Measuring circular economy objectives in urban centres

Ranking of Italy's most circular cities and preliminary comparisons between European cities

CESISP

UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA

Summary

Measuring circular economy objectives in urban centres

Ranking of Italy's most circular cities and preliminary comparisons between European cities

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Introduction

Cities play a key role in the global economy, with more than half of the global population living in urban areas and accounting for about 85% of the world's GDP output. In addition, cities are responsible for 75% of the consumption of natural resources, 50% of global waste production and between 60% and 80% of greenhouse gas emissions.

They are the heart of innovation and growth, although resource consumption and environmental impacts are increasing exponentially in comparison to population growth. This suggests that management of urban development and infrastructure development strategies are inefficient. Such development will not be sustainable in the long term. For this reason, in recent years there has been a shift towards the development of more circular cities based on a more efficient use of resources.

This paper is being published at a time when the COVID crisis has had a massive impact on urban lifestyles. However, this pandemic has shown that cities are crucial hubs in our interconnected global society. In the hope that we can overcome this crisis as soon as possible, we must be aware that we will also have to face up to some long-standing issues: our dependence on fossil fuels, rising CO2 emissions, air pollution, a flawed housing market and use of resources, loss of biodiversity and the problems of social inequality and cohesion within the urban population. This is why we believe that these issues are even more relevant for the future and offer a unique opportunity to study and analyse which of these experiences could be exploited in order to build more sustainable and safer cities.

Upon presenting the ambitious Green New Deal project in January 2020, the European Commission placed the Circular Economy at the centre of the new European policies needed to achieve the objectives that Europe signed up to in Paris in 2015. By renewing its environmental policy, the Union plans to strengthen the measures adopted with the package of Circular Economy Directives published in the European OJ in June 2018, to be transposed by Member States by July 2020.

The new European circular economy package aims to promote a system of design, production and consumption of goods and services, as well as waste management and the reuse of materials within the economic system, in which resource efficiency is the cornerstone of sustainable development. The transition towards a circular economy requires citizens to actively engage in changing their consumption habits.

In this regard, it is essential, on one hand, to create the conditions for efficient markets and waste management systems and, on the other, to create a system of incentives and communication to citizens to support bottom-up initiatives and encourage virtuous behaviour. Large urban areas are a key driver for the promotion, alongside citizens, of conduct and measures to be adopted in order to meet important environmental objectives.

The circular economy is not just an economic model for the efficient management of resources but is also a holistic approach aimed at promoting environmental sustainability and improving social cooperation between all social players.

In the light of the central role played by urban areas, CESISP at Milan University - Bicocca

aimed to promote and expand the ranking of Italy's Circular Cities. The objective of this research project, now in its second edition, is not merely to establish a ranking but, above all, to develop the tools required for an effective evaluation of environmental policies in urban areas. The indicators considered in this paper can in fact be used in impact analyses of new legislative or regulatory proposals and are useful in ex post assessments of the effectiveness of measures adopted. Furthermore, although each Member State is bound by Community objectives, both in terms of circular economy and sustainability, we believe that without widespread implementation, these objectives will be difficult to achieve. Finally, we believe that the social impact is also key to evaluating the effects of many environmental policies at the local level which have thus far often failed to consider the risk of regressive economic impacts in terms of social equity on the most disadvantaged members of urban society.

The report is presented as follows: the second section includes a description of the methodological approach applied, the main indicators taken into consideration and the main critical issues addressed. The third section includes a description of the results obtained by measuring the indicators referring to the various aspects of the analysis. The fourth section summarises the analyses of the various aspects of the circular economy in an overall ranking of the circularity of 20[1] Italian cities selected from the regional capitals and, if there aren't enough information, the main cities by population and information available. The fifth section presents a preliminary attempt to compare major European cities based on available comparative data.

1. Urban circularity index: method and main indicators considered

Cities can not only help to reduce their negative impacts on ecosystems but can also become veritable drivers of transformation and innovation. New solutions must therefore aim to reduce resource consumption through more efficient use. With this in mind, circular economy practices increase the productivity of extracted resources, while minimizing their negative effects. However, economic analysis has not yet established a reference perimeter for the shared measurement of overall performance policies. Since this is a challenge that begins with the day-to-day conduct of all citizens, a common data and knowledge base is required in order to support all stakeholders involved, particularly members of the public. That is why it is important to start by setting out proximity policies for residents and

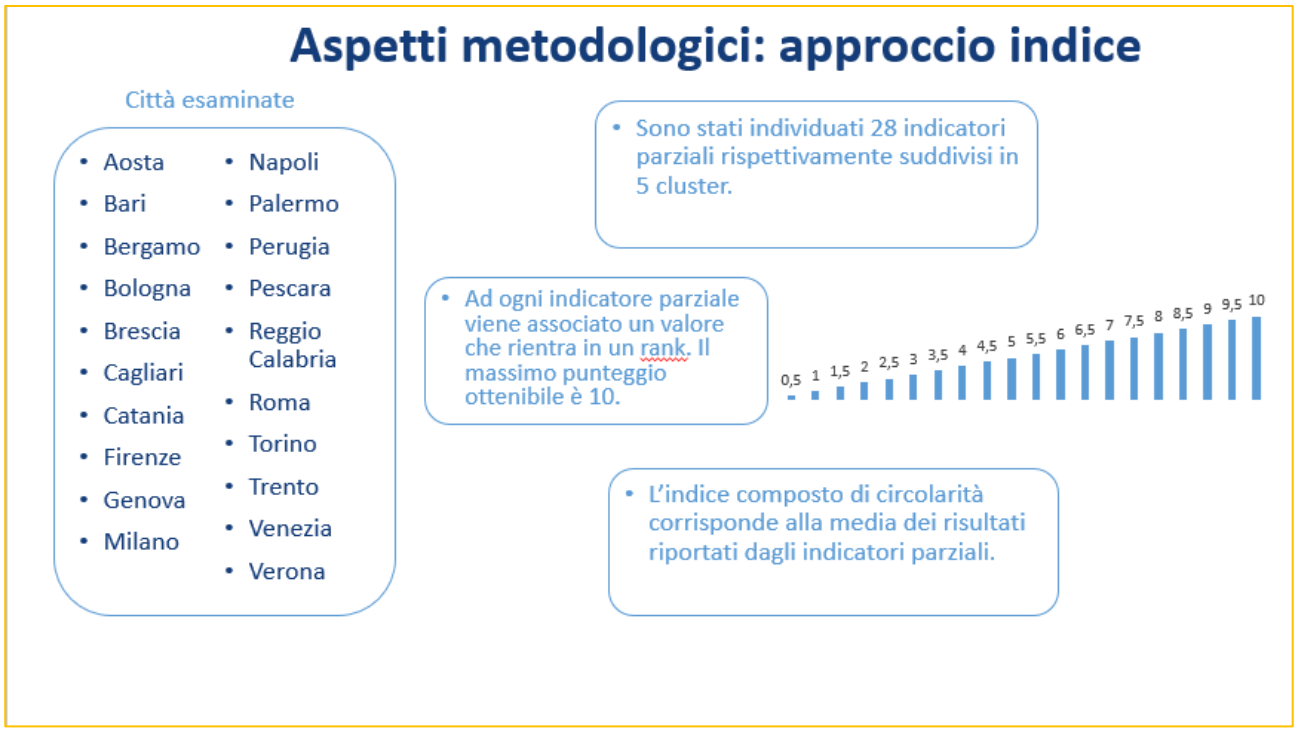
[1] We have examined the top 10 cities by population. To improve the research, the number of cities has been extended to 20 and the additional ones have been selected first by regional capitals. However not all the regional capitals had all the information required therefore, for example, Pescara and Reggio Calabria were identified as representing the Abruzzo and Calabria regions to replace their respective capitals. At this point we have a sample of 17 cities. The last three (Bergamo, Brescia and Verona) were selected by population and information available. In particular Bergamo, although it ranks 35th by population, had more information than other cities with a bigger population.

measuring the effectiveness of urban areas which, as mentioned earlier, are currently the drivers of economic and social development. The objective is therefore to develop a circularity index in order to facilitate regulatory impact analysis of environmental and sustainability policies. The aim is to provide a tool to support analysis and impact assessments for the purpose of developing circular economy policies as indicated by European and national legislation. Cesisp has developed a system to measure the circular economy in the top 20 Italian cities by population and information available: in alphabetical order, Aosta, Bari, Bergamo, Bologna, Brescia, Cagliari, Catania, Florence, Genoa, Milan, Naples, Palermo, Perugia, Pescara, Reggio Calabria, Rome, Turin, Trento, Venice, Verona. By starting with a widely used synthetic model of circular economy it is possible, by adapting it to a certain extent, to represent the concept of urban circular economy through clusters.

- Sustainable inputs: use of inputs from renewable sources or from reuse and recycling;
- Social sharing: volunteering / platforms for asset sharing in order to reduce waste;
- Use of goods as services: innovative business models to offer products in the form of services;
- End of life: solutions aimed at preserving the end-of-life value of an asset and reusing it;
- Extending the life of products: actions aimed at increasing the useful life of goods and services.

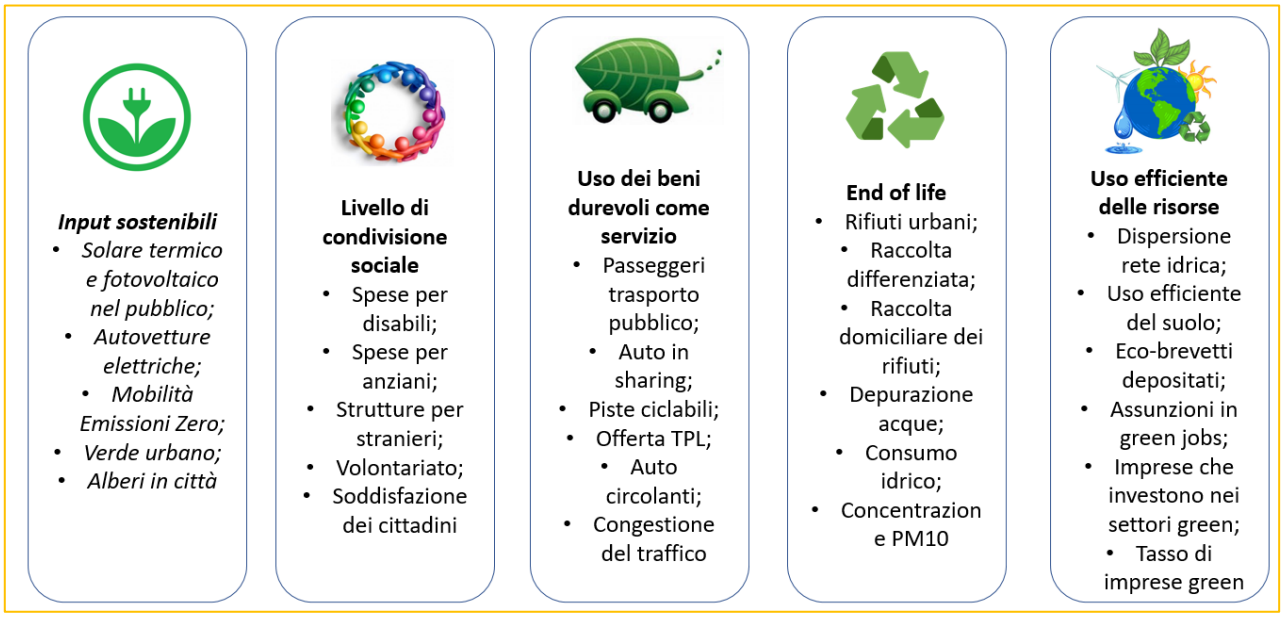
Using the fundamental characteristics of each above-mentioned basic principle of the circular economy, it is possible to obtain some indicators that measure the performance of the urban areas considered. Based on the value of each indicator described below, a score from 0 to 10 was assigned to each city considered, after which a qualitative and quantitative ranking of the most circular Italian cities was drawn up based on the overall score achieved.

Figure 1: method used for our research



The following graph/table summarises the variables and their positioning within the identified clusters.

Figure 2: Clusters and variables Source: CESISP data



2. Indicators and results within the various areas of the urban circular economy

In this section, we consider the five areas of the circular economy set out in the previous sections. Each aspect considered will be used to assess the value of the partial indicators attributable to the urban areas considered. The aim is also to highlight the granularity of available statistically relevant data in order to consider their possible completion. The partial rankings, including the various aspects, are subsequently linked to a general ranking in the next chapter.

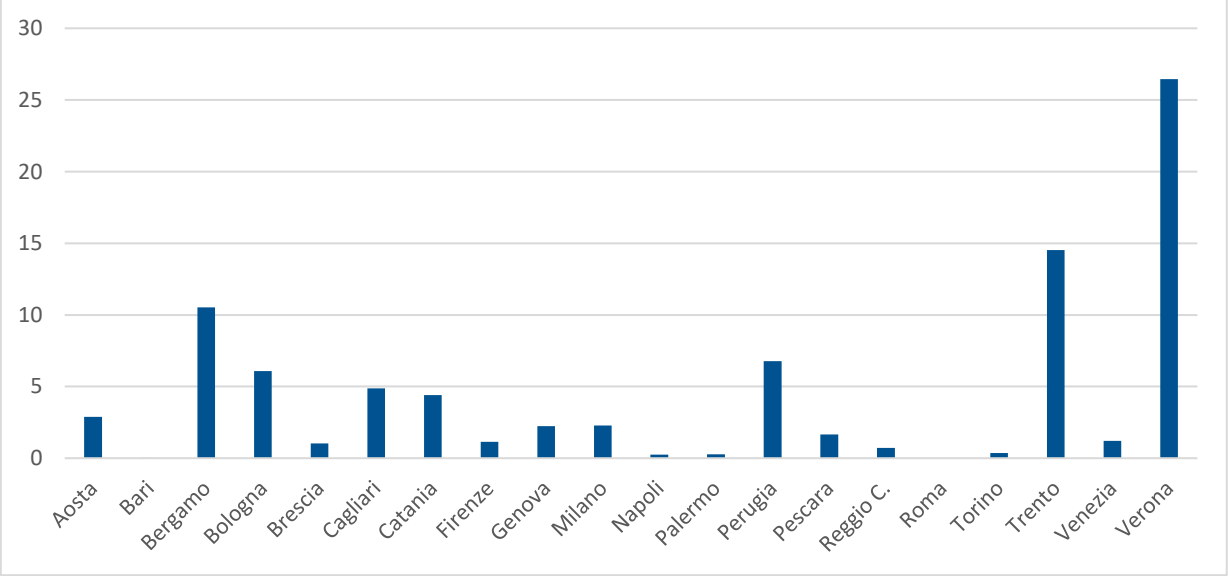
a. Indicators for measuring urban sustainability

The first cluster, "Sustainable Inputs", reflects the new circular model where each resource, once used and exhausted, re-enters the production process as a new secondary raw material. The sensitivity of Italian cities to sustainable inputs is analysed using six indicators related to the use of renewable raw materials, mobility or the urban environment:

A1 Renewable solar thermal energy in the public sector measured in kW.

This represents the distribution of energy from renewable sources, in particular solar thermal systems in public buildings.

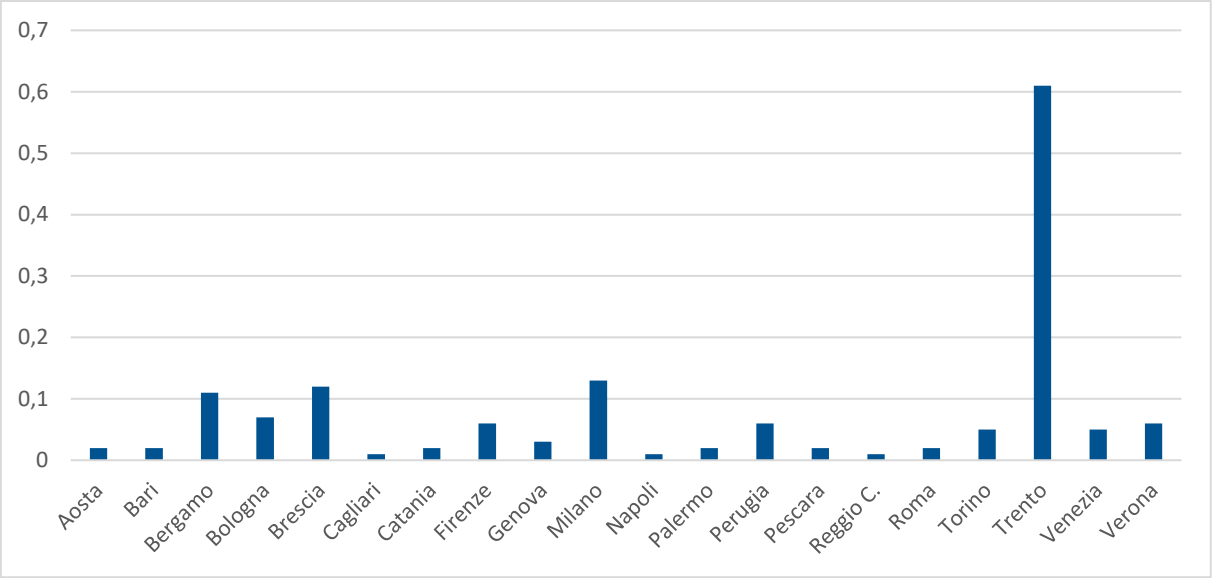
Figure 3: Solar thermal and photovoltaic energy in the public sector (kw/1000 inhabitants)



A.2 Electric cars as a percentage of the total number of privately owned cars

To analyse the level of sustainable mobility, we calculated the number of private electric cars owned as a percentage of the total number of cars registered in each city. The percentage of electric cars on the roads accounts for no more than 1% of cars in all of the Italian cities considered;

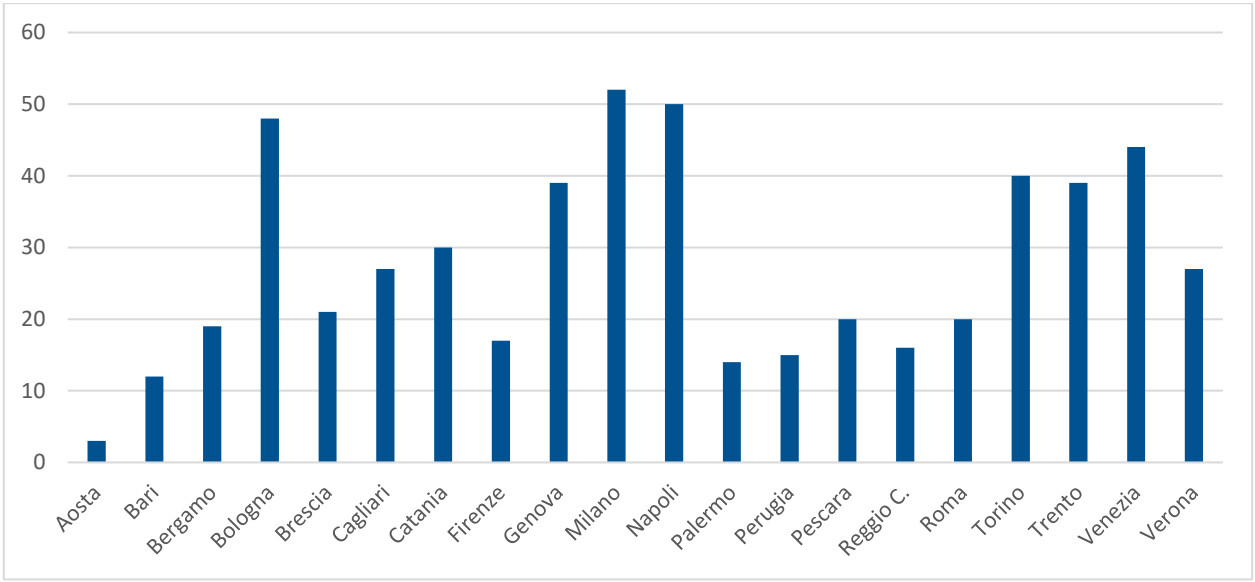
Figure 4: Number of electric cars (%)



A.3 Percentage of Zero Emission Mobility (ZEM);

The ZEM (Zero Emissions Mobility) index expresses the percentage of "zero emission" car journeys out of the total number of car journeys in urban areas. This includes all journeys made using transport other than fossil fuelled cars. Electric and public transport, as well as walking and cycling, are considered to be sustainable. The leading city in terms of sustainable mobility is Milan with a ZEM indicator value of 52%.

Figure 5: Emission-free mobility (%)

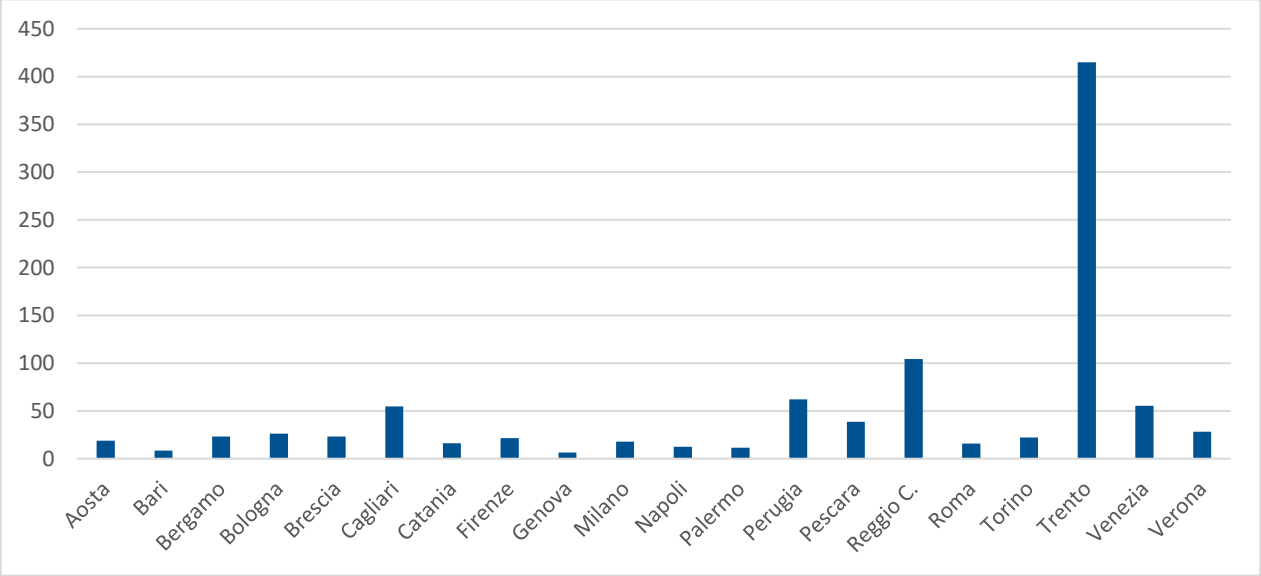


A.4 Quantity of urban green areas measured in sqm/inhabitant;

A.5 Quantity of trees in an urban area measured in terms of number of trees per 100 inhabitants.

The last two indicators analysed take into account quality aspects of the urban environment from a green perspective. The law provides that all municipalities of over 15,000 inhabitants must have a land register of the trees present in the city and, as of January 2019, must undertake to plant a new tree for each child born or adopted. The ISTAT data analysed for the first indicator concern the square meters of urban green areas available to each inhabitant, while the second index represents the number of trees in each city per 100 residents.

Figure 6: Square meters of green areas



The overall results achieved by the cities in question are set out below:

Table 1: Sustainable inputs

City	Solar thermal and photovoltaic energy in the public sector	Private electric cars [%	ZEM [%]	Urban green spaces [sqm/inhabitant]	Trees in city [n./100 inhabitant]
Aosta	2.89	0.02	3	18.8	11
Bari	0.01	0.02	12	8.6	N/A
Bergamo	10.53	0.11	19	23.4	19
Bologna	6.08	0.07	48	26.1	21
Brescia	1.04	0.12	21	23.1	64
Cagliari	4.88	0.01	27	54.9	17
Catania	4.41	0.02	30	16.3	5
Florence	1.15	0.06	17	21.5	19
Genoa	2.24	0.03	39	6.4	10
Milan	2.28	0.13	52	17.9	34

City	Solar thermal and photovoltaic energy in the public sector	Private electric cars [%	ZEM [%]	Urban green spaces [sqm/inhabitant]	Trees in city [n./100 inhabitant]
Naples	0.24	0.01	50	12.6	6
Palermo	0.28	0.02	14	11.6	11
Perugia	6.78	0.06	15	62	29
Pescara	1.65	0.02	20	38.6	14
Reggio Calabria	0.72	0.01	16	104.4	6
Rome	0	0.02	20	15.9	11
Turin	0.36	0.05	40	22.2	13
Trento	14.52	0.61	39	414.9	17
Venice	1.2	0.05	44	55.5	24
Verona	26.46	0.06	27	28.2	19

b. Indicators for measuring social sharing levels

The second cluster, "level of social sharing", highlights the collaboration and participation of all players within Italian cities and municipalities, which is key to achieving full circularity and closure of the so-called economic circle.

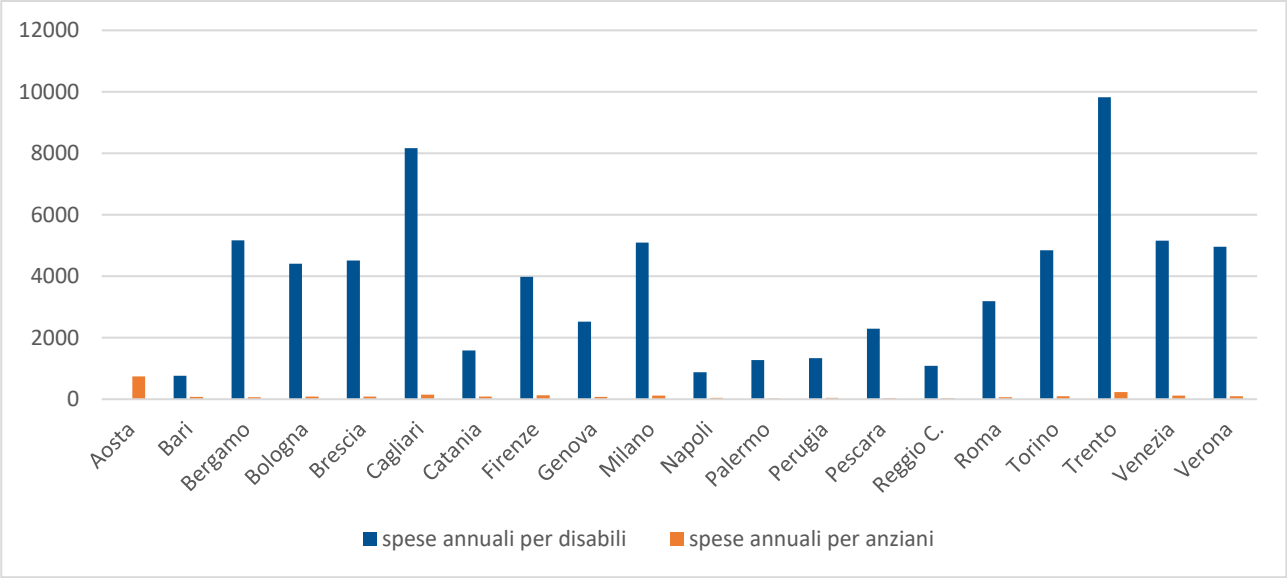
The indicators examined are as follows:

B1 Annual municipal expenditure for the disabled;

B.2 Annual expenditure for the elderly.

The first two indicators analysed reflect the services that the State makes available to cities (social circularity), each of which then decides, on the basis of its own priorities and budget assessments, to offer its most disadvantaged citizens. On average, the municipalities of Northern Italy spend twice as much as the municipalities of Central Italy and five times as much as the Southern regions, both to protect and care for the disabled and to assist the elderly. The biggest difference can be seen between the cities of Bolzano and Bari: the former spends an average of €15,141 per year on care, assistance, services and infrastructure for each disabled person. The city of Bolzano's urban policy focuses heavily on the social integration of its citizens, partly through annual expenditure for the elderly (over 65). The municipality of Trentino-Alto Adige spends an average of 1,164€ each year.

Figure 7: Annual expenditure for disabled and elderly people



B.3 Residential facilities for migrants in absolute terms

The survey, which was carried out on the basis of the Ministry of the Interior's annual census on the number of reception and residential centres for migrants, focuses in particular on the location of these facilities within the country. Around 35% of all facilities for migrants are located in Northern Italy. More specifically, the greatest number are located in Turin, with 229 reception centres. The situation is completely different in Milan: the capital of Lombardy is in striking contrast with the trend in the rest of Northern Italy, with just two residential facilities for migrants. On the other hand, the large cities of Rome (82 facilities) and Florence (57) are above the national average.

B.4 Number of non-profit organisations per 10,000 inhabitants.

Volunteering is the most important and symbolic indicator for the evaluation of social sharing. In Italy, 6.63 million (12.6%) people give their time free of charge to help others or for the common good: 4.14 million (7.9%) Italians do so via organisations and 3 million (5.8%) individually. The non-profit sector continues to expand and records even higher average annual growth rates than companies operating in the same market. In addition to the number of volunteers, the number of institutions and organisations that provide non-profit aid continues to grow. According to data collected by ISTAT in 2018, there are over 360,000 voluntary associations in Italy, compared to just 200,000 at the turn of the century. The data collected through our survey represents the number of voluntary institutions found in Italian cities per 10,000 inhabitants. The best results were recorded in Trentino-Alto Adige in the autonomous province of Trento, where there are 116 non-profit organisations per 10,000 inhabitants.

B.5 Citizen satisfaction.

The last social value expresses the rate of satisfaction perceived by citizens. In order to quantify this indicator, residents of the various cities were interviewed, and asked to award a score from zero to ten to rate their satisfaction with employment, public transport, green areas and their living environment. As shown by the previous

indicators, our analysis of the level of citizen satisfaction also shows a marked difference between the North, Centre and South. The overall results achieved by Italian cities are summarised as follows:

Table 2: Level of social condition

City	Annual expenditure for the disabled	Annual expenditure for the elderly	Residential facilities for migrants	No. of voluntary organisations/ 10 thousand inhabitants	Citizen satisfaction
Aosta	0	741	N/A	109.5	7.46
Bari	764	75	33	42.4	6.64
Bergamo	5,172	70	21	N/A	7.15
Bologna	4,413	85	23	61.4	7.16
Brescia	4,514	90	22	N/A	7.17
Cagliari	8,165	145	2	62.8	6.7
Catania	1,582	87	28	N/A	6.37
Florence	3,983	133	57	73.7	7.27
Genoa	2,526	76	2	70	7.23
Milan	5,098	118	2	56.2	7.49
Naples	882	41	38	36	6.47
Palermo	1,272	28	48	43.5	6.43
Perugia	1,333	41	14	77.7	6.97
Pescara	2,290	34	10	61.2	6.9
R. Calabria	1,091	34	31	47.9	6.53
Rome	3,194	69	82	54.7	7.13
Turin	4,845	98	229	67.8	6.83
Trento	9,826	230	11	116	7.59
Venice	5,154	116	8	62.4	6.77
Verona	4,958	100	40	62	6.67

c. Indicators for measuring the efficient use of services and goods

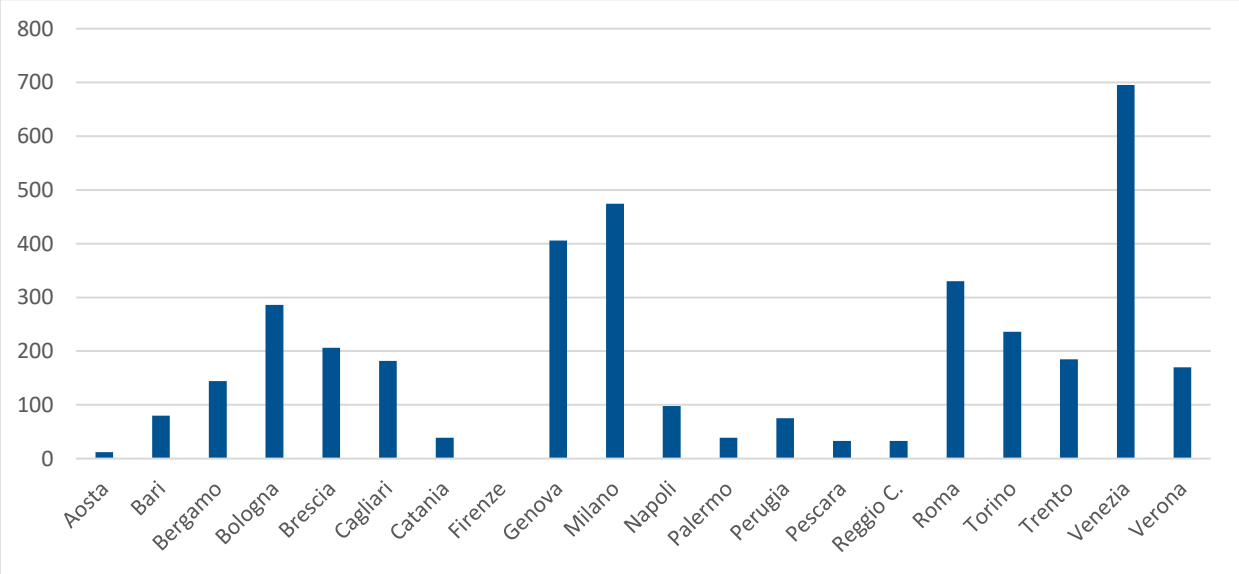
The circular economy is based on the new concept of "product as a service", which is diametrically opposed to the concept of mere consumerism. The final consumer no longer buys a good but benefits from a service provided by the producer, which acts as a supplier. The most obvious example is the public transport system, where residents are the consumers who use and pay only for the service provided by the producer-supplier-Municipalities, without having to bear the costs of ownership and management. For the

third cluster; "use of durable goods as a service", the transport system in urban areas was analysed. ISTAT data, collected on the basis of the number of inhabitants and the catchment area of the various cities, have been processed to arrive at the indicators shown in the table below:

C.1 Public transport passengers.

This indicates the number of journeys each inhabitant makes in a calendar year [journeys/inhabitant]. Public transport service use is on the rise in small, medium and large cities. In 2018, the highest percentage growth was recorded in small towns and cities. Public transport use is also growing in medium-sized cities, albeit at a slower pace. An example of this sudden growth is Bari, where per capita journeys stood at 67 in 2016, 76 in 2017 and 80 journeys/inhabitant/year in 2018. The top spots are held by tourist destinations such as Venice, followed by Milan and Genoa.

Figure 8: Public transport passengers (travel/inhab.)



C.2 Number of shared cars in the city.

The leading cities in terms of car sharing are Milan with 3,290 cars on the road and Rome with 2,303. (the value analysed represents the number of shared cars per 1000 inhabitants). This type of service is not yet offered in many Italian cities, and it is mostly limited to large cities.

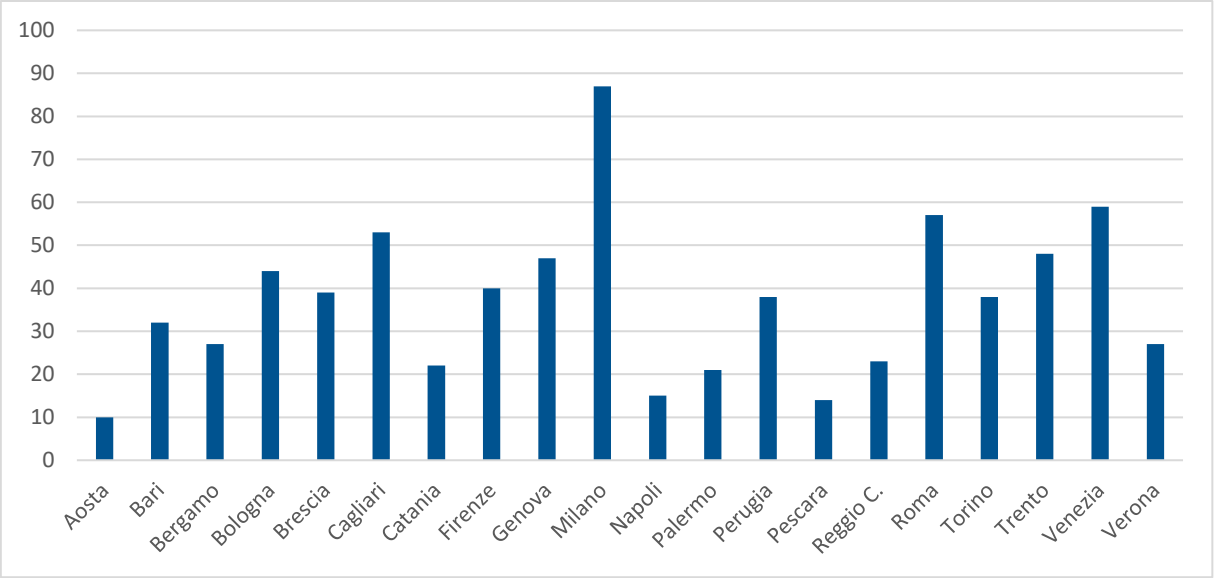
C.3 Total km and the equivalent meters of cycle paths per 100 inhabitants.

In order to obtain an effective indicator to measure a city's cycle path facilities, the following have been considered: km of cycle routes, km of reserved lane cycle paths, on-pavement cycle paths, mixed bike/pedestrian paths and finally cycle paths in urban green areas, i.e. paths that do not run alongside the road but are, for example, located in parks or along riverbanks. The leading city for green two-wheeled transport is Bologna.

C.4 Public transport offer.

This represents all the various modes of local public transport within a given city. The public transport offer is calculated in terms of kilometres travelled annually by vehicles per resident [km-vehicle/inhabitant/year]. Amongst the larger cities, in terms of public transport offer, the city of Milan comes in first on the ranking, then Venice at the second place.

Figure 9: Local public transport offer - cars / resident



C.5 Cars in circulation per 100 inhabitants.

The motorisation rate is one of the most critical problems for Italian cities. Moreover, this figure continues to rise, and between 2017 and 2018 there was a further increase from 63.3 to 64 cars per 100 inhabitants. The cities with the highest rates of cars in circulation are Perugia and Catania, at 74 and 72 per 100 inhabitants, respectively. The only cities that average below 50 (i.e. less than one car for every two people) are Genoa and Venice.

C.6 Traffic congestion.

The last indicator analysed is the level of traffic congestion in Italian cities, as it provides an overall indication of the transport service in urban areas but, at the same time, highlights the associated environmental damage in terms of smog and pollution. This indicator represents the average percentage increase in the duration of a car journey due to traffic. The worst performer is Rome, where traffic increases the duration of each car journey by 39% compared to the time actually needed, with consequent damage to the environment in terms of smog and pollution. At the other end of the scale is Turin with 24%.

Figure 10: Traffic congestion levels

The following table summarises the overall results for each city:

Table 3: Use of durable goods as a service

City	Passengers pub.tr.	Shared cars/ 1000 inhab.	Cycle paths	Km bike lanes	Km travelled by pub.tr.	Cars in circulation per 100 inhab.	Level of traffic congestion (%)
Aosta	12	0	8.04	8.7	10	64	N/A
Bari	80	0	2.24	26	32	56	27
Bergamo	144	0.01	17.05	36.7	27	60	14
Bologna	286	0.57	12.03	153.2	44	53	25
Brescia	206	0.03	18.02	97.5	39	61	14
Cagliari	182	0.57	4.5	21	53	65	22
Catania	39	0.35	2.07	11.3	22	72	28
Florence	N/A	1.7	6.9	60.1	40	52	25
Genoa	406	0.19	0.25	11.5	47	47	31
Milan	474	2.43	4.09	174	87	50	30
Naples	98	0.02	0.49	19.2	15	57	30
Palermo	39	0.23	1.68	33.8	21	59	35
Perugia	75	N/A	4.18	14.1	38	74	N/A
Pescara	33	N/A	4.52	26	14	61	21
R. Calabria	33	0.12	0.44	5.8	23	63	27
Rome	330	0.8	1.28	129	57	62	39
Turin	236	1.2	5.17	147	38	66	24
Trento	185	0.08	9.87	41.8	48	64	N/A
Venice	695	0.11	7.15	111.6	59	43	N/A
Verona	170	N/A	11.23	76.1	27	65	20

d. Indicators for measuring the effectiveness of policies to reduce environmental impacts

One of the main objectives of the circular economy model is to treat today's waste as tomorrow's resources. The new circular model goes beyond the concept of "end of life". Waste should not be the final stage of a product to be sent to landfill but can and must be reintroduced into the production chain as an input for a new and different cycle. Taking inspiration from this clear and simple vision, the "End of Life" cluster focuses on waste and municipal waste produced annually in major Italian cities. The indicators used are shown below.

D.1 Municipal waste production.

The Italian national average waste per capita is about 537 kg per year. Italy set a target to halve this amount by 2050. Although it will be difficult to meet this target by 2050, data shows that Italian cities and their inhabitants are on the right track. Indeed, in 2017, the average amount of waste per inhabitant in Italian municipalities was 544.5 kg. If we compare this figure with the average for 2018, we can see that the average amount was reduced by about 10 kg per person in just one calendar year.

D.2 Percentage of separate collection.

The most efficient and sustainable solution to overcome the worthless accumulation of waste is separate collection. The uptake of separate collection practices in urban areas has continued to grow in recent years and now stands at a national average of 54.3%, four percentage points higher than the previous year (50.4%) and as much as seven points higher than in 2016 (47.4%). In recent years, a number of policies and services have been adopted and introduced by municipalities to help and encourage citizens to recycle waste properly, including door-to-door collection of municipal waste which, in some cases, also ensures the proper disposal of bulky waste and that classified as "special waste", such as used cooking oil.

D.3 Percentage of citizens using door-to-door waste collection services.

As the data shows, in a large number of the cities analysed (regardless of geographical location) the service is inefficient or non-existent, such as in Florence, Pescara, Venice and Verona. However, an overall analysis of the data again shows a significant difference in the quality of the service between the North and South of the country. Only northern municipalities guarantee 100% door-to-door collection rates, such as Milan, Bergamo and Brescia.

D.4 Percentage of water purification.

This indicator shows how efficiently each city purifies waste water before it ends up in the sewerage system. The results are positive: the treatment rate of the urban water purification networks of around half of Italian cities is over 90%. The worst performers are Treviso, where only 33% of urban water is purified, and Catania, at 56%.

D.5 Daily water consumption.

In Italy, annual domestic water consumption is around 200 litres per capita per day, but in some cities this figure is well above average: Milan is a classic example, where average

water consumption stands at 275 litres per inhabitant/day.

D.6 Concentration of fine particles (PM10) in the air.

The last environmental problem analysed related to waste as pollution is air quality. The ISTAT data analysed indicates the number of days on which air quality meters located in provincial capitals show that the safe limit for human health of PM10 was exceeded.

Based on the data collected, the most polluted cities are Turin and Milan, where the safe limit was exceeded on 75 and 73 days in a single calendar year, respectively. The results of these two regional capitals are affected by the large number of polluting industrial sites and factories in the vicinity. The following table shows the overall data obtained from the cities considered:

Table 4: End of life

City	Municipal waste [kg/inhabitant/year]	Separate collection [%]	Door-to-door waste collection [%]	Water purification [%]	Water consumption [litres/inhabitant/day]	PM10 concentration
Aosta	471	67.3	91.2	100	N/A	12
Bari	613	43.1	15.6	95	136.5	14
Bergamo	523	71.4	99.4	97	183.4	53
Bologna	597	52.9	10.7	99	152.8	33
Brescia	584	66.9	100	97	224.4	56
Cagliari	582	36	100	97	161.5	50
Catania	733	7.7	16	56	N/A	10
Florence	641	51.4	1.4	96	136.8	24
Genoa	486	33.3	N/A	100	121.9	11
Milan	504	59.7	100	100	274.7	73
Naples	527	36	50.4	95	150.3	58
Palermo	572	16.2	29.6	61	140.3	45
Perugia	580	64.5	100	85	139	23
Pescara	585	36.2	0.1	91	176	36
R. Calabria	396	44.8	95.1	96	240	8
Rome	605	43.9	33.9	87	165.2	41
Turin	512	45.7	54.5	100	197.6	75
Trento	465	85.1	0.1	99	150.2	19
Venice	640	59.4	0	72	164.3	73
Verona	527	48	0	84	177	50

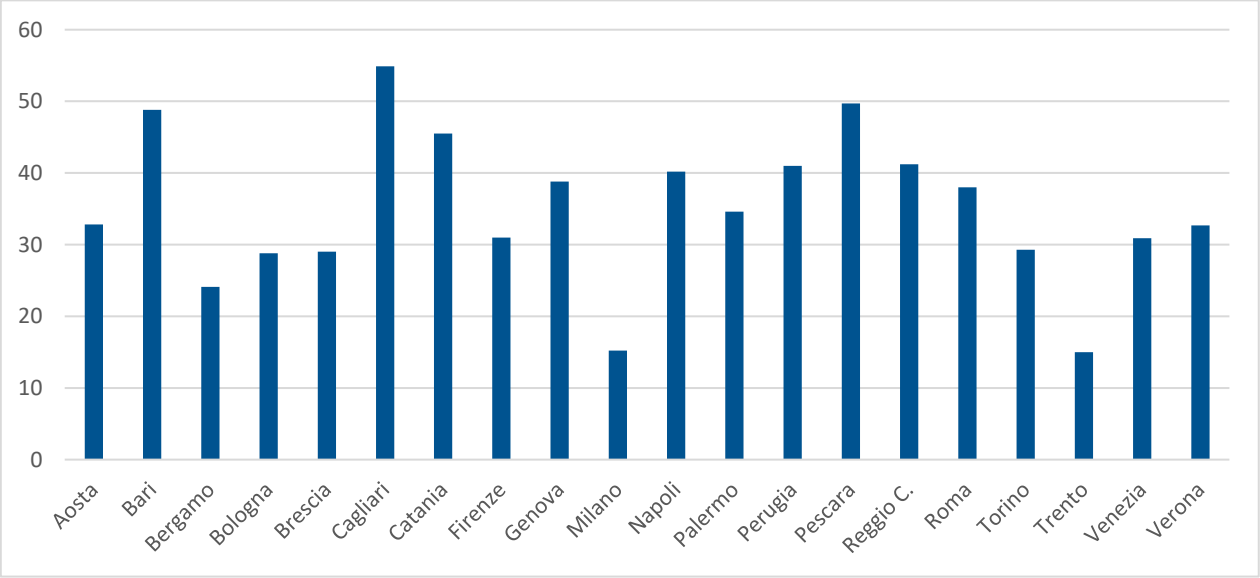
e. Resource efficiency indicators

As regards the last cluster examined, "efficient use of resources", and in order to close the economic cycle completely by preventing unnecessary waste, cities are required to make the best use of the resources available to them. The three main resources (water, land and labour) available to cities and the management of consumption or waste were analysed. We also added a new indicator that shows the sustainable research and innovation policies implemented by society to drive resource efficiency. The indicators analysed are:

E.1 Efficiency rate of public water networks.

The first ISTAT indicator analysed shows the efficiency of a city's water network, i.e. the percentage difference between the amount of water distributed and the amount actually consumed by users. In order to estimate the potential leakage, the share of drinking water fed into the network but not actually consumed for industrial, agricultural or civil use (domestic, services, public uses) is considered as leakage. On the other hand, in addition to actual physical leakages, all other water waste due to malfunctioning or poor maintenance of the network, spills and holes in tanks, theft and unauthorised withdrawals, is calculated implicitly. In many cities, such as Cagliari, Pescara and Bari, leakage amounts to 50% of water pumped into the network, i.e. one litre wasted for every two litres of drinking water fed into the water supply. These results are all the more alarming given the limited amount of water resources available.

Figure 11: Water network efficiency (%)



E.2 Percentage land use efficiency;

Land use efficiency is defined as the percentage of land devoted to the use and construction of infrastructure. Large cities play an important role in terms of land consumption and use. Large cities occupy just 6% of Italian land area, but their consumption accounts for 15% of the total. Compared to the rest of the country, where the largest share of land is occupied by infrastructure, in

regional and provincial capitals land is mostly used for housing: according to ISTAT figures, 42% of the population of Italy (about 25.8 million people) lives in the 16 main metropolitan areas. In order to attribute a value to efficient and sustainable land consumption, we awarded a score (from 0 to 10) that includes the two indicators under examination: per capita land consumption and "land use efficiency", which measures changes in land use in relation to residents.

E.3 Number of sustainable Eco-patents filed.

This represents patents as a measure of sustainability based on the number of patents filed by municipality in Italy. The data analysed indicates the number of economic patents in matters of sustainability filed with the European Patent Office (EPO). This is an important indicator of how far along the linear-circular transition Italian cities are, as it shows level of interest and engagement of municipalities and citizens in sustainable research and innovation. Each city needs to foster and encourage the development of patents for advanced and sustainable technical innovations, in order to include them in new production and consumption systems as soon as possible.

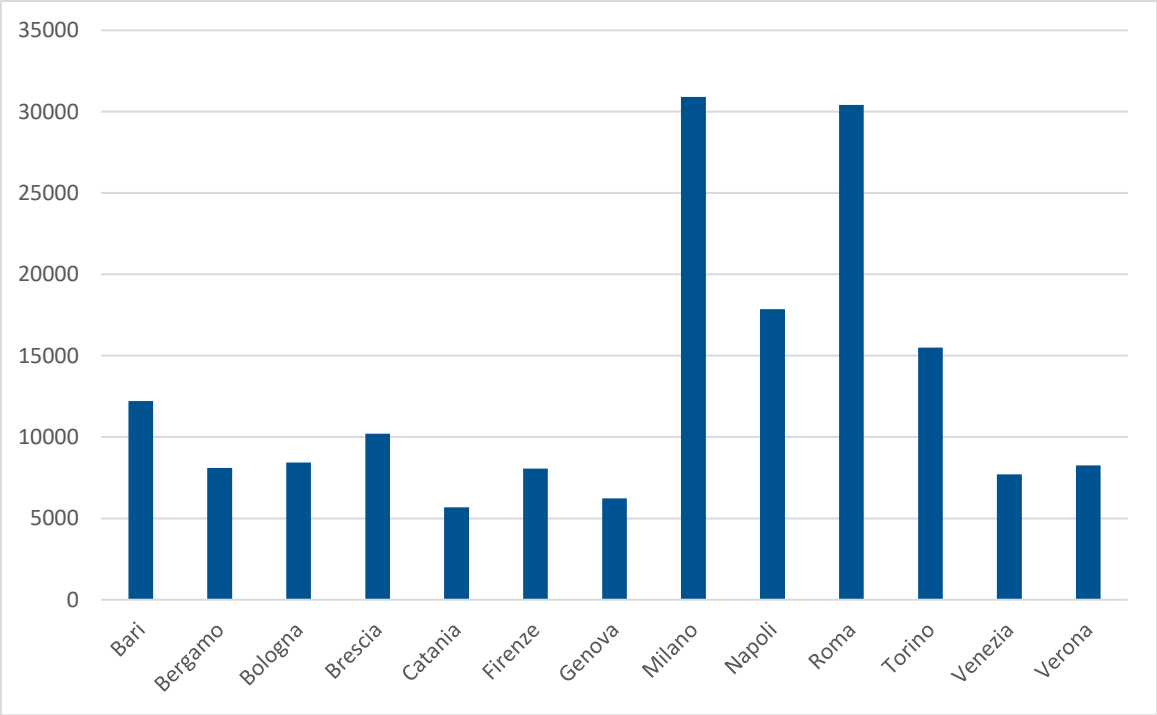
E.4 Number of workers employed in green jobs in 2018.

E.5 Absolute number of companies investing in the green sector.

E.6 Green businesses as a percentage of the total number of companies in the province.

Using the last three indicators, work and business activities in the circular economy were considered as a resource for the development of Italian cities. In more detail, we assessed the efficiency of human resources employed in the circular sector in Italian municipalities. In Italy, over three million workers are employed in the circular sector and the number of so-called "green jobs", i.e. jobs that make a significant contribution to preserving or restoring environmental quality, is growing all the time. In fact, in the year 2018 alone, the number of green jobs increased by 3.4% compared to 2017 (which corresponds to more than 150,000 jobs), indicating that the general trend in large cities and large companies is to move towards the current circular economy model: suffice it to say that in 2018 63,242 new workers were employed by companies and businesses actively operating in the sustainable sector in the municipality of Milan alone, which accounts for 13.4% of the total number of workers hired during the year. The largest number of green companies can be found in the cities of Milan and Rome, with 30,902 and 30,406 respectively. The number of companies (in absolute terms) that have adopted the circular economy model is shown in the following graph taken from the annual report of the association GreenItaly.

Figure 12: Workers and green companies



The following table shows the overall data obtained:

Table 5: Resource efficiency

City	Water network efficiency [%]	Land use efficiency [€]	No. of sustainable patents	Workers employed in green jobs in 2018 [%]	Companies that invest in green sector	Green companies as a percentage of total enterprises in the province [%]
Aosta	32.8	6.25	51.24	N/A	N/A	N/A
Bari	48.8	5.2	15.22	2.1	12,214	32.40
Bergamo	24.1	9.35	116.21	2.5	8,095	30.70
Bologna	28.8	9.35	199.56	2.6	8,430	33.60
Brescia	29	7.75	75.72	1.4	10,201	30.60
Cagliari	54.9	8.65	7.58	N/A	N/A	N/A
Catania	45.5	6.25	5.61	N/A	5,671	28.70
Florence	31	7.95	73.91	1.7	8,068	28.20
Genoa	38.8	7.6	73.49	1.6	6,228	32.60
Milan	15.2	10	96.53	13.4	30,902	35.10

City	Water network efficiency [%]	Land use efficiency [€]	No. of sustainable patents	Workers employed in green jobs in 2018 [%]	Companies that invest in green sector	Green companies as a percentage of total enterprises in the province [%]
Naples	40.2	8.6	9.48	3.5	17,866	30.40
Palermo	34.6	8.25	4.83	N/A	N/A	N/A
Perugia	41	6.05	38.89	N/A	N/A	N/A
Pescara	49.7	6.55	24.06	N/A	N/A	N/A
R. Calabria	41.2	5.9	6.36	N/A	N/A	N/A
Rome	38	8.65	28.89	7.9	30,406	31.50
Turin	29.3	7.9	116.36	5	15,499	33.20
Trento	15	7.4	54.45	N/A	N/A	N/A
Venice	30.9	3.9	59.22	1.3	7,709	33.70
Verona	32.7	4.9	77.25	1.8	8,258	34.20

4. Ranking of the most Circular Italian Cities

On the basis of the twenty-six circular indicators, the results were analysed by drawing up a symbolical ranking of the most circular Italian cities. For each indicator a partial ranking of the cities was drawn up, and according to the position reached on each ranking, each city was assigned a score (rank) of between 0.5 and 10, in order to be able to compare the results achieved. The objective was to develop an Urban Circularity Index (UCI) which is based on the weighted average of the scores obtained from the valuation of partial indicators: the final score, i.e. the sum of all the partial scores obtained in the various tables, is divided by the number of indicators used in the research. The following table shows the results achieved by the various cities and the associated UCI:

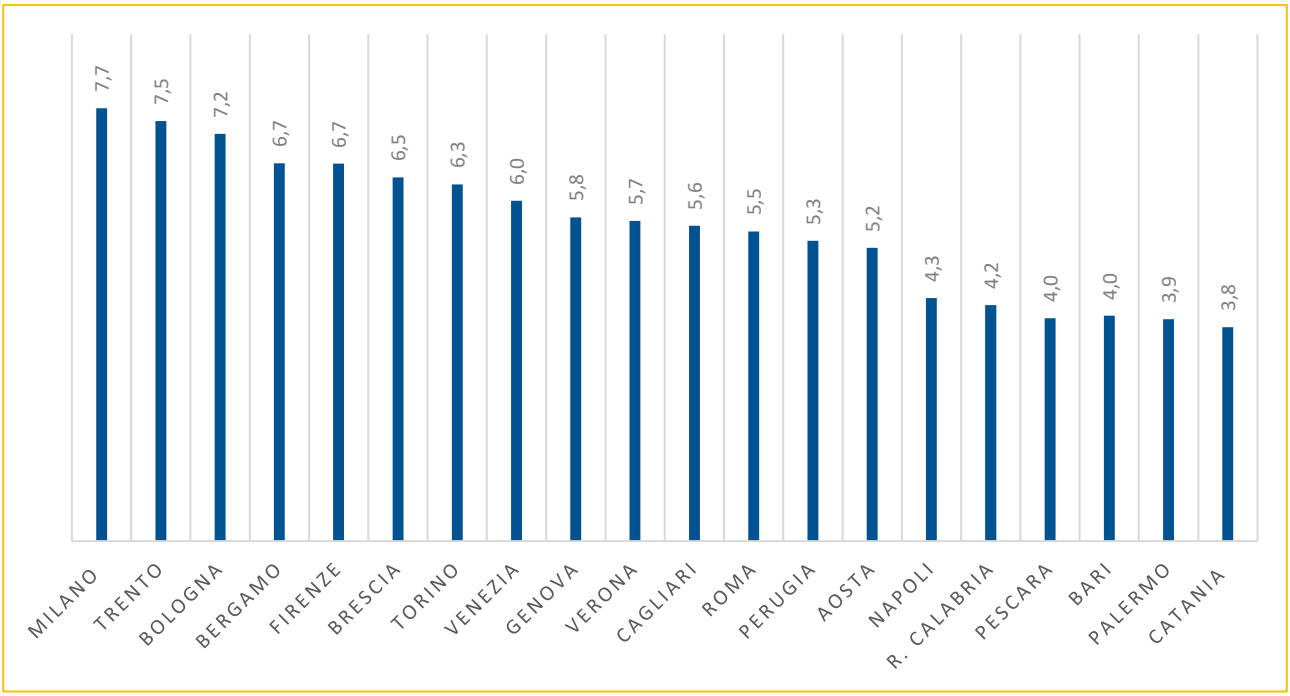
Table 6: Circularity index

City	Sustainable Inputs	Social Sharing	Use of goods as a service	End of life	Resource efficiency	UCI
Aosta	4.0	4.1	3.0	9.2	5.0	5.2
Bari	2.2	3.6	4.4	6.1	2.5	4.0
Bergamo	6.8	6.1	5.4	6.9	9.2	6.7
Bologna	7.9	6.0	8.0	6.0	9.3	7.2
Brescia	6.6	6.7	6.4	6.0	7.3	6.5
Cagliari	6.6	5.0	5.8	5.8	3.8	5.6
Catania	4.6	3.6	3.2	4.8	2.5	3.8
Florence	5.2	7.9	7.6	5.9	7.0	6.7
Genoa	4.5	4.8	6.6	7.1	5.5	5.8
Milan	7.7	7.4	8.5	6.4	9.3	7.7
Naples	3.9	3.3	3.6	5.7	4.8	4.3
Palermo	2.9	3.1	4.1	5.1	4.5	3.9
Perugia	7.2	4.0	3.2	7.5	3.8	5.4
Pescara	5.5	2.8	3.2	4.7	3.2	4.0
R. Calabria	4.4	2.7	3.1	7.3	2.5	4.2
Rome	3.5	6.7	6.5	5.0	5.8	5.5
Turin	5.4	7.4	5.9	5.8	8.0	6.3
Trento	8.4	8.1	6	7.8	7.0	7.5
Venice	7.3	5.4	8.4	4.1	5.0	6.0
Verona	7.5	6.3	4.6	4.8	5.5	5.7

As can be seen from the table, the most circular city of those analysed is Milan, with a score of 7.7 out of 10, followed by Trento and Bologna.

The overall ranking of cities, based on the global circularity indicator, is as follows:

Figure 13: Ranking of circular cities



The ranking clearly shows a marked difference between Northern and Southern Italy: the top 10 cities in the ranking are located in Northern or Central-Northern regions, while the bottom positions are held exclusively by cities in Southern Italy. The difference between North and South is less surprising than the difference between North and Central Italy. The top cities in central Italy are Rome and Perugia, which manage a mere 12th and 13th place, both scoring below the "pass mark" (5.5 and 5.3 respectively). The only city in Northern Italy to score below the "pass mark" is Aosta, with 5.2 points. The worst performer of the twenty Italian cities analysed is Catania: the Sicilian city is ranked in last place as the least circular city in Italy, with just 3.8 points, 0.1 lower than the score of another big city in Sicily, Palermo. The results of the ranking by global circularity index are not encouraging on the whole: in fact, just eight municipalities of the twenty considered currently manage to achieve a satisfactory score based on the circular indicators analysed. Moreover, the significant regional differences represent a real obstacle for the growth of the circular economy in Italy: for individual cities it is difficult, if not impossible, to introduce innovative circular policies for their own development when neighbouring, urban areas are lagging behind. Synergy is needed among the various municipalities at a local level. As a result, there is a risk that Northern cities will continue to progress while those in the South will fall behind, thus widening the gap.

4.1. The results: preliminary considerations

As the results of our analysis of the indicators show, the city with the highest global index of urban circularity is Milan. With a score of 7.7/10, the capital city of Lombardy is the most circular city in Italy. According to the analyses, the city of Milan ranks first in two of the five circular economy clusters. With regard to sustainable mobility in particular, it scores an 8.5/10. Indeed, in recent years, Milan has adopted a new Urban Sustainable Mobility Plan with the aim of radically changing mobility over ten years by promoting sharing alternatives, improving cycle routes and creating a transport system called "Mobility as a Service". The purpose of the new transport system is to create a single transport ticket that is valid for all types of services, including car sharing. This represents the main offer of this new type of service: the number of shared vehicles in Italy grew almost five-fold between 2013 and 2018, while the number of members and rentals increased by eighteen and thirty-seven times respectively. Milan is the top performer once again, with the largest offer and variety of car sharing in Italy. By analysing the data collected, we can see that there are more shared cars on the streets of Milan alone than there in the whole of the rest of Italy. In addition to traditional petrol-powered vehicles, there is choice of electric vehicles, mopeds, bicycles and, in the last two years, electric scooters. In fact, it is no coincidence that the offices of the two main start-up companies offering this type of service, Enjoy and Car2go, are located in Milan. In the field of sustainable mobility, Milan is not just the leading city in Italy, but, according to recent statistics produced by the British company Mobility Futures, it is ranked sixth among the top performing cities in the world in this area. The second field in which Milan ranks first is resource efficiency: in this partial ranking it scored 9.3/10 and is the only Italian municipality to obtain the maximum score in terms of land use efficiency. This is the result of a targeted urban renewal initiative launched by the City Council to revitalise Milan's suburban neighbourhoods and foster environmental regeneration of derelict areas. Milan's lowest score can be found lowest in the fourth macro-area analysed (End of Life). In this area, Milan's performance is inconsistent and fluctuating, thus affecting its final score. Lombardy's capital is one of the top performers in Italy in terms of indicators relating to the production of municipal waste and the associated separate collection practices. In two out of five indicators (separate door-to-door waste collection and water purification) it obtains the maximum score of 10 and is ranked first in the partial ranking.

However, Milan ranks seventh in the partial ranking *End of Life* related to municipal waste. This result, the worst recorded by the regional capital of Lombardy, is impacted by high daily water consumption (the highest in Italy) and the high concentration of fine particles (second worst result in Italy after Turin).

Due to the excessive number of highly polluting companies in the surrounding area, in terms of the partial PM10 concentration indicator Milan scores just 2 points. In the remaining two areas analysed (Sustainable Inputs and Social Sharing), Milan scores an average of 7.7 and 7.4 respectively and, in both cases, ranks third behind Trento and Bologna/Firenze. In these areas, the main critical issues in Milan, in addition to those already discussed, are related to the green areas available as a percentage of total surface area and solar energy production. Despite this, Milan has undertaken a number

of environmental rehabilitation and reforestation initiatives in recent years.

In 2019, the City of Milan launched an initiative called "ForestaMI", a project with the ambitious target of planting 100 thousand trees this year alone, in order to reach three million plants by 2030, one for each person living in the metropolitan city area.

4.2 Relationship between the urban circularity index and quality of life

We thought it appropriate to compare our ranking with another important evaluation of the quality of life in Italian cities that is updated annually by "Il Sole 24 Ore". This allows us to establish a relationship between circular economy and quality of life, understood as the level of individual well-being of residents in relation to the socio-cultural and environmental context in which they live. Three pairs of socio-economic values are taken into account for this analysis: environment and services, wealth and consumption, business and employment. According to the ranking system used by Il Sole 24 Ore, the best performing cities are awarded one thousand points and the worst performing cities zero points, with those in between awarded a score in proportion to the gap between each of their scores and the highest and lowest scores. For each category, fifteen indicators were analysed, and the final result is based on the arithmetic average of the scores attained in the partial rankings. Using the same criteria adopted in previous analyses, each value recorded by the cities is assigned a score (rank) from 0 to 10 in proportion to the results obtained in the ranking. This ranking also shows a clear difference between North and South: ten of the first eleven cities are located in the North or Central-Northern regions, the only exception being Cagliari (as in the analysis performed for the UCI index). By analysing the QLI and UCI rankings, we see that some cities hold the same position in both rankings. Milan and Trento are first and second respectively, while Palermo and Catania hold the bottom two positions. The only cities that show markedly different scores in the two rankings are Aosta and Bergamo. Bergamo obtained an insufficient score on average in all categories analysed in the QLI ranking, coming in at 11th, while in terms of UCI it ranks 4th. Aosta, on the other hand, obtained insufficient scores on the UCI ranking, at 14th while in the QLI ranking comes in at 5th place with a final score of 7.83. The ranking of Italian cities by quality of life (QLI) was drafted in order to compare and contrast the qualitative values of cities with the results obtained from the UCI index regarding the adoption of the circular economy model in urban areas, in order to establish a possible correlation between the variables.

5. A preliminary comparison of European cities

After analysing the situation in Italy, we believed it would be interesting to attempt to compare performances in Europe. In order to do this, we compared Milan, the leading circular city in Italy, with some important European cities. To begin with, we examined the following cities, in alphabetical order: Amsterdam, Berlin, Brussels, Copenhagen, London, Madrid, Milan, Paris and Prague. As with the previous analysis, circularity indicators were calculated for each of these cities, and divided into five clusters. A partial ranking and a final ranking were drawn up for each indicator.

Figure 14: Clusters and partial indicators

The five clusters representing the circular economy are: social sharing and sharing economy, water and air pollution, waste management, renewable energy sources and sustainable inputs, sharing mobility. For each of these categories, indicators were calculated, and partial rankings were drawn up to compare the level of circularity in individual cities in each of these sectors.

5.1 Social sharing and sharing economy

In this cluster, the sharing economy is examined in addition to the participation of all players within the economic systems. This is a new market model in which relations between players take place through the use of technology and the Internet. The indicators analysed are:

Citizen satisfaction

For this indicator, data was obtained from a Eurostat survey. Citizens were asked to rate their satisfaction with various aspects of life in the city on a scale of zero to ten. This data allows us to establish the value that citizens apply their cities and the way they are managed by local authorities. The indicator was obtained based on the arithmetic mean of the following aspects: satisfaction with employment, public transport, green areas, living environment.

Use of collaborative platforms

This indicator measures the level of sharing economy practices. These are online platforms that provide access to services such as carpooling, home food deliveries, bike or scooter rental. These services represent the new frontier of urban life and have been expanding steadily in recent years. Paris scored the highest, followed by Berlin, Madrid and Milan. Based on the average of the results obtained in the individual categories, the final ranking was calculated as follows:

Table 8: "Social sharing" cluster final score

City	Final score
COPENHAGEN	4.00
BERLIN	3.75
PARIS	3.75
AMSTERDAM	3.50
LONDON	3.00
MADRID	2.75
PRAGUE	2.50
MILAN	2.25
BRUSSELS	2.00

As we can see, the most circular cities in terms of social sharing and sharing economy are Copenhagen, Berlin and Paris, with a substantial lead on other cities and very good results in all the partial indicators. Residents of these cities perceive the highest level of social wellbeing.

5.2 Water and air pollution

The second cluster examined analyses two very important aspects in cities: air pollution and the water cycle. It is important to note that in this case, for some indicators such as air quality or traffic congestion, the higher the value the less circular the city (e.g. because it is more polluted), so a high value will be given a low score and vice versa. The indicators examined in this cluster are:

Per capita consumption of water in litres

Milan is the city with the highest level of consumption, with almost 90 litres of water consumed per capita more than Paris, which ranks eighth. Excluding Milan, where consumption is at 274 litres/inhabitant, cities record per capita consumption of 100 litres on average. The most virtuous city is Brussels with consumption of 93 litres per capita.

Water purification

This measures water quality. In the cities examined the level of purification is very high. The only city that deviates from the norm is Brussels, which, although high, is around ten points below other cities.

Per capita greenhouse gas emissions

This is an important indicator of pollution levels. Paris, Madrid, London and Copenhagen record the lowest level of emissions per capita, partly thanks to recent policies

adopted by authorities to reduce emissions and the environmental impact. They have all joined the "C40 Cities" network, a global network of large cities working to develop and implement policies to reduce greenhouse gas emissions and the environmental damage caused by climate change.

Traffic congestion levels

This indicator represents the average percentage increase in the travel time of a car journey due to city road traffic. In this case, London and Paris are the most congested cities, while the levels found in Madrid and Copenhagen are very positive. Milan is roughly halfway down the ranking. The final ranking is structured as follows:

Table 9: Final score for air and water pollution clusters

City	Final score
MADRID	3.00
COPENHAGEN	2.75
PARIS	2.33
LONDON	2.25
MILAN	2.17
PRAGUE	1.92
BERLIN	1.83
BRUSSELS	1.75
AMSTERDAM	1.75

In this cluster, the most circular cities are Madrid and Copenhagen. Generally speaking, we can say that all the cities examined, with the exception of the first two in the ranking, are highly polluted and for this reason the European Union has taken common measures for all Member States.

5.3 Waste management

As we know, waste management is a key aspect of the circular economy. Reuse of materials and the extension of the useful life of products are two mainstays of this model. Therefore, efficient management of municipal waste is essential for the adoption of a circular economy model. The indicators examined in this cluster are:

Recycling rate

This represents the percentage of waste that is reused for the production of new goods. This indicator allows us to establish how active and efficient municipal waste recycling systems are. Milan recycles almost two thirds of its total waste and Berlin also boasts very high recycling rates. The remaining cities analysed show rates of around 50% and the worst performers are Madrid and Prague, which only recycle just over a third of the waste produced.

Waste per capita

This partial index allows us to measure the amount of municipal waste, i.e. the waste produced annually by each citizen.

Amsterdam, Milan and Paris are the worst cities with a respective 513, 504 and 489 kg of waste produced per inhabitant. The highest-scoring cities are Madrid and Prague with 329 and 322 kg of waste produced annually by each inhabitant, respectively. Waste per capita in all other cities is at around 400 kg.

Percentage of separate collection

This measures the amount of waste collected separately as a percentage of total waste generated. The transition to a circular economy is facilitated by high levels of separate collection that allow for better recycling of waste and less wastage of resources. The cities with highest levels of waste separation are Milan, with 59.7%, and Brussels, with 55%. Indeed, in recent years these two cities have adopted various policies to encourage waste separation. In almost all cities there is a positive correlation between the amount of waste recycled and the level of separate collection.

Waste destined for landfill

This indicator shows how much waste is disposed of in landfills as a percentage of total municipal waste. Madrid and Prague rank in the last two positions with 57% and 50% of waste going to landfill, respectively. Once again, there is a correlation between these values and separate collection levels. Low levels of separate collection are associated with a high level of landfill use and poor waste recycling. Conversely, more virtuous cities such as Brussels, Milan, and Berlin, which have higher rates of separate collection and recycling, also have lower rates of waste disposal in landfills.

Number of workers employed in the recycling chain compared to the population

This indicator represents the number of workers employed in the recycling sector taking into account the total population in the individual cities. London ranks first with 0.000896 workers employed in the recycling sector in proportion to the local population. Milan is in second place at 0.000507, where 1,572 are workers are employed in the recycling chain out of a population of 3,100,000 inhabitants. Prague ranks last with just 106 inhabitants employed in the recycling sector out of a population of 1,700,000.

Productivity of resources (Euro/kg)

The last partial indicator is an economic measure calculated as the ratio of GDP to raw material consumption. Unlike other indicators, this is a national indicator. High values represent a greater production capacity of the country and a better use of natural resources for the production of goods. Amsterdam scores highest, reflecting that of the Netherlands, with productivity at 4.10 Euro/kg. The average value for this indicator is 2-3 Euro/Kg. The final ranking based on the average of the results obtained from the partial indicators is as follows:

Table 10: Final score for the waste management cluster

City	Final score
MILAN	4
BERLIN	3.66
AMSTERDAM	3.66
LONDON	3.5

BRUSSELS	3.25
COPENHAGEN	3.00
PARIS	2.83
MADRID	2.83
PRAGUE	2.08

Milan is the second most circular city in terms of waste management after Berlin. The last positions in this cluster are held by Madrid and Prague, which both have inefficient waste management systems.

5.4 Renewable resources and sustainable inputs

This cluster includes indicators related to the use of renewable resources and those concerning more generic inputs. Specifically, we have identified the following:

Percentage of renewable resources used in the production of goods

This indicates what percentage of total goods are produced using renewable energy sources. The best performing city is Copenhagen, with 36% of products made using renewable resources. In recent years it has implemented “renewable islands” and is now a top player in this field, so much so Denmark aims to achieve a target of 100% of energy generation from renewable sources in all sectors. Milan reports a good percentage, 18%, in fact renewable energy in Italy is a rapidly expanding sector. Suffice it to say that 40% of electricity produced in Italy comes from renewable sources. At the bottom of the ranking we find London with just 9.3%, as oil is still the most widely used energy source.

Percentage of renewable sources used in transport

This index is also calculated as the ratio of renewable resources used in transport to total energy resources consumed by transport. Berlin, Paris and Copenhagen are the most virtuous cities, but the other cities are also moving closer to their results. On average, 6% of resources used for transport come from renewable sources. The European Union aims to increase this level by introducing incentives to switch to renewable sources, especially in the transport sector.

Circular Material Use Rate (EOL-RIR)

This stands for "End of life Recycling input rates", i.e. the ratio of recycled materials to demand for raw materials. How much recycled raw materials are reused vs. the total demand for raw materials. Amsterdam has the highest score, at around 10 points ahead of Paris in second place. The Netherlands was one of the first countries to move in this direction.

Useable green areas

This partial index is calculated as the ratio of green areas available to citizens to total city surface area. London is the city with the most usable urban green areas. Copenhagen and Paris also achieve positive results, ahead of other cities by almost 10 points.

Patents for recycling and secondary raw materials

This is a national figure and indicates the number of patents for the recycling of secondary raw materials per million inhabitants. A large number of patents indicates a strong innovative drive for sustainable development as they stimulate investment in research and development by giving patent holders the exclusive right to use them for commercial purposes. In Germany, we find the highest number of patents per million inhabitants, followed at a considerable distance by France. It is worth noting that the number of patents for the recycling of secondary raw materials increased by as much as 35% throughout Europe between 2000 and 2013, most of these patents concerning the recycling of glass and plastic (European Commission). The overall results obtained are summarised as follows:

Table 11: Renewable resources and sustainable inputs - final score

City	Final score
PARIS	4.20
BERLIN	3.70
COPENHAGEN	3.40
MILAN	3.40
BRUSSELS	3.30
AMSTERDAM	3.20
LONDON	3.00
MADRID	2.90
PRAGUE	2.50

The most circular city in terms of the "Use of renewable resources and sustainable inputs" is Paris, followed by Berlin, Copenhagen and Milan. As already mentioned, these cities have made several investments in this sector in recent years and the results are clear.

5.5 Sharing mobility

Shared mobility refers to the shared use of a vehicle, bicycle or other mode of transport. This is a transport strategy that allows users to access transport services as needed. The indicators analysed in this cluster are:

Km of Metro for every hundred thousand inhabitants

This indicator is important as in order to achieve effective urban circularity it is important that public transport, and in this specific case the Metro, is efficient and meets the needs of residents by representing a valid alternative to the use of their own car. Madrid offers 8.9 km of Metro for every hundred thousand inhabitants and has one of the largest networks in Europe, ninth in the world. Next, we find Copenhagen and Milan, which in recent years have expanded and modernised their Metro networks.

Means of transport for every hundred bike journeys

This indicator tells us the number of bike journeys for every 100 journeys. We are not surprised by the figures from Brussels, Amsterdam and Copenhagen, where cycling as a means of transport is part of their popular culture. These cities boast very many kilometres of cycle paths, the highest numbers in Europe. Belgium recently joined the Dutch cycle network project and is achieving good results. In Denmark, use of "cargo bikes" is widespread, i.e. bicycles that allow the rider to transport almost anything: people, animals, shopping bags. Parents often take their children to school using this type of transport. Madrid, Prague and Paris perform poorly.

Means of transport for every hundred journeys on foot

Like in the previous case, this indicator shows the number of journeys made on foot out of every hundred journeys. Madrid and Prague, unlike in the previous case, are the cities where walking is most prevalent. This is helped by the fact that these cities have very large pedestrian zones and based on, like-for-like journey times, people would rather walk than take public transport. Milan, with 12 journeys on foot out of 100, is halfway down the ranking, and Brussels, with only three journeys out of 100, is in last place.

Means of transport for every hundred journeys by public transport

The last indicator of this cluster takes into account public transport, which according to the principles of the circular economy should be encouraged and used predominantly given that they pollute much less than cars by transporting more people at the same time while producing less CO2. The city with the highest rate of public transport use is Paris, with 68 out of 100 journeys made using public transport. Paris has an efficient public transport service, and many investments have been made in recent years to expand and modernise the rail and metro network. It is followed by London. Milan is halfway down the ranking at 38 journeys out of 100. In past place we find Copenhagen, but as we have seen from previous indicators, residents prefer other means of transport such as cycling. The overall results, calculated as the average of the results obtained in the partial rankings, are as follows:

Table 12: Sharing economy and urban mobility - final score

City	Final score
COPENHAGEN	3.63
MADRID	3.50
AMSTERDAM	3.25
LONDON	3.13
MILAN	3.13
PRAGUE	3.00
PARIS	3.00
BERLIN	2.88
BRUSSELS	2.38

The most circular cities according to this cluster are Madrid, Paris and Copenhagen. Residents prefer more circular means of transport than those in the other cities considered. The least sustainable city is Brussels where residents prefer to travel by car.

5.6 Ranking of Europe's most circular cities

After analysing the results of the partial rankings for each cluster, we obtained the final ranking and the final circularity index, which was created based on the arithmetic mean of the final cluster rankings.

Table 13: urban circularity index

CITY	RANKING
COPENHAGEN	3,26
PARIS	3,21
BERLIN	3,18
MILAN	3,13
AMSTERDAM	3,10
LONDON	3,05
MADRID	2,98
BRUSSELS	2,69
PRAGUE	2,39

Based on the data available to us and taking into account the results obtained in the five clusters, the most circular city is Copenhagen with an average score of 3.26 out of 5. In second place we find Paris with a score of 3.21 out of 5. Milan ranks fourth with an average score of 3.13 out of 5.

Conclusions

With this report, for the second year CESISP has updated its research project aimed at developing indicators to map the degree of urban circularity of the main Italian cities. This project, undertaken in 2019 using the ten largest urban areas in terms of population as a sample has been updated to include the 20 most important Italian cities in terms of urbanisation.

If we consider the growing importance of urban areas within the economic system, cities are a strategic reference point in terms of policies for the sustainability and quality of life of the population. From a methodological point of view, we do not consider the measurement of city performances to be complete but intended to make a contribution to the assessment of the impact of environmental policy regulation on the resolution of important long-term problems in modern economies. In this second edition, Milan takes first place once again thanks to its large and well-respected public transport systems, advanced car sharing services,

efficient water network, effective separate waste collection and high turnover from used goods sales.

Our measurement of circular economy practices in the top 20 Italian cities by population has provided a numerical value to the five clusters or pillars of the circular economy: re-use of resources, social sharing, environmental sustainability, sharing of assets and the efficient use of goods and resources.

The objective of the study is to establish the relationship between the new circular economy model and Italy by analysing the level of circularity achieved.

At the same time, the model analysed is intended as a tool to support environmental policies in urban areas in response to the climate and environmental crisis. It is clear that the results differ substantially, particularly between North and South.

Results are encouraging in the "circular triangle" consisting of Lombardy, the Triveneto area and Emilia-Romagna and are about twice as high those recorded in Southern Italy. The worst result is to be found in Sicily, with the two cities (Palermo and Catania) positioned in the bottom two spots of the final ranking. This region proved unable to exploit the potential for action thanks to its status as an autonomous region and has wasted enormous opportunities.

At the opposite end of the scale, we find Milan, which is the most circular city. This is thanks to the careful planning of the Milanese authorities, which have led the way in Italy, and are among the first in Europe to have applied and benefited from the principles of the circular economy. The only cities that are close to achieving Milan's results are Trento and Bologna.

In this edition of the urban circularity index, we made a preliminary comparison between Milan and eight other important European cities. The results of this second analysis show that Milan is ranked fourth among the nine cities analysed. The most circular European city in our sample is Copenhagen, which has achieved excellent results, ranking in the top positions in all clusters except for "waste management", where it ranks fourth-to-last. Conversely, the least circular European city in our sample is Prague. However, on the whole, almost all cities obtained an average score of almost 3 out of 5 points, with the exception of Prague and Brussels which hold the bottom two spots. The development of a system to measure the circular economy in European cities is a key area in which CESISP intends to play an important role in order to support public decision-makers. The main purpose is not so much to draw up a ranking - although this is still useful for encouraging virtuous behaviour, in comparative terms - but rather to offer an analysis to be made available to the various Administrations in order to help them understand the strengths and weaknesses of their policies. It is the Authors' belief that the challenges of sustainability and circular economy depend primarily on policies and local services available to citizens that are able shape the urban environment and promote an inclusive, waste-free and fairer economic system.

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