TI-UP Enquiry:

Job Creation Outcomes from Electricity Provision

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This paper presents the findings of a research exercise to establish the current consensus of any available literature on the methodologies for assessing job creation outcomes from the provision of electrical power, covering in particular developing countries.

The document is structured simply and introduced through a preface of the development context.

- Development Context
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- Economic Activity as a Proxy
- Human Development as a Proxy
- Correlation and Causation Analyses
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- Conclusions

DEVELOPMENT CONTEXT

The UK Department for International Development (DFID) is a primary facilitator of Overseas Development Aid (ODA) for poverty alleviation to the world's poor and developing countries and as such, DFID recognises that energy provision can be an effective vector by which to deliver ODA.

A strong correlation between the availability of electricity and the level of human social development has been acknowledged since at least 1895 with the electrification of Niagara Falls with alternating current (AC) technology invented by Nikola Tesla[1]. This awareness has been continued and developed upon since then and now forms a key arm of overseas development assistance. However, examining the benefits of human social development and extracting from that outcomes in terms of job creation is poorly understood and sometimes intangible, preventing the optimisation of a robust, transparent and replicable method of development assistance for this purpose.

This briefing paper seeks to introduce electrical power provision as a vector of international aid and techniques for judging its developmental benefits, in particular job creation as part of broader economic activity.

CURRENT UNDERSTANDING AND GAP ANALYSIS

The key requirement of electricity provision is usually for either the renewal of existing power capacity (as in developed, energy-secure nations), the consolidation of existing power capacity (as in transition nations), or the addition of new capacity. The addition of new electrical power capacity occurs in nearly all countries but is most pronounced in those attaining rapid economic growth such as middle-income and some developing countries. With one of three requirements usually driving the necessity for electrical power, assessing the job creation outcomes must be understood in context.

Given the scope of DFID's involvement in the facilitation of aid in the form of electricity provision, it is necessary to define the scope of this study to that of the provision of new electrical power capacity where it previously did not exist, and the consolidation of electricity to a quality at which reliable supply previously did not exist. Direct, and to a lesser extent, indirect job creation outcomes from

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[1] Tesla Memorial Society of New York, http://www.teslasociety.com/dctrip.htm/ (Retrieved 11th August 2010)

electricity provision are well understood; these are often costed into the operation life of the project and can be inferred with reasonable assumptions although the clarity becomes slightly more tenuous when considering tertiary jobs associated with a particular electrical power project (for example informal employment sectors). The most significant area of interest is that of job creation *enabled* by the supply of electricity where it otherwise would not have been possible. In the context of electricity renewal (in developed countries, say) this is less important and outside of DFID's interest area so has been excluded from the study boundaries. However, for consolidation and addition of new power capacity, the development outcomes in terms of job creation may be significant.

Fig 1 – Job creation from the provision of electricity is poorly understood at scales significant enough to stimulate economic activity

Electricity Requirement	Job creation		
	DIRECT (construction, O&M etc)	**INDIRECT** (consulting, finance, logistics etc)	**ENABLED** (services enabled by electricity provision)
RENEWAL of electricity supply to replace with superceding technologies, or end of life	Already accurately quantifiable at a project level	Reasonably quantifiable but uncertainty from boundary placement	Currently very poorly understood, likely to be negligible in developed economies unless there is technological change (e.g. green jobs)
CONSOLIDATION of electricity supply to improve security and reslience	Already accurately quantifiable at a project level	Reasonably quantifiable but uncertainty from boundary placement	Currently very poorly understood but important in transition and developing countries
ADDITION of new capacity where electricity supply did not previously exist	Already accurately quantifiable at a project level	Reasonably quantifiable but uncertainty from boundary placement	Currently very poorly understood but important in transition and developing countries

ROLE OF ELECTRICITY PROVISION

Electrical power can be deployed in a number of ways and configurations; typically this has been informed by spatial requirements for the supply of electricity to a population but other factors such as fuel costs and, in the case of nuclear power stations for example, environmental aspects also come into play. Current trends include geo-spatial mapping of population clusters[2] to estimate energy density from which to devise a supply strategy; in principle, one would infer that a dense settlement in an otherwise rural area would benefit from community micro-generation, whereas a settlement spatially distributed over a wider area would likely benefit from off-grid 'islanded' generation.

Compounding the complexity of electricity supply configuration are other issues such as resiliency of supply and fuel cost. In developing countries the default tends to be diesel generation, as noted by *Ekpo* (2009) citing the example of Nigeria that it is "running a generator economy with its adverse effect on cost of production". As a result, large rural populations in many developing countries have often meant that many people live outside the reach of any national grid and electricity provision, if any, is ad hoc and supplied by fuels which may be comparatively expensive (electricity from diesel generators, for example, costs around 60% more than grid electricity in many parts of the world).

In addition, adverse environmental implications may arise from the local combustion of fuels such as issues pertaining to air quality, greenhouse gas emissions, associated health impacts, waste flue treatment etc.

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[2] Modi Research Group, Columbia University http://modi.mech.columbia.edu/2010/04/finding-and-connecting-people-to-infrastructure-using-satellite-imagery-and-mathematical-modeling/ (Retrieved 11th August 2010)

BASIC FINDINGS

When considering the default of diesel generation in off-grid areas, the provision of electricity under the regime of adding new power capacity where otherwise there was none immediately presents itself with identifiable benefits. However, this is very poorly understood and articulated; in evaluating literature within the field, this study found only **one** allusion to the enabling of job creation as a result of energy provision. *Naude and McCoskey* (2000) evaluated the Spatial Development Initiative[3] (SDI) programme of South Africa, of which five projects were identified as involving an intervention in the electricity sector (as defined by UK SIC(92)[4]) at a cost of $415 million. Although job creation had been quantified for other sectoral interventions that for the electricity sector was omitted, recognising the difficulties in doing so. Quantified methodologies for assessing job creation in isolation as a direct consequence of electricity provision have not been found during the data collection phase of this preliminary study.

ECONOMIC ACTIVITY AS A PROXY

From the literature reviewed, it is apparent that whilst job creation is not singled out in isolation, a useful and common proxy for it appears to be the broader association with economic activity that is stimulated as a result of electricity provision. Indeed, *Drnovsek* (2004) asserts as much that small and medium-sized enterprises (SMEs) are 'close to being a synonym for job creation' in the European context at least. The measurement of increased activity of SMEs may be difficult to obtain and the extent of inferred job creation may be underestimated in developing countries because these typically operate as unregistered services within an informal economy, further clouding the impact of electricity provision on economic activity. Despite these uncertainties in data gathering, the general consensus seems to be that there is a relationship between electricity provision and economic activity. For example, in the context of additive electrification in Africa, *Ndebbio* (2006) argues that electricity supply drives the industrialisation process in Nigeria whilst *Adenikinju* (2005) qualifies this by citing the poor quality of Nigerian electricity supply as a reason for dampening the growth trajectory that industrialisation would otherwise have followed.

Anecdotally, such macroeconomic assertions are supported by ground-level investigations which depend on surveys such as those conducted in Ghana by *Elsworth* (2004). These kind of studies aim to construct end use profiles of electricity consumption in newly-connected communities, and reporting the marginal benefits such as the operation of lights for evening schooling, refrigeration for medicine storage, mobile phone charging for farmers in the field, and the provision of electricity to run sewing machines which developed into a cottage business in the villages of Kparepare and Dedesa Wireko. Thus the problem in evaluating job creation due to electricity provision, even using economic activity as a barometer, is that there exists a knowledge gap between case study-based evidence at a small scale and national-level indicators of economic development.

However, it should be recognised that simple connectivity does not entirely cover the issue when considering job creation from electricity provision; costs to consumers must be taken into account and this can be determined by policies at a national, regional and local scale. For example, the structure of a country's electricity market will influence the attractiveness of infrastructural investment and the mechanisms by which Independent Power Producers (IPPs) can feed into a national grid, as well as be dependent upon the harmonisation of tariffs, and the extent to which a recipient government is willing to underwrite capital power generation projects, to name a few factors. At a regional-scale, an evaluation of available natural resources is required as is transmission potential and at a local level, maintenance of substations, backup generators and other staffing costs can add significantly to the cost of electricity to the consumer. *Malzbender* (2005) ultimately summarises that schemes to deliver electricity, such as South Africa's National Electrification Programme, go beyond connectivity and ultimately depend on affordability and whether that electricity provision is significant enough to not only cover basic functions (i.e. sanitation and comfort) but also enable discretionary activities which may result in the procurement of other services.

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[3] The Spatial Development Initiative programme was set up in 1995 to restructure the economy and enhance employment creation in post-apartheid South Africa http://www.southafrica.info/doing_business/economy/development/sdi.htm (Retrieved 11th August 2010)

[4] The UK Standard Industrial Classification is used to classify economic activity. Electricity and water are counted within Section E http://www.statistics.gov.uk/methods_quality/sic/ (Retrieved 12th August 2010)

HUMAN DEVELOPMENT AS A PROXY

At a higher level is the reported co-benefit of an improved human development index (HDI) through the addition of electric power. *Pasternak* (2000) observes that electricity provision is strongly related to the HDI and that 19 of the 20 countries with an HDI<0.6 (i.e. low-medium human development) have a per capita electricity provision of less than 1,000 kWh/yr. By comparison, all countries ranked as high human development (HDI>0.9) have a per capita electricity provision of at least 4,000 kWh/yr. The World Energy Outlook (2004) devised the Energy Development Index as a parallel to the Human Development Index, incorporating energy poverty, contribution from modern fuels, progress in providing essential energy infrastructure and proportion of commercial energy consumption. The appropriateness of human development as a barometer of job creation from electricity provision is slightly less clear than it is for economic activity but *Pasternak's* (2000) and *Alam's* (1991) basing on statistical correlation at least suggests a relationship between the two.

Fig 2 – Electrical consumption greater than 4,000 kWhpp/yr does not result in significantly improved HDI whereas in countries whose per capita consumption is less than 1,000 kWhpp/yr, small increases in electrical provision results in drastically increased human development [Pasternak (2000)]

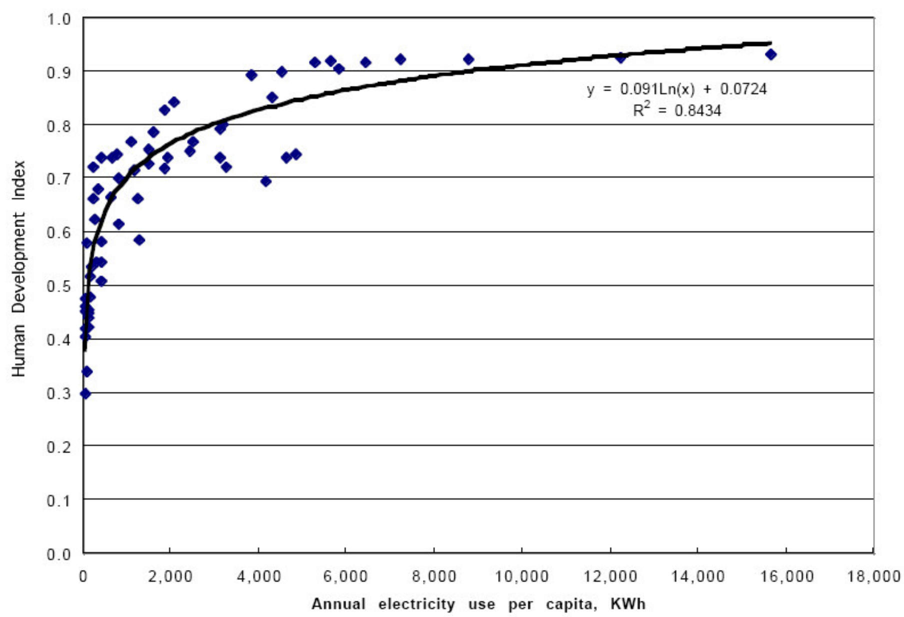
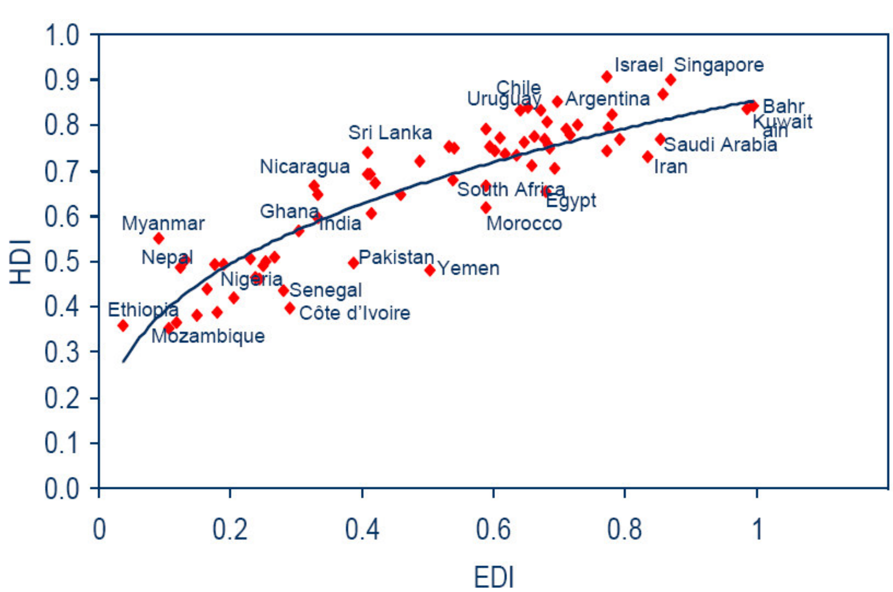


Fig 3 – The link between EDI and HDI is strong but non-linear, the pace of HDI improvement drops as EDI rises [IEA (2004)]



In addition, it can be seen from Fig 2 that if HDI is deemed to be a suitable proxy for job creation, then the greatest increase in that metric would occur in countries which are expanding its provision of electricity from a very small consumption base. This could then inform strategic direction on aid delivery across a portfolio of countries say – so whilst job creation at a project level may still be intangible, an overall feel of that metric via an increase in economic activity could be associated with it at a national level.

CORRELATION AND CAUSATION ANALYSES

Economic activity and HDI as a proxy measurement of job creation from electricity provision is treated in a variety of ways. A common preliminary method is establishing whether or not there is a correlation between electrical power provision and economic activity. *Alam et al.* (1991) correlated personal electricity consumption with quality of life data in 112 countries and found that this was a positive relationship. Checking that electricity provision and not total energy availability was in fact the dominant driver of the two in terms of economic activity, *Pasternak's* (2000) regression between electricity provision and HDI gave an $R^2 = 0.84$ compared to $R^2 = 0.81$ for the relationship between total energy consumption and HDI, showing marginally better agreement for the former relationship.

However, to simply demonstrate a relationship is limited when explaining the *mechanism* of electricity provision upon economic activity and human development which we use as indirect indicators of enabled job creation. Causality testing is a method used by economists and statisticians to understand, in this context, the directionality between electricity provision and economic growth – that is, which variable determines the other and if there are feedback effects between the two. Prior work in causality testing within this context has been undertaken by *Ghosh* (2002), *Wolde-Rufael* (2004) and *Yoo* (2005). There are two established methods in assessing the causal relationship between electricity provision and economic activity (taken broadly to mean GDP):

1. **Multivariate autoregression** which optimises how a basket of variables (electricity provision, labour, capital, technological change) will best organise itself to deliver the strongest causal relationship in terms of a probability (rather than just a regression analysis, as is used in correlation analyses)
2. **Bivariate simulation** which simulates the performance of one variable (electricity provision) against economic activity across a range of scenarios to observe the causal relationship under the specific endogenous/exogenous conditions of that scenario

Altinay and Karagol (2004) built upon the method of causality testing devised by *Granger*[5] (1988) to establish that there is a very small probability (P=0.0037) that electricity does not cause an increase in GDP (i.e. a very large probability that it does). *Altinay and Karagol* (2004) thus conclude that (in the case study of Turkey 1950-2000, at least) there is strong causality from electricity provision to real GDP from which we infer some degree of job creation.

Further causal analysis between electricity supply and economic development in Nigeria between 1970-2008 is undertaken by *Udah* (2010) who evaluates the feedback of industrial output *on* electricity provision under a multivariate autoregression regime and suggests a 4.5% increase in electricity provision for every 1% increase in industrial output. Finally, *Udah* (2010) establishes the causal relationship between electricity provision and labour (although this is not a quantification of the employment outcomes, rather a *quantification of the correlation* between the two – so is not reported in this study as a methodology for consideration). He concludes that it is a unidirectional relationship without feedback.

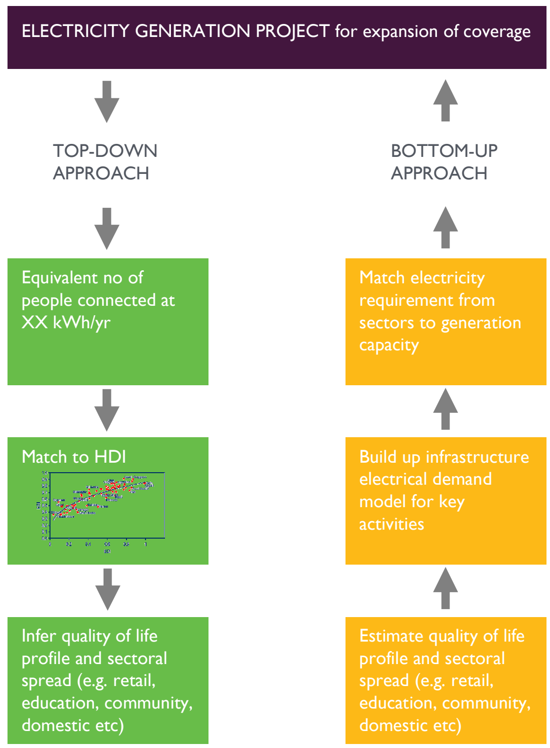
A summary of the probabilities of causal correlation from the studies in Nigeria 1970-2008 and Turkey 1950-2000 are provided in Fig 5.

[5] Without getting into detail, the Granger Representation Theorem is to the author's understanding, a mathematical procedure that draws a regression between the stochastic change in one variable with time and compares it to the other (or another in multivariate optimisation) then limits the other variable if a particular condition is met. This is so that two variables which are showing independent behaviour (i.e. are non-cointegrated) are not made to be dependent on each other. This means that each variable is discarded throughout the cointegrated time series as and when certain conditions are met (autoregression) until there are only two variables which can be isolated and tested against each other, resulting in a statement such as *X causes Y*. In this context, X is usually electricity provision and Y is either economic activity (GDP) or another variable. See *Udah* (2010) for simulation when Y is job creation.

WHAT OTHER PRECEDENTS EXIST FOR JOB CREATION ASSESSMENT?

A key problem in the inability to quantify job creation as a result of electricity provision has been its utility as a form of power; *Pasternak* (2000) notes that the ease of transmission and high energy density of electrical power means that its end uses are diverse. Reconciling end use with supply is therefore mired with uncertainty. As a result, two approaches may be possible in attempting to estimate job creation enabled by electricity provision:

Fig 4 – Possible empirical approaches to assessing job creation enabled through the provision of electricity



- **a bottom-up approach** of profiling an individual's lifestyle in terms of infrastructure required e.g. breaking down to an elemental level the functions of a direct recipient of new electrical power such as the running time of refrigerators, domestic lighting, television, mobile phone chargers etc. This domestic profile would be combined with a 'civic' profile of shared amenities such as street lighting for example, community water pumps etc to be applied across the direct recipients of electrical power. Ignoring complexities of opportunity costing and discretion in lifestyle choices, the marginal increase in electricity consumption could be apportioned to employment sectors for which values could be estimated

- **a top-down approach** of dividing the electricity yield of additional power capacity across the recipient population to obtain a value of XX kWhpp/yr. This could be correlated to HDI using *Pasternak's* (2000) method[6] to construct a profile of likely employment sectors arising at a national scale

Other precedents include drawing correlations during past additive electrifications, such as during the industrial revolution (*Oxley*, 1998) or more recently during South Africa's National Electrification Program, set up to reduce energy poverty in rural areas and townships that had suffered from lack of connectivity during apartheid[7].

[6] *Pasternak* (2000) reports strong correlation between Human Development Index and electricity consumption (R^2 = 0.8434) in a 1997 sample of 60 countries

[7] The National Electrification Program was instrumental in increasing electrical coverage from 36% of households in 1993 to 66% by 2001 as well as subsidisation of 50kWh per month per household

CONCLUSIONS

The literature reviewed for this study did not yield any usable methodologies or elasticities for the assessment of job creation enabled by the provision of electricity. However, various studies exist that describe a relationship between the provision of electricity and other proxies, namely economic activity and human development. The limitation of these however are that they are typically statistical correlations of indicators which are a function of several variables themselves (although the correlation is supported by causal statistical analysis to determine directionality of electricity provision and economic activity). Only a few of the causal relationship techniques are documented here although there exists many in the literature pertaining to root causes of economic growth as a whole. They therefore do not fully capture the social and economic dimension in the use of electricity to enable new jobs and industries and this inability to categorise or predict an end use of additional electricity is the endemic problem in this exercise. Possible avenues for doing so would be to interpret electricity provision into sectoral economic activity by constructing labour models from either a bottom-up (elemental) or top-down (prescriptive) approach, using assumptions of electricity points of end use in each sector and estimating labour associated with those activities. The development of a methodology in understanding the tangible job creation outcomes from the provision of electrical power would add accountability, assurance and replicability to that mode of overseas developmental assistance.

Fig 5 – Summary of causal relationships against the proxies used for job creation

Electricity Provision	Job Creation	Proxies for Job Creation	
		Increased Economic Activity	Increased Human Development
Correlation	No data. Inferred from economic activity and HDI	**0.9966** [Udah (2010) Nigeria]	**0.8434** [Pasternak (2000) 60 Countries]
Causation	**0.2741** [Udah (2010) Nigeria]	**0.9914** [Altinay & Karagol (2005) Turkey] and **0.9712** [Udah (2010) Nigeria]	No data

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