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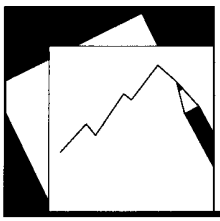

IMF Working Paper

Modeling Macro-Critical Energy Sectors in Low-Income Countries: A General Framework and an Application to Côte d'Ivoire

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Modeling Macro-Critical Energy Sectors in Low-Income Countries: A General Framework and an Application to Côte d'Ivoire

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Abstract

This paper proposes a general framework for monitoring macro-critical energy sectors in low-income countries, defined as consisting of the three subsectors of crude oil and natural gas production, refinery, and electricity production. It aims to derive consistent information on physical and financial flows in the sector, including on interlinkages between the subsectors. It then applies this framework to Côte d'Ivoire. While being an important source of growth, the Ivoirien energy sector is found to have important shortcomings, in particular as regards transparency, efficiency and contribution to fiscal revenue. Among the key problems are partially intransparent production sharing arrangements for hydrocarbon production, price distortions for natural gas, administered prices for refined petroleum products, underfunding and lack of investment in the electricity sector, and inefficient government subsidies in the latter two subsectors.

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Keywords: Energy sector modeling, low-income countries, hydrocarbon production, petroleum products, electricity, transparency, Côte d'Ivoire

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> "No matter what path of development is chosen by a country, ultimately development depends upon the effective substitution of other means of energy for human labor. Whether this energy is used to move water, make cement, heat or cool a house, move a truck, or cook food, it is an input into making the human condition more bearable." (Churchill and Saunders 1989)

A. Introduction

1. While many low-income countries have diverse energy sources, often in abundance, their energy sectors are typically immensely underdeveloped. This is all the more problematic as energy sector development is crucial to sustained economic development. For example, Africa's current energy problems have significant growth- and welfare-reducing effects.[2] Moreover, despite its abundant energy endowment, fuel imports constitute a large share of Africa's total imports, consuming a significant proportion of scarce foreign exchange. In addition, the significantly higher costs of electric power and petroleum products in Africa compared to other regions are a drag on Africa's competitiveness. There is thus an urgent need to study more comprehensively energy sector issues beyond hydrocarbon production from a macroeconomic perspective. Such analysis should endeavor to transcend a national perspective at an early stage because the small sizes of most African economies, the huge investment requirements and economies of scale all point to regional solutions to Africa's energy problems. A sustainable energy sector policy is also needed to stop the environmental degradation that results from current policies. In particular, the still wide-spread use of wood-fuels contributes enormously to deforestation and desertification.[3]

2. Formal models that integrate the main subsectors of oil and gas production, refinery and electricity production are rare. While Berrie (1983) acknowledges the need for "macro-economic driven energy sector models" (p. 291) and outlines the requirements for such models, this paper does not develop a mathematical model itself. The Energy Sector Management Assistance Program (ESMAP), which was conducted jointly by UNDP and the World Bank, was only partly based on formal energy sector models for the countries analyzed (UNDP and World Bank 1990); however, the comprehensive report on Côte d'Ivoire's energy sector produced by ESMAP (UNDP and World Bank 1985) does not contain such a model. Moreover, Côte d'Ivoire's crude oil and natural gas subsector was only beginning to develop at the time of the latter report, and electricity production was based to a much larger extent on hydropower than today.

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[2] For example, on January 11, 2007, Reuters reports: "... southern Africa is on the cusp of an energy crisis that threatens to clip industrial growth and stymie plans to deliver electricity to millions without. ... A lack of sustained long-term investment in power generation, low levels of hydroelectric dams during periods of drought and the high capital and fuel costs faced by thermal power stations are at the root of the energy crisis." For a recent analysis of Africa's Power Supply Crisis, see also IMF (2008, p. 74n.).

[3] See Iwayemi (1998) for a more detailed discussion of the issues mentioned in this paragraph.

3. Against this background, this paper presents a general framework for the analysis of macro-critical energy sectors in low-income countries and applies it to Côte d'Ivoire. Being not only rich in hydrocarbons, but also having significant refinery and electricity production capacities, the case of Côte d'Ivoire lends itself to an integrated analysis of energy sector activities. A key objective of the framework is to monitor and project both physical and financial flows, including fiscal revenues. It can be used both to perform consistency checks for historic – or preliminary – data and to project future flows in a coherent way. It could serve both policy makers not only in calculating fiscal revenue, but also to identify medium-term trends, and possibly reform needs, and could inform the public debate about transparency, good governance and efficiency, not least with a view to fully realizing the growth potential of the sector. The general framework is designed deliberately general in order to facilitate its application to low-income countries other than Côte d'Ivoire.

4. For the purposes of this paper, the energy sector is defined as comprising three subsectors, which are a) oil and natural gas production and distribution; b) refinery and the production and distribution of petroleum products; and c) electricity production and distribution. As described below, these subsectors are interlinked as, for example, crude oil is an input to refinery, and natural gas is an input to both refinery and electricity production. As governments usually are key players in the energy sector, this paper gives special emphasis to the government's involvement in it.

5. This paper is organized as follows. Section B gives a brief overview of the Ivoirien Energy Sector. Section C presents the general framework. Section D applies the framework to Côte d'Ivoire and discusses the main results. Section E offers some international comparisons. Section F discusses implications for improving transparency, efficiency, and fiscal sustainability. Section G concludes.

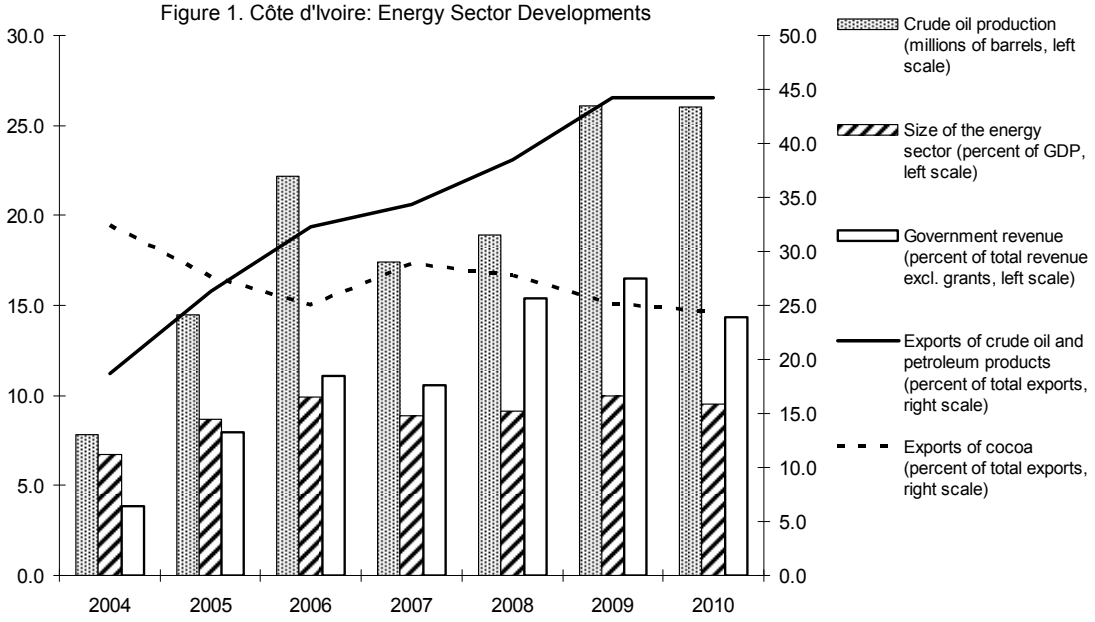
B. Overview of the Ivoirien Energy Sector

6. The Ivoirien energy sector has emerged as a major source of growth and fiscal revenue over the past few years, with oil, gas, electricity and fuel production combined accounting for 9.9 percent of GDP in 2006, up from 6.7 percent in 2004. Crude oil production has grown from 7.6 million barrels in 2003 to 22.2 million barrels in 2006. While technical exploration problems are slowing down production in 2007, a further rise to around 26 million barrels is currently projected for 2009. Almost all Ivoirien oil is exported. Natural gas production fluctuated around an 2003-2006 average production of 53 million MMBTU (millions of British Thermal Units) and is used by the domestic electricity producers and the local refinery. A substantial part of domestic electricity production is exported. The local refinery, one of the largest in the region, produces car, jet and heavy fuels both for domestic consumption and exports, using mostly imported, but also some local crude oil. The refinery initially enjoyed a high degree of protection, but progress in its competitiveness enabled the authorities to reduce this protection over time.

7. Helped by rising oil prices, exports of crude oil and petroleum products in percent of total exports exceeded cocoa exports, Côte d'Ivoire's traditional cash crop, in 2006 for

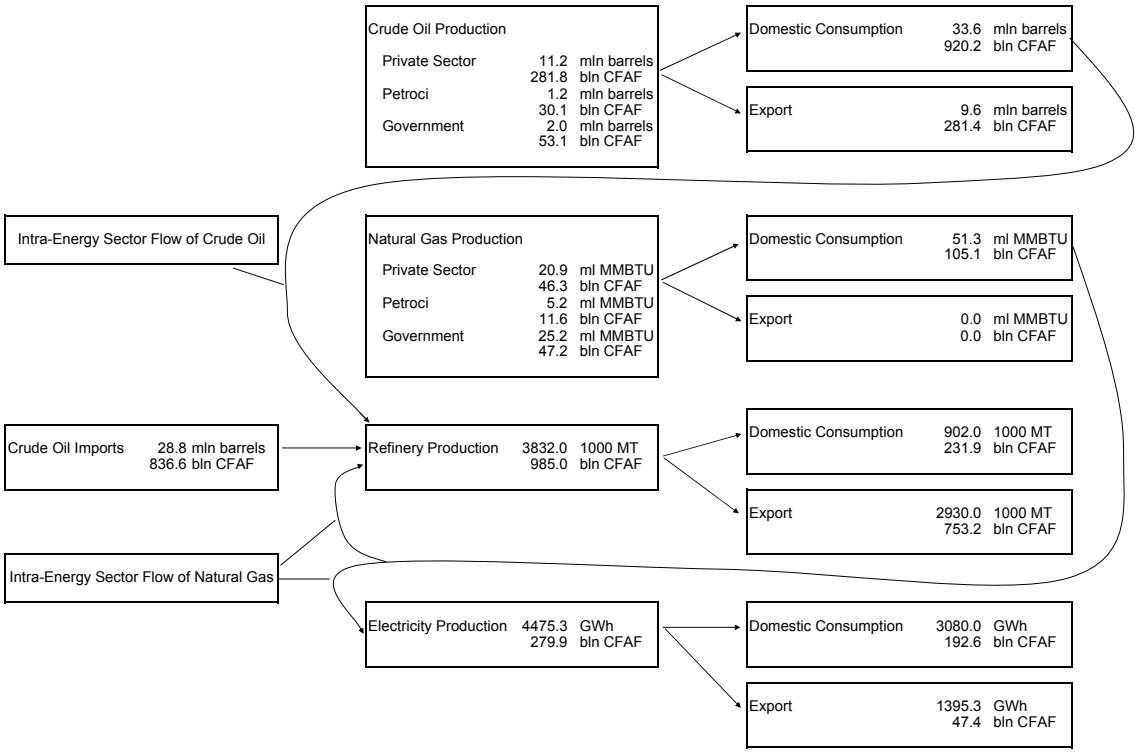
the first time. Total government revenue from oil, gas and petroleum products has also risen strongly from an estimated 3.4 percent of total revenue in 2003 to 11.1 percent in 2006, but has decreased in 2007 due to the slowdown in production. It is projected to grow to a maximum of 14.2 percent in 2009. Figure 1 presents the main trends over time and Figure 2 shows the key flows between the subsectors, the government, the domestic economy, and the rest of the world in 2005.

Figure 1. Côte d'Ivoire: Energy Sector Developments



Source: Ivoirien authorities; and IMF staff estimates.

Figure 2. Côte d'Ivoire: Key physical and financial flows in the energy sector in 2005



Source: Ivoirien authorities; and IMF staff estimates.

C. A Simple Energy Sector Model

Crude oil and natural gas production

8. The starting point of the model is crude oil and natural gas production. Typically, crude oil and natural gas are found together. While most of the focus usually is on oil, gas provides an important source of income as well. Hence, it is worthwhile to trace both commodities separately. Oil and gas are usually found in several separate fields, and the share of oil and gas, and their quality, can differ across fields. In addition, the production of crude oil and gas is often shared among several agents, most commonly private oil firms, a state-owned oil firm, and the government, through production-sharing agreements and royalties. The terms and conditions of production sharing agreements may differ from field to field and over time. Formally,

$$(1) \qquad Y_t^{oil} = \sum_{i=1}^{n} Y_{i,t}^{oil} = \sum_{i=1}^{n} (Y_{i,t}^{oil,priv} + Y_{i,t}^{oil,soc} + Y_{i,t}^{oil,state})$$

with $$Y_{i,t}^{oil,soc} = \left[c_{i,t}^{oil,soc} + (1 - c_{i,t}^{oil,priv} - c_{i,t}^{oil,soc})\,\theta_{i,t}^{soc} - \rho_{i,t}^{oil,soc} \right] Y_{i,t}^{oil}$$

$$Y_{i,t}^{oil,state} = \left[(1 - c_{i,t}^{oil,priv} - c_{i,t}^{oil,soc})\,\theta_{i,t}^{state} + \rho_{i,t}^{oil,priv} + \rho_{i,t}^{oil,soc} \right] Y_{i,t}^{oil}$$

$$Y_{i,t}^{oil,\,priv} = \left[c_{i,t}^{oil,priv} + (1 - c_{i,t}^{oil,priv} - c_{i,t}^{oil,soc})\theta_{i,t}^{priv} - \rho_{i,t}^{oil,\,priv} \right] Y_{i,t}^{oil}$$

(2) $$Y_t^{gas} = \sum_{i=1}^{n} Y_{i,t}^{gas} = \sum_{i=1}^{n} (Y_{i,t}^{gas,priv} + Y_{i,t}^{gas,\,soc} + Y_{i,t}^{gas,state})$$

with $$Y_{i,t}^{gas,\,soc} = \left[c_{i,t}^{gas,soc} + (1 - c_{i,t}^{gas,priv} - c_{i,t}^{gas,soc})\,\phi_{i,t}^{soc} - \rho_{i,t}^{gas,soc} \right] Y_{i,t}^{gas}$$

$$Y_{i,t}^{gas,\,state} = \left[(1 - c_{i,t}^{gas,priv} - c_{i,t}^{gas,soc})\,\phi_{i,t}^{state} + \rho_{i,t}^{gas,priv} + \rho_{i,t}^{gas,soc} \right] Y_{i,t}^{gas}$$

$$Y_{i,t}^{gas,\,priv} = \left[c_{i,t}^{gas,priv} + (1 - c_{i,t}^{gas,priv} - c_{i,t}^{gas,soc})\phi_{i,t}^{priv} - \rho_{i,t}^{gas,\,priv} \right] Y_{i,t}^{gas}$$

where Y represents production expressed in physical quantities, t the relevant year and i the oil and gas field, c the share of cost oil or gas in total oil production that goes to the private sector or the state-owned company, θ (ϕ) the share of non-cost oil (gas) that goes to either the state-owned company, the government or the private sector, with the shares summing up to 1, and ρ the royalty. Summing up over n fields yields aggregate production by agent in the sector:

(3) $$Y_t^{oil} = Y_t^{oil,priv} + Y_t^{oil,soc} + Y_t^{oil,state}$$

(4) $$Y_t^{gas} = Y_t^{gas,priv} + Y_t^{gas,soc} + Y_t^{gas,state}$$

9. The government may sell its share of crude oil and natural gas directly, swap one against the other with oil companies and then sell it, or it may use it itself. To the extent that a swap takes place, it is important to know the rate of that swap because any deviation from the swap rate implied by market prices would amount to an implicit subsidy or tax. In principle, the swap rate could be equal to the rate implied by the world price for crude oil and natural gas less the relevant discounts (d), but could differ from that rate depending on the contracts between the gas seller and buyer which may reflect the specific circumstances in the local market for gas. Hence, we monitor

(5) $$s_{i,t} = \frac{\tilde{Y}_{i,t}^{gas,state}}{\tilde{Y}_{i,t}^{oil,state}} = \frac{p_{i,t}^{oil,WEO} - d_t^{oil}}{p_{i,t}^{gas,WEO} - d_t^{gas}} \frac{\left[\frac{US\$}{bl} \right]}{\left[\frac{US\$}{MMBTU} \right]} = \frac{p_{i,t}^{oil,WEO} - d_t^{oil}}{p_{i,t}^{gas,WEO} - d_t^{gas}} \left[\frac{MMBTU}{bl} \right]$$

where the tilde denotes the quantity of oil the government exchanges against a quantity of gas, or vice versa. For example, if the government swaps some crude oil for gas, the government's total gas and oil share become, respectively:

(6) $$\overline{Y}_{i,t}^{gas,state} = Y_{i,t}^{gas,state} + s_i \tilde{Y}_{i,t}^{oil,state}$$

(7) $$\overline{Y}_{i,t}^{oil,state} = Y_{i,t}^{oil,state} - \tilde{Y}_{i,t}^{oil,state}$$

10. Depending on the level of oil and gas production and the structure of the economy, a certain share of oil and gas production may be exported. At the same time, there may be imports of crude oil or gas. The model assumes that the refinery subsector is the only domestic consumer of crude oil and that the refinery and electricity sectors are the only consumers of domestic natural gas. Thus, economy-wide supply and demand can be expressed as follows

$$Y_t^{oil} + M_t^{oil} = C_t^{oil,fuel} + X_t^{oil} \tag{8}$$

$$Y_t^{gas} + M_t^{gas} = C_t^{gas,fuel} + C_t^{gas,elec} + X_t^{gas} \tag{9}$$

11. Government revenues from oil and gas production can then be derived by applying the appropriate international prices, converted into domestic currency, to the physical quantities, taking into consideration any discounts or markups related to product quality, and adding royalties, all of which can again differ across fields, plus the profit of the state-owned company:

$$T_t^{prod} = \sum_{i=1}^{n}\left[\left(p_{i,t}^{oil,WEO} - d_i^{oil}\right)e_t Y_{i,t}^{oil,state} + \left(p_{i,t}^{gas,WEO} - d_i^{gas}\right)e_t Y_{i,t}^{gas,state}\right] + \alpha^{soc}\pi_t^{soc} \tag{10a}$$

$$\pi_t^{soc} = \sum_{i=1}^{n}\left[\left(p_{i,t}^{oil,WEO} - d_i^{oil}\right)e_t Y_{i,t}^{oil,soc} + \left(p_{i,t}^{gas,WEO} - d_i^{gas}\right)e_t Y_{i,t}^{gas,soc}\right] - c_t^{soc} \tag{10b}$$

where p denotes international oil price as published in the IMF's World Economic Outlook in US$, e the exchange rate in domestic currency over foreign exchange (US$), d_i the discount (or, when negative, markup) of oil/gas field i's oil or gas price on international markets, π the profit of the state-owned oil company, α the share of this profit that goes to the government, and c_t^{soc} the production cost of that company.

Refinery and petroleum products

12. The refinery sector is modeled as consisting of only one refinery, typical of most low-income countries, which uses mainly crude oil and natural gas as inputs for the production of car fuels, kerosene, butane, and heavy fuels. The inputs can come from domestic production and/or imports. Conversely, the refinery's output can be either consumed domestically or exported. While the cracking of crude oil into petroleum products is a production process that is largely determined by relatively simple chemical reactions, the efficiency of the standard process depends on the refinery's production technology. Formally,

$$\mathbf{Y_t^{fuel}} \equiv \begin{pmatrix} Y_{1,t}^{fuel} \\ \vdots \\ Y_{l,t}^{fuel} \\ \vdots \\ Y_{q,t}^{fuel} \end{pmatrix} = \mathbf{g}(C_t^{oil,fuel}, C_t^{gas,fuel}, O_t, A_t) \tag{11a}$$

13. Thus, economy-wide physical output of petroleum product *l* is derived from the refinery's production function $\mathbf{g}$, which is a *q* x 1 vector,[4] where *q* denotes the number of petroleum products, with inputs as described above as well as other inputs (*O*) and technological factors (*A*). Note that the consumption of oil and gas link the oil and gas production and refinery sectors. One way to specify (11a) is to assume a fixed proportions production function:

$$(11b) \quad \mathbf{Y_t^{fuel}} \equiv \begin{pmatrix} Y_{1,t}^{fuel} \\ \vdots \\ Y_{l,t}^{fuel} \\ \vdots \\ Y_{q,t}^{fuel} \end{pmatrix} = \begin{pmatrix} \beta_1 \\ \vdots \\ \beta_l \\ \vdots \\ \beta_q \end{pmatrix} \times A_t \min\left\{\lambda_1 C_t^{oil,fuel}, \lambda_2 C_t^{gas,fuel}, \lambda_3 O_t\right\}$$

14. The petroleum products, in turn, may be consumed domestically, stored in fuel tanks,[5] or exported. Depending on production and consumption patterns, there may also be imports of certain or all petroleum products. Thus, economy-wide supply and demand for fuel *l* can be expressed as

$$(12) \quad Y_{l,t}^{fuel} + M_{l,t}^{fuel} = C_{l,t}^{fuel} + X_{l,t}^{fuel} \;\; \forall \; l = 1,...,q$$

15. In many low-income countries, prices for petroleum products follow some price adjustment mechanisms that are administered by the government and to varying degrees follow international price developments. The price for petroleum product *l* on the domestic market is thus a function of the international price, the exchange rate, refinery protection,[6] transport costs, two different types of petroleum product taxes, and any other costs:

$$(13) \quad p_{l,t}^{fuel} = p_{l,t}^{fuel,world} e_t (1 + c_{l,t}^{trans})(1 + t_t^{prot})(1 + t_{l,t}^{fuel,A}) + t_{l,t}^{fuel,B} + c_{l,t}^{other} \;\; \forall \; l = 1,...,q$$

16. The central government raises revenue through taxing petroleum products as well as through refineries' profits accruing to it:

$$(14a) \quad T_t^{fuel} = \sum_{l=1}^{q} Y_t^{fuel} \left[p_{l,t}^{fuel,world} e_t (1 + c_{l,t}^{trans})(1 + t_t^{prot}) t_{l,t}^{fuel,A} + t_{l,t}^{fuel,B} \right] + \alpha^{ref} \pi_t^{ref}$$

[4] Since petroleum products are produced jointly from the same inputs, this paper does not introduce a separate production function for each petroleum product.

[5] For the purposes of this paper, storage in fuel tanks is considered domestic consumption.

[6] Refinery protection can take the form of a tax or a protective margin, like in Côte d'Ivoire.

(14b) $$\pi_t^{ref} = \sum_{l=1}^{q} p_{l,t}^{fuel,world} e_t (1 + c_{l,t}^{trans})(1 + t_t^{prot}) Y_{l,t}^{fuel} - c_t^{ref}$$

where t_t^{prot} and $t_{l,t}^{fuel,A}$ are ad valorem taxes, $t_{l,t}^{fuel,B}$ is a specific tax, $\pi_{j,t}^{ref}$ is the refinery's profit, α^{ref} is the share of this profit going to the government, and c_t^{ref} is the cost of the refinery.

Electricity

17. Electricity production uses natural gas, fuel oils or water, depending on the technology of the power plant. The electricity sector typically consists of a number of electricity companies of varying size. Their inputs can come from domestic production and/or from imports. Conversely, the electricity sector output can be either consumed domestically or exported. The efficiency of the electricity production process will depend on the power plant's production technology (*h*). Formally,

(15) $$Y_t^{elec} = \sum_{u=1}^{r} h_u (C_{u,t}^{gas,elec}, C_{u,t}^{fuel,elec}, C_{u,t}^{water}, K_{m,t}, L_{m,t}, A_{m,t})$$

18. Note that *Y* in (15) symbolizes net production, i.e., less technical and non-technical losses. Also note that the consumption and the imports of gas and fuel link the electricity sector with the oil and gas production and refinery sectors.

19. Electricity may, in turn, be consumed domestically, exported or imported, depending on the connection to a power grid. Thus, the supply and demand equation is

(16) $$Y_t^{elec} + M_t^{elec} = C_t^{elec} + X_t^{elec}$$

20. In many low-income countries, electricity prices are administered by the government and only indirectly follow international price developments. Here, the electricity price is assumed to be a function of the (unit) production costs and government taxation:

(17) $$p_t^{elec} = c_t^{elec}(1 + t_t^{elec,A}) + t_t^{elec,B}$$

21. Since the government is also a consumer of energy, its net revenue from the electricity sector is electricity taxation less its own electricity consumption plus the share of electricity companies' profits accruing to it:

(18) $$T_t^{elec} = \sum_{v=1}^{s} (Y_t^{elec} - C_t^{elec,\,state})(c_t^{elec} t_t^{elec,A} + t_t^{elec,B}) + \sum_{u=1}^{r} \alpha_u^{elec} \pi_{u,t}^{elec}$$

D. Application to Côte d'Ivoire

Crude oil and natural gas production

22. Most of Côte d'Ivoire's crude oil and natural gas production takes place offshore. Total oil production has risen significantly in recent years and is currently projected to increase until 2009 and remain about flat for several years thereafter. Natural gas production is fluctuating around a constant average production level. Taken together, the share of oil and gas production in nominal GDP is projected to rise from 1.1 percent in 2003 to 4.8 percent in 2009. Oil and gas reserves are forecast to be largely depleted by 2029, but this forecast is subject to high uncertainty as there is speculation about new discoveries and information on current reserves and production profiles is also uncertain. At present, oil and gas are produced in four separate fields. Table 1 presents the production profile and the first parts of equations (1) and (2) for i=4 and t=2003, ... , 2008.

Table 1. Côte d'Ivoire: Crude Oil and Natural Gas Production

	2003	2004	2005	2006	2007 Est.	2008 Proj.
Total oil production (in millions of barrels)	7.613	7.814	14.471	22.194	17.430	18.936
growth in percent		2.6	85.2	53.4	-21.5	8.6
Fields						
CI 11	1.175	1.199	1.127	0.871	0.752	0.548
CI 26	6.439	6.616	6.590	10.433	9.452	10.950
CI 27	0.000	0.000	0.202	0.188	0.167	0.139
CI 40	0.000	0.000	6.553	10.703	7.060	7.300
Total gas production (in millions of MMBTU)	48.6	55.7	51.3	57.9	53.8	59.4
growth in percent		14.5	-7.9	13.0	-7.2	10.5
Fields						
CI 11	18.3	23.5	25.5	20.9	18.3	14.6
CI 26	4.8	5.1	2.1	3.3	3.8	12.8
CI 27	25.6	27.1	23.2	31.2	29.6	29.2
CI 40	0.0	0.0	0.5	2.6	2.0	2.8
Memorandum						
Nominal GDP (billions of CFAF)	7984.3	8178.5	8621.2	9029.2	9379.3	10103.2
Of which: oil and gas value added 1/	89.4	116.4	236.5	353.2	313.6	384.8
in percent of nominal GDP	1.1	1.4	2.7	3.9	3.3	3.8

Source: Ivoirien authorities and IMF staff estimates.
1/ From national accounts data.

23. Exploration and production rights as well as the production sharing modalities are determined by contracts between private energy companies, the government, and Petroci, the fully state-owned oil company. For all oil fields, Côte d'Ivoire uses simplified production-sharing agreements (PSAs) that give the government a share of total physical

oil production. There are no royalties, special company profit taxes, or other fees or levies (i.e., $\rho = 0$ in equations (1), (2) and (10)). Petroci handles the government's share of oil production. Total production is divided into cost oil, which is meant to cover the current and capital costs of production for the private companies (and, in the case of field CI 26, Petroci), and profit oil, which is shared between government, Petroci, and private companies. The shares vary between fields and over time. Table 2 summarizes the main features of the PSAs for each field in 2005, and hence the parameters θ and ϕ in equations (1) and (2).

Table 2. Côte d'Ivoire: Main Features of Production Sharing Agreements in 2005 by Field (in percent)

Field	Split Cost/Profit		Shares of total production (cost and profit oil)			
			Government	Petroci	Total State	Private sector
CI 11	Cost Oil	0.0	0.0	0.0	0.0	0.0
	Profit Oil	100.0	60.0	8.0	68.0	32.0
	Cost Gas	0.0	0.0	0.0	0.0	0.0
	Profit Gas	100.0	60.0	8.0	68.0	32.0
CI 26	Cost Oil	80.0	0.0	8.9	8.9	71.1
	Profit Oil	20.0	10.3	4.0	14.3	5.7
	Cost Gas	0.0	0.0	0.0	0.0	0.0
	Profit Gas	100.0	60.0	8.0	68.0	32.0
CI 27	Cost Oil	40.0	0.0	0.0	0.0	40.0
	Profit Oil	60.0	30.0	28.0	58.0	2.0
	Cost Gas	40.0	0.0	0.0	0.0	40.0
	Profit Gas	60.0	36.0	12.8	48.8	11.2
CI 40	Cost Oil	80.0	0.0	0.0	0.0	80.0
	Profit Oil	20.0	9.4	3.0	12.4	7.6
	Cost Gas	0.0	0.0	0.0	0.0	0.0
	Profit Gas	100.0	60.0	8.0	68.0	32.0
Average all fields	Profit Oil	26.8	14.0	4.2	18.2	8.6
	Profit Gas	81.9	49.1	10.2	59.3	22.6

Source: Ivoirien authorities; and IMF staff estimates.

24. For example, cost oil in the CI 40 oil field amounts to 80 percent of oil production. The government's take is 9 percent of total oil production. Petroci receives about 3 percent. Hence, the respective elements of (1) become

(19) $$Y_{CI\,40,2005}^{oil,soc} = 0.03\, Y_{CI\,40,2005}^{oil}$$

(20) $$Y_{CI\,40,2005}^{oil,state} = 0.09\, Y_{CI\,40,2005}^{oil}$$

25. The government has commissioned Petroci to sell a portion of its crude oil at market rates. Depending on market conditions and the availability of gas, a portion of the

government's oil share is swapped into natural gas, which is then sold, together with the government's share of natural gas, to the country's electricity producers and the local refinery. The government pays a small service fee of CFAF 100 (about 0.2 US$) per barrel to Petroci to swap its share of crude oil into natural gas. All transactions typically take place on a monthly basis. The swap rate is based on the local price for crude oil, which follows world market developments less the relevant quality discounts, and the local price for gas, which is largely determined by long-term contracts between sellers and buyers of gas and is indexed to international price developments for some gas fields and is fixed at a pre-determined level for others. Hence, the discounts as defined in equation (5) reflect quality differences in the case of crude oil and contract specifics in the case of natural gas.

26. Table 3 presents the oil and gas production shares for the private sector, Petroci, and the government both before and after the swap and the average swap rates over world market prices, reflecting equations (3)-(7). A breakdown for all fields can be found in the appendix (Table A1). Table 3 shows that the actual average swap rate is much higher than the swap rate implied by international prices. This is due to local gas prices that are much below the world market prices because of long-term contracts that have been signed in the early years of Ivoirien oil and gas exploration. Since the government sells on the swapped gas to the electricity sector at the same local prices, one could argue that the low gas prices constitute a subsidy to the electricity sector. At the same time, the market for natural gas in Côte d'Ivoire is largely determined by local (rather than global) supply and demand as the storage and transportation of natural gas is expensive. Nevertheless, the stationarity of local gas prices in an environment of sharply increasing hydrocarbon prices may not give the right signal for efficient resource allocation.

Table 3. Côte d'Ivoire: Crude Oil and Natural Gas Production Shares

	2003	2004	2005	2006	2007 Est.
Total oil production (millions of barils)	7.613	7.814	14.471	22.194	17.430
Private sector before swap	5.322	5.465	11.248	17.746	13.755
Petroci before swap	0.924	0.949	1.193	1.788	1.537
Government before swap	1.368	1.401	2.031	2.660	2.138
Government after swap	0.0	0.0	1.1	1.6	2.7
Private sector and Petroci after swap	7.613	7.814	13.403	20.595	14.723
Total gas production (millions of MMBTU)	48.6	55.7	51.3	57.9	53.8
Private sector before swap	20.5	23.0	20.9	24.5	22.9
Petroci before swap	5.1	5.8	5.2	6.1	5.7
Government before swap	23.0	26.9	25.2	27.3	25.2
Government after swap	35.9	43.8	43.3	45.5	40.3
Private sector and Petroci after swap	12.7	11.9	7.9	12.4	13.5
Crude oil price (US$/bl, WEO)	28.9	37.8	53.4	64.3	71.1
Natural gas price (US$/MMBTU, WEO)	3.6	3.8	6.0	8.4	8.3
Implied WEO swap rate (MMBTU/bl)	8.1	9.9	8.9	7.7	8.6
Actual swap rate, weighted average (MMBTU/bl)	9.4	12.1	16.0	16.9	14.5
Memorandum					
Exchange Rate CFAF/US$ (period average)	580.1	527.6	526.6	522.4	478.6

Source: Ivoirien authorities; and IMF staff estimates.

27. Table 4, which summarizes equations (8) and (9), shows the supply and use of oil and natural gas resources. Côte d'Ivoire is both an importer and exporter of crude oil because the local refinery, *Société Ivoirienne de Rafinage* (SIR), uses a lighter oil than that produced locally. Hence, it imports a large amount of the crude oil it uses, mostly from Nigeria. SIR is the only importer of crude oil in Côte d'Ivoire. Most of the domestically produced crude oil is exported and not refined in Côte d'Ivoire. The entire supply of natural gas is produced domestically and is consumed entirely in the country, in particular by the electricity sector, but also by SIR (see below).

Table 4. Côte d'Ivoire: Supply and Use of Crude Oil and Natural Gas

	2003	2004	2005	2006	2007 Est.	2008 Proj.
Oil (thousands of metric tons)						
Supply						
Domestic Production	1042.9	1070.5	1982.4	3040.2	2387.7	2594.0
Imports	2599.3	3668.4	3941.5	3631.3	3776.6	3885.4
Use						
Domestic Consumption	2695.5	3707.8	4608.6	3591.5	3745.3	3963.7
Exports	946.7	1031.1	1315.3	3080.1	2419.0	2515.7
Gas (millions of MMBTU)						
Supply						
Domestic Production	48.6	55.7	51.3	57.9	53.8	59.4
Imports	0.0	0.0	0.0	0.0	0.0	0.0
Use						
Domestic Consumption	48.6	55.7	51.3	57.9	53.8	59.4
Exports	0.0	0.0	0.0	0.0	0.0	0.0

Source: Ivoirien authorities; and IMF staff estimates.

28. Table 5 presents the potential government revenue from oil and gas production as defined by equation (10). Given the highly simplified PSAs described above, the government's revenue consists of the domestic currency value of its production shares of oil and gas for each field plus the profit of Petroci less the cost of swapping oil for gas. Revenue from oil and gas production as a percentage of total revenue excluding grants is projected to rise from 3.4 percent in 2003 to 13.7 percent in 2008.

Table 5. Côte d'Ivoire: Government Revenue from Crude Oil and Natural Gas Production
(in billions of CFA francs, unless otherwise indicated)

	2003	2004	2005	2006	2007 Est.	2008 Proj.
Total government revenue from oil and gas 1/	46.3	55.4	117.0	185.0	191.5	301.2
in % of total sector proceeds from oil and gas	24.1	24.1	24.9	21.6	31.3	29.7
in % of total government revenues excl. grants	3.4	3.9	8.0	11.1	10.5	15.4
Total public sector revenue from oil and gas 2/	64.4	75.0	142.0	225.5	216.4	359.8
in % of total sector proceeds from oil and gas	33.5	32.5	30.2	26.3	35.3	35.4
Direct revenue from oil and gas	43.5	49.7	100.3	151.0	163.3	270.4
Oil 3/	13.3	16.9	53.1	86.0	105.6	200.0
CI 11	4.5	5.4	19.3	17.9	11.7	14.9
CI 26	8.8	11.4	16.9	34.8	75.7	151.9
CI 27	0.0	0.0	1.5	1.9	1.5	1.9
CI 40	0.0	0.0	15.4	31.4	16.8	31.2
Gas 3/	30.2	32.9	47.2	64.9	57.6	70.4
CI 11	5.5	6.4	18.9	19.0	14.4	9.8
CI 26	6.6	6.9	4.1	7.2	7.9	25.6
CI 27	18.1	19.6	23.8	36.6	33.8	33.0
CI 40	0.0	0.0	0.4	2.1	1.5	2.0
Petroci profit 4/	3.0	5.8	16.8	34.1	28.3	31.0
Petroci revenue after swap	21.1	25.4	41.7	74.7	53.3	89.6
Cost of swap	0.1	0.1	0.1	0.1	0.1	0.1
Memorandum						
Total sector proceeds from oil and gas	192.1	230.3	470.1	857.2	612.7	1015.5
Total government revenues excl. grants	1343.8	1431.6	1471.4	1672.1	1817.9	1960.5

Source: Ivoirien authorities; and IMF staff estimates.
1/ Excluding the direct oil and gas revenue of Petroci, but including profits of Petroci.
2/ Direct revenue from oil and gas plus Petroci revenue after swap less cost of swap.
3/ Before swap; by definition, swap leaves overall revenue unchanged, except for cost of swap as shown. Evaluated at actual price at which oil or gas is exported (oil) or sold domestically (gas).
4/ For 2003-06 from Annual Reports, from 2007 projected to grow in line with oil production.

Refinery and pricing of petroleum products

29. SIR enjoys a monopoly in Côte d'Ivoire. Petroci owns 45 percent of SIR, the government of Burkina Faso 5 percent, the government of Côte d'Ivoire one percent, and the private sector 49 percent – mostly international oil companies, some of which are currently selling their shares.

30. SIR produces car, jet and heavy fuels. Table 6 summarizes SIR's technology along the lines of equation (11b). For 2006, (11b) is estimated as follows:

$$\mathbf{Y_t^{fuel}} \equiv \begin{pmatrix} Y_{Super,t}^{fuel} \\ Y_{Diesel,t}^{fuel} \\ Y_{DDO,t}^{fuel} \\ Y_{FO,t}^{fuel} \\ Y_{Jet,t}^{fuel} \\ Y_{Other,t}^{fuel} \end{pmatrix} = \begin{pmatrix} 0.167 \\ 0.346 \\ 0.058 \\ 0.136 \\ 0.272 \\ 0.021 \end{pmatrix} \times 0.81 \min\left\{1.09\, C_t^{oil,fuel}, 25.33\, C_t^{gas,fuel}, 23.69\, O_t\right\}$$

Table 6 also presents the overall balances given by equation (12), showing that Côte d'Ivoire is a significant exporter of refined petroleum products.

31. Table 6 shows that domestic consumption of petroleum products amounts to less than a quarter of domestic production. Thus, not only is Côte d'Ivoire an important producer of crude oil and natural gas, it is also a major exporter of refined products. The only petroleum product that is imported is butane (in Table 6 reflected by a negative sign in the exports section), where SIR's output falls short of domestic demand. Overall, the share of petroleum products value added in GDP is rising constantly and is projected to reach 3.2 percent in 2007, up from 1.9 percent in 2003.

32. After several difficult years, SIR is now running well and is making healthy profits. It is among Africa's biggest refineries. Against this backdrop, the SIR's protection rate, a mark-up over the import parity price to assure a sufficient price margin for SIR, has been reduced from 13 percent to 8 percent of the import parity price in May 2006 and from 8 percent to 6 percent in May 2007. The reduced protection benefited the government which increased taxation of ex-refinery fuel so that retail prices remained constant.

33. Turning to the pricing of petroleum products, as described in equation (13), it is worth noting that in Côte d'Ivoire an automatic pricing mechanism has been applied since around 1994, then suspended, and re-introduced in revised form in 2002, but only partially applied thereafter. The government decided to postpone its full implementation until the political situation would improve. As a result, the pass-through of higher world oil prices has been highly incomplete, with taxation (in various forms) taking the slack.

34. Under the current petroleum pricing mechanism (Table 7), transport and insurance costs are added to the CIF Rotterdam price of the petroleum product under consideration to arrive at CIF Abidjan, or import parity price. To this price are added the refinery protection and a transport fee to arrive at the ex-refinery price. A butane cross-subsidy and a margin that buffers against fluctuations of world market prices, are added to arrive at the maximum ex-refinery price. Various fiscal and parafiscal levies, all subject to VAT, and margins for distributors and retailers are added to arrive at the retail price.

Table 6. Côte d'Ivoire: Production, Domestic Consumption and Exports of Petroleum Products
(in thousands of metric tons unless otherwise specified)

	Coefficients	2002	2003	2004	2005	2006	2007
Inputs	1.000	2717.7	2935.3	4037.6	4481.8	4033.8	4131.3
Crude Oil	0.918	2495.6	2695.5	3707.8	4047.0	3704.2	3793.8
Fuel Gas	0.039	107.3	115.9	159.4	188.2	159.3	163.1
Other	0.042	114.7	123.9	170.5	246.6	170.3	174.4
Technology Ratio		1.01	0.90	0.87	0.86	0.81	0.83
Production	1.000	2750.3	2637.2	3501.6	3832.0	3275.0	3415.3
% change		0.0	-4.1	32.8	9.4	-14.5	4.3
Regular and Super Unleaded	0.167	460.5	441.6	586.3	641.6	548.3	571.8
Diesel	0.346	952.2	913.0	1212.3	1326.7	1133.8	1182.4
Distillate-DDO	0.058	160.6	154.0	204.4	223.7	191.2	199.4
Fuel oil	0.136	373.0	357.6	474.8	519.6	444.1	463.1
Jet fuel	0.272	747.8	717.0	952.0	1041.9	890.4	928.6
Butane and others	0.021	57.3	55.0	73.0	79.9	68.3	71.2
Consumption		860.8	766.3	745.7	902.0	848.7	866.5
Regular and Super Unleaded		106.5	94.8	92.2	111.6	105.0	107.2
Diesel		502.9	447.7	435.6	527.0	495.8	506.2
Distillate-DDO		15.8	14.1	13.7	16.6	15.6	15.9
Fuel oil		34.4	30.6	29.8	36.0	33.9	34.6
Jet fuel		82.2	73.2	71.2	86.2	81.1	82.8
Butane and others		119.1	106.0	103.2	124.8	117.4	119.9
Exports (+) / Imports (-)		1889.5	1870.9	2755.9	2930.0	2426.3	2548.8
Regular and Super Unleaded		354.0	346.8	494.1	530.0	443.4	464.7
Diesel		449.3	465.3	776.6	799.7	638.0	676.2
Distillate-DDO		144.8	139.9	190.8	207.2	175.6	183.5
Fuel oil		338.6	327.0	445.1	483.6	410.2	428.6
Jet fuel		665.5	643.8	880.8	955.7	809.4	845.8
Butane and others		-61.7	-51.0	-30.2	-44.9	-49.1	-48.7
Average product price (CFAF/ton)			153,494.3	183,127.5	257,054.3	284,370.2	293,407.3
Value of production (billions of CFAF)			404.8	641.2	985.0	931.3	1,002.1
Value of consumption (billions of CFAF)			117.6	136.6	231.9	241.3	254.2
Export revenues (billions of CFAF)			287.2	504.7	753.2	690.0	747.8
Memorandum							
Nominal GDP (billions of CFAF)		8006.1	7984.3	8178.5	8621.2	9029.2	9379.3
Of which: petroleum products value added 1/		151.3	150.5	241.1	290.6	320.3	298.3
in percent of nominal GDP		1.9	1.9	2.9	3.4	3.5	3.2

Source: Ivoirien authorities and IMF staff estimates.
1/ From national accounts data.

35. The automatic petroleum pricing mechanism is only partially applied because for car and jet fuels the tax base is not the maximum ex-refinery price, but a historic value of this price, which is much lower. As a consequence, lower taxes are added to the maximum ex-refinery price. Moreover, the price buffer is negative for Super, reducing the maximum ex-refinery price itself.

36. Government revenue from taxing petroleum products, as defined by equation (14a) is also shown in Table 7. Using the consumption figures from Table 6 yields total fiscal revenue of CFAF 103.8 billion.

Table 7. Côte d'Ivoire: Pricing of and Fiscal revenues from Petroleum Products projected for 2007 1/

	Super	Jet fuel	Diesel	Fuel oil	DDO	DDO AD
	light fuels			heavy fuels		
CIF Rotterdam (USD/MT)	627.06	611.85	544.41	268.46	506.30	506.30
CIF Rotterdam (CFAF/MT)	311,272.58	303,722.34	270,245.12	133,263.54	251,327.97	251,327.97
Transport costs and insurance	15,403.35	15,363.32	15,185.84	14,832.52	15,085.55	15,085.55
CIF Abidjan (CFAF/MT)	326,675.93	319,085.66	285,430.96	148,096.06	266,413.52	266,413.52
CIF Abidjan (CFAF/L) / Import Parity Price	243.09	259.55	243.25	137.37	235.68	235.68
Protection factor (1+k)	1.08	1.08	1.08	1.08	1.08	1.08
Unloading fee (CFAF/MT)	3,551.00	3,551.00	3,551.00	3,551.00	3,551.00	3,551.00
Ex-Refinery price (CFAF/MT)	356,361.00	348,163.51	311,816.44	163,494.74	291,277.60	291,277.60
Ex-Refinery price(CFAF/L or KG at 25°C)	265.18	283.21	265.74	163.49	291.28	291.28
	CFAF /L	CFAF /L	CFAF /L	CFAF /Kg	CFAF /Kg	CFAF /Kg
Butane subsidy	20.00	20.00	20.00	20.00	20.00	20.00
Price buffer	-17.05	31.26	69.62	90.64	59.63	59.63
Maximum ex-refinery price	268.13	334.47	355.36	274.14	370.91	370.91
Tax base	146.97	145.99	132.10	274.14	370.91	370.91
Import tax	14.70	7.30	13.21	13.71	18.55	18.55
Statistics fee	1.47	1.46	1.32	2.74	3.71	3.71
Specific tax	155.61	2.80	37.49	1.50	50.50	1.50
Fiscal levies 2/	171.77	11.56	52.02	17.95	72.75	23.75
VAT on fiscal levies	57.37	28.36	33.14	52.58	79.86	71.04
Parafiscal levies	24.95	24.95	24.95	7.45	7.45	7.45
VAT on parafiscality	4.49	4.49	4.49	1.34	1.34	1.34
Distributors' margin	58.93	41.57	48.88	39.45	44.98	41.96
VAT on distributors' margin	10.61	7.48	8.80	7.10	8.10	7.55
Retailers' margin	18.75	17.15	17.35	0.00	0.00	0.00
Retail price	615	470	545	400	585	524
Total taxation by product	244.24	51.89	98.45	78.97	162.05	103.69
in % of the retail price	0.40	0.11	0.18	0.20	0.28	0.20
	m3	m3	m3	tons	tons	tons
Consumption (est.)	144,011	101,751	593,995	34,583	7,954	7,954
			(billions of CFAF)			
Fiscal revenue by product	35.2	5.3	58.5	2.7	1.3	0.8
Total fiscal revenue						103.8
Memorandum						
CFAF/US$ exchange rate used by refinery	496.40	496.40	496.40	496.40	496.40	496.40

Source: Ivoirien authorities and IMF staff estimates.
1/ Price structure as of April 2007.
2/ Import tax (10 or 5 percent of tax base, depending on fuel), specific tax (e.g. 156 CFAF/L for super, 37 CFAF/L for diesel) and statistics tax

Electricity

37. The Ivoirien electricity sector accounts for 2 ½ percent of GDP (Table 8) and comprises six hydropower and three thermal power plants. The physical production of electricity from gas is carried out by the independent power producers (IPPs). *Compagnie ivoirienne d'éléctricité* (CIE) produces electricity from liquid combustibles and hydropower, but not from gas, and, being the main operator of the country's power grid and electricity distribution, buys electricity from the IPPs. The regulatory authority

Societé de gestion du patrimoine du secteur de l'éléctricité (SOGEPE) supervises the process in which the government swaps its crude oil for gas and sells its gas to the electricity sector. Electricity tariffs are set by the government.

38. Côte d'Ivoire produces more electricity than it consumes domestically and exports electricity to neighboring countries. Despite rising energy costs worldwide, electricity tariffs remained unchanged between 2002 and 2007. While domestic electricity consumption is subject to VAT, exports are not taxed. Table 8 gives an overview of electricity production, consumption and exports, representing equations (15) and (16).

Table 8. Côte d'Ivoire: Selected Electricity Sector Indicators

	2002	2003	2004	2005	2006	2007 Est.
Quantities						
Input of gas (millions of MMBTU)	43.0	39.2	43.9	49.6	48.5	49.2
Productions of electricity from gas (GW/h)	3,554.5	3,241.3	3,629.6	4,104.2	4,006.3	3,686.0
Production of electricity from water (GWh)	1,721.7	1,823.1	1,739.9	1,425.0	1,502.3	1,789.6
Total electricity production (GWh)	5,276.2	5,064.4	5,369.5	5,529.2	5,508.6	5,475.6
Technical losses (GWh) 1/	177.7	162.1	181.5	246.3	280.4	294.9
Non-technical losses incl. theft (GWh)	595.1	884.6	662.2	807.6	892.2	950.8
Domestic consumption (GWh)	2,934.8	2,693.1	3,106.3	3,080.0	3,273.0	3,457.4
Exports (GWh)	1,568.6	1,324.6	1,419.5	1,395.3	1,063.0	772.5
Selected financial data						
Electricity tariffs (CFAF/KWh)						
Average national price	53.0	53.0	53.0	53.0	53.0	53.0
VAT rate applicable to average national price (%)	20.0	20.0	20.0	18.0	18.0	18.0
Average national price incl. VAT	63.6	63.6	63.6	62.5	62.5	62.5
Export price	34.0	34.0	34.0	34.0	34.0	34.0
Value of total electricity production (bln CFAF) 2/	240.0	216.3	245.8	240.1	240.8	242.5
Value of domestic electricity consumption (bln CFAF) 3/	186.7	171.3	197.6	192.6	204.7	216.2
Value of electricity exports (bln CFAF)	53.3	45.0	48.3	47.4	36.1	26.3
Total government revenue from electricity sector (bln CFAF	26.4	24.3	28.0	25.0	26.5	28.0
VAT revenue	26.4	24.3	28.0	25.0	26.5	28.0
Profits	0.0	0.0	0.0	0.0	0.0	0.0
Memorandum						
Nominal GDP (billions of FCFA)	8,006.1	7,984.3	8,178.5	8,621.2	9,029.2	9,379.3
Of which: electric energy value added	182.5	179.0	190.4	219.0	221.8	221.3
in percent of nominal GDP	2.3	2.2	2.3	2.5	2.5	2.4

Source: Ivoirien authorities and IMF staff estimates.
1/ Estimated at 5% of total production.
2/ Excluding technical and non-technical losses.
3/ Including VAT.

39. In the recent past, substantial cross arrears have emerged in the electricity sector. While CIE continued to provide electricity to the rebel-held north of the country, it

received no payments for this provision. Bill recovery in the south is also weak, and unlawful electrical wiring continues to be a important source of revenue loss. Moreover, the public sector (central government, public enterprises, hospitals and other public institutions) in recent years has not paid fully its electricity bills to the electricity companies. At the same time, the electricity sector has not paid for the gas it receives from the government. The government, in turn, did not disburse VAT refunds to the electricity sector. Foreign consumers are also in arrears to CIE. In 2007, the government and the CIE signed a convention in which both sides agreed to forgive the accumulated arrears of the other side and to settle the remaining amounts. They also agreed to start honoring their mutual obligations again. However, the government will subsidize the energy sector by giving it part of its gas for free. Despite these measures, the sector is underfunded and the infrastructure is neither properly maintained nor sufficiently enhanced to cope with rinsing demand. Consequently, investments need to take place urgently.

E. Some International Comparisons

40. As Table 9 shows, Côte d'Ivoire is a relatively small producer of crude oil when compared to other oil-producing countries in Sub-Saharan Africa. Once natural gas production is included, the picture changes somewhat, with the value of total crude oil and natural gas production in US dollars approaching Cameroon's level until 2007, when the above-mentioned technical exploration problems set in. While rising, the share of the Ivoirien oil and gas sector's value added in total GDP will remain the lowest among the countries included in Table 9, reflecting also the relatively well-diversified Ivoirien economy. Total government revenue from oil and gas is low compared to the other countries considered in Table 9. Expressed in percent of the total value of crude oil and natural gas production, Côte d'Ivoire's total government revenues from oil and gas are far lower than those of its peers, indicating that Côte d'Ivoire could reap greater revenue from its hydrocarbon activities.

Table 9. Côte d'Ivoire: International Comparison of Crude Oil and Natural Gas Production and Fiscal Revenue

	2003	2004	2005	2006	2007 Est.
Total crude oil production (millions of barrels)					
Angola	314.9	356.0	448.8	513.8	618.0
Cameroon	35.6	32.7	30.1	31.9	31.2
Chad	24.4	63.4	62.9	56.7	52.4
Congo, Republic of 1/	81.6	82.1	92.6	98.8	97.2
Côte d'Ivoire	7.6	7.8	14.5	22.2	17.4
Equatorial Guinea	95.1	128.9	133.1	119.4	122.2
Gabon	98.1	98.4	97.1	87.1	88.5
Nigeria 2/	895.3	913.4	915.7	861.6	807.9
Total natural gas production (millions of barrels of oil equivalent)					
Angola	...	...	...	...	...
Cameroon	...	...	...	...	...
Chad	...	...	...	...	...
Congo, Republic of 1/ 3/	3.3	2.8	2.8	3.1	2.9
Côte d'Ivoire	8.3	9.5	8.7	9.9	9.1
Equatorial Guinea	8.3	10.5	13.8	14.1	26.8
Gabon	...	...	...	...	...
Nigeria 4/	122.2	146.5	185.4	211.8	257.2
Value of total crude oil and natural gas production (millions of US$) 5/					
Angola	8,884	12,857	22,422	31,525	41,431
Cameroon	949	1,155	1,492	1,965	2,173
Chad	670	1,791	2,681	2,964	3,132
Congo, Republic of 1/	2,336	2,844	4,499	5,978	4,523
Côte d'Ivoire	331	437	893	1,641	1,280
Equatorial Guinea	2,780	4,697	7,244	8,048	10,005
Gabon	2,706	3,518	4,904	5,248	6,161
Nigeria 4/	26,826	36,272	52,420	57,467	62,096
Share of oil and gas sector value added in GDP (%)					
Angola	...	...	62.0	59.3	55.3
Cameroon	6.1	6.5	8.4	10.2	9.6
Chad	8.7	44.3	40.4	34.8	31.1
Congo, Republic of 1/	50.0	52.5	60.4	64.9	54.1
Côte d'Ivoire	1.1	1.4	2.7	3.9	3.3
Equatorial Guinea	80.0	81.8	79.1	75.2	68.4
Gabon	42.2	44.9	51.8	51.5	49.9
Nigeria 4/	31.4	36.4	38.4	37.3	34.1
Total government revenues from oil and gas 6/					
in millions of US$ 5/					
Angola	3,892	5,624	9,891	16,807	22,424
Cameroon	561	616	833	1,229	1,440
Chad	0	125	248	772	1,182
Congo, Republic of 1/	727	1,005	1,937	2,930	2,115
Côte d'Ivoire	75	94	191	289	341
Equatorial Guinea	660	1,339	2,521	3,330	3,970
Gabon	1,007	1,244	1,723	1,939	2,003
Nigeria	16,093	24,988	36,249	42,746	36,605
in percent of total government revenues excl. grants					
Angola	73.5	74.8	79.4	80.2	81.0
Cameroon	25.5	25.7	28.5	35.5	33.8
Chad	0.0	33.3	45.0	72.3	73.7
Congo, Republic of 1/	69.8	71.9	82.3	85.2	79.8
Côte d'Ivoire	3.2	3.5	6.8	9.0	9.0
Equatorial Guinea	81.4	85.8	88.4	85.1	82.4
Gabon	54.9	56.2	63.3	64.0	58.6
Nigeria	75.4	81.3	85.1	85.9	77.0
in percent of total value of crude oil and natural gas production					
Angola	43.8	43.7	44.1	53.3	54.1
Cameroon	59.2	53.3	55.8	62.6	66.3
Chad	0.0	7.0	9.2	26.1	37.7
Congo, Republic of 1/	31.1	35.3	43.1	49.0	46.8
Côte d'Ivoire	22.6	21.6	21.3	17.6	26.6
Equatorial Guinea	23.7	28.5	34.8	41.4	39.7
Gabon	37.2	35.4	35.1	36.9	32.5
Nigeria	60.0	68.9	69.1	74.4	58.9

Source: National authorities; and IMF staff estimates.

1/ 2006-07 data for Republic of Congo is tentative.

2/ Liftings, includes condensates.

3/ Includes gas and derivatives (Methanol, LPG, Butane, Propane, and LNG).

4/ Excludes reinjection and flaring. Evaluation of 2007 gas production is tentative.

5/ Production quantities valued at export prices. Domestic currency conversion at period average exchange rates.

6/ Including royalties, production or concession fees, value of oil and gas from production sharing agreements accruing to government, oil/gas sector specific taxes on companies' turnover or profit; excluding share of profits of oil companies in which government has a share.

Table 10. Côte d'Ivoire: International Comparison of Prices and Taxation of Petroleum Products in 2006
(in US$ unless otherwise indicated)

	Côte d'Ivoire	Ghana	Senegal	Mali	Burkina Faso
Super Unleaded					
Pre tax price	0.66	0.43	0.53	0.77	0.77
Taxation 2/	0.51	0.42	0.58	0.40	0.47
Retail price	1.18	0.85	1.11	1.18	1.23
Diesel					
Pre tax price	0.81	0.52	0.64	0.81	0.78
Taxation 2/	0.24	0.31	0.36	0.19	0.31
Retail price	1.04	0.83	1.00	1.00	1.09
Kerosene					
Pre tax price	0.75	0.54	...	0.70	0.83
Taxation	0.15	0.19	...	0.14	0.04
Retail price	0.90	0.73	0.75	0.84	0.87
Fiscal revenue from petroleum products taxation 1	1.15	3.50	3.20	3.00	1.43
Memorandum					
Domestic currency units per US$	522.40	9174	522.40	522.40	522.40

Source: National authorities and IMF staff estimates.

1/ In percent of GDP. 2005 for Mali and Burkina Faso.
2/ Taxation levels for Senegal from 2005 data.

41. Table 10 compares prices and taxation of petroleum products internationally.[7] It shows that the retail price of both Super and Diesel is higher in Côte d'Ivoire than the average of the other countries shown, and the price of Kerosene is the highest among the countries considered. Tax revenue from petroleum products taxation is lower in Côte d'Ivoire than in the other countries, suggesting the need to improve revenue collection. Since taxation per liter is broadly in line with the other countries and since retail prices are already high, the only way other than improved collection to increase fiscal revenue would be to increase tax rates at the expense of the other factors driving the retail price, e.g. in particular by reducing the price buffer, protection, subsidy, distributor's and retailer's margins described above.

42. Table 11 compares electricity prices in the subregion in 2007. As is evident from this table, Côte d'Ivoire has, on average, the lowest tariffs in the region. Given that the Ivoirien electricity sector does not appear to be more cost effective than the other sectors in the region and in light of the Ivoirien sector's financial difficulties, this underscores the need for Côte d'Ivoire to increase its tariffs to extract more revenue to invest in the ailing sector.

[7] For a discussion of the pass-through of higher oil prices to domestic prices, see IMF (2006a, p. 11, 2006b, p. 23n, and 2008, p. 17).

Table 11. International comparison of average electricity tariffs (in FCFA)

	Benin	Burkina Faso	Côte d'Ivoire	Guinea-Bissau	Mali	Niger	Senegal	Togo
Household tariff 1/	60.5	127.3	41.4	...	87.2	...	...	51.9
Social tariff 1/	50.6	108.4	24.3	...	72.1	...	...	51.3
Industrial tariff 1/	54.5	103.0	26.9	...	88.1	...	...	53.2
Low tension 2/	93.3	86.0	61.2	175.0	59.4	96.4	83.8	65.8
Medium tension 2/	63.3	121.0	51.9	115.0	88.0	79.9	78.5	63.3

1/ Source: World Bank (2007 tariffs, except Burkina Faso, 2006)
2/ Source: *BCEAO, Rapport sur la compétitivité des économies des États menbres de l'UEMOA en 2005 (2006 tariffs)*

F. Implications for Improving Transparency, Efficiency, and Fiscal Sustainability

Transparency

43. It has been argued that natural resource abundance creates opportunities for rent-seeking behavior and is conducive to a high level of corruption.[8] While Côte d'Ivoire joined the Extractive Industries Transparency Initiative (EITI) in May 2006 and became an EITI candidate country in May 2008, further improvements in the transparency and accuracy of reporting on the Ivoirien energy sector would be welcome.

44. The present model offers some tools to assess transparency issues. First, it enables tracing physical and financial flows and to identify discrepancies. Second, the framework could be used to forecast these flows; discrepancies between the model's forecast and the numbers actually recorded could then be attributed to a lack of fit of the model – or to a lack of transparency . Third, this data could be used to inform government decision making. Finally, making such a framework available to the public would underscore the government's stated commitment to transparency, in particular if the authorities used its publication to explain discrepancies between projections and results, thereby addressing head-on any concern about the diversion of resources.

45. Table 12 compares the model's revenue estimates with the revenues actually recorded or projected in the budget. For government revenue from petroleum products taxation, the comparison shows that discrepancies decline over time. The model continues to project higher direct government revenue from oil and gas than the budget, pointing to the need to further reconcile the underlying price assumptions, but also to the need for better revenue recovery.

Efficiency

46. Once West Africa's economic powerhouse, Côte d'Ivoire has lost substantial ground to its regional competitors because of political instability and civil conflict.

[8] See e.g., Leite and Weidmann (1999) for a theoretical model with empirical application and a survey of the literature.

Furthermore, Côte d'Ivoire ranked 141 out of 175 countries in the World Bank's Cost of Doing Business Index in 2006.

Table 12. Côte d'Ivoire: Model versus Budget Figures of Energy Sector Revenue
(in billions of CFA francs unless otherwise noted)

	2005	2006	2007 Est.	2008 Proj.
Government direct revenue from crude oil and natural gas 1/				
Model	100.3	151.0	163.3	270.4
Budget	75.8	137.5	133.7	220.0
Difference to model in %	-24.5	-8.9	-18.1	-18.6
Government revenue from petroleum products taxation				
Model	107.7	102.3	103.8	119.5
Budget	77.0	82.2	93.4	120.0
Difference to model in %	-28.5	-19.6	-10.0	0.4

Source: Ivoirien authorities and IMF staff estimates.
1/ Excluding cost of swap, excluding profits of Petroci.

47. The Ivoirien energy sector is not immune to these trends. However, since most oil and gas production takes place offshore and with the involvement of foreign companies, technical efficiency is close to industry standards, but could be improved further. Since part of the exploration takes place in deep water, even the most efficient production structure involves high costs. Going forward, assuring an efficient allocation of resources would involve awarding exploration rights to the highest bidders in a transparent way. As concerns SIR, the large share of capital in private hands has assured a relatively high level of efficiency, although the refinery still enjoys protection.

48. The biggest efficiency problems are in the electricity subsector. Despite rising fuel costs, electricity tariffs have been increased at the beginning of 2008 for the first time since July 2001. But even with this increase, the current price structure does not yield sufficient revenue to sustain operations. The subsector suffers from under-investment in maintenance, in more efficient technologies and in additional hydropower plants, from high technical and non-technical losses, a lack of cost recovery due to a lack of payments from the north and low payment morale in the south, a shortage of natural gas, and wasteful use of energy due to low electricity prices. At the same time, domestic electricity consumption increases strongly so that domestic production might soon be too low to satisfy domestic, let alone external demand.

49. Unless a major turnaround is achieved soon, the reliability of electricity provision might be at stake. The remedial measures are to improve revenue collection in all parts of the country, step up maintenance of the existing infrastructure, rehabilitate infrastructure that has been destroyed by the civil conflict and invest to improve the current technology and to build new power plants. With the implementation of these measures, Côte d'Ivoire could safeguard its position as a major regional supplier of electricity at a time when

demand for electricity is set to grow significantly and the Ivoirien energy sector is challenged by foreign competition in connection with the emergence of the West African Power Pool. The next section will investigate the impact of improved energy sector efficiency on fiscal revenue and growth.

Fiscal sustainability

50. There is a large and growing body of economic literature on assessing fiscal sustainability in natural resource-rich countries.[9] A key consideration in many of these studies is an adaptation of the permanent income hypothesis[10] to the management of natural resource wealth.[11] While a fully-fledged fiscal sustainability analysis of Côte d'Ivoire's oil and gas policies is beyond the scope of this paper, some general observations are offered.

51. First, it should be pointed out that the present paper analyzes the energy sector in its entirety, i.e., including petroleum products and electricity. The latter two activities are not subject to exhaustible resource considerations. Second, when deriving the optimal fiscal policy under the permanent income hypothesis for a country like Côte d'Ivoire, emerging from civil conflict and with a huge reconstruction need, it should be kept in mind that the (social) discount rate might be much higher than the rate of return on saved oil wealth. Due consideration should be given to Davoodi (2002) who points out: "A main lesson of economic theory is that ... given the low initial capital stock of a typical low-income, resource-rich country, earlier generations should use up the natural resource quite fast, while building the capital stock in turn (Solow, 1974; Stiglitz 1974)."

52. Against this backdrop, the focus in the case of Côte d'Ivoire may be less on intergenerational equity regarding energy sector revenue than on maximization of this revenue to assure that the subsectors contribute adequately to fiscal revenue. Increasing revenue could be done directly or indirectly. Direct measures would consist of raising tax rates, increasing the tax base and improving revenue collection. Indirect measures consist of improving the efficiency of the energy sector and hence its overall output, thus increasing the tax base in particular, and GDP growth in general.

53. Direct measures would differ across subsectors. Since no taxes are levied on oil and gas extraction, the only source of government revenue from this activity is through the PSAs. As existing PSAs are hard to change, reforming the way new contracts are bid for and concluded is the only way to assure that revenue is adequate by international standards. As regards petroleum products, adequate revenue could be secured both through an appropriate level of taxation, with a view to levels of taxation in neighboring countries, and through better control of taxable volumes. In the electricity sector, further

[9] See for example Davoodi (2002), Katz et al. (2004), Leigh and Olters (2006) and Segura (2006).

[10] For a general presentation, see Blanchard and Fischer (1989), p. 285n.

[11] Another channel through which richness in natural resources could affect fiscal sustainability is growth. See Bhattacharya and Ghura (2006) for an analysis for the Republic of Congo.

tariff increases and better revenue collection would reduce the deficit of the electricity sector and hence enable the government to phase out its subsidization of the sector.

Table 13. Côte d'Ivoire: The impact of improved energy sector efficiency on fiscal revenue

	Oil and gas Simulation A 1/	Refinery Simulation B 2/	Electricity Simulation C 3/	Total sector Simulation D 4/
Fiscal revenue 5/				
2008				
Current projection (bln CFAF)	1960.5	1960.5	1960.5	1960.5
Simulation (bln CFAF)	1971.5	1972.5	1966.6	1989.6
Absolute change (bln CFAF)	11.0	12.0	6.1	29.1
Change in percent	0.6	0.6	0.3	1.5
2009				
Current projection (bln CFAF)	2159.6	2159.6	2159.6	2159.6
Simulation (bln CFAF)	2231.5	2184.1	2168.5	2265.0
Absolute change (bln CFAF)	71.9	24.5	8.9	105.4
Change in percent	3.3	1.1	0.4	4.9
2010				
Current projection (bln CFAF)	2388.8	2388.8	2388.8	2388.8
Simulation (bln CFAF)	2500.3	2429.6	2404.5	2557.1
Absolute change (bln CFAF)	111.5	40.9	15.7	168.3
Change in percent	4.7	1.7	0.7	7.0
Real GDP growth				
2008				
Current projection (in %)	2.9	2.9	2.9	2.9
Simulation (in %)	3.1	3.1	3.2	3.6
Change in %-points	0.2	0.2	0.2	0.7
2009				
Current projection (in %)	5.1	5.1	5.1	5.1
Simulation (in %)	5.5	5.4	5.4	6.0
Change in %-points	0.4	0.2	0.3	0.9
2010				
Current projection (in %)	5.6	5.6	5.6	5.6
Simulation (in %)	5.9	5.9	5.9	6.4
Change in %-points	0.3	0.3	0.3	0.8
Buoyancy 6/				
2008	1.4	2.0	1.4	1.6
2009	3.2	1.9	0.9	2.3
2010	3.2	1.9	0.9	2.3

Source: Ivoirien authorities and IMF staff estimates.
1/ 10% increase in oil&gas production over baseline in 2008-10.
2/ 10% increase in petroleum products production over baseline in 2008-10.
3/ 10% increase in electricity production over baseline in 2008-10.
4/ Combination of simulations A-C.
5/ Excluding grants.
6/ Buoyancy defined as the percentage change in overall fiscal revenue due to the respective simulation divided by the percentage change nominal GDP due to the respective simulation.

54. To gauge the effects of indirect measures to increase revenue, i.e., efficiency enhancing reforms that increase sectoral output, Table 13 presents the results of four

simulations. Simulation A assumes that real crude oil and natural gas production will be ten percent higher than in the baseline scenario in 2008, will grow a further ten percent over the previous year's simulated production in 2009, and again in 2010. Simulation B assumes that real refinery output growth will be ten percentage points higher than in the baseline scenario each year between 2008 and 2010. Simulation C assumes that real electricity production growth will be ten percentage points higher than in the baseline scenario each year between 2008 and 2010. Simulation D combines these three simulations.

55. As Table 13 shows, fiscal revenue reacts strongest to increases in oil and gas production. The low increase in fiscal revenue for simulation C reflects the above-mentioned taxation problems in the electricity sector. By contrast, the impact of all scenarios on real GDP growth is largely uniform.

G. Conclusion

56. This paper presents a general framework to analyze energy sectors and applies it to Côte d'Ivoire. The analysis shows that Côte d'Ivoire's energy sector has significant potential and could remain an important source of growth. This is not only because of crude oil and natural gas production, but also because Côte d'Ivoire is well placed to produce, for both domestic consumption and exports, higher value-added products like petroleum products and electricity. Enhancing the efficiency of the management of the three subsectors, particularly the electricity sector, is hence crucially important for increasing Côte d'Ivoire's growth potential. Enhancing its transparency is imperative for the attraction of urgently needed foreign direct investment and donor assistance to develop the sector.

57. International comparison has shown that the energy sector in Côte d'Ivoire contributes much less to government revenue than in other countries in Sub-Saharan Africa and that there is scope for reforms such as negotiating more favorable production sharing agreements in the oil and gas subsector, improving revenue collection for electricity and petroleum products, and changing their price and tax structure to enhance revenue.

58. In conclusion, it should be noted that Côte d'Ivoire, while being an important energy producer and net exporter, is also a major exporter of cocoa and a variety of other agricultural products. It also has one of Africa's biggest ports. However, the energy sector offers significant potential for further growth, contributing to net exports and to ensuring adequate supply to the domestic economy.

59. The general framework in this paper is simple and broad enough to be applied to a variety of countries. One possible extension would be to model sectoral interlinkages using Input-Output tables as in Klueh et al. (2007). Another extension could consist of estimating the implicit and explicit subsidies in the sector to gauge the sector's distortions. International comparisons beyond those attempted in this paper could reveal further interesting similarities and differences, help identify best practices and thus inform the debate on how to most efficiently develop energy sectors.

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Appendix

Table A1. Côte d'Ivoire: Crude Oil and Natural Gas Production Shares

	2003	2004	2005	2006	2007 Est.
Total oil production (millions of barils)	7.613	7.814	14.471	22.194	17.430
Private sector before swap	5.322	5.465	11.248	17.746	13.755
Petroci before swap	0.924	0.949	1.193	1.788	1.537
Government before swap	1.368	1.401	2.031	2.660	2.138
Government after swap	0.0	0.0	1.1	1.6	2.7
Private sector and Petroci after swap	7.613	7.814	13.403	20.595	14.723
CI 11	1.175	1.199	1.127	0.871	0.752
Private sector before swap	0.376	0.384	0.361	0.279	0.241
Petroci before swap	0.094	0.096	0.090	0.070	0.060
Government before swap	0.705	0.719	0.676	0.523	0.451
Government after swap	0.000	0.000	0.000	0.000	0.000
Swap rate (MMBTU/bl)	12.721	16.493	23.129	22.601	19.688
Discount ($/bl)	1.0	1.0	1.0	1.3	-17.1
CI 26	6.439	6.616	6.590	10.433	9.452
Private sector before swap	4.946	5.081	5.062	8.014	7.260
Petroci before swap	0.830	0.853	0.849	1.345	1.218
Government before swap	0.663	0.681	0.679	1.075	0.974
Government after swap	0.000	0.000	0.478	0.705	2.142
Swap rate (MMBTU/bl)	5.870	7.386	7.638	8.836	8.421
Discount ($/bl)	-6.0	-6.0	-6.0	-2.3	-10.2
CI 27	0.000	0.000	0.202	0.188	0.167
Private sector before swap	0.000	0.000	0.085	0.079	0.070
Petroci before swap	0.000	0.000	0.057	0.053	0.047
Government before swap	0.000	0.000	0.061	0.056	0.050
Government after swap	0.000	0.000	0.000	0.000	0.000
Swap rate (MMBTU/bl)	6.733	8.357	8.769	10.463	9.269
Discount ($/bl)	-6.0	-6.0	-6.0	-1.0	-9.8
CI 40	0.000	0.000	6.553	10.703	7.060
Private sector before swap	0.000	0.000	5.740	9.375	6.185
Petroci before swap	0.000	0.000	0.197	0.321	0.212
Government before swap	0.000	0.000	0.616	1.006	0.664
Government after swap	0.000	0.000	0.590	0.894	0.566
Swap rate (MMBTU/bl)	8.805	12.215	18.213	22.988	20.387
Discount ($/bl)	-6.0	-6.0	-6.0	-4.5	-18.1
Total gas production (millions of MMBTU)	48.6	55.7	51.3	57.9	53.8
Private sector before swap	20.5	23.0	20.9	24.5	22.9
Petroci before swap	5.1	5.8	5.2	6.1	5.7
Government before swap	23.0	26.9	25.2	27.3	25.2
Government after swap	35.9	43.8	43.3	45.5	40.3
Private sector and Petroci after swap	12.7	11.9	7.9	12.4	13.5
CI 11	18.3	23.5	25.5	20.9	18.3
Private sector before swap	5.8	7.5	8.1	6.7	5.9
Petroci before swap	1.5	1.9	2.0	1.7	1.5
Government before swap	11.0	14.1	15.3	12.6	11.0
Government after swap	19.9	26.0	30.9	24.4	19.9
Discount ($/MMBTU)	-1.2	-1.5	-3.7	-5.5	-5.6
CI 26	4.8	5.1	2.1	3.3	3.8
Private sector before swap	1.5	1.6	0.7	1.0	1.2
Petroci before swap	0.4	0.4	0.2	0.3	0.3
Government before swap	2.9	3.0	1.3	2.0	2.3
Government after swap	6.8	8.1	2.8	5.2	6.1
Discount ($/MMBTU)	0.3	0.5	0.2	-1.3	-1.1
CI 27	25.6	27.1	23.2	31.2	29.6
Private sector before swap	13.1	13.9	11.9	16.0	15.2
Petroci before swap	3.3	3.5	3.0	4.0	3.8
Government before swap	9.2	9.8	8.4	11.2	10.7
Government after swap	9.2	9.8	8.9	11.8	11.1
Discount ($/MMBTU)	-0.2	0.0	-0.6	-2.1	-1.7
CI 40	0.0	0.0	0.5	2.6	2.0
Private sector before swap	0.0	0.0	0.2	0.8	0.6
Petroci before swap	0.0	0.0	0.0	0.2	0.2
Government before swap	0.0	0.0	0.3	1.5	1.2
Government after swap	0.0	0.0	0.8	4.1	3.2
Discount ($/MMBTU)	-1.0	-1.2	-3.4	-5.8	-5.7
Memorandum:					
Crude oil price (US$/bl, WEO)	28.9	37.8	53.4	64.3	71.1
Natural gas price (US$/MMBTU, WEO)	3.6	3.8	6.0	8.4	8.3
Implied WEO swap rate (MMBTU/bl)	8.1	9.9	8.9	7.7	8.6
Actual swap rate, weighted average (MMBTU/bl)	9.4	12.1	16.0	16.9	14.5
Exchange Rate CFAF/US$ (period average)	580.1	527.6	526.6	522.4	478.6

Source: Ivorien authorities and IMF staff estimates.