

PROBABILISTIC ASSESSMENT OF POWER QUALITY IN FUTURE RESIDENTIAL NETWORKS

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PROBABILISTIC ASSESSMENT OF POWER QUALITY IN FUTURE RESIDENTIAL NETWORKS

Why?

1

RESIDENTIAL NETWORKS

- Little studied
- Poorly monitorized

POWER-ELECTRONICS BASED LOADS



EVs AND DISTRIBUTED GENERATION (PV)



2

POWER QUALITY

- Non linear loads
- Single-phase



Harmonics



Unbalances



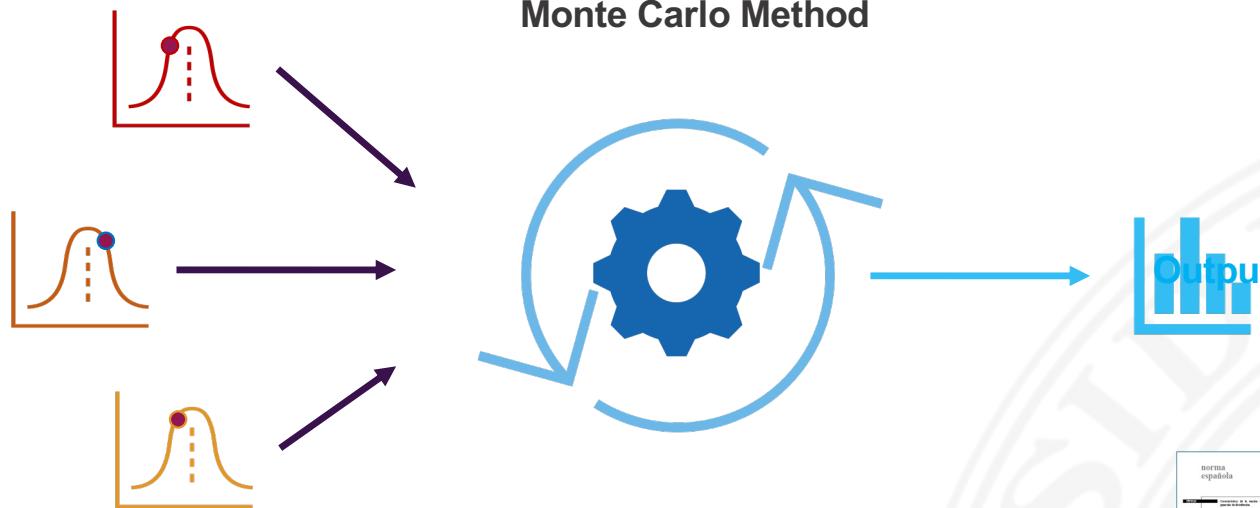
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PROBABILISTIC APPROACH

- Uncertain behaviour
- Statistical evaluation (standards)

1. The methodology



Uncertain inputs:
Probability distribution

Weekly profiles
10-minutes 1008 values

Monte Carlo Method

Problem resolution
Multiple iterations

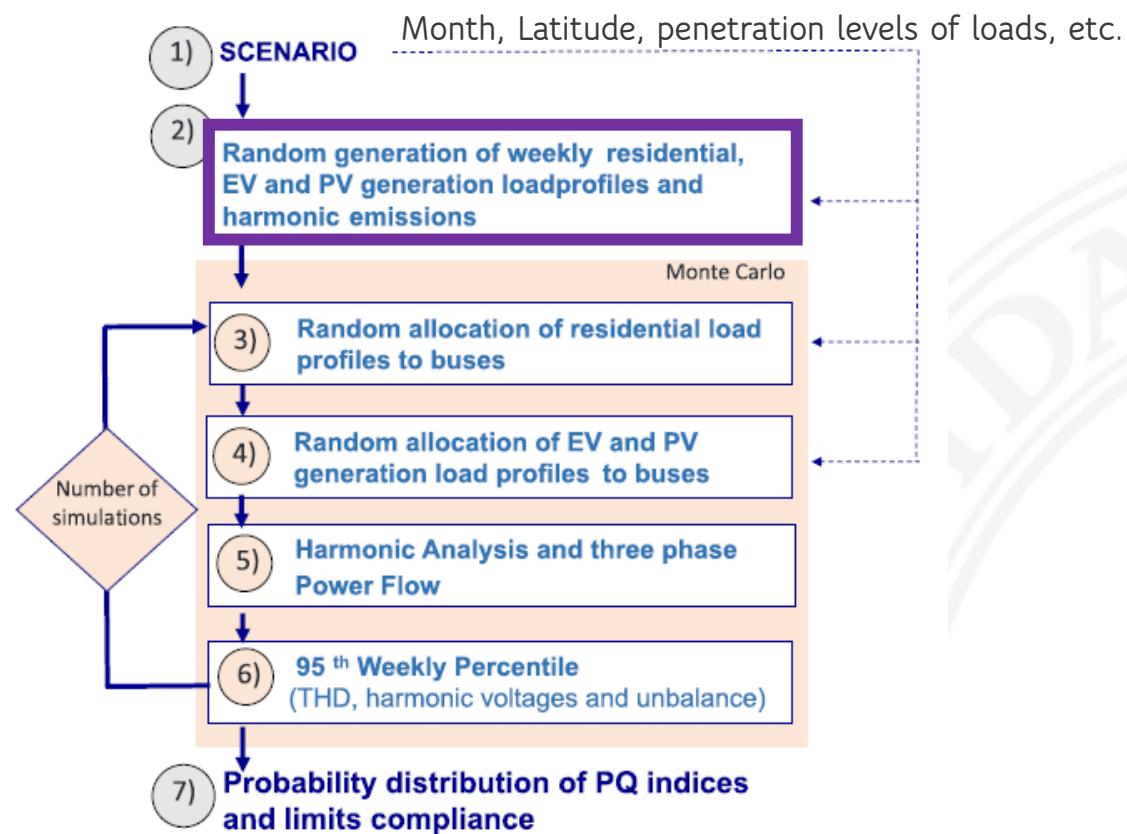
Three phase load flow
Harmonic injection



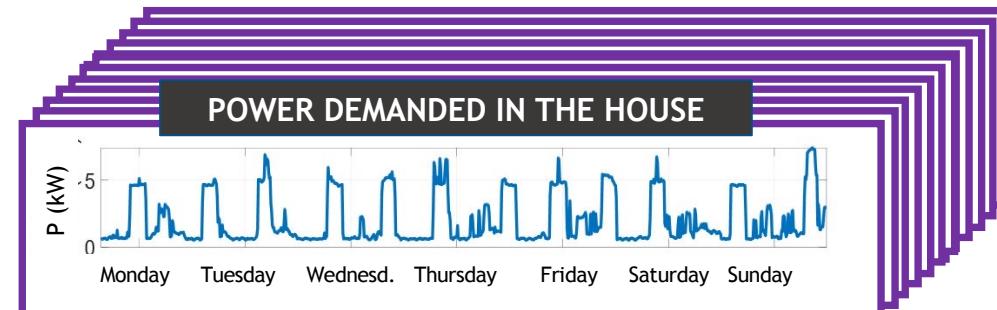
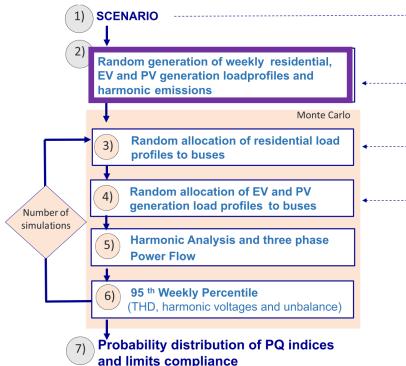
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Weekly profiles
(95th percentile)

1. The methodology



1. The methodology



1. Random generation of weekly house load profile
(10 minutes resolution)

Probabilistic aspects

- Number of active occupants, outside temperature and solar irradiation, etc.
- Markov chains: occupants behaviour

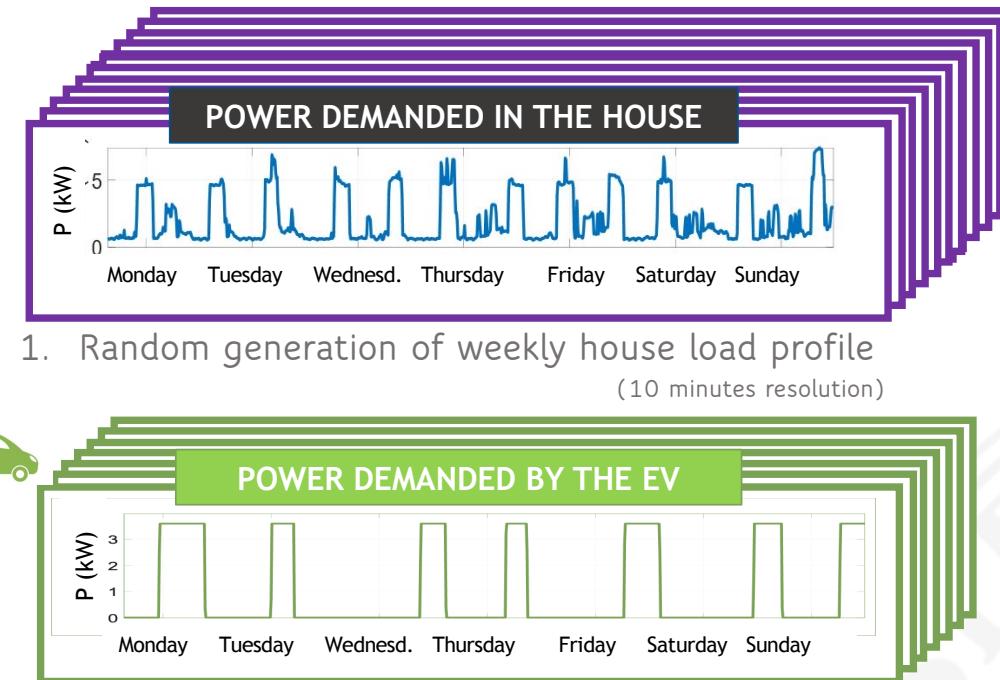
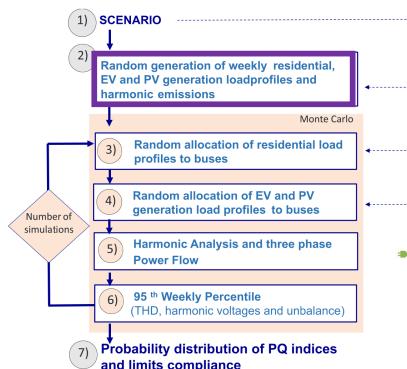
House Load Electricity ([Bröden et al. 2017])

Harmonic injection

- Characteristic probability distribution of current harmonic spectra
- Depending on the percentage of NL loads
- Depending on the time of the day

([Au et al. 2007])

1. The methodology



1. Random generation of weekly house load profile
(10 minutes resolution)

2. Random generation of weekly EV load profiles
(10 minutes resolution)

Probabilistic charger size, initial and final SOC, etc

Four Charging Modes:

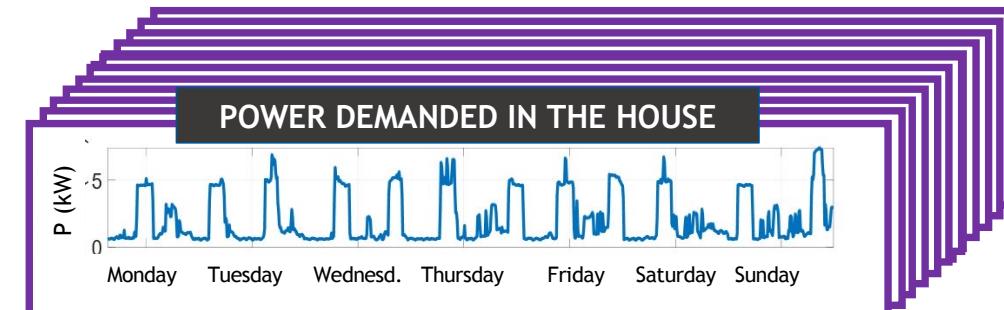
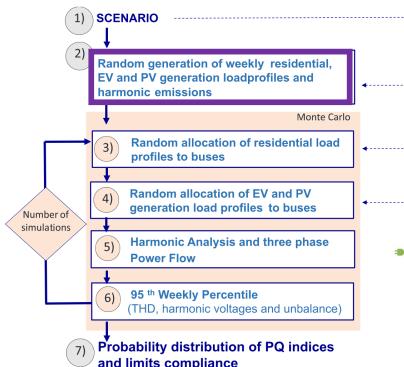
- Uncontrolled: Charging at arrival from work
- Controlled: Between 21:00 and 00:00
- Smart: to avoid coincident charges and peak load
- Measured: Based on statistics obtained from measurements

(Quiros-Tortos et al. 2018)
(Jiang et al. 2014)

Probability distribution of harmonic injection

(Staats et al. 1997)

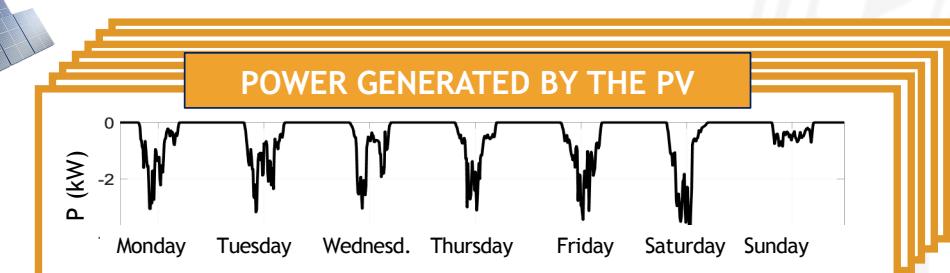
1. The methodology



1. Random generation of weekly house load profile
(10 minutes resolution)



2. Random generation of weekly EV load profiles
(10 minutes resolution)



3. Random generation of weekly PV generation profiles
(10 minutes resolution)

PV sizing

Stochastic solar irradiation, passing clouds

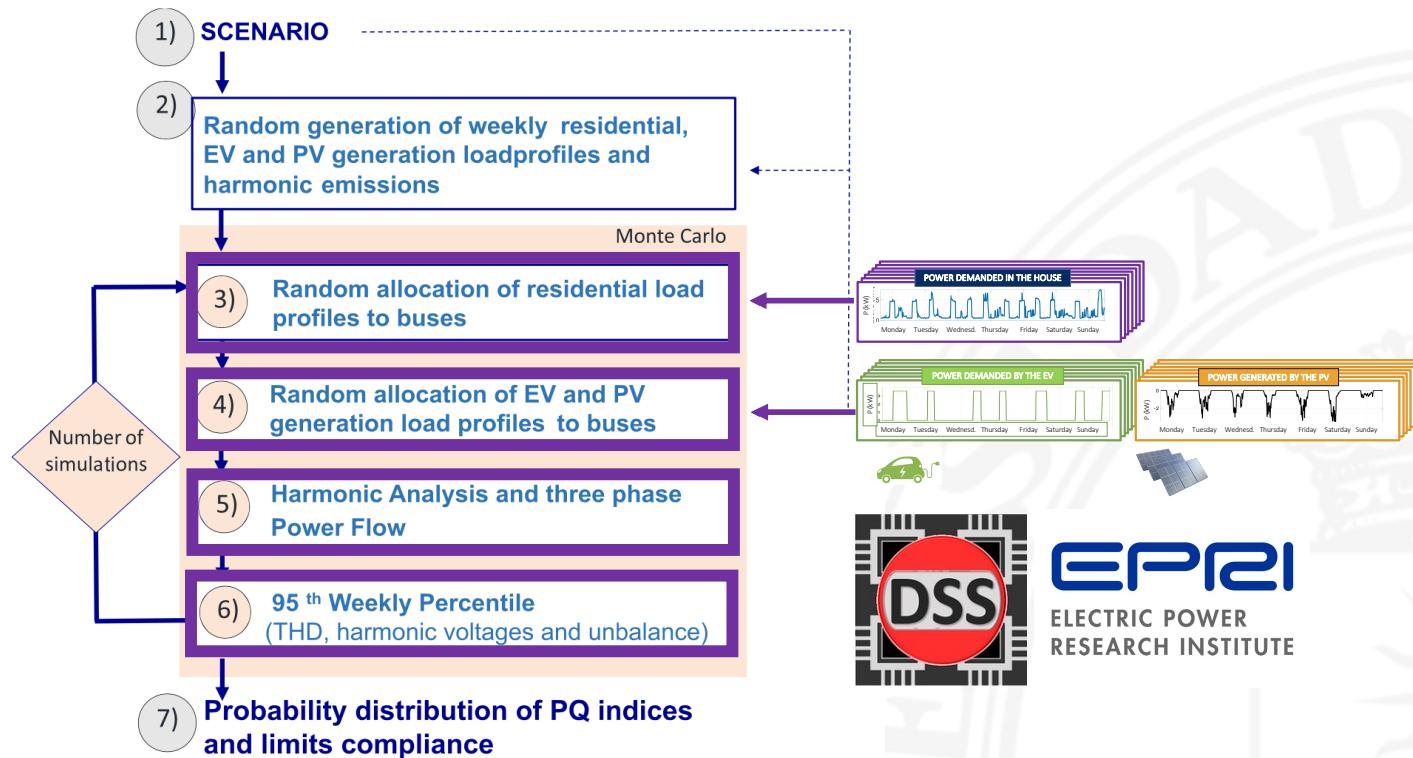
(Richardson et al. 2013)

Harmonic injection

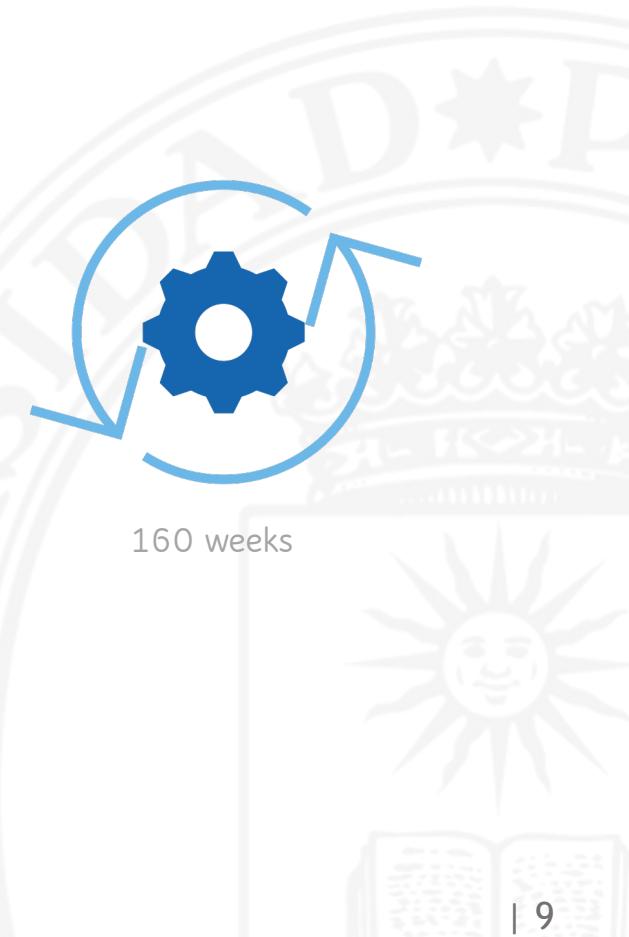
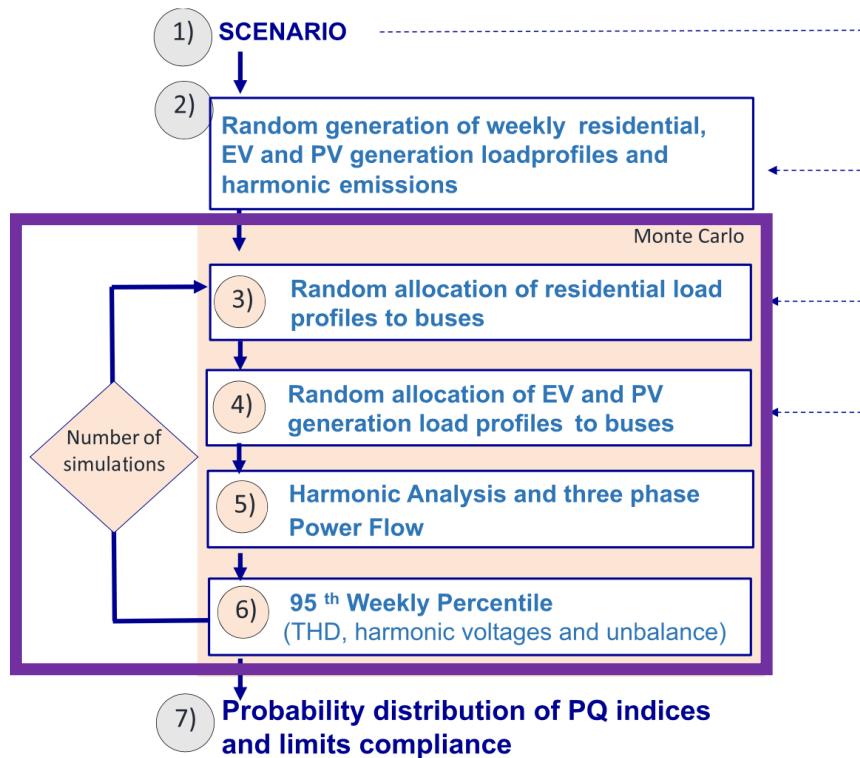


(Blanco et al. 2012)

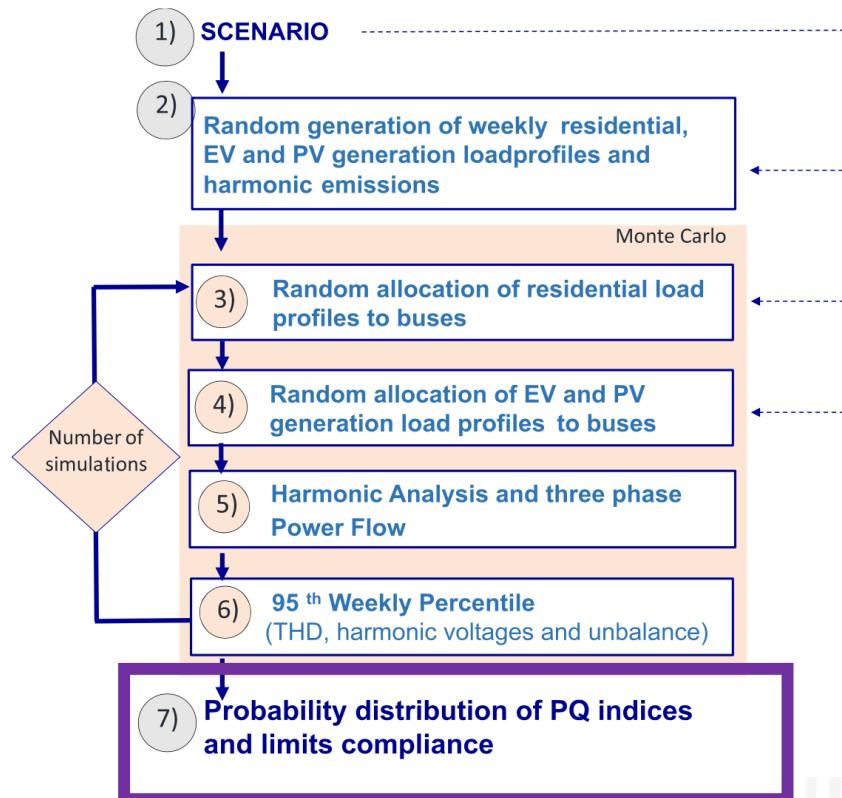
1. The methodology



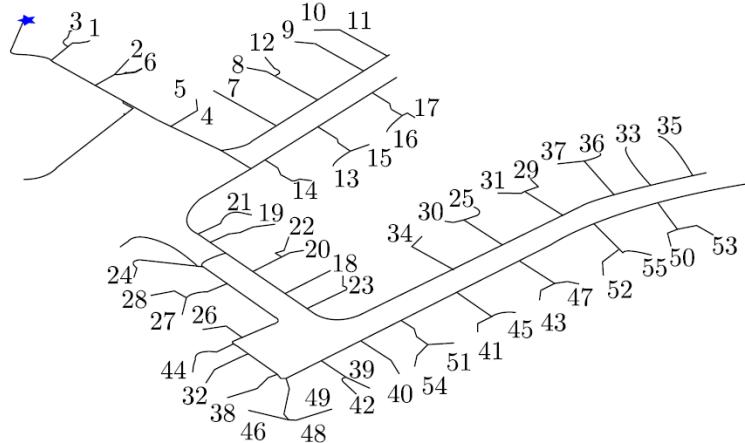
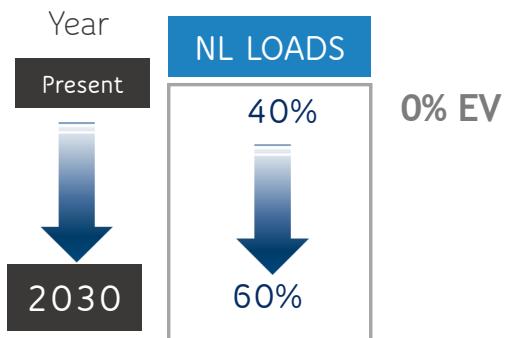
1. The methodology



1. The methodology



2. Case study 1: NL Loads



IEEE LV test feeder

- 55 residential consumers
 - Radial topology
 - Transformer 11/0,416 kV, 800kVA
 - Semi-urban

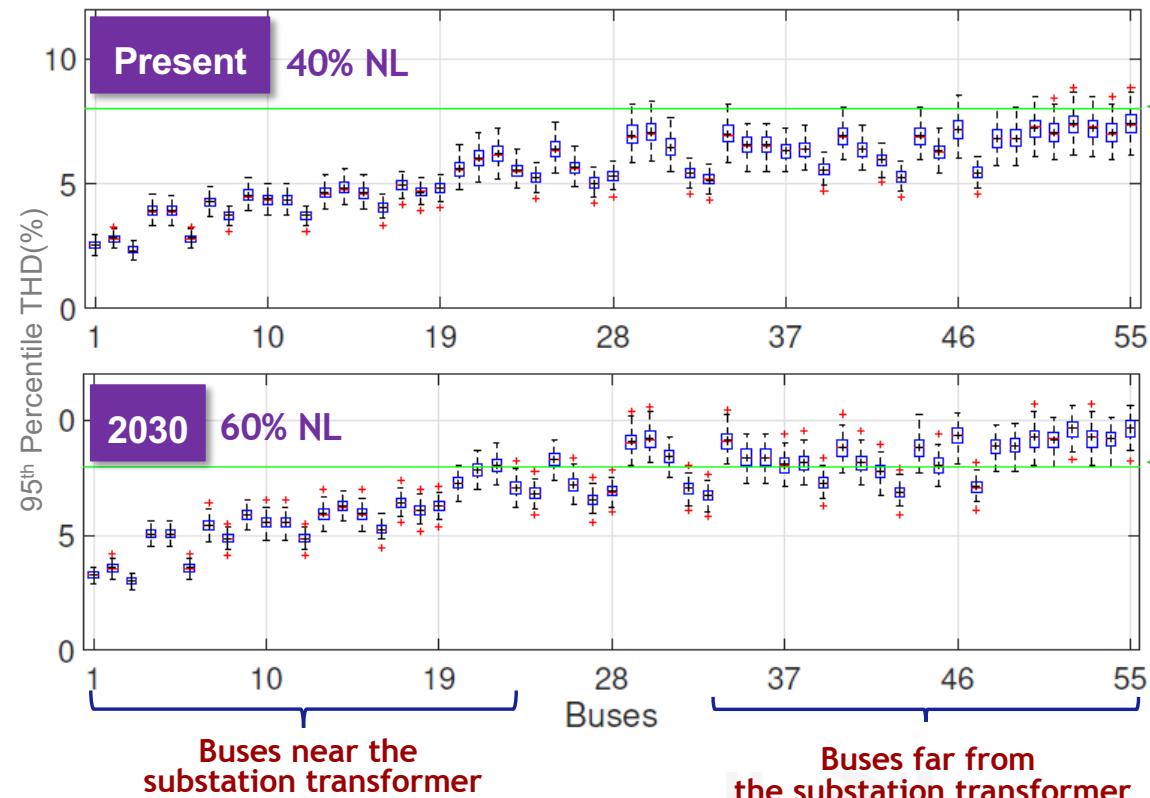


(Distribution Test feeder WG, 2017)

2. Case study 1: NL loads

Voltage THD

Increasing NL load levels can jeopardize PQ indices



Harmonics

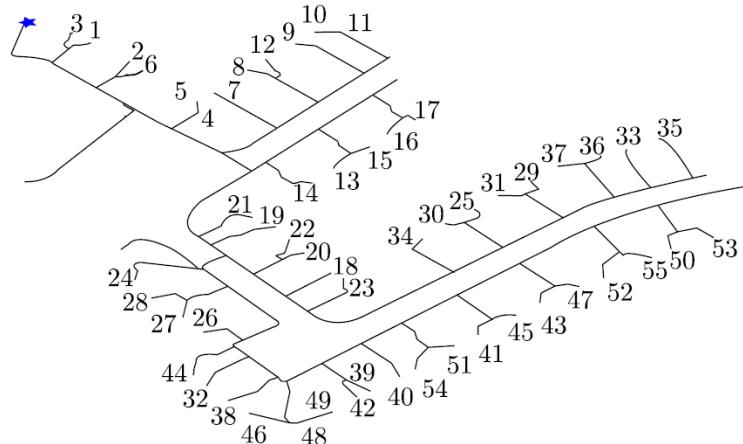
Unbalances

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limit

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limit

3. Case study 2: with 20% EV

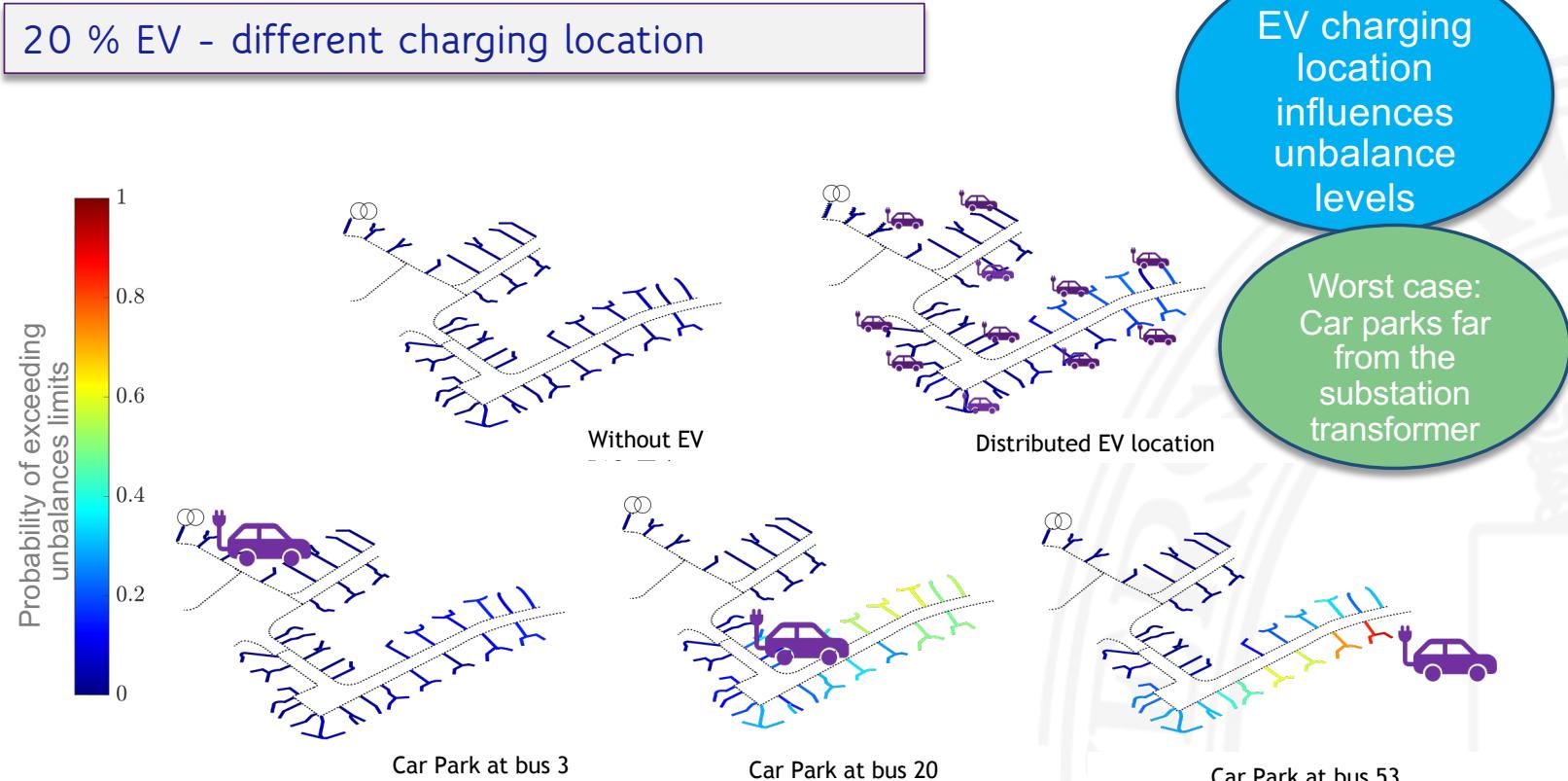
Year	NL LOADS	EV
Present	40%	
2030	60%	20%



Four Charging Location Types:

- Distributed
- Concentrated (Car park)
 - Near the substation)
 - Middle
 - Far from the substation

3. Case study 2: with 20% EV



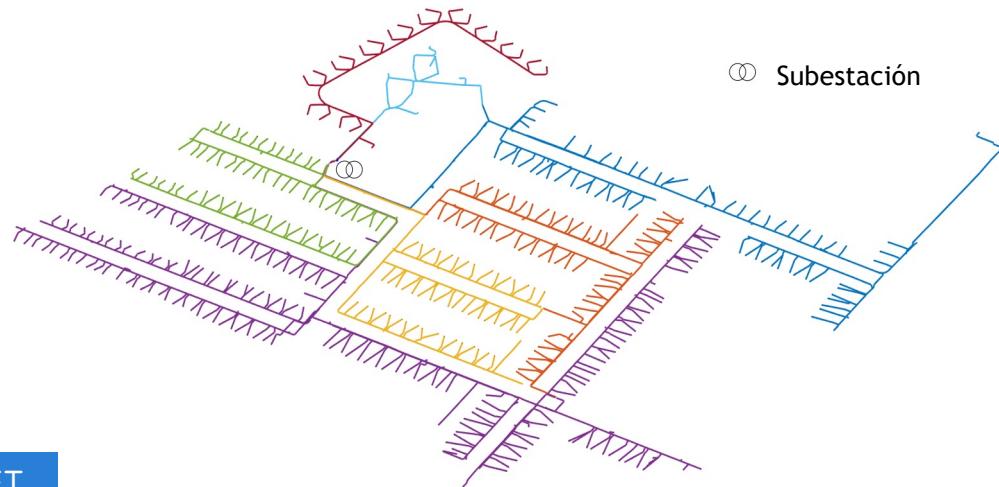
EV charging location influences unbalance levels

Worst case:
Car parks far from the substation transformer

Harmonics
Unbalances

4. Case study 3: EV and PV

NL LOADS	EV PENET.	PV PENET.
40%	20% ↓ 60%	0% ↓ 40%



Representative European Network #7

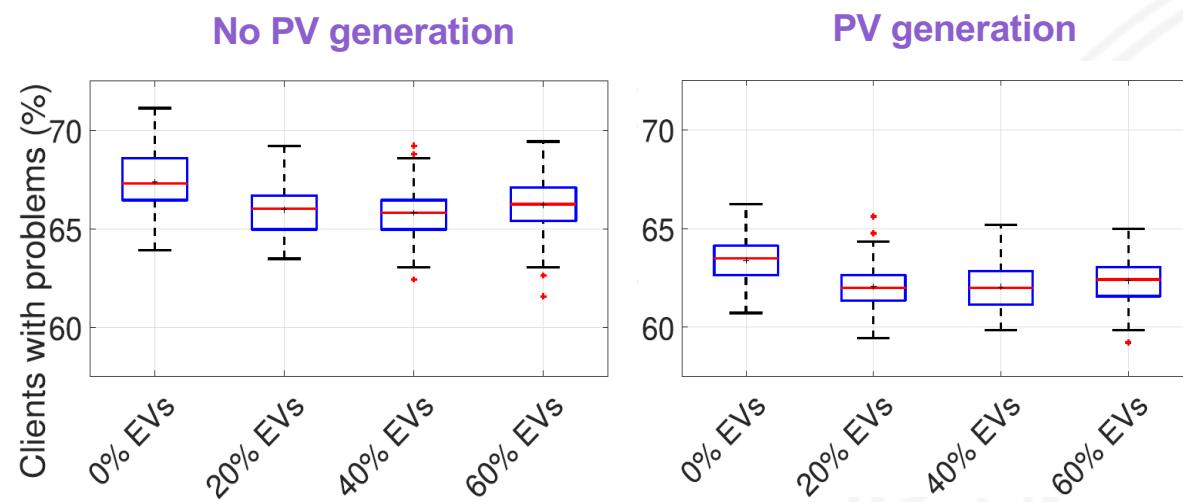
- 471 residential consumers
- 7 feeders
- Transformer 11/0,416 kV, 4 MVA
- Semi-urban

(Rigoni et al, 2016)

4. Case study 3: EV and PV

% Clients with problems of non-compliance harmonic limits

Harmonics
Unbalances



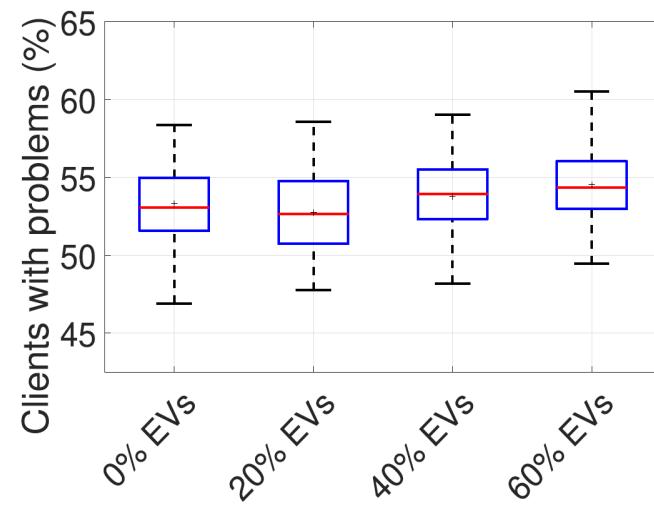
PV generation improves PQ levels in residential networks

4. Case study 3: EV and PV

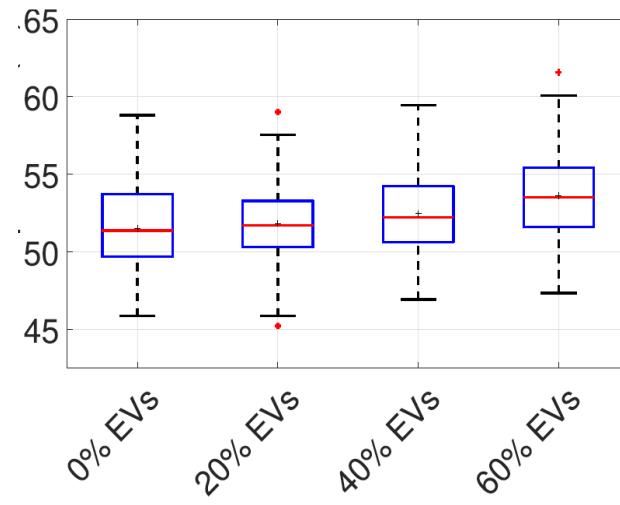
% Clients with problems of non-compliance unbalance limits

Harmonics
Unbalances

No PV generation



PV generation

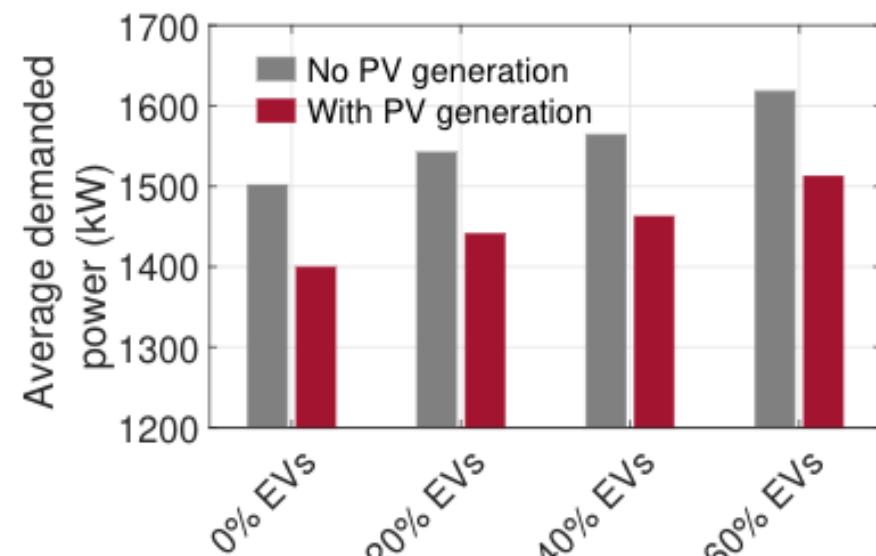


PV generation improves PQ levels in residential networks

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4. Case study 3: EV and PV

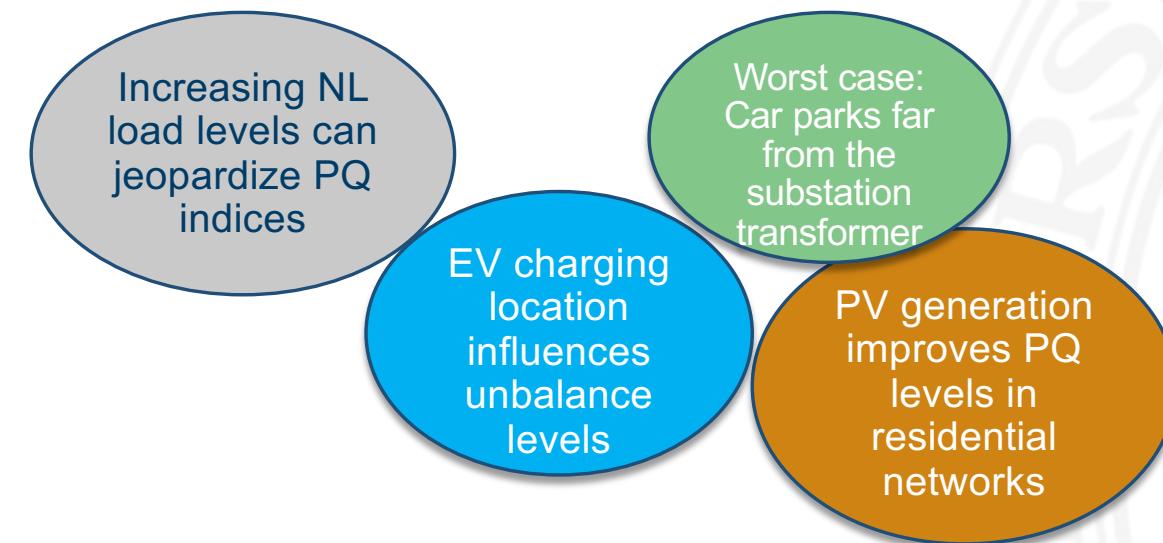
Average aggregated demanded P(kW) at the substation transformer



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5. Conclusions

- Methodology for the assessment of Power Quality in residential networks approached probabilistically
- Increasing penetration of electronic-based loads and new devices (EV and PV)
- The same methodology can be applied to other loads and other types of networks



Bibliography

Journal

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C2	P. Rodríguez-Pajarón, A. Hernández, J. V. Milanovic , "Probabilistic Assessment of Harmonics in a Residential Network", 2020 19th International Conference on Harmonics and Quality of Power (ICHQP), 2020, pp. 1-6, DOI: 10.1109/ICHQP46026.2020.9177873.	ICHQP
C3	P. Rodríguez-Pajarón, A. Hernández, J. V. Milanovic, "Influence of Transformer Rating on Power Quality Indices in Low Voltage Residential Networks", 2020 IEEE 20th Mediterranean Electrotechnical Conference (MELECON), 2020, pp. 594-598, DOI: 10.1109/MELECON48756.2020.9140504.	MELECON

Open-data base

Rodríguez Pajarón, P., Hernández Bayo, A., "Measurements of residential injections of harmonics - MEMORIA", e-cienciaDatos, 2021, DOI: <https://doi.org/10.21950/JOW63G>.

PROBABILISTIC ASSESSMENT OF POWER QUALITY IN NEXT GENERATION GRIDS (PA-PQ)



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