
The link between Power Investments and Jobs in Senegal

Final Report

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Contents

Executive Summary	i
Methods	i
Key findings	i
1 Introduction	1
1.1 Structure of report	1
2 Senegal: economy and power profile	2
2.1 Macro-economic profile.....	2
2.2 Power profile	3
3 Analysis framework	5
4 Impact via the outage pathway	6
5 Impact via the price pathway	7
5.1 Methodology.....	7
5.2 Results.....	7
5.2.1 Supply-demand model and effect on price	7
5.2.2 Effect on economic output.....	11
5.2.3 Effect on employment	13
5.3 Multipliers	14
6 Conclusions and recommendations	15
Annex 1: References	16

THE LINK BETWEEN POWER INVESTMENTS AND JOBS IN SENEGAL FOR PIDG

EXECUTIVE SUMMARY

In this study a framework is developed to quantify the employment effect of PIDG's investments in power infrastructure in Senegal. PIDG's investments include financing of dual-fuel plant Tobene (70 MW), which started operations in 2016, and solar project Senergy 2 (20 MW), expected to start production in 2017.

Methods

The methodology we used in this study to estimate the economic impact of investments in the electric power sector in Senegal largely follows the one developed and tested during our previous studies in the Philippines and Turkey (IFC), Uganda (CDC), India and Uruguay (PROPARCO). In these studies we analyzed the current power supply and demand situation in a country and then constructed a counterfactual situation of what would have happened had the new generation capacity not been commissioned. In this way we calculated the changes in electricity price and employment relative to a hypothetical case in which DFI-invested projects were not realized.

The composite methodology developed in this research project consists of:

1. Econometric and statistical analysis of the existing data sources to quantify how power availability and affordability affect economic output;
2. Construction of an electricity price model based on the available supply and demand information in Senegal for 2016 and construction of a situation in which PIDG-invested projects are added to the power fleet;
3. Estimation of the related economic output and employment increase in Senegal using input-output model and employment intensity data from Senegal.

The study is based on desk research and relies on publically available data.

Key findings

1. Prior to PIDG supported projects, Senegal has 772 MW installed capacity, of which about 465 MW effectively in use. About 75% of the total capacity is HFO/Diesel, including 80MW of rental diesel stations;
2. PIDG-supported plants Tobene (70 MW) and Senergy 2 (20 MW) will add an estimated 60 MW effective capacity (adjusted for utilization). This is equal to 13% of Senegal's effective capacity;
3. The demand for electricity is met partly by the emergency diesel stations;
4. Firms in Senegal experience outages 2-5% of operations time in 2014. Outages have significantly decreased since the power shortage of 2011-2012. Furthermore, emergency power is being phased out, indicating stabilization of the reserve margin in Senegal. Therefore Tobene and Senergy 2 are not expected to have a significant effect on reduction of outages in the country.
5. By adding base load cheaper than the rental plants and competitively priced solar respectively, Tobene and Senergy 2 are expected to decrease the weighted average generation costs in the country by 12.6%. This will lead to 6.3% decrease in the final consumer tariff in the long-run, provided that the tariffs are cost-reflective.

6. The decrease in electricity prices will enable firms to increase their electricity consumption and consequently production. The economic output growth is estimated at USD 434.5 million, equal to 1.7% of total economy output. Of this, USD 415.6 million is due to increased economic output from sectors dependent on electricity (manufacturing, trade, transport, construction, business services). USD 18.9 million is the output increase of the agriculture sector, which increases its production to meet growing demand for its products by electricity-dependent sectors (e.g. food processing).
7. The resulting employment effect is estimated at 68,500 jobs (1.3% of total employment), of which 49,700 at electricity-dependent sectors and 18,800 in agriculture. The results represent headcount/people affected rather than full-time equivalent due to wide-spread underemployment in Senegal (27% of total employment).
8. These results reflect the effect of adding Tobene and Senergy 2 plants to Senegal's fleet, without taking into consideration the proportion of the effect that is attributable to PIDG.

THE LINK BETWEEN POWER INVESTMENTS AND JOBS IN SENEGAL FOR PIDG

1 INTRODUCTION

The absence of reliable, adequate and affordable power is recognised as one of the main barriers to broad-based economic growth and social development. Poor and/or expensive electricity supply stifles economic activity by reducing productivity and hampering the development of industry and trade which are important drivers of employment and growth.

Electricity in Senegal is produced predominantly by thermal power plants. In 2011-2012, the country experienced severe power shortages caused mainly by lack of fuel. Reliance on expensive (emergency) thermal power has led to high electricity tariffs, higher than in other Sub-Saharan countries. In 2012, the government of Senegal adopted an Energy Sector Development Policy, which aimed to ensure energy security, diversify supply, accelerate liberalisation, and increase competition in the sector. Since then the situation has improved. But energy demand is growing together with supply and the country needs to ensure that further shortages do not occur again.

Contributing to Senegal's power sector development, PIDG has made investments in power generation in the country. Investments include financing of dual-fuel plant Tobene (70 MW), which started operations in 2016, and solar project Senergy 2 (20 MW), expected to start production in 2017.

The theory of change and previous research indicate that a stronger physical infrastructure, in particular in the power sector, has an important impact on economic development for shared prosperity and poverty reduction. The objective of this report is to assess the impact of PIDG's recent power generation investments on employment in Senegal. By doing so we aim to contribute to the understanding of how improvements in power availability and affordability affect development across economic sectors and actors.

1.1 Structure of report

The remainder this report covers the following topics:

- Section 2 provides an overview of Senegal's economy and its power sector;
- Section 3 describes the analytical framework on which the analysis is based;
- Section 4 discusses the impact of PIDG investments on outages;
- Section 5 presents the methodology and results of the analysis of PIDG's supported capacity on electricity price and consequently on employment;
- Section 6 summarises the main conclusions of the analysis and presents a few recommendations.

2 SENEGAL: ECONOMY AND POWER PROFILE

2.1 Macro-economic profile

Senegal's macroeconomic performance in 2016 was strong with GDP growth at 6.6%, slightly higher than the 6.5% achieved in 2015. These growth rates are above the Sub-Saharan Africa (SSA) average, and make Senegal the second fastest growing economy in West Africa and the fourth fastest in SSA as a whole. This is a significant rebound compared to 2006 – 2014, when growth averaged only 3.4% a year. Reforms and public investment under the *Plan Senegal Emergent* (the government's socio-economic development plan launched in 2014), good weather, and low oil prices were behind the notable economic progress of the country.

The growth was led by 10% expansion in the primary sector (fishing and agriculture), due to solid outcomes from sub-sectors targeted by government (groundnuts, rice, horticulture). Agriculture plays a predominant socio-economic role in Senegal. It accounts for 18% of GDP and it is the main source of income for most rural households. Nearly 56% of Senegal's population lives in rural areas and worked in small-scale subsistence farming agriculture. Industry accelerated by 6.8% with strong performances by extractives, food, and chemicals. Services, accounting for more than half of Senegal's GDP, expanded at 5.6%, mainly by advances in transport and financial services.

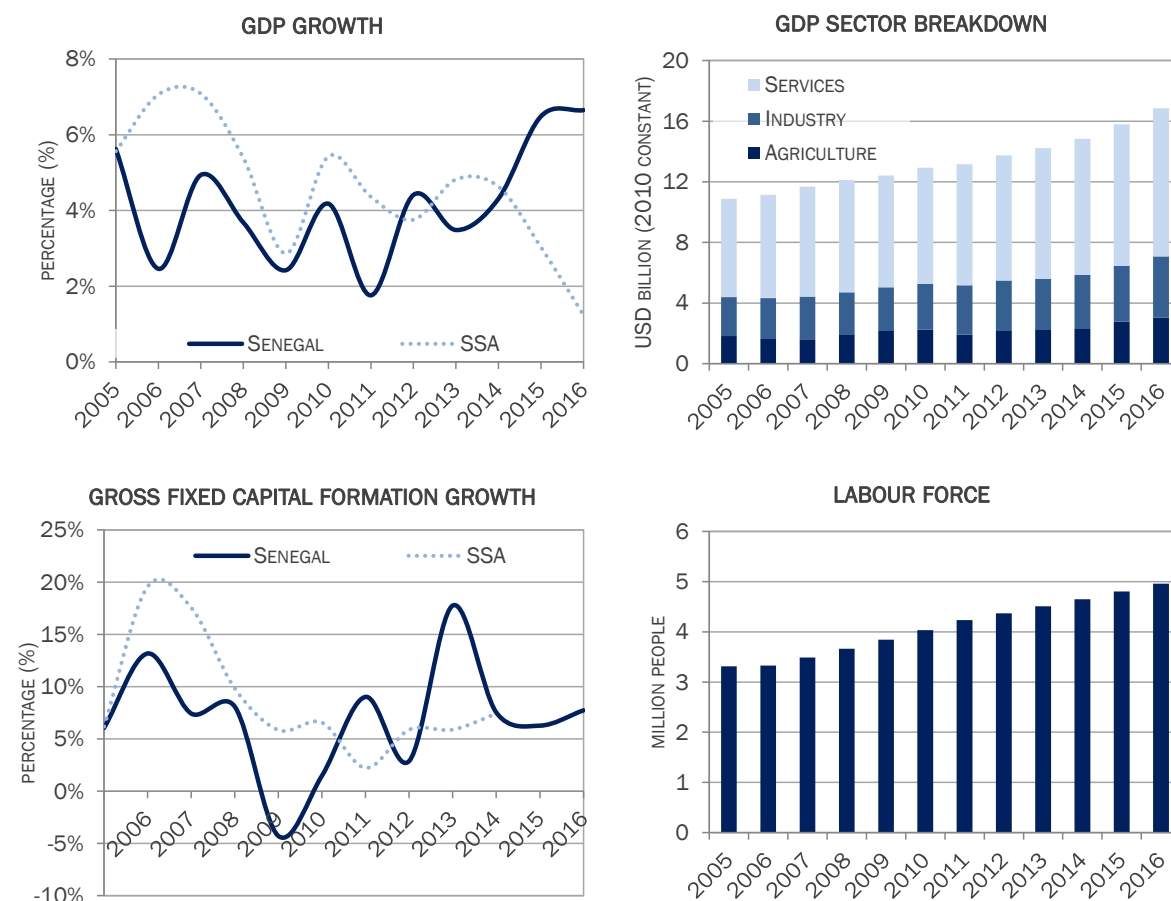


Exhibit 1: Overview of Senegal's economy

Senegal's current account deficit fell from 7.0% of GDP in 2015 to 6.5% in 2016, as exports increased faster than imports, driven by lower energy imports. Similarly, the fiscal position improved as the government reduced expenditure and increased tax revenue to 20% of GDP. As a result, the fiscal deficit fell from 4.8% of GDP in 2015 to 4.2% in 2016.

Despite the positive economic outlook, the country is still facing challenges. In 2016, Senegal ranked 146th out of 190 countries in the World Bank Doing Business ranking (in the 2017 edition, it slipped one position further down). In addition, the economy suffers from a weak competitiveness of exports, which though relatively diversified, still cannot count as a powerful growth engine. The same can be said for the country's attractiveness. Although foreign direct investment inflows rose from 2.1% of GDP in 2013 to 2.5% in 2014-15, they are still two times less than the average for the oil importing countries of Sub-Saharan Africa.

Average unemployment in the last quarter of 2016 was 16.6%, but higher in the youth segment – three out of five unemployed were between 15 and 34 years of age (for a 20.7% unemployment). The rate is higher for the people aged 20-24 – 26.3%. Underemployment (measuring the share of employed people who involuntarily work less than 40 hour a week) is wide spread at 27%, but higher among youth. Poverty remains high in Senegal, affecting 38% of the population. Inequality is moderate; however, geographic disparities are very pronounced. Almost two out of three residents are considered poor in rural areas (especially in the south) versus one in four in Dakar.

2.2 Power profile

Senegal's power sector is operated by the state-owned SENELEC, a vertically integrated power company that generates, transmits, distributes and sells electric energy to customers. The sector is overseen by an independent electricity sector regulator, Commission de Régulation du Secteur de l'Electricité (CRSE) which reviews electricity tariffs, secures investments, and safeguards the interests of consumers.

The total installed generation capacity in 2016 was 772 MW, of which about 455 MW was effectively in use.¹ SENELEC owns about half of the generation capacity. Some of its power stations are out of use due to faults and some are closed for refurbishment. The remaining capacity is owned by Independent Power Producers (IPPs) which sell the generated electricity exclusively to SENELEC. Senegal was among the first countries in SSA to introduce private sector participation in the power sector in the late 90s. The first IPP was GTi, a 52 MW combined cycle oil-fired power plant commissioned in 2000. The track record of IPPs in the country has been mixed, mainly as a consequence of variations in the quality of fuel delivered, grid instability, and other technical difficulties which have reduced electricity output from these plants.²

The country relies on imports of electricity from two hydro stations in Mali, of which 42 MW produce power for Senegal, and a diesel plant owned by SOMALEC (Electricity Company of Mauritania). In 2016, Senegal had a total of 80 MW rental diesel capacity, down from 149 MW in 2015.

47 MW of non-grid connected installed capacity (mainly owned by SENELEC) serves isolated centres in areas away from the main grid.

The generation mix is dominated by thermal power stations (diesel and HFO), followed by steam turbines, gas turbines and the hydro power station in Mali (42 MW). Following power shortages in 2008 and 2011 –marked by severe outages³ and the renting of expensive short-term diesel capacity– the government has been working to ensure energy security. Besides refurbishing SENELECS capacity, the government of Senegal (GoS) has committed to diversifying its energy mix with coal, natural gas, hydroelectricity, and renewable technologies. Even though there have been delays in the commissioning of some of the planned projects, the power situation has since stabilised, with load shedding being practically eliminated and rental stations being phased out.

The government has also committed to having renewable sources (excluding biomass) account for 15% of primary energy supply by 2025. In its Paris Agreement Intended Nationally Determined Contribution (INDC), Senegal listed developing 250MW of solar and 200MW of wind energy to achieved its pledge of 21% emission reduction (compared to a business-as-usual scenario) by 2030.⁴

¹ Based on 2016 data on capacity and actual production from SENELEC (2016) and CRSE (2016) and (2017).

² The Law Reviews (2017). The Energy Regulation and Markets Review - Edition 6: Senegal.

<http://thelawreviews.co.uk/edition/the-energy-regulation-and-markets-review-edition-6/1144551/senegal>

³ 270 days of load-shedding in 2011

⁴ The country pledged 5% unconditional reduction and -16% conditional. Source: World Bank Group 2016

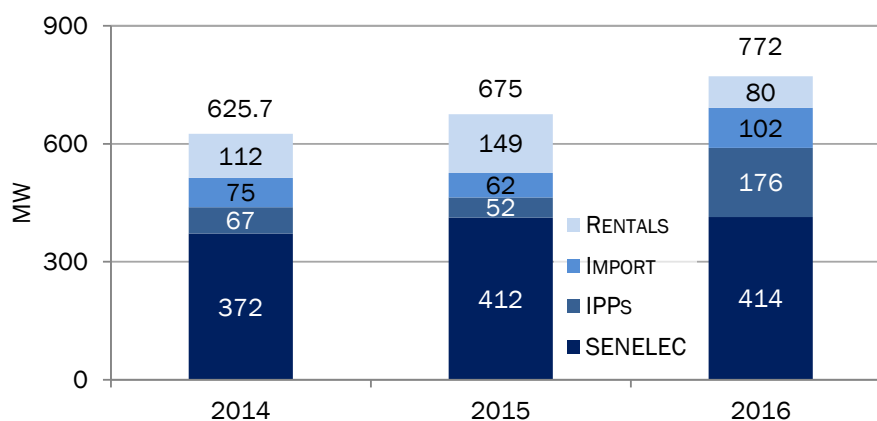


Exhibit 2: Installed capacity (Source: CSRE 2016)

Nevertheless, new capacity will be necessary to meet the population's increasing electricity needs. Average monthly peak demand reached 490 MW in 2015 (with a maximum of 533 MW in October), 6.2% higher than in 2014. In 2016, the peak is estimated at 522 MW. Conservative projections of electricity demand estimate growth at 5.6% annually in the coming years.⁵ Total electricity consumed in 2014 was 3,210 GWh⁶. Households were the largest consumer group (33% of total), followed by the industry (28%) and commercial (25%) sectors. The relatively low industry consumption is to a large extent driven by the lack of reliable supply in the past.

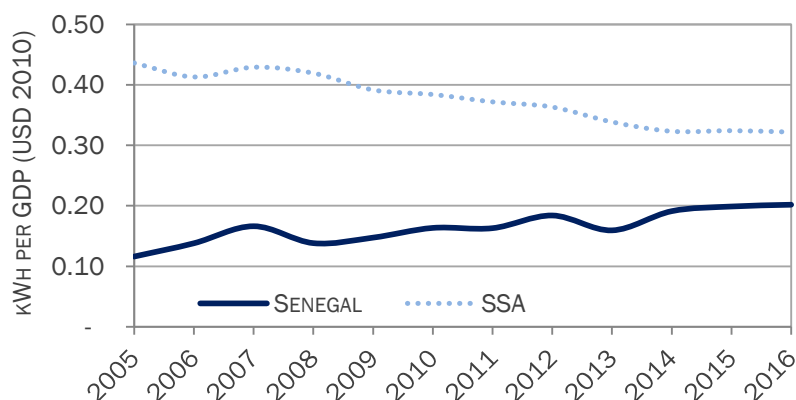


Exhibit 3: Electricity intensity of Senegal versus SSA

The country's overall electricity intensity is 1.6 times lower than that of other SSA countries. Nevertheless, while the intensity in SSA is decreasing, in 2016 Senegal recorded an increase of 23% since 2010 and 27% since 2013.

In terms of electricity pricing, Senegal has some of the highest tariffs in the region. The average electricity tariff is USD 0.24 per kWh compared to global average of approximately USD 0.10 per kWh, USD 0.09 in Nigeria, USD 0.11 per kWh in Ghana, and USD 0.13 per kWh in Côte d'Ivoire. This is not surprising, given the substantial reliance on expensive imported fuel (and on emergency thermal capacity). In 2011, production costs reached CFA 170/kWh (USD 0.34/kWh), while the tariff was CFA 118/kWh (USD 0.24/kWh)⁷, which implies heavy subsidies. The situation has improved significantly, and tariffs have been moving towards cost-reflective. Since 2016, SENELEC is no longer subsidised by the government due to low commodity

⁵EAIF (2016) Tobene credit paper

⁶ Latest available EIA figures as of writing of the report.

⁷ The Energy and Mining Sectors (2013).

https://www.developingmarkets.com/sites/default/files/MEM_LONDON_2013_VERSION15062013.pdf

prices and its improved financial stability.⁸ In January 2017, the end-user electricity price was reduced by 10%.

3 ANALYSIS FRAMEWORK

The analysis framework for the economic impact of increasing power supply is presented in Exhibit 4. We previously applied this framework to estimate the economic impact of power sector investments in studies for IFC (in the Philippines and Turkey), CDC (in Uganda), PROPARCO (India and Uruguay), and the Nigerian Infrastructure Advisory Facility (in Nigeria).

Going from left to right in Exhibit 4, an increase in power generation capacity decreases the price of power and/or reduces the number of outages. Lower prices and fewer power outages increase the production level at which companies maximise their profits which will henceforth increase electricity use to produce more output⁹. 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. The potential pathway of additional supply allowing more household consumers to connect to the grid is not included in the framework either. This is because we expect residential consumption to not significantly increasing overall electricity use in the short term. Residents often depend on (rural) state electrification programs to be connected to the grid, while the majority of firms already have electricity connections and can benefit from more and cheaper power as soon as it is available.

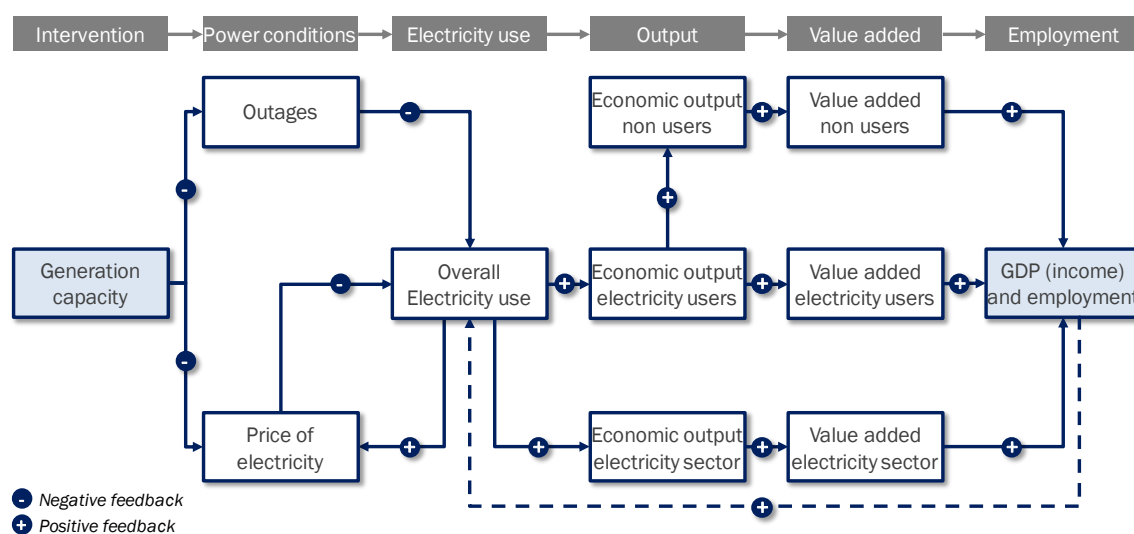


Exhibit 4: Analysis framework for the impact of increase in power sent into the grid on GDP (value added) and employment

It is important to note that in different countries, one of the pathways is typically dominant. For example, the outage pathway will be key in countries with very low reserve margins where insufficient capacity causes blackouts. In a country where the power sector is subsidised and prices are not cost-reflective, addition of capacity would not necessarily lead to change of electricity price. The price pathway is especially relevant for countries where new capacity replaces existing expensive thermal generation. The lower price for electricity due to more (and cheaper) 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,

⁸ Climatoscope 2016. *Senegal Profile*. <http://global-climatescope.org/en/country/senegal/#/details>

⁹ 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).

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 cost¹⁰.

4 IMPACT VIA THE OUTAGE PATHWAY

Outages can have a substantial impact on firm output and productivity. They can affect economic output through (i) loss of production; (ii) restart costs (iii) equipment damage; and (iv) spoilage of raw or finished materials. There are a number of factors which can completely or partly mitigate these negative impacts. In addition to self-generation, firms can continue operations without electricity or reschedule production; adopt technologies that allow faster production during hours when power is available; or procure energy intensive semi-finished goods and thereby eliminate power-intensive production steps.

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. Research shows that when reserve margins are low, addition of capacity does prevent blackouts.¹¹ In order to determine the effect of additional capacity 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 %) and economic production.

Unfortunately, there is no publically available exhaustive dataset on Senegal from which the trends in outages can be inferred.

Nevertheless, it is known that outages were a serious issue in the country during the power crisis of 2011-2012, when they were predominantly caused by lack of fuel.¹² Blackouts have significantly decreased since. Data from the 2014 World Bank Enterprise Survey puts the outage time for companies at 5.0 to 15.0 hours per month, which is about 2% to 5% of operational time. An indication for 2016 puts total annual outages at 73 hours¹³, or at about 6 hours per month. Furthermore, in 2016 the GoS is scaling down on rental capacity, indicating that the reserve margin is steadily improving. These outage numbers are low by Sub-Sahara African standards.¹⁴ Moreover, we know from other African countries that outages are not only caused by insufficient generation capacity but also caused by insufficient generation and distribution.

For these reasons we can conclude that the addition of the Tobene and Senergy 2 plants did not have a significant effect on outage reduction. The leading pathway through which the new projects support impact in Senegal is therefore likely through reduction of generation price, discussed in detail in the following section.

¹⁰ 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.

¹¹ See Steward Redqueen (2016), Zafir et al (2016).

¹² https://www.developingmarkets.com/sites/default/files/MEM_LONDON_2013_VERSION15062013.pdf

¹³ West Africa Brief (2017). <http://www.west-africa-brief.org/content/en/senegal-cheaper-electricity-prices>

¹⁴ In 2014, firms in Senegal reported 6 monthly outages, 1.8 hours each. The reported figures for SSA were 8.8 outages, 5.4 hours each. <http://www.enterprisesurveys.org/data/exploreconomies/2014/senegal?topic=infrastructure>

5 IMPACT VIA THE PRICE PATHWAY

5.1 Methodology

To estimate the impact of PIDG supported plants on employment in Senegal, we analyse how the additional capacity affects electricity prices.

We start by calculating the effect of the new plants on electricity generation costs and consequently on the end-user tariff based on a power supply-demand model and the structure of the tariffs. Reduction in the generation cost will lead to decrease in the end-user tariff only when the latter is cost-reflective. If that is the case, we estimate to what extent the lower price stimulates electricity consumption based on an indication of the elasticity of electricity demand. Using an estimate of how companies change their production due to changes in their use of electricity (i.e. electricity factor shares), we quantify the additional economic production (i.e. output) attributable to the new power capacity. To translate this increased production into employment, we rely on employment intensities and high-level input-output multipliers from Senegal's official National Accounts. The analysis considers the effect of PIDG-supported energy generation plants on Senegal's employment. We do not seek to quantify the proportion of the effects that is attributable solely to PIDG, which has operated alongside several other financiers and development partners. This approach, summarised in Exhibit 5, is explained in more details in the sections below.

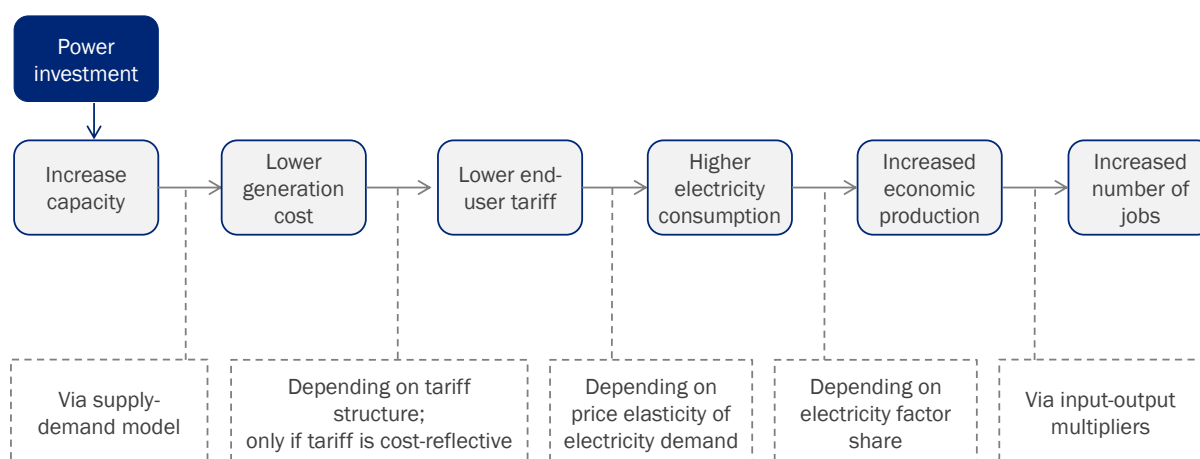


Exhibit 5: Price pathway approach

5.2 Results

5.2.1 Supply-demand model and effect on price

The effect of new capacity on the Senegalese economy is derived by constructing a power price model based on the specification of a power supply and demand curve. A power supply curve ranks all power plants side by side based on dispatch order commensurate with their capacity (in MW). For each plant, it gives the levelised cost of electricity (LCOE).¹⁵ We construct the power supply curve by using the information on the effective power generation fleet of Senegal, i.e. installed capacity adjusted for utilisation.

By combining the supply curve with the observed power demand of a country (in MW), one can determine the demand-weighted average generation cost. The impact of the addition of generation capacity is determined by deriving two power supply curves: one with and the other without the PIDG-backed plants. Determining the weighted average generation cost for both situations allows one to calculate the effect of

¹⁵ Model is based on LCOE rather than short-run costs since there is not an electricity spot market, meaning the costs need to be all inclusive.

adding generation capacity to the power fleet. The effect on generation cost is translated to end-user tariff change based on the structure of the tariff (shares of generation cost and T&D margins).

This model has been shown to adequately reproduce observed price behaviour in the Philippines¹⁶, Turkey¹⁷ and Uganda¹⁸. The method relies on availability of LCOE data for plants, which is often not public. In these cases, proxy costs from international databases have been assigned. In Appendix 2 we outline the costs and utilization factors used per plant. When no observed price information is available the model still holds, but the results cannot be verified. However, with realistic estimations of LCOE one can still assume that results will be directionally correct.

Supply curve

To construct the country's supply curve, we assigned LCOE values for each of the available power plants in Senegal, based on plant-specific or proxy data (Exhibit 6). The curve represents the operational capacity, adjusted for utilization rates. The non-dispatchable plants, which must supply power when available (hydro and solar), are placed at the left hand side of the curve. The rest of the dispatch order is based on IFC merit analysis.^{19,20}

Exhibit 7 shows a hypothetical supply curve in which Tobene and Senergy 2 are both added to Senegal's power fleet.²¹ Again, the merit order is based on IFC analysis. The two power plants add 60 MW (or 13%) effective solar (8 MW) and HFO (52 MW)²² capacity (adjusted for utilization, based on conservative projections) to Senegal's power fleet and shifts the supply curve to the right, reducing the cost of generation.

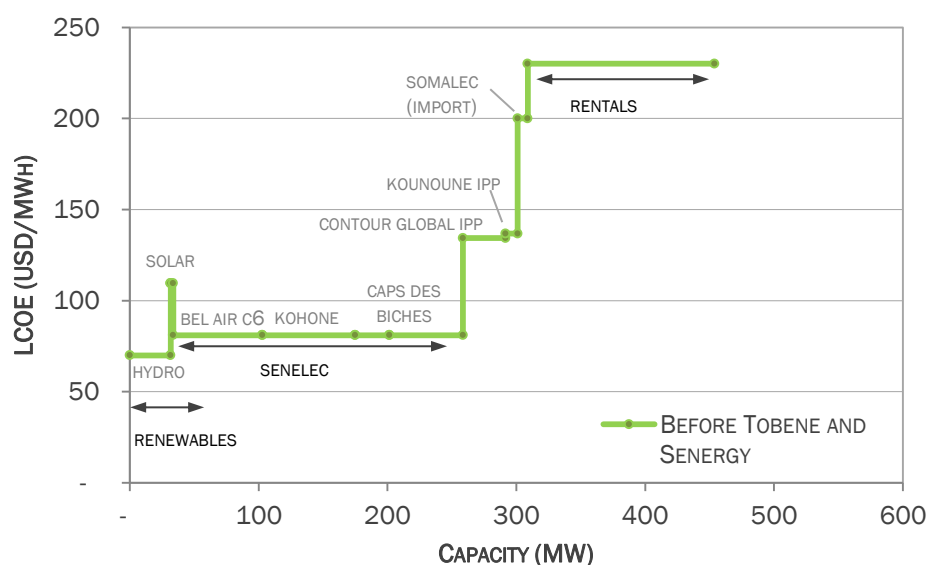


Exhibit 6: Supply curve before Tobene and Senergy 2

¹⁶ Let's Work study on the impact of power investments in the Philippines, Steward Redqueen 2015.

¹⁷ IFC, *How Power Contributes to Jobs and Economic Growth in Turkey*, 2016.

¹⁸ CDC, *What is the Link between Power and Jobs in Uganda* 2016.

¹⁹ EAIF (2016) Tobene credit paper

²⁰ The reason for the low cost of generation of the SENELEC plants is most probably the fact that they are running on short-run cost because they have been written off

²¹ Tobene was operational in 2016

²² The actual annual average utilization rate of Tobene in 2016 was 56%, based on 2016 data on installed capacity and production. The annual utilization rate used here is 75%, to correct for the fact that Tobene only started producing electricity in Q2 of 2016.

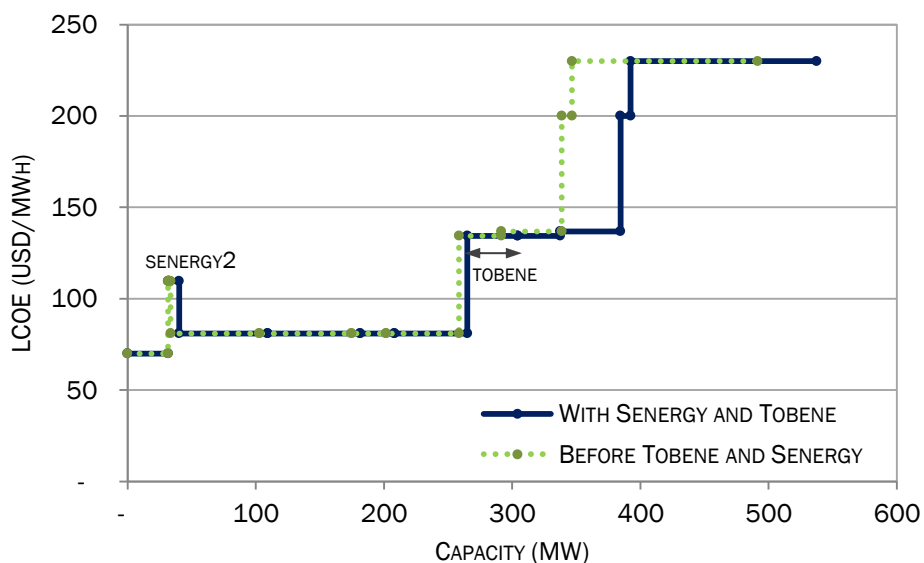


Exhibit 7: Hypothetical supply curve after the addition of Tobene and Senergy 2

Demand 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. The curve shows the level of power load in the course of a typical day. Ideally, for the construction of such a curve, one would use hourly power load data from the same randomly selected day of each month. Unfortunately, to our knowledge such data for Senegal is not publically available. The only information we found was on the monthly and annual average peak load in Senegal (i.e. the maximum load achieved in the system). Based on this data and the total consumption of electricity in Senegal, we construct a daily load curve for the country. The peak at 564 MW between 19:00 and 21:00 is 1.4 times the average load (392 MW), which is in line with typical demand profiles. A smaller peak between 7:00 and 8:00 (450 MW) has been modelled to reflect the high electricity consumption in the morning.

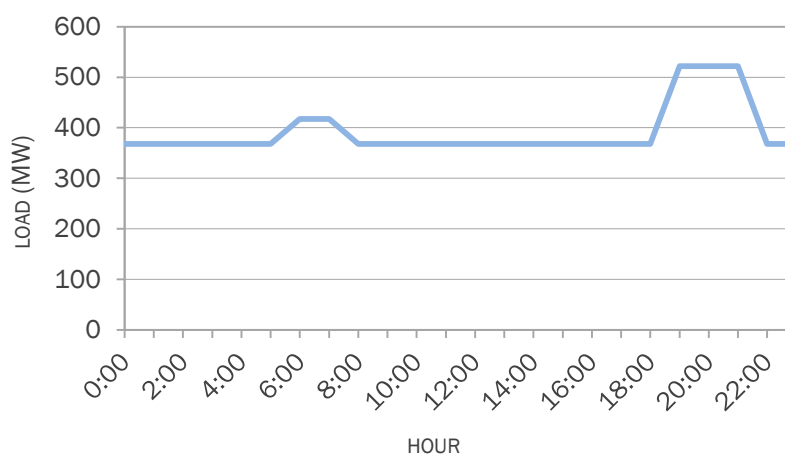


Exhibit 8: Demand curve

Price model

The effect of Tobene and Senergy 2 on the generation cost is determined by combining the two supply curves. The results are shown in Exhibit 9 and Exhibit 10. The blue line illustrates the demand, while the striped gay lines showing which capacity is used to cover the demand.

Looking at Exhibit 9, without Tobene and Senergy 2, the rental power plants need to be constantly on to meet even average demand. In contrast, with Tobene and Senergy 2 the base demand is covered by IPPs, while rental is needed only to cover the high evening consumption (Exhibit 10).

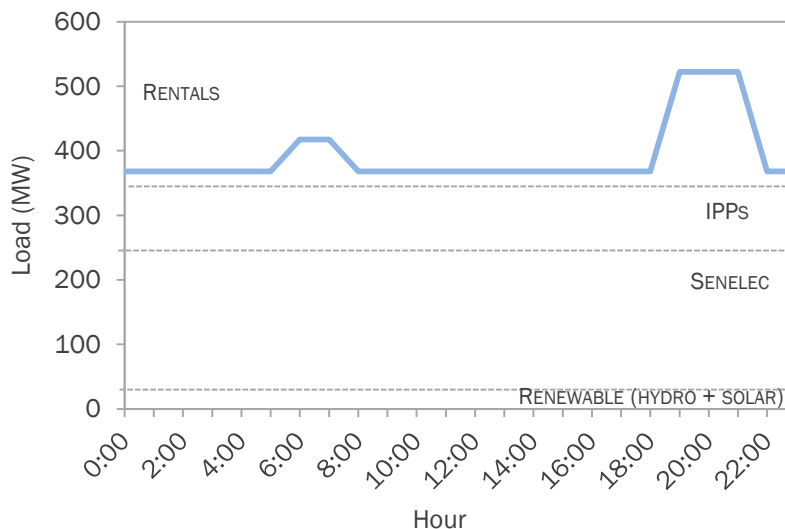


Exhibit 9: Supply versus demand without Tobene and Senergy 2

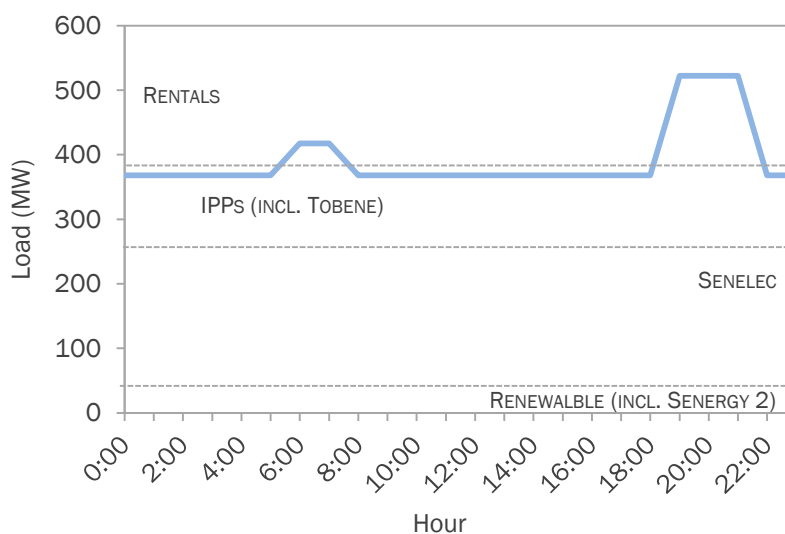


Exhibit 10: Supply versus demand with Tobene and Senergy 2

Effect on price

The supply and demand curves were combined in a price model, which matches the hourly demand to the available capacity and yields the (load-weighted) average generation cost per MWh for each month of the year. As indicated earlier, Tobene and Senergy 2 offer additional capacity which means the rental diesel plants do not need to be on all the time. Furthermore, the power generated by the new plants is cheaper compared to the rentals. For these reasons we estimate that the additional capacity will decrease the estimated weighted average kWh cost by 12.6% (from estimated \$0.12 to \$0.10; CFA 71 to CFA 62).

Reduction in the generation cost will lead to decrease in the end-user tariff when the latter is cost-reflective. Given that Senegal is rolling out subsidies in the electricity sector and that an actual price

decrease took place in 2017, it is realistic to conclude that Tobene and Senergy 2's effect on generating costs would affect the final consumer price.

The average end-user tariff in Senegal (before the 2017 decrease) was USD 0.24 per kWh. Based on the supply-demand model estimates, the generation cost before the new additional capacity was USD 0.12 per kWh, or 50% of the final price, which is a realistic share.²³ Assuming T&D margins would not change, the decrease in the production cost of 12.6% will lead to a 6.3% drop in the final tariff. Again, such a decrease seems realistic, given the mentioned 10% decrease in prices which went into effect in January 2017 (driven by low fuel prices, the addition of new cheaper capacity, efficiency improvements, and improvement of the financial situation of SENELEC).

5.2.2 Effect on economic output

To arrive at the elasticity of economic output (Y) with respect to electricity price P , one needs to multiply the factor share of electricity consumption, ε , by the price elasticity of electric power consumption, θ

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

Price elasticity

The price elasticity of electricity demands is an indication of how electricity use changes in response to changes in electricity price. Ideally, the price elasticity of electric power consumption will be estimated making use of econometric analysis based on electricity consumption, GDP and the average tariffs panel data. However, such panel data regarding electricity costs of firms is not publically available for Senegal and therefore realistic values need to be established based on academic literature.

Atalla, Bigerna, and Bollino (2016)²⁴ estimated the elasticity for Senegal at -0.86, meaning that 1% decrease in price leads to 0.86% increase in electricity consumption.

Factor shares

The electricity factor share expresses the change of economic output in response to increase use of electricity. It is thus the elasticity of economic output with respect to electricity use. It can be determined using information from the World Bank Enterprise Surveys.

In order to determine the shares one can apply the extended Cobb Douglas^{25,26} production function:

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

With Y firm sales; L labour (number of employees); K capital (here replacement capital²⁷), M annual cost of materials (US\$), and E annual electricity use (MWh). A is the so-called total factor productivity (TFP)²⁸ 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:

²³ We found similar breakdowns of the final tariff in our research in Uganda (2016) and Philippines (2015).

²⁴ Atalla, Bigerna, and Bollino (2016). *Quantifying Worldwide Demand Elasticities as a Policy Tool*. <https://www.kapsarc.org/wp-content/uploads/2016/08/KS-1644-DPO38A-Quantifying-Worldwide-Demand-Elasticities-as-a-Policy-Tool.pdf>

²⁵ 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.

²⁶ 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 Cobb Douglas functions) become too unwieldy in terms of parameters that need to be estimated when more than two variables are considered.

²⁷ 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.

²⁸ 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.

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

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.

The factor shares for Senegal are based on the World Bank Enterprise Survey 2014. The data set consists of 601 firms, of which 249 in manufacturing, 146 in services, and 206 in wholesale, retail and hotels and restaurants (from here on – trade). Ideally, the regression analysis would be performed on the whole sample. However, not all of the required data is (properly) reported by all firms. Therefore the sample used in the study is smaller (396 companies).

Table 1 presents the derived factor shares. As expected, the manufacturing sector is the most sensitive to changes in electricity consumption – it would upscale production by 0.48% for each 1% increase in electricity. This factor share is higher than the ones derived in other countries for previous projects.²⁹ One reason for this could be the low electricity use by the industry sector due to years of power shortages. For businesses operating in the trade and other sectors (such as construction, transport, and other services) electricity is a fixed rather than variable cost. Their operations are dependent on electricity to a lesser extent than manufacturing firms (for whom electricity is a variable expense). Therefore it makes sense that these sectors will have a weaker output response than manufacturing.

Table 1: Electricity factor shares

Sector	Observations	Factor share
Manufacturing	92	0.480***
Trade	159	0.340**
Others	145	0.381***

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Effect on output

The additional capacity of Tobene and Senegal leads to lower electricity prices (-6.3%), enabling local businesses to expand production. Output effect is estimated for two groups of economic agents:

- Companies/sectors which directly benefit from the lower electricity prices – firms operating in manufacturing, trade, business services, depend on electricity for their operations (to various extents) and will thus directly benefit from the lower electricity prices;
- Companies/sectors which do not directly benefit from the lower electricity prices – firms operating in the agriculture sector do not rely on electricity for their operations. Therefore, lower tariffs would not have a direct effect on agricultural production. However, agro businesses will benefit indirectly due to increased procurement from other sectors affected by the change in price (most notably food & beverage manufacturing). We quantify this effect using Senegal's Input-Output table³⁰. We calculate how USD 1,000,000 increase in the sectors affected from the lower electricity price translates into higher output of the agriculture sector. Based on these multipliers, we estimate the total increase in agriculture output related to the higher production of the electricity-dependent sectors.

²⁹ In Uganda 0.18; Nigeria 0.09, Philippines 0.21, Turkey 0.03, Uruguay 0.18

³⁰ The most recent IOT for Senegal comes from the Global Trade Analysis Program (GTAP).

Based on the elasticity and the factor shares presented above, we estimate that the production output related to these lower prices is USD 415.6 million among firms which are dependent on electricity use (as presented in Exhibit 11). Companies in the manufacturing sector upscaled production by USD 168.8 million (2.7%), while the trade sector increased output by USD 81.1 million (1.9%). Output in other sectors (such as transport, construction, and other services) grew by USD 165.7 million (2.1%).

Businesses in agriculture did not directly benefit from lower tariffs given their negligible use of electricity. However, due to the increased production –and thus procurement– from the ‘dependents’, the agri-sector also expanded its output in order to meet the growing demand for its products. This procurement effect increase total economic output value by USD 18.9 million (0.8%).

The total output increase in Senegal was thus USD 434.5 million, equal to 1.7% of total economy output.

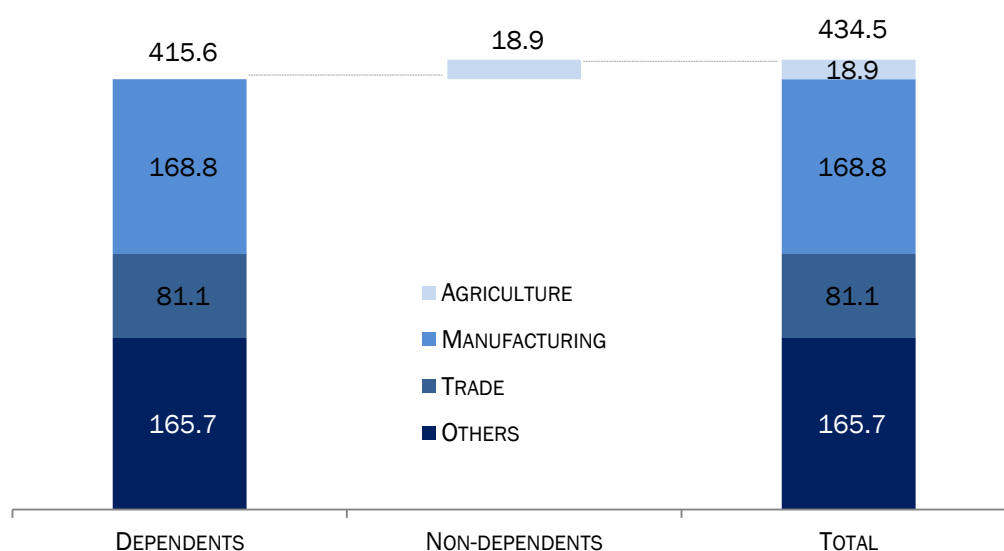


Exhibit 11: Increase in output (USD million)

5.2.3 Effect on employment

In order to translate the sectoral changes in economic output into employment effects we determined the employment intensity of the economic sectors in Senegal. For this, we use data on the National Accounts of Senegal, published by UN.³¹ The latest available output and employment data is from 2013. These are extrapolated to 2016 using annual labour force and GDP growth figures from the World Bank Development Indicators database. From these sources we established the 2016 employment for 10 economic sectors (ISIC Rev. 3 classification). Using the output produced in the corresponding sector and year, we calculate the number of jobs needed in a sector to produce one unit of output (in USD), i.e. the employment intensity of the sector.

Approximately 68,500 jobs can be attributed to the additional capacity of Tobene and Senergy 2, which is equivalent to 1.3% of the total employment (Exhibit 12).

³¹ National Accounts Statistics: Main Aggregates and Detailed Tables 2014 Senegal
<http://dx.doi.org/10.18356/addc18ed-en>

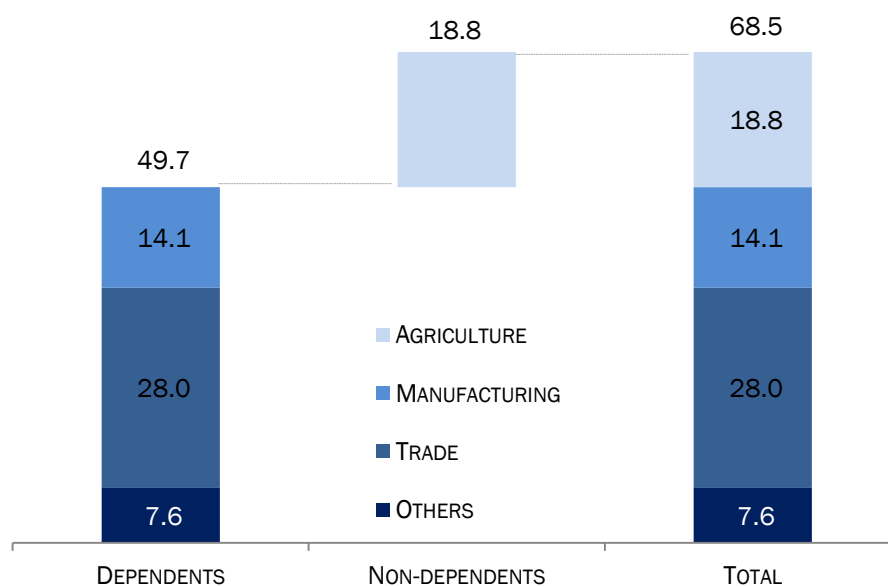


Exhibit 12: Employment supported (total headcount)

Most jobs are added in the labour intensive trade sector (28,000, or 1.9%). The manufacturing sector which experiences the highest output growth added 14,100 employees (2.7%). Other 'dependent' sectors added 7,600 employees. 18,800 additional people were involved in agricultural production (0.8%).

As discussed in Section 2.1, the level of underemployment in Senegal is high at 27%. Many employment opportunities are not permanent and could entail a few hours of work. Therefore these employment results should not be interpreted as jobs in full-time equivalents (FTE), but as people affected.

5.3 Multipliers

Tobene and Senergy 2 are adding 60 MW of effective capacity, equal to 13% of Senegal's dependable power base. The results derived in Section 5.2 presented the total effect of this new capacity to the economy. In Table 2 we expressed the price and employment results as key ratios – per 1% and per 1 MW increase in capacity.

Table 2: Key multipliers

	Per 1 % capacity increase	Per 1 MW capacity increase
Δ Generation cost (%)	-0.94%	-0.21%
Δ End-user tariff (%)	-0.47%	-0.10%
Δ Employment (# jobs)	5,150	1,136
Δ Employment (%)	0.10%	0.02%

The multipliers for Senegal are higher than the ones for Uganda, where we found an additional MW of capacity to lead to 807 jobs. In the case of Uganda, we analysed the impact of adding the hydro dam Bujagali to the country's grid. The lower response in the East African country can be explained by the fact that its grid already consisted of cheaper hydro capacity. In Senegal, replacing expensive emergency thermal with cheaper HFO and solar technology has a relatively bigger effect on the generation price.

The job effect per MW in Senegal is also much higher than the 226 jobs for each MW estimated in the Philippines. This is due to (i) the lower labour productivity in Senegal, and (ii) the stronger production response of firms in Senegal to increase in the availability of electricity.

6 CONCLUSIONS AND RECOMMENDATIONS

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

1. PIDG-supported plants Tobene (70 MW) and Senergy 2 (20 MW) will add an estimated 60 MW effective capacity (adjusted for utilization). This is equal to 13% of Senegal's effective capacity;
2. Firms in Senegal experience outages 2-5% of operations time in 2014. Outages have significantly decreased since the power shortage of 2011-2012. Furthermore, emergency power is being phased out, indicating stabilization of the reserve margin in Senegal. For these reasons Tobene and Senergy 2 are not expected to have a significant effect on reduction of outages in the country.
3. By adding base load cheaper than the rental plants, Tobene and Senergy 2 are expected to lead to:
 - a. Lower weighted average generation costs of 12.6%;
 - b. Lower final consumer tariff of 6.3% provided that the tariffs are cost-reflective.
4. The decrease in electricity prices will enable firms to consume more electricity and consequently increase production. The economic output growth is estimated at USD 434.5 million, equal to 1.7% of total economy output, of which:
 - a. USD 415.6 million due to increased economic output from sectors dependent on electricity (manufacturing, trade, transport, construction, business services);
 - b. USD 18.9 million increase in the agriculture sector, which intensifies its production to meet growing demand for its goods by electricity-dependent sectors (e.g. food processing).
5. The resulting effect is estimated at 68,500 employment opportunities, of which:
 - a. 49,700 at electricity-dependent sectors;
 - b. 18,800 in agriculture;
 - c. The results represent headcount/people affected rather than full-time equivalent due to wide-spread underemployment in Senegal (27% of total employment).
6. These results reflect the effect of adding Tobene and Senergy 2 plants to Senegal's fleet, without taking into consideration PIDG's attribution.

Considering the developments in Senegal's power sector and the results of this report, we make the following recommendations:

1. The study has demonstrated that inclusion of relatively cheaper power capacity to Senegal's grid can decrease generation costs. When these lower costs are then translated into actual tariff reductions, they enable firms to use more electricity, increase output and create employment opportunities. This can only be achieved if the country's tariff structure is cost-reflective. Power markets with such structures are generally more stable as they are able to attract investments and ensure the long-term sustainability of the system.
2. Despite recent actual and planned capacity additions to Senegal's power fleet, new capacity will be needed to meet the country's increasing power demand. The government has set an ambitious agenda to increase renewable power base and decrease carbon emissions. Currently, solar has a small installed base, vast potential, and decreasing costs. Supporting further (small and large scale) solar generation projects could help lower electricity costs while greening Senegal's power generation and reducing its import dependence.

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