# Exploring an Electricity Tax on Mega Projects in Mozambique

Aurelio J. Bucuane and Peter Mulder

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Contact:
**Aurelio J. Bucuane**
National Directorate of Studies and Policy Analysis;
Ministry of Planning and Development
Av. Ahmed Sekou Touré nº 21, 7º andar
Maputo, Moçambique
Tel: (+258) 21499442
Fax: (+258) 21497663
Web: www.mpd.gov.mz
Email: abucuane@mpd.gov.mz

**Peter Mulder**
National Directorate of Studies and Political Analysis (DNEAP)
MPD
and
Directorate of Studies and Planning (DEP)
Ministry of Energy
Maputo, Mozambique
Email:pmulder@gmail.com

**Abstract**

In this paper we explore the arguments, the appropriate level and tax base as well as potential revenues of from a tax on electricity *consumption* by mega projects and a tax on electricity *production*, respectively. We argue that mega projects offer a good opportunity to extend the tax base in Mozambique from the point of view of raising government revenues and compensation for negative environmental and social externalities. We conclude that in particular a tax on electricity production seems a promising instrument. We estimate annual tax revenues of a 0.1-0.2 US$c/kWh tax on electricity production in the range of US$ 16-84 million during the period 2007-2020. By and large the burden of a tax on electricity production in Mozambique will fall on neighbouring countries due to the large share of electricity generation earmarked for export. We show that the regional electricity market provides ample space to increase electricity prices without compromising Mozambique's comparative advantage in electricity production.

## 1. Introduction

The energy sector in Mozambique plays an increasingly important role in the economic development of Mozambique. The main reason for this is that Mozambique has abundant and yet largely unexplored natural resources, which are attracting substantial foreign direct investments in large energy-intensive industries as well as in the mining, exploration and transformation sectors. These are projects of large dimensions, often referred to as ‘mega projects’. So far, some mega projects have been realized, such as the Mozal aluminium smelter near the capital Maputo, while several new projects are planned or already under construction. It is to be expected that the recent transfer of the ownership the Cahora Bassa hydro dam from Portugal to Mozambique will accelerate the realization of various new mega projects, like for example the construction of the Mphanda Nkuwa hydro dam.

In this paper we will argue that these mega projects offer a good opportunity to extend the tax base in Mozambique for two reasons. First, with a typically small tax base in Mozambique, mega projects offer a unique source to increase government revenue, thereby lowering the dependence on foreign aid. Second, electricity production, energy-intensive production processes and mining are known for their substantial negative impact on the environment. An energy tax is an important instrument to internalize these negative externalities.

With the exception of natural gas exploration as such, electricity is a key issue for all existing and future mega projects in Mozambique. The industrial and mining projects all depend critically on the availability of cheap electricity in large quantities while the other mega projects are engaged in the production of electricity. Therefore, we focus in this paper on an electricity tax on mega projects as a new policy instrument in Mozambique. This implies that we do not consider the taxation of non-renewable resource extraction, like for example the exploration of natural gas or coal. Currently, resource extraction is already subject to taxation, and it is outside the scope of this article to review this tax regime.

The paper is organized as follows. In section 2 we provide a brief description of the energy sector in Mozambique, focussing on electricity and the role of mega projects.

Section 3 elaborates upon the arguments in favour of an electricity tax on mega projects. In section 4 we explore the appropriate level and base of the tax. In section 5 we present the potential revenues from implementing a tax on electricity *consumption* by mega projects and a tax on electricity *production*, respectively. Section 6 discusses the possibilities and limitations of the various tax proposals. Section 7 concludes.

## 2. The energy sector and mega projects

In this section we provide a brief overview of the energy sector in Mozambique for the period 2000-2020, with a focus on electricity and mega projects. Before 2000 the energy sector was characterized by decline, disruption and initial post-war reconstruction, while the year 2000 marks the beginning of a new era with the introduction of the Mozal aluminium smelter as the first mega project in Mozambique.[1] Moreover, it is expected that the energy sector in Mozambique will undergo a rapid expansion until 2020, mainly because of the realisation of a number of new mega projects. Our overview is based on original data for the period 2000 to 2005, in combination with projections for the period 2006-2020. To this aim we used the software tool LEAP (Long-range Energy Alternatives Planning system), a scenario-based energy-environment modelling tool.[2] The LEAP scenarios presented in this paper are based on comprehensive accounting of how energy is consumed, converted and produced in Mozambique under a range of assumptions on population, economic development, technology, and so on. The figures below are all based on the reference scenario, representing the most likely development path.[3]

### 2.1 Production

Traditionally, primary energy production in Mozambique consists mainly of biomass, including predominantly fuelwood, but also charcoal. With the realization of the Cahora Bassa hydro dam (HCB) in 1974, Mozambique became a potential large producer of

[1] Except for, of course, the Cahora Bassa hydro dam, realized in 1974.
[2] For more information see: http://www.energycommunity.org
[3] For the period 2007-2020 we assume 2.4% annual population growth, a household size of 5 persons and an annual GDP growth rate of 6%. The required information concerning the new mega projects in the reference scenario stems from personal communication within the Ministry of Energy as well as recent feasibility studies for the various projects.

hydroelectricity (for export to South Africa), but destruction of the transmission lines during the post-independence civil war prevented this from happening for a long time. Post-war reconstruction allowed for production to pick-up in 1997, and since then the amount of electricity produced has been gradually increasing, and will continue to grow because of new generation projects (see below). Large scale natural gas production started in 2004 with the exploration of the Pande/Temane gas fields in the Inhambane province by the South African company Sasol, and is expected to grow steadily over the next years. Coal production used to be small-scale and became marginal during the civil war. This situation is, however, going to change since the Brazilian Company Vale do Rio Doce (CVRD) won a bid in 2004 to develop the Moatize coalfield in Tete province, with an expected coal production of 14 to 15 million tonne per year, starting in 2009 (Yager, 2005).

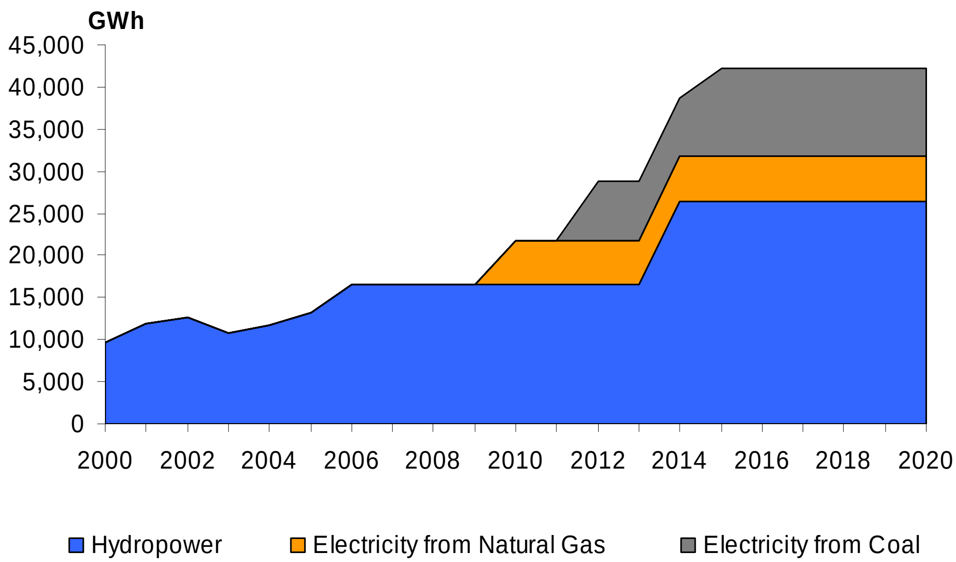


*Figure 1. Electricity Production*

Notwithstanding the importance of natural gas and coal, electricity is the key issue when talking about the development of existing and new mega projects. Figure 1 gives an overview of current and future electricity production in Mozambique, indicating a spectacular growth in production from about 10.000 GWh in 2000 to about 42.000 GWh as of 2014. Currently, virtually all electricity produced is hydro electricity generated by HCB. Since 1997 the production by HCB has gradually increased and is currently close to reach its maximum capacity (2075 megawatt). HCB is and will be the main producer of electricity in Mozambique, exporting about 80% of its production (mainly to South Africa) while the remaining 20% is acquired by the national electricity utility Electricidade de Moçambique (EdM). The latest information we have from the Ministry of Energy indicates that we may expect a second large hydro dam, Mphanda Nkuwa, to become operational in 2014 with a capacity of 1300 megawatt (MW), thereby increasing base-load hydroelectricity production capacity in Mozambique with more than 50%. We expect that of the total capacity of 1300 MW, 650 MW will go to the extension of Mozal (shortly referred to as Mozal III) while the other 650 MW will be exported.[4] Another new mega project in the electricity sector is a 700 MW natural gas-fired electricity plant, fuelled by gas from the Pande/Temane fields, and expected to become operational in 2010. The most likely scenario is that initially all its electricity will be exported to South Africa, while as of 2014 about 100 MW might be acquired by EdM and as of 2017 an additional 200 MW might go to the Chibuto Heavy Sands project. Finally, the large-scale exploration of the Moatize coal mine in the near future has given rise to the possibility of constructing a coal-fired power station with a capacity of 1500 MW. It is to be expected that 1000 MW will become operational as of 2012 while the remaining 500 MW will probably be available as of 2015. We assume in this paper that about 10% of its electricity production will be consumed at the site of the Moatize coal mine itself and in the northern region of Mozambique, while 90% will be exported. In sum, the current and new electricity generation plants together account for a total base-load electricity production equivalent to 5575 MW and a total investment value of 5.7 billion US$ (for more details see Table A.2 in Annex).

### 2.2 Export & Import

Most energy produced in Mozambique is exported. With respect to the coal from the Moatize mine, we expect 15% to be marketed in Mozambique, including consumption by

[4] A third large hydro project in Mozambique with a capacity of 600 MW is HCB North, to be build at the north bank of HCB´s site. Probably to be realised somewhere between 2010-2015, HCB North is meant to meet peak-load demand in the SADC region. Since peak-load is a very different market from base-load, and not suitable to serve base-load demand of mega projects, in this paper we do not take HCB North further into consideration (see also section 5.2).

the electricity plant, while the remainder will be exported for consumption by steel plants in Brazil (Yager, 2005). The vast majority of natural gas is and will be exported to South Africa, although domestic consumption tends to increase due to the realization in 2005 of a new pipeline to the Beleluane industrial park near Maputo and because of the natural gas-fired electricity plant to be constructed.

Also in terms of electricity, almost all production is exported. About 75% of Mozambique's major electricity generation site HCB is exported, mainly to South Africa but also to Zimbabwe and Botswana, and in the future also to Malawi. It is to be noted that this fact is due to the traditionally low domestic electricity demand as well as lack of transmission infrastructure from HCB (located in the northern Tete province) to the southern region of Mozambique – the economically most vibrant part of the country. Thus, electricity consumption in the southern part of Mozambique, including the large electricity consumption by Mozal has to be wheeled through South Africa, and/or imported from South Africa. As a result, we arrive at the somewhat peculiar fact that Mozambique is currently an (almost equally big) exporter as well as importer of electricity.

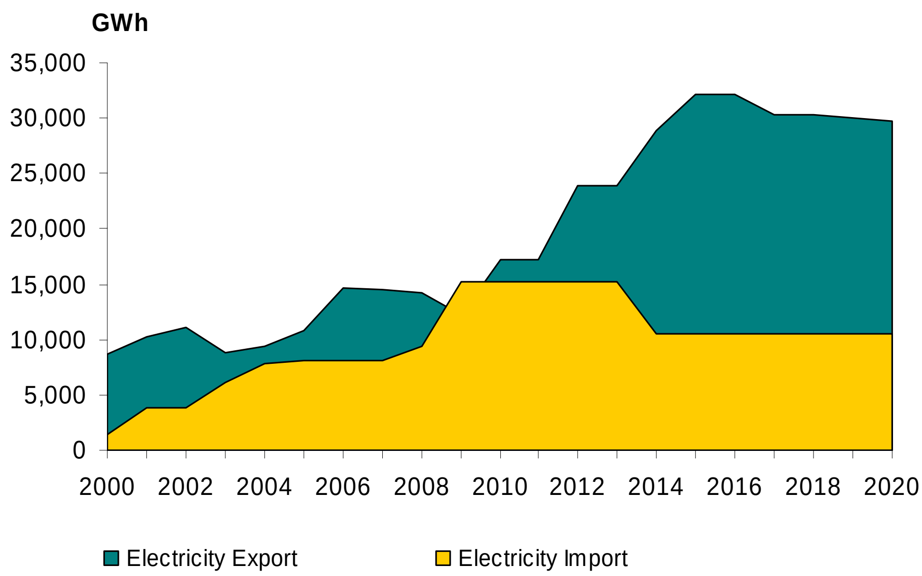


*Figure 2. Electricity export & import*

As said before, the Moatize coal-fired electricity plant will mainly produce electricity for export (we assume in this paper 90%), implying a considerable increase in electricity exports as of 2012 (see Figure 2). As mentioned in section 2.1, the new natural gas-fired electricity plant is expected to produce primarily for export (see also below), while in the long run it will presumably also deliver electricity to EdM and the Chibuto heavy sands mine.

Concerning energy imports, those consist in Mozambique primarily of oil products and electricity. Given the absence of refineries, all domestic consumption of fuels is imported.[5] Electricity imports have been rapidly increasing since 2000, mainly due to the start of Mozal, which imports its electricity consumption from South Africa.[6] From Figure 2 it can be seen that electricity import will increase substantially between 2009 and 2014. This is mainly due to the foreseen realization of Mozal III in 2009, which depends on electricity imports from South Africa until the Mphanda Nkuwa dam can take over electricity delivery as of 2014. The second-most likely scenario here is that Mozal III will fail to import its electricity from South Africa due to the severe capacity problems of ESKOM, in which case we may expect the natural gas-fired electricity plant to supply Mozal III until 2014 instead of exporting its electricity. Finally, although negotiations are not yet finalised, we assume that the Chibuto Heavy Sands mine in Gaza province, which is expected to start in 2009, will also import its electricity initially from South Africa.

### 2.3 Consumption

Access to modern energy services is still very low in Mozambique, with about 80% of the population relying entirely on traditional biomass to meet their energy needs. Electricity consumption is in principal very low: only about 8% of the population have access to electricity and electricity consumption in the service and industry sectors is still very limited due to the small scale of economic activity. The various mega projects, however, (will) consume large amounts of electricity, about 6 – 9 times as much as the rest of the

[5] A plan exists to build refinery capacity, for example to produce LPG from natural gas, but so far it is very uncertain whether and when this will be realized.

[6] It can be argued that the South African national power company Eskom is able to provide Mozal with a large quantity of cheap electricity because it obtains cheap electricity from HCB. Hence, this implies that in effect Eskom facilitates principally the transport of electricity from HCB to Mozal, similar to their role in transporting the electricity that EdM acquired from HCB for distribution in the south of Mozambique.

country all together. This dual nature of the Mozambican electricity market is illustrated in Figure 3.

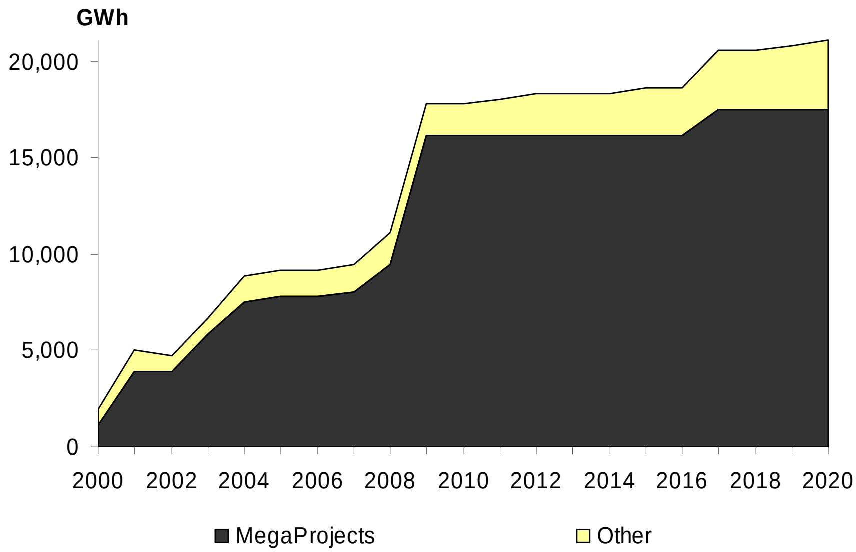


*Figure 3. Electricity consumption*

'Normal' demand for electricity will grow as a result of ongoing rural electrification and continuous economic growth. At the same time electricity consumption by mega projects will sharply increase in the (near) future. By and large Mozal is and will be the main electricity consumer in Mozambique. As mentioned before, Mozal operates since 2000 (constructed in two phases, shortly referred to as Mozal I+II) while we assume that Mozal III starts to operate in 2009. Furthermore, we assume the Moma Heavy Sands mine to start in 2007, receiving its electricity from HCB through a newly constructed transmission line from Nampula. We suppose that the Chibuto Heavy Sands mine starts in 2009, with a second phase starting in 2017.[7] Finally, we assume the Moatize coal mine to start operating in 2009. Initially they will be supplied by HCB, while the new coal fired plant is expected to take over electricity supply as of 2012. Together these mega

[7] Recently the investor, BHP Billiton, announced the probability of further delays in the project due to increased mining costs (journal O País, 2nd March 2007). At the time of finishing this paper, senior government officials within the Ministry of Energy, however, could not confirm delay of the project and we cannot exclude the possibility to interpret the news in terms of strategic behaviour in the context of current negotiations over electricity supply, among others.

projects account for a total electricity consumption equivalent to 1882 MW and a total investment value of 5.5 billion US$ (for more details see Table A.1 in Annex).[8]

## 3. Principles of an electricity tax

We would like to highlight two reasons as to why mega projects offer a good opportunity to extend the tax base in Mozambique: revenue-raising and negative externalities. In this section we will discuss these arguments, both from a theoretical point of view as well as in the particular context of Mozambique.

### 3.1 Revenue-raising

As a developing country, Mozambique is characterized by a typically small tax base due to, amongst others, the relatively large scale of the informal economy and a traditionally weak fiscal institutional infrastructure. As a result, Mozambique continues to depend on foreign aid, currently accounting for about half of the government budget. The existence of mega projects offers a unique opportunity to extent the tax base in Mozambique, thereby increasing government revenue and lowering the dependence on foreign aid.

Tax theory suggests that where the aim is to raise revenue for public expenditure, goods for which demand is least sensitive to price increases are best suitable for taxation. This is true for base-load electricity consumption by mega projects, given the lack of technological alternatives to their electricity needs.[9] For example, one simply cannot run an aluminium smelter on diesel or heat power. Moreover, mega projects constitute high sunk costs because of the large capital investments, and hence investors will not easily change location because of a small electricity price increase.

In addition, the costs of raising revenues through an electricity tax are relatively low as compared to other tax instruments. Collecting ordinary taxes on import, income and profit is relatively expensive and complicated as compared to taxing mega projects

[8] Recently the Norwegian energy company NorskHydro relaunched the plan for a second aluminum smelter in Mozambique, most likely to be located at the port of Nacala in the northern province of Nampula. Electricity is supposed to be supplied by the Moatize coal-fired plant that presumably becomes operational as of 2012. The plan is, however, too premature to be included in our analysis.

[9] It is to be noted that this argument does not hold for peak-load electricity consumption, which is much more sensitive to marginal price increases. Recall that for this very reason we do not take the HCB north hydro dam into consideration (see section 2).

due to the large number of entities involved against a small number of mega projects. Moreover, an electricity tax on mega projects neither suffers from the problems raised by the large scale of informal economic activities nor from evasion problems (see for example Van Dunen 2007).

While there are thus good reasons to tax mega projects, so far these projects have been enjoying a highly preferential tax treatment. For example, Mozal is entitled to pay a 1% revenue tax only (against a standard tariff of 32%) while enjoying a range of specific tax exemptions, resulting in annual estimated tax benefit of about US$ 100 million. For more details we refer to the paper by Alice Krueger in this volume. The issue here is that these large tax incentives are not necessary, because it is highly likely that mega projects such as Mozal, Sasol and the Moma and Chibuto Heavy Sand projects would also have gone forward under a less favourable tax regime, given their dependence on the availability of cheap natural resources in Mozambique in combination with (port) infrastructure to facilitate exports. In this respect, Mozambique exhibits a large competitive advantage (also in comparison to most of its neighbouring landlocked countries) and will therefore remain to be an attractive location for mega projects. Of course, economic feasibility requirements set a limit to electricity price increases, but current low electricity prices in Mozambique suggest that by far we have not yet reached this limit. In section 4.1 (Figure 4) it is detailed that Mozambican industrial electricity prices belong to the lowest in the world, and this is particularly true for mega projects.

At the same time, the structural positive impact of the capital intensive mega projects on the Mozambican economy is very limited: amongst others, they provide only limited employment opportunities and do not create many links with other sectors (see, for example, Anderson 2001, Carlos-Branco and Goldin 2003). Since all these projects enjoy substantial benefits from consuming or generating cheap electricity, an electricity tax provides a good opportunity to increase the social benefits of these mega projects through their contribution to government funds.

### 3.2 Internalizing negative externalities

Electricity production, energy-intensive production processes and mining are known for their substantial negative impact on the environment. As described in section 2.1, hydropower is and will be the most important source of electricity production in Mozambique. Contrary to electricity generation based on fossil fuel, hydroelectricity does not lead to air pollution, and is thus a clean technology from an air quality and climate change point of view. However, the construction of large dams does have substantial social and environmental impacts. Social impacts include the replacement and resettlement of inhabitants of the flooded area, while environmental impacts include reduction in wetland habitat, restricted fish migration and reduced biodiversity downstream of the dam, because of lower levels and changed patterns of water flow. For example, environmental impact studies have found that the Cahora Bassa dam has caused, amongst others, a 40% loss of mangrove, coastal erosion, a 60% decline in prawn catch rates between 1978 and 1995, and a virtually non-existent bird and mammal life as compared to the 1970s (Davies et al. 2000).

As mentioned before, in addition to foreseen extension of hydro power capacity, concrete plans exist to build two thermal plants for electricity generation in Mozambique: one on the basis of natural gas (2010) and one on the basis of coal (2012-15). This will lead to local effects such as air pollution (nitrogen oxides, sulfur oxides, particulates), medium-distance effects such as acid rain and long-range, long-term phenomena such as global warming from the emission of carbon dioxide and other greenhouse gases. Our scenario analyses indicate that the new coal-fired electricity plant by far will become the largest air polluter in the country, followed by air pollution from natural gas-fired electricity generation.

An energy tax has proven to be an effective instrument to attempt internalizing these negative externalities from energy production and consumption. Externalities or external effects refer to effects that are not accounted for in the transactions between buyer and seller, and hence are not reflected in the price of the good or service. The aforementioned environmental effects are thus typical examples of negative externalities. According to economic theory, a socially optimal level of energy consumption, as well as an optimal distribution among different producers of energy, can be obtained if the full marginal costs of energy production and consumption (thus including externalities) are reflected in the price. If the energy prices are to reflect the total costs of energy production, all (social and environmental) externalities from production must be identified, valued and internalised into the price. As said before, this internalization can be made with taxes.

The classic Pigovian view on efficient environmental taxes is that they should be direct and uniform, i.e. a uniform rate on emissions itself (Baumol and Oates 1988). In the end, it is pollution and not energy production or consumption per se that is the problem. An electricity tax on mega projects violates this principle in two respects: it is an indirect environmental tax (one taxes electricity instead of emissions), and it is not uniform since it discriminates among various types of consumers (mega projects only). However, recent theoretical developments in the literature indicate that indirect and non-uniform taxes can very well be efficient instruments in a second-best world (Bovenberg and Goulder 2001, Cremer et al. 1998, Cremer and Gahvari 2001). Without going into detail, the main reasons for this result are the existence of a revenue-raising government, heterogeneous administrative costs across different type of consumers, and the fact that it is difficult to adequately observe emissions and their marginal social damage (i.e. there is a constraint on policy instruments). As has been noted in the previous section, administrative costs of various taxes differ with an electricity tax on mega projects being a relatively cheap policy instrument. In addition, if there is a close link between energy and emissions and if pollution abatement costs are high, taxing energy instead of emissions might be the preferable option, particularly if administrative costs are low for taxing energy and high for taxing emissions (Smulders and Vollebergh 2001). It is clear that these conditions are met in the case of electricity generation on the basis of fossil fuels.[10]

## 4. Tax level

In this section we provide some building blocks for determining the appropriate level and tax base of an electricity tax. We follow the structure of the previous section by first discussing the electricity tax from a revenue-raising point of view, and then from the point of view of internalizing negative (environmental) externalities.

[10] Instead of taxing fossil fuel-based electricity one could also opt for directly taxing fossil fuels. On the one hand, taxing fuels provides an incentive to improve the efficiency of the electricity generation production process. On the other hand, taxing electricity has the advantage to discourage electricity consumption as a relatively inefficient use of fossil-fuel energy (conversion losses in the electricity sector are, on average, much higher than in the direct use of these fuels).

### 4.1 Revenue-raising motive

Setting a tax levy for mega projects in order to raise government revenues inevitably includes some arbitrariness, given the absence in real life of theoretical constructs such as a well-defined objective function of a social planner (government), agents (firms and consumers) in a competitive equilibrium, an exogenously given level of expenditures, etc.. It is, however, beyond doubt that using electricity tax as an instrument to compensate foregone revenues resulting from tax exemptions allowed to mega projects, would imply an excessively high electricity tax. For example, to compensate for the circa US$ 100 million annual tax benefit awarded to Mozal would require a tax levy of about 1.3 US$c/kWh over its electricity consumption which is equivalent to a tax rate of about 125%. While this of course is far from realistic (if desirable at all), it does indicate that any reasonably moderate electricity tax levy will by no means jeopardize the highly preferential tax treatment to existing mega projects.

If we take a look at the international perspective, the average electricity tax on industries is in the range of 6-10%, with some countries such as France (11.4%) and Norway (18.8%) imposing even higher electricity tax rates (IEA, 2006). It is to be noted that those countries with relatively high electricity tax rates also exhibit relatively low electricity price levels, implying that their overall electricity prices remain moderate so as to preserve the competitive position of their industries. This is also true for Mozambique, and even stronger: the electricity prices that the mega projects currently pay are among the lowest in the world (See Figure 4).

Figure 4 shows that whereas the average EdM tariff of 5.12 US$c/kWh to small and medium sized enterprises in Mozambique is already low in international perspective, Mozal pays only 1.03 US$c/kWh and the Chibuto and Moma heavy sands project are paying 2.3 and 2.05 US$c/kWh, respectively.[11] A moderate electricity tax of up to 10% will not change this picture. When we look at energy taxes in domestic perspective it is to

[11] Source: EdM 2006, personal communication. It is to be noted that the Moma Heavy Sands project pays a nominal electricity tariff of 0.9 US$c/kWh to EdM. However, Moma constructed the required 200km transmission line originating from Nampula itself at a cost of about US$ 13 milion. Given a 30-year economic lifetime of the line, a discount rate of 10% and 193 GWh annual electricity consumption this yields 1.15 US$c/kWh. Hence, the effective electricity tariff to Moma is about 2.05 US$c/kWh (0.90 + 1.15 US$c/kWh).

be noted that EdM's industrial and commercial customers pay a monthly fixed tax, which translates into an average tax rate of about 3%.[12] For residential EdM customers the monthly fixed tax implies an effective tax rate of 5-10%, depending on the level of electricity consumption.[13] Moreover, all EdM customers are due to pay an additional 17% VAT. In contrast, the mega projects currently pay no electricity tax while also enjoying (general or specific) VAT exemptions.

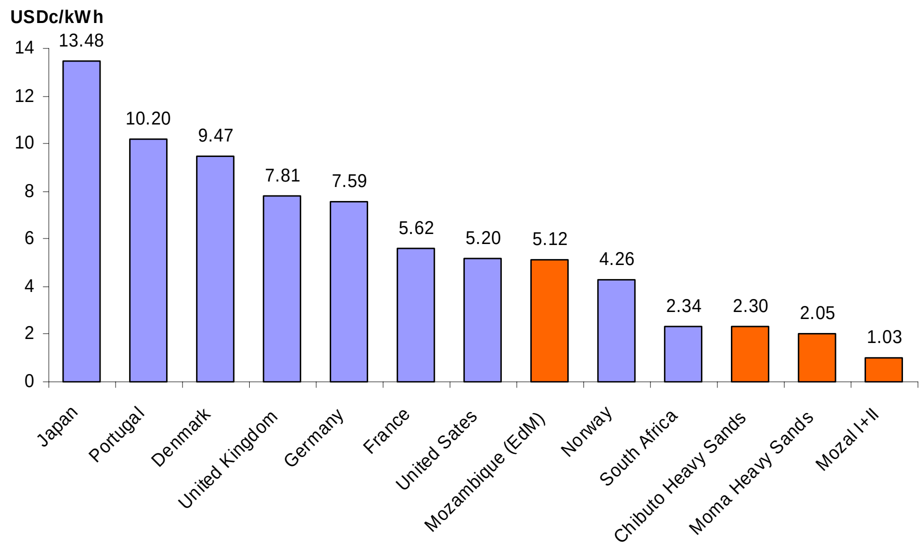


*Figure 4 Industrial electricity prices of Mozambique in international perspective (2005 prices; Source: IEA, EDM, ESKOM)*

Finally, implementing an electricity tax requires a definition of the tax base. The tax can be defined either as a percentage of the current electricity price, or as an amount per unit of electricity consumption/production (kWh). The main advantage of a (uniform) percentage price tax is to avoid disturbance of the current relative electricity prices across the various mega projects. This is for example relevant with respect to appreciating the relatively low costs of hydropower as compared to coal-based electricity from an environmental point of view. Unlike a percentage tax, a fixed tax per kWh would distort this price difference by making clean hydroelectricity relatively more expensive, and thus effectively rewarding dirty coal-based electricity generation. However, a percentage price

[12] Source: own calculations, based on Ministério da Energia (2007a,b).

[13] Source: own calculations, based on Ministério da Energia (2007a,b). Note that residential customers eligible to the social tariff are exempted from the monthly tax.

tax does have a couple of practical disadvantages, mainly resulting from difficulties in defining the current electricity price that should serve as the basis for taxation. One source of indeterminacy is that power generation plants commonly apply price discrimination among their clients, often in the form of (long lasting and frequently sub-optimal) specific power purchase agreements. For example, South Africa (ESKOM), Zimbabwe (ZESA) and EdM all pay different tariffs for electricity acquired from the same HCB. What then should be taken as the price of electricity generation?

Another important source of difficulty in defining the electricity price is the fact that some mega projects invest in transmission lines themselves (like, for example, Moma Heavy Sands project), while others don't (like, for example, Chibuto Heavy Sands project). Although this in principle should not have any (significant) impact on the effective price per kWh, it does of course make a difference in the nominal tariff the mega projects pay (in case of electricity consumption) or ask (in case of electricity generation). Should the basis for a percentage electricity tax then be the nominal tariff or the effective price per kWh? Taking the effective electricity price including transmission infrastructure costs requires information and consensus about the investment costs calculations, which might prove to be difficult in practice.[14] Applying a percentage tax to the nominal tariff, on the other hand, will imply an incentive for mega projects to construct the transmission lines themselves since this lowers their tax base. That might actually be a good idea, since these (long distance) transmission lines might well serve as important backbones for extending and strengthening the national grid, thereby facilitating rural electrification programs. However, discrepancy between private and social benefits might give rise to disputes about the optimal route of transmission lines. Moreover, mega projects differ in terms of new transmission line requirements and thus a nominal tariff-based tax might promote considerable discrimination across the various mega projects. In any case, defining the current electricity tariff of mega projects that will serve as a base for the percentage tax is likely to be less simple than it might look at first sight.

[14] For example, which discount rate is appropriate for an investment done in a developing country with high interest rates by a multinational with easy access to cheap foreign capital?

A fixed electricity tax per kWh produced or consumed will solve for the aforementioned complications. However, as mentioned before, from an environmental point of view it does create some sort of a perverse incentive against relatively cheap hydroelectricity. On the other hand, the relatively low production cost of hydroelectricity in comparison with fossil-fuel bases electricity constitutes a free good, since the end product (electricity) is the same. A relatively high increase of hydroelectricity prices as a result of taxation per kWh will then partly absorb the producer surplus that arises from this free good characteristic, which in principal is a good idea from a welfare point of view. In sum, we tend to argue in favour of an electricity tax per kWh consumed or produced. In the section 5 we will, however, explore both a percentage and fixed tax levy.

### 4.2 Environmental externalities motive

Quantifying negative externalities is far from easy, because often it is difficult to define and observe all effects and also because the effects are typically characterized by a lack of markets and thus prices. For example, to determine the value of loss of biodiversity or negative health impacts one needs to place a price on species lost and on human life, respectively. Nevertheless, a range of methodologies exists to establish such prices, using all kind of indirect approaches such as shadow prices, willingness to pay and estimates of statistical life.

As noted before, the negative social and environmental impacts of electricity generation are diverse: amongst others it includes resettlement of people and biodiversity loss as a result of hydro dams, and different kinds of air pollution (mainly $NO_x$, $SO_2$, $CO_2$) from fossil fuel-based electricity generation. It is beyond the scope of this paper to quantify all these effects for the different electricity generation sites in Mozambique. Instead, we make use of a methodology developed in the European Union (EU) to quantify the externalities of different power generation technologies applied in various EU countries (Bickel and Friedrich, 2005). The methodology consists of an integrated assessment of the chain of processes linked to the generation of electricity from a given fuel. The impact assessment and valuation of this ‘fuel cycle’ include the effects of electricity generation on human health, crops, forests, freshwater fisheries and biodiversity. Methods range from the use of simple statistical relationships, as in the case of occupational health effects, to the use of series of complex models and databases, as in the cases of acid rain and global warming effects. The underlying principle for economic valuation is the willingness to pay to avoid a negative impact, or the willingness to accept with respect to the opposite. Table 1 summarizes some key results.

*Table 1. Environmental Damage Costs*

| *USDc/kWh* | Environmental Damage Costs *EU* | Environmental Damage Costs *Best Average* | Price electricity generation Mozambique | Environmental Damage Costs (Best Average) as % of price electricity generation |
|---|---|---|---|---|
| Coal | 2.0 - 26.3 | 4.93 | 3.5 | 140.8% |
| Gas | 0.6 - 9.7 | 2.13 | 3.2 | 66.7% |
| Hydro | 0.04-0.64 | 0.45 | 2.7 | 16.7% |

The Table shows that the estimated environmental damage costs of coal based electricity generation range from 2-26.3 US$c/kWh, depending on the technology used and other site specific characteristics. Environmental damage costs from electricity generation based on natural gas are substantially lower, varying from 0.6-9.7 US$c/kWh. On average, human health damages due to aerosols account for 5-25% of total environmental damage from these fossil fuel cycles, while global warming impacts account for 40-80% and ozone damage due to $NO_x$ emissions are roughly 5-20% of total damage. It is to be noted that global warming damage from natural gas cycle is substantially lower than for the coal cycle. As compared to fossil fuel cycles, environmental damage costs of the hydro cycle are small: they are estimated at 0.04-0.64 US$c/kWh. The most important components of the quantified externalities from hydroelectricity generation concern the impacts on natural ecosystems and especially on the different fauna species which live in the vicinity of the project.

Combining this information and the underlying characteristics of the plants in the EU with the characteristics of the Mozambican electricity generation sites allows us to come up with a rough best average estimate of environmental damage costs for the Moatize coal fired electricity plant, the Pande/Temane gas fired electricity plant and the Cahora Bassa and Mphanda Nkuwa hydro dams. As shown in the table, we estimate these costs at about 4.9 US$c/kWh for the coal plant, 2.1 US$c/kWh for the gas plant and 0.45 US$c/kWh for the hydro dams. In Table 1 we compare these rough estimates with the costs of electricity generation in Mozambique. This leads to the conclusion that internalizing all negative externalities would imply an electricity tax of 141% for coal based electricity, 67% for gas based electricity and 17% for hydroelectricity. In sum, although the presented estimates of environmental damage costs are far from perfect, we can draw the conclusion that the negative externalities caused by electricity generation are considerable and that any reasonable electricity tax will only account for a small part of this, particularly in the case of coal-based electricity generation.

## 5. Tax Revenues

In this section we present the estimated potential revenues from implementing an electricity tax on mega projects. We distinguish between a tax on electricity consumption by mega projects, and a tax on electricity generation. Obviously, in order to avoid double taxation the government has to choose between implementing a tax on electricity production *or* electricity consumption. Both tax systems are to be motivated by revenue-raising and internalizing environmental externalities, as discussed in the previous sections. Based on our calculations in section 4, we evaluate a fixed electricity tax in the order of 0.1 – 0.2 US$c/kWh as well as 5-10% percentage tax of 5-10%.

### 5.1 Taxing electricity consumption by Mega projects

To calculate the potential revenues from a tax on electricity consumption we consider the following mega projects: the existing aluminum smelter Mozal (Mozal I+II) (2000-2002), the Moma Heavy Sands mine (2007), the Chibuto Heavy Sands mine (2009, 2017), the Moatize coal mine (2009) and the extension of the Mozal aluminum smelter (Mozal III) (2009), with a total electricity consumption equivalent to 1882 MW (circa 17,500 GWh). We refer to section 2.3 for more details on these projects. The value of electricity consumption by these mega projects is calculated using constant electricity prices. More specific, we use the actual price paid by Mozal I+II in 2005 (1.03 US$c/kWh) and the foreseen prices for the new mega projects in their initial year, based on the respective feasibility studies and internal communication with EdM (i.e Moma: 0.90 US$c/kWh; Chibuto: 2.30 US$c/kWh; Moatize: 2.50 US$c/kWh). Furthermore, recall that we use the nominal electricity tariffs, and thus excluding eventual own investments costs in transmission infrastructure (see section 4.1). Finally, in line with the most likely reference scenario as discussed in section 2 we assume that Mozal III will pay 1.5 US$c/kWh for imported electricity until 2014, and 2.7 US$c/kWh for electricity from Mpanda Nkuwa from 2014 onwards.

The resulting value of electricity demand by mega projects ranges from about 80 million US$ in 2007 to 328 million US$ in 2020. In Figure 5 we present the annual potential revenues from a tax on electricity consumption by Mega projects over the period 2007-2020 under different tax rates. The Figure shows that a 5% tax on electricity consumption will generate annual revenues between US$ 4-16 million during the period 2007-2010. A 10% tax doubles these revenues to about US$ 8-32 million annually. A tax of 0.1 US$c/kWh yields annual revenues between US$ 8-17 million, while a 0.2 US$c/kWh tax rates doubles these figures to US$ 16-35 million. In terms of total projected tax revenues in Mozambique, a 0.1–0.2 US$c/kWh tax on electricity consumption accounts for 1–3.5% of this over the period 2007-2020.[15]

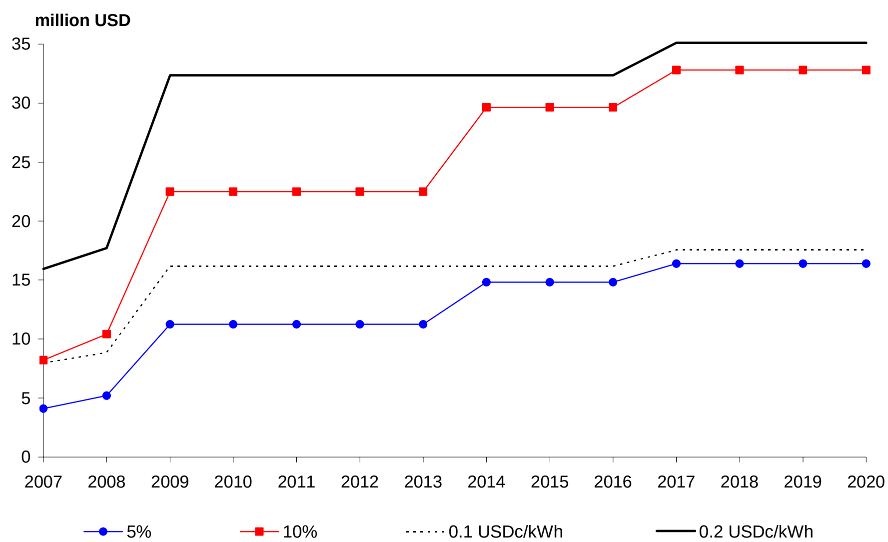


*Figure 5. Potential revenues from a tax on electricity consumption by mega projects*

In Table 2 we present a breakdown of these revenues for each mega project for a tax regime of 10% and 0.2 US$c/kWh. The Table shows that at constant 2005 electricity

[15] Total tax revenue projections up to 2010 come from the QuadroMacro model of DNEAP, while we assume a nominal annual growth of 10% from 2010-2020.

prices the total accumulated revenues over the period 2007-2020 will be about US$ 351 million at a 10% tax rate, and US$ 433 million US$ at a tax rate of 0.2 US$c/kWh. In the case of a percentage tax, 32% of these revenues originate from Mozal I+II while Mozal III will contribute another 45%. The other Mega projects together roughly account for the remaining 24%. A fixed tax rate per kWh, however, places the main burden on Mozal, in total 83%, with the other Mega projects being responsible for the remaining 17%.

*Table 2. Breakdown of Electricity Consumption Tax Revenues*

| MegaProject | Mozal I+II | Mozal III | Moma | Chibuto I | Chibuto II | Moatize | TOTAL |
|---|---|---|---|---|---|---|---|
| Price (USDc/kWh) | 1.03 | 1.50 / 2.70 | 0.90 | 2.30 | 2.30 | 2.50 | |
| **10% Tax** | | | | | | | |
| After Tax Price (USDc/kWh) | 1.08 | 1.58 / 2.84 | 0.95 | 2.42 | 2.42 | 2.63 | |
| Average Annual Tax (million USD) | 8.0 | 11.2 | 0.2 | 2.9 | 3.2 | 2.2 | 25.1 |
| Cummulative Tax 2007-2020 (million USD) | 112.5 | 157.1 | 2.4 | 37.8 | 12.6 | 28.7 | 351.2 |
| % contribution | 32.0% | 44.7% | 0.7% | 10.8% | 3.6% | 8.2% | |
| **0.2 USDc/kWh Tax** | | | | | | | |
| After Tax Price (USDc/kWh) | 1.13 | 1.60 / 2.80 | 1.00 | 2.40 | 2.40 | 2.60 | |
| Average Annual Tax (million USD) | 15.6 | 10.2 | 0.4 | 2.5 | 2.7 | 1.8 | 30.9 |
| Cummulative Tax 2007-2020 (million USD) | 217.8 | 142.8 | 5.4 | 32.9 | 11.0 | 23.0 | 432.9 |
| % contribution | 50.3% | 33.0% | 1.2% | 7.6% | 2.5% | 5.3% | |

This considerable difference in tax burden between the two tax regimes is of course due to the combination of Mozal's high electricity consumption and a relatively low price, which is particularly true of Mozal I+II. To a lesser extent this is also true for the Moma Heavy Sands projects, due to its low nominal electricity tariff.[16] On the contrary, thanks to the relatively low electricity consumption and high price of the other mega projects (as compared to Mozal), their tax burden will be somewhat smaller under a fixed tax per kWh then under a percentage tax.

## 5.2 Taxing electricity production by mega projects

To calculate the potential revenues from a tax on electricity production we take into account the following mega projects: the Cahora Bassa hydro dam (HCB) (1974), the natural gas-fired electricity plant (2010), the Moatize coal-fired electricity plant (2012, 2015), and the Mphanda Nkuwa hydro dam (2014) with a total electricity production equivalent to 5575 MW (circa 42,000 GWh). We refer to section 2.1 for more details on these projects. The value of electricity consumption by these mega projects is again calculated using constant electricity prices. More specific, we use the weighted average

[16] Recall that this low nominal tariff is due to the fact that Moma invested itself in transmission infrastructure. See also section 4.1.

of the actual selling price of HCB to its various clients (1.43 US$c/kWh)[17], while for the other projects we take the base-load price that covers the cost price of generation as indicated in the most recent feasibility studies of these projects (gas plant: 3.2 US$c/kWh; coal plant: 3.5 US$c/kWh; Mpanda Nkuwa: 2.7 US$c/kWh). In doing so we again exclude eventual own investments costs in transmission infrastructure by the new projects (see section 4.1).

The resulting value of electricity production by mega projects ranges from about US$ 247 million in 2005 to circa US$ 1,032 million in 2020. In Figure 6 we present the annual potential revenues from a tax on electricity consumption by mega projects over the period 2007-2020 under different tax rates. The Figure shows that a 5% tax on electricity production will generate annual revenues between US$ 12-52 million during the period 2007-2010. A 10% tax doubles these revenues to about US$ 25-103 million annually. A tax of 0.1 US$c/kWh yields annual revenues between US$ 16-42 million, while a 0.2 US$c/kWh tax rates doubles these figures to US$ 33-84 million. In terms of total projected tax revenues in Mozambique, a 0.1–0.2 US$c/kWh tax on electricity production accounts for 1.6–5.1% of this over the period 2007-2020.

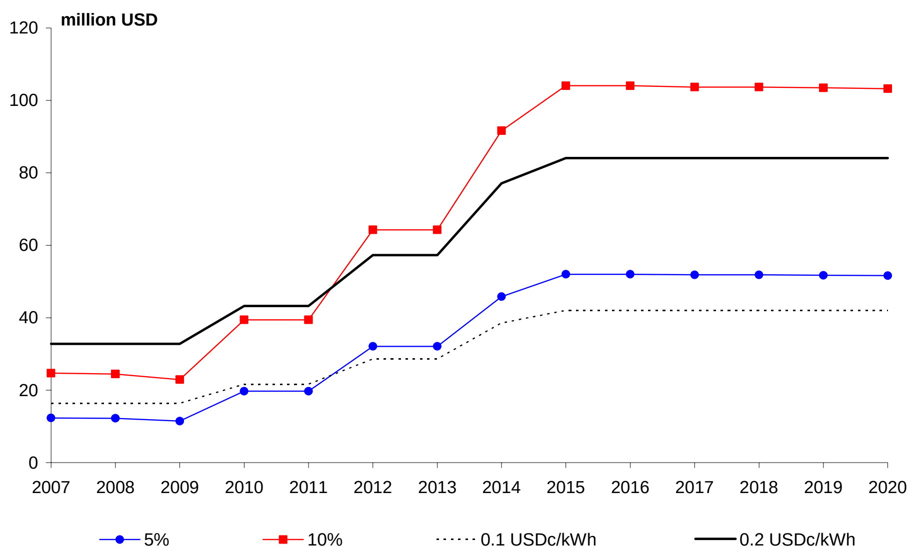


*Figure 6. Potential revenues from a tax on electricity production*

[17] We assume the following tariffs per client: ESKOM: 1.6 US$c/kWh as of 2007 (70% of production), EdM: 0.8 US$c/kWh, Moma: 0.9 US$c/kWh.

In Table 3 we present a breakdown of these revenues for each mega project. The Table shows that at constant 2005 electricity prices the total accumulated revenues over the period 2007-2020 will be roughly US$ 993 million at a 10% tax rate, and US$ 881 million US$ at a tax rate of 0.2 US$c/kWh.[18] In the case of a percentage tax, 33% of these revenues originate from HCB, 29.6% from the Moatize coal-fired plant, while the natural gas fired electricity plant and the Mphanda Nkuwa hydro dam each account for about 18% of total revenues. A fixed tax rate per kWh, however, places the main burden on HCB, in total 52%, with the other projects almost equally each share the remaining 48%.

*Table 3. Breakdown of Electricity Production Tax Revenues*

| MegaProject | **Natural Gas** *Inhambane* | **Coal** *Moatize* | **Hydro** *HCB* | **Hydro** *Mphanda Nkuwa* | **TOTAL** |
|---|---|---|---|---|---|
| Price (USDc/kWh) | 3.20 | 3.50 | 1.43 | 2.70 | |
| **10% Tax** | | | | | |
| After Tax Price (USDc/kWh) | 3.52 | 3.85 | 1.57 | 2.97 | |
| Average Annual Tax (million USD) | 16.7 | 29.4 | 23.4 | 26.8 | 70.9 |
| Cummulative Tax 2007-2020 (million USD) | 183.5 | 294.3 | 328.2 | 187.3 | 993.2 |
| % contribution | 18.5% | 29.6% | 33.0% | 18.9% | |
| **0.2 USDc/kWh Tax** | | | | | |
| After Tax Price (USDc/kWh) | 3.40 | 3.70 | 1.63 | 2.90 | |
| Average Annual Tax (million USD) | 10.4 | 16.8 | 32.8 | 19.8 | 62.9 |
| Cummulative Tax 2007-2020 (million USD) | 114.7 | 168.2 | 459.5 | 138.7 | 881.1 |
| % contribution | 13.0% | 19.1% | 52.2% | 15.7% | |

This considerable difference in tax burden between the two tax regimes is due to HCB's combination of high electricity production and a relatively low selling price. On the contrary, the Moatize coal-fired plant will face a considerable lower tax burden under a fixed tax per kWh then in case of a percentage tax (US$ 16.8 million instead of US$ 29.4 million, annually) due to the relatively high (cost) price of coal-fired electricity.

## 6. Taxing electricity consumption or production?

So far we have explored a tax on both electricity consumption and production by mega projects. Obviously, to avoid double taxation the Government of Mozambique (GoM) has

[18] By way of illustration one may also want to compare the total accumulated tax revenues of US$ 881 million over the period 2007-2020 with the total investment of about US$ 850 million required to increase access to electricity to about 20% by 2020 (EdM, 2004) or the required payment of US$ 750 million to Portugal in order to secure transfer of HCB's ownership from Portugal to Mozambique.

to opt for either a tax on consumption or a tax on production. What is the best option? Standard tax theory argues that distortions should be confined to final consumption, leaving production undistorted (Diamond and Mirrlees 1971). However, this conclusion assumes the absence of any market failures. From the point of view of internalizing negative externalities, however, it makes more sense to tax electricity generation than consumption. As we have argued in section 3, it is the production rather than the consumption of electricity that causes negative environmental (and social) impacts. Moreover, in the context of international agreements (such as the Kyoto protocol) the global pollution caused by electricity generation is assigned to the country where the electricity plant is located. In the case of Mozambique this implies for example that the pollution from the electricity consumed by Mozal is assigned to South Africa, from where Mozal imports its electricity. Implementing a tax on electricity consumption by Mozal on environmental grounds is therefore difficult, and might require coordination with South Africa.

In addition, a tax on electricity consumption might prove to be difficult, if not impossible, given the contracts between the GoM and the existing mega projects. For example, Mozal's 50(!) year contract with the GoM includes a clause that guarantees indemnification if changes in the law were to impact its profitability (see also Kuegler 2007). As shown in Table 4, a large part of the projected revenues from a tax on electricity consumption were to come from Mozal. Excluding Mozal from a tax on electricity consumption will not only considerably reduce the projected revenues but will also further discriminate fiscal treatment across the various mega projects (with Mozal already enjoying the largest benefits).

A tax on electricity production, might then be a way to circumvent the (too) generous tax regime for existing mega projects since it is likely to serve as an indirect tax on electricity consumption by mega projects, presuming that electricity producers will pass the tax burden on to their clients, as much as possible. This raises the question as to who then will effectively pay the tax bill. In Table 4 we provide a breakdown of annual tax payment according to the (most likely) destinations of the produced electricity. From the Table it can be seen that while all new mega projects that consume domestic electricity will probably face increasing electricity prices, by far the largest burden will fall on neighboring countries through higher export prices.

*Table 4. Transfer of Electricity Production Tax*

| MegaProject | **Natural Gas** *Inhambane* | | **Coal** *Moatize* | | **Hydro** *HCB* | | **Hydro** *Mphanda Nkuwa* | |
|---|---|---|---|---|---|---|---|---|
| **10% Tax** | | | | | | | | |
| Average Annual Tax (million USD) | 16.7 | | 29.4 | | 23.4 | | 26.8 | |
| *Of which:* | | | | | | | | |
| Export | 13.4 | 81% | 26.5 | 90% | 20.6 | 88% | 13.4 | 50% |
| EdM | 1.5 | 9% | 1.0 | 3% | 2.7 | 11% | | |
| Chibuto Heavy Sands | 1.7 | 10% | | | | | | |
| Moatize Coal mine | | | 2.0 | 7% | | | | |
| Moma Heavy Sands | | | | | 0.2 | 1% | | |
| Mozal III | | | | | | | 13.4 | 50% |
| **0.2 USDc/kWh Tax** | | | | | | | | |
| Average Annual Tax (million USD) | 10.4 | | 16.8 | | 32.8 | | 19.8 | |
| *Of which:* | | | | | | | | |
| Export | 8.4 | 81% | 15.1 | 90% | 25.7 | 78% | 9.9 | 50% |
| EdM | 0.9 | 9% | 0.6 | 3% | 6.7 | 20% | | |
| Chibuto Heavy Sands | 1.1 | 10% | | | | | | |
| Moatize Coal mine | | | 1.1 | 7% | | | | |
| Moma Heavy Sands | | | | | 0.4 | 1% | | |
| Mozal III | | | | | | | 9.9 | 50% |

In principle there is no need to tax exports of electricity. After all, Mozambique has a typical comparative advantage in producing cheap electricity, and classical trade theory suggests that increasing trade in this good will then enhance welfare. More specifically, increasing exports help to improve the balance of payment, which currently shows a considerable deficit. However, there will be no complete trade-off between export benefits and tax benefits because of the low electricity prices in Mozambique (see Figure 4). To illustrate this point, Figure 8 compares the electricity generation costs in Mozambique, including a tax of 0.2 US$c/kWh, with those in South Africa, by far the most important buyer of Mozambican electricity.[19] The Figure shows that the relatively low costs of electricity generation in Mozambique, thanks to abundant natural resources, provide ample space to sustain its comparative advantage in electricity production, even after including a tax levy of 0.2 US$c/kWh. This is particular true for hydro electricity while room for price increases is smallest for coal based-electricity.

[19] Source: NER 2004.

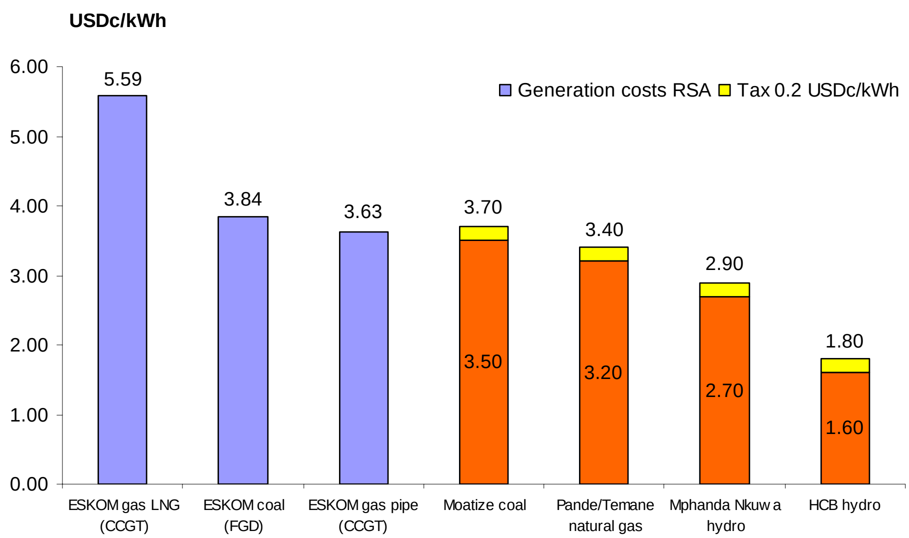


*Figure 8. Electricity generation prices Mozambique – South Africa*

Of course, Mozambique has to be careful with increasing its prices of electricity exports to South Africa, for the very reason that Mozambique depends on South Africa to sell its electricity, due to the combination of excess production capacity in Mozambique and the dominance of South Africa on the regional electricity market. This evidently places South Africa in a comfortable position to negotiate low prices for its electricity imports, a situation that has characterised the past and in particular the last decade during which South Africa had considerable excess capacity of its own. This situation, however, is rapidly changing with South Africa entering a situation of excess demand (NER 2004, SAPP 2005). In spite of (a relatively cheap) increase of production capacity in South Africa until 2010 in the form of returning several mothballed units to service, South Africa continues to face excess demand that can only be satisfied by a further increase in generation capacity. As shown in Figure 8, electricity generation costs in Mozambique are (highly) competitive even after taxation, implying that Mozambique is rapidly gaining market power in the regional electricity market, also after 2010.[20]

[20] The latter conclusion also holds after taking into account potential new capacity in other SADC countries, which mainly consists of relatively expensive thermal capacity, except for the giant potential of the Inga hydro dam (10.000 MW) in the Democratic Republic of Congo and the sum of 4 medium sized hydro dams in Zambia (1290 MW). The Inga dam is, however, not likely to jeopardize Mozambique's competitive advantage in electricity generation because the unstable political situation in Congo prevents realization of the dam in the short and medium rum while its long distance from South Africa implies relatively high transmission costs.

So far we have assumed private ownership of the electricity generation capacity. However, in November 2006 an agreement has been signed to transfer the majority ownership of HCB from Portugal to the GoM. In addition, it is not an unlikely scenario that the GoM will also become the major shareholder in the Mpanda Nkuwa hydro dam to be constructed. The latest developments concerning this project indicate that the Chinese Exim bank is willing to finance the project in return for collateral in the form of natural resources like minerals. Since minerals are state property this in effect means that the GoM will become the owner of the dam (over time). The fossil-fuel based electricity plants will most likely develop as private enterprises. Imposing a tax on (hydro) electricity produced by state owned enterprises of course is a form of circulating money. In this case, our plea for imposing a tax on electricity production changes into a plea for setting appropriate market-conform electricity prices with the 'tax revenues' to be interpreted as additional profit.

Finally, if it turns out to be practically or politically impossible to implement a tax on electricity consumption, one might consider the option of extending the existing EdM cross-subsidy scheme to include mega projects. To facilitate the availability and affordability of electricity in rural areas, EdM currently applies a cross-subsidy scheme consisting of two components. First, the electricity tariff applied to domestic consumers is progressive, meaning that large consumers pay a higher price per unit than small consumers. Second, there is a uniform tariff structure across the country, while costs of supplying electricity vary considerably – costs per unit are much higher in remote rural areas than in densely populated urban centers. This in effect implies a cross-subsidy from the southern and also the central region to the northern region of Mozambique. The current rural electrification program will imply that the current cross-subsidy scheme will come under great pressure over the next years because of the relatively sharp increasing number of small (poor) customers in remote areas. One way to solve this problem is to extend the cross-subsidy scheme such that it also includes mega projects. There are good reasons to do so. First of all, rural electrification generates substantial positive externalities, originating from increased productivity in the private sector, freeing up time and labour for education and/or income generating activities, and improved health and environmental conditions. Furthermore, due to the high costs of rural electrification, without subsidies there will be underinvestment in expanding the national grid from a social point of view, given the aforementioned positive externalities. Finally, mega projects enjoy substantial private benefits from consuming large quantities of cheap electricity while their positive impact on the Mozambican is currently very limited, as argued before. The calculations in the previous section have shown that a minor price increase of electricity consumption by mega projects may generate considerable funds that could be used to subsidy the costs of electricity supply to small consumers (in rural areas), thereby contributing to economic growth and increased welfare while largely preserving the private benefits of mega projects.[21]

## 7. Conclusions

Mega projects offer a good opportunity to extend the tax base in Mozambique for two reasons. First, with a typically small tax base due to, amongst others, the relatively large scale of the informal economy and a traditionally weak fiscal institutional infrastructure, they offer a unique source to increase government revenue, thereby lowering the dependence on foreign aid. Second, electricity production, energy-intensive production processes and mining are known for their substantial negative impact on the environment. An energy tax is an important instrument to internalize these negative externalities. In this paper we have detailed these arguments, the appropriate level and tax base as well as potential revenues from a tax on electricity *consumption* by mega projects and a tax on electricity *production*, respectively. We conclude that in particular a tax on electricity production seems to be a promising instrument. Existing contracts between mega projects and the GoM are likely to prohibit the implementation of a new tax regime at the consumption side. Furthermore, compensating for negative environmental externalities argues for taxing electricity production rather than consumption. We estimate annual tax revenues of a 0.1-0.2 US$c/kWh on electricity production in the order of US$ 16-84 million during the period 2007-2020. By and large the burden of a tax on electricity production in Mozambique will fall on neighbouring countries due to the large share of electricity generation earmarked for export. We have shown that the regional electricity

[21] One may want to consider the option that if mega projects invest in transmission lines they are allowed to subtract these costs from the amount of supposed cross-subsidy payment, since transmission lines also constitute a valuable contribution to rural electrification programs, as argued before.

market provides ample space to increase electricity prices without compromising Mozambique's comparative advantage in electricity production. Finally, we have argued that any reasonably moderate electricity tax levy will by no means jeopardize the highly preferential tax treatment to existing mega projects, while such a tax may contribute to realizing the social benefits of the presence of mega projects. As such, an electricity tax on mega projects is a valuable instrument to help transforming Mozambique's natural resource abundance into increased welfare for the society as a whole.

***Acknowledgements***

We would like to thank Alice Kuegler and Anders Petersen for their comments on an earlier version of this paper. Peter Mulder would like to thank Danida for financial support.

# Annex

*Table A.1 Electricity consumption by mega projects*

| | Project | Year | MW | Location | Activity | Investor | Investment (million USD) |
|---|---|---|---|---|---|---|---|
| 1 | Mozal I + II | 2000/2 | 850 | Maputo | Production and Export of Aluminium | Biliton(UK),IDC(RSA), Mitsubishi (JP) | 2250 |
| 2 | Heavy Sands Moma | 2007 | 22 | Nampula | Exploration and Export of Minerals | Kenmare Resources PLC (Ireland) | 200 |
| 3 | Heavy Sands Chibuto I | 2008 | 155 | Gaza | Exploration and Export of Minerals | SMC(RSA),IDC(RSA),WMC(Australie) | 500 |
| 4 | Moatize Coal Mine | 2009 | 100 | Tete | Exploration and Export of Coal | Companhia Vale do Rio Doce (Brazil) | 1000 |
| 5 | Mozal III | 2009 | 650 | Maputo | Production and Export of Aluminium | Biliton(UK),IDC(RSA), Mitsubishi (JP) | 860 |
| 6 | Heavy Sands Chibuto II | 2017 | 105 | Gaza | Exploration and Export of Minerals | SMC(RSA),IDC(RSA),WMC(Australie) | 700 |
| | **Total** | | **1882** | | | | **5510** |

*Table A.2 Electricity production by mega projects*

| | Project | Year | MW | Location | Activity | Investor/Owner | Investment (million USD) |
|---|---|---|---|---|---|---|---|
| 1 | Cahora Bassa hydropower plant (HCB) | 1974 | 2075 | Tete | Production of electricity for export (85%) e domestic consumption (15%) | Portugal (15%), Mozambique (85%) | 1300 |
| 2 | Mphanda Nkuwa hydropower plant | 2014 | 1300 | Tete | Production of electricity for export (25%) e domestic consumption (75%) | ? | 2300 |
| 4 | Gas fired electricity plant | 2010 | 700 | Inhambane | Production of electricity for export (30-90%) e domestic consumption (70-30%) | Siemens, Sasol (RSA) | 827 |
| 5 | Coal fired electricity plant | 2011 | 1500 | Tete | Production of electricity for export (90%) e domestic consumption (10%) | Companhia do Vale do Rio Doce (Brazil) | 1300 |
| | **Total** | | **5575** | | | | **5727** |

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