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Development Impact Evaluation

Evidence Review

What are the links between power, economic growth and job creation?

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What's in this report?

About CDC's evaluations

CDC regularly commissions independent evaluations to increase understanding of our development impact and to guide future investments.

About this report

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The views presented in this paper are those of the authors and do not necessarily represent the views of CDC or ODI.

Foreword

600 million people in sub-Saharan Africa currently lack access to electricity: 70 per cent of the population. Half of all businesses say that the lack of reliable electricity is a major constraint. Power outages cost African countries an estimated 1-2 per cent of their GDP annually.

The last few years have seen major initiatives to tackle this massive development challenge. In September 2011, UN Secretary-General Ban Ki-moon launched Sustainable Energy for All, a global initiative to mobilise action on: providing universal access to modern energy services; doubling the global rate of improvement in energy efficiency; and doubling the share of renewable energy in the global energy mix. In 2013, President Obama launched Power Africa to bring together technical and legal experts, the private sector, and governments from around the world to work in partnership to increase the number of people with access to power. And in late 2015, the UK's Energy Africa campaign was launched to help Africa achieve universal energy access by 2030.

2015 has also seen CDC Group and Norfund take direct ownership and control of Globeleq Africa in a new partnership to boost power generation in Africa by adding at least 5,000 megawatts (MW) of generating capacity over the next 10 years.

In countries as diverse as Côte d'Ivoire, Kenya and Tanzania, we found that both GDP and formal private sector employment were closely and positively correlated with increased supply and consumption of electricity over the past decade. But despite dozens of studies, we couldn't establish whether it was the economic growth that drove increased electricity supply or vice-versa.

That is why we commissioned ODI to undertake this systematic review of the evidence on the relationships between energy use, economic growth and employment. We believe the report offers a balanced but definitive perspective on these complex relationships, having reviewed almost 100 reports. It also provides useful guidance on how to measure and monitor the impact of power projects on employment in the African context.

In 2016, we intend to publish, as a follow-up to this review, an evaluation of the links between power and job creation in Ugandan businesses.

Alex MacGillivray
Director, Development Impact, CDC Group

Key findings

1. **Energy plays a fundamental part in the economic growth process.** More than three quarters of the good quality statistical studies we review find a positive correlation between energy use and economic growth, and half the studies find a positive and significant causal link from energy use to economic growth. Energy use is either the cause or the facilitator of economic growth. The literature also suggests that the relationship between energy and economic growth varies by country and within countries.

2. **Insufficient, unreliable or costly access to power can be a binding constraint to business.** Detailed growth diagnostics, which are country-level studies assessing which factors are binding constraints, suggest this is the case in South Asia (Bangladesh, Nepal, Pakistan). They also suggest insufficient and unreliable supply is a major obstacle to businesses in several sub-Saharan African countries (Benin, Nigeria, Rwanda, Senegal, Uganda, Zambia, Liberia, Democratic Republic of Congo, and Kenya), and likely to become a major constraint in countries such as Ghana.

3. **Electricity is a binding constraint for all sizes of business.** Data from World Bank enterprise surveys, which survey a sample of an economy's private sector, reveal that this is the case, especially for those businesses operating in the manufacturing sector. Electricity provision is of relatively greater concern to low-income countries and in sub-Saharan Africa. In the latter, Guinea, Nigeria and Central African Republic are the countries most affected by the lack of reliable and sufficient electricity.

1. What does this report do?

The question

It is common knowledge that energy use and economic growth go hand in hand. But if investments by development finance institutions (DFIs) are to achieve maximum impact, a key question is whether increased energy supply leads to economic growth, or whether economic growth leads to greater energy demand.

The power sector usually has three components: generation, transmission and distribution. Investment projects in the power sector can be in one or several of these components. In most countries, power generation is separate from power transmission and distribution, allowing multiple power generators to supply electricity into a single grid. Investment in a generation plant is often a discrete project, and its costs and benefits assessed as such. However, this assessment needs to consider the full 'electricity value chain', which includes the source of primary energy used to generate electricity, the consumers of electricity, as well as generation, transmission and distribution.

Figure 1.
The electricity value chain

Public investment and support for the power sector in developing countries needs to be justified in terms of its public benefit. Electricity enables economic and social activity and receives public support because of this, not because of the benefits that might be generated from the construction and operation of power sector infrastructure or services. Policy makers in developing countries are most interested in the impact of improved access to power.

The approach

To answer the question of whether increased energy supply leads to economic growth, or whether economic growth leads to greater energy demand, this report systematically reviews the evidence of relationships between energy use, economic growth and employment.

To do this, we examine the macro and micro effects. Section 2 reviews the statistical evidence of the macroeconomic effects of electricity on economic growth and vice-versa. Section 3 looks at what the available country-level growth diagnostics tell us about whether electricity provision is a binding constraint to growth. Section 4 considers business-level evidence from World Bank enterprise surveys. Section 5 considers the impact, especially employment impact, of investment at the power-project level. Section 6 proposes a simple framework for tracking the impact of power projects on job creation. Section 7 concludes.

2. Energy use, growth and employment: a statistical review

This section systematically reviews the available statistical studies on the causal relationship between energy consumption on one side, and economic growth and employment on the other. The review is limited to statistical studies that examine the macro-level evidence.

2.1 Evidence on the link between energy use, economic growth and employment

Over time, research on the links between energy consumption and economic growth has resulted in four different hypotheses. These theories can also be applied to energy consumption and employment. They are summarised below (Shahateet, 2014).

Box 1.
Energy consumption and economic growth hypotheses

- **Neutrality hypothesis:** assumes no causal link between energy consumption and economic growth. An increase or decrease in energy use will not affect economic growth and vice-versa.
- **Conservation hypothesis:** assumes a unidirectional causal link from economic growth to energy consumption. Economic growth will lead to increased energy consumption.
- **Growth hypothesis:** assumes a unidirectional causal link from energy consumption to economic growth. An increase in energy consumption will have a positive impact on economic growth.
- **Feedback hypothesis:** assumes bidirectional causal links between energy consumption and economic growth. Changes in energy consumption will have an effect on economic growth whilst changes in economic growth will impact the demand for energy.

Studies on the relationship between economic growth and energy consumption are not new. For example Kraft & Kraft (1978) examined the link between Gross National Product (GNP) and energy consumption in the USA between 1947 and 1974, finding that increases in GNP led to increases in energy consumption. A number of other studies have followed, although the results over time have varied. For example, Stern (1993) looked at the USA from 1947 to 1990 and found that whilst economic growth had an impact on energy consumption, energy consumption also had an impact on economic growth. Research by Chang *et al.* (2001) on Taiwan between 1982 and 1997 supported the hypothesis that energy consumption affected economic growth.

One of the first papers to assess the relationship between energy and employment was published by Akarca & Long (1979). The paper analysed the relationship between total employment and total energy consumption in the USA between 1973 and 1978, finding that when energy consumption increased, employment went down. Over time, other studies have challenged Akarca & Long's initial findings (i.e. Erol & Yu, 1987 and 1989, Yu *et al.*, 1988, and Cheng, 1998) and have found no relationship between energy consumption and employment when using different methodologies (Asafu-Adjaye, 2000).

Other studies have, on the other hand, supported the theory that a relationship exists. For example, Yu & Lee (1995) showed that in the USA, changes in energy consumption have an effect on employment whilst changes in employment impact the demand for energy. A similar result was also obtained by Erol (1990).

For both employment and economic growth, the results of research vary. This is partly the result of looking at different countries or time periods, but also the result of different methodologies. As an example, To *et al.* (2013) find no relationship in Australia but Narayan & Smith (2005) show that changes in real income have an impact on electricity consumption.

2.2 Energy use and economic growth

Stern (2010) argues that energy plays an important role in economic growth as production should be seen as a function of capital, labour and energy. Traditionally it is only seen as a function of capital and labour. However, energy is required to power industrial processes and to produce goods, equipment and services in the majority of productive sectors within an economy. The provision of energy is also strongly associated with improved human development (Bergasse *et al.*, 2013).

Economic growth requires the availability of energy, but the nature of the relationship between energy and economic growth is unclear. We now examine the empirical evidence that links energy with economic growth and assess the existence and direction of any causal relationship between the two.

2.2.1 Developing country studies

Asia

Morimoto & Hope (2001) analyse the impact of electricity supply on economic growth in Sri Lanka. The study looks at the period from 1971 to 1995, using the country's annual electricity production and annual GDP growth rate. The model finds that GDP growth increases electricity supply and vice-versa.

Asafu-Adjayel (2010) assesses the relationship between energy consumption and economic growth in India, Indonesia, the Philippines and Thailand. The study covers 1973 to 1995 for India and Indonesia and 1971 to 1995 for Thailand and the Philippines. It finds that for India and Indonesia, a change in energy consumption has an impact on incomes, whilst in Thailand and the Philippines, as well as energy consumption impacting incomes, incomes also impact energy consumption.

Atif & Siddiqi (2010) examine the link between electricity consumption and GDP in Pakistan between 1971 and 2007. The study finds that an increase in the use of electricity in Pakistan leads to an increase in economic growth. The paper suggests that the slowdown in electricity consumption within the country has hindered economic growth. Growth in energy consumption fell from 7.6 per cent in 2006/2007 to 0.9 per cent in 2007/2008, and the paper suggests this slowdown has led to a decrease in GDP growth from 6.7 per cent in 2006/2007 to 4.1 per cent in 2007/2008.

Shaari *et al.* (2013) not only assess the link between economic growth and energy consumption, but also look at the role of population growth in Malaysia between 1991 and 2011. The study concludes that population growth affects energy consumption, which in turn affects economic growth.

Lau *et al.* (2011) analyse 17 Asian countries from 1980 to 2006, and examine primary energy consumption and GDP growth. The study finds that there is no long-term link from energy consumption to GDP, but there are some significant short-term links from energy consumption to GDP. There are also long-term links from GDP growth to energy consumption.

Binh (2011) assesses the relationship between energy consumption and economic growth in Vietnam between 1976 and 2010. The paper finds that GDP growth increases energy use.

Bin Amin & Rahman (2011) investigate the relationship between energy and output in Bangladesh between 1973 and 2007. The study finds that economic growth leads to higher energy use. The study states that in Bangladesh, economic growth causes the expansion of the industrial and commercial sectors which in turn causes increased energy consumption.

Africa

Wolde-Rufael (2006) analyses 17 African countries from 1971 to 2001 to assess the relationship between electricity consumption and real GDP (see Table 1 below). The study finds that:

- In five countries there is no link between electricity consumption and economic growth;
- In three countries electricity consumption has an impact on economic growth;
- In six countries economic growth has an impact on electricity consumption;
- In three countries economic growth has an impact on electricity consumption and vice-versa.

Table 1.
Energy – growth relationship results for 17 African countries

Country	Direction	Causality
Algeria	Neutral	–
Benin	EC ▶ EG	Positive
Cameroon	EG ▶ EC	Positive
Congo DR	EC ▶ EG	Positive
Congo, Rep.	Neutral	–
Egypt	EC ◀▶ EG	Positive
Gabon	EC ◀▶ EG	Positive from EG ▶ EC Negative from EC ▶ EG
Ghana	EG ▶ EC	Positive
Kenya	Neutral	–
Morocco	EC ◀▶ EG	Positive
Nigeria	EG ▶ EC	Positive
Senegal	EG ▶ EC	Positive
South Africa	Neutral	–
Sudan	Neutral	–
Tunisia	EC ▶ EG	Negative
Zambia	EG ▶ EC	Positive
Zimbabwe	EG ▶ EC	Positive

Note: EG = Economic Growth; EC = Electricity Consumption; a ▶ denotes unidirectional causality, whilst a ◀▶ denotes bidirectional causality

Source: Wolde-Rufael (2006)

Wolde-Rufael (2009) re-examines the analysis in Africa, looking again at 17 African countries from 1971 to 2004, but this time considering the impact of capital and labour. The analysis shows that whilst energy influences economic growth within these countries, it is just a contributing factor, with capital and labour being the most important factors.

Menyah & Wolde-Rufael (2010) assess the link between energy consumption and economic growth in South Africa. The study covers the 1965 to 2006 period and also looks at the impact of labour and capital. The study finds that an increase in energy consumption leads to an increase in economic growth.

Odihambo (2010) examines the relationship between energy consumption, energy prices and economic growth in South Africa, Kenya and the Democratic Republic of Congo (DRC) between 1972 and 2006. The study finds that an increase in energy consumption leads to economic growth in South Africa and Kenya whilst economic growth leads to an increase in energy consumption in the DRC. The study also finds that in Kenya, energy prices influence economic growth whilst in the DRC, energy use influences energy prices.

Adebola (2011) investigates the relationship between electricity consumption and real GDP in Botswana from 1980 to 2008. The paper tests a model where economic growth is a function of capital, labour and electricity. The paper finds that long-term increases in energy consumption are associated with increases in real GDP. It also finds that capital formation has an impact on real GDP. The paper speculates that as the economy of Botswana is highly dependent on energy, the ability of capital to positively influence economic growth is partly determined by the availability of adequate energy within the country.

Adom (2011) assesses the link between electricity consumption and economic growth in Ghana between 1971 and 2008. The study states that Ghana's most productive sectors – agriculture and services – are not energy intensive, and the industrial sector – which theoretically links electrical consumption to economic growth – has been in decline. As a result, electricity consumption has not been a driver of economic growth, and instead economic growth has led to greater electricity consumption.

Eggoh *et al.* (2011) provide empirical evidence on the relationship between energy consumption and economic growth in 21 African countries between 1970 and 2006. The study finds that a change in energy consumption has an impact on economic growth, and equally a change in economic growth has an impact on energy consumption.

Fowowe (2012) analyses 14 sub-Saharan African countries from 1971 to 2004. The paper finds that for all countries, changes in energy consumption have an effect on economic growth, and changes in economic growth impact the demand for energy.

Ziramba's analysis (2013) is more specific as it seeks to understand the link between hydroelectricity, capital and economic growth. The study looks at this relationship in Algeria, Egypt and South Africa from 1980 to 2009. The study finds that in Algeria, changes in hydroelectricity consumption have an effect on economic growth, and changes in economic growth have an effect on hydroelectricity consumption. In Egypt, the study finds that hydroelectricity and economic growth are not linked whilst in South Africa a change in economic growth leads to a change in hydroelectricity consumption.

Dlamini *et al.* (2013) examine the relationship in South Africa from 1971 to 2009. The analysis finds that from 2002 to 2003 and from 2005 to 2006, a change in electricity consumption leads to a change in GDP. In other periods of time, electricity consumption and GDP are not linked. The paper presumes that the two exceptional periods correspond to periods of particular economic significance within the country's electricity market where increases in electricity tariffs occurred. The paper states that in the two periods, growth in electricity consumption led to growth in GDP but the observed effect was negative due to increases in electricity prices.

Dogan (2014) assesses the relationship between energy consumption and economic growth in Kenya, Congo, Benin and Zimbabwe from 1971 to 2011. It finds that there is no causal relationship in Congo, Benin and Zimbabwe, whilst in Kenya changes in energy consumption led to changes in economic growth.

Middle East and North Africa (MENA)

Nonejad & Fathi (2014) survey the relationship between energy consumption and economic growth in Iran from 1971 to 2009. The study finds changes in energy consumption have an effect on economic growth and changes in economic growth impact the demand for energy.

Shaheet (2014) examines the relationship between energy consumption and economic growth in 17 Arab countries, from 1980 to 2011. The study finds no link between the two in 16 of the 17 countries except for Kuwait, where changes in energy consumption led to changes in GDP growth.

Bouoiyour & Selmi (2012) examine the link between electricity consumption and economic growth in the MENA countries between 1975 and 2010. The study finds mixed results. In two countries, there is no relationship between economic growth and energy consumption. In five countries, changes in economic growth have an impact on energy consumption, and changes in energy consumption affect economic growth. In two countries, a change in energy consumption leads to a change in economic growth. And in three countries, a change in economic growth leads to a change in energy consumption.

Abid & Sebri (2012) look at Tunisia from 1980 to 2007. The paper evaluates the relationship between energy consumption and economic growth for Tunisia's total economy as well as for the transport, industrial and residential sectors. At the total economy level, results show that energy can be a limiting factor to economic growth and economic growth spurs increased energy use. For individual sectors results vary.

Other countries

Kalyoncu *et al.* (2013) examine the relationship between GDP and energy consumption in Georgia, Azerbaijan and Armenia between 1995 and 2009. The paper finds that there is no relationship between GDP and energy consumption in Georgia and Azerbaijan but that in Armenia, GDP has an impact on energy consumption.

Campo & Sarmiento (2013) assess the relationship between energy consumption and GDP in 10 Latin American countries between 1971 and 2007. The study finds that for all countries, an increase in energy consumption leads to an increase in GDP, and an increase in GDP leads to an increase in energy consumption. The paper states that these results are broadly similar to those found by Narayan *et al.* (2010) and Lee (2005) who ran similar tests on Latin American countries.

Chontanawat *et al.* (2006) assess the link between energy use and GDP, using a set of 30 OECD and 78 non-OECD countries. The data for OECD countries covers 1960 to 2000 whilst the data for non-OECD countries covers 1971 to 2000. The paper then uses Human Development Indicator data to rank the development of countries. The paper finds that energy has an impact on economic growth, and economic growth has an impact on energy, in both OECD and non-OECD countries. However, these links are more prevalent in OECD and high-development countries.

Table 2.
Energy – growth relationship in OECD/non-OECD countries

Country Type	Energy to Growth Casualty	Growth to Energy Casualty
OECD	70%	57%
Non OECD	46%	47%
High development	69%	56%
Middle development	42%	51%
Low development	35%	29%

Source: Chontanawat *et al.* (2006)

Adhikari & Chen (2011) examine the relationship between energy consumption and economic growth in 80 developing countries[1] between 1990 and 2009. The study finds that there is a strong long-term relationship between energy consumption and economic growth in developing countries.

1 Including upper middle income, lower middle income and low income countries – based on World Bank classifications

2.2.2 Developed country studies

Ciaretta & Zarraga (2006) investigate the link between electricity consumption and economic growth in Spain from 1971 to 2005. They find that an increase in electricity consumption leads to an increase in GDP. Ucan *et al.* (2014) examine the relationship between energy consumption and economic growth in 'developed' European countries between 1990 and 2011. The report considers 15 countries in the EU, concluding that an increase in non-renewable energy consumption has an impact on economic growth.

Archibong (2011) examines the role energy consumption plays in economic growth in China between 1971 and 2008. The paper finds that increases in GDP lead to increases in energy consumption whilst changes in energy consumption have no impact on economic performance. This suggests that China's economic growth is not determined by the amount of energy consumed within the country, but that increases in energy consumption occur as a result of economic growth. The results contrast with analysis by Shiu & Lam (2004) who found in a previous study that electricity consumption influenced real GDP in China.

Taking a different approach, Ladu & Meleddu (2014) assess whether there is a relationship between energy consumption and total factor productivity (TFP). This approach allows energy consumption to be linked to technological change. The paper looks at the link in Italy from 1996 to 2008 and finds that when energy consumption increases so does TFP.

To *et al.* (2013) look at the link between energy and economic growth in Australia from 1970 to 2011. They find that there is a weak relationship between energy consumption and economic growth in the country. On the other hand, a previous study on Australia by Narayan & Smith (2005) shows that real income affects electricity consumption.

2.3 Energy use and employment

Whilst the section below is limited to research that seeks to understand whether there is a causal relationship between energy and employment, a brief overview of the theoretical relationship between the two variables may still be useful.

There are a number of theoretical effects that can link increased employment and energy consumption; these include the demographic, income, price, substitution and technology effects (Arouri *et al.*, 2014).

Box 2.
Energy consumption and employment effects

- **Demographic effect:** can affect either energy consumption or employment i.e. a rising population will have a greater demand for energy, whilst a greater number of workers entering the work force may result in more energy required.
- **Income effect:** as an economy rapidly grows, increased employment will increase incomes, resulting in higher domestic demand for goods and services – including higher demand for energy.
- **Price effect:** external shocks can effect energy sources such as coal and oil prices, which can have an impact on economic growth and subsequently, on employment.
- **Substitution effect:** constraints in energy availability can lead to substitution through increased labour use and vice-versa.
- **Technological effect:** the replacement of old energy technologies with new technologies can enhance employment although the extent of this impact can depend on a country's level of development.

2.3.1 Developing country studies

Ghosh (2009) assesses the relationship between electricity supply, employment and GDP in India between 1971 and 2006. The study shows that economic growth leads to increased electricity supply which in turn leads to increased employment. It states that growth in real GDP and the electricity supply in India are responsible for the high level of employment in the country.

Ziramba (2009) examines the relationship between energy consumption and industrial output in South Africa between 1980 and 2005. The paper finds that energy consumption has an impact on employment, and employment has an impact on energy consumption. However in the specific case of coal consumption, the relationship only works in one direction, with an increase in coal consumption leading to an increase in employment.

Odhiambo (2010b) examines the link between electricity consumption, economic growth and labour force participation in Kenya between 1972 and 2006. The study finds that electricity consumption has an impact on employment, but also that both electricity consumption and economic growth contribute to increased labour force participation in the country.

Bayat *et al.* (2011) look at the relationship between electricity consumption and employment within the manufacturing sector in Turkey between 1960 and 2005. Whilst the study finds that GNP has an impact on electricity consumption, it also finds that there is no relationship between electricity consumption and employment in the manufacturing sector. Polat & Uslu (2012) also examine the link between energy consumption and employment in Turkey from 2005 to 2010. Unlike the Bayat *et al.* (2011) study, the authors find that electricity consumption does have an impact on employment.

Leesombatipoon & Joutz (2011) assess the link between oil and the Thai economy between 1974 and 2007. The paper finds that in the short-term, when oil usage increases, labour within the country also increases. A similar study by Shahbaz & Dube (2012) on coal consumption in Pakistan between 1972 and 2009 finds that whilst coal consumption, capital use and labour participation have a positive effect on economic growth, there is no direct relationship between coal consumption and employment.

Gurgul & Lach (2011) evaluate the employment effects of energy consumption within Poland between 2000 and 2009. The study finds that energy consumption has an impact on employment and economic growth. In addition, it finds that economic growth has an impact on employment and vice-versa.

Zamani (2012) examines the link between energy consumption and employment in Iran between 1979 and 2009. The study finds that as employment increases so does energy consumption.

Arouri *et al.* (2014) assess the relationship between energy and employment across 16 African countries between 1991 and 2010. The study finds that:

- Employment has an impact on energy consumption in Tunisia, Cameroon, Zambia and Ethiopia;
- Energy consumption has an impact on employment in the DRC and Egypt;
- Energy consumption has an impact on employment, and employment has an impact on energy consumption in Algeria, Benin, Kenya, Mozambique and Tanzania;
- There is no link between energy consumption and employment in South Africa, Nigeria, Morocco, Ghana and Senegal.

Chang *et al.* (2001) assess the link between energy consumption and employment in Taiwan from 1982 to 1997. The study finds that energy consumption has an impact on employment, and employment has an impact on energy consumption. In addition, it finds that energy consumption has an impact on economic growth.

2.3.2 Developed country studies

Oxley *et al.* (2004) assess the relationship between energy consumption and employment in New Zealand between 1960 and 1999. The paper examines coal, oil, electricity and gas separately and finds that oil and electricity consumption has an impact on employment.

Narayan & Smyth (2005) assess the relationship between electricity consumption and employment in Australia between 1966 and 1999. The study finds that in the long term, employment has an impact on electricity consumption.

Payne (2009) examines the relationship between energy consumption and employment within the state of Illinois, USA between 1976 and 2006. The study shows that in the long-term, energy consumption has an impact on employment. Ewing *et al.* (2007) look at the same relationship for the whole of the USA between 2001 and 2005 but find that there is no link between energy consumption, as measured by coal consumption, and employment.

Magazzino (2013) assesses the causal relationship between energy demand, GDP and employment in Italy from 1970 to 2009. Whilst the study finds that GDP growth has an impact on electricity demand, and electricity demand has an impact on GDP growth, there is no link between employment and electricity demand.

2.4 Summary of results

The following section summarises the results of the literature review, first presenting a summary of the energy and economic growth studies and then a summary of the energy and employment studies.

2.4.1 Energy and growth

Eggoh *et al.* (2011) provide a good summary of studies on the relationship between energy and growth in developing countries (see table 3 below) up to about 2010. Table 4 then summarises the additional literature on developing countries reviewed within this paper.

Table 3.
Summary of previous studies on the relationship between energy and growth in developing countries[2]

Countries	Period	Direction	Paper
Nigeria Tanzania	1960-1984 1960-1981	EC ◀▶ EG EC ◀▶ EG	Ebohon (1996)
Philippines Thailand India Indonesia	1971-1995 1973-1995	EC ◀▶ EG EC ◀▶ EG EC ▶ EG EC ▶ EG	Asafu-Adjayel (2000)
Malawi	1970-1999	EC ◀▶ EG	Jumbe (2004)
18 developing countries	1975-2001	EC ▶ EG	Lee (2005)
19 developing countries	1971-2001	EG ▶ EC (6 countries) EC ▶ EG (3 countries) EC ◀▶ EG (2 countries) Neutral (9 countries)	Wolde-Rufael (2005)
Burkina Faso	1968-2003	EC ◀▶ EG	Ouedraogo (2010)
Ivory Coast Congo Ghana Cameroon Nigeria Kenya South Africa	1970-2007	EC ◀▶ EG EG ▶ EC EG ▶ EC Neutral Neutral Neutral Neutral	Esso (2010)
Bahrain, Kuwait, UAE, Oman, Qatar, Saudi Arabia	1960-2002	EG ▶ EC	Al-Iriani (2006)
20 energy importers and exporters	1971-2002	EC ◀▶ EG (developed) EC ▶ EG (developing, short run)	Mahadevan & Asafu-Adjaye (2007)
11 sub-Saharan countries	1980-2003	EG ▶ EC (6 countries) Neutral (5 countries)	Akinlo (2008)
82 low, middle and high income countries	1960-2001	EG ▶ EC (middle/high Income countries) Neutral (low income countries)	Huang *et al.* (2008)
Tanzania	1971-2006	EC ▶ EG	Odhiambo (2009)
6 Latin American countries	1991-2005	EC ▶ EG	Apergis & Payne (2009)
51 low and middle income countries	1971-2005	EC ▶ EG (low income countries) EC ◀▶ EG (middle income countries)	Ozturk, Asian & Kalyoncu (2010)

Note: EG = Economic Growth; EC = Electricity/Energy Consumption; a ▶ denotes unidirectional causality, whilst a ◀▶ denotes bidirectional causality

Source: Eggoh *et al.* (2011)

2 Papers in the table are not provided in the bibliography as the table was adapted from Eggoh *et al.* (2011) and can be found in the original paper's bibliography

Table 4.
Summary of reviewed studies on energy and growth in developing countries

Countries	Period	Direction	Extra information	Paper
Algeria Egypt South Africa	1980-2009	EC ◀▶ EG Neutral EG ▶ EC	Feedback between electricity consumption and economic growth	Ziramba (2013)
Bangladesh	1973-2007	EG ▶ EC	–	Bin Amin & Rahman (2011)
Botswana	1980-2008	EC ▶ EG	Energy consumption leads to economic growth, but is also affected by capital formation	Adebola (2011)
China	1971-2008	EG ▶ EC	–	Archibong (2011)
Kenya DRC South Africa	1972-2006	EC ▶ EG EG ▶ EC EC ▶ EG	Results apply both in short and long term	Odhiambo (2010)
Kenya Congo Benin Zimbabwe	1971-2011	EC ▶ EG Neutral Neutral Neutral	Causality only in Kenya	Dogan (2014)
Ghana	1971-2008	EG ▶ EC	Declining industry has led to decreased importance of electricity	Adom (2011)
Georgia, Azerbaijan and Armenia	1995-2009	EG ▶ EC (Armenia)	No relationship in Georgia and Azerbaijan	Kalyoncu *et al.* 2013
Iran	1971-2009	EC ◀▶ EG	Both long-term and short-term bidirectional causality	Nonejad and Fathi (2014)
India Indonesia Philippines	1973-1995 1973-1995 1971-1995	EC ▶ EG EC ▶ EG EC ◀▶ EG	Per capita income used in lieu of GDP	Asafa-Adjayel (2010)
Thailand	1971-1995	EC ◀▶ EG		
Malaysia	1991-2011	EC ▶ EG	Population growth affects energy consumption, which in turn affects growth	Shaari *et al.* (2003)
Pakistan	1971-2007	EC ▶ EG	–	Atif & Siddiqi (2010)
Sri Lanka	1954-1997	EC ◀▶ EG	1 MWh leads to between Bangladeshi Rs 88,000 to Rs 137,000	Morimoto & Hope (2001)
South Africa	1965-2006	EC ▶ EG	–	Menyah & Wolde-Rufael (2010)
South Africa	1971-2009	None	Neutral, except between 2002 and 2003 and 2005 and 2006 where it was unidirectional causal EC ▶ EG	Diamini *et al.* (2013)
Tunisia	1980-2007	EC ◀▶ EG	–	Abid & Sebri (2013)
Vietnam	1976-2010	EG ▶ EC	–	Binh (2011)
21 African countries	1970-2006	EC ◀▶ EG	–	Eggoh *et al.* (2011)
14 sub-Saharan African countries	1971-2004	EC ◀▶ EG	–	Fowowe (2012)
17 African countries	1971-2001	EC ▶ EG (5 countries) EG ▶ EC (6 countries) EC ◀▶ EG (3 countries)	Neutrality for 5 countries.	Wolde-Rufael (2006)

Table 4.
Summary of reviewed studies on energy and growth in developing countries (continued)

Countries	Period	Direction	Extra information	Paper
17 African countries	1971-2004	Neutral	Energy is a contributing factor to GDP growth, but capital and labour are more important	Wolde-Rufael (2006)
80 developing countries	1990-2009	EC ◀▶ EG	–	Adhikari & Chen (2011)
30 OECD & 78 non-OECD countries	1971-2000	EC ◀▶ EG	Bidirectional causal link between energy use and growth, more prevalent in OECD/High Income countries	Chontanawat *et al.* (2006)
17 Arab countries	1980-2011	EC ▶ EG (Kuwait)	Neutral for 16 out of 17 countries	Shaheet (2014)
12 MENA countries	1975-2010	EC ▶ EG (2 countries) EG ▶ EC (3 countries) EC ◀▶ EG (5 countries)	Neutrality for 2 countries	Bouoiyour & Selmi (2012)
17 Asian countries	1980-2006	EG ▶ EC	No long-run causal relationship between energy consumption and economic growth but some evidence of short-run relationships. Long-run relationship from economic growth to energy consumption	Lau *et al.* (2011)
10 Latin American countries	1971-2007	EC ◀▶ EG	Positive bidirectional causality	Campo & Sarmiento (2013)

Note: EG = Economic Growth; EC = Electricity/Energy Consumption; a ▶ denotes unidirectional causality, whilst a ◀▶ denotes bidirectional causality

Table 5 attempts to summarise the results, based on the four different energy – economic growth hypotheses. Some studies contain multiple countries and may not provide results for individual countries. Therefore, the table counts results for individual countries where they are given and counts multiple countries as a single result where they are not given.

Overall, there is no prevailing hypothesis. However more than three quarters of the studies find a positive correlation between energy use and economic growth, and half the studies find a positive and significant causal link from energy use to economic growth.

Table 5.
Energy – growth hypotheses prevalence

Hypothesis	Causal Direction	No. of Instances	% of Instances
Conservation Hypothesis	EG ▶ EC	33	29
Growth Hypothesis	EC ▶ EG	26	23
Feedback Hypothesis	EC ◀▶ EG	30	26
Neutrality Hypothesis	Neutral	25	22

Note: EG = Economic Growth; EC = Electricity/Energy Consumption; a ▶ denotes unidirectional causality, whilst a ◀▶ denotes bidirectional causality

2.4.2 Energy and employment

Table 6 provides a summary of the energy and employment literature reviewed in this paper.

Table 6.
Summary of reviewed energy and employment studies

Countries	Period	Direction	Extra information	Paper
Iran	1979-2009	EL ▶ EC	–	Zamani (2012)
India	1971-2006	EC ▶ EL	Unidirectional causality from growth to energy consumption to employment	Ghosh (2009)
Kenya	1972-2006	EC ▶ EL	Also unidirectional causality from EC ▶ EG and EG ▶ EL	Odhiambo (2010b)
Pakistan	1972-2009	Neutral	Coal usage instead of total energy or electricity. Coal consumption (with capital use and labour participation) affects growth i.e. EC ▶ EG	Shahbaz & Dube (2012)
Thailand	1974-2007	EC ▶ EL	Oil usage instead of total energy or electricity	Leesombatipoon & Joutz (2011)
Turkey	1960-2005	Neutral	Limited to manufacturing sector, also finds EC ▶ EG	Bayat *et al.* (2011)
Turkey	2005-2010	EC ▶ EL	Short study timeframe may limit robustness	Polat & Uslu (2012)
South Africa	1980-2005	EC ◀▶ EL (energy) EC ▶ EL (coal)	Bidirectional causality between oil consumption and industrial production. Bidirectional causality between energy consumption and employment, but for coal is it unidirectional from coal consumption to employment.	Ziramba (2009)
16 African countries	1991-2010	EL ▶ EC (4 countries) EC ▶ EL (2 countries) EC ◀▶ EL (5 countries)	Neutral (no causality) in 5 countries including South Africa, Nigeria & Morocco.	Arouri *et al.* (2014)
New Zealand	1960-1990	EC ◀▶ EL	Also bidirectional causality between employment and growth	Oxley *et al.* (2004)
Italy	1970-2009	Neutral	No causality for employment but finds EC ▶ EG	Magazzino (2013)
Poland	2000-2009	EC ▶ EL	Also finds EL ◀▶ EG and EC ▶ EG	Gurgul & Lach (2011)
Australia	1966-1999	EL ▶ EC	Also unidirectional relationship from income to employment	Narayan & Smyth (2005)
Taiwan	1982-1997	EC ◀▶ EL	Also finds EC ▶ EG	Chang *et al.* (2001)
USA (Illinois)	1976-2006	EC ▶ EL	–	Payne (2009)
USA	2001-2005	Neutral	Coal usage instead of total energy or electricity. Also finds EC ▶ EG	Ewing *et al.* (2007)

Note: EL = Employment; EG = Economic Growth; EC = Electricity/Energy Consumption; a ▶ denotes unidirectional causality, whilst a ◀▶ denotes bidirectional causality

Table 7 summarises the results, based on the four different energy – employment hypotheses. It shows that whilst there is not one dominant hypothesis, the growth and feedback hypotheses are more prevalent than the conservation and neutrality hypotheses.

Table 7.
Energy – employment hypotheses prevalence

Hypothesis	Casual Direction	No. of Instances	% of Instances
Conservation Hypothesis	EL ▶ EC	6	22
Growth Hypothesis	EC ▶ EL	9	33
Feedback Hypothesis	EC ◀▶ EL	8	30
Neutrality Hypothesis	Neutral	4	15

Note: EL = Employment; EC = Electricity/Energy Consumption; a ▶ denotes unidirectional causality, whilst a ◀▶ denotes bidirectional causality

2.5 Conclusions

This section has reviewed the available statistical studies that look at the causal relationship between energy and economic growth as well as between energy and employment. The review shows that:

- Academic studies propose four different energy and economic growth/employment hypotheses. These are the 'conservation hypothesis' (higher economic growth/employment leads to increased energy use), the 'growth hypothesis' (increased energy use leads to higher economic growth/employment), the 'feedback hypothesis' (energy and economic growth/employment mutually affect one another) and the 'neutrality hypothesis' (there is no link between energy and economic growth or employment).
- There is no one dominant prevailing theory. However, in most cases there is a causal relationship between energy and economic growth, as the conservation, growth and feedback hypotheses combined are much more prevalent that the neutrality hypothesis. Depending on the country, the link is either unidirectional or bidirectional.
- Similar conclusions can be drawn for the energy and employment relationship. There is a causal link between energy consumption and employment; however there is no prevailing evidence of the direction of causality between the two.
- We can interpret this to mean that in most cases energy and economic growth are closely linked i.e. increased use of energy leads to increased economic growth, or increased economic growth requires higher energy consumption. Energy use is either the cause or the facilitator of economic growth. Either way, energy use plays a fundamental part in economic growth.
- Relationships between energy and economic growth can vary between countries, within countries, and within time periods.

3. The impact of electricity: evidence from growth diagnostics

The 'growth diagnostics and binding constraints' approach designed by Hausmann *et al*. (2005) has been used to assess which factors are binding constraints to economic growth. This country–specific approach is a more detailed approach and complementary to the macroeconomic statistical approach of the previous section. This section reviews the extent to which growth diagnostics have identified electricity provision as a binding constraint to economic growth.

3.1 East Asia and Pacific

Ianchovichina and Gooptu (2007) perform growth diagnostics for Mongolia, and find that less than a quarter of the firms in the country view electricity supply as a major obstacle. Infrastructure is far from perfect, but firms seem much more dissatisfied with transport bottlenecks. Indeed, while in East Asia a day of electrical outage can lead to a production decline equivalent to 0.75 per cent of sales, in Mongolia the loss is equivalent to just 0.06 per cent of sales. This does not mean that electricity is not a priority, but at the time of the study, transport deficiencies were a more pressing constraint for growth.

ADB *et al*. (2010) conduct a growth diagnostics exercise for Indonesia. According to their study, firms consider electricity to be a major constraint to their operations. Indeed, several industries and manufacturers have to rely on private generators since electricity supplied by the state-owned electricity distribution company is not available or reliable. Self-generation of electricity is very expensive and not easy, especially for small and medium-sized enterprises.

Hang (2011) finds that electricity and gas in Cambodia experienced rapid expansion between 1999 and 2009, but the sector is still unable to meet the increasing demand of the population and businesses. The country still imports electricity from its neighbours. A large proportion of electricity production is generated from oil which means electricity tariffs are closely linked to petroleum prices. This means that the electricity cost for businesses is one of the highest in the region and the world. Although a number of hydropower projects and coal-fired plants have been developed across the country, the cost of electricity is expected to remain a significant constraint to businesses in the short and medium term.

ADB (2007) conduct a growth diagnostics study for the Philippines. Results show that the quality of electricity provision, which is behind most of the country's neighbours, is a critical constraint on growth.

Li *et al*. (2011) highlight that electricity is not a binding constraint for China, as the country has invested aggressively in power generation capacity since the 1990s.

3.2 Europe and Central Asia

Burkadze (2011) and Babych and Fuenfzig (2012) find that electricity supply is not a binding constraint for businesses in Georgia. Indeed, from 2003 to 2010, availability of electricity increased from around 8 hours per day to 24 hours, and domestic power generation from 6.9 TWh to 10.0 TWh. Power outages and use of generators are also low amongst businesses.

In the case of Kosovo, Sen and Kirkpatrick (2011) identify the lack of reliable electricity provision as the second binding constraint for business, after the cost and access to finance. This is confirmed by a more recent study by Mehmedi *et al*. (2012) which highlights that electricity is the most important constraint for businesses in the country. This is due to the fact that the frequency and cost of power outages in Kosovo are much higher than in comparable countries in the region and in the world. No new generation capacity has been installed since the 1980s.

Kuzmanovic and Sanfey (2014) examine the case of Serbia. The authors highlight that electricity infrastructure in the country is among the best in the region and is unlikely to represent a constraint for businesses. Instead, the main impediments are weak competition, a burdensome tax administration, restrictive labour regulations, and pervasive corruption.

Moore and Vamvakidis (2008) argue that the constraints in Croatia are mainly a weak business environment and excessive role of the state. Electricity is well developed compared to regional standards and does not represent a binding constraint on growth.

3.3 Latin America and the Caribbean

Hausmann and Klinger (2008) review the major constraints for Peru and although its infrastructure is not the best, power concerns rank low in the priority list for the country.

In the case of Argentina, Sánchez and Butler (2008) find that in 2004 the country had the cheapest electricity in Latin America, even though it imported energy from Brazil and Paraguay. At that time electricity was already a scarce good, and the low prices contributed to a lack of investment in the power grid by energy firms and consequently led to power outages and price increases in 2006. In turn, this severely affected the industry and electricity became a binding constraint.

A study by Calvo (2006) looking at Bolivia finds that continuous and unpredictable road blockages and uncertainty about enforcement of property rights have been the main obstacles to investment in power infrastructure. Inadequate electricity provision is a binding constraint for the country.

3.4 Middle East and North Africa

A study by Enders (2007) argues that in Egypt, electricity is cheap and highly subsidised. Consequently, power supply is not among the most binding constraints.

A joint report published in 2013 by the African Development Bank, the Government of Tunisia and the Government of the United States points to favourable indicators of electricity provision in Tunisia[3]. This is partly due to the fact that the national development strategies have focused on providing adequate electricity at reasonable costs. As a result, businesses do not perceive electricity supply as an obstacle to their development.

3.5 South Asia

In Bangladesh, electricity supply is considered a major constraint. Rahman and Yusuf report that power shortages were so chronic that the issue deserved to be widely discussed in the 2008 general election. The media ranked the deficient electricity supply as a bigger threat to the country's economy than the global financial crisis.

According to the Asian Development Bank (2009), the lack of affordable and reliable electricity supply in Nepal represents a major constraint for businesses and economic growth. This is confirmed by a 2014 paper by the Government of Nepal in collaboration with the United States Government and a number of key stakeholders, which finds that electricity and policy uncertainty are the biggest constraints to the country's growth[4]. Nepal accounts for the worst electricity shortages in South Asia, and in 2013 electricity supply was only able to meet just over half of estimated demand. The availability of electricity is further reduced by high losses in transmission and distribution. This creates significant costs for businesses which have to run expensive generators. The study suggests that for large businesses in Nepal, self-generation accounts for 40 per cent of electricity usage, and the cost of generator-produced electricity is about four times the cost of electricity from the grid.

Pakistan also has a deficient power supply. Qayyum *et al.* (2008) note that the country ranks 87th according to the Global Competitiveness Report 2006-07 on quality and development of electricity supply. It therefore represents a major bottleneck for growth.

3.6 Sub-Saharan Africa

In Africa, access to reliable and affordable energy is problematic. According to Ndulu *et al.* (2007), this is due to government failures and dominance of state-owned monopolies. These have led to inefficiencies such as the length of time it takes to get connected to a power grid and frequent power outages. As a consequence, business productivity declines and businesses have to bear high costs to get back-up facilities such as generators.

Lejarraga (2009) conduct a review of growth diagnostics in 15 African countries, and find that power supply is a binding constraint in Benin, Nigeria, Rwanda, Senegal, Uganda and Zambia. They also find that electricity provision will possibly be a binding constraint in the future in Malawi and Tanzania.

Ulloa *et al.* (2009) find that in the DRC, electricity is constrained in supply as well as in capacity. Along with government failures, it is the most important constraint for industries and manufacturers.

Lejarraga (2010) highlight that in Ghana, power deficiencies may become a major obstacle for businesses which are expanding and therefore have an increased demand for energy. This is confirmed by a paper produced by a joint United States Government – Government of Ghana technical team in 2011, which says that insufficient and unreliable power is recognised by firms in Ghana as the most important constraint to their growth[5].

A World Bank report (2008) finds that expensive, unreliable or unavailable electricity is a major barrier for Kenyan businesses.

In Malawi, unreliable power is a binding constraint to business activities as well as a deterrent for investment in industries with a high demand for power (Lea and Hanmer 2009). The unreliable supply of electricity has been cited as one of the causes for cigarette manufacturer BAT to move its operations out of the country and for the failure of textile investments in the country.

Joint analysis by the Tanzanian and United States governments (2011) points out that power outages, limited power coverage, and a high degree of generator use represent a binding constraint for firms in Tanzania.

In Liberia, power supply is also recognised as a major obstacle to firm operations (Government of Liberia and United States Government, 2013). There are two power supply challenges for businesses. First, electricity is very expensive. High power tariffs are a consequence of the destruction of Liberia's hydroelectric dam and the diminished capacity of the Liberia Electricity Corporation. Second, the power supply is low and unreliable. As a consequence, businesses have to bear high costs to rely on generators and find it difficult grow.

3 The paper is available at: http://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Towards_a_New_Economic_Model_for_Tunisia_-_Identifying_Tunisia_s_Binding_Constraints_to_Broad-Based_Growth.PDF

4 The paper is available at: http://mof.gov.np/ieccd/pdf/Nepal_CA_report.pdf

5 The paper is available at: http://www.state.gov/documents/organization/202533.pdf

3.7 Conclusions

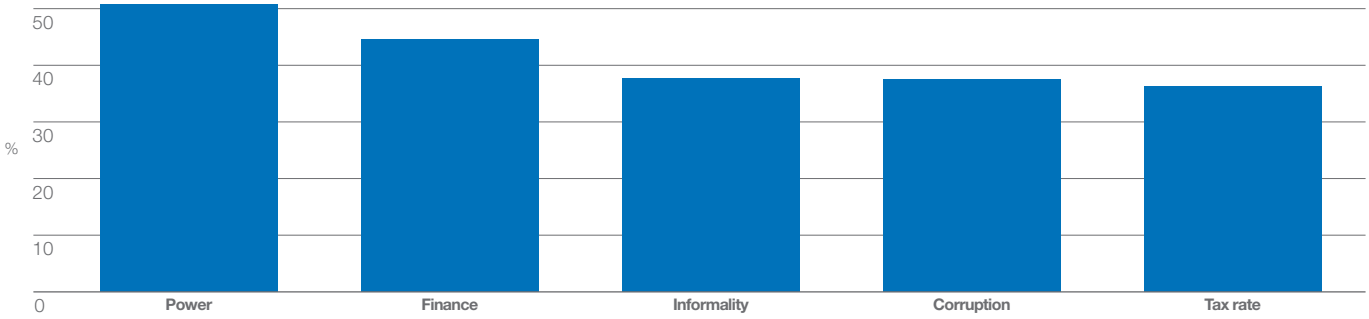
The reports we have reviewed[6] indicate that insufficient, unreliable or costly access to power is an important binding constraint in South Asia (Bangladesh, Nepal, and Pakistan). Insufficient and unreliable power supply is also a major obstacle to businesses in several sub-Saharan African countries (Benin, Nigeria, Rwanda, Senegal, Uganda, Zambia, Liberia, the DRC, and Kenya, among others), and it is likely to become a major constraint in countries such as Ghana. Evidence is more mixed in East Asia and Pacific (power supply is a constraint in Mongolia, Indonesia, Cambodia, and Philippines, but it is not a constraint in China), in Europe and Central Asia (electricity is a constraint in Kosovo, but it is not a constraint in Georgia, Serbia, and Croatia), and in Latin America and the Caribbean (power is a binding constraint in Argentina and Bolivia, but it ranks low among the most important constraints in Peru). In the Middle East and North Africa, power supply appears not to be a constraint in Egypt and Tunisia.

6 For the purposes of this study we reviewed a selected sample of papers on growth diagnostics and binding constraints. A list of additional papers on these issues available in the literature can be found at: http://www.hks.harvard.edu/fs/drodrik/GrowthDiag.html

4. The impact of electricity: evidence from business-level surveys

This section reviews the business-level evidence based on World Bank Group enterprise surveys, which survey a sample of an economy's private sector. This data reveals that in the overall sample we considered (108 countries), access to electricity is the top constraint for businesses (IEG 2014). Indeed, over 50 per cent of the interviewed African businesses identify electricity provision as a major or severe constraint, against 45 per cent and 38 per cent of businesses listing access to finance and informality respectively as their biggest constraint (Figure 2). Corruption and tax rate follow as the most important concerns.

Fig. 2
Percentage of African businesses facing major or severe constraints



Source: Adapted from IEG (2014)

As shown in Table 8, access to power is the top constraint for businesses of all sizes in terms of number of employees, i.e. micro, small, medium, large and extremely large firms.

Table 8.
Top five major or severe constraints facing businesses, by employee size

Number of employees	5-9	10-19	20-99	100-299	300+
1st obstacle	**Power**	**Power**	**Power**	**Power**	**Power**
2nd obstacle	Corruption	Corruption	Corruption	Tax rate	Worker skills
3rd obstacle	Tax rate	Tax rate	Tax rate	Corruption	Corruption
4th obstacle	Finance	Political Instability	Political Instability	Political Instability	Transportation
5th obstacle	Political Instability	Informality	Informality	Worker Skills	Tax rate

Source: Adapted from IEG (2014)

Looking at the different country income groups, access to power is the top constraint in low-income countries. In lower-middle income countries it is the second major or severe constraint facing businesses after corruption, while in upper-middle and high-income countries it comes third (Table 9).

Table 9.
Top five major or severe constraints facing businesses, by country income group

	Low Income	Lower-Middle Income	Upper-Middle Income	High Income
1st obstacle	**Power**	Corruption	Tax rate	Tax rate
2nd obstacle	Finance	**Power**	Corruption	Worker Skills
3rd obstacle	Tax rate	Political Instability	**Power**	**Power**
4th obstacle	Corruption	Crime, theft, disorder	Worker Skills	Political Instability
5th obstacle	Political Instability	Informality	Informality	Finance

Source: Adapted from IEG (2014)

From a regional perspective, power supply is a top five constraint for businesses in all regions. As shown in Table 10, in sub-Saharan Africa electricity provision represents the biggest concern for businesses, whereas in East Asia and Pacific and in South Asia it comes second only to corruption. On the other hand, in Europe and Central Asia, Latin America and the Caribbean, and the Middle East and North Africa, businesses consider other obstacles to be their top constraints, leaving access to power further down the list.

Table 10.
Top five major or severe constraints facing businesses, by region

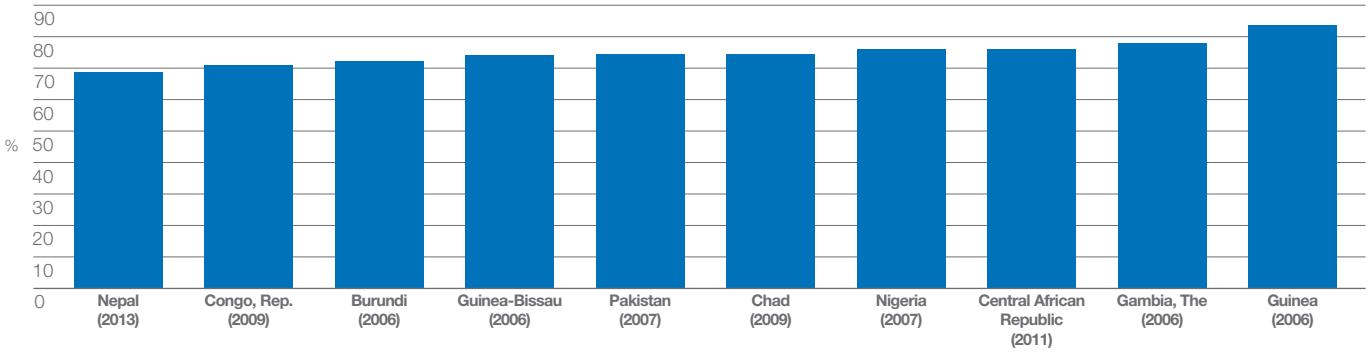
	Sub-Saharan Africa	East Asia and Pacific	Europe and Central Asia	Latin and Central America	South Asia	Middle East and North Africa
1st obstacle	**Power**	Corruption	Tax rate	Corruption	Political Instability	Corruption
2nd obstacle	Finance	**Power**	Political Instability	Skills	**Power**	Political Instability
3rd obstacle	Informality	Skills	**Power**	**Power**	Corruption	Land
4th obstacle	Corruption	Political Instability	Corruption	Tax rate	Finance	**Power**
5th obstacle	Tax rate	Tax rate	Worker Skills	Political Instability	Land	Informality

Source: Adapted from IEG (2014)

Eight out of the top ten countries where electricity is a major constraint for businesses are sub-Saharan African economies (Figure 3). Businesses in Guinea appear to be the most affected by the lack of reliable and sufficient electricity, followed by those in Nigeria, Central African Republic, and the Gambia. The only two non-African countries in the top-ten list are Pakistan and Nepal.

There are various reasons behind this bottleneck for businesses. They range from inadequate or non-existent power grids, to corruption and lack of maintenance. For example, in Nigeria, the long-term government monopoly and corruption contributed to the deterioration of the power grid, which in turn led to an increase in power shortages. In Pakistan, political instability continues to drain precious resources that could be channelled to infrastructure and used to improve the national power grid.

Fig. 3
Top ten countries with the highest percentage of businesses identifying electricity as a major constraint



Source: Authors' elaboration on the World Bank Group's enterprise surveys data

Finally, from an industry perspective and according to recent International Finance Corporation (IFC) analysis of enterprise survey data (IFC, 2013), unreliable access to power appears to be the second biggest obstacle for businesses operating in the manufacturing sector, after access to finance. In the retail sector it ranks third, and it is not among the top three constraints in the services sector (Table 11).

A number of country case studies carried out by the United Nations Industrial Development Organisation (UNIDO) with the assistance of the Centre for the Study of African Economies also confirm that electricity provision is a binding constraint for businesses in the manufacturing sector. In the case of Kenya, Söderbom (2001) reports that power shortages rank third among problems cited by businesses in the manufacturing sector. Power shortages are perceived as a more severe constraint by large businesses than by small businesses.

On the other hand, Malik *et al.* (2006) argue that in Nigeria, unreliable and irregular power supply is the most important bottleneck for manufacturers. Indeed, businesses in the manufacturing sector have mains electricity for less than three days per week and are forced to rely on expensive private generators. The study also finds that lack of power is a more binding constraint for small and micro businesses than for large businesses, since the former are not well connected to National Electric Power Authority (NEPA) officials and are usually unable to afford private generators.

Table 11.
Top three constraints, by industry

	Manufacturing	**Retail**	**Services**
1st obstacle	Finance	Finance	Finance
2nd obstacle	**Power**	Informality	Tax rate
3rd obstacle	Informality	**Power**	Informality

Source: Adapted from IFC (2013)

4.1 Conclusions

Enterprise surveys reveal that businesses of all sizes report electricity provision to be a binding constraint on the way they work, particularly those operating in the manufacturing sector. Electricity provision is of greater concern to businesses in low-income countries, and sub-Saharan Africa. In the latter, Guinea, Nigeria and the Central African Republic are the most affected by the lack of reliable and sufficient electricity.

5. The impact of electricity: evidence from power projects

The economic effects of power sector projects fall into four categories: direct, indirect, induced, and second-order effects.

Box 3.
Four kinds of economic effect

- **Direct:** jobs and output created by the construction and operation of a power station
- **Indirect:** jobs and output created by the suppliers of goods and services used in the construction and operation of a power station; plus additional jobs and output created in electricity transmission and distribution to consumers
- **Induced:** jobs and output arising from new workers spending their wages on local goods and services
- **Second order:** economy-wide jobs and output arising from the use of the additional electricity supplied

The additional electricity that is supplied by power sector projects results in what are known as 'second-order effects'. Although these second-order effects deliver a development impact, they have not routinely been estimated for individual projects. One reason for this has been the absence of a good methodology. Another reason is that investors have only recently been asked to account for the development impact of power sector projects. This section reviews the project-level evidence.

The IFC's jobs study reviews 35 studies in the energy sector. These indicate that energy projects can have a significant impact on employment, when the analysis looks beyond direct employment (IFC, 2013). These studies assess direct, indirect and induced effects, by estimating the ratio of direct, indirect, and induced jobs to direct jobs to estimate overall employment. The IFC review finds that studies estimating second-order effects are 'very scarce', citing only another IFC study, the Powerlinks study (IFC, 2012), as an example.

Similarly, Bacon and Kojima (2011) provide a review of power sector projects and a methodology for estimating their employment effects. Their review finds that studies do not go beyond direct, indirect, and induced effects. As is the case with the IFC review, very few of the studies reviewed by Bacon and Kojima are of projects in developing countries.

In the United States, the National Renewable Energy Laboratory (NREL) has developed 'Jobs and Economic Development Impact' models to estimate the impact of electricity generation and other energy sector projects. These models use an 'input-output' methodology to estimate local or state-level effects. Direct, indirect and induced effects are estimated and reported for construction and operation periods. These models are only suitable for comparing power plants with the same energy source. The NREL methodology does not estimate the second-order effects of the consumption of electricity.

Second-order effects are usually not estimated through macroeconomic assessments, as it is difficult for consumers to distinguish the electricity supplied by one power station from that of another.

The IFC (2013) hypothesises that the ratio of direct jobs to other types of jobs will generally be larger in developing countries than high-income countries because the economy is generally more labour intensive. However, the informal sector in developing countries is often significant, but not captured by the data sources used to estimate employment effects.

The purpose of power sector investments in developing countries also differs from high-income countries. Investment in high-income countries is more likely to replace obsolete plants or to improve the efficiency of existing plant, while in most low- and lower middle-income countries the purpose is to meet unmet and growing demand for electricity.

Only two studies appear to have estimated the second-order effects of the use of electricity in addition to the direct, indirect and induced effects included in other impact studies. These are a study of the construction and operation of a transmission line between Bhutan and India, and a study by ODI, for the Private Infrastructure Development Group, of a small hydropower plant in Uganda.

5.1 Powerlinks project

The Powerlinks study assesses the job creation of a transmission line project linking a hydropower plant in Bhutan with the grid in India. The 1,200 km transmission line supplies one buyer, the Power Grid Corporation of India Limited. The study estimates direct, indirect, induced and second-order effects. Second-order effects were identified due to an increase in the electricity supply and an improvement in the reliability of the supply. The second-order effects were estimated using both a 'vector error correction model', and by means of a 'step-by-step estimation model'. Multipliers used for the estimation of job creation in India were drawn from input-output tables. The study also relied on long-run time series data on employment and electricity consumption. For Bhutan, input-output tables were unavailable and a more qualitative approach was used. Induced and second-order jobs were found to be significantly higher in number than direct and indirect jobs.

5.2 Bugoye project

The study of the Bugoye small hydropower project by ODI (Scott *et al*., 2013) adapts the methodology used in the Powerlinks study. The project consists of construction and installation of a generation plant, which sells all of its electricity to the transmission company and the grid. However, the grid is also configured to limit supplies to the local network. The study uses a production function estimated from the most recent World Bank Enterprise Survey data and, in the absence of suitable input-output tables, estimates a multiplier using expenditure and employment data. Induced and second-order effects are found to be more significant than direct and indirect effects.

The Powerlinks and Bugoye studies identify a number of limitations which are related to the developing country context of the projects. The data sources used omit the informal sector, and the second-order effects may therefore be under-estimated. Input-output tables are not always available for developing countries, and if they are available they don't always reflect the reality of a dynamic economy.

The literature indicates that methods to estimate direct, indirect and induced effects are well-established, though with limitations in developing country contexts. However, there are limited attempts at estimating the second-order effects of individual power projects. Nonetheless, both the Powerlinks and Bugoye studies distinguish between, and consider the impact of, reliability and additional power.

6. A framework to track the employment effects of power projects

This section proposes a framework to help track the employment effects of power projects that will supply to a grid with adequate transmission and distribution infrastructure. The framework proposes four types of employment effects: direct, indirect, induced and second-order effects.

Direct employment effects:

During construction, jobs are created in the building and installation of the power station. These jobs can be significant though are likely to be short-term (around two-three years). The number of jobs and the period each lasts can be used to calculate the full-time equivalent jobs during construction and installation. Engineering, Procurement, Construction (EPC) contractors should readily be able to supply this information, including a breakdown of jobs by gender and skill level, and wages paid.

During the operation and maintenance of the power station, jobs are also created by the operating company. These jobs are longer-term, and may be higher-skilled, though typically will be fewer in number. These jobs can be monitored, using company records, for the life of the plant from commissioning to decommissioning. Again, this information should include a breakdown of jobs by gender and skill level, and remuneration.

Indirect employment effects:

During construction, jobs are created by the suppliers and sub-contractors to the companies building and installing the power station.

During operation and maintenance, jobs are created by suppliers to the company operating the power station. In the case of a thermal generation plant, this will include the suppliers of fuel, whether that is coal, oil, gas or biomass. Renewables projects typically require fewer indirect jobs.

Indirect jobs are also created during the transmission and distribution of electricity, and during the processing and disposal of waste from thermal generation.

The information required to calculate these indirect jobs could be obtained from the suppliers and buyers identified by the operating company. These companies could indicate the actual number of jobs associated with their provision of goods and services to the operating company, or their total workforce and the proportion of their turnover accounted for by sales to the operating company. As with direct jobs, this information should ideally include a breakdown of jobs by gender and skill level and wages.

Induced employment effects:

As a result of the direct and indirect jobs created during the construction and operation phases, there is the potential for increased wages to be spent on local goods and services.

The first step is to estimate the increase in income received by workers upon taking up these jobs. The new wages and salaries can be compared with sector averages to estimate a differential. If the wages and salaries of indirect jobs are not available, they can be estimated.[7]

The second step is to apply an employment multiplier to the additional income, assuming that income translates into local spending (i.e. no income is saved). Where available, input-output tables can be used to derive this multiplier.[8]

Second-order effects:

Electricity generated by the power station can have two effects. Firstly, effects due to improved reliability of electricity and secondly, effects due to an increase in electricity supplied to the grid. It is also necessary to distinguish between electricity consumption by businesses and consumption by residential consumers. For the sake of simplicity, we can assume negligible employment effects from electricity consumption by residential consumers.[9]

For businesses, the first step is to estimate the impact of power outages on sales. World Bank Enterprise Surveys can be used for this purpose. For example, power outages in Tanzania cost businesses around 15 per cent of annual sales, according to a 2013 survey of 813 firms.[10] Calculating the change in output per worker in response to a reduction in the duration of outages, coupled with data about sales losses due to outages, allows an estimate of employment effects from improved electricity reliability.

The proportion of businesses that experience an employment effect from reduced outages can be obtained from this analysis. The proportion of total additional power supplied to the grid by the power station can be estimated from power sector statistics. Together with the estimated multiplier and national employment statistics, these allow an estimate of the total second-order employment effects of the project.

Total employment effects:

The total employment effect of a power station project would be the sum of the estimated direct, indirect, induced and second-order effects. It can be expressed in terms of the total number of person years' employment created or a total number of full-time equivalent jobs.

7 For example, a differential between national average unskilled manufacturing wage rates and average agricultural incomes can be used to provide an approximation.

8 In the absence of input-output tables, a multiplier based on average household expenditure patterns can be used. The proportion of household expenditure spent on food, manufactures and services, combined with average sector ratios of employment to sales in agriculture, manufacturing and services, allows for the estimation of additional employment induced by the additional income from the jobs created.

9 In reality, there are employment effects from domestic use of power, such as the major growth of employment in the entertainment sector in Nigeria from increased television viewership.

10 World Bank Group Enterprise Surveys: http://www.enterprisesurveys.org/data/exploreeconomies/2013/tanzania. A regression of sales on capital and labour, including an indicator of the duration of outages, can be used to calculate the effects of outages on sales. A regression of sales per worker on capital and labour, including an indicator of the duration of outages, can be used to estimate the effects of outages on labour productivity.

7. Conclusion

This paper has reviewed evidence on the relationships between energy use, economic growth and employment. It has considered whether increased energy supply leads to economic growth, or whether economic growth leads to greater energy demand. If the provision of energy leads to economic growth, the channelling of more finance towards energy provision is likely to have a significant impact.

We first considered the statistical evidence. More than three quarters of the studies find a positive correlation between energy use and economic growth, and half the studies find a positive and significant causal link from energy use to economic growth. Energy is either the cause or the facilitator of growth and plays a fundamental part in economic growth. The literature also suggests that the causal relationships can vary between countries and within countries.

Country growth diagnostics provide further evidence. Insufficient, unreliable or costly access to power is recognised to be an important binding constraint in South Asia (Bangladesh, Nepal, Pakistan) and a major obstacle to firm operations in several sub-Saharan African countries (Benin, Nigeria, Rwanda, Senegal, Uganda, Zambia, Liberia, Democratic Republic of Congo, and Kenya, among others), and it is likely to become a major constraint in countries such as Ghana. Evidence is more mixed in East Asia and Pacific (power supply is a constraint in Mongolia, Indonesia, Cambodia, and Philippines, but it is not a constraint in China), in Europe and Central Asia (electricity is a constraint in Kosovo, but it is not a constraint in Georgia, Serbia, and Croatia), and in Latin America and the Caribbean (power is a binding constraint in Argentina and Bolivia, but it ranks low among the most important constraints in Peru). In the Middle East and North Africa, power supply appears not to be a constraint in Egypt and Tunisia.

World Bank enterprise surveys reveal that electricity provision is the most binding constraint for all sizes of business, especially those operating in the manufacturing sector. Electricity provision is of relatively greater concern to low-income countries and in sub-Saharan Africa, with Guinea, Nigeria and Central African Republic most affected by the lack of reliable and sufficient electricity.

References

Abid, M & Sebri, M (2012) 'Energy Consumption-Economic Growth Nexus: Does the Level of Aggregation Matter?', International Journal of Energy Economic and Policy, Vol. 2, No. 2, 2012.

ACEEE (nd.) 'How does energy efficiency create jobs?', Fact Sheet, ACEEE, available at: http://aceee.org/files/pdf/fact-sheet/ee-job-creation.pdf

ADB (2007) 'Philippines: Critical Development Constraints', Country Diagnostic Studies, Manila, Philippines: Asian Development Bank.

ADB, DFID, & ILO (2009) 'Nepal: Critical Development Constraints', Country Diagnostics Studies, Manila, Philippines: Asian Development Bank.

ADB, ILO & IDB (2010) 'Indonesia: Critical Development Constraints', Manila, Philippines: Asian Development Bank.

Adebola, SS (2011) 'Electricity Consumption and Economic Growth: Trivariate investigation in Botswana with Capital Formation', International Journal of Energy Economic and Policy, Vol. 1, No. 2, 2011.

Adhikari, D & Chen, Y (2012) 'Energy Consumption and Economic Growth: A Panel Cointegration Analysis for Developing Countries', Review of Economics & Finance, October 2012.

Adom, PK (2011) 'Electricity Consumption-Economic Growth Nexus: The Ghanian Case', International Journal of Energy Economic and Policy, Vol. 1, No. 1, 2011.

Akarca, AT & Long II, TV (1979) 'Energy & Employment: A Time-Series Analysis of the Causal Relationship', Resources and Energy 2, 1979.

Archibong, OD (2011) 'What is the relationship between energy consumption and economic growth in China?', University of Dundee, January 2011.

Arouri, EHM, Youseff, AB, M'Henni, H & Rault, C (2014) 'Exploring the Causality Links between Energy and Employment in African Countries', IZA DP No. 8296.

Asafu-Adjaye, J (2000) 'The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries', Energy Economics 22, 2000.

Aslan, T, Ari, A & Zeren, F (2013) 'The Impact of Electricity Consumption on Economic Development in Turkey: A Geographically Weighted Regression Approach', Siyaset, Ekonomi ve Yönetim Araştırmaları Dergisi, 2013, Yıl:1, Cilt:1, Sayı:1.

Atif, SM & Siddiqi, MW (2010) 'The Electricity Consumption and Economic Growth Nexus in Pakistan: A New Evidence'.

Babych, Y & Fuenfzig, M (2012) 'An Application of the Growth Diagnostics Framework: The Case of Georgia', ISET Policy Institute, Tbilisi, Georgia.

Bacon, R & Kojima, M (2011) 'Issues in estimating the employment generated by energy sector activities', World Bank Sustainable Energy Department, June 2011.

Bayat, T, Aydin, AF, Kayhan, S & Adiguzel, U (2011) 'Causality Analysis of Economic Growth, Electricity Consumption and Employment in Manufacturing Industry: Examples of Turkey', Akademik Fener.

Bergasse, E, Paczynski, W, Dabrowski, M & Dewulf, L (2013) 'The relationship between energy and socio-economic development in the Southern and Eastern Mediterranean', paper produced for the MEDPRO Project, 2013.

Bin Amin, S & Ataur Rahman, AFM (2011) 'Energy-Growth Nexus in Bangladesh: An Empirical Study', International Review of Business Research Papers, Vol. 7, No.2, 2011.

Binh, PT (2011) 'Energy Consumption and Economic Growth in Vietnam: Threshold Cointegration and Causality Analysis', International Journal of Energy Economics and Policy, Vol. 1, No. 1, 2011.

Bouoiyour, J & Selmi, R (2012) 'The nexus between electricity consumption and economic growth in MENA countries', MPRA Paper No. 50806, October 2013.

Breitschopf, B, Nathani, N & Resch, G (2011) 'Review of approaches for employment impact assessment of renewable energy deployment', Final Report, EID-EMPLOY, study commissioned by IEA-RETD.

Burkadze, E (2011), 'A growth diagnostic study for Georgia', Master of Economics Thesis Paper, available at: http://www.iset.ge/files/eter_burkadze.pdf

Calvo, S (2006), 'Applying the Growth Diagnostics Approach: the Case of Bolivia', Washington DC: The World Bank, available at: https://www.imf.org/external/np/seminars/eng/2006/growth/sc.pdf

Campo, J & Sarmiento, V (2013) 'The Relationship Between Energy Consumption and GDP: Evidence from a Panel of 10 Latin American Countries', Latin American Journal of Economics, Vol. 50, No. 2, November 2013.

Chang, T, Fang, W & Wen, L (2001) 'Energy consumption, employment, output and temporal causality: evidence from Taiwan based on cointegration and error-correction modelling techniques', Applied Economics, Vol. 33, Issue 8, 2001.

Chontanawat, J, Hunt, LC & Pierse, R (2006) 'Causality between Energy, Consumption and GDP: Evidence from 30 OECD and 78 Non-OECD Countries', SEEDS Discussion Paper, June 2006.

Ciaretta, A & Zarraga, A (2006) 'Electricity Consumption and Economic Growth: Evidence from Spain'.

Dlamini, J, Balcilar, M. Gupta, R & Inglesi-Lotz, R (2013) 'Revisiting the Causality between Electricity Consumption and Economic Growth in South Africa: A Bootstrap Rolling-Window Approach', University of Pretoria.

Dogan, E (2014) 'Energy Consumption and Economic Growth: Evidence from Low-Income Countries in Sub-Saharan Africa', International Journal of Energy Economics and Policy, Vol. 4, No. 2, 2014.

Eggoh, JC, Bangake, C & Rault, C (2011) 'Energy consumption and economic growth revisited in African Countries', CESifo Working Paper, Energy and Climate Economics, No. 3590.

Enders, K (2007) 'Egypt—Searching for Binding Constraints on Growth', IMF Working Paper: WP/07/57, Washington DC: International Monetary Fund.

Ewing, BT, Sari, R & Soytas, U (2007) 'Disaggregate energy consumption and industrial output in the United States', Energy Policy, Vol. 35, No. 2, 2007.

Fowowe, B (2012) 'Energy consumption and real GDP: Panel co-integration and causality tests for sub-Saharan African countries', Journal of Energy in Southern Africa, Vol. 23, No. 1, February 2012.

Ghosh, S (2009) 'Electricity supply, employment and real GDP in India: evidence from cointegration and Granger-causality tests', Energy Policy, Vol. 37, Issue 8, 2009.

Governments of Liberia and the United States of America (2013) 'Liberia Constraint Analysis', September 2013, available at: http://mof.gov.lr/doc/LIBERIA%20CONSTRAINTS%20ANALYSIS_FINAL%20VERSION.pdf

Governments of the United Republic of Tanzania and the United States of America (2011) 'Tanzania Growth Diagnostic Partnership for Growth (2011)', available at: http://www.state.gov/documents/organization/202534.pdf

Gurgul, H & Lach, L (2011) 'The interdependence between energy consumption and economic growth in the Polish economy in the last decade', MPRA Paper No. 52283, December 2013.

Hang, SC (2011) 'Searching for Binding Constraints on Growth Using Growth Diagnostic Approach: The Case of Cambodia', Cambodia Development Resource Institute.

Hausmann, R & Klinger, B (2008) 'Growth Diagnostics in Peru', CID Working Paper No. 181, Harvard University.

Hausmann, R, Rodrik, D & Velasco, A (2005) 'Growth diagnostics', Harvard University Working Paper, Harvard University.

Ianchovichina, E & Gooptu, S (2007) 'Growth Diagnostics for a Resource-Rich Transition Economy: The Case of Mongolia', Policy Research Working Paper No. 4396, Washington DC: The World Bank.

IEG (2014) 'The Big Business of Small Enterprises. Evaluation of the World Bank Group experience with targeted support to small and medium-size enterprises, 2006-12', March 2014, Independent Evaluation Group.

IFC (2012) 'Estimating Employment Effects of Powerlinks Transmission Limited Project in India and Bhutan', International Finance Corporation Development Impact Department.

IFC (2013) 'IFC Jobs Study. Assessing Private Sector Contributions to Job Creation and Poverty Reduction', January 2013, International Finance Corporation.

IRENA (2013) 'Renewable Energy Jobs: Status, Prospects & Policies, Biofuels and Grid-Connected Electricity Generation', IRENA NREL.

Kalyoncu, H, Gursoy, F & Gocen, H (2013) 'Causality Relationship between GDP and Energy Consumption in Georgia, Azerbaijan and Armenia', International Journal of Energy Economics and Policy, Vol. 3, No. 1, 2013.

Kraft, J & Kraft, A (1978) 'On the Relationship between Energy and GNP', Journal of Energy and Development, Vol. 3, 1978.

Kuzmanovic, M & Sanfey, P (2014) 'Diagnosing Growth Constraints in South-Eastern Europe: The Case of Serbia', European Bank for Reconstruction and Development Working Paper No. 167.

Ladu, MG & Meleddu, M (2014) 'Is there any relationship between energy and TFP? A panel cointegration approach for Italian regions'.

Lau, V, Chye, XH & Choong, CK (2011) 'Energy-Growth Causality: A Panel Analysis', Paper for the International Conference on Applied Economics, 2011.

Lea, N & Hanmer, L (2009) 'Constraints to Growth in Malawi', Policy Research Working Paper 5097, Washington DC: The World Bank.

Leesombatpiboon, P & Joutz, F (2011) 'A Multivariate Cointegration Analysis of the Role of Oil in the Thai Macroeconomy'.

Lejárraga, I (2009) 'Beyond the Financial Crisis: Critical Factors Binding Economic Growth. A Survey of African Growth Diagnostics', paper prepared for the African Economic Conference 2009, 'Fostering Development in an Era of Financial and Economic Crises', 11 – 13 November 2009, United Nations Conference Centre, Addis Ababa, Ethiopia, available at: http://www.uneca.org/sites/default/files/page_attachments/aec2009beyond-thefinancialcrisis.pdf

Lejárraga, I (2010) 'Roaring Tiger or Purring Pussycat: A Growth Diagnostics Study of Ghana', paper prepared for the session on 'Growth Diagnostics in Practice', Annual Meeting of the American Economic Association, 4 January 2010, Atlanta, USA, available at: http://www.hks.harvard.edu/fs/drodrik/Growth%20diagnostics%20papers/Growth%20Diagnostics%20Ghana_December%202009.pdf

Li, W, Mengistae, T & Xu, LC (2011) 'Diagnosing Development Bottlenecks. China and India', Policy Research Working Paper No. 5641, Washington DC: The World Bank.

Magazzino, C (2013) 'Electricity Demand, GDP and Employment: Evidence from Italy', Frontiers in Energy 8, 1, 2013.

Malik, A, Teal, F & Baptist, S (2006) 'The Performance of Nigerian Manufacturing Firms: Report on the Nigerian Manufacturing Enterprise Survey 2004', available at: http://www.gprg.org/pubs/reports/pdfs/2006-04-malik-teal-baptist.pdf

Mehmedi, M, Mehmeti, A, Gashi, L, Peja, D & Dell, T (2012) 'Kosovo Growth Diagnostic: Constraints Analysis', Pristina, Kosovo, available at: http://pdf.usaid.gov/pdf_docs/PA00JM3S.pdf

Menyah, K & Wolde-Rufael, Y (2010) 'Energy consumption, pollutant emissions and economic growth in South Africa', Energy Economics 32, 2010.

Moore, D & Vamvakidis, A (2008) 'Economic growth in Croatia: potential and constraints', Financial Theory and Practice, 32(1), pp. 1-28.

Morimoto, R & Hope, C (2001) 'The Impact of Electricity Supply on Economic Growth in Sri Lanka', Research Papers in Management Studies WP 24/2011.

Narayan, P & Smyth, R (2005) 'Electricity Consumption, Employment and Real Income in Australia', Monash University Department of Economics, Discussion Paper No. 08/03.

Ndulu, BJ, Chakraborti, L, Lijane, L, Ramachandran, V & Wolgin, J (2007) 'Challenges of African growth: opportunities, constraints, and strategic directions', Washington DC: The World Bank, available at: https://openknowledge.worldbank.org/bitstream/handle/10986/6656/399890PAPER0AF101OFFICIAL0USE0ONLY1.pdf?sequence=1

Nonejad, M & Fathi, S (2014) 'A survey of the causality relation between energy consumption and economic growth in Iran', International Journal of Management, Accounting and Economics, Vol. 1, No. 1, August 2014.

Odhiambo, NM (2010) 'Energy consumption, prices and economic growth in three SSA countries: A comparative study', Energy Policy 38, 2010.

Odhiambo, NM (2010a) 'Electricity consumption, labour force participation rates and economic growth in Kenya: an empirical investigation', Problems and Perspectives in Management, Vol. 8, Issue 1, 2010.

Oxley, L, Scrimgeour, F & Fatai, K (2004) 'Energy Consumption, Employment and the Kyoto Protocol in New Zealand: Searching for Causality' in: Pahl-Wostl, C. *et al.* (eds) Proceedings of the iEMSs Second Biennial Meeting: Complexity and Integrated Resources Management, International Environmental Modelling and Software Society, Ottawa, Canada, July 2004.

Payne, JE (2009) 'On the Dynamics of Energy Consumption and Employment in Illinois', Journal of Regional Analysis & Policy, Vol. 39, No. 2, 2009.

Polat, O & Uslu, EE (2010) 'Causality between Energy Consumption, Employment and Output in Turkey: Evidence from Monthly Data', Paper for the 7th Silk Road International Conference 2010.

Pueyo, A (2013) 'The Evidence of Benefits for Poor People of Increased Renewable Electricity Capacity: Literature Review', Institute of Development Studies.

Qayyum, A, Khawaja, I, & Hyder, A (2008) 'Growth Diagnostics in Pakistan', European Journal of Scientific Research, 24(3), pp.433-450.

Rahman, J and Yusuf, A 'Economic growth in Bangladesh: experience and policy priorities', available at: http://www.hks.harvard.edu/fs/drodrik/Growth%20diagnostics%20papers/Economic%20growth%20in%20Bangladesh%20-%20experience%20and%20policy%20priorities.pdf

Sánchez, G & Butler, I (2008) 'Competitiveness and Growth in Argentina: Appropriability, Misallocation or Disengagement?', Washington DC: Inter-American Development Bank, available at: http://www.hks.harvard.edu/fs/drodrik/Growth%20diagnostics%20papers/Argentina%20--%20competitiveness%20and%20growth.pdf

Scott, A, Darko, E, Seth, P & Rud, J-P (2013) Job Creation Impact Study: Bugoye Hydropower Plant, Uganda, report prepared for the Private Infrastructure Development Group.

Sen, K & Kirkpatrick, C (2011) 'A diagnostics approach to economic growth and employment policy in low income economies: The case of Kosovo', Journal of International Development, Vol. 23, Issue 1, pages 132–154, January 2011.

Shaari, MS, Rahib, HA & Rashid, IMA (2013) 'Relation among population, energy consumption and economic growth in Malaysia', The International Journal of Social Sciences, Vol. 13, No. 1, 2013.

Shahateet, MI (2014) 'Modelling Economic Growth and Energy Consumption in Arab Countries: Cointegration and Causality Analysis', International Journal of Energy Economics and Policy, Vol. 4, No. 3, 2014.

Shahbaz, M & Dube, S (2012) 'Revisiting the relationship between coal consumption and economic growth: cointegration and causality analysis in Pakistan', Applied Econometrics and International Development, Vol. 12, No. 1, 2012.

Söderbom, M (2001) 'Constraints and Opportunities in Kenyan Manufacturing: Report on the Kenyan Manufacturing Enterprise Survey 2000', available at: https://www.unido.org/fileadmin/user_media/Publications/Pub_free/Constraints_and_opportunities_in_Kenyan_manufacturing.pdf

Stern, D (1993) 'Energy and Economic Growth in the USA, A Multivariate Approach', Energy Economics 15, 1993.

Stern, D (2010) 'The Role of Energy in Economic Growth', CCEP Working Paper 3.10, October 2010.

To, H, Wijeweera, A & Charles, MB (2013) 'Energy Consumption and Economic Growth – The Case of Australia', Southern Cross University Business School, Australia.

Ulloa, A, Katz, F, & Kekeh, N (2009) 'Democratic Republic of the Congo. A study of binding constraints', available at: http://www.hks.harvard.edu/fs/drodrik/Growth%20diagnostics%20papers/DRC_Growth_Diagnostic.pdf

Wolde-Rufael, Y (2006) 'Electricity consumption and economic growth: a time series experience for 17 African countries', Energy Policy 34, 2006.

Wolde-Rufael, Y (2009) 'Energy consumption and economic growth: the African experience revisited', Energy Economics 31, 2009.

World Bank (2008) 'Kenya: Accelerating and Sustaining Inclusive Growth', Report No. 42844-KE, Washington DC.

Zamani, M (2012) 'Evaluating the Relationship between the Energy Consumption and the Macroeconomic Indicators', Research Journal of Environmental and Earth Sciences, Vol. 4, No. 12, 2012.

Ziramba, E (2009) 'Disaggregate energy consumption and industrial production in South Africa', Energy Policy Vol. 36, Issue 6, 2009.

Ziramba, E (2013) 'Hydroelectricity Consumption and Economic Growth Nexus: Time Series Experience of Three African Countries', European Scientific Journal, Vol. 9, No.1, 2013.

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