Research by Infrastructural Design: Systems thinking from the perspective of thermodynamics

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Research by Infrastructural Design: Systems thinking from the perspective of thermodynamics

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Smog has contributed largely to the environmental problems of many cities in China. On the other hand, China has gone through a period of rapid infrastructure growth in the urbanisation process. People have noticed the potential of infrastructure in mega-cities as part of the built environment, and the paper presents three infrastructure-oriented proposals from a summer school project named “Design against Smog: Air through the Lens of Thermodynamic Architecture” which aims to deal with the problems in Lujiazui area of Shanghai. The proposals show their systems thinking on urban functions, use different types of infrastructure as bridges to connect the air to urban activities and give their possible strategies for purifying smog.

KEYWORDS: infrastructure, smog, urbanism, high-rise, thermodynamic architecture

RSD TOPIC(S): Architecture & Planning, Cases & Practice

Presentation description

Smog plays a significant role in air problems in Chinese cities; it wreaks havoc on the environment over time, like a “slow catastrophe”. But does rapid urbanisation have to sacrifice environmental quality? Is there a more systematic view based on interdisciplinary knowledge and concerns on social ecology? We have noticed the potential of infrastructure in mega-cities as part of the built environment.

Context in Lujiazui, Shanghai

China has gone through a period of rapid infrastructure growth. With the emergence of high-rises with large numbers of people, the contradiction between the traditional urban fabric and mega infrastructure is becoming increasingly prominent (Tan, 2017). A documentary about China’s smog issue, “Under the Doom”, has attracted much attention over the past years (Figure 1). Lujiazui Finance & Trade Zone is one of the biggest central business districts in Shanghai, covering an area of 6.8 square kilometres. It is located on the east bank of the Huangpu River and has more than 100 high-rises forming a cluster. Lujiazui’s skyline sometimes disappears into smog, forcing architects, engineers and urban planners to come up with approaches in response to the air pollution problem.

Figure 1. Smog in Lujiazui, Shanghai (Li, 2016).

Research by design: from a thermodynamic perspective

Environmental degradation leads to the unsustainability of urban paradigms. We hope to find a way for infrastructural design in new vertical cities from the thermodynamic perspective. With the support of the College of Architecture and Urban Planning (CAUP), Tongji University, Linxue Li organised an international summer school, “Design against Smog: Air through the Lens of Thermodynamic Architecture”, based in Lujiazui area in Shanghai. It brings together many researchers and students to consider the potential of designing urban infrastructure from a thermodynamic perspective.

The research was divided into two phases:

1) Finding a thermodynamic prototype to represent the relationship between air, infrastructure, architecture and city, studying their system logic of energy flow.

2) Implanting the prototype into the built environment.

The goal is to propose a conceptual solution to deal with smog, including systematic thinking about airflow, the efficiency of infrastructure and the building form in Lujiazui area, thus providing a contemporary remedy for the developed metropolis.

Three proposals to cope with the smog issue in the Lujiazui area

After lectures, discussions, and reviews in the research groups, three prospective proposals were presented to show the potential of infrastructures in this area and their systems thinking about urban functions.

1/CORRIDORS: transport systems with interconnected thermal engines

The proposal re-evaluates the functions of transportation systems such as roads, sidewalks and elevated highways, suggesting that they could provide coherence and integration for the high-rises. This is a new type of complex infrastructure that reduces pollution through fewer vehicle emissions and better ventilation. They consider the long-term quality of life from the perspective of urban spatial structure.

1) They analysed three main problems in the Lujiazui area. As a result, people involuntarily increase smog emissions with fewer transportation options: road network - roads function as barriers; transportation - people have to travel several kilometres between homes and offices; automobile - the excessive use of cars produces a lot of smog.

2) They also studied the resources available on site: river - the site is surrounded by Huangpu River, which can be used to preheat or precool the air; green spaces - parks can act as purifiers; high rises - a large number of high-rises on site have the potential to be solar chimneys for natural airflow; elevated pedestrian paths – path network could be expanded and connected to the buildings to make this area a whole.

Thus, the proposal put forward a “purify” corridor system connecting existing high-rises. At one end of the corridor is the entrance of air, usually located in a green space. The other end is linked to the core of a high-rise that acts as a thermal chimney (Figure 2). The elevated pedestrian bridges in Lujiazui offer many possibilities to become an extension of the building ventilation system, connecting end-to-end like snakes to form a network (Figure 3). The corridor system will be multi-functional, providing a healthier and more diverse lifestyle for citizens. At the same time, the corridors are porous, for being opened whenever they need to adapt to the surroundings.

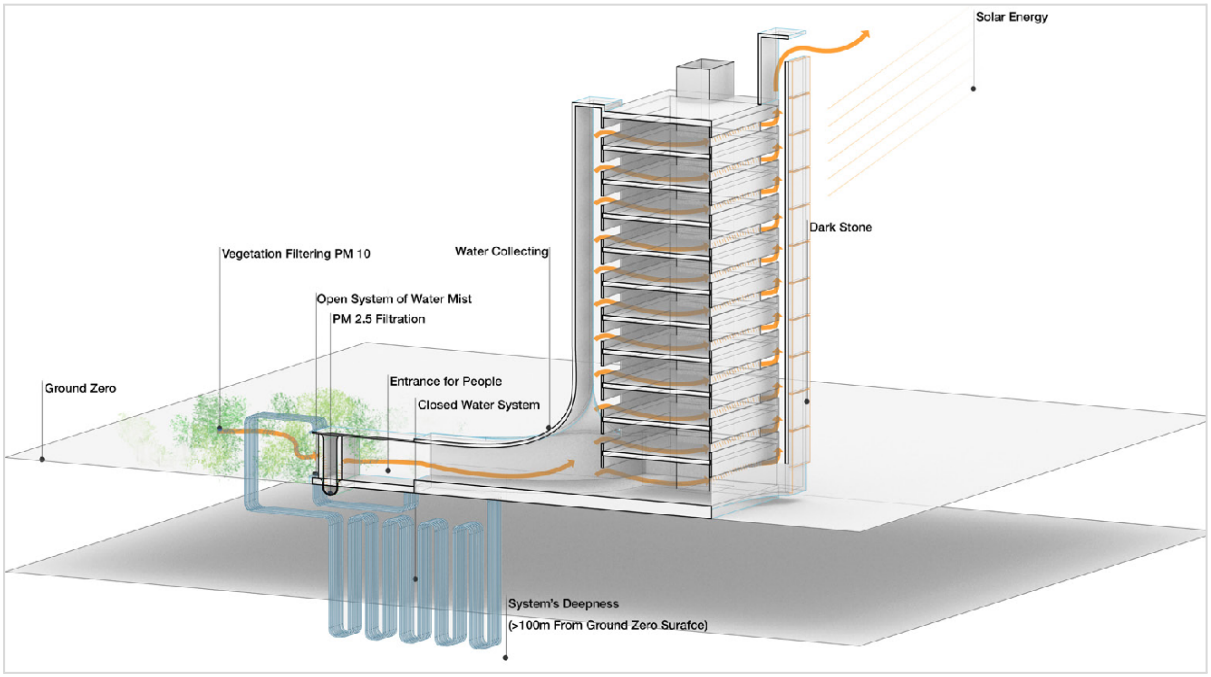


Figure 2. Purify corridor system linked to the core of high-rises.

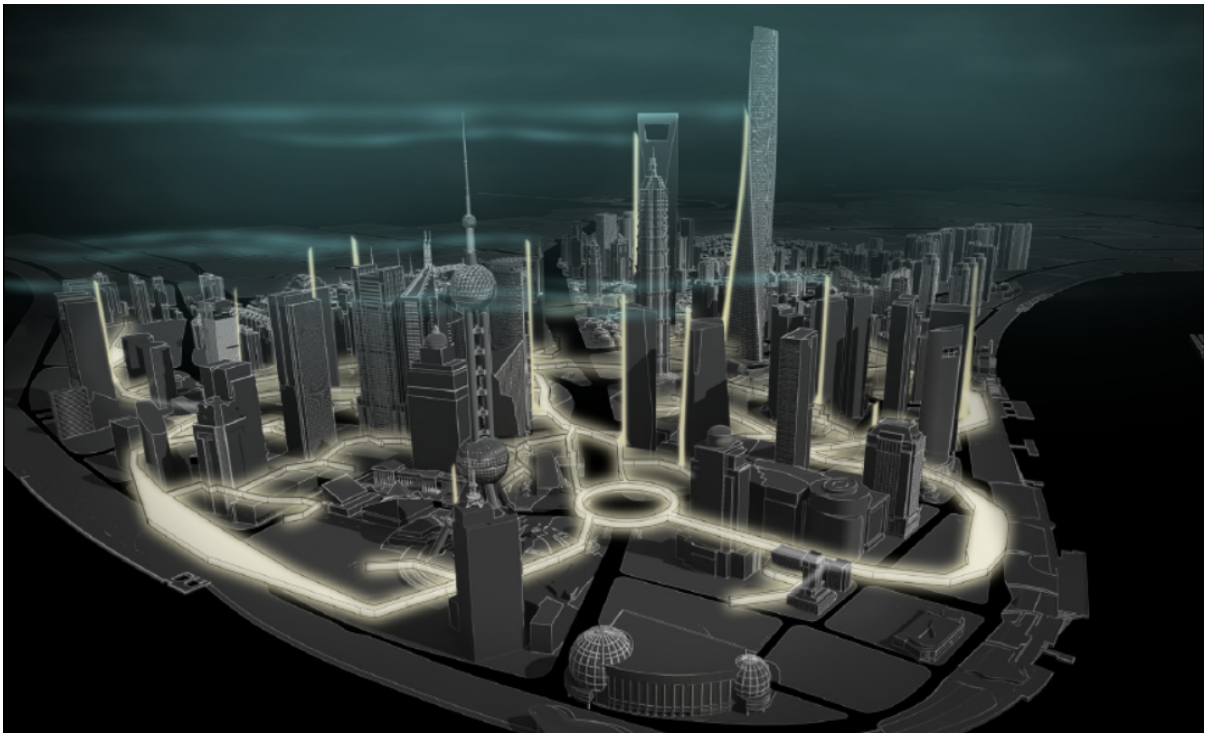


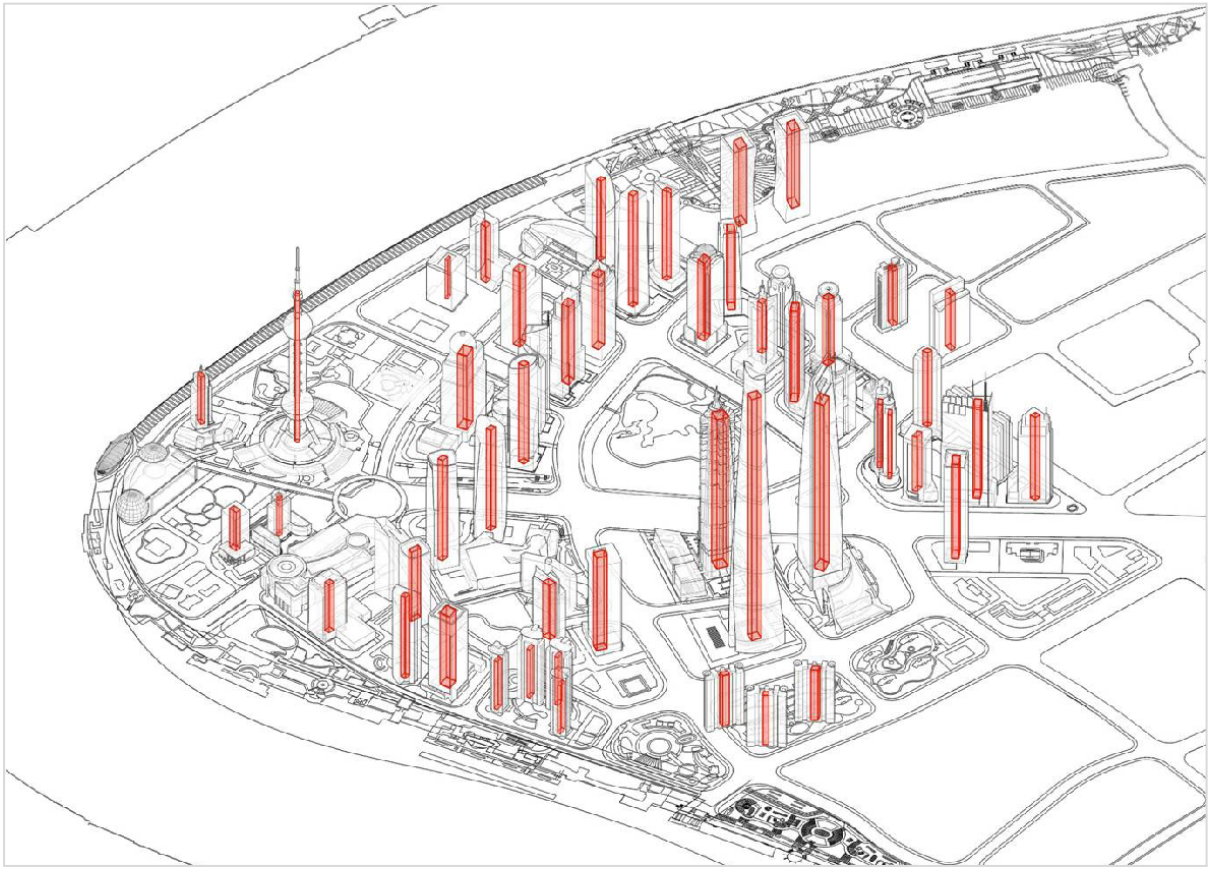
Figure 3. The corridor network connected end to end.

Image source: Alexander Matthias Jacobson, Inés Brotons Borrell, et. Advisors: Zhou Jianjia, Gao Jun.

2/CORES: redefined thermodynamic cores of high-rises

The proposal liberated the “core” of high-rises from simple pipeline pathways, structural support and vertical transportation and proposed a new “core” integrated with the thermal function of air circulation and purification to reconstruct the space and energy flow of high-rises.

The by-products of urban infrastructures, such as the piston effect of metro and elevators, and the stack effect of atrium and pipes in buildings, have the potential to promote ventilation. However, they are generally unexplored, and the “core” proposal intends to utilise these passive energies as the source of airflow. Passive airflows from subways, elevators and atriums will be conducted through a series of carefully designed spaces and devices where pollutants in the air could be absorbed by efficient methods like centrifuges, wet deposition, phytoremediation, and low voltage adsorption (Figures 4 & 5). The public spaces are arranged throughout the whole process of air handling to increase public awareness of the smog problem by spatial interaction.



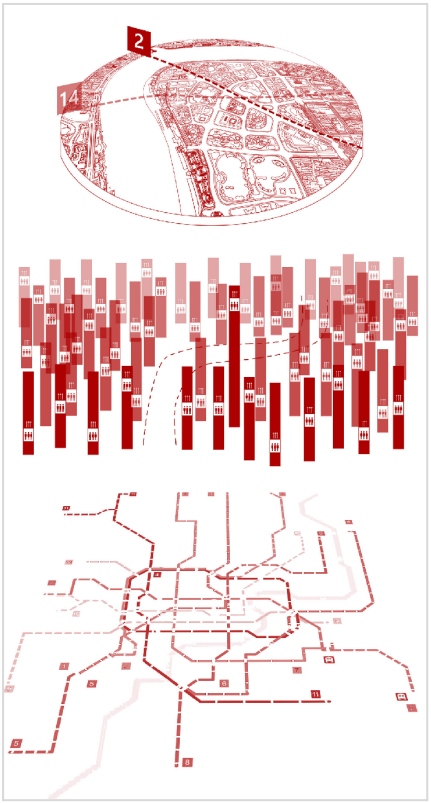
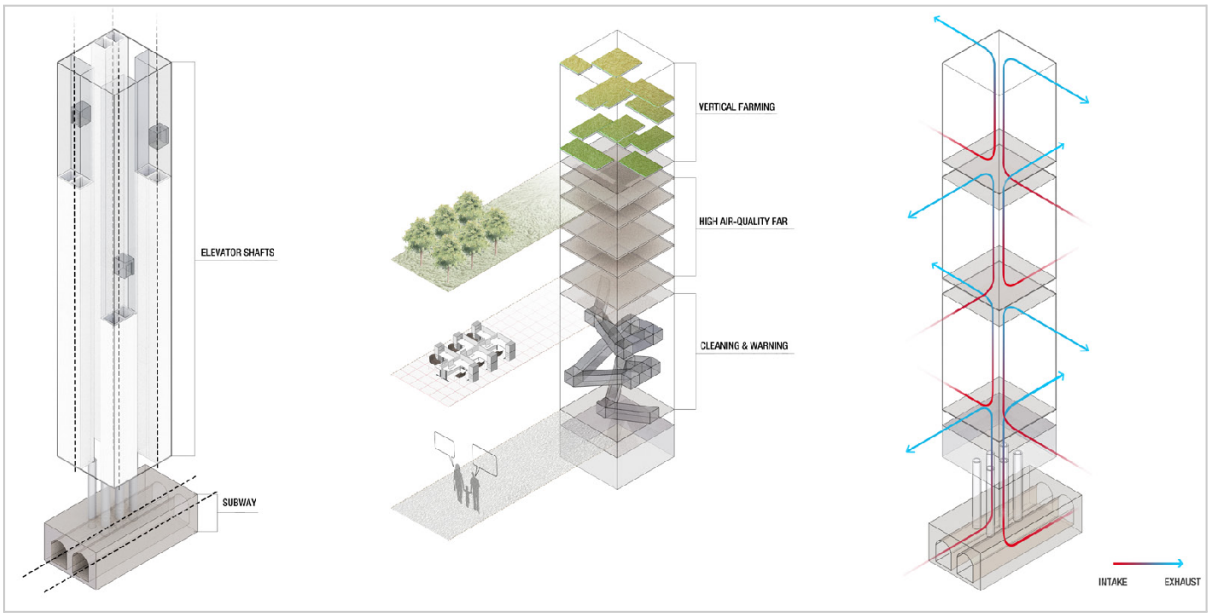


Figure 4. Existing cores in the Lujiazui area.



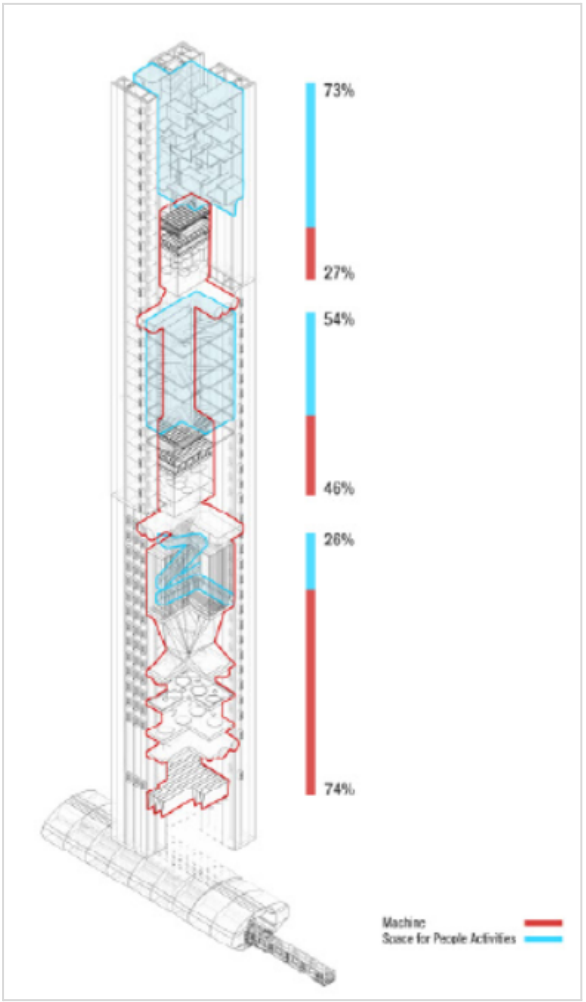


Figure 5. The new multifunctional cores.

Source (Figures 4 & 5): Tomoki Shoda, Liu Fangshuo, et. Advisors: Luo Jing, Wang Zigeng.

3/COOPERATIONS: thermal-reciprocity “bridges” on rivers

Focusing on production and consumption as the basic law of urban energy flow, the proposal rediscovered the potential of urban waterfront spaces to reduce emissions and promote air circulation. The proposal redefines a reciprocal environmental exchange system from the perspective of consumers and producers of smog, considering both the industries that produce smog and the infrastructures that consume it. Their goal is to control the growth of urban centres and integrate the infrastructure system to take advantage of inherent sources.

1) Rivers: to create a generic model, they took rivers as commonality in-between cities. In terms of thermodynamics, rivers have enormous energy, and most of the energy generated by wind and water movement is concentrated here.

2) Integrated core: we may imagine the city could grow within the Huangpu River and develop a prototype of integrated cores. The core buildings could be mobile “bridges” with several programs: transmission system, hydraulic energy production, connectivity waste treatment, recycling centre, housing and public spaces (Figure 6).

3) Recycle hub: some functional spaces generate large amounts of waste within the “bridge”, such as markets, parks, and b terminals. Traditionally relies on transportation for waste disposal; the proposal imagines a recycling hub that combines all waste disposal programs to reduce transportation costs (Figure 7).

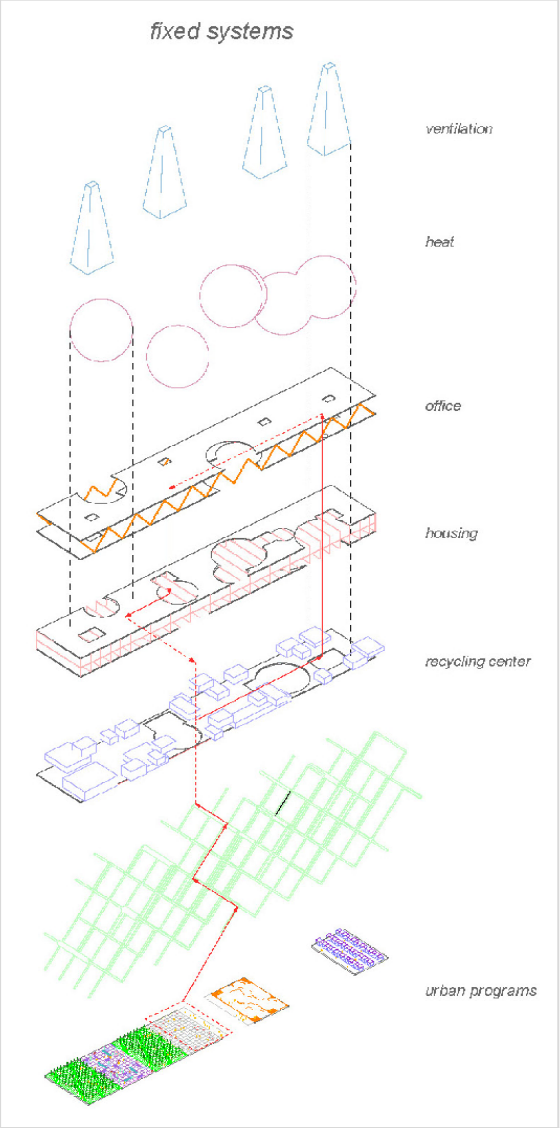


Figure 6. The integrated core and the movable system.

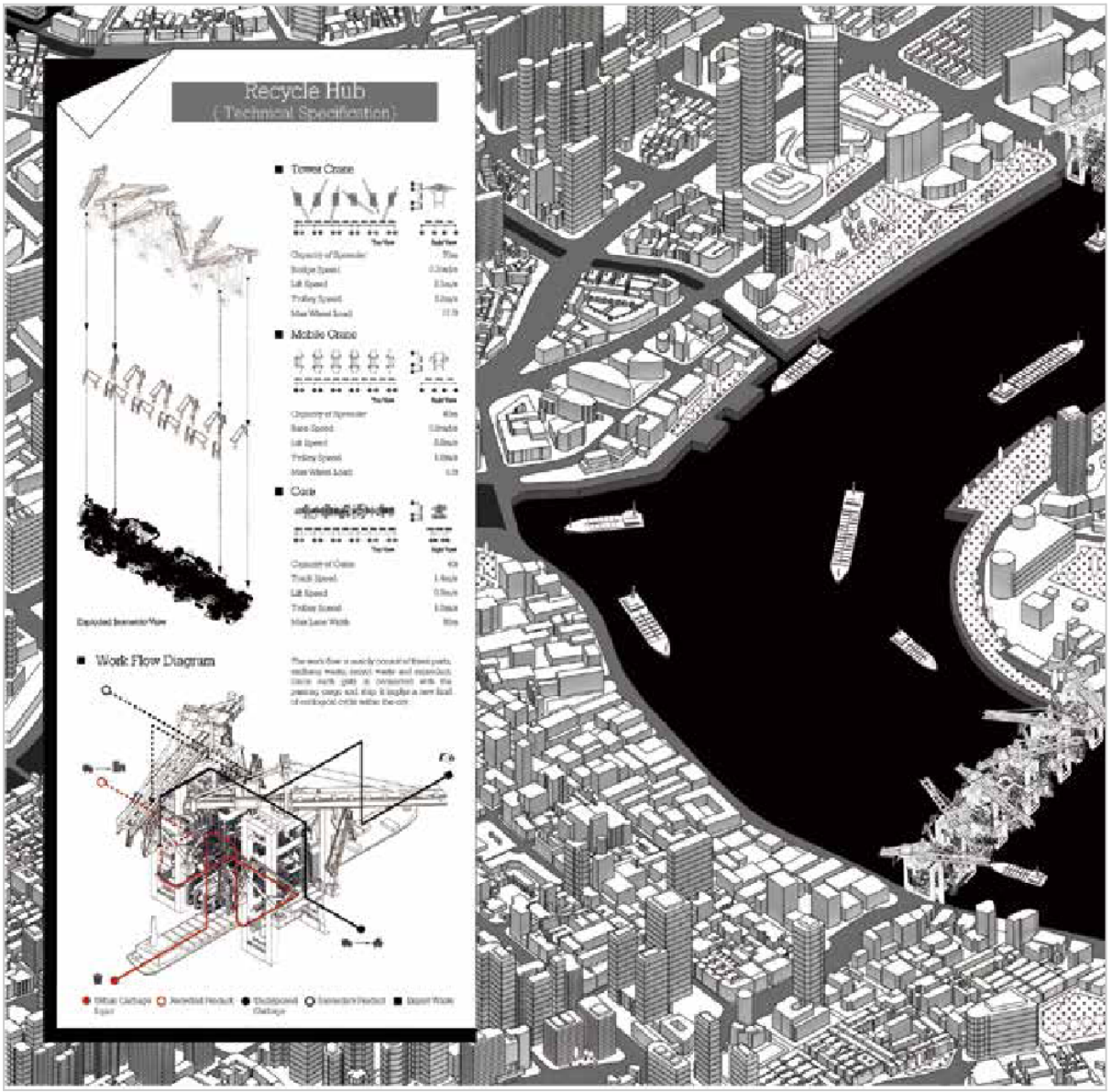


Figure 7. Workflow of the recycling hub.

Source (Figures 6 & 7): Sofia Blanco Santos, Fuyu Miyamoto, et. Advisors: Liu Yuyang, Oscar Ko.

Conclusion

Infrastructure-oriented research is an opportunity to face the smog problem: our facilities will increase the smog, and what can we do? In those proposals, we can find the transformation of infrastructure systems, the rethinking of traditional architectural and urban patterns, and the reliance on integrated technical means. We take this kind of systems thinking as the greatest value and notice the great potential of the impact of air, energy and environmental problems in developing new technologies, new forms, new organisations and new social experiences.

Acknowledgements

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