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Finding a Scientific Method to Reduce Carbon Dioxide Emissions from Urban Areas in Iraq/ Baghdad as a Model

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Abstract
This research represents the different analytical methodologies (Models) of carbon dioxide reduction and their various categorizations as well. Then, it explains many of these models and makes a comparison among them. The research explores the characteristics that affect energy consumption and carbon dioxide emissions associated in urban areas. Although, there is rich body of research has been conducted to determine these effects, most of them concentrated on transportation sector. The research illustrates the effects on energy consumption in the building sector. The research problem is arising because there is a difficulty in finding a scientific and applicable method to reduce carbon dioxide emissions from urban areas of Baghdad. In order to cover this gap, the research establishes its thesis which is: it could be found the suitable method of carbon mitigation for the city of Baghdad by collecting and analysing the available information and applications in this topic globally. So, the aim of this paper is to establish a suitable and scientific base to choose a method for the sake of carbon dioxide mitigation in Baghdad. The paper suggests the most suitable model for Baghdad to be used in carbon mitigation endeavour. What data available in this topic? Which of carbon modelling systems, tools and techniques are suit this city? What are the main drivers that could affect the choice? What is the goal of using any of these models? How could the obtained results be evaluated? All of these questions are considered to choose a model for Baghdad to meet its goal of carbon emissions reduction. After choosing MARKAL model, the relevant analytical features of MARKAL model are illustrated to be used. In addition, this research shows the main reasons of using this model which are; it is used in more than 50 countries, it is related with the differences in energy demands that caused by the different urban areas, it suggests the optimal carbon mitigation strategies in its results that are suit each area, and the richness of literature available. This research discusses three tasks: explain carbon mitigation models and conducting a comparison among them, explain the use of MARKAL in other countries and the capability of using MARKAL in Baghdad as the right tool to use in carbon mitigation in the city.
Keywords: Carbon dioxide emissions, carbon and energy models, energy demands, Business-As-Usual, MARKAL model

1. Introduction

At the last decade of twentieth century, the scientific evidence of climate change was demonstrating that if cities continue with 'Business-As-Usual' BAU would mean allowing the rate of global temperatures to rise. It will reach a level never experienced before by human society with serious implications for livelihoods and natural environmental systems (Mulugetta et al., 2010). BAU assumes that people will continue behaving just as they have been(Agnew et al., 2009). So, it is essential for human community to search for solutions related with energy consumption and greenhouse gases GHGs, especially carbon dioxide emissions associated. More than three decades of scientific attempts to find models and techniques to be implemented as alternative solutions for 'business-as-usual', a number of energy system models are now available and have been developed for the planning of large energy systems at national or regional scales (Bhatt et al., 2010).

It is known that Iraq has a big deficit in energy resources especially electricity. As a result, many types of electrical generators are used to cover these demands. These generators release an increasing amounts of greenhouse gases namely carbon dioxide.

A question arising by this research is: which of carbon reduction methods is suitable for our country especially for the capital Baghdad. In other words; how can we reduce the continuous growing in carbon concentrations in Baghdad and how can we find the appropriate tools for the sake of carbon mitigation?

2. Carbon and energy models' classifications

Many of scientific efforts are conducted to classify carbon and energy models according to the specific needs of each country or a city. This paper collects and categorizes these models based on general criteria that models could be associated.There are different visions in categorizing methodologies for carbon and energy modelling. So, these models could be categorized as listed below:

2.1 Classification based on analysis techniques

Four types of models could be seen at this classification which are; technological, predictive, renewable related models and simulation models.

2.1.1 Technological models

The energy and environment systems model EES provides a quantitative vision of technology and management strategy options in order to deploy energy efficiency (Bhatt et al., 2010). It is common in use improving equipment efficiency to reduce carbon emissions.

2.1.2 Predictive models

- The energy and environmental prediction model EEP provides tool for quantifying energy use and associated emissions for cities (Jones and Dickson, 1996).
- The Community Domestic Energy Model CDEM and the Building Research Establishment Domestic Energy Model version 8 BREDEM-8, predict the energy use and CO2 emissions for the housing stock (Lomas, 2010). These models work by estimating the heat losses, internal temperatures and energy flows in the dwellings.
- MUNTAG – model used to estimate the impacts of land use and public transportation to promote greener transport, and alternative vehicle technologies.
- Domestic Energy and Carbon Model (DECM) which is used to estimate the energy demand for domestic uses. This model involves housing database and building energy model(Condon et al., 2009). These models are predictive and require much of data that are not available in the case of Baghdad recently.

2.1.3 Renewable related models

The optimal renewable energy mathematical (OREM) model allocates optimal renewable energy sources for different end-uses such as lighting, cooking, pumping, heating and cooling (Iniyana,2003).The renewable energy resources have many technologies, such as, solar thermal and wind turbines(Town and Country Planning Association, 2009). These models depend on techniques limited in use in Baghdad now.

2.1.4 Simulation models

- The Geometry Information System GIS-based DECoRuM model estimates and maps baseline energy use and CO2 emissions on a house-by house level (Gupta, 2007).
- District energy system simulation DEES model depicts the energy flow of a district as the sum of total energy flow in each building (Scheer, 2001). The data of these models require long time to be collected and they depend on prediction.

2.2 Classification based on the process of modelling

This classification depends on the direction and the method of counting the energy use and emissions associated. These methods are different from whole amount of energy of a city to specific building.

2.2.1 Top-down models

These models capture the whole systems of energy and its interactions with other parts of the economy.

2.2.2 Bottom-up models

in this set, each important energy-using technology is identified by a detailed description of its inputs, outputs, unit costs, and several other technical and economic characteristics (Bhatt et al., 2010). In these models, a sector is constituted by a usually large number of logically arranged technologies, linked together by their inputs and outputs which may be energy forms or carriers, materials, emissions, and demand services. The success of such bottom-up initiatives depends on their ability to inspire and draw in voluntary participants maintain their interest (Mulugetta et al., 2010).

2.2.3 Accounting frameworks

These models ask users to specify outcomes. LEAP, MEDEE, The main function of these tools is to manage data and results with simple spread sheet calculations (Bhatt et al., 2010). This type depends on questionnaire and takes too much time and concentrates on dwelling sector.

2.2.4 Simulation models

They analyse the dynamics of previous behaviour of the energy system and simulate the energy system to project the future.

2.2.5 Optimization models

The more complex model and many of them are bottom-up, namely, MARKAL, EFOM, WASP, and DEECO (Bhatt et al., 2010).

It could be seen that the last two types of models require an accurate data that is difficult to collect in Baghdad at the moment.

2.3 Classification according to the purpose of analysis

Based on the purpose of analysis, carbon and energy models could be divided into two sets of tools:

2.3.1 Accounting inventory modelling tools

They involve top-down models which collect data from national to the local level, and bottom-up models from local to the whole nation scale.

2.3.2 Policy making modelling tools

The purpose of these models is to improve the energy systems along time(Calderon and Keirstead, 2012). Carbon mitigation strategies are related with policy making more than inventory models.

Although inventory is important for carbon mitigation strategies, there were some policy making models could be applied for the case of Baghdad without inventories.

2.4 Classification based on data resources

Carbon mitigation models differ in data required and resources. Types of data resources play the main role in model design and run process.

2.4.1 Technology design models**:** these models deal with the technology used in urban areas, such as wind turbines, solar energy systems and fuel cells. These models deal with renewable energy systems.

2.4.2 Building design models

The subject of these models is the urban circumstances that affect buildings, for instance, urban planning at different scales, from single building to the whole city. They can estimate the yearly energy consumption of dwellings of heating, lighting and other housing purposes. BREDEM-8 is an example of these models(Keirsteada et al., 2012). The main two drivers for this type of models are urban planning and housing sector.

2.4.3 Urban climate models

These models analyse the natural and operational conditions inside buildings to estimate the kind and the amount of energy demand for their services, for example, they deal with the effect of urban heat island. Based on these models, local climate depends on urban energy consumption.

2.4.4 System design models

The major consideration of these models is the way to improve the urban energy systems of existing buildings and network heating in urban areas. These models need urban systems that could address heat radiation.

2.4.5 Policy assessment models

These are evaluating models that examine the effectiveness of the new intervention applications regarding urban energy systems, considering the effects of urban parameters such as density and urban fabric patterns.

2.4.6 Transportation and land use models

The models are more complex and deal with correlation between land use change and transportation types(Keirsteada et al., 2012).

The last two types require data collection for a long time taking in account future expansions.

2.5 Classification according to their methodologies

The process of data analysis and result conducting are various from model to another. This classification depends on the methodologies followed in each model.

2.5.1 Spatial and non-spatial methodologies

The spatial methodologies concentrate on the relationships among physical elements within the urban areas. They are more related with transportation patterns through a city. So, these tools used for transportation modelling. On the other hand, the non-spatial tools, explore the resulted information numerically, without considering the relationships between the physical urban elements(Condon et al., 2009).

The use of spatial methodologies offers the results of modelling to be represented in visual manner, in case of using GIS technologies, which allow users to understand the impact of carbon mitigation strategies on the urban environment.

2.5.2 The top-down and bottom-up methodologies

These tools have different trends; top –down are used for large scale modelling, such as regional and municipal level. Conversely, bottom-up tools concentrate at the local scale, for instance, district and city level. However, some of these methodologies could be used for both scales such as MARKAL model.

2.5.3 Simulation and End-state methodologies

The simulation methods depend on two sets of input data, which are the land use conditions in present time and the development parameters, such as patterns of behaviour and new technologies. In contrast, the end-state tools begin with proposed future conditions to achieve the preferable scenario in a given future time. From this point of view, end-state methodologies are faster than those of simulation tools.

2.5.4 The observation-based and process-based methodologies

The observation-based tools utilise measured data to establish the required parameters for the model, such as the impact of urban density on the walking trips. However, the process-based tools analyse choices of a model, or the correlation between single components through the energy system. They don't consider the local circumstances of urban areas(Condon et al., 2009).

The discussions and deliberations at urban energy and carbon modelling determine a number of research challenges. Some of the key challenge areas are related to data and information gaps, developing long-term scenarios, establishing a consistent urban carbon accounting framework, understanding of the urban system dynamics, and interaction of urban activities related to carbon emissions across the multiple system boundaries, formulating appropriate policies, and making the policy in operation with its instruments.

What data available in the case of Baghdad in terms of energy use and gases emissions? Which of carbon modelling systems, tools and techniques are suit this city? What are the main drivers that could affect the choice? What is the goal of using any of these models? How could the obtained results be evaluated? All of these questions are considered to choose a model for Baghdad to meet its goal of carbon emissions reduction.

As the large gap between the huge information about carbon mitigation tools and models at the global scale, a little information available related with carbon mitigation in the case of Baghdad. It is clear from the previous review that it is so difficult to analyse all of carbon models. This research choose the most common in use model that require a little data which could be collected in the case of Baghdad easily. The main reasons of choosing this model are; it is used in more than 50 countries, it is related with the differences in energy demands that caused by the different urban areas, it suggests the optimal carbon mitigation strategies in its results that are suit each area, and the richness of literature available.

3. MARKAL model

This model is MARKAL (acronym for MARKet ALlocation) which is a widely applied bottom-up, dynamic technique, originally and mostly a linear programming (LP) model developed by the Energy Technology Systems Analysis Program (ETSAP) of the International Energy Agency (IEA) (ETSAP, 2001). MARKAL depicts both the energy supply and demand sides of the energy system (EIA, 2006).

3.1 What is MARKAL?

MARKAL is an energy model for demand meeting. The extracted energy is obtained from the natural resources and transported by carriers as fuel and electricity by supply technologies. These types of energy are used by various end-use sectors, such as residential and industrial technologies. The final stage is to express these amounts of energy use to final demand as heating or lighting loads. So, MARKAL is guided by the definition of the useful demand loads that are belonging to the whole energy system or for each sector separately. This means that the final energy consumption for each sector has not specified as static case, but the model determines the final energy consumption by comparing many technologies to achieve the useful demands. The main parameter of this competition is fuel type (EIA, 2006).

MARKAL could demonstrate and analyse the energy system of a city for long term and divides the time into many stages, for instance, eight times for five years each. It deals with all technologies with different initial capacities for a defined period of time taking in account the service life of these technologies. It also accepts the potential new technologies that are could be occurred at particular time.

As a combined model of technology and economy, MARKAL involves numerous components of parameters in its database, such as, technical coefficients that explore the supply and demand technologies, and the cost, life time and the capability of their existence in the future.

MARKAL could draw the vital characteristics of an energy system, especially:

1- The importance of meeting the final energy demand requirements
2- The restricted initial resources availability.
3- The essential role of the conversion technologies to achieve the equilibrium between the supply and demand energy
4- The importance of installing the appropriate energy capacity in order to meet the required level of operation.
5- The continuity of changing process of capacity, through new generation, maintaining the old ones and removing the rest of capacity.
6- The interaction between the input and output variables of different activities.
7- The permitted amount of carbon dioxide emissions in the energy system plan.

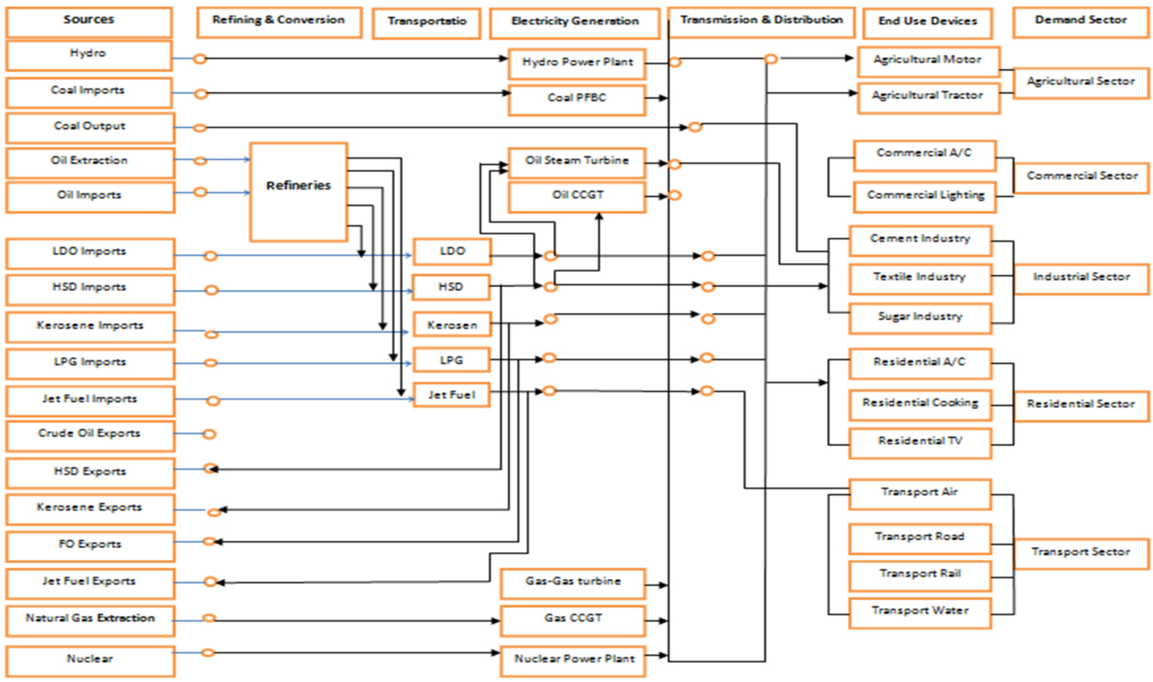

Figure 1 The analysis process in MARKAL model

3.2 Why MARKAL?

MARKAL is a simulation, optimization and bottom-up model used in more than 50 countries. It is one of the most common in use around the world, which enables researchers to compare the situation of Baghdad with other cities in different countries. In addition, it doesn't require an inventory data for energy consumption of each sector in a city, as the situation in Baghdad is too difficult that collecting inventory data required such a long time and that needs many team workers, because there is no data available and reliable to be used in the analysis, due to discontinuous reporting process for energy consumption in the city governorates. MARKAL is related with the integrated energy system that involves the energy demands and supply, considering the transition from resources to the end-use in services. It is more related with the city scale than the building scale, which offers the opportunity for researchers to address the differences between various urban areas at the district scale of the city. In other words, it could determine the difference in energy supply and demands in various districts in Baghdad.

3.3 Advantages of using MARKAL

1- Studying the national energy system is more beneficial than regional, at the same time, studying the local energy system is more important. This classification enables users and stakeholders to compare the analysis results between countries as well as cities. It is agreed that countries and cities have different, available technologies, economic systems, primary energy resources and other variables. Using the common energy models and tools to analyse different energy systems, could facilitate the comparison between these countries in terms of international conventions, for instance, Kyoto protocol.
2- MARKAL is a linear programming model. It analyses the supply data of an energy system at beginning of analysing and processes the demand output at the end of it(Sulkan et al., 2010).
3- MARKAL is one of the decision frameworks and common in use model to analyse carbon mitigation impacts. MARKAL's methodology is flexible and applicable for different scales from regional, country and city level. The most widely application for this model is to analyse the designed strategies to mitigate the carbon dioxide emissions from energy sector and to reduce the consumption of natural resources. Thus, it is the most suitable for my research to apply for the purpose analysing the carbon mitigation strategies and to develop a long term energy system plan for Baghdad (International Resources Group, 2001).

The use of MARKAL in modelling energy systems involves many benefits, namely:

- The required data for cost and technological options are involved in any type of technology separately.
- It offers a various mix of technologies along the time periods.
- It gives calculation of prices from analysing technology and cost options

- The model analyses the energy supply and demands at the same time in each scenario.
- It offers the ability to compare the both sides of technologies used, in supply and end-use.

It enables users to choose the level of detail for various energy systems to be modelled.

4. MARKAL in countries

Many countries and cities have used this model. It is common in use in the developed countries more than the developing countries. As Iraq is one of the promising developing countries, this research has chosen the use of MARKAL model in the same class considering variety in locations. The chosen countries are Turkey, China, Pakistan and Nigeria.

4.1 Turkey

There are four main variables need to be determined in turkey's MARKAL example; the resource technologies, energy carriers, the technologies of conversion processes and energy demands. This action forms the first step in modelling analysis by MARKAL model. The second step is to identify the appropriate positions and relationships among these variables, in the model hierarchy. Finally, the reference energy system for Turkey could be established in numerical information as a base line scenario to be available for comparison purposes in case of applying alternative interventions for energy system and carbon reduction processes (Sulkan et al., 2010). The aim of this study is to provide a clear vision of the preferred options of energy to be used in Turkey. This study suggested some technology choices to let Turkey meets its energy needs in the future, and reduce the impact of energy consumption on the local environment.

The two sides of MARKAL equation are the supply data and the energy demand. This model classifies the patterns of technologies that suit the energy system and finds the optimum cost for the specified system, taking in consideration all limitations defined by users. MARKAL model for Turkey involves wide range of technologies in order to give the opportunity for various scenarios to be developed. Turkey is modelled as a single region.

The optimum solution for the reference energy system has been established and explored the main changes in the two sides of supply and demand, the amount of carbon dioxide emissions associated and their reflection on the economic status. This base scenario forms a reference for comparisons with other propose scenarios.

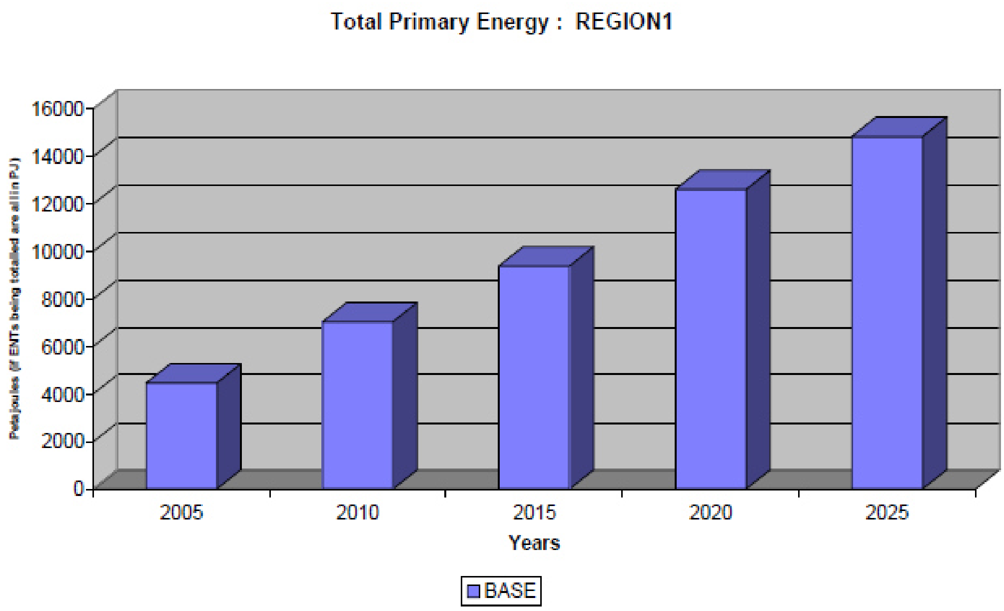

Figure 2 Total primary Energy

The future scenarios that could be adopted in turkey base on the reference scenario are:

1- Improve the efficiency of the power plans and end-use technologies that could affect energy production, consumption and the amount of Co2 emissions.
2- Analyse the power plants to estimate the yearly expenditure and the amount of produced electricity.
3- Analyse the effects of the renewable energy resources growth and nuclear power stations on the whole energy system at the national scale.
4- Analyse the renewable domestic energy generation on the energy demand from the national system.
5- Explore the carbon mitigation scenario on the planning for new environmental aspects.

6- Analyse the effects of potential evolutions on the imported fuel prices.

4.2 China / Shanghai

This study demonstrates the proposed policies of carbon mitigation in the city of Shanghai in china. The study uses MARKAL model in its analysis.

Due to the rapid changes in the energy system of China, the econometric models have not the capabilities to analyse this system for long time prediction. Thus, the engineering tools are the appropriate alternatives for Shanghai study. The economic status is modelled in MARKAL as a system, and it is seen as a processes and monetary transfers among these processes.

The database and the major constrains are defined by the analyst. These are represented by the total demands for services that have to be covered by the energy system. The analyst inserted the range of new interventions, the proposed energy resources, and the environmental target of carbon reduction. The main processes in the model are classified according to their real inputs and outputs, costs and the emissions produced. It could be recognised that the upper rates of emissions cost considered as a constraint, so, the lower amount of emission have been chosen as an optimal model configuration. The model defined carriers of energy, materials, processes and demand categories. The national technology studies supported the technical data used in this study. The study determined the current used technologies (some of them are not wide spread) to meet the most relevance policy in mitigation scenarios (Gielen and Changhong, 2001).

In the base line scenario, the co2 emissions in Shanghai have been estimated to increase by 56% in 2020 due to the huge depending on coal fuel and the rapid growth of national economy. The limitation of Co2reduction, which is 10%, related with the improvement of energy efficiency measures that are developed by Shanghai city recently. The proposed reduction in Co2 emissions should be achieved according to the use of energy policies and air pollution reduction policies, which is estimated to be about 24 % in comparison with the base line levels.

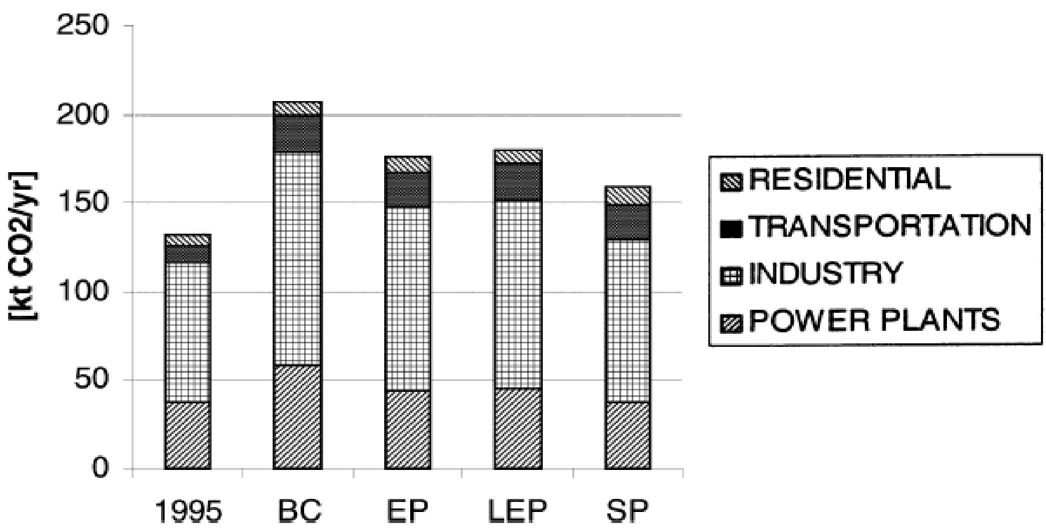

Figure 3 The impact of policies on the Co2 emissions 2020

- Base case BC
- Energy policy EP
- Local environmental policy LEP
- Sustainability policy SP

4.3 Pakistan

This study examines the effects of limitation of imported energy and the national energy supply on the variation of energy system components, such as, energy resources and supply technologies in Pakistan in the period from 2005 to 2050. The analysis has been conducted by using MARKAL energy model.

The basic four steps of MARKAL model are consisting in Pakistan model. These steps are; define the energy supply resources such as, hydro and crude oil, technologies of conversion processes which are power generation and transmission network, end-use technologies and the final demand for services(Anwar, 2010).

The main two strategies that need to apply for Pakistan energy system using MARKAL model are restricting the imported energy and reduce the energy supply in order to improve the energy system in terms of security. The effects of these two policies are demonstrated by estimating the appropriate indicators of energy security for the reference case and through the named time horizon.

The results show that following the two strategies in all scenarios leads to decrease the energy consumption and carbon dioxide emissions, in comparison with the base line scenario.

4.4 Nigeria

This study has been applied to examine the potential future use of renewable resources on the national economy in Nigeria by utilizing MARKAL model. It realised that MARKAL is not a predictive model, so, the study used simulation model called Model for Analysis of Demand for energy MADE-II to speculate the energy demand that required in MARKAL calculations. Then, MARKAL identified the optimal economic choice to compare with the base line energy system. The main reason for studying the effects of carbon dioxide in this study is because this gas has the responsibility of more than 50% of the whole amount of radiation in the atmosphere, based on its highly concentration inside it(Akinbami, 2001).The study relied on the following assumptions as parameters:

1- Demography; the growth rate of population is assumed as 2.8 %, 2.1% and 1.45 in three different scenarios.
2- Economy; the GDP growth rate is assumed to be 3%, 5% and 6% in the same scenarios respectively.
3- Prices of fuel;
   - Oil prices are assumed as $16.69/barrel in 1990, $17/barrel in 1995, $24/barrel in 2010 and $28/barrel in 2030.
   - Natural gas prices are assumed to be $27.84/1000m by the year 2001 according to the World Bank report in 1993.

There are three main targets in this study base on using MARKAL model:

1- Analyse the potential cost of carbon mitigation plans in Nigeria for its energy sector.
2- Define the optimal energy components taking in account the proposed carbon mitigation strategies in this sector.
3- Determine a plan for implementing these strategies in Nigeria' energy sector.

RENEWABLE ENERGY RESOURCES AND TECHNOLOGIES IN NIGERIA

TABLE VII

Default CO_2 emission factors (IPCC 1995)

Fuel type	Emission factor (kg CO_2/GJ)
Coal	101.2
Oil	73.3
Natural Gas	56.1
Gasoline	69.3
Diesel	74.1
Fuel Oil	77.4
Kerosene	71.3
Liquefied petroleum gas	63.1
Condensate	55.7

Figure 4 According to the Intergovernmental Panel on Climate Change (IPCC), the figure shows the emission coefficient of carbon dioxide for each fuel.

5. An energy model for Baghdad

The urban planning of Baghdad and its characteristics such as, streets' network, green areas, public open spaces, buildings' archetypes and urban density have a serious impact on the amounts of energy used and carbon dioxide emissions (Town and Country Planning Association, 2009).This impact could be seen at different scales, from street to district. It offers various opportunities for buildings to gain benefits from natural environmental elements, such as sunlight and wind circulation (Ibid). The impact of urban planning on carbon dioxide emissions is greater than fuel replacement(Marshall, 2008).It is accepted that urban planning of a city or a district has a great impact on the energy system of this urban area in terms of energy supply and demands, production, distribution and end-use.(Condon et al., 2009).

The main driver for study of Baghdad is the impact of urban area factors on the energy supply, conversion, energy transporting and the useful demand. The main purpose of this model is to explore the impact of different carbon mitigation options in various scenarios along time.

The required data are listed below to build the energy model for Baghdad base on MARKAL model:

- The forms of energy that need to be represented in the new model.
- The main criteria of the proposed technologies and their types
- The national amounts of available initial resources
- The expected aspects of prices for import and export energy resources.
- The amount of energy required for each targeted sector as a useful demand.
- The proposed limitation of permitted amount of carbon dioxide emissions.

5.1 The description of technology

The following technical data are required for the sake of technology description in MARKAL model:

- Types of fuel as input data.
- Forms of energy that represented as an output data.
- The process efficiency
- The availability of utilizing new technologies at a particular date.
- Definition of service life for each technology.
- The available capital for each new technology and its capacity.
- The expected cost of operation and maintenance for each unit of capacity, excluding the cost of required fuel.
- The carbon dioxide emissions technical coefficients.

5.2 Variables

The variables involved in MARKAL model are both internal and external. The external variables, which involved the useful energy demands and fuel prices, are supplied by the database while the internal ones are consisted in the model. The internal variables are listed below:

- The energy carriers variables
- The definition of amount of each available fuel type at a specific time.
- The energy supply technologies variables.
- The proposed investment for any technology used in each period of time.
- The capacity of technology at a particular time to be installed.
- Specify the used capacity of each technology in a specific time.
- The energy demand variables.

MARKAL determine each value of the above variables as a solution by the linear programming.

5.3 Constraints

Constrains are the logical relationships that control the various variables inside the model. These relationships could be represented as in the following(EIA, 2006):

- The energy demands meeting
- The balances of fuel
- The operation limitations.
- The capacity conservation from time to time
- The external individual technologies availability
- The maximum permitted amount of carbon dioxide emissions from the energy system.

5.4 Objective Function

In its operation, MARKAL will make a decision for the values of all variables in order to meet the constraints and find the minimum cost for the energy system. This is the objective function of the model, which means the whole reduction in the cost of an energy system at all time periods. In addition, it may indicate the total carbon dioxide emissions.

5.5 MARKAL Outputs

In each period of time, MARKAL gives the following outputs:

- The difference in capacity in both trends of increase and decrease of technologies for energy supply.
- The activity's level of the chosen technologies.
- Determine the technologies for end-use that are the most effective at a minimum cost.
- Illustrate the calculations for all types of energy that used in the system.

- The initial value of all forms of energy
- Minimize the value of all activities that occur at a negative level in optimal solution.

The model deals with the various forms of fuel and their technologies in detail, and the minimum cost of carbon emissions' mitigation. In the process of optimization, the model offers its flexibility in continuous changing the types of fuel used and their prices. The model calculates the fuel prices for all energy forms in the system without considering any extra costs, such as taxes. Base on linear programming, the model could calculate the complex situations, for instance, peak load electricity.

6. Conclusions

Finding the appropriate tool for carbon mitigation in Iraq should optimises between the international obligation by Kyoto Protocol and the huge deficit in information required to meet this obligation. The research has analysed many carbon mitigation models used over the world and found that MARKAL model offers the flexibility required for the case of Iraq and has made the conclusions listed below:

1- It is important for Iraq to identify the appropriate tools to meet the international obligation about mitigation the carbon dioxide emissions through Kyoto protocol.
2- The difference occurs between carbon mitigation models depend on the purpose of use and development stages.
3- The process of choosing the right model for Baghdad should concern the specific circumstances of information shortage about carbon emissions, the traditional energy sources that depend on oil and the irregular use of private electrical generators.
4- The model has chosen should have the elasticity when input variables have changed, such as developing energy sources and final use improvement.
5- The model should have the ability to use at different scales.
6- In order to gain the maximum benefit from using the carbon mitigation model in Baghdad, the modelling analysis will be consisted three main steps. Firstly, Baghdad will be divided into number of districts according to their urban area characteristics. Secondly, MARKAL model will be run for each district to determine the required carbon mitigation technologies for each type of urban areas. Finally, define the appropriate carbon mitigation strategies according to the results of model runs.
7- The research could gain more benefits from MARKAL by running the model many times in different scenarios and compare the obtained results, to determine the main effective variables and to recognise the similarities and differences among all scenarios. This process can explore the sensitive components of the energy system that respond to the various assumptions in different scenarios.
8- The research can assess the unexpected changes in the energy system according to the variety of assumptions for the parameters included in the model, such as substitution of prices, the new technologies that could be available at a specific time and the allowable amount of carbon dioxide emissions. Changing any of the exterior parameters, for instance, energy demands and the technical coefficient for the fuel type, the new results will be recomputed by the model, accordingly.
9- MARKAL is an ideal tool for analysing the situation on carbon mitigation strategies in various scenarios when the exogenous variables changed base on the different requirements for many urban forms for Baghdad's districts. We can use the conditions of what if questions in changing the parameters related with urban form and carbon mitigation strategies, because each of them has strong relationships with energy supply and demands in different stages of the analysis.

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إيجاد طريقة علمية لتخفيض إنبعاثات غاز ثاني أوكسيد الكاربون من المناطق الحضرية في العراق/ مدينة بغداد أنموذجا

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المستخلص

إن هذ البحث يوضح الاختلافات الموجودة في المناهج التحليلية (نماذج) تخفيض غاز ثاني اوكسيد الكاربون في الجو و كذلك طرق تصنيفها. يقوم البحث بشرح موجز لعدد من هذه النماذج و يقارن بينها.

البحث يستعرض الخصائص المؤثرة على استهلاك الطاقة و الانبعاثات المرافقة لها من غاز ثاني اوكسيد الكاربون في المناطق الحضرية. حيث وجد انه على الرغم من كثرة البحوث في هذا المجال على مستوى العالم الا ان القسم الاغلب منها يركز على قطاع النقل. هذا البحث يسلط الضوء على عملية استهلاك الطاقة في قطاع الابنية في العراق و خاصة في العاصمة بغداد حيث تم تحديد مشكلة البحث بالاتي: هناك صعوبة في إيجاد طريقة علمية قابلة للتطبيق لوضع منهجية واضحة من اجل تخفيض نسبة غاز ثاني اوكسيد الكاربون في مدينة بغداد. و لغرض تغطية هذه الفجوة إقترح البحث الفرضية الاتية : يمكن إيجاد الطريقة المناسبة لحل هذه المشكلة من خلال جمع و تحليل المعلومات و التقنيات المستخدمة و التطبيقات على مستوى العالم في هذا المجال و تحديد الالية الاكثر ملائمة لتخيض الكاربون في مدينة بغداد مع الاخذ بعين الاعتبار الظروف الخاصة لهذه المدينة. و لذلك فإن هدف البحث هو إيجاد القاعدة العلمية المناسبة لأختيار الطريقة الامثل في السعي لتخفيض غاز ثاني اوكسيد الكاربون المصاحب لأستهلاك الطاقة في المناطق الحضرية من مدينة بغداد.

يقترح البحث نموذج تخفيض الكاربون الاكثر ملائمة لمدينة بغداد في سعيها لتحقيق اهدافها في هذا المجال. ما هي المعلومات المتوفرة لدعم هذا التوجه و ما هي الانظمة و الادوات و التقنيات المناسبة لهذه المدينة. ما هي المحددات التي من الممكن ان تؤثر في عملية الاختيار و ما هي الغاية من استعمال اي من هذه النماذج و كيف تتم عملية تقييم النتائج المستخلصة ؟ كل هذه الاسئلة قد تم اخذها بنظر الاعتبار لاختيار نموذج تخفيض الكاربون المناسب لمدينة بغداد في تحقيق هدفها في تخفيض كميات انبعاثات غاز ثاني اوكسيد الكاربون.

بعد اختيار نموذج التخفيض (ماركال) تم توضيح المكونات الرئيسية التي تدخل في عملية التحليل لهذا النموذج . كذلك فقد تم توضيح أهم الاسباب التي أدت الى إختيار هذا النموذج و أهمها: تم إستخدام هذا النموذج في اكثر من 50 بلدا حيث يعتبر الاكثر شيوعا , ان هذا النموذج يتعامل مع الاختلاف الحاصل في الطلب على الطاقة الناتجة عن الاختلاف و التنوع الموجود في المناطق الحضرية لمختلف الاسباب , انه يقترح ستراتيجيات تخفيض الكاربون الاكثر ملائمة لكل منطقة حضرية و لتوفر المعلومات الخاصة بهذا النموذج بشكل كبير.

إن هذا البحث يناقش ثلاث مراحل أساسية هي: توضيح نماذج تخفيض الكاربون المختلفة و اجراء مقارنة فيما بينها في ضوء هدف البحث, توضيح تجارب إستخدام النموذج المقترح لمدينة بغداد في عدد من دول العالم و امكانية تحقيق الهدف في تخفيض نسبة غاز ثاني اوكسيد الكاربون في هذه المدينة.

الكلمات الرئيسية: إنبعاثات غاز ثاني اوكسيد الكاربون, نماذج الطاقة و الكاربون, الطاقة المطلوبة, صرف الطاقة كما هو معتاد, نموذج ماركال.