Appendix C

Topics Related to Contingency

Stability of networks

Network stability is characterized by the fluctuations in the powers flowing in the network and is measured by the variations in time of the associated voltages and frequencies.

A distinction must be made between:

- Stability in steady state: the network has a stable behavior, i.e., when subjected to small disturbances it returns to its initial point of operation with, possibly, damped oscillations until balance is restored.
- Stability in transient state: on moving from one steady stable state to another as a result of a voluntary or accidental durable disturbance, the change in balance is accompanied by a damped oscillating variable state considered to be acceptable with respect to the predefined limits of ΔU, Δf, Δt.
- Instability in the transient state is observed when, further to a serious disturbance, the oscillating state is divergent. Either a loss of power supply or a new unacceptable stable state is induced (e.g. a « crawling »motor).

Stability in dynamic state: the network is able to avoid all divergent oscillating states and to return to an acceptable stable state. This includes tripping of protection and automatic devices according to the disturbance under consideration.

The dynamic stability studies consist of:

- Considering the main critical scenarios such as short-circuit, loss of mechanical power, loss of electrical supply, load fluctuations, process constraints,
- Predicting network reactions to these disturbances,

- Recommending the appropriate operating measures such as type of protection device, relay setting, load shedding, configurations… in order to avoid undesirable operating modes.

Such studies therefore enable the reactions of the network considered (public private, HV or LV) to be mastered.

The HVDC technology

The fundamental process that occurs in an HVDC system is the conversion of electrical current from AC to DC (rectifier) at the transmitting end, and from DC to AC (inverter) at the receiving end. There are three ways of achieving conversion:

- Natural Commutated Converters. Natural commutated converters are most used in the HVDC systems as of today. The component that enables this conversion process is the thyristor, which is a controllable semiconductor that can carry very high currents (4000 A) and is able to block very high voltages (up to 10 kV). By means of connecting the thyristors in series it is possible to build up a thyristor valve, which is able to operate at very high voltages (several hundred of kV).The thyristor valve is operated at net frequency (50 hz or 60 hz) and by means of a control angle it is possible to change the DC voltage level of the bridge. This ability is the way by which the transmitted power is controlled rapidly and efficiently.
- Capacitor Commutated Converters (CCC). An improvement in the thyristor-based commutation, the CCC concept is characterized by the use of commutation capacitors inserted in series between the converter transformers and the thyristor valves. The commutation capacitors improve the commutation failure performance of the converters when connected to weak networks.
- Forced Commutated Converters. This type of converters introduces a spectrum of advantages, e.g. feed of passive networks (without

generation), independent control of active and reactive power, power quality. The valves of these converters are built up with semiconductors with the ability not only to turn-on but also to turn-off. They are known as VSC (Voltage Source Converters). Two types of semiconductors are normally used in the voltage source converters: the GTO (Gate Turn-Off Thyristor) or the IGBT (Insulated Gate Bipolar Transistor). Both of them have been in frequent use in industrial applications since early eighties. The VSC commutates with high frequency (not with the net frequency). The operation of the converter is achieved by Pulse Width Modulation (PWM). With PWM it is possible to create any phase angle and/or amplitude (up to a certain limit) by changing the PWM pattern, which can be done almost instantaneously. Thus, PWM offers the possibility to control both active and reactive power independently. This makes the PWM Voltage Source Converter a close to ideal component in the transmission network. From a transmission network viewpoint, it acts as a motor or generator without mass that can control active and reactive power almost instantaneously.

Smart Grid

Transforming the Electricity System to Meet Future Demand and Reduce **Greenhouse Gas Emissions:**

Most of the world's electricity delivery system or "grid" was built when energy was relatively inexpensive. While minor upgrades have been made to meet increasing demand, the grid still operates the way it did almost 100 years ago—energy flows over the grid from central power plants to consumers, and reliability is ensured by maintaining excess capacity.

The result is an inefficient and environmentally wasteful system that is a major emitter of greenhouse gases, consumer of fossil fuels, and not well suited to distributed, renewable solar and wind energy sources. In addition, the grid may not have sufficient capacity to meet future demand.

Several trends have combined to increase awareness of these problems, including greater recognition of climate change, commitments to reduce carbon emissions, rising fuel costs, and technology innovation. In addition, recent studies support a call for change:

- Power generation causes 25.9 percent of global carbon (CO2) emissions.
- CO2 emissions from electricity use will grow faster than those from all other sectors through 2050.

Given this information, governments and regulators, utility companies, and technology firms are rethinking how the electricity grid should look. Already, utility companies and governments around the world are launching efforts to:

- Increase distributed solar and wind power generation to increase the electrical supply without additional greenhouse gas emissions
- Use plug-in hybrid electric vehicles (PHEVs) to generate and consume electric power intelligently
- Sequester (scrub and store) the carbon from coal plant emissions
- Use demand management to improve energy efficiency and reduce overall electricity consumption
- Monitor and control the energy grid in near-real time to improve reliability and utilization, reduce blackouts, and postpone costly new upgrades.

For all of these efforts—solar and wind plants, PHEVs, active home-energy management, and grid monitoring—to work together in one integrated system, a new level of intelligence and communication will be required. For example:

- Rooftop solar panels need to notify backup power generators within seconds that approaching clouds will reduce output.
- The grid needs to notify PHEVs about the best time to recharge their batteries.

- Utility companies need to communicate with and control appliances such as refrigerators and air conditioners during periods of peak electricity demand.
- Factory operators must know the cost of electric power every few minutes to manage their energy use economically.
- Homeowners need to become smart buyers and consumers of electricity by knowing when to adjust thermostats to optimize energy costs.

Unfortunately, these activities cannot be achieved with the current energy grid. Today's electric infrastructure simply cannot coordinate and control all the systems that will be attached to it.

A new, more intelligent electric system, or "Smart Grid," is required that combines information technology (IT) with renewable energy to significantly improve how electricity is generated, delivered, and consumed.

A Smart Grid provides utility companies with near-real-time information to manage the entire electrical grid as an integrated system, actively sensing and responding to changes in power demand, supply, costs, and emissions—from rooftop solar panels on homes, to remote, unmanned wind farms, to energy-intensive factories A Smart Grid is a major advance from today, where utility companies have only basic information about how the grid is operating, with much of that information arriving too late to prevent a major power failure or blackout.

Components of a Smart Grid

A Smart Grid comprises three major components:

1. Demand management,
2. Distributed electricity generation, and 3) transmission and distribution grid management.

NEPLAN Software Program:

NEPLAN is very user friendly planning and information system for electrical, gas and water network. This software program provided by BCP Switzerland.

Main Characteristic of NEPLAN:

Most intuitive Graphical User Interface

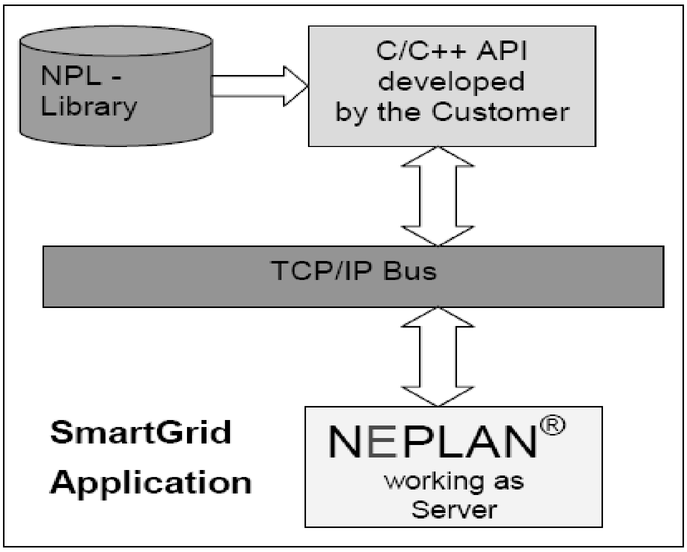
- Multi-document and multi-window system.
- All equipment can be entered graphically and/or table oriented (like in a excel sheet).
- There is no restriction on drawing sizes and number of nodes and elements.
- Extensive editing functions like undo, redo, delete, copy, move and zoom for processing the network diagram are available. An element can be moved from one node to an other node without deleting the element.
- OLE functionality: Data and graphic can be moved to and from third party software (like MS-Excel, MS-Word). Project documentation was never easier.
- The equipment data are entered in dialogs, with plausibility checks provided. A coloring tool helps to show which data is needed for which analysis (e.g. short circuit, transient stability etc.)
- Integrated Variant Manager (insert, delete, append, compare variants, compare results, etc.).
- ASCII file or SQL database oriented import/export functions for exchanging network data, topology data and load data are available.
- Interfaces to external programs (e.g. measured data) can be implemented.
- Import of a geographic map as a background graphic, for easier schematic capturing.

- Import of almost any raster and vector graphic files (e.g. PCX and DXF files).
- Graphics can be exported as raster files (e.g. JPG, which can be used in any internet web browser).
- Option for combining and separating networks. Any number of independent network areas and zones are possible. Each element and node can belong to any independent area and zone.
- Extensive functions for network statistics and network documentations are available.
- A state of the art library manager with extensive libraries for each element type facilitates data entry.
- All computation modules access a shared database.
- Integrated chart manager allows to analyze and compare all results from all variants.
- Multi-lingual Graphical User Interface.

NPL - NEPLAN Programming Library

The NPL – NEPLAN Programming Library is a C/C++ API library, which includes functions to access NEPLAN data and calculation algorithms through a C/C++ user written program. Functions
included among others are:

- Access any variable of any component.
- Change any variable of any component
- Execute any analysis/calculation function
- Retrieve the calculation results
- Add new components to the network
- Delete components from the network
- Add and change the graphical
- information (x, y coordinates, symbols, etc.) of any component



SCADA Overview:

SCADA is an acronym for Supervisory Control and Data Acquisition. SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining and transportation. These systems encompass the transfer of data between a SCADA central host computer and a number of Remote Terminal Units (RTUs) and/or Programmable Logic Controllers (PLCs), and the central host and the operator terminals. A SCADA system gathers information (such as where a leak on a pipeline has occurred), transfers the information back to a central site, then alerts the home station that a leak has occurred, carrying out necessary analysis and control, such as determining if the leak is critical, and displaying the information in a logical and organized fashion. These systems can be relatively simple, such as one that monitors environmental conditions of a small office building, or very complex, such as a system that monitors all the activity in a nuclear power plant or the activity of a municipal water system. Traditionally, SCADA systems have made use of the Public Switched Network (PSN) for monitoring purposes. Today many systems are monitored using the infrastructure of the corporate Local Area Network (LAN)/Wide Area Network (WAN). Wireless technologies are now being widely deployed for purposes of monitoring.

SCADA systems consist of:

- One or more field data interface devices, usually RTUs, or PLCs, which interface to field sensing devices and local control switchboxes and valve actuators.
- A communications system used to transfer data between field data interface devices and control units and the computers in the SCADA central host. The system can be radio, telephone, cable, satellite, etc., or any combination of these.
- A central host computer server or servers (sometimes called a SCADA Center, master station, or Master Terminal Unit (MTU).
- A collection of standard and/or custom software [sometimes called Human Machine Interface (HMI) software or Man Machine Interface (MMI) software] systems used to provide the SCADA central host and operator terminal application, support the communications system, and monitor and control remotely located field data interface devices.