Are EU homes ready for full electrification?

February 24, 2022
16h00 – 17h00

Leonardo ENERGY Webinar Channel
copper.fyi/letube

10th Webinar of the Electrification Academy

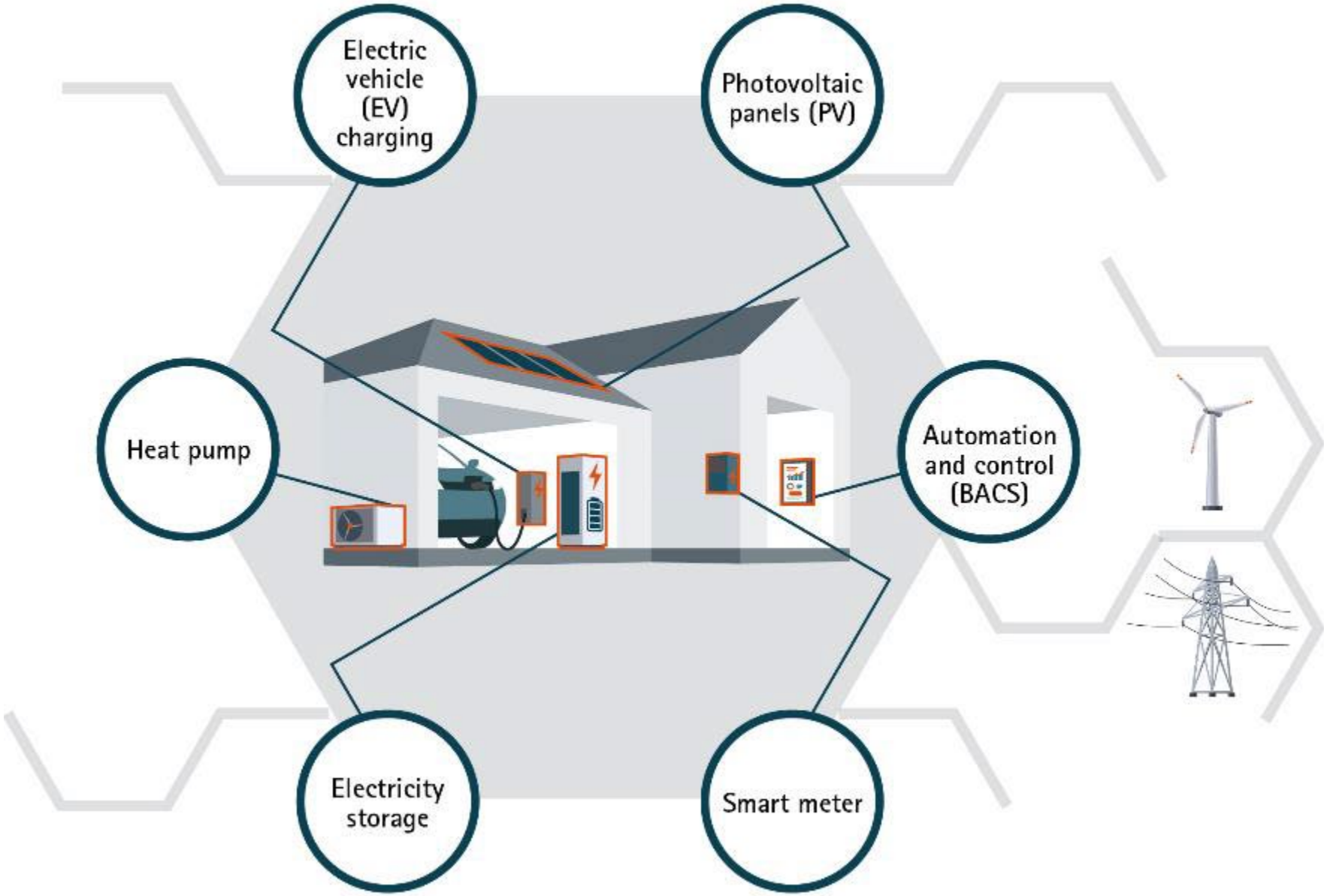
RAP®

Leonardo ENERGY

Speaker:
Angelo Baggini,
University of Bergamo

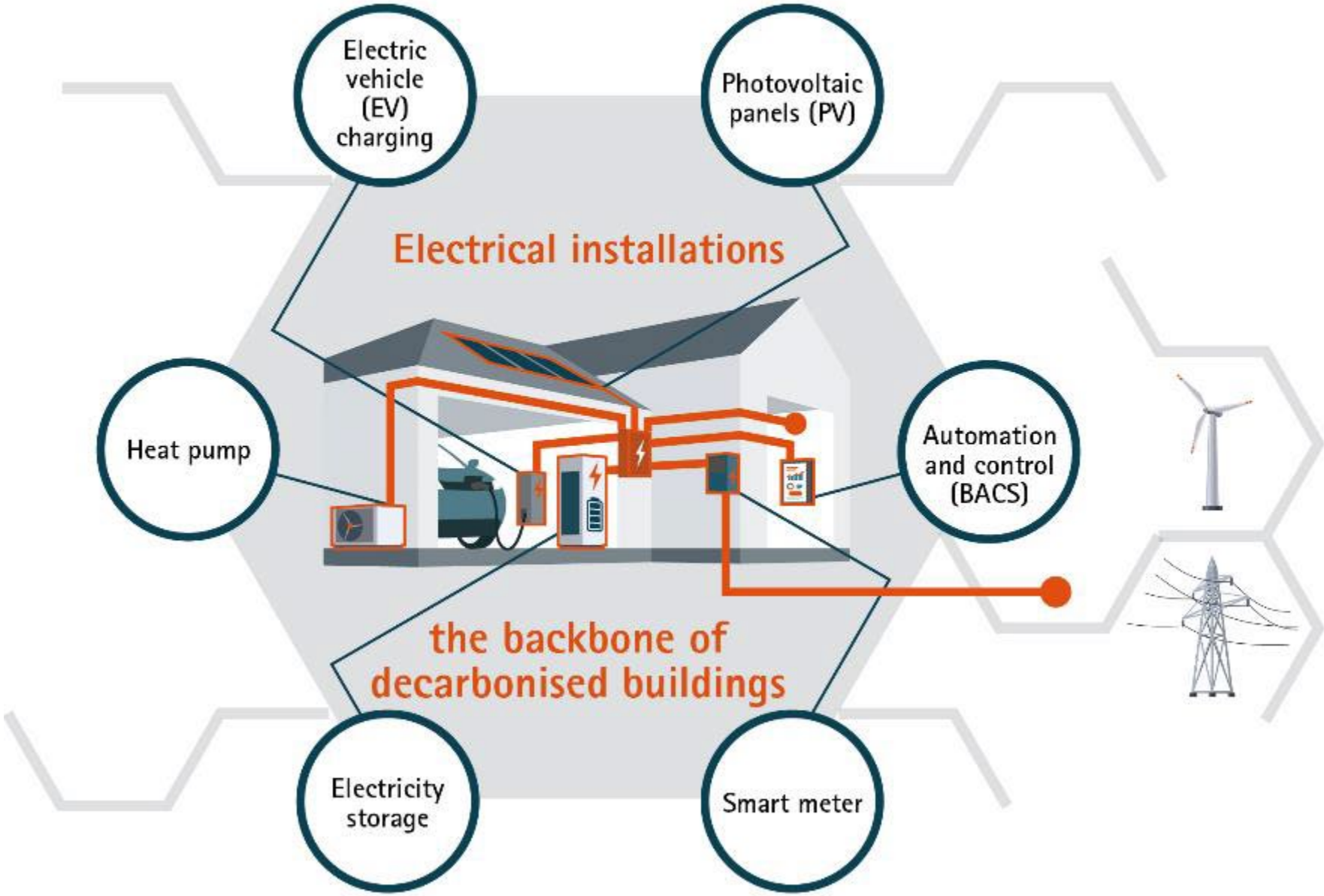
As part of the 'renovation wave,' solar photovoltaic power systems, heat pumps, electricity storage and electric vehicles chargers will become prevalent in our homes. This raises the question whether the EU dwelling stock is ready for this transition. Around 50% of domestic buildings were built before 1990 without anticipating the needs of today and tomorrow. Prof. Angelo Baggini from the University of Bergamo shares his analysis of electrical installations in Europe and proposes solutions on the path towards zero-emissions buildings.

The road to decarbonised buildings



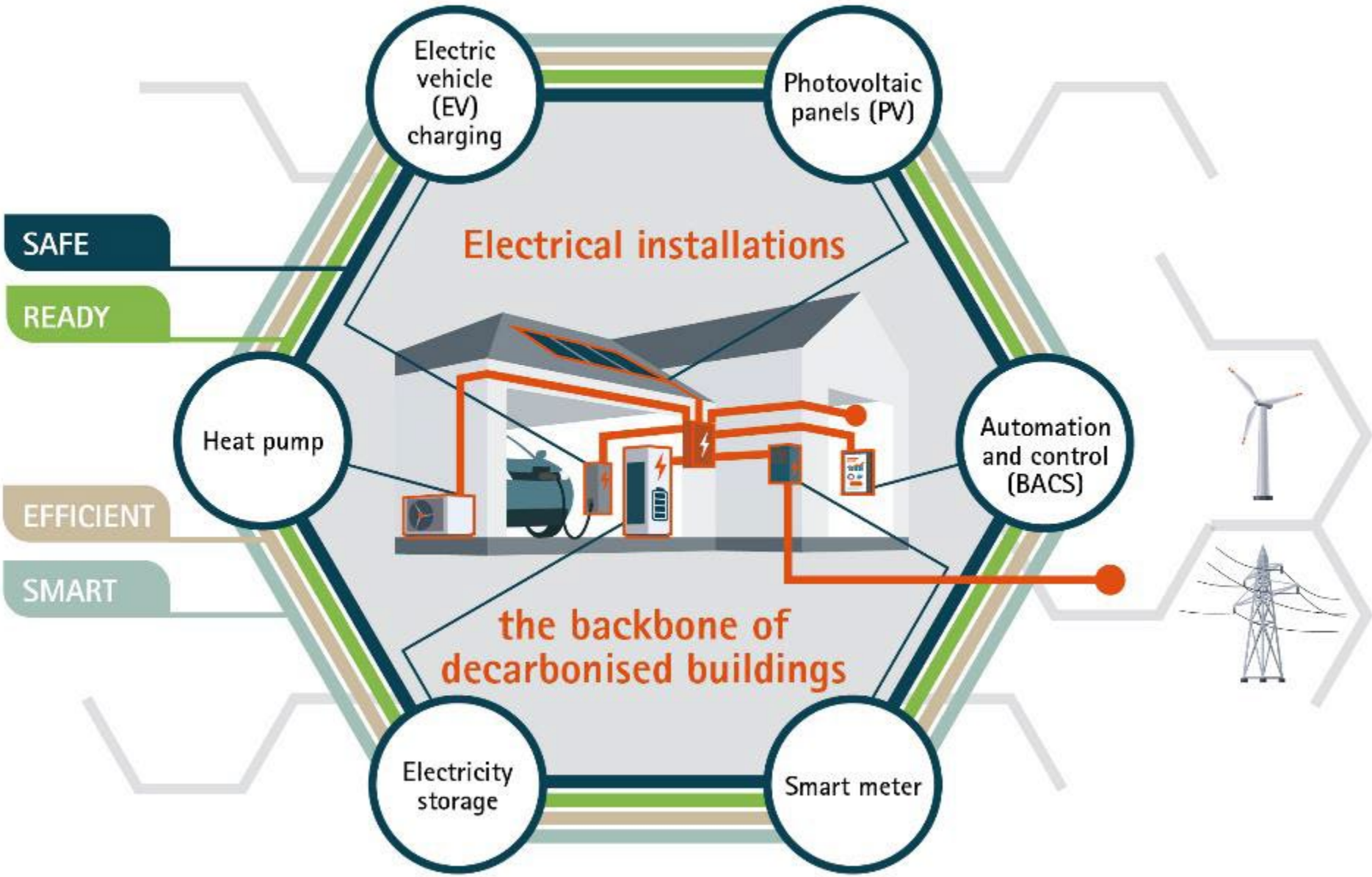
Cu

The road to decarbonised buildings



Cu

The road to decarbonised buildings

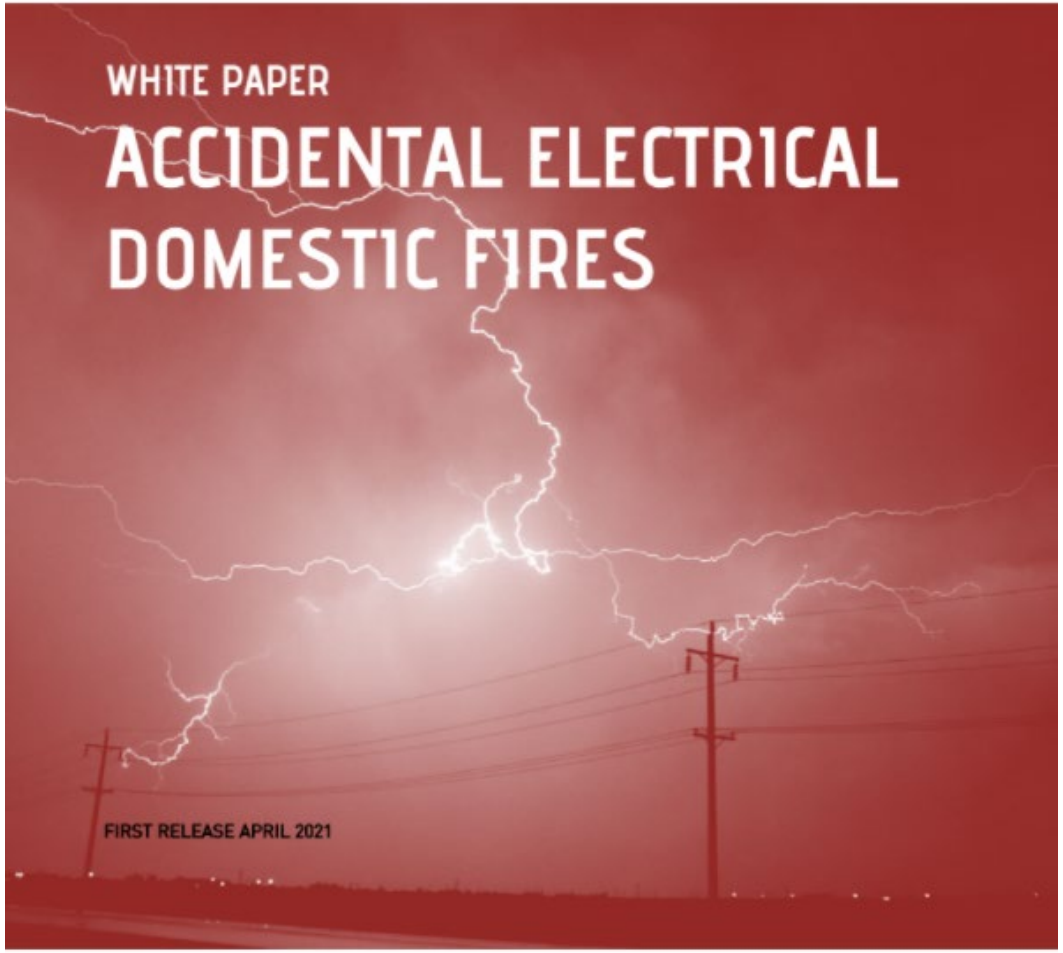


Cu

SAFE

"**30%** of domestic and **50%** of domestic accidental fires have an electrical source"

FEEDS
Forum for European Electrical Domestic Safety



Available on www.feedsnet.org

Cu

READY

“**132 million** domestic electrical installations are obsolete in the EU”

EFFICIENT

2% of electricity generated in EU is lost in indoor electrical installations

SMART

Smart integration of highly efficient heat pumps, EV charging infrastructure, storage and renewable generation can contribute to an efficient and stable electrical grid

Are EU homes ready for full electrification?

Angelo Baggini*, Franco Bua**
*angelo.baggini@unibg.it, Bergamo University -Via Marconi 5, 24044 Dalmine (BG) – Italy
** franco.bua@ecd.it, ECD Engineering Consulting and Design Pavia - Italy

Photo by Terry Magallanes from Pexels

The context

(Volta's generator credit Luigi Chiesa)

Factors of change

- Electrification of usages
- General consumption trend
- Energy conversion efficiency
- Distributed generation and storage
- Automation

These changes will affect:

- The electrical energy consumption
- The electrical power required

by **each single residential user** (as well as the **distribution network**)

Electrification of usages

Household energy use	Annual electrical consumption (kWh)	Power demand (kW)
Space heating (SH)	10.500	2,7
Domestic water heating (DWH)	2.500	1 - 2,5
Cooking	1.000	2
Transport	2.000-3.500**	3,7 – 50*

Note: * power demand for smaller 2 wheels EV is to be considered negligible and included into general consumption trend. ** ref. to 15000 km/year 1 car

General consumption trend

Household energy use	Annual electrical energy (kWh)	Power demand (kW)
Space cooling (SC)	146	3
Other (sauna, IT equipment at home etc.)	0,7÷1 %/y	1÷3

Energy conversion efficiency

Household energy use	Annual electrical energy (kWh)	Power demand (kW)
Lighting	-325	-50
Electrical appliances	-2.000	-300

Distributed generation and Storage

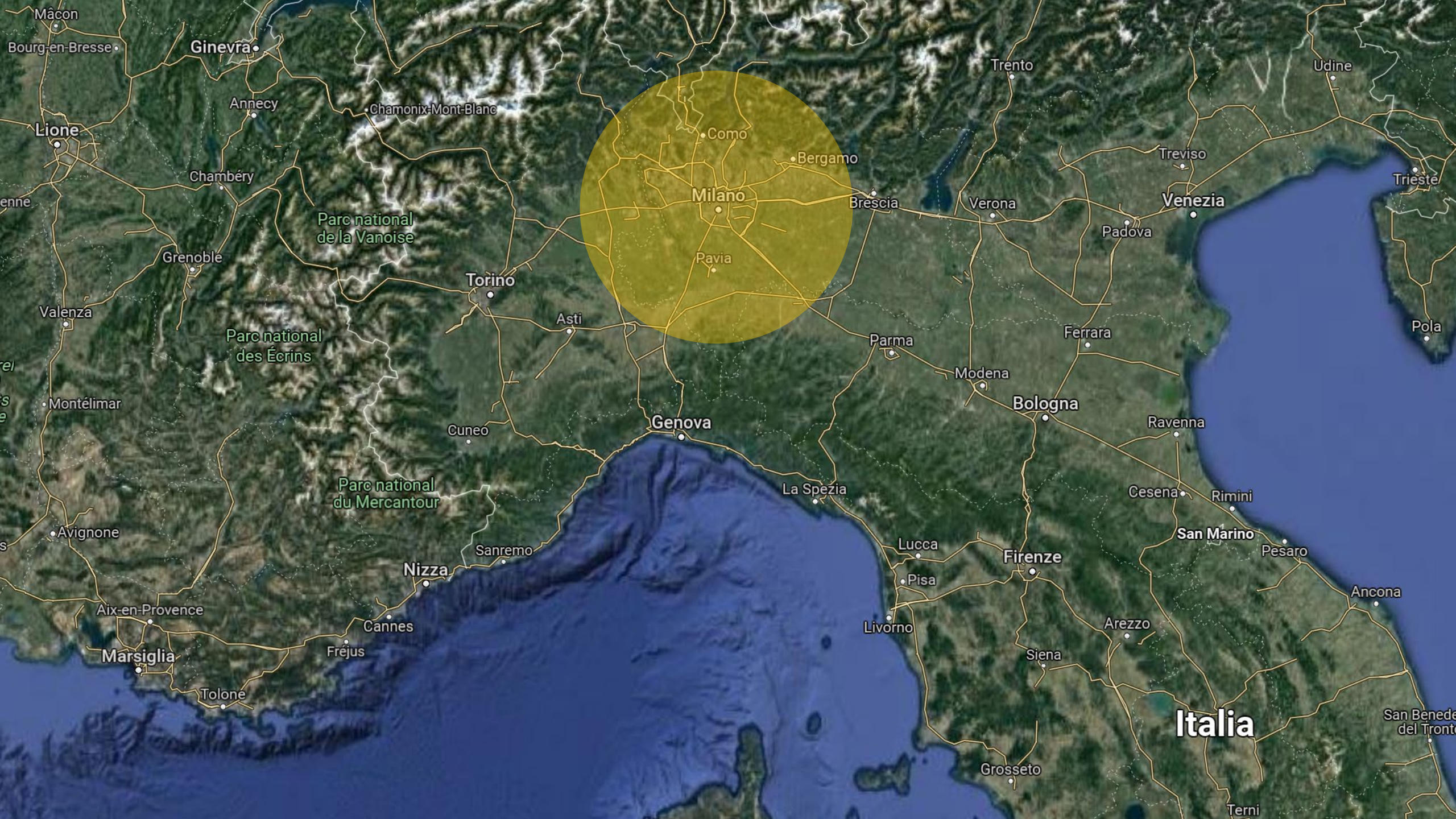
Household energy use	Annual electrical energy (kWh)	Power demand (kW)
Distributed generation	-3.000*	0
Storage	2,5-3,5**	-2,5

Note: * Annual electrical energy, **Rated storage capacity

Automation

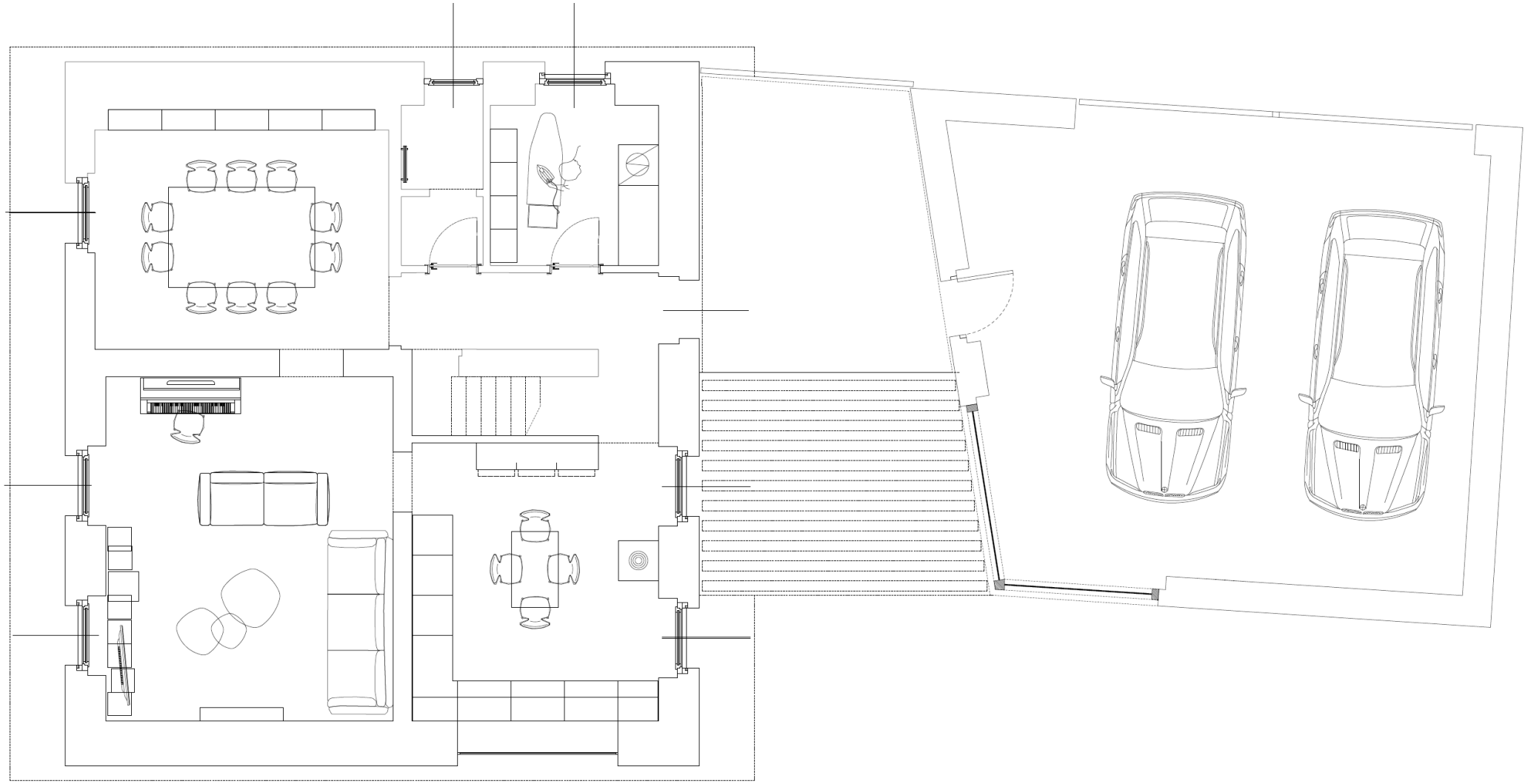
Household energy use	Electrical energy (pu)	Power demand (pu)
Electrical	0,81*	0,2-0,8

* ref. EN 15232


Mâcon
Bourg-en-Bresse
Ginevra
Annecy
Chamonix-Mont-Blanc
Lione
Chambéry
Parc national de la Vanoise
Grenoble
Torino
Valenza
Asti
Parc national des Écrins
Montélimar
Cuneo
Parc national du Mercantour
Avignone
Sanremo
Nizza
Aix-en-Provence
Cannes
Fréjus
Marsiglia
Tolone
Como
Bergamo
Milano
Pavia
Brescia
Trento
Udine
Treviso
Verona
Venezia
Padova
Trieste
Pola
Parma
Ferrara
Modena
Bologna
Ravenna
Genova
La Spezia
Cesena
Rimini
San Marino
Pesaro
Lucca
Firenze
Pisa
Ancona
Livorno
Arezzo
Siena
Grosseto
Terni
Italia

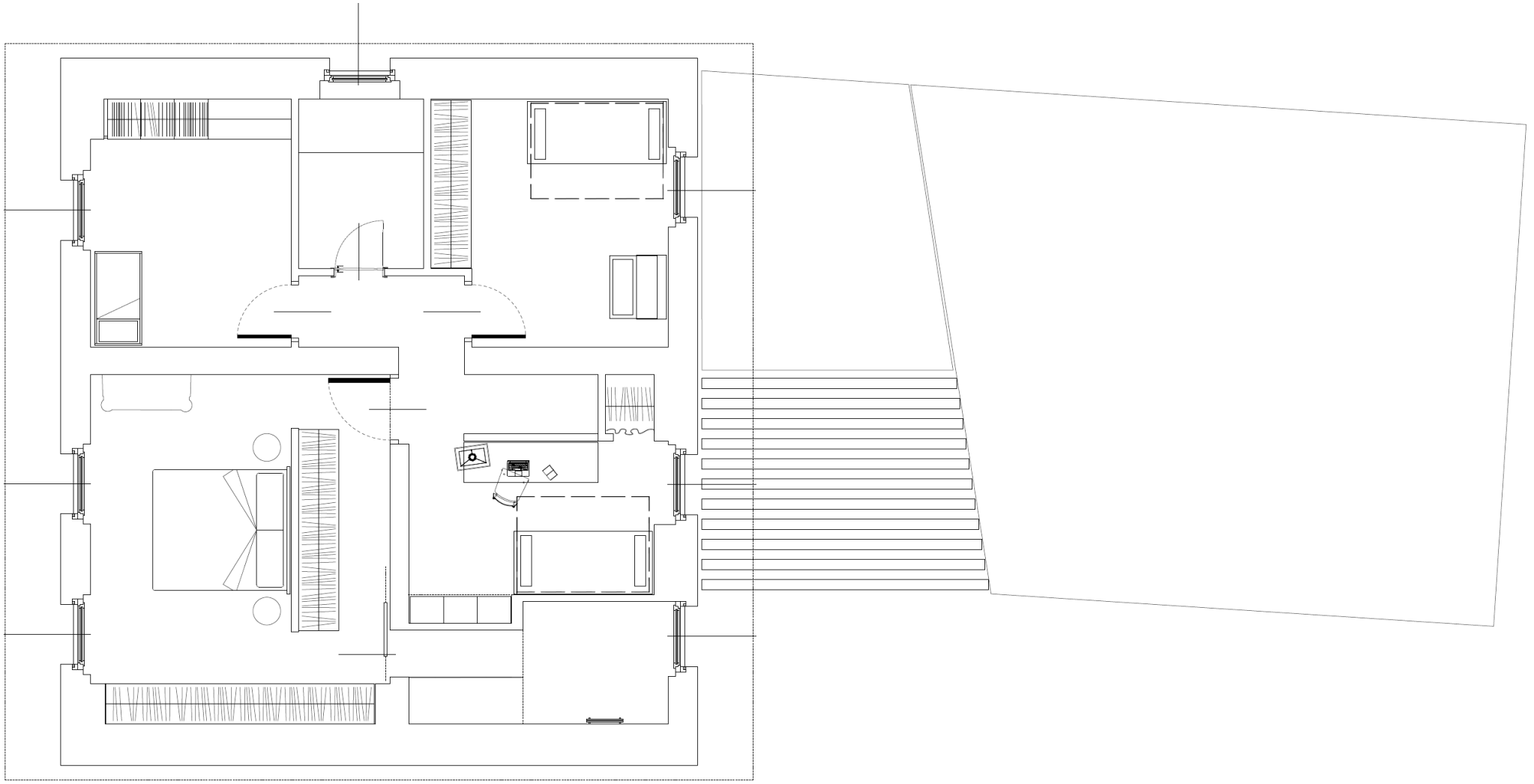
Existing situation

Home layout



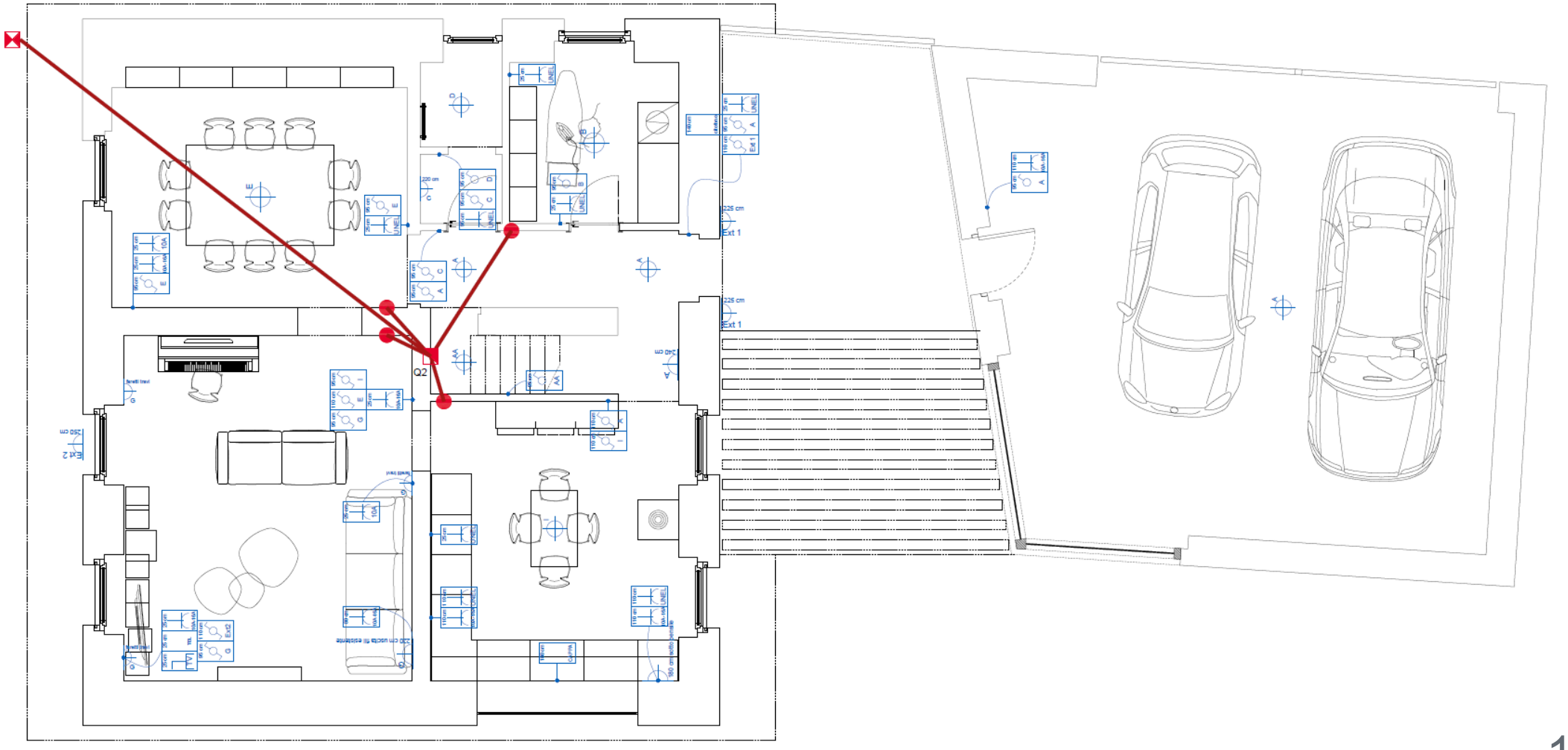
1990

Home layout



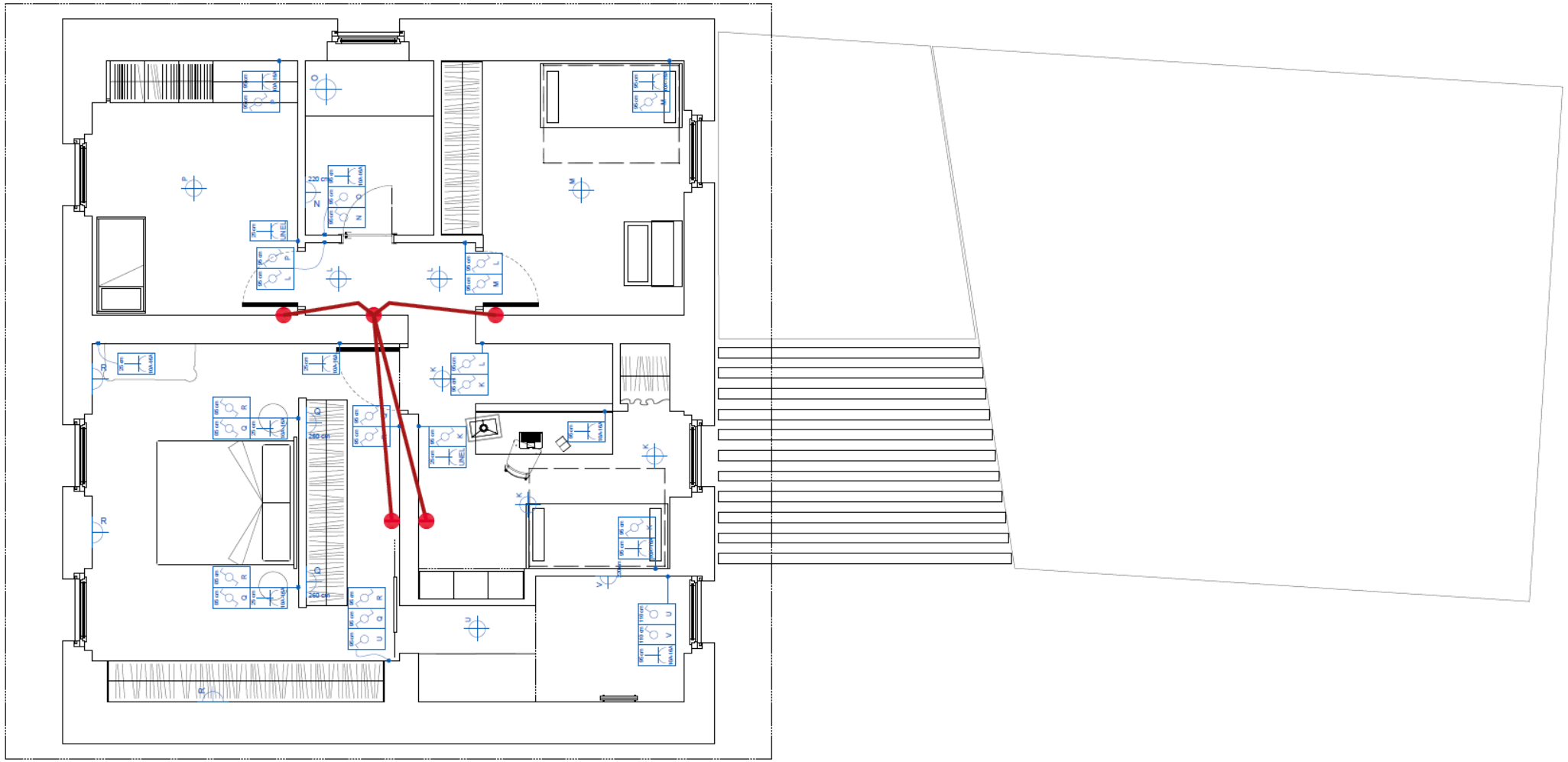
1990

Existing installation



1990

Existing installation



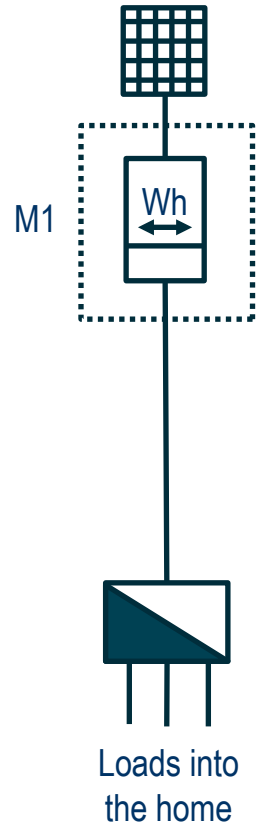
1990

Existing electrical installation

Description	Quantity
Switchboards	1*
Circuits***	4
Sockets	25**
Light points	14
Light commands	20

Note: * 1 Switchboard far from the POD, ** Number of different points (lines) with sockets, being each point equipped with one or more sockets. *** Circuit definition according with IEC 60364

Line	Cross section (mm^2)
Lights and light commands	1,5
Sockets (including electrical oven)	2,5
Aux	1,5
Main line	2,5



1990

Full electrification case

Horizon 2030

Full electrification case - Data

The electrical installation is requested to serve sockets, light points and switches and the following applications:

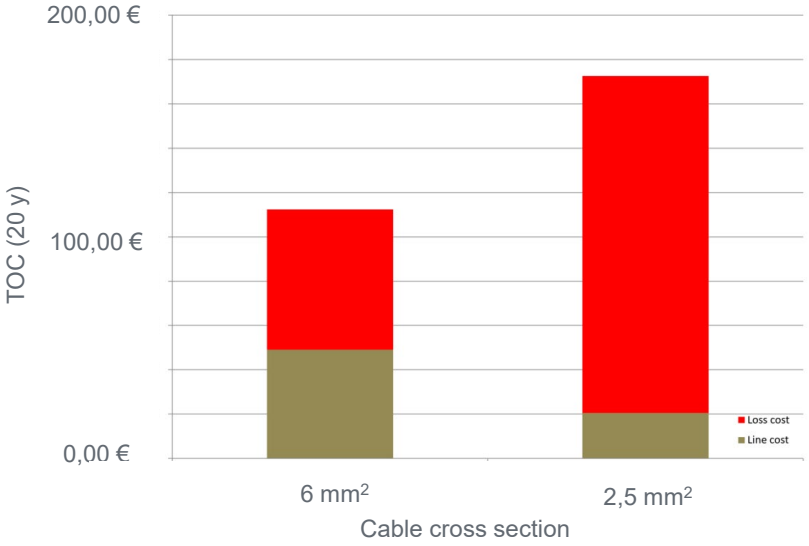
- electrical space heating (SH)
- electrical space cooling (SC)
- electrical domestic water heating (DWH)
- Cooking
- Sauna
- PV roof
- EV charger

The electrical installation includes an automation system.

EV charger

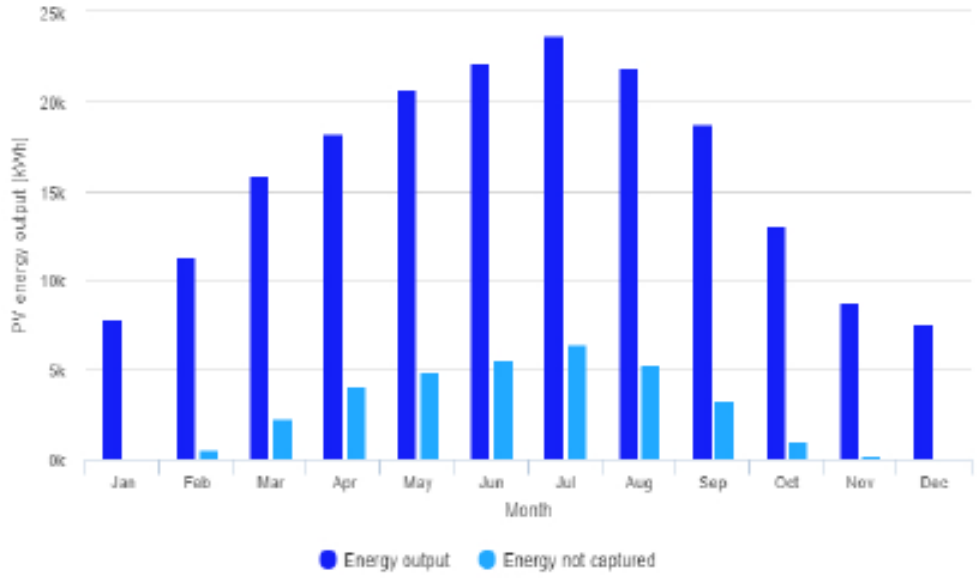
Type of charge			Range charged in		Time to charge
			1 h	15 min	10 km
AC	Slow	3,7 kW	13-15 km	3-5 km	40-45 min
	Medium	11 kW	25-50 km	12-15 km	12-15 min
	Rapid	22 kW	90-100 km	25-30 km	6-7 min
		43 kW	Full	50-60 km	3-4 min
DC	Rapid	50 kW	Full	60-70 km	2-3 min

Number of charging points					Box line characteristics	
3,7 kW	7,4 kW	11 kW	43 kW	50 kW	Standard	Optimized*
2	0	0	0	0	1 ph - 6 mm^2	1 ph - 16 mm^2
2	0		0	0	3 ph - 1,5 mm^2	3 ph - 4 mm^2
1	1		0	0	3 ph – 2,5 mm^2	3 ph – 6 mm^2
0	0	1	0	0	3 ph – 2,5 mm^2	3 ph – 6 mm^2
0	0	2	0	0	3 ph – 6 mm^2	3 ph – 10 mm^2
0	0	0	1	0	3 ph – 16 mm^2	3 ph – 16 mm^2
0	0	0	0	1	3 ph – 16 mm^2	3 ph – 25 mm^2

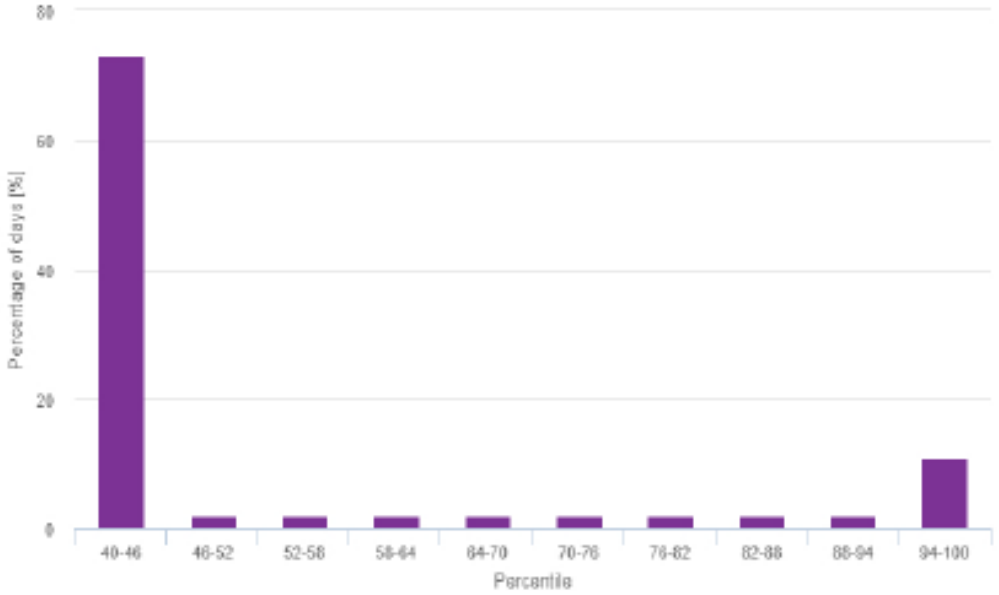


PV roof and storage

Power production estimate for off-grid PV:



Probability of battery charge state at the end of the day:



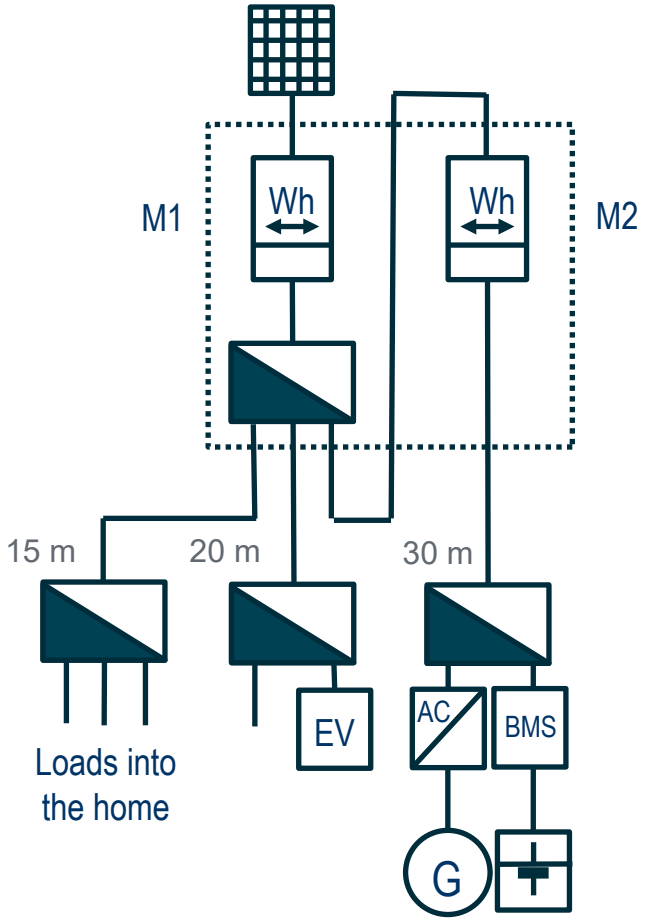
https://re.jrc.ec.europa.eu/pvg_tools/it/tools.html

Other new power circuits

New electrical user/service	Number of new power circuits	Cross section of new power circuits
Automation	+1*	Single phase 1,5 mm^2
Space heating and cooling (SHC) and Domestic water heating (DWH) Heat Pump	+1	3 phase 4 mm^2
Induction plate	+1	3 phase 2,5 mm^2
Lights (ordinary and emergency)	+2*	Single phase 1,5 mm^2
Plugs	+2*	Single phase 2,5 mm^2

Note: * In addition the all the final circuits required by aesthetic and enhanced functionality

Schema



Main line

Rated power of the main line (coincidence factor 0,8) by the EV charger.

EV charger total power(kW)	Main line @mLF (kW)	Main line @MLF (kW)
0	5,68	11,12
3,7	8,64	14,08
7,4	11,6	17,04
11	14,48	19,92
22	23,28	28,72
43	40,08	45,52
50	45,68	51,12

Size of the main 3 phase line for different power demand.

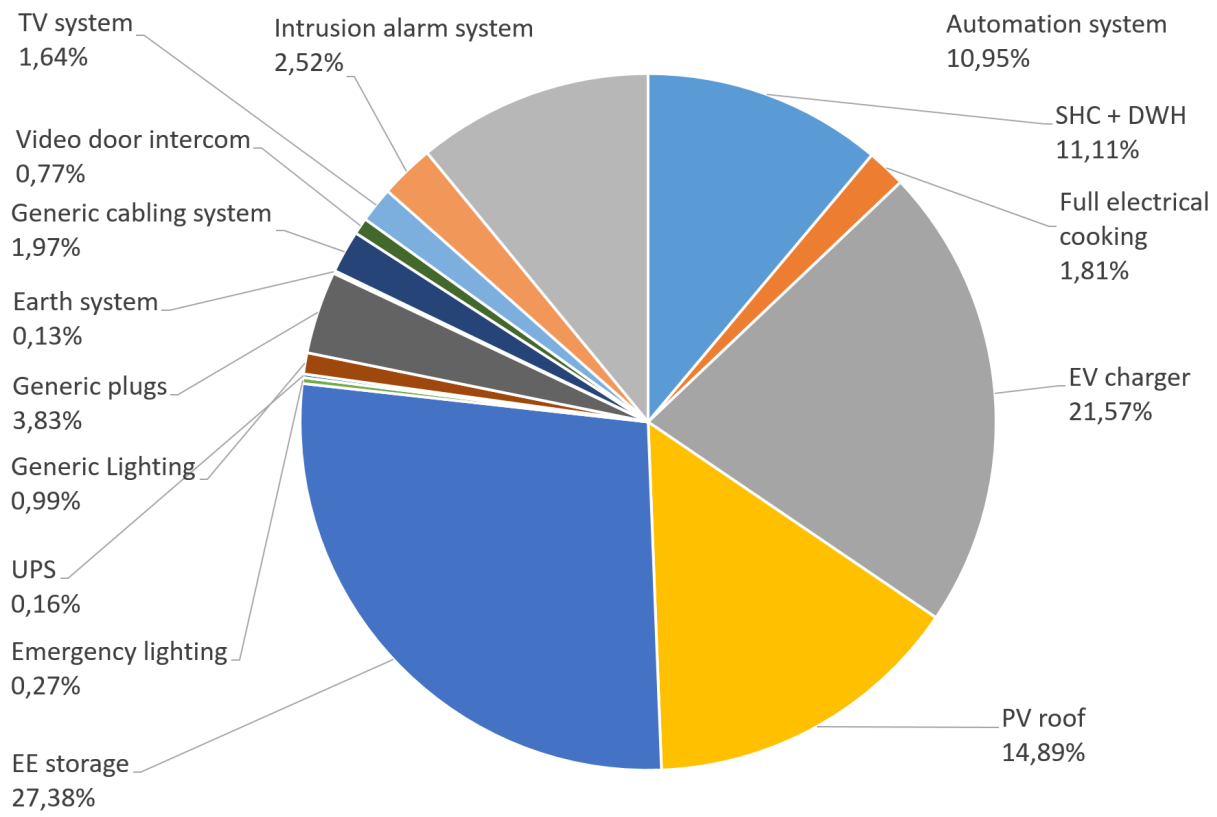
Power demand (kW)	≤10	15	20	25	30	40	50
Cross section (mm^2)	1,5*	2,5	6	10	10	25	50

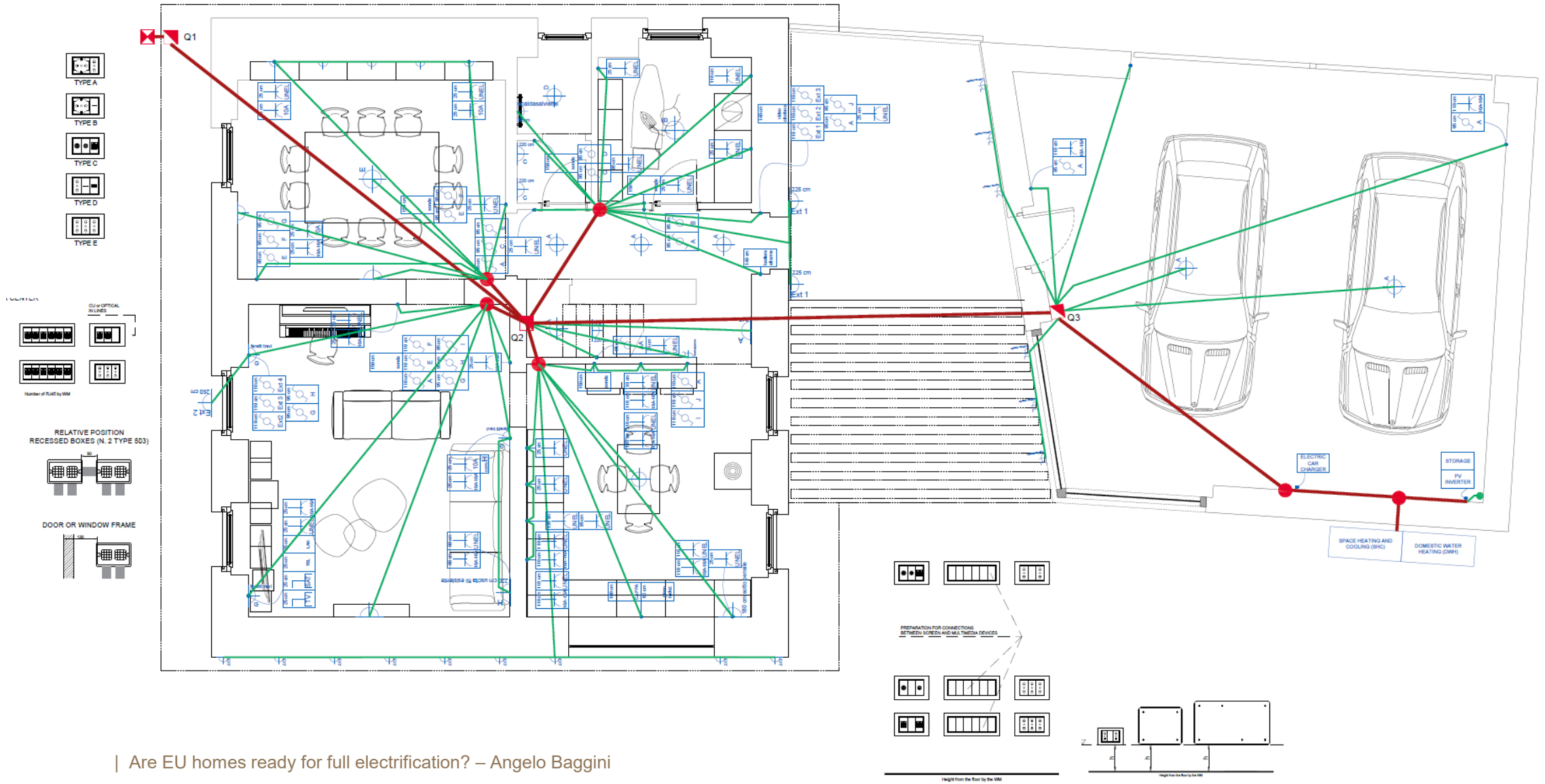
Size of the main 3 phase line for the 3 EV charger options (min. med. max).

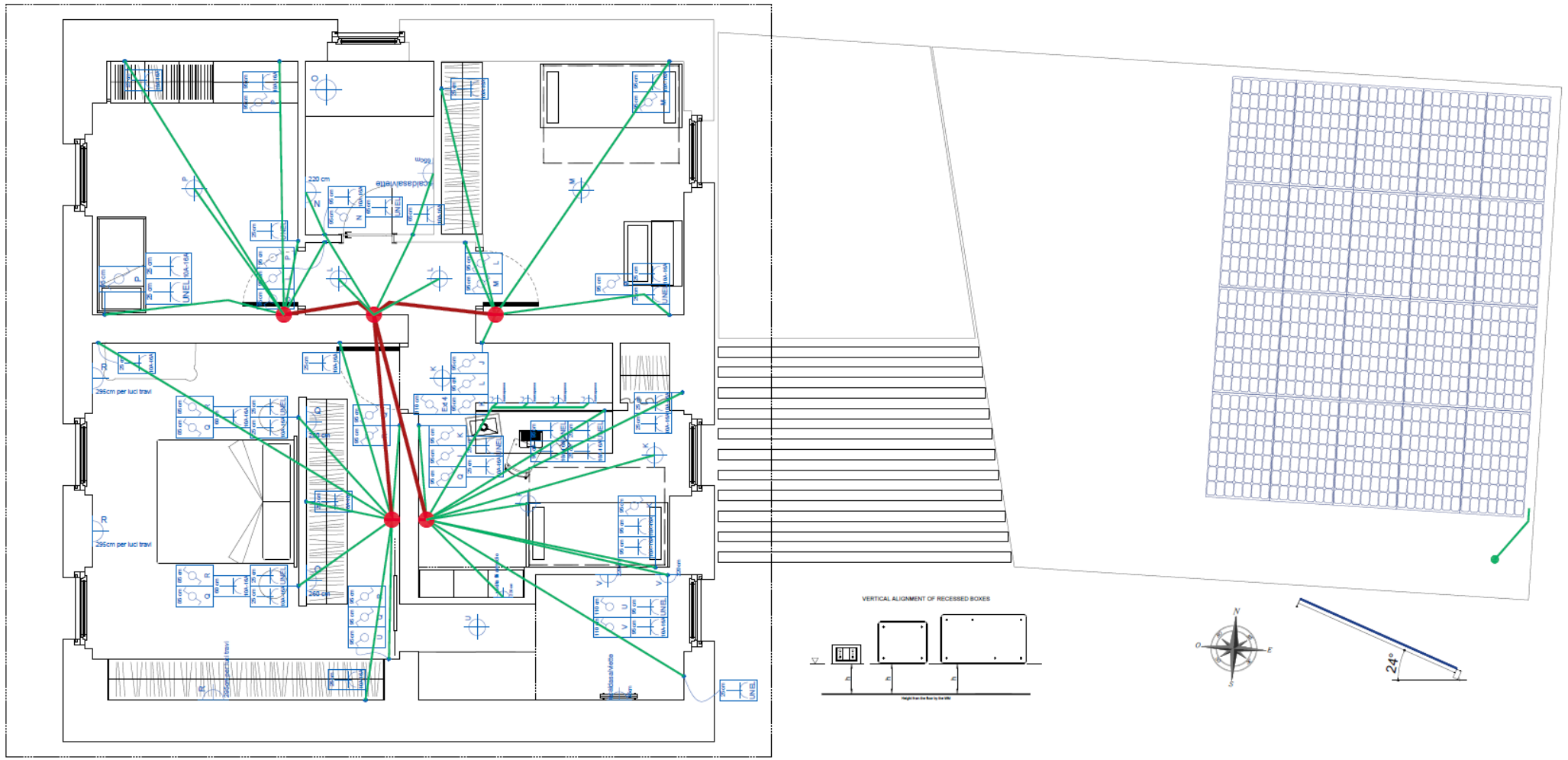
EV charger power (kW)	2x3,7	11	50
Cross section (mm^2)	4	6	50

Installation cost comparison

Desired option	Full installation	Cabling and electrical protections sized for		Electrical appliances sized for	
		full	reduced	full	reduced
Heat pump	10150,00 €	150,00 €	NA	10000,00 €	NA
Full electrical cooking	1650,00 €	150,00 € (7,6 kW)	150,00 € (3,7 kW)	1500,00 € (7,6 kW)	600,00 € (3,7 kW)
EV charger	19700,00 €	8200,00 € (50 kW)	1200,00 € (2x3,7 or 11 kW)	11500,00 € (50 kW)	2300,00 € (2x3,7 or 11 kW)
PV roof	13600,00 €	3600,00 € (6 kWp)	2500,00 € (3 kWp)	10000,00 € (6 kWp)	5000,00 € (3 kWp)
EE storage	12500,00 €	3500,00 € (10 kWh)	2000,00 € (5 kWh)	9000,00 € (10 kWh)	4500,00 € (5 kWh)
Emergency lighting	250,00 € (4 appliances)	NA	NA	NA	125,00 € (50%)
UPS	150,00 € (1500 VA)	NA	NA	NA	NA
Generic Lighting	900,00 €	160,00 € (44 end point)	60,00 € (15 end point)	700,00 € (44 end point)	240,00 € (15 end point)
Generic plugs	3500,00 €	650,00 € (66 end point)	210,00 € (22 end point)	2800,00 € (66 end point)	930,00 € (22 end point)
Earth system	120,00 €	NA	NA	NA	NA
Generic cabling system	1800,00 € (12 sockets)	NA	NA	NA	1100,00 € (6 sockets)
Video door intercom system	700,00 €	NA	NA	NA	NA
TV system	1500,00 €	NA	NA	NA	NA
Intrusion alarm system	2300,00 €	NA	NA	NA	NA
Automation system	10000,00 €	NA	NA	NA	NA




TYPE A
TYPE B
TYPE C
TYPE D
TYPE E
RELATIVE POSITION
RECESSED BOXES (N. 2 TYPE 503)
DOOR OR WINDOW FRAME
Q1
Q2
Q3
ELECTRIC CAR CHARGER
STORAGE
PV INVERTER
SPACE HEATING AND COOLING (SHC)
DOMESTIC WATER HEATING (DWH)
PREPARATION FOR CONNECTIONS BETWEEN SCREEN AND MULTIMEDIA DEVICES


VERTICAL ALIGNMENT OF RECESSED BOXES
24°

The question now is:
is the EU building stock ready for that?

No as it is, but it will be possible to make it ready for the upcoming energy transition. We have to update and adapt it in the proper way.

It is crucial to act on time to avoid risks and deregulation.

After all, we are in front of one of the most important revolutions humans experienced in the last century.

What is needed?

- **Technical standards** requiring a minimal consistency of the electrical installation
- **Efficiency**: an efficient design of electrical installation can reduce energy losses
- **Readiness**: guidelines for the design of electrical installations anticipating future needs and guidelines to assess readiness of current installations
- **Skills**: qualified professionals for design, installation and control
- **Inspection** of existing installations and certification of new installations or upgrades
- **Information** on existing installations to house owner: status and readiness of the electrical installation should be available within relevant tools (such as Energy Performance Certificates)

Thank you

For more information please contact

Angelo Baggini
Università di Bergamo
Dipartimento di Ingegneria
Viale Marconi 5,
24044 Dalmine (BG) Italy
email: angelo.baggini@unibg.it

Engineering Consulting and Design