The Link between Renewable Energy and Jobs

Final Report

October 2016

Contents

THE LINK BETWEEN RENEWABLE ENERGY INFRASTRUCTURE PROJECT FINANCING AND JOBS

EXECUTIVE SUMMARY

In this study a framework is developed to quantify job creation due to investments in renewable energy (RNE) infrastructure. The framework has been applied to two PROPARCO-financed case studies: Polesine in Uruguay and Azure in India. Using the results of the two case studies as well as four other studies conducted by *Let's Work* partners (IFC, CDC and DFID's Nigerian Infrastructure Development Facility) an online toolkit has been constructed with which GDP and employment effects can be estimated for 120 countries in PROPARCO's investment universe.

Because the six case studies on which the toolkit is based encompass a wide range of different economic and power conditions, the toolkit produces dependable ex-ante estimations of the impact of new investments. The toolkit can henceforth contribute to investment decision making and strategy development effective immediately. When more detailed case studies become available and are integrated into the toolkit, the reliability of the estimations will improve further.

Hitherto power and RNE investments decisions have been based mainly on financial risk & return projections and a climate footprint assessment. The GDP and employment estimations from this toolkit enable the inclusion of the development impact perspective in the investment process.

Methodology

From February until September 2016 Steward Redqueen developed and applied a methodology to evaluate the economic impact of investments in RNE infrastructure. The methodology developed in this research project consists of:

1. Construction of a model of how increased power generation capacity reduces outages and thereby increase economic output;
2. Construction of an electricity price model based on the observed current supply and demand situation in countries where outages of limited importance and the translation of the effect of electricity price on economic output;
3. Construction of an economic input-output model with which the construction and operation expenditures of power projects and the increased economic output as mentioned under points 1 and 2 lead to value added and employment;
4. Development of an Excel-based interpolation method with which value added and employment results due to RNE investments can be generated for 120 countries, based on project-specific data and the results of the mentioned six case studies.

Headline results

The main findings of this research are:

1. The indirect and induced (or backward) impact of an RNE project is driven by its construction and operation expenditures. The second-order growth (or forward) impact is driven by the effective generation capacity of the project and depends on the installed capacity and the capacity utilisation. These two effects can only be expressed as multipliers (i.e. impact per million Euro) by taking into account the capital cost per MW installed capacity, which depends on generation technology, country and project-specific characteristics;
2. In Uruguay, the presence of Polesine's 50 MW installed capacity, which on average is used for 42%, decreases the average generation power costs by 2.4% and, assuming that in the long run

this decrease is reflected, 1.3% lower end-user electricity tariffs (which include transmission and distribution costs). This results in € 3.3 million more GDP and 169 jobs. The construction and operation of the power plant generate an additional € 3.3 million value added and 157 more jobs. Allowing for a 30% PROPARCO attribution, the total results are € 2.0 million more GDP and 98 more jobs;

3. In India, the presence of Azure's 110 MW installed capacity (based on data till March 31, 2015), which on average is used for 19%, decreases outage time. This increases the operation time for companies by 0.0003%. Taking into account that companies partly mitigate the effect of outages, the increased production time leads to € 6.4 million more GDP and 2,339 more jobs. The construction and operation of the power plants generate an additional € 5.3 million value added and 1,747 more jobs. Counting only the 5.6% attributable to PROPARCO, the total results are a GDP increase of € 0.7 million and 241 more jobs;

4. For countries where no detailed power impact studies are available, power-to-output multipliers can be derived using an interpolation technique. The technique determines a country's "similarity" to six countries where power impact studies have been completed. This similarity is based on three uncorrelated variables that together capture the essence of a country's economic and power profile:

    a. GDP per capita (total GDP of a country divided by the total population);

    b. Electricity intensity (kWh electricity consumed per national US dollar GDP);

    c. Time loss due to outages (number of electrical outages multiplied by the average duration of an outage).

5. PROPARCO has invested € 655 million in 32 RNE projects with a cumulative generation capacity of 3.866 MW. Together, these projects are estimated to have added just over one billion euros to GDP and to have created 218 thousand jobs. When considering the 409 MW that are attributable to PROPARCO, the total GDP increase is about € 111 million and the number of jobs created 21 thousand. Although these estimations may change when more detailed information becomes available, they provide a directionally correct impression of the economic impact of PROPARCO's RNE investments.

1 INTRODUCTION

1.1 Introduction

Employment creation is one of the main objectives of international development finance institutions (IFIs). Many IFIs have joined forces in the World Bank lead *Let's Work* partnership as a concerted effort to share and develop approaches and methods to measure the impact of their interventions on the creation of jobs.

The lack of electric power is considered a major hurdle to economic development in many countries. Many IFIs have therefore build up substantial portfolios of investments in generation, transmission and distribution of electric power. The measurement of the impact of these investments is rather complex however. The reason for this is that whereas for companies employment creation can be measured by 'counting' jobs along the supply or value chain, the main impact of power investments does not come from the actual production or distribution of power but rather from how it is used in the economy.

The *Let's Work* partnership therefore intends to develop methods to analyse the employment creation. This study follows on other IFI initiated impact studies like the study on Powerlinks transmission in India/Bhutan (IFC, 2012), the Bugoye power station in Uganda (PIDF, 2013), power generation in the Philippines (IFC, 2015), power generation and household electrification in Uganda (CDC, 2016) and power generation and distribution in Turkey (IFC 2016).

PROPARCO, on behalf of the European Development Finance Institutions (EDFI), has commissioned this study to contribute to the *Let's Work* partnership with an evaluation of the impact of Renewable Energy (RNE) infrastructure project financing on employment creation.

PROPARCO has financed many renewable energy infrastructure (RNE) projects over the last 10 years. Between 2005 and 2015, EUR 2 billion has been committed to climate change projects in some 28 countries on four continents. These projects, of which most are in Africa, Latina America and Asia, include solar energy, wind energy, geothermal energy, hydro power and, to a lesser extent, biomass energy.

1.2 Objectives

The objectives of this report are:

- To quantify the multiplier effect of energy infrastructure projects by estimating value added and job effects for different RNE technologies on a country-specific level;
- To provide guidance on a replicable methodology to measure indirect, induced and second-order employment effects by means of an Excel-based tool.

The Report includes a review of the academic literature, explanation of the methodology, case-specific analysis of two of PROPARCO's RNE investments, explanation of the toolkit and conclusions on the findings. In addition to this report, we deliver an impact tool that displays job and value added (GDP) results based on different selection criteria (e.g. country and RNE technology).

1.3 Report structure

The structure of the reports is as follows:

- Section 2 summarises the literature on the relationship between energy or electricity consumption and economic growth. Based on the findings in the literature we developed an analysis framework for the economic impact of increasing power supply;

- In Section 3 we describe our methodological approach and (data) requirements to analyse the effects of power on jobs and value added along the lines of the analysis framework developed in Section 2;
- Section 4 puts our methodological approach into practice by looking at two different RNE investments of PROPARCO: the Polesine wind farm in Uruguay and the Azure solar power plants in India;
- Section 5 makes use of the results of both case studies from Section 4 as well as the findings from other power impact studies executed by *Let's Work* partners in order to explain the impact toolkit that has been constructed for PROPARCO;
- In Section 6 we conclude and summarise the main findings of this report.

2 LITERATURE REVIEW AND ANALYSIS FRAMEWORK

Renewable energy (RNE) projects affect economies through so-called direct, backward and forward effects. Direct and backward effects are related to the construction and operation of power projects which create value added and employment. Forward effects come from the use of the generated power which also generates value added and employment. In this study these forward effects are also called second-order growth effects.

The pathways through which direct and backward effects occur have been extensively researched and input-output and/or computable general equilibrium (CGE) modelling techniques are available. This literature review thus focuses on the pathways of the forward effects, which tend to be larger and more long-term.

In Section 2.1 we summarize the literature on the relationship between electricity consumption and economic growth. In Section 2.2 we review the literature on the impact of power outages on economic output and in Section 2.3 we combine our findings from the literature into an analysis framework that we will use to determine the actual forward effects.

2.1 Relationship between electricity consumption and economic growth

A large body of academic literature exists on the relationship between energy or electricity consumption and economic growth and which one causes the other. Typically the findings vary by country, analysis methodology[1], selected variables, considered economic sectors and the period under consideration. Unsurprisingly, no consensus has been reached and results for many countries are often contradictory; all four possible relationships between electricity consumption (EC) and GDP have been found:

- Growth hypothesis: electricity consumption causes GDP growth (EC $\Longrightarrow$ GDP);
- Conservation hypothesis: GDP growth causes electricity consumption (GDP $\Longrightarrow$ EC)
- Feedback hypothesis: electricity consumption and GDP growth cause each other (EC $\Longleftrightarrow$ GDP);
- Neutrality hypothesis: electricity consumption and GDP growth are uncorrelated (EC $\not\Leftrightarrow$ GDP).

Lemma et al. (2016)[2] provide a detailed overview of the academic literature on the relationship between energy or power and economic growth. They observed that depending on the country and time period studied, all different hypotheses are supported. Because the neutrality hypothesis seems less prevalent than the other three, they conclude that in most cases power plays if not a facilitating than at least an enabling one in economic growth.

Looking specifically at renewable energy and economic growth (and not controlling for the impact of non-renewable energy), Apergis and Danuletiu (2014)[3] show that renewable energy consumption Granger causes GDP in the long-run across 80 different countries. At the same time, the results show that GDP Granger causes renewable energy consumption in the long-run and across the same regions. Analysing data from a large number of countries, Adhikari and Chen (2012)[4] found a strong relation running from energy consumption (of which electricity is a small part) to economic growth for upper middle income countries and lower middle income countries and a strong relation which mostly runs

[1] Notably Granger causality and co-integration analysis, applied in bivariate or multivariate ways.

[2] Lemma, A., Mass, I. and te Velde, D.W. *What are the links between power, economic growth and job creation?*, Development impact evaluation, 2016.

[3] Apergis, N., Danuletiu, D.C., *Renewable Energy and Economic Growth: Evidence from the Sign of Panel Long-Run Causality,* International Journal of Energy Economics and Policy, 4(4), 578-587, 2014.

[4] Adhikari, D. and Chen, Y., *Energy Consumption and Economic Growth: A Panel Cointegration Analysis for Developing Countries*, Review of Economics & Finance, 2012.

from economic growth to energy consumption for low income countries. But Adikhari and Chen stress that regardless of the causality, energy is an essential factor for economic growth in all developing countries and that therefore the relation between energy consumption and economic growth are an integral part of development process. In many low-income countries, electricity consumption is hampered by the frequent power outages, which weaken the relationship between grid electricity consumption and economic growth.

Because electricity is so crucially important, many companies that can afford investments in back-up generation capacity have done so. Companies that turn to self-generation to substitute for grid electricity typically incur a cost increase because of the scale advantages present in electricity generation and because typically expensive fuel must be transported to the site. This means that the effective (i.e. weighted average grid and self-generation) electricity cost are higher, rendering them less competitive and with a lower output level at which they maximize profits. Power outages effectively are a time-varying tax on electricity. This tax is lower for larger companies due to scale advantages in power generation.

Below we discuss for Africa, Asia and Latin America a number of papers that by and large support these findings. We note however that in a recent meta-analysis of 136 studies, Bacon and Kojima (2016)[5], applying, arguably overly, strict data and methodological criteria,[6] concluded that there exists no reliable statistical evidence that an increase in energy consumption contributes to economic growth.[7]

2.1.1 Africa

Wolde-Rufael (2006)[8] looked at 17 African countries and concluded that for the period 1971-2004 for three countries the (Granger) causality ran from electricity consumption to GDP per capita growth; for six countries the causality was from GDP per capita growth to electricity consumption; for three countries bidirectional causality was established and for five countries there was no relationship. However, the study only considered grid electricity which covered a small fraction of total electricity consumed and the author advised that the results should be interpreted with caution. Nondo et al. (2010)[9] found support for the feedback hypothesis for a panel of 18 COMESA countries in the long-run and the neutrality hypothesis in the short-run[10].

2.1.2 Asia and Turkey

For a panel of seventeen countries for the period 1980-2006, Lau et al. (2012)[11] concluded that causality runs from electricity consumption to GDP in the short-run, while the long-run causal linkage exists from GDP to EC. This indicates that energy is a force for economic growth in the short-run, but in the long-run, the EC is fundamentally driven by economic growth. For six Asian countries, Rafiq (2008)[12] determined long-run uni-directional causality from energy consumption to economic output

[5] Bacon, R., and Kojima, M., *Energy, Economic Growth, and Poverty Reduction*, World Bank, 104866 version 1.

[6] E.g. simultaneous equation bias, omitted variables, non-stationarity, heterogeneity and measurement errors.

[7] Only three of the 133 studies did not suffer from econometric estimation problems and two of those have potential data measurement issues.

[8] Wolde-Rufael, Y, *Electricity consumption and economic growth: a time series experience for 17 African countries*, Energy Policy 34, 1106-1114, 2006.

[9] Nondo, C., Kahsai, M and Schaeffer, P., *Energy Consumption and Economic Growth: Evidence from COMESA Countries*, Southwestern Economic review, 107-119, 2012

[10] The usual definition of short and long run is that the former assumes unchanged production structures and the latter includes the effect of capital investment and thus a incorporates a changed production structure.

[11] Lau, E., Chye, X.Y. and Choong, C.K. *Energy-Growth Causality: A Panel Analysis*. J. Eur. Econ. (11), 2012.

[12] Rafiq, S., *Energy consumption and income in six Asian developing countries: a multivariate cointegration analysis.* In: 2nd IAEE Asian Conference: Energy Security and Economic Development under Environmental Constraints in the Asia-Pacific Region, 5-7 Nov, 2008.

over the period 1965-2006. This was confirmed by Aslan and Kum (2010).[13] In contrast, Chiou-Wei et al. (2008)[14] concluded that for the period 1954-2006 GDP growth caused energy consumption. Asafu-Adjaye (2000) for energy and Chen et al. (2007)[15] for electricity found evidence for the feedback hypothesis. Mohanti and Chaturvedi (2015)[16] conclude that in India electricity consumption fuels economic growth in the short and long-run. Specifically they find that an increase of electricity consumption of 1% increases GDP growth by 1.2%. Academic literature on the nexus between electricity consumption and GDP growth in Turkey mostly points to the growth or feedback hypothesis. Acaravci et al (2015)[17] found a unidirectional short-run and long-run causality running from per capita electricity consumption to per capita GDP growth for the period 1974-2013. Aslan (2014)[18] confirms the bidirectional relationship between electricity consumption and GDP growth. Finally, Dogan (2015)[19] finds support that in the long-run, renewable electricity consumption (Granger) causes economic growth and a bi-directional causation between non-renewable energy consumption and economic growth exists[20].

2.1.3 Latin America

Yoo and Kwak (2010)[21] established a causal relationship between electricity consumption and GDP growth for Argentina, Brazil, Chile, Colombia, Ecuador, Peru and Venezuela over the period 1975-2006. Except for Peru they found that in the short-run an increase of electricity consumption drives economic growth. Using panel data for 16 Latin American countries for 1971-2000, Pasten et al (2015)[22] concludes that a 1% increase of energy consumption results in a GDP increase of 0.4%. Al-Mulali et al. (2014)[23] found for 18 Latin American countries over the years 1980-2010 that electricity consumption contributes to economic growth. Specifically they found that the effect of renewable electricity had a stronger impact than non-renewable. Solarin and Ozturk (2015)[24] confirm this finding for hydro-electricity. Although not stated in these papers, this difference is probably due to the larger domestic GDP contribution of renewable technologies as they do not rely on imported fuel.

[13] Aslan, A., and Kum, H., *An investigation of cointegration between energy consumption and economic growth: Dynamic evidence from East Asian countries*, Global Economic Review 39(4), 431-349, 2010.

[14] Chiou-Wei, S.Z. et al., *Economic growth and energy consumption revisited — Evidence from linear and nonlinear Granger causality*, Energy economics 30(6), 2008.

[15] Chen, S.T., Kuo, H.I. and Chen, C.C., *The Relationship Between GDP and Electricity Consumption in 10 Asian Countries*, Energy Policy, 35, pp. 2611-2621, 2007.

[16] Mohanty, A. and Chaturdevi, *Relationship between Electricity Energy Consumption and GDP: Evidence from India*, D. Intl. J. Econ. and Fin. 7(2), 2015.

[17] Acaravci, A., Erdogan, S. and Akalin, G., *The Electricity Consumption, Real Income, Trade Openness and Foreign Direct Investment: The Empirical Evidence from Turkey*, Intl. J. Energy Econ. and Policy, 5(4), 2015.

[18] Aslan, A. *Electricity Consumption, Labor Force and GDP in Turkey: Evidence From Multivariate Granger Causality*, Energy Sources, B Economics, planning and policy, 9(2), 2014.

[19] Dogan, E., *The relationship between economic growth and electricity consumption from renewable and non-renewable sources: A study of Turkey*, Renewable and Sustainable Energy Rev. 52, 2015

[20] Based on these findings the author somewhat puzzlingly recommends to reduce the share of electricity from renewable resources and to increase the usage from non-renewable resources for sustained growth rates.

[21] Yoo, S.H. and Kwak, S.Y., *Electricity consumption and economic growth in seven South American countries, Energy* Policy 38(1), 2010.

[22] Pasten, R. Saens, R., and Marin, R.C., *Does energy use cause economic growth in Latin America?*, Applied Economic Letters 22(17), 2015

[23] Al-mulali, U., Fereidouni, H.G. and Lee, J.Y.M., *Electricity consumption from renewable and non-renewable sources and economic growth: Evidence from Latin American countries*, Renewable and Sust. Energy Reviews 30, 2014.

[24] Solarin, S.A. and Ozturk I., *On the causal dynamics between hydroelectricity consumption and economic growth in Latin America countries*, Renewable and Sust. Energy Reviews 52, 2015.

2.1.4 Importance of electricity for industrial development

Considering the above-mentioned studies, it is hard to deny the importance of energy in production. Economic production is in its essence the transformation of material inputs into outputs through the addition of energy and knowledge and organization (i.e. labour and capital). In this thermodynamics-based view of the production process, energy and materials are the primary factors of production in contrast to mainstream economics which considers capital, labour and land as the primary factors. And because electricity has become the dominant carrier of energy,[25] one might extend this statement that electricity is a primary factor. It is clear that electricity cannot be substituted (entirely or considerably) by capital or labour. In fact, the industrial revolution was made possible by extracting thermodynamic work from energy sources other than humans.

Viewed in this way, energy and thus electricity play an especially important role in the industrial sectors. A number of studies have confirmed this. Inglesi-Lotz and Blignaut (2011)[26] concluded that in South Africa only industrial output exhibits statistically significant price elasticity. Soytas and Sari (2007)[27] found that in Turkey causality runs from electricity consumption to manufacturing value added and electricity consumption seems to affect value added somewhat more than the labour and investment inputs, a finding that was confirmed by Kargi (2014).[28] Soytas and Sari also find that manufacturing output responds positively to positive shocks in electricity consumption. For manufacturing in Malaysia, Bekhet and Harun (2012)[29] observe long-run (but not short-run) uni-directional causality from energy consumption to production for the period 1978-2009. Harun and Ishak (2014)[30] also find that compared to capital and labour, energy is a more important factor for the industrial sector in Malaysia. Qazi et al. (2012)[31] draw the same conclusion for electricity consumption and industrial output in Pakistan from 1972-2010 and even conclude that "energy shortage is one of the main reasons of the downturn of the industrial sector. As a result, plenty of small-scale industries are shut down and many large-scale industries are moving out of Pakistan." Kwakwa (2012)[32] found that although in Ghana economic growth (uni-directionally) Granger causes energy consumption, electricity consumption and manufacturing Granger cause each other. In Kenya, Nelson et al. (2013)[33] found short and long-run bidirectional causality between electricity consumption and industrial output. Electricity consumption was found by Abid and Mraihi (2014)[34] to Granger cause industry GDP in the long-run in Tunisia. Most recently, in a working paper of the IMF, Alvarez and Valencia (2015)[35]

---

[25] Electricity is the highest grade (lowest entropy) form of energy which can be converted into other forms (heat, motion etc) at great efficiency and is easily transported over distances.

[26] Inglesi-Lotz, R and Blignaut, J.N., *Estimating the price elasticity of demand for electricity by sector in South Africa*, South African journal of economic and management sciences, 14(4), 2011.

[27] Soytas, U. and Sari, R., *The relationship between energy and production: evidence from Turkish manufacturing*, Energy Economics, 2007.

[28] Kargi, B., *Electricity Consumption and Economic Growth: A Long-Term Co-integrated Analysis for Turkey*, Intl. J. Econ. And Fin. 6(4), 2014.

[29] Bekhet, H.A. and Harun, N.H.B., *Energy essential in industrial manufacturing in Malaysia,* International Journal of Economic and Finance, 4(1), 2012.

[30] Harun, N.H. and Ishak, M.S., *Analysis of the production theory for manufacturing industry and construction industry in Malaysia*, Proceeding of the Global Summit on Education GSE 2014.

[31] Qazi, A.Q., Ahmed, K. and Mudassar, M., *Disaggregate Energy Consumption and Industrial Output in Pakistan: An Empirical Analysis*, Economics E-Journal, 2012.

[32] Kwakwa, P.A., *Disaggregated energy consumption and economic growth in Ghana*, International Journal of Energy Economics and Policy, 2(1), 2012.

[33] Nelson, O., Mukras, M.S. and Siringi, E.M., *Causality between disaggregated Energy Consumption and manufacturing growth in Kenya: an Empirical Approach*, J. Econ. Sust. Development 4(16), 2013.

[34] Abid, M. and Mraihi, R., Energy consumption and industrial production: Evidence from Tunisia at both aggregated and disaggregated levels, J. Knol. Econ, 2014.

[35] Alvarez, J. and Valencia, F., *Made in Mexico: Energy Reform and Manufacturing Growth*, IMF WP/15/45, 2015.

conclude that a 1% decrease of electricity price would increase of manufacturing value added in Mexico by 0.28%.

The reason that the industrial output response to cheaper electricity is found to be stronger than that of commercial sectors is because electricity is largely a variable cost for manufacturing and largely a fixed one in most other sectors. (Put very simply, an office needs to be lit or cooled independent of the number of employees present whereas increasing manufacturing output requires more electricity, although many sectors fall somewhere between these two extremes). This is probably the main reason why the World Bank Enterprise Surveys only ask information on electricity use from companies in the industrial sector.

2.1.5 Conclusions regarding the importance of electricity consumption

Based on the literature presented above we conclude the following:

- The balance of evidence point towards the *validity of the growth or feedback hypotheses, meaning that electricity consumption is an important enabler of economic growth and thus employment* creation. This is especially the case for the lower and upper middle income countries in Asia, Latin America and Turkey. There is less evidence for the growth or feedback hypotheses in African countries, but the negative impact of frequent power outages on economic growth is well established as will be discussed in more detail in Section 2.2.
- The *causality runs primarily but not exclusively through electricity intensive industrial sectors*;
- *Cheaper electricity will have a positive effect on economic output and employment*.

2.2 Impact of power outages and self-generation

Power outages can affect economic output through (i) loss of operating time and production; (ii) restart costs (iii) equipment damage; and (iv) spoilage of raw or finished materials. There are a number of factors that can completely or partly mitigate these negative impacts. In addition to self-generation, which was discussed in the previous section, firms can (i) continue operations without electricity or reschedule production; (ii) adopt technologies that allow faster production during hours when power is available; or (iii) procure energy intensive semi-finished goods and thereby eliminate power-intensive production steps. The diverse impacts and mitigation measures and the fact that outages are often unknown beforehand make it plausible that the ensuing effect of power outages varies substantially per economics sectors.

An often used indicator to monetize the impact of outages is the so-called Value of Lost Load (VoLL). The VoLL expresses the value per kW power load, although it is more commonly expressed as the value lost per kWh foregone electricity consumption (Value of Lost Consumption, VOLC). It can be expressed for an individual firm, for an economic sector or for an entire economy. When expressed as loss of value added per kWh it essentially is the inverse of the electricity intensity. VoLL values are nearly always an order of magnitude higher than the all-inclusive cost of power, an argument that is often used that investments in power yield great economic returns. But because the VoLL does not reflect self-generation or any of the other mentioned mitigation measures it is obvious that it is a drastic overestimation. Moreover, when the VoLL would be determined for individual sectors it would yield the logical but counterintuitive result that it is highest for the least electricity intensive sectors. For example, construction is not very electricity intensive and thus has a very large VoLL but it is obvious that the bulk of construction activities can continue when there is no power.

The heterogeneity of how power outages affect firm output is illustrated by Alam (2013)[36] who studied brick kilns, rice mills and steel mills in India. The majority of brick kilns do not use any electricity at all and their output is thus not seriously affected by outages. Rice mills are electricity intensive but can

[36] Alam, M.M, *Coping with Blackouts: Power Outages and Firm Choices*, Working Paper, Dept. Economics, Yale University, 2013.

change their production such that a 10% increase of outages affects their output by only 0.1% (although profitability is affected more because material use goes up by 7%). An identical increase of outages in steel mills in contrast leads to 11% loss of output (and 2% lower use of materials). Alcott (2014)[37] also found that electricity shortages have very different effects for self-generators and grid dependents in India, but notes that power shortages affect profitability much less than revenues due to avoidable cost. Abotsi (2016)[38] found that the number of power outages impact negatively on firm production efficiency using World Bank data of 2,755 firms in 10 African countries. In Senegal, Cissokho (2013)[39] showed that in response to more frequent power outages the ownership of generators increased by 47% in between 2006 and 2011. The same study shows that although SMEs tend to become better in dealing with outages (higher technical efficiency), outages do hinder their growth (scale efficiency).

Using three different methods[40], Oseni and Pollitt (2013)[41] estimate the outage cost for almost 7,000 firms in 12 African countries to be in the range USD 0.87 – 4.81[42] per kWh. They also point out that the back-up rate of companies which own backup power generators ranges from 14% in Kenya to 43% in Nigeria. Steinbuks and Foster (2010)[43] compared the cost and benefits of self-generation in 16 African countries. They concluded that the benefits outweigh the costs in only four of these countries. However, the results of the study may be too conservative because it only considered lost sales. Using the World Bank Enterprise Survey (WBES) data, Steward Redqueen observed in Uganda and Turkey, and as shown in this report in India, that self-reported company sales losses (as a percentage of total sales) are less that than the percentage of production time affected by power outages. This observation points to the ability of firms to partially mitigate the effect of outages. The one exception is the food and beverage industry where firms without back-up generation suffered relatively large sales losses than outage time, probably due to the loss of raw or semi-finished materials. It is important to note that firms with back-up generation also suffered sales losses, because back-up capacity is typically insufficient to maintain full production, as is shown by Oseni and Pollitt (2013).[41]

Based on the literature presented above we conclude the following:

- The *negative impact of power outages on economic output is quite heterogeneous across countries, economic sectors and company size categories*;
- This *heterogeneity is evidenced by differences in ownership of (partial) backup generation capacity and self-reported data on sales losses*;
- From World Bank Enterprise Survey data it is clear that *the ability of companies to mitigate the effect of lost operation time varies across economic sectors*.

---

[37] Alcot, H., Collard-Wexler, A. and O'Conell, S.D., *How Do Electricity Shortages Affect Productivity? Evidence from India,* NBER Working Paper No. 19977, 2014.

[38] Abotsi, A.K., *Power Outages and Production Efficiency of Firms in Africa*, Int. J. Energy Econ. and Policy, 6(1), 2016.

[39] Cissokho, L. and Seck, A., *Electric Power Outages and the Productivity of Small and Medium Enterprises in Senegal*, ICBE-RF Research report No. 77/13, 2013.

[40] Marginal cost analysis of backup power; incomplete backup analysis (i.e. analysis of the optimal size of backup generators which depends on unmitigated losses and investment cost); and subjective evaluation method which relies on self-reported data by firms on power outages and sales losses.

[41] Oseni, M.O. and Pollitt, M.G., *The Economic Costs of Unsupplied Electricity: Evidence from Backup Generation among African Firms*, Cambridge working papers in Economics, EPRG Working paper 1326, 2013

[42] The range found by the authors was USD 0.60 – 3.32 in 2007 dollars which here are inflated to 2014.

[43] Steinbuks, J. and Foster, V., When do firms generate? Evidence on in-house electricity supply in Africa, Energy Economics 32(3), 2010.

2.3 Analysis framework

Based on the literature reviewed in Sections 2.1 and 2.2, the analysis framework for the economic impact of increasing power supply is presented in Exhibit 1. Going from left to right, an increase in power generation capacity decreases the price of power or reduces the number of outages. The price effect is predominant in countries with relatively advanced power infrastructures and the outage effect is more important in countries with insufficient power supply and or inadequate electricity networks. A lower price and/or fewer power outages increase the production level at which companies maximize their profits and they will increase their electricity use to produce more output[44]. This in return increases their intermediate demand from other firms (both users and non-users, e.g. agriculture) and value added. The resulting increase of value added increases GDP and employment. Finally the higher GDP increases the demand for electricity, which increases the electricity price and thus offsets some of the before-mentioned effects. The framework does not include the effect of lower electricity price on capital investment (either directly or indirectly), a feedback that may be relevant in the longer run.

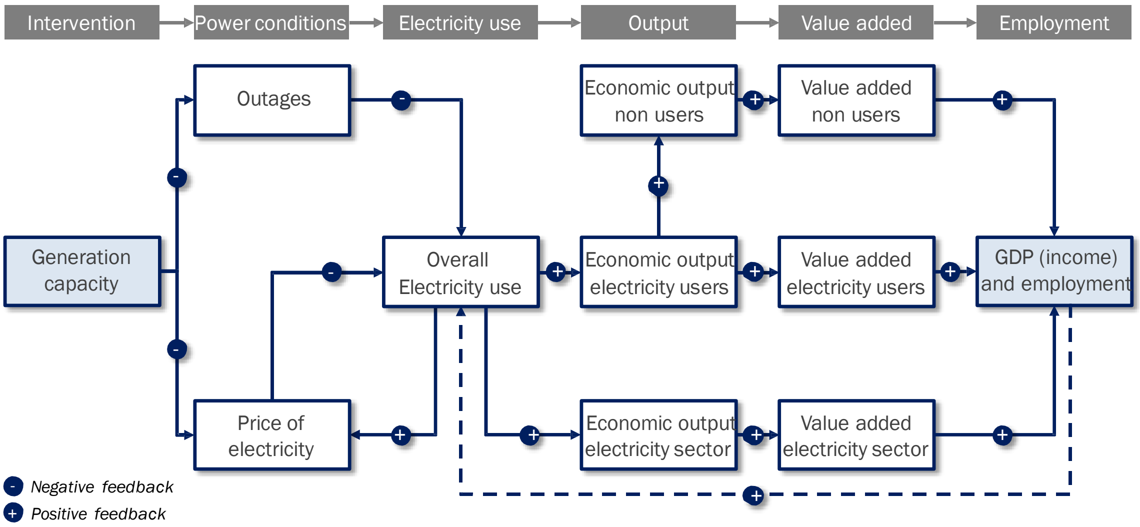

Exhibit 1: Analysis framework for the impact of increase in power sent into the grid on GDP (value added) and employment.

The lower price for electricity due to more generating capacity can come about in two different pathways, depending on the specific power conditions. In countries where the grid electricity is normally sufficient in quality and quantity, an increase of generation capacity lowers the price of electricity, depending on the short and long-run cost level of additional capacity relative to the average wholesale electricity price. In countries where the grid is not able to deliver sufficient power (e.g. Nigeria) increased capacity will reduce the dependency of companies on expensive self-generation, thereby lowering their effective electricity cost[45]. In the following sections the steps of the analysis framework presented in Exhibit 1 will be elaborated upon in a more technical fashion.

[44] The exhibit depicts relationship between two variables. The negative relationship between e.g. electricity price and consumption means that a lower price is associated with more consumption (and vice versa)

[45] Although the quality of grid electricity may not be sufficient for some firms to switch from self-generation to grid power, at the level of an entire sector or economy this is not of great importance; electricity not used by one firm is available for another one.

3 METHODOLOGY FOR THE CASE STUDIES

The essence of the analysis framework in Section 2 is that an increase in power generation capacity decreases the price of power and/or reduces the power outage time. Each of these two outcomes increases the production level at companies resulting in more value added and jobs in the wider economy. We will apply two different methodologies in order to distinguish between the following value added and jobs effects:

1. *Direct effects:* effects at investee-level, i.e. the RNE company or project that PROPARCO has invested in;
2. *Indirect effects:* effects associated with the RNE project's direct and indirect suppliers;
3. *Induced effects:* effects due to the spending of salaries earned by employees of the RNE project and its direct and indirect suppliers[46];
4. *Second-order growth effects:* effects due to additional provision of electricity provided by the RNE project.

Whereas direct effects solely require the collection of investment-specific data; indirect, induced and second order growth effects require more detailed calculations. In Section 3.1 we propose some straw-man rules for attribution of effects to PROPARCO. We subsequently discuss our choice for a combination of sector-specific and Input-Output modelling in Section 3.2. In Section 3.3 we explain the Input-Output model used to estimate the indirect and induced effects. Section 3.4 deals with the estimation of second order growth effects. *Inevitably, the methodology description is somewhat technical in nature, especially in Section 3.4. But the non-technical reader will be able to understand the case studies in Section 4 without having read this section.*

3.1 PROPARCO attribution

In order to attribute an amount of power generation capacity to PROPARCO we propose the following two rules[47] as a straw man:

1. For equity financing the power generation capacity is multiplied by the percentage ownership equity ownership;
2. For debt financing, the capacity addition is multiplied by the PROPARCO debt financing as a percentage of the total deal value. Because all the loans were provided for greenfield projects the capacity addition is equal to the plant capacity.

3.2 Choice of methodology

Many of the studies reviewed in Section 2.1 were econometric or time-series analyses to establish the causality –and in some cases the magnitude– of the relationship between electricity consumption and (macro) economic growth. For that reason econometric analysis is less suited for analysing the impact of individual investments. A second approach is to use the Input-Output (IO) or Computable General Equilibrium (CGE) methodology. These methods use the quantified interlinkages between economic sectors to trace the GDP and employment effects of a particular intervention. Of the two approaches, the CGE methodology is theoretically preferable because it allows for volume and price effects whereas the IO methodology only account for volume effects. However, the CGE methodology requires a lot more data to specify and calibrate all parameters which are often not available for developing countries. The IO methodology therefore is often the most practical approach and provided that the

[46] To avoid double-counting induced value added results are left out in this Report.

[47] These attribution rules are subject to discussion with the PROPARCO team. It is important to note that the attribution methodology can easily be changed without affecting the methodology. The results obviously are highly dependent on the attribution rules chosen.

size of an intervention is small relative to the entire economy the results have proven sufficiently reliable. Indirect and induced effects will therefore be estimated using the IO approach (which we elaborate upon in Section 3.2), but to determine the second-order growth effects, the IO methodology is insufficient. For that we will make use of sector-specific modelling. The main advantage of this approach over pure IO modelling (e.g. the recently developed IFC tool (IFC, 2015a)[48], is that it takes non-linear aspects (e.g. price signals) into account. For the power sector, where the relationship between power capacity and power price tends to be highly non-linear this is crucial. In Section 3.4 we will explain in detail the sector-specific modelling approach.

3.3 Determining indirect and induced effects

Money flows relating to the construction and operation power plants are being traced using the IO methodology. This allows for the quantification of GDP and employment impact. The key-ingredient in this process is a so-called Social Accounting Matrix (SAM) shown in Exhibit 2. The SAM describes the financial flows of all economic transactions that take place within an economy; it is a statistical and static representation of the economic structure of a country. In the SAM the number of columns and rows are equal because all sectors or economic actors (industry sectors, households, government and the foreign sector) are both buyers and sellers. Columns represent buyers (expenditures) and rows represent sellers (receipts). As shown in the exhibit, consumption induces production which leads to financial transfers between the various sectors which subsequently generate incomes for households (salaries), governments (taxes) and companies (profits and savings). The latter three represent the GDP (value added) effect related to the financial transaction. To calculate the job effects of the related production, we make use of sector-specific employment intensities showing the number of employees needed in a certain economy/sector to produce one unit of output. These intensities are based on the latest output and employment statistics from national statistics institutions.

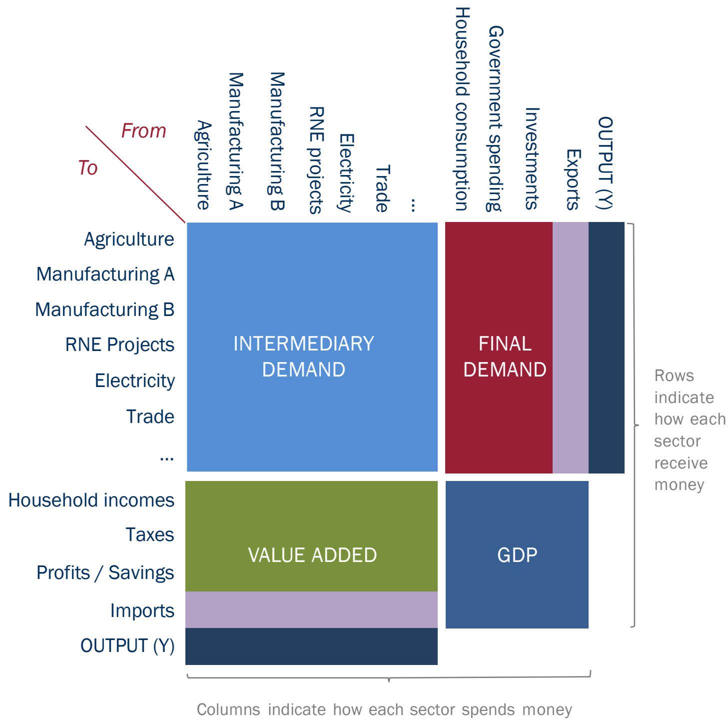

Exhibit 2: Social Accounting Matrix

48 IFC, *Power Sector Economic Multiplier Tool: Estimating the Broad Impacts of Power Sector Projects*, Methodology note, June 2015a.

3.4 Determining second-order effects

Whereas the IO methodology is used to estimate indirect and induced effects, the second-order growth effects requires sector-specific modelling as suggested in Section 3.2. In this section we explain in detail the sector-specific analysis, which consists of the construction of a price model and determination of the effect of power outages on economic output.

3.4.1 Impact on power price and outages

Impact of power price change

A model for power price requires the specification of a power supply and demand curve. A power supply curve ranks all power plants side by side commensurate with their capacity (in MW) and ordered from lowest to highest Levelised Cost of Electricity (LCOE) or Short Run Marginal Cost (SRMC).

We construct the power supply curve by using the information on the installed power generation fleet of a country. By combining the supply curve with the observed power demand of a country (in MW), one can determine the market clearing plant at any level of electricity demand. The cost level of that market clearing plant is then the wholesale electricity price. This model has been shown to closely reproduce observed price behaviour in the Philippines[49] and Turkey[50] and indeed for Uruguay as shows in Section 4.1.3. The method relies on availability of LCOE and SRMC data for plants, which often is not available. In Appendix A we outline a method to estimate a range LCOE and SRMC values for each technology based on the equations for LCOE and SRMC and a ranges of observed parameters. When no observed price information is available the model still holds, but the results cannot be verified. However, with realistic estimations of LCOE and SRMC (Appendix A) one can still assume that results will be directionally correct.

The impact of the addition of generation capacity by PROPARCO is determined by deriving two power supply curves: one with and the other without the PROPARCO-backed plants. Determining the market clearing plant and market clearing price for both situations allows one to calculate the effect of adding generation capacity to the power fleet.

Impact of power outage time change

Second-order effects can also be exerted through a reduction of outage time. As shown in Section 2.2, outages can have a significant impact on firm output and productivity. A complication factor here is that outages occur for many different reasons: insufficient power generation capacity (often leading to planned load shedding); (unplanned) tripping of power plants; (planned) maintenance of the transmission and distributions networks; or (unplanned) faults in the network. In order to determine the effect of RNE projects on power outages one therefore has to:

1. Determine which fraction of the total outage time is caused by insufficient power supply, something which is likely to vary greatly from country to country;
2. Determine how an increase of power supply reduces the outage time caused by insufficient generation capacity (as determined under point 1);
3. Convert the outage time reduction into a relative increase of production time (in %).

On the first point, the fraction of outage time caused by insufficient power supply depends highly on the quality of the electricity network and thus varies a lot from country to country.

Regarding the second point, quite some literature is available on the relationship between the so-called reserve margin[51] (RM) and the loss of load expectation (LOLE). When there is ample generation

[49] Let's Work study on the impact of power investments in the Philippines, Steward Redqueen 2015.

[50] IFC, *How Power Contributes to Jobs and Economic Growth in Turkey,* 2016.

[51] Reserve Margin is defined as (Installed generation capacity – Peak Load demand) / Peak Load demand

~~capacity (i.e. large reserve margins), even a large addition of generation capacity is not expected to~~

reduce the outage time because the system could satisfy demand without it. When reserve margins are low, however, even a small addition of generation capacity could prevent the system from a blackout. Although this points to a highly non-linear relationship, most real world situations are simpler. The reason for this is that a high reserve margin is economically not viable because it implies that expensive capacity would stand idle most of the time. Over the resulting smaller range of economically viable reserve margins (typically in the order of 10–20% the relationship between RM and LOLE is much more linear. In Malaysia, Zafir et al. (2015)[52] find that in Malaysia an increase of RM from 12.5% to 18.8%, due to an increase of generation capacity of 5.6% decreases the outage time from 5.4 to 2.0 hours per month.

Considering point 3 above and based on an average of 270 hours operation time per month this means an increase of production time of 1.2%. This means that for each 1% capacity increase, production time increases by 0.22%, In case only half of a country's outages are due to insufficient power supply, as we will assume for India in Section 4.2.3), this means that a 1% capacity increase would increase operation time by 0.11%. This value is very similar to the 0.16% we found in Uganda, where we had very detailed statistics on power outages. The higher value in Uganda is explained by the fact that load shedding (i.e. lack of power generation) was the by far largest driver of outage time. This is not entirely coincidental because power systems in many countries exhibit a fairly similar range of reserve margins as mentioned before.

In this report and the accompanying toolkit we will thus assume that a 1% increase of generation capacity increases available production time by 0.11%. Although based on only two empirical studies, this heuristic assumption is directionally correct and its simplicity does not require the specification of additional parameters.

3.4.2 Quantification of price and outage effects on economic output

The objective of this section is to explain the methods used to determine the effect of the additional electricity use on output.

Price effect

By multiplying the factor share of electricity use for a particular sector, ε, with the price elasticity of electric power consumption, θ, one arrives at the elasticity of economic output with respect to electricity price P which allows the change of manufacturing output to be expressed:

$$\frac{dY}{dP}\frac{P}{Y} = \frac{dY}{dE}\frac{E}{Y}\cdot\frac{dE}{dP}\frac{P}{E} = \varepsilon\cdot\theta \quad \Longrightarrow \quad \Delta Y \approx \varepsilon\cdot\theta\cdot\frac{\Delta P}{P}\cdot Y \qquad (1)$$

In the next sections we will explain how we determine the factor share of electricity use in manufacturing, ε, and the price elasticity of electric power consumption, θ. The factor share can be determined using information from the World Bank Enterprise Surveys for the countries in the two case studies.

<u>Electricity factor shares</u>

In order to determine the electricity factor shares one can apply the extended Cobb Douglas[53,54] production function:

[52] Zafir, S.R.M., Razali, N.M.M. and Hashim, T.J.T., *Relationship between the loss of load expectation and reserve margin for optimal generation and planning.* Jurnal Teknologi, 2016.

[53] Charnes, Cooper, W.W., and Schinnart, A.P., *A theorem on homogeneous functions and extended Cobb-Douglas forms*, Proc. Natl. Acad. Sci. USA 73(10), 1976.

[54] Constant Elasticity of Substitution (CES) production functions may be preferable in theory but nesting forms for factors make determination less reproducible. Moreover, given limited importance of capital it would lead to unconventional 'nests'. Transcendental Logarithmic (Translog) production functions (which are generalised

$$Y = A \cdot L^{\alpha} K^{\beta} M^{\gamma} E^{\varepsilon} \qquad (2)$$

With Y firm sales; L labour (number of employees); K capital (here replacement capital[55]), M annual cost of materials (US$), and E annual electricity use (MWh). A is the so-called total factor productivity (TFP)[56] and α, β, γ and ε the factor shares or output elasticities. In case of constant returns to scale, the elasticities sum up to 1. The elasticities can be determined using multiple linear regression analysis on the logarithmic form:

$$\log Y = \log A + \alpha \log L + \beta \log K + \gamma \log M + \varepsilon \log E \qquad (3)$$

When performing the regression analysis, the sample size is restricted by the number of companies for which all variables are available. It thus makes sense to eliminate the variables with the least explanatory value in order to obtain statistically meaningful results for the entire sample as well as sub-sectors or size segments. Specifically, if a regressor could not be determined with more than 95% confidence (*i.e.* p-values larger than 0.05) it is omitted from the regression. This means that the sample size increases because not all inputs are known for all firms. This procedure is repeated until all remaining regressors are estimated with more than 95% confidence, although most are within the 99% confidence interval.

Price elasticity of electric power consumption

Ideally, the price elasticity of electric power consumption will be estimated making use of econometric analysis for the period for which data are available. However, often panel data regarding electricity costs of firms is absent and therefore realistic values need to be established based on academic literature. If data is available we assume for commercial and industrial firms:

$$EC_i = A \cdot GDP_i^{\varphi} \cdot P_i^{\theta} \qquad (4)$$

Where for each group i, EC indicates the electricity consumption, GDP the GDP contribution in constant prices and P the average tariff in constant prices, φ the GDP (or value added or income) elasticity, θ the price elasticity of electricity use and A a factor productivity constant. For the household user group we replace GDP by GDP per capita (*GDP_PC*) in constant prices and use a different regression coefficient.

$$EC = B \cdot {GDP_{PC}}^{\varphi} \cdot P^{\theta} \qquad (5)$$

Using log-linear regression we can then estimate the elasticities φ and θ, which can be used in Equation 1.[57]

In case we have to make use of academic literature it is important to note that in the literature a distinction is made between short-term and long-term elasticities, the latter including companies' adaptation of production technologies through switching and substitution decisions. Long-run elasticities tend to be significantly larger (i.e. more negative) than short-run elasticities.

Sullivan et al. (2013)[58] estimate price elasticity for Nigerian manufacturing firms to be close to unity in the long-run, with demand elastic in the long-run and inelastic in the short-run. Adeyemo et al (2007)[59]

Cobb Douglas functions) become too unwieldy in terms of parameters that need to be estimated when more than two variables are considered.

[55] The Enterprise Survey has two indications for capital: book value and replacement value of which the latter is deemed more representative, although the analyses are hardly affected by the choice between the two.

[56] TFP is a dimensionally meaningless 'fudge' factor to account for changes in productivity unexplained by changes of factor inputs. It does not feature in this study.

[57] In Uganda we found a φ of +0.99 and θ of -0.4

[58] Sullivan, O. and Anyaka B., *Impact of Price Expectation on the Demand of Electric Energy,* IOSR Journal of Electrical and Electronics Engineering Volume 8, Issue 1 (Nov. -Dec. 2013), PP 86-92, 2013

[59] Adeyemo, O.O., Mabugu, R. and Hassan, R.H., *Interfuel substitution: the case of the Nigerian industrial sector, J. of Energy in Southern Africa,* 18(1), 2007.

indicate a long-run price elasticity of electricity demand of -0.95 across the Nigerian manufacturing sector. For Chile and Indonesia Eskeland et al. (1994)[60] found price elasticities of -0.98 and -1.02 respectively. Chaudhry (2010)[61] found the price elasticity of electricity for manufacturing firms in Pakistan to be -0.57. In South Africa, Inglesi-Lotz and Blignaut (2011)[26] found an elasticity of -0.87 for the industrial sector. In a related analysis, Inglesi-Lotz (2012)[62] found a value of -0.95 for the industrial sector which was very constant after it changed from -1.0 in the 1970s, The authors noted that given the historically low electricity prices in South Africa, electricity demand may become elastic (i.e. an elasticity smaller than -1) when prices go up. This has in fact been observed by Aberese (2013)[63] who found a price elasticity of -1.2 for manufacturing firms in India. In the more developed markets of Germany and the UK, Agnolucci (2009)[64] found a value of -0.64. Hill and Cao (2013)[65] found the short term price elasticity of electricity demand in the Australia manufacturing sector to be -0.24. Bernstein and Madlener (2010)[66] found short term price elasticities for manufacturing sector to range from zero to -0.57, while indicating that long-run elasticities are considerably larger. Using a 150 year time series, Stern and Enflo (2013)[67] found price elasticities of energy demand of -0.28 to -0.73 in Sweden, for different econometric model formulations.

Outage time effect

Based on statistics in the World Bank Enterprise Survey on power outage time and the associated sales losses we can quantify the loss mitigation factor for individual sectors *i*:

$$\phi = \frac{Y^{lost}/Y}{T^{lost}/T} \qquad \Rightarrow \quad Y_i^{lost} = \phi_i \cdot \frac{Y_i}{T_i} \cdot T_i^{lost} \quad (6)$$

With ϕ loss mitigation factor, Y^{lost} the sales lost, Y total sales, T^{lost} the operation time lost (number of outages per month multiplied by their average duration), T the operation hours per month[68]. This means that, the output increase of sector *i* is equal to the reduction of output loss which results from a decreased outage time (be it a lower outage frequency or a reduced average duration):

$$\Delta Y_i = -\Delta Y_i^{lost} = -\phi_i \cdot \frac{\Delta T_i^{lost}}{T_i} \cdot Y_i \quad (7)$$

3.4.3 Determining the employment and GDP impact

Having determined the PROPARCO-attributable change of economic output, the final step in Exhibit 1 comprises the determination of the associated value added and employment. A SAM (Exhibit 2) is well suited for this since it allows one to trace the knock-on effects of changes in one sector on other

60 Eskeland, G.S., Jiminez, E. And Lieu, L., *Energy pricing and air pollution – economic evidence from manufacturing in Chile and Indonesia*, Policy research Working paper 1323, World Bank, 1994.

61 Chaudhry, A.A., *A panel data analysis of electricity demand in Pakistan*, Lahore J. of economics (15), 2010.

62 Inglesi-Lotz, R., *The sensitivity of the South African industrial sector's electricity consumption to electricity price fluctuations*, University of Pretoria Department of Economics Working Paper Series 2012-25, 2012.

63 Aberese, A.B., *Electricity Cost and Firm Performance: Evidence from India,* Discussion Paper 1213-26, Department of Economics, Columbia University, 2013.

64 Agnolucci, P., *The energy demand in the British and German industrial sectors: Heterogeneity and common factors,* Energy Economics (31), 2009.

65 Hill, C. and Cao, K., *Energy Use in the Australian Manufacturing Industry: An Analysis of Energy Demand Elasticity,* Australian Bureau of Statistics, Analytical Services Branch, 2013.

66 Bernstein, R. and Madlener, R., *Short- and Long-Run Electricity Demand Elasticities at the Subsectoral Level: A Cointegration Analysis for German Manufacturing Industries*, FCN working paper 19/2010, FCN, 2010.

67 Stern, D.I. and Enflo, K., *Causality between energy and output in the long-run,* Lund P. Econ. Hist. 126, 2013.

68 The fraction outage time for a firm is defined as the outage hours per month (outage frequency * average duration) divided by the number of monthly operation hours. When the firm has not reported the number of operation hours the median value of 278 hours has been used.

sectors. It should be noted that one of the main criticisms of the IO methodology –the inability to consider demand induced price changes– hardly applies here: the impact of PROPARCO-attributable power generation has been determined using detailed supply-demand analysis which together with the output elasticities have resulted in output changes[69]. The SAM is used here solely to trace the impact of that output increase on other sectors[70].

The RAS[71] procedure is used to analyse the effects of increased sector output on non-manufacturing sectors. Although it is still assumed that sectors maintain their individual production structures, these structures change in one important aspect namely that the electricity costs for all sectors fall due to lower electricity prices. If electricity use does not change, these lower electricity costs translate into higher profits and (corporate) taxes for all electricity consuming sectors at the cost of lower profits and taxes in the utilities sector (i.e. economy-wide value added remains practically unchanged). This leads to the following changes in the original SAM (Exhibit 2):

1. Electricity spending decreases for all sectors in proportion to the price decrease (which can be zero);
2. Increase the profits and taxes of all sectors to compensate for the lower electricity spending;
3. Increase all elements in the sector columns increase by the relative change of sector-specific output $\Delta Y/Y$;
4. Increase all elements in the rows increase by the relative change of sector-specific output $\Delta Y/Y$ and lower the imports row by the same amount, reflecting that the increased output substitutes for imports.[72]

Driven by these changes the RAS procedure will, after a number of iterations, yield a balanced SAM[73] in which all the sectors produce the necessary additional intermediary output needed by the manufacturing sectors. The economy wide increase of output and value added induced by an increase of manufacturing output, due to the lower electricity-price, is thus quantified.

It is important to note that the typical application of the input-output methodology, and indeed the original formulation by Leontief, is demand-driven: changes in final demand cause changes in supply and hence value added changes. The chain of events here is different: an electricity-price induced

69 In fact, it would be very difficult to include the intricate treatment of the highly non-linear behaviour of power price response to changes in demand and supply in CGE models.

70 The other significant assumption made input-output modelling –constant input prices– is made here as well (with the exception of electricity of course). However, the increase of manufacturing output is rather small (< 1.5%) that this is considered not overly severe. In addition, the Philippine economy is rather open and imports would help to constrain prices increases (in fact, imports constitute a sizeable portion of inputs).

71 The RAS method is a bi-proportional matrix balancing techniques (the letters reflect the symbols in a matrix multiplication rather than an acronym). A detailed description can be found in Miller, R.E. and Blair, P.D., *Input-Output Analysis – Features and Extension*, pp 784, 2009.

72 The reduction of imports serves to minimise differences between row and column total which would force the RAS method to make unrealistic numerical changes. Economically it can reasonably be expected that lower electricity costs render local manufacturing firms more competitive vis-a-vis imports.

73 Although economic interpretations of the RAS methodology are given (the alternating rounds of adjustments essentially being changes of intra-sector production efficiency and inter-sector substitution), the method is a mathematical procedure to solve a system of more variables than fully-known equations. In practice this means that many solutions are possible. By starting the iterations one time with the new row totals and one time with the new column totals, two different solutions are arrived upon. Because of the linear nature of the procedure, the average of these two solutions is a solution as well. This average solution can be shown to be a better prediction of how cheaper electricity and higher output drives changes elsewhere in the economy. The reason for this is that the sum of squared differences of the diagonal terms between the original and the updated average table is smaller than for two alternatives. The diagonal terms represent the auto consumption of sectors and can (heuristically) be expected to change least in the non-manufacturing and non-electricity sectors (e.g. one would expect the change of demand for agricultural products within the agricultural sector to change relatively little).

change in manufacturing output causes changes in demand of the non-manufacturing sectors which affects value added. This formulation is more akin to the so-called Ghosh input-output methodology except that in this approach the event chain starts with a change in value added that affects output which then forces a change of demand. The Leontief and Ghosh formulations are two sides of the same coin, each suffering from their own limitations[74]. Given the small output changes imposed, the here used formulation (in between Leontief and Ghosh) is adequate.

[74] For a more in depth discussion: Manresa, A. and Sancho, F., *Leontief versus Ghosh: two faces of the same coin*, REAP2012-18, Xarxa de Referencia en economia Aplicada, 2012.

4 CASE STUDIES

Based on the literature review in Section 2 we developed a methodology that quantifies the effects of power investments on value added and jobs. This methodology was described in a technical fashion in Section 3. In this section we apply the methodology to two different RNE investments from PROPARCO; the Polesine wind farm in Uruguay and the Azure solar power plants in India. These two investments are selected because power sector investments in these countries have, as far as we know, not been studied before by any of the Let's Work partners (in terms of value added and jobs results) and because fewer insights are available for the specific RNE technologies (wind and solar).

Section 4.1 elaborates on the effects of the Polesine investment in Uruguay and Section 4.2 discusses the effects from an investment of PROPARCO in Azure, India.

4.1 Polesine in Uruguay

In 2013 PROPARCO provided a € 28 million senior loan with a 15-year maturity to Polesine S.A. (Polesine), a subsidiary of French renewable developer Akuo Energy S.A.S (Akuo), to finance the construction and operation of a wind farm in Uruguay. Using the attribution rules from Section 3.1, this means that 30% of the projects economic impact is attributed to PROPARCO. This new wind farm, with a capacity of 50 MW and a capacity factor of 42%, is located in the Florida Department, 100 km to the north of the capital Montevideo. The wind farm benefits from a so-called Feed in Tariff (FiT), which is the regulator-set price paid for each kWh generated. We apply the methodology described in Section 3.3 to determine the indirect and induced effects and the methodology described in Section 3.4 to determine the second-order growth effects of Polesine.

4.1.1 Macro-economic and energy profile of Uruguay

Macro-economic profile

Uruguay achieved more than a decade of high and inclusive economic growth, supported by social stability and reduced regional dependency. So far, the country has weathered the recent global and regional headwinds relatively well, and GDP growth is still growing on an annual basis (see Exhibit 3).

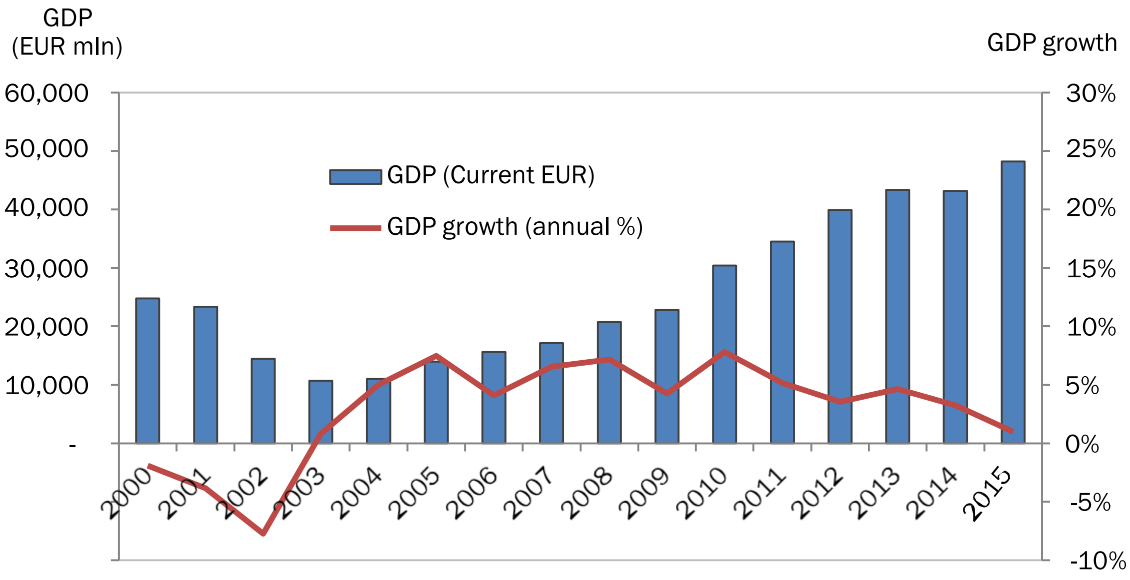

Exhibit 3: GDP and GDP growth in Uruguay (2000-2015)

The sound macroeconomic performance is also reflected in the labour market, which recorded historically low unemployment rates in 2014 (6.6%), although this has increased to 7.4% in June 2015 due the current slowdown. As a high-income country, Uruguay has a significantly higher labour productivity than other case study countries. This reduces the effect of investments on employment as fewer jobs are associated with the same output.

Uruguay stands out in Latin America for its success as an equitable society and its high per capita income, low poverty rate and absence of extreme poverty. The World Bank ranked Uruguay as a high-income country with a GDP per capita of € 14,042 in 2015. Moderate poverty declined from 32.5% in 2006 to 9.7% in 2014, whereas extreme poverty practically disappeared; from 2.5% to 0.3% during the same period. Uruguay also ranks high on several measures of well-being, such as the Human Development Index, the Human Opportunity Index and the Economic Freedom Index.

Energy profile

Uruguay's total energy consumption in 2013 was 3.98 megatons of oil equivalent (m t.o.e.)[75] and the energy use per capita was 1,351 kg oil equivalent (kg.o.e). A third of the total energy is consumed by the industrial sector. The transportation sector accounts for about 30% of the energy consumed, residential use is at 20%, while agriculture use is only 5%. Energy consumption in the agricultural sector and by households has decreased over the past years, while industry has shown a solid increase in relative energy consumption.

Electricity comprises more than 50% of the country's overall energy mix. In 2013 the country consumed a total of 10,173, GWh which is 1,637 KWh per capita. Uruguay's electricity intensity is 0.29 KWh per for each Euro of GDP. As shown in Exhibit 4, this is comparable to the Latin America and Caribbean average, but is below countries like Paraguay and Argentina indicating it relies less on electricity for economic growth.

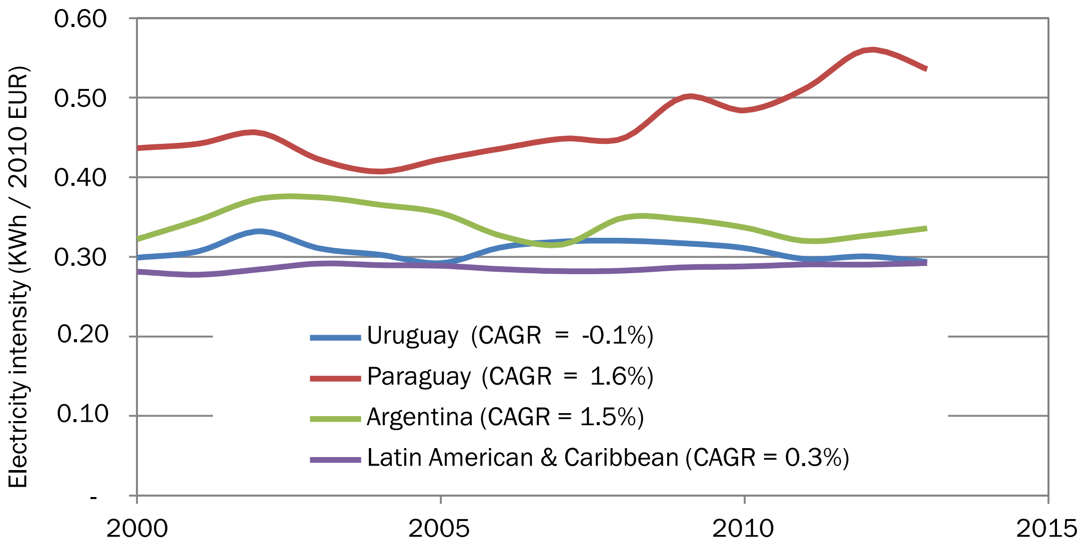

Exhibit 4: Electricity intensity of the economy (kWh electricity per € GDP)

Power sector overview

Exhibit 5 shows the organisation of the power sector in Uruguay. About 56% of generation capacity is owned and operated by the national utility company UTE[76]. The remaining capacity comes from the Salto Grande hydroelectric plant (945 MW), co-generation and smaller private investments in

[75] More recent information is currently not available.

[76] La Administración Nacional de Usinas y Trasmisiones Eléctricas (UTE).

renewable sources. Both transmission and distribution activities are fully under the control of UTE, as established by the 1997 law and the power sector's regulatory body is URSEA[77].

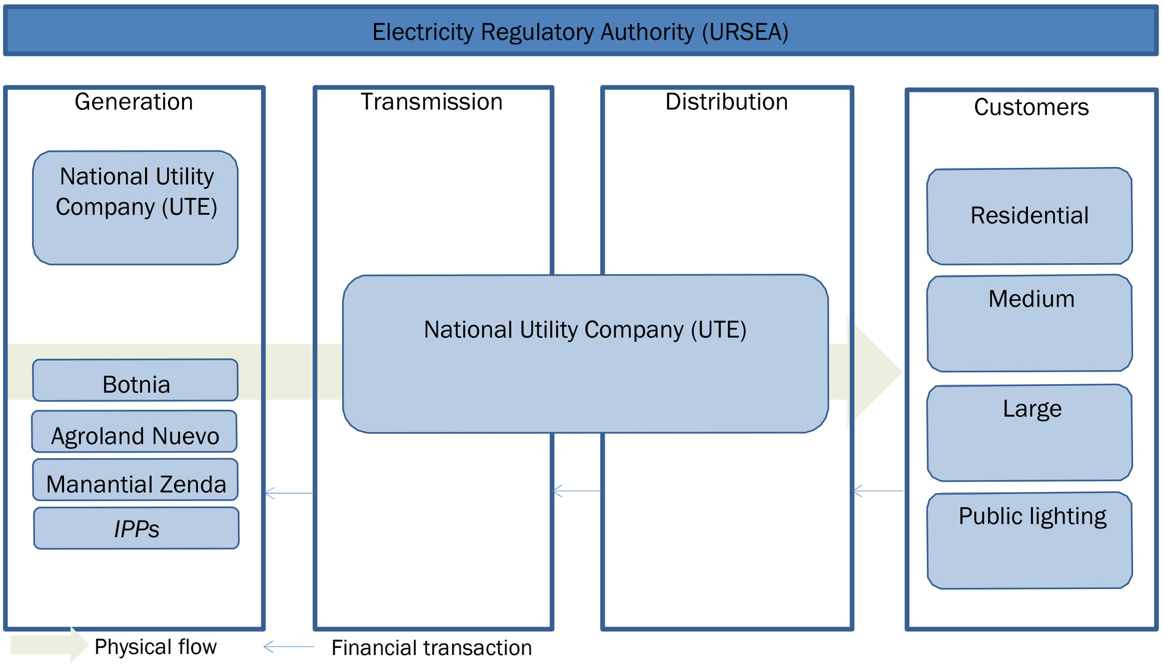

Exhibit 5: Organisation of the power sector in Uruguay

The electricity sector of Uruguay traditionally relies on domestic hydropower along with thermal power plants and on imports from Argentina and Brazil at times of peak demand. The legal and regulatory sector reforms in 1997, 2002, and 2006 led to large new investments in electrical production capacity including investments from the private sector. Thanks to these investments the sector has been modernized which resulted in an increase in the use of renewable energy sources. Wind power capacity has surged over the last 5 years, going from negligible in 2012 to 20% of installed capacity by 2015 (Exhibit 6). Uruguay is on track to become the country with the highest wind power coverage globally by the end of 2016 and is recognized for progress on decarbonizing its economy, with the World Bank and Economic Commission for Latin America and the Caribbean specifying Uruguay among its Green Energy Leaders.

The transition towards more renewable energy sources included the crafting of a competitive bidding mechanism for large-scale renewable energy projects and a feed-in tariff for smaller-scale systems. In addition, non-utility power producers are now also able to sell their excess renewable energy to the grid at standardized prices since the state-owned utility is required to buy all clean power generated. In response, the regulator has steadily decreased the feed in tariffs for renewable electricity. Together with the decreasing prices of fossil fuel, the developments explain the decreasing electricity prices since 2013 (Exhibit 7).

[77] Unidad Reguladora de Servicios de Energía y Agua (URSEA).

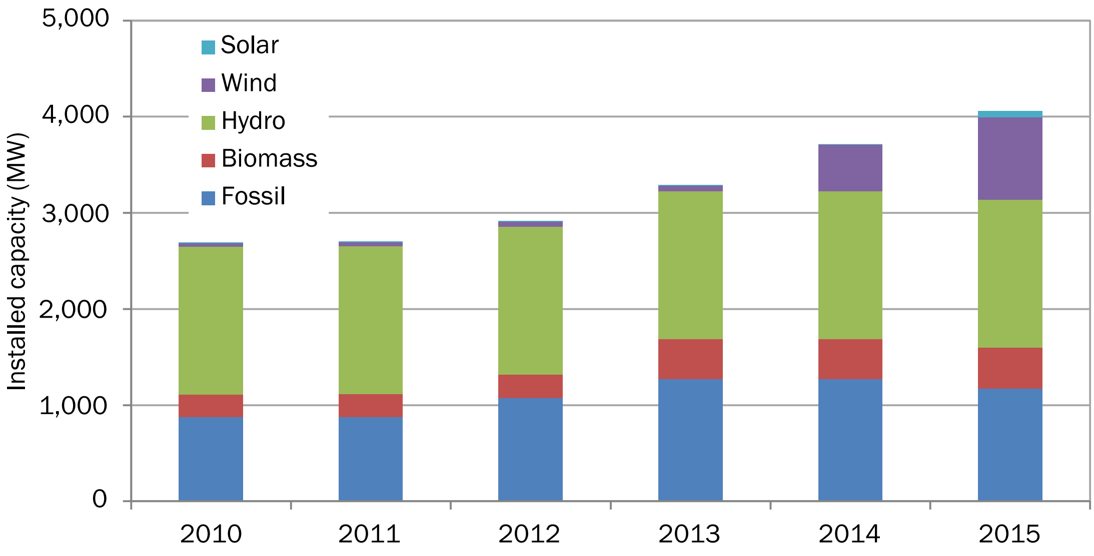

Exhibit 6: Installed capacity by technology type

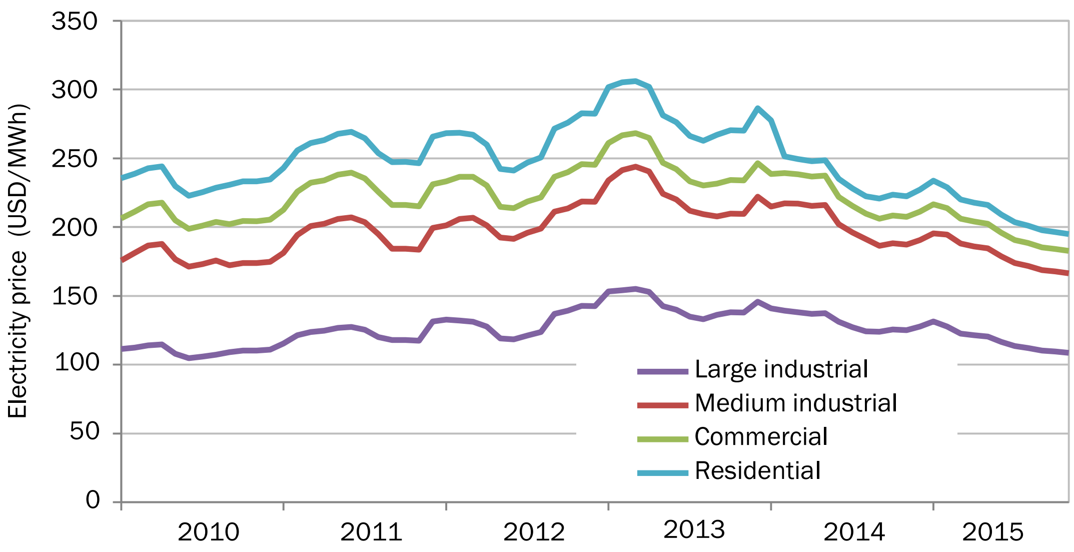

Exhibit 7: Electricity tariffs for different user groups

4.1.2 Indirect and induced effects of Polesine

Polesine's operating and construction expenditures indicate the economic output produced by its suppliers, which again trickle further down the supply-chain. These mechanisms can be captured using the Input-Output methodology described in Section 3.3 to yield quantitative estimations of so-called indirect and induced value added and jobs. The results in this section capture the value added and jobs effects that are attributable to the overall project and in specific to PROPARCO; attribution is based on PROPARCO's stake in the project which is 30%.

Operation

Exhibit 8 shows the various steps to quantify the value added and employment results related to the operating expenditures of the Polesine wind farm in 2015. Starting point are the current operating expenditures of the wind farm (€ 1.8 million). From Polesine we know how much they spend on maintenance, grid connection fees and insurance and how much of that is spent locally (98%).

Because the focus is on the impact on Uruguay, only local expenditures are considered when estimating the impact. Tracing these expenditures through the Social Accounting Matrix of Uruguay results in € 0.05 million output in the agricultural sector, € 0.6 million output in the manufacturing sector, € 0.2 million output in the other industries sector and € 2.8 million in the service sector. Using the output-to-value added ratio and the employment intensity[78] of Uruguay the value added and employment per sector are estimated (Exhibit 8). These sectoral results sum up to a total of € 1.7 million value added and 76 permanent jobs being supported when operating the Polesine wind farm. Due to PROPARCO's sizeable investment 30% of these impact results are attributable to PROPARCO; € 0.5 million value added and 23 jobs are supported.

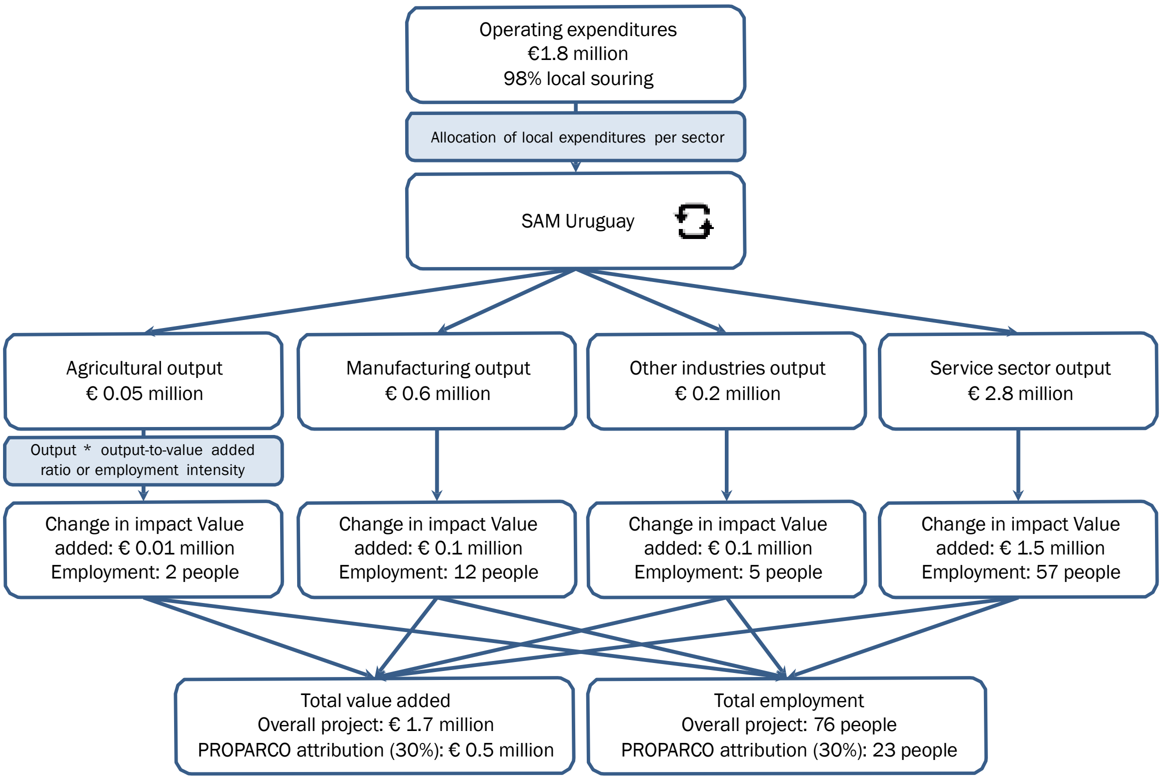

Exhibit 8: Quantification of value added and employment results during the construction of the Polesine wind farm

Construction

Polesine's construction expenditures were approximately € 83 million, of which 44% was spent locally. Using the exact same approach as is shown in Exhibit 8 this results in an overall value added of € 33 million and 1,623 man years[79] of employment supported. When we apply the 30% attribution of PROPARCO this results in of € 10 million value added and 487 man years employment.

Overall results

In order to summarize the indirect and induced job results from operating and construction expenditures we have to annualise the impact results from construction. That is because the value added and jobs are supported during a specific construction period, while operating effects occur on annual basis. Therefore we divide the value added and job results by the life-span of the project in order to come up with annual indirect and induced effects. The actual life-span of the project is unknown and therefore we make use the typical 20 year lifetime of a wind project (see Annex 1). This

[78] The number of employees needed in a certain economy/sector to produce € 1 of output.

[79] Given that jobs due to construction expenditures are temporary, we speak of jobs in man-years instead of permanent jobs.

means value added sums up to € 3.3 million value[80] added and 157 jobs[81] are supported on an annual basis, or € 1.0 million and 47 jobs, considering PROPARCO's attribution

4.1.3 Second order-growth effects of Polesine

The second order-growth effects of Polesine are the effects of the additional provision of electricity by Polesine on the Uruguayan energy market and the economy as a whole. The effects are expressed in terms of value added (GDP) and employment (jobs). Unlike the indirect and induced effects, second order-growth effects are forward effects in the sense that they indicate the effects of the *use* of electricity.

In the case of Polesine, the second order-growth effects are driven by a reduction of the electricity price rather than a reduction of outages. As will be explained in more detailed in this section, the effect of outages is negligible compared to the price effect as outages do not occur frequently and their duration is minimal.

Following Section 3.4.2, the economic output increase due to increased power supply is calculated in five steps:

1. Determine the electricity price decrease (in %) for companies due to the presence of Polesine;
2. Multiply the price decrease with the price elasticity of demand which yields the relative increase of electricity consumption (in %) by companies in different manufacturing sectors;
3. Multiply the increase of electricity consumption with the so-called electricity factor share to yield the relative increase of economic output (in %) by companies in the different sectors;
4. Multiply the relative increase of economic output of the different sectors with the respective total sector output to yield the increase of economic output in Euros;
5. The increased manufacturing output has spill-over effects in other sectors: companies need more inputs from other sectors which cause an output increase in sectors which are not directly affected by the lower electricity prices. Growing production in turn means more value added and jobs in the economy. These effects are traced using the IO model.

Power supply curve

Table 1 provides an overview of the Uruguayan power fleet as per early 2015. Using the average availability per technology, the installed capacity of 4,059 MW translates into an average available capacity of 2,435 MW. Hydro plants represent the lion's share of installed capacity, yet gas and diesel plants make up the largest part of available capacity. This is due to the fact that hydro plants cannot run at full capacity throughout the year. It is also important to note that the annual average is not representative under most circumstances; hydro and wind power plants exhibit considerable seasonal variation. From September through March hydro power is abundant, sharply reducing thermal power generation.

For each of the 68 available power plants in Uruguay, Short Run Marginal Cost (SRMC) values are determined based on observed data[82] in order to construct the country's power supply curve. The non-dispatchable plants, which must supply power when available (i.e. small hydro, wind and solar), are placed at the left hand side of the curve. These non-dispatchable technologies receive a fixed feed-in tariff for their supply.[83]

[80] Value added from operations (1.7) + (Value added from construction (33) / life-span of project (20)) = 1.7 + 1.6 = € 3.3 million value added

[81] Employment from operations (76) + (Employment from construction (1,623) / life-span of project (20)) = 76 + 81 = 157 jobs

[82] Administración del Mercado Eléctrico, http://www.adme.com.uy/mmee/cvr.php

[83] Tariff data based on International Renewable Energy Agency research

Table 1: Overview of installed and available capacity by technology

Technology	Number of plants	Installed capacity (MW)	Availability (MW)	Available capacity (MW)
Solar Photo	5	64	0.18	12
Hydro large	4	1,538	0.61	945
Wind onshore	29	857	0.24	205
Diesel	8	86	1.00	86
Gas Turbine	12	1,091	1.00	1091
Biomass	10	423	0.23	96
Total	68	4,059		2,435

When taking into account the average yearly availability determined in Table 1, the resulting power supply curve is shown in Exhibit 9. As becomes apparent, the electricity costs vary considerably per technology. Renewable plants run at a very low (short run) costs, whereas biomass, diesel and gas plants cost more per kWh to run. To examine the influence of the PROPARCO-attributable capacity, the power supply curve depicted in Exhibit 9 is modified by taking out that capacity, thereby shifting the supply curve to the left.

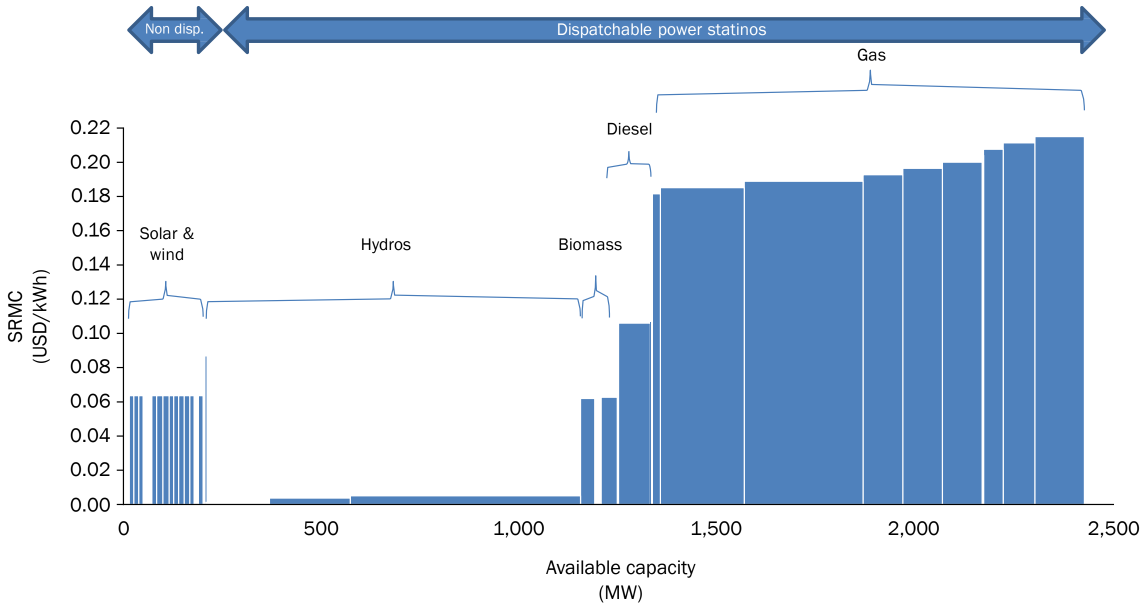

Exhibit 9: SRMC power supply curve based on average available capacity

Power load curve

In order to determine electricity prices one needs to know the so-called power load (MW) curve which essentially amalgamates the total power consumption in the system. For the power load curve, we use hourly power load data from the second Wednesday of each month. The advantage of using individual days is that it allows for a comparison of the model with the observed prices from the spot market. Electricity demand fluctuates, both over the course of the day and per month, as shown in Exhibit 10. Power demand during daytime is about 600 MW higher than during the night, but fairly stable without very pronounced peaks. There is a clear seasonality with demand in mid-winter and summer about 200 MW higher.

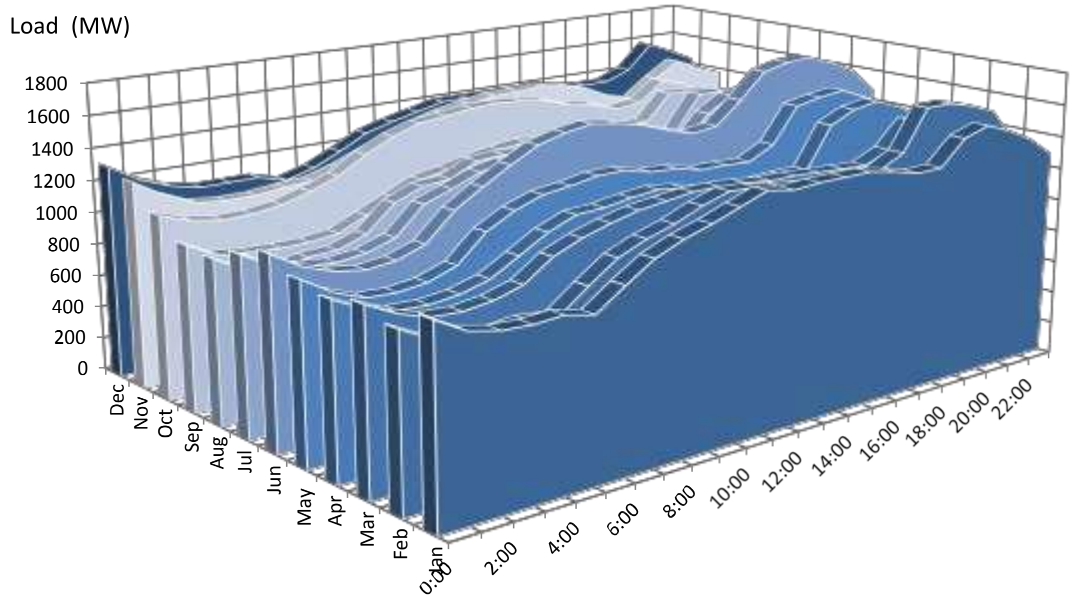

Exhibit 10: Daily power load curves based for the second Wednesday of each month[84]

Model validation

The power supply and load curves as described in the previous sections are combined in a price model. For each hourly load value the model determines the market clearing plant, who's SRMC is assumed to be the market clearing price. The results are shown in Exhibit 11.

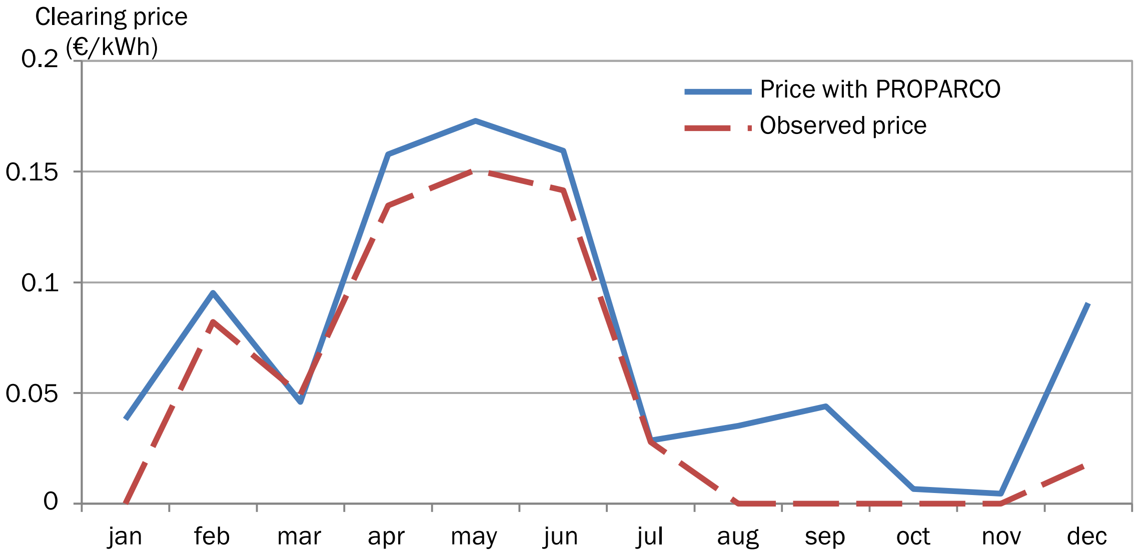

Exhibit 11: Market clearing price in €/kWh

Overall, the modelled and observed market clearing prices agree pretty well, given that the model does not include many aspects of the market bidding process and assumes daily constant rather than time-

[84] Demand data acquired through the Ministry of Industry, Energy and Mining (MIEM)

varying capacity factors. In general modelled prices are somewhat higher than observed prices, which most likely is due to the fact that many plants tend to bid somewhat lower than their SRMC in order to avoid expensive shut down and restart costs. Because the model is able to reproduce the observed behaviour of market clearing prices, it can be applied to determine the marginal effect of Polesine capacity, as will be done in the next section.

Determining the weighted average price of electricity

The market clearing price shown in Exhibit 11 applies for all the plants that do not benefit from feed in tariffs. To take this into account, we need to use the weighted average price (WAP) of electricity generation in Uruguay. The WAP is calculated as the average of the market clearing price and the feed-in tariff, each weighted by the amount of electricity generated under both[85]. Application of the model using the power supply curve with and without the Polesine capacity yields the actual and the counterfactual (i.e. without Polesine) WAP. This is shown in Exhibit 12, which also depicts the WAP difference.

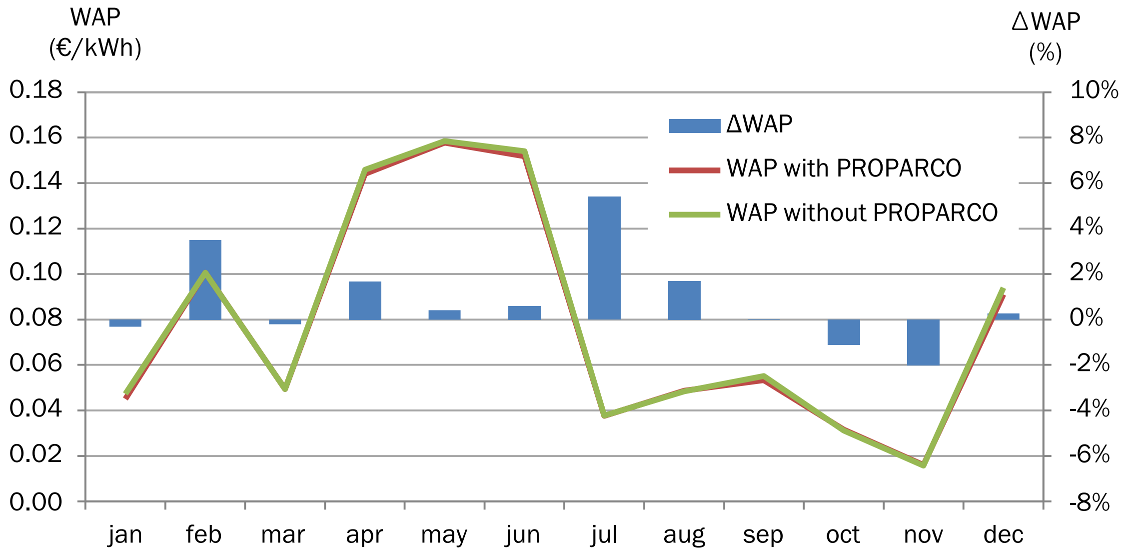

Exhibit 12: Weighted average electricity generation price in 2015

The difference in WAP across 2015 is 0.80%. Overall price differences are in the -2% - 5% range. In October and November there is a negative price difference; for these months the price with Polesine is higher. During these months the average price of electricity is relatively low because the hydro power plants run at higher than average capacity. The Feed-In Tariff (FiT) that Polesine receives for its renewable electricity then raises the WAP. Corrected for the transmission and distribution part of the end-user tariff the price difference expressed in WAP amounts to 0.44%.[86]

Determination of the electricity price elasticity

To estimate the price elasticity of electricity demand one would ideally use log-linear regression on panel data. In absence of such data for Uruguay, literature review provides price elasticity values that can be used for this study. In review of electricity price elasticities in Latin-America, Chang & Martinez Combo (2003) estimate the industrial price elasticity of demand at between -0.12 and -0.25. As the price elasticities of demand of other studies are in the -0.25 to -0.75 range (Section 3.4.2), we use the lower absolute value of -0.25 in our analysis.

[85] It is well possible that the thermal generation plants have entered into bilateral purchasing power agreements. Because we do not know the structure and price arrangements of such contracts we assume the spot market price to be a good indicator for these contracts as well.

[86] Generation cost share in total electricity tariff is 55%.

Determination of the electricity factor shares

Electricity factor shares express the change of economic output in response to increase use of electricity. The factor shares for Uruguay are based on the World Bank Enterprise Survey 2014. The results per company size and economic activity are shown in Table 2.

Table 2: Factor shares for different sectors in Uruguay

Sector	Size	Log electricity	Log labour	Log materials	Log capital	Observations
Manufacturing	Small	0.24	0.19	0.46	0.05	63
	p-value	*0.00*	*0.26*	*0.00*	*0.33*	
	Medium	-1.13	1.00	0.75	0.95	51
	p-value	*0.01*	*0.17*	*0.01*	*0.00*	
	Large	0.12	0.70	0.26	0.16	40
	p-value	*0.24*	*0.00*	*0.00*	*0.07*	
	Food	0.33	0.43	0.35	0.16	40
	p-value	*0.03*	*0.01*	*0.00*	*0.09*	
	Textiles	-0.05	0.24	0.45	0.33	49
	p-value	*0.87*	*0.73*	*0.15*	*0.14*	
	Chemicals	-0.10	0.66	0.58	-0.02	26
	p-value	*0.47*	*0.00*	*0.00*	*0.82*	
Retail	Total	1.23	0.75			22
	p-value	*0.20*	*0.65*			

Because of the small sample size for most of the sectors, not all electricity factor shares are realistic (positive) and/or significant at the 5% confidence level. Looking at companies by size, only the small and large[87] subgroups have realistic electricity factor shares, respectively 0.24 and 0.12. Similar values can be found in existing literature. Casacuberta and Fachola (2003) look at the Uruguayan manufacturing sector and estimate the electricity factor shares at 0.122. The factor share used in this study is the average of the small (0.24) and large company shares (0.12), which is 0.18.

Change in manufacturing output due to cheaper electricity

Combining the price decrease (obtained from the price model); price elasticity; factor share; and manufacturing output yields the increase of output related to cheaper electricity. We multiply the factor share of all manufacturing sub-sectors (0.18) by the price elasticity (-0.25) and the price decrease (0.44%) to determine the change in output of the manufacturing sector (0.02%). If we combine that with the overall output of the manufacturing sector (€ 16.8 billion) that results in a € 3.3 million increase in economic output.

Change in economic output, value added and employment

Having determined the PROPARCO-attributable change of manufacturing output, the final steps comprise the determination of how this additional production will affect other economic sectors. Once we derive the total output increase in the economy (in manufacturing and all other sectors), we calculate the associated value added and employment. As mentioned in Section 3.4.3, the Uruguayan input-output table is well suited for this analysis, since it allows one to trace the knock-on effects of changes in one sector on other sectors. Therefore, as outlined in Section 3.4.3 we adapt the Uruguayan SAM to account for:

1. The lower electricity price paid by users to the electricity sector;
2. The lower profits and corporate taxes paid by the electricity sector as a result of the lower price;
3. The higher manufacturing output of 0.02% (ΔY);

[87] Even though the electricity factor share is significant only at the 25% confidence level, it is realistic and in line with other estimates; therefore we take it into account as a lower bound value.

4. The larger procurement of the manufacturing sector from other sectors (proportionate the increase of manufacturing output), and the consequent increase of output of the rest of the sectors.

Key results and multipliers

The total impact of the electricity price reduction on the economy, derived after carrying out the changes outlined in the previous sub-section and accounting for PROPARCO's 30% attribution are summarised in Table 3. Compared to results from other countries the effects of investments in wind power plants in Uruguay on employment are relatively small. There are two reasons for this. First, the output and GDP effects are relatively small compared to other studies because the factor shares and price elasticity are relatively low. Second, as mentioned in the economic profile, the labour productivity of Uruguay is comparatively high: Uruguay, classified as a high-income country, has a large GDP to employment ratio. This results in a reduction of the effect on jobs as fewer jobs are associated with the changes in manufacturing output. The lower output of the electricity sector reflects the electricity price decrease due to the additional capacity and likewise lower profits and thus less value added.

Table 3: Project and PROPARCO-attributable output, GDP and employment results in Uruguay, broken down by sector

	Project's contribution			PROPARCO's contribution		
	Output	Value added	Employment	Output	Value added	Employment
Sector	€ million	€ million	jobs	€ million	€ million	jobs
Total	-4.1	3.3	169	-1.2	1.0	51
Agriculture	0.9	1.1	24	0.3	0.3	7
Manufacturing	11.2	7.0	127	3.3	2.1	38
Electricity	-16.9	-10.9	0	-5.1	-3.3	0
Other industries	0.1	0.7	3	0.0	0.2	1
Services	0.7	5.4	15	0.2	1.6	5

The results derived for Uruguay are expressed as key ratios in Table 4. These ratios represent the change in output, GDP and employment related to 1% increase in the effective capacity of the country (i.e. the capacity needed to meet the electricity demand in the country). The output multipliers derived here, together with similar power-to-output multipliers from other impact studies we have executed in the power sector, are one of the key elements for estimating the current and potential impact of PROPARCO in the countries where it invests, as described in details in Section 5.[88]

Table 4: Power-to-output, value added and employment multipliers per one percent effective capacity increase

Sector	Output	Value added	Employment
Agriculture	0.009%	0.019%	0.009%
Manufacturing	0.038%	0.064%	0.038%
Other industries	0.001%	0.009%	0.001%
Services	0.001%	0.009%	0.001%

[88] The multipliers for the electricity sector have been excluded from the other industries sector because they are not a result but an input.

4.1.4 Total value added and employment impact of Polesine

Table 5 summarises the indirect, induced and second order growth impact for Polesine, as derived in Sections 4.1.2 and 4.1.3. Exhibit 13 shows how the results have been obtained in a simple diagram. The results reflect the 30% attribution of PROPARCO.

Table 5: Direct[89], indirect, induced and second order effects of Polesine

Capacity (in MW)	50	
Capacity factor	42% (186 GWh/year)	
	Project's contribution	PROPARCO's contribution
Effects on job creation (in FTE)	326	98
Direct	0	0
Indirect and induced	157	47
Second-order effects	169	51
Contribution to GDP (in million €)	6.6	2.0
Direct		
Indirect and induced	3.3	1.0
Second-order effects	3.3	1.0

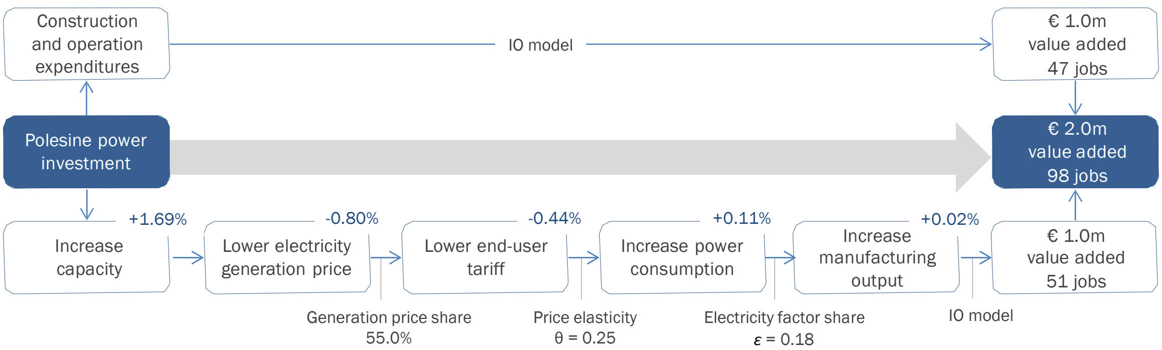

Exhibit 13: Total value added and employment impact of Polesine

4.2 Azure Power

In May 2013 and July 2015 PROPARCO provided Azure Power (Azure) with respectively € 7.0 million and € 7.8 million of equity and quasi-equity in order to expand its generation capacity. Azure is a solar energy specialist that develops, constructs and operates solar power plants in India with a total installed capacity of 110 MW as of March 31, 2015. The company intends to install another 790 MW[90] in the next years. Based on the € 262 million project size[91] this means that 5.6% of Azure's economic impacts can be attributed to PROPARCO (see Section 3.1 for attribution method).

In this section, after providing a short economic and energy profile of India, we will analyse the indirect and induced effects related to the construction and operations of Azure and quantify the second-order growth effects related to the additional generation capacity.

[89] Data on direct GDP contributions of Polesine has not been collected and therefore cannot be reported.

[90] http://www.azurepower.com/about-us.html - The Key Facts as on May 31st 2016.

[91] Information provided by PROPARCO

4.2.1 Economy and energy profile

Macro-economic profile

Over the past 70 years, India transformed from one of the poorest countries into one of the world's fastest growing economies. Albeit rather volatile, growth over the past 20 years has averaged 7% (Exhibit 14). India's economy grew by 7.6% percent in 2015, faster than any other large country. Despite strong GDP growth in the last year, India's GDP per capita (€ 1,426) is still much lower than in neighbouring China (€ 7,145).

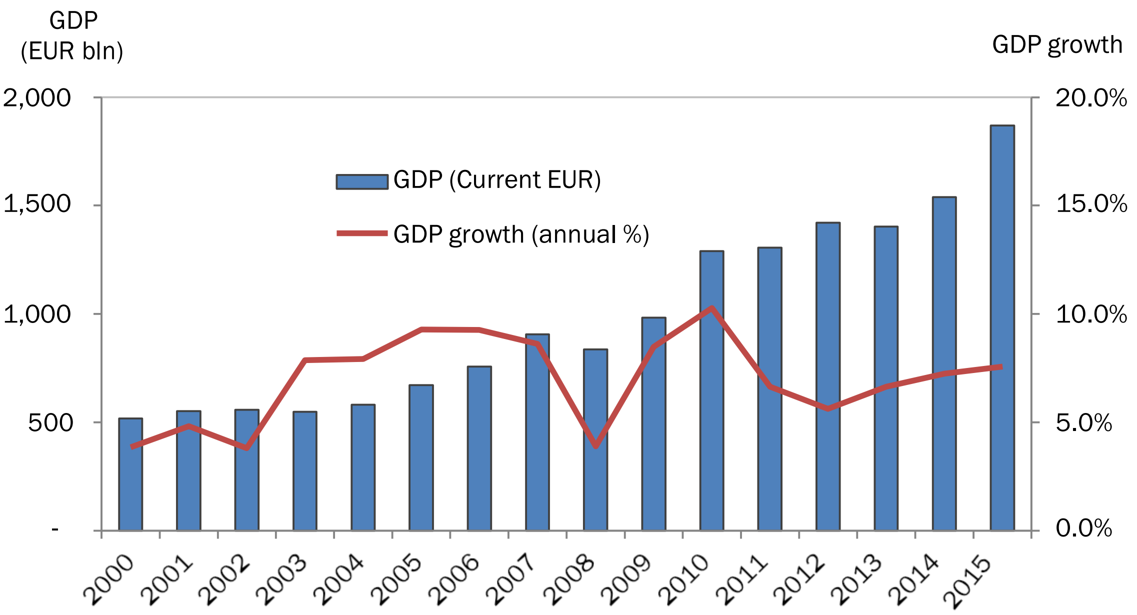

Exhibit 14: GDP and GDP growth in India (2000-2015)

Supported by lower oil prices, the Indian government has made considerable efforts to put its public finances on solid footing, with its fiscal deficit falling to 4.1 percent of GDP in 2014/15. By improving opportunities for higher infrastructure spending, these fiscal reforms can have a significant impact on economic growth and much needed job creation.

With 1.3 billion people, of which 29% under 15 years old, India will soon have the largest and youngest workforce in the world. At the same time, the country is experiencing a wave of urbanisation as some 10 million people move to towns and cities each year in search of jobs and better livelihoods. Massive investments will be needed to create the jobs, housing, and infrastructure to accommodate these trends. Economic growth which benefits everyone will be essential as nearly 300 million people still live below the poverty line.

Energy profile

India's total energy consumption in 2013 was 775 megatons of oil equivalent (t.o.e.) and the energy use per capita was 606 kg oil equivalent (kg.o.e). The industry sector consumed most energy in 2013 (approximately 47%), while in 2000 the energy consumption was dominated by the residential and commercial sectors. Industrial energy demand almost doubled over the 2000-2013 period, along with a large expansion of energy-intensive sectors such as steel production. Agriculture accounts for only 5% of the total energy consumption. Nevertheless, the sector's energy consumption has grown in absolute terms in the past decade as more farmers obtain electric (irrigation) equipment.[92]

[92] India Energy Outlook (2015). International Energy Agency http://www.worldenergyoutlook.org/media/weowebsite/2015/IndiaEnergyOutlook_WEO2015.pdf

Almost three-quarters of Indian energy demand is met by fossil fuels, a share that has increased since 2000 driven by the rapid rise of coal-fired power generation as well as a decreasing role of biomass for cooking. The country's primary energy source is coal (44%), followed by biomass (23%) and oil (22%). Hydropower, nuclear power and other renewables (solar, wind and geothermal) are used predominantly in the power sector and account for less than 5% of the total energy consumption. Nevertheless, the Indian government is pursuing policies to develop the renewable energy market, mainly in the sphere of solar and wind power generation.[93]

In 2013 India consumed a total of 978,817 GWh of electricity, which is 765 KWh per capita. India's electricity intensity, i.e. the electricity consumption per € 1 of GDP, is below that of China (Exhibit 15). Insufficient generation capacity and aggregate technical and commercial losses caused a power supply deficit of approximately 5% in 2015 which resulted in more power outages.[94] The WBES 2014 reports that companies face on average 16.7 outages per month; each with an average duration of 1.6 hours. The median company loses 30 hours of production time in an average month whereas in China the loss of production time is less than 1 hour a month.

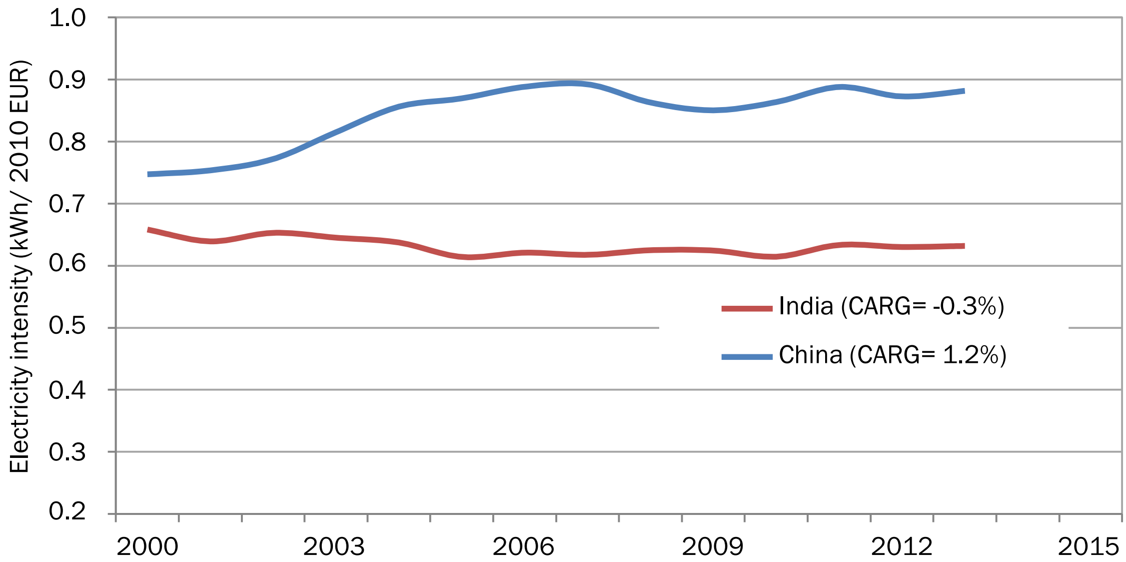

Exhibit 15: Energy intensity of the Indian economy

Power sector overview

Exhibit 16 provides an overview of the organisation of the power sector in India. The sector is regulated by the Ministry of Power. About 27% of total installed capacity derives from the central sector, i.e. power plants owned by the central government of India[95] and 35% of total installed capacity comes from the state sector; power plants owned by the different states in India. The private sector owns 38% of all installed capacity in India. These three generation sectors make use of two different transmission companies; the Central Transmission Utilities (CTU) takes care of both intra and inter-state transmissions and the State Transmission Utilities (STU) enable intra-state transmissions. Both state and privately owned distribution companies distribute power to end users. Distribution companies procure electricity bilaterally from power producers but spot-markets, amongst others the Indian Energy Exchange and the Power Exchange India Ltd., also play a role in matching supply and demand.

[93] "With around 300 days of sunshine every year, India has among the best conditions in the world to harness solar energy" - Onno Ruhl, World Bank Country Director in India.

[94] Executive Summary Power Sector – March 2015. Publication of Central Electricity Authority.

[95] As on 31st of March 2015; reported by the Central Electricity Authority which is part of the Ministry of Power.

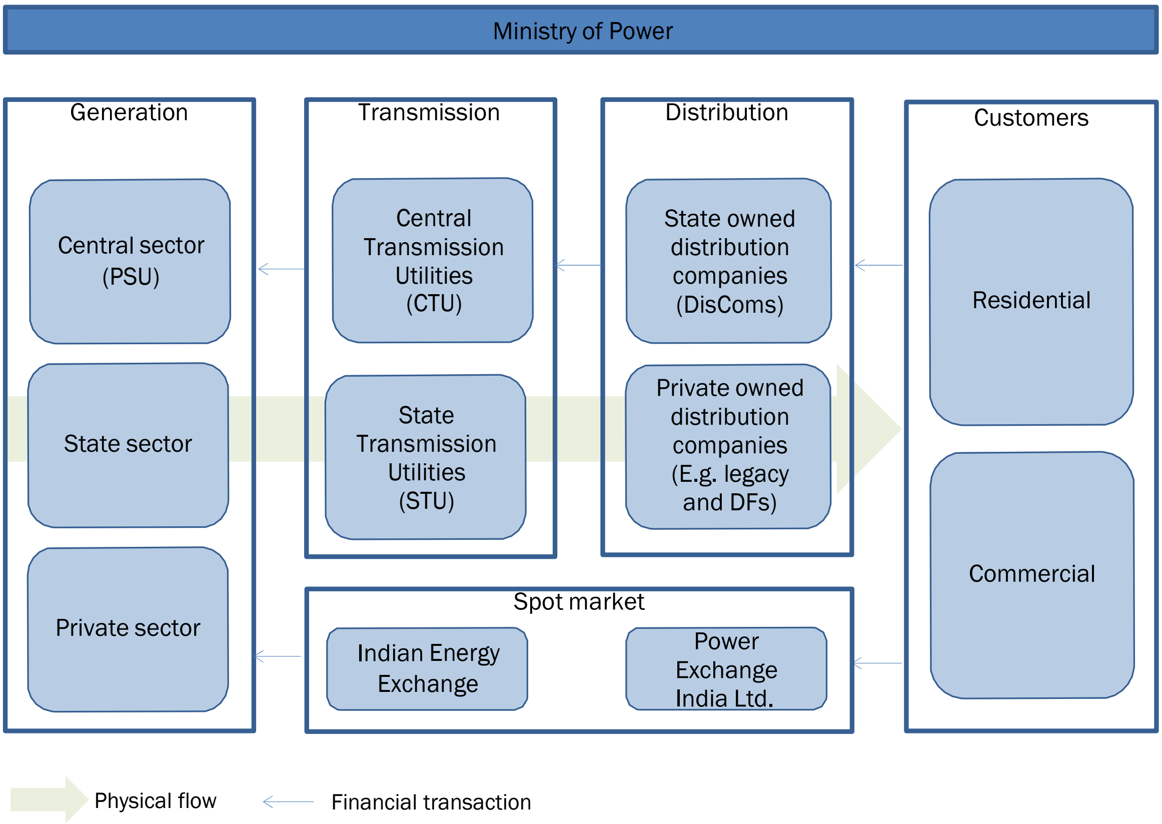

Exhibit 16: Organisation of the power sector in India

The electricity sector of India heavily relies on thermal energy sources (see Exhibit 17). Coal, gas and diesel together comprise 70% of the overall installed capacity in the country. Renewable energy sources together provide 28% of the installed capacity and the remaining 2% is nuclear power. With 45,323 MW installed, hydro power (small and large) is currently the largest source of renewable energy. The Government of India plans to ramp up its solar power generation to 100,000 MW in 2022, which seems ambitious as it would mean an increase of 15 times the currently installed solar power capacity (6,763 MW in 2016). However, developments in the solar power sector are promising; investments are increasing and installed solar power capacity almost doubled in 2015.

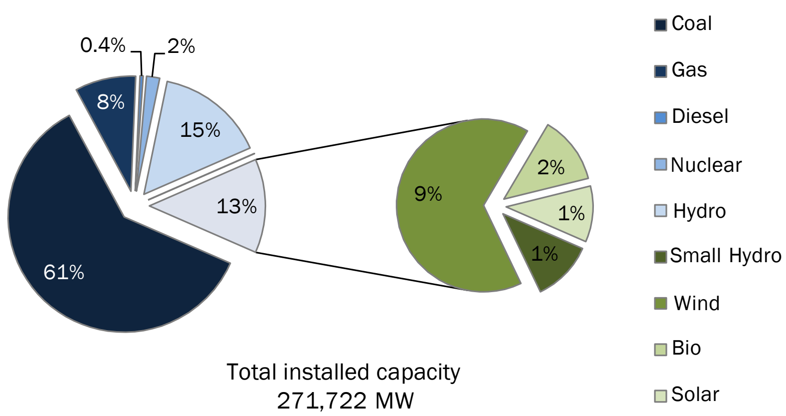

Exhibit 17: Installed capacity per technology type (31st of March, 2015)

4.2.2 Indirect and induced effects of Azure

For Azure we can only estimate the indirect and induced effects from their operating expenditures because data on construction expenditures is not available. As explained in Section 4.1.2, the operating expenditures represent revenues (economic output) for Azure's suppliers which partially trickle further down the supply-chain. The Input-Output methodology, as described in Section 3.3, allows capturing these different rounds of spending related to the initial expenditures of Azure. In each of these spending rounds, value added and jobs are supported and those results are summarised in this section. Attribution is based on PROPARCO's stake in Azure which is 5.6%.

Operations

Exhibit 18 shows the steps taken to quantify the value added and employment results related to the operating expenditures of Azure in 2015. Starting point are the operation expenditures during of € 6.2 million. Because we have no specific information on the allocation of operational expenditures to the different sectors and the share of local procurement, we make use of the average spending pattern of the solar power sector in India (this information is obtained from the GTAP9 energy database). We follow the operating expenditures of Azure through the Indian SAM. The result is approximately € 0.5 million output in the agricultural sector, € 4.3 million output in the manufacturing sector, € 1.8 million output in the other industries sector and € 7.4 million in the service sector. Using the output-to-value added ratio and the employment intensity[96] of India, the value added and employment per sector are estimated (Exhibit 18). These sectoral results sum up to a total of € 5.3 million value added and 1,747 permanent jobs being supported due to the operating expenditures of Azure. If we consider PROPARCO's stake in Azure, € 0.3 million value added and 98 jobs are attributable to PROPARCO.

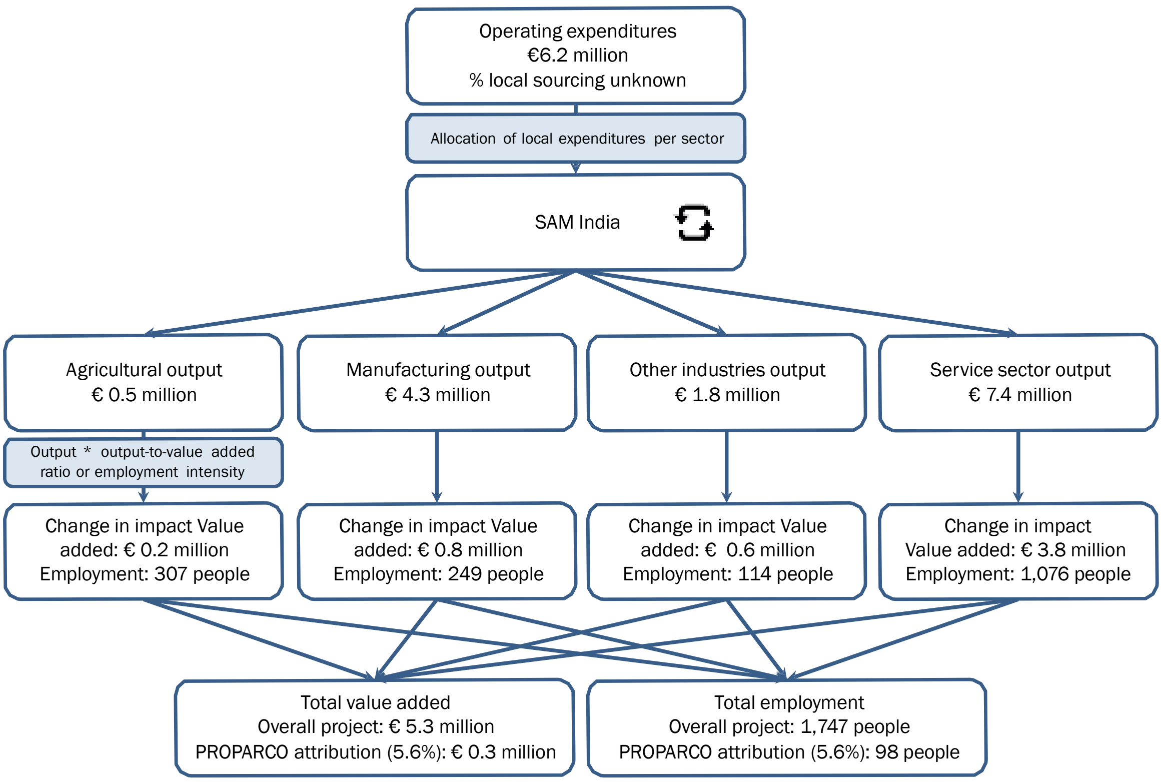

Exhibit 18: Quantification of value added and employment results from the operating expenditures of Azure in 2015

[96] The number of employees needed in a certain economy/sector to produce € 1 of output.

4.2.3 Second-order growth effects of Azure

Data from the World Bank Enterprise Survey 2014 show that companies in India consider power outages a substantial bottleneck. Table 6 shows that in 2013 the monthly duration of power outages was in the 30 – 45 hour range (median – average).[97] Using the sample's average of 270 productive hours per month means that power outages affected companies for 11% – 17% of their operational time, which is substantial. This outage time causes firms to forego production and lose sales revenues. Therefore reduction of outages is an important pathway through which additional generation capacity could affect firms productivity and consequently value added and employment generation.

Table 6: Number, duration, and total outage time (in hours)

	Number of outages		Duration of outages (h)		Total outage time (h)	
	Median	Average	Median	Average	Median	Average
All	20.0	26.1	1.0	2.0	30.0	43.6
Small	20.0	27.9	1.0	2.0	30.0	43.1
Medium	20.0	25.5	1.0	2.0	30.0	43.6
Large	20.0	24.6	2.0	2.0	30.0	44.0
Food	20.0	28.5	1.0	1.8	30.0	41.6
Other industry	20.0	26.8	1.0	2.0	30.0	44.7
Services	15.0	23.4	1.0	2.2	30.0	42.1
Retail	15.0	23.4	1.0	1.9	25.0	36.4

In terms of Exhibit 1, we analyse the effect of Azure on the reduction of outages and consequently on income and job generation. We do not investigate the effect of the investment on the electricity generation price, as we did for Polesine in Uruguay. The reason for that is that the effect of Azure on the price of electricity will be very limited because (i) the relatively small addition of installed capacity; (ii) the fact that solar tariffs[98] are higher than market average generation price, and (iii) the low and statistically insignificant electricity factor shares, suggesting that firm production will not strongly respond to lower prices.

Following Section 3.4.2, the economic output increase due to reduced power outages is calculated in four steps:

1. Determine the relative increase of effective generation capacity (in %) of Azure;
2. Translate the relative capacity increase in into a relative increase of production time (in %);
3. Multiply the increased production with the sector-specific outage mitigation factors which yield the relative increase of economic output (in %) for companies in different sectors;
4. The increased output of the various sectors have spill-over effects in other sectors: companies need more inputs from other sectors which cause an output increase in sectors which are not directly affected by the lower electricity prices. These effects are traced using the IO model.

Contribution to effective generation capacity

The 110 MW installed capacity of Azure (based on data as per March 31, 2015) constitutes 0.04% of India's total generation capacity (see Exhibit 17). In terms of effective capacity contribution, using the capacity factor of 0.187 that Azure provided, it means that Azure contributes 0.02% of India's total power demand of 126 GW. Together with the before-mentioned 5.6% attribution factor this means that PROPARCO contributes 0.001% to the effective generation capacity.

[97] Data on outages experienced during the working hours of a company in a typical month.

[98] In 2015 8 Rupees per kWh for solar vs a market clearing price of 3 Rupees per kWh and a real cost of electricity in the range of 3-6 Rupees per kWh.

Increase of operation time for companies

An increase of generation capacity reduces the power outage time which of course increase the time that companies can be operational. Although the relationship between increased generation capacity and outage time is by no means straightforward, in Section 3.4.1 (on page 16) we argue based on two empirical studies that 1% increase of generation capacity translates into a 0.11% increase of production time. That means that PROPARCO-attributable increase of operation time is 0.0001%. Although this number is very small at the scale of all of India, one has to keep in mind that at the regional or local scale the impact of Azure's solar plants is very much larger. But as Azure is present in 15 states we have to consider the Indian economy in its totality.

Increase of economic output

The increased time that companies can operate due to the reduced outage time must be converted into an increase of actual economic output. This means accounting for the heterogeneity of how outages affect companies if different economic sectors. The reasons for this heterogeneity were explained in Section 2.2). Table 7 shows the sales losses suffered by companies in different sectors as a result of the power outage experienced (see Table 6).

Table 7: Relative sales losses due to power outages

Company characteristics	% sales lost		% self generation	
	median	average	median	average
All	2.0%	4.7%		
generator	*2.0%*	*4.7%*	*5.0%*	*8.5%*
no generator	*2.0%*	*4.5%*		
Small >=5 and <=19	3.0%	5.4%		
generator	*3.0%*	*5.6%*	*5.0%*	*9.5%*
no generator	*3.0%*	*4.8%*		
Medium >=20 and <=99	2.0%	4.7%		
generator	*2.0%*	*4.7%*	*5.0%*	*8.1%*
no generator	*2.0%*	*4.3%*		
Large >=100	2.0%	3.8%		
generator	*2.0%*	*3.9%*	*5.0%*	*8.4%*
no generator	*2.0%*	*3.4%*		
Food	3.0%	5.7%		
generator	*3.0%*	*5.8%*	*5.0%*	*8.7%*
no generator	*3.0%*	*5.3%*		
Other industry	2.0%	5.0%		
generator	*2.0%*	*5.0%*	*5.0%*	*8.5%*
no generator	*2.0%*	*5.2%*		
Services	2.0%	2.8%		
generator	*2.0%*	*3.1%*	*5.0%*	*6.6%*
no generator	*1.0%*	*1.9%*		
Trade	2.0%	3.4%		
generator	*2.0%*	*3.0%*	*5.0%*	*6.8%*
no generator	*3.0%*	*4.2%*		

As expressed in Equation 6 (page 19), division of the percentage sales lost by the percentage lost production time yields the mitigation factor: the extent to which production time losses translate into loss of economic output. The median, mean and mid-point value of this mitigation factor for different company size classes and economic sector is given in Table 8.

Table 8: Mitigation factor ϕ (% sales lost / % outage time)

Company characterisctics	φ		
	median	average	mid point
All	0.19	0.27	0.23
generator	*0.19*	*0.27*	*0.23*
no generator	*0.22*	*0.31*	*0.26*
Small	0.25	0.29	0.27
generator	*0.15*	*0.29*	*0.22*
no generator	*0.20*	*0.30*	*0.25*
Medium	0.19	0.28	0.24
generator	*0.19*	*0.28*	*0.23*
no generator	*0.28*	*0.33*	*0.30*
Large	0.22	0.23	0.23
generator	*0.22*	*0.23*	*0.23*
no generator	*0.25*	*0.24*	*0.25*
Food	0.29	0.37	0.33
generator	*0.32*	*0.37*	*0.35*
no generator	*0.29*	*0.34*	*0.32*
Other industry	0.19	0.29	0.24
generator	*0.18*	*0.28*	*0.23*
no generator	*0.22*	*0.35*	*0.29*
Services	0.21	0.17	0.19
generator	*0.17*	*0.16*	*0.16*
no generator	*0.25*	*0.23*	*0.24*
Trade	0.20	0.24	0.22
generator	*0.21*	*0.20*	*0.20*
no generator	*0.25*	*0.33*	*0.29*

Looking at the total sample, the mid-point mitigation factor is 0.23 which means that a 1% increase of production time leads to 0.23% increase of economic output. Across all sectors the mitigation factors are very similar for firms with and without generators. One reason for this is the relatively small capacity of the back-up generators which can only partially cover firm operations.

Multiplication of the relative operation time increase by the mitigation factor and then by the total sector economic output results in the change of economic output per individual sector. The results are presented in Exhibit 19. The increase of output in the food and beverages sector is the largest[99] because its mid-point mitigation factor is the largest. The increase as a percentage of total sector output are of course very small because we consider a very small PROPARCO-attributable increase of generation capacity (0.001% as mentioned before) and the fact that most Indian companies are fairly well able to mitigate the effect of power outages on their output (low mitigation factors).

It is important to notice that the reduction of outages will only have a direct output effect on the sectors that are dependent on electricity use for their production. Agricultural production, for example, will not pick up as a result of the better power reliability, as the sector is not a heavy electricity user.

The total increase of output of all sectors is € 0.79 million per year.

[99] 0.00011%*0.33 = 0.000036%

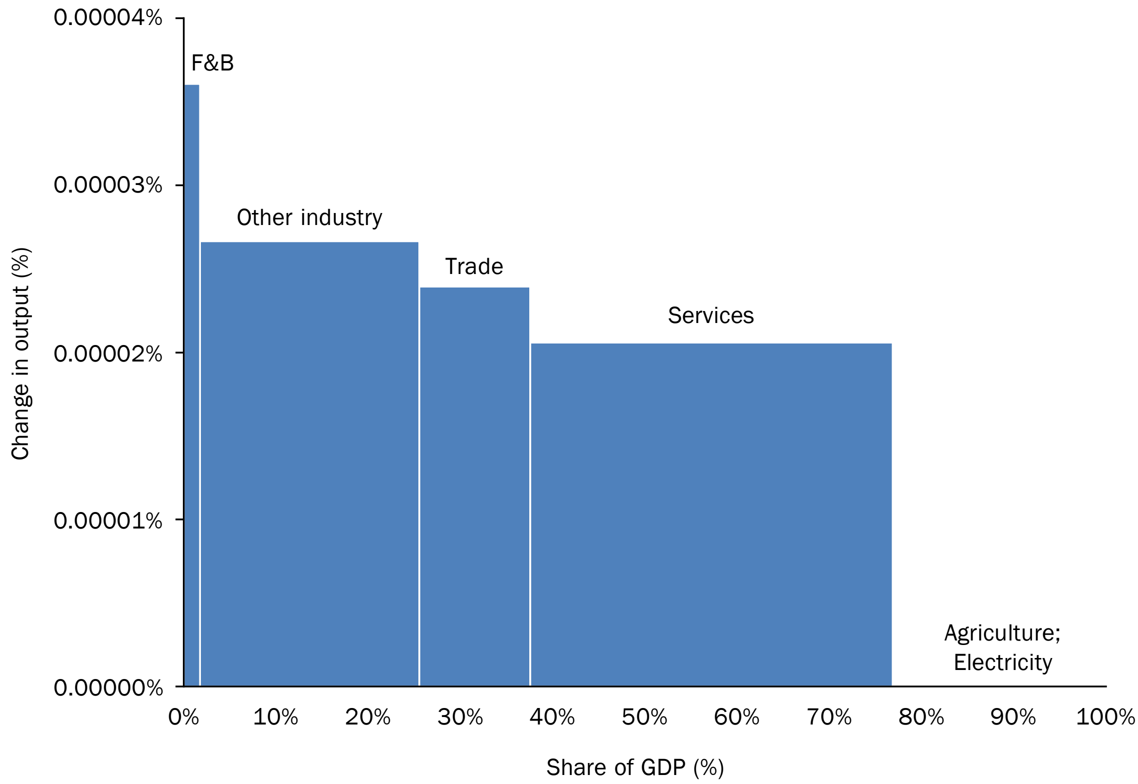

Exhibit 19: Change in output and share of sub-sector

Key results and multipliers

The change in output is traced through the Social Accounting Matrix using the RAS procedure (see Section 3.4.3) to yield estimations of the economy-wide value added and employment effects. Table 9 summarises the results. The total output increase is € 0.79 million. As explained earlier, € 0.76 million is related to output increase in the sectors directly affected by the outage decrease. The extra € 0.03 million is the procurement effect on other sectors, such as agriculture. For example, as food producers increase production, they need to buy more raw materials from local farmers, which leads to growth in the Indian agriculture sector (€ 0.02 million). The extra value added is rather small because most sectors directly benefit from outage reduction (see Exhibit 19).

Table 9: Project and PROPARCO-attributable output, GDP and employment results in India, broken down by sector[100]

	Project's contribution			PROPARCO's contribution		
	Output	Value added	Employment	Output	Value added	Employment
Sector	€ million	€ million	jobs	€ million	€ million	jobs
Total	14.16	6.37	2,333	0.79	0.36	131
Agriculture	0.28	0.25	221	0.02	0.01	12
Manufacturing	5.68	1.75	413	0.32	0.10	23
Electricity	0.15	0.05	0	0.01	0.00	0
Other industries	1.70	0.82	336	0.10	0.05	19
Services	6.34	3.51	1,364	0.36	0.20	76

100 Sums may not add up due to rounding.

The services sector (which includes trade, financial, professional and public services) experienced the highest production increase in absolute terms: € 0.36 million. This results in the creation of 76 jobs and € 0.20 million in value added. Although the change in manufacturing output (€ 0.32 million) comes close to that of the service sector, value added and employment results are twice lower (€ 0.10 million and 23 jobs). That is because the manufacturing sector uses more intermediary inputs and is less labour intensive than the service sector. As sectors increase their production, they also use more electricity, which leads to growth of output in the sector of € 0.01 million. However, in the short term this small output increase is unlikely to affect jobs in this non-labour intensive sector.

The results derived for India are expressed as multipliers in Table 10. These multipliers represent the change in output, value added and employment related to a 1% increase in the effective capacity of the country (i.e. the capacity needed to meet the electricity demand in the country). The power-to-output (PTO) multipliers derived here, are one of the key elements for estimating the current and potential impact of PROPARCO in the countries where it invests, as described in details in Section 5.[88]

Table 10: Power-to-output, value added and employment multipliers per one percent effective capacity increase

Sector	Output	Value added	Employment
Agriculture	0.004%	0.005%	0.004%
Manufacturing	0.030%	0.031%	0.029%
Other industries	0.025%	0.025%	0.028%
Services	0.023%	0.023%	0.023%

4.2.4 Total value added and employment impact of Azure

Table 11 summarises the indirect, induced and second order growth impact for Azure, based on data as per March 31, 2015, as derived in Sections 4.2.2 and 4.2.3. Exhibit 20 shows how the results have been achieved in a simple diagram. The results reflect the 5.6% attribution of PROPARCO.

Table 11: The direct[101], indirect, induced and second order effects of Azure

	Azure (India)	
Capacity (in MW)	110	
Capacity factor	18.7% (183 GWh/year)	
	Project's contribution	PROPARCO's contribution
Effects on job creation (in FTE)	4,308	241
Direct	222	12
Indirect and induced	1,747	98
Second-order effects	2,339	131
Contribution to GDP (in million €)	11.7	0.7
Direct		
Indirect and induced	5.3	0.3
Second-order effects	6.4	0.4

[101] Data on direct GDP contributions of Azure has not been collected and therefore cannot be reported.

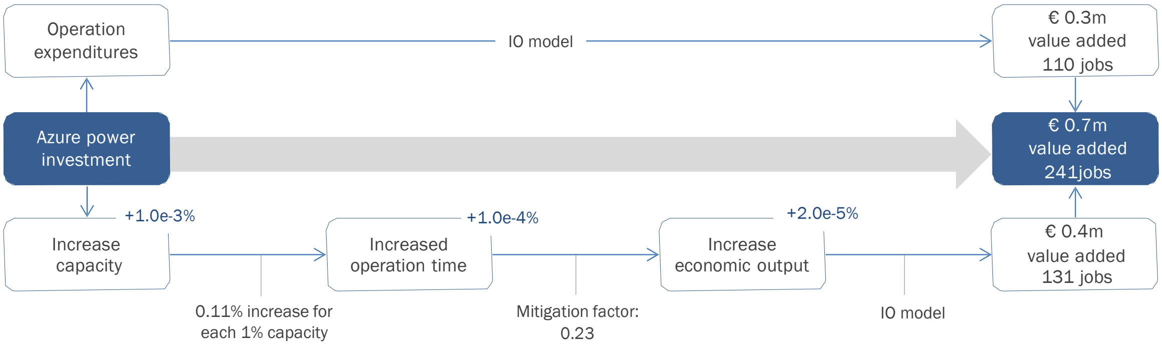

Exhibit 20: Applied analysis framework for impact of Azure Power investment on value added and employment

4.3 Case study comparison

In this section we will compare the results of the Uruguay and India case studies. In Section 5.2 we will also make comparisons of the results from other power-sectors studies that have we have conducted because these are included in the Impact toolkit. When comparing the results of two case studies it is important to note that the sources of indirect and induced impacts on the one hand and second order growth effects on the other are quite different. The former scale are driven by the amount of money spend on construction and operation whereas the latter are driven the effective generation capacity.

4.3.1 Indirect and induced effects

Comparison of the results in Table 5 and Table 11 show that the Proparco-attributable indirect and induced value added of Polesine in Uruguay is three times higher than of Azure in India, not entirely surprising given that the investment in Polesine is almost twice as big as the one in Azure. The indirect and induced employment impact of Azure is twice as big as for Polesine. The explanation for this is the much lower employment intensity in India; overall labour productivity in India is nine times lower than Uruguay, especially due to the presence of a large and unproductive agricultural sector.

4.3.2 Second-order growth effects

Comparison of the multipliers in Table 4 and Table 10 show that the output, value added and employment multipliers in India are different than in Uruguay. There are three main reasons for this:

1. The impact in Uruguay is the result of a lower electricity price, which mostly affects companies for whom electricity consumption is a variable rather than a fixed cost of production, i.e. mostly for manufacturing. Indeed, the effect can only be analysed for manufacturing companies because the World Bank Enterprise Survey does not ask the necessary question to non-manufacturing companies. Impacts in other sectors than manufacturing come about through spill-overs in manufacturing supply chains. In contrast, the impact in India comes about as a result of reduced outages, which affect all sectors;
2. The employment multipliers in India are on average almost nine times as large as in Uruguay, as mentioned in Section 4.3.1, which means that it takes more people to generate the same amount of output;
3. The overall employment multiplier in India is lower than the individual multipliers in the manufacturing, other industries and services sectors. This is because in India a relatively large number of people are employed in agriculture, which exhibits a small employment multiplier (due to virtually no effect of power outages and absence of economic linkages to other sectors because it is primary production);

5 IMPACT TOOLKIT

The two case studies provide us with economic output, value added (or GDP contribution) and employment results for Uruguay and India. PROPARCO, however, would like to quantify the economic impact of its current and potential RNE investments.

Ideally, this impact would be calculated using detailed modelling approaches as done for Uruguay and India. However, given the fact that PROPARCO considers investments in 120 countries, this would be prohibitively cost and labour intensive. Therefore, we have developed a tool which enables PROPARCO and other IFIs to (ex-ante) estimate the effects of their power investments based on insights and results of country-specific studies we have previously carried out, some of them under the *Let's Work* Partnership (CDC, 2016[102]; IFC, 2015b[103]; IFC, 2016[104]; NIAF, 2015[105]). The tool enables the estimation of the indirect and induced effects of the construction and operating expenditures of an RNE investment, as well as the second-order effects of the additional power supply related to PROPARCO investments. Environmental aspects such as CO_2 emissions are not included in this toolkit but could be added at a later stage.[106]

In this section we explain the methodology used in the toolkit. A visual image of what the toolkit looks like is shown in Exhibit 21. Similar to the case studies, the toolkit distinguishes between indirect and induced effects and second-order growth effects, each of which is discussed below.

[102] CDC, *What Is the Link Between Power and Jobs in Uganda?*, 2016.

[103] IFC, *Economic Impact of IFI Investments in Power Generation in the Philippines,* 2015b

[104] IFC, *How Power Contributes to Jobs and Economic Growth in Turkey,* 2016.

[105] NIAF, *Tracing the Economic Effects of Increased Power Supply in Nigeria,* 2015.

[106] The toolkit constructed under the scope of this project is excel-based; a web-version of the toolkit can also be developed which would allow PROPARCO and other Let's Work partners to easily produce and share the results with internal and external stakeholders in user-friendly manner.

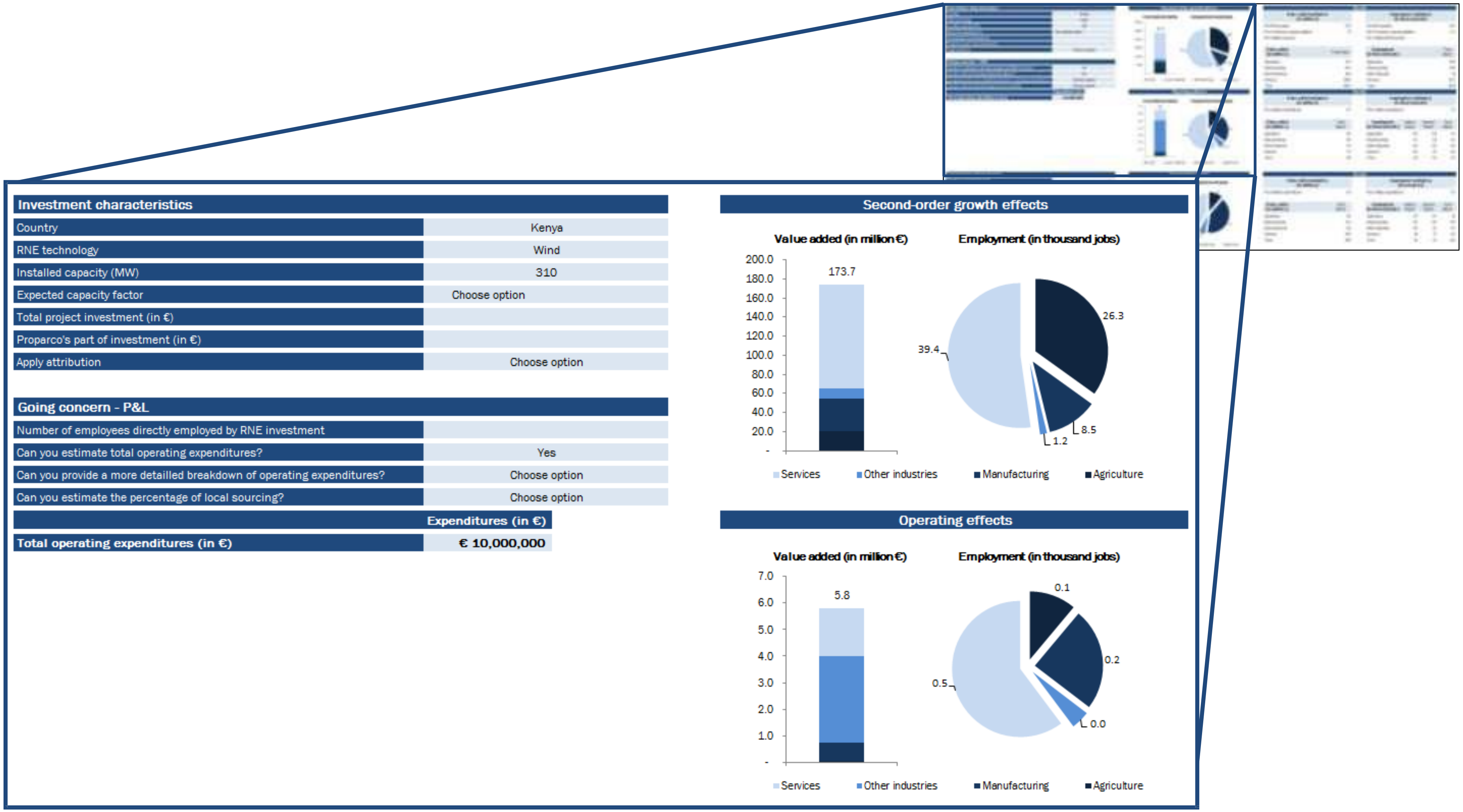

Exhibit 21: Toolkit interface showing the impact of a hypothetical RNE investment in Kenya

5.1 Indirect and induced effects

The tool enables the estimation of the indirect and induced effects of the construction and operation expenditures related to PROPARCO-financed projects. This is done using the Input-Output methodology, as explained in Section 3.3 (and similar to the IFC IO excel tool (IFC, 2015a).[107] The approach consists of tracing the flow of expenditures through the economy of a country and to capture value added and employment effects. There is one substantial difference: rather than using 120 country-specific SAMs, the tool relies on 11 regional SAMs and sets of employment intensities (see Exhibit 27 in Annex 1 for an overview of the countries and regions). Such regional aggregation approach is commonly used (amongst others in CDC, 2015[108]; FMO, 2015[109]; FISEA, 2015[110]; Standard Chartered, 2013[111]) and has been proven to provide reliable results.

To compute the value added and employment results, the toolkit requires users to provide investment-specific data. At the minimum, the total construction expenditures and yearly operating cost are required for the toolkit to capture the effects of project development and operations. If available, more details on the cost breakdown and the share of local procurement can be provided. If these details are not available, the toolkit will automatically allocate the expenditures, as follows:

- For construction: based on the expenditures related to the construction of the Polesine wind farm in Uruguay;[112]
- For operating expenditures: the average spending pattern of the relevant renewable electricity generation sector (hydro, solar, wind or other (biomass and geothermal)) in the country, obtained from the GTAP9 energy database.

The more detailed the cost breakdown, the more accurate the estimate of the indirect and induced effects will be. Annex 6 and 7 provide quantifications of the indirect and induced effects for some of PROPARCO's RNE investments.

5.2 Second-order growth effects

For the second-order growth effect, we make use of so-called power-to-output multipliers (PTO) derived from the two case studies described in this report and from the other power impact studies executed by Steward Redqueen i.e. India, Uruguay, Turkey, Uganda, Nigeria, and Philippines (referred to as the 'studied countries'). These multipliers are used to translate a relative increase of effective generation capacity into a relative change in economic output, and consequently into value added and employment results. To derive the PTO multipliers for other countries, the tool applies an interpolation methodology which determines the extent to which a particular new country's economic and electricity profile is similar to the economy and energy profile of each of the studied countries. The PTO multiplier of any country is then the average of the multipliers of the studied countries, weighted for the level of similarity. The approach is described in more detail in the sub-sections below.

[107] IFC, *Power Sector Economic Multiplier Tool: Estimating the Broad Impacts of Power Sector Projects,* Methodology note, 2015a.

[108] CDC, *CDC Group plc Annual Review 2014 – Development performance*, 2015

[109] FMO, *FMO Impact Model Methodology*, Methodological Note, https://www.fmo.nl/development-impact, 2015

[110] FISEA, *Evaluation of the Results Achieved by Fonds D'Investitssement et de Soutien aux Entreprises en Afrique,* 2015.

[111] Standard Chartered, *Banking on Africa – Standard Chartered's Social and Economic Impact,* https://www.sc.com/en/resources/global-en/pdf/sustainabilty/Africa_impact_report.pdf, 2013.

[112] We realize this cost breakdown is likely not representative for all RNE types, given that Polesine is a wind farm. However, currently no better proxy information is available.

5.2.1 Similarity scaling between countries

For the toolkit, we use of three key variables to capture the economic and power profile of any country:

- GDP per capita (total GDP of a country divided by the total population);
- Electricity intensity (kWh electricity consumed per national US dollar GDP);
- Time loss due to outages (number of electrical outages multiplied by the average duration of an outage).

GDP per capita is the most commonly used indicator for economic development of a country. The electricity intensity indicates the extent to which a country relies on electricity for economic growth. And the time loss signals the reliability of a country's power system. The three indicators are obtained for all countries from reputable sources (World Development Indicators and the Word Bank Enterprise Surveys).[113] The three variables provide a fairly exhaustive, mutually independent (see Table 12) and visual characterisation of the most important similarities between countries.

Table 12: Correlation coefficients for the three selected indicators

Correlations			
Indicators	GDP per capita	Energy intensity	Time loss
GDP per capita	1.00		
Energy intensity	-0.05	1.00	
Time loss	-0.11	-0.16	1.00

To illustrate the approach, in Exhibit 22 the studied countries are plotted in a three-dimensional space based on the normalized values (from 0 to 100) of the mentioned indicators. As one would expect, Uganda and Nigeria are fairly close to each other, as are the more developed Turkey and Uruguay. To estimate the effect of a typical RNE investment in a new country, for example Kenya, one can position it in the same space and determine the distances to each of the studied countries. The weights assigned to these countries are inversely proportional to these distances, i.e. the smaller the distance, the larger the similarity. The distance from Kenya to Uganda is smaller in comparison to the other studied countries and therefore the PTO multiplier of Uganda will have a larger weight in determining the multiplier for Kenya, while the ones of Uruguay and Turkey would have the lowest weight.

Table 13 provides a couple of examples of the weights assigned to the six studied countries (see Annex 3 for the weights for all countries in scope). As mentioned, Kenya mostly resembles Uganda, and as a result the weight assigned to the multiplier of Uganda is 43%. The weight for Nigeria would be 22%. Pakistan is somehow equally similar to all six countries with a somewhat higher similarity to India (32%) and Panama by far is most similar to Uruguay (64%). Using the weights in Table 13, one can express the PTO multipliers for each of the three countries as a weighted average of the studied countries. An overview of the weights for all countries is provided in Annex 3.

Making estimations for 120 different countries based on six case studies could be considered a stretch from a statistical point of view. However, as we will show, the six case studies span a wide set of economic and power conditions and it is not a stretch to see most emerging countries to fall somewhere in between countries, say, Uruguay and Uganda. We therefore feel that the estimations are dependable. The reliability of results will improve when more case studies become available and are integrated in the toolkit. That said, the ex-ante estimations of the toolkit are not a substitute for a more detailed analysis of the impact of power in a particular country.

113 Data gaps are populated using historical data or of regional averages. Electricity data gaps are filled using the U.S. Energy Information Administration database.

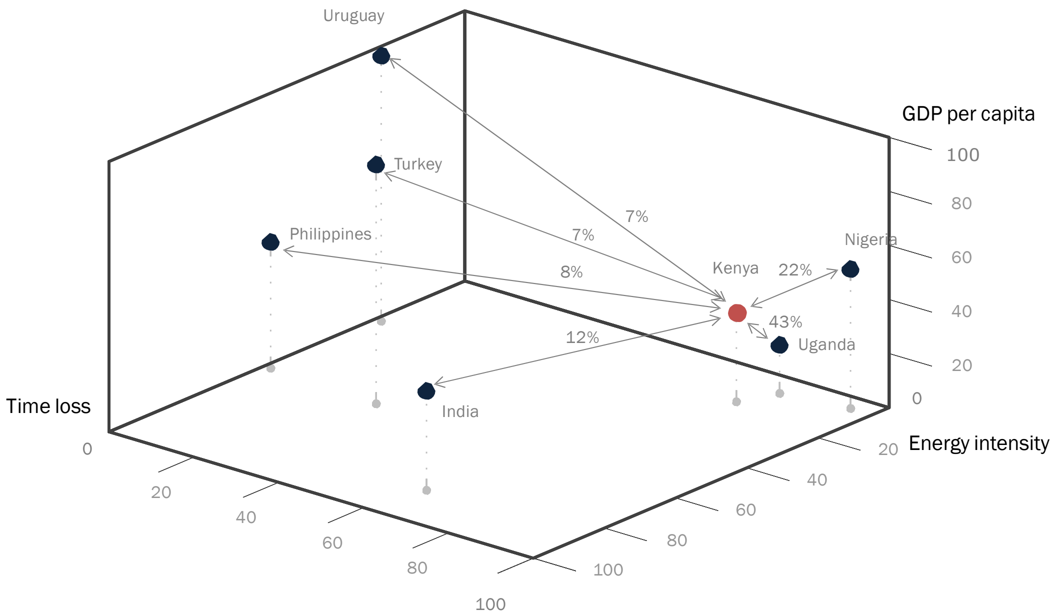

Exhibit 22: Three-dimensional space showing the similarity scaling for Kenya

Table 13: Weights of the studied countries for Kenya, Pakistan, and Panama

	Kenya	Pakistan	Panama
Weight to India	12%	32%	4%
Weight to Nigeria	22%	18%	5%
Weight to Philippines	8%	13%	9%
Weight to Turkey	7%	12%	13%
Weight to Uganda	43%	17%	5%
Weight to Uruguay	7%	8%	64%

5.2.2 Country specific power-to-output multipliers

Using the weights as determined in the previous section, the PTO multiplier for any country is determined as the weighted average of the PTO multipliers for the six studies countries. Table 14 shows the PTO multipliers from the six studied studies. We make use of high-level sector specific output multipliers to account for differences in the electricity intensity and labour productivity.

Table 14: Power-to-output multipliers from the six power impact studies

	Output multipliers			
	Agriculture	Manufacturing	Other industries	Services
India	0.004%	0.030%	0.025%	0.023%
Nigeria	0.003%	0.018%	0.007%	0.002%
Philippines	0.112%	0.280%	0.006%	0.011%
Turkey	0.012%	0.033%	0.018%	0.014%
Uganda	0.006%	0.067%	0.048%	0.092%
Uruguay	0.009%	0.038%	0.001%	0.001%

The multiplier variations between countries are due to differences in the macro-economic profiles, as well as differences in the scope of the studies performed. Exhibit 23 summarises the scope of the six studies countries.

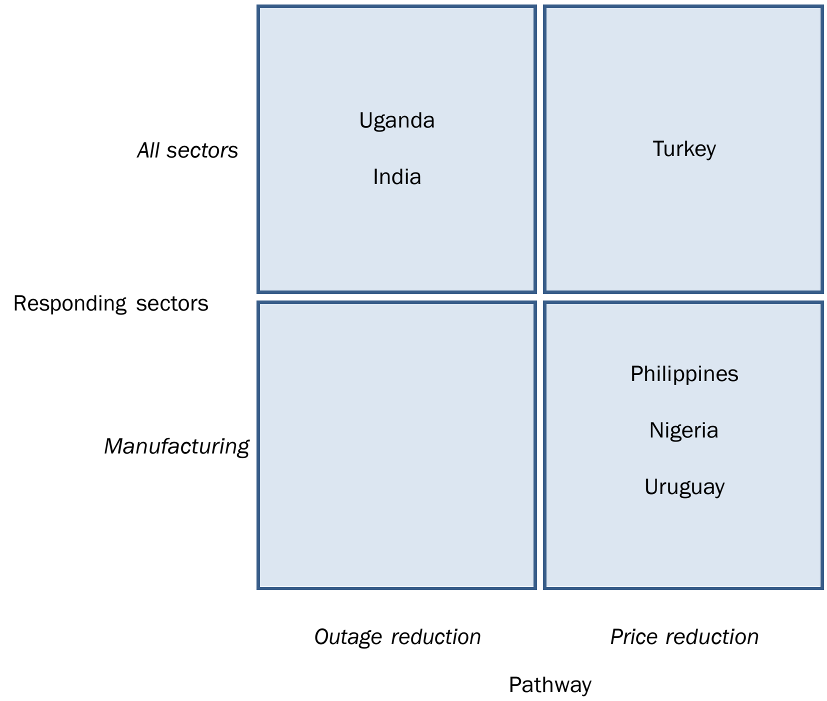

Exhibit 23: Power-to-output multiplier differences due to the different realities on the ground and in the scope of the studies

In Turkey, the Philippines[114], Nigeria[115], and Uruguay the main pathway through which additional power affects economic output is through the price effect (see Exhibit 1). Among these three studies, only the one for Turkey covers the impact of electricity price decrease for all economic sectors. This is because there a large panel data set was available, allowing us to estimate how companies from all economic sectors would change their economic output in response to changes in their electricity use (i.e. factor shares of electricity). For the other countries, we made use of WBES cross-sectional data. While the WBES sets include data from manufacturing and non-manufacturing firms (in wholesale, retail and services), the sample of the latter is usually small and firms report on only a few factors of production.[116] Therefore, the availability of data does not allow for reliable factor shares estimation for sectors other than manufacturing.

In Uganda and India, reduction in outages rather than in price causes the expansion of output. These effects are quantified using WBES data on outage time, sales loss data and estimated mitigation factors, as done for India in Section 4.2. Since this data can be derived for all economic sectors the power-to-output multipliers are less skewed towards the manufacturing sector.

Table 15 shows how the sector-specific PTO multipliers of the studied countries are translated into PTO multipliers for Kenya, Pakistan and Panama. The manufacturing PTO multipliers for all three

[114] Although power outages are somewhat frequent in the Philippines, they are largely due to the quality of the grid. More power generation therefore affects electricity generation price.

[115] In Nigeria outages are so omnipresent that one cannot speak of outage reduction. Instead the additional electricity allows companies to substitute expensive self-generated electricity for cheaper grid-electricity, which reduces the effective electricity price incurred by companies.

[116] While manufacturing firms report electricity use, number of employees, fuel, replacement capital, and value of intermediate materials, service, wholesale and retail firms report only electricity use and employees.

countries are the largest, respectively 0.065% for Kenya, 0.068% for Pakistan and 0.059% for Panama. However, the order of magnitude for the other sector-specific multipliers is significantly different. That is because the countries are fairly dissimilar as we can observe from the different weight scores.

At this point, the toolkit results for any country are based on the PTO multipliers for the available six studied countries. When detailed studies on the impact of power investments in other countries become available they can be included in the toolkit. The larger the number of studies included, the more reliable the interpolation results become. In addition, the toolkit serves as an instrument to include the results of different studies in a harmonised manner. Please note that the results of the actual toolkit may well deviate from the in Annex 4 stated multipliers because of different project cost per MW generation capacity and different local sourcing estimates.

Table 15: Power-to-output multipliers estimations for Kenya, Pakistan and Panama

	A	B	C	D	W	A_N*W_N	B_N*W_N	C_N*W_N	D_N*W_N
India	0.004%	0.030%	0.025%	0.023%	12%	0.000%	0.004%	0.003%	0.003%
Nigeria	0.003%	0.018%	0.007%	0.002%	22%	0.001%	0.004%	0.002%	0.000%
Philippines	0.112%	0.280%	0.006%	0.011%	8%	0.009%	0.023%	0.000%	0.001%
Turkey	0.012%	0.033%	0.018%	0.014%	7%	0.001%	0.002%	0.001%	0.001%
Uganda	0.006%	0.067%	0.048%	0.092%	43%	0.003%	0.029%	0.020%	0.039%
Uruguay	0.009%	0.038%	0.001%	0.001%	7%	0.001%	0.003%	0.000%	0.000%
Kenya					100%	0.014%	0.065%	0.027%	0.045%
					Pakistan				
India	0.004%	0.030%	0.025%	0.023%	32%	0.001%	0.010%	0.008%	0.007%
Nigeria	0.003%	0.018%	0.007%	0.002%	18%	0.001%	0.003%	0.001%	0.000%
Philippines	0.112%	0.280%	0.006%	0.011%	13%	0.015%	0.036%	0.001%	0.001%
Turkey	0.012%	0.033%	0.018%	0.014%	12%	0.001%	0.004%	0.002%	0.002%
Uganda	0.006%	0.067%	0.048%	0.092%	17%	0.001%	0.012%	0.008%	0.016%
Uruguay	0.009%	0.038%	0.001%	0.001%	8%	0.001%	0.003%	0.000%	0.000%
Pakistan					100%	0.019%	0.068%	0.020%	0.027%
					Panama				
India	0.004%	0.030%	0.025%	0.023%	4%	0.000%	0.001%	0.001%	0.001%
Nigeria	0.003%	0.018%	0.007%	0.002%	5%	0.000%	0.001%	0.000%	0.000%
Philippines	0.112%	0.280%	0.006%	0.011%	9%	0.010%	0.025%	0.001%	0.001%
Turkey	0.012%	0.033%	0.018%	0.014%	13%	0.002%	0.004%	0.002%	0.002%
Uganda	0.006%	0.067%	0.048%	0.092%	5%	0.000%	0.003%	0.002%	0.004%
Uruguay	0.009%	0.038%	0.001%	0.001%	64%	0.006%	0.024%	0.000%	0.001%
Panama					100%	0.018%	0.059%	0.007%	0.009%

5.2.3 Value added and employment results

Once we know the country specific power-to-output multipliers for a new country, we can derive the additional output related to a one percent increase in effective capacity in this country simply by multiplying the PTO multiplier for a given sector by the total economic output value of this sector. From there, using output-to-value added ratios[117] and employment intensities per sector, we can derive the value added and jobs related to PROPARCO's current and potential RNE investments in the country. Once the user (i) selects the country where the investment takes place and the RNE technology, and (ii) fills in the installed capacity of the RNE investment and its capacity factor, the results are quantified automatically in the toolkit. Exhibit 24 shows the quantification of value added and employment results for the Lake Turkana wind park investment of PROPARCO.

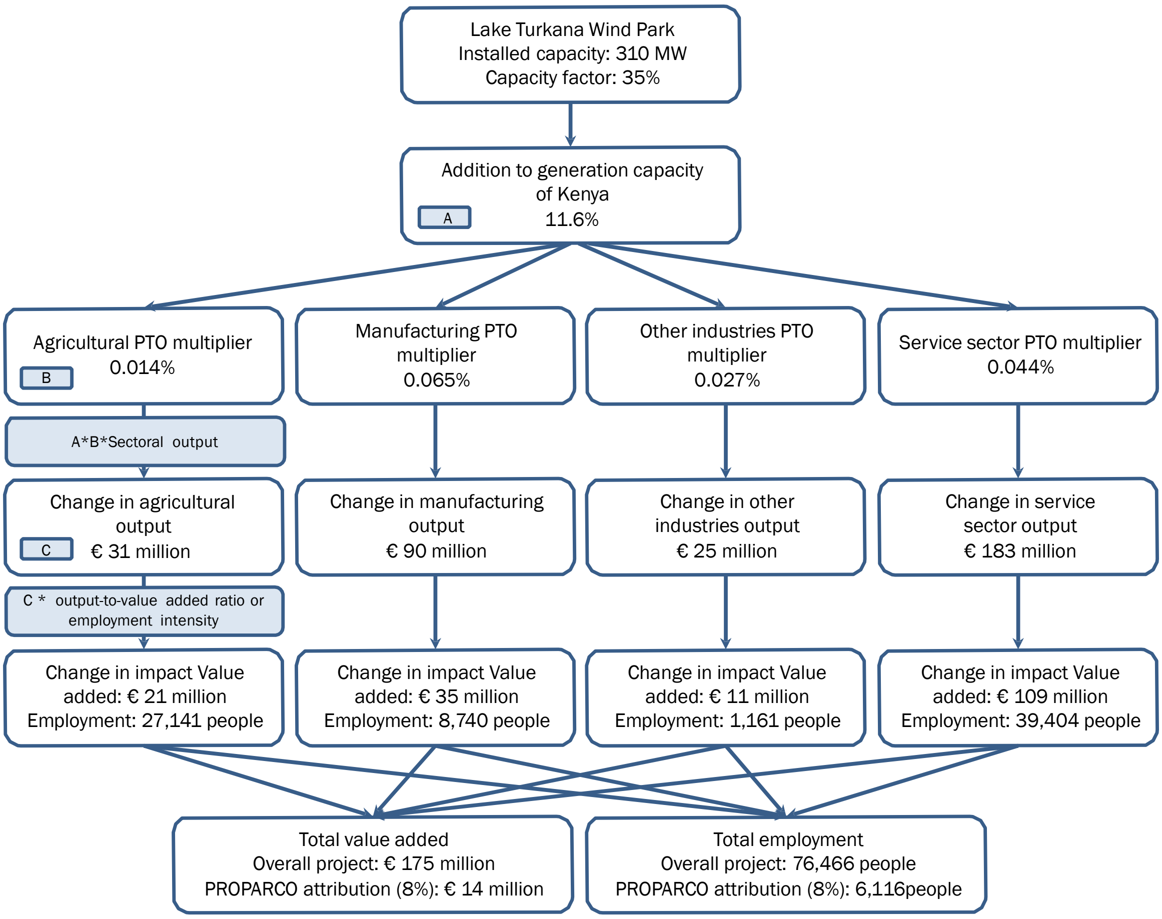

Exhibit 24: Quantification of value added and employment results for the Lake Turkana wind park project

Lake Turkana's wind park in Kenya has an installed capacity of 310 MW and a capacity factor of 35%[118]; adding 950,460 MWh[119] yearly. The total electricity generation in Kenya for 2015 was

[117] The World DataBank provides a sectoral breakdown of GDP for the agricultural, manufacturing, other industries and service sector. We translate these sectoral GDP figures into sectoral output figures using a sectoral output-to-value added ratio. The sectoral output-to-value added ratios show output per unit of GDP and are obtained from the 11 regional SAMs that are constructed for the toolkit.

[118] This assumption of 35% is based on our LCOE Monte Carlo analysis for different generation technologies (see Table 16 in Annex 1). If a more accurate capacity factor is available this can be manually populated in the toolkit.

[119] 310 MW capacity * 365 days/year * 24 hours/day * 35% capacity factor = 950,460 MWh electricity produced annually.

approximately 8,190,909 MWh[120], which means the wind park adds 11.6%[121] to the overall country capacity. From the multipliers calculated in the previous section we know that a one percent increase in effective capacity in Kenya would lead to 0.014% increase in the output of the agriculture sector, 0.065% of manufacturing, 0.027% of other industries and 0.044% in the output of service sector. This means that the economic output of each sector increases by the multiplication product of the overall generation capacity addition share (11.6%) with the sector specific power-to-output multiplier. For the agricultural sector in Kenya this results in an increase of economic output of € 31 million.[122] Using output-to-value added ratios[123], and employment intensities[124] per sector, we can translate the, for example, additional economic agricultural output into value added and employment effects; respectively € 21 million of value added[125] and approximately 27 thousand jobs[126]. Overall, Lake Turkana supports € 175 million in terms of value added and more than 76 thousand jobs. Note that these results are not entirely attributable to PROPARCO. If we consider PROPARCO's stake in the project, € 14 million value added and approximately six thousand jobs can be attributed to PROPARCO.

5.2.4 Combined indirect, induced and second-order growth effects multipliers

As mentioned, the indirect and induced effects associated with the construction and operation of power plants are driven by the monetary amounts whereas the second-order growth effects are driven by the expansion of effective generation capacity. The only way to harmonise the two effects is to convert the per MW multiplier into a per € 1 million multiplier using the capital cost to build 1 kW. Table 16 (Annex 1) provides a range of the capital cost of 1 kW for different generation technologies. By using a single (i.e. median) value one does not take this variation into account.

Another important caveat is the fact that in lieu of operating expenditures we derive the annual fixed and variable operating cost from Table 16. Using the kW capacity associated with € 1 million investment, the fixed operating cost can be derived directly from the table. The variable operating costs are derived by determining the expected annual electricity production in kWh[127] multiplied by the cost per kWh multiplied by the technology capacity factor.

With these two important caveats, Annex 4 and Annex 5 provide ball-park estimates of the indirect, induced and second-order growth effect multipliers for value added and employment. We emphasise that when using the toolkit with project specific data, the results will deviate from the high-level estimates in Annex 4 and Annex 5 because of assumptions required for the construction of the tables.

Nevertheless, the two annexes show that the impact on GDP and jobs of an investment depend on the specific RNE technology and the country in which it is made.

---

[120] The World DataBank provides generation capacity figures per country up to 2013 and therefore we apply an extrapolation methodology based on a 5-year average energy consumption growth in combination with a 5-year GDP growth to estimate 2015 generation figures.

[121] 950,460MWh/8,190,909 MWh = 11.6%

[122] 11.6 (generation capacity increase) *0.014% (agricultural power-to-output multiplier) * € 18,326 million (agricultural economic output) = € 31 million change in economic output

[123] Value added ratios are derived from the 11 regional SAMs that are constructed for the Toolkit.

[124] Employment intensities are estimated by combining macro-economic and labour force data of 11 proxy countries. The 11 proxy countries can be found in Exhibit 27 in Annex 2.

[125] € 31 million (change in economic output) * 69% (agricultural value added ratio) = € 21 million of agricultural value added.

[126] € 31 million (change in economic output) * 880 (agricultural employment intensity; jobs per € 1 million of economic output) = 27,141 people employed in the agricultural sector.

[127] The expected yearly kWh production is the kW capacity of a particular technology per € 1 million investment multiplied by 8,760 hours per year multiplied by the capacity factor in Table 16.

5.2.5 Estimation of value added and employment impact of PROPARCO RNE portfolio

First estimations of the value added and employment impact of 32 PROPARCO RNE investments for which we have sufficient information, i.e. project cost and capacity data, are shown in Annex 6 and Annex 7. The projects cumulatively represent € 655 million of PROPARCO investments and 3,866 MW installed capacity, of which 409 MW is attributable to PROPARCO.

The indirect and induced effect has been estimated using the multipliers described in the previous section whereas the second order growth effects have been estimated using the toolkit and reported generation capacity data.

The total annual value added associated with the 32 projects is estimated at € 111 million and the number of jobs at 21 thousand. Although these estimations will change when more detailed information becomes available, the results provide a directionally correct impression of the economic impact of PROPARCO's RNE investments.

It is important to comment that the results of the six case studies are not exactly reproduced in the toolkit and in Annexes 6 and 7 for three reasons:

1. In the case studies we use the best available data for each country whereas in the toolkit we use the most consistent data source. For example, in the India case study we make use of the GDP statistics from the Indian Statistical Institute, which is available for a large number of sectors. In the toolkit we use the World Bank GDP data which is available for four aggregated sectors only, i.e. agriculture, manufacturing, industry excluding manufacturing and services;
2. In the case studies we apply employment intensities at the most granular level for which they are available. In the toolkit the employment intensities are amalgamated to the four sectors mentioned under point 1;
3. As the toolkit includes 120 countries, we apply Social Accounting Matrices and employment intensities which are representative for entire regions. To illustrate this, the employment results in the toolkit for Uruguay will be higher than in the case study because labour productivity in Uruguay is high compared to the entire South-American region. This fact is reflected in the case study results, but in the toolkit the lower regional average labour productivity is used which translates the same output increase in more jobs.

6 CONCLUSIONS AND KEY ISSUES

6.1 Conclusions

Based on the results discussed in this report the following conclusions can be drawn:

1. Renewable power project have backward (construction and operation related) and forward (the productive use of power) economic impacts.
    a. Backward effects are quantified using the Input-Output methodology and project-specific investment data;
    b. Forward effects are quantified using a power-sector specific model followed by the Input-Output methodology.
2. Based on the two case studies in this report (and four other case studies) we conclude that the forward impact of renewable electricity projects can be markedly different:
    a. In countries with sufficient power generation capacity (e.g. Uruguay), renewable generation capacity will cause the electricity generation price to come down. The economic impact of this price decrease depends on the feed-in tariffs, the extent to which this lower price will be reflected in end-user tariffs and the extent to which companies in response will increase electricity use. Through that economic output increases and hence employment;
    b. In countries with a power generation deficit (e.g. India), renewable generation capacity will cause a reduction of power outage time which increases economic output and hence employment.
3. In Uruguay, the presence of Polesine's 50 MW installed capacity, which on average is used for 42%, decreases the average generation power costs by 2.4% and, assuming that in the long run this decrease is reflected, 1.3% lower end-user electricity tariffs (which include transmission and distribution costs). This results in € 3.3 million more GDP and 169 jobs. The construction and operation of the power plant generate an additional € 3.3 million value added and 157 more jobs. Allowing for a 30% PROPARCO attribution, the total results are € 2.0 million more GDP and 98 more jobs;
4. In India, the presence of Azure's 110 MW installed capacity (based on data as per March 31, 2015), which on average is used for 19% decreases outage time. This increases the operation time for companies by 0.0003%. Taking into account that companies partly mitigate the effect of outages, the increased production time leads to € 6.4 million more GDP and 2,339 more jobs. The construction and operation of the power plants generate an additional € 5.3 million value added and 1,747 more jobs. Counting only the 5.6% attributable to PROPARCO, the total results are a GDP increase of € 0.7 million and 241 more jobs;
5. The substantially lower multipliers in Uruguay than in India reflect the fact that the country is much more developed and that electricity supply is rather efficient; in response to a price decrease, companies would not produce much more economic output (i.e. a low electricity factor share and low electricity price elasticity);
6. For countries where no detailed power impact studies are available, power-to-output multipliers can be derived using an interpolation technique. The technique determines a country's "similarity" to countries for which power impact studies have been completed. This similarity is based on three variables:
    a. GDP per capita (total GDP of a country divided by the total population);
    b. Electricity intensity (kWh electricity consumed per national US dollar GDP);

    c. Time loss due to outages (number of electrical outages multiplied by the average duration of an outage).

7. The power-to-output multipliers can then be used to translate the relative increase of effective generation capacity of an RNE investment into a change in economic output. Consequently, this change in economic output can be translated into value added and employment results;
8. These calculations and the results of six case studies are incorporated in a toolkit which enables PROPARCO to estimate the direct, induced and second-order growth effects of current and potential RNE investments. An online version of the toolkit is also available;
9. Because the six case studies on which the toolkit is based encompass a wide range of different economic and power conditions, the toolkit produces dependable ex-ante estimations of the impact of new RNE investments. The toolkit can henceforth contribute to investment decision making and strategy development effective immediately. When more detailed case studies become available and are integrated into the toolkit, the reliability of the estimations will improve further.
10. PROPARCO has invested € 655 million in 32 RNE projects with a cumulative generation capacity of 3.866 MW. Together, these projects are estimated to have added just over one billion euros to GDP and to have created 218 thousand jobs. When considering the 409 MW that are attributable to PROPARCO, the total GDP increase is about € 111 million and the number of jobs created 21 thousand. Although these estimations may change when more detailed information becomes available, they provide a directionally correct impression of the economic impact of PROPARCO's RNE investments.

6.2 Key issues

The three most important methodological and data issues in this report are:

- Most of the results are based on statistical analyses of cross-sectional observations in combination with economic modelling. Ideally one would apply a longitudinal analysis where businesses are followed over time to have direct observations of the effect of the increased availability and affordability of electricity on productivity and income generation;
- The relationship between increased power generation and increased operation time for business (due to fewer outages) has been derived using two case studies. Additional research will be needed to verify the validity of the relationship for other markets;
- The input-output model used to trace the effect of economic output changes associated with changes of power outages and price, relies on a number of well-documented assumptions. Although we judge these assumptions justified given the limited accuracy of macro-economic statistics in many emerging markets, some of the economic growth and employment spill-over effects may have been somewhat over-estimated.

ANNEX 1: DETERMINING LCOE AND SRMC FOR DIFFERENT TECHNOLOGIES

LCOE information for different technologies

Different power technologies incur distinct costs. Broadly speaking one can differentiate five different cost components: Investment cost, fixed operating cost, variable operating cost, fuel cost and environmental cost. In order to construct a comparable cost picture of different generation technologies, the capital and fixed cost, which are driven by installed power capacity (MW), must be spread out over the life-time power production in order to arrive at a cost per unit of work (kWh). The so-called Levelised Cost of Electricity (LCOE) achieves that by dividing the sum of all costs over the lifetime of a power plant by the sum of all electricity produced over that lifetime. Rather than projecting all cost items for each year, one can use average annual values for the variable (i.e. per kWh) cost and level the investment and fixed operating cost using assumptions on lifespan, discount rate and capacity utilization, as shown in the equation[128] below.

$$LCOE = \frac{\sum_{t=1}^{N} C_t^{TOTAL}}{\sum_{t=1}^{N} E_t} = LC_I + LC_{FOM} + C_{VOM} + C_{FUEL} + C_{ENV} = LC_I + LC_{FOM} + SRMC$$

With:

$$LC_I = \frac{C_I \cdot CRF}{8{,}760 \cdot c_f} \cdot \frac{(1 - T \cdot D_{PV})}{(1 - T)}$$

$$LC_{FOM} = \frac{C_{FOM}}{8{,}760 \cdot c_f}$$

$$C_{FUEL} = P_f \cdot H$$

$$CRF = \frac{(d + d')(1 + d + d')^N}{(1 + d + d')^N - 1}$$

Where:

C_t^{TOTAL}	Total annual cost in year t	USD
LC_I	Levelised investment cost	USD / kWh
LC_{FOM}	Levelised fixed operating & maintenance cost	USD / kWh
C_{VOM}	Variable operating & maintenance cost	USD / kWh
C_{FUEL}	Fuel cost	USD / kWh
C_{ENV}	Environmental cost	USD / kWh
$SRMC$	Short Run Marginal Cost ($C_{VOM} + C_{FUEL} + C_{ENV}$)	USD / kWh
C_I	Investment cost	USD / kW
C_{FOM}	Fixed operating & maintenance cost	USD / kW / y
CRF	Capital recovery factor	%
D_{PV}	Present value of depreciation	%
T	Corporate tax rate (20% in Turkey)	%
c_f	Capacity utilisation factor	%
d	Minimum discount rate in power sector in Turkey	%
d'	Technology-specific discount premium	%
N	Lifespan	years
P_F	Price of fuel	USD / BTU
H	Heat rate	BTU / kWh

[128] We here follow *The Manual for the economic evaluation for energy efficiency and renewable energy technologies* by Short. W, Packey, D and Holt, T., DOE-NREL, 1995.

Ideally the LCOE would be known for all technologies in all countries. However, when for a particular country the generation technology breakdown is known one can use international data sources to construct a reasonable picture of their LCOE. We have combined information from the OpenEI Transparent Cost Database, the US Energy Information Agency (EIA) and the World Energy Council and (for solar technologies) PROPARCO investment data to get minimum, median, average and maximum values on several parameters in the LCOE equation. Fuel price ranges are based on observed prices in Turkey. This allows a Monte Carlo simulation to establish a reasonable range of LCOE value per technology[129]. Specifically we assume five independent stochastic variables (underscored):

$$LCOE = f\left(\underline{C_I}, \underline{C_{FOM}}, \underline{C_{VOM}}, \underline{P_f}, \underline{c_f}, \underline{H}; d, D_{PV}, N\right)$$

By assuming probability density functions (pdf) for each of the stochastic variables[130], a large number[131] of possible combinations have been generated, each of them with a corresponding LCOE value. Using the parameter values given in Table 16, the resulting LCOE probability distribution for the technologies is shown in Exhibit 25.

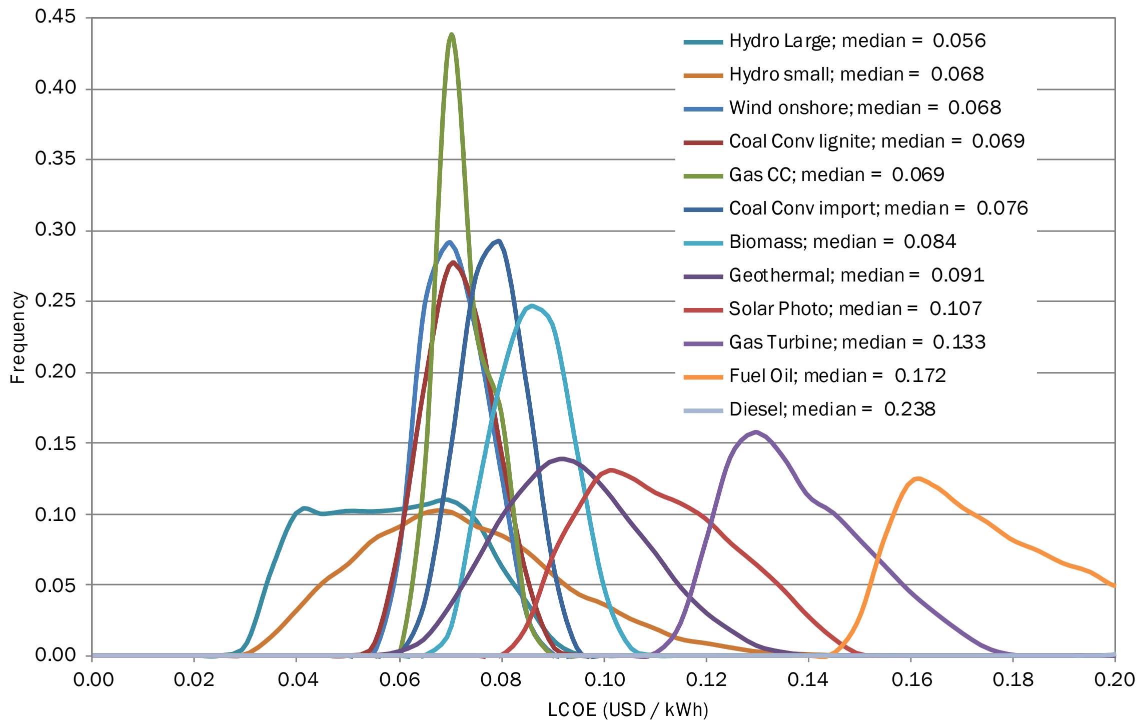

Exhibit 25: LCOE distributions resulting from Monte Carlo analysis

[129] We have not considered the environmental cost (e.g. carbon taxes) which would increase the fossil-fuel based technologies. Their inclusion would be very straightforward however as a cost incurred per kWh.

[130] We have assumed the distribution of each variable to consist of two parts: half of the probability mass is uniformly distributed between the minimum and median and the other half is uniformly distributed between the median and the maximum value. In case the median value is exactly in between the minimum and maximum values this is a uniform pdf. In case it is not, the skewness of the distribution is preserved. This would not be the case if the "lack of knowledge" triangular distribution was used.

[131] The accuracy of the Monte Carlo method is inversely proportional to the square root of the number of realizations. The 20,000 realizations used here are sufficiently large for accurate results. A doubling to 40,000 realizations would only improve the estimations of the mean values from $0.007\sigma_{LCOE}$ to $0.005\sigma_{LCOE}$, which is insignificant given the inaccuracy of the specified minimum, median and maximum values.

Over their entire life cycle, power plants must achieve a price equal to their LCOE in order to break even. In the short run, however, plants will deploy excess capacity when they can realise a price above their short-run marginal costs (SRMC). Exhibit 26 shows the SRMC distributions of the technologies depicted in Exhibit 25.

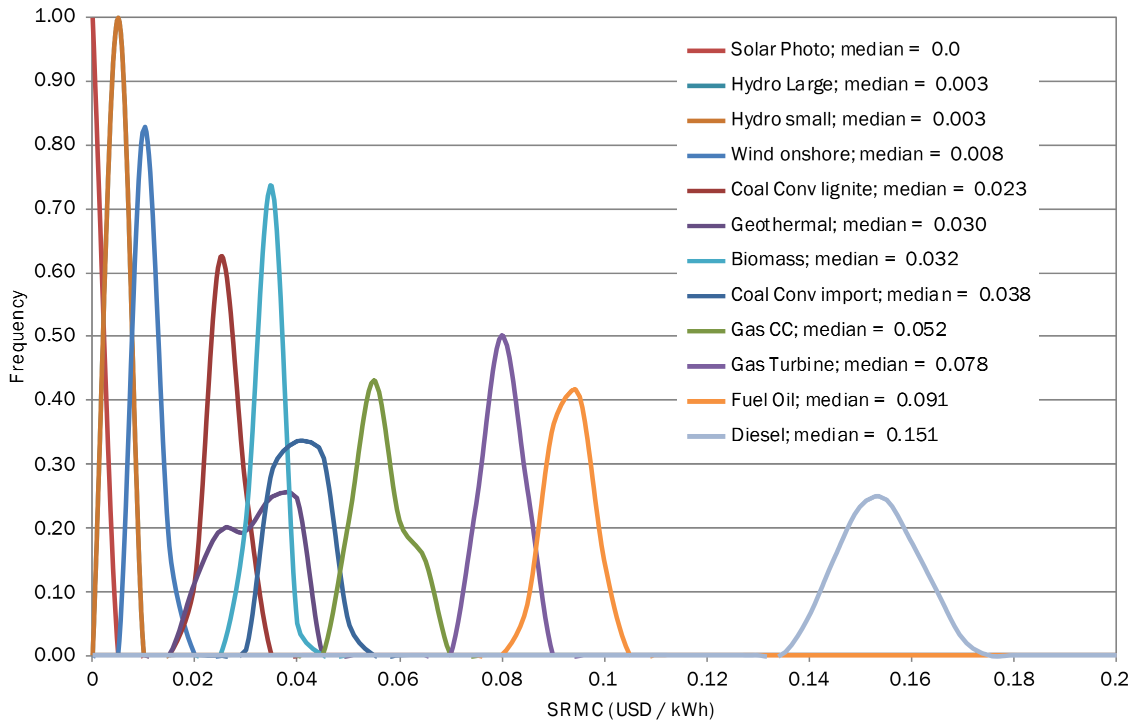

Exhibit 26: SRMC distributions resulting from Monte Carlo analysis

Reading the different technologies from left to right in the graph resembles the so-called merit order. By and large, plants will run (i.e. dispatch power) according to their position in the merit order, although there are some exceptions. Small (run of river) hydro plants which cannot store large amounts of water, wind and solar plants are 'non-dispatchable' technologies, which cannot be turned on at will. These plants, which have near zero SRMC and therefore dispatch electricity whenever they can. These plants typically receive a pre-determined feed-in-tariff (FiT) and are not included in the merit order[132]. Large hydro plants with reservoirs are dispatchable (i.e. can be turned on at will) and come first in the merit order but in order to preserve hydraulic head they sometimes run only when electricity market prices are high (i.e. at peak times). Of the non-renewable technologies Lignite coal plants tend to be cheapest although their availability (and thus capacity factor) tends to be rather low. Geothermal, biomass and especially the imported coal plants provide the base load and tend to dispatch whenever available (i.e. their capacity utilization equals their availability). Combined cycle natural gas (gas CC) plants supply base load, but depending on their efficiency will not all be in merit during non-peak hours (i.e. capacity utilization is lower than their availability). When demand is very high, gas turbine, fuel oil and diesel generators, which have low capital cost but a high SRMC, can be used to satisfy demand.

[132] Because these non-dispatchable plants decrease the time that other plants can run, they effectively increase the LCOE of plants in the merit order (a lower c_f in the LCOE equation causes the LCOE to go up).

Technology	Capital cost (USD / kW)			Fixed OM cost (USD / kW·y)			Variable OM cost (USD / kWh)			Fuel cost (USD / mmBTU)			Heat rate (BTU / kWh)			Capacity factor (-)			Discount rate prem	Deprec. pres val	Lifespan (year)
	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max			
Wind onshore	1,570	1,725	1,880	22.00	23.50	35.75	0.006	0.008	0.011	-	-	-	-	-	-	0.30	0.35	0.40	0%	0.832	20
Solar photo	2,000	2,250	2,500	24.69	26.22	27.75	-	-	-	-	-	-	-	-	-	0.20	0.25	0.30	2%	0.832	30
Solar thermal	4,960	5,067	5,200	60.00	65.00	71.00	0.003	0.003	0.020	-	-	-	-	-	-	0.29	0.39	0.45	2%	0.832	30
Geothermal	2,660	3,920	5,890	68.37	112.16	170.00	0.017	0.030	0.040	-	-	-	-	-	-	0.70	0.80	0.90	1%	0.832	40
Hydro large	1,000	2,040	3,000	13.59	14.85	26.03	0.002	0.003	0.005	-	-	-	-	-	-	0.35	0.40	0.45	1%	0.544	40
Hydro small	1,150	2,250	3,000	11.80	23.20	85.00	0.002	0.003	0.005	-	-	-	-	-	-	0.25	0.35	0.45	0%	0.832	30
Gas CC	960	1,110	1,310	13.17	14.27	15.37	0.002	0.003	0.004	8.10	8.20	8.30	5,593	5,986	7,417	0.65	0.75	0.85	0%	0.544	30
Gas Turbine	676	825	973	7.04	7.19	7.34	0.002	0.003	0.004	8.10	8.20	8.30	8,530	9,099	9,749	0.10	0.15	0.20	0%	0.595	30
Coal conv import	2,300	3,000	3,500	31.18	34.49	37.80	0.004	0.005	0.005	3.20	3.40	3.60	7,700	9,850	12,000	0.80	0.85	0.90	1%	0.544	40
Coal conv Lignite	2,300	3,000	3,500	31.18	34.49	37.80	0.004	0.005	0.005	1.60	1.80	2.00	8,200	10,300	12,600	0.60	0.70	0.80	1%	0.544	40
Diesel	600	700	800	45.00	50.00	55.00	0.000	0.001	0.002	14.00	15.00	16.00	9,500	10,000	10,500	0.10	0.15	0.20	0%	0.832	20
Fuel oil	1,300	1,350	1,400	4.00	5.00	6.00	0.000	0.000	0.001	9.00	9.50	10.00	9,000	9,500	10,000	0.10	0.15	0.20	0%	0.832	30
Biomass	2,400	3,370	4,240	84.00	99.40	158.82	0.004	0.004	0.007	1.80	2.00	2.20	13,000	13,500	14,000	0.75	0.80	0.85	0%	0.832	30

Table 16: LCOE and SRMC Monte Carlo analysis parameter values per generation technology (Source: EIA, Open EI cost database and PROPARCO investments)

ANNEX 2: REGIONAL SCOPE

Regions	Countries in SAM	Country for employment intensities
Sub-Saharan Africa		
Southern Africa & Indian Ocean	Angola, Botswana, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe	Namibia
East Africa	Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan, Tanzania, Uganda	Tanzania
Central Africa	Cameroon, Central African Republic, Chad, Democratic Republic of Congo, Equatorial Guinea, Gabon, Republic of Congo, Sao Tome and Principe	Cameroon
West Africa	Benin, Burkina Faso, Cabo Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Senegal, Sierra Leone, Togo	Ghana
Nigeria	Nigeria	Nigeria
Asia		
North and Southeast Asia	Cambodia, Indonesia, Lao PDR, Malaysia, Mongolia, Myanmar, Philippines, Thailand, Vietnam	Indonesia
South Asia	Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka	India
Latin America		
South America	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela	Peru
Central America & The Caribbean	Antigua and Barbuda, Belize, Costa Rica, Cuba, Dominica, El Salvador, Grenada, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, St. Lucia, St. Vincent and the Grenadines	Mexico
Mediterranean and Middle East		
North Africa	Algeria, Egypt, Libya, Mauritania, Morocco, Tunisia	Tunisia
Middle East - Central Asia - Southeast Europe - Turkey - Caucasia	Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Georgia, Iraq, Jordan, Kazakhstan, Kosovo, Kyrgyz Republic, Lebanon, Macedonia, Moldova, Montenegro, Palestinian Autonomous Territories, Serbia, Syria, Tajikistan, Turkey, Turkmenistan, Ukraine, Uzbekistan, Yemen	Lebanon

Exhibit 27: The regional scope of PROPARCO, the countries that are included in the SAMs and the countries that serve as a proxy for the regional employment intensities.

ANNEX 3: COUNTRY WEIGHING

	Weight to India	Weight to Nigeria	Weight to Philippines	Weight to Turkey	Weight to Uganda	Weight to Uruguay
Afghanistan	28%	14%	14%	12%	24%	8%
Albania	40%	10%	14%	17%	9%	9%
Algeria	17%	12%	18%	31%	10%	13%
Angola	9%	43%	8%	9%	22%	9%
Antigua and Barbuda	12%	11%	13%	32%	10%	22%
Argentina	9%	8%	12%	40%	7%	23%
Armenia	18%	8%	34%	18%	8%	14%
Azerbaijan	9%	6%	22%	40%	6%	18%
Bangladesh	30%	16%	13%	12%	21%	8%
Belize	14%	13%	19%	27%	11%	16%
Benin	18%	16%	14%	12%	30%	11%
Bhutan	14%	7%	43%	18%	7%	10%
Bolivia	12%	8%	39%	22%	8%	10%
Bosnia and Herzegovina	22%	9%	21%	26%	8%	13%
Botswana	17%	12%	15%	32%	11%	13%
Brazil	10%	9%	12%	38%	8%	22%
Burkina Faso	14%	16%	9%	8%	45%	8%
Burundi	8%	19%	6%	6%	55%	6%
Cabo Verde	18%	24%	14%	14%	19%	13%
Cambodia	15%	10%	33%	17%	13%	13%
Cameroon	22%	19%	13%	11%	25%	9%
Central African Republic	12%	25%	9%	8%	38%	8%
Chad	11%	25%	8%	7%	42%	7%
Chile	7%	6%	17%	40%	5%	25%
Colombia	8%	10%	15%	22%	9%	36%
Comoros	7%	13%	5%	5%	66%	5%
Congo, Dem. Rep.	23%	16%	14%	13%	26%	9%
Congo, Rep.	3%	81%	3%	2%	8%	2%

Costa Rica	7%	8%	12%	31%	8%	34%
Cote d'Ivoire	18%	17%	16%	14%	21%	13%
Cuba	12%	11%	16%	33%	10%	18%
Djibouti	13%	19%	17%	15%	21%	14%
Dominica	14%	13%	15%	31%	11%	17%
Ecuador	10%	8%	23%	34%	7%	18%
Egypt, Arab Rep.	52%	10%	11%	11%	9%	6%
Equatorial Guinea	11%	27%	10%	16%	17%	18%
Eritrea	0%	0%	0%	0%	0%	0%
Ethiopia	8%	14%	6%	5%	62%	5%
Gabon	13%	21%	11%	19%	17%	19%
Gambia, The	13%	21%	10%	9%	38%	8%
Georgia	22%	9%	24%	24%	8%	13%
Ghana	20%	22%	12%	11%	27%	9%
Grenada	8%	7%	13%	48%	6%	18%
Guatemala	13%	18%	18%	18%	15%	18%
Guinea	13%	23%	10%	9%	37%	8%
Guinea-Bissau	13%	17%	9%	8%	46%	8%
Guyana	23%	18%	17%	18%	15%	11%
Honduras	27%	11%	24%	19%	10%	9%
India	100%	0%	0%	0%	0%	0%
Indonesia	10%	8%	42%	18%	7%	14%
Iraq	18%	22%	14%	20%	14%	11%
Jamaica	14%	12%	19%	30%	10%	15%
Jordan	17%	8%	31%	21%	8%	16%
Kazakhstan	11%	7%	17%	39%	6%	21%
Kenya	12%	22%	8%	7%	43%	7%
Kosovo	43%	12%	13%	14%	10%	8%
Kyrgyz Republic	33%	9%	19%	17%	11%	10%
Lao PDR	25%	9%	27%	20%	9%	10%
Lebanon	22%	19%	13%	22%	13%	12%
Lesotho	52%	9%	11%	10%	12%	6%

Liberia	16%	14%	18%	15%	24%	14%
Libya	24%	11%	15%	28%	10%	12%
Macedonia, FYR	20%	9%	21%	27%	8%	14%
Madagascar	39%	11%	14%	12%	16%	8%
Malawi	37%	12%	13%	12%	18%	8%
Malaysia	13%	7%	21%	28%	7%	24%
Maldives	19%	18%	14%	24%	14%	12%
Mali	18%	15%	14%	12%	30%	11%
Mauritania	55%	8%	11%	10%	10%	6%
Mauritius	5%	4%	8%	71%	3%	9%
Mexico	11%	11%	13%	34%	10%	21%
Moldova	23%	8%	32%	16%	8%	11%
Mongolia	30%	10%	18%	21%	9%	11%
Montenegro	25%	10%	15%	27%	9%	13%
Morocco	11%	7%	51%	16%	6%	10%
Mozambique	35%	10%	17%	15%	14%	10%
Myanmar	12%	27%	8%	7%	39%	7%
Namibia	12%	8%	24%	36%	7%	13%
Nepal	17%	16%	12%	11%	34%	10%
Nicaragua	47%	10%	14%	12%	11%	7%
Niger	11%	17%	8%	7%	50%	7%
Nigeria	0%	100%	0%	0%	0%	0%
Pakistan	32%	18%	13%	12%	17%	8%
Panama	4%	5%	9%	13%	5%	64%
Paraguay	20%	10%	20%	29%	9%	12%
Peru	9%	9%	20%	25%	8%	28%
Philippines	0%	0%	100%	0%	0%	0%
Rwanda	11%	16%	8%	7%	50%	7%
Salvador	12%	9%	26%	32%	8%	12%
Sao Tome and Principe	12%	38%	9%	8%	26%	8%
Senegal	21%	15%	17%	14%	23%	11%

Serbia	20%	9%	19%	30%	8%	14%
Sierra Leone	12%	20%	9%	8%	43%	8%
Somalia	9%	15%	7%	6%	58%	6%
South Africa	21%	9%	17%	32%	8%	13%
South Sudan	13%	17%	18%	14%	23%	15%
Sri Lanka	14%	22%	16%	16%	18%	15%
St. Lucia	14%	13%	14%	31%	11%	17%
St. Vincent and the Grenadines	11%	10%	16%	37%	9%	18%
Sudan	14%	25%	13%	11%	26%	11%
Suriname	7%	6%	15%	49%	5%	17%
Swaziland	26%	10%	22%	22%	9%	10%
Syrian Arab Republic	0%	0%	0%	0%	0%	0%
Tajikistan	50%	10%	11%	10%	13%	7%
Tanzania	7%	14%	5%	4%	66%	4%
Thailand	14%	8%	30%	22%	7%	18%
Togo	24%	14%	14%	13%	27%	8%
Tunisia	13%	8%	37%	21%	7%	14%
Turkey	0%	0%	0%	100%	0%	0%
Turkmenistan	21%	10%	14%	33%	9%	13%
Uganda	0%	0%	0%	0%	100%	0%
Ukraine	20%	9%	34%	16%	8%	13%
Uruguay	0%	0%	0%	0%	0%	100%
Uzbekistan	53%	9%	12%	11%	9%	7%
Venezuela, RB	9%	6%	11%	57%	5%	12%
Vietnam	23%	8%	32%	16%	9%	12%
West Bank and Gaza	32%	16%	16%	14%	15%	8%
Yemen, Rep.	14%	31%	10%	8%	29%	8%
Zambia	74%	5%	7%	6%	5%	3%
Zimbabwe	45%	11%	11%	10%	17%	7%

ANNEX 4: COUNTRY & RNE SPECIFIC MULTIPLIERS – VALUE ADDED

The value added multipliers in Table 17 show the indirect and second-order effects per € 1 million investment. The indirect results capture the effects from both construction and operating expenditures and the second order effects capture the effects from the additional generation capacity.

To determine value added multipliers for 120 different countries and for five different RNE types we translate an investment of € 1 million into:

- Installed capacity (KW) using the RNE-specific (median) capital cost from Annex 1. Installed capacity can then be translated into additional generation capacity (KWh) which is necessary to determine the second-order effects and to estimate the operating expenditures;
- Operating expenditures using the fixed and variable operation & maintenance cost from Table 16 in Annex 1 and the additional generation capacity. For biomass we also consider the fuel cost;
- Construction expenditures using a linear relationship, i.e. the size of the investment equals the construction expenditures.

The additional generation capacity, construction and operating expenditures are then translated into value added multipliers by applying the same methodology as described in Section 5.

These multipliers deviate from the case study and toolkit results due to the generic figures used from the Monte Carlo analysis in Annex 1. The results from the Monte Carlo analysis are based on a world-wide scope, while the 120 countries in PROPARCO's scope are in the less developed areas of the world. Keeping this in mind it seems that overall cost estimates (capital, fixed and variable operation & maintenance and fuel cost) are too low.

Table 17: Value added results per € 1 million investment

	Biomass			Geothermal			Hydro			Solar			Wind		
Country	Indirect	Second order	Total	Indirect	Second order	Total	Indirect	Second order	Total	Indirect	Second order	Total	Indirect	Second order	Total
Afghanistan	0.10	0.29	0.39	0.08	0.25	0.33	0.03	0.20	0.23	0.03	0.11	0.14	0.05	0.25	0.29
Albania	0.10	0.06	0.16	0.09	0.05	0.15	0.03	0.04	0.07	0.03	0.02	0.06	0.05	0.05	0.10
Algeria	0.10	0.22	0.32	0.09	0.19	0.28	0.03	0.15	0.18	0.03	0.08	0.11	0.05	0.19	0.23
Angola	0.10	1.00	1.10	0.10	0.86	0.95	0.03	0.69	0.72	0.04	0.37	0.41	0.05	0.85	0.90
Antigua and Barbuda	0.10	0.14	0.24	0.09	0.12	0.20	0.03	0.10	0.13	0.03	0.05	0.09	0.05	0.12	0.16
Argentina	0.11	0.16	0.27	0.10	0.14	0.24	0.04	0.11	0.15	0.04	0.06	0.10	0.05	0.14	0.19

Armenia	0.10	0.11	0.21	0.09	0.10	0.19	0.03	0.08	0.11	0.03	0.04	0.08	0.05	0.10	0.14
Azerbaijan	0.10	0.07	0.17	0.09	0.06	0.15	0.03	0.05	0.08	0.03	0.03	0.06	0.05	0.06	0.11
Bangladesh	0.10	0.20	0.30	0.08	0.17	0.26	0.03	0.14	0.17	0.03	0.08	0.11	0.05	0.17	0.22
Belize	0.10	0.07	0.17	0.09	0.06	0.15	0.03	0.05	0.08	0.03	0.03	0.06	0.05	0.06	0.11
Benin	0.09	0.46	0.55	0.07	0.40	0.47	0.03	0.32	0.35	0.03	0.17	0.21	0.04	0.40	0.43
Bhutan	0.10	0.06	0.16	0.08	0.05	0.14	0.03	0.04	0.07	0.03	0.02	0.06	0.05	0.05	0.10
Bolivia	0.11	0.20	0.31	0.10	0.17	0.28	0.04	0.14	0.18	0.04	0.08	0.12	0.05	0.17	0.23
Bosnia and Herzegovina	0.10	0.06	0.16	0.09	0.05	0.15	0.03	0.04	0.07	0.03	0.02	0.06	0.05	0.05	0.10
Botswana	0.10	0.18	0.29	0.10	0.16	0.25	0.03	0.13	0.16	0.04	0.07	0.11	0.05	0.16	0.21
Brazil	0.11	0.19	0.30	0.10	0.16	0.27	0.04	0.13	0.17	0.04	0.07	0.11	0.05	0.16	0.22
Burkina Faso	0.09	0.64	0.73	0.07	0.55	0.62	0.03	0.44	0.47	0.03	0.24	0.27	0.04	0.55	0.58
Burundi	0.09	0.59	0.69	0.07	0.51	0.59	0.03	0.41	0.44	0.03	0.22	0.25	0.04	0.51	0.55
Cabo Verde	0.09	0.32	0.41	0.07	0.28	0.35	0.03	0.22	0.25	0.03	0.12	0.15	0.04	0.28	0.31
Cambodia	0.10	0.04	0.14	0.09	0.03	0.12	0.03	0.02	0.06	0.04	0.01	0.05	0.05	0.03	0.08
Cameroon	0.10	0.28	0.38	0.09	0.24	0.33	0.04	0.19	0.23	0.04	0.10	0.14	0.05	0.24	0.29
Central African Republic	0.10	1.01	1.12	0.09	0.87	0.96	0.04	0.70	0.73	0.04	0.38	0.42	0.05	0.87	0.91
Chad	0.10	0.50	0.60	0.09	0.43	0.52	0.04	0.34	0.38	0.04	0.19	0.22	0.05	0.43	0.48
Chile	0.11	0.14	0.25	0.10	0.12	0.23	0.04	0.10	0.14	0.04	0.05	0.09	0.05	0.12	0.18
Colombia	0.11	0.24	0.35	0.10	0.20	0.31	0.04	0.16	0.20	0.04	0.09	0.13	0.05	0.20	0.26
Comoros	0.09	1.36	1.46	0.07	1.17	1.25	0.03	0.94	0.97	0.03	0.51	0.54	0.04	1.17	1.21
Congo, Dem. Rep.	0.10	0.23	0.34	0.09	0.20	0.29	0.04	0.16	0.19	0.04	0.09	0.12	0.05	0.20	0.25
Congo, Rep.	0.10	0.22	0.33	0.09	0.19	0.28	0.04	0.15	0.19	0.04	0.08	0.12	0.05	0.19	0.24
Costa Rica	0.10	0.23	0.33	0.09	0.20	0.29	0.03	0.16	0.19	0.03	0.09	0.12	0.05	0.20	0.25
Cote d'Ivoire	0.09	0.29	0.38	0.07	0.25	0.32	0.03	0.20	0.23	0.03	0.11	0.14	0.04	0.24	0.28
Cuba	0.10	0.21	0.31	0.09	0.18	0.27	0.03	0.14	0.18	0.03	0.08	0.11	0.05	0.18	0.22
Djibouti	0.09	0.28	0.37	0.07	0.24	0.31	0.03	0.19	0.22	0.03	0.10	0.13	0.04	0.24	0.28
Dominica	0.10	0.19	0.29	0.09	0.16	0.25	0.03	0.13	0.16	0.03	0.07	0.10	0.05	0.16	0.21

Ecuador	0.11	0.23	0.34	0.10	0.20	0.30	0.04	0.16	0.20	0.04	0.09	0.13	0.05	0.20	0.25
Egypt, Arab Rep.	0.10	0.10	0.20	0.09	0.09	0.18	0.03	0.07	0.10	0.03	0.04	0.07	0.05	0.09	0.13
Equatorial Guinea	0.10	7.49	7.60	0.09	6.44	6.53	0.04	5.15	5.19	0.04	2.81	2.84	0.05	6.40	6.45
Eritrea	0.09			0.07			0.03			0.03			0.04		
Ethiopia	0.09	0.49	0.59	0.07	0.42	0.50	0.03	0.34	0.37	0.03	0.18	0.22	0.04	0.42	0.46
Gabon	0.10	0.35	0.46	0.09	0.30	0.40	0.04	0.24	0.28	0.04	0.13	0.17	0.05	0.30	0.35
Gambia, The	0.09	0.24	0.33	0.07	0.20	0.28	0.03	0.16	0.19	0.03	0.09	0.12	0.04	0.20	0.24
Georgia	0.10	0.08	0.18	0.09	0.07	0.16	0.03	0.06	0.09	0.03	0.03	0.06	0.05	0.07	0.12
Ghana	0.09	0.18	0.27	0.07	0.16	0.23	0.03	0.13	0.16	0.03	0.07	0.10	0.04	0.16	0.19
Grenada	0.10	0.21	0.31	0.09	0.18	0.27	0.03	0.15	0.18	0.03	0.08	0.11	0.05	0.18	0.23
Guatemala	0.10	0.35	0.45	0.09	0.30	0.39	0.03	0.24	0.27	0.03	0.13	0.17	0.05	0.30	0.35
Guinea	0.09	0.41	0.50	0.07	0.35	0.43	0.03	0.28	0.31	0.03	0.15	0.19	0.04	0.35	0.39
Guinea-Bissau	0.09	1.07	1.16	0.07	0.92	1.00	0.03	0.74	0.77	0.03	0.40	0.43	0.04	0.92	0.95
Guyana	0.11	0.20	0.31	0.10	0.17	0.28	0.04	0.14	0.18	0.04	0.08	0.11	0.05	0.17	0.23
Honduras	0.10	0.21	0.31	0.09	0.18	0.26	0.03	0.14	0.18	0.03	0.08	0.11	0.05	0.18	0.22
India	0.10	0.07	0.16	0.08	0.06	0.14	0.03	0.05	0.08	0.03	0.03	0.06	0.05	0.06	0.10
Indonesia	0.10	0.35	0.45	0.09	0.30	0.39	0.03	0.24	0.27	0.04	0.13	0.17	0.05	0.30	0.35
Iraq	0.10	0.15	0.25	0.09	0.13	0.22	0.03	0.10	0.14	0.03	0.06	0.09	0.05	0.13	0.18
Jamaica	0.10	0.19	0.29	0.09	0.16	0.25	0.03	0.13	0.16	0.03	0.07	0.10	0.05	0.16	0.21
Jordan	0.10	0.13	0.23	0.09	0.11	0.21	0.03	0.09	0.12	0.03	0.05	0.08	0.05	0.11	0.16
Kazakhstan	0.10	0.11	0.21	0.09	0.09	0.19	0.03	0.07	0.11	0.03	0.04	0.07	0.05	0.09	0.14
Kenya	0.09	0.48	0.57	0.07	0.41	0.49	0.03	0.33	0.36	0.03	0.18	0.21	0.04	0.41	0.45
Kosovo	0.10	0.06	0.16	0.09	0.05	0.15	0.03	0.04	0.07	0.03	0.02	0.06	0.05	0.05	0.10
Kyrgyz Republic	0.10	0.04	0.13	0.09	0.03	0.13	0.03	0.02	0.06	0.03	0.01	0.05	0.05	0.03	0.08
Lao PDR	0.10	0.17	0.27	0.09	0.15	0.24	0.03	0.12	0.15	0.04	0.06	0.10	0.05	0.15	0.19
Lebanon	0.10	0.11	0.20	0.09	0.09	0.18	0.03	0.07	0.10	0.03	0.04	0.07	0.05	0.09	0.14
Lesotho	0.10	0.14	0.24	0.10	0.12	0.21	0.03	0.09	0.13	0.04	0.05	0.09	0.05	0.12	0.17

Liberia	0.09	0.38	0.47	0.07	0.32	0.40	0.03	0.26	0.29	0.03	0.14	0.17	0.04	0.32	0.36
Libya	0.10	0.30	0.40	0.09	0.26	0.35	0.03	0.21	0.24	0.03	0.11	0.14	0.05	0.26	0.30
Macedonia, FYR	0.10	0.05	0.14	0.09	0.04	0.13	0.03	0.03	0.06	0.03	0.02	0.05	0.05	0.04	0.09
Madagascar	0.10	0.25	0.35	0.10	0.21	0.31	0.03	0.17	0.20	0.04	0.09	0.13	0.05	0.21	0.26
Malawi	0.10	0.13	0.24	0.10	0.12	0.21	0.03	0.09	0.13	0.04	0.05	0.09	0.05	0.11	0.16
Malaysia	0.10	0.21	0.32	0.09	0.18	0.28	0.03	0.15	0.18	0.04	0.08	0.12	0.05	0.18	0.23
Maldives	0.10	0.45	0.55	0.08	0.39	0.47	0.03	0.31	0.34	0.03	0.17	0.20	0.05	0.39	0.43
Mali	0.09	0.51	0.60	0.07	0.44	0.52	0.03	0.35	0.38	0.03	0.19	0.22	0.04	0.44	0.47
Mauritania	0.10	0.46	0.56	0.09	0.39	0.49	0.03	0.32	0.35	0.03	0.17	0.20	0.05	0.39	0.44
Mauritius	0.10	0.17	0.27	0.10	0.14	0.24	0.03	0.11	0.15	0.04	0.06	0.10	0.05	0.14	0.19
Mexico	0.10	0.24	0.33	0.09	0.20	0.29	0.03	0.16	0.20	0.03	0.09	0.12	0.05	0.20	0.25
Moldova	0.10	0.10	0.20	0.09	0.09	0.18	0.03	0.07	0.10	0.03	0.04	0.07	0.05	0.09	0.14
Mongolia	0.10	0.09	0.20	0.09	0.08	0.17	0.03	0.06	0.10	0.04	0.04	0.07	0.05	0.08	0.13
Montenegro	0.10	0.04	0.14	0.09	0.04	0.13	0.03	0.03	0.06	0.03	0.02	0.05	0.05	0.04	0.08
Morocco	0.10	0.29	0.39	0.09	0.25	0.34	0.03	0.20	0.23	0.03	0.11	0.14	0.05	0.25	0.29
Mozambique	0.10	0.07	0.18	0.10	0.06	0.16	0.03	0.05	0.08	0.04	0.03	0.06	0.05	0.06	0.11
Myanmar	0.10	0.55	0.66	0.09	0.48	0.57	0.03	0.38	0.41	0.04	0.21	0.24	0.05	0.47	0.52
Namibia	0.10	0.17	0.27	0.10	0.15	0.24	0.03	0.12	0.15	0.04	0.06	0.10	0.05	0.15	0.20
Nepal	0.10	0.26	0.36	0.08	0.22	0.31	0.03	0.18	0.21	0.03	0.10	0.13	0.05	0.22	0.27
Nicaragua	0.10	0.16	0.26	0.09	0.14	0.22	0.03	0.11	0.14	0.03	0.06	0.09	0.05	0.14	0.18
Niger	0.09	0.75	0.84	0.07	0.64	0.72	0.03	0.51	0.54	0.03	0.28	0.31	0.04	0.64	0.67
Nigeria	0.12	0.19	0.31	0.11	0.16	0.27	0.04	0.13	0.17	0.04	0.07	0.11	0.06	0.16	0.22
Pakistan	0.10	0.15	0.25	0.08	0.13	0.21	0.03	0.10	0.14	0.03	0.06	0.09	0.05	0.13	0.17
Panama	0.10	0.12	0.22	0.09	0.10	0.19	0.03	0.08	0.11	0.03	0.04	0.08	0.05	0.10	0.15
Paraguay	0.11	0.18	0.29	0.10	0.15	0.26	0.04	0.12	0.16	0.04	0.07	0.11	0.05	0.15	0.21
Peru	0.11	0.23	0.35	0.10	0.20	0.31	0.04	0.16	0.20	0.04	0.09	0.13	0.05	0.20	0.26
Philippines	0.10	0.56	0.66	0.09	0.48	0.57	0.03	0.38	0.42	0.04	0.21	0.24	0.05	0.48	0.53

Rwanda	0.09	1.25	1.35	0.07	1.08	1.15	0.03	0.86	0.89	0.03	0.47	0.50	0.04	1.07	1.11
Salvador	0.10	0.28	0.38	0.09	0.24	0.33	0.03	0.19	0.23	0.03	0.11	0.14	0.05	0.24	0.29
Sao Tome and Principe	0.10	0.22	0.32	0.09	0.19	0.28	0.04	0.15	0.19	0.04	0.08	0.12	0.05	0.19	0.24
Senegal	0.09	0.21	0.30	0.07	0.18	0.25	0.03	0.14	0.17	0.03	0.08	0.11	0.04	0.18	0.22
Serbia	0.10	0.07	0.16	0.09	0.06	0.15	0.03	0.05	0.08	0.03	0.02	0.06	0.05	0.06	0.10
Sierra Leone	0.09	1.84	1.93	0.07	1.58	1.66	0.03	1.27	1.30	0.03	0.69	0.72	0.04	1.57	1.61
Somalia	0.09	1.72	1.81	0.07	1.48	1.55	0.03	1.18	1.22	0.03	0.64	0.68	0.04	1.47	1.51
South Africa	0.10	0.07	0.17	0.10	0.06	0.15	0.03	0.05	0.08	0.04	0.03	0.06	0.05	0.06	0.11
South Sudan	0.09	1.82	1.91	0.07	1.56	1.64	0.03	1.25	1.28	0.03	0.68	0.71	0.04	1.56	1.60
Sri Lanka	0.10	0.41	0.51	0.08	0.35	0.44	0.03	0.28	0.31	0.03	0.15	0.19	0.05	0.35	0.40
St. Lucia	0.10	0.15	0.25	0.09	0.13	0.21	0.03	0.10	0.14	0.03	0.06	0.09	0.05	0.13	0.17
St. Vincent and the Grenadines	0.10	0.20	0.29	0.09	0.17	0.25	0.03	0.14	0.17	0.03	0.07	0.11	0.05	0.17	0.21
Sudan	0.09	0.68	0.77	0.07	0.59	0.66	0.03	0.47	0.50	0.03	0.25	0.29	0.04	0.58	0.62
Suriname	0.11	0.15	0.26	0.10	0.13	0.23	0.04	0.10	0.14	0.04	0.05	0.09	0.05	0.12	0.18
Swaziland	0.10	0.32	0.42	0.10	0.27	0.37	0.03	0.22	0.25	0.04	0.12	0.16	0.05	0.27	0.32
Syrian Arab Republic	0.10			0.09			0.03			0.03			0.05		
Tajikistan	0.10	0.04	0.14	0.09	0.03	0.13	0.03	0.03	0.06	0.03	0.01	0.05	0.05	0.03	0.08
Tanzania	0.09	0.70	0.79	0.07	0.60	0.68	0.03	0.48	0.51	0.03	0.26	0.29	0.04	0.60	0.64
Thailand	0.10	0.21	0.31	0.09	0.18	0.27	0.03	0.14	0.18	0.04	0.08	0.11	0.05	0.18	0.23
Togo	0.09	0.19	0.29	0.07	0.17	0.24	0.03	0.13	0.16	0.03	0.07	0.10	0.04	0.17	0.20
Tunisia	0.10	0.20	0.30	0.09	0.17	0.27	0.03	0.14	0.17	0.03	0.07	0.11	0.05	0.17	0.22
Turkey	0.10	0.11	0.21	0.09	0.09	0.19	0.03	0.07	0.11	0.03	0.04	0.07	0.05	0.09	0.14
Turkmenistan	0.10	0.15	0.24	0.09	0.13	0.22	0.03	0.10	0.13	0.03	0.05	0.09	0.05	0.12	0.17
Uganda	0.09	0.64	0.73	0.07	0.55	0.62	0.03	0.44	0.47	0.03	0.24	0.27	0.04	0.54	0.59
Ukraine	0.10	0.05	0.14	0.09	0.04	0.13	0.03	0.03	0.06	0.03	0.02	0.05	0.05	0.04	0.09
Uruguay	0.11	0.06	0.17	0.10	0.05	0.16	0.04	0.04	0.08	0.04	0.02	0.06	0.05	0.05	0.11
Uzbekistan	0.10	0.06	0.16	0.09	0.05	0.14	0.03	0.04	0.07	0.03	0.02	0.06	0.05	0.05	0.10

Venezuela, RB	0.11	0.16	0.27	0.10	0.14	0.24	0.04	0.11	0.15	0.04	0.06	0.10	0.05	0.14	0.19
Vietnam	0.10	0.08	0.18	0.09	0.07	0.16	0.03	0.06	0.09	0.04	0.03	0.07	0.05	0.07	0.12
West Bank and Gaza	0.10	0.12	0.22	0.09	0.10	0.20	0.03	0.08	0.11	0.03	0.04	0.08	0.05	0.10	0.15
Yemen, Rep.	0.10	0.28	0.37	0.09	0.24	0.33	0.03	0.19	0.22	0.03	0.10	0.14	0.05	0.24	0.28
Zambia	0.10	0.10	0.20	0.10	0.08	0.18	0.03	0.07	0.10	0.04	0.04	0.07	0.05	0.08	0.13
Zimbabwe	0.10	0.09	0.19	0.10	0.08	0.17	0.03	0.06	0.10	0.04	0.03	0.07	0.05	0.08	0.13

ANNEX 5: COUNTRY & RNE SPECIFIC MULTIPLIERS – EMPLOYMENT

The employment multipliers in Table 18 show the indirect, induced and second-order effects per € 1 million investment. The indirect and induced results capture the effects from both construction and operating expenditures and the second order effects capture the effects from the additional generation capacity.

To determine employment multipliers for 120 different countries and for five different RNE types we translate an investment of € 1 million into:

- Installed capacity (KW) using the RNE-specific (median) capital cost from Annex 1. Installed capacity can then be translated into additional generation capacity (KWh) which is necessary to determine the second-order effects and to estimate the operating expenditures;
- Operating expenditures using the fixed and variable operation & maintenance cost from the Monte Carlo analysis in Annex 1 and the additional generation capacity. For biomass we also consider the fuel cost.
- Construction expenditures using a linear relationship, i.e. the size of the investment equals the construction expenditures.
- Salaries using the operating and construction expenditures as starting point and following those expenditures through the country SAM.

The additional generation capacity, construction and operating expenditures and salaries are then translated into employment multipliers by applying the same methodology as described in Section 5.

These multipliers deviate from the case study and toolkit results due to the generic figures used from the Monte Carlo analysis in Annex 1. The results from the Monte Carlo analysis are based on a world-wide scope, while the 120 countries in PROPARCO's scope are in the less developed areas of the world. Keeping this in mind it seems that overall cost estimates (capital, fixed and variable operation & maintenance and fuel cost) are too low. In addition, regional employment intensities (Annex 2) are used to quantify the employment results whereas for the case studies country-specific employment intensities are used. This significantly affects the employment results in Uruguay because its labour force is far more productive than that of Peru; the country that serves as proxy for the Latin-America region.

Table 18: Employment results per € 1 million investment

	Biomass				Geothermal				Hydro			
Country	Indirect	Induced	Second order	Total	Indirect	Induced	Second order	Total	Indirect	Induced	Second order	Total
Afghanistan	50	10	91	151	21	9	78	108	7	3	63	73
Albania	6	1	5	12	3	1	4	7	2	0	3	5

Algeria	9	2	24	35	3	1	21	25	2	1	16	19
Angola	23	3	128	154	6	2	110	118	4	1	88	93
Antigua and Barbuda	10	2	7	19	3	1	6	10	1	1	5	7
Argentina	17	3	17	37	3	2	14	20	2	1	12	15
Armenia	6	1	10	17	3	1	8	12	2	0	7	9
Azerbaijan	6	1	5	12	3	1	4	8	2	0	3	6
Bangladesh	50	10	56	115	21	9	48	78	7	3	38	49
Belize	10	2	5	17	3	1	5	8	1	1	4	6
Benin	54	6	253	313	18	2	217	237	13	2	174	188
Bhutan	50	10	27	87	21	9	23	53	7	3	18	29
Bolivia	17	3	26	46	3	2	23	28	2	1	18	21
Bosnia and Herzegovina	6	1	5	12	3	1	4	8	2	0	3	5
Botswana	23	3	19	45	6	2	17	24	4	1	13	18
Brazil	17	3	19	38	3	2	16	21	2	1	13	16
Burkina Faso	54	6	295	355	18	2	253	273	13	2	202	217
Burundi	63	8	266	336	13	4	228	246	8	3	183	193
Cabo Verde	54	6	140	200	18	2	120	140	13	2	96	111
Cambodia	26	8	9	43	8	5	8	20	4	2	6	12
Cameroon	63	9	135	208	20	5	116	141	12	3	93	107
Central African Republic	63	9	578	651	20	5	497	522	12	3	397	412
Chad	63	9	280	353	20	5	241	266	12	3	193	207
Chile	17	3	13	33	3	2	11	16	2	1	9	12
Colombia	17	3	23	43	3	2	20	25	2	1	16	19
Comoros	63	8	580	651	13	4	499	516	8	3	399	409
Congo, Dem. Rep.	63	9	113	185	20	5	97	122	12	3	77	92
Congo, Rep.	63	9	52	125	20	5	45	69	12	3	36	50
Costa Rica	10	2	13	24	3	1	11	14	1	1	9	11

Cote d'Ivoire	54	6	162	222	18	2	140	160	13	2	112	126
Cuba	10	2	13	25	3	1	11	14	1	1	9	11
Djibouti	63	8	157	228	13	4	135	152	8	3	108	119
Dominica	10	2	15	27	3	1	13	16	1	1	10	12
Ecuador	17	3	25	45	3	2	22	27	2	1	17	20
Egypt, Arab Rep.	9	2	11	22	3	1	9	13	2	1	7	10
Equatorial Guinea	63	9	3,515	3,588	20	5	3,022	3,047	12	3	2,416	2,430
Eritrea	63	8			13	4			8	3		
Ethiopia	63	8	223	294	13	4	192	209	8	3	153	164
Gabon	63	9	99	172	20	5	86	110	12	3	68	83
Gambia, The	54	6	103	163	18	2	88	108	13	2	71	85
Georgia	6	1	6	14	3	1	6	9	2	0	4	7
Ghana	54	6	81	141	18	2	70	90	13	2	56	70
Grenada	10	2	13	25	3	1	12	15	1	1	9	11
Guatemala	10	2	22	34	3	1	19	23	1	1	15	17
Guinea	54	6	169	229	18	2	145	165	13	2	116	130
Guinea-Bissau	54	6	527	587	18	2	453	473	13	2	362	376
Guyana	17	3	28	48	3	2	24	29	2	1	19	22
Honduras	10	2	15	26	3	1	12	16	1	1	10	12
India	50	10	16	76	21	9	14	44	7	3	11	22
Indonesia	26	8	66	99	8	5	57	69	4	2	45	51
Iraq	6	1	10	18	3	1	9	12	2	0	7	9
Jamaica	10	2	11	23	3	1	10	13	1	1	8	10
Jordan	6	1	11	18	3	1	9	13	2	0	7	9
Kazakhstan	6	1	8	16	3	1	7	10	2	0	6	8
Kenya	63	8	208	279	13	4	179	196	8	3	143	154
Kosovo	6	1	5	12	3	1	4	8	2	0	3	5

Kyrgyz Republic	6	1	3	10	3	1	2	6	2	0	2	4
Lao PDR	26	8	44	78	8	5	38	51	4	2	30	37
Lebanon	6	1	8	15	3	1	7	10	2	0	5	7
Lesotho	23	3	16	42	6	2	14	22	4	1	11	16
Liberia	54	6	208	268	18	2	179	199	13	2	143	157
Libya	9	2	32	43	3	1	28	32	2	1	22	25
Macedonia, FYR	6	1	4	11	3	1	3	7	2	0	3	5
Madagascar	23	3	45	71	6	2	39	46	4	1	31	36
Malawi	23	3	27	52	6	2	23	31	4	1	18	23
Malaysia	26	8	36	70	8	5	31	43	4	2	25	31
Maldives	50	10	104	164	21	9	90	120	7	3	72	82
Mali	54	6	291	350	18	2	250	270	13	2	200	214
Mauritania	9	2	49	60	3	1	42	46	2	1	33	37
Mauritius	23	3	20	46	6	2	18	25	4	1	14	19
Mexico	10	2	12	24	3	1	11	14	1	1	8	10
Moldova	6	1	9	16	3	1	7	11	2	0	6	8
Mongolia	26	8	19	53	8	5	16	29	4	2	13	19
Montenegro	6	1	3	11	3	1	3	6	2	0	2	4
Morocco	9	2	33	45	3	1	29	33	2	1	23	26
Mozambique	23	3	14	40	6	2	12	20	4	1	10	15
Myanmar	26	8	96	130	8	5	83	95	4	2	66	72
Namibia	23	3	26	52	6	2	22	30	4	1	18	23
Nepal	50	10	92	152	21	9	79	109	7	3	63	74
Nicaragua	10	2	11	23	3	1	10	13	1	1	8	10
Niger	54	6	351	411	18	2	302	322	13	2	241	256
Nigeria	22	2	22	47	9	1	19	29	8	0	15	24
Pakistan	50	10	50	110	21	9	43	73	7	3	34	45

Panama	10	2	6	18	3	1	6	9	1	1	4	6
Paraguay	17	3	25	45	3	2	22	27	2	1	17	20
Peru	17	3	24	43	3	2	20	25	2	1	16	19
Philippines	26	8	106	140	8	5	91	104	4	2	73	79
Rwanda	63	8	566	637	13	4	487	504	8	3	389	400
Salvador	10	2	19	31	3	1	16	20	1	1	13	15
Sao Tome and Principe	63	9	101	174	20	5	87	112	12	3	70	84
Senegal	54	6	112	172	18	2	96	116	13	2	77	91
Serbia	6	1	5	13	3	1	4	8	2	0	4	6
Sierra Leone	54	6	932	992	18	2	801	822	13	2	641	655
Somalia	63	8	718	789	13	4	617	635	8	3	493	504
South Africa	23	3	8	34	6	2	7	15	4	1	6	11
South Sudan	63	8	1,036	1,107	13	4	891	908	8	3	712	723
Sri Lanka	50	10	104	164	21	9	90	120	7	3	72	82
St. Lucia	10	2	8	20	3	1	7	10	1	1	5	7
St. Vincent and the Grenadines	10	2	13	24	3	1	11	14	1	1	9	11
Sudan	63	8	336	407	13	4	289	307	8	3	231	242
Suriname	17	3	16	35	3	2	13	18	2	1	11	14
Swaziland	23	3	47	73	6	2	40	48	4	1	32	37
Syrian Arab Republic	6	1			3	1			2	0		
Tajikistan	6	1	3	10	3	1	2	6	2	0	2	4
Tanzania	63	8	270	340	13	4	232	249	8	3	185	196
Thailand	26	8	36	69	8	5	31	43	4	2	24	31
Togo	54	6	110	170	18	2	94	115	13	2	76	90
Tunisia	9	2	22	33	3	1	19	23	2	1	15	18
Turkey	6	1	8	16	3	1	7	11	2	0	6	8
Turkmenistan	6	1	11	18	3	1	9	13	2	0	8	10

Uganda	63	8	224	295	13	4	193	210	8	3	154	165
Ukraine	6	1	4	11	3	1	3	7	2	0	3	5
Uruguay	17	3	6	26	3	2	5	11	2	1	4	8
Uzbekistan	6	1	5	12	3	1	4	7	2	0	3	5
Venezuela, RB	17	3	16	36	3	2	14	19	2	1	11	14
Vietnam	26	8	18	52	8	5	15	28	4	2	12	18
West Bank and Gaza	6	1	9	16	3	1	8	11	2	0	6	8
Yemen, Rep.	6	1	19	26	3	1	16	20	2	0	13	15
Zambia	23	3	11	37	6	2	9	17	4	1	8	12
Zimbabwe	23	3	12	38	6	2	11	18	4	1	9	14

	Solar				Wind			
Country	Indirect	Induced	Second order	Total	Indirect	Induced	Second order	Total
Afghanistan	8	3	34	45	10	4	78	92
Albania	2	0	2	4	2	0	4	6
Algeria	2	1	9	12	3	1	20	24
Angola	4	1	48	53	4	1	109	115
Antigua and Barbuda	1	1	3	5	2	1	6	8
Argentina	2	1	6	9	2	2	14	18
Armenia	2	0	4	6	2	0	8	11
Azerbaijan	2	0	2	4	2	0	4	7
Bangladesh	8	3	21	32	10	4	48	62
Belize	1	1	2	4	2	1	5	7
Benin	12	2	95	108	13	2	216	231
Bhutan	8	3	10	21	10	4	23	37
Bolivia	2	1	10	13	2	2	23	26

Bosnia and Herzegovina	2	0	2	4	2	0	4	6
Botswana	4	1	7	12	4	1	17	22
Brazil	2	1	7	10	2	2	16	20
Burkina Faso	12	2	110	124	13	2	252	267
Burundi	8	3	99	110	9	3	227	239
Cabo Verde	12	2	52	66	13	2	120	135
Cambodia	4	3	3	10	5	3	8	16
Cameroon	12	3	51	65	14	3	115	132
Central African Republic	12	3	216	231	14	3	494	511
Chad	12	3	105	119	14	3	239	256
Chile	2	1	5	8	2	2	11	15
Colombia	2	1	9	12	2	2	20	24
Comoros	8	3	217	228	9	3	496	508
Congo, Dem. Rep.	12	3	42	57	14	3	96	113
Congo, Rep.	12	3	19	34	14	3	44	61
Costa Rica	1	1	5	7	2	1	11	13
Cote d'Ivoire	12	2	61	75	13	2	139	154
Cuba	1	1	5	7	2	1	11	13
Djibouti	8	3	59	69	9	3	134	146
Dominica	1	1	6	7	2	1	13	15
Ecuador	2	1	9	13	2	2	21	25
Egypt, Arab Rep.	2	1	4	7	3	1	9	12
Equatorial Guinea	12	3	1,316	1,331	14	3	3,004	3,021
Eritrea	8	3			9	3		
Ethiopia	8	3	83	94	9	3	191	202
Gabon	12	3	37	52	14	3	85	102
Gambia, The	12	2	38	52	13	2	88	103

Georgia	2	0	2	5	2	0	6	8
Ghana	12	2	30	44	13	2	70	85
Grenada	1	1	5	7	2	1	11	14
Guatemala	1	1	8	10	2	1	19	21
Guinea	12	2	63	77	13	2	144	159
Guinea-Bissau	12	2	197	211	13	2	450	465
Guyana	2	1	10	14	2	2	24	28
Honduras	1	1	5	7	2	1	12	15
India	8	3	6	17	10	4	14	28
Indonesia	4	3	25	31	5	3	56	65
Iraq	2	0	4	6	2	0	9	11
Jamaica	1	1	4	6	2	1	10	12
Jordan	2	0	4	6	2	0	9	11
Kazakhstan	2	0	3	5	2	0	7	9
Kenya	8	3	78	88	9	3	178	190
Kosovo	2	0	2	4	2	0	4	6
Kyrgyz Republic	2	0	1	3	2	0	2	5
Lao PDR	4	3	17	23	5	3	38	46
Lebanon	2	0	3	5	2	0	7	9
Lesotho	4	1	6	11	4	1	14	20
Liberia	12	2	78	91	13	2	178	193
Libya	2	1	12	15	3	1	27	31
Macedonia, FYR	2	0	1	4	2	0	3	6
Madagascar	4	1	17	22	4	1	38	44
Malawi	4	1	10	15	4	1	23	28
Malaysia	4	3	13	20	5	3	31	39
Maldives	8	3	39	50	10	4	89	104

Mali	12	2	109	122	13	2	248	263
Mauritania	2	1	18	21	3	1	42	45
Mauritius	4	1	8	13	4	1	18	23
Mexico	1	1	5	6	2	1	10	13
Moldova	2	0	3	5	2	0	7	10
Mongolia	4	3	7	14	5	3	16	25
Montenegro	2	0	1	3	2	0	3	5
Morocco	2	1	13	16	3	1	29	32
Mozambique	4	1	5	10	4	1	12	18
Myanmar	4	3	36	43	5	3	82	91
Namibia	4	1	10	15	4	1	22	28
Nepal	8	3	34	46	10	4	79	93
Nicaragua	1	1	4	6	2	1	9	12
Niger	12	2	131	145	13	2	300	315
Nigeria	8	1	8	17	8	1	19	28
Pakistan	8	3	19	30	10	4	42	57
Panama	1	1	2	4	2	1	5	8
Paraguay	2	1	9	13	2	2	21	25
Peru	2	1	9	12	2	2	20	24
Philippines	4	3	40	46	5	3	91	99
Rwanda	8	3	212	222	9	3	484	496
Salvador	1	1	7	9	2	1	16	19
Sao Tome and Principe	12	3	38	52	14	3	87	103
Senegal	12	2	42	56	13	2	96	111
Serbia	2	0	2	4	2	0	4	7
Sierra Leone	12	2	349	363	13	2	797	812
Somalia	8	3	269	279	9	3	614	625

South Africa	4	1	3	8	4	1	7	13
South Sudan	8	3	388	398	9	3	886	898
Sri Lanka	8	3	39	50	10	4	89	104
St. Lucia	1	1	3	5	2	1	7	9
St. Vincent and the Grenadines	1	1	5	7	2	1	11	13
Sudan	8	3	126	136	9	3	288	299
Suriname	2	1	6	9	2	2	13	17
Swaziland	4	1	17	22	4	1	40	45
Syrian Arab Republic	2	0			2	0		
Tajikistan	2	0	1	3	2	0	2	5
Tanzania	8	3	101	111	9	3	231	242
Thailand	4	3	13	20	5	3	30	39
Togo	12	2	41	55	13	2	94	109
Tunisia	2	1	8	11	3	1	19	22
Turkey	2	0	3	5	2	0	7	9
Turkmenistan	2	0	4	6	2	0	9	12
Uganda	8	3	84	94	9	3	191	203
Ukraine	2	0	1	4	2	0	3	5
Uruguay	2	1	2	6	2	2	5	9
Uzbekistan	2	0	2	4	2	0	4	6
Venezuela, RB	2	1	6	9	2	2	13	17
Vietnam	4	3	7	13	5	3	15	24
West Bank and Gaza	2	0	3	5	2	0	8	10
Yemen, Rep.	2	0	7	9	2	0	16	18
Zambia	4	1	4	9	4	1	9	15
Zimbabwe	4	1	5	10	4	1	11	16

ANNEX 6: PORTFOLIO IMPACT – VALUE ADDED

From the 32 RNE investments of PROPARCO we are able to quantify the value added results (in Euros). To quantify the indirect effects we use the multipliers in Table 17 and the overall project cost (i.e. total investment) for each investment. The second-order growth effects are quantified using the Impact toolkit described in Section 5 and the expected installed capacity of the investment.

These results deviate from the case study results because both case studies make use of country-specific and more detailed investment data.

	Overall project			PROPARCO attributable		
Investment	Indirect	Second-order	Total	Indirect	Second-order	Total
Alisios	6,456,085	22,246,677	28,702,762	2,239,207	7,715,963	9,955,170
Azure Power	8,529,688	5,056,619	13,586,307	481,830	285,641	767,471
Bajo Frio	5,007,472	8,047,248	13,054,720	891,133	1,432,093	2,323,225
Belen Electrik	2,432,517	3,858,716	6,291,232	553,939	878,717	1,432,657
Bpcl	1,157,022	2,091,602	3,248,623	316,373	571,922	888,295
Brennand	6,844,233	17,774,058	24,618,291	769,015	1,997,085	2,766,100
Ejre	1,717,715	1,964,871	3,682,586	693,532	793,322	1,486,854
Electra	7,313,832	27,448,545	34,762,377	1,153,522	4,329,128	5,482,650
Eolos	2,167,589	3,472,844	5,640,433	1,493,228	2,392,404	3,885,632
Eolos 2	2,880,485	1,157,615	4,038,100	491,320	197,453	688,773
Eolonica	4,043,109	8,242,797	12,285,906	923,839	1,883,455	2,807,293
Eurus	20,201,932	70,183,764	90,385,696	1,204,823	4,185,689	5,390,512
Greenland	842,017	893,123	1,735,140	352,651	374,055	726,705
Gul Ahmed Wina Power	4,554,382	8,986,817	13,541,198	754,852	1,489,493	2,244,345
Itezhi Tezhi	6,283,833	13,732,584	20,016,417	1,034,974	2,261,816	3,296,790
Khi Csp	14,132,354	2,336,891	16,469,246	874,335	144,578	1,018,912
Krnovo	6,382,153	3,547,181	9,929,334	818,867	455,124	1,273,991
Lake Turkana	26,263,967	175,472,787	201,736,754	2,111,251	14,105,530	16,216,781
Laraib	6,766,852	15,097,852	21,864,704	565,409	1,261,512	1,826,921
Marcona & Tres Hermanas	14,052,443	36,150,976	50,203,419	1,452,186	3,735,860	5,188,046
Nrppl	18,747,365	80,446,213	99,193,578	542,354	2,327,277	2,869,631
Olkaria Iii	8,995,888	62,102,811	71,098,699	838,394	5,787,827	6,626,221
Oryx	774,656	893,123	1,667,779	321,192	370,312	691,504
Penonome	15,196,600	29,830,316	45,026,916	757,708	1,487,351	2,245,060
Polaris	25,694,249	30,830,201	56,524,450	1,213,475	1,456,033	2,669,508
Polesine	4,556,065	3,671,966	8,228,031	1,366,820	1,101,590	2,468,409
Sindicatum	4,190,540	50,933,945	55,124,485	1,055,071	12,823,868	13,878,939
Solaire Direct	3,413,940	5,217,451	8,631,391	712,463	1,088,841	1,801,304
Solarpark Chile	2,435,905	2,512,106	4,948,011	696,669	718,462	1,415,131
Terra Solar	3,576,405	7,027,607	10,604,012	395,894	777,928	1,173,822
Theun Hinboun Power	18,752,737	44,266,413	63,019,149	940,139	2,219,228	3,159,367
Vesa	5,979,570	12,298,312	18,277,882	852,495	1,753,344	2,605,839
Total	260,343,601	757,794,029	1,018,137,631	28,868,960	82,402,898	111,271,858

ANNEX 7: PORTFOLIO IMPACT – EMPLOYMENT

From the 32 RNE investments of PROPARCO we are able to quantify the employment results (in FTE). To quantify the indirect and induced effects we use the multipliers in Table 18 and the overall project cost (i.e. total investment) for each investment. The second-order growth effects are quantified using the Impact toolkit described in Section 5 and the expected installed capacity of the investment.

These results deviate from the case study results because both case studies make use of country-specific and more detailed investment data.

	Overall project				PROPARCO attributable			
Investment	Indirect	Induced	Second-order	Total	Indirect	Induced	Second-order	Total
Alisios	233	96	1,188	1,517	81	33	412	526
Azure Power	1,993	899	1,205	4,097	113	51	68	231
Bajo Frio	204	88	440	732	36	16	78	130
Belen Electrik	96	21	292	409	22	5	67	93
Bpcl	258	114	499	871	71	31	136	238
Brennand	340	230	1,735	2,305	38	26	195	259
Ejre	90	20	157	266	36	8	63	107
Electra	364	246	2,679	3,289	57	39	422	519
Eolos	86	19	263	367	59	13	181	253
Eolos 2	114	25	88	226	19	4	15	39
Eolonica	146	60	579	785	33	14	132	179
Eurus	730	300	3,640	4,671	44	18	217	279
Greenland	44	10	71	125	18	4	30	52
Gul Ahmed Wina Power	1,016	449	2,936	4,401	168	74	487	729
Itezhi Tezhi	700	193	1,552	2,444	115	32	256	403
Khi Csp	1,467	399	281	2,146	91	25	17	133
Krnovo	253	55	265	573	32	7	34	74
Lake Turkana	5,466	1,902	76,446	83,814	439	153	6,145	6,737
Laraib	1,599	733	4,933	7,265	134	61	412	607
Marcona & Tres Hermanas	601	387	3,645	4,634	62	40	377	479
Nrppl	4,183	1,847	19,178	25,208	121	53	555	729
Olkaria Iii	1,613	475	27,055	29,144	150	44	2,521	2,716
Oryx	41	9	71	121	17	4	30	50
Penonome	550	226	1,632	2,407	27	11	81	120
Polaris	749	292	2,165	3,205	35	14	102	151
Polesine	195	126	376	697	58	38	113	209
Sindicatum	2,164	425	12,143	14,731	545	107	3,057	3,709
Solaire Direct	164	112	477	752	34	23	99	157
Solarpark Chile	117	80	230	426	33	23	66	122
Terra Solar	140	60	491	691	16	7	54	76
Theun Hinboun Power	2,044	1,351	11,512	14,907	102	68	577	747
Vesa	216	89	858	1,164	31	13	122	166
Total	27,976	11,335	179,082	218,392	2,841	1,057	17,124	21,022