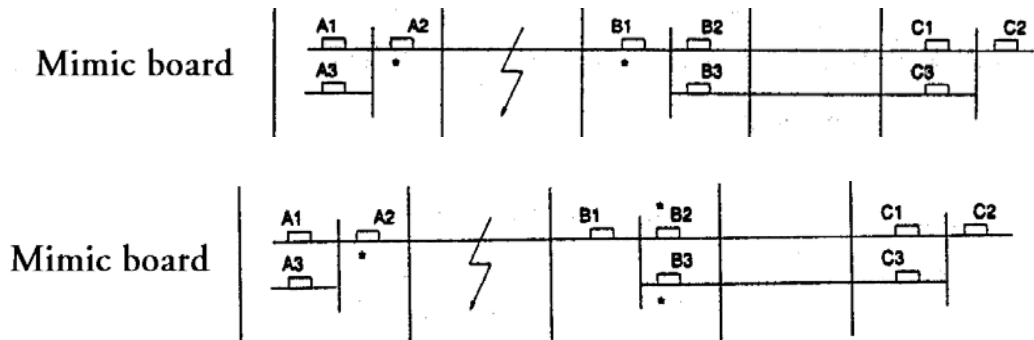


3.3 Data Base for Reliability Calculation - Statistics

On a high technical level manufactured network components normally can be operated 20...30...40...80 years.

Disturbing influences are external or internal occasions that lead to an outage

Operational:



- * **disturbing occasions:** (ex.: short circuit)
- atmospheric
 - storm
 - thunderstorm
 - foreign layer
 - moisture
 - cold, ice coating
 - heat
 - conductor oscillations & others
 - strange influences
 - persons
 - animals
 - trees
 - digging work
 - earth quake
 - shake
 - burning & others
 - operating
 - operating of elements
 - wrong operating
 - overload
 - auxiliary equipment & others
 - reactions from
 - own network
 - foreign networks of same voltage level
 - foreign networks with other voltage level
 - customers installations

* **failure site:** (ex.: backward flash-over)

- Overhead line (OHL)
 - wooden pole line
 - steel tower with earth conductor
 - steel tower without earth conductor
 - concrete tower with earth conductor
 - concrete tower without earth conductor
 - other differentiation
- cable
 - between stations
 - in connection with OHL
 - inside of stations
- substation, transformer station
 - pole transformer station
 - building made of metal
 - building made of concrete
 - building made of plastic
 - integrated building
- switchgear
 - open air metal-clad
 - indoor metal-clad
 - cast resin
- position in switchgear
 - bus-bar
 - feeder
 - transformer
 - capacitor
 - elements connected with the SP
 - compensation coil

* **failure reason:** (ex.: grounding resistance to high)

- production, material
- construction
- maintenance
- operation
- supervisory
- over stressed, mechanical
- over stressed, electrical
- diminution of quality, mechanical
- diminution of quality, electrical
- foreign influence

* **other information:**

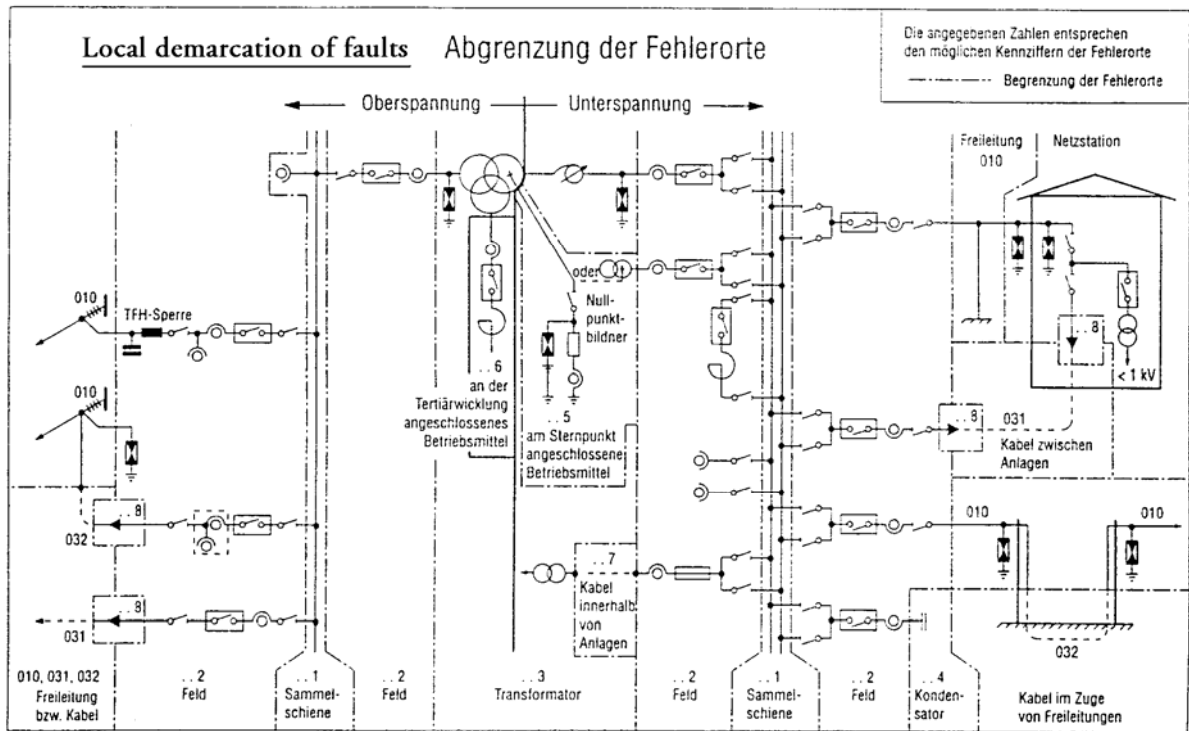
- outage time, repair time, interrupted power, non delivered energy, repair time
- network definition (per voltage level)
- length of line, number of elements (per voltage level)

* **damage - damage reason - analysis**

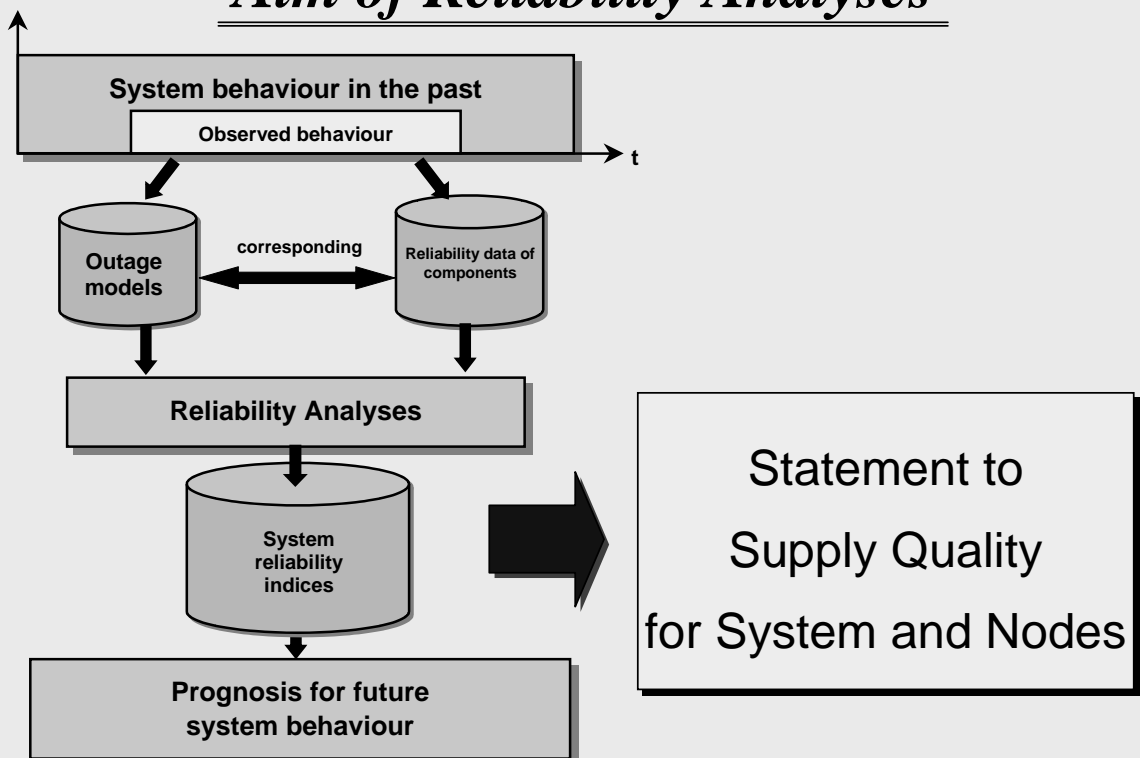
- mechanical
- electrical
- production and material defect
- construction fault
- over stressed (mechanical, electrical)
- diminution of mechanical (electrical) forces
- foreign influences
- arc
- others
- OHL
 - damage of tower
 - tower break down
 - damage of insulator
 - break of chain insulator
 - ...
 - conductor
 - ...
 - grounding resistor
 - ...
 - termination
 - ...
 - oscillation damper
 - ...
 - surge arrester
- UGC
 - ...
- substations, transformer stations and switchgear
- ...

* **failure and damage statistics:**

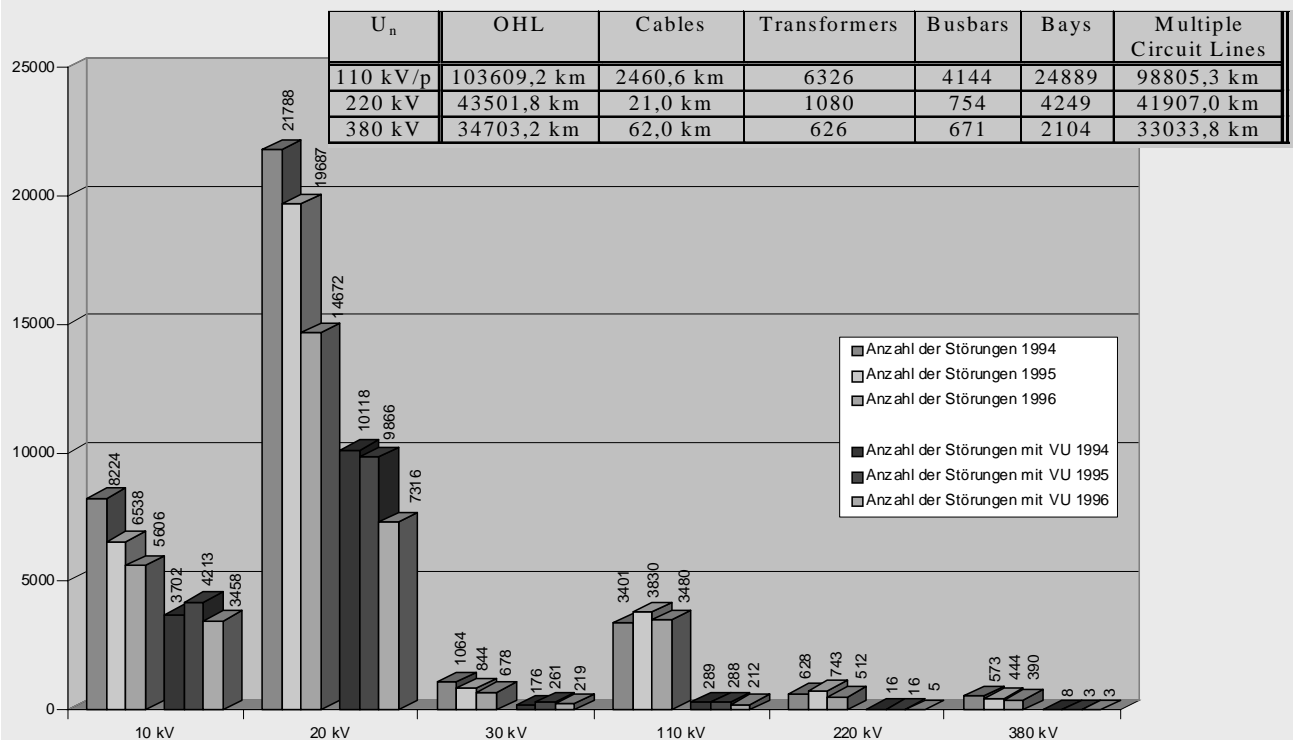
- precise documentation of failure and damage necessary
- form easy to fill up
- all information needed (others, if no attachment possible)
- analysis of failure rates,... (quality, availability)
- analysis of damages, ... (weak points of design, work, material, systematic,...)



Aim of Reliability Analyses



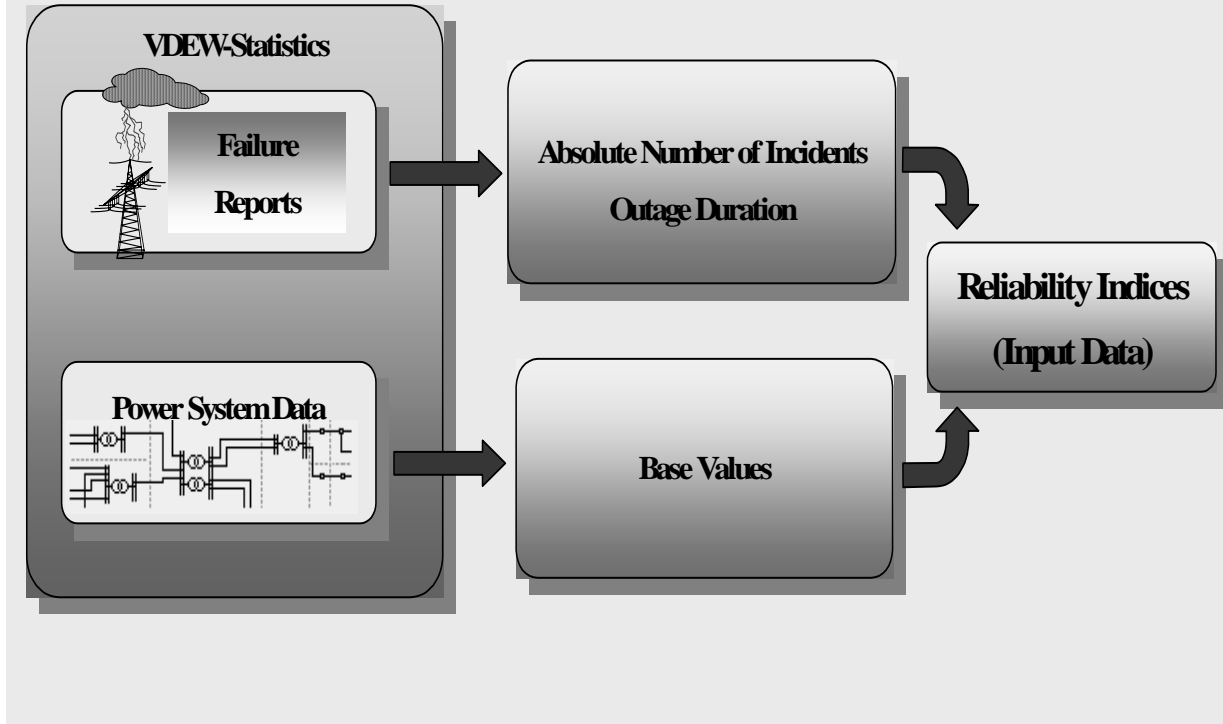
Absolute Number of Incidents in the Public Power Systems in Germany for 1994 - 1996



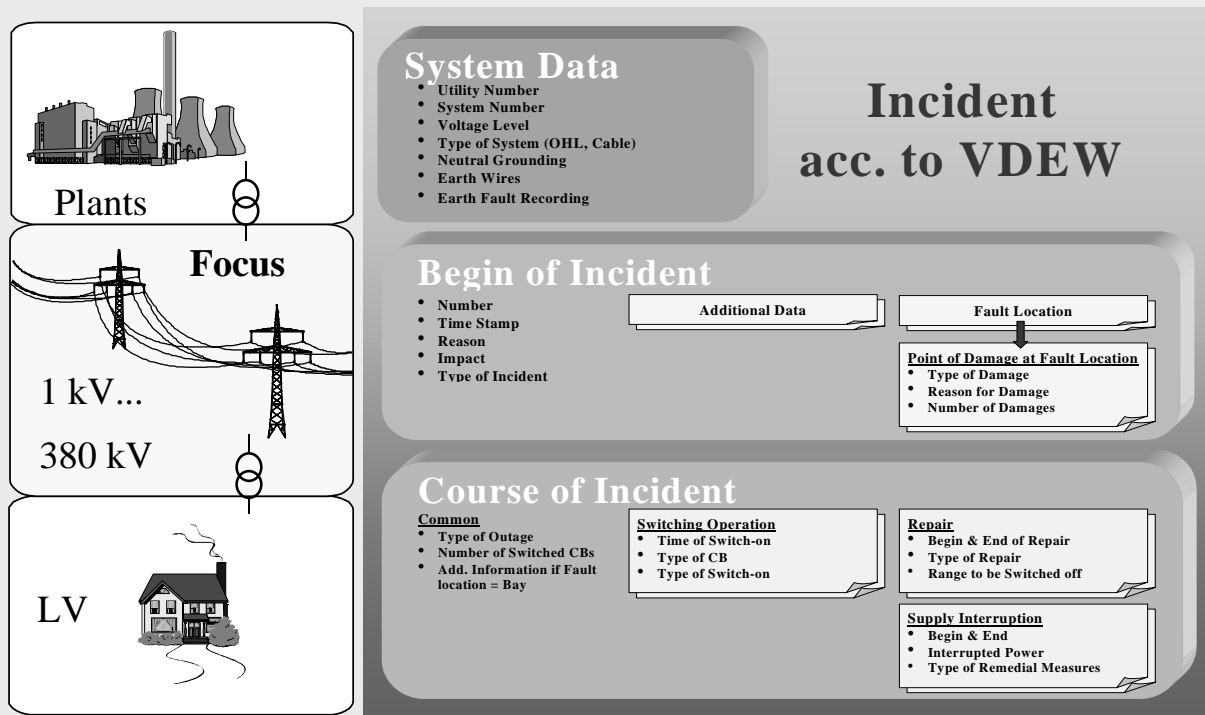
Outage Models according to VDEW Statistics

- *independent single failure*
- *common mode failure*
- *malfunction of protection devices*
- *unnecessary protection operation with multiple outages*
- *multiple earth faults with multiple outages*
- *failure during maintenance of the reserve component*
- *maintenance*
- *accidental failure during maintenance of the reserve component*
- *independent unnecessary protection operation*
- *delayed switching-off*
- *malfunctions of circuit breakers*

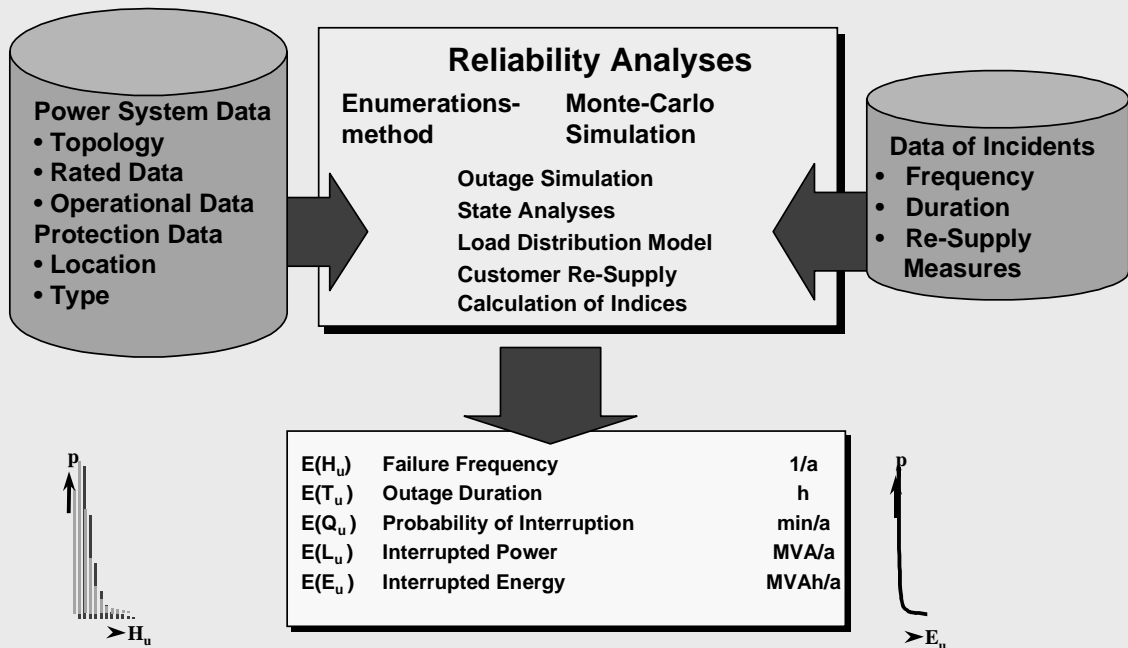
VDEW Statistics of Incidents



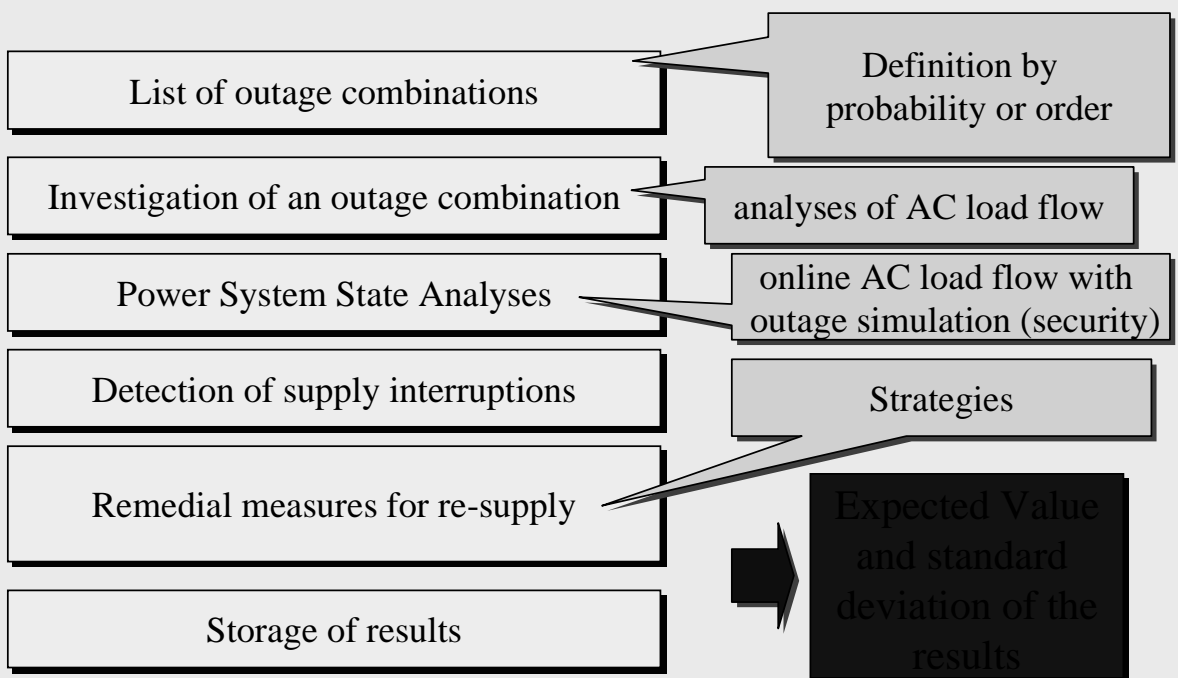
VDEW Statistics of Incidents - General Information



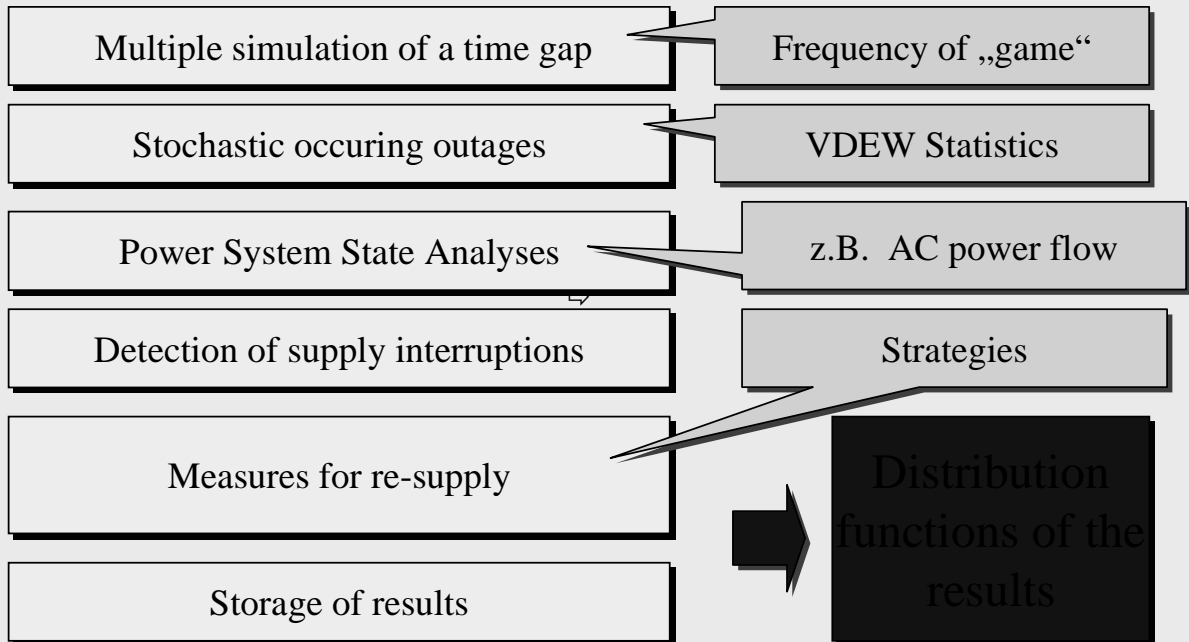
Principle of a Reliability Analyses



Calculation Procedure - Analytic Method



Calculation Procedure - Simulative Method



ZUBER - Features I

- **Calculation methods**
 - ⇒ Enumeration method
 - ⇒ full time-sequential Monte Carlo simulation
- **Main Characteristics**
 - ⇒ all system levels including composite system studies (generation & transm.)
 - ⇒ algorithms for power flow calculations (full AC,DC, transportation model)
 - ⇒ time dependent variables possible (Monte Carlo simulation only)
 - ⇒ reliability equivalents available
 - ⇒ separation of calculation and analyses part
- **Outage Models**
 - ⇒ full set of failure models of network components acc. to VDEW
 - ⇒ 6 state model for power stations (including peaking stations)
- **Remedial measures - measures for re-supply**
 - ⇒ automatic network re-switching
 - ⇒ automatic generation rescheduling
 - ⇒ optimistic / pessimistic power allocation model
 - ⇒ time sequential proceeding

ZUBER - Features II

- **Output**

- ⇒ all simulation results available in a data base
- ⇒ list or bar chart type output
- ⇒ interface to Microsoft Access and Excel
- ⇒ expected values and probability distributions available
- ⇒ all generic indices
(frequency, duration, unavailability, interrupted power & energy)
- ⇒ system and customer reliability indices
- ⇒ all indices can be broken down according to failure modes, failure order, affected components, protection tripping areas
- ⇒ time dependent sequence of individual failure combinations and remedial measures
- ⇒ user defined criteria for selecting special interesting failure combinations
- ⇒ check against violations of user defined planning criteria