

Imperium in 2120

Overview

One hundred years ago, Imperium - from Latin, meaning power - was named Port Vila, the capital of the Republic of Vanuatu. Vanuatu is an island chain in the Pacific Ocean, located in the Pacific Rim of Fire. Due to the risk of natural disasters such as earthquakes, typhoons and volcanoes, Vanuatu consistently tops the UN's World Risk Report¹.

The climate of Vanuatu is tropical, with annual rainfall of 2 to 4 meters. Temperatures average 23° C in the winter and 28° C in the summer. Southeast trade winds bring cooling breezes in the afternoon.



Figure 1: Port Vila becomes Imperium²

In 2018, Port Vila's population was 45,000 and growing at 2% per year. Farming, tourism, and the off shore financial industry were major economic drivers, with manufacturing less than 9% of the economy.

In town, houses were made from cement and brick. Outlying areas used aluminum, bamboo, palm, coral, and cane. Port Vila had no high-density housing. Only 27% of houses had electricity, generated by burning diesel fuel. A solar panel trial in Espiritu Santo generated 40 kW for public buildings. The Devil's Point wind farm produced a peak power of 3.6 MW³. Renewable energy sources were 20% of the island's energy supply.

City leaders noted that in 100 years, Port Vila's population would reach 320,000. The island's culture of local food production was at risk due to depletion of fish near shore and limited arable land. It was time for Port Vila to develop innovative solutions in housing, food, transportation, and energy to support the future population growth.

Innovative Infrastructure

Civil engineers integrated Vanuatu's culture into the new city design. Instead of endless lines of haphazard tall buildings, engineers planned compact communities consisting of spacious buildings with mixed residential and commercial use. Most services are within walking distance, with abundant transportation options to other communities.

By 2120, Imperium's compact communities are green - using renewable energy sources, but also literally green, with trees, parks and farms inside the buildings. Food is raised locally in the community gardens, and vertical fish farms are integrated within communities, keeping Vanuatu's agricultural traditions intact. Additionally, green communities add to the health and happiness of the population, encouraging exercise and decreasing stress among citizens.

Rain water is collected and filtered by porous concrete and asphalt pavement on roads and walkways. By capturing, treating, and distributing water locally, erosion from storm runoff is reduced and clean water is readily available. Rainwater collection also reduced the power required to desalinate water by 45%, reducing the island's energy needs⁴. Local water treatment, using reverse osmosis, raised the cost of building construction, an important tradeoff. However, the benefits of local clean water availability during natural disasters and the energy savings outweighed the tradeoff of the higher cost.

All buildings are designed using earthquake hardening construction techniques such as solid foundations in bedrock, rubber shock absorbers, cross bracing, and strong steel frames. Buildings include additional resiliency measures such as safe assembly zones, supplemental shelters, and emergency power generators using coconut oil biofuel. The local food and water supplied by compact communities protect citizens from supply chain disruptions after earthquakes.

The elderly and children are most at risk when earthquakes hit. Schools may be closed until it is safe for students to return. Resilient buildings contain parks and exercise areas for citizens to enjoy their time until all services are restored. Elderly and citizens with health conditions are flagged by the smart-grid and given priority for backup power.

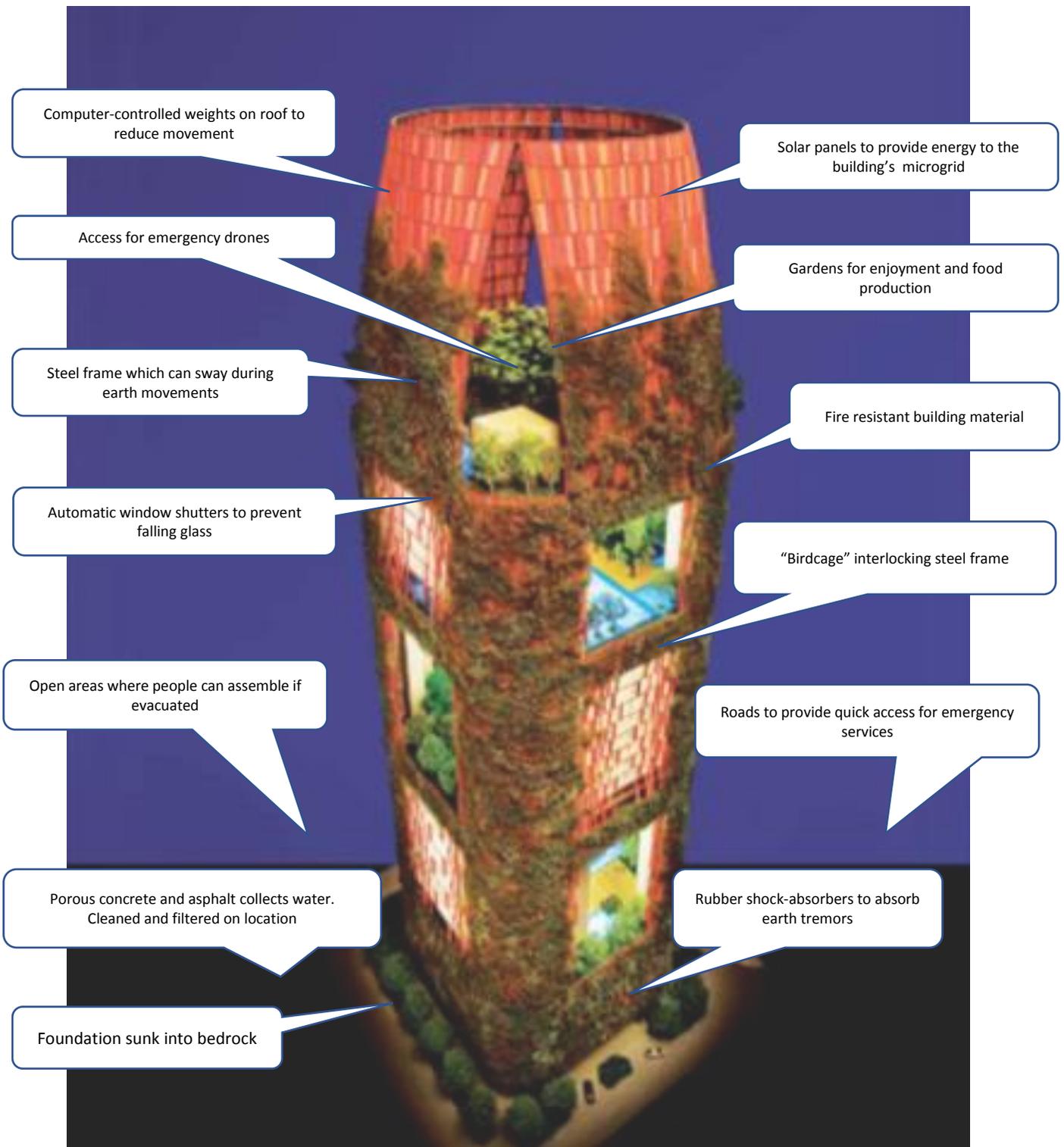


Figure 2: Construction and Survival Techniques²

Strength was not the only criteria. Prior to the building permit process, each building was evaluated against environmental and sustainability criteria, shown in Table 1.

Green Plot Ratio	460%	
Community Plot Ratio	250%	
Civic Generosity Index	100%	
Ecosystem Contribution Index	100%	
Self-Sufficiency Index	Energy 100%	
	Food 100%	
	Water 100%	
Earthquake Resistance	100%	

Table 1: Building Evaluation Criteria

Earthquake Effects

Vanuatu is located on the boundary of the Australian and Pacific tectonic plates, and regularly experiences volcanic activity and earthquakes. Earthquakes harm people immediately if buildings collapse from seismic disturbances or soil liquefaction, and cause fires due to damaged gas and electric lines. Earthquakes can pose long-term effects, including lack of access to food, water, shelter, and sanitation failures. Citizens located in remote areas are more vulnerable to long-term effects because rescuers are far away.

The electric grid, consisting of a generation source, transmission lines, substations, and distribution lines, can be damaged. Damage to the generation source could result in a widespread loss of power. Earthquakes may also damage individual substations or transformers, causing localized power outages. Falling trees or rocks could take down overhead transmission lines.

Power Grid Infrastructure

Civil engineers built several generation sources around the island to provide redundancy and de-risk the probability of an island-wide outage. Generation sources were grouped into five macro grids, with the ability to load share in the event of an outage.

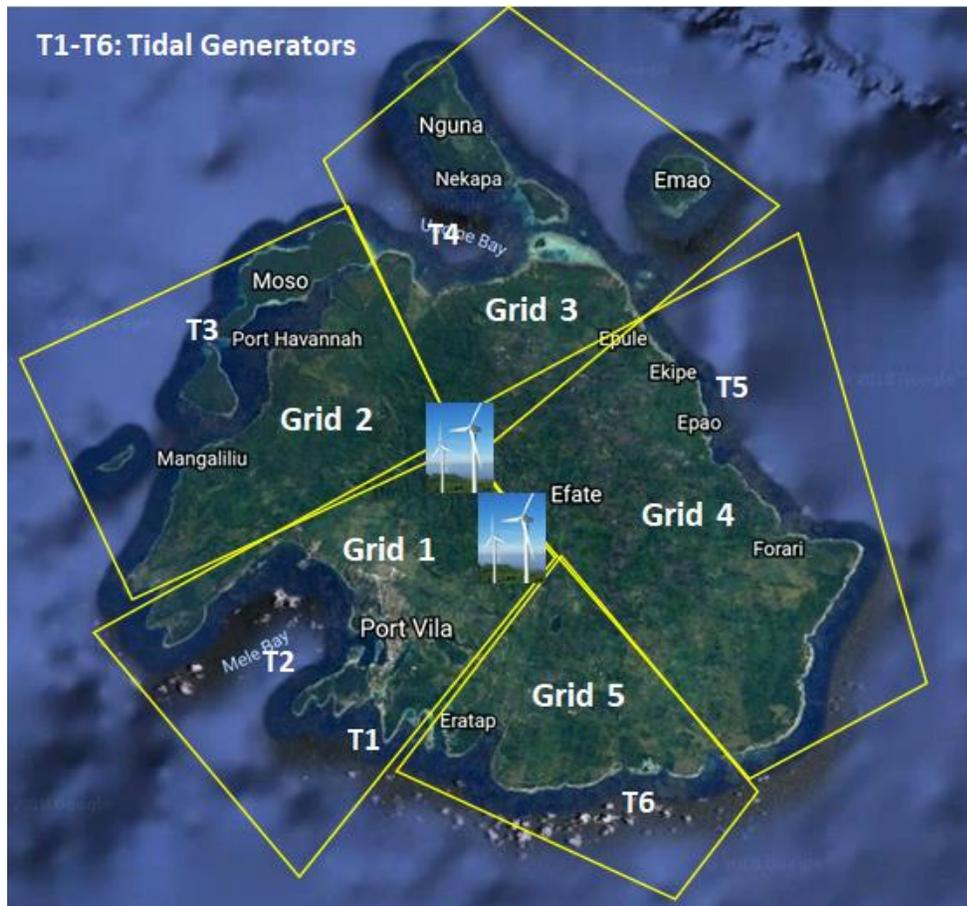


Figure 3: Macro Grids

Engineers selected Green and Blue Energy based on the island's natural resources. Green Energy consists of wind and solar power, and coconut oil. Civil and mechanical engineers designed wind turbines on the hilltops to provide energy to the island's interior. Compact communities contained solar panels throughout the building design, forming micro grids to supplement the macro power.

Blue Energy is tidal power (T1-T6 above), chosen since the island has ready access to the ocean. Tidal energy is harnessed by 20 m diameter turbines suspended from a floating platform anchored to the ocean floor⁵. The turbines are spun by water movement as the tide rises and falls. When the tide is flowing, the water's kinetic energy, 1,000 times more dense than wind, generates 4 MW per turbine. Engineers built six tidal generators, each with four turbines, for a total generation of 96 MW. Generated power is routed over transmission lines to substations, and distributed through transformers to end users. A tradeoff to using tidal power is that no energy is generated when the tide direction is changing.

Households and businesses are equipped with solid state batteries which store excess capacity during peak production periods, and supply power to users when power generation dips. Solid state batteries still work if punctured, and do not explode, which is important in earthquake

prone areas. Solid state batteries can handle a higher power density and recharge more rapidly than lithium batteries⁶.

Smart Grid and Resiliency

Instead of above-ground transmission lines, Vanuatu uses underground lines to avoid damage from falling trees or rocks. Civil engineers designing the electrical grid used graphene nanoribbon transmission lines, a flexible and resilient material to further protect lines.

Imperium's smart grid measures power consumption to every residence and can quickly flag deviations from normal usage. Service fluctuations from norm would be flagged for investigation and repair, and identify where to send rescuers in an emergency.

During extended power outages, balloons carrying high altitude turbines connect directly into buildings or microgrids. Drones deliver spare batteries to critical locations such as hospitals, clinics, food production, police and fire rescue facilities. Emergency light is provided by hydro flashlights, powered by adding water⁷. The flashlights can be stored for extended periods of time without going bad, unlike lithium batteries.



Figure 4: Movable High-Altitude Wind Turbine

After an earthquake, Imperium releases drones to fly over the affected areas, scanning and wirelessly uploading images that are automatically compared against baseline, pre-earthquake images. Computers rapidly identify damaged areas - road or bridge damage, building collapses, fallen rock, etc. Rescue teams are sent where they are needed most, using safe travel routes. Supply drones fly food, water, and medical supplies to remote areas to help people until relief teams arrive. If citizens are seriously hurt, larger drones fly in first responders, and fly out the injured people to hospitals.

City Services

With many safety innovations, Imperium's citizens feel secure. Robots and drones using artificial intelligence and wireless 15G technology aid police in their daily tasks. Firefighters use snake-inspired robots to navigate collapsed or burning structures to locate citizens. Flying drones with advanced thermal and infrared cameras generate 3D maps of the fire inside buildings. Imperium's firefighters use advanced exoskeleton suits to aid them in rescues. The suits strap on over a firefighter's protective equipment and transfer the load directly to the ground, improving ability to walk fast and carry efficiently. The suit is also equipped with a water gun system, and can deploy a sonic wave fire extinguisher, using low frequency waves to suck out oxygen.

Health care has vastly improved. Biomedical engineers designed nanobots capable of repairing hearts from heart attacks, performing minor surgery, and attacking cancer cells. Citizens use smartwatches to monitor their health and keep in contact with doctors. For instance, if a diabetic citizen's glucose level is high, the smartwatch would automatically schedule a doctor appointment. The watch can call an ambulance if a medical emergency is detected.

Empowering the Future

Imperium's solid construction, redundancy and resilience provide a safe and comfortable city that also embraces Vanuatu's cultural heritage. Citizens feel safe with resilient buildings that produce food, clean water, and support a micro-grid for emergency power. The Green and Blue Energy macro grids provide clean, safe and reliable power for all citizens.

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