Technical Elements of Interconnections

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Agenda

- Types of Interconnections
- Advantages and Disadvantages
- Rules
- Examples
- Conclusions
Types of Interconnections

- Direct Connections

- Synchronous Connections for Radial Operations (Load or Generation)

- Synchronous Connections of two or more Systems

Direct Connections

- Under sea connection: England-France; Italy Corsica; Norway-Denmark, ....
- Frequency changes 60 Hz/50 Hz: Saudi Arabia-GCCIA, Japan
- Political reasons: Before 1991 between western and eastern part of Europe; back to back station between Germany and Austria and Hungary. Still exists the station in Vyborg: Finland-Russia.
Types of Interconnections

Radial Operations
- Load fed on another system: Lebanon (Anjar, Deir N’Bouh).

- Generating units connected on another system: Maritza power plant (Bulgaria) connected Turkey; Bushtin island (Ukraine) to UCTE.

- DC links and Radial Operations are not real interconnections.

Synchronous Connections
- Largest interconnected system: UCTE (300 000 MW), More than 50 years old.
- Nordel
- PJM (Pennsylvania, New Jersey, Maryland).
- Former USSR interconnected system

- Common frequency, flows on the interconnections are determined by the electrical laws.
Advantages and Disadvantages

Advantages of the synchronous connections
- Mutual assistance in case of disturbances (demand/generation unbalance).
- Reserves Sharing ➔ Reserves Reduction
- Interconnected System bigger ➔ Installed capacity more adapted in terms of type, size and total.
- Better load forecast

Disadvantages of the synchronous connections
- In case of disturbances, the whole interconnected system is concerned. The incidents in a neighbouring system affects the other systems.
- The rules should be applied by all members otherwise the system could be jeopardized in case of disturbances.

➤ Safety is a common matter
➤ Coordination is very important in an interconnected system
Rules

A common set of rules should be mutually agreed.

- Interconnection Code or Regional Code. The code deals with the planning, the operations and the connection.
  - The code defines the planning criteria, the connection rules for the generating units and the operations rules.
  - UCTE rules are mainly applied in interconnected systems.

UCTE rules.

- N-1 criterion

- Primary reserves: In case of reference incident (loss of the two largest generating units), maximum deviation 800 mHz and 200 mHz after the action of the primary reserve.

- Secondary reserves: return to 50 Hz within 15 mn and restoration of the primary reserves.
Rules

UCTE rules.

- Voltage and reactive control
- Common Load shedding schemes
- Defence and restoration plans

Rules

UCTE rules.

- Power System Adequacy
- Operational Planning
- Communication and data exchanges
Examples

**UCTE:**
- Largest interconnected system, peak load around 300,000 MW

**IFA 2000:**
- DC interconnection between France and England

**UCTE/MOROCCO:**
- AC cables through the strait of Gibraltar, 300 MW

**Greece/Italy:**
- DC cable, 500 MW; a second cable will be implemented in the near future

**Nordel/UCTE:**
- Interconnections DC between the northern system and UCTE, 3000 MW

**EIJST interconnection,** in operation since 1998

**ENG interconnection,** between UAE in operation since 2006

**GCCIA interconnection,** phase 1 in operation since 2009

**Future:**
- GCCIA phase 2
- Interconnection UCTE/Turkey: under study
- Interconnection UCTE/Ukraine: under study
- Interconnection UCTE/ former USSR, discussions
Electrical Interconnections:
Technical Elements

Conclusions

- System reliability and security are increased in an interconnected system.
- Reduction of reserves
- Reduction of the installed capacity
- An interconnected system is a community: common rules, solidarity and communication are required.