A USAID Research Funded Project

The Benefits to Mali from ECOWAS Collective Long-Term Electricity Capacity Expansion Planning

Brian H. Bowen
F.T. Sparrow

PURDUE UNIVERSITY
Power Pool Development Group

February 26, 2001

Summary

With no trade in electricity the total costs for Mali increase by 145%. When trade is encouraged then Mali avoids high fuel costs and the cost of unserved energy. Mali is one of the countries, of the ECOWAS region, that can make very large national savings from improved regional collective construction for electricity supply.

136MW of new hydropower and 63MW generation expansion on the existing thermal station capacity is added to the Mali system. There is a 330MW transmission capacity expansion on the line between Mali and Guinea.

This report is based on the February13, 2001, demonstration version of the ECOWAS regional electricity trade model. Parameter values come from the ECOWAS Data Set #4 (February 2001). The fixed cost of the new line to Guinea is by far the cheapest to build. The Mali forecast of 24% growth in the immediate future needs more careful attention.

1 Mali's Electricity Demand Forecast for 2001 to 2020

The level of electricity demand for Mali in 2001 is 78MW and has extremely high growth rates in the early years of 24% and then 6% in the rest of the planning horizon. There is a rapid rise in expansion to 250MW and then over 700MW is forecast for 2020. The 24% growth rate for the early years of expansion is a value that will require further confirmation. (Table 1).

Table 1 The Electricity Demand for Mali

Year	2005	2010	2015	2020
PEAK DEMAND (MW) (From input files)	250	384	539	721

2. Mali's Existing and Optimal Generation Capacities

Two expansion scenarios are considered. The first is with 50% autonomy factors for energy trade in MWh and trade of reserves in MW. Secondly the scenario is one of full autonomy with energy and power autonomy factors both set at 100%. Table 2 shows the existing generation capacity and Tables shows the

Table 2 The Existing and Proposed Generation Stations in Mali

Station Name	***MW***	***Station Type***	***Station Code #***
9. Mali – *Received Dec20, 2000*			
Darsalam1	10.0	PGO	Mal Stat1
Darsalam2	20.0	PGO	Mal Stat2
Balingue	18.0	PGO	Mal Stat3
Sotuba	5.4	H	Mal Stat1
Selingue	44.0	H	Mal Stat2
Manantali	200.0	H	Mal Stat3
Gouina	104.0	HN	Mal Stat1
Felou	105.0	HN	Mal Stat2
Petit Kenie	56.0	HN	Mal Stat3
Markala	5.2	HN	Mal Stat4

3. Mali's Capacity Expansions (least cost)

In both a free trade and limited trade environment Mali builds 63MW of expansion on the existing thermal capacity and 136MW of new hydropower expansion (Table 3). The new international transmission line to Guinea is to be constructed with a capacity of about 330MW. The cost data of the new lines to Mali needs careful validation as the country can make significant savings from importing electricity supplies. The model in this report contains four time periods (4 periods and 5 years per period gives the 20 year

planning horizon) with the demand growth in the first period set at 24%. With smaller time periods (two years or one year per period) then the demand growth will not be so dramatic at the start of the planning horizon. When the ECOWAS data is further improved then the greater number of time periods will be justifiable.

The bulk of Mali's new international transmission line capacity is constructed during the 2016 to 2020 period.

Table 3 Mali Optimal Generation Expansions for 2001 to 2020

	AFs = 0.5	**AFs = 1.0**
Old Thermal station expansion (MW)	63 (2011-15)	63 (2011-15)
New Hydropower Expansion (MW)	132 (2001-15)	136 (2001-15)
Existing hydropower Expansion (MW)	6 (2011-15)	6 (2011-15)
New transmission expansions, Mal-Gui, (MW)	304 (2005-2020)	330 (2005-20)
Unserved Energy (MWh)	0	703431 (2016-20)

4. Mali's Capacity Expansion Costs

About 1% of the ECOWAS region total expansion cost is accounted for with the Mali expansion and operational costs for 2001 to 2020. The cost of fuel and unserved energy causes the total electricity costs, to Mali, to more than double when trade in electricity is severely restricted (Table 4).

Table 4 Mali's Expansion Costs for the Period 2001 to 2020

COSTS (FpNCC = $3.2 per 10^6Btu)	**AFs = 0.5**	**AFs = 1.0**
ECOWAS Total Cost ($ $10^{6\ \text{present value}}$)	20,112.0	26,620.0
Mali's Total Cost ($ $10^{6\ \text{present value}}$)	192.7	473.2
Capital Cost of Existing hydropower expansion ($ $10^{6\ \text{present value}}$)	1.8	1.9
Capital Cost of New hydropower stations ($ $10^{6\ \text{present value}}$)	149.1	151.5
Expansion cost for new transmission capacity ($ $10^{6\ \text{present value}}$)	3.8	4.6
Water costs (existing & new hydro) ($ $10^{6\ \text{present value}}$)	6.2	6.4
Fuel costs (old thermal) ($ $10^{6\ \text{present value}}$)	0	120.9
Unserved Energy ($ $10^{6\ \text{present value}}$)	0	131.4

4. Electricity Trade (Energy MWh) and Mali

Mali is dependent upon electricity imports from Guinea. It is possible to force the optimization model to construct alternative international lines. In this case study no time constraints are being placed on the construction of new international lines. In the model Mali is given the choice to build from three proposed new international lines. These are:

Mali to Cote D'Ivoire, Fixed capital cost of $88 million
Mali to Guinea, Fixed capital cost of $53 million
Mali to Senegal, Fixed capital cost of $111 million

The Guinea line is selected for the least cost optimization and imports into Mali 11,028GWh in the 2011 to 2020 time period (Table 5) when free trade is allowed.

Table 5 Electricity Trade (Energy GWh total) for Mali 2001 - 2020

	AFs = 0.5	**AFs = 1.0**
Electricity Exports (GWh)		
To: Guinea	448.6 (2006-2015)	0
To: Cote D'Ivoire	13.6 (2006-2010)	
Electricity Imports (GWh)		
From: Guinea	11,028.6 (2011-2020)	0
From: Cote D'Ioire	1.7 (2011-2015)	

s

Appendix I

Table (A)1 Existing ECOWAS Thermal Stations

Station Name	Station Code #	PGOinit (MW)	Oexpcost ($/MW)	PGOexpstep (MW)	PGOmax (MW)	FORPGO (%)	UFORPGO (%)	Crfi (%/yr)	VarOM0 ($/MWh)	HRO 10^6Btu/ MWh
Mali *Received Dec20, 2000*										
Darsalam1	Mal Stat1	10.0	541,667	10	20	0.05	0.10	0.1627	125	1
Darsalam2	Mal Stat2	20.0	708,333	25	25	0.02	0.03	0.1627	3.33	1
Balingue	Mal Stat3	18.0	442,094	6	18	0.04	0.08	0.1627	7.09	1

Table (A)1 (Continued) Existing ECOWAS Thermal Stations

Station Name	Station Code #	Fuel cost FpO ($/MWh)	Fuel escalation (fpescO (%/yr)	Decay rate (%/yr)	Min usage Pgmin (MWh/yr)	Forced decommissioning (AT period ty)
Mali						
Darsalam1	Mal Stat1	93.33	1.02	0.001	3100	2005
Darsalam2	Mal Stat2	108.33	1.02	0.008	-	2015
Balingue	Mal Stat3	78.89	1.02	0.001	-	2015

Table (B)1 Existing ECOWAS Hydropower Stations

Station Name	Existing hydro Station code #	Hoinit (MW)	HOVcost ($/MW)	Hoexpstep (MW)	HOVmax (MW)	HOLF (MWH/yr)	FORoh (%/yr)	Crfih (%/yr)	VarOMoh ($/MWh)
Mali *Received Dec20, 2000*									
Sotuba	Mal Stat 1	5.4	1 000 000*	6	6	39 000	0.01	0.1315	31.25
Selingue	Mal Stat 2	44.0	0	0	0	180 000	0.01	0	36.67
Manantali	Mal Stat 3	200.0	0	0	0	807 000	0.0114	0	0.2*

Table (B)1 (Continued) Existing ECOWAS Hydropower Stations

Station Name	Existing hydro Station #	DecayHO (%/yr)	Reshyd (%)	MinH (MWh/yr)	FdecomH (Period)
9. Mali					
Sotuba	Mal Stat 1	0.001	0.1*	29 000	-
Selingue	Mal Stat 2	0.001	0.1	130 000	-
Manantali	Mal Stat 3	0.001	0.1*	360 000	-

Table (B)2 Proposed/New ECOWAS Hydropower Stations

Station Name	Existing hydro Station code #	HNinit (MW)	HNFcost ($)	HNVcost ($/MW)	HNVmax (MW)	HNexpstep (MW)	HNLF (MWh/yr)	FORNH (%)	Crfnh (%/yr)
Mali *Received Dec20, 2000*									
Gouina	Mal Stat 1	104.0	189 258 333	0	0	0	461 000	0.01	0.1315
Felou	Mal Stat 2	105.0	205 933 350	0	0	0	494 000	0.01	0.1315
Petit Kenie	Mal Stat 3	56.0	75 861 667	0	0	0	188 400	0.01	0.1315
Markala	Mal Stat 4	5.2	36 245 000	0	0	0	33 000	0.01	0.1315

Table (B)2 (Continued) Proposed/New ECOWAS Hydropower Stations

Station Name	Existing hydro Station code #	FixOMnh ($/yr)	VarOMnh ($/MWh)	DecayHN (%/yr)	AtHn (Period)	BefHN (Period)	AftHN (Period)	MinHN (MWH/yr)
Mali								
Gouina	Mal Stat 1	1 892 583	0.2*	0.001	-	-	-	315 000
Felou	Mal Stat 2	2 059 334	0.2*	0.001	-	-	-	347 000
Petit Kenie	Mal Stat 3	1 517 233	0.2*	0.001	-	-	-	0
Markala	Mal Stat 4	724 900	0.2*	0.001	-	-	-	28 000