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Department of Civil Engineering and Architecture

RENEWABLE ENERGY POLICY IN ETHIOPIA: STATUS, CHALLENGES AND SUPPORT BY THE EU

ETIOOPIA TAASTUVENERGIA POLIITIKA: OLUKORD, VÄLJAKUTSED JA ELi TOETUS

MASTER THESIS

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AUTHOR'S DECLARATION

Hereby I declare, that I have written this thesis independently.
No academic degree has been applied for based on this material.
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TASK FOR THE FINAL PAPER

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Summary in Estonian (for Estonian speaking students):

Töö eemärgiks on selgitada Etioopia energia sektori olukord ja nõrkused ning pakkuda välja võimalusi arenguks. Energiapoliitika kriitilise analüüsi tulemusena antakse hinnang poliitika senise rakendamise tulemuslikkusele ning pakutakse välja erinevaid lahendusi, kuidas finantstoetuse mõju energiasektorile suurendada.

Summary in English:

The study aims at the assessment of current situation of the energy sector in Ethiopia to identify the possible weaknesses and opportunities for improvements, and conducts a critical analysis on the energy policies, identifies gaps and assesses the progress of policy implementation.

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ABBREVIATIONS

CCS – Carbon Capture and Storage

CRGE - Ethiopia's Climate-Resilient Green Economy

ECLAC – Economic Commission for Latin America and the Caribbean

EEOCo – Ethiopian Electric Power Corporation

EEP – Ethiopian Electric Power

EEU – Ethiopian Electric Utility

EU - European Union

FDI - Foreign Direct Investment

GDP – Gross Domestic Product

GHG – Greenhouse gas

GTP - Growth and Transformation Plan

IEA - International Energy Agency

ILS – Inter-connected system

MDG - Millennium Development Goals

OECD – The Organisation of Economic Co-operation and Development

OLADE – Latin America Energy Organisation

RE - Renewable Energy

SCS – Self-contained system

SDG - Sustainable Development Goals

SE4All - Sustainable Energy for All

UN - United Nations

UNEP – United Nation Environmental Programme

WB - World Bank

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1 INTRODUCTION

1.1 Background

Over the past decade, the global energy consumption as well as CO2 emissions increased 25%. Conventional energy sources generated more than one-third of greenhouse gas (GHG) emissions. In 2012, the European Union (EU), the G20 and the Organisation of Economic Cooperation and Development (OECD) were collectively responsible for 85.50% of global CO2 emissions, the EU alone accounted for 11% of the emissions [1].

This has made the policy makers, environmentalists, international organisations to shift their focus away from conventional fossil energy sources towards the use of clean energy. Both, developed and developing countries should make an effort reducing their GHG emissions despite that big economies still emit more than smaller emerging ones. Some scholars have estimated that increasing the share of clean energy consumption in total energy consumption supports creating sustainable economic growth [1]. United Nation Environment Programme (UNEP) new report from 2016 [2] shows that investing in clean energy in developing countries helps moving towards the promise for restricting global warming to 2C and creating sustainable business opportunities. Therefore, the contribution of developing countries should not be underestimated.

Renewable energy (RE) technology has many advantages over traditional fossil fuel technologies. For example, it has environmental benefits, is reliable and secure energy source, offers energy security and sustainability of supply, in time the technology is becoming cheaper and, and most importantly, renewable energy is renewable [3, 4]. There are of course also many challenges that need to be faced. The upfront costs are still high, RE depends on climate and weather conditions, often suppliers are fronted with inadequate legal framework and do not receive sufficient financial support from public sector [3]. Deployment of renewable energy technologies, like hydro, wind and solar photovoltaic, has risen rapidly, and the reduced costs and raising confidence in the technologies is opening new opportunities. This is especially important in emerging and developing countries, where the need for energy is strong and renewable resources are favourable [4].

The International Energy Agency (IEA) has identified three principal interlinked reasons why governments and consumers take measures to increase the share of renewable energy technologies [5]:

- to improve energy security - this relates to sufficient and reliable energy supplies to satisfy demand at all times and at affordable prices, while also avoiding environmental impacts. The key-words are energy availability, affordability and sustainability;
- to encourage economic development - so-called natural capital is considered as an important factor in enhancing well-being in the society;
- to protect the climate and the wider environment form impacts of fossil fuels use.

Most of the societies make considerable efforts on developing renewable energy sources. In 2008, investments in sustainable energy projects reached USD 155 billion and surpassed first time fossil fuel investments [6]. By 2014 the clean energy investments have increased to USD 310 billion, more precisely, developed economies invested USD 138.9 billion and developing economies USD 131.3 billion in clean energy investments, the rest was invested by international organisations [1]. In 2011 renewable energy resources contributed about 19.3% to global energy generation demand, without taking into account large hydropower and biomass, renewable generation was 3.4% [4]. Hydropower is the major source of renewable electricity [7].

It is recommended that nations cooperate politically for reducing their CO2 emissions and increasing share of renewable energy sources since political cooperation can play an important role in terms of exchanging ideas, sharing technological innovations and financial resources, identifying common problems and looking for the appropriate solutions for them [1]. The EU is one of good examples of a long-term political cooperation among its member states and with the so-called third parties. The EU has been working together with many third countries on the aim of moving towards clean and sustainable energy policies and technologies [8, 9, 10, 11]. Some of the countries have made remarkable progress (e.g. China), some of them still falling behind (e.g. Ethiopia).

In order to understand to which direction the international community is trying to move, it

should be established first, what is meant by sustainable energy, renewable energy or sustainable energy policy.

1.1.1 Energy and the Dimension of Sustainability

Universal access to electricity by 2030 is one of the key goals of the UN Sustainable Energy for All (SE4All) initiative [12]. Universal access to sustainable, affordable and reliable energy is highlighted in the 7th Sustainable Development Goal (SDG) [13].

In 1987 the World Commission on Environment and Developments proposed one of the most widely used definitions of sustainable development. It is "... development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [14]. This definition is widely disputed as raising more questions than explaining how to asses if the development is sustainable or not. In substance, this definition refers to interactions between human societies and environment, reasonable exploitation of natural resources, including energy production and consumption.

The criteria of sustainability of resources emphasize that the stock of resource remains the same over time, i.e. the rate of recovery at least equals the rate of destruction [6]. This applies both to renewable and non-renewable resources, if the consumption of renewable resource is faster than recover then the consumption cannot be considered sustainable. The unsuitable management of biomass or hydropower for example, which are considered to be renewable energy sources, may lead to their degradation with the resulting decline of their future availability, they may have negative impacts on soil, water, the surrounding environment.

The concept of sustainable energy has more elements in it than non-depletion. It is discussed by many scholars as well as international organisation, each proposing its own definition. For the International Energy Agency sustainable energy is a balance between energy security, economic development and environmental protection [5]. Basically energy sustainability refers to the contribution of the energy sector to sustainable development [15].

Renewable energy technologies include often wind, solar, geothermal, ocean thermal and kinetic, hydrokinetic, biomass and hydropower. Some authors exclude large dams from

renewable energy sources, i.e. hydropower is considered renewable only if it is up to about 100 MW [7].

Hydro power is the main source of renewable energy counting about 84% of renewable energy generation, followed by wind and solar photovoltaic (PV). As regards renewable heat, biomass is the dominant technology, and it includes the traditional biomass with low efficiency for heating and cooking. Growth in solar heating and geothermal heating technologies has also been remarkable. [4]

1.1.2 Sustainable Energy Policy

Energy policy decisions can have major influence on the achievement of a sustainable development of a country due to the following reasons [15]: greater efficiency in energy production and consumption contributes to the achievement of steady **economic growth**; meeting basic energy requirements is essential for **social equity**, rational use of natural energy resources and the use of renewables has inevitable **environmental impact**.

As regards the policy making process, the energy policy should be part of the general national development agenda, it should be the responsibility of the state and all stakeholders should participate in the design of the policy [15].

Energy policy is framed by four aspects: availability (security of supply), affordability (competitiveness), efficiency and environmental stewardship [5, 16].

1.2 Statement of the Problem

The Federal Republic of Ethiopia (hereinafter Ethiopia) with its energy sector has been chosen to be the object of the study because it is currently in an interesting stage of development. It is making a considerable effort in becoming middle income country [17] while the energy sector is rather poorly developed and most of the population has no access to electricity [18]. There seems to be a link between achieving a sustainable development of a country and having an access to clean energy. Ethiopia has a very low GHG emission per capita, huge renewable energy reserves, and since the access to energy is still one of the lowest in the world, it could

show an interesting example to the rest of the world if it is at all possible to move towards clean sustainable energy without having to go through all the phases of the fossil fuel technologies that developed countries have used.

In Ethiopia there are considerable amount of opportunities for energy system integration but also many barriers that prevent them from being tapped. In order to overcome these obstacles, actions from the government are needed. It is important to keep in mind that the elaboration of policy from the perspective of sustainability should be based on the reality of Ethiopia, and it cannot be imported from another country. Nevertheless, a support from developed countries, e.g. the EU, could facilitate the transition.

1.3 Objectives of the Study

The aim of the study is to analyse energy situation and policies of Ethiopia with the intention of identifying their relevance and suitability for moving towards the sustainable renewable energy access in the country. The choice of policy instruments, policy design and regulations should take into account the actual conditions and specificity of the country, so the experience of the EU, one of the big donor of Ethiopia, cannot be copied blindly. However, the EU with its long-term presence could assist Ethiopia in moving towards its energy objectives. This study is making an attempt to analyse the Ethiopia's current energy situation and to investigate possibilities for the EU to assist Ethiopia in this challenging path of renewable energy sector's development.

More specifically, the objectives of the study are to:

- identify the strengths, weaknesses, opportunities and threats (SWOT analysis) of the energy sector in Ethiopia;
- analyse the contents of the RE supporting policies in Ethiopia, their overall purpose, substance, targets;
- Identify gaps in RE policy documents and in their implementations, propose areas for improvement;
- Look into the role of the EU in assisting Ethiopia in its policy implementation and propose most efficient areas of interventions.

1.4 Research Questions

In achieving the above mentioned objectives the study explores the following questions:

- How is the current situation of RE sector in Ethiopia?
- To which extent do the RE policies and strategies of Ethiopia address the problems of the RE situation, what could be improved?
- What could the EU change about the way it supports Ethiopia in developing its RE sector?

1.5 Research Methodology

This study is a descriptive and comparative analysis, using elements from qualitative and quantitative research when and where appropriate. As regard the qualitative analysis, the analysis of policy and strategy documents have been conducted, and previous relevant studies have been previewed based on scientific articles. Some relevant statistics and data have been assessed using elements of quantitative research methodologies.

The used data consists on policy and strategy documents, development plans, and articles. The policy documents used were collected mainly from the energy policy experts working in Ethiopia. The reports were prepared by the prominent international organisations such as the World Bank, the European Union, the International Energy Agency, and the Government of Ethiopia, more precisely National Planning Commission, and Ministry of Water and Energy of the Federal Democratic Republic of Ethiopia. All documents were available in English since the international donors' network is big and Ethiopia has to keep the donors on loop of the situation in the country. As regards the used statistical data, the accuracy of the data was verified as much as possible with the experts in the field.

The website of the European Commission was a valuable source for obtaining the EU policies documents, regulations and progress reports. Scientific articles were obtained via TTU library network from the database of articles. Only most recent articles were used since the situation in the field is changing rapidly, and older data could jeopardize the reliability of the study and its conclusions.

In this study the legal acts and regulations of the Federal Democratic Republic of Ethiopia have not been analysed because these are out of the scope of the study. Moreover, legal acts are not easily available in the English language.

Another limitation of the study is that it relies on the secondary data and depends on the accuracy of data available. The most recent data is used as much as possible. Getting access to up-dated data seems to be a general problem in Ethiopia since even some of the government's own reports rely on data that goes back to two-three years, which in a fast growing country might be an issue. Nevertheless, it is possible to see the development trends and draw conclusions.

1.6 Structure of the Study

This paper is divided into five chapters. It starts with introducing the topic, states the problem and presents the objective of the study. The second chapter presents an overview of the energy situation in Ethiopia and concludes with a SWOT analysis that provides a valuable input to the third chapter where renewable energy strategic documents are being analysed. Chapter four concentrates on the EU renewable and sustainable energy policies and trends, highlighting relevant lessons to Ethiopia. In addition, the EU-Ethiopia relations are being analysed and recommendations for increasing the EU's leverage are proposed. The last chapter presents a synopsis of the answers to the research questions and concludes the study.

2 ETHIOPIA'S ENERGY SITUATION

This chapter provides an overview of the energy situation in Ethiopia having a closer look at the current state of play and potential of renewable energy sources. The chapter is closed by a SWOT analysis of the Ethiopia's energy portfolio providing a valuable input for the next chapter where current energy policies are being analysed.

2.1 Country Overview

Ethiopia is an East African landlocked country in the Horn of Africa (Figure 1) with a total area of 1 104 300 km^2 [19]. It is surrounded by unstable states while facing also internally violent civil unrests. The government of Ethiopia has declared a state of emergency on 9 October 2016 which has not been lifted by the time of printing these theses.

Figure 1 Map of Africa showing Ethiopia [58]

The population of Ethiopia has grown 5 times in just 50 years and has reached 99 million inhabitants in 2016 [20]. The current growth rate is 3% and 4.7% in urban areas [21]. It is estimated that by the year 2030 the population has reached 130 million inhabitants. Vast majority, i.e. about 80% of the population lives in the rural areas [22]. The population density

in Ethiopia is 99 per km^2 [23].

Despite of the fast economic growth, it is the 11th poorest country in the world by income per capita with a GDP of USD 691. Using the international poverty line (US$ 1.90/day in 2011 purchasing power parity), poverty in Ethiopia fell from 55.3% in 2000 to 33.5% in 2011. The World Bank estimates that the poverty has continued to fall since the last survey in 2011 [24].

There are about 80 different tribes and 90 languages spoken in the country [22]. The main environmental challenges these people are facing, differ from region to region, but the main ones are environmental degradation, water scarcity, deforestation, drought, food shortage, etc.

2.2 Energy Situation, Supply and Demand

Africa has a huge renewable energy potential. Despite of that more than 620 million people, which is about two-thirds of sub-Saharan Africa's population, are without electricity (Table 1). In other words, about half of the world's population who have no access to electricity live in Sub-Saharan Africa and 70 million of them live in Ethiopia. In Ethiopia the electrification rate is 23%. In the cities about 85% of people have access to electricity while in rural areas the rate is only 10%. This is below the average of Sub-Saharan Africa and one of the lowest in the world.

The effects of the lack of electricity goes beyond mere discomfort, tackling the energy poverty remains a priority for the government of Ethiopia because by reducing the energy poverty, health conditions of the population are improved, access to the education is increased, and possibilities are created to move out of poverty [25, 26].

Table 1 Electricity access in 2012 in Ethiopia and in the region [18]

Region	Population without electricity (millions)	Overall electrification rate (%)	Urban electrification rate (%)	Rural electrification rate (%)
Developing countries	1283	76	91	64
Africa	622	43	68	26
North Africa	1	99	100	99
Sub-Saharan Africa	621	32	59	16
Ethiopia	70	23	85	10
Developing Asia	620	83	95	74
Latin America	23	95	99	82
Middle East	18	92	98	78
Transition economies and OECD	1	100	100	100
World	1285	82	94	68

At the same time there is great hydroelectric power potential, year-round solar irradiation, favourable conditions for geothermal resources, possibilities for big wind farms and biomass potential in Ethiopia.

Table 2 shows clearly how underused the energy potential is, renewable and fossil fuels as well. Only biomass fuel, i.e. wood and agricultural waste, is widely used. The government is already investing in order to deploy hydropower resources. Other renewable energies such as geothermal, solar and wind energy are less exploited but are planned to be developed in accordance to their cost competitiveness [29].

Table 2 Exploitable potential of energy resources in Ethiopia [27, 28, 29]

Resource	Unit	Exploitable Reserve	Exploited Percent
Wood	Million tons	1 120	50%
Agricultural waste	Million tons	11-20	30%
Hydropower	MW	45 000	<5%
Solar	kWh/m^2/day	5-6	<1%
Wind	GW	1350	<1%
Geothermal	MW	5 000	<1%
Natural gas	Billion m3	113	0%
Coal	Million tons	300 - 400	0%
Oil shale	Million tons	253	0%

Despite the variety of renewable energy resources, the energy consumption pattern in Ethiopia has not much variety as shown in Figure 2. Most of the national energy consumption is met from traditional biomass sources, which accounts for about 92% of total national energy consumption.

Modern energy sources petroleum fuels and electricity account mere 7% and 1% of the national energy consumption respectively. Approximately 92% of the biomass energy is used by households, petroleum fuels are mainly used in the transport sector. As regards the electricity consumption, the main consumers are industries with 40%, followed by households with 33% and service sector with 26%. The per capita electricity consumption per year is less than 100kWh, while the Sub-Saharan Africa is on the average of 521 kWh/capita. [27]

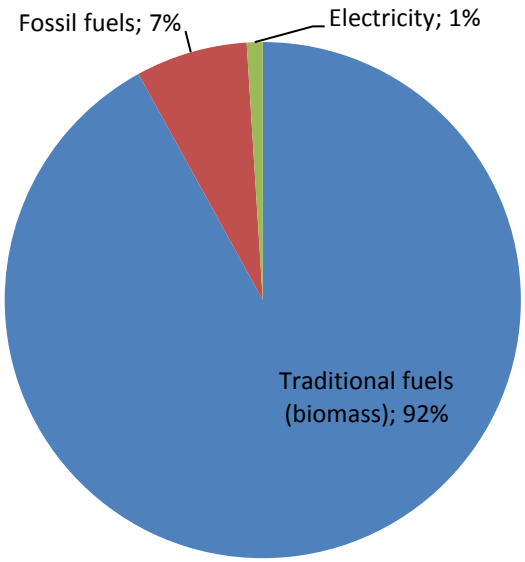

Figure 2 Ethiopia's energy consumption in 2011 [30]

As regards sectorial consumptions, the biggest energy consumers are households that accounts for about 89% of total energy consumption, 74% by rural and 15% by urban households. Households rely mainly on wood, animal dung and agricultural residues. The transport sector accounts for 6% of the energy consumption, followed by service sector with 3.6%. The agricultural and industrial sectors use mere 0.9% and 0.5% of total consumption, respectively. The agricultural sector in rural areas relies almost entirely on human and animal power and to a limited extent on commercial sources such as diesel. [27]

Ethiopia is one of the fastest growing economies in the world. In different forecasts Ethiopia is placed on different positions in top 10, but the growth estimation compiled by Business Insider based on the data of World Bank sees Ethiopia as a country with the fastest growing GDP rate (Figure 3).

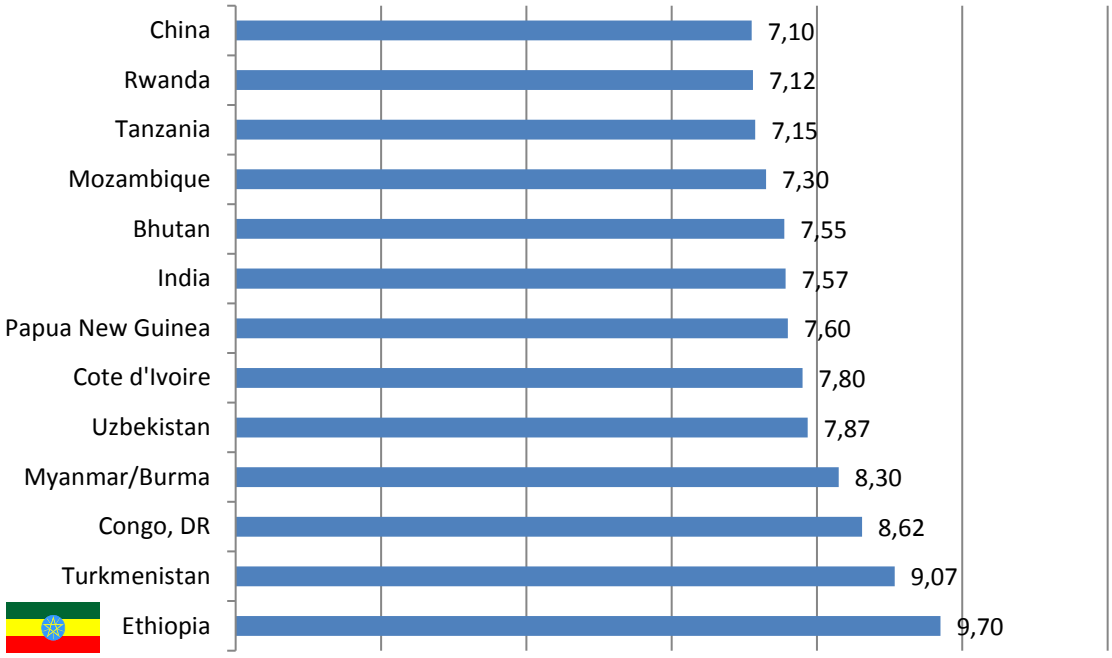

Figure 3 The fastest growing economies in the world between 2014 – 2017, average real GDP growth in percentage [31]

It is obvious that in the context of fast population growth and rapid expansion of economy, the demand for the energy is increasing faster than the government's ability to address the demand. The problem cannot be solved by simply building new power plants, but the strategies have to go hand in hand with increasing the energy efficiency and introducing new renewable energies to the market. The encouraging aspect is that since the 90ies energy consumption and economy development have been decoupling globally [32].

2.2.1 Electricity

The major supplier of electricity, Ethiopian Electric Power Corporation (EEOCo) was restructured in 2013. Generation and transformation responsibilities are now managed by Ethiopian Electric Power (EEP), while distribution service is provided by the Ethiopian Electric Utility (EEU) [29]. In addition there are few community and privately-owned systems. There are two power supply systems; a) interconnected system (ICS), which has grid connections and

is mainly supplied from hydropower plants; and b) self-contained system (SCS), which is made up of isolated power-generating units operating with diesel [26, 28]. 98.2% of the generated energy comes from the ICS, and only 1.8% from SCS system [28]. The current capacity of Ethiopian Electric Power both is ICS and SCS systems is presented in Table 3.

Table 3 Capacity of EEP in 2015 [17, 18, 28]

Capacities	**Amount**
Installed capacity of power plants (MW)	2 360
Annual energy production (GWh)	4 980
Gross consumption (GWh)	3 844
Length of distribution network (km)	166 967
Number of customers (Million)	2.31
Electricity access rate	23% (60% according to EEP)

Ethiopia has 2 360 MW of installed power generating capacity of which over 90% is hydro capacity. The capacity by technology is as follows: 1953 MW in hydropower plants, 324 MW wind, 75MW in diesel and 7.30 MW in geothermal power plants [29].

With annual energy production of 4 980 GWh, the electricity access of the country is limited to 23% of the population. According to the official data from the EEP, the electricity access rate is 60%. The difference comes from the approach, the EEP takes into account the population living in the electrified areas, this however does not reflect the real number of population who has access to electricity [28]. The actual access rate is lower since many of the poor living in the areas that are electrified, have nevertheless no access to the electricity since they are unable to pay the costs related to the distribution lines from the national grid to their homes.

The progress of the installed capacity is shown in Figure 4. There has been steady growth in the installed capacity since the beginning the century, but the three major on-going hydroelectric projects, which are in the final stage of implementation, are adding 8 370 MW to

the electricity capacity after their completion. These projects are Gibe III, Genale III and IV and the Grand Ethiopian Renaissance Dam which are further analysed in section 2.2.3.

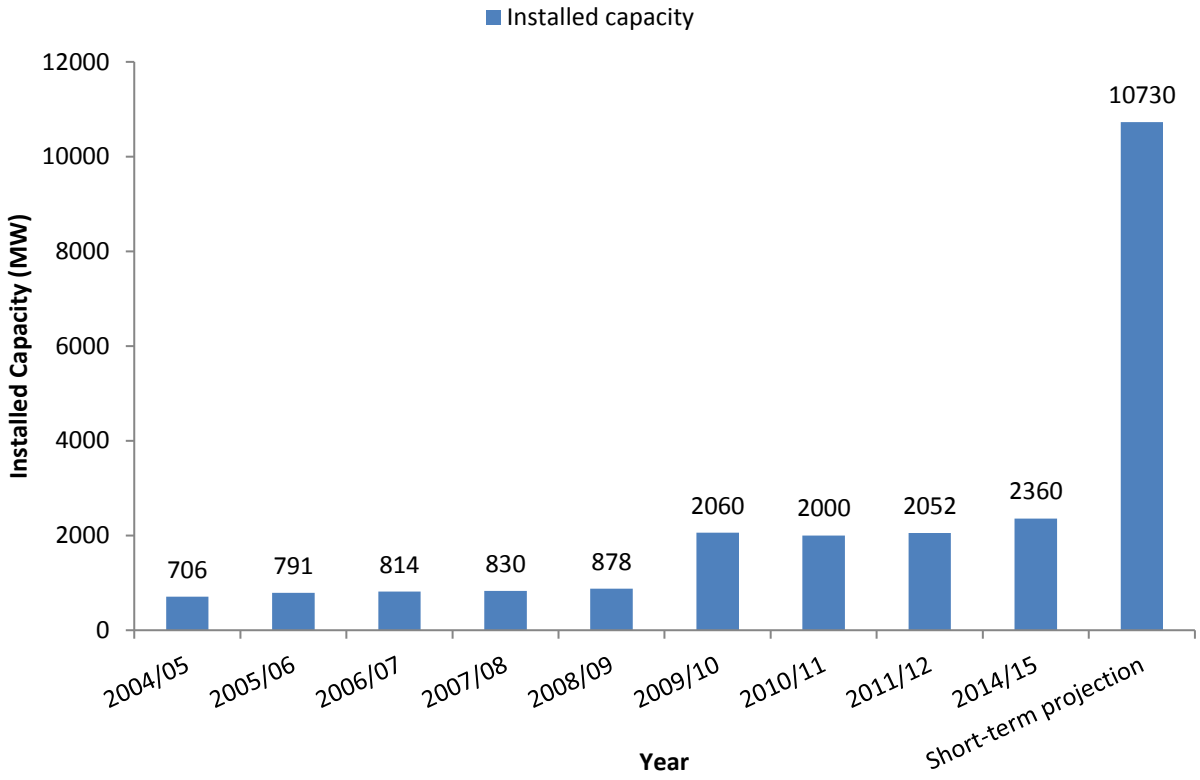

Figure 4 Installed capacity of EEPCo (EEP) for the last decade and the short-term projection (including three on-going hydroelectric projects) [17, 28, 29]

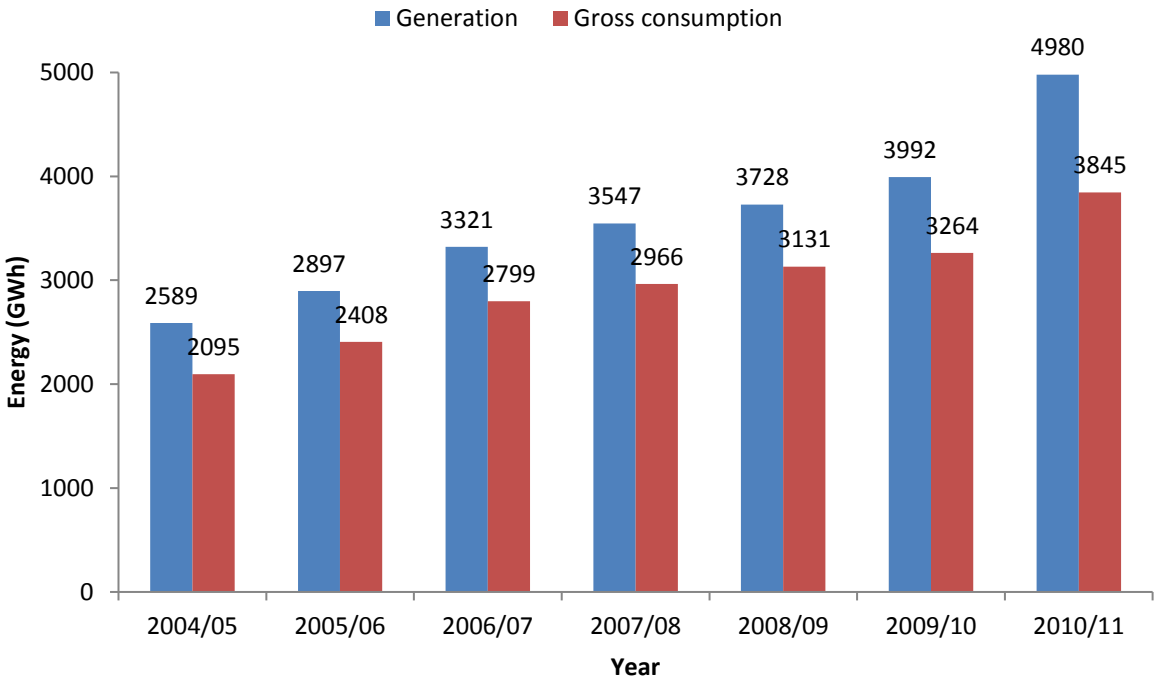

Figure 5 Electricity generation and gross consumption in Ethiopia in years 2004 – 2011 [28]

The electricity generation has almost doubled during the period 2004-2011, also the consumption has grown substantially at an average growth rate about 15%. The growth rate has resulted primarily from a rapid expansion of service coverage and served customers [29]. Figure 5 shows that there is a little margin for an electricity export to neighbouring countries, which is being used to fill foreign currency reserve. It is common in Ethiopia to experience black outs and to rely on private generators although enough electricity for the current consumption is produced [33]. Even though the country has still low total installed capacity, it is undertaking billions of dollars of investments on renewable energy projects that would help Ethiopia to become one of Africa's leading exporter of power. Ethiopia has already made agreements to supply to Sudan, Djibouti and Kenya, and looking into possibilities to export also to Burundi, Tanzania, Ruanda and Uganda [28].

Per capita electricity consumption in Ethiopia by the end of 2011 has been about 60kWh/year. This is much lower than the modern society needs for reasonable quality of life as identified in the Millennium Development Goals, i.e. about 2000 kWh/year; and meets barely the basic human needs of 50-100 kWh/year [34]. It is one of the lowest among the least developed

countries. In the neighbouring Egypt for example the per capita use is 1743 kW/h [35].

Ethiopian energy sector is one of the least developed in the world in terms of access to the electricity and per capita energy consumption despite that it has made remarkable progress during last decades [28].

The government of Ethiopia has recognised the big discrepancy between current supply and demand of the energy, and has looked deeply into the possibilities of taking advantage of the renewable energy potential. Before viewing the measures the state has taken to overcome energy poverty in the country, current energy sources and potentials are being analysed.

2.2.2 Biomass

In the sub-Saharan Africa about 80% of the population rely on traditional biomass for cooking [36]. Ethiopia is no different. As was shown in Figure 2, about 92% of total national energy consumption comes from biomass.

For a vast majority of Ethiopians the primary source of energy is biomass fuel such as wood, charcoal, animal dung, crop residues, sawdust, residue from processing of coffee. Biomass fuels are mainly used for traditional cook stoves for cooking and heating, and lighting in rural households, but also by rural cottage industries such as blacksmiths and potters, and trade establishments (food and beverage houses). The per-capita consumption of biomass fuel in rural areas was estimated in 2014 to be around 0.7-1 tons, of which about 80% or 40-55 million tons annually came from the wood, followed by crop residues and animal dung. [27] The consumption of forests at this rate has led to continuing destruction of forests, degradation of rural ecosystems and shortage of fuel wood. [36]

In addition, inefficient burning of wood and charcoal inside a house causes for the population serious health problems, such as acute lower respiratory tract infections, low birth weight, nutrition deficiency, lung disease, lung cancer, tuberculosis, cardiovascular disease and cataracts [37]. It is estimated that about 3.3% of diseases worldwide are a result of indoor air pollution from smoke. Each year about 1.6 million people die prematurely, about 600 000 of these in Africa [18]. The statistics about diseases and deaths due to indoor air pollution in

Ethiopia, given its dependence on biomass, is proportionally even worse. About 4.9% of the diseases in Ethiopia can be attributed to solid fuel use in cooking, resulting in 50 000 deaths annually [37]. In the energy sector overview papers and strategic documents health issues were not identified as one of the core problems to be addressed. The core problems of the biomass sector that the government has identified are linked more to the inadequate and worsened access to cooking fuels for households and inadequate access to biomass fuels required by cottage industry [27].

There have been numerous attempts to replace the traditional cooking stoves widely in use in Ethiopia by modern improved biomass cook stoves, since the health problems tend to be greater where the traditional stoves are in use. The programmes have not been very successful due to technical problems (quality of stoves), due to lack of an appropriate promotion strategies, and due to a lack of understanding of customer tastes. [37] In addition, the factors that affect cooking stove choices and fuel consumption patterns are, among others, income, local food habits and cooking frequency, ethnicity, local traditions and institutions, food taste preferences [36]. Unfortunately, the experience of other countries, where traditional stoves have been replaced by improved more efficient ones, does not show that new stoves would contribute to reduction in demand for firewood [36, 37].

The intensive use and the increasing scarcity of biomass fuels contribute to the gender inequality since this is normally woman's task to collect fuel for cooking, which requires more and more time and reduces available labour for productive activity. Sales of wood fuels, forest products and craft are a considerable source of additional income for rural population, which is lost with the disappearance of forests. [18, 27]

Biomass is so widely used in Ethiopia because of two main reasons [30]:

- general access to electricity is still very low especially in rural areas, and
- price of other household fuels is relatively expensive compared to electricity and biomass, and it has been growing over the past years.

Substitutes for biomass energy in rural areas, where it is often the only available energy, are mostly not available or are available in insignificant amounts. Also, rapid growth in demand for wood for fuel, construction, furniture; and inadequate development and management of

forest resources are the direct causes for deteriorating the availability of biomass fuels [27]. It is clear that diversification of energy sources has to be one of the priorities for the government.

2.2.3 Hydropower

The major source of electricity in Ethiopia comes from hydro power, which represents about 90% of the total supply [27]. This makes Ethiopia a major hydroelectricity producer in Eastern Africa, the second only after Egypt (Figure 6).

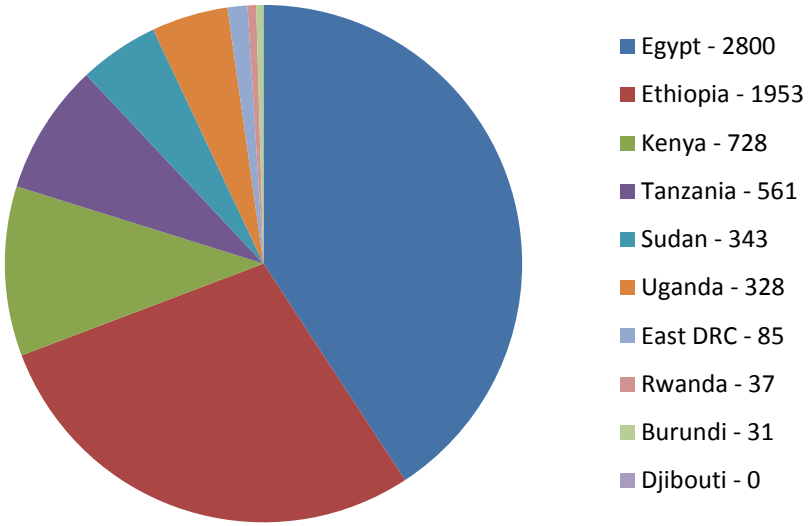

Figure 6 The production of hydroelectricity in sub-Saharan African countries, in MW

Nevertheless, the hydropower potential is still under used. Different experts have estimated the economically affordable and feasible hydropower potential between 160 and 260 TWh/year (or 40-50 GW in terms of installable capacity), 50% of which is in the Blue Nile drainage basin [27, 30]. Currently less than 5% is being used as shown in Table 2. By way of comparison, the estimated hydropower potential of the whole continent is about 1000 TWh/year, and the potential of Egypt is around 50 TWh/year i.e. three times less than the potential of Ethiopia [30].

The country has many hydropower projects on-going, and once they are completed, Ethiopia expects to become 'a powerhouse of Africa exporting electricity to its neighbours', Djibouti and Sudan [27].

Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile River is the biggest hydropower project is Africa with the planned capacity of 6 GW. It has raised several geopolitical, financial, technical as well as environmental concerns:

- Egypt and Sudan are concerned that the dam would reduce the flow of water downstream, this has hampered good relations between these countries [38];
- According to the officials of the European Union, no environmental and social impact assessment for the dam has been published, therefore there are many unanswered questions;
- The construction was awarded without international open tender raising doubts if the best constructor who could provide the best value for money was indeed selected [30];
- The project's capacity factor, i.e. the ratio of the power plant actual output over a period of time and its potential output if it had operated at full capacity, is around 30%. This has raised concern if in addition to produce electricity, Ethiopia is planning to use the dam also for irrigation. [30, 39].

The second project under construction, building of Gibe III dam on the Omo river in the southern part of Ethiopia with the capacity of 1,87 GW, has also raised many environmental and financial concerns. Like the GERD, Gibe III was also awarded without open international tender and without securing the full financing. Many NGOs and environmental associations have expressed concern that the dam might greatly endanger the Omo river basin as well as the livelihoods of indigenous people. [30] Omo river valley is a home for many tribes who would be displaced, this would contribute to the insecurity in the already unstable region.

There are many more hydropower projects currently under preparation (like Genale III and Genale IV with combined capacity of 500 MW) or being considered to be constructed in Ethiopia. If all of these will materialise, the overall capacity would increase by 9556 MW (9.6 GW). [27, 30]

The government of Ethiopia sees a very big opportunity in electrifying the country [29], however, hydropower projects do not come without risks. Since the rainfall in Ethiopia varies considerable from year to year [40] and the results of climate change may make the precipitation even less predictable, overdependence on hydropower makes the energy supply very unstable.

Diversification needs to be high in the priority of the green energy agenda.

2.2.4 Fossil Fuels and Bio-fuels

Petroleum is the most available modern fuel source in Ethiopia. There might be some fossil fuel reserves in Ethiopia but so far the possible reserves have not been exploited.

Ethiopia is a non-oil producing country and its fuel import accounts for up to 50% of total imports of goods and services. Ethiopia is entirely dependent on the imported oil of which 80% comes from its neighbour Sudan. In the absence of any major pipeline, the bulk of petroleum is shipped from Sudan and Djibouti via tanker trucks, which comes with a very high cost. [30] During the fiscal year 2013/14, a total of about 2.63 million tons of petroleum products worth 47.6 billion Ethiopian Birr (about 1.9 billion euros) was imported, in 2014/15 the volume had increased to 2.82 million tons, and the import is expected to increase by 7.14% in the fiscal year 2015/16.[25] This puts a strong pressure on the country's foreign currency reserve.

About 82% of the petroleum is used for transportation, followed by 12% in residential and 6% in industrial sectors. 99.8% of transport fuel is produced from petroleum, and the rest comes from biofuel [25]. Of the petroleum products, kerosene and LPG provide both light and power in urban and rural areas. In cities and large towns, kerosene is used for cooking, while in medium and small towns without electricity supply, kerosene is used for lighting [26,36]. In recent year the use of kerosene has slightly reduced in favour of fuel wood in the capital Addis Ababa due to the rising price of kerosene and concerns over its health and safety impacts [36].

Recently the Ministry of Water and Energy has developed bio-fuel strategy for Ethiopia with the overall objective to enhance energy security and access to transport fuels. The strategy is focused on allocation of marginal land for biofuel plant cultivation, accelerating bio-ethanol and bio-diesel development and technology transfer, increasing domestic use and export earnings from biofuel and enhancing domestic coordination and international cooperation for the development of biofuel. [27]

2.2.5 Wind, Geothermal and Solar Energy

The existing capacity of wind power is low, even though the potential is estimated to be about 10 000 MW. There are four wind farms under construction and Adama I wind farm with capacity of 52 MW power already completed [28]. Lack of reliable wind data covering the country is one of the reasons why the application of wind energy in Ethiopia has been so far rather limited. As a result of recent studies [28] the data on the wind energy potential is available, and government has included wind power in the renewable energy development plan for the coming years [17].

With the aim of diversifying the energy sources, the government is constructing a number of wind farms with a total capacity of 1116 MW. For Ethiopia wind would be an important alternative source of power generation to hydropower because winds are especially strong in the dry season, while hydropower is at its low point [28]. This makes wind power an important contributor to the energy mix and increases energy security of the country.

Besides wind energy, geothermal energy potential of producing up to 5000 MW electric power has been started to utilize. The Aluto-Langano geothermal power plant with a capacity of 70 MW is currently under construction and the Tendaho geothermal plant is in progress to create 5 MW soon [28]. Developing geothermal power is also a priority for Ethiopian authorities after hydropower. It helps to substitute imported fossil fuels, provide back-up to rainfall-dependent hydropower supplies, serve areas where hydropower is unavailable and contribute to reducing GHG emissions [30].

With an average solar energy potential of 5-6kWh per square meter per day, Ethiopia is not utilizing its solar potential. The reason is that solar power is still the most expensive renewable energy source to produce electricity. There are, however, many small-scale applications installed [30]:

- off-grid solar photovoltaic (PV) generations for domestic and commercial uses, rural schools and health centres, water pumps;
- solar thermal water heating for domestic, commercial and industrial uses.

Stand-alone solar technology can play an important role in providing basic energy access to

about 650 000 people, however, according to a recent study conducted in the country [33], with increasing demand, stand-alone solar loose attractiveness and mini- and grid solutions become more competitive, although just about a decade ago solar PVs were foreseen in many rural energy policies as the best technological solution to the energy problem in rural areas [41]. However, there are some remote areas with low population density where a mini-grid or stand-alone solutions are still the most economic solutions [33].

2.3 SWOT Analysis of the Energy Sector in Ethiopia

In the following sections author summarises the status quo of the Ethiopia's energy sector by pointing out its strengths and weaknesses based on the current situation as explained in the previous chapter. In addition, it highlights the opportunities for improvements and possible threats that can jeopardize the development of the renewable energy in Ethiopia.

2.3.1 Strengths of the Ethiopia's Renewable Energy Sector

1) 90% of the electricity is produced from renewable energy sources, hydropower being the main electricity source.
2) Renewable energies are 93% (biomass and electricity) of total final energy consumption [35].
3) There is a huge potential for exploring and tapping renewable energies.
4) The cost of electricity generated from hydropower is generally low [3];
5) Solar power potential could be most adapted to electrification and off-grid systems of remote rural areas.
6) Currently there is enough biomass fuel to cover the needs of the country.

2.3.2 Weakness of Ethiopia's Renewable Energy Sector

1) No diversification, too much reliance on biomass energy.
2) Most of the projects are related to hydropower development, this is risky due to the unpredictable rainfall in the region, and even more uncertainty due to climate change. Flooding of large areas of land destroys the natural environment and forces local people

to relocate. In addition, water scarcity in the region can cause conflicts between neighbours.

3) Full dependence on imported petroleum.
4) Weak technological capacity to produce the renewable energy technologies in the country, all technologies need to be imported.
5) Modern (renewable) energy is still not available and affordable to the majority of the population.
6) The potential of renewable energies is underused.

2.3.3 Opportunities for Renewable Energy in Ethiopia

1) Since the electrification rate is only 23%, it is a perfect chance to fulfil needs for electricity only with renewable energy. In fact, this is also the target that the government set, by 2025 100% of electricity should come from the renewable sources [42].
2) Falling renewable energy prices. In the worldwide the prices of renewable energy are falling [3]. It is a good time to take advantage that many renewable technologies are getting cheaper than the ones of fossil fuels in many parts of the world. [43]
3) Creating employment: Investing into renewable energy sector creates new jobs in the sector, installation, operation, maintenance of the technologies. The United Nations Environmental Programme concludes that compared to fossil-fuel power plants, renewable energy generates more jobs per unit of installed capacity, per unit of power generated and per dollar invested and International Energy Agency estimates that job creation in the renewable energy sector has a long-term sustainable perspective [5]. The government should make an effort to keep the jobs for the Ethiopians but this requires systematic approach also to education system improvement.
4) Developing skills at engineering.
5) Environmental benefits: moving away from biomass energy helps to slow down deforestation; replacing fossil fuels by renewable energies reduces the greenhouse gas emissions.
6) In isolated rural areas off-grid renewable technologies could provide a sustainable, environmentally friendlier and more cost-effective alternative to traditional biomass

fuels and kerosene lamps. Electricity grid extensions in these areas are often not cost-effective options [5]. Similarly, mini-grids help to increase electrification rates in rural areas.

7) Attract foreign investments: Ethiopian energy market is huge offering many opportunities for investment.

2.3.4 Threats

1) Heavy investments needed, it poses burden to the already fragile state;
2) Weak management capacity of large infrastructure projects, for example building the hydropower dams.
3) Renewables are dependent on the meteorological and climatic conditions, which need to be taken into account while designing the renewable energy plan for the country. For example, increasing number of droughts [40] in the region danger hydropower.

The situation of the Ethiopia's energy situation has been identified. In the following chapter it is being analysed to what extend the renewable energy strategies are already addressing the weaknesses and challenges, and to what extend they need improvement.

3 ETHIOPIA'S RENEWABLE ENERGY POLICY

3.1 Designing Energy Policy

The context presented in the previous chapter shows the necessity for a sustainable long-term energy policy to guide the government, private sector and other stakeholders towards development of national renewable energy sector, and to identify the investments required to make efficient use of energy, diversify the current energy mix and address the growing demand for renewables. The government of Ethiopia has accepted the challenge and developed energy plans, which follow broadly the following approach: makes a sector diagnosis and then proposes mid-term solutions.

The GIZ (former GTZ) together with Latin America Energy Organisation (OLADE) and Economic Commission for Latin America and the Caribbean (ECLAC) have developed a guide for the developing countries about the design of the energy policy [15] that could be well used also in Ethiopia. The central questions the governments should try to answer when designing the policy are [15, 43]:

i. What is the initial situation?
ii. What is the aim?
iii. How to act?

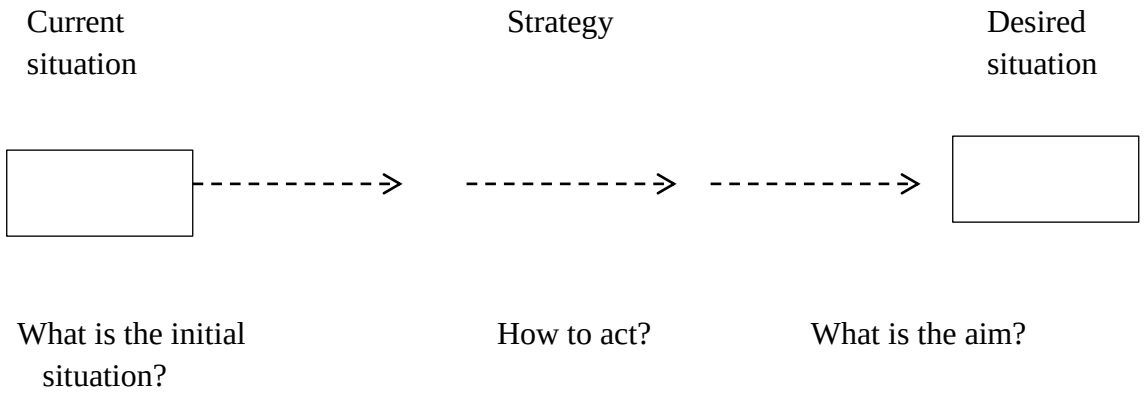

Figure 7 Key factors for the formulation of an energy policy [15, 43]

Considering the above described scheme (Figure 7), while formulating of the renewable energy policy in Ethiopia the three above-mentioned key factors were taken into account. The assessment of the energy sector is elaborated by the Ministry of Water, Irrigation and Energy [27], the vision and general objectives have been set and the action plan, duration and the cost of the plan have been indicated. The first factor, current situation, was thoroughly discussed chapter 2, in chapter 3.2 an overview and an assessment of the other two factors is provided.

In addition, the IEA is proposing its own overreaching principles that a good renewable energy policy should follow [4]:

- provide a **predictable and transparent RE policy framework**, integrating RE policy into an overall energy strategy, focusing on technologies that will best meet the policy needs in short and long term, and develop credible targets;
- take a **dynamic approach** to policy implementation, monitoring national and global market trends and adjusting policies accordingly;
- tackle **non-economic barriers** comprehensively;
- at an early stage, identify and address overall **system integration** issues such as infrastructure and market design that may become constraints as deployment levels rise.

The IEA has observed that the success of a country in deploying renewable energies can be linked to applying these principles to its policies. For example, countries that lack a comprehensive and stable RE policy framework, have suffered from unstable RE market particularly in terms of the domestic supply chain. Positive examples with stable onshore wind market would be Spain, Germany, China, where the policy makers have adopted well their priorities [4]. In order to make predictions on the development of Ethiopia, in chapter 3.3 Ethiopia's RE policy is screened against the IEA best practice principles.

3.2 Key Documents of Ethiopia's Energy Policy

The key document that identifies the vision for the Ethiopia's development is Growth and Transformation Plan (GTP). It is a high level political document that has been consulted with several relevant stakeholders in order to forge the national ownership of the plan. Ethiopia is

working on 5-years cycles. The first GTP sets targets for the period 2010/11 - 2014/15, the new plan covers the period 2015/16-2019/20. The GTP is written to move towards the national vision of poverty eradication and becoming a lower middle-income country by 2025 [17, 44]. Ethiopia has one of the world fastest growing economy, the World Bank expects Ethiopia's economy to continue growing although not with the same speed [24]; therefore reaching this vision is very ambitions.

The government of Ethiopia has realised that following a conventional economic development path would result in a negative environmental impact for the country and for the whole world. The current practices would more than double the greenhouse gas emissions from 150 Mt CO2 in 2010 to 400 Mt CO2 in 2030. Ethiopians have already suffered due to the climate change, and are now ready for changes, they believe the economic development goals could be achieved in a sustainable way. The government has therefore initiated, to supplement the GTP, the Climate-Resilient Green Economy (CRGE) initiative. [42]

The CRGE strategy outlines the vision, strategy, financing and institutional arrangements Ethiopia needs for achieving the triple goals of economic growth, net-zero emissions and building resilience. It was developed considering two scenarios: a trend scenario, i.e. so-called business-as-usual scenario; and a desired scenario. The business as usual scenario is based on the assumption that Ethiopia is acting only in its economic self-interest without the additional incentive to prevent or reduce GHG emissions. In this scenario the power generation will continue to be largely based on hydropower and to smaller extent also other renewable energies. It would lead to an increase of GHG of more than 150%, and an annual emission increase of more than 15% from the industrial sector and around 11% from transport. In addition, this development would put significant pressure on foreign currency reserve due to fossil fuels demand, and would lead to a lock-in into out-dated technologies if Ethiopia continues to import technologies with the lowest up-front costs [42].

The desired scenario is described in the objectives of the renewable energy strategies, i.e. where Ethiopia is aiming to.

3.2.1 Objectives

All targets and indicators in the GTP are linked to the Millennium Development Goals (DMG). It is based on 9 pillars, the last one of which is building climate resilient green economy with the objective of reducing GHG emissions. This objective is planned to be achieved through [17]:

- enhanced crop and livestock production,
- reforestation and natural resource development programmes,
- expanding electricity power generation from renewable sources for domestic and regional markets, and
- leapfrogging to modern and efficient technologies in transport, construction and industry.

Some of the more specific energy policy related targets until 2020 are [17]:

- increase electricity service coverage from 60% to 90%,
- increase the number of customers with access to electric power from 2.31 million three-fold,
- increase power generation capacity 4 times,
- construct 5000km of new distribution lines,
- increase the annual per capita electricity consumption almost 15 times,
- promoting off-grid solar energy supply,
- creating sustainable network with research institutions and universities to adopt biofuel technologies.

There are some corrections and up-dates compared the first 5-years plan, even though the general line remains the same. For example, GTP I aimed to reach universal electricity access in Ethiopia in the medium term as well as to position Ethiopia as power hub in the Eastern Africa Region. The GTP II has postponed the achievement of these targets. Another target was of doubling the number of electricity customers from 2 to 4 million, while the GTP II has set even more ambitious target - to reach 7 million customers by 2020.

Similar development direction is further elaborated in the CRGE strategy document. The

objective of the initiative is to identify, in cooperation with domestic and international players, green economy opportunities that could help Ethiopia reach its ambitious growth targets while keeping greenhouse gas emissions low. Two out of four key pillars are worth highlighting in the context of these theses: expanding electricity generation from renewable sources of energy; and leapfrogging to modern and energy-efficient technologies in transport, industrial sectors, and buildings.

The author of these theses is of the opinion that the sustainable energy pillar of the CRGE is the weakest part of the document. It leaves an impression that all other sectors are more relevant in moving towards green economy than sustainable energy. This approach could be explained by Figure 8 that shows that in Ethiopia power and transport sectors were the least GHG emitting sectors together with buildings and industry in 2010, at the time of drafting the CRGE. The electric power is largely based on renewable energy, with hydropower counting for more than 90% of total power generating capacity, and emitting about 3% (5 Mt Co2 eq) of the country's total emissions. It could be concluded that since the overall aim of the CRGE is reducing GHG emissions then development of renewable energy sector as low emitting sector is a secondary priority.

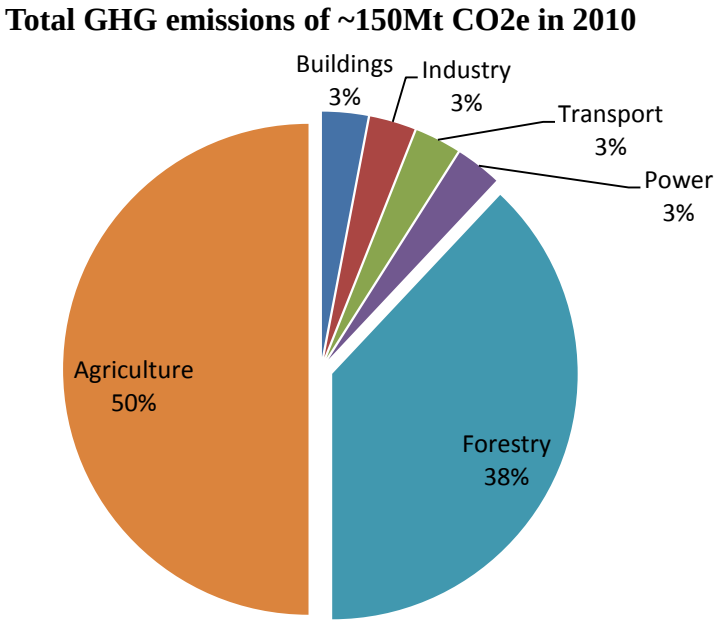

Figure 8 Distribution of GHG emissions per sectors in Ethiopia in 2010 [42]

Another important objective of the CRGE is to turn Ethiopia into a renewable energy exporter in the region. It is foreseen that increasing the energy supply and at the same time maximising energy efficiency would offer the possibility to export clean energy to neighbouring countries. These exports, in turn, would provide the opportunity to replace electric power generated from fossil fuels [42].

3.2.2 How to Get There (Strategies)

To achieve its visions, the government has identified three important aspects: strong commitment, an emerging institutional setup and stakeholders' mobilisation [42]. But without appropriate funding it is not possible to progress.

Government has invested on a large public investment programme to reach the energy targets, mainly through domestic financing of large dams and external loans for transmission lines and various renewable production projects. It is also promoting private sector investment in generation projects. Ethiopia's energy plans imply continued spending of large amounts of public funds on energy generation and access in the years to come [45].

Financing plan of the GTP II includes deficit of 14% to be covered by foreign loans and domestic borrowings. Capital expenditure for infrastructure sector accounts for about 48.4%, of which 21.6% is projected for irrigation and energy sector [17].

To meet the increasing demand for (clean) electricity, which is expected to grow about 20-25% annually, the estimated total investment in expanding electric power generation capacity by 2030 would be approximately USD 38 billion over 20 years or around USD 2 billion annually, over 50% of which would be in foreign currency. This requires doubling of the current expenditure of USD 1 billion. The possible options for obtaining this money would be cost optimisation, increasing internal resource mobilisation through tariff adjustments, attraction of private capital, climate finance and sovereign wealth fund. It is estimated that currently the financing gap is USD 20 billion [42]. To fill this gap, the EU is also contributing as much as it is in its capacities as explained below in chapter 4.2.

Studies have shown that foreign direct investments (FDI) are main source of funding clean energy products around the world. FDI inflows allow business to experience a cheaper and

easier access to foreign capital that can be used for RE technology projects; and they help to transfer advanced technologies to host countries [1]. The conditions for attracting private capital for encouraging the renewable energy market growth can be influenced by several factors such as strong government commitment, the creation of institutions focused exclusively on renewable energy development, the existence of a domestic equipment manufacturing industry, and efforts toward attracting private sector participation [9].

Growth and Transformation Plan (GTP) also recognises that implementation of environmental laws are among the key strategic directions to be pursued. Due to the limitations and scope of these theses, analyses of specific relevant legal framework is left aside.

3.3 Recommendations for Improvements

In this chapter the author makes recommendations on how to improve the existing renewable energy strategies.

First of all, it is advisable that the government should **review** the renewable energy policy documents against **the IEA's best-practice principles** shown in chapter 3.1 and adjust the policies accordingly. None of the four principles are fully followed. System integration issues, non-economic barriers and global market trends have not been reflected in the strategy documents. As regards the predictability and transparency of RE policy framework, and setting credible targets, also this principle needs further improvement. The analysis below can be linked mainly the last-mentioned IEA principle as this was the only one reflected in the documents.

It can be concluded that to certain extent the RE policy framework exists, but neither the GTP nor the CRGE position energy issues in the centre of their strategies. The GTP concentrates more on development of agriculture and industry, the CRGE to agriculture and forestry. The role of energy sector development is recognised but not as the main priority. It is advisable to **develop a separate energy sector strategy plan** including RE energy with clear financing plan.

5-years plans are too short to fix long-term visions, therefore, the GTP II has been designed to carry forward the objectives and strategic directions of the GTP I. Many objectives are largely the same as in the last period. As regards the issues relevant to these theses, the GTP II is once again trying to build climate resilient green economy, and making an effort in expanding electricity generation from renewable sources of energy and leap-frogging to energy efficiency technologies. This is a long-term plan by its nature, and it is positive that the government has not given up on this vision even in the context of difficult economic climate. Comparing the GTP I and the GTP II, there have not been introduced many new plans. In fact, the projects that were started in the previous period, just continue to be implemented.

The GTP includes a financing plan, there is price attached to the ambitious implementation targets. The problem related to the financial plan is that it is **dependent on the mobilisation of private international capital**, however, attracting foreign capital is not easy. In order to attract foreign investments, investment climate should be improved first.

The **interconnectivity of different spheres** of life are well captured and explained. The government has understood that as a result of investing into modern energy-efficient technologies and renewable sources of energy, public health would be improved through better air and water quality. However, as explained in previous chapter, the energy sector pillar is the weakest one.

The CRGE is a **very ambitious documents**, and if all the pillars would be implemented as planned, the improvements in green energy production and energy efficiency would be significant and a good example to any other country in the world. However, the initiative is based on overly ambitious forecast for economic growth. While at the baseline year of 2010 the GDP per capita was USD 380, in only 15 years the GDP per capita is expected to be around USD 1000. This seems unrealistic since by 2016 the GDP per capita reached USD 691. In order to meet this result, the GDP needs to grow by more than 10% per annum. Real GDP growth averaged 10.9% annually in 2004 - 2014, but the World Bank estimates that growth is likely to slow down over the next decade (between 4.5 to 10.5%) [24]. This puts the reliability of the whole plan into question.

Any strategy plan has to be as **realistic** as possible in order to take adequate steps to achieve

the desired results. This approach should apply also to the assessment of the progress made. The GTP II starts with giving an overview of the achievement of the previous period, 2010-2015. The analysis of the government is using extremely positive words, such as "remarkable achievement in real GDP growth, infrastructure development, social development and capacity building at all levels", and "/.../ the Plan /.../ has set the foundation for economic transformation and the country's Renaissance journey." The reality does not match these big words. On one side, the report is too optimistic, nevertheless, some of the weaknesses are also pointed out.

In order to make the strategies more realistic, the business-as-usual scenario, i.e. baseline scenario is used to determine how the country would continue emitting GHG if it continues acting only on its economic self-interest leaving aside environmental and climate change considerations. Once the GHG estimations have been calculated and are indicating clearly the negative developments, it is easier to decide if this is an acceptable way forward. Ethiopia has concluded that it is not the path it wishes to take, the use of second-hand out-dated technologies, the increasing pressure on foreign currency reserves due to increasing demand for fossil fuel, and health problems and low quality of life do not satisfy the Ethiopia anymore.

The GTP claims to care for the environment, while it is not possible to evaluate if necessary measures have been taken to avoid or soften the adverse **environmental impacts** in big infrastructure projects. The EIA of the big infrastructure projects as explained in chapter 2.2.3 is claimed to have been done, however, the public has no access to it. This raises questions about the real priorities of the government.

The GTP does not pay sufficient attention to **human capacity development**. In order to make a big step forward, there is a need for a development of R&D activities in renewable energy technologies. Unfortunately, setting up a decent R&D capacity requires substantial financial resources and highly trained experts, which Ethiopia does not possess at the moment [46]. Attracting foreign companies would be a good alternative, but even this requires a certain amount of trained staff available on the spot. The employment costs could be attractive to foreign investors (average salary is about 30-40 USD/month, no official data available) but what is missing is the know-how. The teaching methods in Ethiopia do not emphasise problem-solving approaches, and the general level is rather low.

RE strategies of Ethiopia concentrate mainly on developing large hydropower projects and leaving all other sources in secondary position. The objective is also to move towards green economy and reducing GHG emissions eventually to zero. What these strategies, however, do not take into account is that some CO2 emissions incur also in all renewable energies, even though the life-cycle assessment studies show that renewable power generation technologies have significantly lower life-cycle CO2 compared to that of fossil fuels [5]. IEA has compiled the data available to show the life-cycle emission of different power generating technologies (Figure 9). These emissions relate to energy from fossil fuels which are needed to manufacture the equipment, dispose waste, recycle, etc.

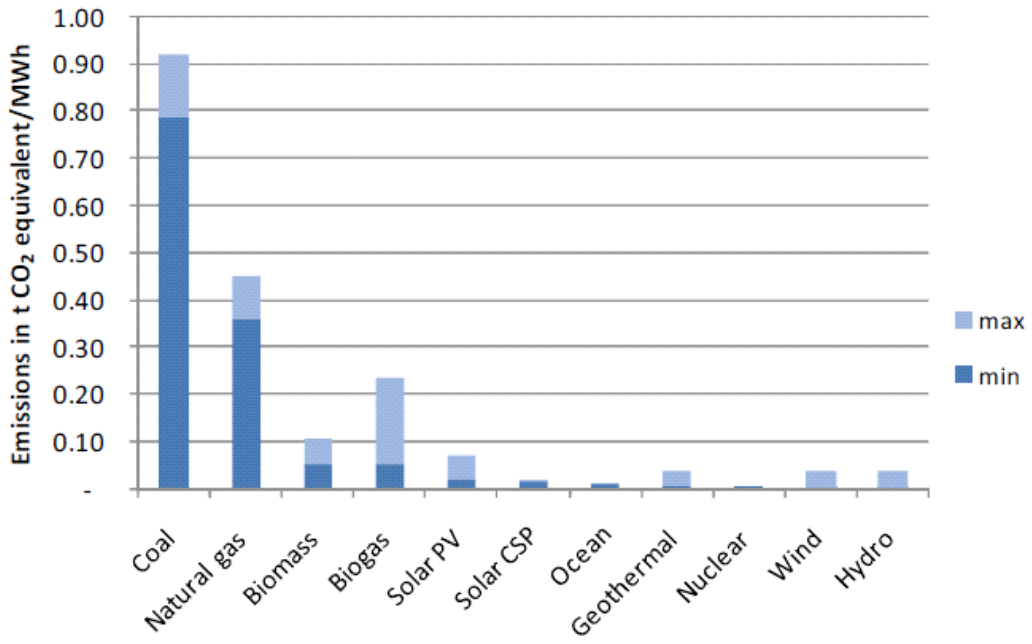

Figure 9 Life-cycle CO2 emissions of power-generating technologies [5]

This figure shows that hydro and wind power productions have indeed the lowest emission of GHG. However, biogas, which is also on the higher priority of the government, is relatively higher emitter compared to other technologies.

The government is aiming also to increase the share of **biofuels**. However, the experience of other countries show that expansion of biofuels should go hand in hand with adequate standards for land use and farming practices, otherwise there is a risk of deforestation, land-conversion

from farmlands, and undesirable GHG emission impacts [7]. These risks are especially high in Ethiopia since deforestation and low quality farm lands are already issues that need to be solved. Adding additional burden from growing biofuels makes it more difficult to address the existing environmental concerns.

There is no reference of **barriers for the deployment of renewables,** no reference to **mitigating measures.** There are many economical and non-economic barriers that deploying renewables would need to overcome. The economic barriers are linked to direct costs of certain technology in comparison to competing technologies, high up-front costs; non-economic barriers refer to regulatory and policy uncertainties, institutional and administrative weaknesses, market barriers such as subsidies to fossil fuels or inconsistent pricing structures that disadvantage renewables, absence of funding opportunities, infrastructure weaknesses, lack of skilled personnel, environmental problems [4, 5]. The GTP ignores these completely. Since there is no assessment of these risks then also the mitigation measures have not been proposed.

3.4 Implementing Renewable Energy Strategies

The Ethiopian renewable energy strategies have already required significant financial resources and professional expertise but there remains much room to improve programme efficacy and effectiveness. During the first GTP period, two big hydroelectric projects, the Grans Ethiopian Renaissance Dam (GERD, 6000 MW) and Gilgel Gibe III (1870 MW) have been completed 40% and 65% respectively. Ashegoda and Adama I wind power projects became operational. [17] Still, most of the targets have not been met (Table 4). In addition, for the second period even more ambitious targets have been set.

Table 4 Energy indicators and achievement of targets [17, 29, 44]

Indicator	**Base year (2009/10)**	**Target in GTP I (2014/15)**	**Actual achievement (2014/15)**	**New indicator in GTP II (2019/20)**
Consumers connections to electricity	2 030 000	4 000 000	2 310 000	6 955 000
Electricity access (towns)	1 402	11 566	7 000	17 295
Distribution network (km)	126 038	258 038	166 967	N/A
Electricity access (towns) - coverage of electricity services	41%	75%	60%	90%
Reduce power wastage of power transmission lines (%)	11	5.6	23	11
Hydroelectric power generating capacity (MW)	2 000	10 000	4 180	13 817
Energy production capacity (GWh)	7 653	32 656	9 515.27	63 207

The analysis of the implementation of the GTP I shows that either the indicators that were developed for measuring the progress were not realistic, or the designed policy was not adequate to reach the objectives. For example, during the first GTP period it was planned to increase the number of consumers with access to electricity from 2.03 million to 4 million, however, in five years the number of consumers increased to 2.31 million, i.e. the increase was only 15% of the target. For the second GTP period the new target is set for 6.955 million. There was no analysis done explaining why the original target was not met, whether it is a question of an ill-chosen indicator or a weakness in the policy. Another example relates to reducing power loss in power transmission lines. The first five-year plan was to reduce the wastage of power from 11% to 5.6% by 2015, instead the loss increased to 23% and during the new period it is planned to bring the loss back to the baseline year 2009/10 level. Once again, there is no explanation provided why the indicator was not met.

The reasons why the implementation of the strategy is going slow would need a comprehensive analysis, this, however, is either not done by the policy makers or is not available for the public except for a brief summary in the GTP II. Nevertheless, the electrification related indicators have been looked into by NRECA International Ltd. [29] in the gap analysis report of Ethiopia national electrification process and concluded that several key issues hinder the successful implementation of the (renewable) electrification plan, among others:

- lack of integrated approach to electrification - coordination at national, regional and local level between engineering planning, commercial management and customer service teams is not sufficient;
- lack of coordination between key sector agencies;
- inadequate capacity - electrification programmes require a number of capabilities to support planning and systematic expansion of services but often teams lack knowledge or motivation or experience.
- inadequate regulatory framework, especially as regards setting tariffs - the current tariff levels do not allow the Ethiopian Electricity Utility (EEU) to recover the operating costs of providing electric services, therefore the EEU has no incentive to connect new customers. The last tariff increase in Ethiopia occurred in 2006, and set the average

tariff at approximately USD0.06kWh, the current value is now approximately USD0.0273kWh.

All these are quite substantial weaknesses and confirm once again that the energy plans need to be revised.

Another reason which has slowed down the implementation of renewable energy plans, is also linked to inadequate regulatory framework, more precisely the aspect of licensing. The significant potential to provide off-grid service via micro-grid systems has been limited by the lack of clarity in the licencing process for new service providers. The process is cumbersome and often expensive, and does not provide a predictable environment for investors [29, 48].

The transition from traditional (such as locally available biomass fuels) to modern fuels (i.e. electricity and petroleum products) in developing countries has often been conceptualised as a three-stage process. In the stage 1 often wood fuel is the predominant source of energy. Country moves to stage 2 when wood availability is decreasing due to deforestation, markets for charcoal and kerosene are increasing, Stage 3 is characterised by developed markets, rising incomes, and large-scale fuel switching to liquefied petroleum gas (LPG) and electricity. [26] Referring to these stages, Ethiopia is currently in the stage 2 suffering from serious deforestation and looking into possibilities to increase the use of modern fuels, mainly by increasing the population's access to electricity. Researchers of Ethiopia [26] have shown, however, that this three-stage transition is not as straightforward and simple. Indeed, the extent of the positive environmental and health externalities is conditioned by many obstacles.

During the first GTP five-years period the major obstacles that were identified relate to implementation capacity limitations (planning, management, contract management, monitoring, changing attitudes, motivation, organisation, etc.) and financial resources limitations [17]. Many other important aspects have not been mentioned, for example implementation barriers in rural areas.

A study conducted already back in 2002 [21] concluded that the national energy policy at the time did not address energy requirements in rural areas for modern productive activities. Rural energy initiatives have not received sufficient attention and funding in Ethiopia due to economic resources constraints and low level of technological advancement [21]. Fifteen years later, the

analysis of the country energy situation and the national energy strategies show, that not much has changed as regards rural areas. The government reports the electrification rate of 60%, however, remote villages, smaller towns, and poor remain untouched by the modern energies. One important aspect that is still missing, is the vision how to lower the constraints the poor are facing to get access to the modern renewable energies.

The scholars who study poverty in rural areas [21, 47] are of the opinion that the energy problem is one of the root causes of underdevelopment and poverty of the country. The World Bank [24] and the strategic documents of the government link the poverty more to high level of unemployment (24% in the capital), and do not place the access to energy in the centre of their attention. In fact, the World Bank does not considering rural electrification currently critical, even though it recognises that in has a potential to improve lives by enabling better education and health services [24].

The strategies do not foresee how to reduce the rural population's dependence on the biomass energy. Many studies show that energy transition away from traditional fuels is not always easy, and the success depends on many factors [26, 49]:

- income growth;
- access to credits in order to finance the start-up costs;
- subsidizing (stove purchase);
- the education level, especially of the one of the head of household;
- life style changes;
- fuel availability;
- rapid urbanisation.

Therefore, broader approach is needed to understand and explain what triggers the fuel choice, and it is important to incorporate these aspects into the RE policies which need to be looked into in a wider context. The educational aspects are already incorporated into GTP II, but the author has not come across a comprehensive approach where the possible barriers would have been taken into considerations.

4 EU ROLE IN SUPPORTING ETHIOPIA'S RE POLICY

Since the EU is one of the big donors of Ethiopia it should have a very good possibility to support the renewable energy development of Ethiopia. This chapter looks closer into the EU-Ethiopia relations in order to make proposals for improving the co-operation. But to start with, the EU energy policy is being reviewed.

4.1 The EU Renewable Energy Policy and Current State of Play

Countries around the world are undergoing a clean energy transition, and EU claims that it wishes to lead the shift towards low-carbon economy. In order to lead the transition, energy efficiency and renewables have been put first [50].

During the last two decades, the European Commission identified many critical challenges related to climate change and sustainable energy. The European commitment to the renewable energy and the penetration of renewable energy to the market has required significant commitments from the EU as well as from its member states [43].

There are many strategic papers, frameworks, roadmaps that are designed for helping to achieve the ambitious challenge to reduce greenhouse gas emissions globally by 50% by 2050 [43]. The European Union and its member states have understood that this means considerable re-organisation of the way in which society works, these challenges are being addressed in various EU policies, among others in the sustainable energy policies.

The European energy and climate change policy was first adopted by the Council and the Parliament in 2008. The EU's sustainable energy policies are driven by three objectives: to secure energy supplies, to ensure competitiveness of energy market, and to make sure that energy consumption would be sustainable through lowering GHG emissions, pollution and fossil fuel dependence [51]. In 2008 sustainability, notably mitigating climate change, was the central element of the energy policy [52]. Now, however, the focus has been moved to energy security and industrial competitiveness.

In 2010 the EU adopted a new energy strategy Energy 2020 - A strategy for comparative, sustainable and secure energy, where the increase in the level of energy efficiency is listed

among five priorities. Improving energy efficiency is considered to be one of the most cost-effective ways of reducing greenhouse gas emissions, increasing security of energy supply, leading to more sustainable energy policy and enhancing industry competitiveness [53].

This energy and climate change package defined clearly five pillars. First of all, the objective is to increase energy efficiency, saving 20% of our energy by 2020. Secondly, increase the amount energy used from renewable sources, tripling renewable energy use to 20% by 2020. Third, raise substantially the amount of clean hydrocarbons we consume. The fourth pillar relates to strengthening the EU's carbon market. Finally, continuing to bolster the internal market. [54]

The EU has taken significant steps towards reaching its energy climate objectives and presented these in several documents, such as the 2020 Energy Strategy, Paris Agreement, COP21 [55], 'Roadmap for moving to a low-carbon economy in 2050' [56].

Table 5 The EU's energy strategy targets [53, 56, 57]

Year	Target
2020	• 20% reduction of greenhouse gas emissions vis-a-vis 1990 level • 20% share of renewable energies in energy consumption • 20% improvements in energy efficiency
2030	• 40% reduction in greenhouse gas emissions vis-a-vis 1990 level • 27% share of renewable energies in energy consumption • 27% improvements in energy efficiency, to be reviewed by 2020 with the potential to raise by 30% • 15% electricity interconnectivity between EU countries after the completion of the internal energy market, and pushing forwards important infrastructure projects
2040	• 60% reduction in greenhouse gas emissions vis-a-vis 1990 level
2050	• 80% reduction in greenhouse gas emissions vis-a-vis 1990 level

The EU medium and long-term targets for 2020, 2030, 2040 and 2050 are summarised in Table 5. These goals and targets are an important part of a stable EU policy framework on

greenhouse gas emissions, renewable energy and energy efficiency, and it gives stakeholders necessary certainty to plan their investments, actions, strategies.

The aim to reduce greenhouse gas emissions in the EU by at least 80% in 2050 vis-a-vis emissions in 1990 requires restructuring of the energy system. In order to achieve all sectors need to contribute. The share of renewable energies in the EU electricity generation is expected to rise from about 15% in 2005 to 50% or more in 2020 [57]. All electricity generation might be covered by the renewable energies, nuclear power and fossil fuels in combination with carbon capture and storage (CCS) in 2050 [56].

According to the European Commission's estimation, the power sector has the biggest potential for cutting emissions (Figure 10). For achieving decline of GHG emission in transport sector and to reduce emissions to more than 60% below 1990 levels by 2050, electricity could replace fossil fuels. The share of biofuels is also expected to increase. Emission reduction from buildings by around 90% is expected to be achieved through passive housing, improving energy efficiency and using electricity and renewables for heating, cooling and cooking. In order to make the transition, the EU would need to invest about EUR 270 billion over the next decades, this corresponds to about 1.5% of the GDP annually. [58]

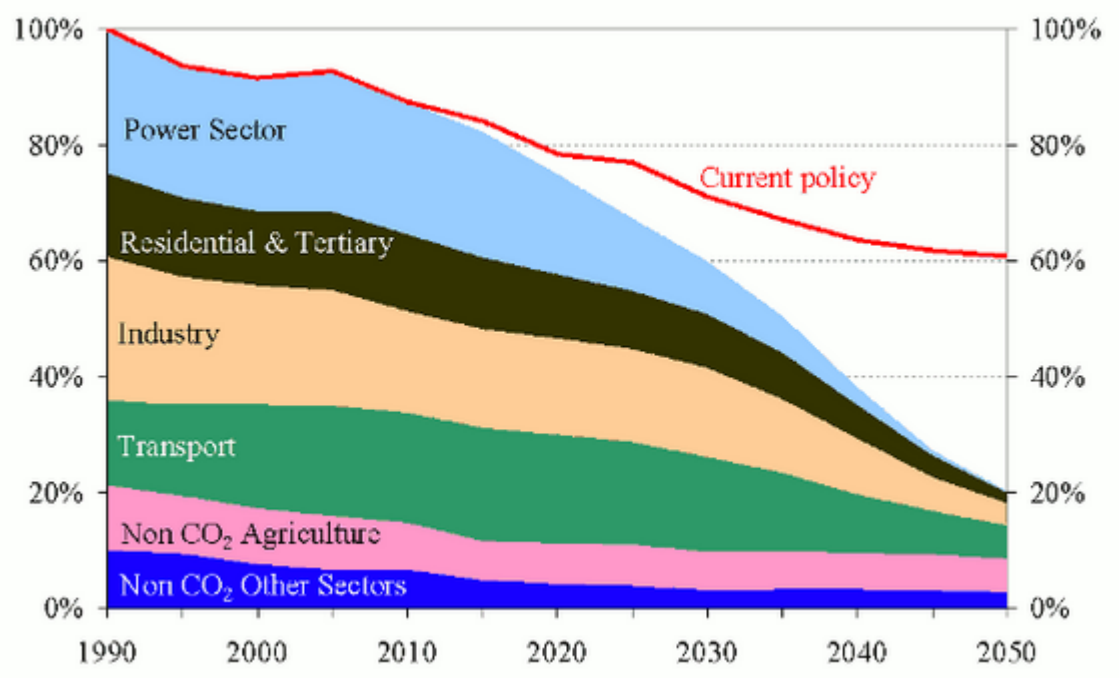

Figure 10 Possible 80% reduction of GHG missions in the EU by 2050 [58]

Formulating emission targets is the first step but equally important is to design of an appropriate, detailed policy strategy with a perspective to implement the targets [57]. In the communication to the European institutions, the European Commission reported on the achievements of the 20-20-20 targets and concluded that substantial progress has been made [59]. Notably, greenhouse gas emissions in 2012 decreased by 18% vis-a-vis 1990 level and are expected to reduce further to levels 24% and 32% by 2020 and 2030 respectively; the share of renewable energy has increased to 13% in 2012 and is expected to rise further to 21% in 2020 and 24% in 2030; the energy intensity of the EU economy has reduced by 24% between 1995 and 2011 whilst the improvement by industry was about 30%, and the carbon intensity of the EU economy fell by 28% between 1995 and 2010 [59].

These objectives are achieved through major investment in reinforcing research, education and innovation.

The European Commission is now reforming renewable energy policy to promote European competitiveness and renewable energy penetration but also to phase out financial subsidies for some of the RE technologies [9]. In the Green Paper of 2013, COM (2014) 15 final [59] and in

the SET plan range of critical challenges that Europe has to address by 2030 have been identified.

The biggest obstacles the EU is facing in achieving the ambitions aim of decarbonising the EU, are the on-going economic crisis and budgetary difficulties of Member States, and difficulty mobilising funds for long-term business investments. The Members States are struggling with high levels of public debts, employment and austerity policies [43]. At the same time there is an increasing dependency on energy imports (higher than 50%) from non EU countries [60]. This dependency is especially alarming due to geo-political tensions, and to deal efficiently with energy concerns in the changing geo-political context, the EU seems to be taking counter-productive steps such as supporting the use of fossil fuels and encouraging RE generation only in selected Member States [51].

With the recently adopted Winter Package (2016), the EU leaves it fully up to the Member States how they contribute to the EU target of 27% renewably energy by 2030. However, it is not defined what would happen if the MSs would not contribute sufficiently. Feed-in tariffs, Spain and Germany are good examples for how to implement successfully renewable energy targets[7].

Sometimes are governments urged to impose additional taxes and/or increase the prices of the conventional energy sources in order to promote the use of clean energy sources and discourage the use of conventional energy sources [1].

4.2. Relevant Lessons to Ethiopia

The EU has well defined framework of policies, legislations, measures with respect to clean energy. These policies are being promoted to other countries, including Ethiopia. Since the objectives of the policies of EU and Ethiopia are on large scale similar, promoting the EU's approach should not face too much resistance. Below is presented author's suggestions about the relevant lessons from the EU to Ethiopia.

Legislative Framework - Unlike Ethiopia, the EU has made a considerable progress in achieving its energy policy targets [59]. Partly because they are not overly ambitious but mainly

because the policies are well designed and the EU has shown serious commitment in meeting its goals. The EU policies are supported by strong legislative framework. The Government of Ethiopia has recognised that developing environmental laws is an important aspect, but there is still no solid legislative framework and no mandatory requirements that would support the implementation of RE strategies.

Long term objectives and strategic planning - Another important lesson to Ethiopia would be not underestimating the importance of setting long-term objectives. This gives the investors more certainty and confirms where the country is going. 5-years plans would not help to achieve ambitious investment plans and meet the targets.

Monitoring and Evaluation – The institutions of the EU have developed comprehensive monitoring and evaluation systems that allows to collect accurate data on progress and make adjustments to the targets, if necessary. The experience of Ethiopia, however, shows that targets and indicators are not always realistic and if their achievement is to some extent monitored, the analysis is lacking.

Cooperation – Although in the EU each member state has its own autonomy to decide on the energy mix, they all contribute to the EU targets of renewably energy. There are other cooperation mechanisms in place, which were not discussed in this study (e.g. European Emission Trading system), that makes the EU to act on the common goal. Ethiopia is receiving support from its donors, but the cooperation in the region is at the early stage of development.

4.3 EU - Ethiopia Cooperation

The EU is recognised by its soft power aspirations, and throughout the past years the EU has developed various dialogues and aid programmes to increase the exposure of its best practices, technologies, expertise [8]. It has the necessary means to lead the transition also beyond the borders of the EU – foreign aid and policy dialogue with the Governments.

The EU is one of the big donors of Ethiopia, but also the country's most important trade partner and among the key investors [46] Ethiopia's current 5-years Growth and Transformation Plan foresees receiving significant technical and financial support from its longstanding developing

partners, among which EU is in the forefront. Since the signing of the first Lomé Convention in 1975 between the EU and the African, Caribbean and Pacific (APC) States, Ethiopia has benefited from the EU's support to finance its development endeavours [61]. The EU has been on the major development partners of Ethiopia for the last 40 years. The support has been increasing from Lomé I to Lomé IV and under Cotonou Partnership Agreement which runs from 2000 to 2020 [62]. Over time the focus and priorities of the co-operation have changed.

The current financial support that Ethiopia is receiving from the EU is about EUR 745 million for the years 2014 - 2020, covering different sectors such as sustainable agriculture and food security, health, roads and energy, in addition several cross-cutting issues such as human rights, gender equality, women empowerment, democratic governance, environmental protection, regional stability [46]. In the energy sector EU is focusing on supporting the efforts of the government of Ethiopia to move towards renewable energy production by diversifying the energy mix (geothermal, wind, solar, biomass), expansion of energy access and improvements in efficiency.

The EU - Ethiopia relationship are based on partnership. Europe cannot influence the development of Ethiopia, meaning Ethiopia would implement its plans even without the presence of the EU. Even without the assistance of the EU, Ethiopia would have recognised that it has to deal with the energy security issue; it would need to invest on renewable energies as matter of national survival. However, the EU's ambition is helping to reduce Ethiopia's exposure to global shocks such as climate change, ecosystem and resource degradation [46]. In order to do that, priority projects for the current 7-years budgetary perspective of 2014-2020 have been identified in Table 6.

Table 6 Major EU projects in the field of climate change and clean energy [46]

Programme	Budget, MEUR
Up-Scaling Energising Development Ethiopia - Access to Energy Through off-grid Renewable Energy Solutions	9
Biogas Dissemination Scale-Up Project (NBPE +)	21
Green Energy Sector Reform Contract – Budget Support	70
Total for the period 2014-2020	**90**

All these projects in contribute to the achievement of three main objectives of the EU [46]:

- improve access to modern, safe and sustainable energy services,
- increase power production from renewables such as biogas, micro-to-mini-hydro, geothermal, solar and wind,
- improve energy efficiency.

Apart from the efforts at the level of the EU, various member states have their own initiatives. France, Germany, United Kingdom and Norway from European countries were financially present during the implementation of the GTP I in Ethiopia. In addition countries like China, Kuwait, India, and development organisations as ADB, BADEA, IDA, OFID participated. [46] The presence of large number of development partners in the country requires a significant coordination effort to enhance the quality of the dialogue between the government and its development partners.

These EUR 90 million that the EU has promised to Ethiopia, is relatively small compared to the estimated annual need of USD 2 billion, therefore, it is of utmost important to design the projects well to maximise the benefit from the implementation. Currently there are two renewable energy projects identified and under implementation.

The 'Up-Scaling Energising Development Ethiopia - Access to Energy Through off-grid Renewable Energy Solutions' (2016) project has an estimated budget of about 9 MEUR and it is co-financed by the EU, Ireland and the United Kingdom. It is a part of a global programme

Energising Development (EnDev) Partnership where the Netherlands, Germany, Norway, Austria, the United Kingdom, Switzerland, Ireland and the EU are working together to increase the number of people who get access to modern energy services, create sustainable jobs, increase renewable energy capacity, reduce CO2 emissions and generate investments from private and public sectors. Since 2006 EnDev has been promoting in Ethiopia decentralised supply of renewable energy technologies to households and social institutions especially in rural areas through market development focusing on private sector involvement. [63]

The objective of the 2016 project that is currently under preparation is to increase access to modern energy supply, i.e. to RE technologies or energy efficiency solutions. The objectives are going to be achieved by supporting the market development of improved cook stoves, high quality Solar Home Systems and pico-size photovoltaic devices. By the end of 2018 about 100 new enhanced stove production sites should be established and 120 village technicians and retailers trained on design, installation, maintenance and repair of solar and Pico-PV systems and on business management. [63] EnDev is also supporting Micro-Finance Institutions (MFIs) in developing financial solutions meeting the needs of potential customers and retailers. Due to the low financial capacity of the population, MFIs are essential in making any project sustainable.

The Biogas Dissemination Scale-Up Project (NBPE +) with a total budget of 21 MEUR aims to improve the living standards of rural Ethiopia by promoting the use of clean and renewable biogas. By the end of the project 35 000 biogas digesters impacting 210 000 persons in eight regions of Ethiopia are being installed. This will help to replace wood fuel, agricultural residues, dung-cake and kerosene by cleaner biogas; provide health benefits; save time for productive, educative and social activities; and improve sanitary conditions. At the national level the programme would reduce overexploitation of the biomass and at the global level reduce greenhouse gas emissions. [64] As it was explained previously, women's time and labour are particularly affected by the wide use of biomass fuel for cooking and heating, therefore, the EU tries to target especially women as more vulnerable target group. The project provides subsidies or investment supports to households.

The third project in table 5 relates to a direct support to a state budget on the conditions that the

government is ready to reform the green energy sector. The exact conditions of the expected reform are still unknown because the negotiations between the EU and the government are still on-going with the aim of reaching a common understanding in 2018.

4.4 How Can the EU Improve Its Support, Conclusions and Recommendations

The EU projects are providing additional support to Ethiopia in its path towards becoming middle income country and increasing its population access to RE energy solutions. The EU is always taking into account the national strategies and plans when developing the co-operation projects. However, since the Ethiopian RE policy is somewhat fragmented and short-term visions only as explained in the previous section, the support that EU is able to provide is also fragmented.

Therefore, first important aspect where EU could assist Ethiopia is helping to **developing sustainable energy policy indicators**. Indicators are useful tools for policy makers and analysts for the assessment of current conditions of energy system, effectiveness of the energy policies and in the definition of strategies for the future [65], they help to quantify and simplify phenomena in order to understand a complex reality better [52]. It is visible from Table 4 and as explained in section 3.4, none of the original RE indicators were reached. Either the indicators that were developed for measuring the progress were not realistic, or the designed policy was not adequate to reach the objectives. Moreover, the analysis explaining why the original target was not met, is it a question of an ill-chosen indicator or a weakness in the policy, is lacking. The EU has long experience with developing sustainable development indicators and assessing its policies against these [65, 66]. In its cooperation with Ethiopia this could be one of the main fields where the EU's assistants would benefit Ethiopia remarkably.

Secondly, the EU should strictly finance only projects that are set there as a **priority**, all projects should be in line with the national development plans such as GTP and CRGE. GTP II has identified hydropower, geothermal, wind and off-grid solar panels as a priority. Nevertheless, the EU has decided to continue financing a biogas project. The aim, of course, is to reduce dependency from the biomass fuels and slowing down deforestation, but since the budget is not unlimited, choices should be made. The EU should put its priorities in Ethiopia in line with the

development plans of Ethiopia. It is true that the Biogas project goes in line with the overall goal of the government to reduce energy poverty and increase access to renewable energies, but the author is of the opinion that the choices should still follow the first priorities of the country.

Moreover, since the EU is suffering from economic difficulties, the foreign aid available to third countries is diminishing. In order to continue assisting Ethiopia as a priority country in the region, the financial support is targeted to fewer sectors. As the EU has recognised the importance of investing in RE sector, Ethiopia keeps receiving funds in this sector.

When the EU concentrates only on priority projects decided by the government of Ethiopia and involves local partners in preparation and implementation process, this increases remarkably the feeling of **ownership** of Ethiopia. At the end of the day it is Ethiopia who should take lead over its development policies, and the role of any other donor is merely supporting them on this challenging road of implementing the strategies. Feeling of ownership increases the chances of success.

In order to increase the impact of projects, the EU is encouraged to move towards **jointly** planned and financed programmes **with other donors**. Cooperation among donors requires trust, agreement on objectives and priorities and like-minded approach to development. The EU has been moving towards joint-programmes already for years and also in the programming document for 2014-2020 recommendation regarding this suggestion has been made, but the progress has been slow, and so far all the projects in the renewable energy sector have been financed and managed by the EU alone.

Another key-word is **capacity building**. Due to financial constraints, the EU is financing less big infrastructure projects and puts more emphasis on training several stakeholders and key players in order to increase the sustainability of the project and provide the country with knowledgeable people who could contribute to the implementation of the RE policy objectives. In all projects there are activities linked to training the local staff. The EU has recognised the importance of qualified individuals, no matter if engineers, solar panels or stove producers or simple villagers as in the 'Energy Through off-grid Renewable Energy Solutions' project. The experience of China and India shows that technical training is as important factor next to investments in research and development, and manufacturing on the road of a country in

becoming global leader in wind energy technology. [67] The education system in general in Ethiopia is rather weak [68], so skills need to be imported.

Therefore, the EU projects normally have a capacity building component and it should stay this way. During the extensive time period that EU has been present in Ethiopia, it has concluded over and over again that the human resources capacity and availability remains an important obstacle [69] and it is necessary to undertake regular trainings. The ability of a society to move out of energy poverty and to switch to RE does not depend only on the availability of the natural resources, but also on the capacity of its people, institutions and organisations. There is a continuous shortage of human resource (engineers, technologists, trained technicians, managers) in the energy sector in Ethiopia [47]. Low level of education is also identified by the World Bank as one of the main constraint that slows done the country's development [24]. Many households in Ethiopia are uneducated, the literacy rate is only 36% [70], and the country needs a structural reform. But the EU could step in on a higher level, not the primary education, to help to reduce the continuous shortage of personnel who would be equipped with the essential skills to respond to technical demands at various levels.

5 CONCLUSIONS

Access to clean and affordable modern energy is essential for social and economic development of any country. Efficient policy frameworks and (renewable energy) programmes are required in order to ensure that people have access to renewable energy in a sustainable manner.

This study argues that despite the limited EU budget available for development aid, careful planning of the financing can contribute the development of the Ethiopia's renewable energy sector. The government of Ethiopia has estimated that it needs to invest about 2 billion USD every year to implement its green economy plan, compared to which the EU budget available for Ethiopia is very small. Nevertheless, the author is proposing several focuses for the EU to amplify the results of financial support, such as assisting in developing sustainable energy indicators, investing only in projects of national priority, encouraging cooperation with other donors, and supporting capacity building.

5.1 Answers to Research Questions

Answers to the questions posed at the beginning of these theses were provided at the end of each chapter. Herewith the main aspects are summarised.

5.1.1 Question 1 – RE Situation in Ethiopia

Understanding the first research question was the precondition before moving on to the following ones. It would not be possible to provide an opinion on the policies without having identified the present situation of the RE in Ethiopia.

The closer look into the RE sector and the author's SWOT analysis in chapter 2 concluded that Ethiopia is already using to a large extend RE energies. The share of fossil fuels is rather low compared to the rest of the world. The main reasons for that are not linked to a modern approach to the management of the energy sector, but rather to a low access to the energy in general among population and to the wide availability of biomass and hydropower. Extensive use of biomass has led to a serious degradation of nature and forcing to search for alternative sources. Fossil fuels are expensive and take a remarkable share from the overall import budget.

Even though access to modern energy sources is still below the average even in sub-Saharan Africa, there is a big potential for development. The positive aspect is that Ethiopia has a huge reserve of unexploited RE sources such as hydropower, wind, geothermal and solar energy. The challenge is to find a suitable and affordable energy mix for the country, and not to concentrate only on hydropower potential but to combine it with wind, geothermal and solar technologies to manage the climate related risks.

5.1.2 Question 2 – What in RE Policies Could Be Improved

In addressing the second research question on policy performance and effectiveness, the study reveals several weaknesses related to design and implementation of the RE policies. In Ethiopia there are two important policy documents, but none of them places the RE in the centre of the attention. Moreover, the visions for the development of the country are short- and medium term, even though the nature of the investments on RE would require long-term vision. A comprehensive answer to this question is provided in chapter 3.

5.1.3 Question 3 – How the EU Could Improve Its Support to Ethiopia

The financial contribution of the EU to the support of implementation of RE policies is rather low compared to the investment needs of Ethiopia for the next decades. This, however, does not mean that the EU would not be able to provide a meaningful and efficient assistance. The author has proposed in chapter 4.3 many areas where the intervention of one of the biggest donor would have significant influence without financings large infrastructure projects.

It is of utmost importance to develop reliable but still ambitious indicators for measuring the achievement of the set objectives and determining if the chosen action plan helps to move towards desired results. The EU has thorough knowledge in this area and could provide assistance while Ethiopia has until now been overambitious in determining its targets. Another field, where the EU is a good partner for developing countries, is supporting capacity building activities. Ethiopia has not managed to create a solid network of engineers, managers, technicians to meet its growing needs for RE related expertise, so the EU would be able to help to fill this gap of knowledge. All this should be done in the spirit of good cooperation,

prioritising the projects according to Ethiopia's strategic plans and in close cooperation with other international donors to multiply the positive effects.

5.2 Summary in Estonian

Juurdepääs puhtale ja taskukohasele kaasaegsele energiale on iga riigi sotsiaalmajandusliku arengu oluliseks osaks. Tagamaks elanikkonna jätkusuutlik juurdepääs taastuvenergiale, tuleks välja töötada effektiivsed taastuvenergia poliitilised raamdokumendid ja programmid.

Etioopia on arenguriik, kus elanikkonna juurdepääs energiale on maailma üks kehvemaid. Samas on riigist märkimisväärne taastuvenergiapotentsiaal. Käesolev uurimus heidab pilgu Etioopia energia sekotori olukorrale tegemaks kindlaks hetkeolukorra nõrgad kohad ning pakkuda välja võimalusi arenguks. Energiapoliitika kriitilise analüüsi käigus selgitatakse välja puudujäägid ja antakse hinnang poliitika senise rakendamise tulemuslikkusele. Töö viimases osas leitakse, et vaatamata ELi piiratud välisabieelarvele, on hoolika planeerimise tulemusena võimalik Etioopia taastuvenergia sektori arengus kaasa rääkida. Etioopia valitsus on arvestanud, et igal aastal tuleks rohelise majanduse plaani elluviimiseks investeerida umbes 2 miljardit USD, millega võrreldes on ELi välisabieelarve väga väike. Sellele vaatamata pakub autor välja erinevaid lahendusi, kuidas finantsoetuse tulemuste mõju suurendada. Näiteks saaks EL toetada taastuvenergia mõõdikute väljatöötamist, investeerida ainult riigi poolt prioriteediks määratud projektidesse, teha koostööd teiste doonoritega ja toetada inimresurrside arengut.

REFERENCES

[1] Paramati, S.-R., Apergis, N., Ummalla, M. Financing clean energy projects through domestic and foreign capital: The role of political cooperation among the EU, the G20 and OECD countries. - Energy Economics 2017, no 62, p. 62 - 71.

[2] UNEP, Norwegian Ministry of Foreign Affairs. Renewable energy and energy efficiency in development countries: Contributions to reducing global emissions. Second report, 2016.

[3] Niyibizi, A. SWOT Analysis for Renewable Energy in Africa: Challenges and Prospects. - Renewable Energy Law and Policy Review 2015, no 4, p. 276 - 293.

[4] IEA. Deploying Renewables, Markets & Policies. Best and Future Policy Practice, 2011. www.iea.org, accessed in 14/4/2017.

[5] IEA. Renewable Energy, Policy Considerations for Developing Renewables. 2011. Available: https://www.iea.org/publications/freepublications/publication/Renew_Policies.pdf, accessed 17/4/2017.

[6] Schilling, M., Chiang, L. The effect of natural resources on a sustainable development policy: The approach of non-sustainable externalities. - Energy policy 2011, no 39, p. 990 - 998.

[7] Arent, D.-J., Wise, A., Gelman, R. The status and prospects of renewable energy for combating global warming. - Energy Economics, 2011, no 33, p. 584 -593.

[8] Holslag, J. China's Scepticism of Clean Energy Champion Europe. - The International Spectator 2010, no 45, p. 115 - 130.

[9] Upadhyay, D.-K. Coping with Climate Change, India-EU Cooperation on Renewable Energy and Clean Technology. - India Quarterly, 2014, no 70, p. 241-256.

[10] Pareja-Alcaraz, P. Chinese investments in Southern Europe's energy sectors: Similarities and divergences in China's strategies in Greece, Italy, Portugal and Spain. – Energy Policy 2017, no 101, p. 700 – 710.

[11] Flamos, A. The Timing is Ripe for an EU-GCC 'Clean Energy' Network. – Energy Sources, Part B: Economics, Planning and Policy 2015, no 10, p. 314 – 321.

[12] SE4All, http://www.se4all.org/, accessed 24/05/2017

[13] Sustainable Development Goals, http://www.un.org/sustainabledevelopment/energy/ accessed 24/02/2017

[14] World Commission on Environment and Development, Our common future, 1987. Oxford University Press.

[15] Latin American Energy Organization (OLADE), Economic Commission for Latin America and the Caribbean (ECLAC), Deutsche Gesellschaft Für Technische Zusammenarbeit (GTZ). Energy and Sustainable Development in Latin America and the Caribbean: Guide for Energy Policymaking. 2010.

[16] Gippner, O., Torney, D. Shifting policy priorities in EU-China energy relations: Implications for Chinese energy investments in Europe. - Energy policy 2017, no 101, p. 649 - 658.

[17] Growth and Transformation Plan II (GTP II) 2015/16 - 2019/20. Federal Democratic Republic of Ethiopia, National Planning Commission, May 2016 Addis Ababa.

[18] Hancock, K.-J. The expanding horizon of renewable energy in sub-Saharan Africa: Leading research in the social sciences. Energy Research & Social Science no 5, 2015, p. 1 - 8.

[19] Coenraads, R., Koivula, J.-I. Imeline Maa. Entsüklopeedia. 2009. Koolibri.

[20] Trade Economics. http://www.tradingeconomics.com/ethiopia/population, accessed 8/5/2017.

[21] Wolde-Ghiorgis, W. Renewable energy for rural development in Ethiopia: the case for new energy policies and institutional reform. - Energy Policy 2002, no 30, p. 1095 - 1105.

[22] Ethnologue, Languages of the world, https://www.ethnologue.com/country/ET, accessed 8/5/2017.

[23] The World Bank. http://data.worldbank.org/indicator/EN.POP.DNST?locations=ET,

accessed 8/5/2017.

[24] World Bank. Ethiopia, Priorities for ending extreme poverty and promoting shared prosperity. Systematic Country Diagnostic. 30 March 2016.

[25] Berhanu, M., Jabasingh, S.-A., Kifile, Z. Expanding sustenance in Ethiopia based on renewable energy resources - A comprehensive review. - Renewable and Sustainable Energy Reviews 2016, http://dx.doi.org/10.1016/j.rser.2016.11.082 , accessed 11/4/2017.

[26] Gebreegziabher, Z., Mekonnen, A., Kassie, M., Köhlin, G. Urban Energy transition and technology adoption: The case of Tigrai, northern Ethiopia. - Energy Economics 2012, no 34, p. 410 - 418.

[27] Ministry of Water, Irrigation and Energy of Ethiopia. Overview of the Energy Sector in Ethiopia. June 2012, Addis Ababa.

[28] Asress, M.-B., Simonovic, A., Komarov, D., Stupar, S. Wind energy resource development in Ethiopia as an alternative energy future beyond the dominant hydropower. - Renewable and Sustainable Energy Reviews 2013, no 23, p. 366 - 378.

[29] NRECA International, Ltd. Ethiopia National Electrification Strategy Project: Gap Analysis Report, January 2016.

[30] Fauvel, J.-B. Ethiopia's energy Sector, May 21st 2013. EU Delegation to Ethiopia.

[31] Holodny, E. The 13 fastest-growing economies in the world. - Business Insider UK, 12/6/2015, available http://uk.businessinsider.com/world-bank-fast-growing-global-economies-2015-6?r=US&IR=T/#-china-1 , accessed 10/5/2017.

[32] IEA. Energy efficiency indicators. Statistics. 2016.

[33] Mentis, D., Andersson, M., Howells, M., Rogner, H., Siyal, S., Broad, O., Korkovelos, A., Bazilian, M. The benefits of geospatial planning in energy access - A case study on Ethiopia. - Applied Geography 2016, no 72, p. 1 -13.

[34] The Secretary-General's Advisory Group on Energy and Climate Change (AGECC). Energy for Sustainable Future. Report and Recommendations. 28 April 2010, New York.

Available http://www.un.org/millenniumgoals/pdf/AGECCsummaryreport[1].pdf, accessed 22/05/2017.

[35] Global Tracking Framework, Egypt, http://gtf.esmap.org/country/egypt, accessed 24/05/2017.

[36] Takama, T., Tsephel, S., Johnson, F.-X. Evaluating the relative strength of product-specific factors in fuel switching and stove choice decisions in Ethiopia. A discrete choice model of household preferences for clean cooking alternatives. - Energy Economics 2012, no 34, p. 1763 - 1773.

[37] Beyene, A.-D., Koch, S.-F. Clean fuel-saving technology adaptation in urban Ethiopia. - Energy Economics 2013, no 36, p. 605 - 613.

[38] De Venage, G. Ethiopian dam creates waves. – The National. 24 April 2017. http://www.thenational.ae/business/economy/ethiopian-dam-creates-waves, accessed 25/04/2017.

[39] Salini Impregilo, https://ethiopia.salini-impregilo.com/en/, accessed 13/05/2017.

[40] USAID. A Climate Trend Analysis of Ethiopia. April 2012.

[41] Karekezi, S., Kithyoma, W. Renewable energy strategies for rural Africa: is a PV-led renewable energy strategy the right approach for providing modern energy to the rural poor of sub-Saharan Africa? - Energy Policy 2002, no 30, p. 1071 - 1086.

[42] Ethiopia's Climate-Resilient Green Economy, Green economy strategy. Federal Democratic Republic of Ethiopia, September 2011 Addis Ababa.

[43] Hills, M., J. Renewable energy pioneers are threatened by EU policy reform. – Renewable Energy 2017, no 108, p. 26 – 36.

[44] Flores, W., C., Ojeda, O., A., Flores, M., A., Rivas, F., R. Sustainable energy policy in Honduras: Diagnosis and challenges. Energy Policy 2011, no 39, p. 551 - 562.

[45] Growth and Transformation Plan 2010/11 - 2014/15. Federal Democratic Republic of Ethiopia, Ministry of Finance and Economic Development, November 2010 Addis Ababa.

[46] National Indicative Programme for Ethiopia 2014 – 2020. Signed between the Government of Republic of Ethiopia and The European Commission in Nairobi on 19 June 2014.

[47] Mulugetta, Y. Human capacity and institutional development towards a sustainable energy future in Ethiopia. - Renewable and Sustainable Energy Reviews 2008, no 12, p. 1435 - 1450.

[48] Bekele, G., Palm, B. Feasibility study of a standalone solar-wind-based hybrid energy systems for application in Ethiopia. - Applied Energy 2010, no 87, p. 487 - 495.

[49] Kebede, B., Bekele, A., Kedir, E. Can the urban poor afford modern energy? The case of Ethiopia. - Energy Policy 2002, no 30, p. 1029 - 1045.

[50] European Commission Dossier. Clean Energy for All Europeans.

[51] Patlitzianas, K., D., Doukas, H., Kagiannas, A., G., Psarras, J. Sustainable energy policy indicators: Review and recommendations. - Renewable energy 2008, no 33, p. 966 - 973.

[52] IEA. Energy Policies of IEA Countries, European Union, 2014 Review. 2014.

[53] European Commission. 2020 Energy Strategy. https://ec.europa.eu/energy/en/topics/energy-strategy/2020-energy-strategy, accessed 23/10/2016.

[54] Garca Carvalho, M. EU energy and climate change strategy. – Energy 2012, no 40, p. 19 – 22.

[55] Sustainable Innovation Forum 2012. www.cop21.paris.org, accessed 1/5/2017.

[56] European Union. Roadmap for moving to a low-carbon economy in 2050. European Commission. Available: https://ec.europa.eu/clima/policies/strategies/2050_en , accessed 05/2017.

[57] Hübler, M., Löschel, A. The EU Decarbonisation Roadmap 2050 - What way to walk? - Energy Policy 2013, no 55, p. 190 - 207.

[58] European Commission, Climate Action. 2050 low-carbon economy. https://ec.europa.eu/clima/policies/strategies/2050_en, accessed 23/05/2017

[59] European Commission. Communication from the Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions, COM(2014)15 final, 22/1/2014, Brussels.

[60] Kasmioui, O., Verbruggen, A., Cuelemans, R. The 2013 reforms of the Flemish Renewable electricity support: missed Opportunities, Renew. – Energy 2015, no 83.

[61] European Commission, Development. From Lomé I to IV bis, available: http://ec.europa.eu/development/body/cotonou/lome_history_en.htm , accessed 8/5/2017.

[62] The Cotonou Agreement and multiannual financial framework 2014-20, European Commission, available: http://www.europarl.europa.eu/intcoop/acp/03_01/pdf/mn3012634_en.pdf

[63] Financing Agreement between the European Commission and the Federal Democratic Republic of Ethiopia, No ET/FED/038-370. Up-Scaling Energising Development (EnDev) Ethiopia - Access to Energy Through off-grid Renewable Energy Solutions, signed on 19/02/2016.

[62] Financing Agreement between the European Commission and the Federal Democratic Republic of Ethiopia, No ET/FED/038-189. Biogas Dissemination Scale-Up Project - National Biogas Programme of Ethiopia (NBPE+), signed on 28/01/2016.

[65] Vera, I., Langlois, L. Energy indicators for sustainable development. - Energy 2007, no 32, p. 875 - 882.

[66] Streimikiene, D., Sivickas, G. The EU sustainable energy policy indicators framework. - Environment International 2008, no 34, p. 1227 - 1240.

[67] Sklarew, J., F. How Can China and India Serve as Models for Developing Nations Striving to Build Absorption Capacity for Renewable Energy Technologies? – Renewable Energy Law and Policy Review 2011, no 3, p. 181 – 194.

[68] Alula Pankhurst. Change and Transformation in Twenty Rural Communities in Ethiopia. Selected aspects and implications for policy. 2017, Wide, Addis Ababa.

[69] Financing Agreement between the European Commission and the Federal Democratic Republic of Ethiopia, Technical Cooperation Facility V signed on 28/01/2016.

[70] Central Statistical Agency of Ethiopia, http://www.csa.gov.et/ , accessed 8/5/2017.