Nautilus: A Holistic City of Growth and Renewal

One hundred and twelve years ago, between the Trans-Ili Alatau Mountains and Big Almaty Lake in Central Asia, lay a Kazakh city with vast potential. Now, at 43.0119° North and 78.4229° East, is Nautilus—whose name symbolizes the continuous expansion of a spiral, representing growth and renewal. With hot summers and cold winters, Nautilus' 3 million inhabitants adapted to climate change and enjoy natural resources.

Nautilus' population is dominated by Kazakhs (48%), ethnic Russians (24%), and Uyghurs (28%). The knowledge economy, digitalization, graphene production, and services provide 52% of jobs; the remainder come from engineering (14%), urban development (10%), and others (24%). Ecotourism is important to the economy, with tourists visiting Big Almaty Lake, Trans-Ili Alatau Mountains' ski resorts, and La Fabrique Nemo, a circular economy amusement park. Community gardens, makerspaces, lifelong learning opportunities, intergenerational housing accommodation, and cross-cultural inclusion allow people to live mentally and physically active lives.

Nautilus has cutting-edge infrastructure based on energy efficiency and smart green development. Buildings integrate greenery on multiple levels and use lightweight glass wool (70% recycled glass) for insulation, trapping air between glass fibers. Historical buildings have been retrofitted to 22nd century standards, and buildings meet the ANSI/BICSI 007-2130 intelligent buildings standard. They incorporate sensors to monitor temperature, motion, occupancy, air quality, electrical current, and slope indication to relay data instantly using the Internet of Things (IoT).

Nautilus' main energy source is nuclear fusion, created by two tokamak nuclear fusion reactors, in which different hydrogen isotopes are heated to extreme temperatures—allowing the nuclei to fuse and generate energy. Supplemental energy sources include remote wind, solar, biomass, and biogas energy. Wind turbines on the Trans-Ili Alatau Mountains harness strong winds, and biomass energy is produced through direct firing of solid human waste briquettes. Geothermal energy provides heating for the city.

Agriculture revolves around hydroponics, which uses abundant energy resources, vermiculite, and treated wastewater to grow plants. In greenhouses, drones monitor produce ripeness and determine optimal harvesting dates. Underground mushroom farms provide food, medicine, and packaging materials. Mushrooms feed on agricultural waste, thriving in the humid underground conditions. Nautilus also supports a 3-D meat printing industry, where bio-ink created from muscle and fat cells is stacked in layers, producing meat substitutes.

Nautilus provides city services in an interconnected smart city system. Montessori-style education, focused on creative thinking, is compulsory from age six to sixteen. Innovative preschool options are also available. The University of Nautilus has strong links with industry and is a regional leader in technology. Nautilus offers technical and vocational education for young adults, along with lifelong learning opportunities.

The city has outstanding public transportation, from trolleybuses to the HyperWay, a system of underground hyperloops. The HyperWay is powered by hydrogen fuel cells extracted from ammonium (NH_3) in Nautilus' waste management process. Magnetic levitation keeps pressurized

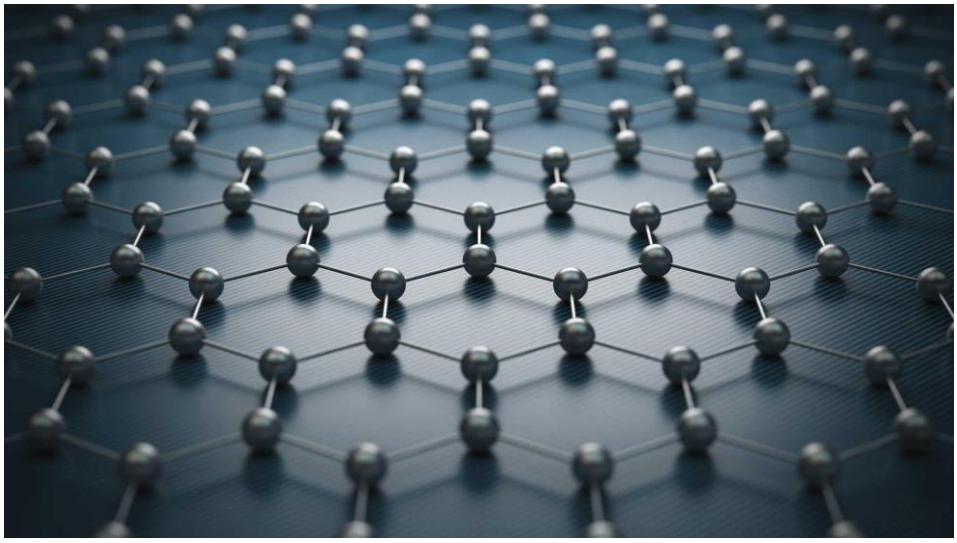
pods travelling at up to 800 miles per hour because of reduced aerodynamic drag. Extensive electric trolleybus networks are also available, accessible for people with disabilities and senior citizens.

Nautilus provides quality healthcare, using artificial intelligence (AI) and machine learning to improve patient experiences, connect data, and optimize medical imagery. Citizens are encouraged to use wearable technology to monitor vitals and report to a centralized electronic health system. In emergencies, an alarm is sent to the system, pinpointing the user's location, and contacting emergency services.

Fire safety and awareness is taught at school and in the workplace. Intelligent buildings have mass notification systems and use the IoT to detect fire, preventing damage and death by using visual flame detectors, air sampling smoke detectors, and self-expanding firefighting foam.

Nautilus has many innovative features, but graphene development has transformed services and transport. In 2089, chemical and industrial engineers developed a method for mass-producing graphene, a carbon sheet one atom thick. Graphite flakes are compressed and rolled out through a process called "graphesion." Graphene batteries soon replaced lithium batteries in cars and electronics—increasing efficiency and battery life. In 2125, engineers developed Holographenes, graphene-powered tablets that form holograms. Engineers record and develop images, so that lasers embedded in tablets interfere and intersect, forming holograms. These have many purposes such as allowing doctors to see organs or architects to visualize designs.

Figure 1: Graphene Sheet

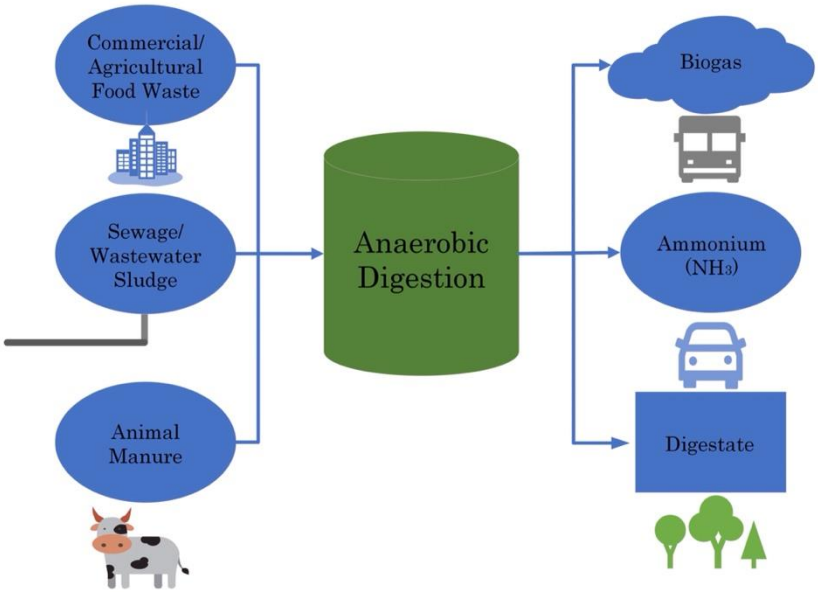


Over 100 years ago, Nautilus' economy was centered on oil (70%) and natural gas (20%), which depleted and damaged ecosystems. Air pollution affected people's health, biodiversity was being destroyed, and weather events were more extreme and frequent. Coal-burning pollution caused one-third of respiratory deaths. Waste was not dealt with efficiently and toxins were emitted from landfills into the air and groundwater. The economy relied heavily on fossil fuel exports, which were running out, so change was necessary.

The transition planning process began with the government offering incentives to make the shift to a circular economy appealing—from free publicity for cutting waste to tax cuts for switching to renewables. It set two major time stamps for transitioning to renewable energy: reaching zero coal usage by 2040 and reaching net-zero fossil fuel reliance by 2060. In the interim, natural gas was used as an alternative to coal. Petroleum engineers planned for the transition and worked with green and nuclear engineers to move toward renewable energy sources.

Nautilus' circular economy depends on three principles—reducing and designing out waste and pollution, reusing and keeping products in use, and regenerating natural systems. Nautilus demonstrates the first principle by repairing and reusing modular parts rather than discarding them. Repair centers in cafes, stores, and stands allow citizens to fix appliances. Parts that cannot be fixed are posted on C2C, an online database that inventories industrial components for manufacturers to use in future products. Styrofoam and single-use plastics have been banned and replaced with mushroom-based alternatives, reducing landfills.

Figure 2: Anaerobic Digestion Process



Nautilus' wastewater systems keep products and materials in use. Biosolids (manure, waste, and sludge) are digested through anaerobic digestion to generate biogas, which powers many city services. A byproduct of anaerobic membrane bioreactors (AnMBRs) is ammonium (NH_3) rich wastewater. Ammonium is broken down and hydrogen fuel cells are extracted and used to power the HyperWay. The leftover, nutrient-rich digestate of AnMBR fertilizes community gardens.

In 2108, circular economy principles guided engineers' landfill transformation into eco-tourism landmark, La Fabrique Nemo, including The Torpedo rollercoaster repurposed from abandoned torpedo factory parts. Keystones, arches, and cubic silicon nitride tunnels guide riders through a subterranean exploration of eco-friendly choices. Underground mushroom farming and methane extraction within the park complete the circular economy cycle by restoring nature and designing out waste.

Figure 3: La Fabrique Nemo – Circular Economy Transformation

To regenerate natural ecosystems, urban developers introduced the sponge city concept whereby water filters naturally through the ground and reaches urban aquifers. To achieve this, Nautilus implemented green roofs, porous sidewalks, bioswales, and contiguously arranged parks. These features allow water to reach urban aquifers and be extracted, treated, and added to the city's water supply. Each household has an intelligent composting collection system (ICCS) to save energy and time by collecting food waste on demand. The ICCS is a bin with sensors that connects to the city's trash collection database, NautilusConnected, other bins within a 1-mile radius, and smartphones via an ICCS app. When the bin reaches 75%−95% capacity, it connects to other bins in the area within that window, sends a signal to NautilusConnected for communal pickup, and notifies the citizen's profile on the ICCS app to take their bin out. After collection, food waste is composted and added to soil in community gardens.

Figure 4: ICCS Connectivity

Nautilus has taken risks, compromised, and made tradeoffs. The biggest risk was geological exposure to landslides and earthquakes. To make the city resilient, the foundations of many buildings were altered using base isolation, where structures were floated from their foundations and steel was added for reinforcement. A tradeoff Nautilus made was sacrificing fossil fuels, whose exports were crucial to the economy, for a more sustainable economic model. This caused a short-term economic shock, but the new circular economy eventually became profitable. A compromise urban developers made when planning the city layout was to retrofit concrete buildings, since demolishing old buildings is less sustainable. This was successful, as some buildings were retrofitted into vertical farming greenhouses, which launched hydroponics.

Nautilus relies on three major engineering disciplines: civil, mechanical, and electrical. Civil engineers build roads, tunnels, buildings, and bridges and connect them through the IoT. They organize water treatment plants and the "sponge city" water system. Mechanical engineers design and create energy supplies, including fusion reactors. Electrical engineers design and manage the city's electrical system and build IoT sensors. They developed Holographenes by recording images, creating lasers, and designing the tablets.

Nautilus blends its beautiful natural surroundings with technology and innovation. Using the three principles of the circular economy, it has become a sustainable city, demonstrating that beneficial change is possible when creative ideas combine with visionary planning.

Word Count: 1,497

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Greenshire

Welcome to Greenshire, a city on the south coast of England, located at 50.3755° N, 4.1111° W. The city is home to 753,000 people, with a temperate oceanic climate and abundant rainfall. The main geographical features include low central plains surrounded by coastal mountains. The beautiful coastline is a popular tourist attraction and will host the city's 73rd annual Sea Turtle Festival this year in 2127.

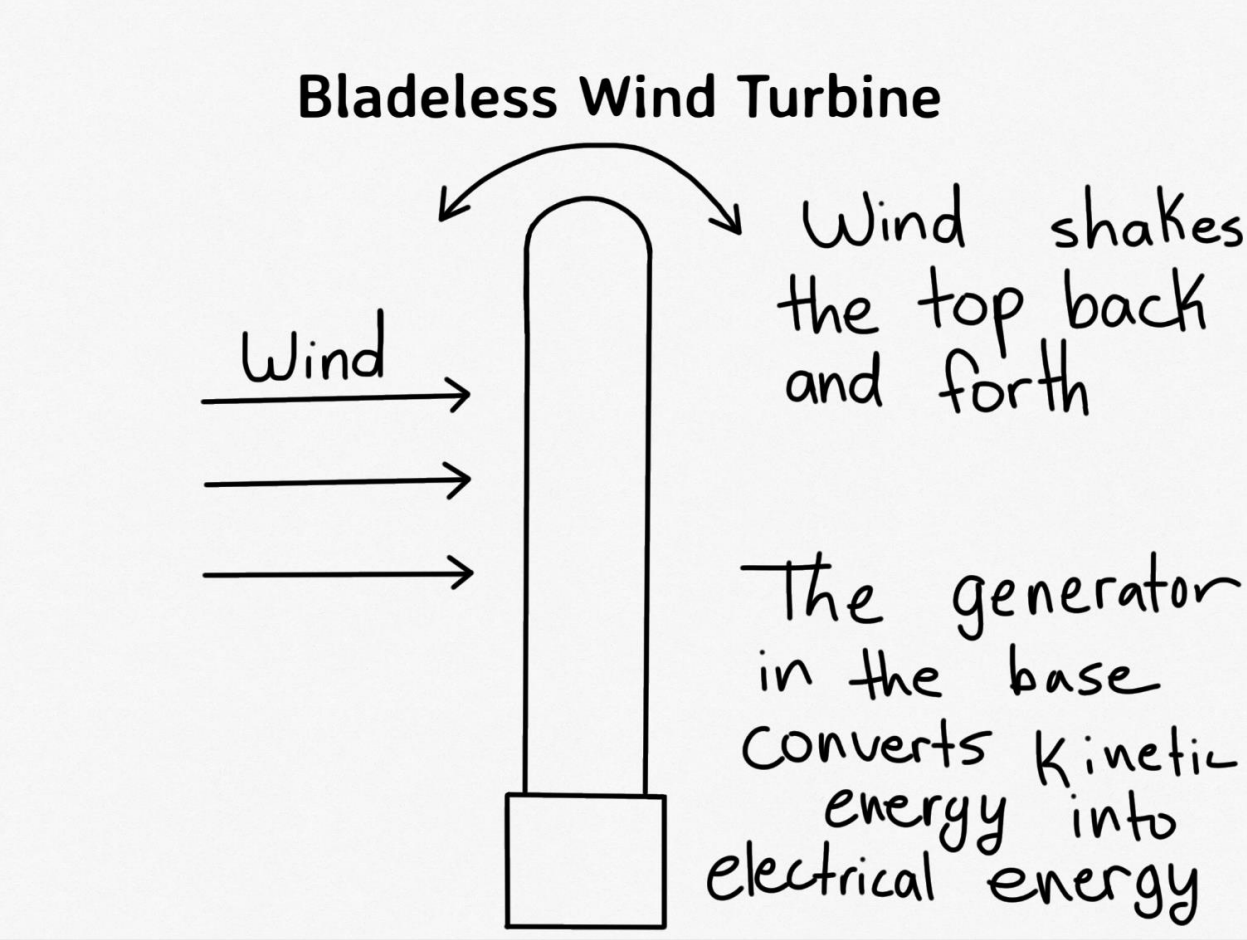
Greenshire is a great place to live. It is a world leader in plastic research; coming up with innovative new modular building techniques, growing bioplastics and harvesting resources out of old landfills. 65% of jobs in Greenshire are related to engineering, repair services and computer science.

Citizens enjoy a healthy work-life balance thanks to the numerous recreational opportunities such as the renowned Greenshire Observatory, Emerald Gate Bridge and the annual Shire Games held at the Sans Déchets Stadium. The natural reserves, hiking trails and wildlife encounters encourage an appreciation of nature.

People live in compact, connected housing communities. Houses in Greenshire are made of modular plastic panels that can be easily taken apart or reconfigured for reuse. Multi-story basements require less material and are insulated to use less energy. Each house has a unique system of specialized pipes that aim to repurpose waste water. Robots, called Aquabots, help maintain these pipes and troubleshoot issues. The Aquabots and pipes are designed using materials derived from waste recycling.

Most of the food is grown locally in vertical farms. Vertical farming is the practice of growing produce in vertically stacked layers using either soil, hydroponic or aeroponic growing methods. This allows farmers to grow 400 times more food on the same amount of land. Since nearly all the water is recycled, a vertical farm uses 95% less water than a traditional farm. As farming takes place indoors, no herbicides and pesticides are needed, and crops can be grown year round.

Greenshire's source of renewable energy uses bladeless wind turbines to generate electricity. These turbines consist of a cylinder fixed vertically with an elastic rod. When the cylinder shakes back and forth with the wind, a generator in its base converts this mechanical movement into electricity. These turbines are more efficient than normal bladed windmills, can be placed closer together, and are not a threat to migrating birds.

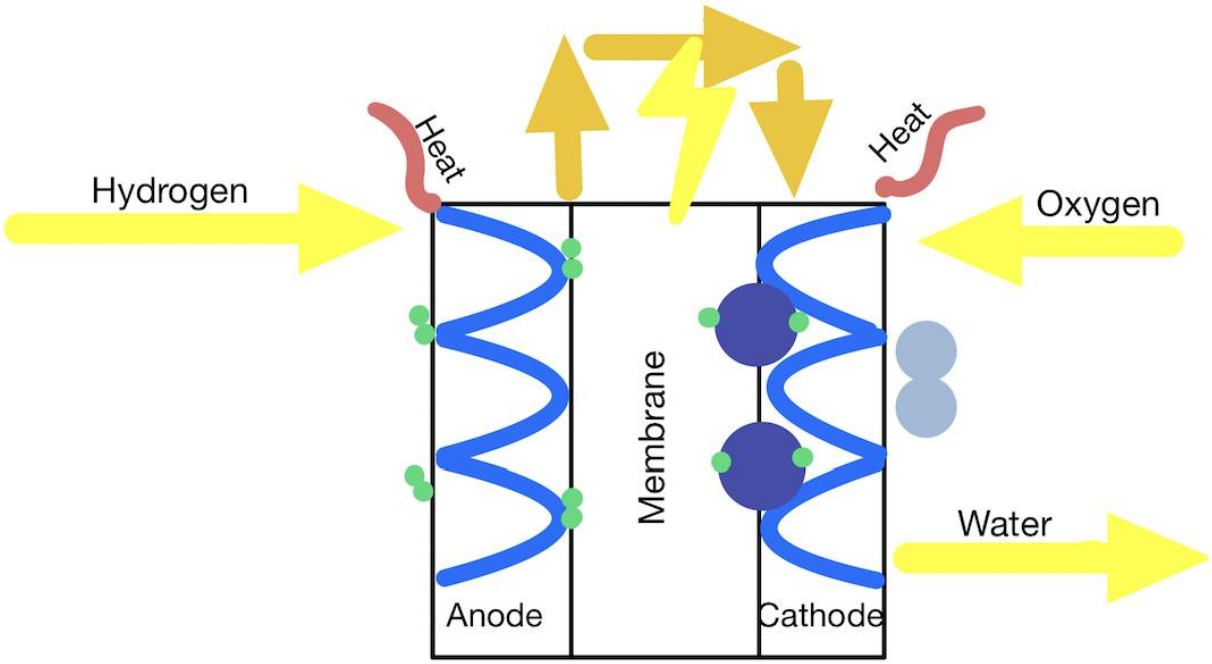


City services in Greenshire support the circular economy. The city partners with local businesses like SNIOC (Salvage New In Old Corporation) which specialize in repair. Instead of a traditional trash service, ReImagination engineers collect broken items weekly, log them, repair them, and send them back to their owners.

Greenshire has many award winning schools. World class astronomy lessons are located at the Observatory. New science classes include “Re-use and the Circular Economy” and “The Physics of Plastics”. Electronics and repair are also part of the curriculum.

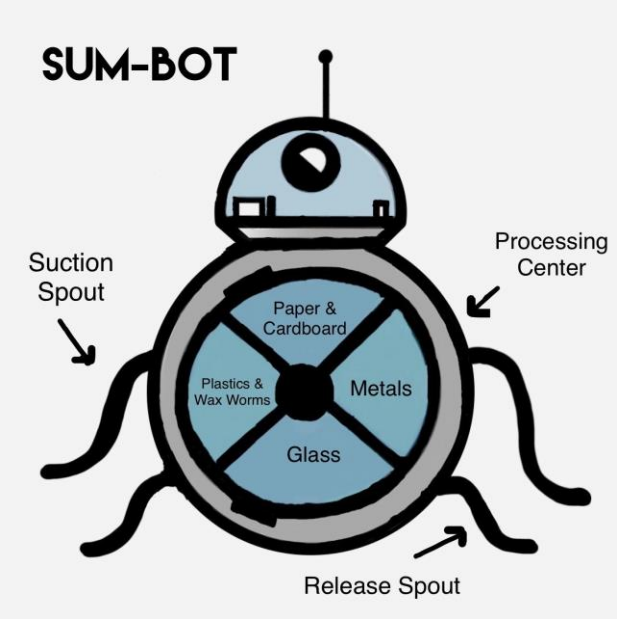
Drones with advanced thermal imaging help firefighters locate and extinguish fires much faster, reducing fire spread and damage. Citizens wear medical bracelets with advanced particle sensor technology. By monitoring volatile organic compounds in the skin and breath, these devices can proactively detect if someone is sick.

The transportation system uses Fuel Cell Electric Vehicles powered by either hydrogen or kinetic energy which are based on the concept of ride-sharing and resource reuse. The most prominent of these shared ride systems is the Hyperloop that combines an ultra-efficient electric motor and magnetic levitation to carry people at fast speeds with zero direct emissions. The Hyperloop also doubles as a freight transport system.



Hydrogen Fuel Cell

Many innovative features help make our city eco-friendly and fun. Aquabubbles made of recycled clear plastic travel underwater, and are a great way to study marine life. At the Greenshire Observatory, people can control real outer space drones and can race other people in the Space Racing League. Greenshire keeps getting greener thanks to SUM-Bots (sucks up materials) that mine materials and plastics from old landfills. These robots have a special storage chamber filled with waxwoms which eat the plastics and decompose them into biodegradable materials.

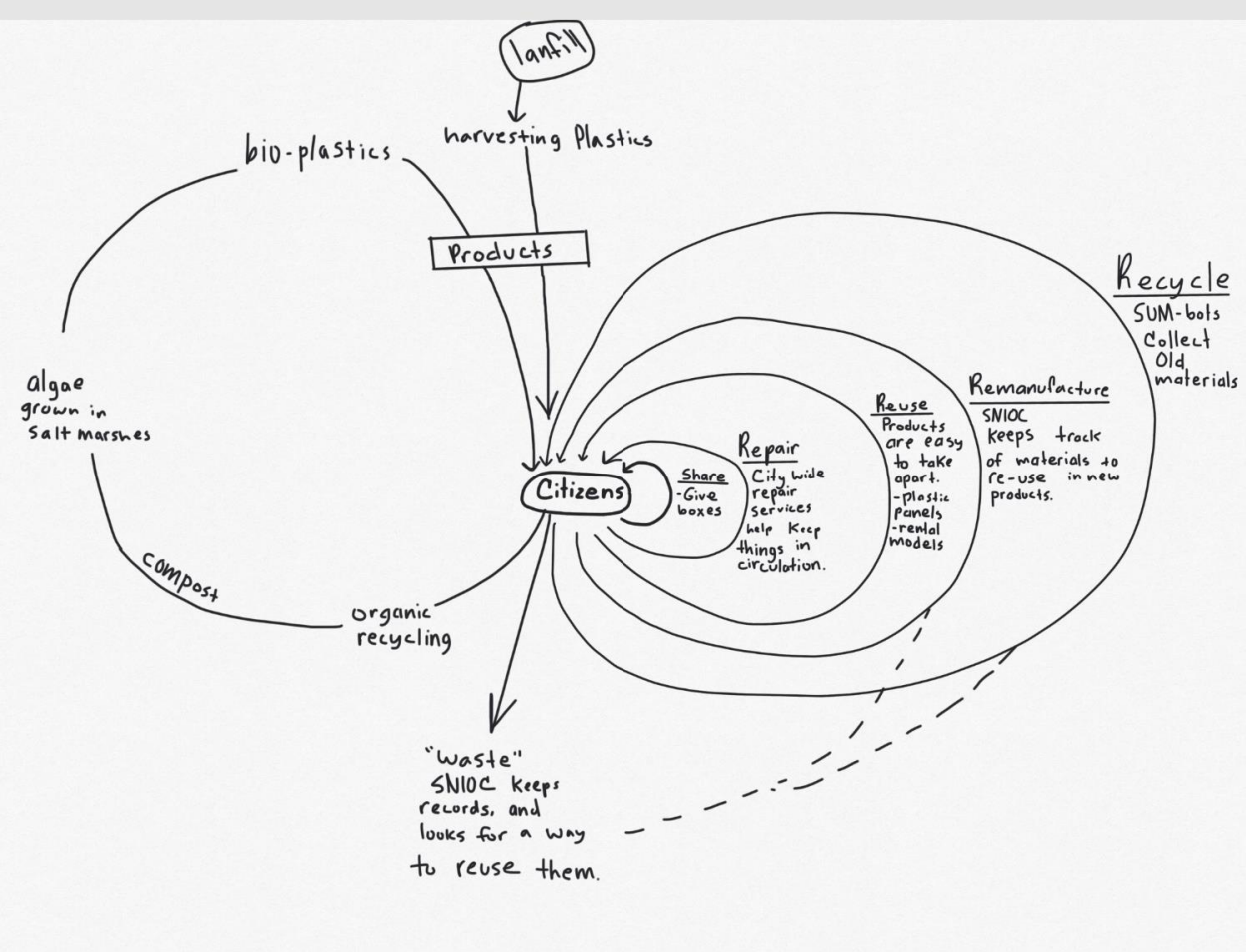


Before our city was circular we had a linear economy with a take, make, waste system. People in Greenshire were using our beach as a seaside landfill. This landfill was harming marine life and destroying the salt marshes, making our city more susceptible to flooding.

Greenshire needed to change from a liner economy to a circular one. To make this transition, the city government zoned for compact housing, so that more green space is made available for regenerative agriculture. It was mandated that all items made in Greenshire should be easy to take apart so they can be reused. The city also mandated that a Cradle-to-Cradle Plan be created for each product. This is a plan describing where to get the materials to make the product as well as what will happen to the product afterwards. Tax incentives are given to companies who make their products easy to repair and reduce the need for new parts. As a result, companies reduced packaging and standardized their parts. Now people own their own containers, and take them to the store to get refills instead of buying new bottles.
Many switched to subscription and rental services, so they could repair and keep products in circulation.

Re-Imagination engineering, an innovative branch of engineering, studies how to repurpose materials. These engineers maintain a huge computer database to keep track of local resources needed for both manufacture and repair. With all products being made from reused local resources, there is much less pollution and waste. On a smaller scale, Give Boxes are set up at community access areas. A Give Box is where people place items that they don't need anymore for others to take and re-use.

As the SUM-Bots cleaned up the landfills, the salt marshes returned. These marshes not only provide food such as crab, shrimp, and fin fish but also reduce flooding by slowing and absorbing rainwater. They also protect water quality by filtering runoff water. Bio-algae harvested from these marshes are turned into plastic pellets (bio-plastics) creating a closed-loop system where we have everything we need locally.



Circular Economy

The transition to a circular economy had trade-offs. The change in system and manufacturing design wasn't easy and took a lot of determination. Reuse of material required additional energy and made products more expensive at first, but as fossil fuels started to run out, reuse became more attractive. Once parts became standardized, everyone started using them, and so the circular economy became less expensive.

Since the circular economy focuses on reducing use of raw materials by keeping them in circulation, fewer products are being made. People got worried that this might be bad for manufacturing jobs. However, rental and subscription services allowed people to try out more variety, which is good for jobs.

Reusable containers also had tradeoffs. They need to be cleaned thoroughly or people will get sick. To address this issue every home is equipped with UV sterilizers.

There was a debate about using plastics as building materials. Plastic is not as strong structurally as other materials. It could be reinforced with concrete, but that would make it harder to separate and reuse. To address this, plastic structures are limited in height to two stories or less. This allowed Greenshire a convenient reconfigurable building material and a way to repurpose the old landfill plastics.

All of these amazing changes were made possible by our engineers. Agricultural Engineers helped preserve and protect our vital salt marshes. Computers Engineers manage our computer database that helps us find materials. A new type of engineer called a ReImagination Engineer, a mix of Mechanical and Material Engineer, specializes in taking broken items and regenerating them for a new purpose.

The city of Greenshire has many innovative features that not only make it eco-friendly but also offer a fun and healthy lifestyle based on a circular economy. All of this would not have been possible without the help of our hard working engineers. It is no wonder the city has seen significant tourist and population growth over the years and we would love for you to come visit!

Word Count: 1475

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