Workshop 2:
-Mitigation possibilities for power quality and operational issues in relation to RE integration in distribution networks.
-Inputs to system operating guidelines.

05.10.2020 - 19.10.2020

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Eskom Danish Energy Agency COWI

Energy Partnership Programme between South Africa and Denmark

About the Programme

- DE2 OUTPUT 3 - CONSULTANT SUPPORT FOR IMPLEMENTING WORKING ACTIVITIES ON RE INTEGRATION AT DISTRIBUTION LEVEL
- Training of distribution network operators – Year 2 (2020)
  - Activity 1: Calculating losses in networks with very high levels of RE generation embedded into the grid
    - Workshop 1 - Training and workshop with Eskom staff focusing on theory and practical calculation of technical losses in power networks with very high levels of RE generation
  - Activity 2: Mitigating solutions for distribution network power quality issues in relation to RE generation and penetration to the distribution network
  - Activity 3: Inputs to system operating guidelines
    - Workshop 2 - Theoretical and practical training activities as specified for Activity 2 & 3.

Workshop 2 – Part 1
Monday 05.10.2020 – Friday 09.10.2020

- Session 1
  - Review on Eskom distribution network planning procedures in relation to power quality
- Session 2
- Session 3

Pre-recorded sessions released on Monday 05.10.2020

QA session: Monday 12.10.2020

Workshop 2 – Part 2
Monday 12.10.2020 – Friday 16.10.2020

- Session 4
- Session 5
- Session 6

Pre-recorded sessions released on Monday 12.10.2020

QA session: Monday 19.10.2020

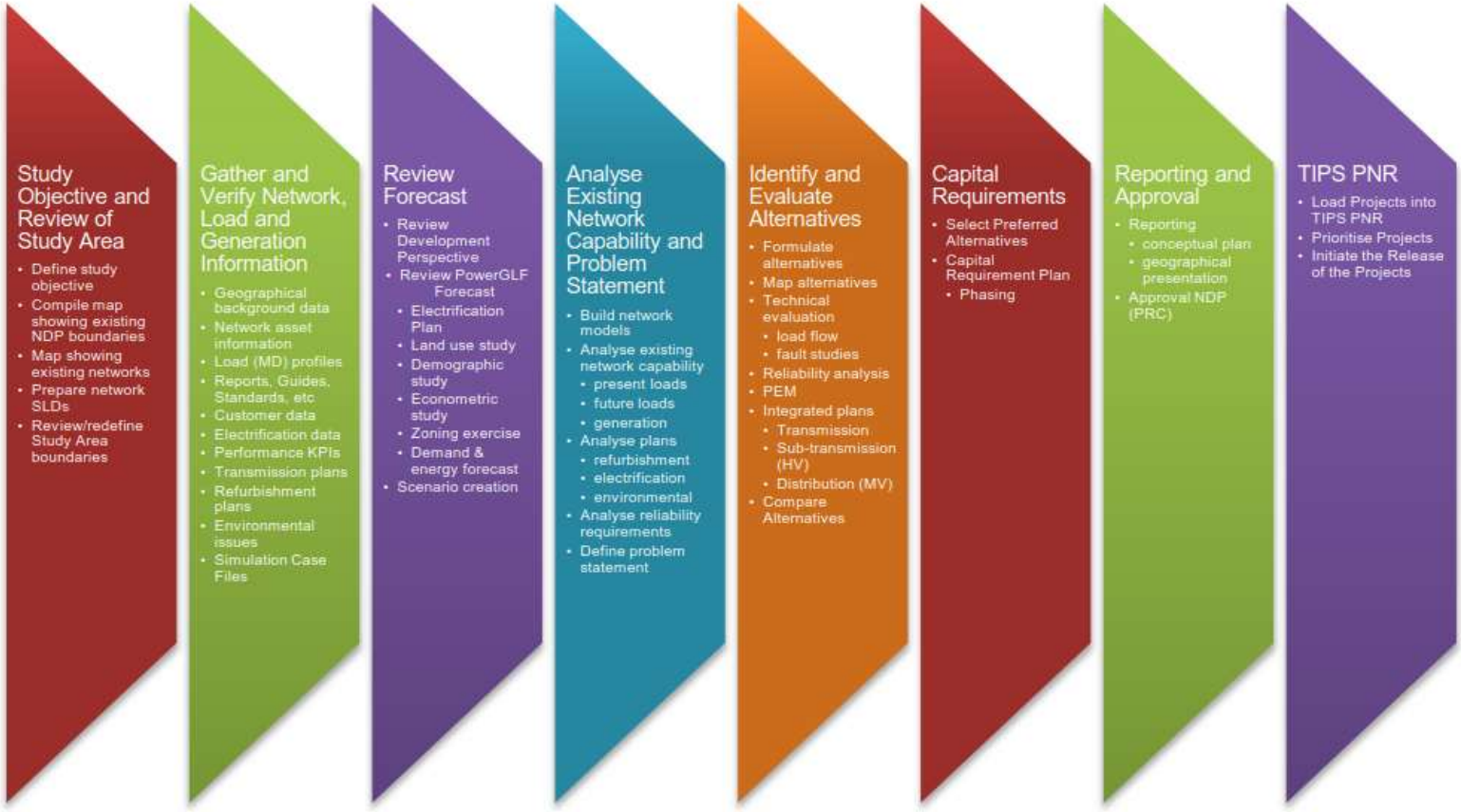
Review on Eskom distribution network planning procedures in relation to power quality

Distribution network planning procedures

Eskom	Guideline	Technology

Title: **METHODOLOGY FOR NETWORK DEVELOPMENT PLANS**

Unique Identifier: **240-125698678**



Distribution network planning procedures

Various planning lead times

- Planning horizons
- Trends for long term planning

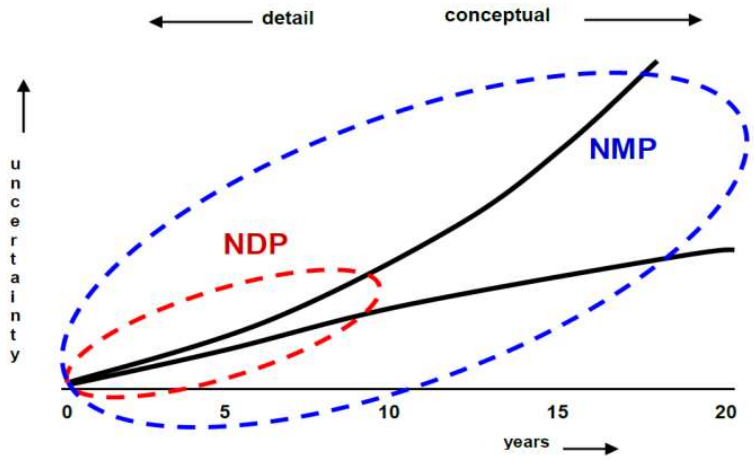
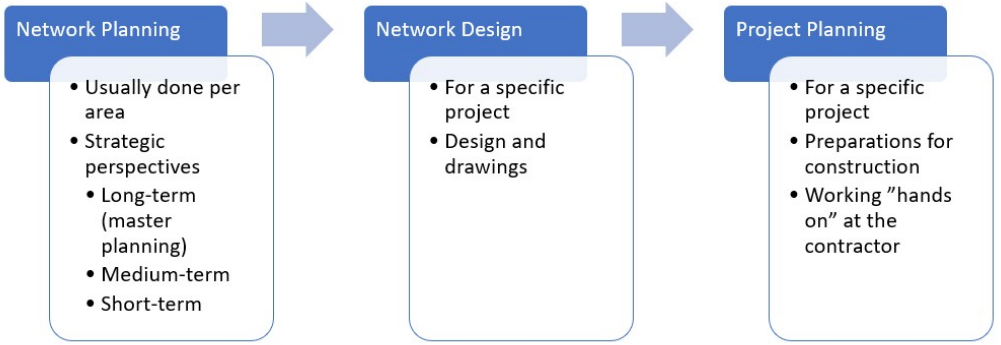


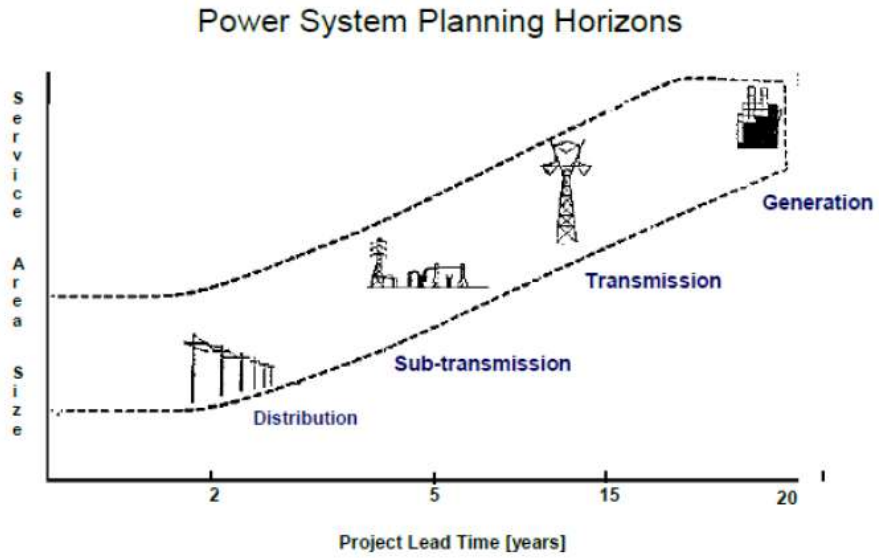
Figure 1: Time Perspectives of NMPs and NDPs

- a 20-year horizon is typically used for integrated planning - generally referred to as Network Master Planning or long term planning
- a 5-10-year horizon is typically used for the orderly and economic expansion of distribution assets - generally referred to as Network Development Planning.
- a 2-3-year horizon is typically used for detailed planning & design - generally referred to as Project Planning

Various planning lead times

- Planning horizons
- Trends for long term planning

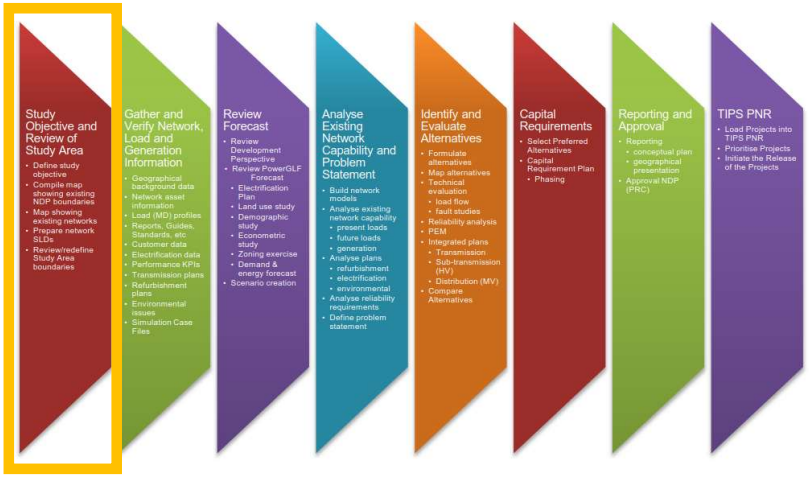




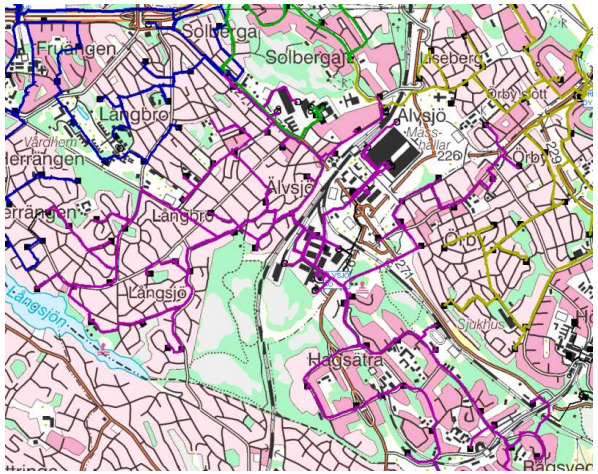
Level of System	Years Ahead
Generation	13
EHV Transmission	9
Transmission	8
Sub-transmission	7
Substation	6
Feeder	3
Branch line	1
Service Level	.2

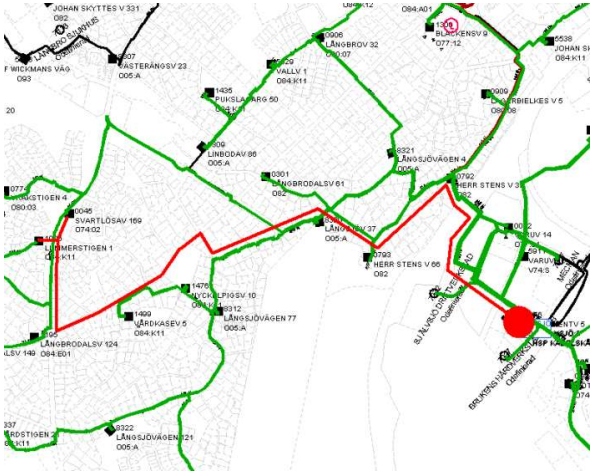
Typical minimum lead times

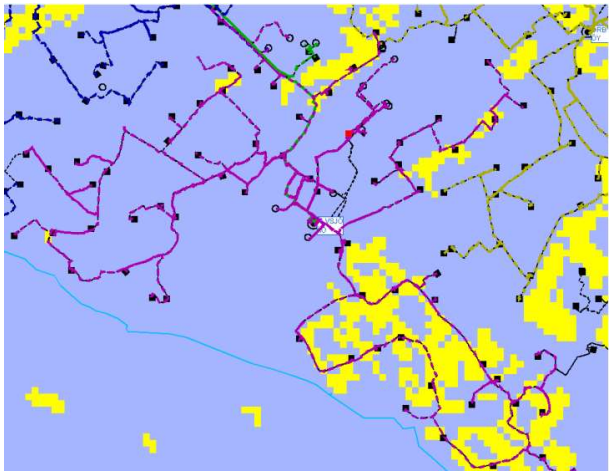
Study Objective and Review of Study Area

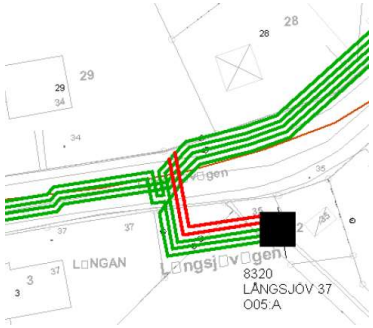


- Includes compiling maps and network information – increased support by further GSI/NIS-development

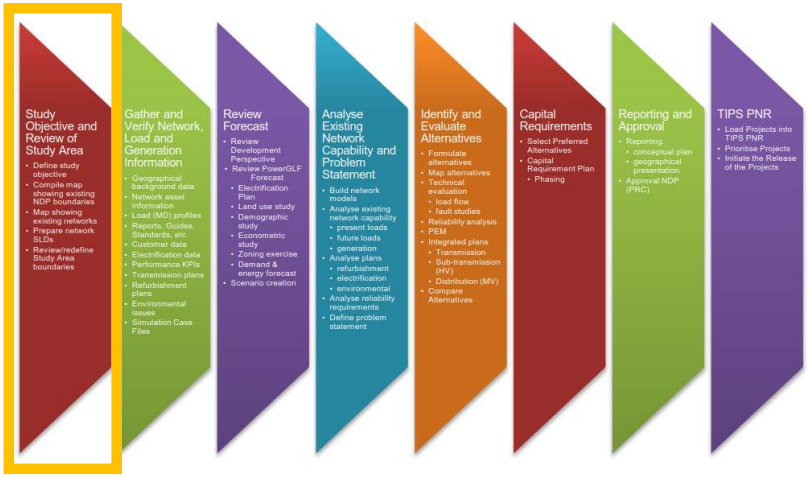






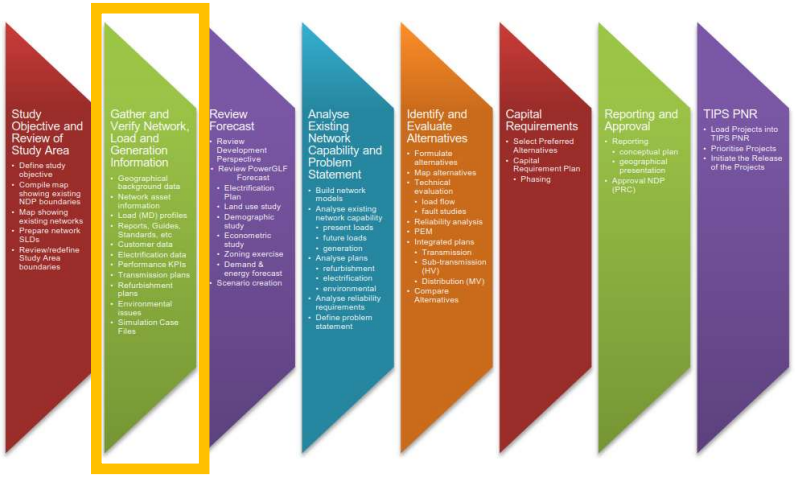


Study Objective and Review of Study Area

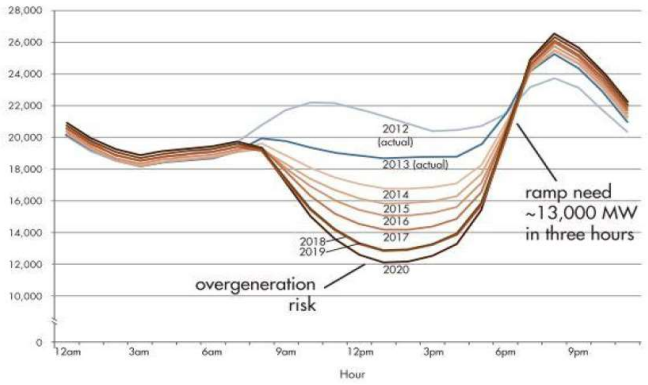


- Includes compiling maps and network information – increased support by further GSI/NIS-development
- Digitalization / digital transformation trends decrease the time spent for this step.

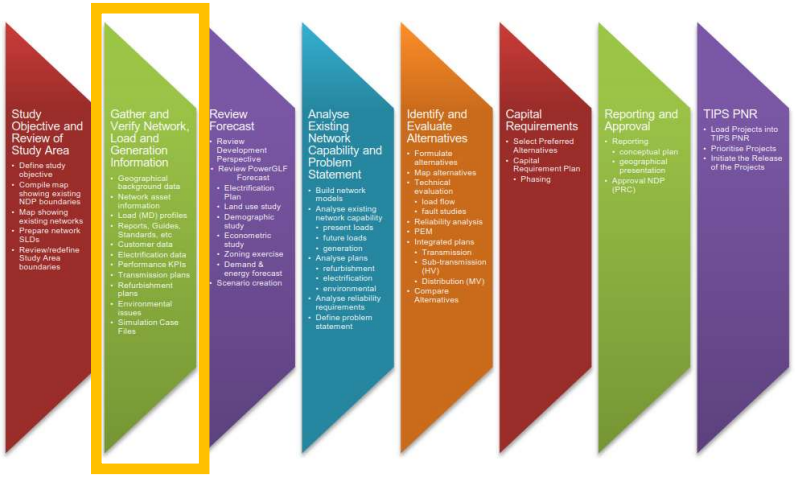
Load and Generation Information



- Updated figures for ADMD (After Diversity Maximum Demand).
- The load estimation must be done in new perspectives.
- How will SSEG impact the peak load in a typical distribution network? Will it lower the peak load?
  - No, the PV generation from SSEG is outside the current evening peak.
    Maybe, if batteries are used.

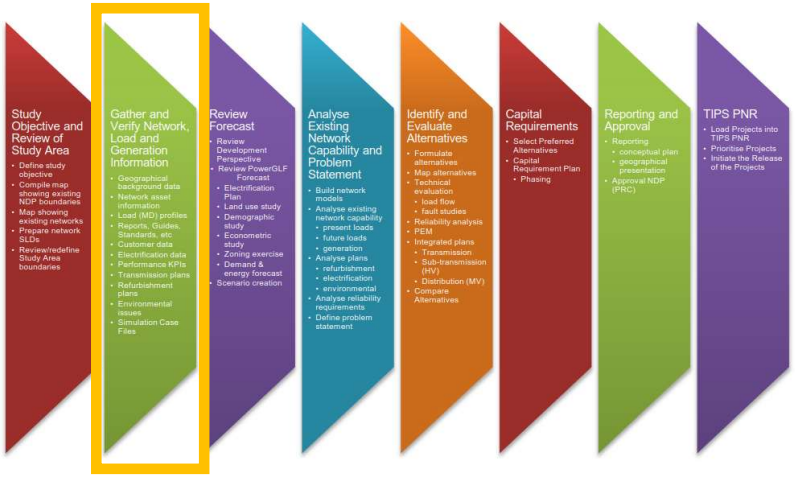


Load and Generation Information



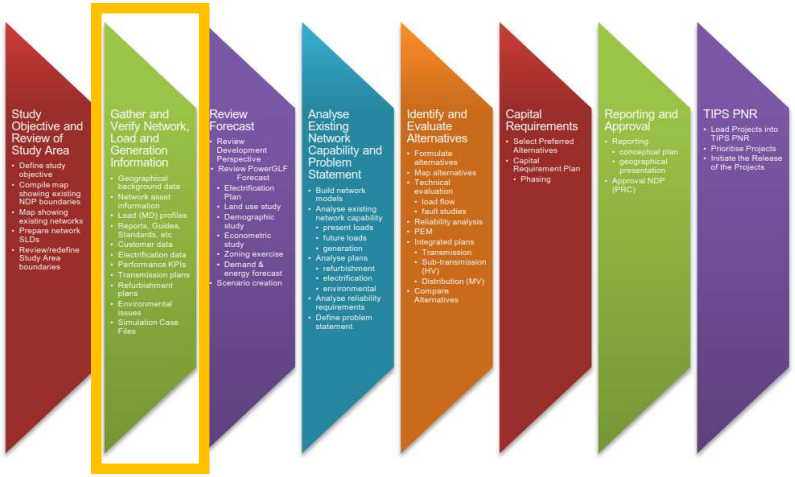
- Updated figures for ADMD (After Diversity Maximum Demand).
- The load estimation must be done in new perspectives.
- How will SSEG impact the peak load in a typical distribution network? Will the reverse flow set the dimension?
  - No, not today. Maybe, in some extreme cases and probably more in a few years' time.

Load and Generation Information



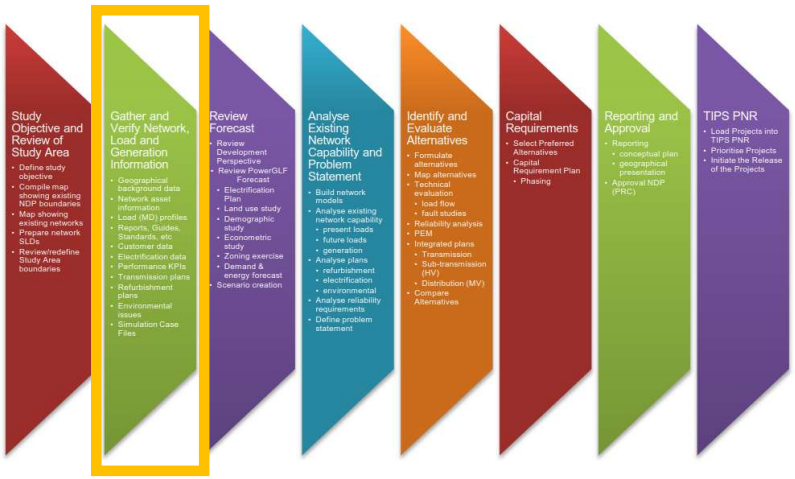
- Updated figures for ADMD (After Diversity Maximum Demand).
- The load estimation must be done in new perspectives.
- How will EVs impact the peak load in a typical network? Will it increase the peak load?
  - Yes, the EV charging coincides with the current evening peak

Load and Generation Information



- From last year's WS:
  - Needing a model of SSEG
  - Scenario development
  - Updated ADMD figures
  - Standards criteria for studies
  - Forecasting tool with load models for SSEG
  - Smart metering
  - Registration process NERSA
  - Capture SSEG installations
  - Enhancing existing platforms or databases for registration of SSEG to increase the percentage of installations captured.

Load and Generation Information



- Gathering load data should be easily available through historical databases
- Best practice - moving toward higher resolution <15 min
- Best practice - increasing data acquisition into the LV grid (at a large share of the DT) and at customers with smart meters.

Tools and systems for registration, metering, energy management and control

Accuracy of estimations can be increased with additional information

- Use of smart meters with monthly readings collected regularly by the utility
- Use of smart meters with hourly readings collected regularly by the utility
- Use of smart meters with readings collected upon instant request by the utility
- Use of smart meters with real time readings collected by the utility
- Adding supervision of the real time aggregated state per network area in SCADA systems.

Tools and systems for registration, metering, energy management and control

- Use of smart meters with monthly readings collected regularly by the utility
  - Correct invoicing

Tools and systems for registration, metering, energy management and control

- Use of smart meters with hourly readings collected regularly by the utility
  - Tariffs based on hourly prices
  - Monitoring load profiles
  - Support to develop new ADMD for SSEG involved

Tools and systems for registration, metering, energy management and control

- Use of smart meters with readings collected upon instant request by the utility
  - Fault detection (LV-outages before relying on customer report)
  - Monitoring power quality
  - Monitoring load and voltage deviations

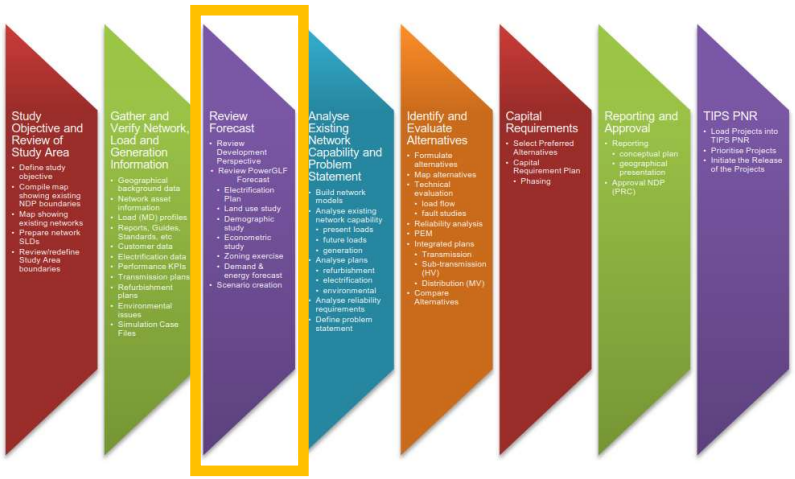
➢ Widespread use among the European utilities

Tools and systems for registration, metering, energy management and control

- Use of smart meters with real time readings collected by the utility
  - Demand side management
    - Combination with batteries and controlled loads gives a distribution system that can take part in frequency control and peak shaving.
    - Frequency control (system balance) usually the focus in media, but for the network planner the peak shaving is what saves investments.
  - Even if only part of the SSEG installations are connected with real time metering – this can be extrapolated per area.

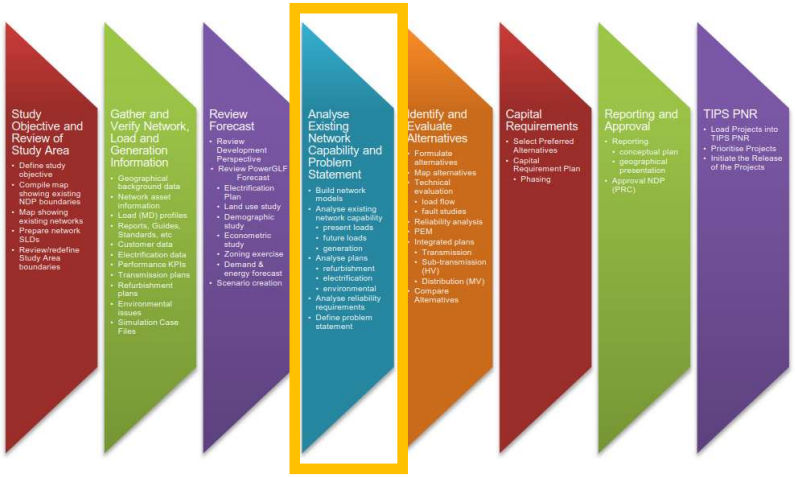
➢Still no widespread use among the European utilities but many “pilot projects” are running.

Review Forecast



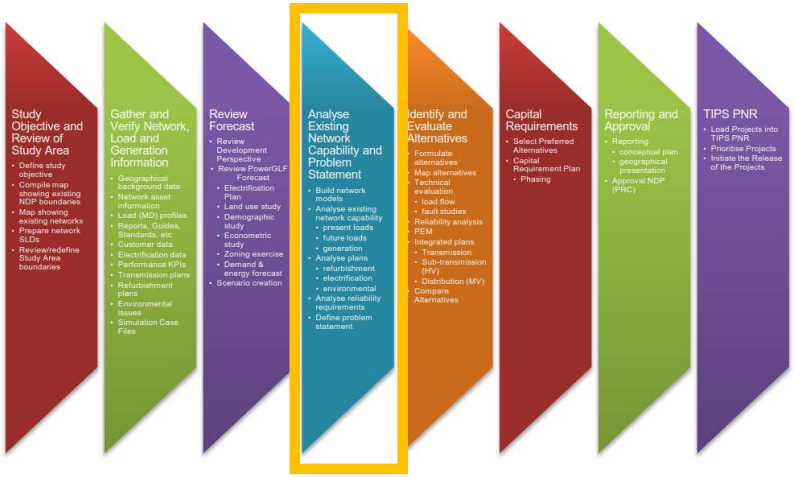
- The activity “Identify future load demand trends” must be further broken down in new sub-activities
- The Load Forecast must include analysis of the effects of DG and new load types as EVs. Especially in the 5-10-20 year perspectives
- DG is briefly mentioned but the impact must be better explained and the new type of analysis required must be listed:
  - Will the SSEG lower the dimensioning peak? If not year 1-5 what happens >5 years when batteries at household level is becoming common?
  - Will the reverse flow set the new dimension? Acceptance of back-feed and feed-in tariffs?
  - How will EVs aggregated charging impact the peak load? With /without DSM?

Analyse Existing Network



- Condition and Reliability analysis - Again digitalization is part of the answer.

Analyse Existing Network



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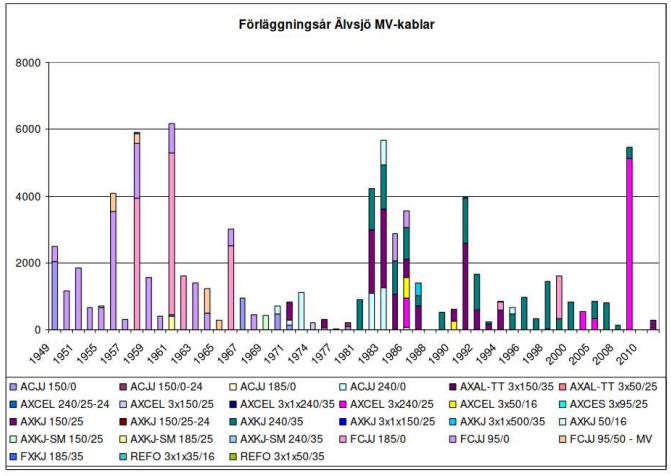
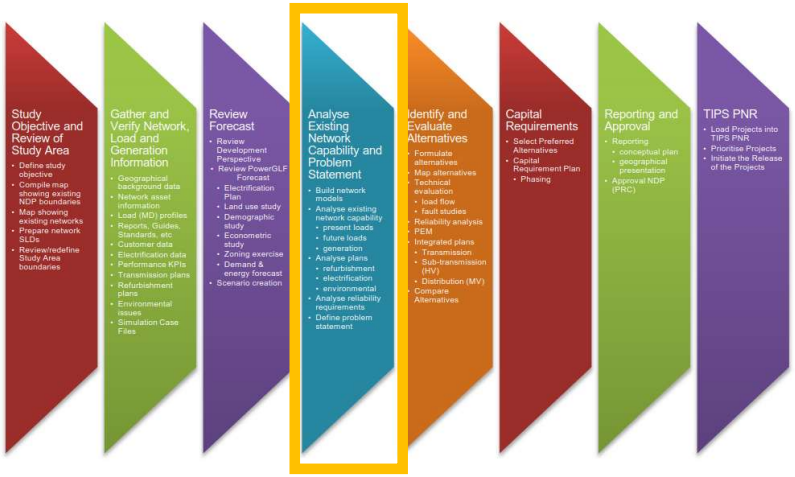
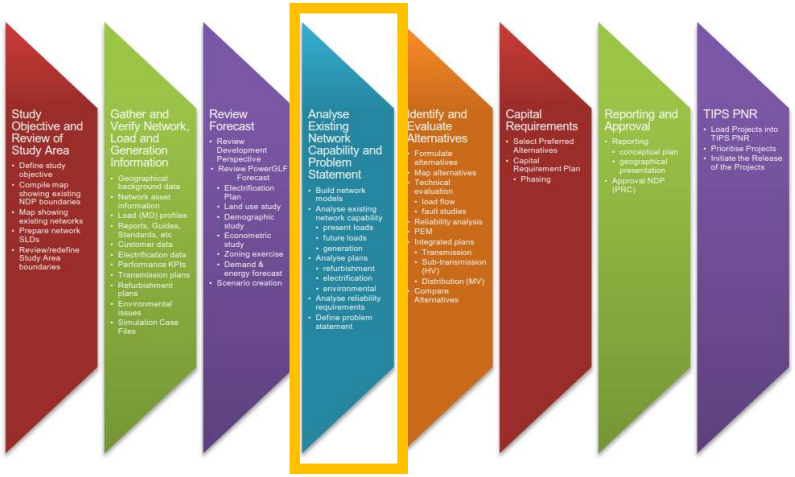


Analyse Existing Network



- Condition and Reliability analysis - Again digitalization is part of the answer.
- Data on the SSEG-installations must be analyzed. Keep record of connections' status and age.
- Correct LV outages must be part of the statistics. Capture thorough smart meters and remote access to distribution transformers. Add the aspect of micro grids with local possibilities to support during load shedding as well as private possibilities to be self supporting.

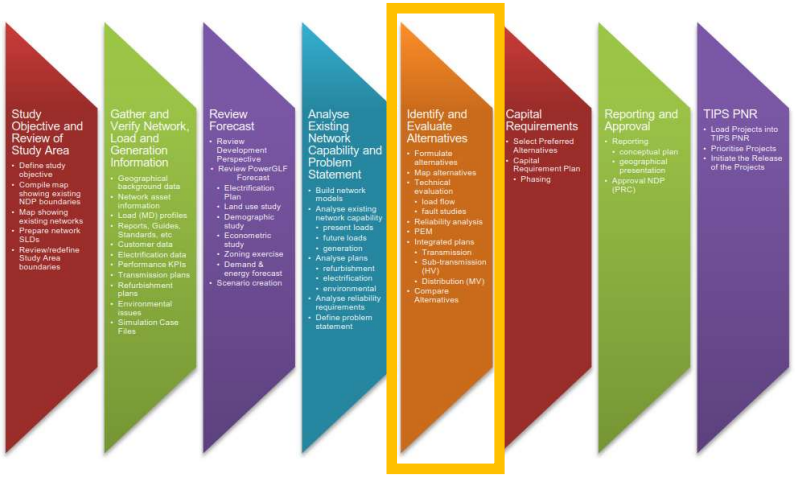
Analyse Existing Network



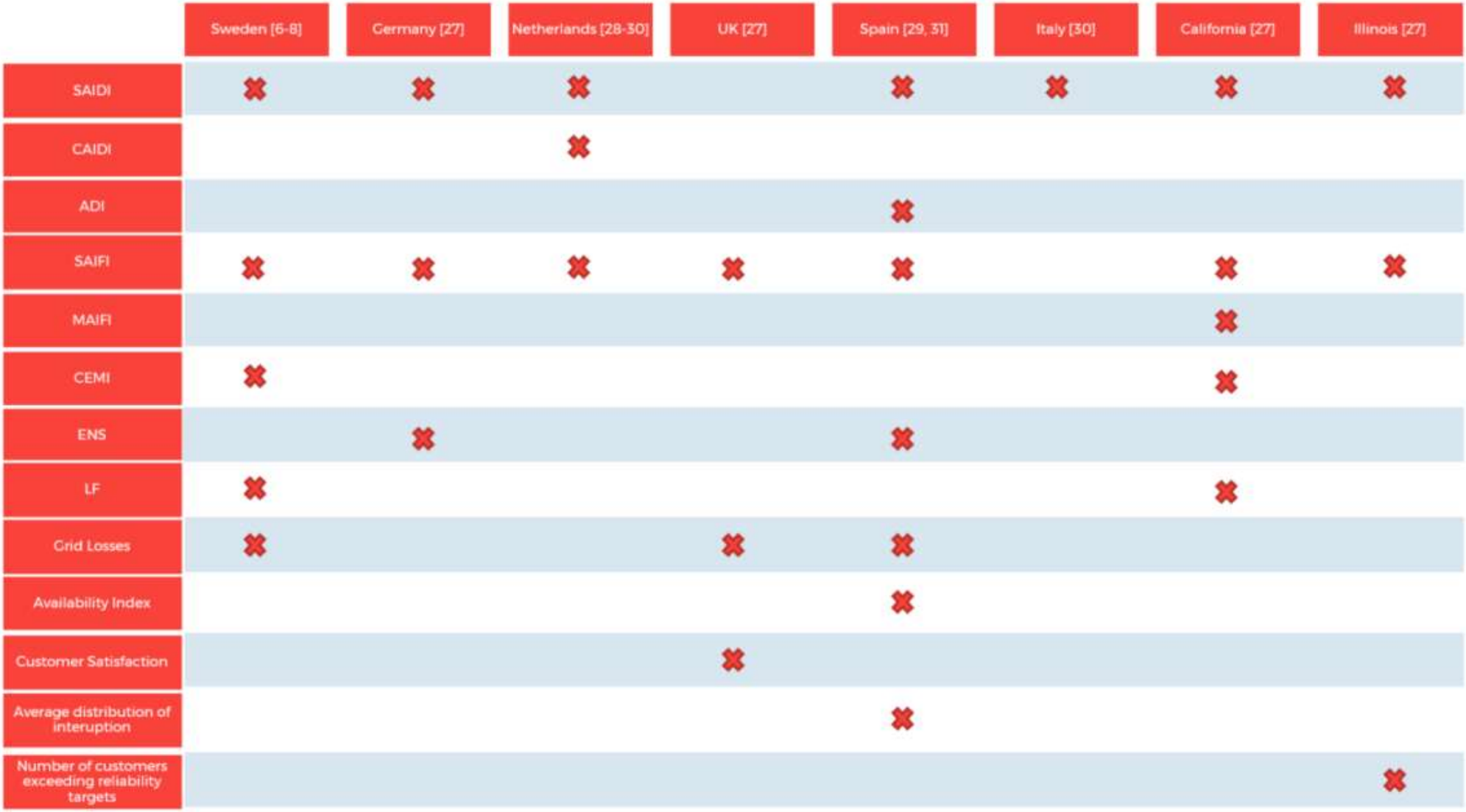
- Varying load and new voltage levels when doing load flow – capture new dimensioning states
- Run the analysis also on the new identified states from the Forecast (SSEG, DVG and EVs)
- Check if hosting capacity is exceeded? Voltage and losses deviating more than acceptable limits.
- Need to add Power quality analysis - measured at DT? - new requirement?

Evaluate Alternatives

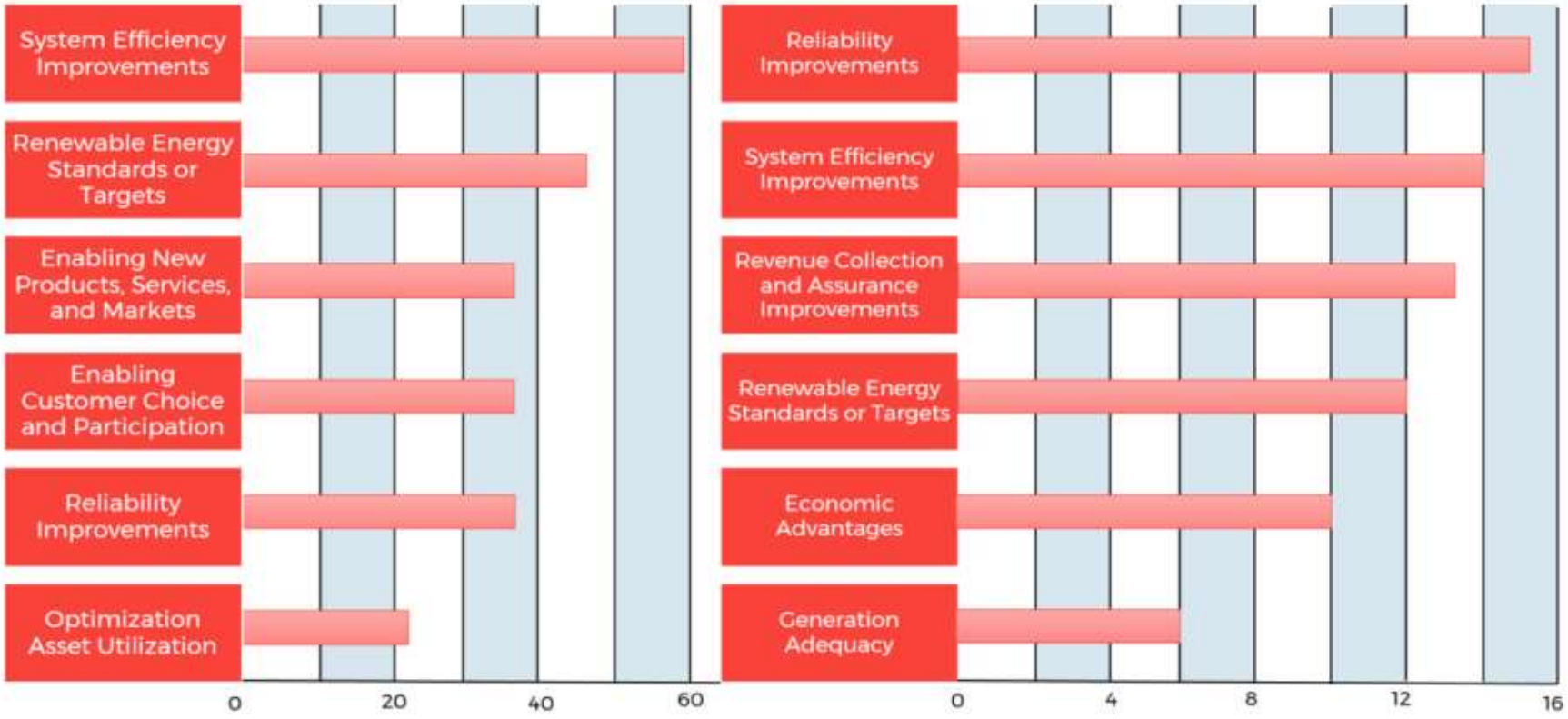
- Hosting capacity for RE sources
- Proportion of local RE production in relation to energy entered
- Energy not supplied from local RE due to limitations in transfer capacity
- Increased spare capacity through the use of dynamic loading levels
- Proportion of distribution transformers with real time measurements
- Proportion of distribution transformers with autonomous functions
- Utilization level
- Average load factor
- Proportion of customers with DSM /AMI
- Occurrence of micro grids



Sub-Activity	Notes
Technical Evaluation	This will include: Quality of supply Thermal loading levels Fault levels Reliability Requirements Operational flexibility and contingencies Maintenance requirements Network losses Safety issues
Environmental Issues	Practical issues w.r.t. line/cable servitudes and substation sites, etc. Environmental impact of alternatives
Economic Evaluation (comparing alternatives against each other)	The PEM will be used for this sub-activity.
Summarise each Alternative	List advantages, disadvantages and costs of each alternative.
Perform Cost Benefit Analysis	Compare costs and technical benefits of alternatives.


Sweden [6-8]
Germany [27]
Netherlands [28-30]
UK [27]
Spain [29, 31]
Italy [30]
California [27]
Illinois [27]
SAIDI
CAIDI
ADI
SAIFI
MAIFI
CEMI
ENS
LF
Grid Losses
Availability Index
Customer Satisfaction
Average distribution of interuption
Number of customers exceeding reliability targets

[1]

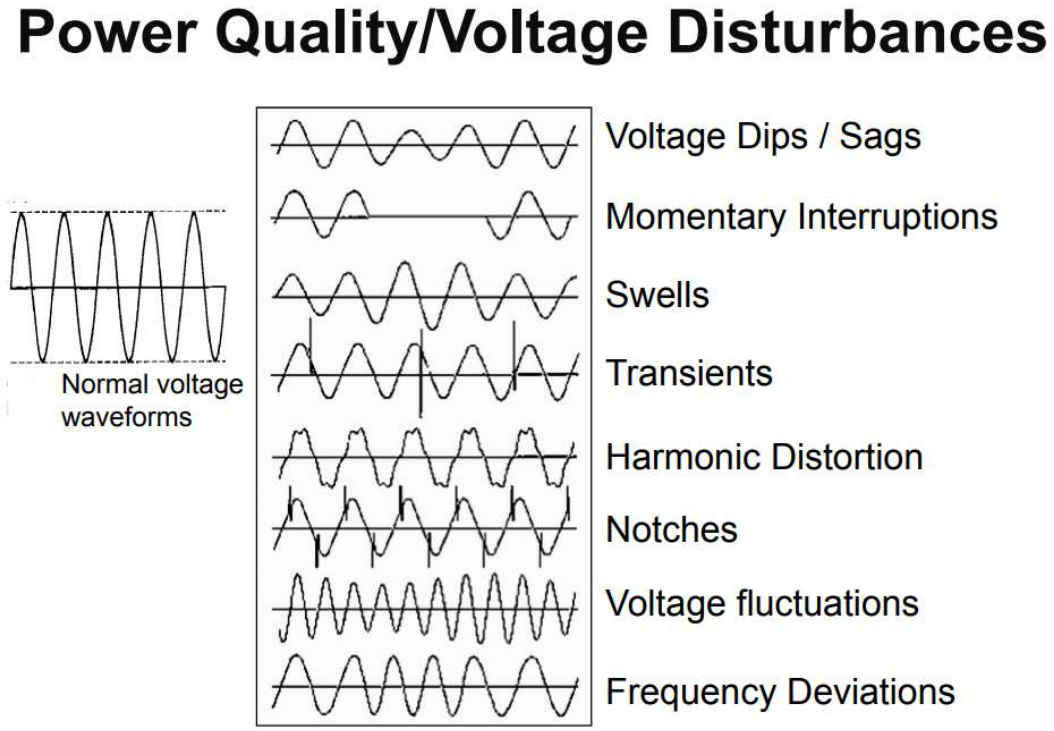


Most important drivers for network development and regulatory indicators for developed countries (left) and developing countries (right)

[1]

Power Quality issues and DG

- harmonic injections
- voltage fluctuations
- voltage sag/swell
- flicker
- impact of low frequency anti-islanding signal injections



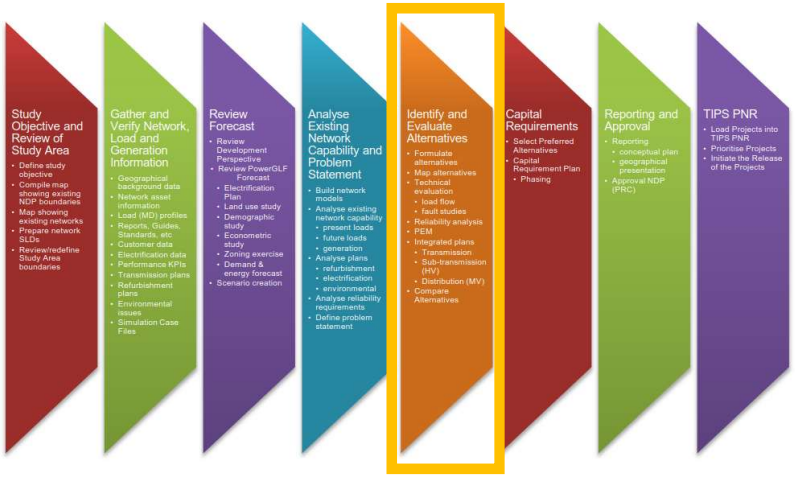
[2]

Power Quality issues and DG

- Since most of the DG units that are connected to the grid are inverter connected (even wind generations are now a days connected through inverters), there is a potential threat to the grid from high frequency harmonics coming out of these power electronic equipment.
- Although those harmonics are mostly localized and get filtered out by the inductances from the transformers and lines, still their impacts on the network, especially nearby magnetic circuits is required to be well understood.
- The situation could be further complicated due to the higher penetration of DG units and active anti-islanding schemes which inject frequency drifting techniques to detect the islanding.
- Harmonic resonance is another concern that also needs investigation.
- This is why it is crucial to understand the potential impacts on power quality and investigate whether there are substantial evidence of power quality problems that may require new solutions and additional infrastructure. [2]

[2]

Evaluate Alternatives



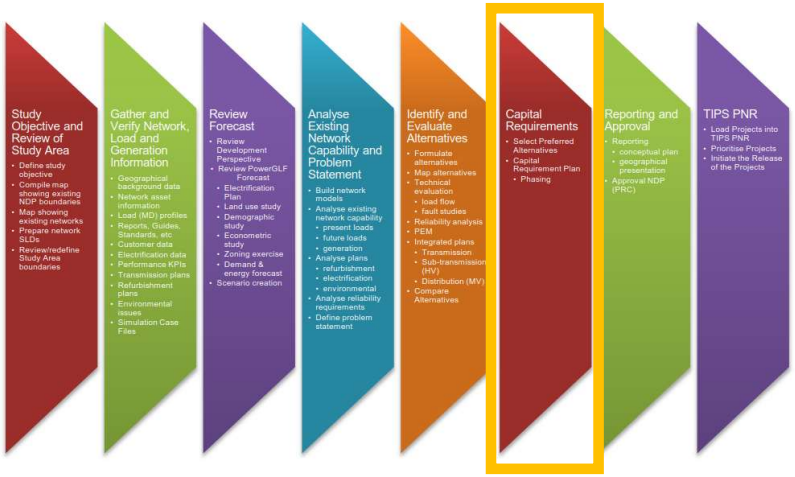
- “Network Planners may request detailed quality of supply studies for the integration of distributed generation sources from Quality of Supply section via Plant and Performance department”
  - Of what detail are they and how frequently are the updated? Based on power quality measurements? Where in the network?

- Need for additional Power Quality and harmonic analysis
  - Simulate harmonic disturbances from ~20, 30, 40 % penetration level of SSEG (without filters in their invertors)
  - Simulate possible unbalance from single phase connected SSEG

- “A basic cost estimate should be compiled for each alternative that complies with the technical analysis.” “PowerOffice costing tool will be used to compile standard cost libraries”
  - How detailed is costing tool? Does it provide the right help for network planners?

- Need for additional fault studies - DG might require updated protections schemes due to changed power flow directions - changed short circuit values as new generators are present at distribution level.

Capital requirements



- Highlight the need for Regulatory optimization
  - Typically when comparing the two alternatives of either building new network or re-investments in the existing network
    - This can fall out differently depending on the regulatory instrument. Even though the cost for the utility is probably higher to build new network, from a business case point of view, it might still be preferable if the regulatory instrument gives the utility a higher asset base for revenue.

The code families

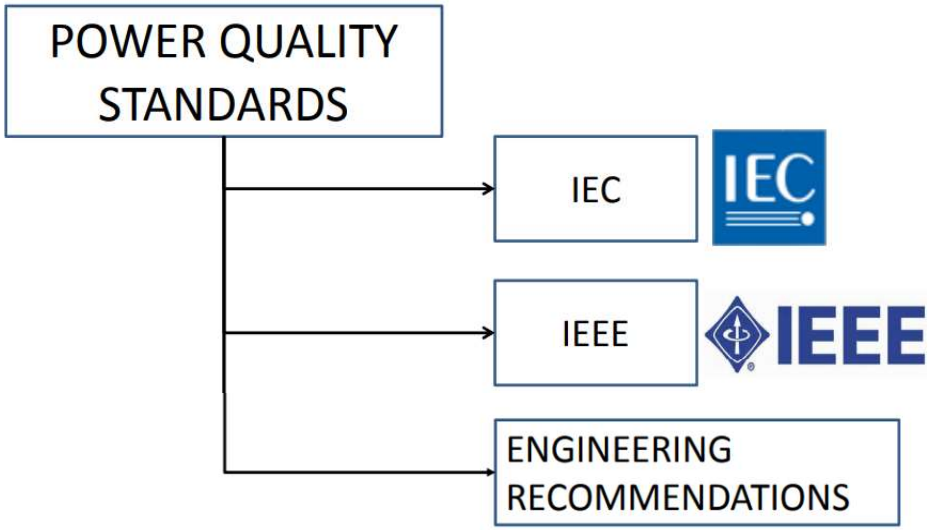
- The types of disturbances that generation sources must be able to cope with, and to what extent.
- Ensure the ability of generation sources to contribute to the functioning of the power system.
- Contribute to increased hosting capacity for renewable electricity production.
- Introduce harmonized rules in the EU for electricity producers.

European Commission

CE marking

The letters 'CE' appear on many products traded on the extended Single Market in the European Economic Area (EEA). They signify that products sold in the EEA have been assessed to meet high safety, health, and environmental protection requirements.

- Inverters must have the CE-marking
- must not disturb or be disturbed by other electrical equipment, so-called electromagnetic compatibility (EMC)
- Anti-islanding
- ICSMS, european database with controlled products
  - https://webgate.ec.europa.eu/icsms/public/productSearch.jsp?locale



IEC 61000 Series:
Power Quality (PQ):

"The ability of a device, equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment "

IEEE 1159:2009,
IEEE 1100:2005

power quality (PQ):

The concept of powering and grounding electronic equipment in a manner that is suitable to the operation of that equipment and compatible with the supply system and other connected equipment.

- International definitions of Power Quality
- International standards for Power Quality

[3]

References

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[3] Understanding Power Quality Standards, Dr.Ir.Mohamed Fuad Faisal
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Workshop 2 – Part 1
Monday 05.10.2020 – Friday 09.10.2020

- Session 1
  - Review on Eskom distribution network planning procedures in relation to power quality
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QA session: Monday 12.10.2020