Integrating PowerLine Communication (PLC) with EVs towards SmartGrids

☑ Libre
☐ Interne
☐ Restreinte
☐ Confidentielle

June 10th 2020
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Goals & Context

ENEDIS is rolling out **35 millions of Smart Meters** (Linky Project), all communicating using **PLC**.
Situation in June 2020 **: 25 Millions meters** already on the field.

System main targets :
- Ensuring **Metering application** (billing, remote operation…)
- **Monitoring the Grid** (Outage detection, Power quality…)
- Enabling action on the Grid (Flexibility…)

ENEDIS has therefore to **leverage on PLC for its digitalization**, strengthening the need for its robustness against new electrical appliances. EV is one of the main usage to come in the upcoming years, and **PLC has to <u>work with it.</u>**
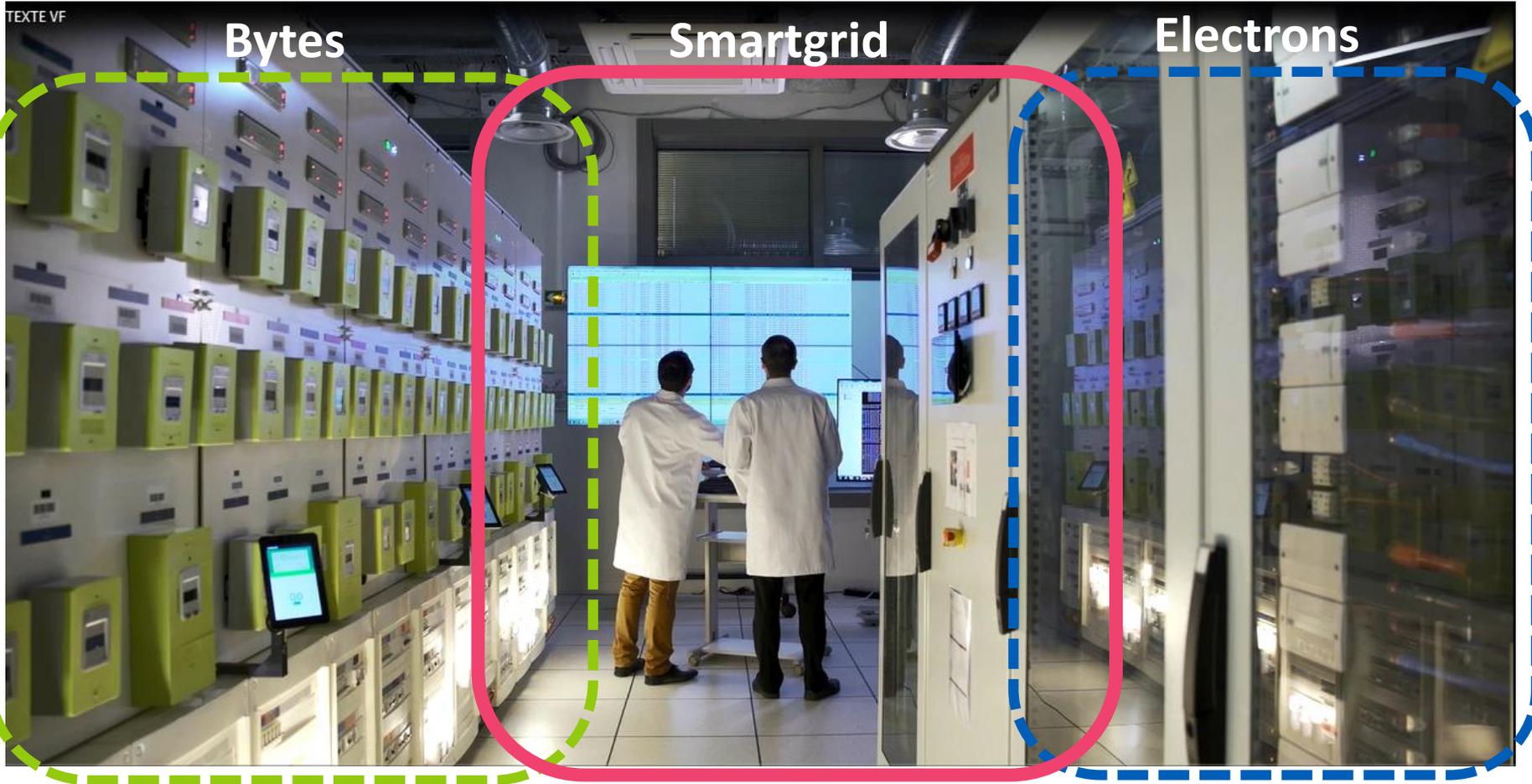
We will present here tests in lab and field condition showing that it is the case.

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01 Test in Laboratory
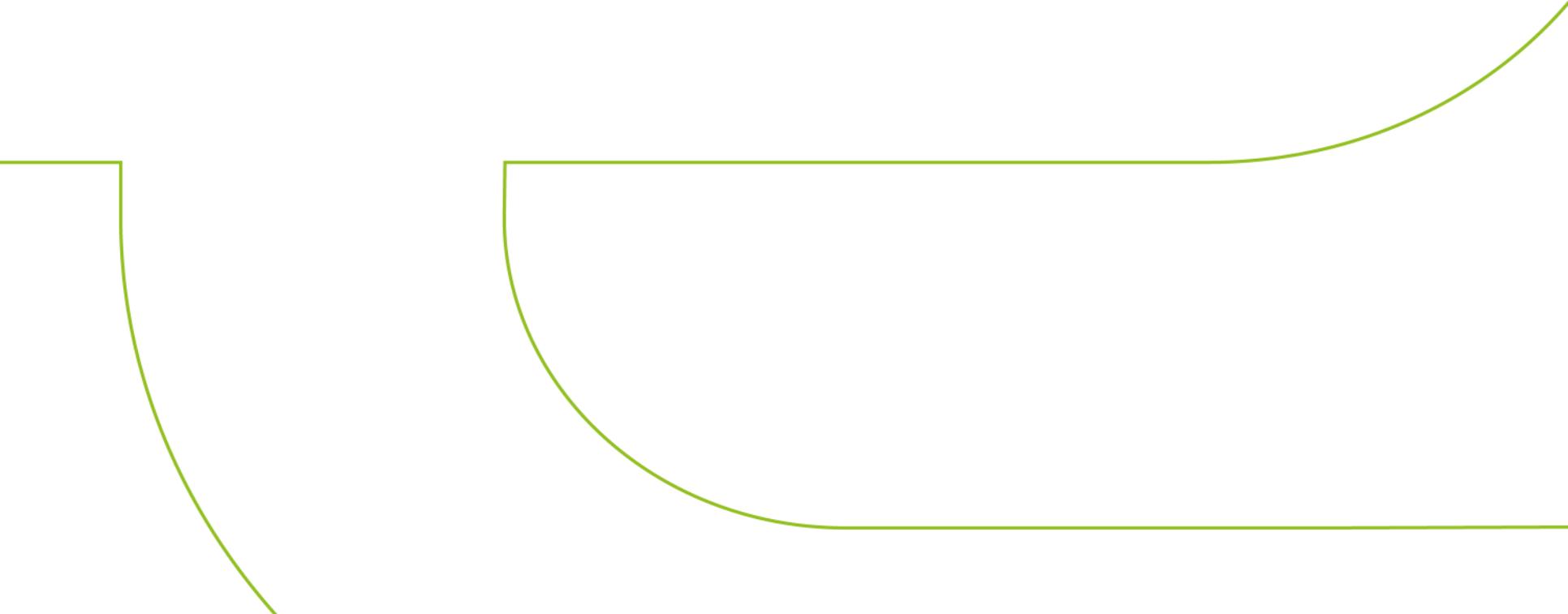
SmartLab : Enabling Smartgrid at industrial scale

Bytes   **Smartgrid**   **Electrons**

Welcome to my office !

EV tested (anonymized in the following)
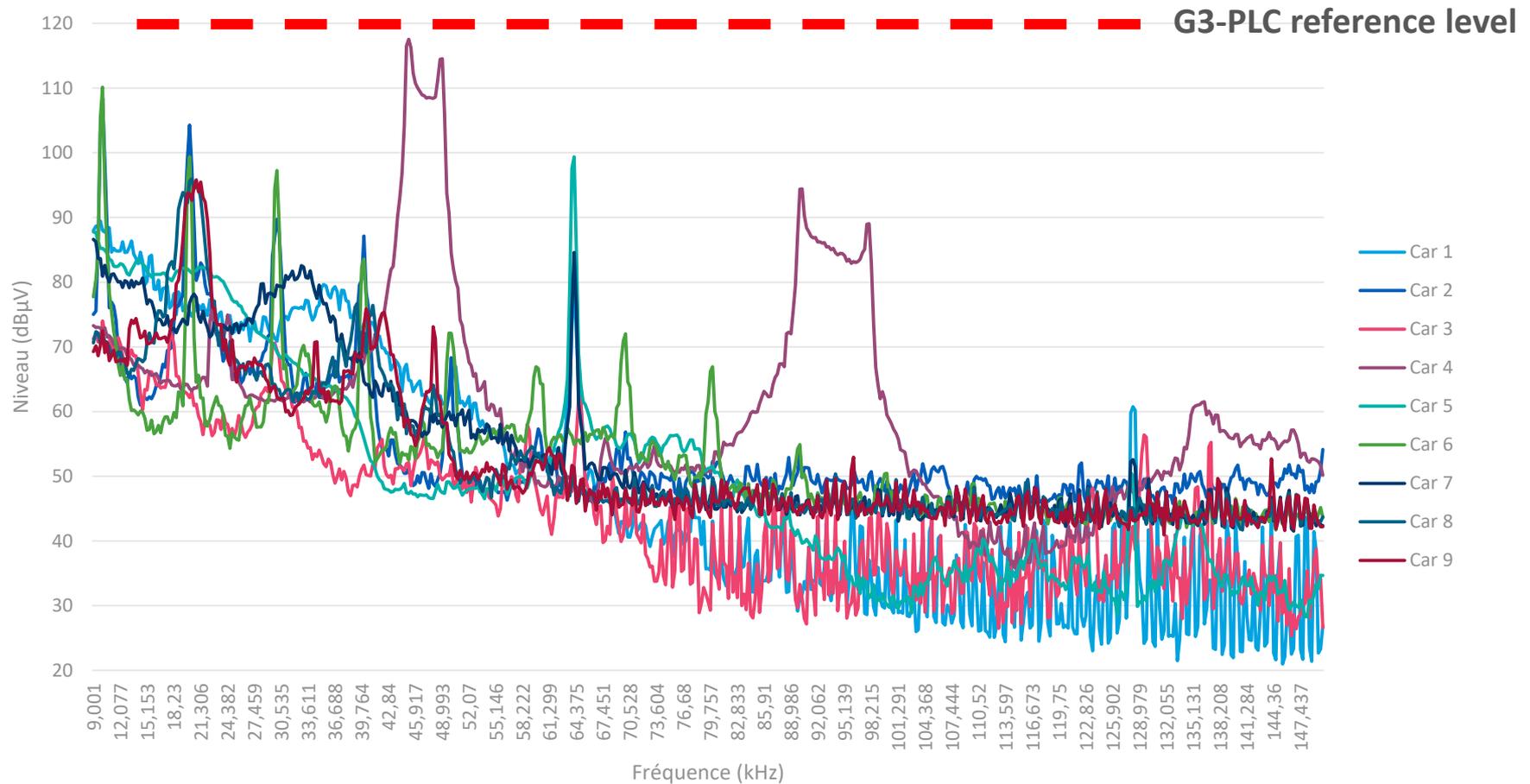
Match the best selling EV in France in 2018-2019

Model
Renault ZOE
Nissan LEAF
Tesla Model 3
Tesla Model X
Smart Fortwo
Peugeot iOn
Hyundai Kona électric
Citroën C-Zero
Tesla Model S

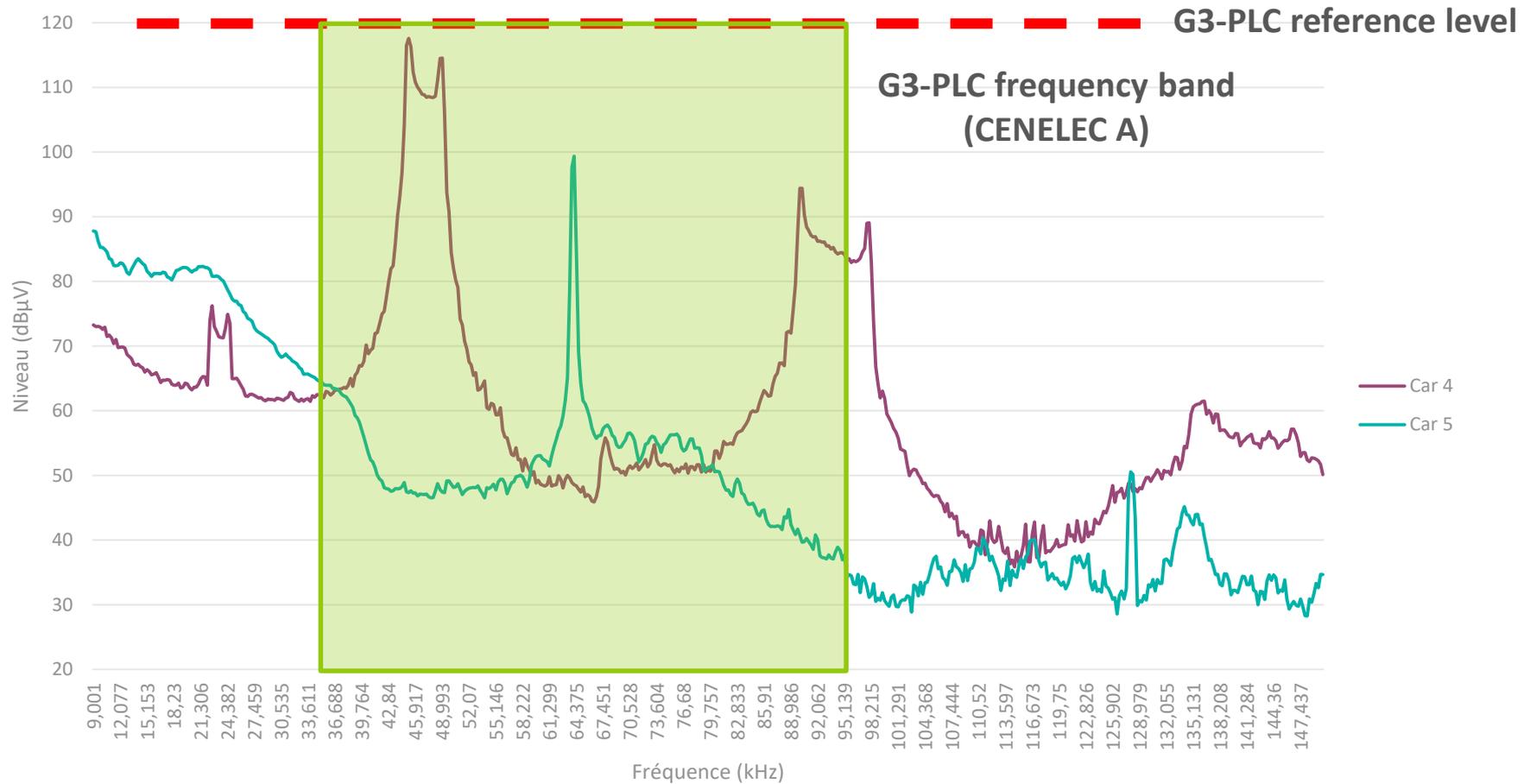Source : www.automobile-propre.com

Results : test #1

Noise measurement during EV Charging

Overall, all EV are possible disturbances for PLC communication

Test #1 : Focus on two challenging cases (Car #4 & 5)

We are reaching low signal noise ratio (SNR) here

What we learned from Test #1

Noise measurements

Most of EV show **disturbances far below PLC signal level** (good news !)

Car #4 show the **highest** disturbances

Car #5 show a **narrow band noise** @ 64 kHz

For several EV, we see **10 kHz periodic noise** that match the power switching frequency of some EV charger

Except Car #4, disturbances are **mostly in the low part of the PLC spectrum**, vanishing with higher frequencies (low pass filter behavior).

Test #2 : PLC Communication during EV charging

	Sagemcom	Itron	Landis+Gyr
Reference Level	📶	📶	📶

Budget Link in dB

0-19	20-29	30-39	40-49	>=50

Risk Matrix	EV	Sagemcom	Itron	Landis
Medium	Car 2	📶	📶	📶
High	**Car 5**	📶	📶	📶
High	**Car 4**	📶	📶	📶
Medium	Car 6	📶	📶	📶
Low	Car 6	📶	/	/
Low	Car 7	📶	📶	📶
Low	Car 3	📶	📶	📶
Low	Car 8	📶	📶	📶
Medium	Car 1	📶	📶	📶

EV charging hurts but does not kill PLC (except Car #4)

Risk Matrix Level = High impact (noise) * High probability (good sales)

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Results : PLC vs EV charging

EV charging **clearly affects PLC** communication quality, **but don't break it** (except for Car #4).

Design of the meter (chip embedded) show **variability in PLC robustness** against EV charging.

G3-PLC communication **is still possible during EV charging** (good news!)

PLC communication in red zone means PLC communication **can be unstable**

Our setup with the meter as close as possible to EV is **the worst case** regarding noise impact on PLC

No PLC communication has been achieved during charging of Car #4

Conclusion in Lab conditions

- For **8** cars tested over **9**, **PLC communication is still possible** in lab **in the worst case** configuration during EV charging.

- **/!** Additional disturbances from other electrical devices, long length of cable to reach the next PLC device, or harsh field conditions (very low impedance) could further affect the PLC communication → **We need to test in real field conditions.**

- Possible enhancements :
  - **Software** : Firmware upgrade with better signal processing
  - **Hardware** : Using a filter embeded in a EV charging point (induces additional cost)

- Next Step : Test in field conditions **for the 2 highest risky case** (Car #4/5).

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02 Test in Field condition for Car #4 & #5
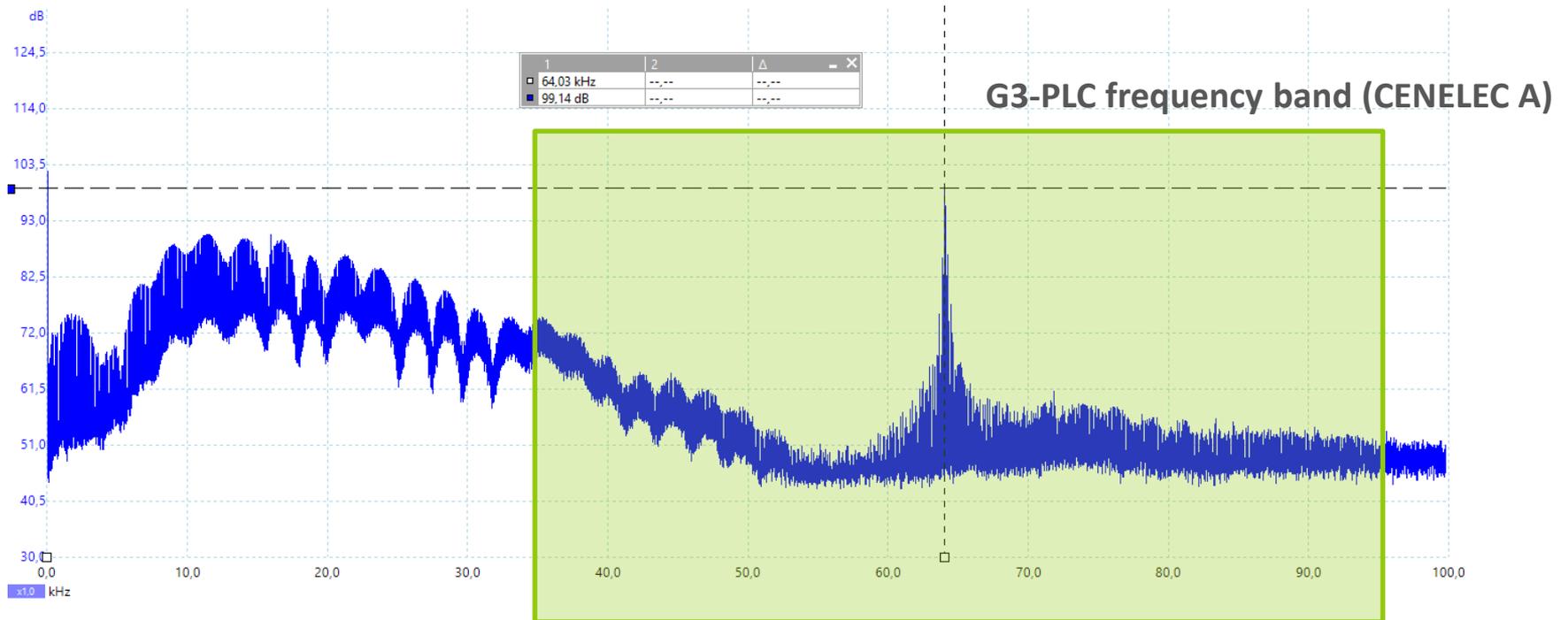
Field Setup

EV charging point beyond a G3-PLC meter
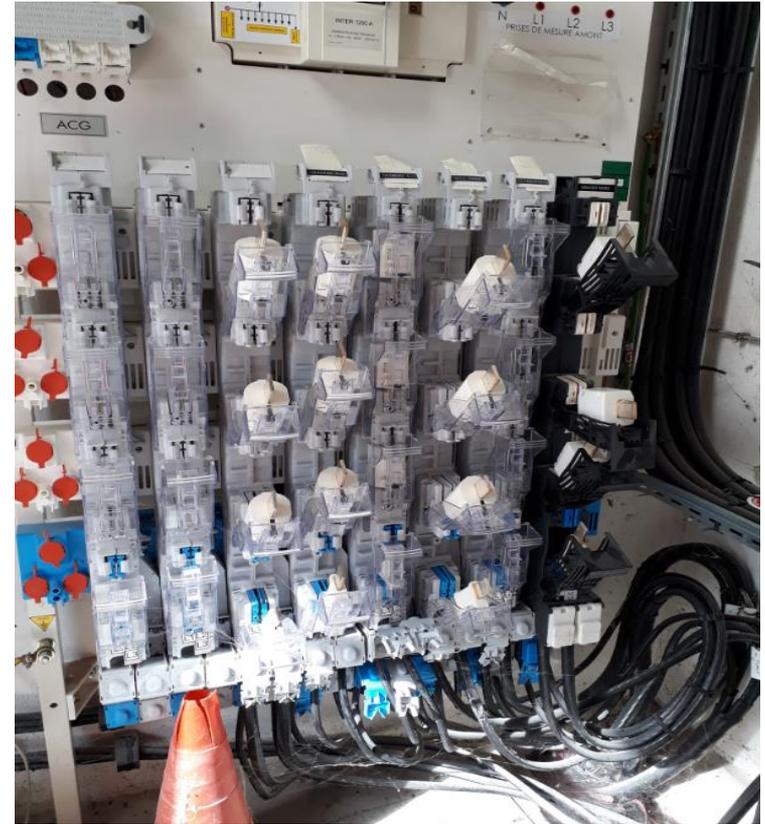
G3-PLC data concentrator in the MV/LV substation
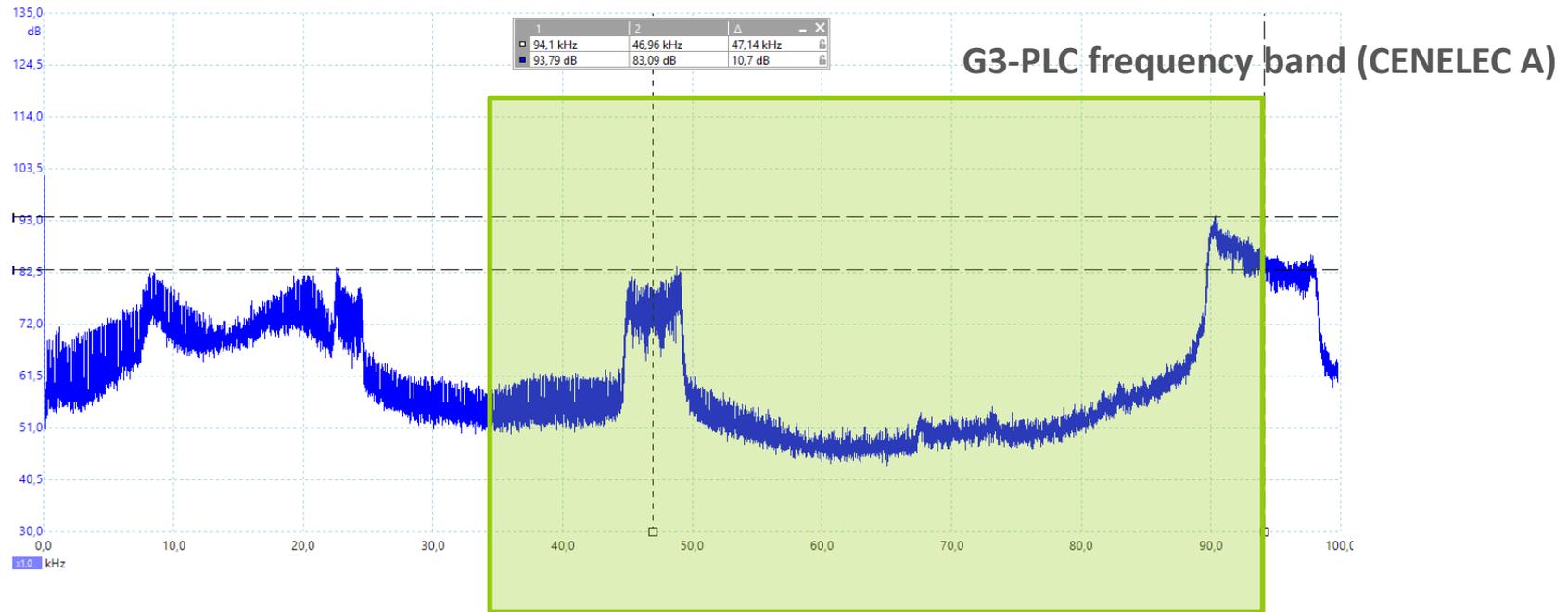
Results in field condition

Car #5 Spectrum Noise

We find back the **narrow noise around 100 dBμV @ 64 kHz** similar to the lab

Results in field condition

Car #4 Spectrum Noise

G3-PLC frequency band (CENELEC A)

We find back the spectrum shape observed in Lab, but the **low frequency part is smaller**. This could be due to the **low impedance of the grid** in low frequency range.

Results in field condition

PLC while Car #5 Charging

Communication Ratio	100%	**Sagemcom**
	200/200	
Communication Ratio	99,5%	**Itron**
	199/200	
Communication Ratio	100%	**Landis Gyr+**
	200/200	

PLC while Car #4 Charging

| Communication Ratio	100%	**Sagemcom**
	200/200	
Communication Ratio	100%	**Itron**
	200/200	
Communication Ratio	100%	**Landis Gyr+**
	200/200	

**G3-PLC** Alliance protocol enable to **cope with EV disturbances** on the field :

- Routing protocol **adds a hop** to reach the meter → From 1 hop with good link to 2 hops with good links (**avoid weak links**).

- PLC modems adapt their **tone map** to notch noisy carriers
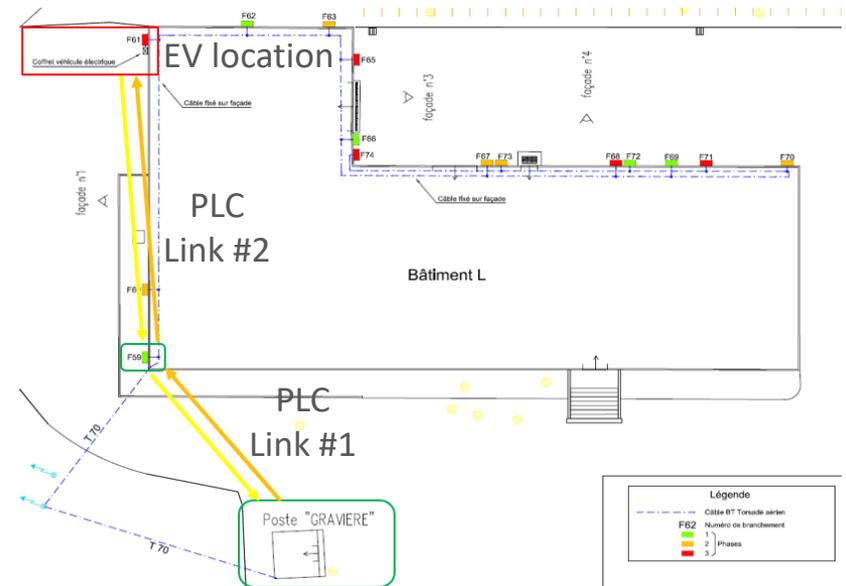
Focus on the ToneMap benefit from G3-PLC

Exemple of carriers notching during EV charging

	35.9375 - 43.75 kHz	45.3125 - 53.125 kHz	54.6875 - 62.5 kHz	64.0625 - 71.875 kHz	73.4375 - 81.25 kHz	82.8125 - 90.625 kHz
0x3d	1	0	1	1	1	1
0x1d	1	0	1	1	1	0
0x1f	1	1	1	1	1	0

Noisy PLC frequency band detected & notched during EV charging
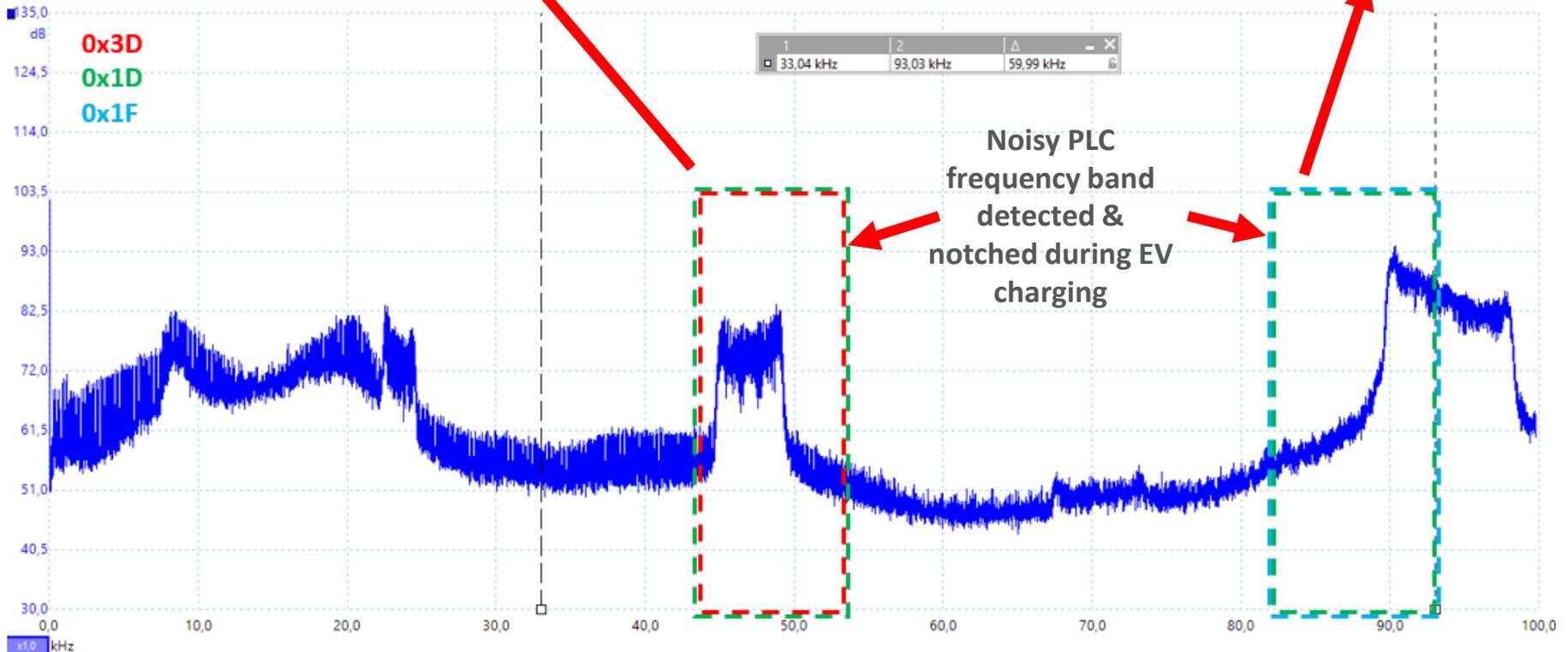
03 **Conclusion & Perspectives**

Conclusions & Perspectives

PLC communication during EV charging

- From **9 EV taken from the best selling models** in France in 2018/2019 tested in lab, we spotted **only few EV with high disturbances** that could affect PLC communication.
- For these 9 EV, tests in lab and field condition show that **EV charging hurts but does not kill PLC**. Though, additional source of disturbances, long length of wire or harsh field conditions should not be omited.
- In field conditions, PLC communications went well, during **one or even two EV charging** at the same time (see bonus slides).

Perspectives : PLC and Smart Meters as a mean for Smart Charging

Tests in real situation (through aVEnir project), in long term situations, with additionnal EV models, and flexibility use case (Smart Charging).

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ENEDIS Lab's in Paris Area

EV

SmartLab
In Smart Grids context, simulation in real conditions of new use cases in Low Voltage Network.

CI Lab (TIC)
Workshops and support for companies working on datas generated by customer interface (CI).

Hardware Lab
Linky product Hardware campaigns , 12 experts using several specific test benches (some of them are fully specified by Enedis), load generators, temperature testing equipement, welding station, etc.

Prototype workroom
Prototype creation (laser engraving machine, 3D printer, oven prototyping CMS, etc).

EV

Ecoflot Lab
Area for IS Ecoflot tests.

Development Team
Software devlopment for all Linky Lab projects.

Diagnostic Team
It provides hardware and firmware expertise concerning labs and field defects.

Telecomunication Lab
It provides expertise on telecomunication studies.

EV

PLC Lab
It provides expertise on PLC studies.

Firmware & system qualification Lab
It is used to qualify the software of Linky products (conformance, interoperability, large scale) and also the end to end test (with IS teams).

Legal Metrology Lab
It is used to control frequently the legal metrology of installed meters, according to regulation in effect.

Storage Room
Linky products flow tracking, meters and data concentrators configuration, storage of more than 16 000 Linky products used for testing, etc.
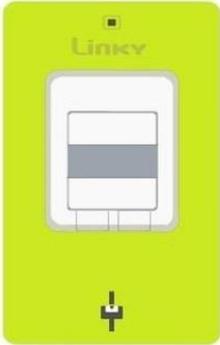
Contact me if you want to visit us !

Equipment and test setup in Lab

Stable and monitored conditions : In this setup, impedance is fixed to 50 Ohms, and charge of EV is limited to 16 A.
This setup is isolated to any noises from the grid except EV.
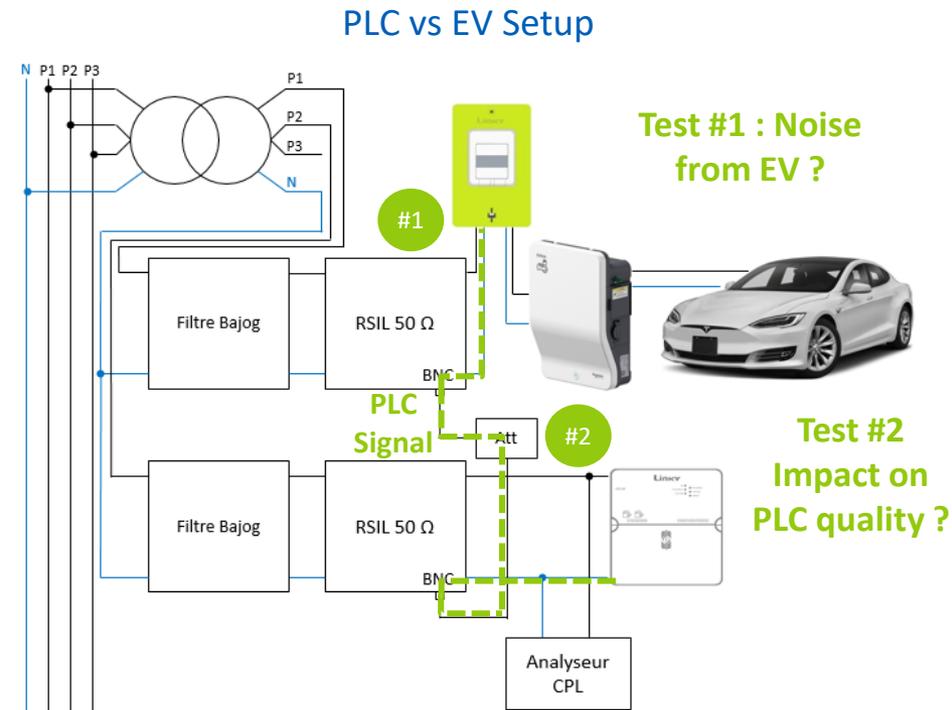
G3-PLC Meters

SAGEMCOM

Itron

Landis+ Gyr+

G3-PLC Alliance

G3-PLC Data Concentrators

G3-PLC Alliance

SAGEMCOM

PLC vs EV Setup

Test #1 : Noise from EV ?

Test #2 Impact on PLC quality ?

PLC Signal

ENEDIS Experimental Field

It's Here

200 connections to low voltage grid

2 Separate LV grid (aerial, underground, mixed, residential building)
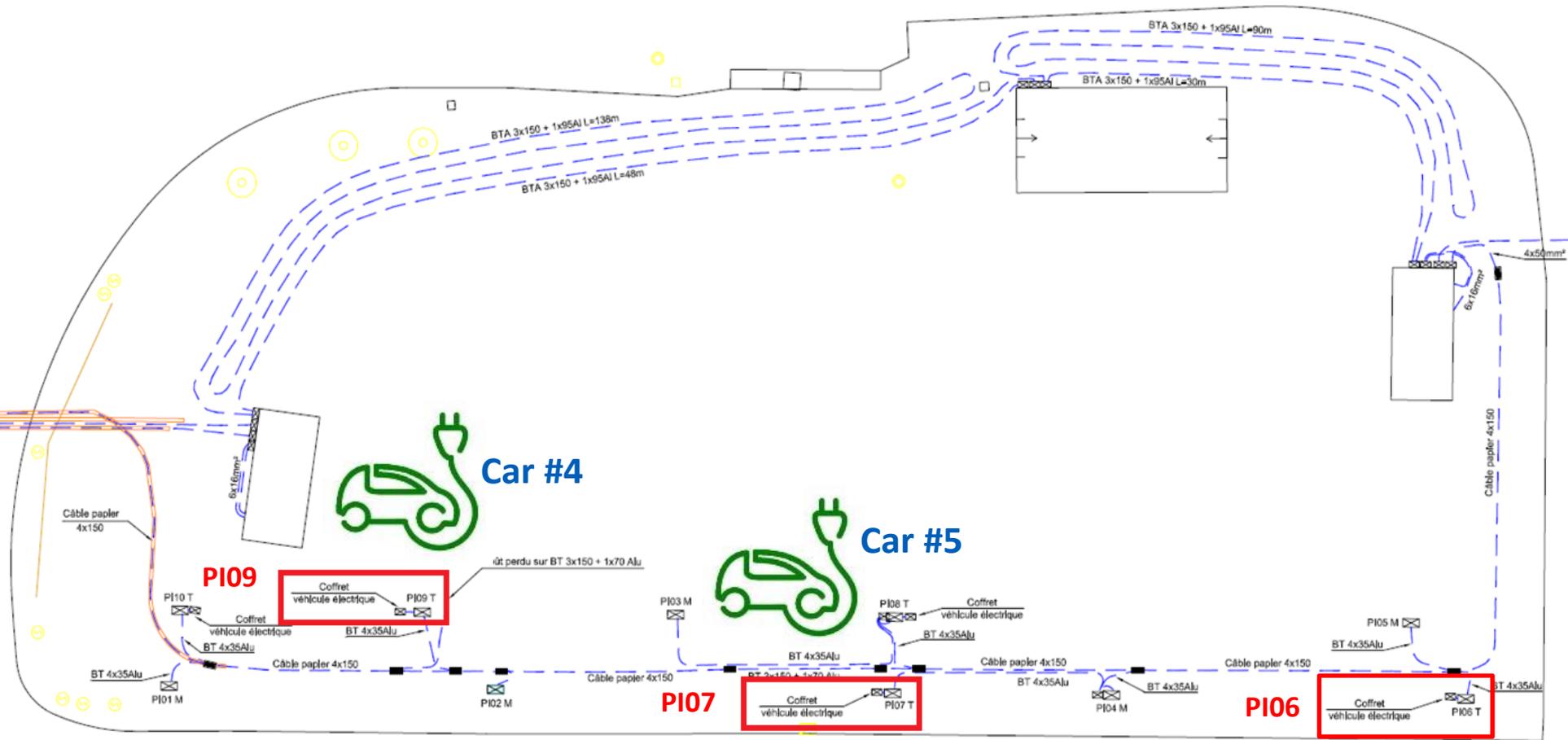
14 EV charging point

4 PV inverters

2 Storage types
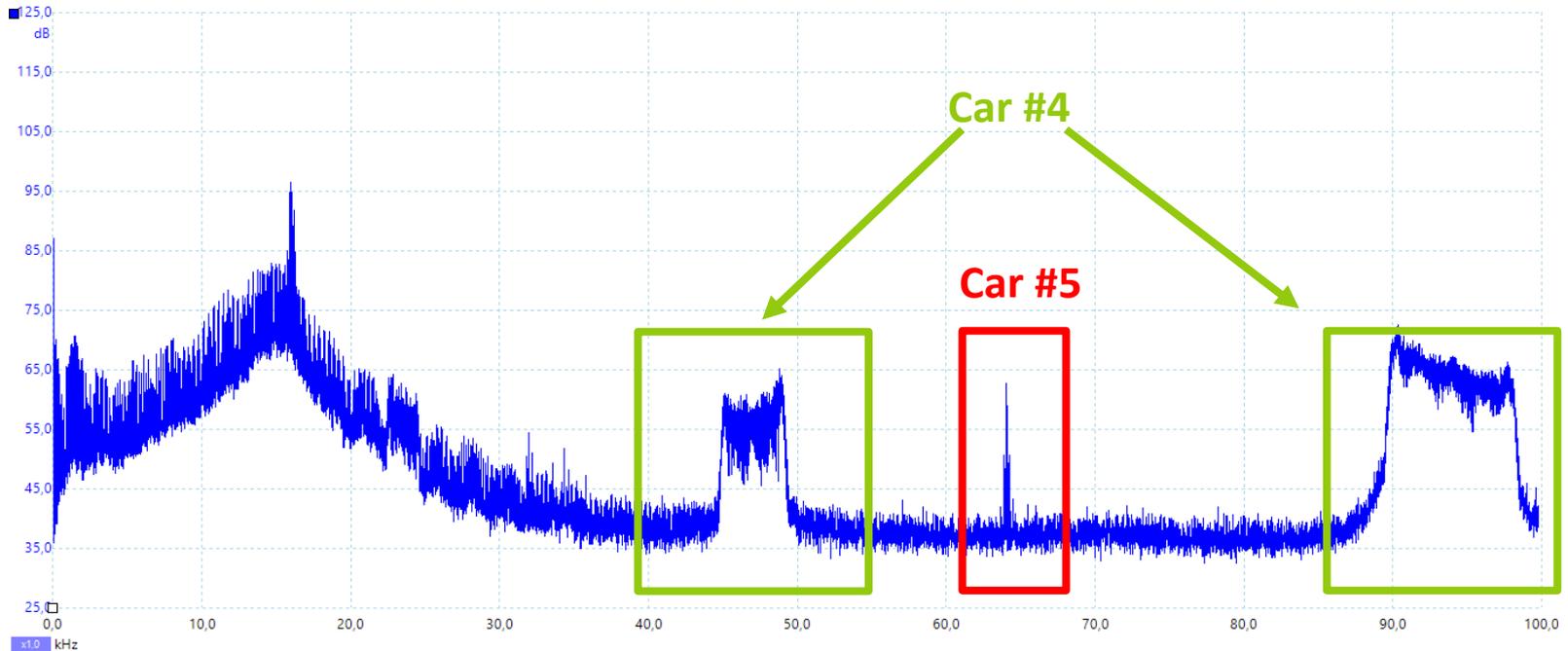

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Multiple EV Charging setup

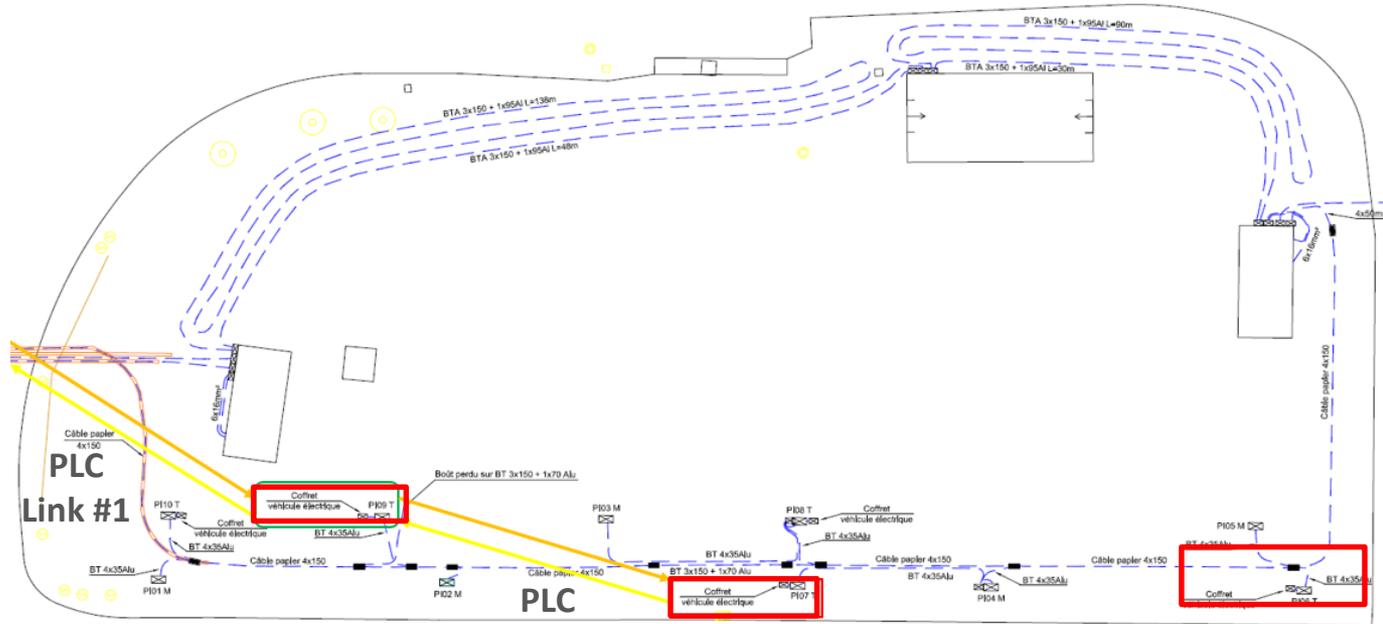# Multiple EV charging setup

Resulting noise measured from Car #4 location

Noises add each other, without additional interference affect

Multiple EV charging results

Same behaviour as single charging setup

Communication Ratio	100%
	200/200

Car #4

Communication Ratio	100%
	200/200

Car #5

Communication Ratio	100%
	200/200

Meter