

# Waste-Free Future: Research Questions

For the competition, your team will use the three principles of a circular economy to design a waste-free city. Below you will find some information and questions to help start your research.

## Today's Linear System

Before you start to design your waste-free future city, it is important to look at two aspects of today's linear system: how we make things (like consumer products, buildings, and food) and how we handle waste and recycling.



A linear economy follows a “take-make-dispose” path. Raw materials are collected, transformed into products that are used, and then eventually discarded as waste.

## Making Stuff

Pick one commonplace item – maybe a pair of pants, your phone, a fence, even the sidewalk in your neighborhood – and research how it is made:

- What natural resources or materials are needed to make it?
- Where do the resources or materials come from? Are they mined, grown, or manufactured? Are they locally available or do they need to be shipped from far away?
- What is the process for making your item?
- Does making it create any waste or pollution?



### Battery Power!

Learn how today's batteries are made in Extraction to E-Waste: The Lithium-ion battery supply chain <https://ulxplorlabs.org/battery-supply-chain/>

- How does your item get to consumers?
- How long is it designed to last? Was it designed for a single use (a candy wrapper or bottle of water)? Or can it be used for a long period of time (a washing machine, phone, or car)?
- What happens to it when it's no longer useful? Is it recycled, reused, or is it thrown away?
- Does it cause pollution or contamination when it is disposed of?

After you have learned about how your item is currently being made, brainstorm with your teammates about what changes you might make to the production process to design out waste and keep your item and/or the materials it is made from in use longer.

## TODAY'S TRASH

When people first learn about a circular economy, they might think it is just another way to talk about recycling. But it is more than that; it combines several strategies like reuse, sharing, repair, refurbishing, remanufacturing, and recycling.

Research how trash and recycling are currently handled in your city or town:

- What waste streams (types of trash) are typically found in trash?
- What happens after trash is collected?
- What role do the 4 R's (reduce, reuse, recycle, and rot) play in today's waste management system?
- How are current systems effectively using the 4 Rs?
- What are some innovative examples of how cities or companies are rethinking or reusing waste?

## Learning More About Circular Economy

There are a lot of great resources. We recommend starting with the Ellen MacArthur Foundation. But don't stop there! Search the internet for examples of a circular economy in action. Ask questions like:

- What does it mean to design out waste?
- What is regenerative agriculture?
- How are cities using the three circular economy principles?
- What roles do engineers play in a circular economy?

## Future City Design: Questions to Consider

Your challenge is to design a waste-free city that is set at least 100 years in the future. How does your city incorporate all three principles of a circular economy to achieve this ambitious goal? What design and planning decisions made the transition from a linear to a circular economy possible?

As you and your teammates begin to design your waste-free city, use the topics and questions below to guide your research, brainstorming, and design sessions. Remember, no city can provide everything. What are the most important features? What tradeoffs do you have to make?

### City Features

- Where is your city located?
- When was your city founded?
- How would you describe the population of your city? Who lives there?
- What are your city's distinctive natural features (e.g., mountains, oceans, rivers)?
- What is the climate like in your city?
- What does your city offer for entertainment, recreation, and cultural enrichment?
- What makes your city futuristic and innovative?



Remember: Even after your city design is complete, these questions are helpful to review as you prepare for the City Q&A.

### Zoning, Government & Budget

- How is your city zoned? Are the zones separate or are there mixed-use zones (e.g., commercial and residential or commercial and industrial) in your city?
- How has your city used zoning to achieve its waste-free goals?
- How is your city governed? Who makes the laws and regulations?
- What regulations does your city impose on manufacturers to ensure adherence to waste-free processes?
- How does your city fund its operations (i.e., utilities, infrastructure, and public services)?

### Environment & Energy

- What energy source(s) powers your future city? For example: gas, solar, oil, wind, nuclear, biomass, biofuels, tidal, hydrogen, wave, etc.
- What are the costs and tradeoffs of different power sources?
- How has your city applied the principles of a circular economy to the production of its power?
- How have your city's circular economy practices had a positive impact on the environment?

### Food & Agriculture

- Where does your city's food supply come from?
- How are local and regional farmers using regenerative food production practices? What have been the benefits and drawbacks to this approach?
- Has your city developed innovative uses for inedible agricultural by-products? Are these products or goods being used by other industries or services in your city? For example, are they being used in regenerative farming, food packaging, medicine, bioenergy, or fashion?

## Industry, Manufacturing & Jobs

- What drives the economy in your city (e.g., tourism, manufacturing, education, agriculture, sports, medicine, the arts)?
- How has the switch from a linear to a circular system affected your city's economy? What tradeoffs did your city or local industries have to make?
- How have businesses and manufacturers designed waste out of their production process?
- What innovative approaches and industry practices are being used to keep products or resources in use?
- How are your city's businesses and manufacturers using renewable and reusable resources as materials?
- How has your city changed traditional supply chains in order to stop using a linear approach to manufacturing?
- What types of jobs are available to your residents?

## Structures & Housing

- Where do your residents live, work, and go to school?
- How have construction practices changed to achieve your city's waste-free goal?
- What materials are used in your city's buildings? What makes them innovative? How are materials produced, used, and potentially re-used?

## Transportation

- What transportation options are available to your residents? Is there more than one way to get around?
- How are goods, materials, and by-products moved around your city for use and reuse?
- How has your city designed waste and pollution out of your transportation system?
- How is your city designed to be accessible for people with mobility issues related to aging or a physical disability?

## Utilities & Services

- What services does your future city provide to its residents (e.g., medical, education)?
- How does your city address the needs of vulnerable populations, including the poor, the sick, the houseless, and the elderly?
- What impact has your city's circular economy had on its utilities - such as water, sewer, waste management and recycling, electricity, Internet, etc.?

## Health & Recreation

- How does your city support a healthy lifestyle for its residents throughout every stage of life?
- How have hospitals and healthcare designed waste out of their systems? Have any new medicines or treatments been created from your city's circular economy approach?
- What do people do in your city's public spaces?

# Waste-Free Future: Real-World Case Studies

## A Building that Cleans the Air

The ancient city of Venlo in the Netherlands has embraced the principles of “cradle-to-cradle” (C2C) in all of its new construction. Every material must be reusable, with none going to the landfill and no loss of quality. So when the centuries-old town hall needed renovating, city leaders chose instead to build a brand new one, which opened in 2016. It showcases the benefits of a C2C design, puts the city on the path to a circular economy, and acts as a model for cities around the world that want to go waste free.

The town hall boasts truly healthy air thanks to several innovations. Its solar chimney warms incoming air, creating a natural draft; no mechanical ventilation is necessary. The top floor is a greenhouse that adds oxygen and humidity to the air before it flows throughout the building. The building itself includes atriums, which aid air flow and provide natural light.

The entire northern façade of the town hall is a vertical garden. The plants provide city birds and insects a place to rest and breed. More than 100 different plants convert carbon dioxide into oxygen and clean particulates out

of the air. The plants also absorb the nitrogen and ozone generated by nearby cars and trains, making the city air cleaner. The plants also insulate the building from heat, cold, and noise.

There are even green walls in the parking garage as well as raised areas with ferns and slowly decomposing logs. The plants do their work of cleaning and humidifying the air of the parking garage, and you can even pick edible mushrooms off the walls!



## Dinner Made from Air

Physicist, bioengineering researcher, and entrepreneur Dr. Lisa Dyson was looking for ways to combat climate change when she came upon some work that NASA scientists did in the 1960s and '70s. They'd discovered microbes (one-celled organisms) that use carbon dioxide to create nutrients. In their natural habitats of hot springs, these microbes are “super-charged carbon recyclers,” explains Dr. Dyson.

She brought together scientists and engineers to unlock the keys for using these microbes. They found that if you combine the microbes with elements from the air (such as carbon dioxide) and add some water and minerals, you can make nutritious food in a matter of days—with no sunlight, land, or pesticides. The process is a bit like making yogurt but in this case, scientists can make pasta, cake, meatless burgers, cooking oil, and other foods.

The protein has the same amino acids as animal protein, but it contains more vitamins and other key nutrients than meat. Tweak the process and the microbes can make biodegradable cleaners and rocket fuel, all with renewable energy.

The potential of this technology is enormous. Traditional agricultural practices often generate greenhouse gases and other harmful byproducts. But these microbes can grow in vertical containers that take up very little space and produce food during any season, in any climate, and in just a few days. Food made from air uses 15,000 times less water and 1.5 million times less land than beef.

## Orange Peels Insulation

Engineers in the city of Negev, Israel have been experimenting with building materials that are sustainable and more energy efficient. In particular, they have been searching for materials that will insulate buildings against the heat. Israel is a hot dry country, and its cities are even hotter because the buildings and pavement trap heat and raise temperatures to the point of being unhealthy as well as uncomfortable.

One promising new material with impressive insulating properties is a biocomposite of dried orange peels and clay. Walls made with it and a second layer of rammed earth, a traditional building material, have greater insulating properties than lightweight concrete. The houses are much more comfortable and save energy. They also make good use of Israel's orange peels—where orange juice production creates 15 million tons of orange peels every year.

In Italy, orange peels, pulp, and seeds are being made into a material called pastazzo. It is an abundant raw material—Sicily alone produces 340 tons of pastazzo a



year! Pastazzo is an effective insulator; it is also used for fertilizer, in the production of clean energy, and as compost. Using it in these ways saves the high cost of carting it to landfills.

A construction company in England combines orange peels with other kinds of food waste to make a strong building material similar to fiberboard. The company is partnering with engineers, designers, and scientists to transform the construction industry by phasing out fossil-fuel materials entirely and replacing them with bioengineered materials like the ones using orange peels.