62	4223.61
Sudan	3887.68	4840.35	4920.07	4737.74	5022.00	5974.67	7064.84	7297.83	7322.17	7409.89	7846.74
Tanzania	2455.02	2485.38	2562.57	2616.53	2769.21	2876.36	2946.80	3002.99	3124.84	3264.20	3425.03
Total	**24285.02**	**25375.98**	**25908.89**	**26063.53**	**27425.19**	**29603.39**	**30958.89**	**31398.94**	**32363.26**	**32570.20**	**34269.61**
Industry	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
DRC	2050.62	1436.99	1228.67	1203.16	1078.45	1141.83	915.30	896.66	949.71	965.73	949.41
Egypt	17780.62	18048.03	18449.94	19455.75	20431.00	21434.33	22420.73	23313.15	24852.64	26166.57	26985.75
Ethiopia	658.78	526.82	669.50	730.57	791.67	819.84	847.99	892.14	941.07	991.39	1042.10
Kenya	2411.12	2409.87	2414.70	2460.69	2547.68	2634.19	2665.58	2671.86	2608.71	2560.92	2701.70
Sudan	2121.22	2097.68	2267.80	2155.55	2284.66	2720.30	2914.09	3170.21	3539.66	4832.58	5115.58
Tanzania	1382.41	1383.01	1329.66	1351.16	1325.21	1413.79	1508.27	1663.50	1775.50	1855.74	1978.30
Total	**26404.76**	**25902.40**	**26360.28**	**27356.89**	**28458.67**	**30164.28**	**31271.96**	**32607.52**	**34667.29**	**37372.92**	**38772.84**
Commercial & Secvices Sector]	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
DRC	5016.51	4413.98	2933.56	2631.95	2271.92	2163.55	1893.69	2007.49	1697.59	1575.32	1556.36
Egypt	22508.00	22995.39	23613.30	24313.48	25531.45	26959.82	28668.62	29882.13	31457.93	33672.62	34864.43
Ethiopia	1974.25	1719.60	2018.05	2164.69	2370.02	2583.42	2686.45	2780.96	2990.50	3291.22	3464.26
Kenya	5951.87	6125.81	6260.31	6475.80	6819.81	7172.87	7294.56	7458.55	7614.20	7757.02	7745.88
Sudan	5671.33	5344.35	5716.35	5966.66	6030.36	7307.32	7749.70	7911.60	8511.84	8840.69	11018.06
Tanzania	3169.62	3278.85	3236.08	3246.32	3336.48	3457.23	3565.07	3712.69	3885.03	4096.43	4362.89
Total	**44291.59**	**43877.98**	**43777.64**	**44798.90**	**46360.04**	**49644.21**	**51858.09**	**53753.42**	**56157.09**	**59233.29**	**63011.89**
Residential	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
DRC	225.14	226.80	228.45	225.63	235.49	239.33	229.85	216.42	229.40	216.57	213.39
Egypt	1489.45	1610.36	1597.91	1777.24	1822.92	1870.50	1994.67	2039.94	2119.78	2223.52	2314.66
Ethiopia	365.00	405.00	437.00	481.00	530.00	558.00	569.00	516.00	497.00	520.00	395.00
Kenya	376.09	379.90	378.32	365.33	375.60	436.12	444.19	475.06	487.98	499.67	496.52
Sudan	465.94	495.39	522.70	556.17	574.16	577.81	553.97	606.97	606.92	576.51	588.48
Tanzania	200.29	196.41	198.03	216.10	213.25	224.24	236.40	257.41	293.73	306.73	311.88
Total	**3121.92**	**3313.86**	**3362.40**	**3621.47**	**3751.41**	**3906.01**	**4028.08**	**4111.79**	**4234.82**	**4343.01**	**4319.93**

6 Appendix A-2 Electricity Consumption in GWh

Agriculture-Forestry-&-others-Sector

Electricity Consumption in the Agriculture Sector of Six EAPP Countries (1991-2010)

Electricity consumption in Gigawatthours			Source: IEA						
	1991	1992	1993	1994	1995	1996	1997	1998	1999
Congo, Dem. Rep.	15.00	15.00	12.00	10.00	10.00	15.00	15.00	15.00	16.00
Egypt, Arab Rep.	6,341.00	6,464.00	6,803.00	7,149.00	7,546.00	6,708.00	7,532.00	8,162.00	8,709.00
Ethiopia	15.00	17.00	10.00	8.00	8.00	8.00	8.00	9.00	10.00
Kenya	-	-	-	-	44.00	47.00	27.00	45.00	54.00
Sudan	191.00	183.00	151.00	35.00	33.00	32.00	36.00	40.00	41.00
Tanzania	124.00	123.00	71.00	59.00	84.00	86.00	89.00	104.00	115.00
Total (except for Kenya 1991-1994)	**6,686.00**	**6,802.00**	**7,047.00**	**7,261.00**					
Total (1995-1999)					**7,725.00**	**6,896.00**	**7,707.00**	**8,375.00**	**8,945.00**
Total (except for DRC 2000-2007)									
Total (except for DRC+Kenya 2000-2007)									

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Congo, Dem. Rep.	-	-	-	-	-	-	-	-	-	-	-
Egypt, Arab Rep.	9,057.00	10,472.00	7,247.00	7,361.00	8,853.00	9,735.00	10,835.00	12,449.00	13,371.00	14,508.00	17,068.00
Ethiopia	12.00	14.00	19.00	23.00	32.00	35.00	53.00	46.00	23.00	26.00	30.00
Kenya	33.00	36.00	38.00	38.00	38.00	47.00	42.00	37.00	-	-	-
Sudan	194.00	48.00	28.00	15.00	105.00	131.00	124.00	116.00	163.00	198.00	221.00
Tanzania	105.00	127.00	133.00	145.00	161.00	185.00	204.00	231.00	248.00	266.00	285.00
Total (except for Kenya 1991-1994)											
Total (1995-1999)											
Total (except for DRC 2000-2007)	**9,401.00**	**10,697.00**	**7,465.00**	**7,582.00**	**9,189.00**	**10,133.00**	**11,258.00**	**12,879.00**			
Total (except for DRC+Kenya 2000-2007)									**13,805.00**	**14,998.00**	**17,604.00**

Gross Value Added at factor Cost of Agriculture Sector in Six EAPP Countries (Constant 2005 US$) in 1991-2010

Data Source	World Bank Database																			
Electricity Component of Services & others in Million USD(at factor cost 2005 US$)																				
Country Name	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
DRC	3,255.51	3,357.14	3,420.22	3,392.18	3,785.83	3,865.34	3,760.19	3,705.51	3,790.73	3,347.23	3,215.68	3,230.67	3,270.10	3,291.28	3,385.74	3,495.67	3,609.28	3,717.91	3,829.82	3,945.10
Egypt	8,054.22	8,211.71	8,416.24	8,738.96	8,992.35	9,268.48	9,586.64	9,932.50	10,279.74	10,629.49	11,023.65	11,420.56	11,818.01	12,144.12	12,539.55	12,946.91	13,423.41	13,872.77	14,312.60	14,809.89
Ethiopia	3,402.62	3,358.85	3,569.41	3,464.79	3,593.27	4,210.15	4,296.49	3,882.30	4,014.21	4,136.77	4,534.90	4,449.86	3,983.30	4,658.26	5,289.12	5,866.09	6,420.33	6,901.96	7,340.98	7,717.60
Kenya	3,229.97	3,122.55	3,020.38	3,113.33	3,262.53	3,408.40	3,303.93	3,577.81	3,831.56	3,782.62	4,223.61	4,075.93	4,175.00	4,247.99	4,541.37	4,744.65	4,855.09	4,648.65	4,451.15	4,735.90
Sudan	3,887.68	4,840.35	4,920.07	4,737.74	5,022.00	5,974.67	7,064.84	7,297.83	7,322.17	7,409.89	7,846.74	8,111.55	8,134.90	8,090.94	8,116.33	8,471.34	8,735.50	9,168.14	9,460.57	9,753.01
Tanzania	2,455.02	2,485.38	2,562.57	2,616.53	2,769.21	2,876.36	2,946.80	3,002.99	3,124.84	3,264.20	3,425.03	3,597.74	3,713.53	3,932.90	4,106.65	4,265.86	4,438.52	4,641.85	4,790.74	4,985.04
Total (except for Kenya 1991-1994)	21,055.05	22,253.43	22,888.52	22,950.20																
Total (1995-1999)					27,425.19	29,603.39	30,958.89	31,398.94	32,363.26											
Total (except for DRC 2000-2007)										29,222.97	31,053.93	31,655.64	31,824.74	33,074.20	34,593.02	36,294.85	37,872.84			
Total (except for DRC+Kenya 2000-2007)																		34,584.71	35,904.90	37,265.54

Electricity Intensity in the Agriculture Sector of Six EAPP countries (1991-2010)

Electricity Intensity (Ii)																				
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
D.R.C.	0.0046	0.0045	0.0035	0.0029	0.0026	0.0039	0.0040	0.0040	0.0042	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Egypt, Arab Rep.	0.7873	0.7872	0.8083	0.8181	0.8392	0.7237	0.7857	0.8217	0.8472	0.8521	0.9500	0.6346	0.6229	0.7290	0.7763	0.8369	0.9274	0.9638	1.0137	1.1525
Ethiopia	0.0044	0.0051	0.0028	0.0023	0.0022	0.0019	0.0019	0.0023	0.0025	0.0029	0.0031	0.0043	0.0058	0.0069	0.0066	0.0090	0.0072	0.0033	0.0035	0.0039
Kenya	0.0000	0.0000	0.0000	0.0000	0.0135	0.0138	0.0082	0.0126	0.0141	0.0087	0.0085	0.0093	0.0091	0.0089	0.0103	0.0089	0.0076	0.0000	0.0000	0.0000
Sudan	0.0491	0.0378	0.0307	0.0074	0.0066	0.0054	0.0051	0.0055	0.0056	0.0262	0.0061	0.0035	0.0018	0.0130	0.0161	0.0146	0.0133	0.0178	0.0209	0.0227
Tanzania	0.0505	0.0495	0.0277	0.0225	0.0303	0.0299	0.0302	0.0346	0.0368	0.0322	0.0371	0.0370	0.0390	0.0409	0.0450	0.0478	0.0520	0.0534	0.0555	0.0572
Total (except for Kenya 1991-1994)	0.3175	0.3057	0.3079	0.3164																
Total (1995-1999)					0.2817	0.2329	0.2489	0.2667	0.2764											
Total (except for DRC 2000-2007)										0.3217	0.3445	0.2358	0.2382	0.2778	0.2929	0.3102	0.3401			
Total (except for DRC+Kenya 2000-2007)																		0.3992	0.4177	0.4724

Industry Sector

Electricity Consumption in the Industry Sector of Six EAPP Countries (1991-2010)

Electricity consumption in Gigawatthours	Source: IEA																			
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Congo, Dem. Rep.	1,054.00	1,072.00	1,194.00	938.00	1,003.00	1,008.00	1,008.00	1,010.00	1,061.00	1,890.00	1,968.00	2,778.00	2,968.00	2,939.00	3,094.00	2,869.00	3,887.00	3,867.00	4,218.00	3,970.00
Egypt, Arab Rep.	17,490.00	18,127.00	18,787.00	19,471.00	20,180.00	20,952.00	21,496.00	22,468.00	23,437.00	24,552.00	25,402.00	26,525.00	28,386.00	30,284.00	32,701.00	34,569.00	37,045.00	37,273.00	38,916.00	40,702.00
Ethiopia	441.00	441.00	499.00	521.00	546.00	564.00	563.00	559.00	534.00	549.00	653.00	692.00	718.00	796.00	945.00	897.00	973.00	1,188.00	1,223.00	1,395.00
Kenya	2,039.00	2,049.00	2,135.00	2,175.00	2,231.00	2,315.00	2,313.00	2,315.00	2,244.00	2,286.00	2,525.00	2,621.00	2,818.00	2,977.00	3,085.00	3,351.00	3,411.00	3,332.00	3,370.00	3,630.00
Sudan	221.00	231.00	231.00	416.00	378.00	388.00	433.00	438.00	468.00	619.00	508.00	398.00	427.00	419.00	497.00	566.00	605.00	547.00	709.00	884.00
Tanzania	465.00	391.00	811.00	806.00	876.00	809.00	635.00	740.00	566.00	614.00	836.00	889.00	755.00	996.00	1,519.00	1,593.00	1,459.00	1,565.00	1,679.00	1,810.00
Total	**21,710.00**	**22,311.00**	**23,657.00**	**24,327.00**	**25,214.00**	**26,036.00**	**26,448.00**	**27,530.00**	**28,310.00**	**30,510.00**	**31,892.00**	**33,903.00**	**36,072.00**	**38,411.00**	**41,841.00**	**43,845.00**	**47,380.00**	**47,772.00**	**50,115.00**	**52,391.00**

Gross Value Added at Factor Cost Industry Sector of Six EAPP Countries (Constant 2005 US$) in 1991-2010

Data Source	World Bank Database																			
Electricity Component of Industry Sector in Million USD(at factor cost 2005 US$)																				
Country Name	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
DRC	2,050.62	1,436.99	1,228.67	1,203.16	1,078.45	1,141.83	915.30	896.66	949.71	965.73	949.41	1,038.18	1,164.81	1,378.22	1,579.52	1,650.82	1,613.39	1,720.34	1,753.57	2,089.46
Egypt	17,780.62	18,048.03	18,449.94	19,455.75	20,431.00	21,434.33	22,420.73	23,313.15	24,852.64	26,166.57	26,985.75	27,955.87	28,310.95	29,140.25	30,303.33	33,284.43	35,932.74	38,979.49	41,215.65	43,521.90
Ethiopia	658.78	526.82	669.50	730.57	791.67	819.84	847.99	892.14	941.07	991.39	1,042.10	1,128.86	1,201.96	1,341.93	1,468.51	1,617.75	1,782.62	1,967.43	2,142.54	2,316.48
Kenya	2,411.12	2,409.87	2,414.70	2,460.69	2,547.68	2,634.19	2,665.58	2,671.86	2,608.71	2,560.92	2,701.70	2,765.10	2,934.30	3,053.81	3,187.81	3,346.06	3,582.64	3,750.40	3,855.40	4,061.58
Sudan	2,121.22	2,097.68	2,267.80	2,155.55	2,284.66	2,720.30	2,914.09	3,170.21	3,539.66	4,832.58	5,115.58	5,785.33	6,239.06	6,795.59	7,128.70	8,300.95	9,958.58	10,369.64	10,548.27	11,349.09
Tanzania	1,382.41	1,383.01	1,329.66	1,351.16	1,325.21	1,413.79	1,508.27	1,663.50	1,775.50	1,855.74	1,978.30	2,163.72	2,400.44	2,661.89	2,937.95	3,187.46	3,488.85	3,789.16	4,054.14	4,387.34
Total	**26,404.76**	**25,902.40**	**26,360.28**	**27,356.89**	**28,458.67**	**30,164.28**	**31,271.96**	**32,607.52**	**34,667.29**	**37,372.92**	**38,772.84**	**40,837.04**	**42,251.51**	**44,371.68**	**46,605.82**	**51,387.47**	**56,358.82**	**60,576.46**	**63,569.57**	**67,725.86**

Electricity intensity in the industry Sector of Six EAPP Countries (1991-2010)

Electricity Intensity (Ii)																				
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
D.R.C.	0.514	0.746	0.972	0.780	0.930	0.883	1.101	1.126	1.117	1.957	2.073	2.676	2.548	2.132	1.959	1.738	2.409	2.248	2.405	1.900
Egypt, Arab Rep.	0.984	1.004	1.018	1.001	0.988	0.977	0.959	0.964	0.943	0.938	0.941	0.949	1.003	1.039	1.079	1.039	1.031	0.956	0.944	0.935
Ethiopia	0.669	0.837	0.745	0.713	0.690	0.688	0.664	0.627	0.567	0.554	0.627	0.613	0.597	0.593	0.644	0.554	0.546	0.604	0.571	0.602
Kenya	0.846	0.850	0.884	0.884	0.876	0.879	0.868	0.866	0.860	0.893	0.935	0.948	0.960	0.975	0.968	1.001	0.952	0.888	0.874	0.894
Sudan	0.104	0.110	0.102	0.193	0.165	0.143	0.149	0.138	0.132	0.128	0.099	0.069	0.068	0.062	0.070	0.068	0.061	0.053	0.067	0.078
Tanzania	0.336	0.283	0.610	0.597	0.661	0.572	0.421	0.445	0.319	0.331	0.423	0.411	0.315	0.374	0.517	0.500	0.418	0.413	0.414	0.413
Total	0.822	0.861	0.897	0.889	0.886	0.863	0.846	0.844	0.817	0.816	0.823	0.830	0.854	0.866	0.898	0.853	0.841	0.789	0.788	0.774

Electricity intensity for Industrial Sector in Six EAPP Countries (1991-2010)

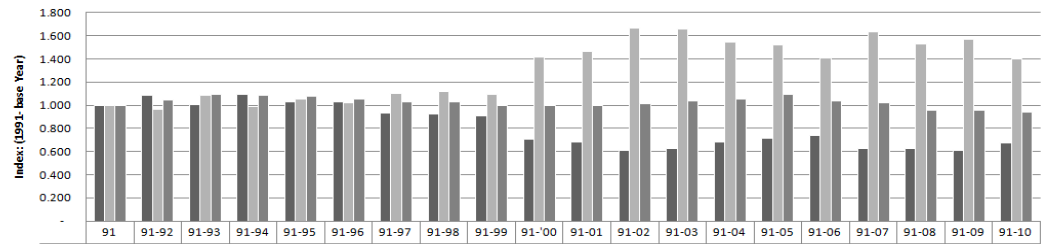
lecricity intenisity(Ii)																				
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Congo, Dem. Rep.	5.19	5.73	6.71	4.47	4.40	4.39	4.68	4.42	4.92	5.77	6.17	5.98	6.09	6.43	6.18	9.74	6.88	6.51	7.02	6.19
Egypt, Arab Rep.	8.78	9.02	8.54	8.75	9.19	9.15	8.98	9.75	10.29	10.59	11.09	11.74	12.43	13.00	13.55	13.92	14.57	15.49	15.48	15.83
Ethiopia	1.62	1.88	1.84	2.05	2.19	1.99	1.89	1.88	1.72	1.90	1.30	1.93	2.04	2.03	1.77	2.01	1.91	1.90	1.79	2.01
Kenya	2.17	2.32	2.54	2.60	1.86	1.91	1.91	1.96	1.77	1.61	1.67	1.85	2.02	2.03	2.00	2.04	2.12	2.14	2.10	2.28
Sudan	1.34	1.34	1.27	1.30	1.35	1.40	1.09	0.96	1.66	1.29	1.74	2.27	2.19	1.76	1.96	2.32	2.38	2.79	3.24	3.84
Tanzania	2.28	2.79	2.52	2.74	2.94	3.92	3.97	3.61	3.67	3.82	3.26	3.29	3.03	3.14	2.18	1.95	3.01	3.07	3.11	3.22
Total	**5.62**	**5.81**	**5.71**	**5.73**	**5.82**	**5.87**	**5.74**	**6.11**	**6.58**	**6.83**	**7.07**	**7.59**	**7.93**	**8.00**	**8.00**	**8.43**	**8.62**	**9.08**	**9.26**	**9.57**

Commercial & Public Services Sector

Electricity Intensity (Ii)	Commercial & Public Services SectorServices								
	1991	1992	1993	1994	1995	1996	1997	1998	1999
Egypt, Arab Rep.	0.057	0.085	0.112	0.136	0.156	0.162	0.198	0.201	0.217
Ethiopia	0.058	0.069	0.061	0.061	0.061	0.065	0.069	0.099	0.102
Kenya	0.028	0.033	0.037	0.042	0.055	0.058	0.057	0.062	0.054
Sudan	0.029	0.030	0.029	0.021	0.025	0.028	0.027	0.035	0.067
Total (except for DRC+Tanzar	**0.048**	**0.067**	**0.084**	**0.099**	**0.114**	**0.117**	**0.140**	**0.146**	**0.161**

Data Source	IEA Energy Balance																			
Electricity consumption in Gigawatthours																				
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Congo, Dem. Rep.	1176.00	1309.00	1514.00	1052.00	1054.00	1010.00	1012.00	1015.00	1066.00	1232.00	1221.00	1228.00	1323.00	1499.00	1562.00	2631.00	2055.00	2045.00	2231.00	2100.00
Egypt, Arab Rep.	14144.00	14418.00	15172.00	15943.00	16829.00	17108.00	17917.00	19889.00	21821.00	23546.00	25673.00	27717.00	29823.00	31311.00	33900.00	36596.00	40271.00	43811.00	47431.00	51370.00
Ethiopia	365.00	405.00	437.00	481.00	530.00	558.00	569.00	516.00	497.00	520.00	395.00	591.00	644.00	711.00	769.00	977.00	1060.00	1178.00	1191.00	1472.00
Kenya	823.00	877.00	927.00	977.00	812.00	847.00	907.00	957.00	886.00	800.00	899.00	981.00	1050.00	1120.00	1193.00	1334.00	1495.00	1504.00	1569.00	1731.00
Sudan	665.00	701.00	704.00	747.00	780.00	774.00	664.00	580.00	958.00	761.00	1057.00	1383.00	1428.00	1262.00	1539.00	1737.00	1907.00	2210.00	2593.00	3105.00
Tanzania	448.00	553.00	545.00	585.00	660.00	927.00	1023.00	1059.00	1126.00	1192.00	1048.00	1120.00	1058.00	1163.00	900.00	871.00	1420.00	1523.00	1634.00	1753.00
Total	**17621.00**	**18263.00**	**19299.00**	**19785.00**	**20665.00**	**21224.00**	**22092.00**	**24016.00**	**26354.00**	**28051.00**	**30293.00**	**33020.00**	**35326.00**	**37066.00**	**39863.00**	**44146.00**	**48208.00**	**52271.00**	**56649.00**	**61531.00**

Appendux A-3 Decomposition Result for Industrial Sector of the Six EAPP Countries (1991-2010)



	91	91-92	91-93	91-94	91-95	91-96	91-97	91-98	91-99	91-'00	91-01	91-02	91-03	91-04	91-05	91-06	91-07	91-08	91-09	91-10
■ D Str	1.00	1.08	1.00	1.09	1.02	1.02	0.93	0.92	0.91	0.70	0.68	0.60	0.62	0.68	0.71	0.73	0.62	0.62	0.61	0.67
■ Dint	1.00	0.96	1.08	0.98	1.05	1.02	1.10	1.11	1.08	1.41	1.46	1.66	1.65	1.54	1.52	1.40	1.63	1.52	1.56	1.40
■ Dtot	1.00	1.04	1.09	1.08	1.07	1.05	1.02	1.02	0.99	0.99	1.00	1.01	1.03	1.05	1.09	1.03	1.02	0.95	0.95	0.94

초 록

사하라 사막 이남 지역 아프리카(SSA)의 전기 보급율은 32%인 반면 아프리카 평균전기 보급율은 43%였다(IEA, 2012). SSA에 대한 이런 데이터는 전기 보급율 면에서 SSA가 열악한 상태임을 알려 준다. SSA의 전기 보급율이 매우 낮은 수준이지만, 이 지역의 많은 국가들은 경제 개발 프로그램을 진행하고 있다.

수요와 공급 사이의 격차를 메꾸는 한 가지 수단으로 전기 시장 통합을 고려하였는데 전기 시장을 통합하면 국가간 전기 거래가 가능하므로, 각 국가가 시장에 참여하기로 결정할 때 엄격하게 주의할 필요가 있다. 전기 시장 통합 프로세스를 계획하려면 많은 정보를 수렴해야 한다. 또한 수출하는 국가들은 현지에서 사용하기 위해 남겨 두어야 할 잔여 전력량을 고려해야 한다. 반면에, 수입하는 국가들은 시장에서 구하려고 하는 전력량의 정당한 근거를 제시해야 한다. 수량과 가격이 상거래와 시장에서 매우 중요하겠다. 하지만, 수량과 가격이 얼마나 잘 기능을 발휘하느냐는 경제 부분의 움직임에 따라 결정된다.

이상의 개념을 근거로 본 연구에서는 전기 사용의 가장 낮은 가능한 결정 변수를 토대로 해당 경제 부문이 필요한 전력량을 어떻게 계산하는지 살펴 보았고 지수 분해 분석(IDA) 방식을 사용하여 선택된 여섯 개의 아프리카 국가, 즉 DRC, 이집트, 에티오피아, 케냐, 수단 및 탄자니아에서 전력 소모량에 영향을 미치는 요소들을 찾아보았는데, 전력 소모량은 두 가지 효과, 즉 구조 효과와 집약도 효과로 나누어졌다.

이 분석에서는 두 가지 모델로 첫째, 각 나라 별로 네 가지 경제 부문, 즉 농업/임업/기타 부문, 산업 부문, 상업/공공 서비스 부문, 그리고 주택 부문으로

구성되는 모델과 둘째, 여섯 개 나라 전체의 경제 부문별 모델을 사용하였다. 이 두 가지 유형의 분석 모델을 토대로 보면, 경제 부문 수준에서 전력 소모량을 추정하고 전력 소모 요인을 사용하면 합계 값을 추정하는 것보다 실제 전력 수요를 더 잘 파악할 수 있음을 알 수 있다. 두 가지 분석 모두 기간은 1990~2010년이었지만, 각 국가에서 사용 가능한 데이터로 인해 실제 기간은 국가마다 차이가 있음을 알 수 있다.

우선, 각 국가의 총 전력량을 분석하여 나온 결과를 네 가지 구조 효과와 집약도 효과로 설정하였다. 첫 번째 분석은 전기 소모량이 경제 부문 구성의 변화와 한 국가 내에서 각 경제 부문이 사용하는 집약도의 변화로 인해 어떤 영향을 받는지 보여주기 위한 것이었으며, 한 국가 내에서의 전기 사용 면에서 중요한 경제 부문을 구분하는 면에서 유의미한 결과가 나왔다.

DRC의 경우, 집약도 효과는 1991~1999, 구조 효과는 2000~2010년, 집약도 효과는 전체 연구 기간 동안 지배적이었다. 또한 1991~1999년에, 산업 부문과 주택 부문이 발전하면서 집약도 효과가 강해졌다. DRC에서 중요한 부문은 산업 부문과 주택 부문이었다. 1996~2010년에 이집트에 대해 나온 IDA 결과는 구조 효과보다 집약도 효과가 더 많이 증가했음을 보여주었다. 게다가, 이집트에서는 산업 부문과 농업/임업/기타 부문이 이 기간 동안 전기 사용 면에서 지배적인 역할을 했다. 에티오피아에 대한 IDA 연구 결과는 구조 효과 증가가 집약도 효과 증가의 절반 밖에 안됨을 보여주었다. 구조 효과와 관련된 경제 부문은 산업 부문과 상업/공공 서비스 부문이었고, 집약도 효과와 관련된 경제 부문은 주택 부문과 상업/공공 서비스 이다.

케냐에서는 이 경제 부문들에 대해 이용 가능한 데이터로 인해 세 가지 기간, 즉 1991-1994년, 1995-2007년 및 2008-2010년에 대해 분석을 수행하였다. 케냐의 경우 분석 결과는 구조 효과 증가가 분석 대상 기간 중의 집약도 효과 증

가에 비해 작음을 보여주었다. 전력 소모량 변화에 영향을 주는 면에서 지배적인 경제 부문은 분석에서 다양하게 나타났다. 수단에 대한 분해 분석 결과는 집약도 효과가 많이 증가했음을 보여준다. 이것은 주로 사용된 전력량에 비해 주택 부문 전력 사용 비용 지출이 적었기 때문이다. 탄자니아에 대한 IDA 결과에 의하면, 구조 효과가 집약도 효과보다 더 적었다. 연구 기간의 많은 부분 동안 집약도 효과가 지배적이었던 추세는 탄자니아에서도 반복되어, 산업 및 주택 부문이 지배적이었다.

각 경제 부문의 전력 소모량이 해당 국가의 점유율 변화로 인해 어떤 영향을 받았는지를 알아 보기 위해 두 번째 분석을 실시하였다. 이 경우, 결과는 다소 정밀함을 알수 있었다. 각 국가를 나머지 다섯 나라와 비교하였는데, 특정 산업 부문의 전력 소모량의 집약도를 근거로 각 나라가 앞으로 어떻게 될지 예측하기가 비교적 단순하여 농업/임업/기타 부문의 총 전력량 집약도를 분해하였다.

1991~1994년 기간의 농업/임업/기타 부문의 총 전력 집약도에 대한 IDA 연구 결과에서는 구조 효과와 집약도 효과가 증가한 것으로 나타났다. 대부분의 나라들이 1995~1999년에 농업 부문에서 전기를 사용하지 않았지만, 전통적인 방식으로 경제적인 산출물을 생산했기 때문에 이 경제 부문에서는 생산을 위해 많은 전기를 사용하지 않았으며, 집약도 효과가 증가하면서 2000~2007년에 이 경제 부문의 전력 사용이 증가하였다. 1991~2010년의 산업 부문에 대한 IDA 연구 결과에서는 구조 효과가 감소한 반면 집약도 효과는 증가한 것으로 나타났다. 집약도 효과가 약간 더 크기는 했지만, 이집트와 DRC가 차지하는 점유율이 감소했기 때문에 활동 구성의 변화가 미치는 효과가 지배적이라 할 수 있겠다.

상업 부문과 공공 서비스 부문에 대한 IDA 연구 결과는 이용 가능한 데이

터를 고려하여 두 가지 유형으로 분류하였다. 1991~1999년에 대한 연구 결과에서는 구조 효과가 감소한 반면 집약도 효과는 급격하게 증가한 것으로 나타났으며, 2000~2010년에 대한 연구 결과는 구조 효과와 집약도 효과가 모두 증가했음을 보여주었다. 구조 효과로 인해 1년 중에 경제적 산출물을 생산하는데 사용된 전력의 양이 감소하였지만, 집약도 효과로 인해 그 안에서 큰 변화가 나타났다.

1991~2010년에 주택 부문에 대한 IDA 분석 결과에서는 구조 효과가 감소한 반면 집약도 효과는 증가한 것으로 나타났다. 집약도 효과가 약간 더 커졌기 때문에, 활동 구성 변화가 미치는 영향이 지배적이었는데 이는 이집트, 수단 및 DRC가 차지하는 점유율이 감소하고 케냐가 차지하는 점유율은 일정하게 유지되었기 때문이다. 또한 이집트의 점유율이 감소하면서 산출량 성장율이 감소한 것으로 나타났고, 그로 인해 생산량이 증가했는데도 전력은 덜 사용하게 되었다. 이 경제 부문에서, 집약도 변화는 1991~2010년 기간 동안 주택 부문의 전기 사용이 지배적이었던 국가를 찾아내는데 중요한 역할을 했다.

국가들은 시장에서 균형을 맞추어야 하며, 자체적인 지역 및 국가별 전력 계획을 잘 수립해야 한다. 이런 개념을 근거로 이 연구에서는 전력 사용의 가장 낮은 가능한 결정 변수를 토대로 해당 경제 부문이 필요한 전력량을 어떻게 계산하는지 살펴 보았다. 전력 소모량 변수 중 가장 낮은 가능한 카테고리부터 시작하여 경제 부문을 고려한 이 연구 결과를 사용하면 부조화를 최대한 줄일 수 있으며, 부조화로 인해 산업 부문의 전기 사용 권한 및 참여하는 국가의 전반적인 경제에 미치는 부정적인 파급 효과도 최대한 줄일 수 있다.

이 동아프리카의 여섯 국가에서는 전기 사용이 주로 경제적 부가 가치가 있는 연간 전기 사용의 긍정적인 변화로 인해 증가하였으며 본 연구에서는 각 국가에서 그런 변화를 일으킨 경제 부문 중에서 가장 전략적인 부문이 확인되

었다. 이것은 해당 국가의 기획자, 의사결정자, 그리고 집행 기구들이 전략적 부문을 찾아내는데 도움이 되었다. 구조 효과와 집약도 효과는 해당 경제 부문에서 사용된 전력량 변화에 직접적으로 영향을 미친 변수들이었다. 그렇기 때문에, 이 여섯 국가에서 정책의 함축적인 영향을 설명할 때 이 요소들이 자주 사용되었다.

에티오피아의 경우, IDA의 연구 결과를 토대로, 다음과 같은 정책의 함축적 영향을 찾아내는 것이 가능했다. 상업 부문과 공공 서비스 부문은 변화에 영향을 미치는 면에서 두 가지 효과 모두에서 지배적이었고, 이것은 해당 경제 부문 또는 국가까지도 활동 구성 및 집약도 효과 면에서 지배적인 영향을 미친다면 막대한 역할을 하게 됨을 의미한다. 이 연구에서는, 상업 부문과 공공 서비스 부문을 전기 수요를 계획할 때 전략적으로 중요한 부문으로 간주할 수 있겠다.

주요어 : 에티오피아 전력 강도, 수요구조, 분해분석지수, 강도영향, 구조효과, 동아프리카전력시장

학 번 : 2011-30799