1. Introduction:

- The primary reason for developing an electricity grid interconnection between countries is to reduce the overall combined economic costs of supplying electricity services in the interconnected countries as well as increase reliability.
- There are also potentially many indirect economic benefits of a grid interconnection for one or more of the countries involved, as well as potential indirect economic costs.
- “The pooling of resources and the interconnection of isolated electric power systems allow optimum use of available resources”.
- Improved electric power systems reliability will foster an increase in quality of service and a reduction in power interruptions that too often lead to productivity losses in the commercial and industrial sectors, affecting average regional manufacturing costs and, finally, the national gross domestic product (GDP).
- Pooling electricity resources is crucial if the electric power systems are to fully contribute to sustainable development.

2. FINANCIAL BENEFIT OF ELECTRICITY INTERCONNECTION TO AFRICA

The potential economic benefits of interconnection of electricity to the people of African continent include:

- Reduced fuel costs (where country providing power is using lower-cost resources)
- Reduced generation capacity costs
- Reduced costs for transmission system improvements

3.0 Economics and Costs of an Interconnected System

Costs an interconnected system include:

3.1. Costs of fuel used to generate exported electricity
3.2. Costs for power plants used to generate exported electricity

3.3. Costs of interconnection infrastructure
- Power line costs include:
  > Costs of electrical conductors and insulators.
  > Costs of purchasing and erecting transmission towers, and of clearing rights-of-way.
  > Costs of substations and transformers to connect grids to the power line.
  > Costs of power line control hardware and software.

3.4. Costs of operation of interconnection infrastructure
3.5. Costs of power system upgrades
3.6. Costs of power purchases

ECONOMIC CONSIDERATIONS FOR INTERNATIONAL ELECTRICITY INTERCONNECTION IN AFRICA

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4.0 INFRASTRUCTURAL DEVELOPMENT IN AFRICA

- According to the New Partnership for Africa's Development (NEPAD), infrastructure is a pressing priority.
- Roads, water facilities, airports, seaports, railways, telecommunications networks and energy systems are vital to economic development of any continent.
- Africa is endowed with resources vast enough to meet all its energy needs.
- Hydroelectricity is by far the single biggest source of electricity in a number of countries. The region possesses some of the largest water courses in the world – the Nile, Congo, Niger, Volta and Zambezi river systems.
- The hydro potential of the Democratic Republic of Congo alone is estimated to be sufficient to provide three times as much power as Africa currently consumes. This potential remains largely untapped.

5.0 ELECTRICITY IN WEST AFRICA TODAY

- Nigeria, Ghana and Côte d'Ivoire are the largest generators of electricity in West Africa.
- Nigeria's major sources of energy are petroleum, natural gas and hydro. The country exports electricity to neighbors like Sakete (Benin) and Niger.
- Ghana primarily relies on hydropower from its Akosombo Dam, on the Volta River about 80 kilometres upstream from the coast. Ghana supplies Benin and Togo with the majority of their electricity.
- In Côte d'Ivoire, thermal generating facilities powered primarily by oil and gas provide the majority of electricity. Countries connected to the Ivorian grid include Mali, Burkina Faso, Benin and Togo.

6.0 WEST AFRICAN POWER POOL (WAPP)

- With cross-border energy networks, countries with surplus power could run their stations at optimum output without risking oversupply. Conversely, countries with limited generation capacity could access affordable power without building costly facilities.
- In October 2000, 14 members of the Economic Community of West African States (ECOWAS) signed an agreement to launch a project to boost power supply in the region.
- Under the West African Power Pool (WAPP) agreement, countries hope to develop energy production facilities and interconnect their respective electricity grids.
- According to the agreement, the work would be approached in two phases. The first involves countries already interconnected, including Nigeria, Benin, Burkina Faso, Côte d'Ivoire, Ghana, Niger and Togo. The second phase involves countries not yet connected: Gambia, Guinea, Guinea-Bissau, Liberia, Mali, Senegal and Sierra Leone.
7.0 OVERVIEW OF SOME WAPP PROJECTS

- The major sources of electricity under the power pool would be hydroelectricity and gas to fuel thermal stations. Hydropower would be mainly generated on the Niger (Nigeria), Volta (Ghana), Baling (Mali), and Bandama (Côte d'Ivoire) rivers.
- In February 2003, the presidents of Ghana, Nigeria, Benin and Togo signed a treaty providing for a comprehensive legal, fiscal and regulatory framework to build a joint gas pipeline.
- Nigeria and the African Development Bank (ADB) signed an agreement in December 2002 to interconnect then Nigerian Electric Power Authority (NEPA) now PHCN and the Compagnie Electrique du Benin (CEB) networks.
- This project has since been completed and Nigeria now wheels an average of 80MW across to CEB networks.
- Ghana has plans to build an additional hydroelectric project on the Black Volta River. The Bui project would have a generation capacity of 400 MW.
- Mali, Mauritania and Senegal completed construction of the Manantali Dam in 1997. The Manantali includes a 200 MW power station and a 1,300 km network of transmission lines to the capitals of Mali (Bamako), Mauritania (Nouakchott) and Senegal (Dakar).
- Manantali’s generating facilities came online in December 2001, supplying power to Mali’s grid.
- Senegal connected its power grid to Manantali in July 2002 and Mauritania in November of that year.
- The Energy Ministers of Togo and Benin agreed in February 2004 to enhance cooperation in building a hydroelectric plant at Adjaralla, on the southern Togo-Benin border.
- Growing demands for power have prompted Burkina Faso to seek to import electricity from neighboring Côte d’Ivoire.

8.0. POLITICAL ASPECTS OF GRID INTERCONNECTIONS

- Effective international legal framework governing the construction and operation of any international electricity grid interconnection requires political agreement and cooperation between the trading countries, as well as between different constituencies inside each of the trading countries.

8.1. Potential Political Benefits of International Grid Interconnection

- International power grid interconnections can offer political benefits to the countries participating in power trading, as well as to individuals and groups within the trading countries.

8.2. Potential Political Liabilities of International Grid Interconnection

- Depending, again, on how interconnection agreements are structured, and often on the nature of the interconnection itself, international grid interconnections may also become political liabilities to one or more of the host countries.

8.3. Types of Political Cooperation Required

- The planning, establishment, and operation of international electrical grid interconnections requires a wide variety of agreements between nations, as well as within nations.
- Below are some types of agreements with political elements so as to underscore that political will and a degree of political organization and internal cooperation is needed in order to come to terms on the necessary accords to allow the construction and operation of interconnections. Namely:
  - Agreements in principle as to sharing power resources.
  - Agreements on moving forward with the interconnection project.
  - Agreements as to how firms included in the interconnection project will be paid, and by whom.
  - Agreements as to how benefits and costs of the project will be shared.
  - Agreements as to how the interconnection will be operated and secured.
  - Agreements as to the sharing of information necessary to plan, operate and protect the interconnection.
8.4. National/Regional Attributes that Help to Support Grid Interconnection

There are a number of national and regional attributes that will smooth the path to full acceptance and development of interconnection infrastructure and institutions. These attributes include:

- Ability to ascertain and enhance the political will for cooperation.
- Culture of regional cooperation
- Culture of long-term planning
- Clarity of internal energy policy goals, and internal energy sector structure
- Willingness to formally ratify and adhere to international agreements
- Demonstrated willingness to enter into cross-border trade in a key commodity like electricity
- Common membership in strong regional organizations

8.5. Barriers to Political Cooperation on Grid Interconnections

For each of the national or regional attributes that help to support grid interconnections, there are potential characteristics that, conversely, serve as barriers to political cooperation on cross-border grid interconnections. These includes:

- Longstanding national rivalries and related distrust
- Religious or tribal rivalries and related distrust between nations
- Internal national disunity
- Substantially different political systems between countries
- Emphasis on national energy self-sufficiency and internal energy sector organization
- Corruption and political interference in the power sector

8.6. Overcoming Barriers to Political Cooperation (National and International)

Some ways to overcome the barriers are as following:

- Make all dealings between parties in the agreements open and transparent
- Include all affected parties in early stages of project formulation and throughout the project
- Establish protocols for data collection and distribution to parties that require data
- Make sure that benefits and costs of the project are fairly distributed
- Work with and through respected international organizations and other intermediaries

9.0 SUMMARY AND CONCLUSIONS

- International electricity grid interconnections are complex undertakings, with varied, varying, and potentially diverse issues, costs, and benefits.
- International electric grid interconnections may bring political benefits to the interconnected countries ranging from increased experience and political comfort with international cooperation, more reasons to avoid conflict with neighbors.
- Key design and operating issues in AC interconnections relate to the constraints on transmission capacity, both of the interconnection and of the grids that it connects, which include thermal limits, stability limits, and voltage regulation
- Simulation software is an essential tool for planning, assessing the technical benefits of, and operating an interconnection.
- For modeling to be effective, however, extensive technical data must first be gathered and shared between systems, and personnel must be trained.
- Grid interconnections require a careful calculation of costs, benefits, and risks. Technical planning of a grid interconnection should be coordinated with economic, organizational, legal, and political aspects of a potential interconnection project from the outset of project consideration.
THANK YOU FOR YOUR ATTENTION