Methodology for the development of electrical vehicle charging infrastructure. Case study: Brescia

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Abstract

The topic of electrical mobility, whether it refers to private or public transport, has taken on increasing importance in recent years, in part due to the issuing of national and international lows aiming at reducing the emission of pollutants into the atmosphere. In fact, electric motors can increase road vehicle energy efficiency and contribute to the reduction of transport CO2 emissions (at a local level), leading to advantages in terms of improving air quality and reducing noise pollution in urban areas. Possible restraints on the uptake of electric vehicles may be the lack of charging infrastructures, insufficient local product positioning and the lack of standardisation on an international level.

In order to resolve this problem, several European Union member states have issued Charging Infrastructure implementation plans. Italy recently published its 'National Infrastructure Plan for Charging Vehicles fed by Electricity' (PNire – Official Journal no. 280 of 02/12/2014), which are defined as the guidelines for guaranteeing the united development of electric vehicle charging services in Italy. Arising from this plan is the need, on the part of municipal administrations, to come up with implementation plans for charging infrastructure to be included as part of the Urban Plans for Sustainable Mobility. Therefore, objectives are set to look into how careful, integrated urban and transport planning can lead to the effective and efficient distribution of charging infrastructures in Italy. To this end, a methodology has been formulated for the planning and localisation of electric vehicle charging infrastructures at a municipal level and it has been adjusted and validated in application to the city of Brescia, considered of interest due to it being representative of a medium-sized urban area. This methodology, which can be applied rapidly, envisages the selection of certain indicators, which form the basis, after the assignation of relative weights, for a map of charging demand. Comparison of the areas identified as "high demand" with the potential supply of charging infrastructures highlights the areas excluded from the possible infrastructure coverage area, thus allowing finely detailed analysis to be carried out only where strictly necessary, resulting in savings in terms of time and money.

1. National Infrastructure Plan for Charging Vehicles fed by Electricity (O.J. 02-12-2014 General series – no. 280)

A ministerial decree, signed by the Minister of Transport and Infrastructure in July 2014[1], modified the 'National Infrastructure Plan for Charging Vehicles fed by Electricity' (PNire) introduced by Article 17.7 of the Italian Law of 7 August 2012, no. 134 (O.J. General Series no. 280 of 02-12-2014).

The PNire divides the charging infrastructure development period into two main phases, which, with annual Plan updating, lead to an established policy for electrical mobility with a time frame of 2020.

The first phase of "Outlining and Development", with the time frame 2013 – 2016, is intended as a preparatory phase that lays down the foundations for the introduction of a minimum number of electric vehicles, thanks in part to a basic infrastructure that guarantees movement within the city and commuter transfers involving metropolitan areas on a national scale. This phase identifies the criteria and strands to develop a national network of electric charging[2], reference models, minimum standard characteristics of the components of the charging process and electrical mobility development incentivisation policies. Three classes of charging infrastructure are identified based on the energy supply capacity:

- normal power: "*Slow*" charge up to 3.7 kW;
- medium power: "*Quick*" charge from 3.7 kW fino a 22 kW;
- high power: "*Fast*" charge over 22 kW.

As part of the process of creating infrastructures for each

1. Source: http://www.mauriziolupi.it/

2. The PNire gives priority to the short-term implementation of infrastructures in urban and metropolitan areas (1-2 years), followed by attention being broadened to extra-urban and motorway areas in the long-term (3-5 years). According to the PNire, the introduction of infrastructures to urban and metropolitan areas must maintain an intended suitable ratio (set at 1 to 8) between the number of public charging infrastructures available to all and the total number of charging infrastructures. In order to minimize the impact on land use, each charging infrastructure must allow the simultaneous charging of two vehicles. The introduction of infrastructures to any certain area must take into consideration the existing electric car pool and the medium-term predicted purchases.

reference area (Municipality, Metropolitan Area, Province or Region), consideration must be taken of the features, such as population, population density, surface area, active population, road taxes, percentage of electric vehicles within a certain time frame, levels of CO_2 and PM10 emissions in the area in question.

The second phase of "Consolidation", with the time frame 2017 – 2020, includes the period in which common regulations will be issued and shared among Member States, in accordance with vehicle manufacturers and standardisation organisations. These regulations must be identified within a brief period of time, in order to give the car manufacturers the necessary time to put them into effect as part of their vehicle development programmes and adapt the charging infrastructures. During this phase, the charging infrastructure network must be completed so as to cover all of the Italian national territory and allow the large-scale distribution of electric vehicles.

The plan, specifying that any choices must respect urban demands and limitations, envisages three intermediate objectives for the introduction of infrastructures in Italy:

- objective 2016: 90,000 public charging stations;
- objective 2018: 110,000 public charging stations;
- objective 2020: 130,000 public charging stations.

The PNire provides the following outlines concerning the charging methods[3]:

- Method 1: "Slow"[4] charge with alternated current from a non-specialized plug. This method uses a *standard* household or industrial plug, the cord is not fixed to either the car or the socket, there are no residual-current devices on the cord and charge does not exceed 16A and single-phase 250V or three-phase 480V;
- Method 2: "Slow" charge with alternated current from a non-specialized plug with cord connected to a residual-current device. This method uses a *standard* household or industrial plug, the cord is not fixed to either the car or the socket, the cord used to connect the vehicle to the socket has a residual-current circuit breaker and charge does not exceed 32A and single-phase 250V or three-phase 480V;
- Method 3: "Slow" or "Quick" charge with alternated current using a designated charging station. This method uses a charging station with a specialized socket, the cord is not fixed to either the car or the socket, the control and protection features are permanently installed in the charging station, communication passes from car to charging station and it is "faster" than Methods 1 and 2;
- Method 4: "Fast"[5] charge with direct current using a designated charging station with external charger. This method uses a charging station that converts alternated current to direct current, the cord is permanently fixed to the charging station, communication passes from car to charging statin and it is "faster" than the three previous methods.
  For this charging method, there are two sub-methods:
  - DC *level* 1 (up to 500V and 80A, power 40 kW);
  - DC *level* 2 (up to 500V and 200A, power 100 kW).

The PNire provides the following outlines concerning development policies:

- integration within Mobility and Logistics Plans: in every municipal and regional Logistics and Mobility plan, a section devoted to electrical mobility should be included. This section should contain a local charging infrastructure installation plan, focusing on car parking plans and any additional services (such as car-sharing), technical characteristics and localisation principles for public and private charging infrastructures.
- policies related to the Italian Traffic Code: as well as the installation of charging stations, there should also be a clear no-parking rule for the area around the stations for anyone not intending to charge their vehicle. Regulations should also be included relative to the sharing of electrical mobility friendly bus lanes and limited traffic lanes.
- Urban Planning revision (incentives and obligations): incentives should be provided for the creation of integrated programmes in promotion of the technological adaptation of existing buildings. Fundamental elements for the creation of such programmes include the simplification of building activities (building plans for approval new constructions with a surface area of more than 500 square metres must include the installation of electrical charging infrastructures for charging vehicles from every covered and open parking space and from every garage), the right of access to a charging station and city planning regulations (infrastructures intended for use as electric vehicle charging stations constitute primary urbanisation works that can be carried out in the whole municipal area); regional laws establish the content, methods and deadlines in order to adapt the tools for general city planning and municipal and extra-municipal territory planning with the provision of a minimum standard of equipment for public electric vehicle charging systems, consistent with the National Plan. Regional laws envisage the adaptation of city planning tools with the provision of a minimum standard of equipment for electric vehicle charging systems for collective use in support of newly-established commercial, tertiary and production activities.
- research and development;
- electric/hybrid vehicle purchasing incentives;
- involvement by end users.

3. In Italy, charging methods 1 and 2 are not allowed in public areas or private areas with public access.

4. Approximately eight hours for a medium-sized car.

5. A maximum of one hour for a medium-sized car.

2. Methodology proposal for electric vehicle charging infrastructure localisation

The proposed methodology for the optimal localisation (and quantification) in urban areas of public (or accessible to the public) charging infrastructures is consistent with the National Infrastructure Plan for Charging Vehicles fed by Electricity described above.

The National Plan establishes that "*urban and metropolitan areas take priority, in the short-term, for the implementation of charging infrastructure*" and identifies the Urban Plans for Sustainable Mobility (PUMS) as possible references for the planning of electrical mobility in urban environments[6], more specifically for infrastructure installation plans containing the charging station localisation principles. These installation plans should contain local social analysis (including population density and characteristics of the area of intended installation) and analysis of the mobility of the area of interest, with possible detail of traffic flows that influence the final choice of infrastructure localisation, a geographical and referenced representation of existing and project coverage areas and the characteristics of the intended charging infrastructure to be installed. From here, it is essential to make proposals for planning starting points, in order to allocate correctly the available resources in the region of interest, via a "rapid" localisation methodology.

The National Plan also underlines the necessity to adopt a minimum equipment standard for electric vehicle recharging systems for collective use in support of newly-established commercial, tertiary and production activities. For this reason, a calculation matrix is created of the number of stalls necessary for the different types of service/hub that attract "Quick" charge traffic.

The methodology propose by municipal bodies in support of the draft Installation Plan for electric vehicle charging infrastructure, introduced in the National Plan, consists of a few systematic stages valid for every regional body, that can be adapted via the numerical parameters and specific features of the place being analysed.

The methodology is set out as follows:

a) Selection of indicators to be analysed: first of all, it is essential to select the indicators to be taken into consideration in support of the localisation choices and demand analysis. For example, the services included in the PGT (Regional Government Plan) Services Plan (including sports services, educational services, administrative services, religious services, public green areas, etc.), the main hubs that attract traffic (large and medium commercial buildings, centres of cultural attraction, restaurants and bars, etc.), public transport (railway, metro, tram, bus, bike-sharing and car-sharing stations, etc.), building car parks and modal interchange car parks, the resident population, operators, traffic flows and the functional classification of the roads etc.

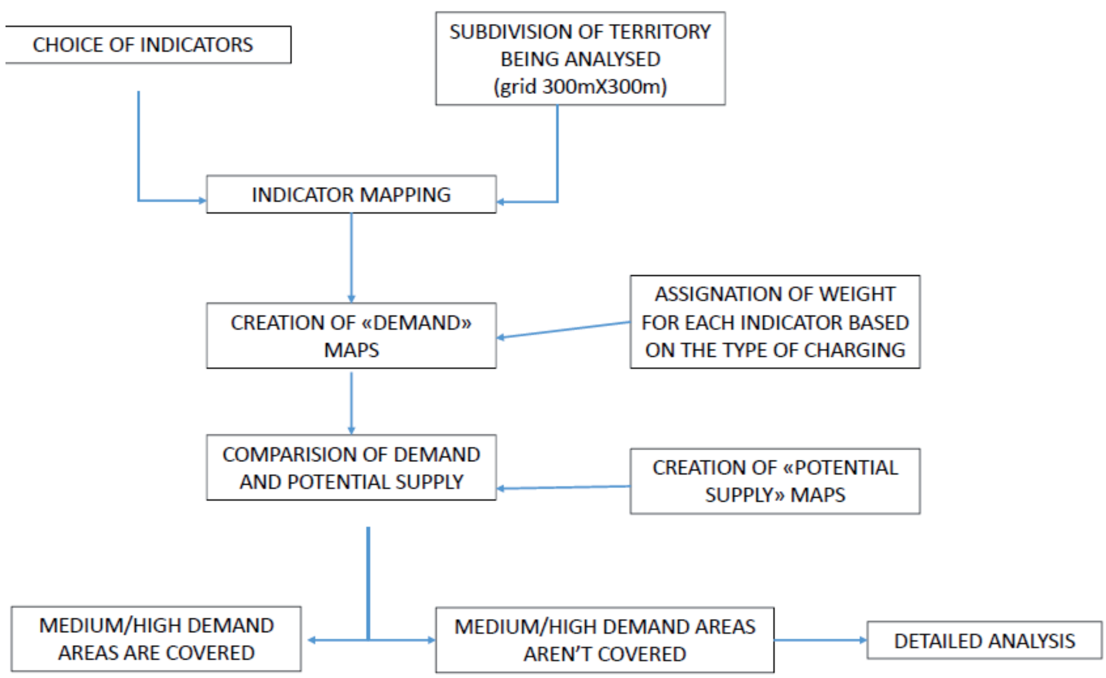

Figure 1 – Methodology for the localisation of charging infrastructure.

b) Subdivision of the territory under examination: in order to proceed with the analysis, the territory must be divided up using a regular grid method. The recommended grid square size is that similar to pedestrian movement (300

6. The National Plan recommends that the Regional Plans follow the indications reported in the same National Plan, and that the guidelines of the Regional Plans be referenced in the Municipal Plans, in order to guarantee coordinated and integrated development.

metres x 300 metres), so as to take into consideration the sphere of influence of movement of a weak user, that is to say, movement not exceeding five minutes in duration.

c) Indicator mapping: once it has been established which indicators are to be analysed, based on the specific features of the territory under examination and on the availability of the georeferenced data, these indicators must be mapped out on the established grid. In this way, a series of thematic maps representing the territorial distribution of the various indicators are created.

d) Indicator weight attribution: a matrix must be prepared for each type of charging ("Slow", Quick", "Fast"), in which a weight is attributed in relation to the demand for charging, for every indicator evaluated. Services that involve a medium-short stay, for example, will carry a heavier weight for "Quick" charging, whilst the presence of a high number of operators or a high population density will carry a high weight for "Slow" charging.

e) Creation of demand maps: the sum of the weights for each grid cell for each type of charging allows the creation of thematic maps showing demand and urban use of the cell itself. The total given by the sum of the weights has to be subdivided into intervals in order to identify the areas of "No", "Low", "Medium" and "High" demand.

f) Choice of possible localisation areas (mapping of potential supply): as far as "Slow" charging is concerned, optimal localisation will be in private properties and shared apartment block yards. Just a small proportion will be on public ground or in building car parks, in particular for areas of high demand with a lack of private space available. As far as concerns "Quick" and "Fast" charging, optimal localisation is in building car parks, in commercial building parking areas, in petrol stations and in modal interchange car parks, etc. Thus, it is possible to identify the cells in a municipal area that include at least one optimal place of localisation and map their areas of pedestrian influence.

g) Comparison with areas of high demand: superimposing the potential supply map for infrastructure localisation with the theoretical demand map enables the rapid verification of territory coverage and the identification of "critical" areas.

h) Precise analysis of uncovered areas: once uncovered "critical" areas are identified, detailed analysis can be carried out precisely, instead of over the whole territory. For such areas, should it not be possible to identify (or create) possible infrastructure localisation sites, it may be necessary to go ahead with the relocation of existing services/attractions.

In order to define a minimum infrastructure equipment standard for "Quick[7]" charging electric vehicles, to be adopted in the City Planning, as required by the National Plan, reference is made to the guidelines of Victoria State, which propose the use of a double-entry matrix. This decision is based on the fact that it is unsuitable to establish an unequivocal standard that doesn't take into consideration the type of traffic-attracting service/hub and its location within the territory in question. A minimum standard of 2% of available stalls is estimated, corrected by a factor taken from the matrix. The matrix, represented by the table below, has an entry "from the left" that takes into consideration the type of traffic-attracting service/hub, which predicts the type of charging infrastructure, and an entry "from below" that takes into consideration the service/hub location within the intervals identified from the thematic demand maps described above.

3. Case study: the city of Brescia

The "rapid" infrastructure localisation method described earlier was applied (with the help of GIS software) to the case study of the city of Brescia, for which in-depth knowledge of the territory made calibration of the coefficients applied to each indicator a much easier task.

Table 1 – Matrix for defining a minimum standard of parking stalls devoted to electric vehicle charging. Matrix applicable to "Medium" type charging.

		Corrective factor		
Coefficient per traffic-attracting type of service/hub	High	1	1,5	2
	Medium	0	1	1,5
	Low	0	0	1
		Low	Medium	High
		Charging demand of the cell in consideration		

The Municipality was firstly subdivided into cells by superimposing a grid map with squares of 300m x 300m. This size

7. It is envisaged that a minimum standard will be indicated only for "Quick" charging, considered to be the most widespread type of charging in public areas. In fact, "Slow" charging will be localized mainly in private areas for the use of electric car owners and only a small proportion will be in public areas or private areas with public access. "Fast" charging, however, is considered too prohibitive in terms of installation costs to need a minimum installation standard and will instead be best localized within the territory based on the available resources.

Table 2 – Installation priority per type of traffic-attracting service/hub.
Source: Adapted from "Guidance on Land – use Planning for Electric Vehicle Parking and Charging – The Victorian Electric Vehicle Trial", September 2012.

Type of traffic-attracting service/hub		Installation priority (High, Medium, Low)
Health services	Doctor's surgery	Low
	Hospital/Clinic	High
	Instrumental Diagnostics Centre	Medium
	Local Health Authority services	Low
	Sports medicine centre	Medium
	Nursing Home/Rehab Centre	Low
Administrative services	Post Office	Medium
	Barracks/Headquarters (police)	Low
	Provincial Offices	Medium
	Municipal Offices	Medium
	Tribunal	Medium
	Prison	Low
	Municipal police and civil protection	Low
Educational services	Primary school	Low
	Nursery school	Low
	Middle school	Low
	High school	Medium
	University	High
Sports services	Sports field	High
	Gym	Medium
	Multi-purpose sports venue	Medium
	Swimming pool	High
	Sports centre	High
	Athletics field	Medium
Attractor hub	Shopping centre/large commercial building	High
	Restaurants and bars	Low
	Theatre	Medium
	Cinema/multiplex cinema	High

was chosen because it is considered to represent the area of influence of a possible charging infrastructure through pedestrian movement. Brescia ended up being divided into 1121 cells.

For localisation analysis of the charging infrastructure, the following indicators were considered: resident population of driving age, number of worker, educational services, administrative services, sports services, health services, large commercial buildings, bike-sharing stations, bus stops, metro stations, railway stations and petrol stations.

3.1 Indicator analysis

A thematic[8] map was built for every indicator, as described below.

• **Resident population of driving age.**

The figure for the resident population in the Municipality of Brescia is taken from 31-12-2013. Given that the parameters to be analysed had to be representative of the potential demand for electric vehicle recharging, it was decided to ex-

8. A common-base-year was not possible for all of the maps due to lack of availability. Therefore, it was chosen to use the most up-to-date data available.

clude people under 18 years of age, in so much as they are not of driving age, and those over 80 years of age, chosen as the upper age limit for driving. The resident population of driving age is mainly tied to the demand for "Slow" charging, typically carried out overnight using household sockets, for an average of eight hours.

The number of educational services is tied to the demand for "Quick" and "Slow" charging, typically carried out during staff working hours or student hours at the institution, for an average of between two and eight hours.

• **Administrative services.**

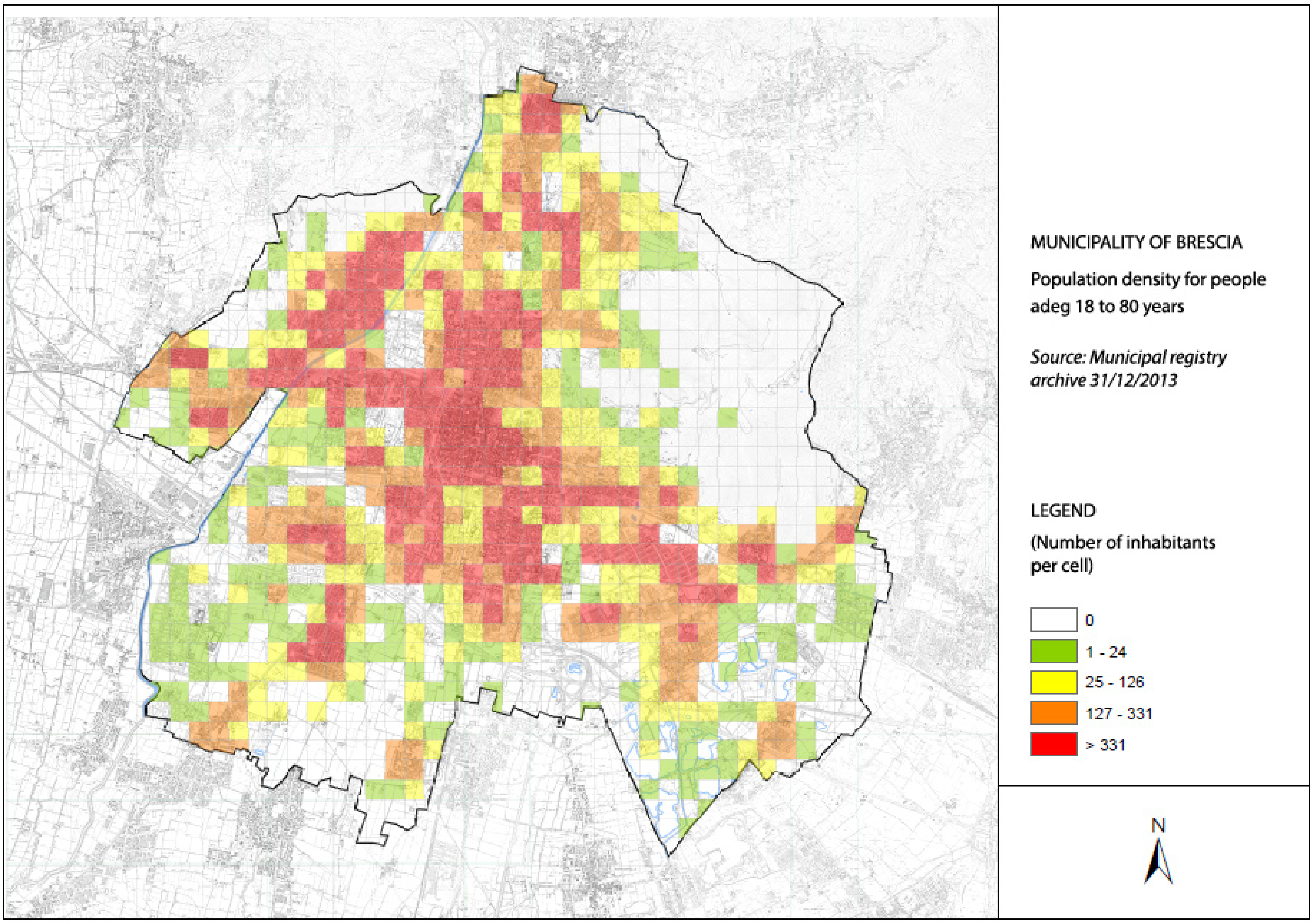

Figure 2 – Population density in the Municipality of Brescia.

• **Number of operators.**

The figure for the number of operators in the Municipality of Brescia is taken from the database of companies active in the territory as of 2011. The number of operators per cell has been subdivided into 5 intervals. From the thematic map, it can be deduced that the areas with the greatest operator density are the city centre, the northern area along the axis of via Triumplina, the "Bresciadue" area and the industrial area located in the southwest of the Municipality. The number of operators is tied to the demand for "Slow" charging, typically carried out during working hours in the workplace, for an average of eight hours.

• **Educational services.**

The figure for the number of educational services is taken from the Municipality of Brescia PGT Services Plan. Secondary level educational institutions and universities were taken into consideration. The number of educational services present in each cell has been subdivided into 4 intervals.

The figure for the number of administrative services is taken from the Municipality of Brescia PGT Services Plan. The number of administrative services present in each cell has been subdivided into 4 intervals. The number of administrative services is ties to the demand for "Quick" and "Fast" charging, typically carried out during the time spent by the user at the service location.

• **Sports services.**

The figure for the number of sports services is taken from the Municipality of Brescia PGT Services Plan. Gyms, sports centres, football pitches, basketball and volleyball courts, swimming pools, etc. were all taken into consideration. The number of sports services present in each cell has been subdivided into 4 intervals. The number of sports services is tied to the demand for "Quick" charging, typically carried out during the hours that the user spends at the sports venue.

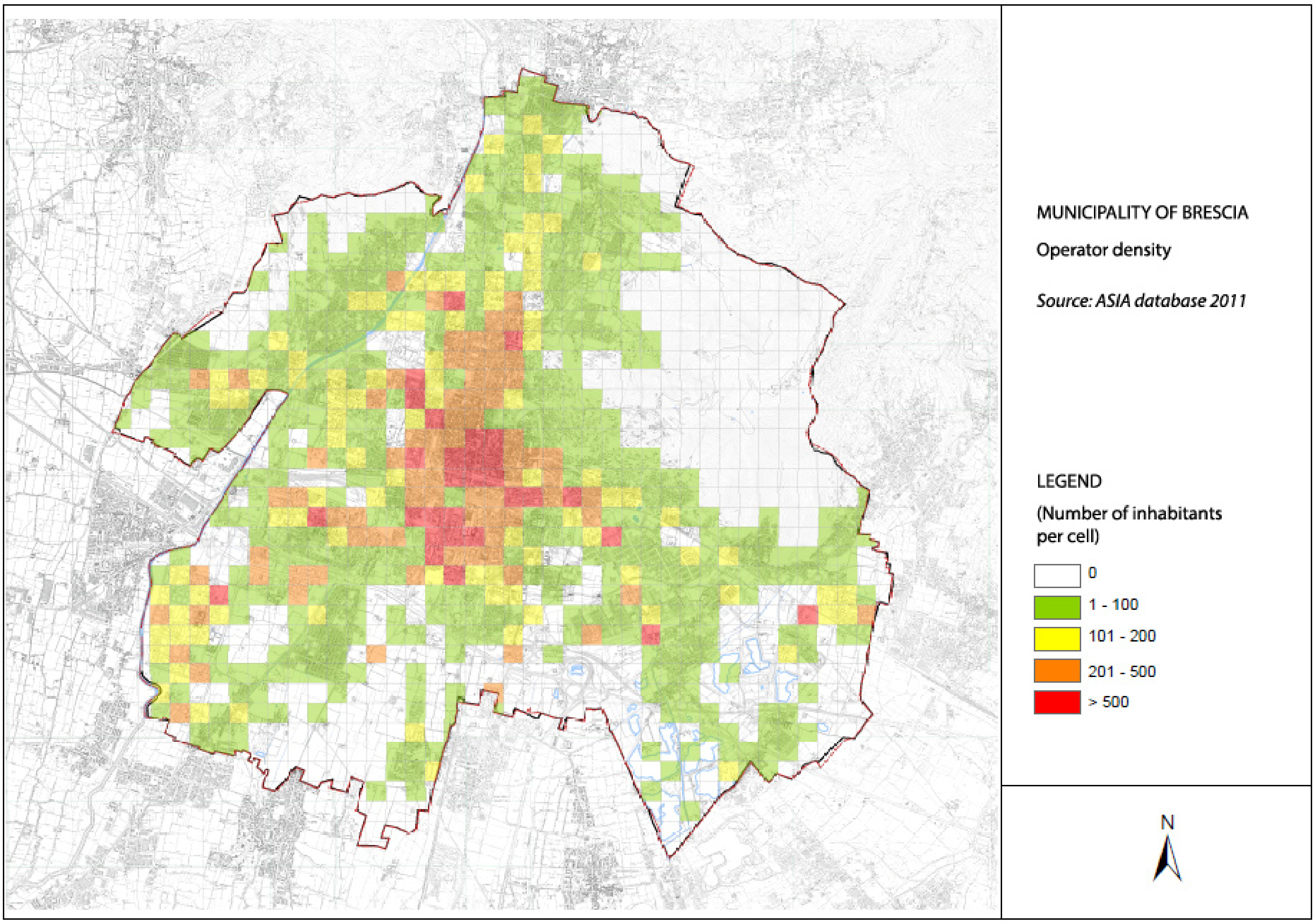

Figure 3 – Operator density in the Municipality of Brescia.

• **Health services.**
The figure for the number of health services is taken from the Municipality of Brescia PGT Services Plan. Hospitals, municipal and supra-municipal health services, doctors' surgeries, Local Health Authority buildings, etc. were all taken into consideration. The number of health services present in each cell has been subdivided into 5 intervals. The number of health services is tied to the demand for "Quick" and "Fast" charging, typically carried out during the time spent by the user at the service location.

• **Large commercial buildings.**
The figure for the number of large commercial buildings was taken from the Lombardy Region geoportal. The number of commercial buildings present in each cell has been subdivided into 3 intervals. The number of large commercial buildings is tied to the demand for "Quick" and "Fast" charging, typically carried out during the hours spend by the user at the shopping centre.

• **Bike-sharing.**
The figure for bike-sharing, updated as of 2015, was taken from the service provider. It was decided to consider the total number of bicycles available for each cell as the indicator, in that this element increases the area desirability in terms of charging, widening the sphere of influence of the charging station.

• **Bus stops.**
The figure for local public road transport, updated as of 2015, was taken from the service provider. It was decided to consider the total number of available bus stops for all bus routes for each cell as the indicator, in that, like for bicycles, this element increases the area desirability in terms of charging, widening the sphere of influence of the charging station.

• **Automatic light rail stations.**
The presence of the automatic light rail transport is considered among the indicators, in that, thanks to the system's commercial speed and frequency, it allows convenient railroad modal interchanging, which guarantees the hypothetical user of charging infrastructure positioned close to the station the possibility of reaching places of interest located at a significant distance in the time it takes to carry out "Quick" or "Fast" charging. For this indicator, mapping took into consideration the distance from the station: cells found within a 300 metre radius from the station are indicated in red and those that are found within a 500 metre radius are indicated in yellow.

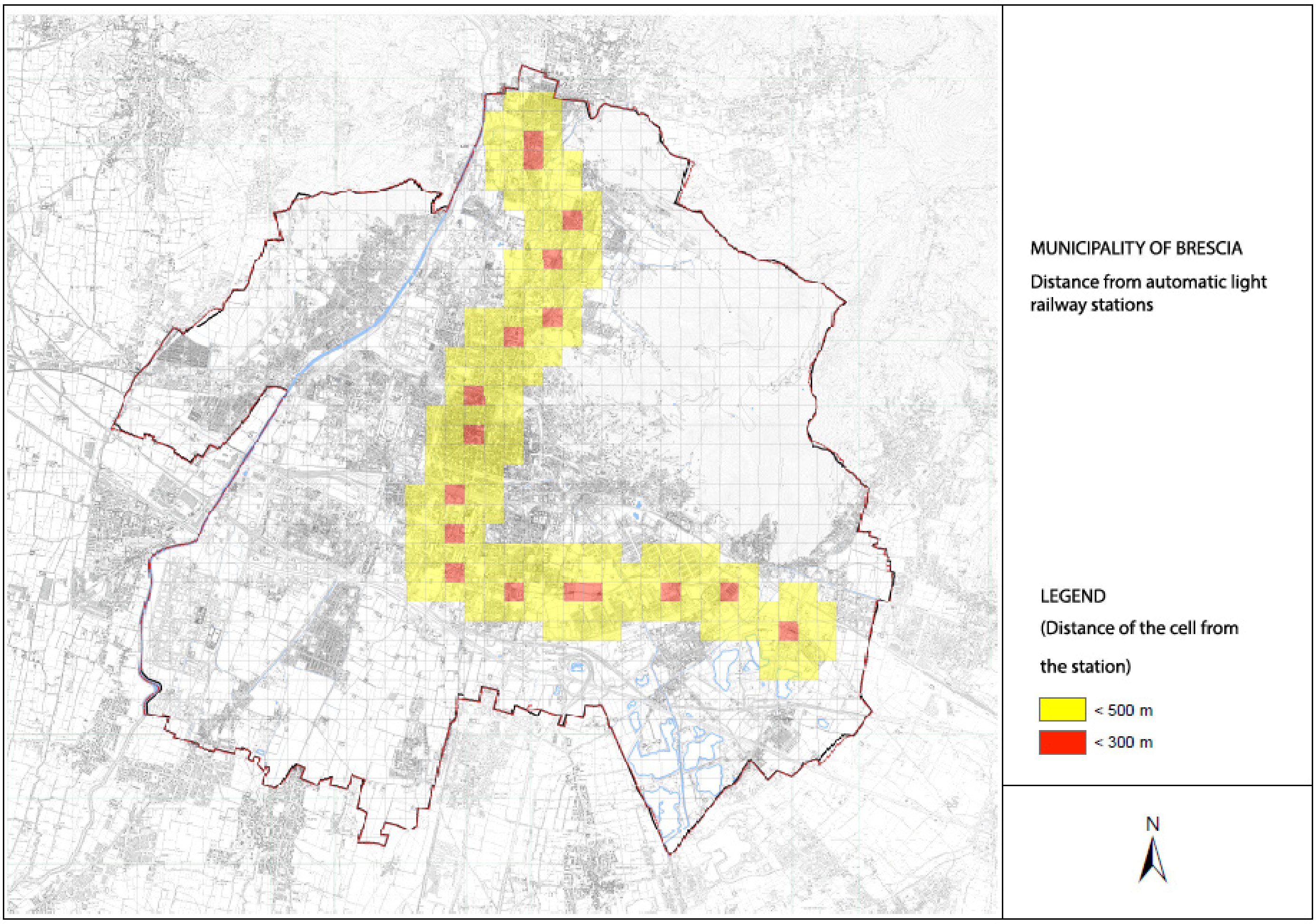

Figure 4 – Distance from the automatic light rail stations.

• **Railway stations.**
The presence of a railway station is considered an indicator of area "desirability", as far as "Slow" charging is concerned, typically carried out by commuters using the railway service, leaving the car parked all day. As with the light rail criteria, the railway stations are mapped according to distance. Thus, the cells found within a 300 metre radius from the station are indicated in red and those that are found within a 500 metre radius are indicated in yellow.

• **Building car parks.**
The presence of a car park inside a building in a cell is considered to be an indicator of area "desirability", in that it guarantees optimal charging infrastructure localisation, protected from atmospheric agents and possible acts of vandalism. Furthermore, building car parks are also considered to be optimal locations for infrastructure installation, in that they guarantee charging station "visibility" and high identifiability, thanks to the use of message display boards to indicate the number of stalls available which can potentially be used to direct the user to the charging station. Building car parks are mapped by indicating the total number of stalls in each cell.

• **Petrol stations.**
The presence of a petrol station is considered to be an indicator of area "desirability" as far as "Quick" and "Fast" charging is concerned, in that it guarantees optimal infrastructure localisation due to the high "visibility" of the charging station. Petrol stations were considered that have suitable space available. The petrol stations were mapped by indicating the number present in each cell.

3.2. Creation of "Demand Maps" and comparison with potential supply

For each type of charging, a matrix was created of weights to be attributed to each indicator, based on its value in individual cells.

For "Slow" charging, the indicators considered were the number of inhabitants per single cell, the number of operators per single cell, the presence of railway stations in each cell, the number of educational services per cell, the number of building car park stalls per cell. For "Quick" charging, the parameters considered were the number of operators per single cell, the number of educational services per cell, the number of administrative, sports and health services per cell, the number of building car park stalls per cell, the number of bike-sharing bicycles per cell, the number of bus stops per cell, the presence of light rail stations in each cell, the number of large commercial buildings per cell. For "Fast charging", the parameters considered were the number of administrative and health services per cell, the number of building car park stalls per cell, the number of large commercial buildings per cell and the number of petrol stations per cell.

The total weight given to the various indicators in each cell was then divided into four intervals of theoretic demand for charging infrastructure for that cell: "no" demand, "low" demand, "medium" demand and "high" demand. For each level of demand, a thematic map was created to highlight its distribution throughout the territory.

• **"Slow" charging.**

The thematic map for "Slow" charging highlights 93 high-demand cells located in the city centre, in Bresciadue, in the area south of the General Hospital and in the Fiumicello and Primo Maggio areas of the city. Other main city areas are revealed to be medium-demand, with a total of 298 cells. There are 314 low-demand cells.

• **"Quick" charging.**

The thematic map f or "Quick" charging highlights 85 high-demand cells, which trace the route of the automatic light railway, with high density in the old town centre and the Bresciadue areas. There are 180 cells identified as medium-demand and 429 low-demand cells.

• **"Fast" charging.**

The thematic map for "Fast" charging highlights 17 high-demand cells, 51 medium-demand cells and 104 low-demand cells.

The use of these maps allows us to identify rapidly which areas are of main priority, due to there being higher demand, for the installation of charging infrastructure, thus enabling the correct territorial distribution of available resources.

More specifically, hypotheses were made related to the potential supply for each type of charging, as described below.

• **As concerns "Slow" charging**, as also indicated by the National Plan, the main infrastructure localisation is in private residential areas. For this reason, the Plan identifies construction and city planning policies to help the user manage the configuration of his own private charging station. In areas of high population density, if there are not enough areas available to be used for charging, the localisation of public "Slow" charging stations is preferable. In these areas, coverage by

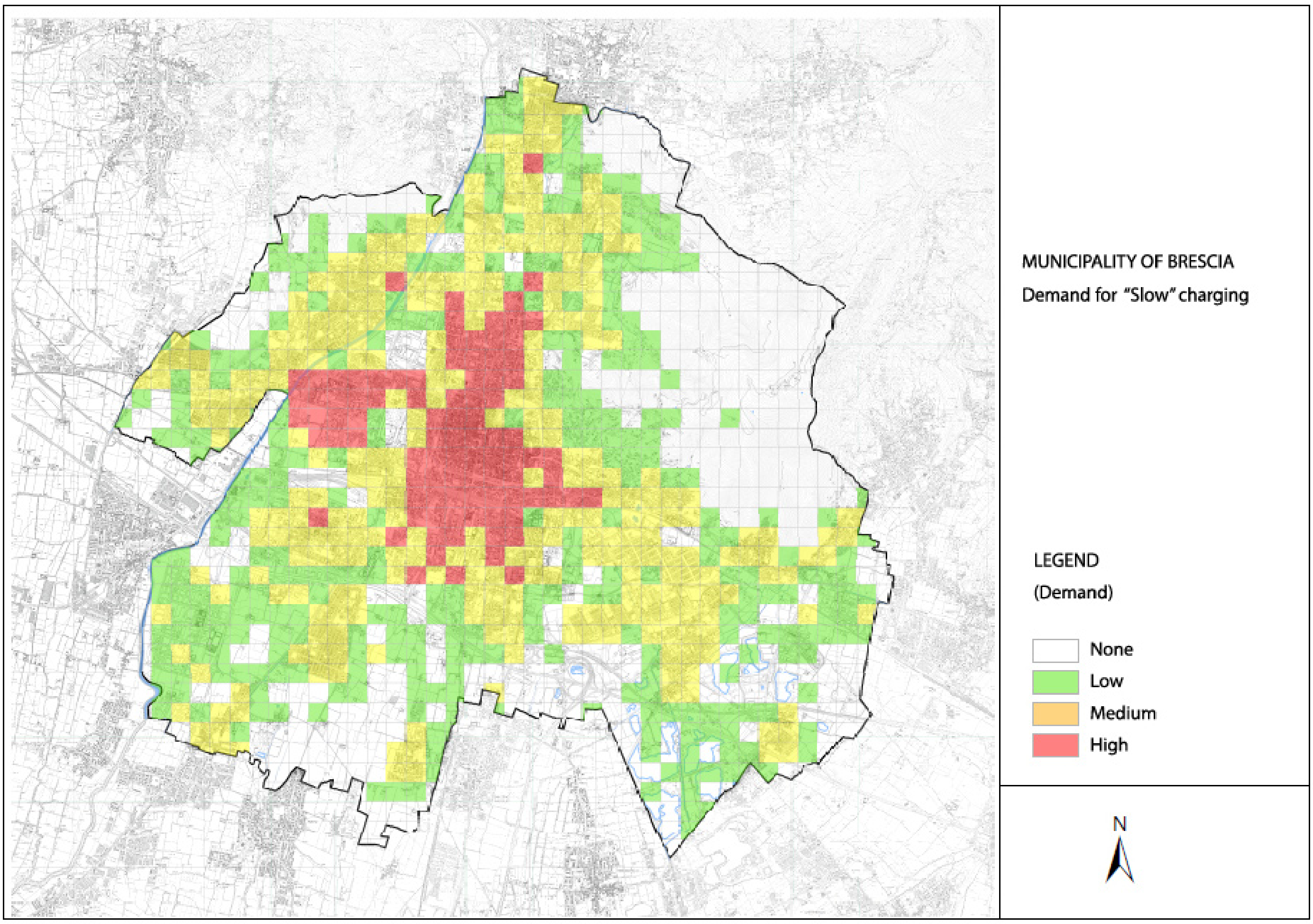

Figure 5 – Demand for "Slow" charging.

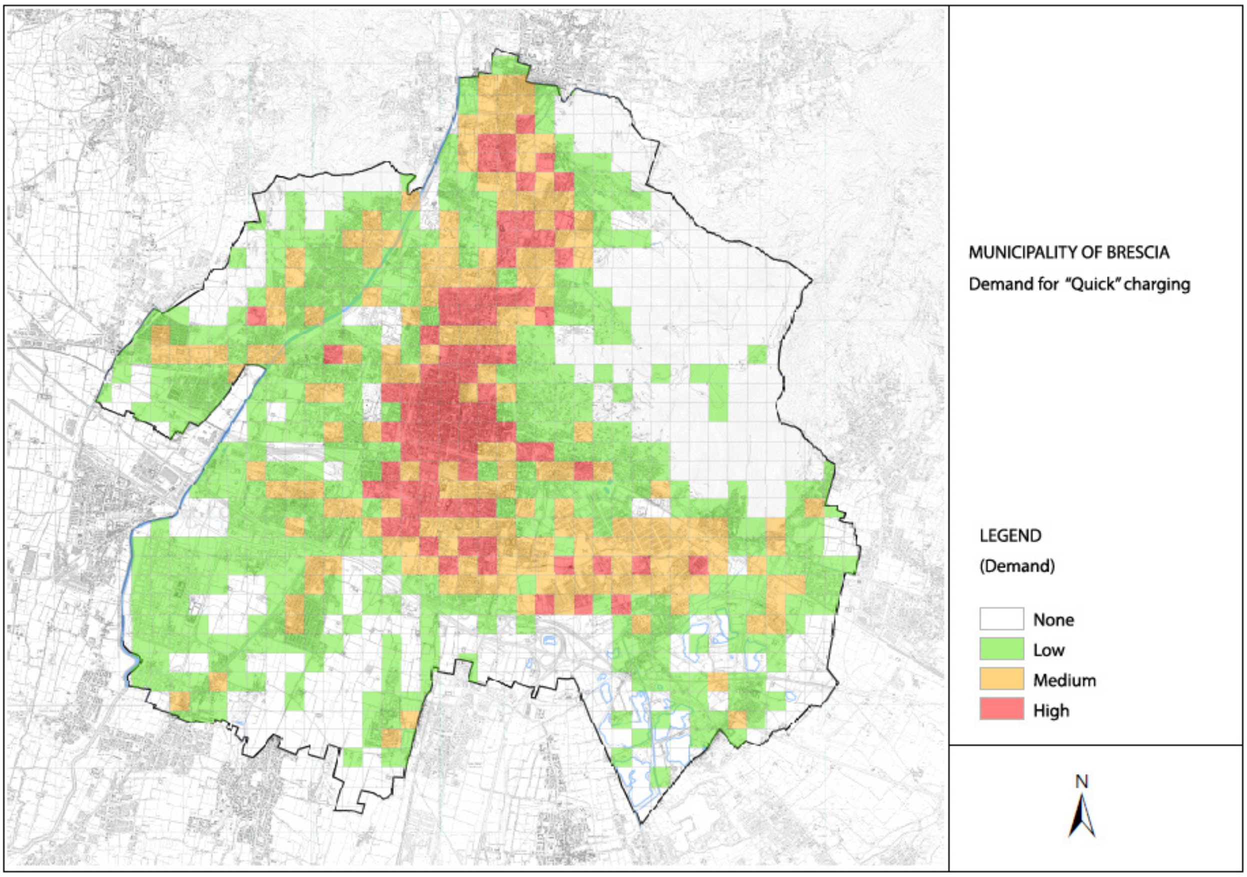

Figure 6 – Demand for "Quick" charging.

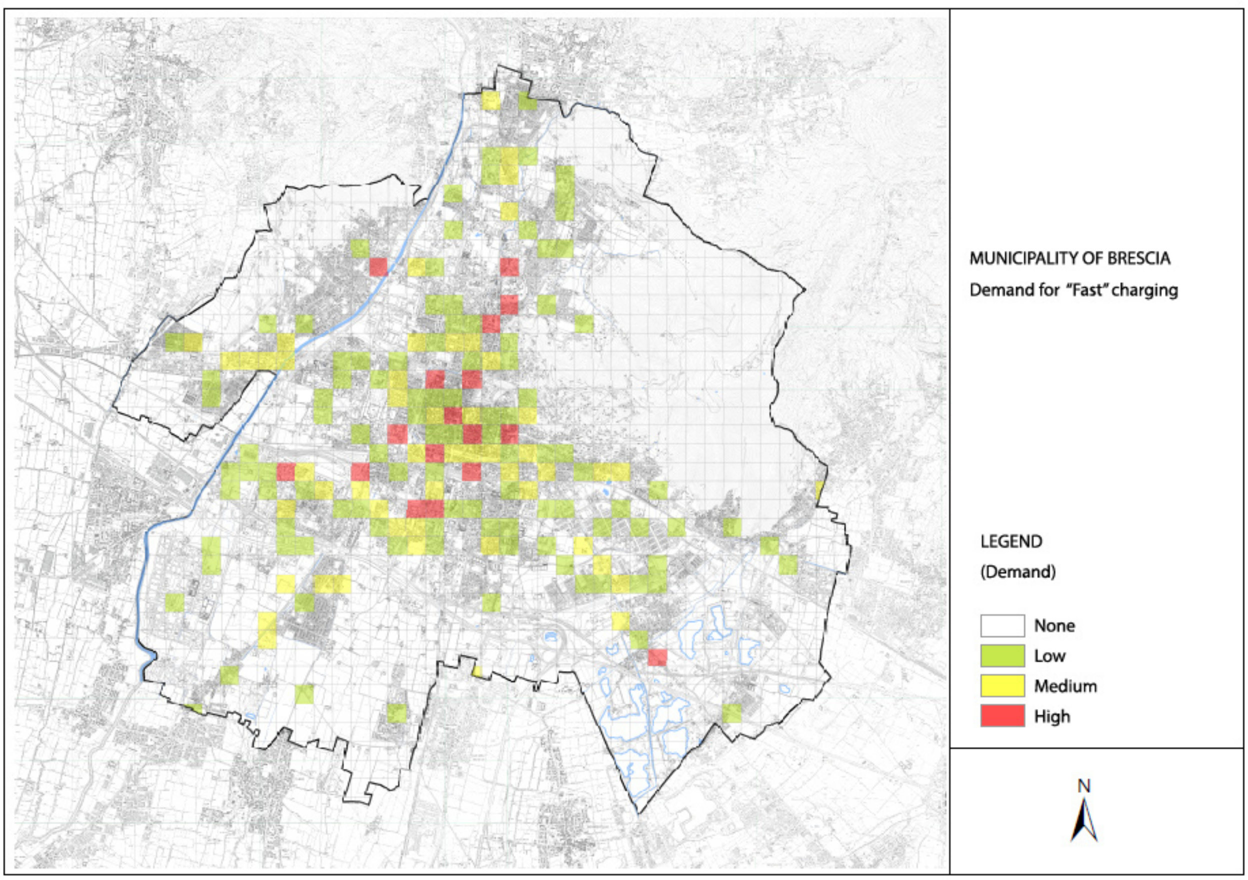

Figure 7 – Demand for "Fast" charging.

higher level infrastructure must also be examined: a "Quick" charging station, used by day by traffic-attracting services or hubs, can also be used at night by local area residents.

• **As concerns "Quick" charging**, it has been estimated that, in the first stage, charging infrastructure will be localised in all building and modal interchange car parks and in all the large commercial building car parks in the municipality. This decision was motivated by the fact that, in such areas, it is easier to identify areas possibly protected from atmospheric agents, used exclusively for charging, placed near the main entrances and easily accessed by the user.

Thus, coverage analysis was carried out of the areas of influence of potential supply, considering a radius of 300 metres, a distance easily covered on foot.

This operation allowed us to identify which areas of the city are not covered by the infrastructure localisation hypothesis, reducing detailed analysis to these areas only.

One example is the northern area of the city, in the Mompiano district. This area contains 6 high-demand cells and 12 medium-demand cells for "Quick" charging that are not covered by the theoretical area of influence of the charging infrastructure.

In this area, the "High" and "Medium" demand cells contain predominantly sports services (e.g. Club Azzurri), gyms, football pitches (e.g. Rigamonti Stadium) and tennis courts, swimming pools (e.g. Mompiano Swimming Pool), doctors' surgeries and health services (e.g. Domus Salutis), schools (e.g. Scuola Edile, Liceo e Scuola Magistrale Zammarchhi, I.T.C. Lunardi), bike-sharing stations or Local Public Transport stops/stations.

Detailed analysis of the area allowed us to identify certain parking areas (mainly private with public access) suitable for the installation of "Quick" charging infrastructure.

Therefore, a new charging infrastructure coverage area was identified with the same 300 metre radius, making sure that, with the newly identified possible locations, the critical area of Mompiano is covered. The plan extract in Figure 6.9 shows the new coverage area.

The same analysis was also carried ot for "Fast" charging, on the assumption that optimal localisation could be, as well as in the areas already taken into consideration for "Quick" charging, at sufficiently spacious petrol stations located on roads classified A to E (Italian system). No areas were identified in which the charging demand was not satisfied by the potential localisation supply.

Once the charging infrastructure installation areas, for the three types of charging, are identified using the methodology described above, the number of stalls to be equipped (for "Quick" charging) can be calculated using the matrix described earlier, carefully analysing which type of traffic-attracting service/hubs are found within the station's area of influence.

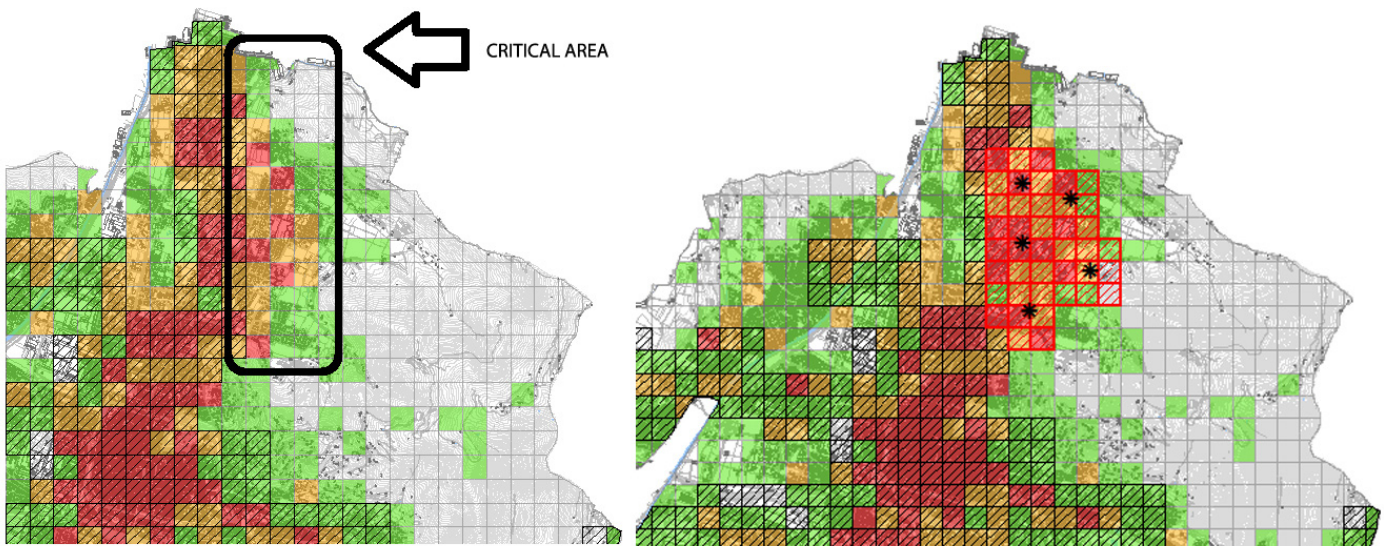

Figure 8 – Extract from the map showing the "Quick" charging infrastructure coverage area. High demand areas in red, medium-demand in yellow, low-demand in green, infrastructure coverage area indicated by the black dotted line. The black square identifies a critical area north of Brescia with high demand but not covered by the infrastructure. In the figure on the right, the black asterisk indicates the possible locations for infrastructure in the Mompiano area. The red dotted line shows the new infrastructure coverage area.

One example could be the station located in the North Hospital building car park. This station is found in an area of high demand, shown in red on the thematic map. Taking into consideration the Hospital service, this proves to be a service with a high demand for charging stalls, as per the methodology described above.

Using the matrix above, a corrective factor of 2 is identified,

Table 3 – Double-entry matrix to determine the corrective coefficient to be used in the identification of a minimum standard of stalls to be equipped with “Medium” charging infrastructure. Case study: Brescia Hospital. The coefficients used are indicated in red.

		Corrective factor		
Coefficient for type of traffic attracting service/hub	High	1	1,5	2
	Medium	0	1	1,5
	Low	0	0	1
		Low	Medium	High
		Charging demand for the cell in question		

which, when applied to the 2% minimum of charging stalls, brings the total percentage to 4% of stalls in the building car park. Given that the North Hospital car park has 1405 available spaces, the desired number of stalls to be equipped with charging infrastructure is 56. These charging stalls should ideally be located near the pedestrian entrances to the car park, in a visible and well-protected position. The number of available charging stalls in the car park should be clearly indicated by message display boards situated outside the car park. Of these stalls, an appropriate number[9] must be made accessible to disabled users.

9. In line with international examples, it can be assumed that at least 2 disabled user stalls will be required (minimum 1 for every 50 charging stalls).

4. Conclusions

Inspired by international examples and in line with that established by our National Plan (Pnire), a new methodology is proposed, calculated and validated in the city of Brescia, for the planning of public or public-accessible charging stations. As far as “Slow” charging is concerned, it is evident that demand will mainly be satisfied by private infrastructure in the domestic environment (maintaining the ratio of 1 to 8 established by the Infrastructure Plan for the number of public vs private charging stations), whilst public stations must be planned for “Fast” and “Quick” charging.

To this end, the methodology developed, which is easily implemented by taking into consideration various indicators and assigning to these indicators a weight based on the type of charging, is deemed to be a valid tool to help draw up infrastructural installation plans quickly and with the advantage of clearly highlighting the areas in which it is necessary to focus in-depth analysis, this avoiding the waste of resources.

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