2024–2025 Portfolio

Aoyun Chen

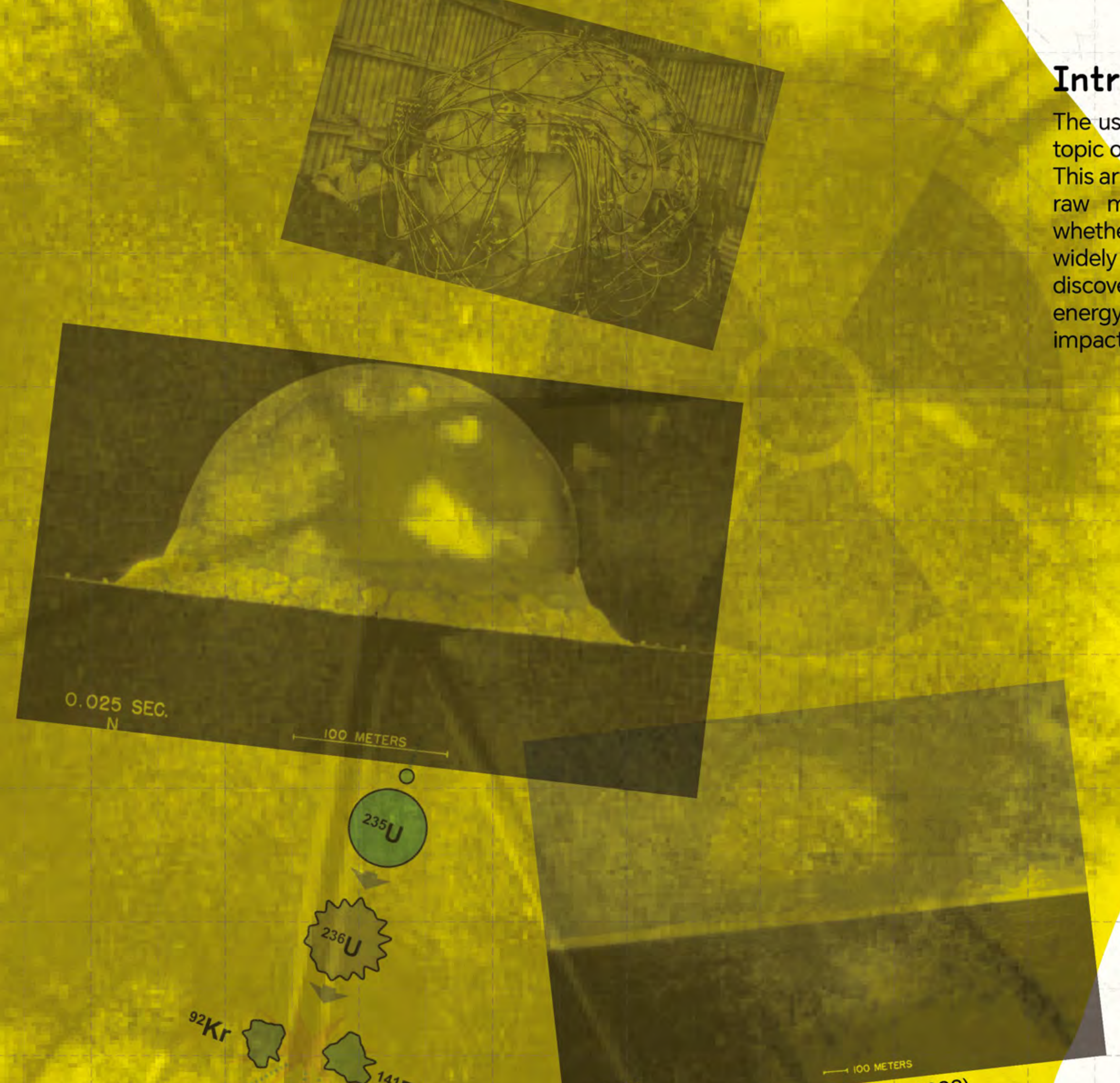
Nuclear Power

Amid rising global energy demand, the rapid depletion of fossil fuels, and an escalating climate crisis, nations are urgently exploring more diverse, secure, and low-carbon energy solutions. Nuclear power—characterized by its high energy density, low emissions, and stable output—has once again emerged as a focal point of global energy discussions.

However, critical concerns surrounding its safety, spent fuel management, and public acceptance remain unresolved. This portfolio reviews the historical development of nuclear power, analyzes its role and impact within the global energy supply chain, and explores the driving forces and challenges behind the nuclear revival—while raising a vital question: how will we view the future we shape by choosing nuclear power?

WILL NUCLEAR POWER BE USED SAFETY AND WIDELY IN THE FUTURE?

Keywords: #Uranium #Nuclear power #Nuclear revival



Oppenheimer (film, 2023)

Introduction:

The use of nuclear power has been a controversial topic of international debate since the Atomic Age. This article takes a look at uranium, a representative raw material for nuclear power, and explores whether nuclear power can be used safely and widely in the future by outlining the history of its discovery and utilization, its supply chain in the energy sector, its social and environmental impacts, and contemporary trends.

Background of uranium:

The 1789 discovery of uranium in the mineral pitchblende is credited to Martin Heinrich Klaproth. Eugène-Melchior Péligot was the first person to isolate the metal, and its radioactive properties were discovered in 1896 by Henri Becquerel. Research by Otto Hahn, Lise Meitner, Enrico Fermi and others, such as J. Robert Oppenheimer starting in 1934 led to its use as a fuel in the nuclear power industry and in Little Boy, the first nuclear weapon used in war (Wikipedia contributors, October 17, 2024).

Nuclear power industry:

After the end of World War II, the world entered the Atomic Age. Although shocked by the power of nuclear bombs used in the military, the people of the 1940s and 1950s remained optimistic that nuclear power could provide cheap and endless energy. Nuclear physicist Alvin M. Weinberg told the U.S. Senate's Special Committee on Atomic Energy in December 1945, "Atomic power can cure as well as kill. It can fertilize and enrich a region as well as devastate it. It can widen man's horizons as well as force him back into the cave. It can widen man's horizons as well as force him back into the cave."(Walker, J. S., & Wellock, T. R., 2010).

The Atomic Energy Act of 1954 allowed for the rapid declassification of U.S. reactor technology and encouraged the private sector to develop it. Since then, nuclear power has been gradually used for civilian power generation.

The uranium supply chain is extremely complex. Uranium fuel used in nuclear power plants is generally made through the steps of Mining, Milling, Uranium conversion, Enrichment and Fabrication, in addition to the complex steps of disposing of the nuclear waste it generates.

The quantities of uranium mined and produced are also uneven across countries, and its supply chain therefore requires cooperation between countries on imports and exports.

Figure I: Nuclear Fuel Cycle
Source: U.S. Government Accountability Office, *Nuclear Weapons, NNSA Should Clarify Long-Term Uranium Enrichment Mission Needs and Improve Technology Cost Estimates*, GAO-18-126, February 2018.

Chernobyl (miniseries, 2019)

The Three Mile Island accident in 1979 and the Chernobyl disaster in 1986 had far-reaching social and environmental impacts, and concerns about nuclear safety rose sharply (the rise of the anti-nuclear energy movement), which prompted many countries to suspend the nuclear power plant process. The nuclear enterprise, like all industrial endeavors, presents challenges to ensure safe and environmentally sound operations (Robert Josephson, P., & Kasperski, T., 2024): such as the disposal of radioactive nuclear waste, the high cost of building and operating nuclear power plants and many other issues.

Weak signals:

However, in the 21st century, issues such as global warming and the shortage of fossil fuel resources have led many countries to refocus their attention on nuclear power. The nuclear sector will need to evolve in important ways if it is going to play a major role in addressing energy security and climate challenges in many parts of the world and beyond the power sector. Several new advanced reactor technologies are under development that are better suited to industrial uses and are being targeted to replace existing coal-fired energy production. China has connected its first high-temperature gas reactor to the grid, and it envisions that it will ultimately be a drop-in replacement for existing coal-fired power plants and will be used for other industrial purposes, such as hydrogen and chemical production (Ted Nordhaus, Juzel Lloyd, 2022).

Despite The Fukushima nuclear accident in recent years, the trend towards nuclear revival is already evident in the initiatives of many countries. For example, A nuclear reactor resumed operation on Oct 29, 2024 for the first time in northeastern Japan since the region was affected by the 2011 earthquake-tsunami disaster, which also triggered a nuclear crisis, joining a dozen reactors in the country that have been rebooted after meeting more stringent safety standards(KYODO NEWS, Oct 29, 2024).

Canadian uranium producers shares got a boost on Sep 18, 2024 after Constellation Energy signed a deal to restart Pennsylvania's Three Mile Island nuclear plant to help power Microsoft's growing artificial intelligence ambitions (Adriano Marchese, Sept 20, 2024).

Furthermore, Energy Security Secretary Grant Shapps announced how Great British Nuclear (GBN) will drive the rapid expansion of new nuclear power plants in the UK at an unprecedented scale and pace on 18 July 2023 . This will boost UK energy security, reduce dependence on volatile fossil fuel imports, create more affordable power and grow the economy, with the nuclear industry estimated to generate around £ 6 billion for the UK economy (Department for Energy Security and Net Zero, Great British Nuclear, Nuclear Decommissioning Authority, The Rt Hon Grant Shapps and Andrew Bowie MP, 18 July, 2023).


Following the Fukushima fishermen out to sea, what are the results of the nuclear radiation tests on the fish caught? @shipindao https://youtu.be/izosdXhVZGo?si=zM7LYHBB7_5pyxF3

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Robert Josephson, P., & Kasperski, T. (2024). *Toward a global history of the nuclear age.* Esboços, 31(57), 330-346. https://doi.org/10.5007/2175-7976.2024.e102709

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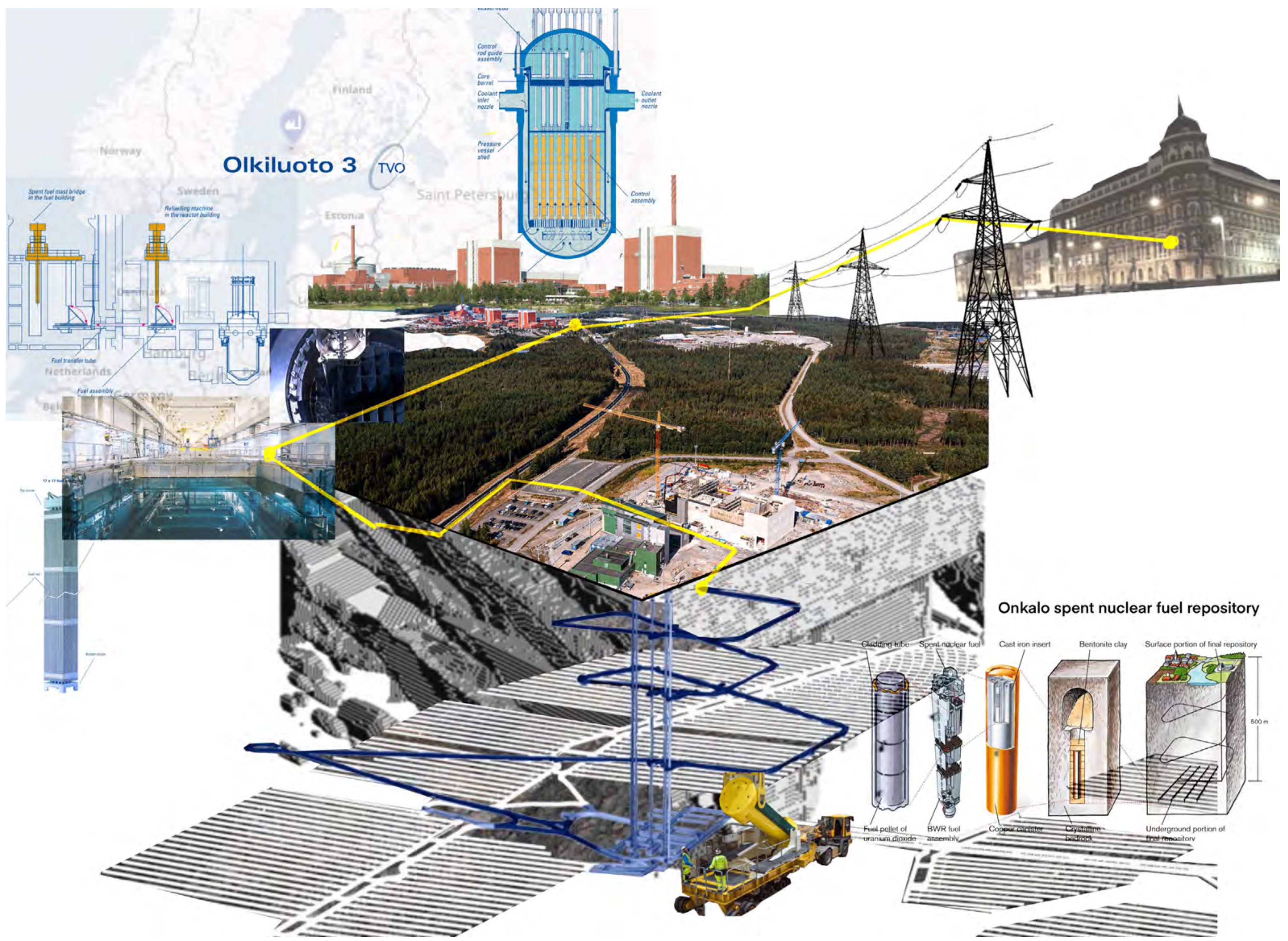
Adriano Marchese. (Sept 20, 2024). *Canadian Uranium Producers Rise as Constellation Energy Plans Nuclear Plant Revival in Pennsylvania.* MarketWatch. https://www.marketwatch.com/story/canadian-uranium-producers-rise-as-constellation-energy-plans-nuclear-plant-revival-in-pennsylvania-dc01b145#comments_sector

Department for Energy Security and Net Zero, Great British Nuclear, Nuclear Decommissioning Authority, The Rt Hon Grant Shapps and Andrew Bowie MP. (18 July, 2023). *British nuclear revival to move towards energy independence.* GOV.UK. https://www.gov.uk/government/news/british-nuclear-revival-to-move-towards-energy-independence

Conclusion:

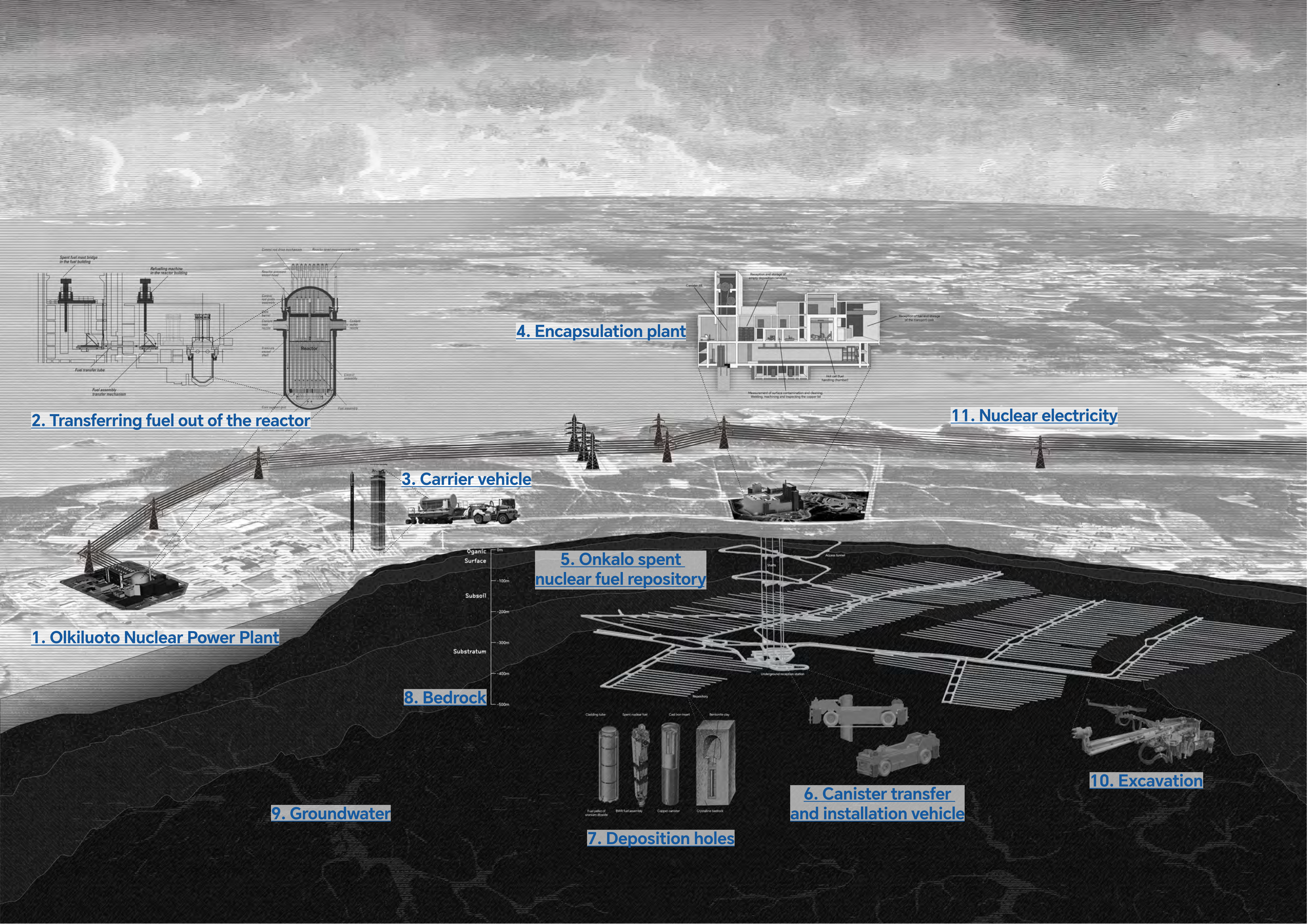
The nuclear revival has been unstoppable, but many unknowns remain: Such as whether the problem of nuclear waste disposal can be permanently solved; whether nuclear power plants can safely cope with the many potential risks, despite the advances in nuclear energy-related technologies; and how to assess the potential environmental impact of the nuclear power supply chain, even though nuclear power is almost a green energy.

As a result, I am skeptical about the nuclear revival after the above research, and I believe that there is still a need for further reflection and weighing of the pros and cons.



In the wake of the global nuclear revival, nations are now forced to confront a long-neglected question: how should spent nuclear fuel be dealt with? Spent fuel, the highly radioactive byproduct of nuclear reactors, still contains reusable isotopes, but its intense radiation and long-lived toxicity make it extremely difficult to handle. Safe isolation is required for tens of thousands of years.

Finland currently leads the world in this effort. On the island of Olkiluoto, the Onkalo deep geological repository is being built to seal spent fuel in copper canisters and bury them hundreds of meters underground. It marks the first time in human history that a technological solution is designed on a timescale of 100,000 years—an attempt to seal danger within the Earth's bedrock and promise safety across millennia.



1. The Olkiluoto Nuclear Power Plant is one of Finland's two nuclear power plants. The plant is owned and operated by Teollisuuden Voima (TVO), and is located on Olkiluoto Island, about 50 kilometres (31 mi) from the city of Pori. The Olkiluoto plant consists of two boiling water reactors (BWRs), each with a capacity of 890 MW, and one EPR type reactor (unit 3) with a capacity of 1,600 MW. This makes unit 3 currently the most powerful nuclear power plant unit in Europe and the third most powerful globally. Construction of unit 3 began in 2005. Commercial operation, originally scheduled for May 2009, began on 1 May 2023.

2. The refuelling machine lifts a fuel assembly out of the reactor core and transfers it to the transfer container, which is in a vertical position. The transfer mechanism turns the transfer container to a horizontal position and moves it from the reactor building through the transfer tube to the fuel building. The container is again turned to a vertical position, and the spent fuel mast bridge lifts the fuel assembly out and transfers it to the spent fuel storage rack in the spent fuel pool.

3. The carrier vehicle transfer the transport cask from TVO's interim storage for spent fuel to Posiva's encapsulation plant along a prespecified route.

4. When final disposal operations are underway, spent fuel is brought from the interim storage to the encapsulation plant for packing in the final disposal canisters made of copper and spheroidal graphite cast iron. The encapsulation plant is connected to the underground disposal facility by means of a canister lift, which transports the canisters down to the deposition level at a depth of 430m to the underground reception station. From there, they are transported with the transfer and installation vehicle to the deposition tunnels.

5. The Onkalo spent nuclear fuel repository is a deep geological repository for the final disposal of spent nuclear fuel from the Loviisa and Olkiluoto sites. It is being built in the granite bedrock at the Olkiluoto site, about five kilometers from the power plants, and will become the world's first long-term disposal facility for spent nuclear fuel. The facility will be operational by 2026, and decommissioned by 2100.

6. The canister transfer and installation vehicle is a remotely operated vehicle. Its task is to transport and install the copper canisters containing spent fuel into the deposition hole. Before setting off, the cylinder is turned to a horizontal position, after which the canister is transported to the selected tunnel. Finally, the vehicle is levelled over the right hole and the canister is lowered in the middle of the buffer blocks.

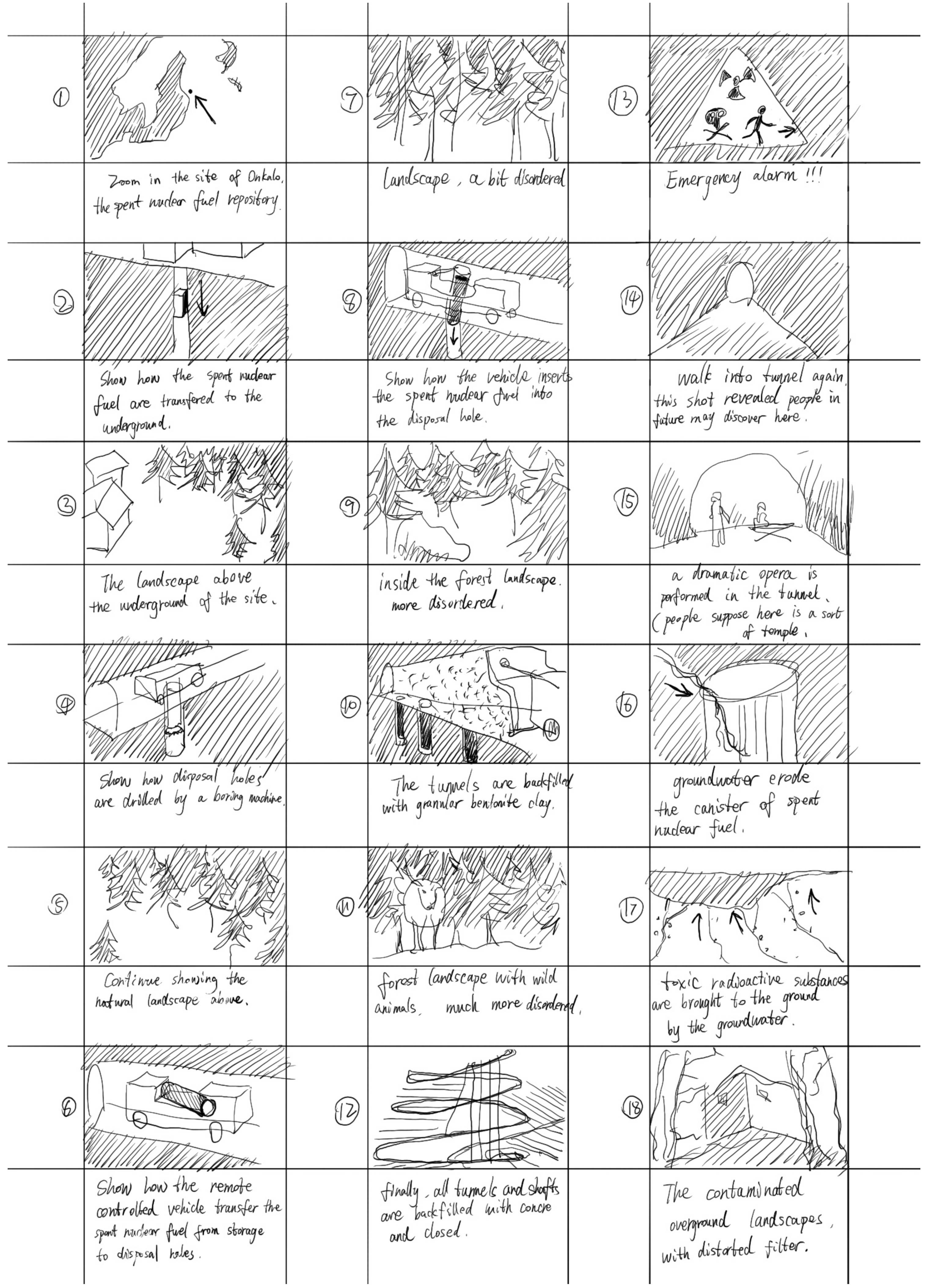
7. When only one final disposal canister is placed in a vertical deposition hole, there is not only bentonite but also rock between separating the canisters. The deposition hole is approximately 8 m deep and 1.75m in diameter. The diameter of the canister is 1.05m.

8. Bedrock separates spent fuel physically from the biosphere and nature. It also makes it almost impossible for humans to access the repository. In addition, bedrock provides predictable mechanical, geochemical and hydrogeological conditions for the engineered barriers.

9. Groundwater flowing through crevices and cracks of bedrock provides the radioactive substances contained in the spent nuclear fuel with the only pathway to make contact with humans and living nature. The final disposal canisters and deposition holes are placed in rock zones where cracking and groundwater movements are minimal.

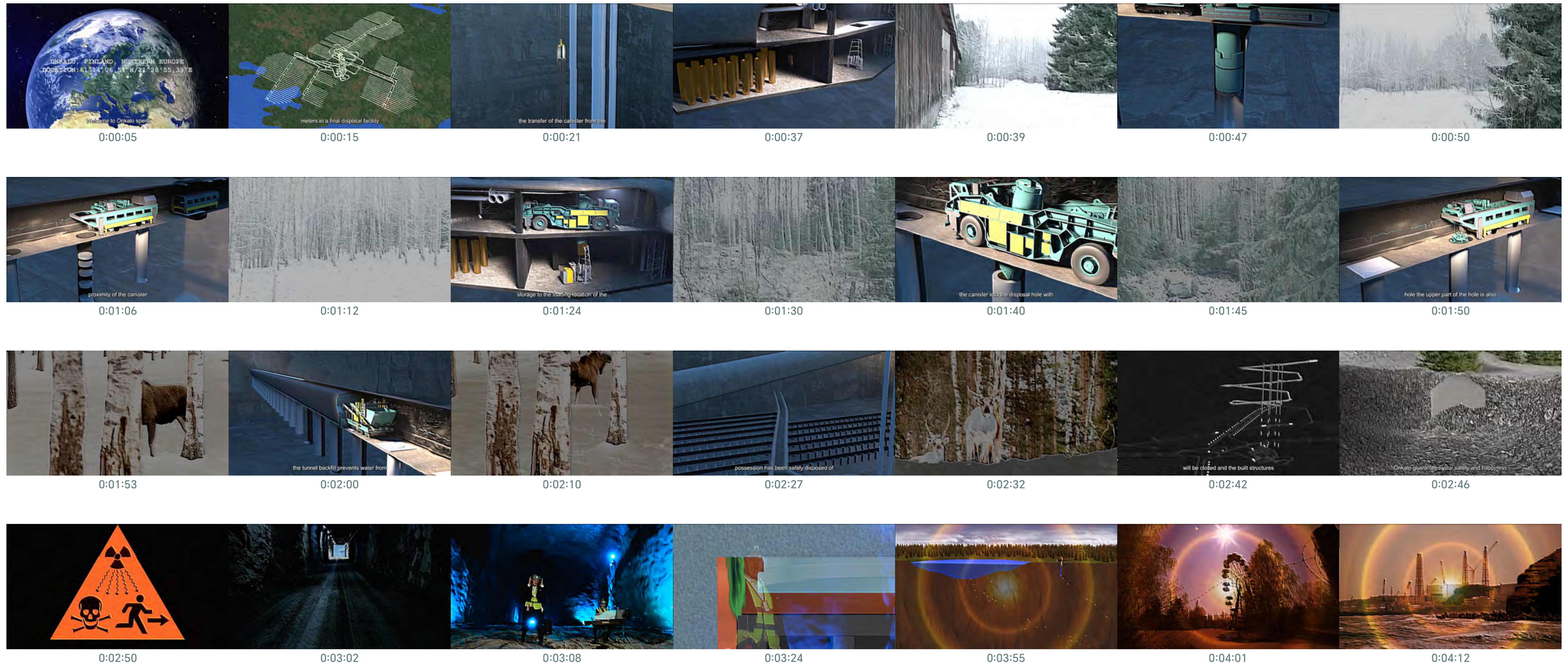
10. ONKALO has been excavated with the drill and blast method. The drill and blast method begins with the drilling of the holes, which are charged. Rock mass is blasted and blasted rock is transported away. The rock walls are washed and loose stones dropped. By 2020, approximately half a million solid cubic metres of rock have been excavated in order to research and implement final disposal. Much of the blasted rock has been utilised in earthwork.

11. Nuclear power provided about 35% of the country's electricity generation in 2022. The Finnish public is among the most nuclear power-friendly nations in the EU: in a 2008 survey, the production of nuclear electricity was supported by 61%, clearly above the EU average of 44%.



But this is not merely a technical solution—it is a moral decision. Can today's society truly bear the responsibility for a future it cannot foresee? What happens if, centuries from now, these sites are unearthed or disturbed? Could earthquakes compromise their integrity? Might groundwater bring hidden dangers back to the surface?

The following short film explores these uncertainties, inviting reflection on the risks, assumptions, and ethical weight behind the choices we make today.



Onkalo

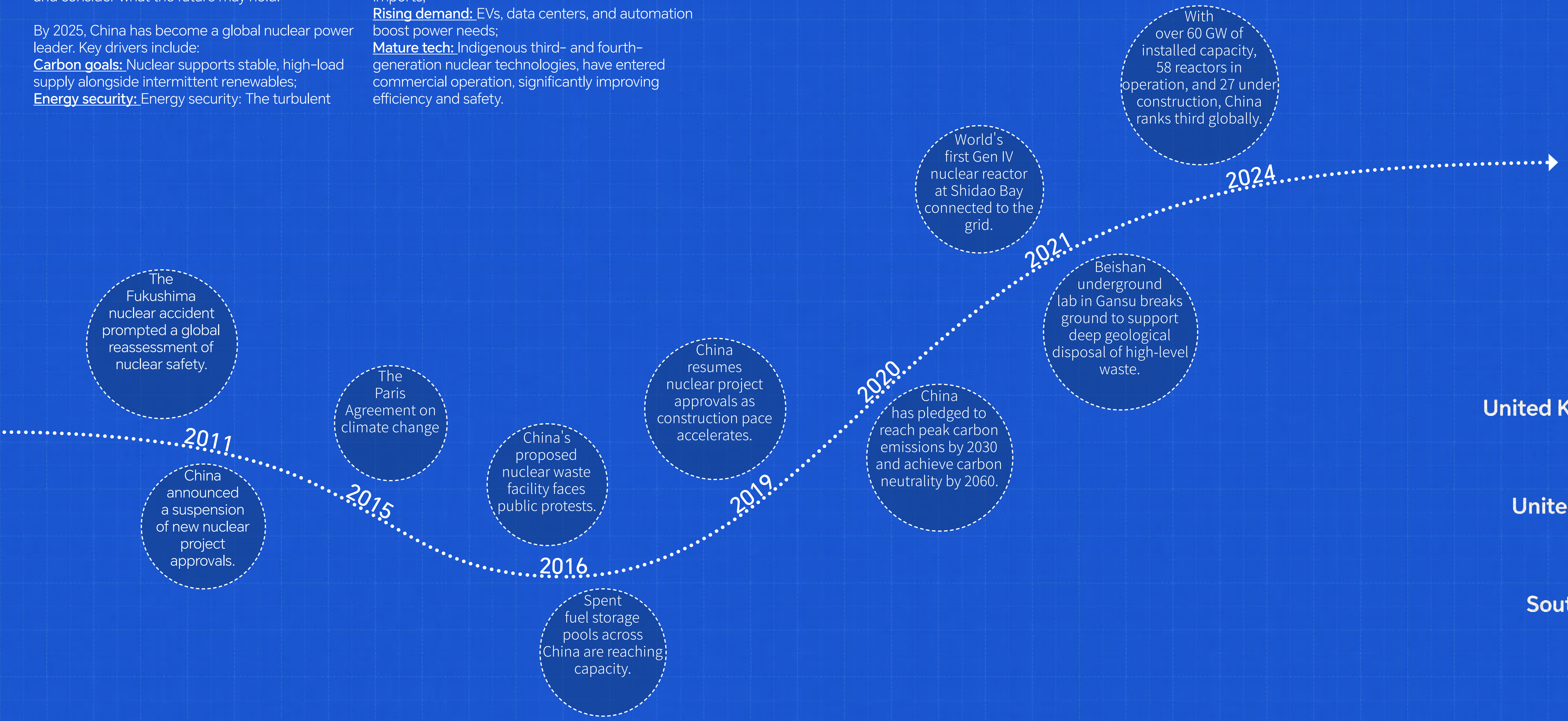
by Aoyun Chen

https://drive.google.com/file/d/1oKNWNvGH8oXXaBTvCuClUEU01Sk-lySi/view?usp=sharing

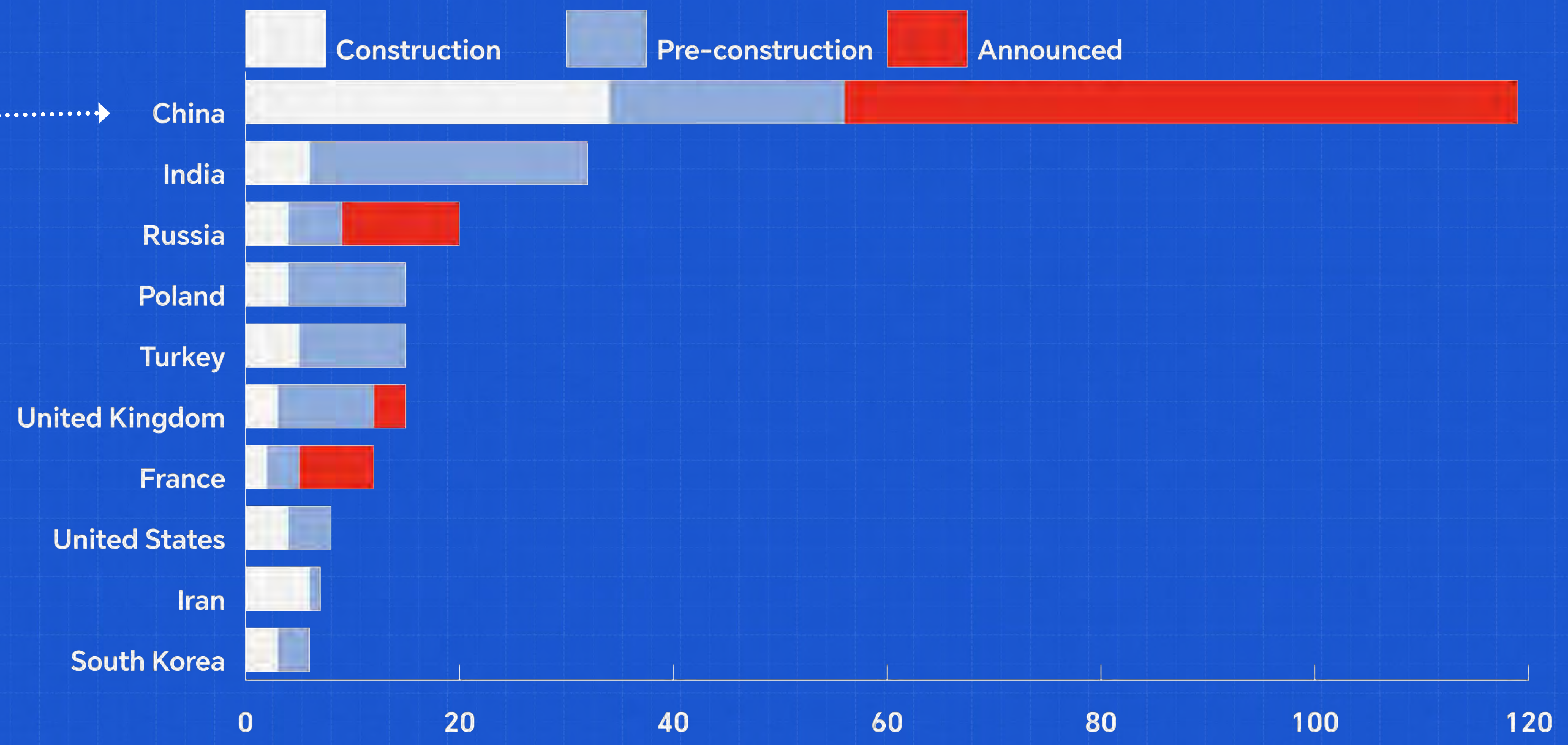
China Nuclear Power Review

Shifting our focus from Finland back to my country—China—we look back on the journey of its nuclear energy development, examine the present, and consider what the future may hold.

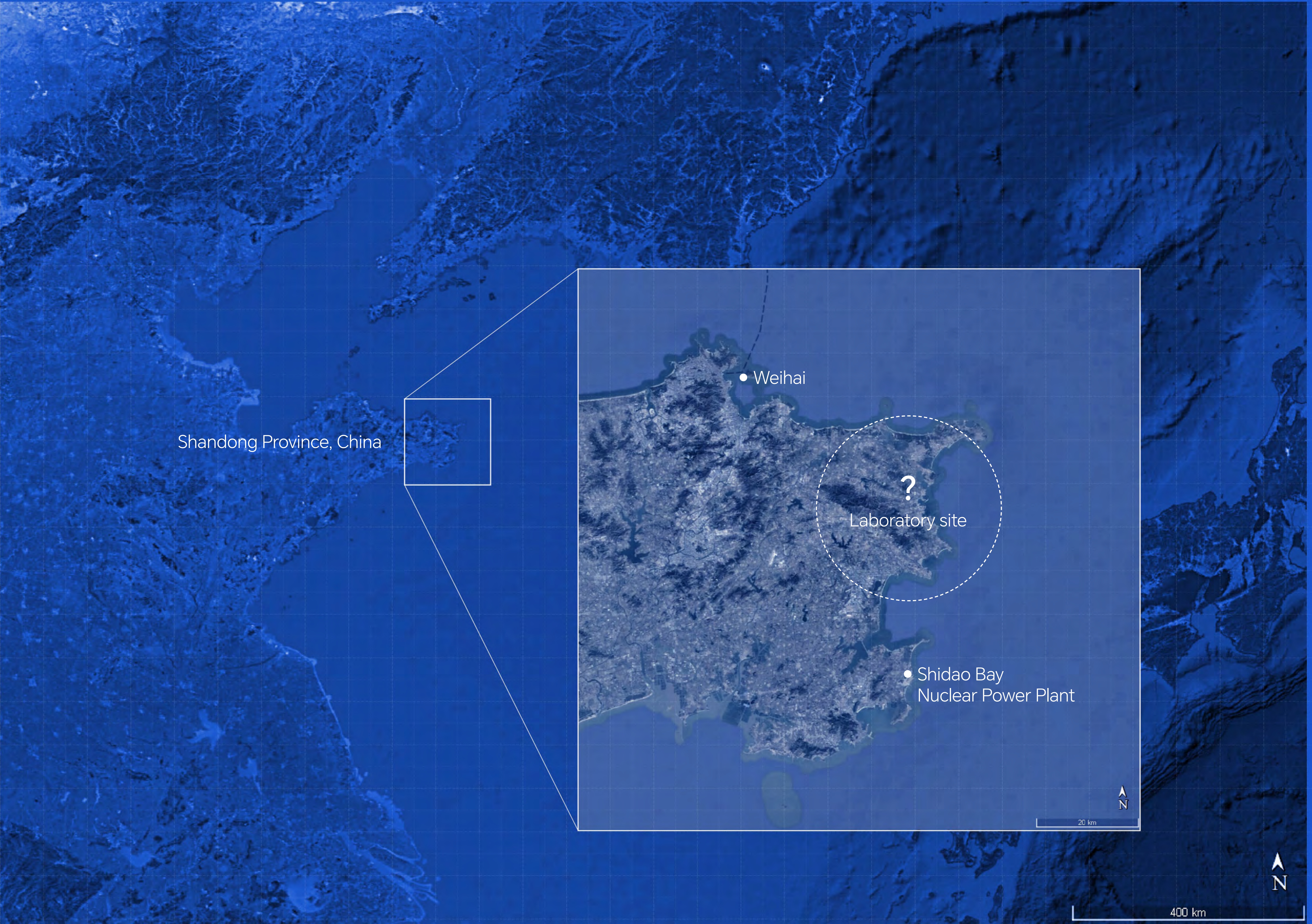
By 2025, China has become a global nuclear power leader. Key drivers include:
Carbon goals: Nuclear supports stable, high-load supply alongside intermittent renewables;
Energy security: Energy security: The turbulent international situation has prompted the improvement of energy independence, and nuclear power has reduced dependence on fossil energy imports;
Rising demand: EVs, data centers, and automation boost power needs;
Mature tech: Indigenous third- and fourth-generation nuclear technologies, have entered commercial operation, significantly improving efficiency and safety.



Prospective nuclear power capacity by country, in gigawatts (GW)



Source: Global Nuclear Power Tracker, July 2024, Golbal Energy Monitor

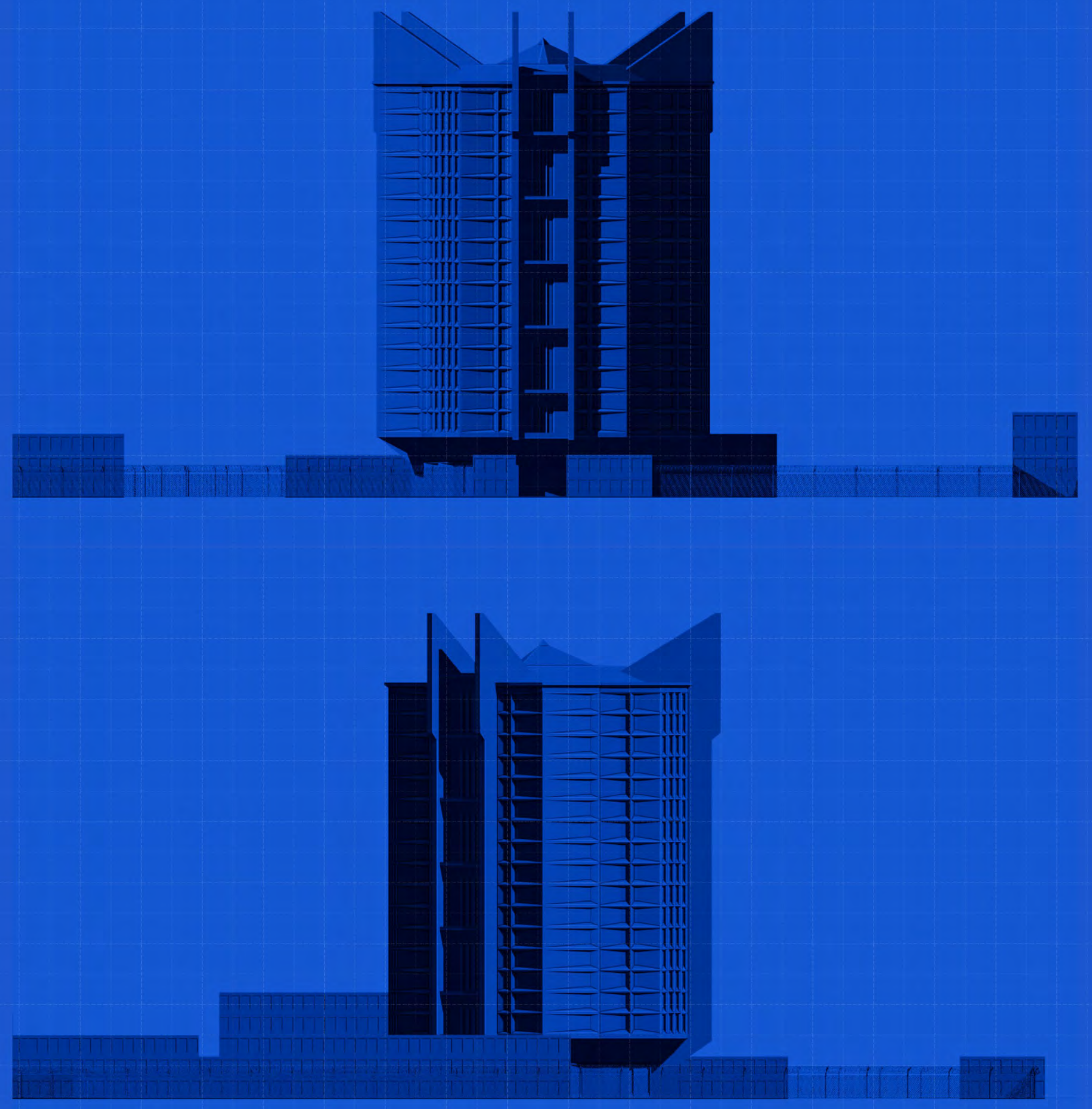


SPENT NUCLEAR FUEL ZERO-WASTE LABORATORY

Since 2019, China has resumed and accelerated its nuclear power development, aiming to achieve carbon neutrality and strengthen national energy security. However, the revival of nuclear energy has also intensified the challenges of managing spent nuclear fuel. Existing storage facilities are projected to reach capacity by 2030, making the construction of a spent fuel reprocessing system increasingly urgent.

In response, the government introduced the **Mandatory Spent Fuel Recycling Policy (2026–2050)** in 2026, setting a national goal to fully recover all spent nuclear fuel by 2050. The policy also outlines a gradual reduction in reliance on conventional solutions such as deep geological disposal, while promoting the development of more advanced and sustainable zero-waste technologies.

As a key step in implementing this policy, China plans to establishthe **Spent Nuclear Fuel Zero-Waste Laboratory** in Weihai, Shandong. Located near the Shidao Bay nuclear power plant, the facility will leverage the region's fourth-generation reactor cluster and existing infrastructure to reduce transport risks and costs while enhancing industrial synergy. The laboratory is scheduled to begin operation in the summer of 2027.



Speculations about the future

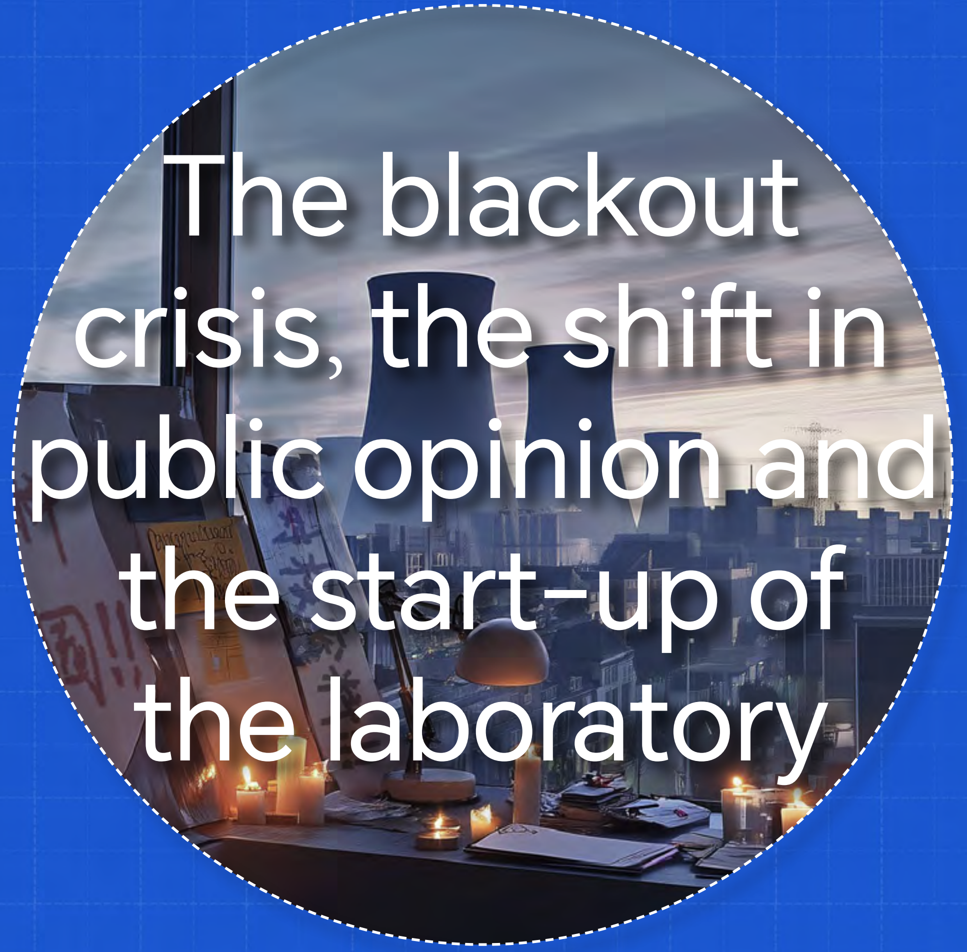
The policy's announcement ignited fierce public opposition and mass protests. In a drastic move to restore control, the government enforced a citywide blackout. Following the crisis, authorities adjusted their approach—revising policies, increasing transparency, and offering reassurances on safety and oversight. This gradually shifted public opinion, allowing the project to resume. As the laboratory progresses, society seems to be approaching the ideal of efficient energy recycling and low-carbon living—yet beneath the surface, subtle signs of environmental degradation have already begun to emerge.

2026

Mandatory Spent Fuel Recycling Policy (2026–2050) and Spent Nuclear Fuel Zero-Waste Laboratory

2027

2029



2040

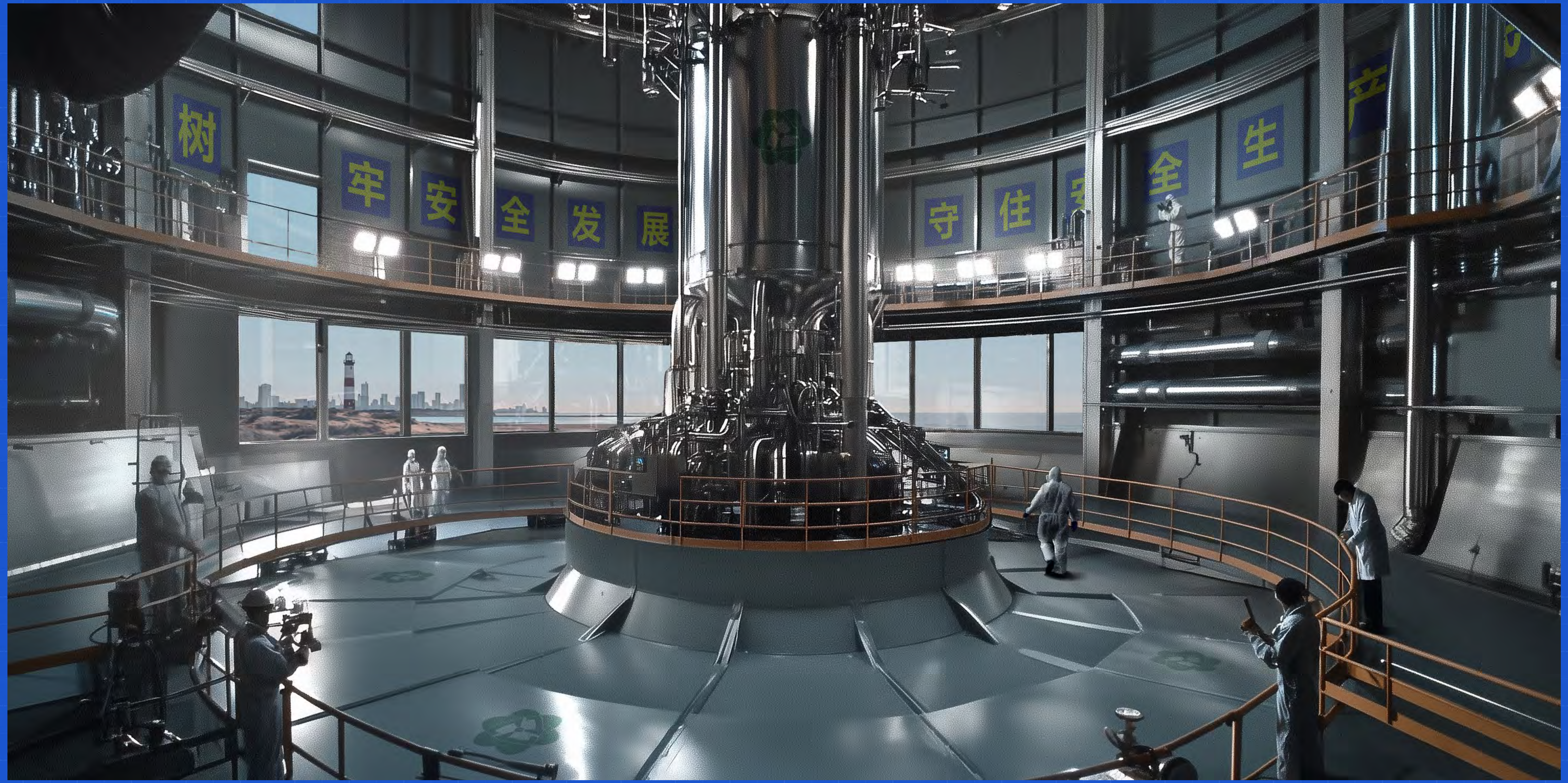
2045

Ethical Reflection on Technology and Environment

Prompt:
Two white-coated scientists look out of a window, outside the window is a laboratory building site at night, the building is covered in tarpaulins and scaffolding, a birght red spotlight (with the Chinese words 'Reject naclear waste') shines on the building in the distance, wire entanglement surrounds the building, crowds of protestors gather outside, 4k widescreen film

Prompt:
A window sill of a anti-nuclear protester's home with large protest placards (with the Chinese words 'Reject naclear waste, protect our homeland' on it),unlit lamp and lit candles on it, an Asian man sits on the window sill looking out of the window at an evening scene in an blackout city, in the distance are the cooling towers of a shutdown nuclear power plant, 4k widescreen film

Final Film

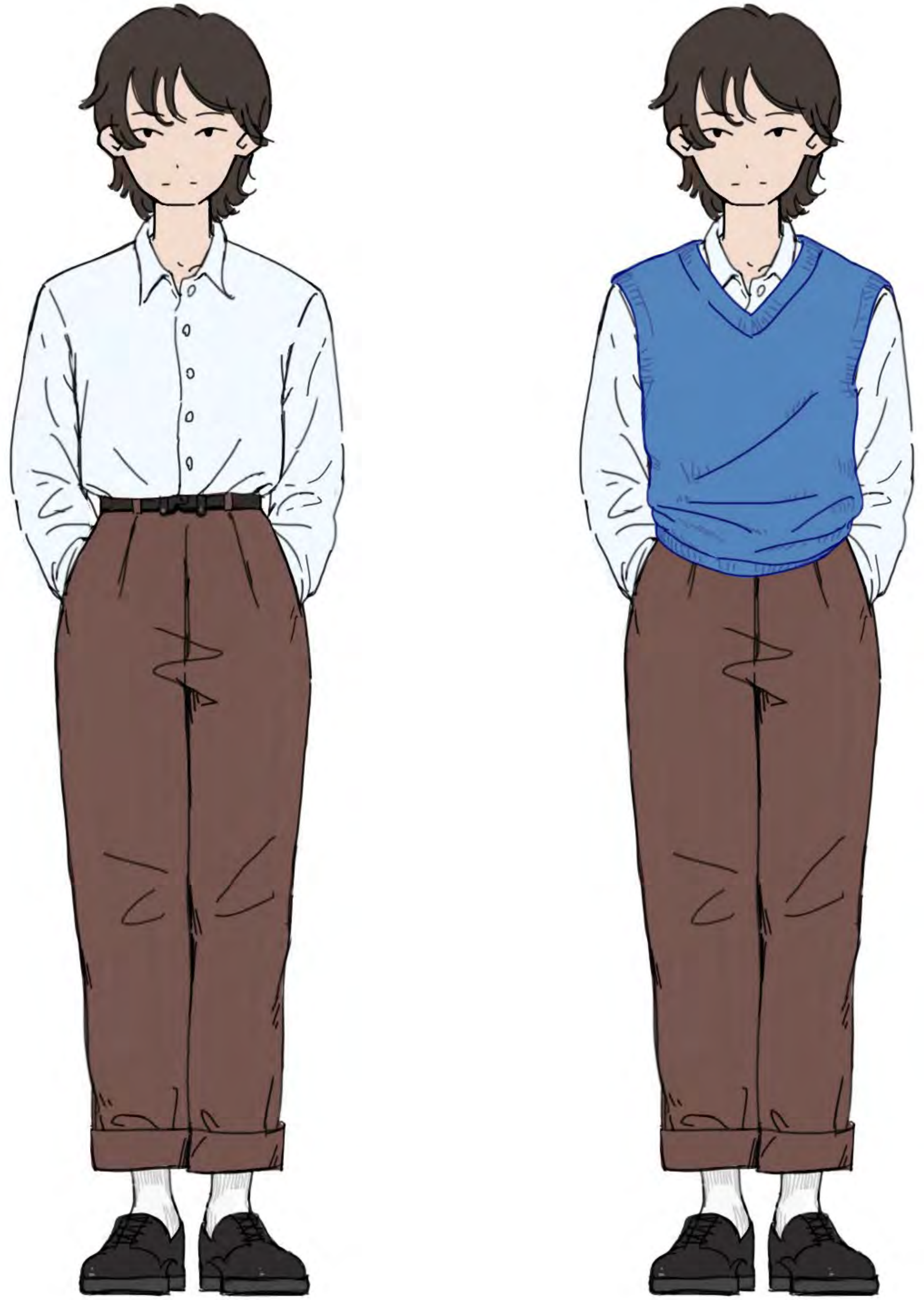


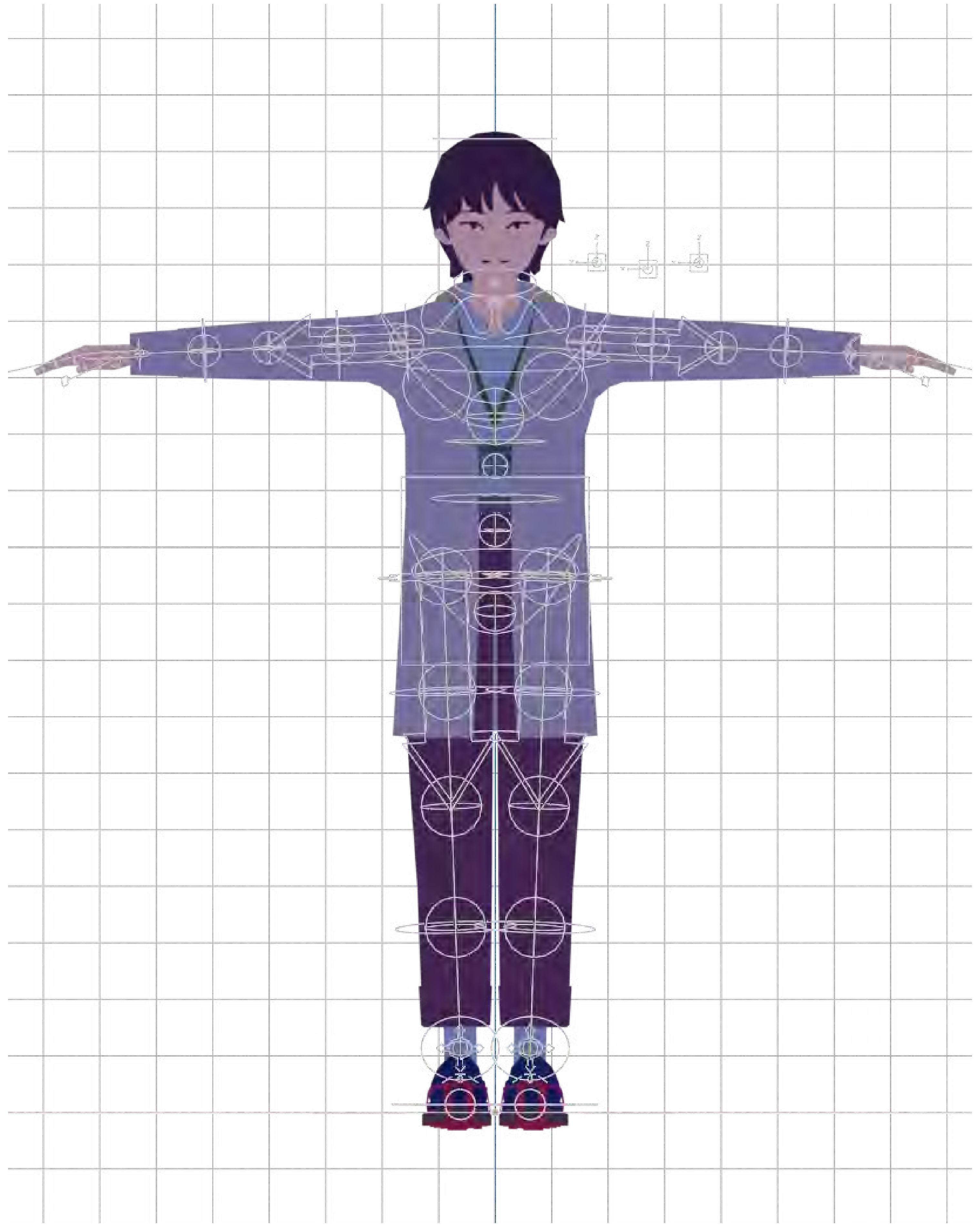
Prompt:
A nuclear fuel recycling laboratory, pipes conectted to the installation, some scientists in the room, A row of continuous transparent floor-to-ceiling windows,Desert beach with blue sky outside the window, lighthouse, Modern big city and Skyscrapers in the distance, 4k widescreen film

Entropy Extinction is a reality-based science fiction animated movie. Set in the near future, the story unfolds as growing concerns over energy security and environmental responsibility drive China to launch the world's first Spent Nuclear Fuel Zero-Waste Laboratory—aiming to balance domestic energy consumption with environmental protection. Yet, does this initiative truly pave the way for a sustainable future, or does it merely open the door to unforeseen upheaval?

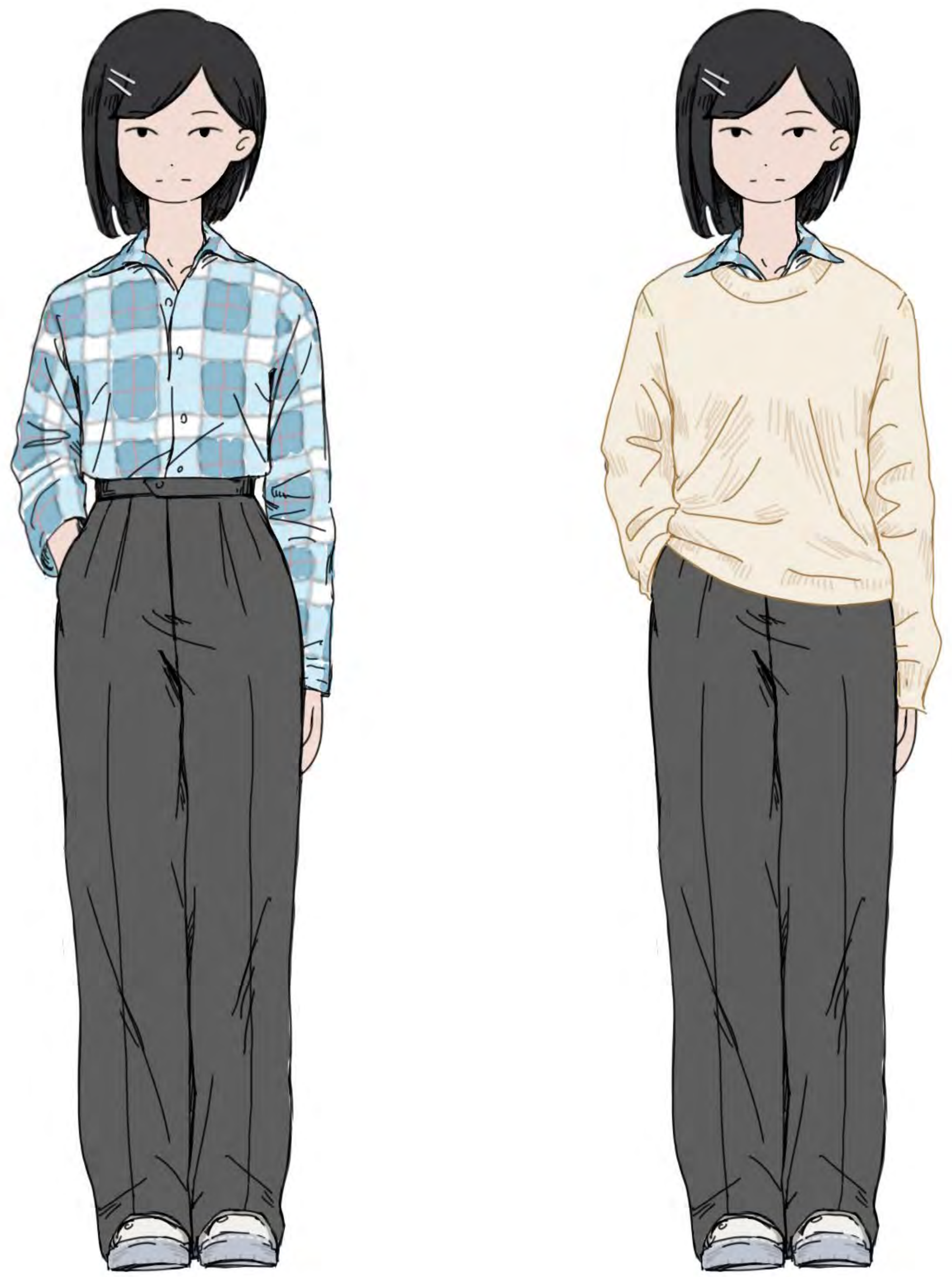
Film link: https://youtu.be/pTM15Z23Qx0

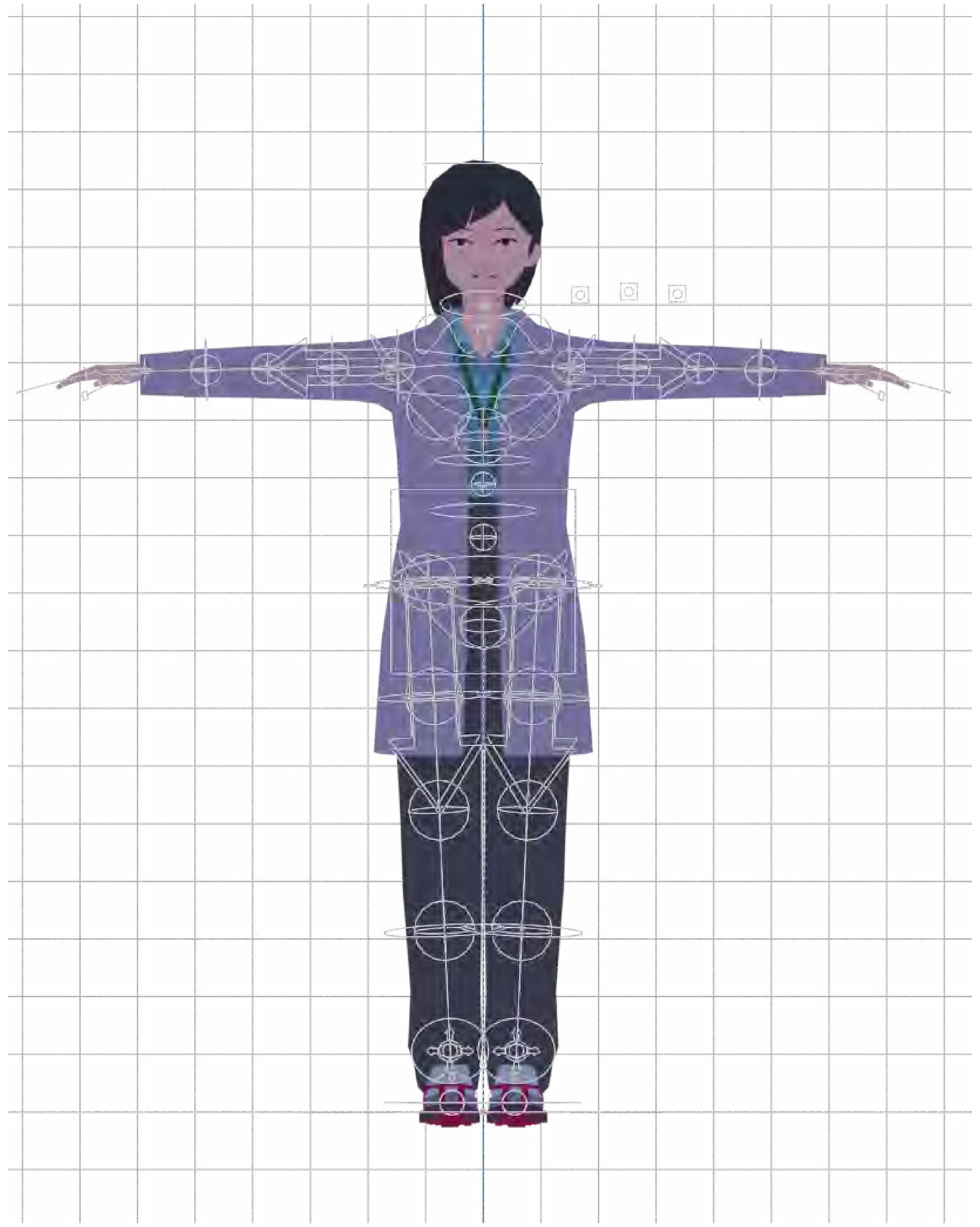
Behind-the-scenes



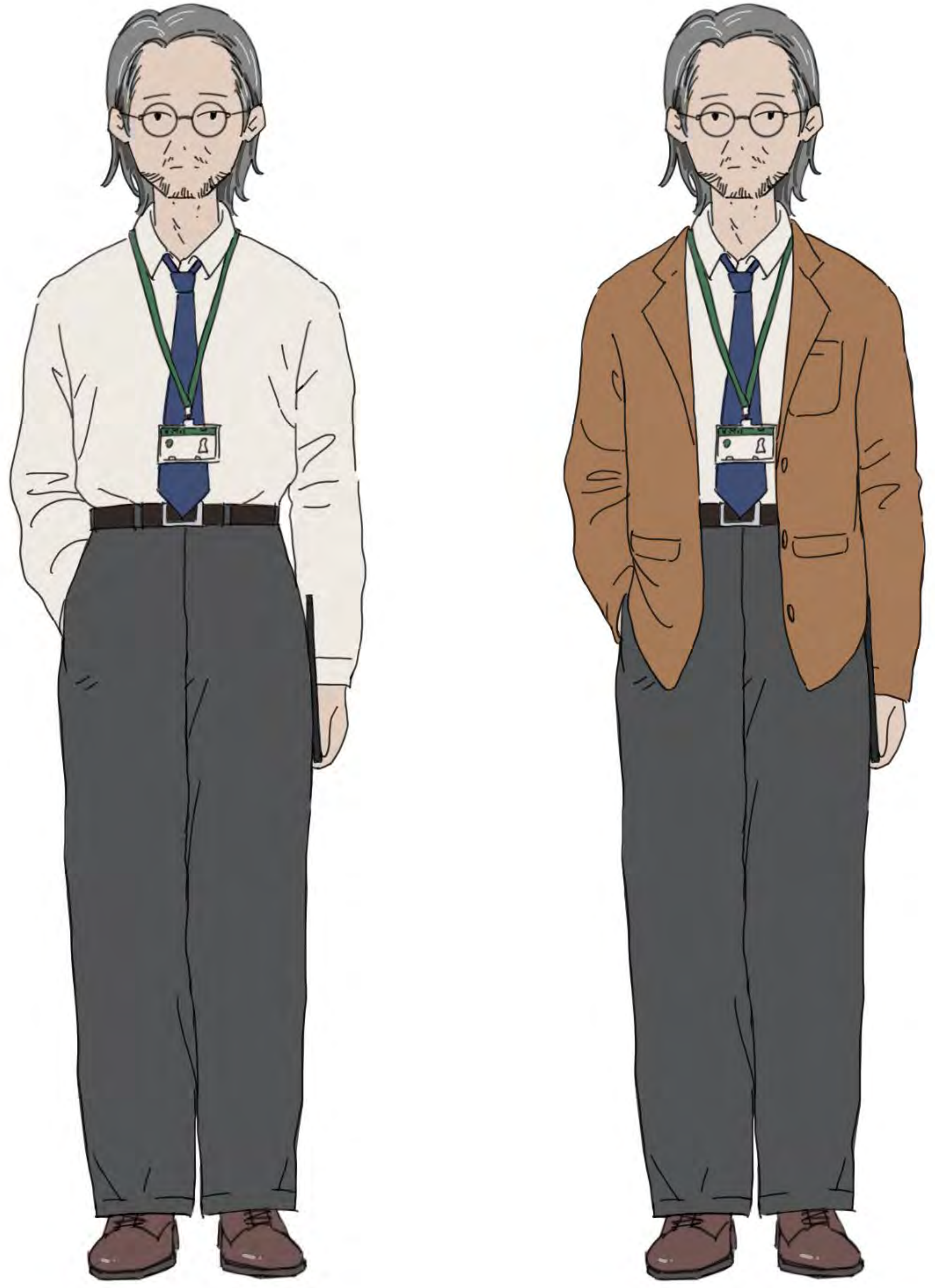
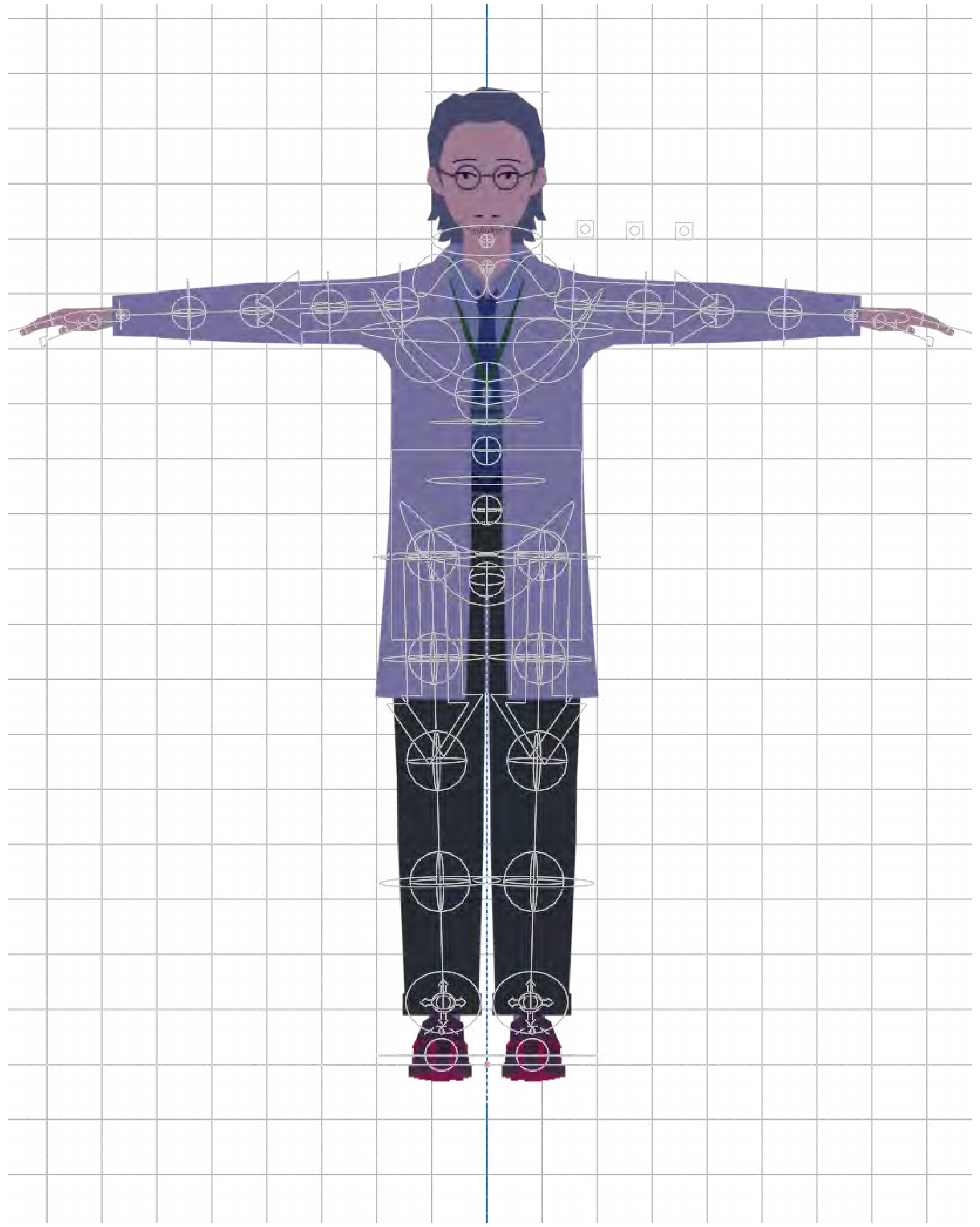


Character: Shen Yiran

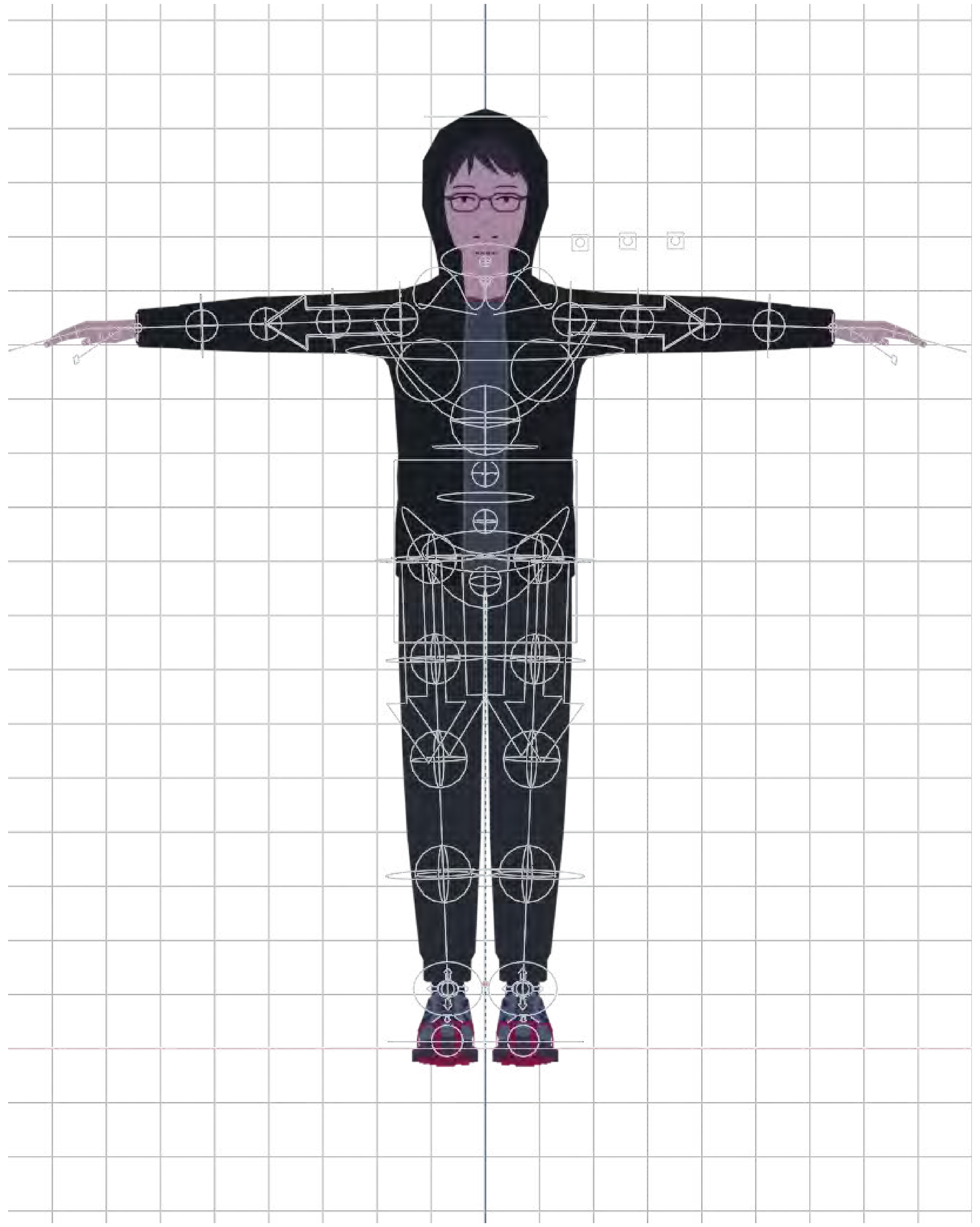




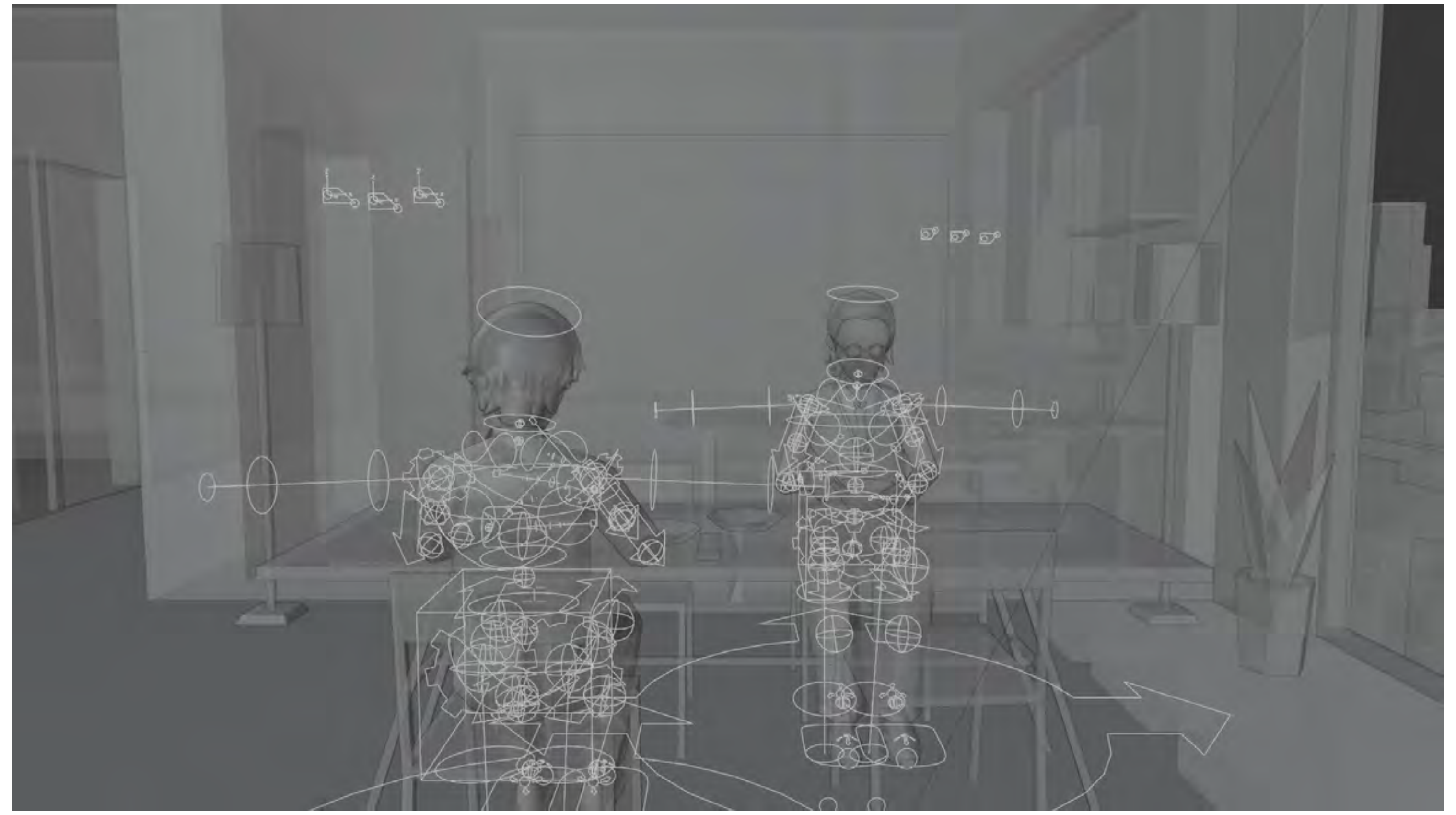
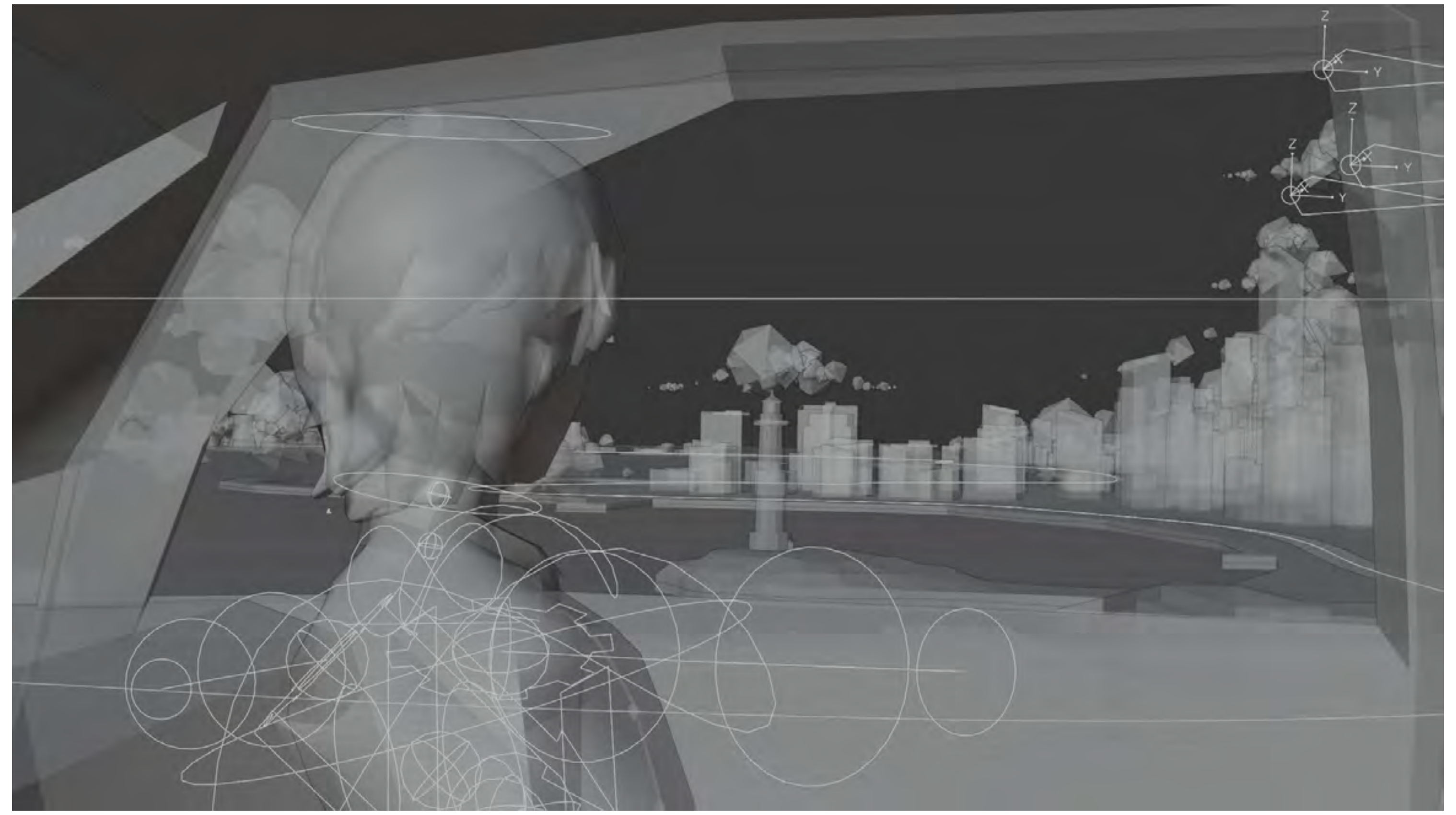
Character: Lin Lan

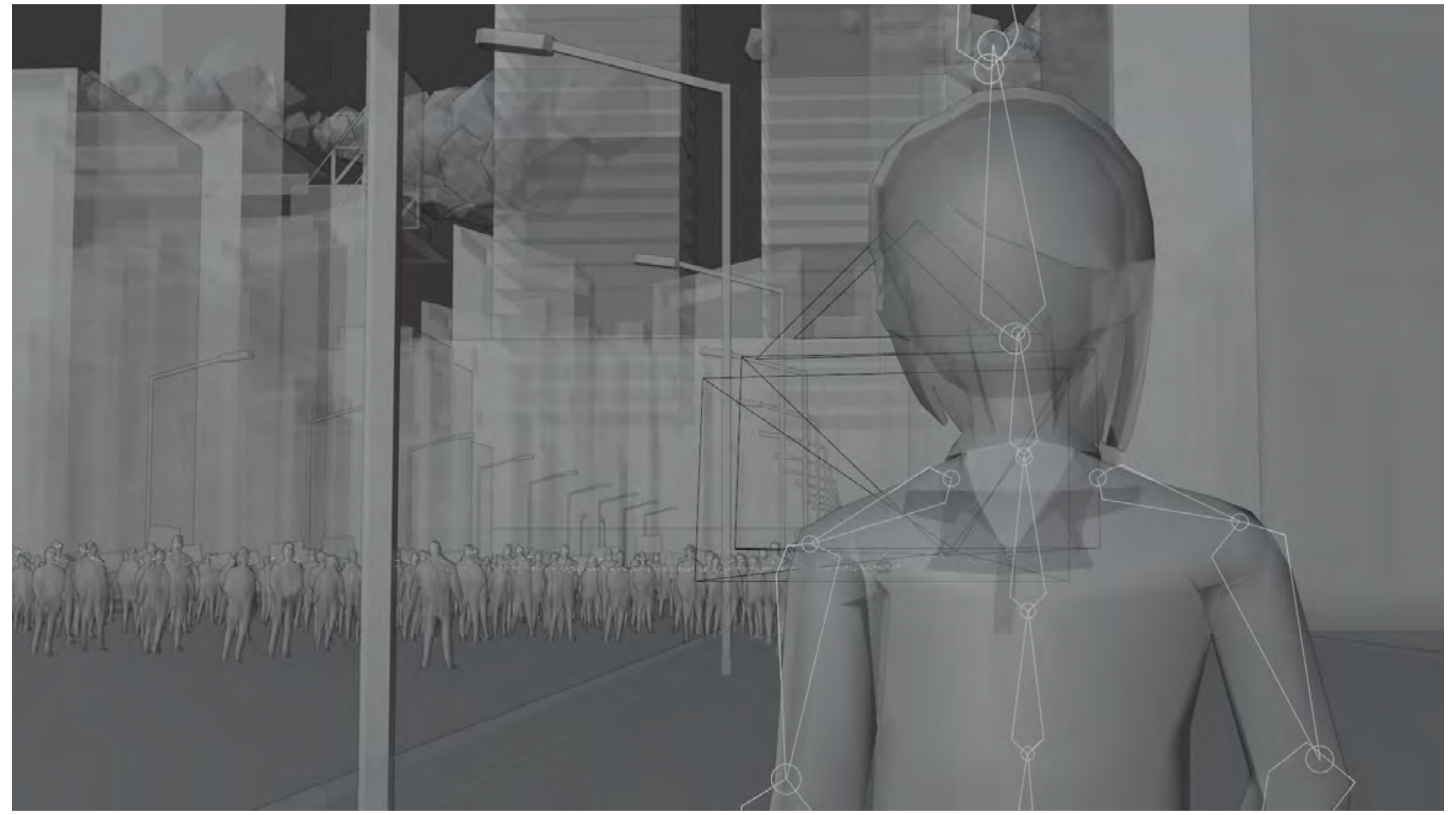
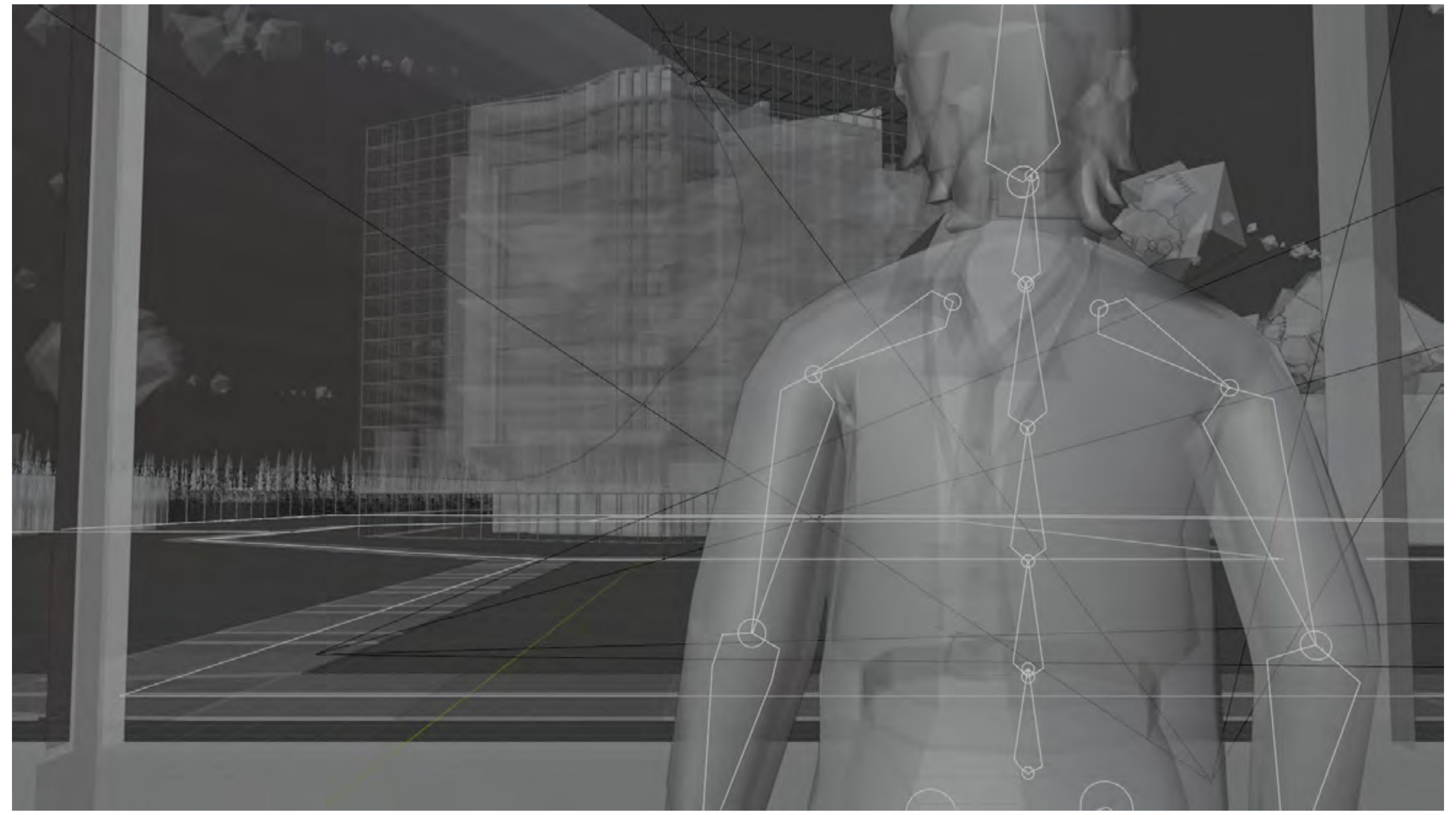



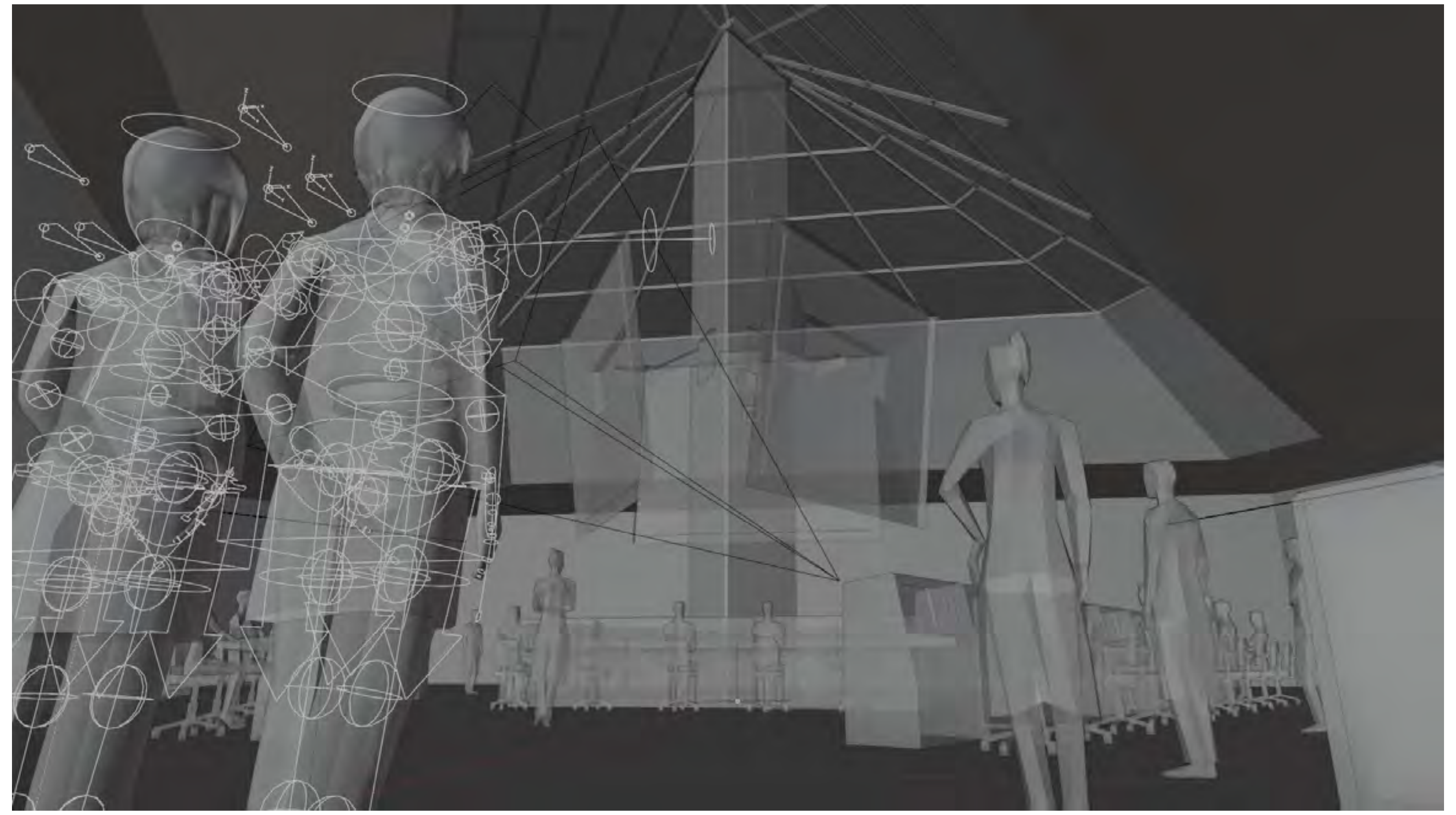
Character: Shen Chong'an

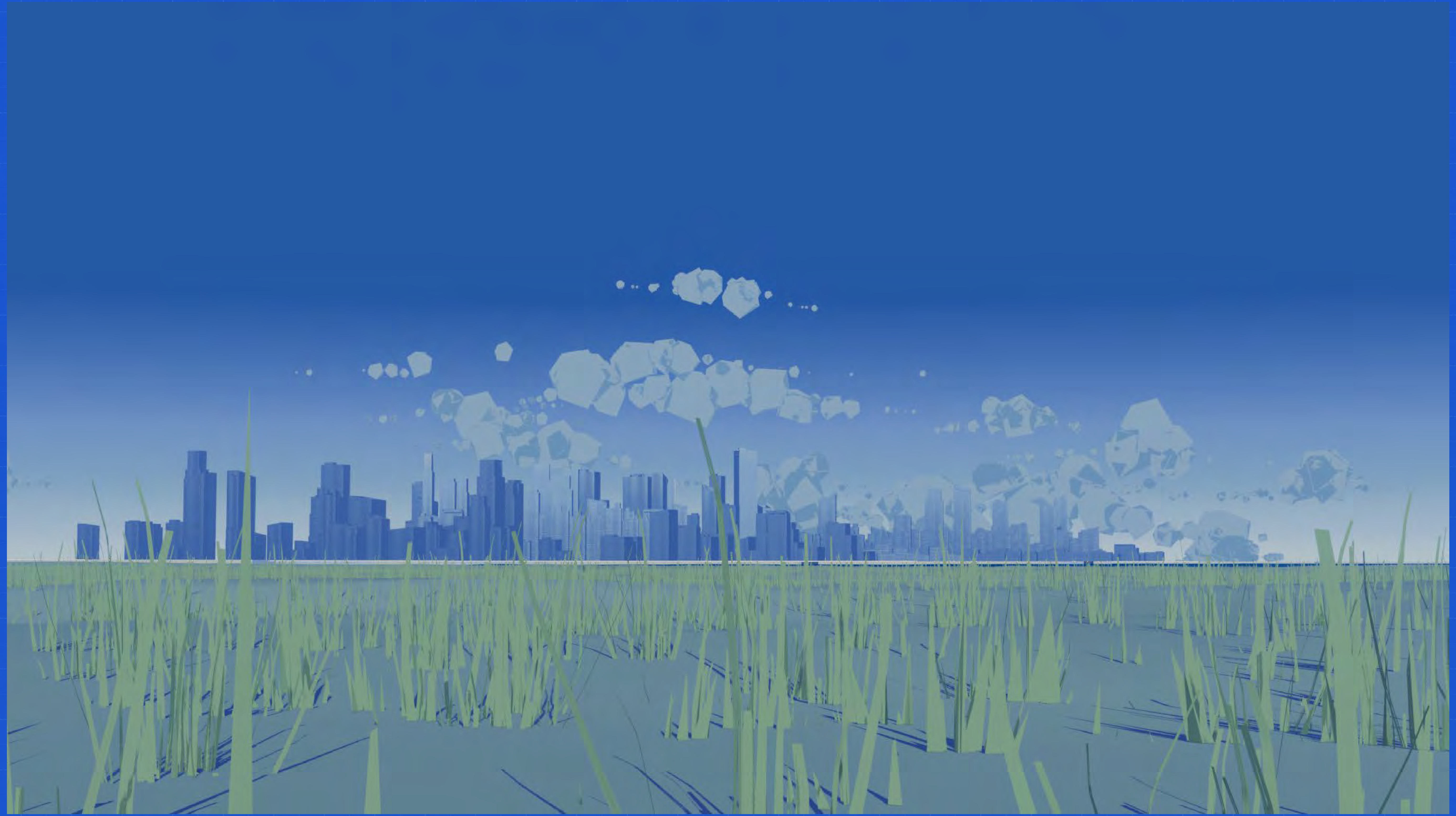



Character: Li Chuan





City Coast Landscape in 2028

City Coast Landscape in 2040

PROP: Lab ID cards

PROP: Goverment leaflets

威海市人民政府文件

威政办〔2027〕第114号

关于紧急恢复供电及民生保障的联合通告

各相关抗议人员及全体市民：

根据《威海市突发事件应对条例》等相关法律法规，为尽快恢复全市正常生产生活秩序，现就有关事项通告如下：

一、主动登记人员优待政策：凡在2027年7月1日前完成登记备案的抗议人员：立即恢复其居所的电力供应、享受电价减免20%优惠政策及免除此前违法聚集行为的行政处罚。提供重要线索或协助劝返其他抗议者的人员：额外奖励5000-50000元与优先安排就业岗位。

二、拒不配合人员惩戒措施：对逾期未登记备案者：无限期推迟其居所的电力供应及纳入社会信用黑名单。对继续从事破坏活动者：依法采取刑事强制措施、取消社会福利待遇与限制子女就读公立学校。

三、登记方式：现场登记：各社区居委会、电话登记：12389（24小时服务热线）。

四、数据公开与监督渠道：所有实验室相关环境监测数据已通过www.weihai-safety.gov.cn 实时公开；即日起开放实验室设施安全参观预约（每日限额100名，详情请见www.weihai-safety.gov.cn）。

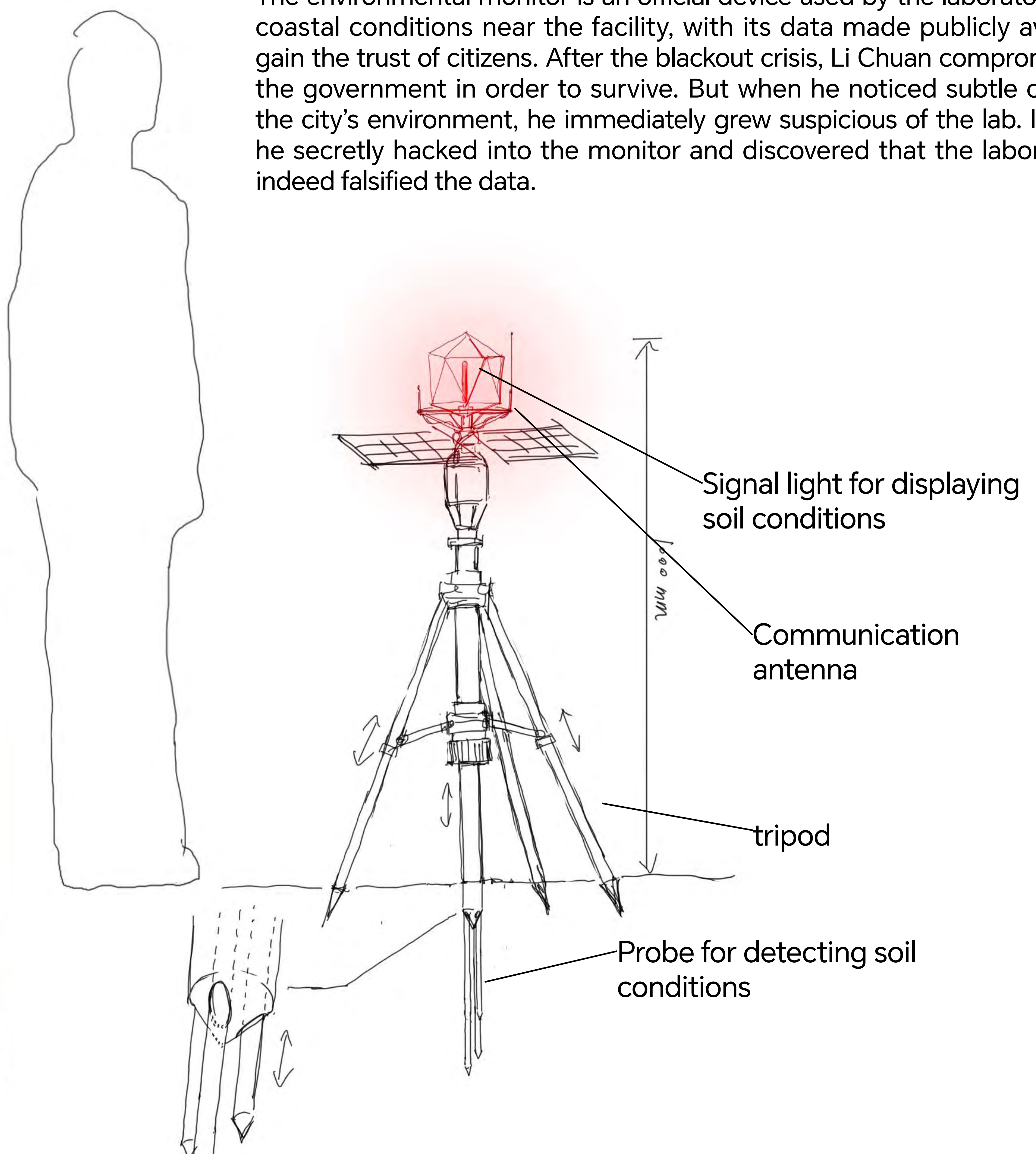
本通告自发布之日起立即生效。请广大市民珍惜机会，主动配合，共同维护社会稳定。

威海市突发公共事件应急管理委员会
2027年6月7日

办公室

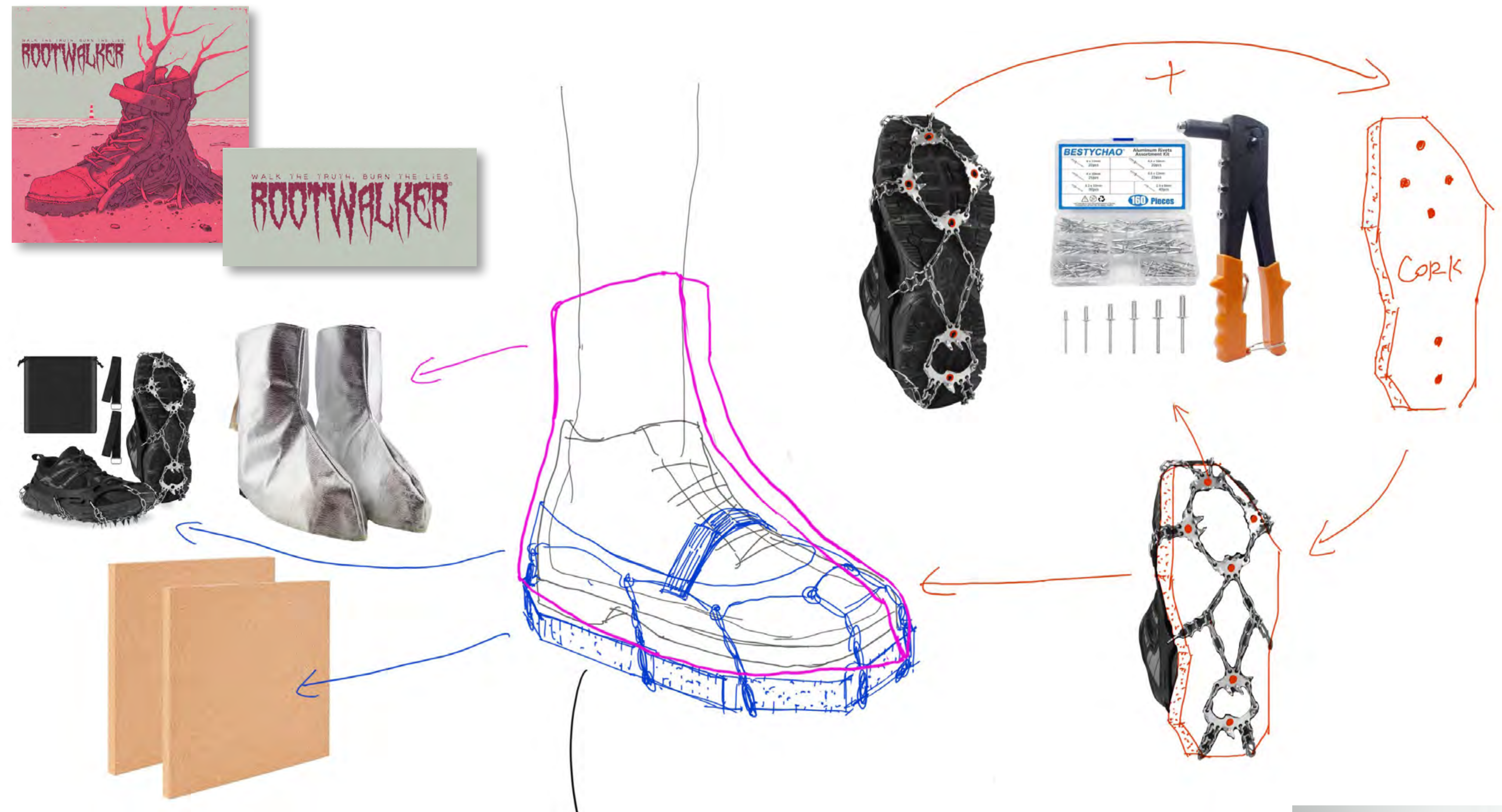
This leaflet is dropped by helicopter by the government on the protesters after the city's blackout in Act 4, and is used to announce preferential policies to persuade the protesters to compromise, as well as disciplinary measures to warn those who refuse to cooperate with the goverment, in order to quell the protests.

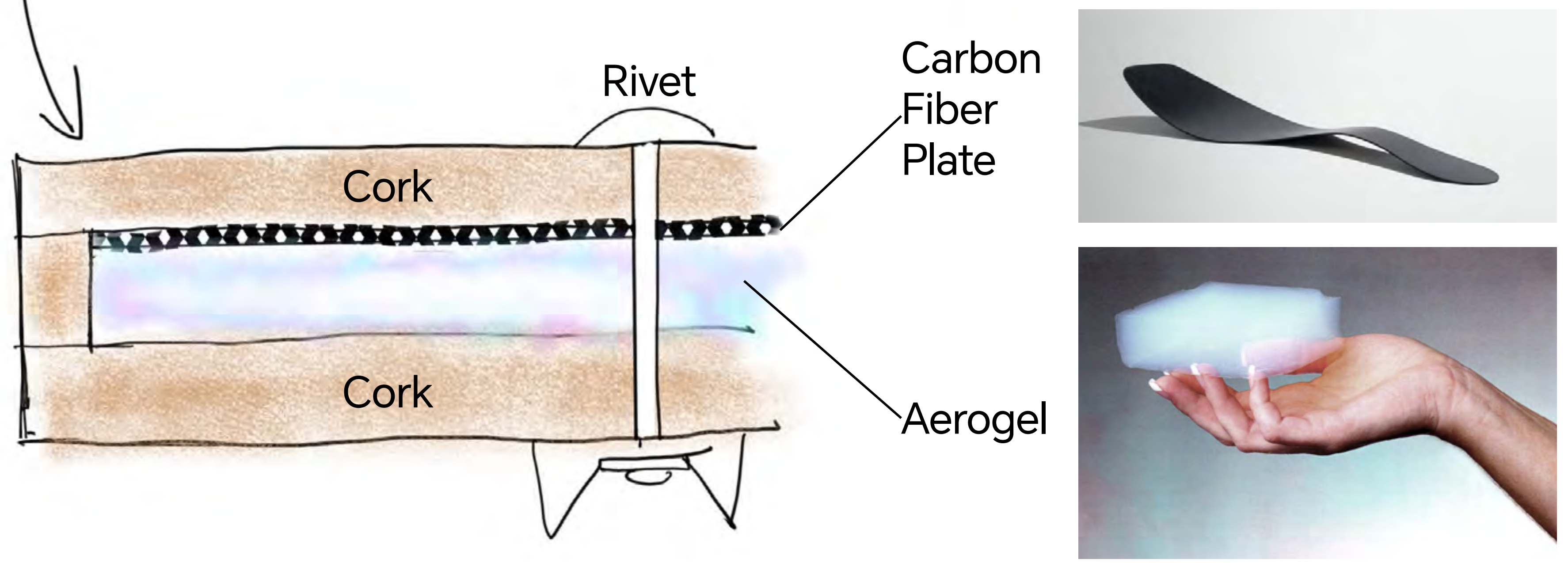
PROP: Environmental monitor



The environmental monitor is an official device used by the laboratory to track coastal conditions near the facility, with its data made publicly available to gain the trust of citizens. After the blackout crisis, Li Chuan compromised with the government in order to survive. But when he noticed subtle changes in the city's environment, he immediately grew suspicious of the lab. In the end, he secretly hacked into the monitor and discovered that the laboratory had indeed falsified the data.

PROP: ROOTWALKER® insulated shoe covers





The ROOTWALKER brand of insulated shoe covers is a product created by Li Chuan and popularised in the city in 2040. The product was originally invented by Li to facilitate his monitoring operations after he discovered that the temperature on the coast had risen abnormally. Afterwards, in order to obtain funds for his operations, Li put the equipment on the Internet for sale, and never expected it to become popular by accident.