

Grid Issues

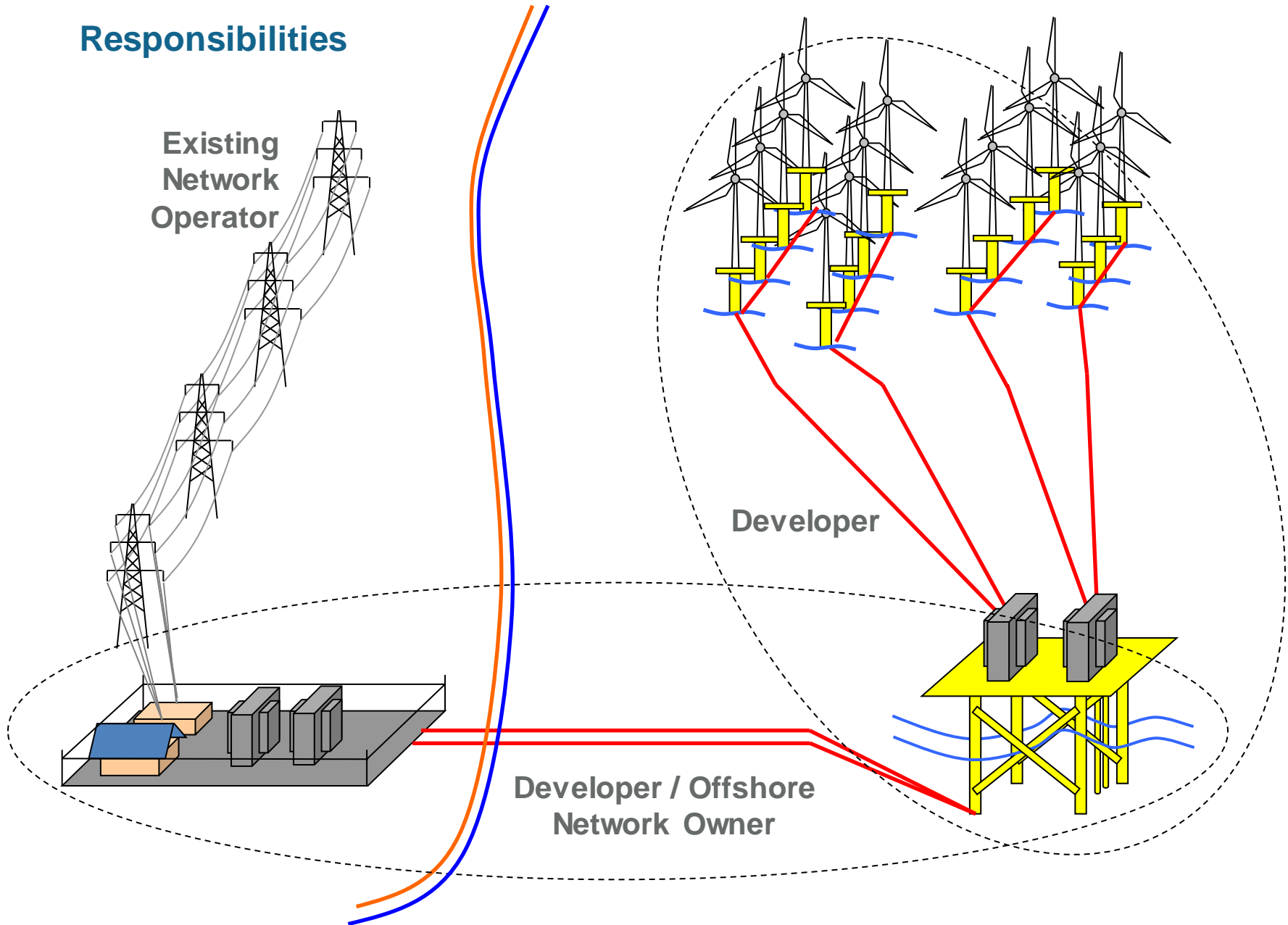
28th November 2011



Grid Issues

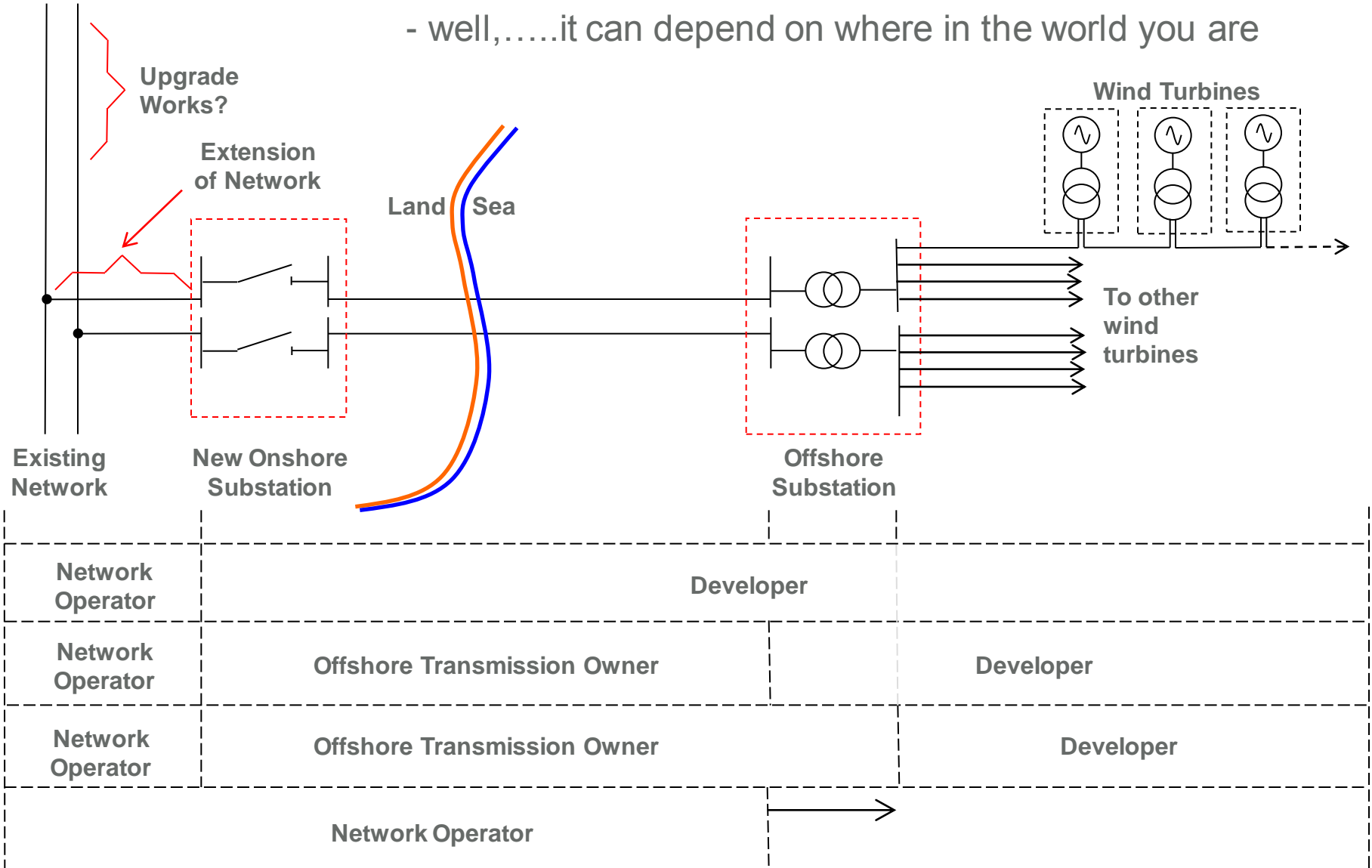
- Applicable Regulatory Regime
 - Onshore grid upgrade works
 - Offshore transmission assets
 - Offshore wind farm infrastructure assets
- Connection Requirements
 - Grid codes
- Electrical Design and Equipment Capabilities
 - Export systems
 - Offshore substation
 - Cable capacitance
 - Wind turbines

Responsibilities



Responsibilities – where is the division of responsibility?

- well,.....it can depend on where in the world you are



Scope of Development Works

- Are onshore network reinforcement works required?
 - Who pays for them?
 - What is the timetable for completion?
- Network Extension – to the coast
 - How much work is required to bring the existing grid to the coast?
 - Is the developer required to pay?
 - What is the timetable for completion?
- Offshore electrical infrastructure
 - Where is the ownership boundary or metering point going to be?
 - Is it the developers responsibility to progress the export system works?
 - An ‘up-front’ capital cost or an annual Use of System charge?
 - Maybe the developer pursues the export works but they are adopted at a later date

The above questions / issues may depend on where a project is being built

Connection Conditions

Connection conditions are the requirements of the network operator so that they can ensure the safe and reliable operation of the electricity network

A Rule Book! – A document which defines exactly how the network operator expects the user of the system to behave!

Normally called Grid codes

All large users (including loads e.g. factories) of the electricity system must comply with the requirements of the network operator

Frequency Control Requirements

Example - loss of 800 MW (Nordel)

- 3 distinct phases, grid highly inductive at 50 Hz

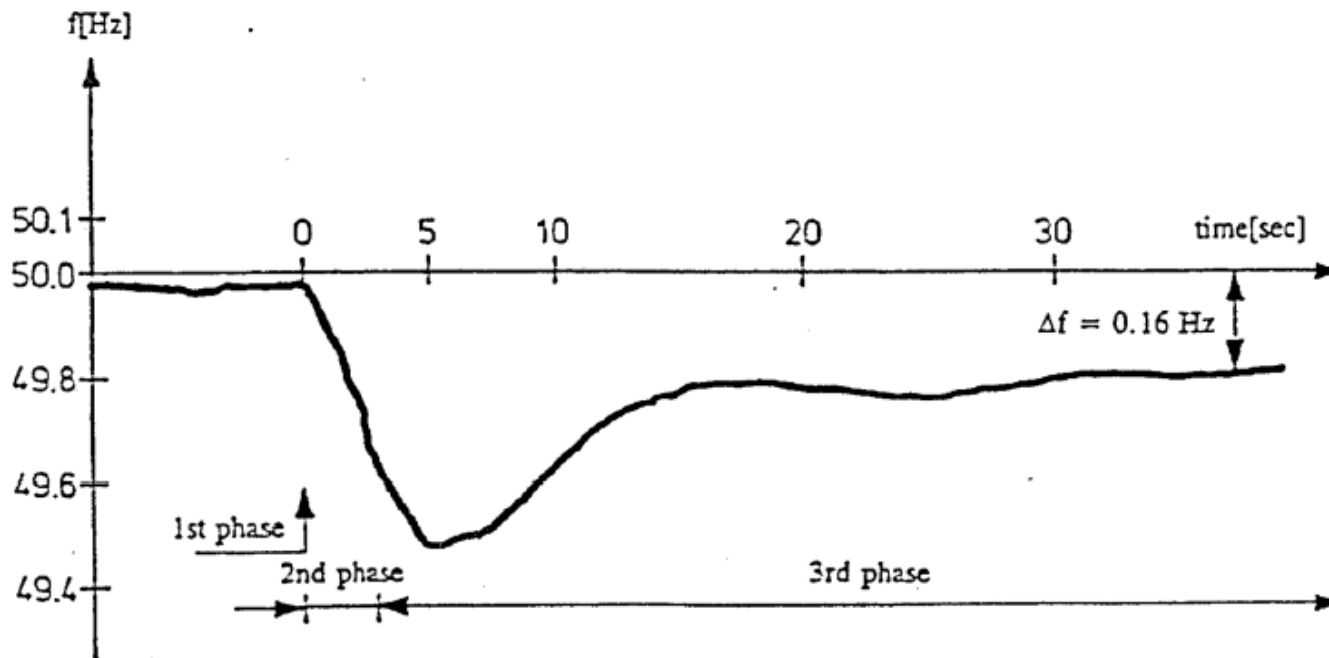


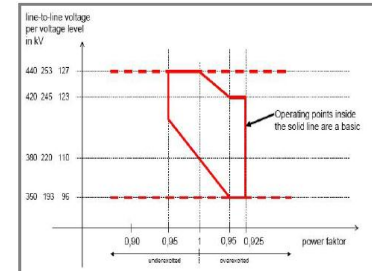
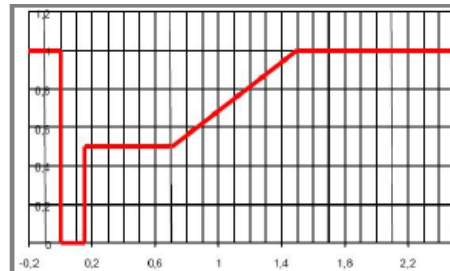
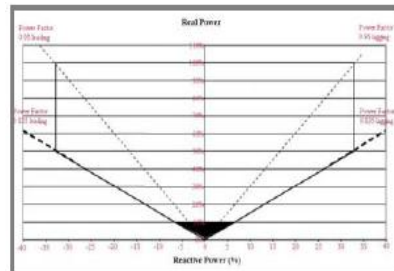
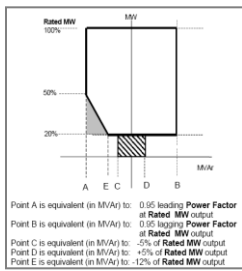
Image courtesy of: Nordel, Vestas

Connection Conditions

Connection conditions materialise as the electrical design and technical capability of the installation

A sample section of key rules.....

- Reactive power capability / Voltage control
- Fault ride-through capability
- Tolerance of equipment to operate within defined electrical parameters
 - Voltage deviations
 - Frequency deviations

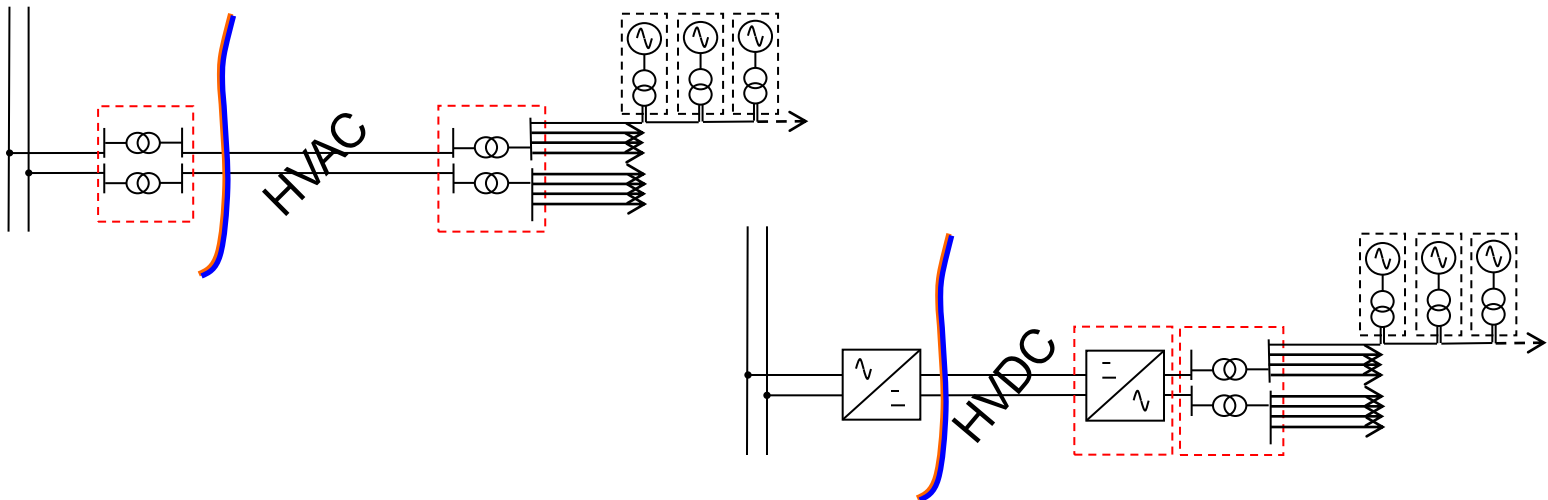


Electrical Design and Equipment Capabilities

The design will be influenced if not largely determined by the applicable regulatory regime and grid codes

Not to mention

- the installed capacity
- distance from shore
- to some extent, the choice of wind turbines
 - (some turbines are more equal than others!)



Electrical Design and Equipment Capabilities

- Offshore Substation Design
 - The grid code requirements and the capabilities of the wind turbines can influence the substation design
- Cable Capacitance
 - Extensive lengths of cable have a significant (and generally unwanted) capacitive effect – this needs to be dealt with
 - Offshore substation reactors
 - Wind turbines capabilities
- Wind Turbines
 - Some wind turbines are better at addressing grid code requirements than others (some turbines are more equal than others!)
 - and therefore influence the wind farm electrical system design

Summary

- Grid Issues can influence all aspects of the wind farm electrical system design
- It depends however on where in the world a project is being built
- Understand the regulatory environment within which you are operating