



Technical Elements of Interconnections

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Agenda

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



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Types of Interconnections

- **Direct Connections**
- **Synchronous Connections for Radial Operations (Load or Generation)**
- **Synchronous Connections of two or more Systems**



Types of Interconnections

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 an other system: Maritza power plant (Bulgaria) connected Turkey; Bushtin island (Ukraine) to UCTE.
- **DC links and Radial Operations are not real interconnections.**



Types of 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
- Less deviation in case of disturbances: better electricity delivery quality. Larger Power System Characteristic (MW/Hz).



Advantages and Disadvantages

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.



Rules

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



Examples

Nordel/UCTE:

- Interconnections DC between the northern system and UCTE, 3000 MW

ELJST 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





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.