EAPP Regional Power Interconnections

- Experiences from East Africa Power Pool

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BACKGROUND

2012: EAPP Interconnection Code developed

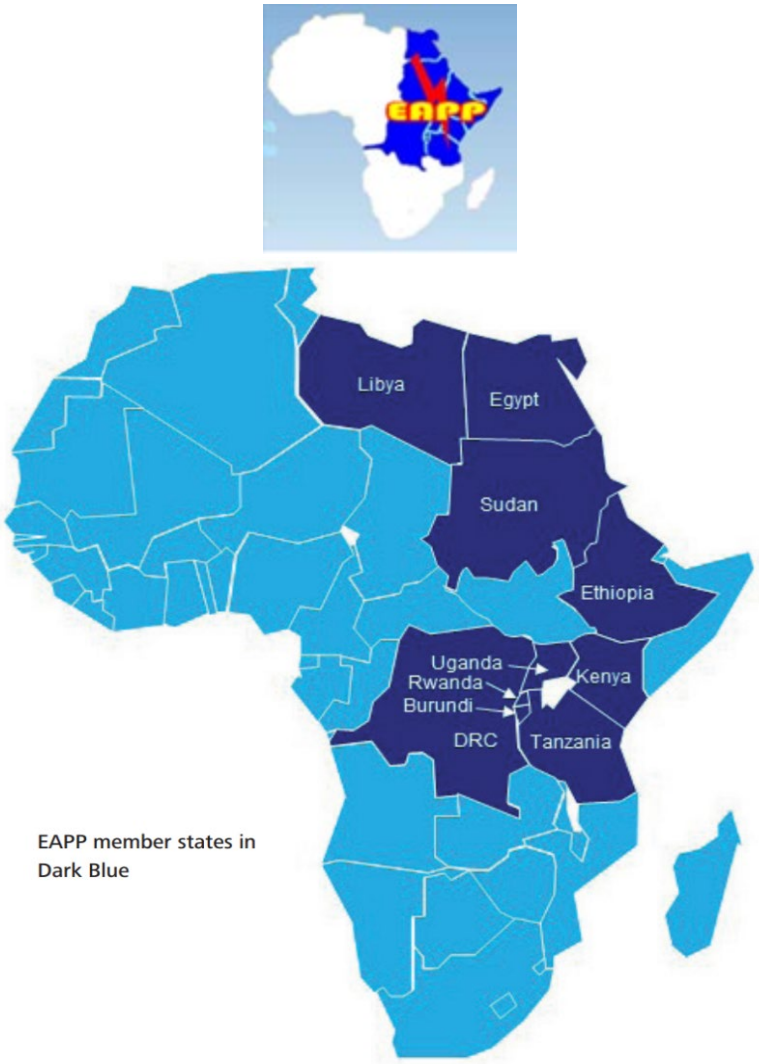
- Technical rules necessary to ensure the East African region transmission grid is planned and operated in a reliable, secure and efficient manner.

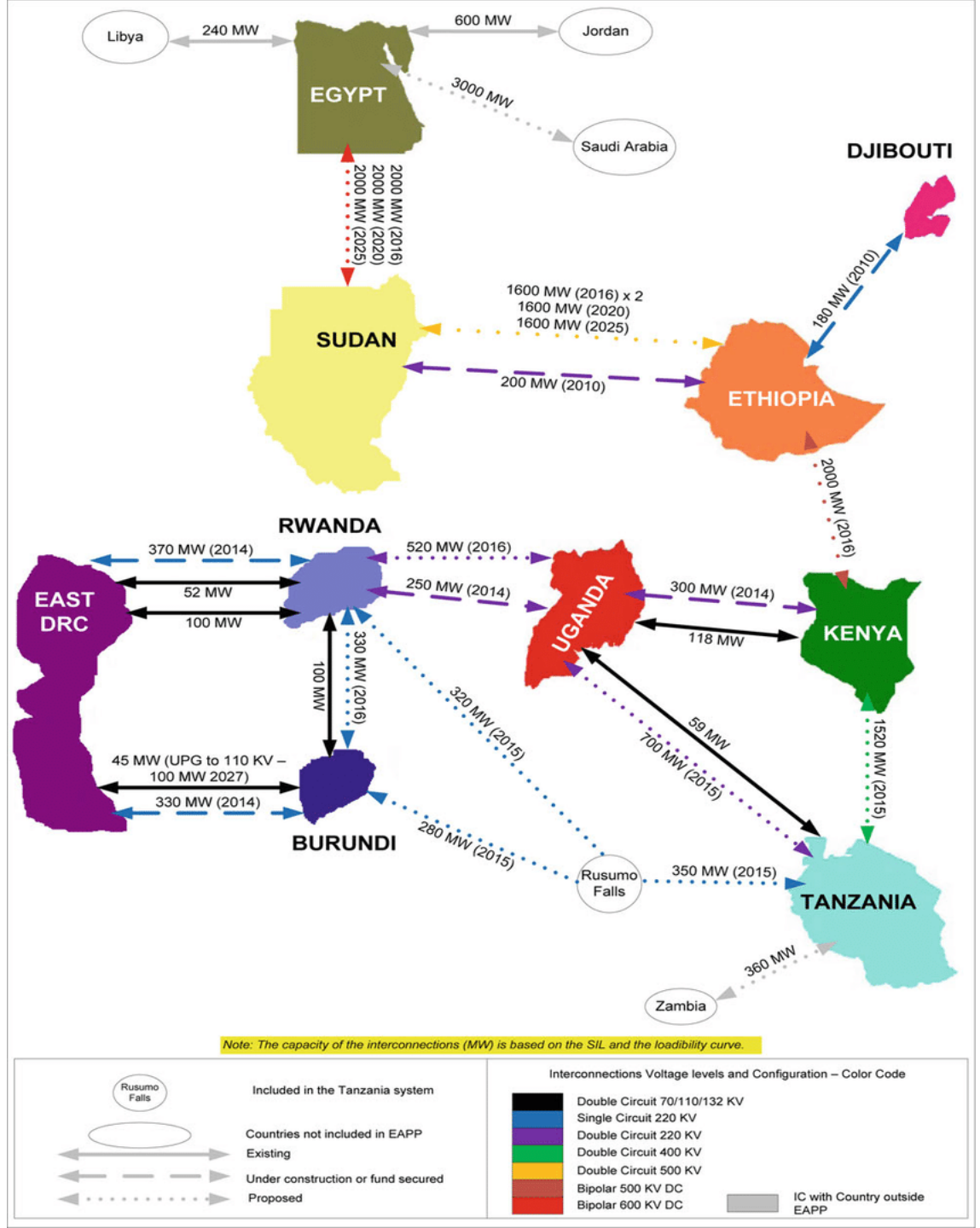
2016: CoM Approves Implementation

- "EAPP Interconnection Code Compliance Program, Stage 1 Operations".

2016-17: Members ID Gaps, Develop Mitigation Plans

- All Members to self-assess their compliance with the EAPP IC Standards related to cross-border, interconnected operations.




Libya
240 MW
EGYPT
600 MW
Jordan
3000 MW
Saudi Arabia
2000 MW (2016)
2000 MW (2020)
2000 MW (2025)
DJIBOUTI
180 MW (2010)
SUDAN
1600 MW (2016) x 2
1600 MW (2020)
1600 MW (2025)
200 MW (2010)
ETHIOPIA
2000 MW (2016)
RWANDA
370 MW (2014)
520 MW (2016)
52 MW
250 MW (2014)
100 MW
EAST DRC
UGANDA
300 MW (2014)
118 MW
KENYA
330 MW (2016)
100 MW
320 MW (2015)
59 MW
700 MW (2015)
1520 MW (2015)
45 MW (UPG to 110 KV – 100 MW 2027)
330 MW (2014)
BURUNDI
280 MW (2015)
Rusumo Falls
350 MW (2015)
TANZANIA
360 MW
Zambia
Note: The capacity of the interconnections (MW) is based on the SIL and the loadibility curve.
Rusumo Falls
Included in the Tanzania system
Countries not included in EAPP
Existing
Under construction or fund secured
Proposed
Interconnections Voltage levels and Configuration – Color Code
Double Circuit 70/110/132 KV
Single Circuit 220 KV
Double Circuit 220 KV
Double Circuit 400 KV
Double Circuit 500 KV
Bipolar 500 KV DC
Bipolar 600 KV DC
IC with Country outside EAPP

EAPP Power Pool History

- Power pools create institutional framework for cross border electricity trade

- Power pooling efforts as far back as the 50's utilized cross border transmission facilities
  - DRC - Burundi - Rwanda interconnected via jointly developed Ruzizi hydro power plant
  - Uganda - Rwanda
  - Uganda - Kenya
  - Uganda - Tanzania
  - Kenya - Tanzania

- Early bilateral interconnected systems didn't coordinate planning gen / trans
  - Resulted in exporting countries running out of surplus generation capacity to meet their own growing power demands and their exportation obligations

- Renewed power pool efforts are emphasizing integrated generation and transmission planning along with near-realtime operational planning

Power Pool Critical Success Factors

– Planning & Operation

- *Harmonization* of legal and *operational framework* is critical
  - Offers a *high degree of certainty and predictability* to Donors and private investors
- *Operational norms* are similar across all member utilities
- Implementation and *compliance* with Interconnection Codes
  - To achieve satisfactory security and reliability.
- Encourage *integrated planning* across all member utilities
  - Resource adequacy; operating reserves and normal/emergency line ratings

Common Gaps Identified & Mitigations Needed

- ✓ Under-Frequency Load Shedding Plans
- ✓ Secondary Response; Automatic Generation Control
- ✓ Primary Response; Generator Governors
- ✓ Operating Reserves
- ✓ System Protection; Types and Settings
- ✓ Voltage Control
- ✓ Communication Links; Fiber Optics
- ✓ System Operator Training and Certification

— Misconceptions of Cross-Border, Interconnected Operations

“Because of the interconnection…, when the problem happened in [*Country A’s]* power system, [Country B] had to be affected.”

“We have disconnected [Country A] from the [Country B] grid so as to connect [Country A] independently”

Challenges and Opportunities

- **Organizational Change Management**
  - Regional Interconnection Codes vs. National Grid Codes
  - Trust Interconnected Tie-Line Operations vs. Islanded National System Operations
  - Strong, consistent leadership and communication across all boundaries
- **Knowledge and Experience in Interconnected Tie-Line Operations**
  - Over 60% of Transmission System Operators are below the age of 40 with less than 5 years operating experience.
- **Capital funds to Upgrade Critical Equipment and Controls**
  - Regional Interconnection Code Standards have been taught and are understood
  - But compliance with regional standards isn't possible without the essential upgrades to wean them off of manual "ring down" procedures primarily used.
- **Compliance Management**
  - Regional Compliance Program doesn't exist
  - No repercussions for non-compliance with regional standards

EAPP Interconnection Codes
- Related to Control Area and Tie-Line Operations

- **Connection Codes (CC)**
  - CC-001 – Maintain Frequency: Nominal 49.5Hz - 50.5Hz
  - CC-002 & CC-003 – Maintain Frequency: N-1 & Extreme Contingencies
  - CC-004 & CC-005 – Maintain Voltage: Normal and N-1 Conditions
  - CC-041 & CC-042 – Generator Governors: Highly Responsive, Standard Droop settings
  - CC-051 & CC-052 – Generators Protection Requirements and Trip on Loss of Excitation

EAPP Interconnection Codes
- Control Area and Tie-Line Operations

Interchange Scheduling & Balancing Codes – ISBC

- ISBC-001 & ISBC-002 – Net Transfer Capability (NTC)
- ISBC-011 – Daily Scheduling: Identify NTC and Reserves on Hourly Basis
- ISBC-019 – Sufficient Generators on AGC
- ISBC-020 – Adequate AGC Equipment to monitor and control system frequency
- ISBC-021 – Sufficient Tertiary Reserve – Non-Spinning Operating Reserves
- ISBC-026 – Primary Response: Generator Governors Response
- ISBC-033 – Power Flow on Tie-Lines Maintained within NTC
- ISBC-034 – Black Start Capability

EAPP Interconnection Codes
- Control Area and Tie-Line Operations

Operating Codes (OC)

- OC-028 – Operational Plans submitted daily at 1500 hours
- OC-036 – Transmission System Restored to Normal after N-1 Event
- OC-037 – Interchange Schedules and Tie-Lines Returned to Normal after N-1 Event
- OC-040 – Voltage Control Procedures and Mvar Flow on Interconnected System
- OC-069 – Control Area Normal, Alert and Emergency Definitions
- OC-080 – Coordination of Tie-Line Protection
- OC-086 – Tie-Lines to Remain Interconnected
- OC-105 – Control Area Duty to Alert Adjacent Control Area of Emergencies
- OC-125 & OC-126 – Controlled Steps: UFLS and Generation UF Protection
- OC-127 – Control Area Load Shedding: up to 60% of it's Available Load

EAPP Interconnection Codes
- Control Area and Tie-Line Operations

System Operators Training Code (SOTC)

- SOTC-001 – System Operator Authorizations for Control Area Operations
- SOTC-003 – System Operators On-Shift Continuously
- SOTC-007 – System Operators are Certified

Next Steps for Operational Readiness

- Develop EAPP Operating Procedures for Cross-Border Tie-Line operations
- Deliver capacity building workshops on the newly adopted Operating Procedures
- Develop System Operator Certification Programs
  - Control Area Operators
  - Transmission System Operators

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