

**ENERGIE
NETZE
STEIERMARK**

Ein Unternehmen der
ENERGIE STEIERMARK

PLC deployment in smart meters in Austria

Wolfgang Ninaus

IEEE International Symposium on Power Line Communications and its Applications
21–22 March 2023 // Manchester, UK



PLC deployment in smart meters in Austria

Content:

- Smart metering (PLC) communication architecture
- The 5 golden PLC rules or which factors influence our PLC performance
- Overall evaluation of the smart metering communication architecture in practice



DSO Energienetze Steiermark GmbH

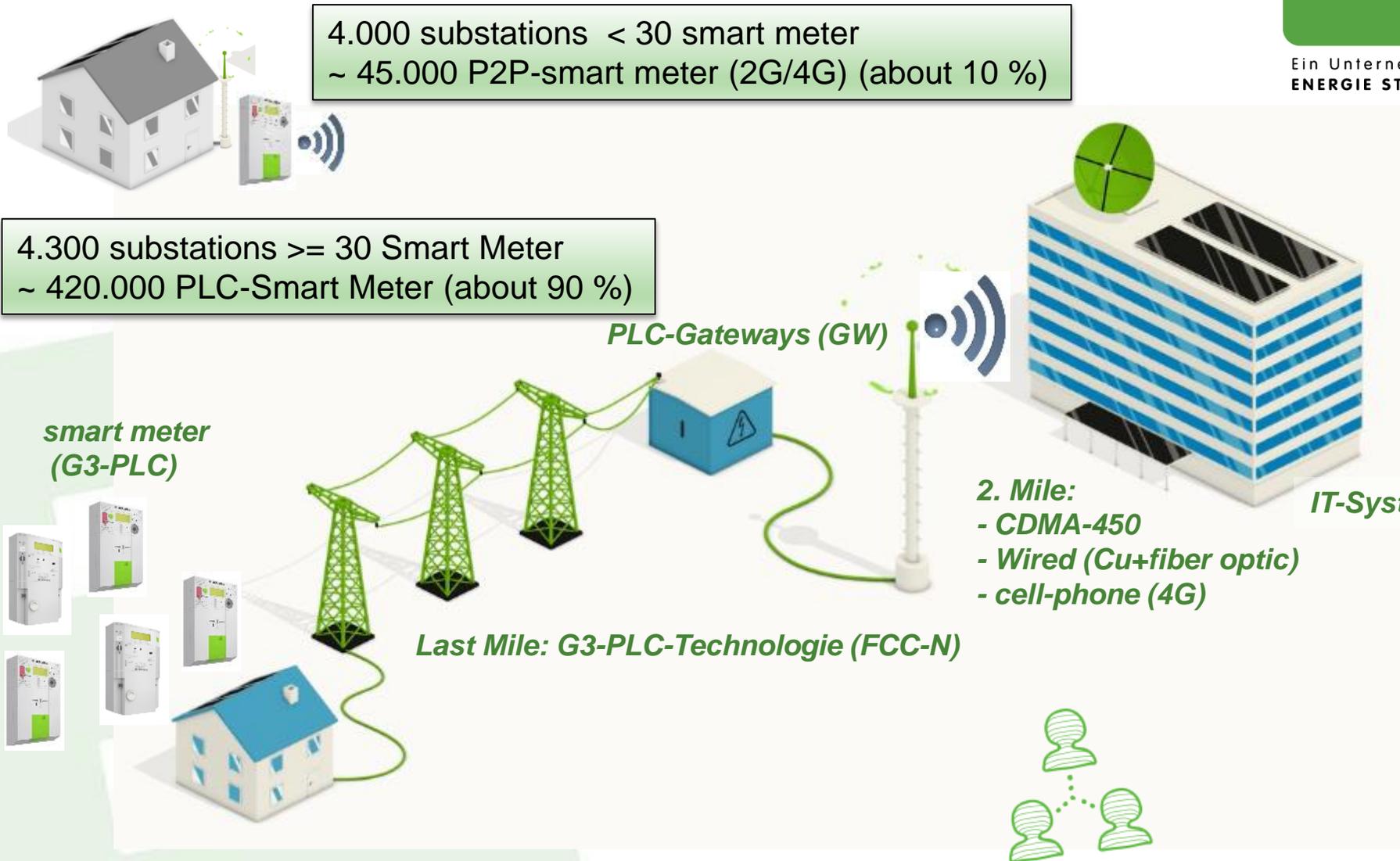
- 29.000 km long electricity supply network
- 4.000 km long gas supply network
- 500.000 network customers
- Annual investments approx. 100 million euros

**ENERGIE
NETZE**
STEIERMARK

Ein Unternehmen der
ENERGIE STEIERMARK



Smart metering communication architecture



■ Smart metering PLC communication architecture

Key facts

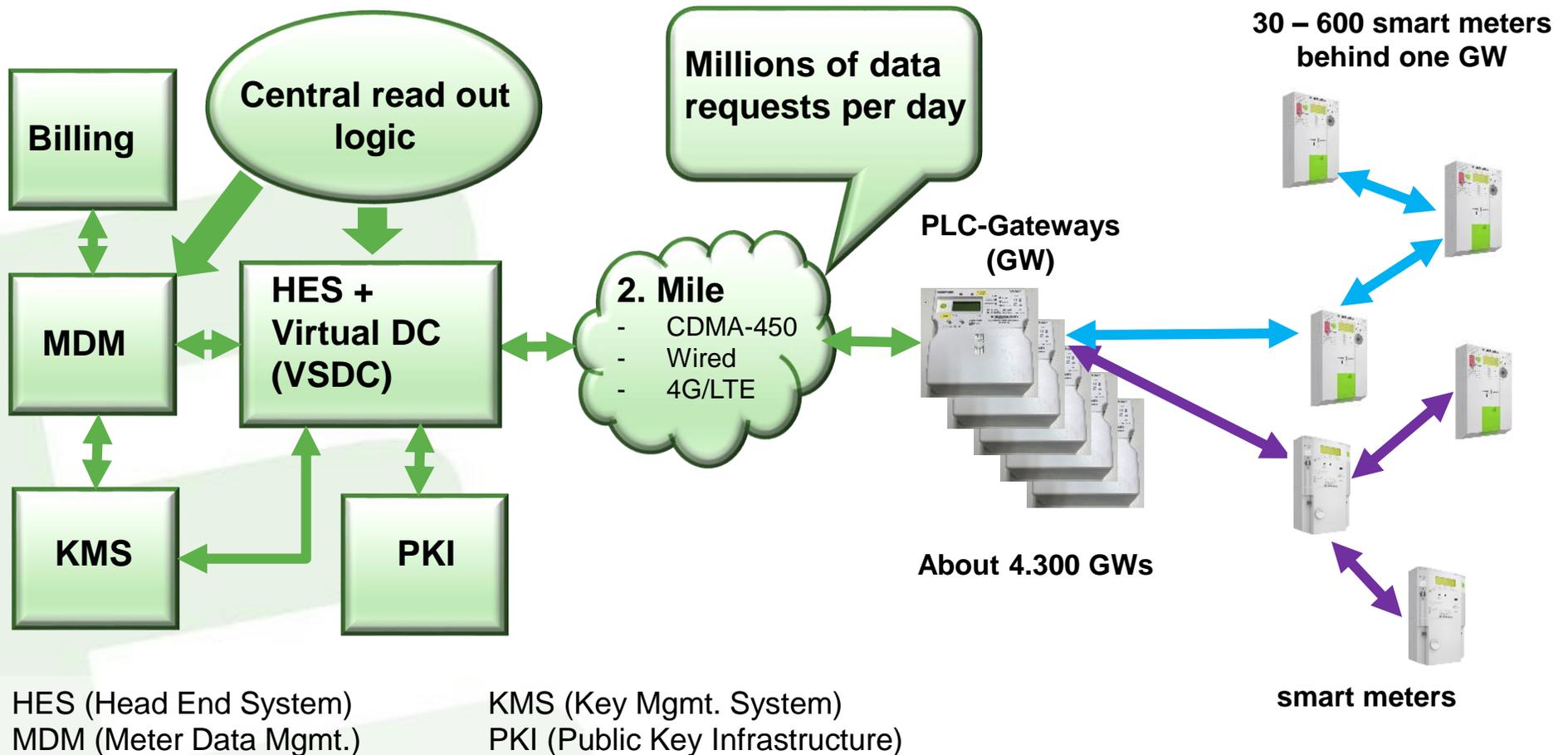
- About **420.000 PLC smart meters (SM)** – **275.000** are installed
- **Transparent PLC-gateways** instead of PLC-data-concentrators
- **30 - 600 smart meters** are connected on **one gateway**
- **Interchangeable smart meters** from **two** different vendors
- **All smart meters** have a remote controlled **breaker switch**
- Daily read out of the **daily (IMS)** or **15 minutes (IME)** energy consumption values
- The energy **consumption values** are **stored** in the meters for **60 days**
- **Most** of the **smart meters** are configured to **IMS (daily values)**

■ Smart metering PLC communication architecture

Key facts

- **G3-PLC** technology and **FCC-frequencies** (150 – 500 kHz) are used
- **About 47 %** of the FCC G3-PLC carriers are notched to protect other radio services (e.g. NDB–aeronautic navigation)
- **smart meters** are using **only phase 1** for **PLC communication** – the **PLC gateway** are using **all 3 phases**
- **Daily raw data collection** rate across all installed smart meters **> 94%**
 - Smart meter rollout and first PLC communication clearing are still in progress
 - 1,5 % are not communicating (different reasons)
 - PLC relevant firmware updates are still in progress
- **97,5 %** of **active** smart meters have a constant **communication**
 - Missing data are available after 5 days at the latest

Smart metering PLC Communication architecture



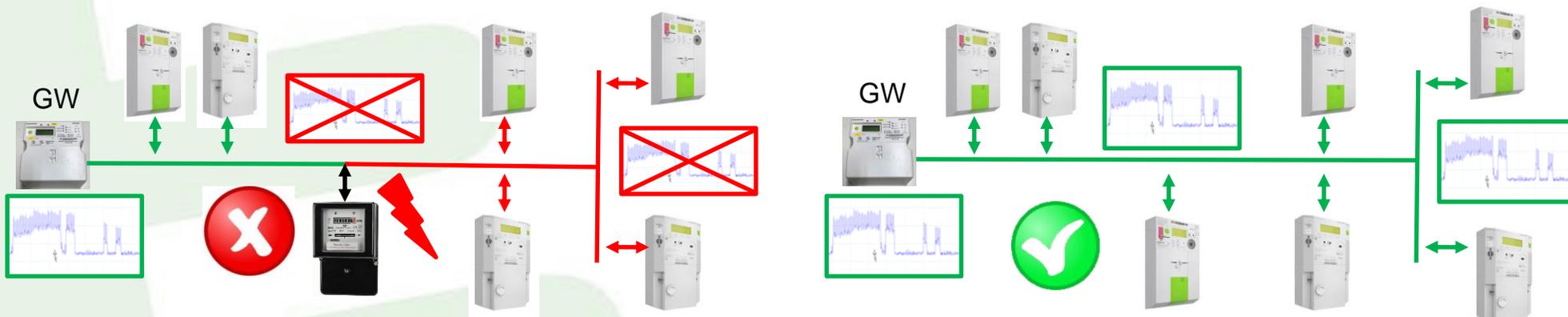
■ **The 5 golden PLC rules - or which factors influence PLC performance**

- **Meter density too low – every smart meter counts → useful signal is too small**
- **High line attenuation in the power grid → useful signal is too small**
- **Phase shift in the electricity network → useful signal is too small**
- **Large substations → PLC capacity too small**
- **Too high interferences in the power grid → signal/noise ratio is too low**

■ The 5 golden PLC rules - or which factors influence PLC performance

1.) Meter density too low – every smart meter counts!

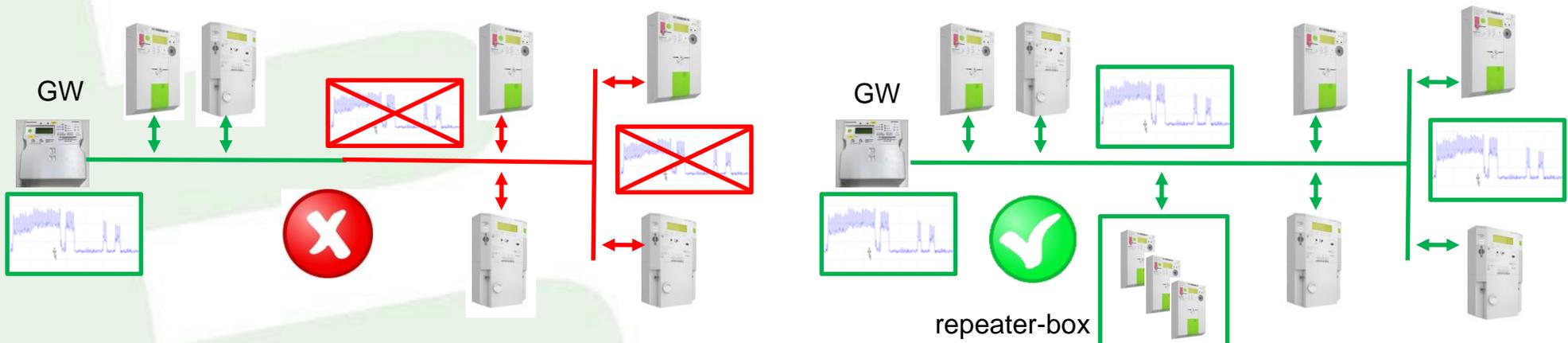
- Meters cannot be changed for technical reasons - e.g. outdated systems, too high back-up fuses, missing meter types
- Customers were not reached
- Customers refuses the meter exchange
- **SOLUTION: Every Ferraris energy meter must be replaced by a smart meter (IMS/IME) or digital standard meter (DSZ) without exception!**



- **The 5 golden PLC rules - or which factors influence PLC performance**

2.) High line attenuation in the grid → signal is too small

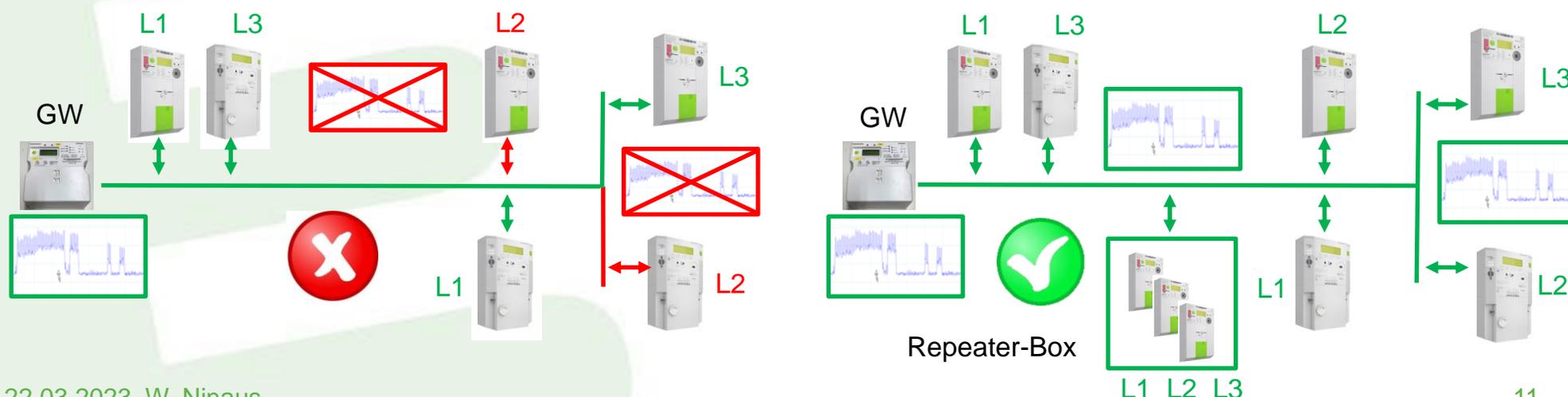
- Excessive distances between the meters (e.g. > 500 m)
- Many feeds in grid junction boxes
- Many and long feeds at the sub station
- Switching from cable to overhead lines (Impedance changes) → big issue!
- **SOLUTION: Install a repeater-box (3 x SM) at a suitable location**



■ The 5 golden PLC rules - or which factors influence PLC performance

3.) Phase shift in the electricity network → signal is too small

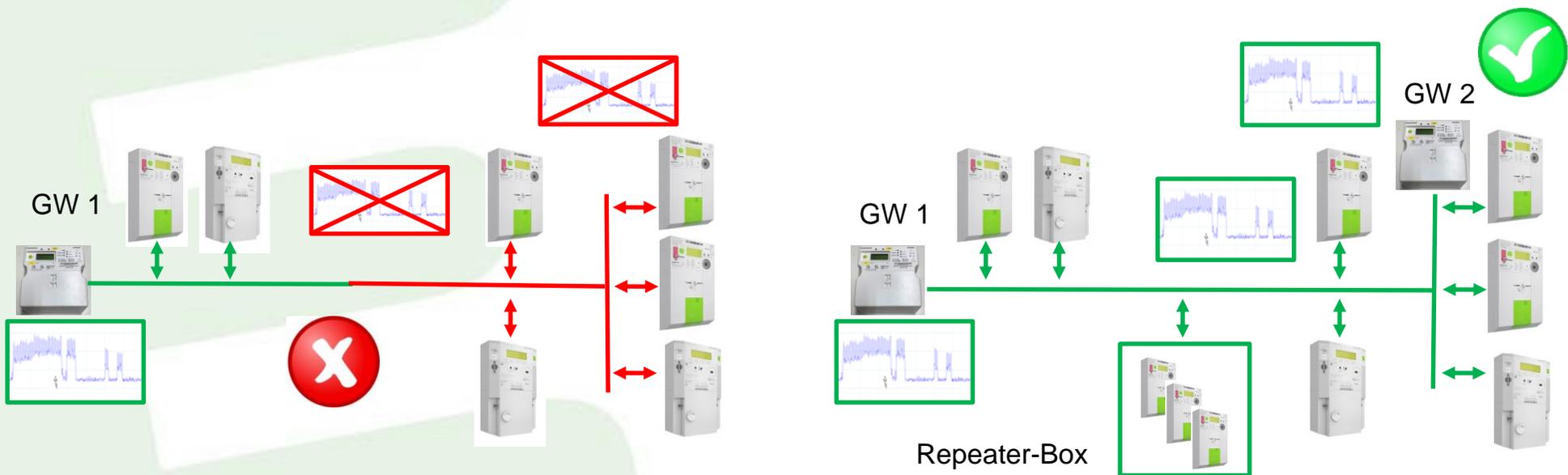
- No clear phase assignment L1, L2 and L3 in the network (History)
- Coupling losses in crosstalk between phases
- smart meters only communicate on the L1 - the GW on all 3 phases → especially critical for non-insulated overhead power lines
- **SOLUTION: Install a repeater-box (3 x SM) at a suitable location and/or change the phase to a better communication phase at the smart meter**



■ The 5 golden PLC rules - or which factors influence PLC performance

4.) Large substations → PLC capacity too small

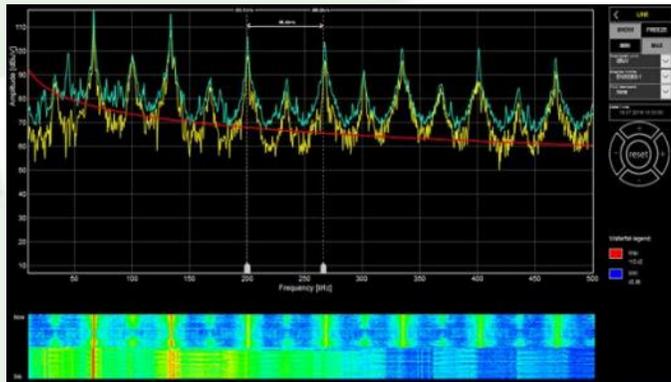
- Substations with more than 400 smart meters behind one GW
- No star topology → the substation (GW) is not in the center of the grid
- Long lines between areas with a lot of meters – specially at the end of the grid
- **SOLUTION: Install a repeater-box (3 x SM) and/or additional GW (Multi GW)**



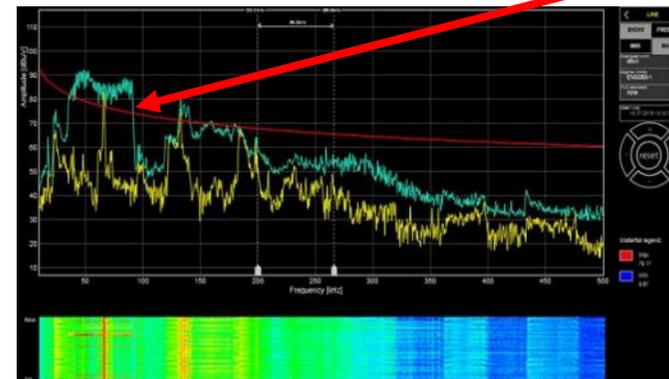
■ The 5 golden PLC rules - or which factors influence PLC performance

5.) To high interferences in the power grid

- Strong sources of noise ($> 60 \text{ dB}\mu\text{V}$) must be found and eliminated
- The basis for troubleshooting are the EMC directives and standards, which every device must comply with without exception (CE marking)
- **SOLUTION: Replace, repair, install a filter or remove the interfering device from the power grid**



Before: old power supply (850 W)



After: new power supply installed

PLC-signal



■ The 5 golden PLC rules - or which factors influence PLC performance

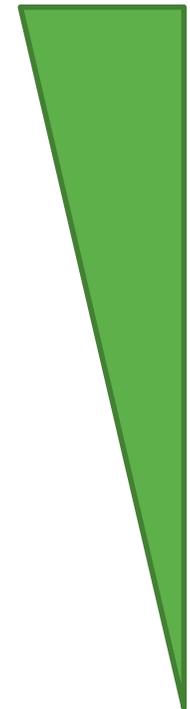
5.) To high interferences in the power grid

Some examples of interference sources

- TV-SAT – Multi-switch
- Access Remote Units – xDSL - Telecom Provider A1
- Plug-in power supplies e.g. from Wifi-router/modems, cameras
- Frequency converter (pumps etc.)
- Power supplies -cell phone transmitter base station
- Different kind of control units (e.g. heating systems)
- SAT receivers
- LED lights without CE mark
- Emergency exit lighting (battery charger)

→ The cause is always defective, old or missing power supply line filters

Number of cases



■ Overall evaluation of the smart metering communication architecture in practice

- Transparent gateway - vs. data-concentrator-concept
- Used PLC technology and frequency bands
- Second mile connections
- Roll-Out strategy - start PLC-communication clean up in parallel
- Analysis tools used and additional PLC equipment in the field
- Outlook

- **Overall evaluation of the smart metering communication architecture in practice**
- **Transparent gateway - vs. data-concentrator-concept**
 - High security and protection level – real end to end encryption
 - + – No customer energy values will be stored in a gateway
 - All smart meter activities can be controlled centrally
 - Relatively low data rates on the second mile
 - Complex and powerful IT-Systems are needed (MDM, VSDC, KMS,..)
 - Simultaneously operation of the 4.500 gateways
 - The “brains” of the data concentrator are centralized in the VSDC
 - Synchronization between gateway and VSDC is needed, not to loose meters
 - Powerful, flexible algorithms for reading out missing data are required
 - The second mile is used for a long time with low data rate (Millions of connections)

■ Overall evaluation of the smart metering communication architecture in practice

■ Used PLC technology and frequency bands

- G3-PLC is a well tested and robust technology
- CENELEC-A frequency band is exclusively for us available – no notching needed
- + – FCC frequency band has a high channel capacity
- FCC frequency band is well protected by EMC-standards
- G3-PLC can connect smart meters in deep undergrounds with thick concrete walls
- G3-PLC-Standard is for multi vendor interchangeability not “standard” enough
- CENELEC-A frequency band is too noisy – problems with customers
- With the necessary notching in FCC frequency band we loose a lot of channel capacity
- – PLC-communication-clean up is necessary and needs time
- Quite high signal attenuation with overhead lines
- Customers do not understand when they are asked to replace noisy devices
- Additional installation costs of special PLC-Equipment like Repeater or Multi-GWs

■ Overall evaluation of the smart metering communication architecture in practice

■ Used Second mile connections

– CDMA-450-Connection: (97,5 %)

- CDMA-450 radio network is our own infrastructure – investments at the beginning necessary 
- Available data rate is not high but absolute sufficient
- 450 MHz has a high range – Omni directed antennas are general sufficient
- Slow, long reading of the smart meter requires a lot of air time (gateway concept) 

– Cooper + Glass fiber: (2 %)

- our own infrastructure – relatively high investment costs for installation 
- Available data rate not used 

– Cell phone 2G/4G: (0,5 %)

- Available data rate (4G) is more than sufficient 
- Dependency on the availability and costs of the telecom provider
- External antennas are also necessary for a stable, powerful connections 

■ Overall evaluation of the smart metering communication architecture in practice

■ Roll-Out Strategy - Start PLC-communication clean up in parallel

- Smart meter roll-out can be optimized (quantity vs. quality) → lower costs
- Legal requirements can be easier achieved – number of installed smart meters
- Difficult customer installations can be skipped
- A significant number of smart meters are also communicating very fast after installation
- About 20 % of the smart meters at one substation are missing → lower density
- The network changes when a smart meter is later installed at a critical point
- Maybe extra PLC-equipment, like repeaters, has to be installed → extra costs
- No clear picture about the whole PLC-network performance from one substation

■ Overall evaluation of the smart metering communication architecture in practice

■ Analysis tools and additional PLC equipment used in the field

- **Analysis tools:** Different spectrum analyzer/oscilloscopes and PLC-Sniffers were tested before
- PLC sniffer with spectrum analyzer capability and a PLC signal generator both from Neuron are used by all our PLC test engineers in the field
- Spectrum analyzer from Rohde & Schwarz and Energizor are used only for special noise investigations and pre-noise screening



- Overall evaluation of the smart metering communication architecture in practice
- Analysis tools and additional PLC equipment used in the field
 - Additional PLC equipment in the field :

➤ Repeater-Box



➤ Multi-GW-Box



- Overall evaluation of the smart metering communication architecture in practice
- Outlook
 - **Finish** the smart meter **mass roll-out** until **2025** - (PLC & P2P)
 - **Reduce** the number of **inactive smart meters**
 - **Finish** the first **PLC communication clearing**
 - **Increase** robustness of the **PLC-network** (**Repeater** and **Multi-GW**)
 - **Optimize** the **PLC notching table** – **currently all smart meters use the same**
 - **evaluate** new **legal requirements** and their **impact** on the **PLC network**: e.g. **100 % IME-smart meter (15 minutes values) !**
 - **Meet the needs of all our stakeholders 😊 !**

**ENERGIE
NETZE
STEIERMARK**

Ein Unternehmen der
ENERGIE STEIERMARK

Thank you for your attention!



■ Attachment

■ G3-PLC

- Signal spectrum of the PLC communication in the CENELEC-A and FCC band

