Reliability and Free Trading in the ECOWAS Electricity Generation Capacity Expansions Plans for 2002 to2012

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Summary

September 7th to 21st was the period of a two-week training workshop held at the Purdue University, Indiana, USA. The workshop centered around training in the use of the Purdue least cost optimization model for the West African Power Pool developed by Purdue's Power Pool Development Group (PPDG) at the Institute of Interdisciplinary Engineering headed by Professor Tom Sparrow. The model captures the dynamic interactions between electricity demand and supply and the operational (generation and capacity expansion) constraints associated with it, optimizing this interaction to produce a least cost model for given demand/supply scenarios. Adequate training materials were provided and support by members of faculty.

The Purdue least cost optimization model has been used to demonstrate the benefits of a regional Power Pool with free trade amongst member states. Whilst this is the ideal situation, member states must decide on a uniform measure of autonomy, as the degree of autonomy affects the outcome of the Purdue least cost optimization module as shown below:

Table1. Total Costs in WAPP for 2002 to 2012 with Reliability & Free Trade

Thermal & Hydro Reserve Margins	*WAPP Total Cost Free Trade ($ million)*	*WAPP Total Cost & Independence ($ million)*	*Percentage Cost Savings with Free Trade*
0%	7904	9288	14.9%
5%	7924	9394	15.6%
10%	7949	9524	16.5%
20%	8060	9990	19.3%
Difference 0% - 20%	2%	7.6%	

There is only a 2% increase in the investment value to guarantee a 20% reserve margin in the free trade scenario as opposed to a 7.6% increase in investment to guarantee the same reserve margin the independent scenario.

There is a great cost savings in the free trade scenario ranging from $1.3 billion to $1.93 billion with corresponding reserve margins ranging from 0-20% in steps of 5%, **the costs savings between free trade and no reserve margins and total independence (self sufficiency) with no reserve margins pays for more than seven times the increase in the investment necessary to guarantee a 20% reserve margin in a free trade scenario**. It is interesting to note that with all the high investment costs in the independent scenario, the power generated is still much less than that generated under the free trade scenario.

This cost summary also includes the costs for building "minor" power plants whose generative capacities will not be measure up to 1MW but is economical to be produced in certain countries. There are a number of facilities that would make this economic model more realistic in operation all such recommendations at end of this report **It is important to know that the figures in this report is based on the ECOWAS data set #5**

Background & WAPP Data

In the light of the shortage in power generation and supply and as part of its efforts to foster economic growth and stability in West Africa, the Economic Community of West African State has identified a regional Power pool as a means of generating cheap electricity, promoting trade and reducing investment costs of power generation in the region. Of course project such as this requires adequate planning and serious commitment on the part of the stake holders, and so after several meetings and delegations involving various representatives of ECOWAS governments a memorandum of understanding was agreed to which birthed the West African Power Pool (WAPP).

The modeling work for this power pool has been undertaken by the power pool development group (PPDG) of the Purdue University, USA for the past two years. Data collection plays an important role in this modeling exercise, training exercises in data collection were conducted in West Africa in preparing the ground work for a realistic model which enhances proper economic evaluation of energy needs in the region, Data set# 5 has been compiled and sent to the regions and presently work is going on Data set# 6 which will be ready January 2003.

The training workshop held at Purdue University centers on the use of the economic model based on the data from the ECOWAS data set# 5, the model has a newly designed user interface which makes operating the model easier to operate and interpret. The first week of training involves the economic theories and assumptions that forms the basis of the model, starting with a static model and then progressively going on to the dynamic models and finally a complete model which puts into consideration all constraints (physical and economic) that affect Power generation, expansion and transmission in the region.

Policy and economic issues that affect the results of the model were discussed, issues such as wheeling charges, cost of unserved energy and unserved megawatts, demand growth rate, firm imports and exports and autonomy factor as such the importance of quality data cannot be overemphasized. All costs are discounted at present at a discounted rate of 10% and this must be looked at critically in light of each member state as opposed to the whole region

Table 2. WAPP Generation Capacity Expansions with Reliability & Free Trade

Thermal & Hydro Reserve Margins	*WAPP Total Capacity Expansions with Free Trade (MW)*	*WAPP Total Capacity Expansions with Independence (MW)*
5%	**Total 8395** Thermal 7096 Hydro 1299	**Total 8064** Thermal 7004 Hydro 1060
10%	**Total 8911** Thermal 7110 Hydro 1301	**Total 8179** Thermal 7011 Hydro 1168
20%	**Total 8914** Thermal 7441 Hydro 1473	**Total 8783** Thermal 7172 Hydro 1611

Tables 1 and 2 above, shows the difference in the results of having free trade and no trade in the region, trade in the region allows countries that have cheap generating costs and enough capacities to expand. This enables serving the demands of requiring member states thereby cutting the costs that would have been incurred by the requiring state in self generation.
While an autonomy factor of 0 would be ideal an agreeable autonomy factor must be fixed/ arrived at such that planning of power generation will be at the least cost to the region.

Periodic Thermal & Hydropower Generation Capacity Expansions from 2002 to 2012

Table 3. Thermal & Hydropower Generation Expansions for 2002 to 2012 & Free Trade

Reserve Margins	*Period 1 2003-4*	*Period 2 2005-6*	*Period 3 2007-8*	*Period 4 2009-10*	*Period 5 2011-12*	*TOTALS*
5%						
Thermal (MW)	1758	3001	655	746	936	7096
Hydro (MW)	263	391	248	235	162	1299
TOTAL (MW)	2021	3392	903	981	1098	**8395**
10%						
Thermal (MW)	1771	3001	655	746	937	7110
Hydro (MW)	261	409	235	235	161	1301
TOTAL (MW)	2032	3410	890	981	1098	**8411**
20%						
Thermal (MW)	1771	3002	670	738	1260	7441
Hydro (MW)	412	446	181	241	193	1473
TOTAL (MW)	2183	3448	851	979	1453	**8914**

Table 3 shows a break down of the generation expansions happening in a ten-year horizon for the region in free trade scenario. There is a marked reduction in generation in 3rd and 4th, periods, this period marks a time at which general demand is met in the region and as such not much energy generation is done. The difference in the total amounts of MW generated is the result of the difference In reserve margins.

Periodic National Generation Capacity Expansions from 2002 to 2012

Table 4. WAPP Generation Capacity Expansions (thermal & hydropower) with 5% Reserve Margins & Free Trade

Country	*Period 1 2003-4*	*Period 2 2005-6*	*Period 3 2007-8*	*Period 4 2009-10*	*Period 5 2011-12*	*TOTALS*
Benin					4	4
Burkina Faso						0
Cote D'Ivoire					247	247
Gambia						0
Ghana				115		115
Guinea	106	388	134	101	2	731
Guinea Bissau	15					15
Liberia	32	3	39	10		84
Mali			95			95
Niger	114				5	119
Nigeria	1736	3001	616	736	840	6929
Senegal	18		19			37
Sierra Leone						0
Togo				19		19
TOTALS	**2021**	**3392**	**903**	**981**	**1098**	8395

A breakdown of tables 4, 5 and 6 shows that most of the energy generated in the region comes from Nigeria due to the size of the capacity expansion that is underway, but it should be noted that it is important to update the Nigerian data so as to have a more accurate forecast for the capacity expansions that would be taking place in the region.

Table 5. WAPP Generation Capacity Expansions (thermal & hydropower) with 10% Reserve Margins & Free Trade

Country	*Period 1 2003-4*	*Period 2 2005-6*	*Period 3 2007-8*	*Period 4 2009-10*	*Period 5 2011-12*	*TOTALS*
Benin					4	4
Burkina Faso						0
Cote D'Ivoire					247	247
Gambia						0
Ghana				115		115
Guinea	121		116	101	2	340
Guinea Bissau	15					15
Liberia	32		39	10		81
Mali			95			95
Niger	110		5		4	119
Nigeria	1736	3001	616	736	841	6930
Senegal	18		19			37
Sierra Leone						0
Togo				19		19
TOTALS	**2032**	**3001**	**890**	**981**	**1098**	8002

Table 6. WAPP Generation Capacity Expansions (thermal & hydropower) with 20% Reserve Margins & Free Trade

Country	*Period 1 2003-4*	*Period 2 2005-6*	*Period 3 2007-8*	*Period 4 2009-10*	*Period 5 2011-12*	***TOTALS***
Benin					4	**4**
Burkina Faso						
Cote D'Ivoire					553	**553**
Gambia						
Ghana				115		**115**
Guinea	149	443	67	107	9	**775**
Guinea Bissau	15					**15**
Liberia	32	3	49		29	**113**
Mali			95			**95**
Niger	123					**123**
Nigeria	1846	3002	621	738	846	**7053**
Senegal	18		19		2	**39**
Sierra Leone					10	**10**
Togo				19		**19**
	2183	**3448**	**851**	**979**	**1453**	**8914**

Data Validity and Future Policy Scenario

It is important to stress what in this model that two commodities are being traded. The energy (MWh) and power reserve (MW). The tables below show the cost of the scarcity of these two commodities in the region. The initial costs are so high in the first three periods for the Unserved Energy because this a shortage of electricity generation in the region but as more plants are put into operation the energy demands are met. Capacity generation that will meet the demands in Nations like The Gambia, Burkina Faso and Sierra Leone should be looked at as the Model sees the option of generating electricity from these nations as costlier than other available options. (Tables 4, 5 and 6)

Table7. Unserved Energy, UE (MWh)
Cost of UE ($ millions)

	Reserve Margin	Period 1 2003/2004	Period 2 2005/2006	Period 3 2007/2008	Period 4 2009/2010	Period 5 2011/2012
Free Trade	5%	597	49	29	0	0
	20%	597	49	29	0	0
Independence	5%	958	49	42	36	37
	20%	958	49	42	36	37

Unserved energy occurs when the demand constraints is not satisfied. If the supply in a country does not meet demand the UE is produce. In the WAPP model **UE is priced at $140/MWh**

The costs associated with Unmet Megawatts are imposed due the reserve margin requirement set by each nation, and from the table below the higher the reserve margin set the more the generating capacity in the region must be.

Table8. Unmet Reserve Requirement, (Unserved MW)
Cost of UM ($ millions)

	Reserve Margin	Period 1 2003/2004	Period 2 2005/2006	Period 3 2007/2008	Period 4 2009/2010	Period 5 2011/2012
Free Trade	5%	53	46	36	0	0
	20%	63	55	37	0	0
Independence	5%	219	46	43	38	156
	20%	419	55	50	90	232

Unmet MW occurs when the reserve margin is not satisfied, UM do not occur in the WAPP model if reserve margin is set at zero. In the WAPP model **UM is priced at $2million/MW**

Recommendations

The recommendations for the WAPP model can be divide into three categories:

1. The modeling parameters
2. The model interface
3. WAPP Capacity Planning Group

1. **Modeling Parameters**

(a) A better model of the region will result from the provision of more nodes for each country within the region in order to represent the roles of IPPs and national utility urban and rural electricity generation and supplies.
(b) Allow for certain regional parameters to be country measures, site, year and wet and dry season (Wcost, water cost; fdrought, drought factor ; Resthm, reserve margin for thermal generation; ResHyd, reserve margin for hydropower generation ; UMcost, cost of unmet reserve ; UEcost, cost of unserved energy).
(c) Allow for the impact of various contracts with third parties providers of electricity services to WAPP (IPPs take or pay contracts, independent transmission providers).
(d) AF, UMcost and UEcost will have to be worked out to reflect the true situation in each country.
(e) The importance of data validation and update must be re-emphasized, as the more accurate and recent the information is the accurate and precise the model predicts results,
(f) Wheeling charges must be agreed to in such a way that all parties involved benefit from the energy trade, of course this will be reflected in the total cost for the region.

2. **User Interface**

(a) The cost summary screen for the WAPP interface should be checked to update data directly from the GAMS output files and possibly a proper financial report included.
(b) Provision can be made for zonal output report for zones A and B.
(c) The print screen facility for the output graphs to be worked on to print properly.
(d) Allow the number of WAPP nodes to be changed through the interface.
(e) Complete the online library documentation users.
(f) Include an interactive tutorial for general users.

3. **A WAPP "Capacity Planning Group**" (CPG) to work with Purdue University on the following tasks:

(a) Preparation of WAPP policy papers.
(b) Data collection.
(c) Regional training needs.
(d) Planning of meetings for coordination and collaboration with WAPP-CDG Purdue University Power Pool Development Group (PPDG) staff. The team of the Capacity Planning Group should include Sidy KANE (Zone A), Alpha SYLLA (Zone B), Olumuyiwa SHOKUNBI (ECOWAS secretariat), plus 2 or 3 other resource people.

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