Evaluation of the End-of-Life of Electric Vehicles according to the State-Of-Health

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The Origin

The **SABINA** project: **SmArt BI-directional multi eNergy gAteway**

- Building's load cover factor increase through renewables
- Reduce building's CO_2 emissions

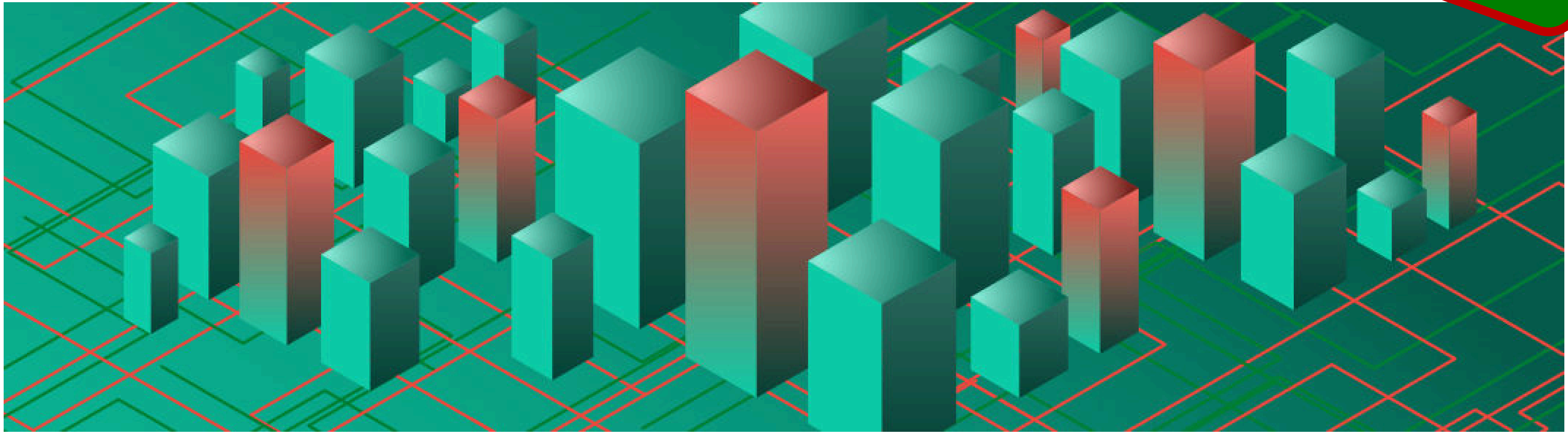
(https://sabina-project.eu/)

The Origin

The aim is to do that thanks to the building's

- Intrinsic (Building Algorithm)
- Extrinsic (Market Integrated District Algorithm)

What's the relation with Electric Vehicles?



The Origin

The flexibility of buildings comes from its elements:

- Photovoltaic panels
- Heating system
- Battery
- Electric Vehicle through **smart charge**

The Origin

The challenge was to estimate the flexibility from EV through

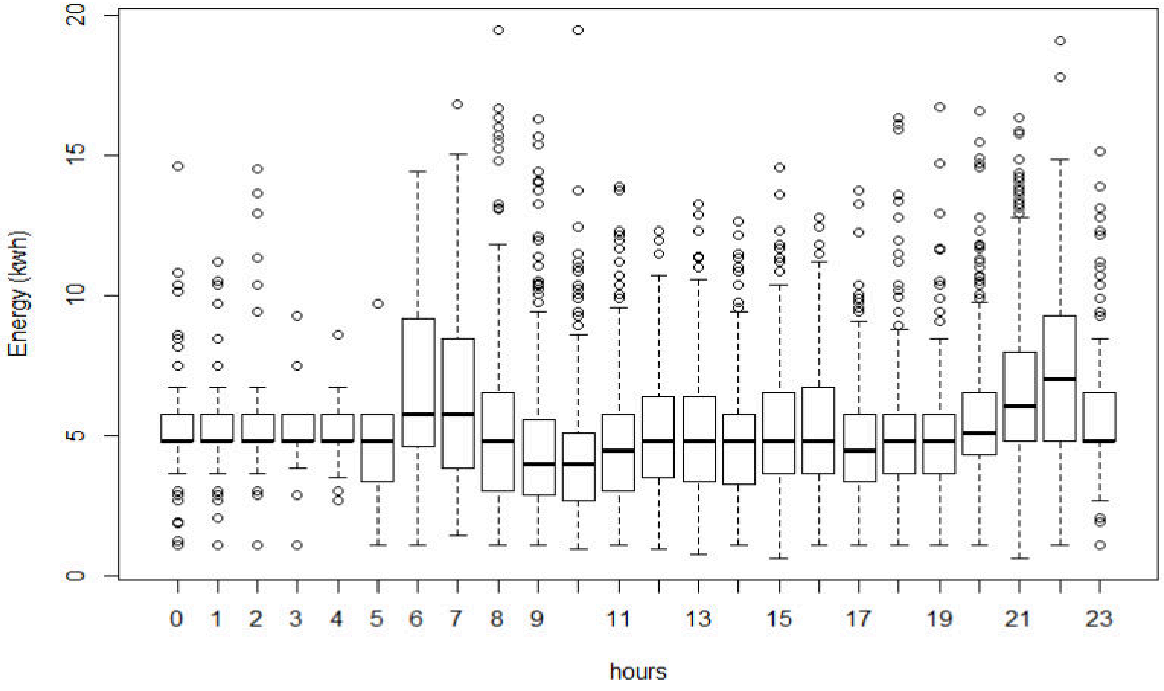
- Forecast of the arrival and departure
  - And, thus, the time plugged-in
- Forecast the **amount of energy to charge**

Methodology

Taking data of thousand of trips from the project Green eMotion

Several approaches were analyzed:

- Charge duration (hours)
- Initial State of Charge (SoC)
- Energy of the charge (kWh)
- Charge ratio (kWh/hours)



Methodology

Subdivision per hours having similar behavior:

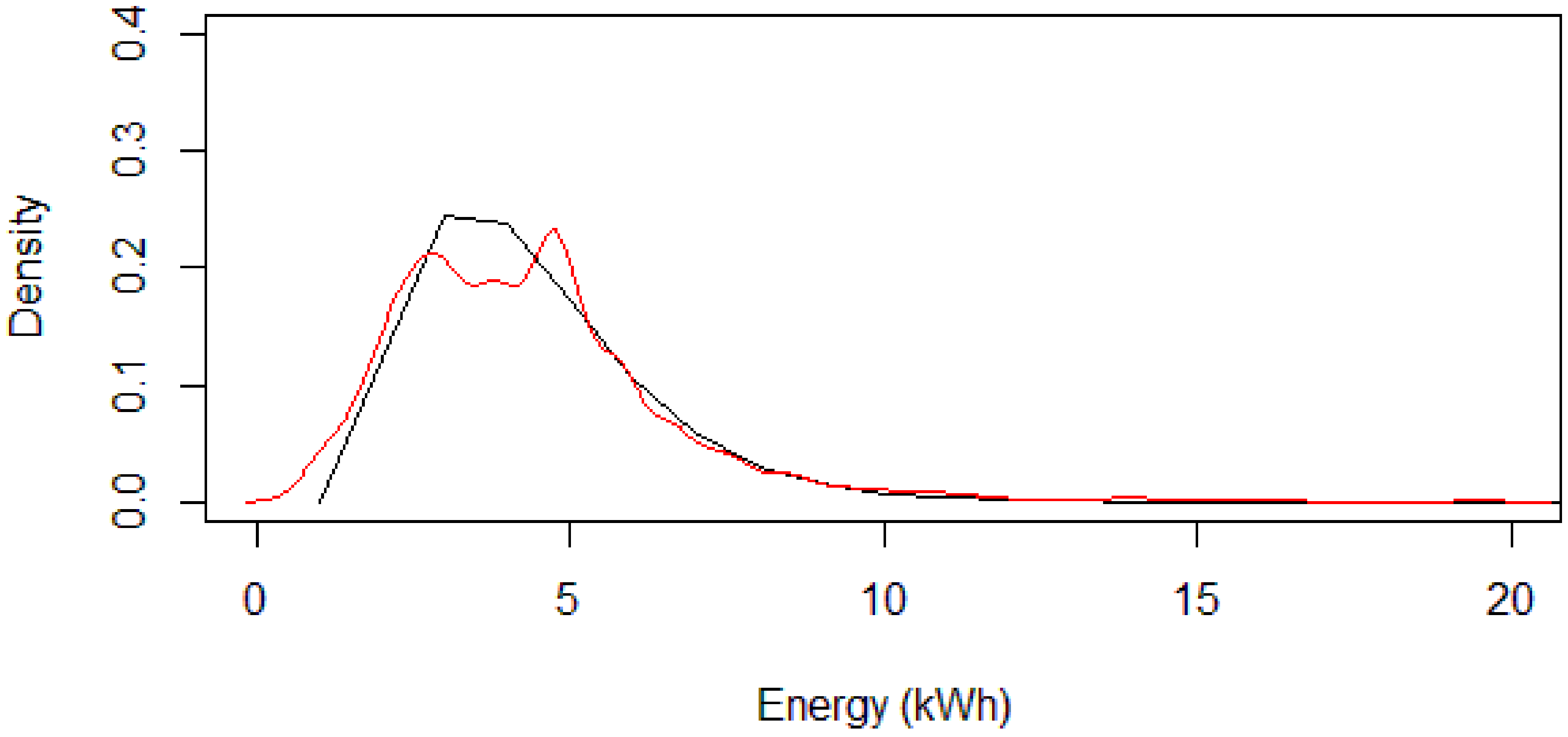
- Group 1: 9 and 10h;
- Group 2: 8, 11, 13, 14, 17 and 19h;
- Group 3: 12, 15, 16 and 18h;
- Group 4: 20 and 23h;
- Group 5: 21h
- Group 6: 22h and from 0 to 7h in the morning

Group	1	2	3	4	5	6
Share	14%	28%	18%	10%	13%	17%

Methodology

Obtain of the distribution of the amount of energy per charge

- Group 1:
- Group 2:
- Group 3:
- Group 4:
- Group 5:
- Group 6:

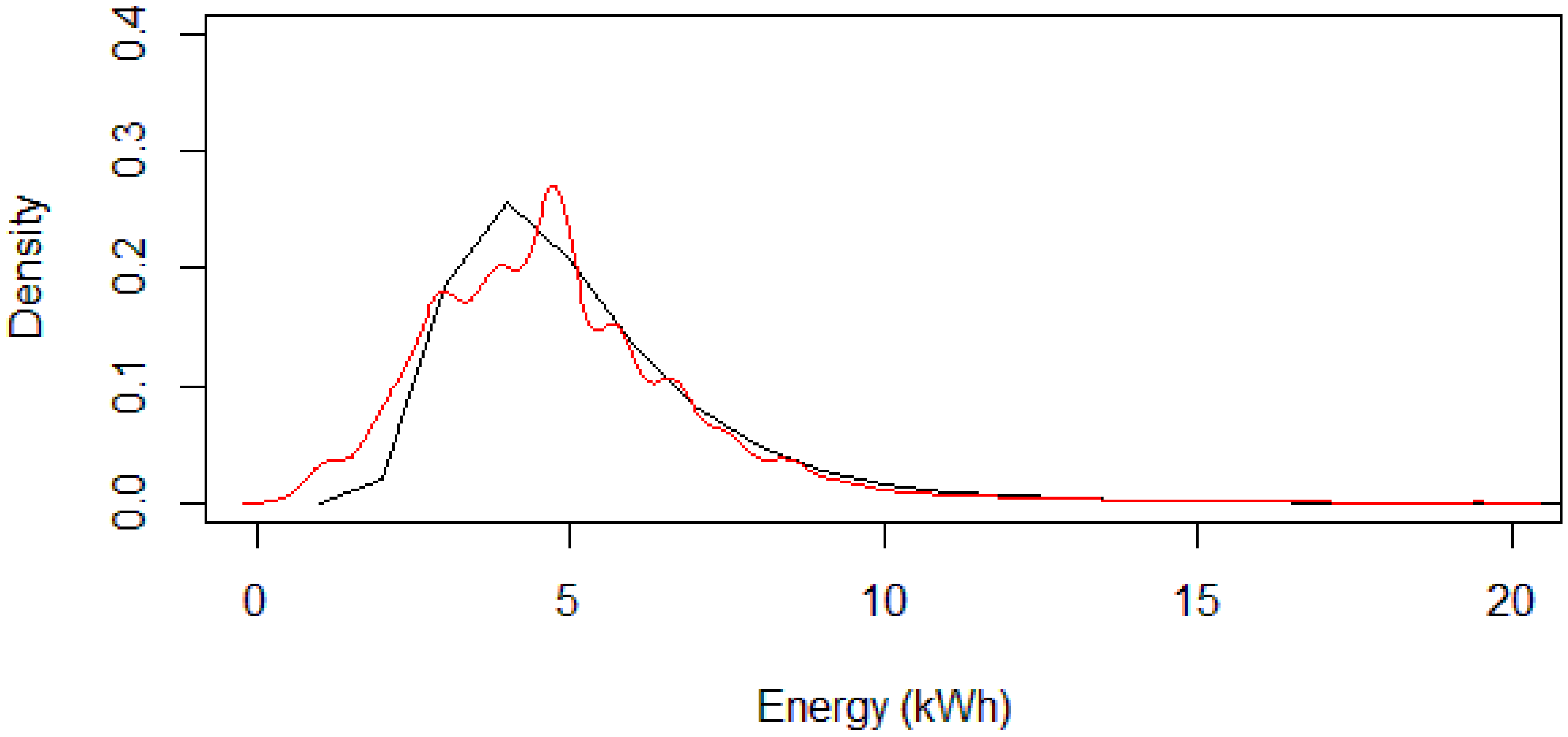


Gamma (shape=3.5, rate=1.043)

Methodology

Obtain of the distribution of the amount of energy per charge

- Group 1:
- Group 2:
- Group 3:
- Group 4:
- Group 5:
- Group 6:

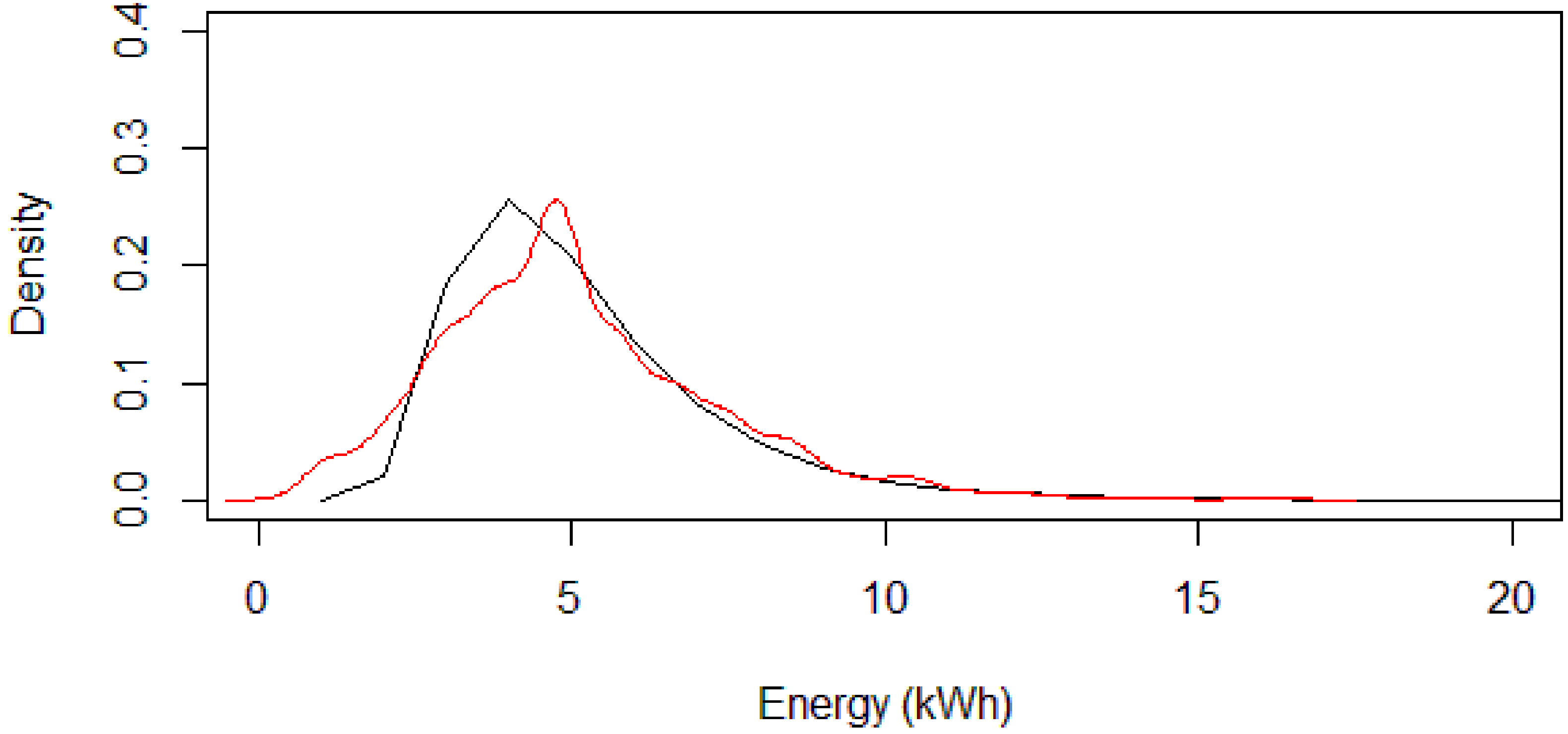


Gamma (shape=4.2, rate=1.091)

Methodology

Obtain of the distribution of the amount of energy per charge

- Group 1:
- Group 2:
- **Group 3:**
- Group 4:
- Group 5:
- Group 6:

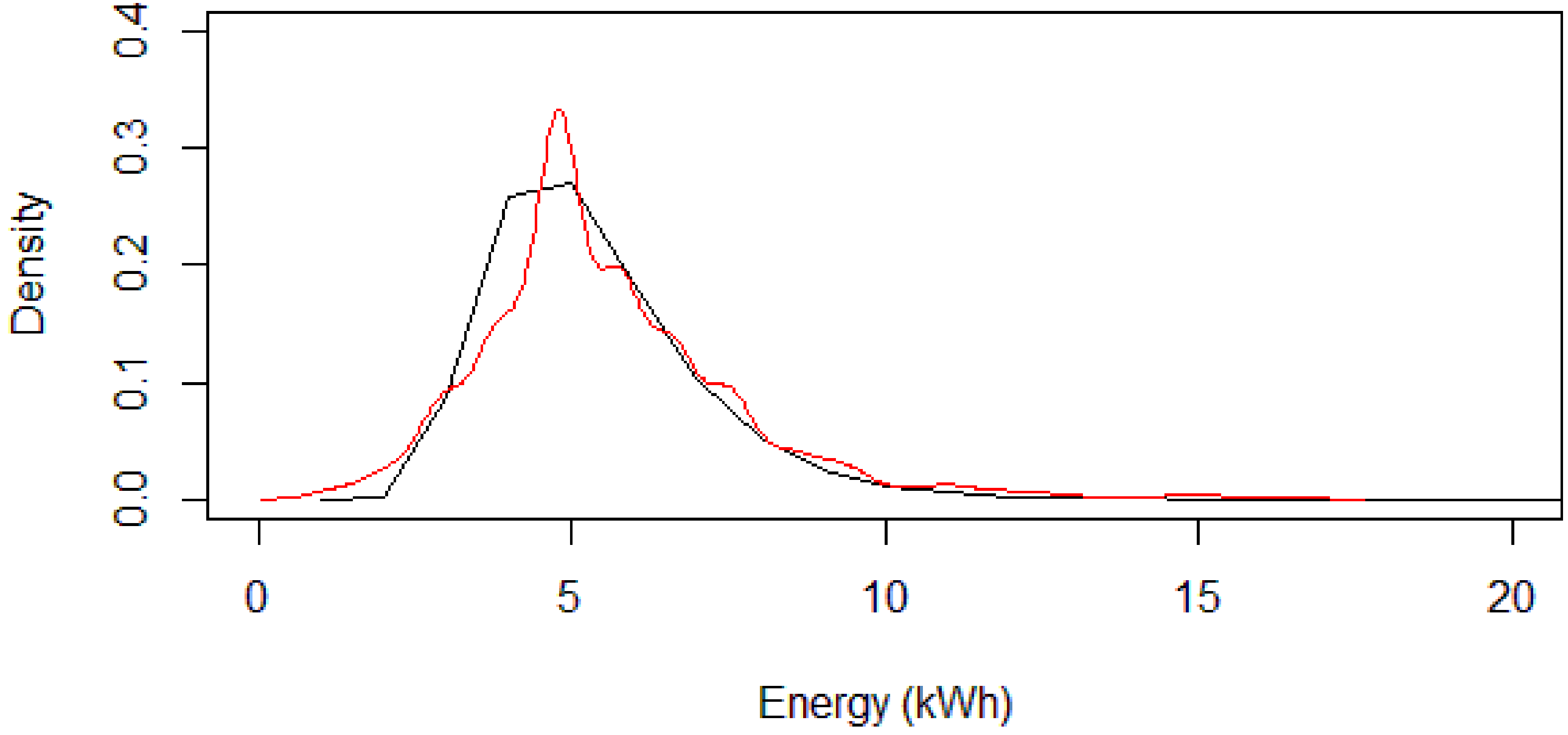


Lognormal (meanlog=1.3, sdlog=0.472)

Methodology

Obtain of the distribution of the amount of energy per charge

- Group 1:
- Group 2:
- Group 3:
- Group 4:
- Group 5:
- Group 6:

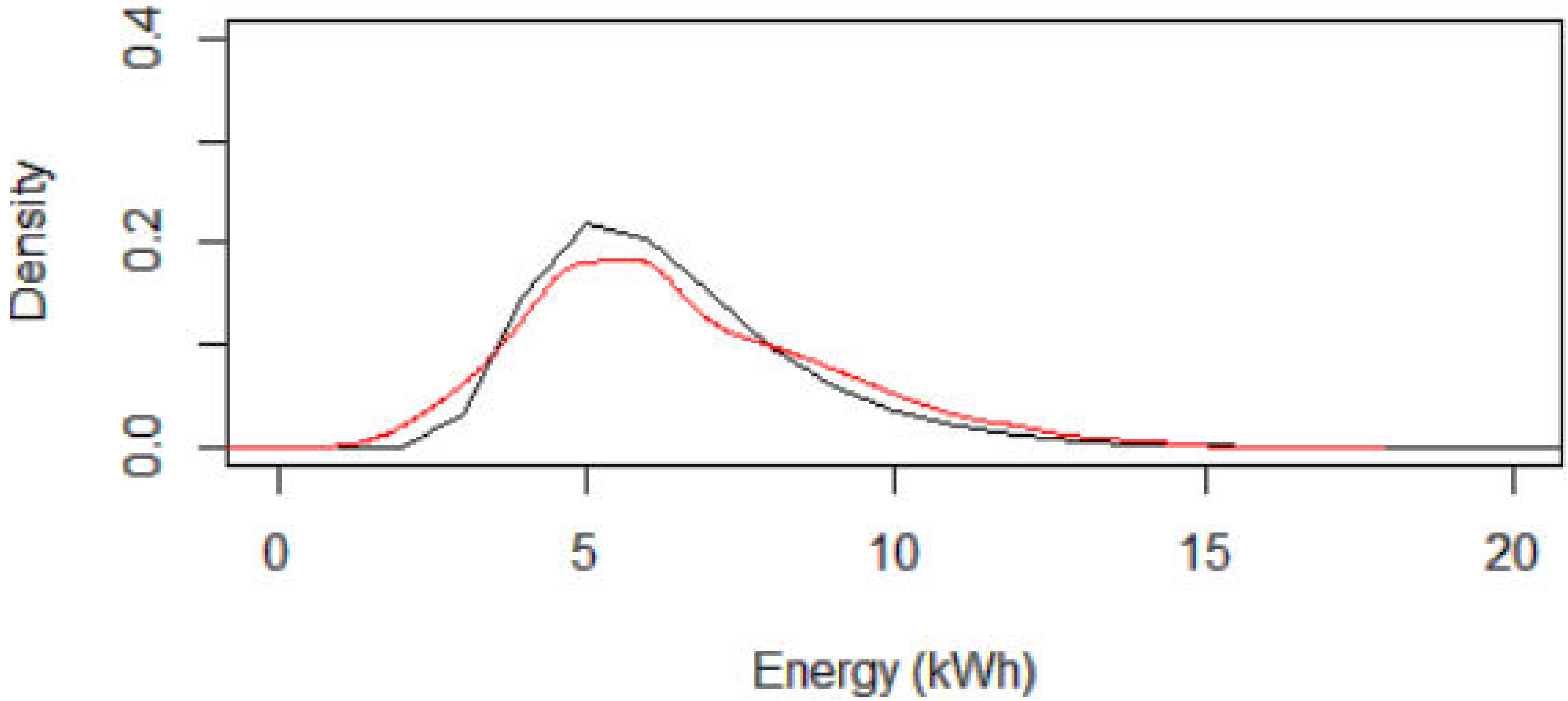


Lognormal (meanlog=1.4, sdlog=0.369)

Methodology

Obtain of the distribution of the amount of energy per charge

- Group 1:
- Group 2:
- Group 3:
- Group 4:
- **Group 5:**
- Group 6:

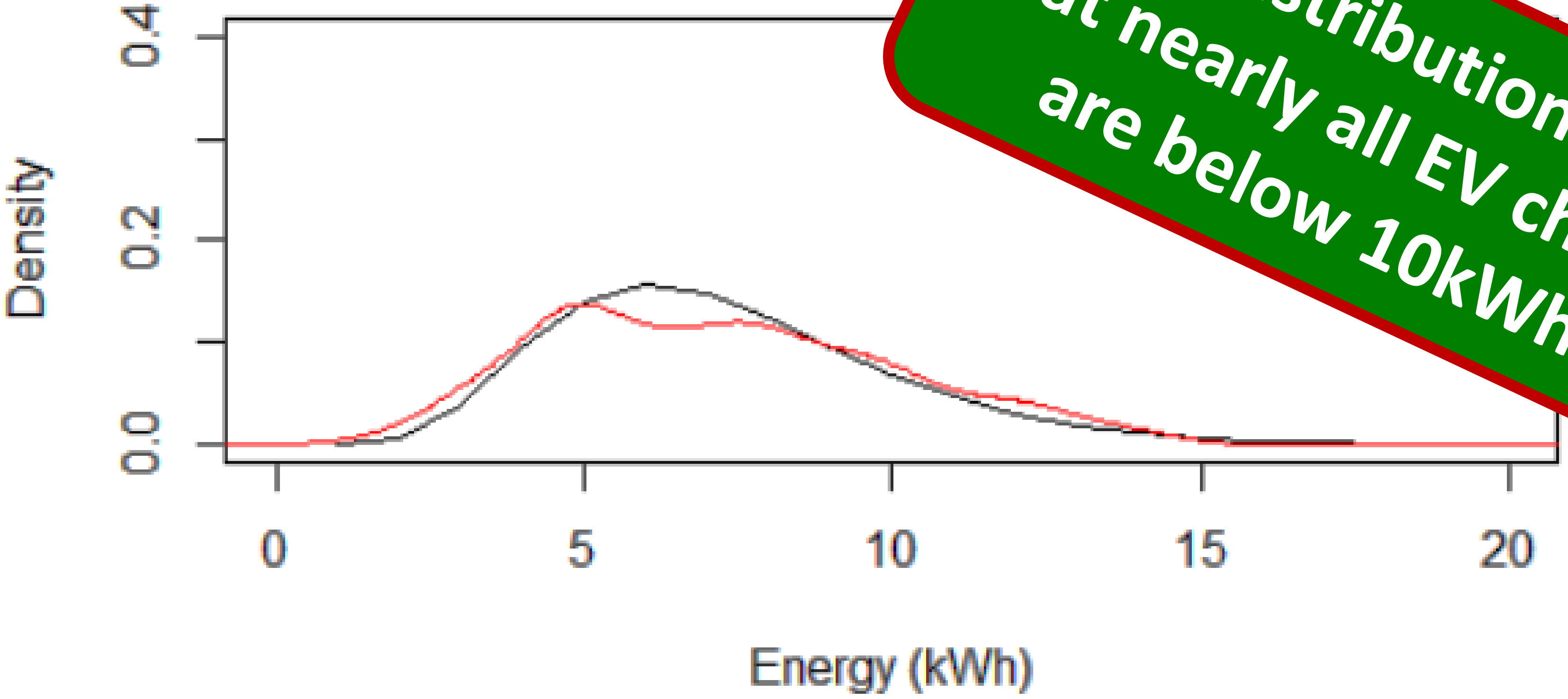


Lognormal (meanlog=1.6, sdlog=0.39)

Methodology

Obtain of the distribution of the amount of ene

- Group 1:
- Group 2:
- Group 3:
- Group 4:
- Group 5:
- Group 6:



Gamma (shape=5, rate=0.082)

These distributions show that nearly all EV charges are below 10kWh!

Results

Considering different capacity of EV batteries:

30 kWh

This represents only 2,5% of the total amount of charges

Batt. Initial Capacity (kWh)	SoH (%)	Capacity at EoL (kWh)	Share					
			Group 1	Group 2	Group 3	[illegible]	[illegible]	[illegible]
16	60	9.6	0.55	0.92	2.08	[illegible]	[illegible]	[illegible]
16	70	11.2	0.15	0.25	0.90	0.29	[illegible]	[illegible]
16	80	12.8	0.04	0.06	0.41	0.09	[illegible]	[illegible]
24	60	14.4	<0,01	0.02	0.19	0. 03	0.31	[illegible]
24	70	16.8	<0,01	<0,01	0.06	<0,01	0.09	[illegible]
24	80	18	<0,01	<0,01	0.04	<0,01	0. 05	0.10
30	60	19.2	<0,01	<0,01	0.02	<0,01	0. 03	0.05
30	70	21	<0,01	<0,01	0.01	<0,01	0. 01	0.02
30	80	24	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01
-	-	10	0.40	0.67	1.68	0.72	3.58	**8.87**

Conclusions

According to the results and the higher capacity of new EV batteries:

- The **SOH** at the End of Life can be clearly **lower than 80%** for most of EV
  - Battery capacity > 24 kWh → 60% SOH at EoL could be acceptable
  - Future EV batteries are expected to have more than 30 kWh

- **Second life** of batteries for SOH at EoL < 70% is **questionable**

- **Life Cycle Assessments (LCA)** should consider this longer SoH

Thank You!

If you have any questions, please contact Lluc Canals Casals lcanals@irec.cat

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