

# EAPP interconnection readiness workshop

*Self-Assessment for EAPP/IC -Compliance  
Rwandan-Grid*

*Gap Analysis & Proposed mitigations*  
GENERATION, TRANSMISSION & DISTRIBUTION

*01<sup>st</sup> October , 2018*

## INTRODUCTION

- It is important for Rwanda and REG to be operationally ready for interconnection due to its strategic position in the EAPP- connected to 4 Countries.
- Rwanda is committed and well on schedule for interconnection to the EAPP.
- Rwanda is a fast developing Country – to keep up our generation has doubled from 100MW in 2012 to 218MW now
- With committed Generation Projects, REG will double the generation again by 2025 by adding an additional 270MW
- With the committed generation plan, Rwanda can be a potential exporter after 2025

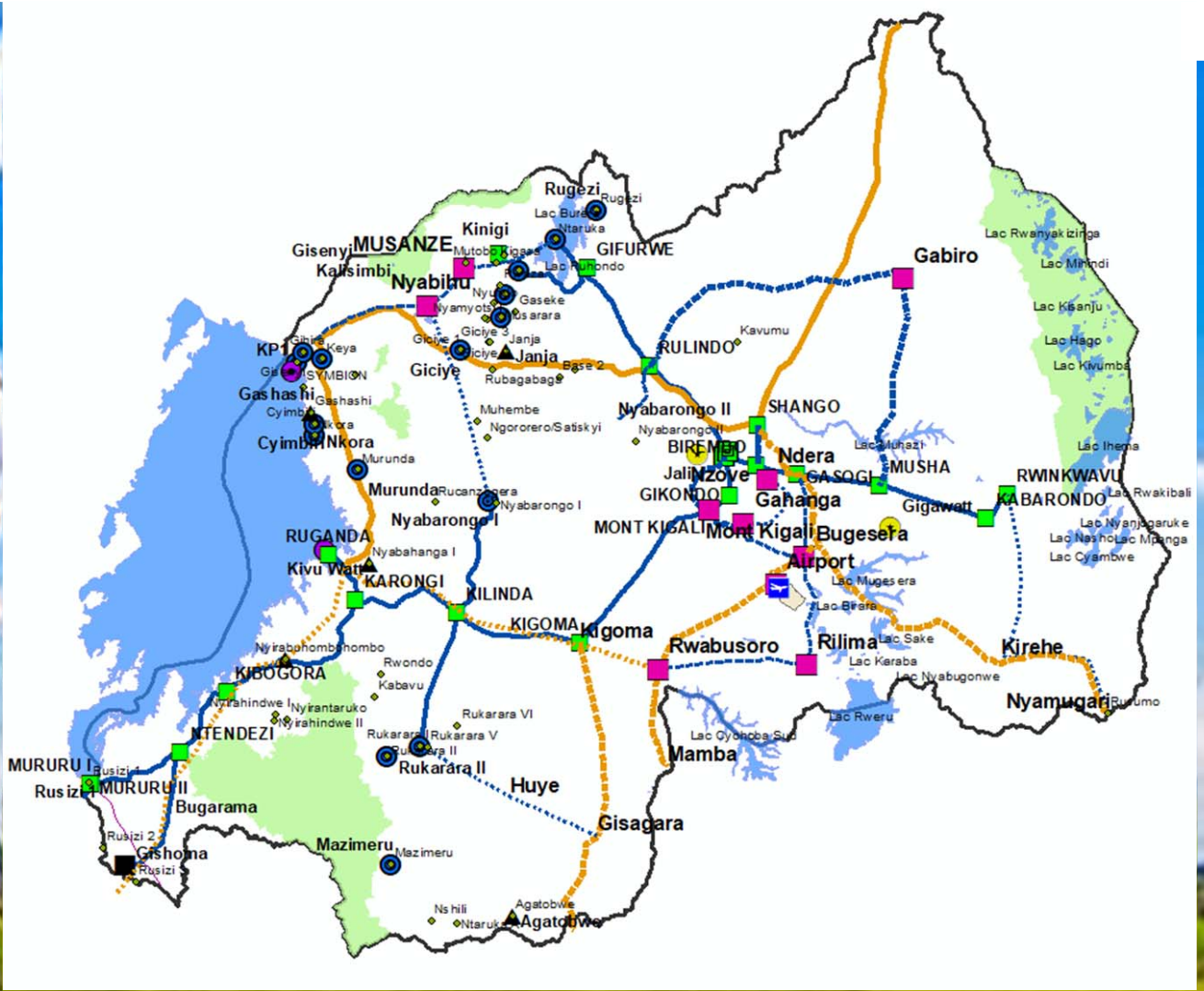
## SUMMARY OF INTERNAL NETWORK IMPROVEMENTS

- Under frequency load shedding scheme was introduced – results: Blackouts reduced from 4 per month to less than 1 every three months.
- All major Power Plants have black start capability (over 70MW)
- Voltage stability greatly improved due to new Transmission lines and improved reactive power management
- Frequency stability is improved as a result of improved spinning reserve management



Rwanda Energy Group

	220kV Completed	250km
	220kV On-going	172km
	220kV Planned	155km
	110kV Existing	
	110kV On-going	
	110kV Planned	



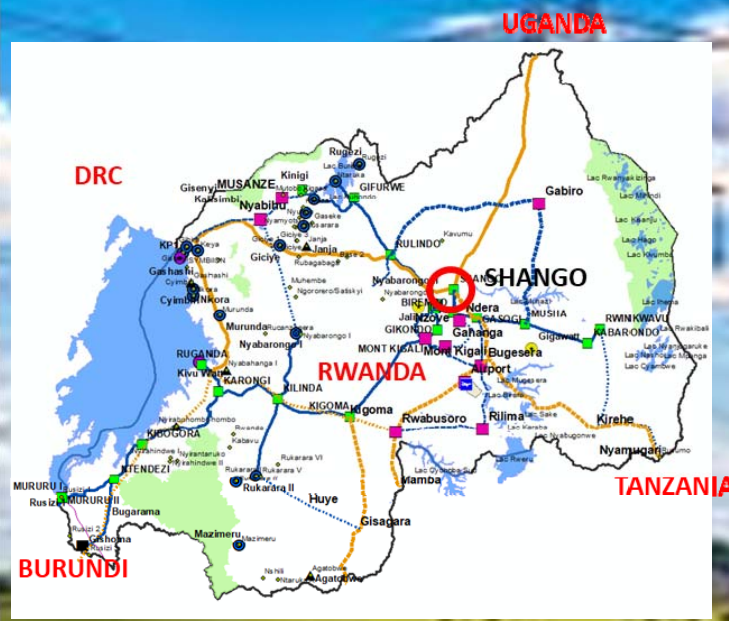
[www.reg.rw](http://www.reg.rw)





# REGIONAL CONTROL CENTER PROPOSAL

- REG is planning to construct a new state-of-the-art Control Center at Shango



# GRID CODE COMPLIANCE GAPS

## A. Improved Gaps

1. OFF Nominal frequency
2. Voltage Control
3. Primary Response and Governors
4. Protection Requirements & Co-ordination
5. Generation & transmission Operator Training

## B. Gaps In progress of Improvement

6. Operational Planning - Outage Schedules
7. Operational Planning - Interchange Schedules

8. Operational Planning - Net Transfer Capability (NTC)

9. Emergency Plans

10. Lines of Communication with Neighboring TSO's, Generation & Distribution Users

## C. Pending Gaps

11. Secondary, Tertiary Response and AGC

# OFF Nominal frequency

<i>GAP DESCRIPTION</i>	<i>EAPP IC- REQUIREMENT</i>	<i>PREVIOUS STATUS 7-18/08/2017</i>	<i>CURRENT STATUS</i>
<ul style="list-style-type: none"> <li>UFLS % of Peak load.</li> </ul>	<ul style="list-style-type: none"> <li>60% of system peak load</li> </ul>	<ul style="list-style-type: none"> <li>42% of Peak load</li> </ul>	<ul style="list-style-type: none"> <li>43.5 &amp; 41.1 % Peak and off Peak</li> </ul>
<ul style="list-style-type: none"> <li>UFLS Blocks</li> </ul>	<ul style="list-style-type: none"> <li>8 blocks</li> </ul>	<ul style="list-style-type: none"> <li>10 blocks</li> </ul>	<ul style="list-style-type: none"> <li>19 blocks</li> </ul>
<ul style="list-style-type: none"> <li>Frequency range</li> </ul>	<ul style="list-style-type: none"> <li>49.5 - 50.5 Hz N.O</li> <li>49 – 51 Hz S.C.E</li> <li>48.75 – 51.25 M.C.E</li> </ul>	<ul style="list-style-type: none"> <li>49.4 - 49.6 Hz</li> </ul>	<ul style="list-style-type: none"> <li>49.8Hz -50.2 Hz N.O</li> <li>49Hz – 51 Hz S.C.E</li> <li>48.9-Hz -51.8Hz M.C.E</li> </ul>
<ul style="list-style-type: none"> <li>UFLS Coordination with neighboring countries</li> </ul>	<ul style="list-style-type: none"> <li>UFLS should be coordinate for the three countries</li> </ul>	<ul style="list-style-type: none"> <li>UFLS was not coordinated for RDA, BRDI &amp; DRC</li> </ul>	<ul style="list-style-type: none"> <li>UFLS Coordination was done with BURUNDI.</li> </ul>
<ul style="list-style-type: none"> <li>UFLS plan &amp; frequency excursions guidelines</li> </ul>	<ul style="list-style-type: none"> <li>Internal written and approved mechanism for UFLS analysis</li> </ul>	<ul style="list-style-type: none"> <li>REG had not established yet UFLS Analysis mechanism</li> </ul>	<ul style="list-style-type: none"> <li>A team was Appointed to analyze UFLS for single and Multiple contingency event.</li> </ul>
<ul style="list-style-type: none"> <li>Inadequate generation resources to serve the load reliably</li> </ul>	<ul style="list-style-type: none"> <li>The system should be Operated with Enough Generating Reserves to serve the load reliably</li> </ul>	<ul style="list-style-type: none"> <li>49.4Hz</li> </ul>	<ul style="list-style-type: none"> <li>50Hz +/- 0.2 N.O with 10% of spinning reserves</li> </ul>
<ul style="list-style-type: none"> <li>A procedure for manual generator ramp down/tripping</li> </ul>	<ul style="list-style-type: none"> <li>Internal written and approved guidelines and procedures ramp down generator manual</li> </ul>	<ul style="list-style-type: none"> <li>This was seen as a gap but Mechanisms were in Place to handle the task.</li> </ul>	<ul style="list-style-type: none"> <li>Generators are equipped with IED that handle the task.</li> </ul>

# Voltage control

<i>GAP DESCRIPTION</i>	<i>EAPP-IC STANDARD REQUIREMENT</i>	<i>PREVIOUS STATUS 7-18/08/2018</i>	<i>CURRENT STATUS</i>
<ul style="list-style-type: none"> <li>System voltage and reactive power are not being controlled within the ranges stated in the EAPP Interconnection Code standards.</li> </ul>	<ul style="list-style-type: none"> <li>To equip all connected generators to the transmission system with AVR in service and are normally operating in automatic voltage control mode.</li> <li>To monitor Voltages at all key busses</li> </ul>	<ul style="list-style-type: none"> <li>All REG generators were Equipped with AVRs But were not Operating in automated mode.</li> <li>The voltage is monitor at all SS buses</li> </ul>	<ul style="list-style-type: none"> <li>EUCL AVRs are Operating in automatic mode but IPPs are not.</li> <li>All bus bar voltage are monitored.</li> </ul>
<ul style="list-style-type: none"> <li>There are no procedures or passive reactive elements on the transmission grid to correct low and high voltages.</li> </ul>	<ul style="list-style-type: none"> <li>To put in place procedures and passive equipment that mitigate low or high voltage condition.</li> <li>To put in place ancillary service agreements with generating companies to supply VAR</li> </ul>	<ul style="list-style-type: none"> <li>EUCL had a project for Reactive power correction &amp; compensation.</li> <li>There is no agreement for VAR ancillary services.</li> </ul>	<ul style="list-style-type: none"> <li>We are at the commissioning stage of stunt reactor &amp; capacitor banks.</li> <li>There is no agreement for VAR ancillary services.</li> </ul>



# Primary Response and Governors

GAP DESCRIPTION	EAPP-IC STANDARD REQUIREMENT	PREVIOUS STATUS 7-18/08/2017	CURRENT STATUS
<ul style="list-style-type: none"> <li>No procedures for the monitoring governor response.</li> </ul>	<ul style="list-style-type: none"> <li>To put in place an written standard procedure to monitor Governor response. EAPP IC-01CC/CC-039</li> </ul>	<ul style="list-style-type: none"> <li>There was no documented procedure to monitor governor response.</li> </ul>	<ul style="list-style-type: none"> <li>Drafted (to be Approved by REG SM).</li> </ul>
<ul style="list-style-type: none"> <li>Inadequate data and information was provided to determine how many of the existing generating units have governors that meet the EAPP Guidelines.</li> </ul>	<ul style="list-style-type: none"> <li>Documentation for each generating unit in order to assess it EAPP/IC standards compliance</li> <li>Procedures to assess Generator unit Compliance with EAPP/IC</li> <li>Tools &amp; procedure to monitor generating units output &amp; system frequency all documented.</li> </ul> <p>01cc/cc-040-041-042-043-051-052 &amp; 053</p>	<ul style="list-style-type: none"> <li>Inadequate data was provided.</li> <li>No procedure Provided.</li> <li>SCADA is serving as Documentation tool for generated P,Q,V,I &amp; system frequency.</li> </ul>	<ul style="list-style-type: none"> <li>Around tour was organized to collect all Generator governors data.</li> <li>Procedures in pipeline.</li> <li>SCADA is serving at Documentation tool.</li> </ul>

## Primary Response and Governors continued.....

GAP DESCRIPTION	EAPP-IC STANDARD REQUIREMENT	PREVIOUS STATUS 7-18/08/2017	CURRENT STATUS
<ul style="list-style-type: none"> <li>No governor standard describing the specifications and performance of generating unit's governors</li> </ul>	<ul style="list-style-type: none"> <li>Equip all generators with Governors speed controllers &amp; fully Operating.</li> <li>Adjustable droop settings for all generator speed controllers.</li> <li>The generator response time should be within 10 Seconds. Also to sustain the response for another 20 seconds.</li> <li>"no higher than 4% droop for combustion turbines and no higher than 5% droop for other technology types; with a dead-band no larger than +/- 0.030 Hz"</li> </ul> <p>See Standard 01cc/cc-040-041-042</p>	<ul style="list-style-type: none"> <li>5 EUCL power Plants were visited &amp; assessed.</li> <li>All 18 generating unit were all equipped with Governor All Adjustable.</li> <li>Fully Functioning.</li> <li>9/18 have a response time in range of 10 seconds &amp; able to sustain the response for another 20 seconds</li> </ul>	<ul style="list-style-type: none"> <li>All power plants &amp; including IPPs were visited and the settings were revised accordingly.</li> </ul>

<i>GAP DESCRIPTION</i>	<i>EAPP-IC STANDARD REQUIREMENT</i>	<i>PREVIOUS STATUS</i>	<i>CURRENT STATUS</i>
<ul style="list-style-type: none"> <li>No process to identify governors that do not meet the EAPP Guidelines and eventual EUCL governor standard to be upgraded to meet the EAPP Guidelines and EUCL Standard.</li> </ul>	<ul style="list-style-type: none"> <li>To establish process to determine damping coefficient of turbine speed controller.</li> <li>To establish Process to Monitor, Record &amp; report the performance of the primary controller of the generator Governor.</li> </ul>	<ul style="list-style-type: none"> <li>There is a need of PSS that could determine Damping coefficient of turbine speed controller.</li> </ul>	<ul style="list-style-type: none"> <li>There is a need for PSS that could determine Damping coefficient of turbine speed controller.</li> </ul>

GAP DESCRIPTION	EAPP-IC STANDARD REQUIREMENT	PREVIOUS STATUS 7-18/08/2017	CURRENT STATUS
<ul style="list-style-type: none"> <li>No indication that EUCL line protection standards will meet EAPP interconnection code standards in terms of types of protection and settings to coordinate with the Uganda tie-line that is under construction, including Out-of-Step relay protection.</li> </ul>	<ul style="list-style-type: none"> <li>To put in Place on transmission lines connecting control areas &amp; to have trip features for when an “Out of Step” pole slipping condition exceeding an agreed limit are observed</li> </ul>	<ul style="list-style-type: none"> <li>The Network is equipped with these type of relays but they are not enable because the network is operated as a single network.</li> </ul>	<ul style="list-style-type: none"> <li>The current protection system was tested and comply with the EAPP protection requirement.</li> </ul>
<ul style="list-style-type: none"> <li>Rwanda has no means of validating the short circuit duties when a fault occurs.</li> </ul>	<ul style="list-style-type: none"> <li>To put in Place trip protection for transmission lines connecting control areas when a line overload occurs when loading &amp; short circuit current values is higher that values agreed between TSO</li> </ul>	<ul style="list-style-type: none"> <li>The evidence of compliance was not provided.</li> </ul>	<ul style="list-style-type: none"> <li>The current protection system was tested and comply with the EAPP protection requirement.</li> </ul>



# Generation & transmission Operator Training

<i>GAP DESCRIPTION</i>	<i>EAPP-IC STANDARD REQUIREMENT</i>	<i>PREVIOUS STATUS 7-18/08/017</i>	<i>CURRENT STATUS</i>
<ul style="list-style-type: none"> <li>There is no formal training program for Interconnected Operations for Generator &amp; transmission Operators.</li> </ul>	<ul style="list-style-type: none"> <li>To put in Place Mechanism for training Generator operators.</li> </ul>	<ul style="list-style-type: none"> <li>The was no Mechanism in Place to address this gap.</li> </ul>	<ul style="list-style-type: none"> <li>CDNA &amp; Gaps Conducted by BTC experts.</li> <li>NCC Operators trained.</li> </ul>
<ul style="list-style-type: none"> <li>There is no written job description that describes a Generator Plant Operators duties and authorities of acting under emergency conditions.</li> </ul>	<ul style="list-style-type: none"> <li>To Put in Place written job description that describes a Generator &amp; transmission Operators duties and authorities when acting under emergency conditions.</li> </ul>	<ul style="list-style-type: none"> <li>The Job Descriptions for G&amp;T operators was not In place.</li> </ul>	<ul style="list-style-type: none"> <li>The Job Descriptions for G&amp;T operators was done and given to all Operators.</li> </ul>

### Operational Planning - Outage Schedules

<i>GAP DESCRIPTION</i>	<i>EAPP-IC STANDARD REQUIREMENT</i>	<i>PREVIOUS STATUS 7-18/08/2017</i>	<i>CURRENT STATUS</i>
<ul style="list-style-type: none"> <li>• There is no formal procedure for notification and coordination of planned outages to transmission and generation facilities.</li> <li>• There is no day-ahead plan for managing generation and transmission planned and forced outages</li> </ul>	<ul style="list-style-type: none"> <li>• To put in Place outage schedules coordinated with Generators &amp; Transmission Operators</li> <li>• To establish mechanism to communicate outages to the neighboring TSO according to the EAPP CC.</li> <li>• To Put in Place day-ahead plan for managing generation and transmission planned and forced outages</li> </ul>	<ul style="list-style-type: none"> <li>• There was no formal Document that describe outage schedule &amp; coordination between GSOs &amp; TSOs</li> <li>• REG had generation plan in place but there was no formal documented transmission planned outage.</li> </ul>	<ul style="list-style-type: none"> <li>• The Operational preparedness has started so that as we interconnect with Uganda, this gap will be addressed properly.</li> </ul>

# Operational Planning - Interchange Schedules

<i>GAP DESCRIPTION</i>	<i>EAPP-IC REQUIREMENT</i>	<i>PREVIOUS STATUS 7-18/08/2017</i>	<i>CURRENT STATUS</i>
<ul style="list-style-type: none"> <li>• There are no written procedures or acceptable practices currently to develop daily operational plans to clearly identify and communicate all security and reliability risks and to develop contingencies of the Rwandan system.</li> <li>• There are no procedures to assure identification of frequency, voltage or system abnormal events.</li> <li>• There are no procedures for recording, reporting and taking corrective actions on system frequency, voltage or power flow abnormalities.</li> <li>• There are no written procedures in place to determine the future inadvertent deviations and for settlement of daily charges as required by the EAPP IC standards</li> </ul>	<ul style="list-style-type: none"> <li>• To put in Place interchange scheduling procedures Document and provide copies of those procedures.</li> </ul>	<ul style="list-style-type: none"> <li>• There was no written procedure for energy exchange with Neighboring countries.</li> </ul>	<ul style="list-style-type: none"> <li>• REG declares available generation including import and dispatch is determined by availability, plant condition and necessary contingencies. This shall however be jointly discussed at prior to commissioning of regional interconnectors</li> </ul>

<i>GAP DESCRIPTION</i>	<i>EAPP-IC STANDARD REQUIREMENT</i>	<i>PREVIOUS STATUS 7-18/08/2017</i>	<i>CURRENT STATUS</i>
<ul style="list-style-type: none"> <li>EUCL has no procedures for determining Net Transfer Capability on the impending tie-line operation with Uganda.</li> </ul>	<ul style="list-style-type: none"> <li>To put in Place procedure for determining Net Transfer Capability with adjacent control areas and provide any related documentation.</li> <li>To Put in Place procedures for assuring that neither actual or scheduled interchange with adjacent control areas exceeds established Net Transfer Capability and provide and related documentation.</li> <li>To put in Place planning procedures that meet the EAPP IC NTC guidelines</li> </ul>	<ul style="list-style-type: none"> <li>There was no Procedure to address these gaps. The company had not started Power exchange yet. NTC information available was based on EATP findings.</li> </ul>	<ul style="list-style-type: none"> <li>The NTC data is available based on the EATP Model, shall formal basis of discussions in operational manual with Uganda/UETCL or other parties that will be interconnected with.</li> </ul>



# Emergency Plans

GAP DESCRIPTION	EAPP-IC STANDARD REQUIREMENT	STATUS AS OF THE DATE OF VISIT (7-18/08/17)	CURRENT STATUS
<ul style="list-style-type: none"> <li>REG does not have any emergency plans that describes how they will manage and control energy and capacity emergencies.</li> </ul>	<ul style="list-style-type: none"> <li>TSO to declare an EMERGENCY and control its ACE when it is unable to return its ACE to zero within 15 minutes</li> <li>To put a rotating outage load shedding plan in sufficient quantity to allow ACE to be maintained within the normal range (ACE to Zero within 15")</li> </ul>	<ul style="list-style-type: none"> <li>There was no Document that address this gap in Place</li> </ul>	<ul style="list-style-type: none"> <li>Internal Emergency Plan is in place</li> </ul>
<ul style="list-style-type: none"> <li>There is no formal written procedure for assuring that there are adequate black start resources</li> </ul>	<ul style="list-style-type: none"> <li>TSO restoration and black start plans. Also to regularly update their plans and communicate each time the interconnected system undergoes a significant change.</li> <li>To establish a network operation simulation model &amp; participate in restoration drills,</li> </ul>	<ul style="list-style-type: none"> <li>(it has however been drafted and is awaiting approval).</li> </ul>	<ul style="list-style-type: none"> <li>Procedure to black start plants are available and being used</li> </ul>
<ul style="list-style-type: none"> <li>There is no procedure for notifying EAPP Coordination Centre or their neighbours of significant incidences.</li> </ul>	<ul style="list-style-type: none"> <li>To establish Public Appeal mechanism, Emergency procedure &amp; issue</li> </ul>	<ul style="list-style-type: none"> <li>The was no Document that address this gap in Place</li> </ul>	<ul style="list-style-type: none"> <li>This has to be standardized.</li> </ul>

## Lines of Communication with Neighboring TSO's, GSOs & DSOs

GAP DESCRIPTION	EAPP-IC STANDARD REQUIREMENT	PREVIOUS STATUS 7-18/08/017	CURRENT STATUS
<ul style="list-style-type: none"> <li>REG does not have any direct lines of communication with neighbouring TSO's within their NCCs, especially DRC and Burundi where daily reliability issues are occurring.</li> </ul>	<ul style="list-style-type: none"> <li>To Put in Place communications facilities with neighboring TSOs &amp; to Test often communications facilities with neighboring TSOs.</li> </ul>	<ul style="list-style-type: none"> <li>This Seen as gap.</li> </ul>	<ul style="list-style-type: none"> <li>Interconnection lines In pipeline at 220 kv will fill this gap soon.</li> </ul>
<ul style="list-style-type: none"> <li>There is no daily communication between neighbours and EAPP coordinating centre regarding changes in generator and transmission status.</li> </ul>	<ul style="list-style-type: none"> <li>To Put in place daily communication between neighbors and EAPP coordinating center regarding changes in generator and transmission status.</li> </ul>	<ul style="list-style-type: none"> <li>This was seen gap.</li> </ul>	<ul style="list-style-type: none"> <li>Interconnection lines In pipeline at 220 kv will fill this gap soon.</li> </ul>
<ul style="list-style-type: none"> <li>EUCL does not have any direct lines of communication with neighbouring TSO's within their National Control Centre, especially DRC and Burundi where daily reliability issues are occurring.</li> </ul>	<ul style="list-style-type: none"> <li>To put in Place a direct line communication with neighboring TSO's within their National Control Centre</li> </ul>	<ul style="list-style-type: none"> <li>This was seen gap.</li> </ul>	<ul style="list-style-type: none"> <li>Required when there is a direct interaction but currently coordination is done through SINELAC</li> </ul>

# Pending gap

## Secondary, Tertiary Response and AGC

<i>GAP DESCRIPTION</i>	<i>EAPP-IC STANDARD REQUIREMENT</i>	<i>PREVIOUS STATUS 7-18/08/2017</i>	<i>CURRENT STATUS</i>
<ul style="list-style-type: none"> <li>• Inadequate secondary reserve to control tie-line bias on the impending tie-line to be interconnected with Uganda.</li> <li>• No capabilities to monitor Area Control Error (ACE) on the impending tie-line operations with Uganda.</li> <li>• Absence of AGC on EUCL generating units (also under secondary, tertiary response and AGC).</li> </ul>	<ul style="list-style-type: none"> <li>• To Equip the system with AGC to control the generation within your system</li> </ul>	<ul style="list-style-type: none"> <li>• Gap</li> </ul>	<ul style="list-style-type: none"> <li>• Still trying to mobilize Funding.</li> </ul>

# Required Equipment funding to mitigate the Gaps

Operating Category	Function	Level of Effort	Cost Impact
Off-Nominal Frequency Plan ( aka UFLS )	TSO / DUser	High	Medium
Secondary Response; Automatic Generation Control	TSO / GUser	High	High
Voltage Monitoring & Control	TSO / GUser	High	High
System Protection	TSO/ GUser / DUser	High	Medium
Primary Response; Generator Governors	GUser	High	Medium
Communication Links; Fiber Optics	TSO	High	Medium

Function: TSO = Transmission System Operator; GUser = Generator User; DUser = Distribution User

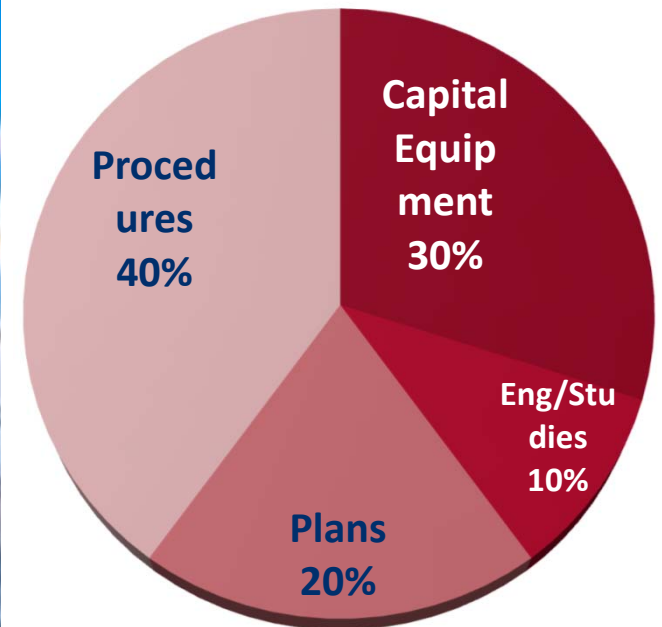
\* Level of Effort: A qualitative assessment of the labor, skills and time required to complete.

\*\* Cost Impact: Low = < \$250,000 USD Medium = \$250,000 - \$1,000,000 High = > \$1,000,000



## Required Plans , Procedures & Eng/studies to mitigate IC GAPS

- Off-Nominal Frequency Operating Plan
- Emergency Manual Load Shedding
- Synchronization Capability
- Governor Response Setting
- Emergency Plans for Capacity or Energy Shortages
- PSS Capability
- Secondary Control
- Out-of-Step Protection Capability
- System Restoration and Black Start Purpose
- Operational Planning





**THANK YOU . . . !**