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Energy and emissions on the African Continent: Can and will the COP21 treaty be implemented?

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Abstract. African nations share a common situation in that they pollute little in terms of CO2s globally speaking, but at the same time global warming may have terrible consequences for the continent, set to face a sharp population increase. They have now access to few energy resources, which is conducive to their poverty. New renewables belong to the future (solar, wind, geo-thermal), whereas old renewables – wood coal – are a thing of the past. The coal or oil and gas dependent giants must start energy transformation, as must the many countries relying upon traditional biomass. The use of wood coal is simply too large for the survival of the African forest. Under the COP21, African countries have right to financial assistance, especially for more electricity to connect its rural and also many urban people to heating, air-conditioning and the electronic high ways. Without the COP21 promises, decarbonisation will be impossible in Africa, and thus its large need for more energy will lead to more CO2:s.
Keywords. COP21 Agreement, African energy diversity, New and old renewables, Coal or oil and gas dependency, Super Fund.
JEL. A10; A22; A23; B10; E10.
SDG. SDG13, SDG17.

1. Introduction

In the climate change process, the African countries suffer badly from the biggest externality in human history (Stern, 2007). They are not among the big emitters of greenhouse gases or CO2: s. But they have to adapt their societies and economies to temperature rise that will most probably go over + 2 degrees, and maybe even + 3 degrees. How to cope? If temperature rise goes even further towards + 4-6 degrees, life will be threatened. How can people work under too hot circumstances? Water? The wildlife?

Yet, African governments have promised to contribute towards the COP21 objectives of decarbonisation by transforming their energy systems. How to pay? Even if African nations carry out their responsibilities under the UN Treaty, there is no guarantee that the big emitters of CO2:s will not renege. And then we have the danger of the new methane emissions.

In this paper, I will render a short overview of the energy-emissions conundrum on the African continent. There is a basic catch-22: The African continent uses less energy per capita than the other global continents, which entails that total emissions of CO2s are lower than in Asia, America and

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Europe. Yet, Africa badly needs more energy, as it is the capacity to do work that result in income and wealth. If Africa could increase its energy share globally, it could reduce poverty. But this continent may contribute to global warming, resulting in great risks for its populations.

2. Energy and emissions on continents

The countries on the African continent do not belong to the great polluters of CO2s in the world. Only a few of them have large CO2s like Egypt, Algeria, South Africa and Nigeria, but they do not rank among the really large 29 polluters in the world. This basic fact reflects their level of affluence, as energy and GDP are closely related. Consider Figure 1 with the global energy scene.

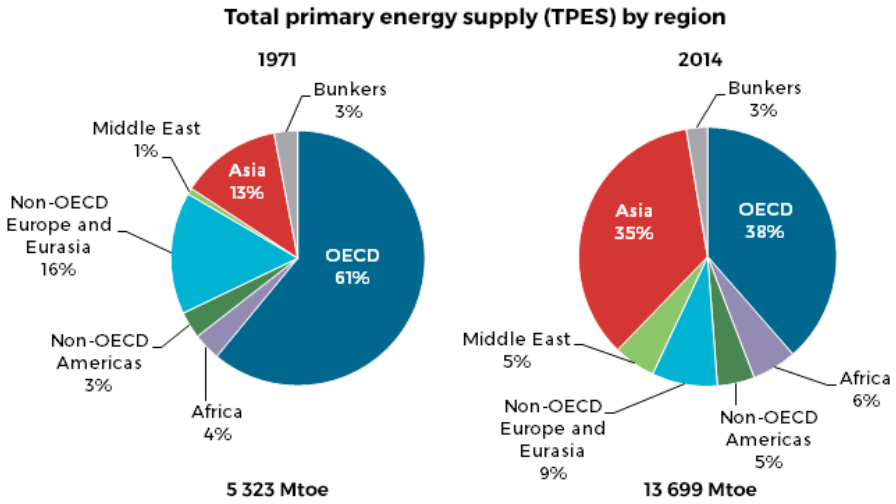

Figure 1. *Global energy*
Source: [Retrieved from].

It is small wonder that the African continent is the poorest, given its low share of global energy consumption. The population of Africa is increasing fast, meaning that much more energy is needed for economic and social development, but the COP21 decarbonisation project must be respected!

African countries are unique in the sense that they do not contribute much to climate change, but they could stand to suffer enormously from global warming – the external effects of climate change. They range from excessive heat, constant need of air-conditioning (also augmenting emissions), droughts, ocean acidification, food shortages, and insupportable working conditions for peasants, etc. Yet, African governments can argue that they need much support for energy transformation, given the low share of global emissions for the continent – see Figure 2.

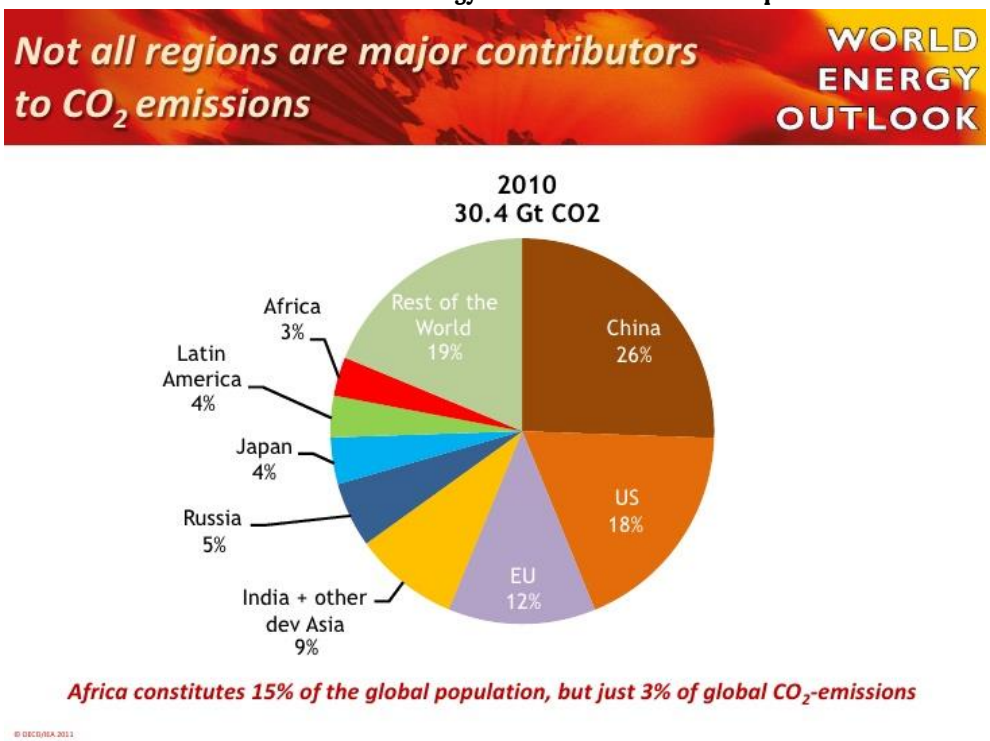

Figure 2. *Global emissions of CO2*
Source: [Retrieved from].

Economic development in poor countries as well as economic growth in advanced countries tends to trump environmentalism. This sets up the energy-emissions conundrum for mankind in this century: Affluence requires energy, as energy is the capacity to do work that renders income – see global Figure 3; but as energy consumption augments, so do emissions of GHG:s or CO2:s (Appendix 1). How to fundamentally transform global energy consumption?

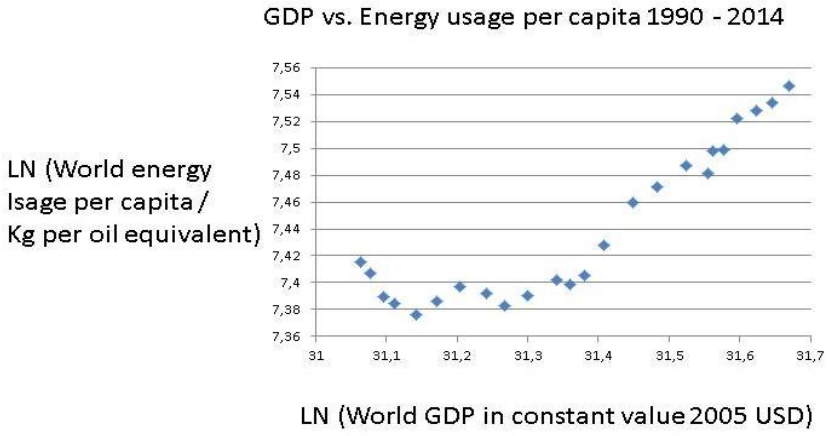

Figure 3. *GDP against energy per person (all countries)*

What is at stake for most people who understand the risks with climate change is not the *desirability* of decarbonisation in some form or another. They crux of the matter is *feasibility*: How to promote decarbonisation so that real

life outcomes come about? The COP21 framework, and its three objectives, namely:

a) Halting the increase in carbon emission up to 2020 (Goal I),
b) Reducing CO2:s up until 2030 with 40 per cent (Goal II),
c) Achieve more less total decarbonisation until 2075 (Goal III),

will prove too demanding for most countries, I dare suggest also for African nations in dire need of the promised Super Fund.

3. GDP-Energy-emission in Africa

African governments must now start energy-emissions policy-making within the framework of the UN Convention on Climate Change. Positively, they can argue that energy consumption is far too low on the African continent. The population is rapidly growing and needs massive electricity supply. Simple global energy-emissions fairness requires this.

Negatively, African nations are much dependent upon coal – wood coal except South Africa that uses stone coal – and oil and gas in the oil producing countries and Egypt. Most African countries employ wood coal and its derivatives, which maintain the continent in poverty. The COP21 project should be used by African governments for rapid electrification by means of NEW renewables.

The energy-emissions conundrum applies also to the African continent, as CO2:s are rising, driven by economic development. The situation in 1990 for 13 major African countries was as depicted in Figure 4.

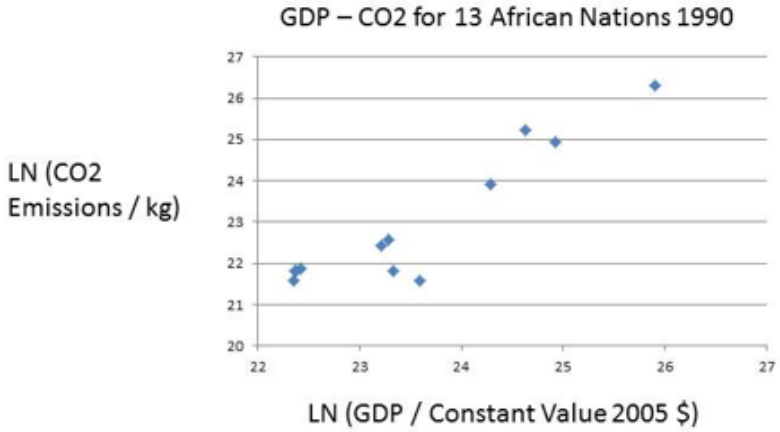

Figure 4. GDP-CO2 link in 1990: y = 1,3354x; R^2 = 0,87

20 years later, emissions have increased following economic development. Surely, the UN would be interested in seeing CO2:s low in Africa, but then it must help with a fundamental energy transition from solids and fossil fuels to NEW renewables. (Figure 5).

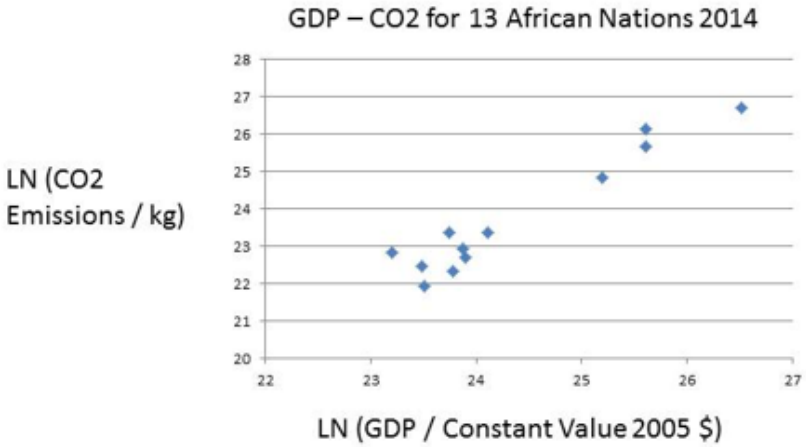

Figure 5. *GDP-CO2 link 2014: y = 1,4684x; R^2 = 0,93*

4. Solar power: Estimation of governments' obligations

Let us first focus upon what this hoped for reduction of fossil fuels implies for the augmentation of renewable energy consumption, here solar power. The use of atomic power is highly contested, some countries closing reactors while others construct new and hopefully safer ones. I here bypass wind power and thermal power for the sake of simplicity in calculations.

Consider now Table 1, using the giant solar power station in Morocco as the benchmark – How many would be needed to replace the energy cut in fossil fuels and maintain the same energy amount, for a few selected countries with big CO2 emissions? Table 1 has the data for the African scene with a few key countries, poor or medium income.

Table 1. *Number of Ouarzazate plants necessary in 2030 for COP21's GOAL II: African scene (Note: Average of 300 - 350 days of sunshine per year was used).*

Nation	Co2 reduction pledge / % of 2005 emissions	Number of gigantic solar plants needed (Ouarzazate)	Gigantic plants needed for 40 % reduction
Algeria	7 - 22	8	50
Egypt	none[ii]	0	80
Senegal	5 - 21	0,3	3
Ivory Coast	28-36[iv]	2	3
Ghana	15 – 45[iv]	1	3
Angola	35 – 50[iv]	6	7
Kenya	30[iv]	3	4
Botswana	17[iv]	1	2
Zambia	25 – 47[iv]	0,7	1
South Africa	none[ii]	0	190

Since Africa is poor, it does not use much energy like fossil fuels, except Maghreb as well as Egypt plus much polluting South Africa, which countries must make the energy transition as quickly as possible. The rest of Africa uses either wood coal, leading to deforestation, or water power. They can increase solar power without problems when helped financially.

Let us show the relevance of the promised Super Fund of the UNFCCC to African nations. They need energy transformation according to COP21, but it cannot be done without the Super Fund.

5. African energy diversity

It cannot be more strongly underlined that energy patterns of consumption vary enormously on the African continent, which have clear policy implications. What has not been recognized is the several countries rely upon old renewables, which pollute. Below I make a short overview of the energy-emission situation in a few major African countries, drawing upon official statistics and refraining from speaking about all the hopes and plan, yet to be fulfilled.

5.1. Coal Dependency: RSA

The RSA has a modern economy running on mainly coal. In transportation, it uses petroleum. This makes the RSA a major polluting nation. It wants to spread electricity to all shanti-towns, but with what energy source? Figure 6 substantiates the basic point that economic development needs lots of energy all the time.

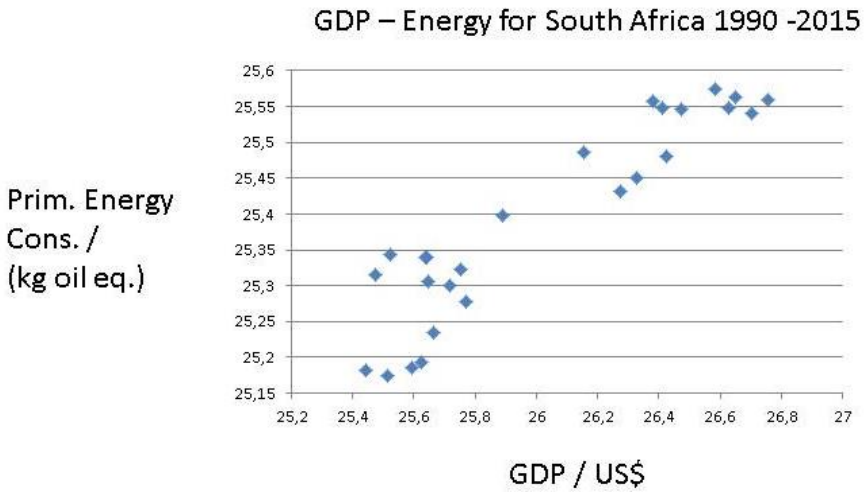

Figure 6. *GDP and energy in RSA : y = 0,2814x; R^2 = 0,8597*

As the RSA wishes to promote socio-economic development in the coming decades, it must increase the access to energy. High rates of economic growth are necessary for poverty reduction, which requires more energy. But energy consumption patterns in urban and rural sited in RSA are based on fossil fuels – see Figure 7.

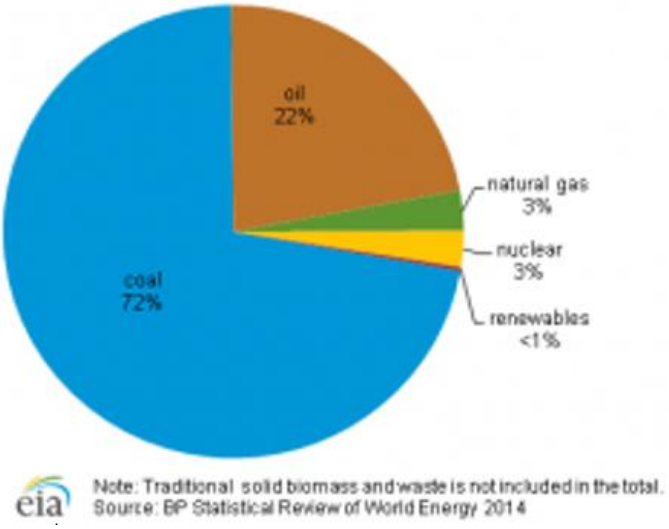

Figure 7. *Energy consumption in RSA*

The question is whether the present government with its weak economy has the determination to turn to renewables or nuclear quickly. Figure 8 displays the standard picture of more economic output – more CO2:s.

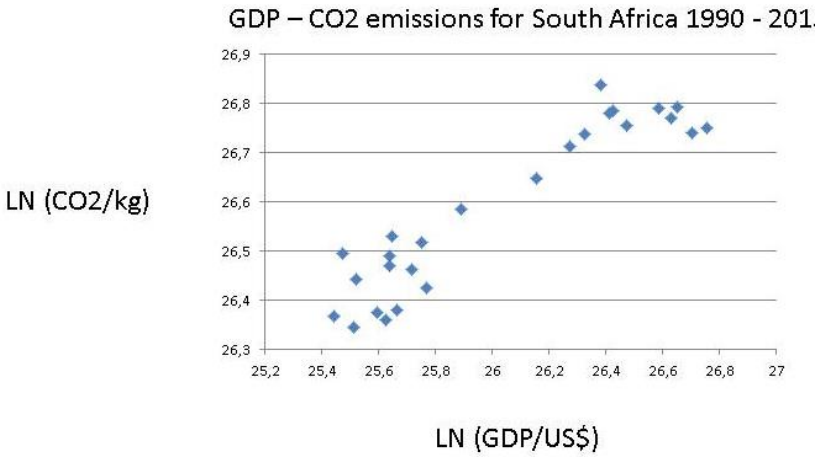

Figure 8. *GDP and emissions 1990-2015: y = 0,3492x; R^2 = 0,8729*

The RSA may not have the policy know how or preferences and motivation to cut the coal consumption fast as well as radically and move to solar energy, for instance? Or would the RSA renege on COP21 – the always available option in collective action endeavours?! South Africa needs the Super Fund and a major change in government policy priorities.

5.2. Oil dependency: Algeria

Some African countries produce lots of oil and consume some of it themselves. One country almost only relies upon oil and gas.

Algeria is a major exporter of natural gas and oil, Thus, we expect that it relies exclusively on fossil fuels, like Mexico, Iran and the Gulf States. Figure 9 verifies this expectation.

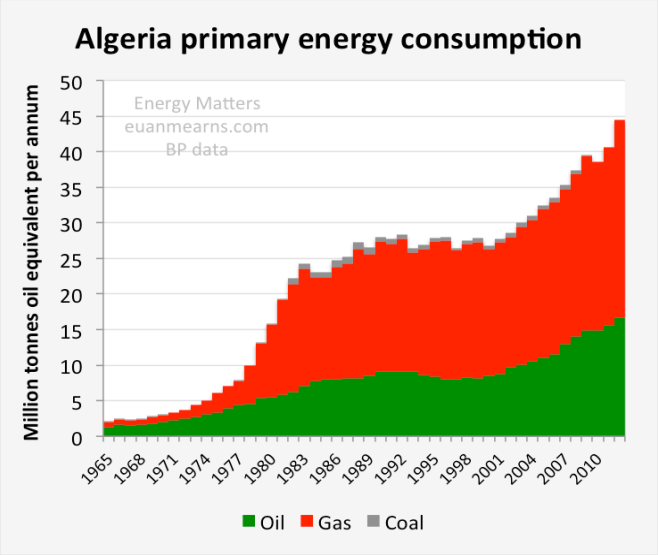

Figure 9. Energy mix in Algeria
Source: [Retrieved from].

Although Algeria may have great trust in the availability of future fossil fuels resources in the country, it still faces the demand for a 30-40% reduction of its CO_2 emissions from the COP21. Emissions have thus far followed the economic progress very closely– see Figure 10.

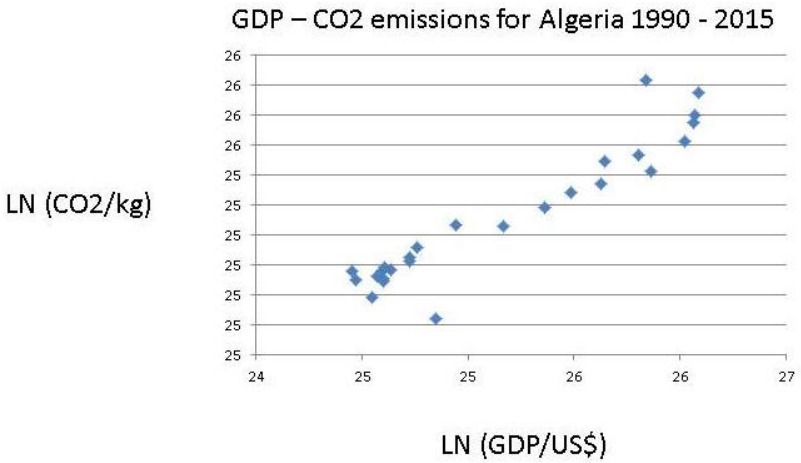

Figure 10. *GDP-CO_2 in Algeria: $y = 0{,}81x$; $R^2 = 0{,}93$*

The truth is that Algeria pollutes heavily. It is of course the need for energy that drives the augmentation in CO_2:s. Figure 11 documents the GDP-energy link.

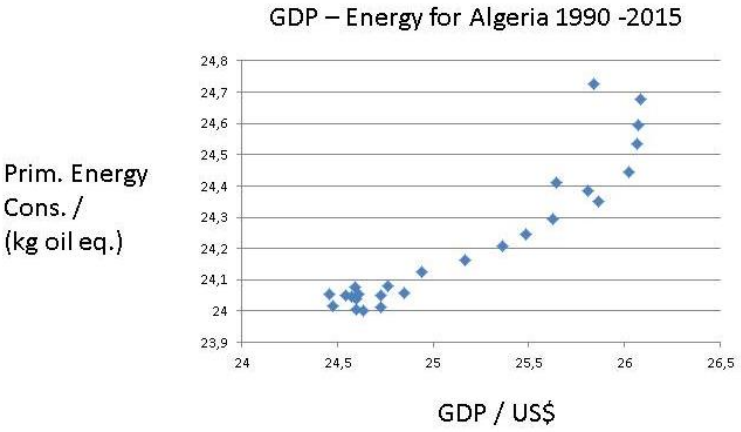

Figure 11. GDP and energy: y = 0,3481x; R^2 = 0,8702

One would naturally suggest solar energy as a viable alternative to the heavy dependence upon fossil fuels in Algeria, given its immense Saharan territory. Yet, Algeria has been plagued by the attacks of terrorists or looters. But solar energy from Sahara would be very interesting for the EU.

5.3 Gas dependency: Egypt

Egypt has a huge population with high unemployment and mass poverty, besides a high level of political instability, resulting from religious conflicts. But surely it has electricity from its giant Assuam dam and the Nile? No, hydro does not count for much for Egypt, where most people live in the Nile delta. CO2:s are on a sharp upward trend for Egypt, because it relies mainly upon fossil fuels, like gas and petrol.

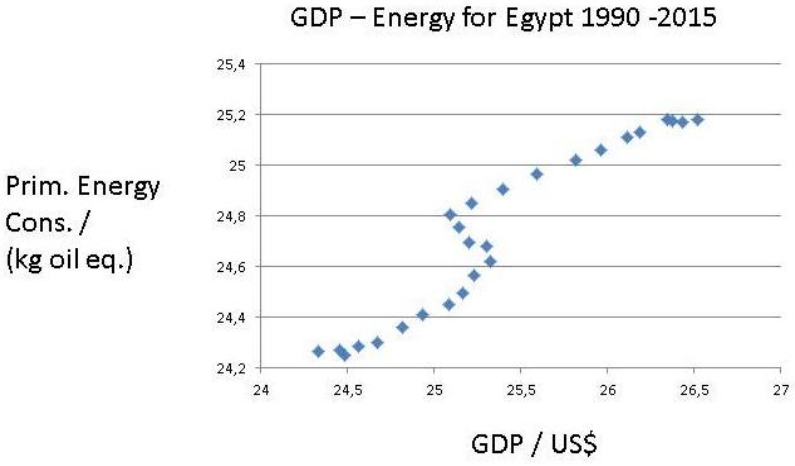

Figure 12. Energy and GDP in Egypt: y = 0,4881x; R^2 = 0,9069

Egypt relies upon huge gas assets in the south, exporting a lot. But its petroleum resources are dwindling. Egypt will have 100 million people, crammed in the Nile delta. It needs much more energy to uplift its population. CO2:s follow economic develoment in Egypt, as elsewhere – see Figure 13.

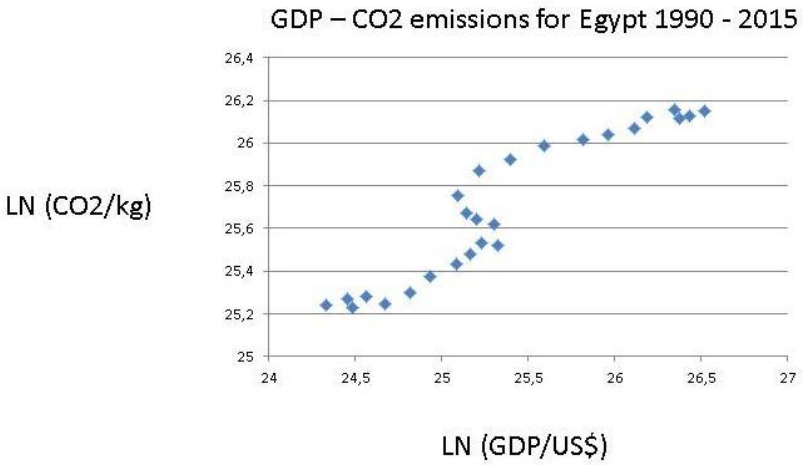

Figure 13. *GDP-CO2 for Egypt: y = 1,02x; R^2 = 0,99*

It will be very difficult for Egypt to make the COP21 transformation, at least without massive external support. But where to build huge solar power plants in a country with terrorism, threat or actual? The share of hydro power is stunning low for a country with one of the largest rivers in the world. Actually, the water of the Nile is the source of interstate confrontation between Egypt, Sudan and Ethiopia, because the latter two have started to exploit it recently on a large scale.

As Egypt relies almost completely upon fossil fuels, it has massive CO_2 emissions (Figure 14).

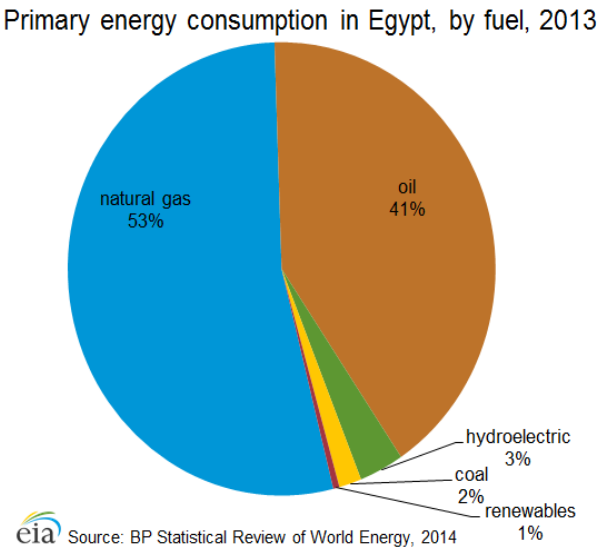

Figure 14. *Egypt's energy mix*

Egypt has made progress with wind energy, but its economy is too weak for the COP21 transformation, as the country is dependent upon US support yearly.

5.4. Dependency on oil and biomass

An enormous reliance upon traditional renewables is to be found also in Africa, like in e.g. Angola and Nigeria, although both have access to massive fossil fuels: oil and gas. Figure 15 describes the energy mix for Angola.

Angola

This country has quite substantial CO_2 emissions that follow economic development, as usual – see Figure 15.

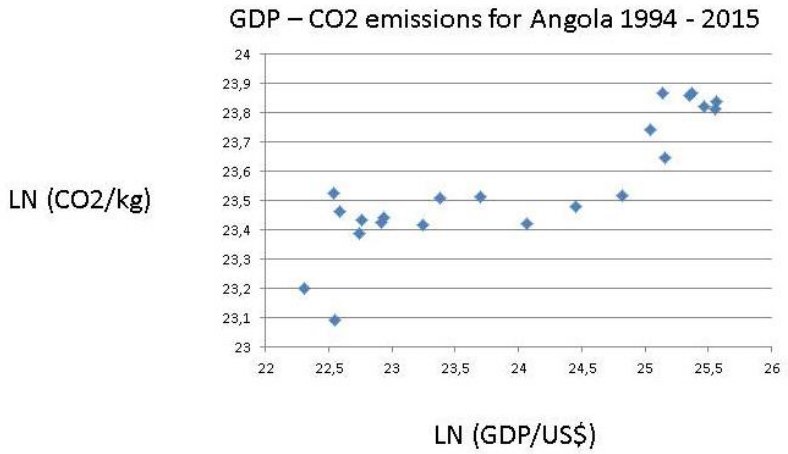

Figure 15. *GDP and CO2:s for Angola: y = 0,1576x; R^2 = 0,7532*

One would be inclined to surmise that the explanation of the upward curve in Figure 15 is the consumption of oil. Angola has become a major petrol exporter, to the benefit of the ruling family. However, the country also employs wood coal in large quantities that are very polluting (Figure 16).

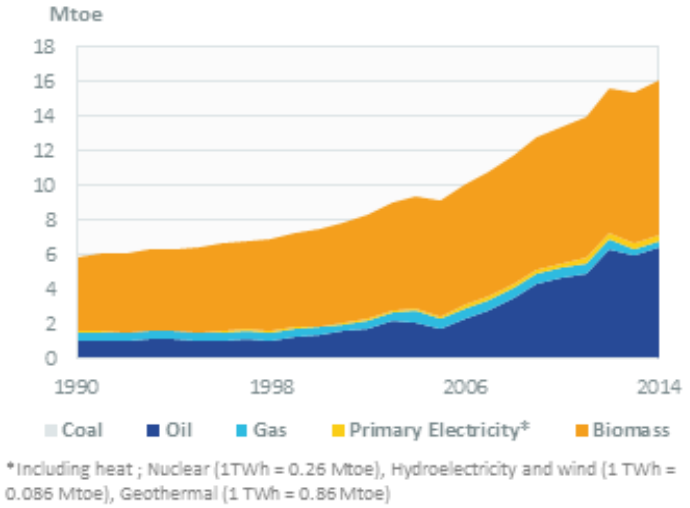

Figure 16. *Angola's energy mix*

Angola has suffered from long and terrible civil war. In the many poor villages, energy comes from wood, charcoal and dung – all with negative environmental consequences. Angola has immense fossil fuels – oil and gas, but the political elite family with a Marxist background prefers to export much of these resources instead of using them for internal electricity generation.

Nigeria

Surprisingly, Nigeria relies much upon traditional renewables, reflecting the poverty of the country. Yet, also wood coal emits CO_2:s. This, Nigeria pollutes much totally, although not per capita. Figure 17 shows a somewhat erratic trend that is upward

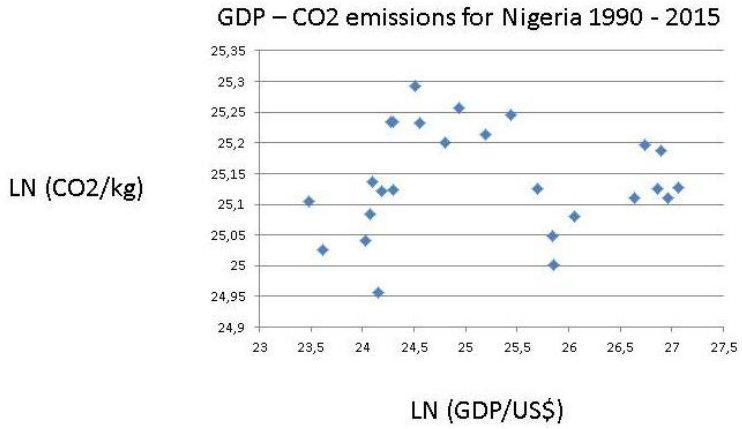

Figure 17. Nigeria: GDP-CO_2 link: y = 0,0032x; R^2 = 0,0018

Giant Nigeria has a resembling energy mix as Angola, with lots of biomass – see Figure 18.

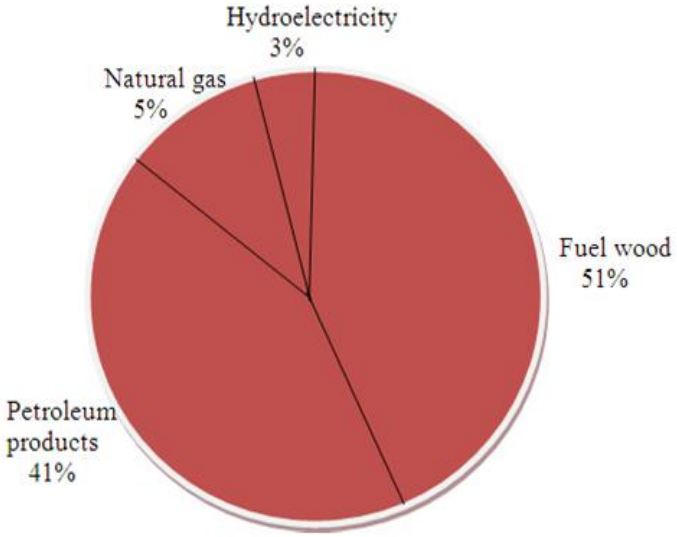

Figure 18. *Nigeria's energy consumption*

As a matter of fact, wood coal is as polluting as stone coal, and worse than oil and gas. Nigeria is a country with deep environmental problems and definitely in need of foreign assistance. Besides the oil spills, the risks of global warming are tremendous, with droughts, etc.

Gabon

Another very telling example is Gabon, where Chinese exploitation cuts down the precious forest, funding the buying streak of the ruling clan, including property in France (Figure 19).

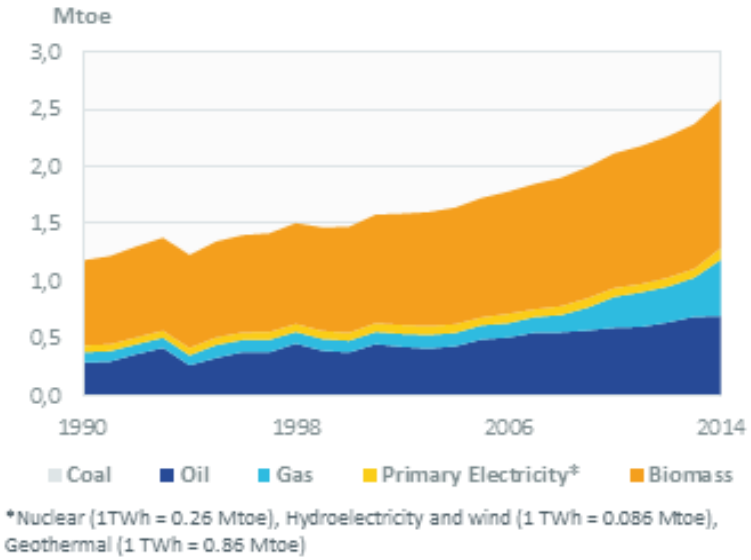

Figure 19. Energy consumption in Gabon
Source: [Retrieved from]. update 2015.

Despite its big oil and gas resources, much of the poor population relies upon biomass, i.e. wood coal with its consequences for deforestation and desertification.

5.5. Oil and coal dependency

Morocco

Despite the enormous success of its huge solar panel plant at *Quarzazate* Morocco remains much dependent upon imports of fossil fuels - see Figure 20.

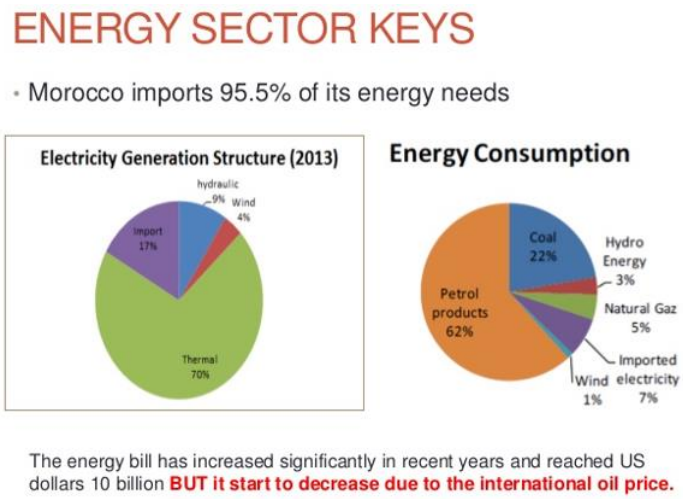

Figure 20. *Energy mix in Morocco*
Source: [Retrieved from].

In order to reduce fossil fuel dependency in the century, Morocco with a rapidly growing population will need more similar plants, which presupposes that assistance will be forthcoming from the COP21 project. Actually, the CO_2:s are substantial in this nation. Its solar plant is a model for the entire Sahara, but this huge desert area needs political stability, lacking in several Saharan countries.

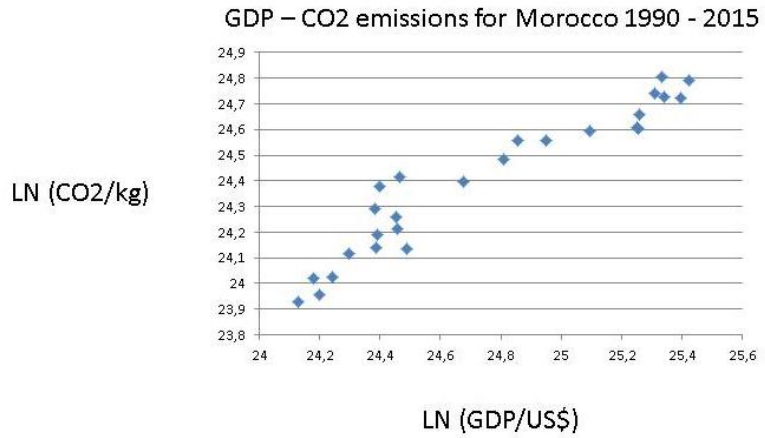

Figure 21. *GDP and emissions in Morocco: y = 0,5846x; R^2 = 0,9124*

Botswana

African countries have sometimes both a traditional and a modern economy. Take the case of Botswana, a democracy with a market economy and traditional chiefs! It has considerable CO2:s despite a rather small population – see Figure 22.

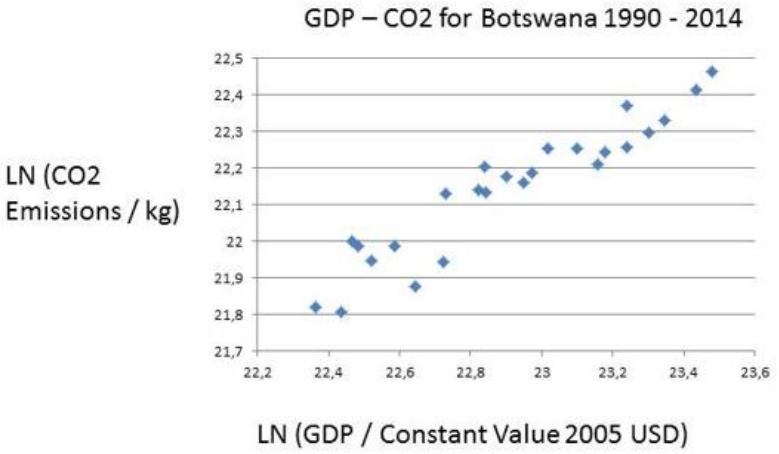

Figure 22. Botswana: GDP-CO2: y = 0,51x; R^2 = 0,89

Yet, Botswana relies mainly upon fossil fuels, oil and coal, to deliver its economic output from mining and minerals (Figure 23).

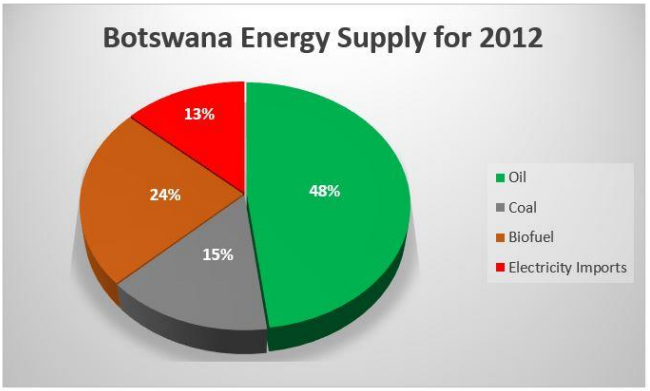

Figure 23. *Energy consumption in Botswana*

Complying with the CO_2 objectives, Botswana can use solar power to diminish the scope of fossil fuels or that of traditional renewables. Botswana has peace, which is extremely important for energy policy-making.

6. Wood coal and hydro

In the climate change discussions and policy-making, it is often stated that renewables should be preferred over non-renewables. Yet, this statement must be strictly modified, as there are two fundamentally different renewables:

- Traditional renewables: wood, charcoal and dung. They are not carbon neutral. On the contrary, employing these renewables results in severe pollution, not only outside but also inside household;
- New renewables: solar, wind, geo-thermal and wave energy that are indeed carbon neutral, at least at the stage of functioning.

In the poor African countries with about half the population in agriculture and small villages, traditional renewables constitute the major source of energy.

6.1. Kongo Kinshasa

One understands the hefty use of wood coal in this giant country, so plagued by political instability, anarchy, anomie and civil wars with foreign involvement (Figure 4).

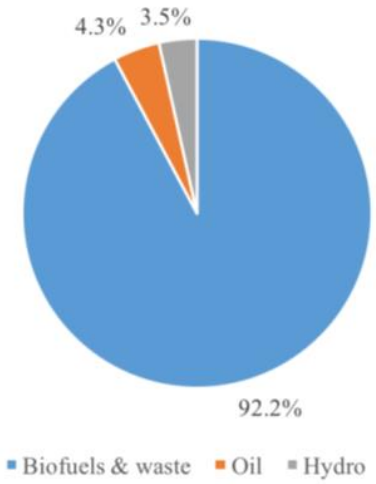

Figure 24. Dr Kongo's energy mix
Source: Democratic Republic of Congo - Energy Outlook, Kungliga Tekniska Hoegskolan

One notes how little of hydro power has been turned into electricity in Kongo, but economic development and political instability, civil war and anarchy do not go together normally. At the same, one may argue that an extensive build-up of hydro power stations would pose a severe challenge to the fragile environment in the centre of Africa. Kongo can now move directly to modern renewables like solar power.

Sudan

The energy consumption of Sudan reflects this situation – Figure 15. The countries relying upon traditional renewables to an extent up to 50 per cent or higher will have to reflect upon how to bring these figures down sharply

with modern renewables. It is an entirely different task than that of countries with too much fossil fuel dependency. Hydro power has increased in Sudan, which is a positive. But the water of the Nile can last only so long for three energy power hungry nations.

Sudan is dismally poor with deep-seated internal conflicts ethnically. How to move to large solar panel plats in a country with so much political instability resulting huge numbers of death from domestic violence? Figure 25 shows the energy mix before the split up of this huge country.

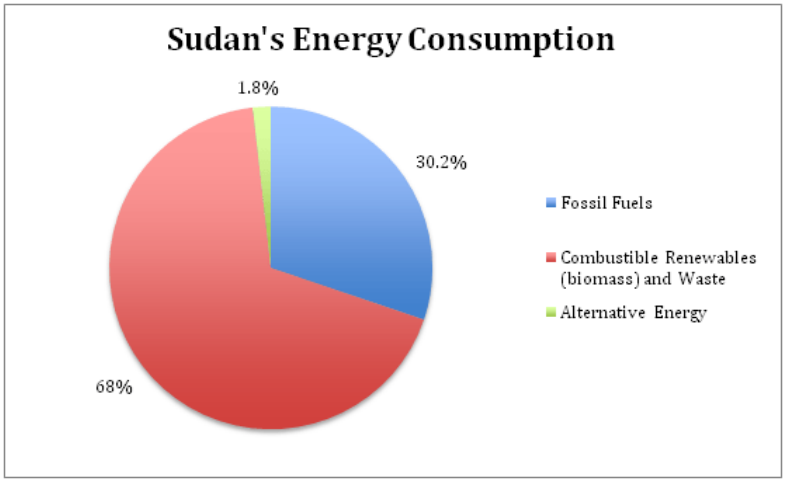

Figure 25. *Sudan's energy mix*
Source: [Retrieved from].

Ethiopia

The reliance upon traditional renewables is so high in neighbouring Ethiopia that electrification must be very difficult to accomplish over the large land area. Figure 26 displays a unique predicament, although a few hydro power stations have increased hydro power substantially since 2008.

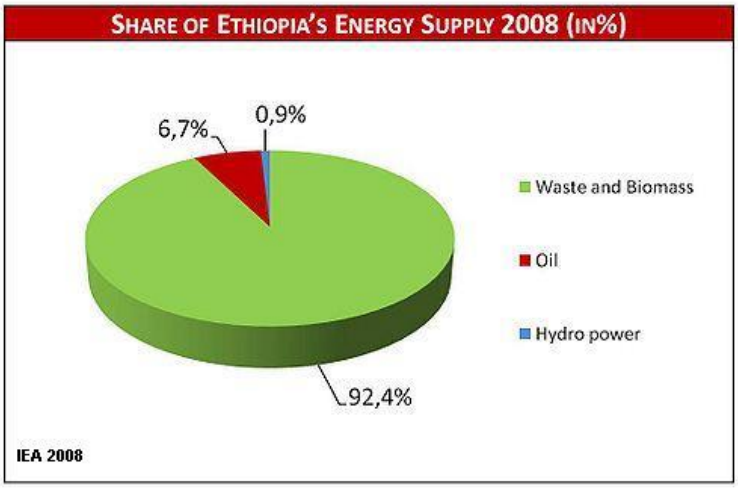

Figure 26. *Ethiopia's energy mix*

Are there any advantages with such a skewed energy mix? No, because even mainly rural Ethiopia delivers with lots of CO2: - see Figure 27.

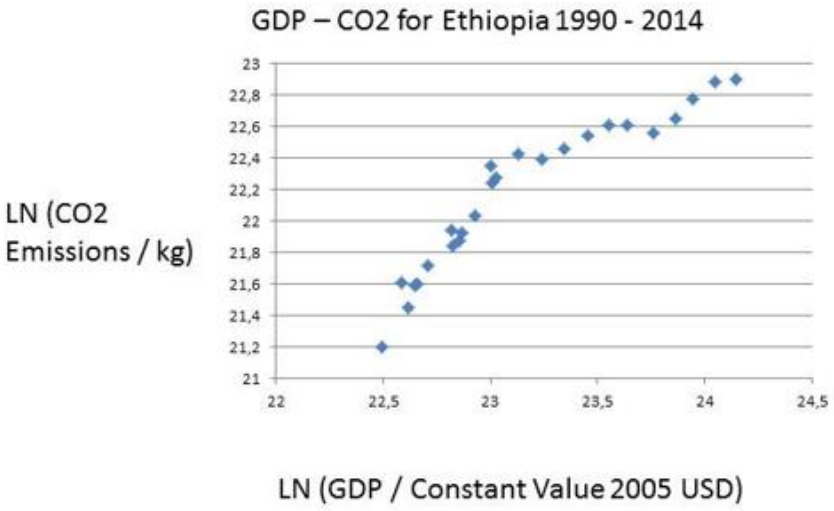

Figure 27. *Ethiopia: GDP and CO2: y = 0,90x; R^2 = 0,88*

The zest with which Ethiopia is pursuing its control over water resources becomes fully understandable, when Figure 26 is consulted. What we see is the same smooth linear function plotting CO2:s upon GDP, as is obvious in countries based upon fossil fuels – see below. For Ethiopia, to comply with COP21 goals is going to pose major challenges, especially if economic development is not going to be reduced. The country needs massive help, both financially and technologically.

The Grand Ethiopian Renaissance Dam in Ethiopia and the Merowe Dam in Sudan bring electricity to Africa. Hydro power could be much more exploited in several African countries, but time is running out. Global warming reduces rivers and enhances draughts. Solar power is the future for all nations, whatever pattern of energy consumption they now have.

Ghana

One of the promising nations in Africa is Ghana, housing both democracy and positive economic development. Figure 28 shows its GDP-CO2 picture for the last two decades, when things have gone well and peacefully.

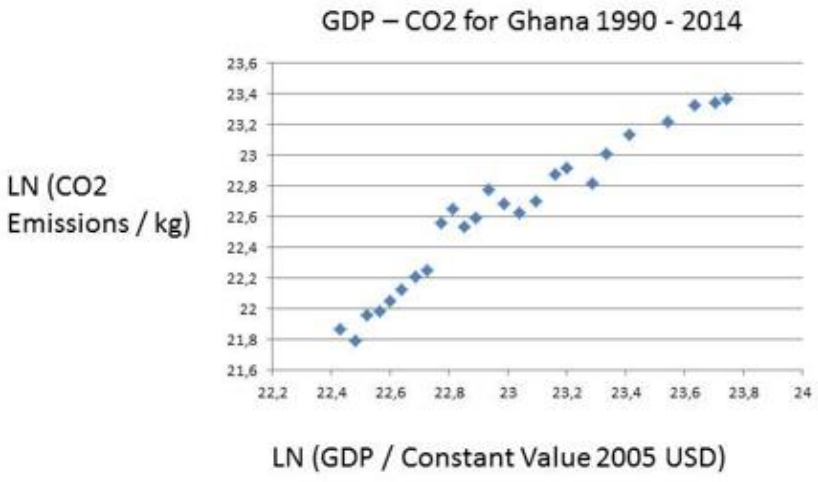

Figure 28. Ghana: GDP-CO2: y = 1,17x; R^2 = 0,94

There is a very strong connection between GDP and CO_2 emissions in Ghana. One would like to examine its energy mix in order to understand this. Figure 29 presents the energy consumption pattern in Ghana.

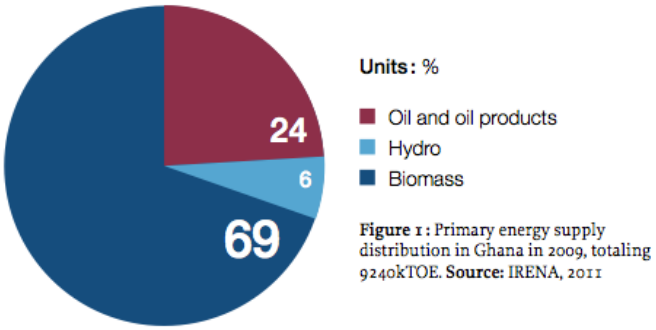

Figure 29. *Ghana's energy mix*
Source: [Retrieved from].

The dominance for fossil fuels and wood coal is enormous in Ghana, but they have hydro energy, which is very positive. Many African could have done much more with hydro power, if they had had access to capital. Now they must turn to new renewables: solar, wind and geo-thermal power. The same observation applies to East Africa.

7. East Africa

The East African region of African continent has become more economically dynamic recently with successful regional integration. Yet, the reliance upon biomass is as Figure 30 shows typical of rural East African countries. As some 50 per cent of the inhabitants live in rural villages, this use of wood coal puts an enormous pressure on the forests.

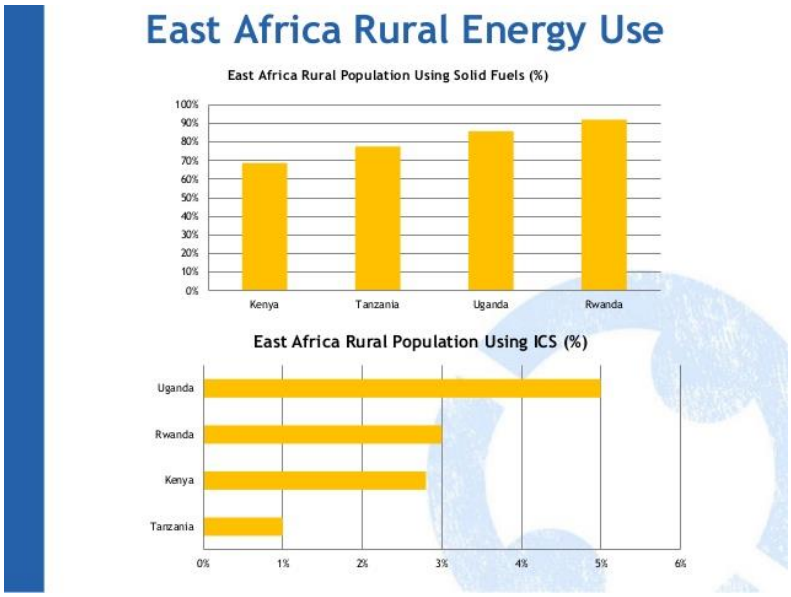

Figure 30. *Energy mix in rural East Africa*

People in the urban areas have an entirely different energy consumption pattern. Positively, hydro power is important in these countries – see Figure

31. Here we are talking about electricity consumption and not overall energy mix.

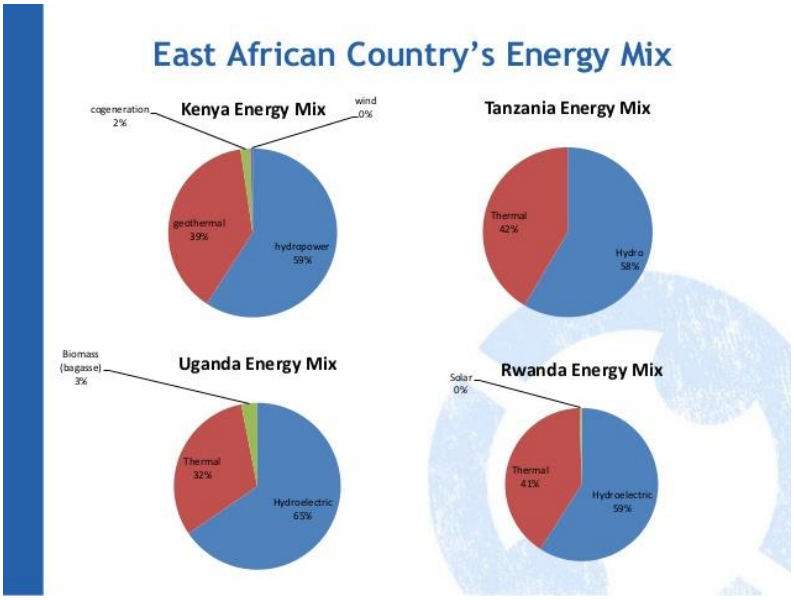

Figure 31. *Hydro power in East Africa*

What these countries need to is to replace the wood coal with electricity from hydro and geo-thermal resources.

The status of biomass or wood coal from the point of view of GHG:s is contested. On the one hand, it is clear that wood coal in its various forms is not carbon neutral when consumed, but on the other hand it is claimed that wood products have already consumed lots of carbon when growing. Whatever, the balance may be, the forests are being cut down, contributing to deforestations and desertification.

In Figure 32, we see that CO2:s follow GDP in Kenya, a strongly developing country in East Africa, relying upon the market (Hayek, 1991). Thus, also Kenya will face difficulties complying with the COP21 goals: Goal I, Goal II and Goal III – see above.

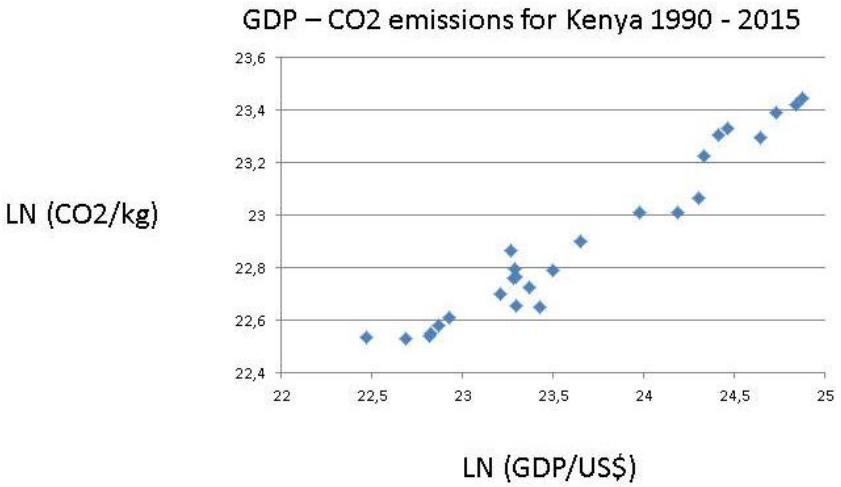

Figure 32. *GDP - emissions for Kenya: y = 0,4154x; R^2 = 0,9501*

The GDP-CO_2 curve for Kenya is the sme as for most African countries, meaning upward sloping. Africa needs energy as well as basic energy transformation – an enormous challenge.

Zambia, Mozambique and Senegal, Cameroon

The same picture of an energy mix dominated by wood cool is to be found for several other African nations. Biomass counts for 50 per cent of more of total energy consumption, complemented by not more than 10 per cent hydro power while the remaining comes from fossil fuels. This puts too much pressure on African forests. And there will be massive CO_2 emissions, because these wood resources are never replaced.

The road ahead is not more fossil fuels, but modern renewables like solar, wind and geo-thermal power replacing wood coal and its derivatives. We quote from the U*N Convention to Combat Desertification*:

Two-thirds of the African continent is desert or dry lands. This land is vital for agriculture and food production, however nearly three-fourths of it is estimated to be degraded to varying degrees. The region is affected by frequent and severe droughts, which have been particularly severe in recent years in the Horn of Africa and the Sahel. Poverty and difficult socio-economic conditions are widespread, and as a result many people are dependent on natural resources for their livelihoods. For many African countries, fighting land degradation and desertification and mitigating the effects of drought are prerequisites for economic growth and social progress. Increasing sustainable land management and building resilience to drought in Africa can have profound positive impacts that reach from the local to the global level. Source: [Retrieved from]. Before desertification often comes deforestation. It is often stated that land hunger drives deforestation. But equally relevant is the search for energy. We quote from a study:

Forests in Zambia are important in supporting life especially in low-income communities both in urban and rural areas. A variety of wood and non-wood forest products are utilised by industries, rural households and urban households in various parts of the country. However, today the forests in the country have been made vulnerable to both man and natural induced disasters. The rate at which forest cover is being lost has increasingly become high such that if this trend is left unchecked time may trigger the complete loss of biodiversity embodied in the Zambian forests. Perhaps the highest loss of forest cover was from 1990 to 2000 with a significant decline of 851,000 ha forest loss per year (FAO 2001). Deforestation as a result of land use change towards agriculture, illegal settlements and Current unsustainable levels of utilisation to mention but a few have contributed to the loss of forest cover in Zambia and the Southern Africa as a whole. The critical question seeking urgent redress is why forests in Zambia are being destroyed more and more. [Retrieved from].

8. Conclusion

African nations may rightfully claim a fair share of the energy consumption in the word, meaning in proportion to its share of global people. The catch-22 problematic is that African governments have signed the decarbonisation Treaty of the UN and must now proceed to implement it, but how to increase energy while decreasing CO_2 emissions? Answer: Use renewables like solar, wind and geo-thermal power! Nuclear power is probably too expensive and

difficult to master. Morocco has set up the largest solar power plant in the world, serving some 2 million inhabitants with electricity. Several hundred millions of Africans are without safe and secure electricity, holding back socio-economic development. But such gigantic investments are only feasible with massive support from the promised Super Fund in the COP21 project.

In my view, the COP21 may be at risk due to a likely American defection. Thus, the only practical solution to the dire global warming is that G20 takes on the problem and cuts down their emissions without all the philosophical debates about elimination of poverty, promoting green sustainability and the other SDGs (*sustainable development goals*). As the G20 is responsible for much of CO2s, they can fix the problem in a transaction cost efficient manner, asking all other counties to cut at least somewhat now and more later.

Poverty on the African continent reflects the energy situation. As African nations increase energy, they must at the same time reduce CO2:s. The COP project is a great opportunity for African peoples, but the promise of support must be forthcoming. If the US reneges, then Africa will suffer. Defection is not the solution to the threats of global warming.

Appendix

An effort to model the greenhouse gases, especially CO2:s, in terms of a so-called identity is the deterministic Kaya equation. The Kaya identity describes environmental (I)mpact against the (P)opulation, (A)ffluence and (T)echnology. Technology covers energy use per unit of GDP as well as carbon emissions per unit of energy consumed (Kaya and *Yokoburi*, 1997). *Kaya's identity* links carbon emissions on changes in population, economic activity as GDP per, energy intensity and carbon intensity of energy. I make an empirical estimation of this probabilistic Kaya model - a cross-sectional test for 2014:

(E2) k1= 0,68, k2=0,85, k3=0,95, k4=0,25; R2 = 0.885.

Note: LN CO2 = k1*LN (GDP/Capita) +k2*(dummy for Energy Intensity) + k3*(LN Population) + k4*(dummy for Fossil Fuels/all) Dummy for fossils 1 if more than 80 % fossil fuels; k4 not significantly proven to be non-zero, all others are. (N = 59)

The Kaya model findings show that total GHG:s go with larger total GDP. To make the dilemma of energy versus emissions even worse, we show above that GDP increase with the augmentation of energy per capita. Decarbonisation is the instrument believed to undo these dismal links by making GDP and energy consumption rely upon carbon neutral energy resources, like modern renewables and atomic energy.

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OECD National Accounts data files

GHG and energy sources:

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EU Joint Research Centre Emission Database for Global Atmospheric Research - http://edgar.jrc.ec.europa.eu/overview.php

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