



# CIRCULAR CHARLOTTE

Towards a zero waste and  
inclusive city



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# EXECUTIVE SUMMARY

Charlotte is the first city in the United States to make a political commitment to adopting the circular economy as a municipal strategy. In its circular future, all of the material resources that now end up in landfills will be the basis for Charlotte's next industrial revolution: the foundation for an era of green manufacturing that unlocks new technological advances, increases local resilience, and supports inclusive development.

Our report, "Circular Charlotte: towards a zero waste and inclusive city", explores how Charlotte can start implementing a strategy to become the first circular city in the United States. We investigate how many valuable resources are currently lost through Charlotte's waste system, and how these could be diverted into new, high-value uses. We present a vision, co-created with stakeholders from the city, for how a Circular Charlotte could look and function. Finally, we describe a roadmap of actions that should be taken on the pathway towards this vision, and detail five initial business cases that can serve as a starting point for action.

## Growth brings transition opportunities

Charlotte is in the midst of a building boom. This expansion of the city points to Charlotte's increasing popularity as a place to live and work: it is now ranked as one of the fastest-growing metropolitan regions in the United States (Thomas, 2018) and was recently named the number one city for attracting millennials (Abadi, 2017). Beyond changing physically, Charlotte is undergoing a broader transformation in its character, evolving from a banking-focused city with a history of manufacturing and logistics, to a dynamic urban center with unique specialties in high-tech industry. This growth is not only an opportunity to cash in on Charlotte's successes, but also to address challenges, such as economic mobility, on which Charlotte is currently ranked lowest out of America's 50 largest metro areas (Chetty, 2017).

The circular economy – a new economic system that is regenerative and waste-free by design – can not only eliminate negative environmental impacts and create new sources of value, but also be used to bridge the wealth divide and create new pathways for upward mobility in Charlotte. Within a circular economy, products and materials are circulated at high value for as long as possible, extending the life of products and enabling high-value component and material recovery for reuse or recycling. The systemic transformation required for a circular economy – from the development of new technologies, to the evolution of new forms of collaboration and business models – has also been shown to have great potential in generating new employment and creating opportunities for skill development.

## THE CIRCULAR ECONOMY

The vast majority of our economic system can currently be defined as linear. We extract resources, which are then transformed to products via the use of labor, energy, and money, and then, soon after their use, these products are thrown away. Every time a product that we have crafted and manufactured with care ends up in landfill, not only do we lose the physical resources it is made up of, but also all of the time and energy that went into its creation. McKinsey estimated that up to 630 billion dollars a year is lost in Europe alone through the loss of materials in the linear economy (EMF & McKinsey, 2011).

In parallel, these material losses translate to unrealized employment potential. The U.S. EPA and the Institute for Local Self Reliance estimate that low-value activities that result in material losses (like incineration and landfilling), only generate 1–6 jobs per 10,000 tons of goods disposed of. Recycling generates an estimated 36 jobs for the same amount of material, while reuse and refurbishment are by far the biggest winners, creating almost 300 jobs for each 10,000 tons of "waste."

To move towards a circular economy, where the value-generating life-cycles of products are extended to the maximum extent possible, we should:

- Design all products for easy repair, disassembly, and full recyclability.
- Create the necessary business structures and incentives to get these materials back into the economy at their highest possible value (preferably as whole products or components).
- Strive to use only responsibly-sourced renewable resources for both energy and material provision.
- Avoid the use of toxic substances that may continue to circulate in our environment.

Successfully achieving this transition is not simply about product reuse and recycling: it means a systems change that requires a new mindset. Preserving the complexity and value of our products should be structurally incentivized, and negative impacts on people and the environment should be eliminated by design. This transition can be supported through alternative business models and purchasing patterns that will support the recovery of materials, such as leasing models and advanced approaches to extended producer responsibility (systems that make manufacturers responsible for what they create and sell, even after the products are sold). Perhaps most importantly, achieving this transition will require a shared vision and strong leadership from both government and civil society.

## VISION OF A CIRCULAR CHARLOTTE

If we take these high level ideas about the circular economy and actually apply them to Charlotte, what kind of changes would potentially take place? Here we envision, from a 2050 perspective, how Charlotte might look if it achieves the full spectrum of a circular economy. We have organized the vision around four thematic areas. For each of these four areas of performance, we have also developed Key Performance Indicators (KPIs) to monitor Charlotte's progress. Though some of

### CHARLOTTE AS A ZERO WASTE CITY



In 2050, Charlotte can proudly call itself a Zero Waste City, where 98% of all residual materials are separately collected. Every household is equipped with smart sorting containers with built-in sensors to tell users if they've sorted something incorrectly. Residents get Charlotte Coins paid directly into their digital wallets for every pound of correctly sorted waste. They can use their earnings for the purchase of local goods branded with the Circular Charlotte label, many of which have been remanufactured or grown from those same residual streams. If they have Charlotte Coins left over, they can also use them to pay for their fully-renewable energy bill, or even pay their taxes. A real-time resource monitoring platform, the Charlotte Circularity Dashboard, continuously reports how much is available of different kinds of residual goods – from citrus peels to old shoes. These resources are automatically diverted to various processing facilities throughout the city, run by large companies and small entrepreneurs alike. The Dashboard keeps a record of orders placed requesting different materials, and ships off materials to the earliest bidders. Due to Charlotte's strong position as a logistics hub, the city also accepts and processes materials from nearby counties, adding to the base of resources used for local manufacturing.

### CHARLOTTE AS A RESILIENT AND HEALTHY CITY



As other circular industries developed, Charlotte and its surrounding region became increasingly independent of foreign imports, with almost all materials sourced from local cycles. Even local food production has grown immensely, with the advancement of vertical farming technology and the reuse of organic waste streams as fertilizer. Most of Charlotte's schools now also have their own small-scale aquaponics facilities, which are used both for hands-on science education as well as to provide farm-fresh produce and fish to the schools' cafeterias. Further efforts to increase the city's health and resilience have focused on the decentralization of certain utility services. Renewable energy, decentralized battery storage, and smart distribution of energy through the city's smart grid have made Charlotte's energy system highly resistant to the impact of storms or floods, with most damage remaining localized.



these ideas may seem farther off in the future than others, every plan starts with imagining the reality we aim to achieve. The picture we describe here will certainly not be a perfect reflection of what actually transpires, but it can provide a starting narrative and inspiration for the next decades of Charlotte's development.

## CHARLOTTE AS AN INNOVATIVE CITY OF THE FUTURE



With Charlotte's innovations in waste collection and sorting, which resulted in the supply of previously-unavailable high-quality and pure resource streams, a whole new cluster of industries began to develop throughout the city. New product development exploded in the early 2020s. At first, the major focus of R&D activities was on processing textiles, plastics, and construction wastes. In 2023, CharM, the city's newly-opened materials lab, a joint project of several of Charlotte's incubators and accelerators, began experimenting on how to convert collected organic wastes into new materials – like clothing, furnishings, and biodegradable packaging. The strong need for materials and product innovation because of the city's ambitious circularity goals also led University of North Carolina Charlotte to establish a new educational facility, the Charlotte Institute of Circular Design and Engineering (CICDE). The Circular Charlotte brand helped the city consolidate its leading position globally, and cemented Charlotte's top position in global rankings such as the Sustainable Cities Index.

## CHARLOTTE AS A CITY WITH OPPORTUNITIES FOR ALL



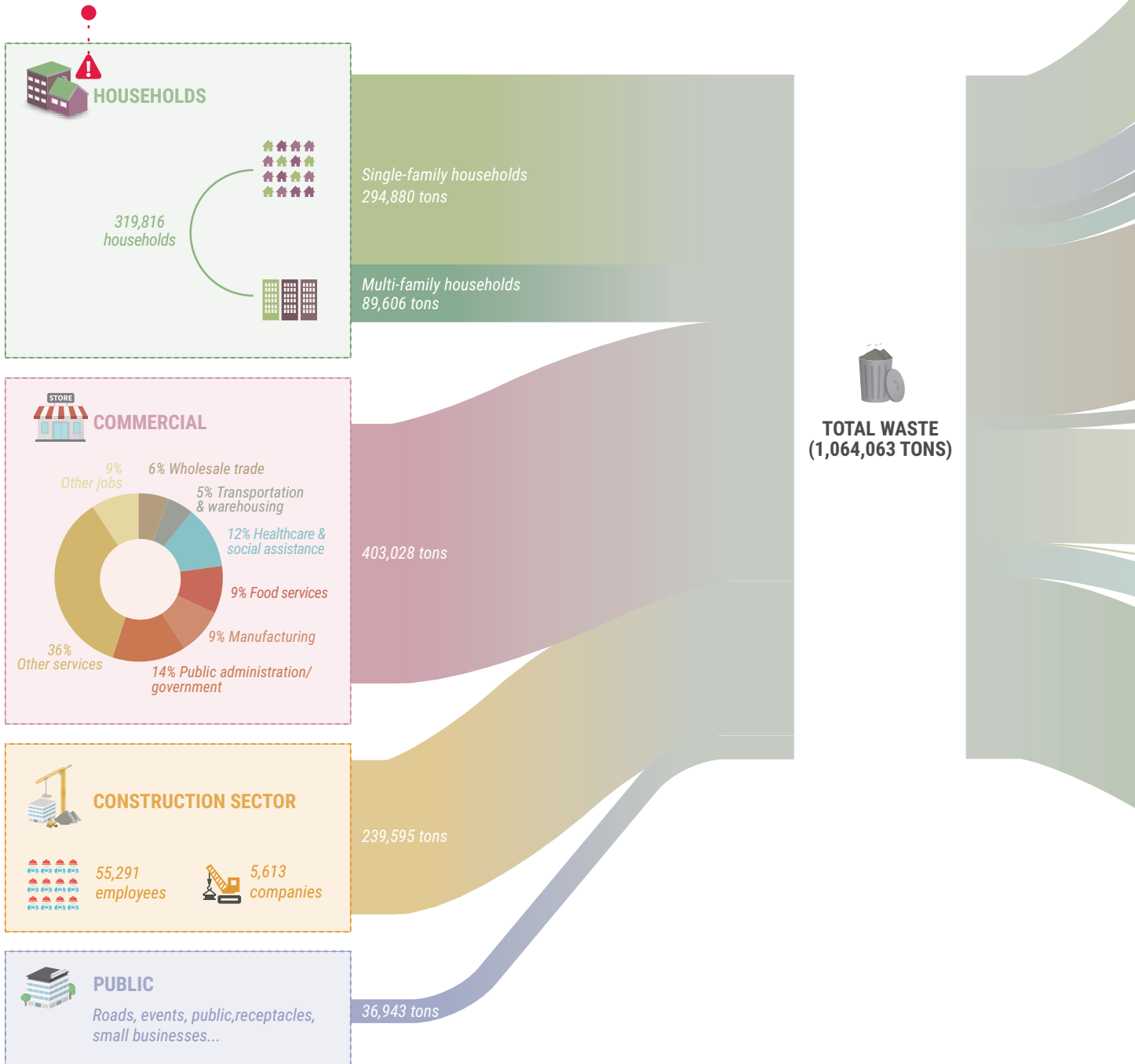
Though Charlotte now has less than 0.5% of its population living in poverty, at the start of its journey towards a circular economy this was far from the case. For this reason, initial efforts on establishing circular industry and innovation were largely focused on skill development, training, and inclusive programs designed to lift up those who were economically disadvantaged. In 2019, the city's solid waste department established a test rehabilitation program for the homeless community, providing employment in plastic waste sorting and remanufacturing. Plastic wastes, which were of too low a quality for automated processing at that time, were sorted, washed, and shredded for the production of small batches of local products like street furniture, waste bins, and trophies for school sporting events. Some of trainees involved in the pilot program went on to start their own companies focused on recycling and product manufacturing.

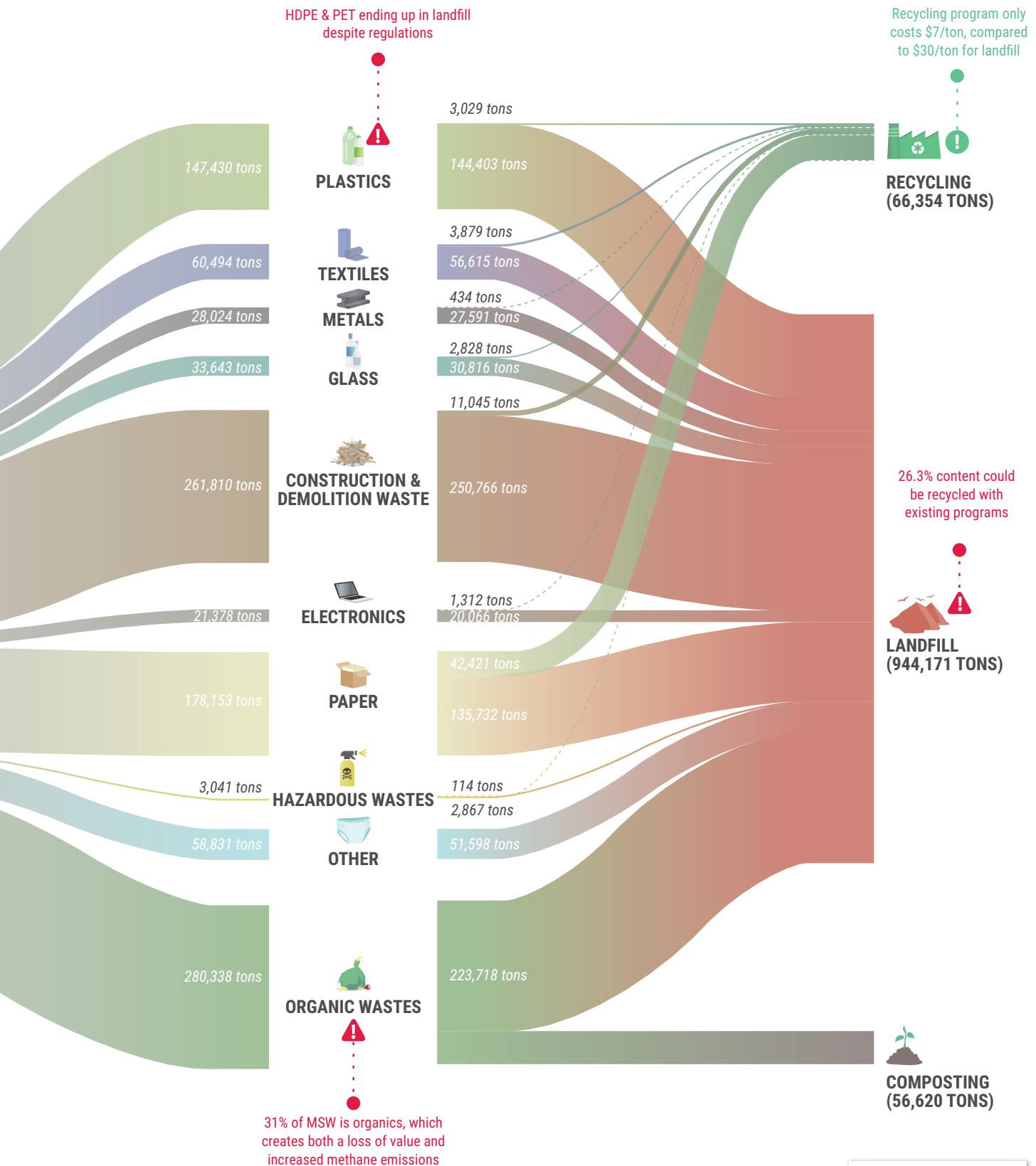
# HOW CIRCULAR IS CHARLOTTE TODAY?

This graphic shows the types of wastes generated in Charlotte and where they ultimately end up. Only 11.5% of the materials that currently enter Charlotte's waste system each year are recycled or composted. In order to make Charlotte circular, the city will need to make it convenient and affordable for households and

businesses to recycle and develop products and markets that can accept recycled materials. For example, 16% of the waste that ends up in landfill is food waste, partly because there are no free organic waste recycling programs that provide an alternative to landfill.

Lower recycling rates for multi-family households





**LEGEND**

----- Under 500 tons

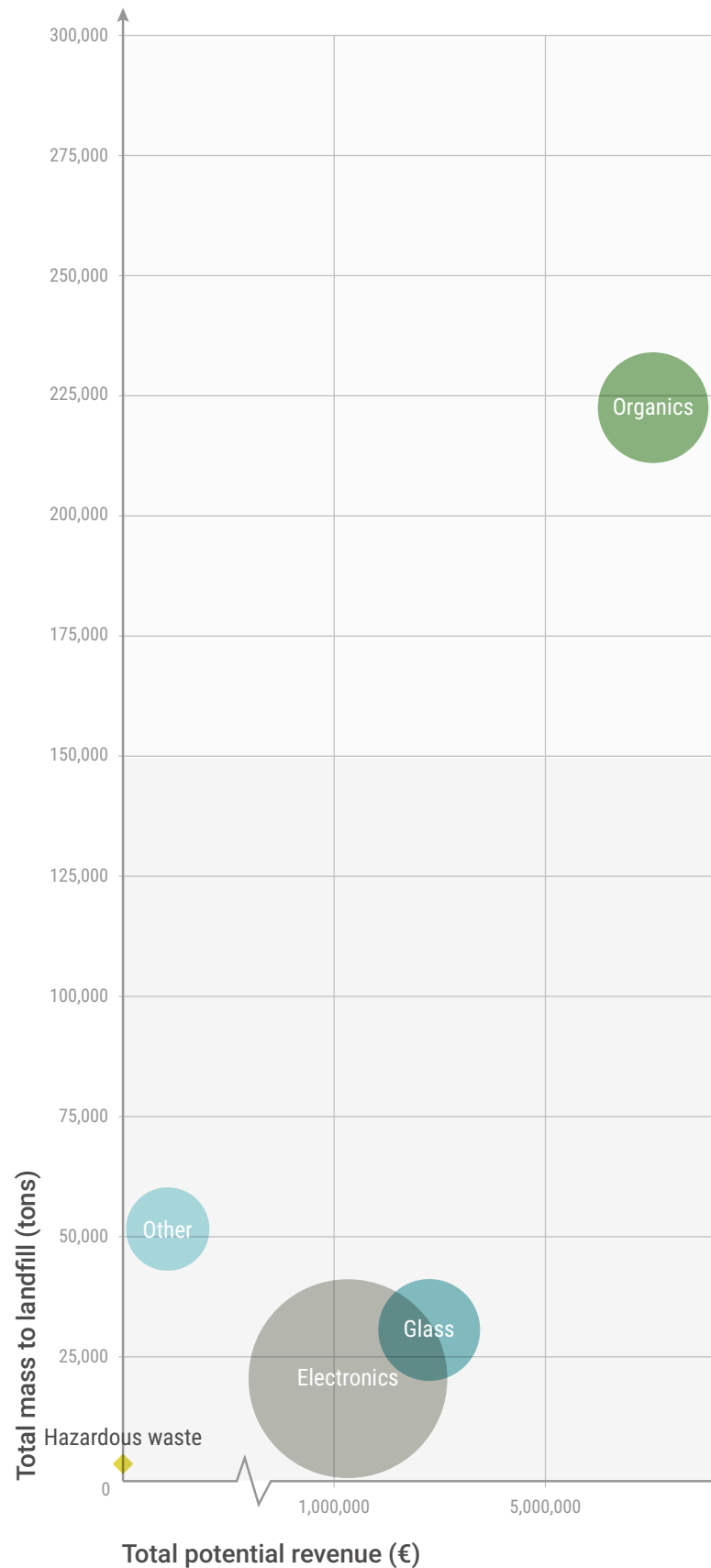
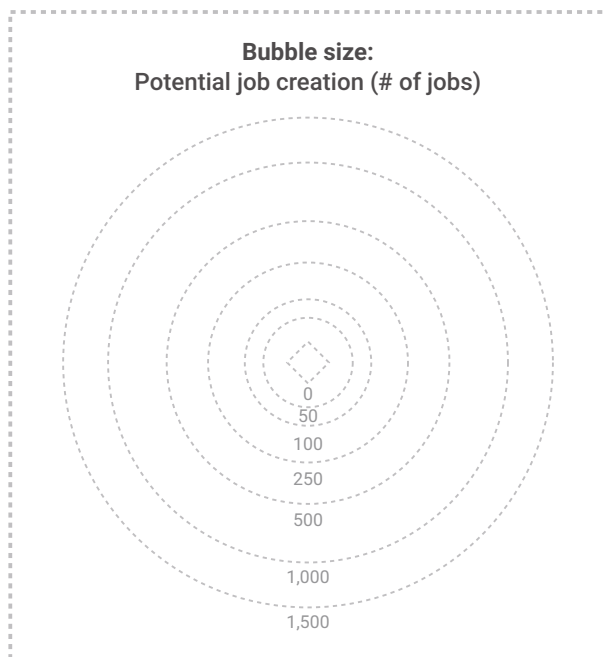
## UNCOVERING THE POTENTIAL OF CIRCULARITY

This figure shows the potential mass (y-axis), revenue potential (x-axis), and job creation potential (bubble size) for each of the material categories currently ending up in Charlotte's landfills.

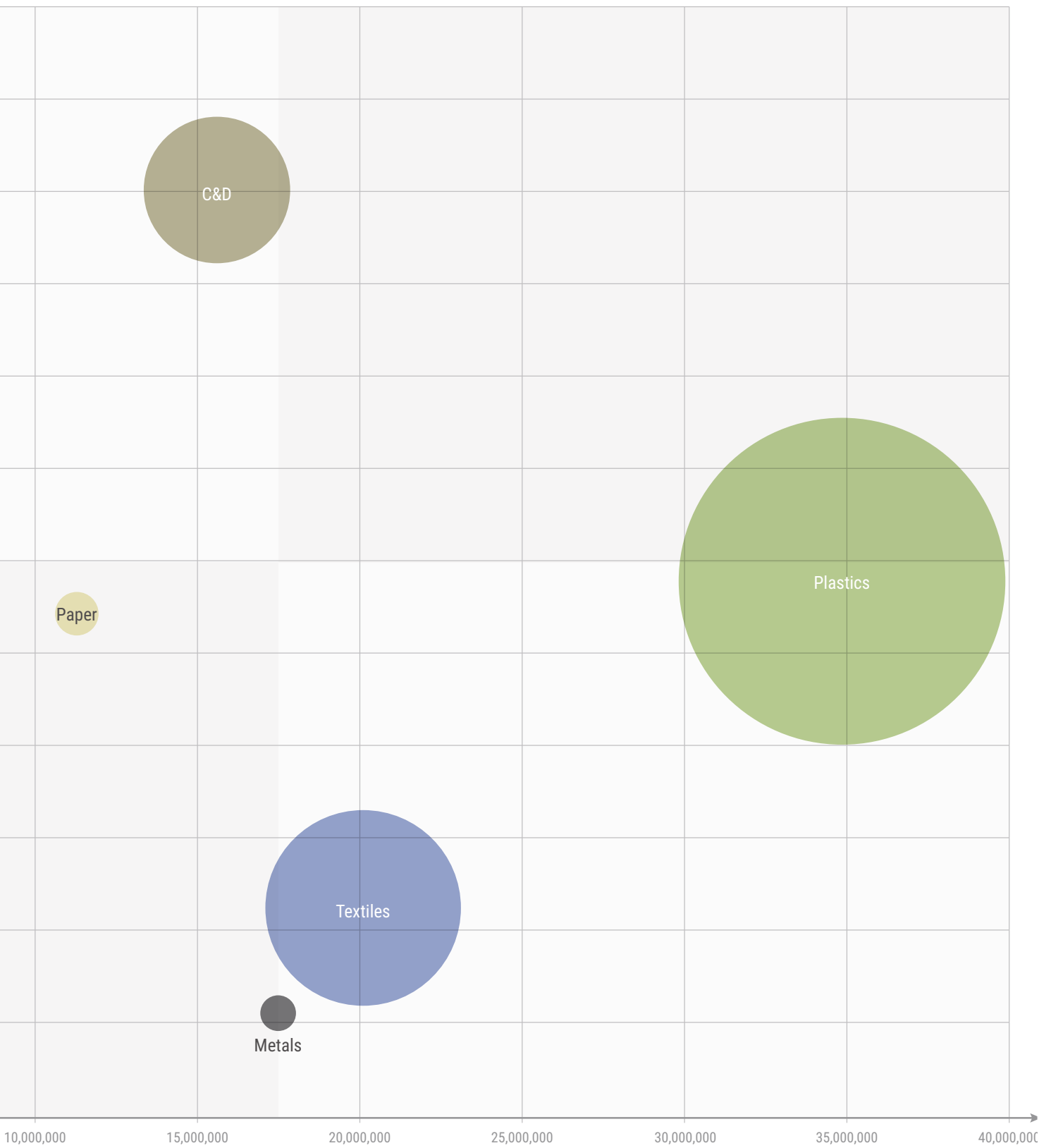
From the graphic, we can see that there is a significant amount of value going literally to waste. In total, we calculate a residual market value of \$111 million in material value and a job creation potential of more than 2,000 new jobs that would be created if these materials were recycled.

It is important to note that here we've only considered the residual scrap value of the materials when they are sold for recycling. When circular business strategies are applied (such as refurbishment, repair, or remanufacturing), more value can be retained than what materials are worth on the scrap market. Design for modularity and disassembly can further increase the value that can be recovered from waste materials, though this also requires participation from parties upstream in the value chain.

Importantly, we also have not considered the added costs of collection and processing in this analysis: this only shows the hypothetical value of all the materials once they have been collected. The business cases we developed show both the costs and revenues of selected material streams when they are processed in a circular manner.







## CIRCULAR OPPORTUNITIES

If done right, a circular economy in Charlotte will create opportunities for local employment, reduce the socio-economic divide in the city, and establish new industries that lead to greater local resilience. Ideally no waste will be going to landfill and all materials flowing through the city will be used as the basis for new circular manufacturing. By definition, training in new skills (such as product repair, remanufacturing, or circular demolition techniques) is required for the transition, creating job potential. In addition to the socioeconomic opportunities that this pathway unlocks, there are a number of other benefits.

Landfilling materials is associated with both financial costs and environmental impacts. Charlotte has recently adopted a low carbon strategy, through which it will strive for a net annual CO<sub>2</sub>e emission of less than two tons per person. Reducing the total waste-to-landfill is one way of reducing emissions. Conventional landfilling of municipal solid wastes contributes between 138-601 lbs CO<sub>2</sub>e per ton (Manfredi et al., 2009). In total, between 0.08 - 0.34 tons of direct CO<sub>2</sub>e emissions per person can be reduced by shifting to a completely zero-waste system.

An additional issue is that sending waste to landfill increases the demand for virgin resources, and can exacerbate impacts upstream associated with material extraction. Recycling materials such as plastic and paper can prevent the need for new production of these materials, while even waste incineration can reduce the need for fossil fuels such as natural gas or

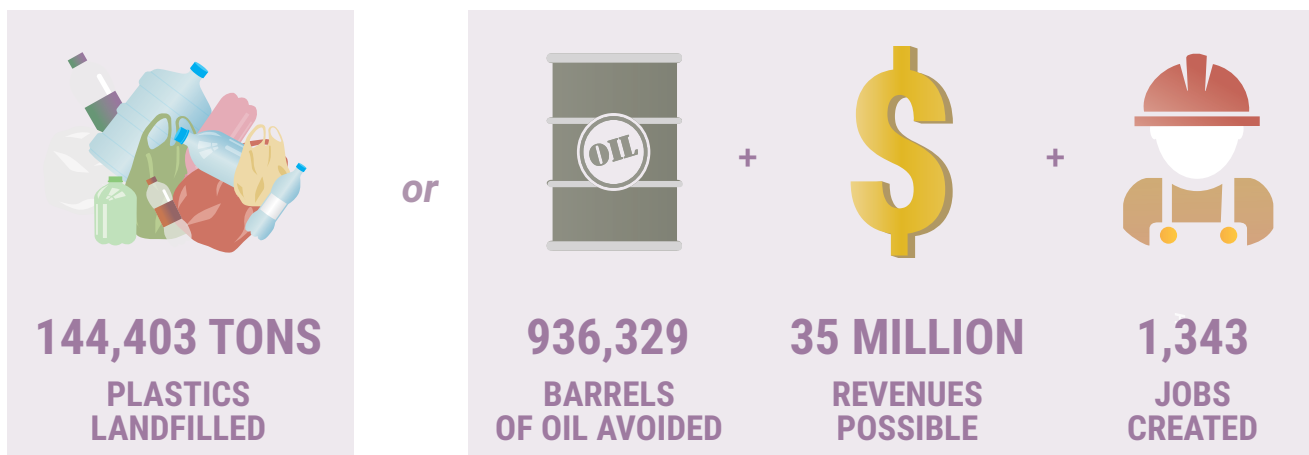
coal in electricity production. As an example, you can consider wood and paper production, which has a large land footprint. To produce the wood and paper that is currently landfilled in Charlotte, you would need an area of nearly 17 square miles. To put this in perspective, you can consider that this is around 5.6% the area of Charlotte or more than 100 times the area of Charlotte's Freedom Park. A large share of this land area could be left unexploited if paper and wood were recycled instead of sent to landfill.

Finally, activities of other stakeholders outside of the scope of Charlotte can have a large impact on how the waste system of Charlotte functions and the opportunities that can be achieved with circularity. One example is China's decision to limit the import of recyclables to those of a high quality, due to environmental and health reasons.

Chinese policy on materials accepted and the quality of recyclates will have a large impact on global markets for recyclables and is expected to have a large negative impact on United States recycling businesses and threaten thousands of jobs (Rosengren, 2017). In some cities in the United States, this ban has already resulted in the refusal of certain types of plastics for recycling (van Fleet, 2017).

By adopting a circular economy strategy, Charlotte can insulate itself from these kinds of impacts and provide local solutions for neighboring counties.

*If all plastics landfilled in Charlotte were recycled instead, this would save 936,329 barrels of oil per year while creating jobs and revenue*



## BUSINESS CASES FOR A CIRCULAR CHARLOTTE

Through our analysis, we have shown that the combined residual value of the waste streams currently ending up in Charlotte's landfills amounts to around \$111 million per year. The top four opportunities of plastic, textiles, construction and demolition waste (C&D), and organics when taken together can reduce landfill mass by nearly 65%, create just under 2,000 jobs, and generate nearly \$80 million in revenue.

As mentioned, these amounts are indicative: they do not take into account the cost of collection or processing, nor do they take into account the real added value that can be generated if these materials are not sold as scrap, but instead turned into higher-value products.

To delve deeper into the real costs and potential value generated through resource processing and recovery, we explore five business cases for circular business models that fit the regional context, matched with local interest from stakeholders, or addressed some of the most impactful or problematic waste flows.

### These five cases include:

1. Developing a local supply chain manager to organize a closed-loop textiles chain for linens and uniforms used in hotels, hospitals, etc.
2. Scaling up food waste collection and establishing a commercial-scale facility to recycle food waste into larvae for livestock feed.

3. Setting up a Materials Innovation Lab for student entrepreneurs to develop innovations for upcycling specific waste fractions into new products.
4. Setting up a tokenized reverse logistics system to provide households with an incentive to recycle materials at a high quality.
5. Establishing a circular concrete chain in Charlotte and producing new concrete from recycled concrete and post-consumer glass.

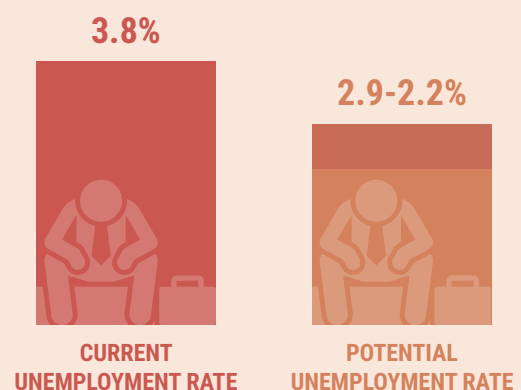
While these business cases cover a relatively small share of the wastes that are going to landfill (around 11-15%), they can result in significant benefits in terms of job creation, CO<sub>2</sub>e emissions reduction, and most importantly in terms of building local capacity for circular economy innovation. Out of a set of 29 Key Performance Indicators (KPIs) we propose to measure circularity in the city, each business case can improve between 13-19 indicators.

Taken together, we estimate that these business cases can generate between \$22 and \$34 million in revenue, and \$6.4 million in profit per year once they are established. Since this is based on only 11-15% of the mass of material going to landfill, it can be seen as in line with (or exceeding) the rough estimates of material value from our rough revenue assessment.

*Together, the business cases can divert 103,000-145,000 tons from the landfill, reducing the total mass by 10.9-15.4%.*



*The business cases can collectively create 290-492 jobs, reducing the number of unemployed by 24-41%.*



# DEVELOPING A STRATEGY FOR CHARLOTTE

## BARRIERS

The magnitude of the transformation that has to happen in Charlotte to achieve the circularity goals outlined in the strategy will require a coordinated set of actions over a number of years, supported by strong leadership from local government, the private sector, and civil society. There are still some significant barriers to tackle along the way.

In conversations with stakeholders, we identified a range of barriers - both real and perceived - that need to be addressed through the city's circular economy strategy.

One key barrier is that there are still some gaps in the physical and technological infrastructure that we need for a transition to a circular economy. For instance, Charlotte currently has no means for recycling styrofoam, plastic dinnerware and cutlery, aluminum or plastic foils and wraps, diapers, ceramics, or any glass that is not used in packaging (glassware, plate glass).

Perhaps more importantly, the majority of products on the market are not designed for high-value reuse and recycling. They are often made of mixed materials, have unknown additives, are assembled with glues making them difficult to take apart, or use problematic dyes and colorants that can contaminate whole recycling streams.

On the social and cultural side, one of the most fundamental challenges that all societal transitions face lies in changing the behavior and mindset of people: their willingness to participate in recycling programs and in the development of new, circular business. The transition to a circular economy will require a great deal of new skills and knowledge: a whole new workforce of people trained to remanufacture products and reuse materials in different ways.

The financial part of change management can sometimes be challenging. Currently, most recyclables have low value - in many cases, because of high levels of contamination among the collected resource streams. A bale of pure PET bottles has much higher value than a bale of mixed plastic, for instance. It is essential to work actively with the market to develop solid business cases for circular resource management.

There are, finally, a number of political and legal barriers. One of these is the Charlotte-Mecklenburg interlocal agreement, which currently dictates how all of Charlotte's waste is handled after collection. On the day-to-day level, existing rules and regulations can hamper how certain waste streams are used and where certain activities (for example, food production) can take place.

## ACTIONS

Charlotte's transformation to a circular city clearly cannot take place overnight. Near term actions should focus on building awareness among the city's citizens, business owners, and other key stakeholders on what the circular economy is and the different opportunities it can provide as well as laying the groundwork for tackling some of the barriers we identified.

In addition, it is essential to identify tangible actions, showcases, and circular business cases that can be executed quickly in order to build support for the approach and demonstrate its value. Further steps should include capacity building and efforts geared at longer-term transformation, such as neighborhood action plans, the establishment of new partnerships and institutions, and monitoring programs to track the city's progress on circular economy metrics. A short, mid, and long-term set of activities that Charlotte should undertake are presented in the roadmap. We have divided near-term actions that the city should take into several categories:

- Establishing political commitment and developing a circular economy strategy
- Launching a communications strategy and developing the Innovation Barn as the city's local circular economy showcase and innovation center
- Building Circular Charlotte's international profile
- Creating circular economy programs for the city and securing long-term staffing and financing
- Building circular infrastructure and resources
- Establishing the basis for data collection and performance monitoring

## NEXT STEPS

In addition to actions that the city should take in the near term, we have summarized some of the steps that other groups of stakeholders (such as funders, commercial and industrial sectors, NGOs, and knowledge institutes) can take in a coordinated effort towards achieving a circular economy.

The initial groundwork for the circular transition, however, should be laid by the government. The city has already demonstrated its political commitment to a circular economy. Now this must be communicated to the local community and made tangible. The Innovation Barn can become one of the first meeting places and centers for activity and learning on this topic, kicking off the start of this shared journey.



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