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Summary
Reaching the objective of universal access to modern energy services will require large investments in infrastructure in developing countries. An important part of funding will be provided in the form of development finance and its effectiveness in producing positive impacts is crucial for this achievement. This paper presents a panel analysis of the relationship between the installed capacity of electricity generation, the development finance committed for the energy sector, and the gross fixed capital formation. We tested four models with a large dataset and found development finance to have, in most cases, a positive influence on installed base.

Keywords: International Aid, Energy Access, Aid Effectiveness

JEL Classification: O19, O21, Q40

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An econometric analysis of the effectiveness of development finance for the energy sector

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Abstract: Reaching the objective of universal access to modern energy services will require large investments in infrastructure in developing countries. An important part of funding will be provided in the form of development finance and its effectiveness in producing positive impacts is crucial for this achievement. This paper presents a panel analysis of the relationship between the installed capacity of electricity generation, the development finance committed for the energy sector, and the gross fixed capital formation. We tested four models with a large dataset and found development finance to have, in most cases, a positive influence on installed base.

Keywords: International aid; Energy access; Aid effectiveness

1. Introduction

The objective of this analysis is to understand if Official Development Finance (ODF) for the energy sector is effective in augmenting the installed electricity generation capacity of recipient countries. This study is a follow-up of previous research that focused on the allocation of aid and development finance for the energy sector, and it shares the same underlying dataset (Gualberti, Bazilian, Haites, & Carvalho, 2012).

The 2012 UN Conference on Sustainable Development (Rio +20) recognised that access to modern energy services is critical to achieve sustainable development, and committed to facilitate support for access to these services (UN, 2012). Reaching the associated goal of Universal Energy Access (UEA) will imply that many investments will be needed to expand the level of installed power generation capacity of developing countries, to refurbish old facilities, to expand the transmission and distribution infrastructure, and to increase the number of decentralised energy systems (IEA, 2011a) (UN-AGECC, 2010).

An important share of the needed financing for lower income countries will be provided as development finance. The IEA calculates that bilateral and multilateral donors would be required to finance around 18 USD billion each year on average until 2030, representing the 37.5% of the total financing needed, the rest being equally split between government funding and private investments (IEA, 2011a). Therefore, the effectiveness of that development finance in leveraging other funding sources in order to produce positive impacts is of crucial importance.

The aid effectiveness literature is vast, although the examples of analysis of effectiveness per sector are much more limited. The effectiveness of development finance for the energy sector has not yet been explored in literature to our knowledge, and thus we took inspiration from examples of aid effectiveness analysis of other sectors, in particular health and education.

We perform a panel data analysis using a large dataset of 160 countries (further subdivided in four country groupings) for 30 years. Our models explore the relation between the amount of installed base for electricity production, as a result of the general level of investments and of the amount of development finance for the energy sector provided by bilateral and multilateral donors. The main outcome of our analysis is that – in the great majority of the cases analysed – development finance for energy is positively correlated with the installed base of electricity generation.

This paper is divided into five sections: following this introduction, section two presents a brief analysis of the literature of aid effectiveness and the main policy developments of international assistance for the energy sector; in section three we describe our data, model and econometric techniques; in section four we present the results of our exercise; and in section five we draw conclusions.

2. Aid policies for the Energy Sector and Aid Effectiveness

2.1 Energy Aid Policies

Energy Poverty has become a priority in the international development agenda since turn of the century. Excluded from the Millennium Development Goals, the centrality of energy for sustainable development and poverty reduction has been explicitly reaffirmed in all recent international development conferences and donors' policy guidelines and commitments.

The ninth session of the United Nations Conference on Sustainable Development (UNCSD-9) was the first time the UN discussed energy as a separate agenda and, among other things, also assessed the international cooperation initiatives active for the energy sector (UNCSD - 9, 2001). UNCSD-9 served as a basis for the subsequent World Summit on Sustainable Development of Johannesburg in 2002, that formulated an incitement to enhance international and regional cooperation to improve access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services, as an integral part of poverty reduction programmes (UN-WSSD, 2002). The implementation plan of Johannesburg JPOI did not contain quantitative targets for financing energy access or any institutionalised mechanism to monitor progresses, due to lack of consensus between countries and regional blocks. However a certain number of commitments and partnerships were signed at the summit, with total pledges of slightly less than 800 USD millions, of which 700 from the EU (Spalding-Fecher, Winkler, & Mwakasonda, 2005).

Few years after the WSSD the international community addressed once again the energy theme in the 14th and 15th session of the UNCSD but was not able to reach consensus, due to disagreements on the role of energy sources, on the institutionalisation of energy in the UN and on the mechanism to revise the progresses in this area (Karlsson-Vinkhuyzen, 2010). The inability to reach a global agreement between member states did not stop international initiatives on energy, in particular from the UN-Secretariat, from international institutions outside the UN-System, and from donors.

The UN Secretariat has been very active in promoting the energy agenda, with the inception in 2004 of the UN-Energy, an inter-agency devoted to coordinate UN work in the area, and the creation of the advisory group on energy and climate change in 2009 (UN-AGECC) (UN-Energy, 2010). The UN-AGECC in 2010 estimated that to reach universal access to modern energy services by 2030, at the basic needs level, there would be necessary around 10-15 USD Billions per year in grants, plus loan capital for 20-25 USD billions, while the IEA puts the level of ODA needed to 18 USD billions (UN-AGECC, 2010) (IEA, 2011a). Other estimates of the global financing and ODA needed have been formulated by development institutions and independent researchers (World Bank, 2006) (Van Ruijven, Schers, & Van Vuuren, 2012) (Bazilian, Nussbaumer, Haites, & Levi, 2010) (UN-Energy/Africa, 2007, pag. 85) (EAC, 2006) (ECOWAS, 2006) (SNC Lavalin International Inc & Parsons Brinckerhoff, 2011) (Bazilian, Nussbaumer, et al., 2012) (Eberhard, Rosnes, Shkaratan, & Vennemo, 2010) (Rosnes & Vennemo, 2009) (World Bank, 2010).

In 2012 two events further supported the energy agenda and development finance commitments to the sector: the establishment of 2012 as the International Year of Sustainable Energy for All (SE4All), and the Rio +20 summit. The SE4All plan, whose objectives are universal access, improved energy efficiency and higher share of renewable energies by 2030, was largely endorsed by developing countries, donors, international institutions and businesses: in particular development banks committed more than 30 USD billions in new resources, of which 20 from the African Development Bank AfDB; the World Bank committed to double the leverage of its energy portfolio to 16 USD billions a year; large bilateral donors (US, EU and Norway) also committed new development finance resources for the energy sector (Sustainable Energy for All, 2012). The Rio +20 summit supported the SE4All agenda although, exactly as its predecessors, did not approve any multilateral agreement, timetable, target, financing or monitoring mechanism for the energy sector (Halle, 2012) (Bazilian, Miller, & Kammen, 2012) (UN, 2012).

2.2 Aid effectiveness

The effectiveness of aid is a highly disputed topic both in the academic literature and in the broader public debate. It is also a high political priority for developing countries and bilateral and multilateral donors that agreed with the Paris Declaration (2005), the Accra Agenda for Action (2008), and the Busan Declaration to implement a detailed multi-year program toward its improvement (OECD, 2008) (OECD, 2011) (4th High Level Forum on Aid Effectiveness, 2011).

The research on the effectiveness of aid has primarily followed three approaches: econometric approaches that focus on investigating the relation between aid flows and economic outcomes ((Selaya & Sunesen, 2012), qualitative studies that explore inside the “black box” of the institutional and policy processes between aid delivery and desired outcomes ((Arndt, Jones, & Tarp, 2011), and studies that analysed the implementation process of the Paris Declaration and aid quality issues (Owa, 2011)(Knack, Rogers, & Eubank, 2011).

A large part of previous econometric analysis on aid effectiveness attempts to understand if aid has an effect on economic growth under various conditions.[1] Typically the aid-growth debate took into account aggregate flows of aid without making distinction by purpose or sector (Mavrotas & Nunnenkamp, 2007). Some examples of sectorial analysis of aid exist; in particular some scholars compared the allocation of aid per sector against the Millennium Development Goals (MDG) indicators (Thiele Nunnenkamp and Dreher 2007) (Hailu and Tsukada 2012) (Baulch 2006). Some empirical studies on the effectiveness of aid per sector also exist, in particular for health and education. These studies often took advantage of the availability of sector specific data collected in the framework of the MDGs (UN 2008).

Sectorial aid effectiveness has been evaluated with various techniques: heuristically, a sector indicator (such as an MDG indicator) is set as the dependent variable, while a measure of aid and of the national spending for the sector are set as explanatory variables; in some cases additional variables are tested covering other institutional, social, or economic factors. Models are generally tested with various specifications and econometric techniques, and specific sectorial analysis tools have been proposed (Elbers Gunning and de Hoop 2009).

For example, in the health sector, Wilson estimates with various econometric models if mortality indicators (dependent variables) are improved by donor assistance in the health sector, increases in GDP, democracy indicators, or aid in other sectors. He finds significant results only for GDP (Wilson 2011). Williamson specified a fixed effects model with inherent endogeneity to explain five health indicators with a similar set of explanatory variables, and using instrumental variables, estimators

[1] On the aid-growth debate, see Burnside and Dollar (2000, 2004), Easterly Levine and Roodman (2004), Easterly (2003), Roodman (2007), Bourguignon and Sundberg (2007), Arndt et al. (2011), Doucouliagos and Paldam (2009), Clemens Radelet Bhavnani and Bazzi (2011), Hansen and Tarp (2000), Lessmann and Markwardt (2012), Hudson and Mosley (2008), Kimura Mori and Sawada (2012), Kodama (2012), and Kosack and Haven (2003).

found GDP only significant for infant mortality, and that aid was generally not significant (Williamson 2008).

Mishra and Newhouse, however, arrive to the opposite conclusion with a dynamic panel model with country fixed effects estimated by generalized method of moments (GMM); they found that income and health aid (and lagged infant mortality) were all significant to explain variation in infant mortality (Mishra and Newhouse 2009). Quisumbing (2003) made a panel analysis to understand, behind other things, the effects of various forms of food-aid with child nutritional status indicators in Ethiopia and found a positive impact. Hayman et al. (2011) make a systematic review of more than 30 studies on the impact of aid on maternal and reproductive health (the majority of which are limited to one or few countries) and found that the studies suggest that aid interventions might be associated (but not necessarily be the cause) with some positive change in the MDG 5 indicators.

Some examples for the education sector: Dreher et al. (2007) use net primary school enrolment as a dependent variable and aid given to the education sector and overall spending on education as explanatory variables in the single equation specification to their model,[2] finding that aid for education was strongly effective in increasing enrolment. Michaelova and Weber (2007) analysed the same research question with a dynamic panel analysis, again estimated by GMM, and found a positive (but small) effect of aid on school enrolment and completion. Finally, Wolf (2007) analyses simultaneously the effects of aid levels and variability for the education, health, water, and sanitation sectors, considering also the effects of the improvements of one sector on the others.

The effectiveness of aid for public infrastructure, including energy, has been analysed mainly with qualitative analysis and case studies: for example, the Japan Bank for International Cooperation analysed the role of aid and international donors in contributing toward institutional development for delivering sustainable infrastructure services; the analysis takes into account 16 case studies, and explores the connections between the modalities of aid delivery, the political will, the long term support and the local ownership and the results (Jerve and Nissake 2008); Garnett et. al (2009) analysed 17 case studies in Africa and Asia to identify lessons learned from the application of the Paris Declaration tenets specifically for the public infrastructure sector, finding progress in the implementation of the ownership and harmonization objectives, less progress with alignment, and very partial implementation of managing for results and mutual accountability tenets.

Despite the importance of the energy sector for developing countries, and for donors, the literature on aid for energy is limited. Tirpak and Adams (2008) analysed bilateral and multilateral ODA for the energy sector, focusing on renewable energy sources and noted that grants are needed in order to reduce the risks associated with the introduction of new technologies and to encourage developing countries to implement the more environmentally friendly options. The OECD produced a short statistical pamphlet presenting the main energy aid data and aggregate historical series for

[2] They also test more multiple equation models accounting for institutional quality and determinants of spending.

multilateral and bilateral donors (OECD 2010). Michaelowa and Michaelowa (2011) have econometrically analysed the political and economic determinants of the shift toward aid for energy efficiency and renewable energies, they argue that the main international environmental events, like the Kyoto protocol in 1997 and its ratification in 2005 did not lead to an increase in development finance for the energy sector, and that the single most robust variable in explaining the change of renewable energy and energy efficiency [aid] over time is the oil price – independently of any change in global or national environmental preferences. Bruggink (2012) analysed the interactions of development and climate aid for the energy sector. He proposes a dualistic approach to foster energy access and climate change adaptation (with ODA) and green growth and climate mitigation (with climate funds). Welle-Strand et al. (2011) analyse if power sector aid boost economic growth and development with a neoclassical Solow model of economic growth and a qualitative analysis of Norwegian aid; they note a high level of correlation between electricity and GDP (but no certainty about their causal relationship) and that, despite Norwegian having a great tradition of assistance to the energy sector of developing countries, there exist few evaluations and monitoring of the results, which makes evaluation of their impact and any potential confirmation of such 'trickle down' effects nearly impossible. Bazilian et al. (2011) have calculated the actual financing flows for the energy sector of developing countries and compared them with estimated requirements for universal energy access, noting that significant funding for energy access will need to be sourced internationally. Gualberti et al. (2012) compared the allocation of development finance for energy with the electrification shares and found that in the latest decade, Development Finance for the energy sector was not directed principally towards the countries with higher share of the population without access, and that this distributional bias should change to attain the objective of universal energy access.

No empirical analysis has been made, to our knowledge, to measure the effectiveness of aid for energy. We make an attempt to fill this gap.

3. Methodology

We present an econometric model to assess the effectiveness of ODF for the energy sector, evaluating its impact on the installed base of electricity generation. Our methodology draws on precedent of analysis developed for the sectors of education and health.

The amount of installed capacity is a reasonable proxy for the level of infrastructure development for the electricity sector and has the advantages of 1) not generally changing dramatically within short-term economic cycle and 2) being available for a large number of countries over time. The Installed base, however, does not describe some equally important characteristics of the electricity sector, such as, *inter alia:* the extension of transmission lines, the share of losses, the reliability of the services, the electrification level, the financial and economic figures of the utilities, and the energy prices. These characteristics do not have widely available indicators, covering many countries and years, and thus couldn't be included in our study.

We have to account for two key methodological issues in our model formulation: the first is that our dependent variable "Installed Base" is not only the result of development finance coming from abroad but also of domestic or foreign investments from public or private entities. To account for the general level of investment in the country we have utilised in our model the Gross Fixed Capital Formation (*GFCF*) indicator for all sectors[3] as a second explanatory variable.

The second issue is that not all development finance for the energy sector has the purpose of augmenting the installed electricity base. To account for that, we have analysed separately the contribution of ODF with the purpose of energy production *ODFp* and ODF for other energy purposes *ODFnp* (table 1).

Table 1. Development Finance for the Energy Sector Used in the Analysis, by Purpose Code and Source

CRS	AidData	Codes	ENERGY GENERATION AND SUPPLY	ODF for electricity production (ODFp)	ODF for other scopes (ODFnp)
	x	23000	Energy generation and supply, combinations of activities		x
	x	23005	Energy generation and supply, purpose unspecified or does not fit under any other		x
x	x	23010	Energy policy and administrative management		x
x	x	23020	Power generation/non-renewable sources	x	
x	x	23030	Power generation/renewable sources	x	
x	x	23040	Electrical transmission/ distribution		x
x	x	23050	Gas distribution	excluded	excluded
	x	23055	Petroleum distribution and storage	excluded	excluded
x		23061	Oil-fired power plants	x	
x		23062	Gas-fired power plants	x	
x		23063	Coal-fired power plants	x	
x		23064	Nuclear power plants	x	
x		23065	Hydro-electric power plants	x	
x		23066	Geothermal energy	x	
x		23067	Solar energy	x	
x		23068	Wind power	x	
x		23069	Ocean power	x	
x		23070	Biomass	x	
x	x	23081	Energy education/training		x
x	x	23082	Energy research		x

[3] We have used GFCF for all sectors instead of GFCF for the Water, Electricity, and Gas distribution sector because of its much wider data availability.

We note that *ODFnp* is a very heterogeneous grouping whose main components are electrical transmission and energy policy, but it may also include activities directly related with electricity production (that could be coded under the headings 23000, 23005 and even 23010).[4] Lastly, we have not used in our model any governance indicators such as the indices of corruption and of regulatory and government effectiveness calculated by the World Bank. Although these factors are clearly important, the time series are not sufficiently long for our analysis.

3.1 Data and Country Selection

For the empirical application, we have constructed a large panel containing information on 160 countries covering the period 1980-2009, making a total of 4800 observations. The variable ODFp includes Official Development Assistance (or Official Aid) and Other Official Flows. The source is AidData.org, research release 2.0[5] (Tierney et al. 2011). Also, *GW* (IEA 2012) and *GFCF* and POP (World Bank 2012) complete the list of variables at the models. The unit measure for population is in millions of individuals and the remaining data is measured in USD 2000 prices (in billions), converted using official DAC deflators provided by AidData.

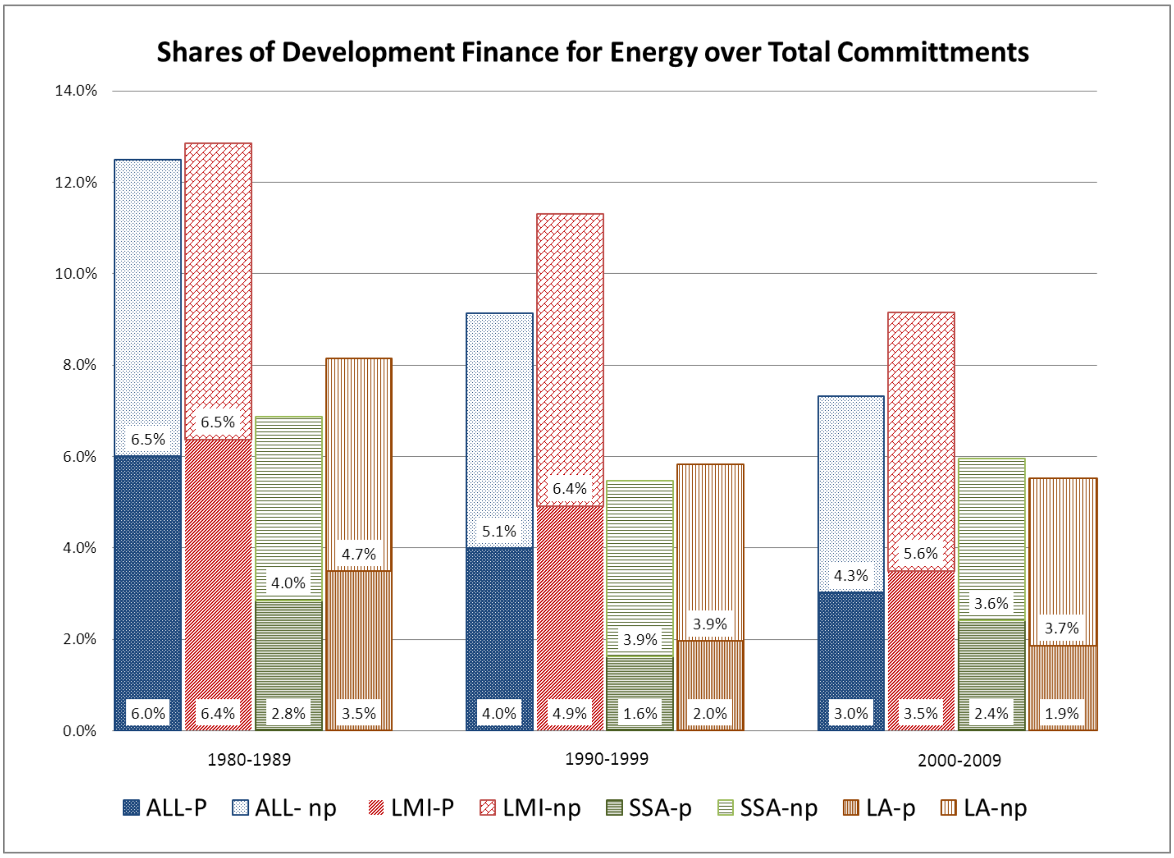
Our dataset has been organized in countries regrouped in four sets: we considered a first group of all countries (*ALL*) that includes all the countries for which exist at least one record of development finance for the energy sector in the period 1980-2009, regardless of their geographical appurtenance or income status today.[6] To restrict the analysis to the countries that are commonly defined as developing countries, we used a subset comprising only the ones that are classified by the World Bank as being "Low income" or "Lower middle income" including all the ones with a Gross National Income per capita up to 4035 USD in 2011[7]: the group of Low and Lower Middle income countries (LMI) is composed of 81 members. We have also considered a geographical group containing 44 countries--the Sub Saharan Africa (SSA), the region where most countries have extremely low access to electricity rates. Finally, we considered the subset of countries that present a level of access to the electricity services of 50% or less of the population in the most recent year: the Low Access Countries (LA) are 48. Access data is derived from the IEA (IEA 2011b) and when not available from UNDP (UNDP and WHO 2009). The list of countries included in the dataset is given in the Appendix A, and the plots of the variables for the four groups in Appendix B.

[4] The OECD guidelines to compile aid statistics suggests to code projects with mixed or unknown purposes as 23010 , while to the projects re-coded by AidData are applied the codes 23000 and 23005 (Gualberti et al. 2012, p. 19)
[5] For a comparison between AidData and the commonly used Creditor Reporting Systems (CRS) of the OECD see Gualberti et al. (2012), Appendix I.
[6] As an example, Portugal, which is now a donor of energy aid and a member of OECD and UE, received several World Bank Loans for the energy sector in 1982 and 1983, and thus it is included in the list.
[7] See: http://data.worldbank.org/about/country-classifications

3.2 Data Description

The first international cooperation projects for the energy sector dates back to the ‘40s and since then energy has always been a relevant share of development finance. Our analysis is limited to the assistance committed since 1980 and we note that at the beginning of the period, energy represented up to 12% of all development finance to developing countries, and that this share slightly lowered in the successive decades to around 9% for 2000-2009 (FIG 1).

Figure 1 - Shares of Development Finance over total Commitments (excluding emergency aid and debt relief)



Source: Author’s elaboration of AidData 2.0 data

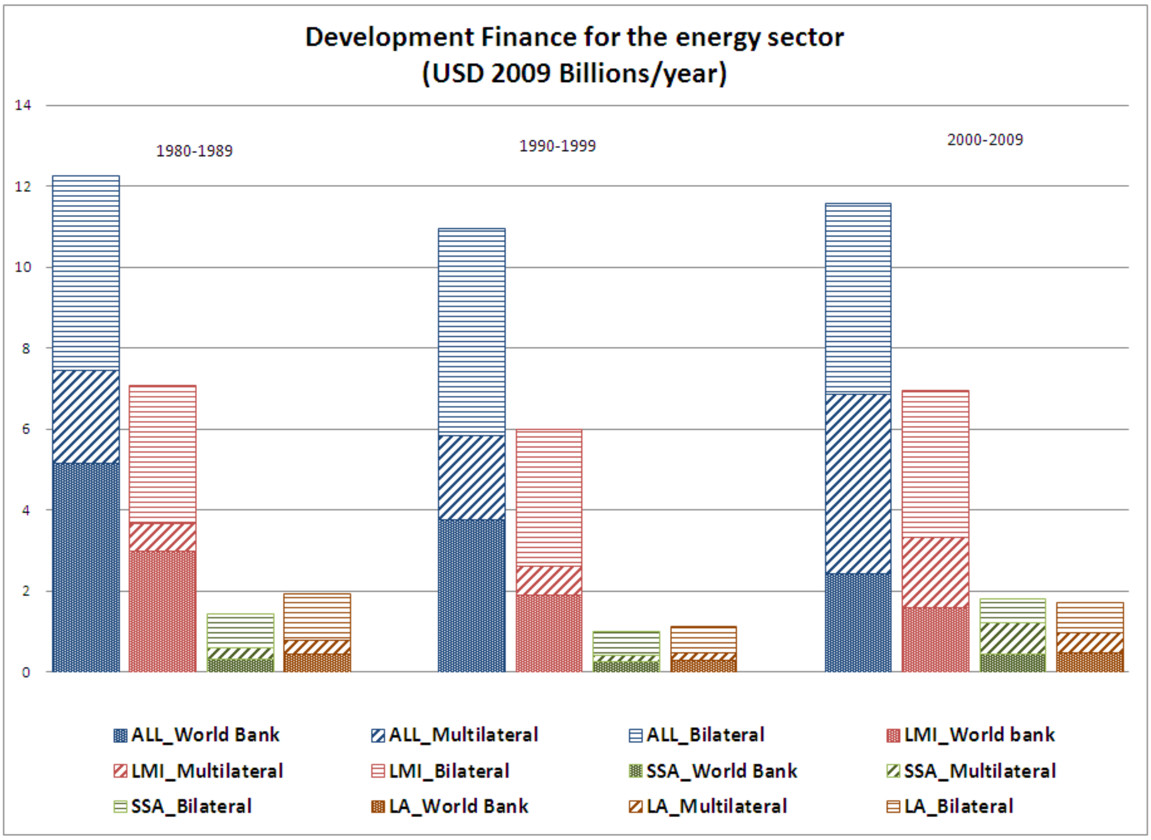
Energy finance for Sub Saharan Africa and Low Access countries is lower, representing 6% or less of the total, suggesting that the group of countries with more unfulfilled energy needs do not have energy prioritised in their incoming development financing[8]. To be noted also that the development finance for energy production purposes is always inferior to the development finance committed for other energy purposes (mainly energy policy and electricity distribution).

In terms of absolute flows development finance for the energy sector has been relatively stable around 11-12 USD Billions (2009) globally, although its composition varied (Fig.2). In particular, while

[8] This is true also considering just ODA and not Development Finance (ODA+Other Official Flows) (Gualberti et al., 2012, p. 10)

bilateral flows to the sector have been quite stable, we register a diminishing level of commitments from the World Bank Group (WBG) counterbalanced by a growing role of other multilateral donors. Development Finance for Low and Lower Middle Income countries represents around two thirds of the total, while the commitments for Sub Saharan Africa and for the countries with low electricity access is slowly growing but yet below two USD billions (2009) per year. The ten years averages shown in the graphical analysis hide an increase in the shares and in the commitments in the most recent years, that has to be acknowledged (Gualberti et al., 2012).

Figure 2 - Development Finance for the Energy Sector- 1980-2009, USD Billions per year, 10 years averages.

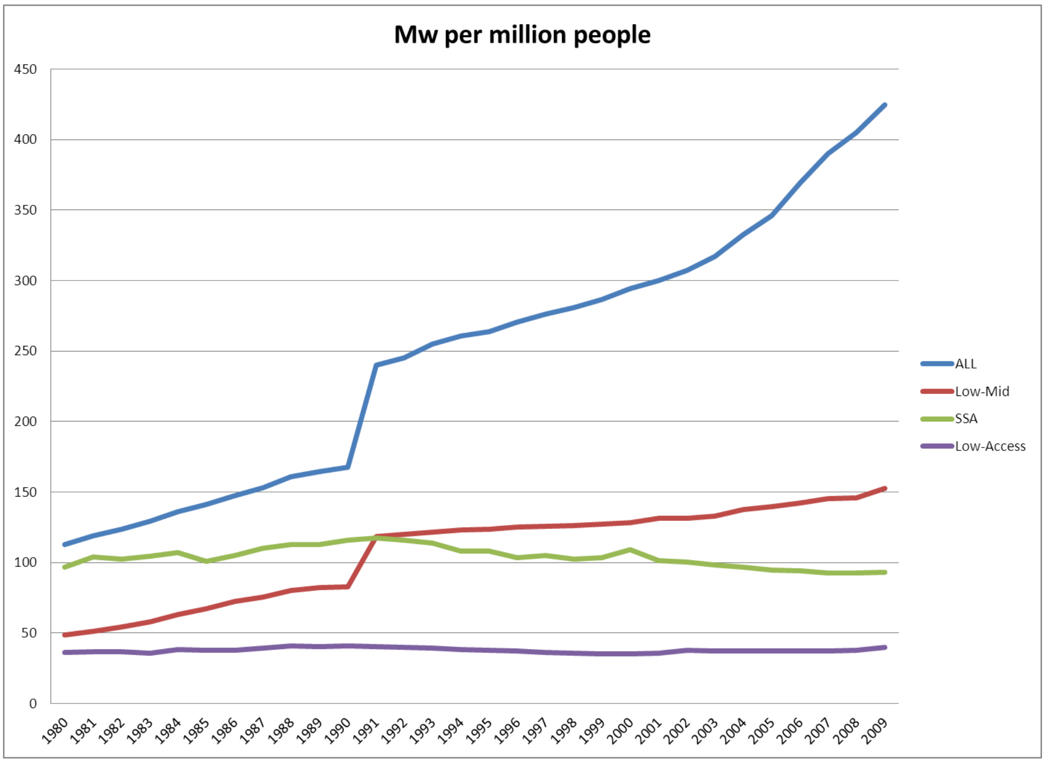


Source: Author's elaboration of AidData 2.0 data

Before going through the exercise of understanding aid effectiveness in our panel, we examined the evolution of the availability of energy services for the country groups of our analysis, using as metric the amount of installed capacity per capita (Fig. 3). Considering the whole panel we see a large increase in the availability of the energy services, mainly to be attributed to the fast developing emerging countries. We note also that developing countries (LMI) in general have seen a two-fold increase in the availability of electricity generation per capita, but that the level for both Sub Saharan Africa and Low Access Countries has remained low and stable, or slowly decreasing. To be noted that the values for SSA drop by half if we exclude South Africa, reaching 42 Mw for million people in

2009, a value compatible to other measurements made in literature and far from the level of 200 MW per million people that is considered the lower threshold of moderate energy access (Bazilian et al. 2012) (Eberhard et al. 2010).

Figure 3. Installed Capacity per Capita - MW per Million People, 1980 - 2009.



Source: author's elaboration of IEA and World Bank Data – the discontinuity in the series “ALL” and “Low-Mid” is due to the inclusion of transition economies after 1990-1991 (population data has been matched with the availability of *GW* data to build this graph).

3.3 Model Specification

To better understand and characterize the impact of aid effectiveness on the installed capacity in electricity production, controlling for the level of investment for all sectors, we considered four model specifications. These include a “benchmark model” (BM), where variables are measured in levels and the relationship is contemporaneous; a “distributed lagged model” (DM), where the financial commitment covariates are evaluated up to two lags to assess whether aid effects take year(s) to be effective; a “log model” (LM), where variables are in (natural) logs, to accommodate for elasticity effects; and a “per capita model” (CM), where the benchmark variables are calculated in per capita terms to possibly control for population disparity. The models are non-nested, with the exception of the BM model that is nested in the DM model, being a special case of it.

The model specifications we consider in the paper are therefore:

- Equation 1 (benchmark model - BM):

$$GW_{it} = \beta_1 + \beta_2 CODFp_{it} + \beta_3 CODFnp_{it} + \beta_4 GFCF_{it} + u_{it}$$

- Equation 2 (log model - LM):

$$logGW_{it} = \beta_1 + \beta_2 logCODFp_{it} + \beta_3 logCODFnp_{it} + \beta_4 logGFCF_{it} + u_{it}$$

- Equation 3 (per capita model - CM):

$$\frac{GW_{it}}{Pop_{it}} = \beta_1 + \beta_2 \frac{CODFp_{it}}{Pop_{it}} + \beta_3 \frac{CODFnp_{it}}{Pop_{it}} + \beta_4 \frac{GFCF_{it}}{Pop_{it}} + u_{it}$$

- Equation 4 (distributed lag model – DM):

$$GW_{it} = \beta_1 + \beta_2 CODFp_{it} + \beta_3 CODFp_{it-1} + \beta_4 CODFp_{it-2} + \beta_5 CODFnp_{it} + \beta_6 CODFnp_{it-1} + \beta_7 CODFnp_{it-2} + \beta_8 GFCF_{it} + u_{it}$$

where Z_{it} represents the value of a particular variable *Z* corresponding to country *i* and evaluated at time *t*.

The variable we are modelling in this paper is denoted by *GW* and represents the amount of installed capacity in electricity production. It is meant to be a measure of the physical investment in energy production infrastructure with a long-time economic life. The covariates of interest are defined by *CODFp* and *CODFnp* and correspond to the cumulative amount of *ODFp* and *ODFnp*, respectively, from the first observation until the one at time *t* and for a given country *i*. Here, *ODFp* only measures commitments to new production plants and *ODFnp* includes commitments to the energy sector for purposes other than electricity production (See Table 1). Moreover, *GFCF* defines Gross Fixed Capital Formation as a measure of the level of investment in fixed assets for all sectors and *POP* is population. Finally, these economic models also include an error term *u* that accommodates for all remaining factors that are left out of the regression models.

We use Cumulative ODF (*CODF*) rather than ODF in our models because we analyse the effect of ODF on investments in fixed assets with long economic life. Everything else equal, an effective ODF investment to build a power plant in country *i* and year *t* will eventually bring a long-lasting increase in the installed capacity *GW* for the years t+1, t+2, t+3, and so on until the end of the economic life of the facility, which is generally in the range of 20-30 years.

We expect that our dependent variable installed base (*GW*) is positively associated with the level of the investments in fixed assets for the economy (*GFCF*) and also with the official development finance for energy production projects (*CODFp*).

We do not have expectations for *CODFnp*: this grouping is constituted by activities not related with energy production (like electricity transmission); by activities whose effect on the installed base is uncertain (like energy policy and energy reforms), and also by power generation activities that are part of larger multi-purpose projects. Furthermore, we cannot assume that this grouping is homogeneous per country and per year.

3.4 Econometric Methodology

To investigate the impact of the development finance for the energy sector on the installed capacity of the recipient countries while controlling for the amount of gross fixed capital formation, we estimate the four above mentioned regressions for each one of the four sets of countries. Our dataset is a typical panel with a large number of cross sections and therefore, the econometric tools associated with panel data are used at the empirical section. For details on the econometrics with panel data, see Baltagi (2005), Arellano (2003), Hsiao (2003), and Wooldridge (2002), among others.

In general, the econometric model is specified as

$$Y_{it} = \beta' X_{it} + u_{it},\ i=1,...,N,\ t=1,...,T,$$

where Y is the dependent variable, X is a vector of regressors, β is a unknown parameter vector, and u is the error of the model.

Before estimating the regressions, we have performed the following series of statistical tests to understand the characteristics of the model, apply the appropriate econometric techniques and aid to the interpretation of the results:

- Fixed Effects, Random Effects, or Pooled Regression.

When estimating the amount of installed capacity in electricity production, conditional on the corresponding covariates, we tested for the existence of pooled regression, random effects and fixed effects, and we only present the results for the specification that best fits the data.

A model with fixed effects allows controlling for fixed unobserved country heterogeneity whereas random effects assumes that α follows a given distribution, while the existence of pooled regression means that individual country effects do not exist.

If individual effects α_i exist (either random or fixed), then the error term is decomposed as follows: $u_{it} = \alpha_i + \varepsilon_{it}$, where ε is an idiosyncratic component. For details on the estimation and inference of panel data models see the above mentioned references, and in particular for testing the possible existence of individual effects see, for example, Breusch and Pagan (1980) and Hausman (1978).

We have performed several statistical tests involving the coefficients of the four models (BM, DM, LM and CM) to better interpret the results. In particular we have tested to understand if there is a statistically significant difference between the coefficients of *CODFp* and *CODFnp*, and between the various lags of the DM model.

- Benchmark Model (BM), Logarithmic Model (LM), per Capita Model (CM)

  (T1) If $H_0: \beta_2 = \beta_3$ is true then the impact of *CODFp* and *CODFnp* on *GW* is equal;

- Lagged Model (DM)

  (T2*i*) If $H_0: \beta_2 = \beta_5$ is verified then the impacts of *CODFp* and *CODFnp* on *GW* at the time t are equal;
  (T2*ii*) If $H_0: \beta_3 = \beta_6$ is verified then the the impacts of *CODFp* and *CODFnp* on *GW* at the time t+1 are equal;
  (T2*iii*) If $H_0: \beta_4 = \beta_7$ is verified then the the impacts of *CODFp* and *CODFnp* on *GW* at the time t+2 are equal;
  (T2*iv*) If $H_0: \beta_2 = \beta_5$ and $\beta_3 = \beta_6$ and $\beta_4 = \beta_7$ are verified then the impact of *CODFp* and *CODFnp* are equal in each lag of the model;
  (T2*v*) If $H_0: \beta_2 + \beta_3 + \beta_4 = \beta_5 + \beta_6 + \beta_7$ is verified then the long term impact of *CODFp* and *CODFnp* are equal;
  (T2*vi*) If $H_0: \beta_2 + \beta_3 = 0$ is verified than the impacts of $CODFp_t$ and $CODFp_{t-1}$ are equal;
  (T2*vii*) If $H_0: \beta_3 + \beta_4 = 0$ is verified than the impacts of $CODFp_{t-2}$ and $CODFp_{t-1}$ are equal;
  (T2*viii*) If $H_0: \beta_2 + \beta_4 = 0$ is verified than the impacts of $CODFp_t$ and $CODFp_{t-2}$ are equal;
  (T2*ix*) If $H_0: \beta_2 + \beta_3 + \beta_4 = 0$ is verified than the long term effect of *CODFp* is null.
  (T2*x*) If $H_0: \beta_5 + \beta_6 = 0$ is verified than the impacts of $CODFnp_t$ and $CODFnp_{t-1}$ are equal;
  (T2*xi*) If $H_0: \beta_6 + \beta_7 = 0$ is verified than the impacts of $CODFnp_{t-2}$ and $CODFnp_{t-1}$ are equal;

(T2*xii*)) If H_0 : $\beta_5 + \beta_7 = 0$ is verified than the impacts of $CODFnp_t$ and $CODFnp_{t-2}$ are equal;

(T2*xiii*) If H_0 : $\beta_5 + \beta_6 + \beta_7 = 0$ is verified than the long term effect of *CODFnp* is null.

(T2*xiv*) If H_0 : $\beta_2 + \beta_3 + \beta_4 = 0$ and $\beta_5 + \beta_6 + \beta_7 = 0$ are verified then the long term impacts of *CODFp* and *CODFnp* are both null

Note that under T2vi (and similar arguments can be applied from T2vi to T2xiv) CODF transforms in ODF, ignoring remaining terms.

$$\beta_2 \mathrm{CODFp}_{it} + \beta_3 \mathrm{CODFp}_{\mathrm{it-1}}$$

$$= \beta_2 \mathrm{CODFp}_{it} - \beta_2 \mathrm{CODFp}_{\mathrm{it-1}} = \beta_2 \left(\sum_{j=1}^{t} ODFp_{ij} - \sum_{j=1}^{t-1} ODFp_{ij} \right) = \beta_2 \mathrm{ODFp}_{it}$$

4. Empirical Results

In this section, we analyse the empirical results model by model and then we look at common trends or discrepancies. Table 2 presents the coefficient of the regressions, standard errors, and additional info.

Table 2. Coefficients of the Dynamic Panel Analysis.

LEGEND: ** significative at 99%; * significative at 95%, standards errors between brackets. ALL- All countries, SSA – Sub Saharan Africa, LI – Low and Lower Middle Income Countries, LA-Low Access Countries, NA-Not Available, rej.-rejected, not rej.-not rejected.

Eq.1 - Benchmark Model (BM)	**ALL**	**SSA**	**LI**	**LA**
CODFp	0.622** (0.314)	-0.006 (0.499)	3.335** (0.127)	0.487** (0.055)
CODFnp	0.685** (0.299)	-0.312 (0.372)	-0.332** (0.123)	0.275** (0.037)
GFCF	0.655** (0.003)	0.456** (0.032)	0.399** (0.005)	0.163** (0.006)
Intercept	1.228** (0.126)	1.132** (0.076)	1.063** (0.047)	0.243** (0.007)
Effects	*Fixed*	*Fixed*	*Fixed*	*Fixed*
R^2	*0.987*	*0.968*	*0.994*	*0.980*
T1	*(0.915) not rej.*	*NA*	*(0.000) rej.*	*(0.012) rej.*

Eq. 2 - Log Model (LM)				
CODFp	0.042** (0.007)	0.073** (0.017)	0.043** (0.009)	0.071** (0.013)
CODFnp	0.057** (0.006)	0.054** (0.016)	0.076** (0.010)	0.068** (0.014)
GFCF	0.433** (0.015)	0.329** (0.026)	0.432** (0.022)	0.295** (0.023)
Intercept	0.297** (0.025)	-0.806** (0.035)	-0.077** (0.021)	-0.762** (0.027)
Effects	*Fixed*	*Fixed*	*Fixed*	*Fixed*
R^2	*0.984*	*0.965*	*0.981*	*0.967*
T1	*(0.233) not rej.*	*(0.531) not.rej.*	*(0.060) rej.*	*(0.915) rej.*

Eq. 3 - Per Capita Model (CM)

CODFp	0.838** (0.125)	1.600** (0.127)	-0.263 (0.168)	0.491** (0.055)	
CODFnp	0.627** (0.104)	-0.398** (0.148)	2.322** (0.197)	-0.522** (0.054)	
GFCF	0.143** (0.005)	0.146** (0.010)	-0.067* (0.040)	-0.002 (0.004)	
Intercept	0.000** (0.000)	0.000** (0.000)	0.000** (0.000)	0.000** (0.000)	
Effects	*Fixed*	*Random*	*Fixed*	*Fixed*	
R^2	*0.940*	*0.459*	*0.916*	*0.967*	
T1	*(0.285) not. rej.*	*(0.000) rej.*	*NA*	*(0.000) rej.*	

Eq.4 - Distributed Lag Model (DM)

CODFp	ns	mod. 1	ns	ns	
CODFp (-1)	ns	ns	ns	ns	
CODFp (-2)	ns	ns	3.133** (0.130)	0.551** (0.056)	
CODFnp	-1.166* (0.645)	mod. 1	-1.143** (0.202)	-0.146* (0.076)	
CODFnp (-1)	ns	ns	ns	ns	
CODFnp (-2)	1.945** (0.623)	ns	0.855** (0.208)	0.369** (0.077)	
GFCF	0.661** (0.003)	mod. 1	0.386** (0.005)	0.167** (0.006)	
Intercept	1.750** (0.143)	mod. 1	1.637** (0.050)	0.263** (0.007)	
Effects	*Fixed*	*Fixed*	*Fixed*	*Fixed*	
R^2	*0.987*	mod. 1	*0.996*	*0.982*	
T2	*all rejected*	*NA*	*all rejected*	*all rejected*	

We analyse separately the DM and the BM, LM, and CM. In the latter we note that:

- *The* coefficents of *CODFp* and GFCF are significant and positive in 10 out of 12 cases. The exceptions for *CODFp* are BM-SSA and CM-LI while for *GFCF,* it is CM-LA and CM-LI. We interpret these results as a confirmation of our hypothesis on the positive correlation between the installed base GW and Development Finance and GFCF.

- The coefficients of *CODFnp* are significant in 11 out of 12 cases (the exception is BM-SSA) and positive in eight cases (exceptions are BM-LI, CM-SSA and CM-LA). In BM-LI and CM-SSA the negative coefficient for *CODFnp* is associated with a higher than usual positive coefficient of *CODFp* (pointing to an overall positive effect of Development Finance). We interpret these discrepancies as a result of the heterogeneous nature of *CODFnp*.

- T1 test is not rejected four times, three of which in the All countries grouping (BM-ALL, LM-ALL and CM-ALL, plus LM-SSA) while in the case of Low Access countries it is always rejected. This points to the conclusion that–if we limit our analysis to developing countries–the effects of development finance for electricity production and for other scopes are clearly distinct.

- The models are characterised by fixed effects in all but one case (CM-SSA), meaning that, as expected, the different intrinsic characteristics of each country influence the relation between our variables.

- Regarding the coefficients for *CODFp* and *CODFnp,* in the Benchmark Model these are between the values of 0.6 and 0.7. This translates as one additional unit of CODF (i.e. one billion USD) is associated with an increase of 0.6-0.7 units of *GW*. The inverse of the coefficient thus indicates how much CODF is necessary to obtain one additional *GW* of installed base. This value (1/0.65=1.60 USD Billion per GW = 1600 USD/kW) is compatible with average prices for new installed base calculated by the World Bank (ESMAP 2007). It should be noted that the effect of CODF in the Base model is much higher for the LI group, while it is slightly lower for Low Access countries.

For the lagged model (DM) we note that:

- For the group of ALL countries, *CODFp* has no significance, while *CODFnp* has opposite signs at t and t-2. This is the only case in which the results are incoherent with our expectations and with the other cases examined.
- For SSA the model reverts to the base model.
- For LI and LA models we have similar results, meaning that in both cases *CODFp* is significant and positive at t-2, while *CODFnp* has opposite signs at t and t-2. To be noted that the long term effect of *CODFnp* (given from the sum of the coefficients at t, t-1 and t-2) is coherent with the Base Model.
- T2 tests, when available, are rejected in all cases, meaning that the impact of the coefficients at various lags is always distinct (T2i-T2viii, T2x-T2xii) and that the long term impact of CODFp and of CODFnp is not null (T2ix, T2xiii, T2xiv).

5. Conclusions

Our analysis tested the relation between Official Development Finance for the energy sector, the installed base for electricity generation GW, and the Gross Fixed Capital Formation. We accounted separately for the development finance directly related with electricity generation and for other energy purposes. We utilised cumulative official development finance rather than the yearly rate of new financing because it is more appropriated for the analysis of long term infrastructure projects. We made a panel analysis with a large dataset of 160 countries subdivided in four country groupings, for 30 years of observations, and we attempted four model specifications.

Our main result is that in the great majority of country groupings and model specifications (13 cases over 16 examined) we note a significant and positive effect of Official Development Finance for electricity production over the installed electricity base, and that in terms of USD/kW our figures are comparable with international standards. The Gross Fixed Capital Formation of the whole economy is also positively associated with the amount of GW installed, which was expected.

We also find that the two types of development finance considered are statistically different for the developing countries groupings, although their effect cannot be distinguished in the large all-country case.

Adding lags to the analysis did not improve the results: for SSA we have not found significant lags and thus we reverted to the base model. For the Low Income and Low Access groupings we found that the coefficients for the lags are comparable with the results of the Base Model, and for the larger set of all countries we found no significance for CODF for the purpose of electricity production.

Our analysis has some inherent limits, mainly due to the data paucity that prevented us to consider other variables, influencing the quality of aid and its ability to deliver results on the ground, as well as other outcomes other than installed base for electricity generation. As mentioned previously, a growing availability of installed base is not *per se* a guarantee that access to modern energy services is expanding; many other factors and policies are involved in the process of reducing energy poverty-analysis which is beyond the scope of this paper.

Taking into account all these limits, our results point to the general conclusion that the development finance for the energy sector is effective in augmenting the installed base for electricity generation, although further research is needed to understand the exogenous factors that can limit or enhance this outcome.

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APPENDIX A. List of Included Countries

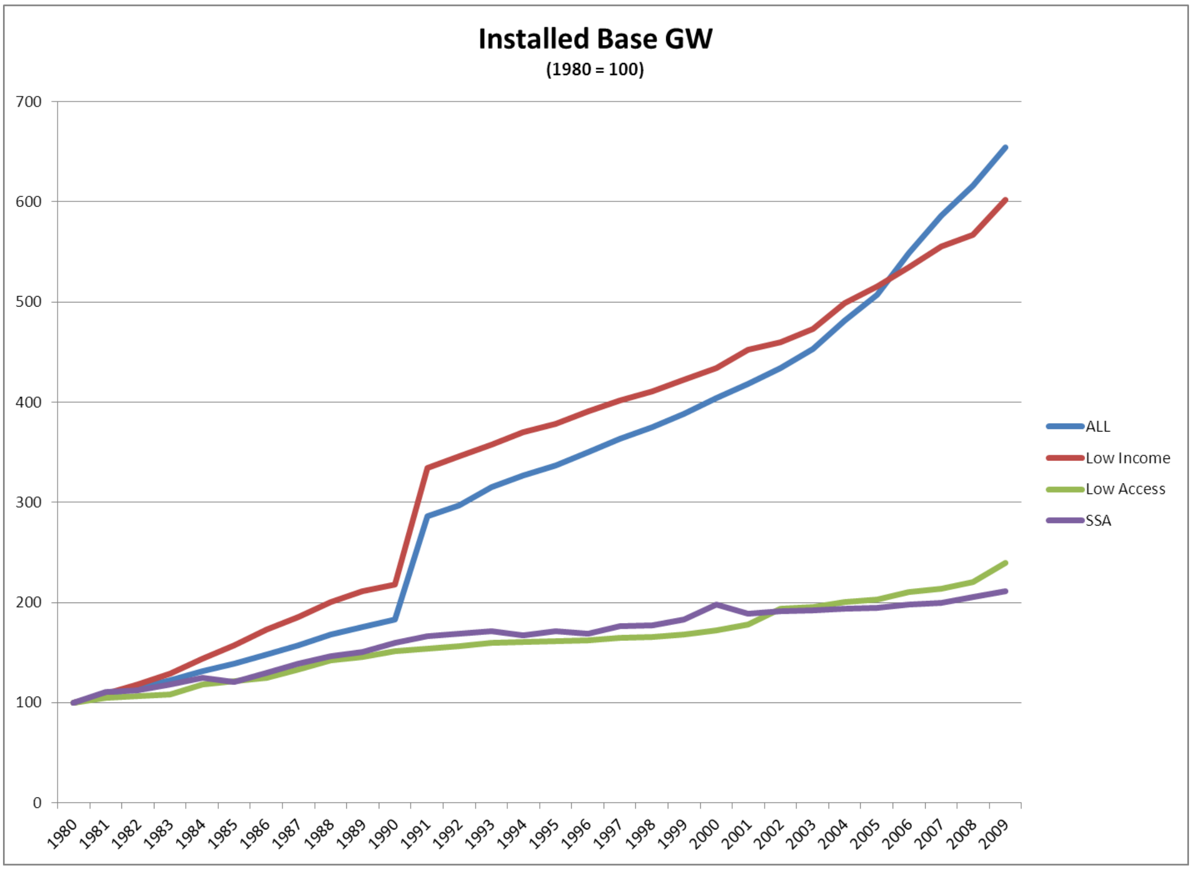
	Countries	Sub Saharan Africa	Low and Lower-Middle income countries	Low Access (<50%)
1	Albania			
2	Algeria			
3	Angola	X	X	X
4	Antigua and Barbuda			
5	Argentina			
6	Armenia		X	
7	Aruba			
8	Azerbaijan			
9	Bahamas, The			
10	Bahrain			
11	Bangladesh		X	X
12	Barbados			
13	Belarus			
14	Belize		X	
15	Benin	X	X	X
16	Bermuda			
17	Bhutan		X	
18	Bolivia		X	
19	Bosnia and Herzegovina			
20	Botswana	X		X
21	Brazil			
22	Brunei Darussalam			
23	Bulgaria			
24	Burkina Faso	X	X	X
25	Burundi	X	X	X
26	Cambodia		X	X
27	Cameroon	X	X	X
28	Cape Verde	X	X	
29	Central African Republic	X	X	X
30	Chad	X	X	X
31	Chile			
32	China			
33	Colombia			
34	Comoros	X	X	
35	Congo, Dem. Rep.	X	X	X
36	Congo, Rep.	X	X	X
37	Costa Rica			
38	Cote d'Ivoire	X	X	X
39	Croatia			
40	Cuba			
41	Cyprus			
42	Czech Republic			
43	Djibouti		X	X
44	Dominica			

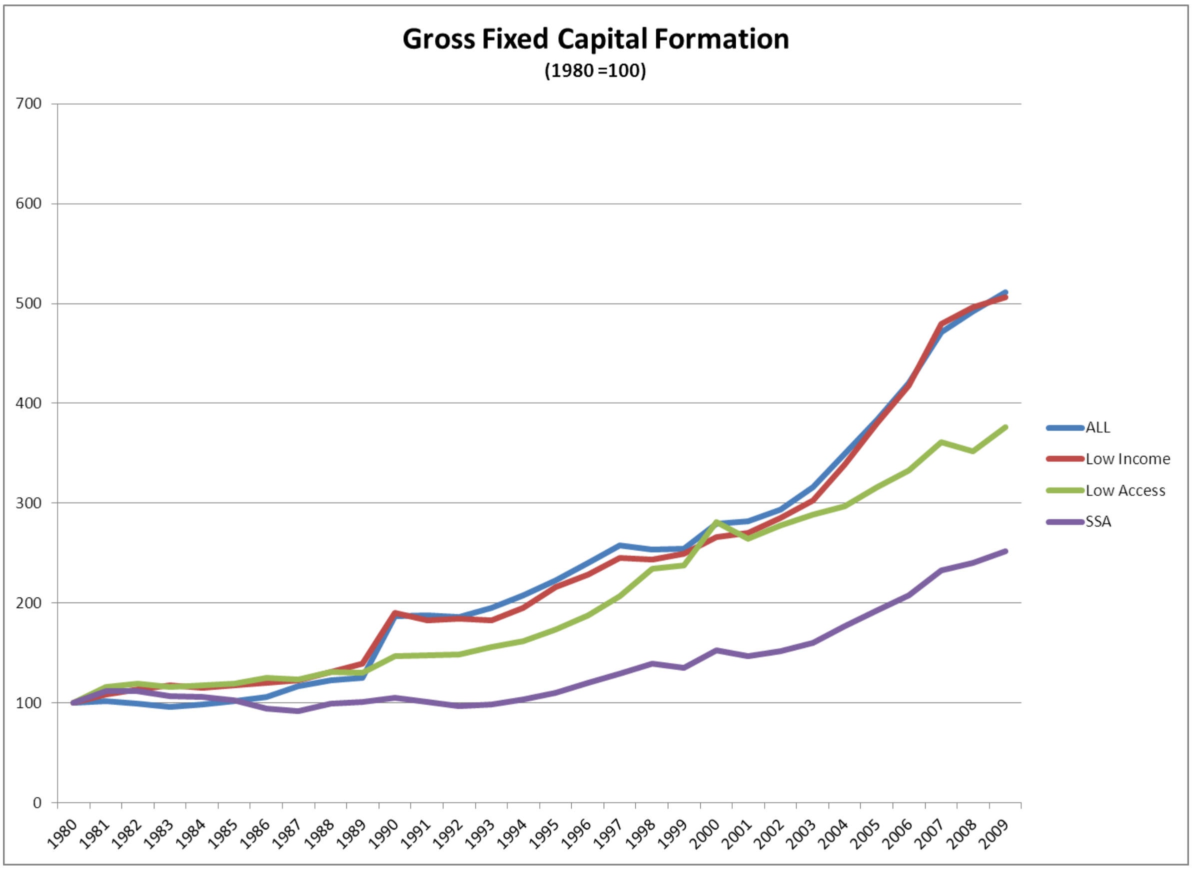
45	Dominican Republic			
46	Ecuador			
47	Egypt, Arab Rep.		X	
48	El Salvador		X	
49	Equatorial Guinea			X
50	Eritrea	X	X	X
51	Estonia			
52	Ethiopia	X	X	X
53	Fiji		X	
54	French Polynesia			
55	Gabon	X		X
56	Gambia, The	X	X	X
57	Georgia		X	
58	Ghana	X	X	
59	Grenada			
60	Guatemala		X	
61	Guinea	X	X	X
62	Guinea-Bissau	X	X	X
63	Guyana		X	
64	Haiti		X	X
65	Honduras		X	
66	Hong Kong SAR, China			
67	Hungary			
68	India		X	
69	Indonesia		X	
70	Iran, Islamic Rep.			
71	Iraq		X	
72	Israel			
73	Jamaica			
74	Jordan			
75	Kazakhstan			
76	Kenya	X	X	X
77	Kiribati		X	
78	Korea, Rep.			
79	Kyrgyz Republic		X	
80	Lao PDR		X	
81	Latvia			
82	Lebanon			
83	Lesotho	X	X	X
84	Liberia	X	X	X
85	Libya			
86	Lithuania			
87	Macao SAR, China			
88	Macedonia, FYR			
89	Madagascar	X	X	X
90	Malawi	X	X	X
91	Malaysia			
92	Maldives			

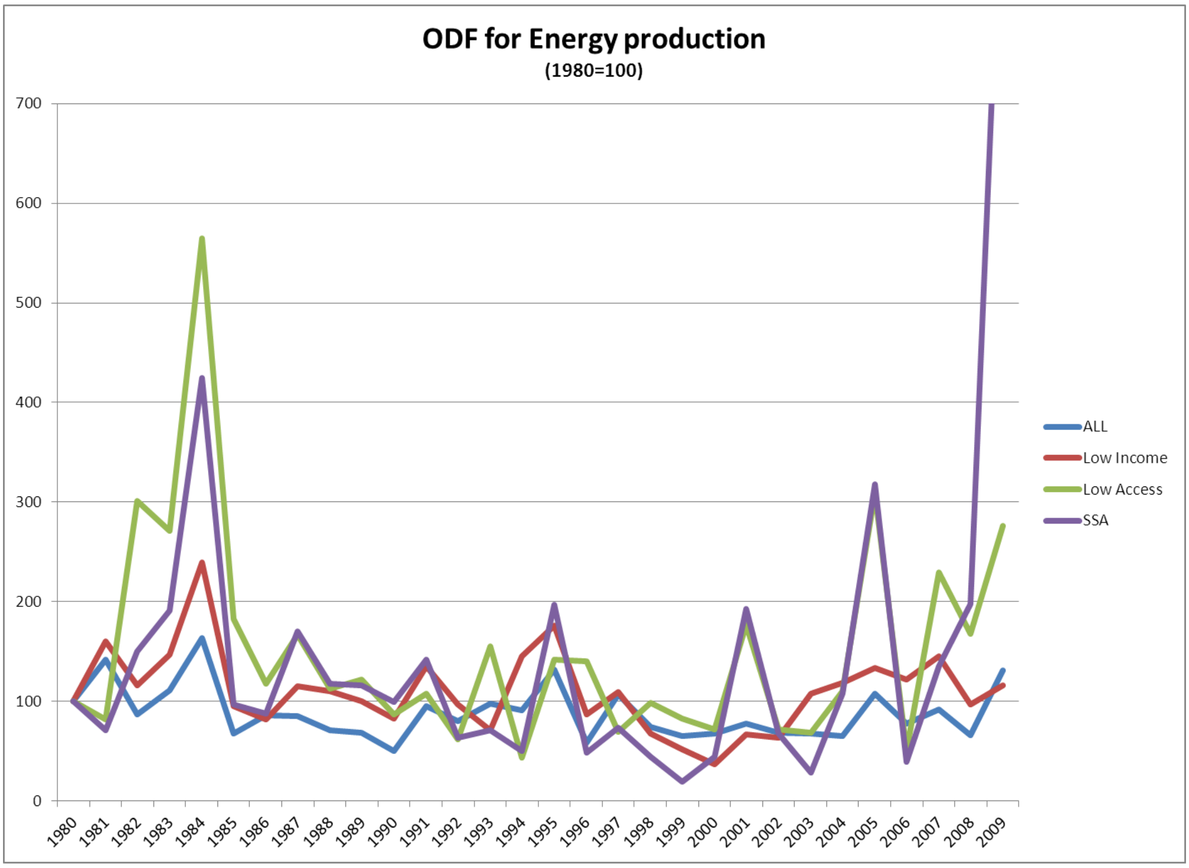
93	Mali	X	X	X
94	Malta			
95	Mauritania	X	X	X
96	Mauritius	X		
97	Mexico			
98	Moldova		X	
99	Mongolia		X	
100	Montenegro			
101	Morocco		X	
102	Mozambique	X	X	X
103	Namibia	X		X
104	Nepal		X	X
105	New Caledonia			
106	Nicaragua		X	
107	Niger	X	X	X
108	Nigeria	X	X	
109	Oman			
110	Pakistan		X	
111	Panama			
112	Papua New Guinea		X	X
113	Paraguay		X	
114	Peru			
115	Philippines		X	
116	Poland			
117	Portugal			
118	Qatar			
119	Romania			
120	Russian Federation			
121	Rwanda	X	X	X
122	Samoa		X	
123	Senegal	X	X	X
124	Serbia			
125	Seychelles	X		
126	Sierra Leone	X	X	X
127	Singapore			
128	Slovak Republic			
129	Slovenia			
130	Solomon Islands		X	X
131	South Africa	X		
132	Sri Lanka			
133	St. Kitts and Nevis			
134	St. Lucia			
135	St. Vincent and the Grenadines			
136	Sudan	X	X	X
137	Suriname			
138	Swaziland	X	X	X
139	Syrian Arab Republic		X	

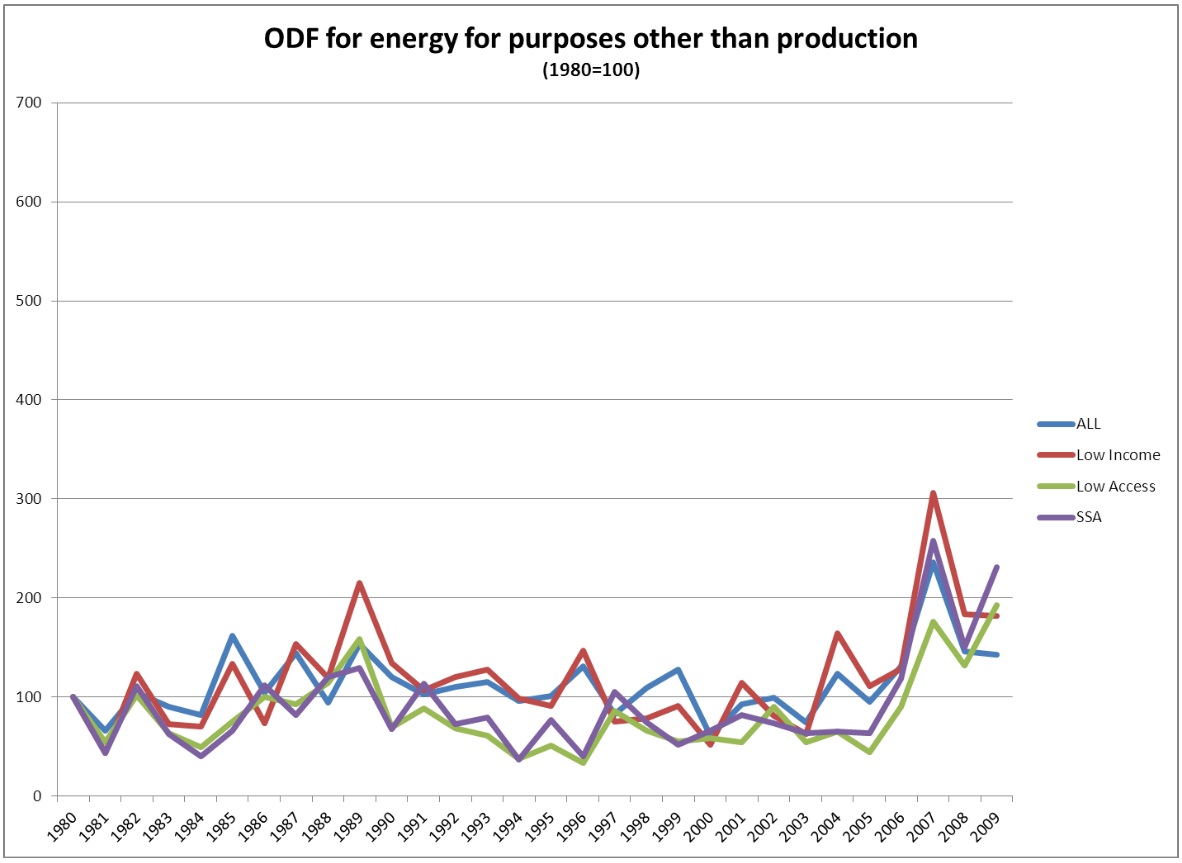
140	Tajikistan		X	
141	Tanzania	X	X	X
142	Thailand			
143	Timor-Leste		X	X
144	Togo	X	X	X
145	Tonga		X	
146	Trinidad and Tobago			
147	Tunisia			
148	Turkey			
149	Turkmenistan		X	
150	Uganda	X	X	X
151	Ukraine		X	
152	Uruguay			
153	Uzbekistan		X	
154	Vanuatu		X	X
155	Venezuela, RB			
156	Vietnam		X	
157	West Bank and Gaza		X	
158	Yemen, Rep.		X	X
159	Zambia	X	X	X
160	Zimbabwe	X	X	X

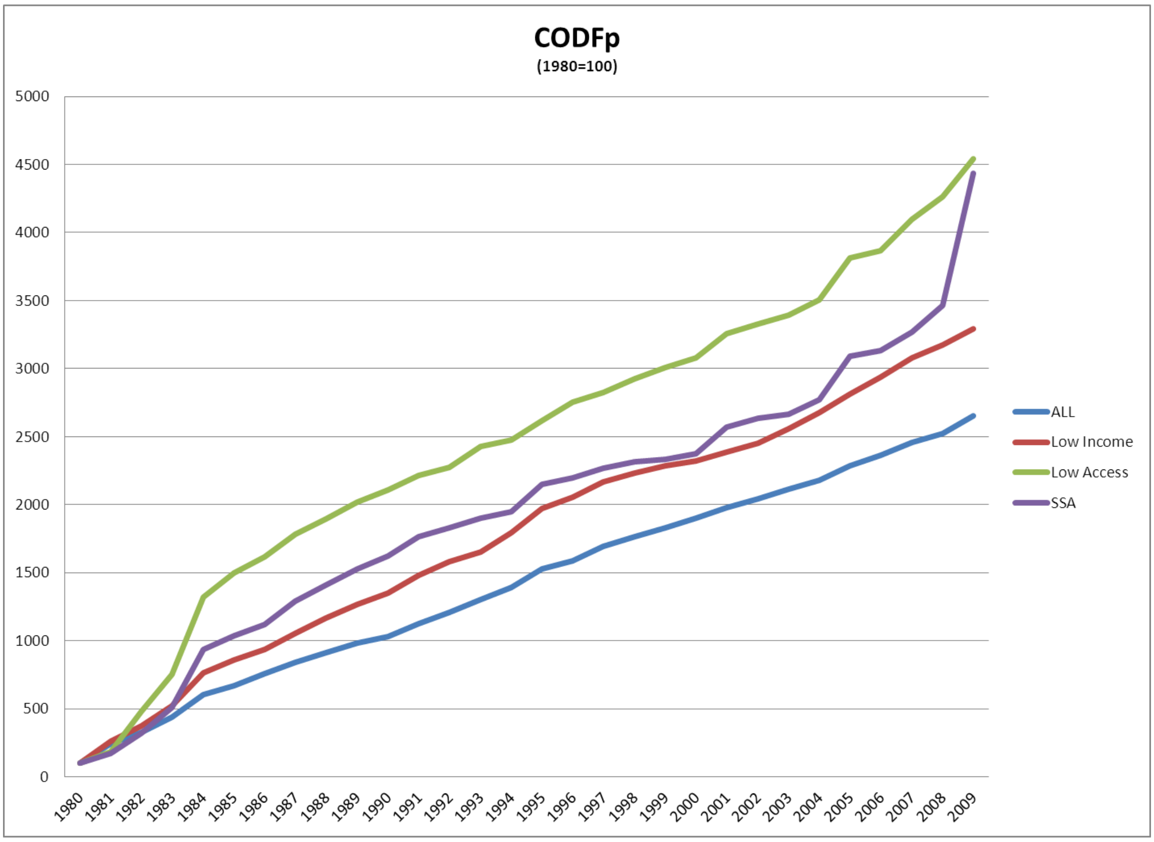
APPENDIX B. Graphical Plots of Variables per Group of Countries

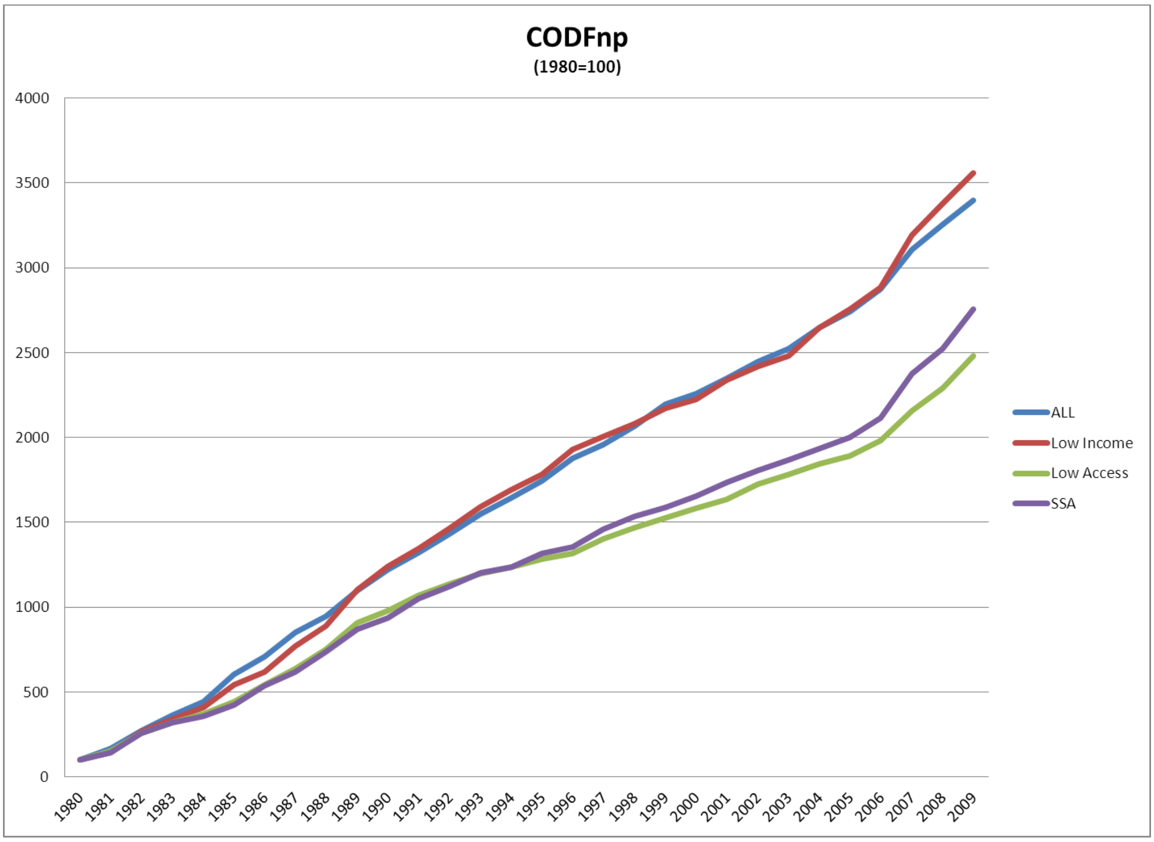


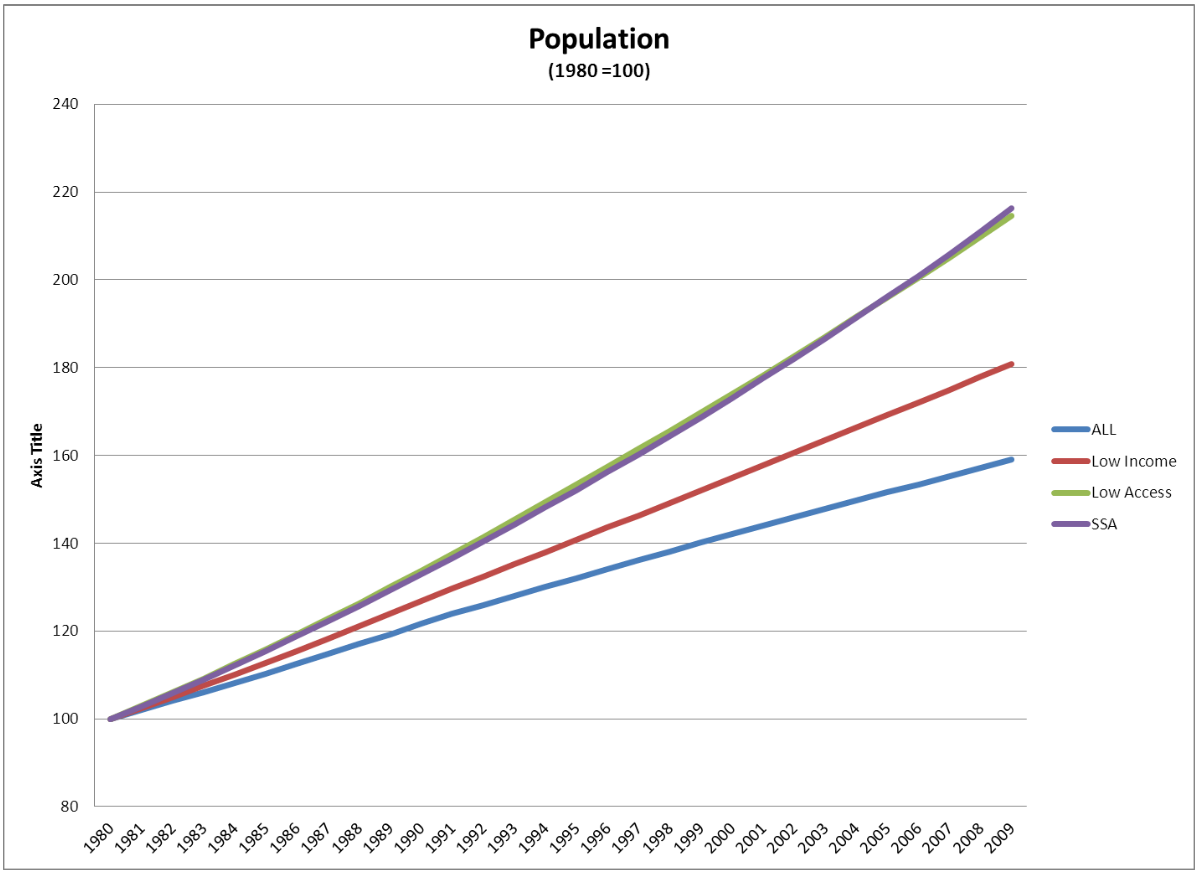



ODF for Energy production
(1980=100)
700
600
500
400
300
200
100
0
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
ALL
Low Income
Low Access
SSA


ODF for energy for purposes other than production
(1980=100)
700
600
500
400
300
200
100
0
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
ALL
Low Income
Low Access
SSA


CODFp
(1980=100)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
ALL
Low Income
Low Access
SSA


CODFnp
(1980=100)
4000
3500
3000
2500
2000
1500
1000
500
0
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
ALL
Low Income
Low Access
SSA


Population
(1980 =100)
Axis Title
240
220
200
180
160
140
120
100
80
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
ALL
Low Income
Low Access
SSA

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