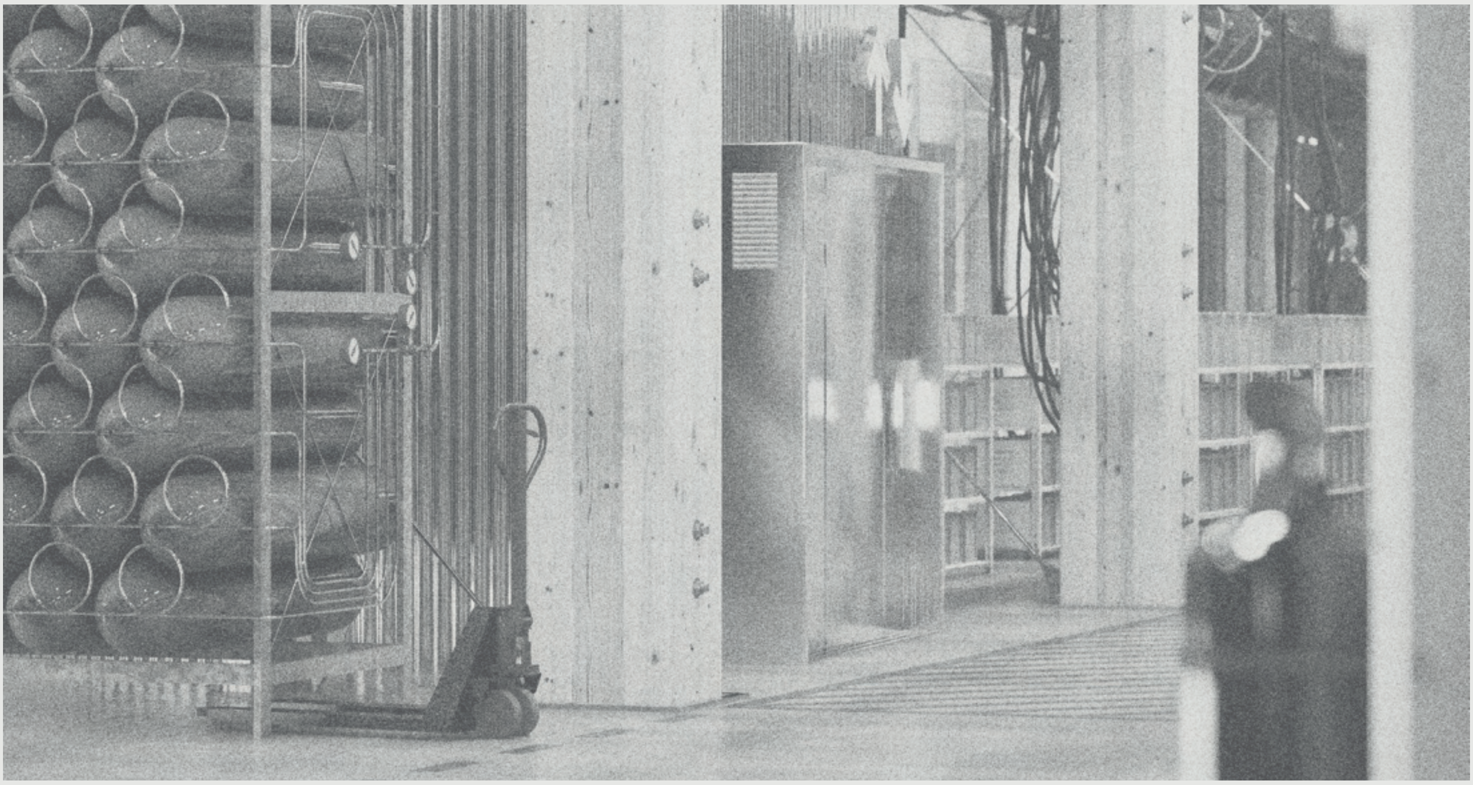
RIKARD MURGÅRD



ELECTRIC CITY

AFFECTIONATE MANIFESTATIONS OF ELECTRIC INFRASTRUCTURE

EXAMINER & SUPERVISOR
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CHALMERS SCHOOL OF ARCHITECTURE
DEPARTMENT OF ARCHITECTURE AND CIVIL ENGINEERING

2024

ELECTRIC CITY:
AFFECTIONATE MANIFESTATIONS
OF ELECTRIC INFRASTRUCTURE

ARCHITECTURAL EXPERIMENTATION:
BEFORE AND AFTER BUILDING

MASTER THESIS

CHALMERS SCHOOL OF ARCHITECTURE
DEPARTMENT OF ARCHITECTURE AND CIVIL ENGINEERING
ARCHITECTURE AND URBAN DESIGN, MPARC

EXAMINER: Daniel Norell
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CHALMERS
UNIVERSITY OF TECHNOLOGY

AFFECTIONATE MANIFESTATIONS OF ELECTRIC INFRASTRUCTURE

This thesis investigates electric infrastructure architecture in a post-carbon future. The aim is to explore how approaches of love and affection, combined with a thorough system understanding of the electric grid, can shift the relation between a city's residents and its electric system. The thesis speculates on how a reimagined architecture of visible electric infrastructure objects can reterritorialize energy and promote a deeper societal engagement with sustainability, fostering a sense of ownership and responsibility among urban inhabitants towards their energy consumption and environmental footprint. Taking cues from current architectural discourse on infrastructure, by theorists such as Hélène Frichot and Céline Condorelli, the thesis advocates for the humanization of infrastructure through poetic pragmatism, making it more relatable and meaningful.

To research this topic, the thesis employs a combination of diagramming, mapping, and development of design strategies as methods. Diagramming was used to analyse the sprawling network of the electric grid in Stockholm, identifying the visual and functional presence of substations, electrical cabinets and light fixtures throughout the urban landscape. Through mappings of current manifestations of electric infrastructure an "atlas" is created, assessing the visual impact of infrastructure and exploring its architectural potential. Building upon the philosophies of designers such as Dieter Rams and François Dallegret, the design strategies lay a foundation for an architectural expression that reflects the pragmatism of a technical system while also becoming an object that people can feel affection for.

The thesis proposes a series of speculative infrastructural interventions in three different scales set in the urban fabric of Stockholm. The design process employs strategies that turn infrastructure into an architectural matter, beyond something merely functional. The interventions try to bring a poetic pragmatism into their function and expression, which is grounded in care and attention to detail, where the detail becomes a tool to express affection and craftsmanship. Inserted into the city, the interventions subtly renew the urban fabric. They reflect a commitment to a more thoughtfully crafted and sustainable built environment, while also redefining of our relation to infrastructure. Overall, the thesis sets out to redefine the boundaries of architectural practice by engaging with topics and objects often seen as insignificant to architecture.

KEYWORDS

Infrastructure, Affection, Love, Poetic Pragmatism

Electrical Cabinets Underneath ↗
Johanneshovsbron, Stockholm


Parkering

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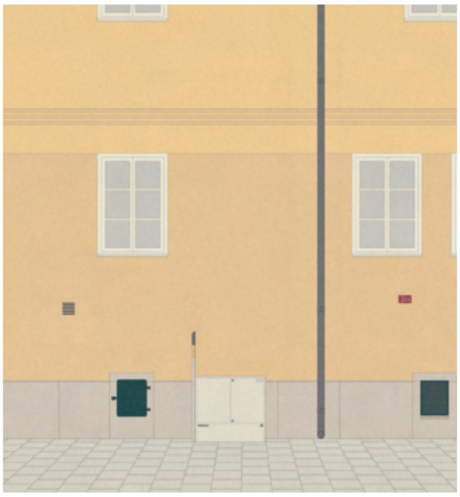

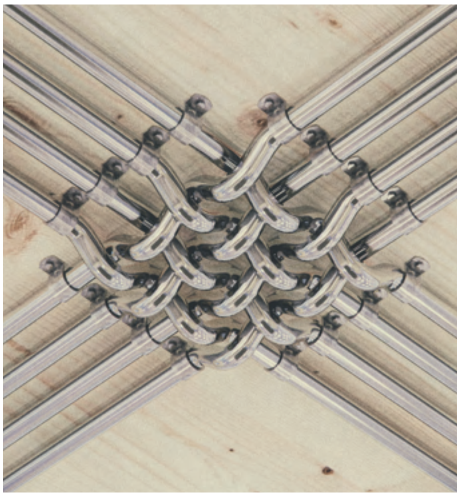

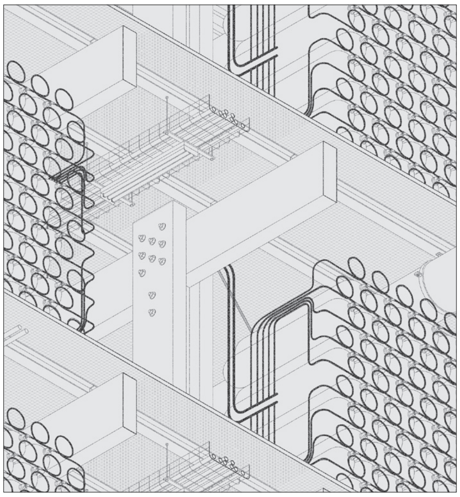

RIKARD MURGÅRD is an architect from Gothenburg, Sweden. With a background in industrial and graphic design, his work seamlessly integrates innovation, functionality and beauty across various scales. Rikard's recent work has focused on material integrity and contextual sensibility to create spaces and objects that will holds large values for generations to come. His profound interest in infrastructure stems from an ambition to understand the world around him, both from a technical and an anthropological perspective.

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EDUCATION

Master of Science, Architecture and Urban design Chalmers University of Technology	2022 - 2024

- Building Tectonics 2
- Design Approaches and Narratives
- Academic Approaches and General Structure
- Matter, Space, Structure 2
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- Architectural Competitions
- Material & Detail
- Sustainable Development and the Design Professions

Bachelor of Science, Architecture Chalmers University of Technology	2018 - 2021

EMPLOYMENT

Architect What! Arkitektur, Göteborg	2022 →
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THESIS QUESTIONS

> What could an approach of love and affection toward urban electric infrastructure architecture entail?

> How can architecture redefine the role and societal appeal of electric infrastructure?

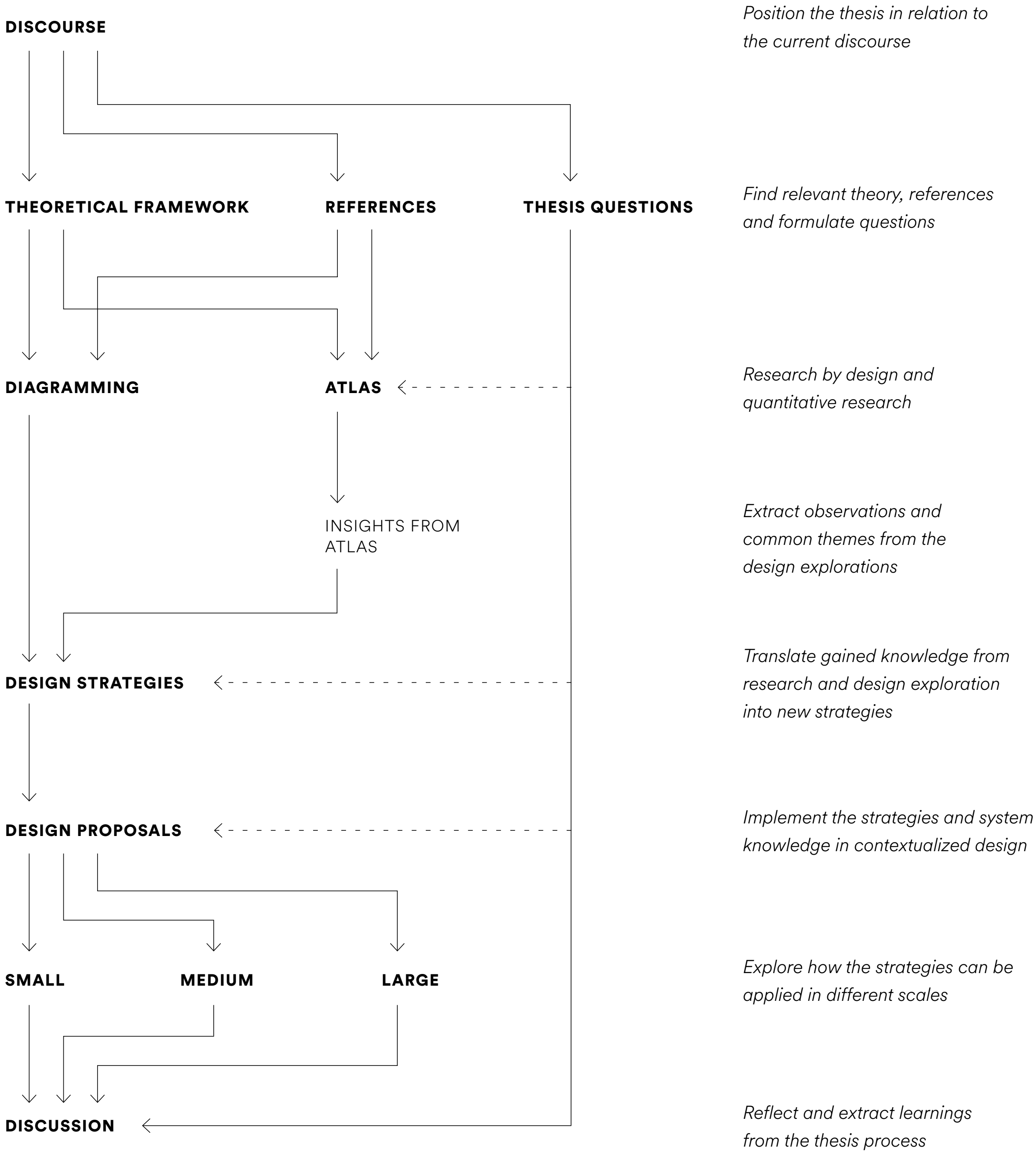
INTENTION

The intention of this thesis project is to shed light on the intricate network of electric infrastructure which is one of many resources that underpin our everyday lives. This complex system is often unnoticed, yet it is crucial for our sustained existence. The thesis seeks to explore how approaches of love and affection towards the architectural objects, which serve as the visual representation of the vast electric grid, can make us more aware of our interconnectedness with these systems and inspire a deeper engagement with our built environment. By doing so, the aim is to foster a greater appreciation and care for the architectural potential of infrastructural elements that for the most part have been overlooked as matters of architectural significance.

DELIMITATION

This thesis focuses on the architectural and aesthetic aspects of electric infrastructure. While it delves deep into the understanding of technical systems, it does not cover the practical implementation of these systems in detail. It is set within a speculative scenario and does not consider aspects of building permits and restrictions at selected sites.

PROCESS DIAGRAM



USE OF KEY TERMS

INFRASTRUCTURE The essential facilities and systems supporting fundamental functions in society. Derived from the Latin “infra” (below) and “structura” (building).

AFFECTION Gentle feeling of fondness, attachment and devotion.

LOVE Deeper, more thoughtful, and emotionally engaged approach to architecture.

CARE The practice of providing attention to preserve the condition and value of an object.

POETIC PRAGMATISM Design philosophy that integrates practical with aesthetic considerations.

SYSTEM Set of interconnected components that work together to perform a function.

BACKGROUND

Modern society's way of living is dependent on, and constructed around, intricate systems so vast and complex that they often operate invisibly in the background, shaping our behaviours, choices, and even our understanding of the world without us being fully aware of their reach or impact (Condorelli, 2009). These networks support essential and to us meaningful functions in our society. They allow us to connect both among ourselves and with the world. But these networks are mostly invisible. Where does the power from the outlet actually come from? What happens behind the scenes when you turn up the heat? What imprint does it leave on the planet when I forget to close the bedroom window?

We have entered a new geological era, the Anthropocene epoch. Human resource consumption increases constantly creating irreversible changes in the planet's system and at the same time, critical services like the electric grid, telecommunication, transport system and hospitals highly depend on these resources.

We find ourselves at a point in time and space. What has been slowly fades into oblivion. Our surroundings change with such small steps that we don't notice in real time. Like when a grocery store changes the design of its paper bags, or a gas station puts up a few new flagpoles. These things don't seem significant as they happen, but when looking back, we realize that much has changed and the context and conditions we live in are not the same as they were a few years ago. A new building appears, another is renovated, a new colour adorns a facade. Over time, an entire city transforms without us necessarily noticing each individual change. But it's the sum of these small steps that makes our surroundings lively and dynamic.

Thus, these sprawling technical systems are not as static as they appear. They are in a perpetual state of slow but continuous evolution, influenced by technological developments, demographic shifts, and changing environmental conditions. These systems are more dynamic and vulnerable than we often realize, posing a complex set of challenges, but also opportunities.

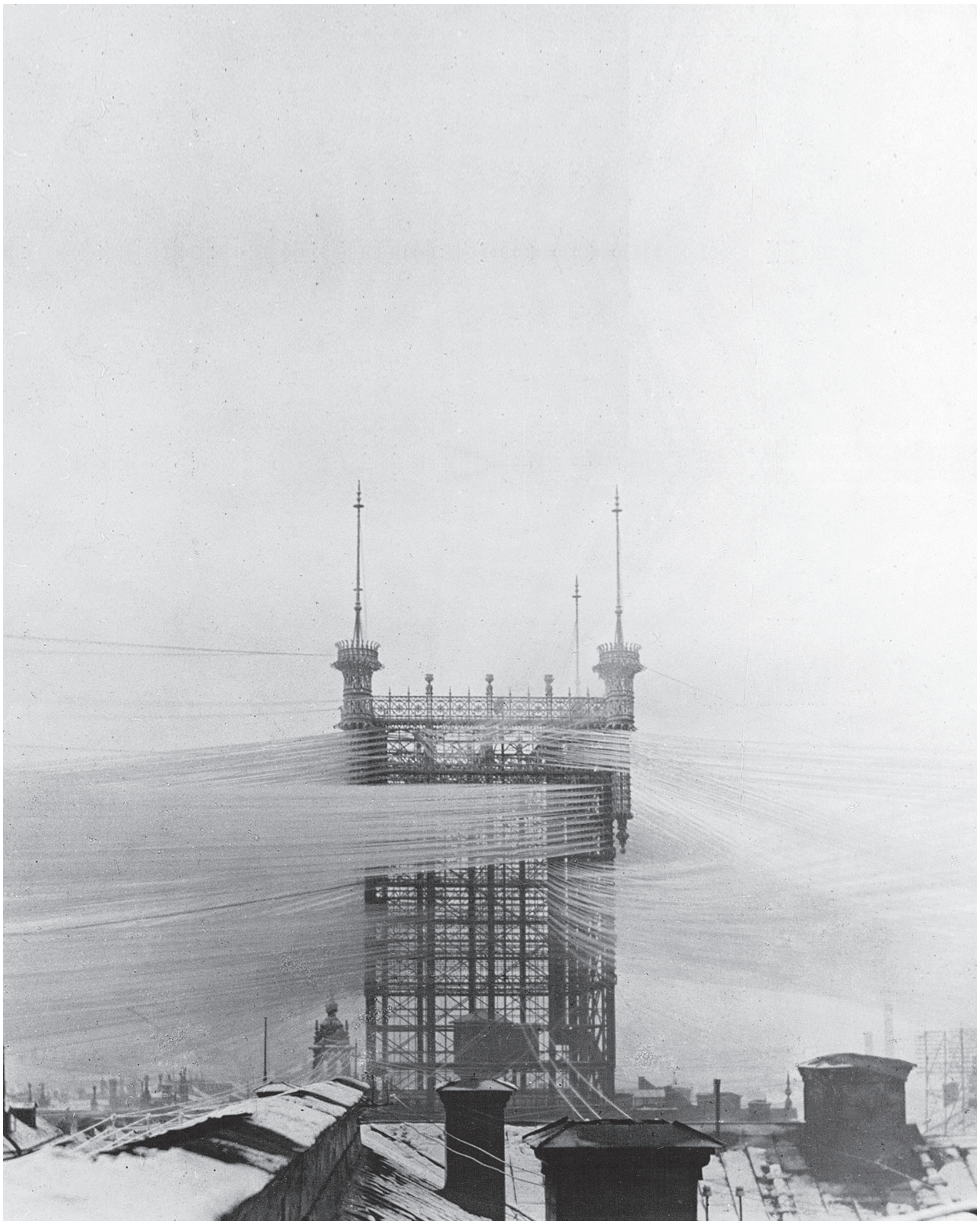
While our resource consumption increases, the physical manifestations of our consumption becomes less visible. Data centres, power plants and substations are placed far away from cities and are built as structures for machines, not people. When entering the urban context power lines go from overhead wires to underground tunnels only visible in the urban fabric in form of small utility sheds and electrical boxes. The only moment we confront our electrical consumption is when the bill arrives in our mailbox. Hence the difficulty in critically relating to a phenomenon when the architecture that houses it aims to be invisible.

The design of modern cities has perpetuated the illusion that infrastructure is merely a utility to be hidden and segregated from our daily landscapes (Frichot et al., 2022). When starting to analyse the built environment a picture emerges of a reliance on various machines and mechanisms, yet buildings and objects are presented without consideration for the conditions that allow them to exist. Infrastructure has often been neglected by architects, often excluded from visualisations and drawings. Consequently, Infrastructure is edited out of visions of the future urban utopia so that new urban landscapes appear more peaceful.

Adopting a systems-thinking approach is crucial for addressing the complexities of modern infrastructure, recognizing that even minor changes can have a ripple effect across the entire network, creating both challenges and opportunities. Given this complexity, any architectural involvement must be approached with humbleness and an acknowledgment that our grasp of these intricate systems is always incomplete. Nevertheless, it's within these limitations that we can find untapped potential to effect meaningful changes. Stepping beyond traditional architectural boundaries allows for the infusion of sustainability, ethics, and adaptability into these sprawling systems, emphasizing not just aesthetic or functional improvements but also a broader, more impactful role in shaping the very foundations of modern society.

The built landscape of our post-carbon tomorrows calls for a new relationship to infrastructure that acts as a link between ourselves and our consumption.

Telephone Tower, ↗
Stockholm, 1890



HISTORICAL CONTEXT

In the annals of urban development, the evolution of infrastructure within cities reflects changing priorities, technological innovations, and aesthetic shifts. Initially, infrastructure served not only as a functional necessity but was also a proud, visible part of the city's landscape. Ancient cities, like Rome, showcased their infrastructural marvels, such as aqueducts and bridges, which symbolized engineering excellence and societal pride, serving both utility and aesthetics (Frichot et al., 2022).

The Industrial Revolution, however, introduced new challenges. Railroads and factories transformed urban landscapes, sometimes disrupting communities. These innovations, while initially celebrated, later became viewed as obstructions or sources of pollution. As the 20th century approached, a mix of technological progress, aesthetics, and health concerns drove the relocation of much infrastructure to city outskirts or concealed them entirely. The emergence of telecommunication and electric systems led to an initial web of overhead wires in cities, but safety and visual concerns soon prompted the move to bury these lines underground.

This transition towards underground infrastructure was influenced by considerations beyond just aesthetics. It offered resilience against weather, reduced maintenance, and addressed the challenges of expanding city boundaries and rising real estate costs. Modern cities now prioritize the concealed yet efficient integration of critical infrastructure, showcasing their sophistication by hiding essential systems and ensuring their optimum functionality.

INFRASTRUCTURE

The term “infrastructure” is derived from Latin, with “infra” meaning “under” and “structura” signifying “to build” or “construct.” It speaks to the foundational yet often invisible structures that underpin our daily lives. In the contemporary urban setting, infrastructure is much more than mere physical constructs; it represents the covert orchestrations that dictate the mechanics of our everyday experiences. This silent choreography is so seamlessly woven into our routines that its presence often goes unnoticed. Yet, its absence or malfunction would quickly draw attention, emphasizing its pivotal role in ensuring the smooth operations of daily life.

Frichot et al. (2022) describes infrastructure as the sociotechnological and spatiotemporal glue that holds our societal systems intact. It transcends mere architectural elements. While the superficial aspects of a house, like gypsum boards and hardwood flooring, contribute to its visual appeal, the essence of liveability lies in the hidden support structures such as electrical wiring and internet connectivity.

In cities, significant infrastructure like bridges and power stations often receive architectural embellishment, while rural infrastructures and small electrical cabinets go unnoticed, designed solely for utility. However, the collective presence of numerous electrical cabinets can profoundly impact the cityscape (Metel, 2023). Thus, there's a need for consistent architectural consideration across all scales of infrastructure to ensure even the smallest elements contribute positively to the urban aesthetic.

To label infrastructure as undesigned is a misinterpretation, there is a careful and deliberate planning that goes into its creation. Each component within an infrastructure system is meticulously designed with the aim of offering functionality and user-friendliness (Ménard, 2023). However, when these components are integrated into larger assemblies, the emphasis on functional utility takes precedence, often at the expense of deeper aesthetic or compositional values. Yet, this functional assembly is crafted with a high degree of care, aiming to fulfil its role efficiently and to be easily maintained. The design of infrastructure, therefore, is not an afterthought but a critical consideration that balances the need for operational efficacy with the practicalities of maintenance and cost-effectiveness, illustrating the nuanced and purpose-driven approach to infrastructure design.

Infrastructure operates on a scale and scope beyond individual human experience, prioritizing the architecture of systems over human-centric design (Frichot et al., 2022). This approach, centred around the system's needs, dictates that maintenance and functionality drive the design process. In creating infrastructure, the primary objective is to ensure that the technical requirements for optimal operation are met, often leading to spaces and buildings that must conform to these necessities. Consequently, design considerations, while not entirely neglected, become secondary to the overarching goal of system efficiency and reliability. This shift in design focus underscores the complexity and critical nature of infrastructure, highlighting its role as the backbone of daily operations and societal function.

ELECTRICITY

Energy, in its most fundamental principles, adheres to the law of conservation: it cannot be created or destroyed, merely transformed from one form to another. This principle underpins the entire concept of electricity and energy usage in our society. The modern electricity grid operates on a "just in time" delivery system, where energy produced is almost immediately consumed (Ménard, 2023). This system distinguishes between 'light' and 'heavy' energies, reflecting the shift towards a post-carbon future. Light energies, such as wind and solar power, contrast with the heavy, carbon-intensive energies of the past, marking a pivotal transition in how we generate, use, and perceive energy. Yet, much of the energy production and transportation system remains invisible to the consumer, with vast wind farms and towering nuclear power plants dotting landscapes far from the end user's sight, making the energy's journey from generation to consumption largely unseen.

The most tangible manifestation of electricity for many is light – a symbol of energy's importance for our lives and ability to transform spaces. Yet, electricity also drives movement, produces heat, and powers the devices that form the backbone of modern life. As we move towards future resilient energy systems, the challenge becomes not just in producing energy more sustainably but in making the invisible visible; ensuring that the infrastructure which underpins our lives is not just efficient and resilient, but also integrated into our urban landscapes in a way that educates and engages. This transition towards visible and integrated energy systems is crucial in fostering a deeper understanding and appreciation of energy's role in our lives, paving the way for more sustainable and informed energy consumption patterns in the future.

SYSTEMS AND SYSTEMS THINKING

In the realm of infrastructure and architecture, the concept of a system holds profound significance. At its core, a system can be defined as a modular network comprising interrelated components that synergistically operate to fulfil a specific task or objective. This interconnectedness is evident in architectural designs tailored for varied purposes. While some structures prioritize human-centred design, focusing on comfort, aesthetics, and functionality, others are crafted with machines in mind, emphasizing efficiency, durability, and technical specifications. This duality underscores the adaptability of systems in architecture, reflecting the ever- evolving balance between human needs and the demands of technology.

Systems thinking involves understanding a problem as a component of an interconnected whole, rather than as an isolated issue (Miller, 2017). It emphasizes recognizing overarching patterns and relationships, and appreciating how modifications in one area can propagate throughout the entire system. In the realm of architecture, this approach facilitates the discovery of synergistic effects and unexpected connections, enriching the design process with considerations that extend beyond conventional boundaries. By adopting systems thinking, architects are empowered to broaden their perspective, enhancing both their role and the potential impact of their work on the environment and society.

Systems showcase an often overlooked beauty through their complex design and cohesive functionality, where each component's unique role contributes to a collective purpose. Their beauty emerges from the intricate dance of inputs and outputs, interdependencies, and the capacity for self-regulation and innovation. Mirroring nature's mesmerizing patterns, from galaxy spirals to fern fractals, systems embody elegance in their efficiency and the order arising from apparent chaos, reflecting the depth of design and spontaneous interactions.

SUPPORT STRUCTURES

The objects within our environment, often subtle yet fundamental, play a pivotal role in defining the identity and functionality of urban spaces. Studio *Ser*'s (2022) interventions in the town of Monte exemplify how small modifications to everyday objects like street lights and benches can significantly alter how spaces are perceived and utilized, infusing them with new meaning and enhancing communal engagement. This aligns with Cèline Condorelli's (2009) concept of support structures, which she describes as the unnoticed yet essential elements that sustain the physical and social fabric of our surroundings. According to Condorelli (2009), these structures are as crucial as the beams that support a building or the emotional ties that underpin relationships, suggesting that without these elements, both physical structures and human connections would falter.

Keller Easterling (2016) expands on this idea by comparing urban infrastructure to an operating system that orchestrates urban life, shaping behaviours, societal norms, and even political directions. This infrastructure acts not just as a physical framework but as a dynamic canvas that captures and moulds the collective aspirations of society. By engaging with and subtly altering these 'operating systems,' interventions in architecture and design can profoundly influence the overarching narrative of a city, demonstrating that our interactions with seemingly mundane objects can deeply influence not only our individual experiences but also our collective identity.

AFFECTION & LOVE

Affection in architecture encompasses a deep, empathetic concern for both the form and function of structures, recognizing that buildings inevitably elicit emotional responses (Frichot et al., 2022). While affect cannot be explicitly designed into a building, it naturally emerges through the interactions between people and the architectural environment. This concept aligns with affect theory, which posits that emotional responses are pre-cognitive and arise from dynamic engagements with our surroundings. Thus, architects can craft spaces that facilitate these interactions, subtly guiding the emergent emotional landscape without dictating specific feelings.

Poetic pragmatism, as a design philosophy, emphasizes the integration of affective and pragmatic elements within architectural practices. It suggests that structures and systems should not only meet technical and functional requirements but also engage the senses and emotions, fostering connections that enhance human experience and contribute to social well-being. Frichot describes this practice as bringing "love back into the ordinary gestures" of places and relationships, highlighting the importance of care, maintenance, and repair (Frichot et al., 2022). This philosophy extends to how infrastructure operates not just on a physical or technical level but as part of the socio-political fabric of urban life.

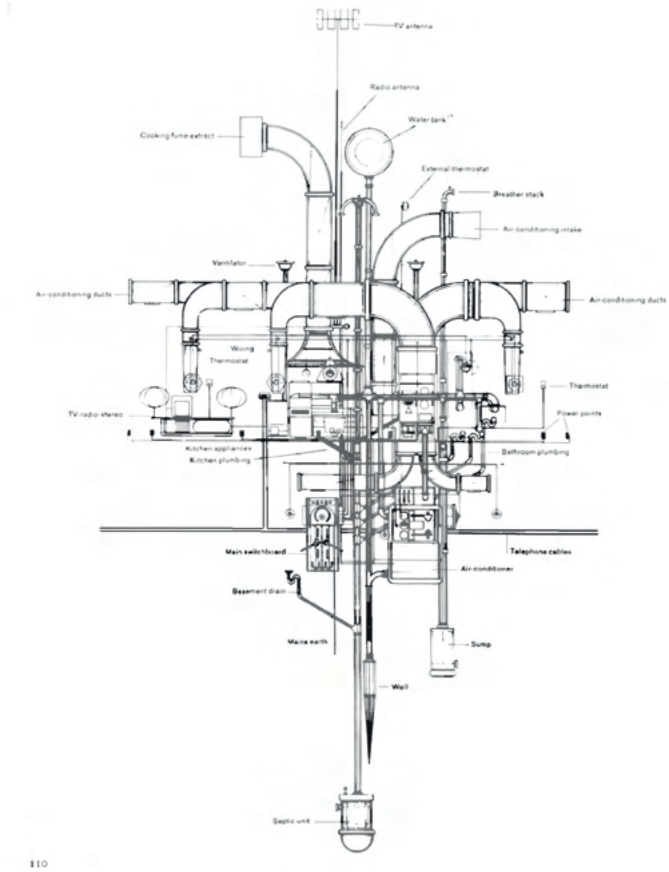
Professor in sociology and social theory, Hartmut Rosa's (2021) concept of resonance offers a profound insight into the emotional and psychological impacts of rapid development on personal and collective well-being. Rosa argues that in our fast-paced world, there is a vital need for relationships that slow down life's pace. According to Rosa, we are in need of relationships with people, objects, and environments that create a sense of closeness and peace. In the realm of architecture and infrastructure, this translates into designing spaces and systems that people can connect with, that make the high-speed world feel more manageable and more intimately connected to human scales and speeds.

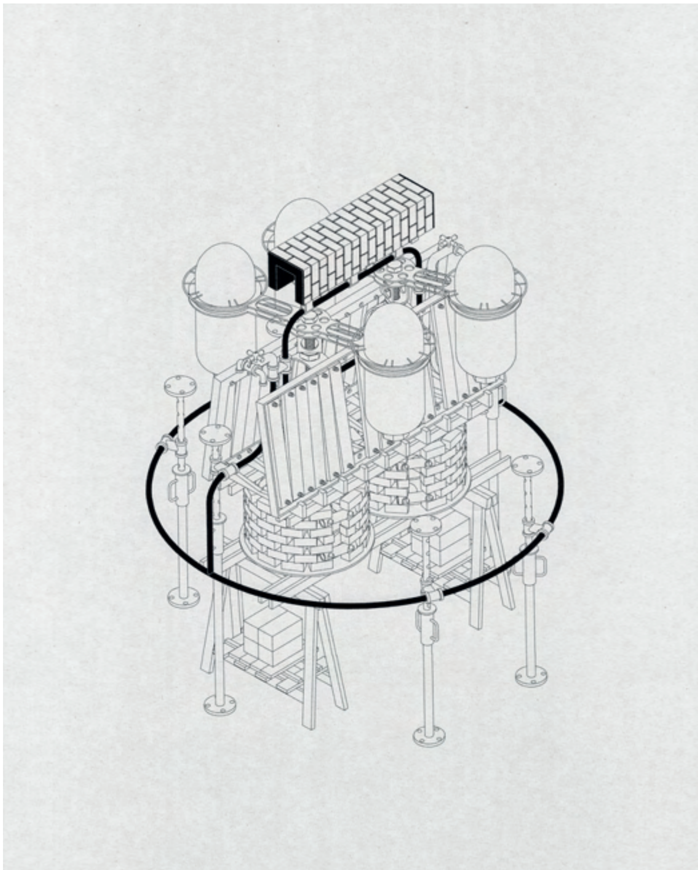
CARE & DETAILS

The concept of care emphasizes an ethic of attention, maintenance, and relationally within the built environment (Frichot et al., 2022). This perspective challenges traditional architectural priorities by advocating for spaces that nurture human and ecological relationships, highlighting the importance of support structures not just as physical entities but as embodiments of social and environmental stewardship. Care in this context is about crafting environments that are responsive to the needs of their inhabitants and the planet, promoting sustainability, inclusivity, and a sense of community (Condorelli., 2009). It's a call to architects and designers to consider the impacts of their creations on human well-being and the natural world, urging a shift from a focus on monumentalism and aesthetics to one of empathy, continuity, and support.

Details in architecture act as a conduit for expressing love. The difference between a structure that merely functions and one that resonates on an emotional level often lies in the attention given to the details. Photographer Roland Barthes (1980) introduces the concept of the punctum in his book Camera Lucida: Thoughts on Photography. The punctum is a detail that catches the observer off-guard, generating a personal, emotional reaction. Similarly, in architecture, it is those carefully considered, often unnoticed details that evoke an almost unconscious appreciation and affection.

Architectural character plays a crucial role in constructing a sense of collective appreciation. The character of a building is shaped by the aggregate of its details, material forms, and spatial arrangements and thus does not emerge by accident but is the result of intentional design decisions that reflect a deep care and love for craftsmanship. Ludwig Mies van der Rohe's (1969) maxim, "God is in the detail," captures the essence of how the meticulous handling of each part of an architectural assemblage can elevate the whole.





A Home is Not a Building, ↖
Reyner Banham &
Fançois Dallegret, 1961

Field Series, ↑
Teenage Engineering,
2023

Les Toits, Olivier Campagne, ←
2023

Bacchus (F1) I, ↑
Digital Print,
Stijn Jonckheere, 2018

A HOME IS NOT A HOUSE

This work by Reyner Banham and François Dallegret challenges the idea that a home is defined by its walls and roof, but by the flow of information, management of energy and the provision of comfort and convenience. Their main point underscores the idea that the essence of a home is defined by the experiences and functionalities it offers, rather than its structural form.

ÉNERGIES LÉGÈRES

The "Énergies Légères" exhibition, directed by Raphaël Menard at the Pavillon de L'Arsenal in Paris, redefines our energy relationship by visualizing the unseen and quantifying the immeasurable. This exhibition underscores the role of architectural objects in shaping a sustainable future by transforming energy use. It explores the connection between architecture and energy, revealing their impacts across territorial, aesthetic, and cultural dimensions. From windmills to solar chimneys, it presents a vision of a post-carbon future through innovative models and prototypes that aim to revolutionize our landscapes and promote sustainability.

TEENAGE ENGINEERING

Building on the legacy of Dieter Rams, Teenage Engineering have designed audio technology that expresses their technical functions through their exterior enclosure. Teenage Engineering work with proportions, grids, and symbols in a manner reminiscent of graphic design, creating a visually compelling narrative.

STIJN JONCKHEERE

Multidisciplinary visual artist and architect Stijn Jonckheere from Belgium works at the intersection of architecture, art, and graphic design. He often portrays parallel realities, showing the beauty in complex technical structures using his distinct detailed, monochromatic style.

REFERENCES

Teenage Engineering, Dieter Rams, Banham and Dallegret are used as method references. Banham and Dallegret proposes that the infrastructure is what makes architecture liveable and thus should be treated as of more importance than spatial layout and walls. Teenage Engineering and Rams focuses more on the visual expression of technical system.

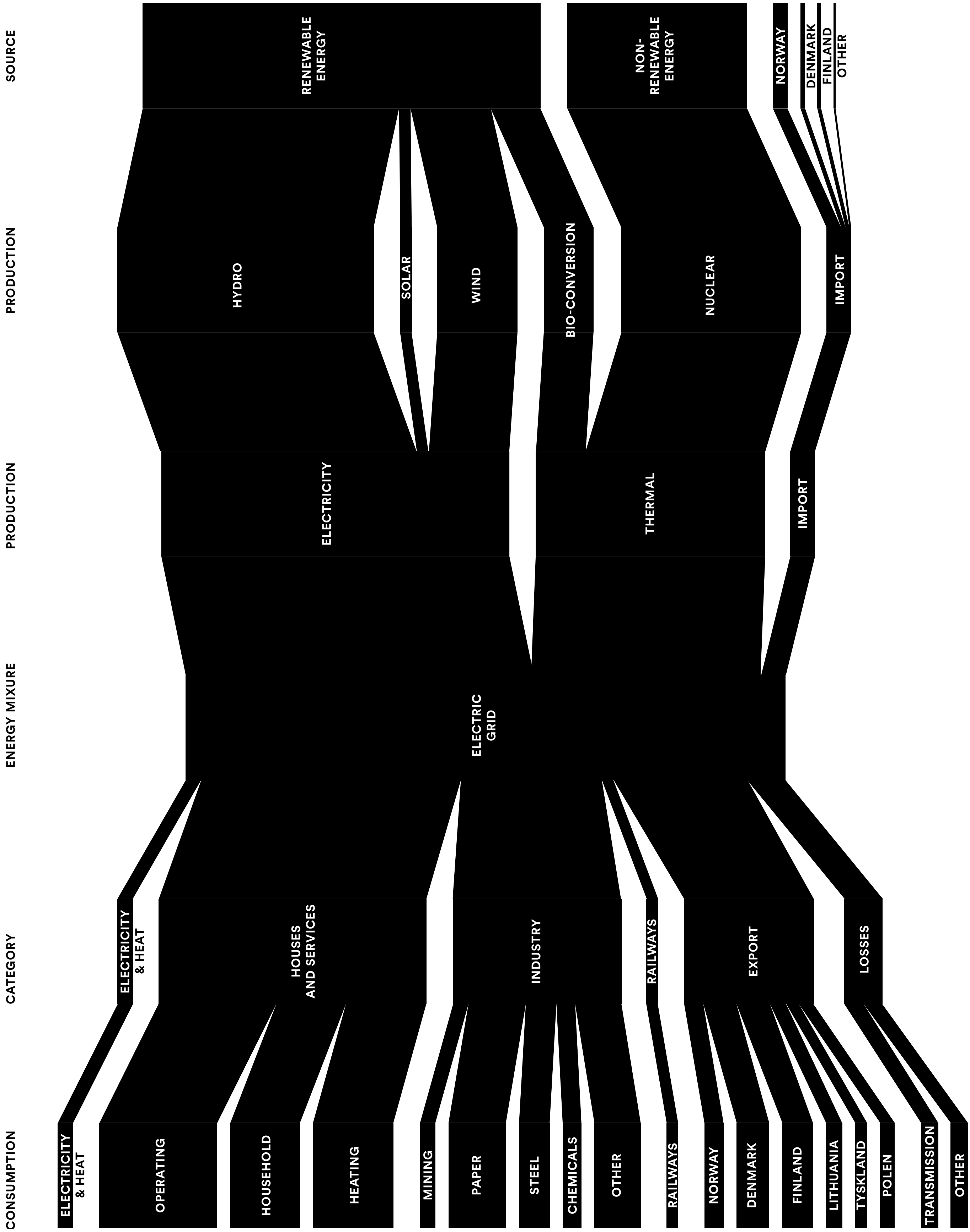
Energies Légères and Jonckheere are visual references. The digital composite images in Energies Légères show how small intervention will shift what our cities look like in a post-carbon future. Jonckheere's representation method emphasises the technical aspects of an object with an extra emphasis on the structures core structure through the bold, black-outed pipes.

METHOD

METHOD:
DIAGRAMMING ELECTRIC INFRASTRUCTURE AND ENERGY

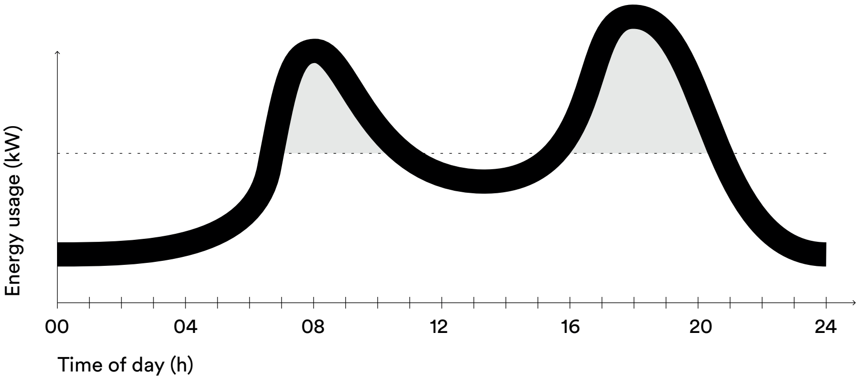
Utilizing a series of diagrams to map out various aspects of the electric grid and energy system proves to be a crucial method for dissecting and comprehensively understanding the intricate network of relationships within the electric grid and energy infrastructure. Diagramming visually outlines energy flows, utility layouts, and points of human interaction with the infrastructure, offering a clear and comprehensive view of the system's complexity. This approach enables a deeper understanding of how different components of the grid interconnect and impact each other, revealing the underlying structure and highlighting potential vulnerabilities or inefficiencies.

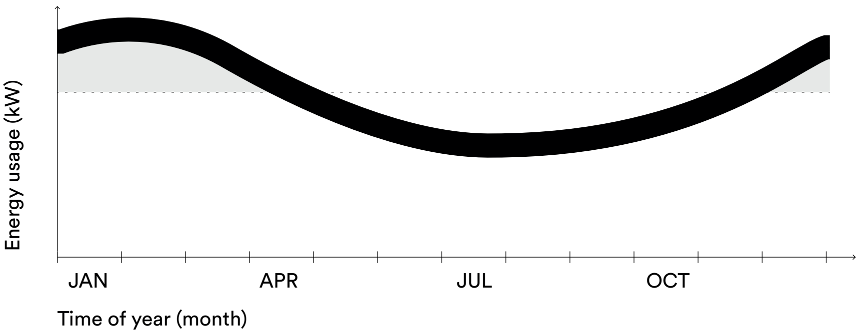
Diagramming can actively identify strategic points for intervention, where architectural innovations can have the most significant effect. It brings attention to areas ripe for improvements or reimagination, with the goal of enhancing functionality, sustainability, or user engagement. By guiding the creation of architectural interventions, this method ensures that the interventions are well-informed, targeted, and impactful. Diagramming allows us to craft solutions that address current challenges and also anticipate future needs and threats, thus improving the resilience, accessibility, and integration of the electric grid with the urban landscape.



ENERGY FLOW CHART

This flow chart shows the movement of energy through the electric system in Sweden. It illustrates where our energy is produced and where it gets consumed. The width of each segment represents the amount of energy in each category. From this, we learn that households and services, mainly in cites, account for the largest amount of energy consumption. We also can see that the energy mix is mostly from renewable resources, but it's important to note that renewable energy, such as bio-conversion, is not the same as emission-free.





ENERGY USAGE GRAPHS

These two graphs show the average energy usage of household electricity consumers in Sweden throughout a day and over a year. From the day-graph, we can decipher that energy usage peaks during breakfast hours and dinner hours. The yearly graph indicates that energy usage is higher during the winter months, primarily due to increased heating needs. There's potential in assisting the electric grid to provide more power during peak times to make it more robust, resilient, and lower the strain on the electric grid.

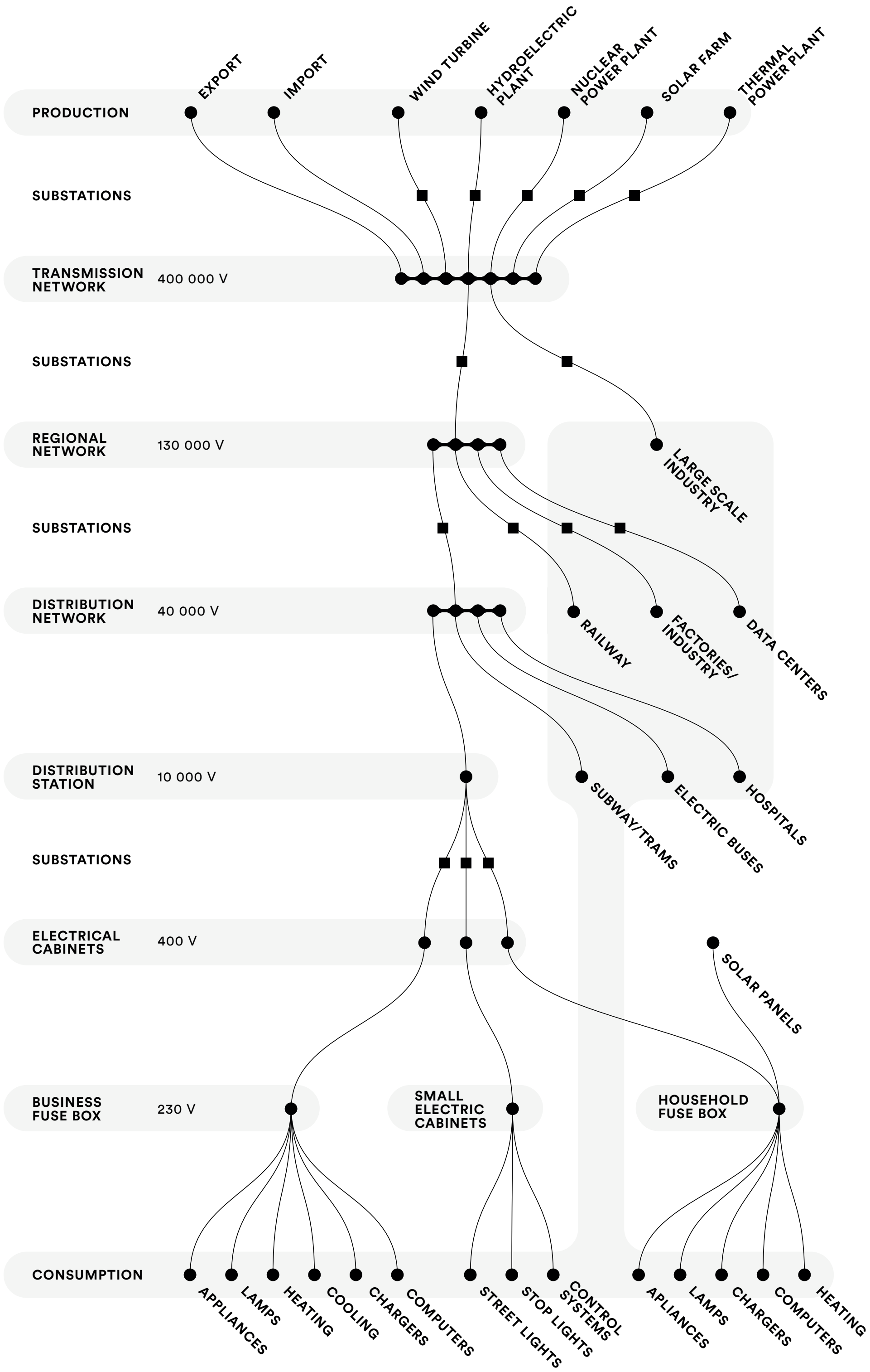


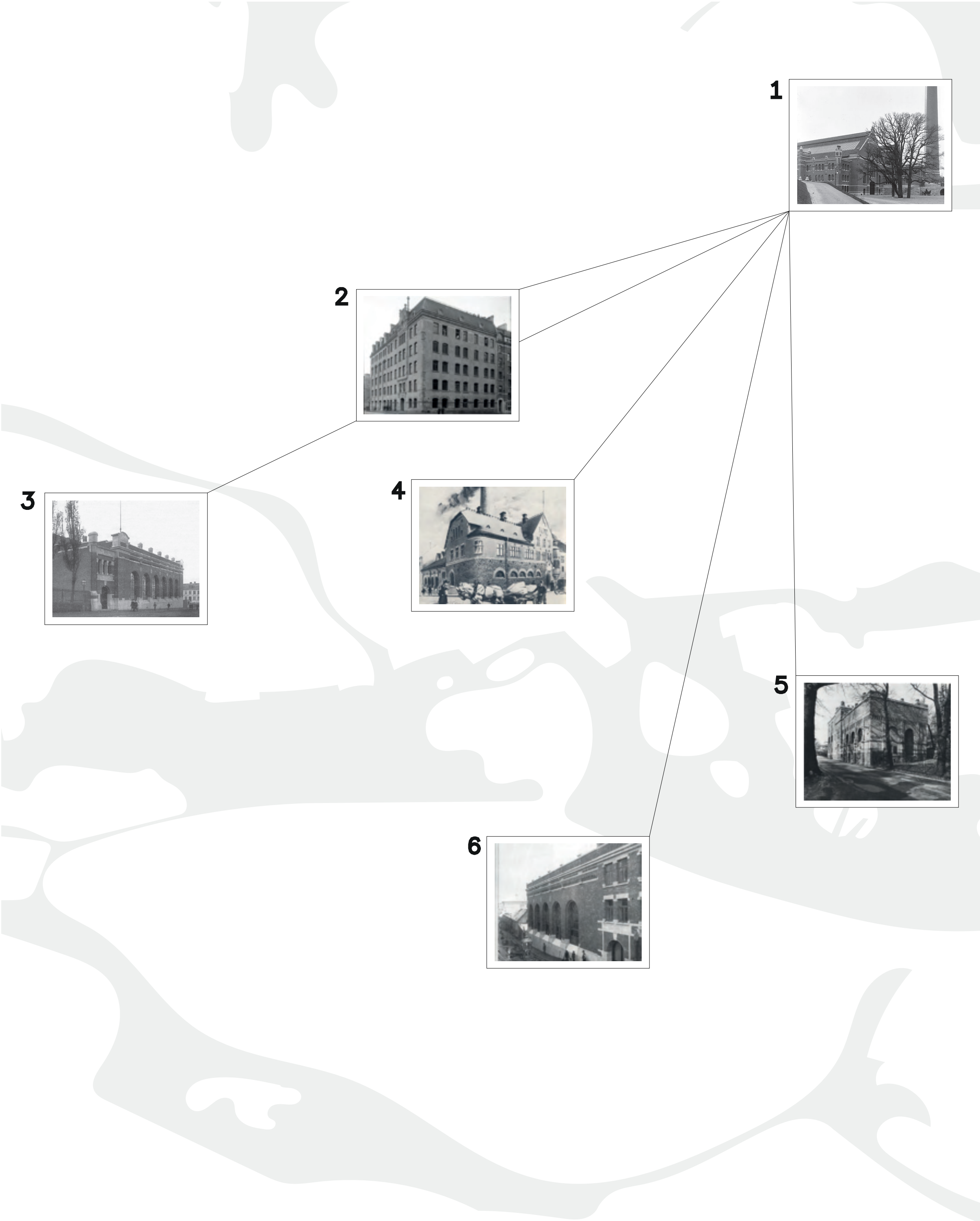
CHART OF THE ELECTRIC GRID STRUCTURE

Shows the utilities the system and network that the electric grind consist of, from the production, to the transmission and finally to different consumers. The difference in voltages across various parts of the system is due to the fact that higher voltages result in lower energy losses during transmission. Therefore, it is most efficient to transform the voltage closer to the end consumers.

MAPPING OF SUBSTATIONS AND ELECTRIC CABINETS

This map shows part of the Vasastaden neighbourhood in Stockholm and how the electric grid sprawls throughout the city and where it appears in the urban fabric through small substations and electric cabinets. The data is sourced from *Stockholms elnät i förändring* by Peter Metel (2023) and from own observation. The large amount of cabinets show that, although each cabinet may not have a lot of impact on our experience of urban spaces, the system of the thousands of cabinets together is part in shaping the experience of our surroundings.

■ ELECTRIC CABINET
● SUBSTATION
✸ DISTRIBUTION STATION



1	VÄRTAVERKET	1903
2	TULESTATIONEN	1906
3	KRONOBERGSSTATIONEN	1903
4	BRUNKEBERGSVERKET	1911 (1889)
5	DJURGÅRDSSTATIONEN	1906
6	KATARINASTATIONEN	1905

MAPPING OF STOCKHOLM'S FIRST TRANSFORMER STATIONS

This map depicts Stockholm's first electric grid which had its starting point at the coal-fired Värtan power plant (Hallerdt, 1992). Värtan generated alternating current electricity, which was then distributed to large transformer stations. These stations converted the alternating current to direct current, the common form used in households at that time. To minimize energy losses, transformer stations were strategically located near consumers. Due to their central locations, they were designed to be aesthetically pleasing and harmonious with their surroundings. Many of these robust buildings have avoided demolition due to their solid construction and versatile design, allowing for their adaptation to new functions and uses.

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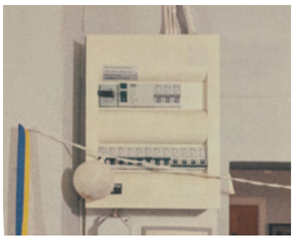

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14

01 Nuclear Power Plant

Monumental scale, isolated object in coastal landscape

02 Co-generation Plant

Suburban industrial scale building, disruption in urban fabric

03 Hydroelectric Power Plant

Large scale and disruption in nature due to dams

04 Wind Turbine

Tall, visible structures dotted in rural, coastal and offshore landscapes.

05 High Voltage Substation

Large industrial scale, naked technical system

06 Power Line Pylon

Towering structure, creating dramatic lines through the landscape

07 Distribution Station

Community-scale, nestled within other buildings

08 Indoor Serviced Substation

Moderate scale, scattered throughout the city

09 Outdoor Serviced Substation

Small and compact scale, more common outside of city centre

10 Large Electric Cabinet

Furniture scale, always present wherever you are

11 Small Electric Cabinet

Small object scale, so small they often go unnoticed

12 Fuse Box

Household object scale, connection from grid to consumer

13 Junction Box

Tiny scale, present in most places either concealed or visible

14 Street Light

Small object, suspended or on pole, aligned along streets

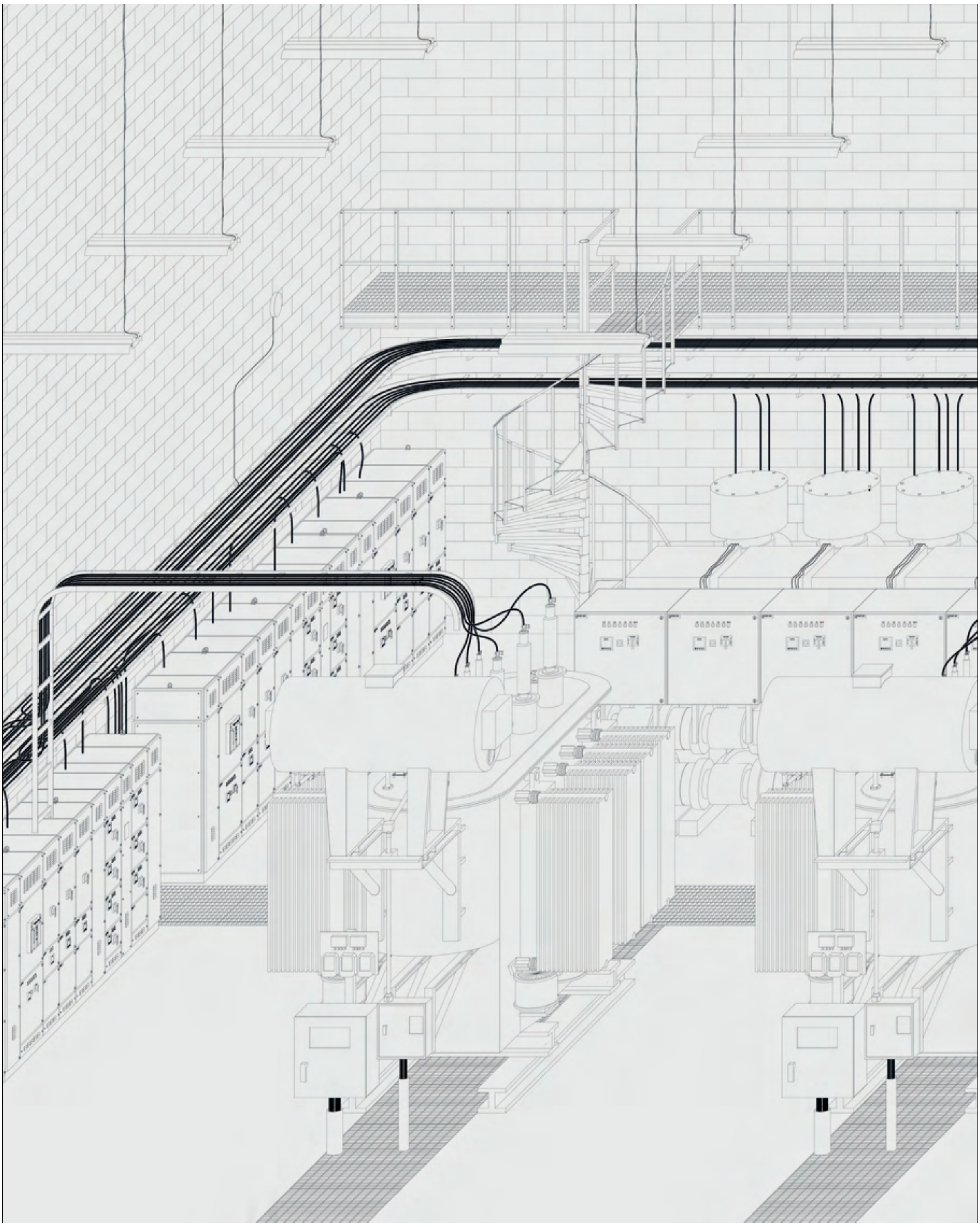
METHOD:
ATLAS OF URBAN ELECTRIC ARCHITECTURES

This design exploration studies four architectural objects connected to the electric grid: a distribution station, a box-type substation, an electrical cabinet, and a suspended street light. These objects are presented through illustrations that reveal both their visible and hidden components, evaluating their significance in terms of energy and matter. This documentation serves not only to identify the elements comprising the system but also to develop a theoretical perspective on the relationships within electric infrastructure.

For each scenario, the analysis aims to illuminate potential critiques of these objects and explores how strategic interventions might alter the perception and interactions with these infrastructural elements.

↑ Map of Stockholm Showing Location of Infrastructural Objects

← Collection of Visible Manifestations of Electric Infrastructure in all Scales



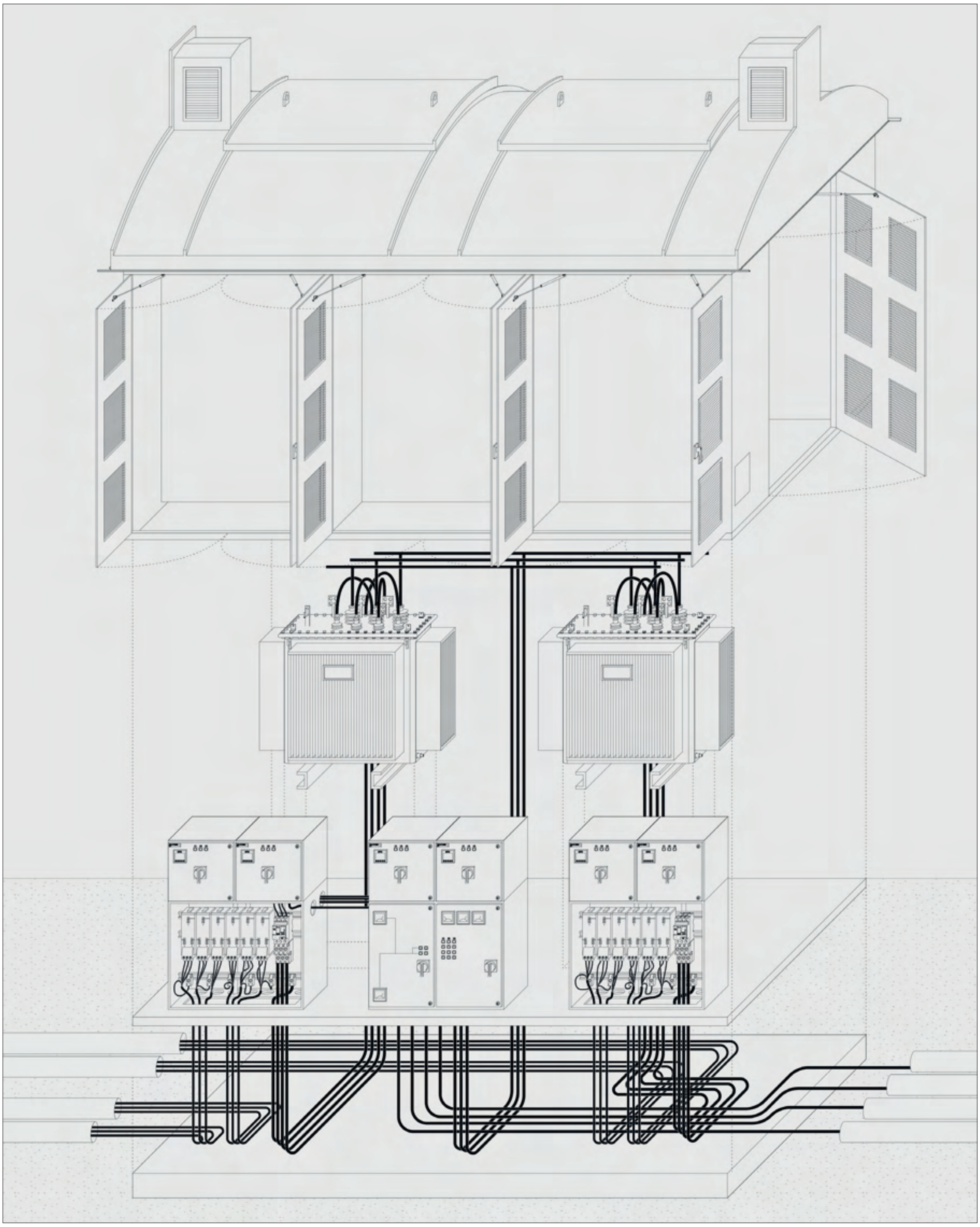
URBAN DISTRIBUTION STATION

Although not immediately apparent, there's something unusual with this building on Östgötagatan. At first glance, it might not appear as any different to other buildings. However, upon closer inspection, it becomes clear that this is not an ordinary apartment building or office. The buildings two unusually large gates, enough to accommodate a giant, sets it apart. The construction with red painted in-situ concrete and characteristic copper gates referencing energy integrate both form and function in a balanced way. This building is more of a "duck" than a "decorated shed" to use terms popularised by Denise Scott Brown and Robert Venturi (1977).

↗ Interior of Distribution Station Katarina

← Distribution Station Katarina, Östgötagatan 14, Arksam & Mikael Pauli, 1992


SAND



COMPACT TRANSFORMER SUBSTATION

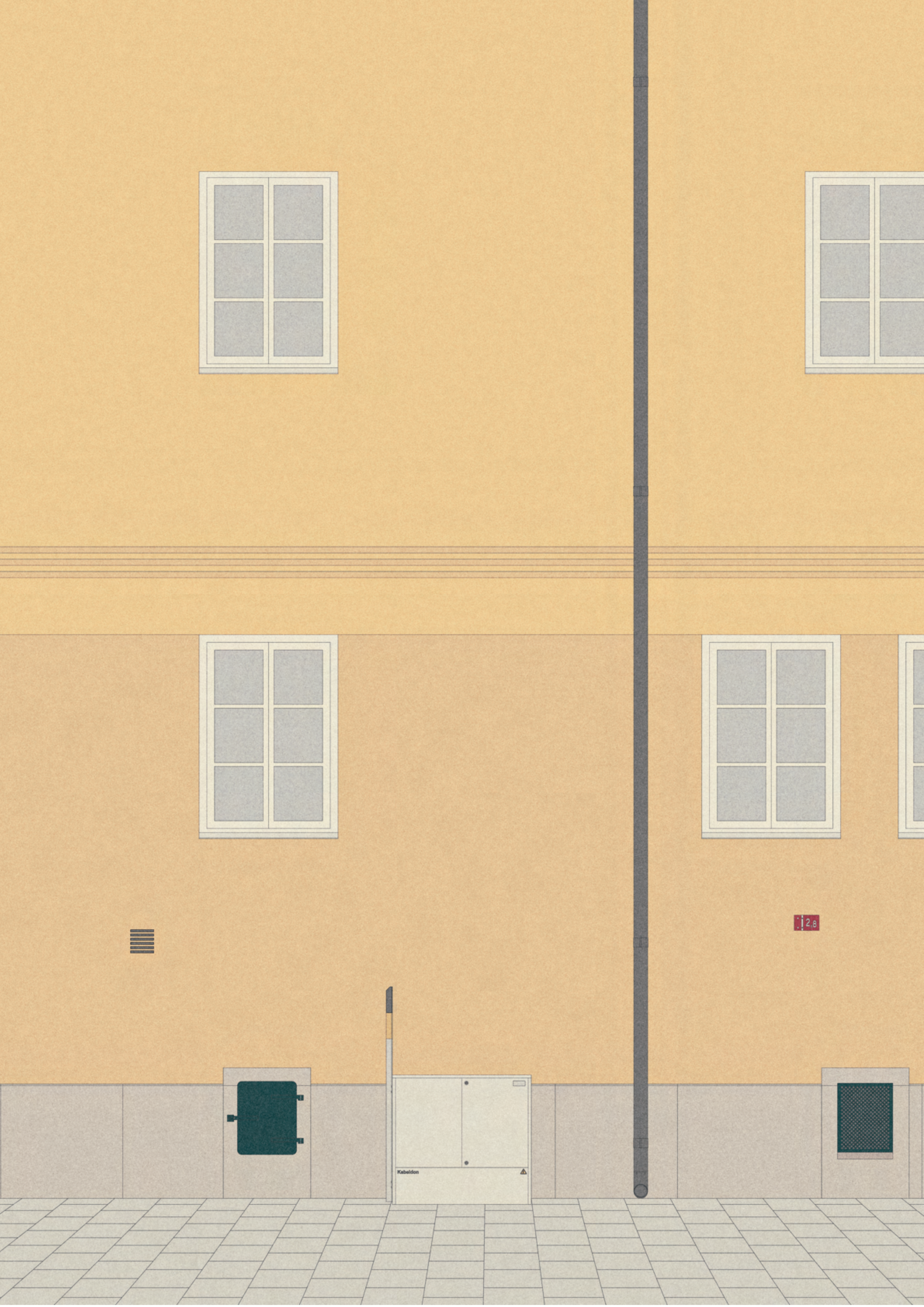
Designed by Bengt Lindroos, this substation harmonizes with its surroundings through its arched roof, structured ventilation grilles, and distinctive yellow colour. Produced in the 90s for a short period, it was discontinued after 20 units due to high costs, with the local electricity company not valuing its unique design.

Questioning why substations can't be as valued as Shinto shrines or small pilgrimage chapel, this view suggests rethinking how we appreciate the structures that enable our technology-centric lives. These temple of power try to blend into the environment, yet there's potential for them to be more visually expressive. This could demystify their operation and better add character into urban landscapes.

↗ Anatomy of a Substation

← Outdoor Serviced Substation, Sandhamnsgatan 22, Bengt Lindroos, 1995

→ Small Urban Shinto Shrine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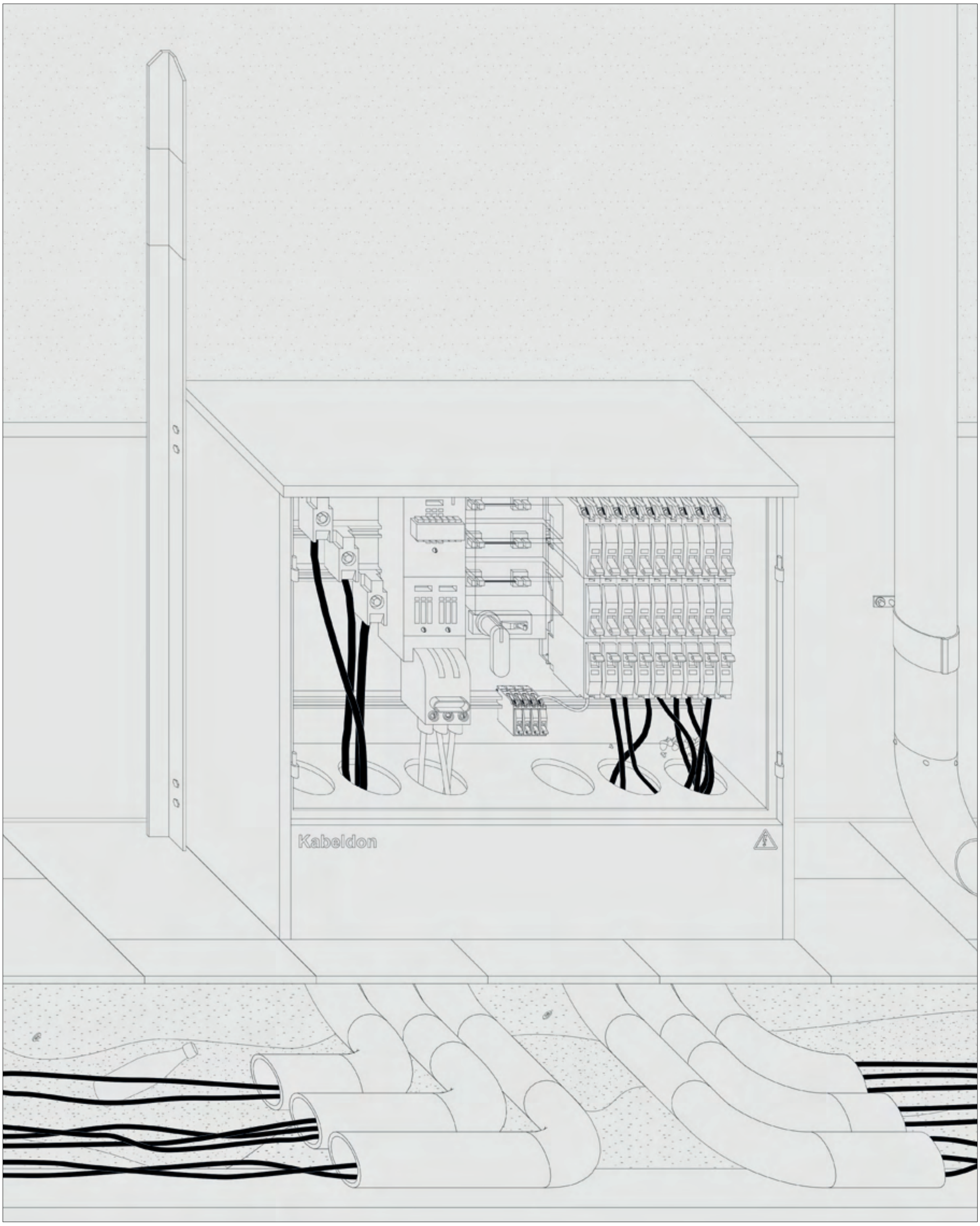


ELECTRICAL CABINET

The electrical cabinets scattered around the cities streets are plagued by an aesthetic neglect. The electric companies exclusively care about low cost and ease of maintenance. If these boxes could have a more emphasised placement and aesthetic treatment as a drinking fountain, they could be transformed into focal points of public interest and identity building for its neighbourhood. Inside an electrical cabinet you find many smaller components. Viewed as a purely functional assembly, they have no inherent aesthetic values. However, when observed individually or when a component is repeated, aesthetic values can emerge. Sometimes, the discovery of acorns and similar items inside electrical cabinets reveals that these spaces, unintended for such use, become homes to unwanted inhabitants like rodents.

↗ Interior of an Electrical Cabinet

← Distribution Cabinet, Dalagatan 86, Unnamed Designer, ABB

→ Fountain and Bench, Monte, Studio *Ser*, 2022


41 A
C o D
41 B ➔

STREET LIGHT AND SUPPLEMENTARY COMPONENTS

A lot of love and effort went into designing the light fixture, however, the love seems to dissipate beyond that point. The supplementary components and support structures has character but fall short in terms of love, care and attention to detail. Compare it to Sigurd Lewerentz's flower kiosk where every element is handled with conscious care and equality. When every part of a creation is imbued with love, it resonates deeply evoking a almost unconscious sensation in the observer's stomach. Light, as the most prominent visual manifestation of electricity, deserves respect. Its use should go beyond function and reflect the care and attention that elevate it from a mere utility to a form of art. Neon signs exemplify this, with their intricate craftsmanship and care highlighting the artistry in lighting.

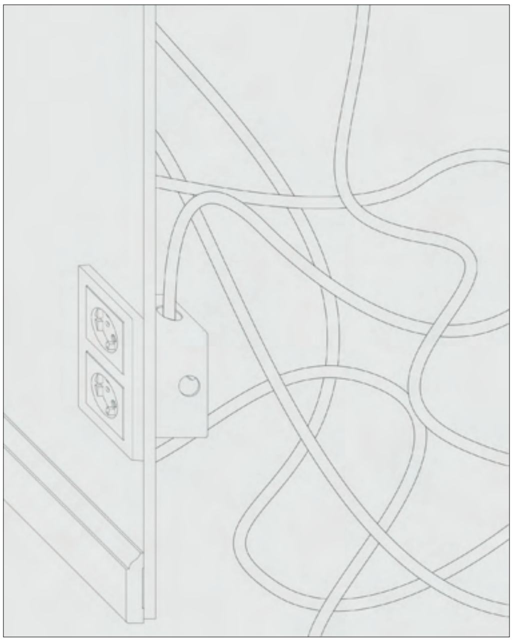
↗ Anatomy of a Suspended Street Light

← Suspended Street Light and Supplementary Components, Wollmar Yxkullsgatan 41, Olle Anderson, 1990

→ Cables and Light Sockets, Flower Kiosk, Sigurd Lewerentz, 1969

01

02



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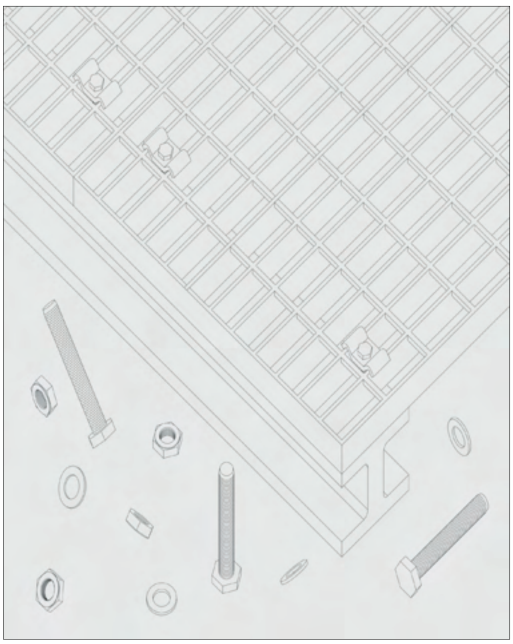

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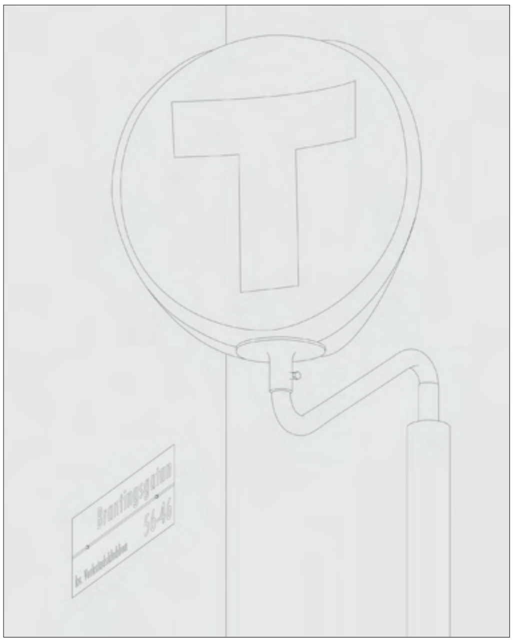

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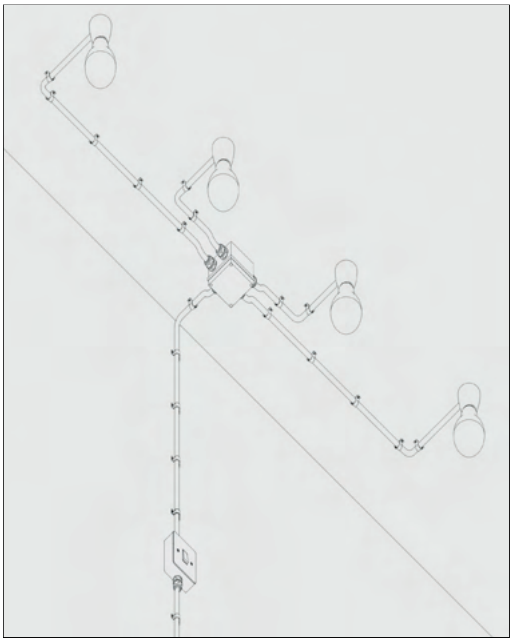

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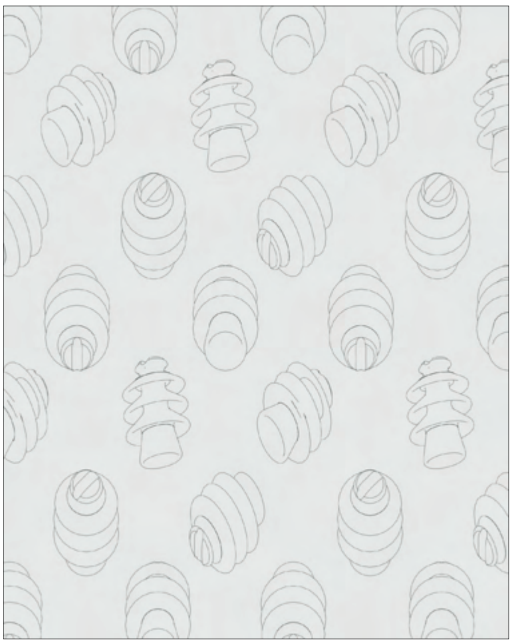


INSIGHTS FROM ATLAS

From studying the electric infrastructure atlas, six qualities have been identified that highlight its design and function. These insights help explain the complex nature of the built environment and form the foundation for approaching the design of new infrastructural objects.

One general reflection is that larger urban infrastructures often receive more design attention than smaller ones due to their significant impact and visibility in urban space. In contrast, smaller infrastructures, such as street lamps or drainage systems, while crucial, typically prioritize functionality because they, as a singular object, does not have a large impact of the appearance of urban space. While individual small infrastructure elements have minimal influence on the appearance of our cities individually, collectively, as a system of thousands of small objects, they significantly impact how we perceive our urban environments.

01 THE INFRASTRUCTURAL ARRAY

When analysing infrastructure a rhythmic repetition of identical components emerged. From pylons forming patterns in the landscape and uniform electric cabinets evenly distributed along a street to the smallest components inside of an electric cabinet repeats. This repetition speaks of a deep, systemic order, where we can find meaning and beauty in the monotony.

02 ORDER OUT OF COMPLEXITY

Out of the complex and incomprehensible electric system an order emerges where all part work in harmony to support our interaction through the interfaces of the electric grid such as wall sockets and lamp buttons. There's a beauty in the idea that order can emerge from a system that from the outside can seem like chaos.

03 STANDARD PARTS

The use of standard parts is a characteristic of infrastructure, enabling modularity, adaptability, and reversibility in both structures and technical installations. This approach to standardization not only streamlines construction and maintenance but also offers a way to express technical sophistication. Through the visible application of these standardized components, the inherent technicality of infrastructure is articulated, showcasing the elegant functionality that lies at the core of its engineered design.

04 IDENTITY FROM OBJECTS

This quality highlights the subtle intricacies and the unique assembly of objects that contribute to the distinct character of an environment. It emphasizes how objects, for which one can feel affection, play a crucial role in defining our collective identity, from manhole covers to public toilet. There's potential in infusing infrastructure with more personality, thereby enriching the identity of a space.

05 CONSCIOUS ASSEMBLY OF PARTS

The quality of craftsmanship, noticed in the care and attention to detail, has an immediate impact on our perception of a space. Installations arranged with symmetry and attention to detail, rather than convenience, elevate a space's aesthetic and harmony. When all detail are handled consciously you don't really notice because there are no disturbances.

06 OBJECTS OF BEAUTY

Within the practical, there's an unexpected beauty. Certain components of the electric grid, such as porcelain insulators and power line pylons, can possess inherent aesthetic qualities, from their material composition to their distinctive forms. Designed solely for functionality, these elements inadvertently become embodiments of beauty, uniting utility with visual appeal.

METHOD:
DESIGN STRATEGIES

Drawing on insights from the exploration of existing electric infrastructure through diagramming and the atlas, five design strategies have been developed for the architecture of new urban electrical infrastructure. These strategies aim to depart from conventional ways of planning infrastructure and instead highlight architectural aspects that are often overlooked.

THE RACK

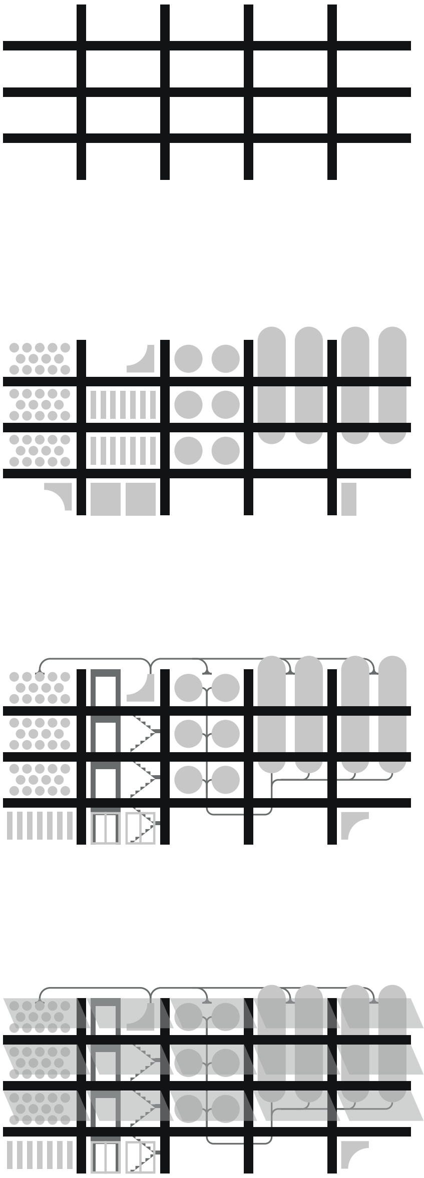
This design strategy focuses on the rational organization of technical components within a system, emphasizing clarity, overview, and pragmatic modularity. Components in this system are not permanent and can be replaced as technology evolves or reaches its operational end. This approach not only optimizes aesthetic and spatial efficiency but also improves readability and maintenance ease.

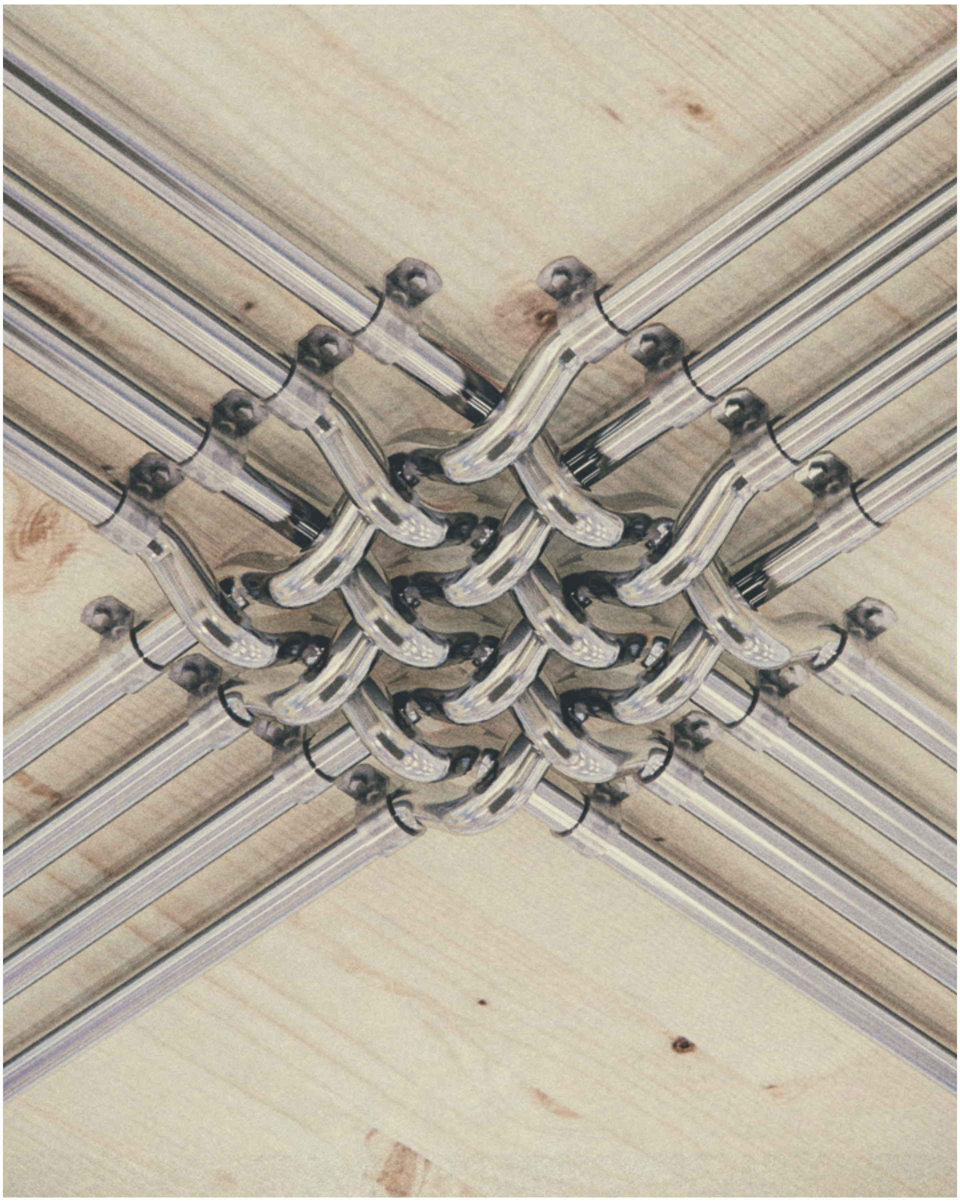
Using “The Rack” as a tool to organize infrastructural systems is akin to an arranged display of parts or components. It facilitates efficient management and component replacement, and transforms the infrastructure into a visually coherent entity. This method introduces order and visibility to typically concealed systems, integrating them seamlessly into the architectural expression.

THE DISPLAY WINDOW

This design strategy introduces an engaging visual element to urban infrastructure, enticing passersby to pause and observe. By transforming typically hidden infrastructural elements into visible, kinetic, and almost living parts of the urban landscape, it offers a captivating and dynamic presence on the streets.

Unlike traditional designs that enclose and isolate infrastructure from public view, this approach makes these systems’ inner workings a focal point of architectural expression. By showcasing the infrastructure’s internals, such as mechanical systems, wiring, and support structures, not only as functional but as essential aesthetic components, it enhances the urban space.





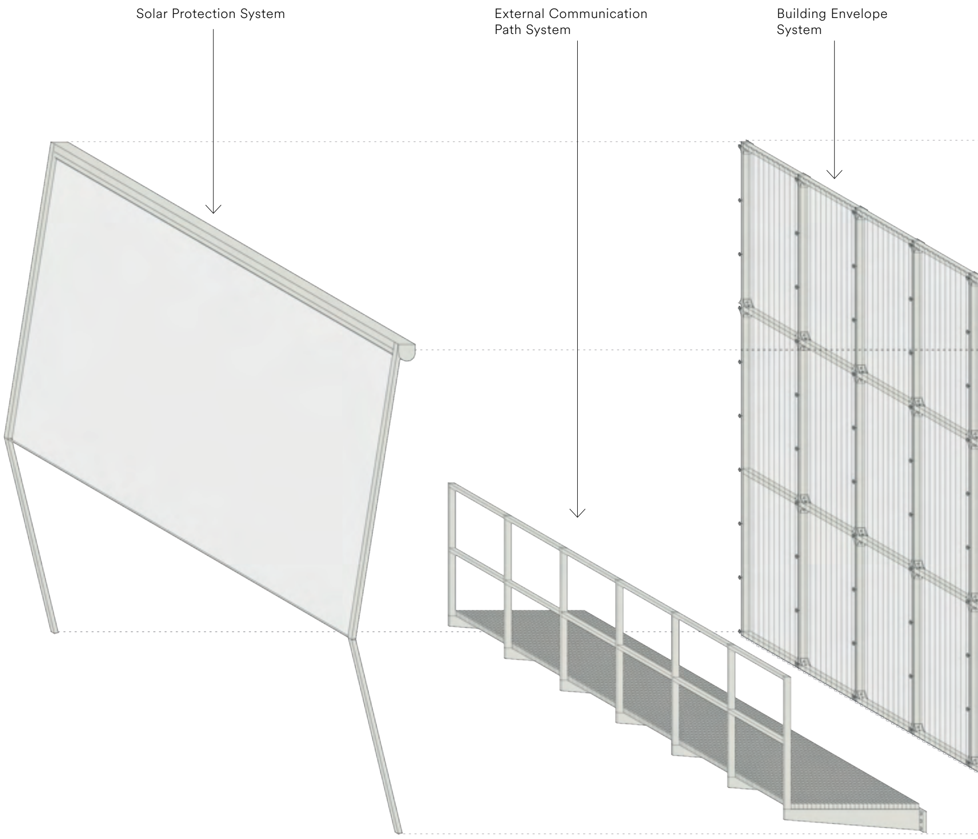
ORNAMENTAL SYSTEMS

Infrastructure can transcend mere functionality and become ornamental when designed with deliberate care and intention. By meticulously crafting details and strategically choosing, arranging, or emphasizing certain components, even mundane elements like pipes or cross-braces can serve as ornamentation, adding unique character to a space. This approach transforms basic support structures within a building, such as ductwork, pipes, and mechanical systems, into aesthetic features reminiscent of how an ornate radiator enriches its surroundings. Deliberate planning concerning the placement of mechanisms, buttons, fire alarms, and other utility components can enhance the architectural value, making these elements integral to the design rather than afterthoughts. Such thoughtful integration ensures that infrastructure not only fulfils its practical purpose but also contributes to the visual and spatial experience, enriching the environment and elevating the overall aesthetic of a project.

This concept is exemplified in Bengt Lindroos's substation design (page 34), where the placement of ventilation grills is meticulously considered, contrasting sharply with regular substations. Lindroos's design brings a harmonious unity to the structure, demonstrating how thoughtful architectural decisions can transform typically utilitarian features into significant design elements that enhance both functionality and aesthetic appeal.

↑ Illustration of "The Rack" Strategy:
1. The Rack
2. Furnished with Components
3. Support Systems
4. Building Envelope

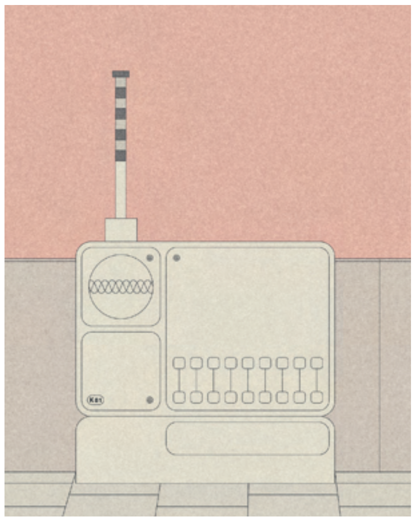
↗ Design Exploration of Weaving Tubes Showing how a System can be Ornamental

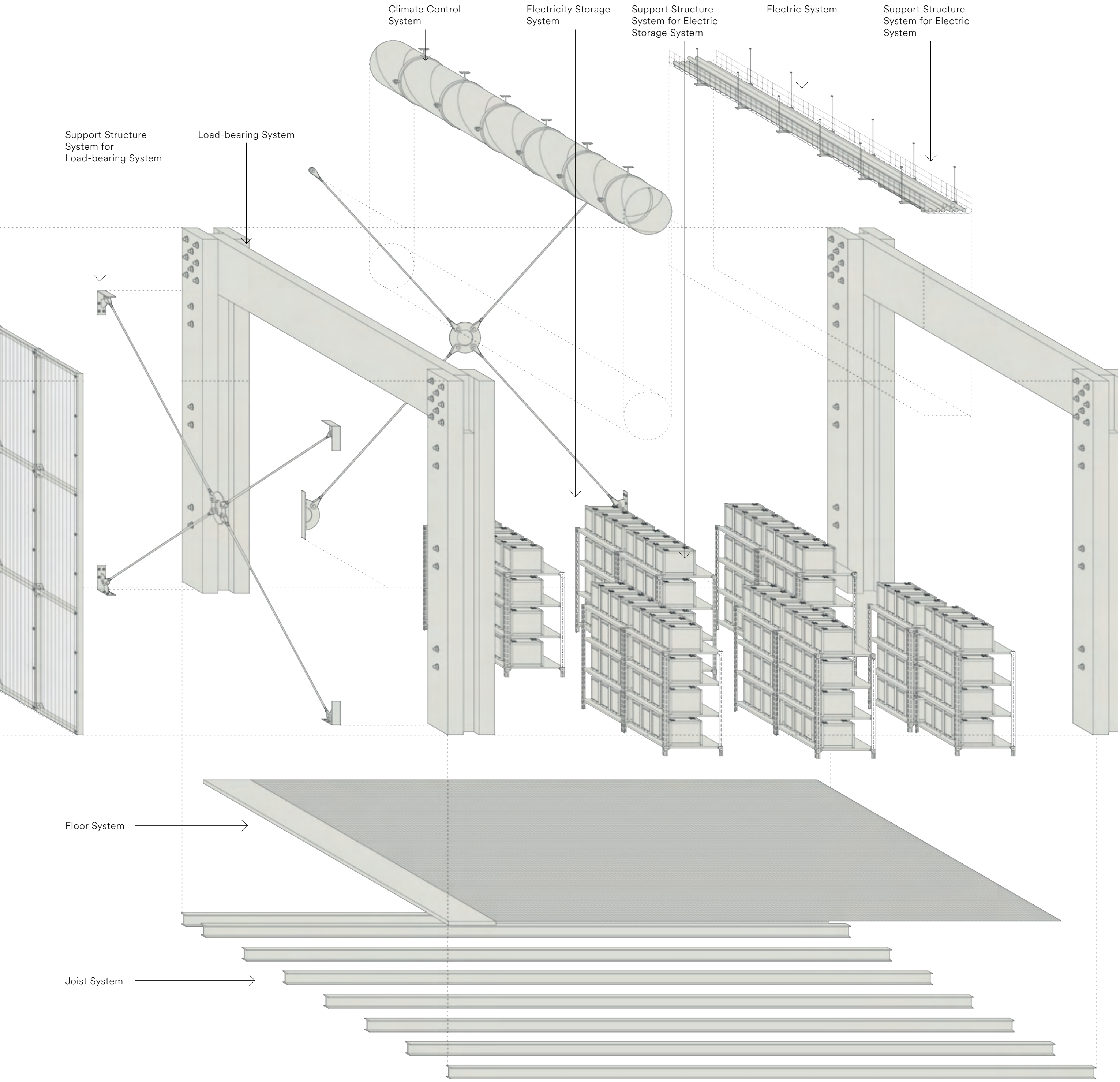


GRAPHIC DESIGN METHOD

The “Graphic Design Method” is deeply influenced by Dieter Rams’ philosophy and is linked to “The Rack,” focusing on the strategic arrangement of parts. This method prioritizes proportions and the placement of various objects relative to each other, addressing aspects such as relationships, clarity, readability, understanding, and user-friendliness. By carefully organizing components, this design strategy enhances the aesthetic and functional coherence of infrastructure systems, making them more intuitive and accessible for users. Each component’s placement is meticulously considered to optimize both interaction and visual appeal.

For example, in infrastructure architecture, rather than placing elements like fire alarms and control buttons merely where it is easiest, this method advocates for thoughtful placement where the relationship among objects is taken into account. This approach can be seen in how user interfaces are integrated into architectural elements like openings, façade focuses, and structural visibility, rather than relying solely on direct interaction. This strategy not only enhances the functionality but also the aesthetic integration of these elements into the urban landscape, demonstrating a commitment to both practical and visually appealing design solutions.





SYSTEM LAYERS

Usually the main system in infrastructure reigns supreme while in reality, a building is composed of multiple layers of systems, such as structural framework, technical systems, climate envelope, and even spatial configuration. The design strategy of selectively revealing and concealing these layers not only highlights each component but also enhances their aesthetic and functional integration, showing each layers' importance.

Drawing inspiration from François Dallegret's theories, this approach emphasizes that critical systems like wiring, which are as essential as the load-bearing structures for the function of the building, should not be hidden behind plasterboards. Instead, every layer, from infrastructural and support systems to load-bearing, facade, and climate control systems, requires careful and meticulous design. This ensures that all systems are harmonized and interact seamlessly, enhancing the building's operational efficiency and architectural integrity.

This strategy departs from conventional infrastructure architecture, where typically a closed shell conceals all but the climate envelope. By making each system visible, this approach challenges the traditional notion of infrastructure as merely functional and hidden, promoting a design where the infrastructure itself becomes a feature to appreciate, not just a necessity to conceal. This visibility not only improves the building's overall architectural expression but also makes each layer readable and functionally integral, fostering both aesthetic appeal and structural coherence.

↑ Exploded Axonometric of a Infrastructure Buildings System-Layers

← Design Exploration of Reimagined Electric Cabinet using Graphic Design as Method

DESIGN PROPOSALS

DESIGN PROPOSALS

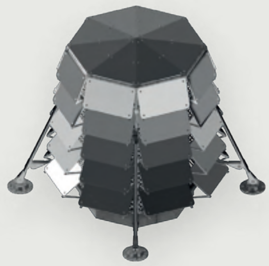
To implement the design strategies developed, this thesis explores three architectural manifestation of infrastructural nodes of the electric grid. The studied objects appear within the urban fabric of northern Stockholm in three different scales; small (**A**), medium (**B**), and large (**C**). The aim of the design proposals is to examine how these infrastructural elements interact with the architectural landscape, fostering a deeper relationship between the city's inhabitants and their infrastructure through more affectionate and engaging designs.

The goal is to construct these infrastructural objects so they, not only fulfil their functional needs but also fit in with their surroundings, while being undoubtedly infrastructural. The structure of the building and the infrastructure and support structures within the building should speak the same architectural language of assembled parts into functional wholes where each part is dependent on all other parts to create a coherent structure. The proposals tries to implement the five design strategies developed and for example investigates how the different infrastructural layers of these structures interact, creating enriched situations that enhance the experience and perception of these objects in the urban environment.

This approach is a deliberate shift from treating the architecture of infrastructure manifestations as mere enclosures. Every component both on the inside and outside, should be thoughtfully considered, such as the handling of piping and wiring to the placement of buttons. The design transcends mere functionality and embraces aesthetic significance, aiming to create loveable urban objects.

Three architectural manifestation of nodes on in the electric grid ↗

A



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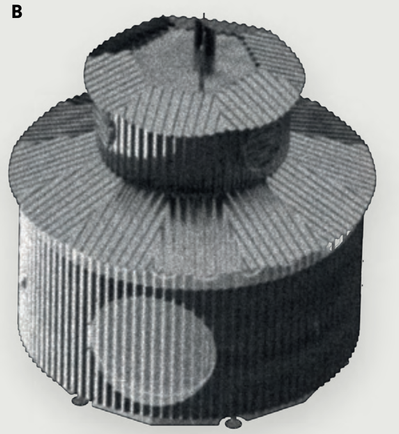

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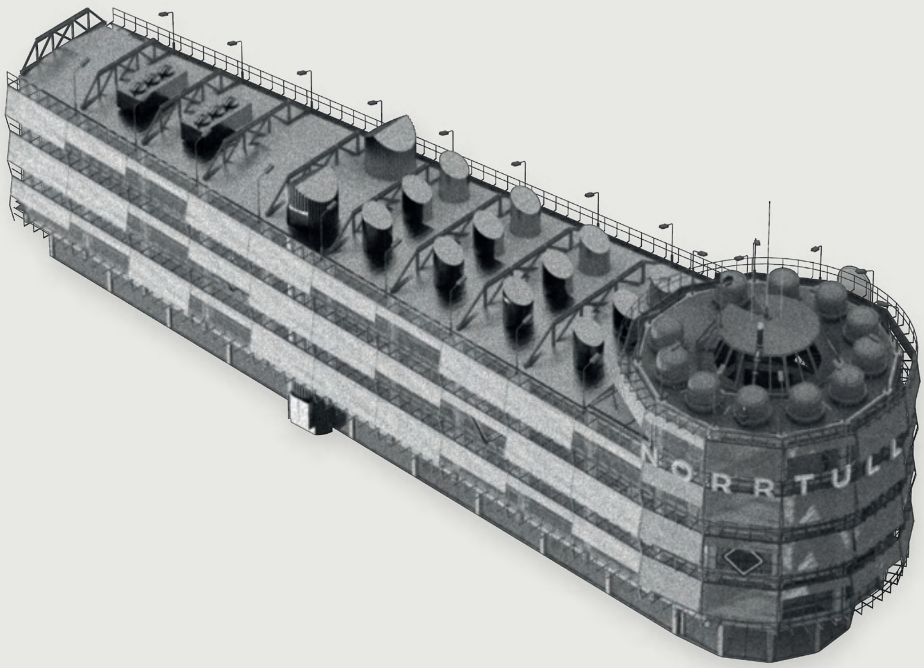


ENERGY STORAGE FACILITY

01 HIGH VOLTAGE TRANSFORMER
Quantity: 2
Transform electricity from the electric grid from 10 000 V to 400 V

02 SWITCHGEAR
Quantity: 2
Monitors and distributes the electricity throughout the facility

03 LITHIUM BATTERY RACK
Quantity: 16 * 96 = 1536
Capacity: 490 000 kWh
Batteries are used to store electricity on a daily cycle and as a intermediary due to the delay when extracting energy from the gas tanks

04 FUEL CELL
Quantity: 10
Converts the energy of hydrogen into electricity through a pair of redox reactions with water as the by-product

05 HIGH-PRESSURE HYDROGEN TANKS
Quantity: 100*48 = 4800
Volume: 0,14 * 4800 = 680 m³
Capacity: 520 000 kWh
For storing hydrogen in its gaseous form under high pressure

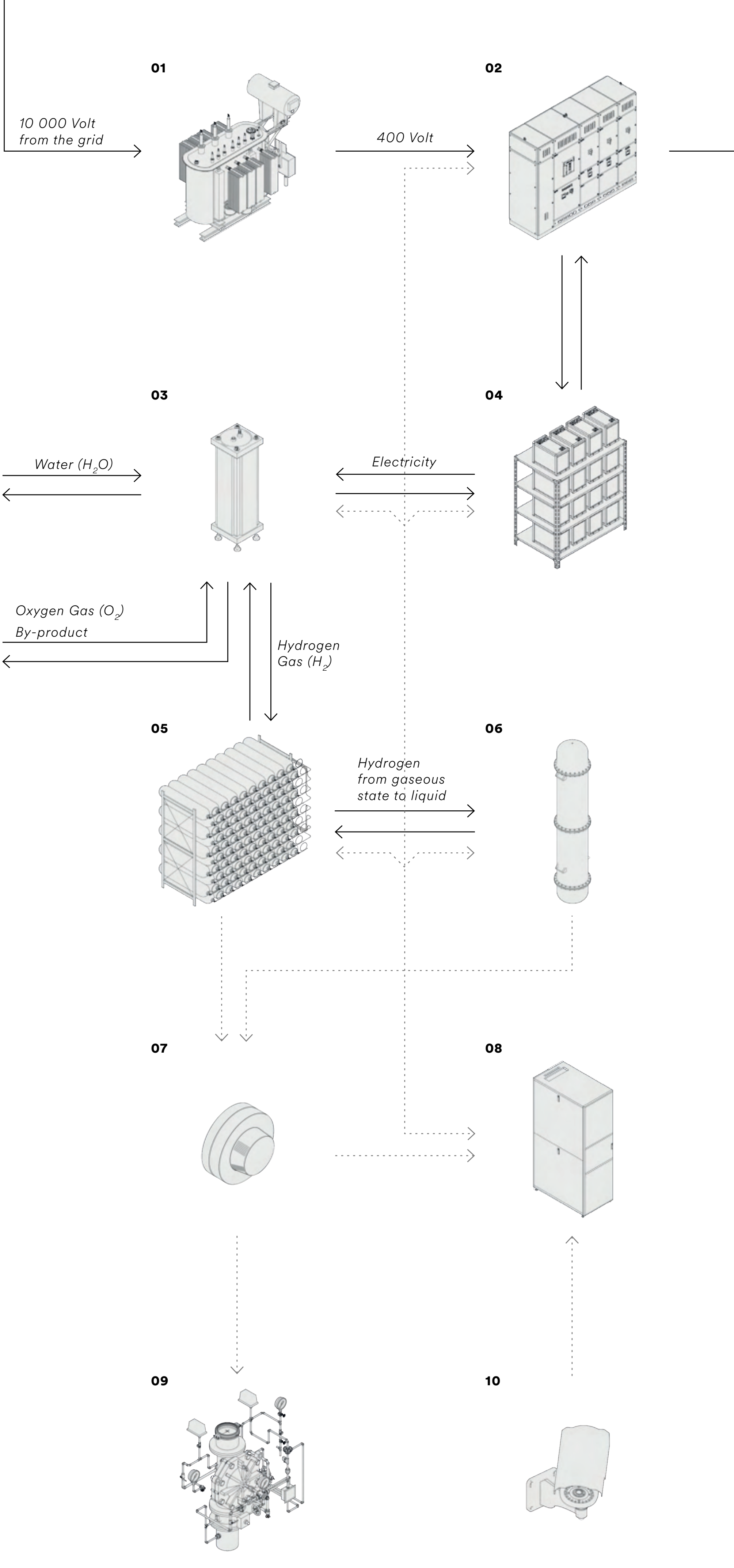
06 CRYOGENIC HYDROGEN TANK
Quantity: 11
Volume: 40 * 11 = 440 m³
Capacity: 1 034 000 kWh
For storing hydrogen in its liquid form at extremely low temperatures

07 GAS DETECTION SYSTEM
Detects potential leaks of hydrogen gas which is highly explosive

08 COMPUTER RACK
Quantity: 4
The computers monitor and control the systems in the facility, operating valves and managing energy levels while it also logs data

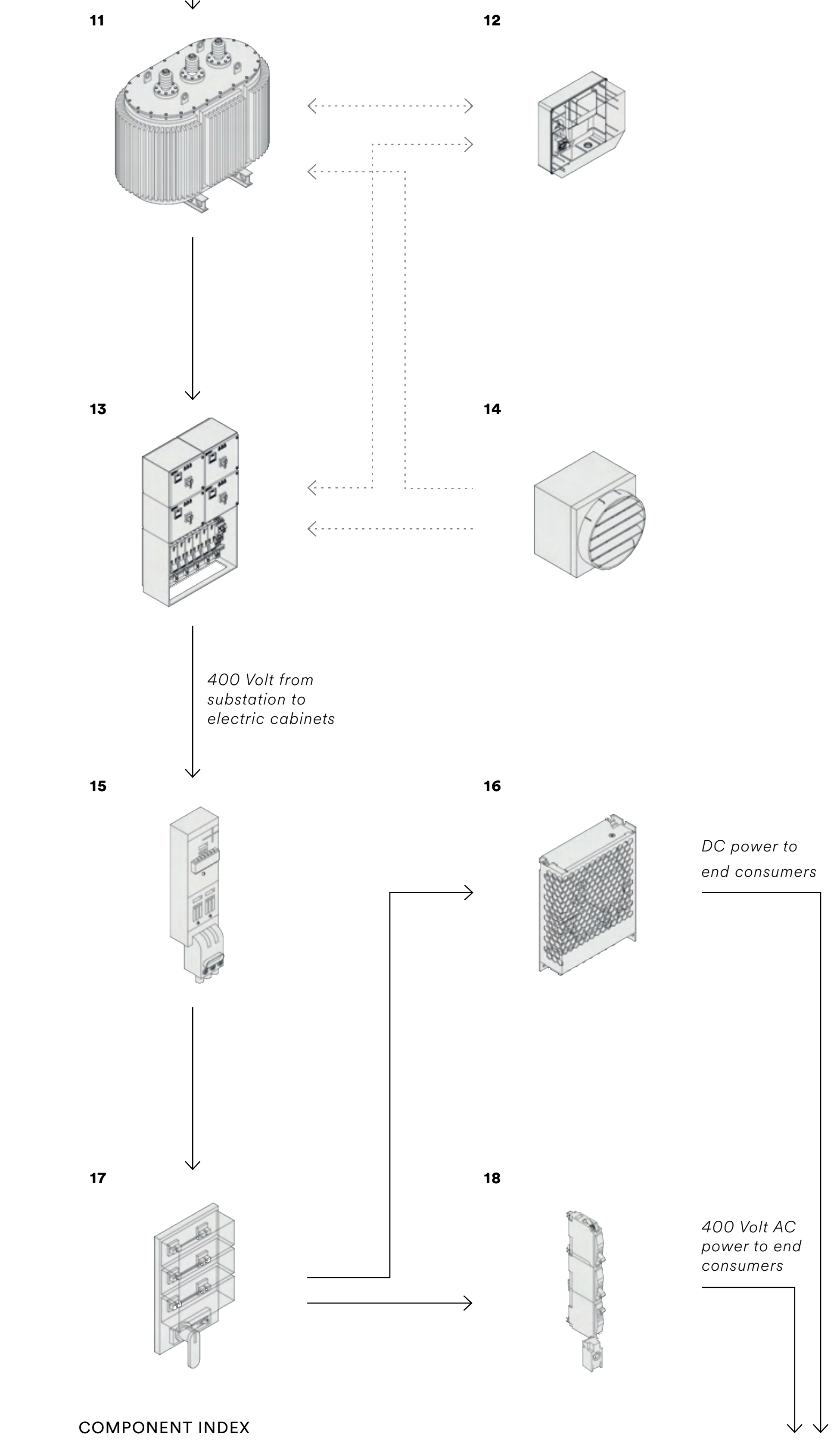
09 INERT GAS SUPPRESSION FIRE SYSTEM
The fire protection system releases inert gas to reduces oxygen levels to below the level that supports combustion

10 SECURITY SYSTEM
Prevents unauthorized entry or sabotage to the facility



COMPONENT INDEX

This index provide a understanding of how each component is interconnected in the three situations systems. It illustrates not only the functionality of the primary systems but also the essential support systems that underpin its operation. Effective infrastructure architecture must originate from a thorough understanding of the system it houses, adapting form to accommodate function in a manner that elevates both.



MEDIUM VOLTAGE SUBSTATION

11 **MEDIUM VOLTAGE TRANSFORMER**
Quantity: 1
Transform electricity from the grid from 400 V to 230 V

12 **MONITORING COMPUTER**
Quantity: 1
Measures the electricity that flows through the substation and relays the data via telecommunica-tion

13 **SWITCHGEAR**
Quantity: 4
Controls, switches and distributes incoming and outgoing lines

14 **VENTILATION SYSTEM**
Quantity: 3
Ensures that the transformer does not overheat

ELECTRIC CABINET

15 **MAIN BREAKER**
Quantity: 1
The main breaker is the primary control and safety and allows for manually turning of power to the entire cabinet

16 **AC/DC CONVERTER**
Quantity: 1
Converts alternating current to direct current to power DC-devices

17 **CIRCUIT BREAKER**
Quantity: 1
The circuit breaker provide over-current protection and auto-matically cuts off the power when the currents exceeds a safe level

18 **FUSE DISCONNECT SWITCH**
Quantity: 13
This component works both as a fuse and a manual switch for each outgoing line


HOTEL ODEN
T
Tunnelbana
Metro
Pendeltåg
Commuter rail
Odenplan
Stockholm Odenplan
BARBERSHOP
SKOMAKERI
BARBERSHOP

SMALL:
ELECTRIC CABINET

On the pavement near one of Odenplan's subway entrances, a new electric cabinet is installed. This cabinet contains the latest technology for the electricity network, one advancement being its ability to convert alternating current (AC) to direct current (DC). As many devices charge and use direct current, new and renovated apartments are being equipped with DC outlets because it is more energy-efficient to convert electricity centrally rather than inefficiently converting AC to DC individually in each device.

The advanced technology places high demands on the design of the electric cabinet, particularly in terms of ventilation. This requirement is reflected in its nearly transparent casing, which is covered with awning-like stainless steel panels. The casing is also equipped with LED lighting that pulses almost like a breathing organism, signifying that this is an object that is constantly at work.

The design proposal of the electric cabinet addresses the following:

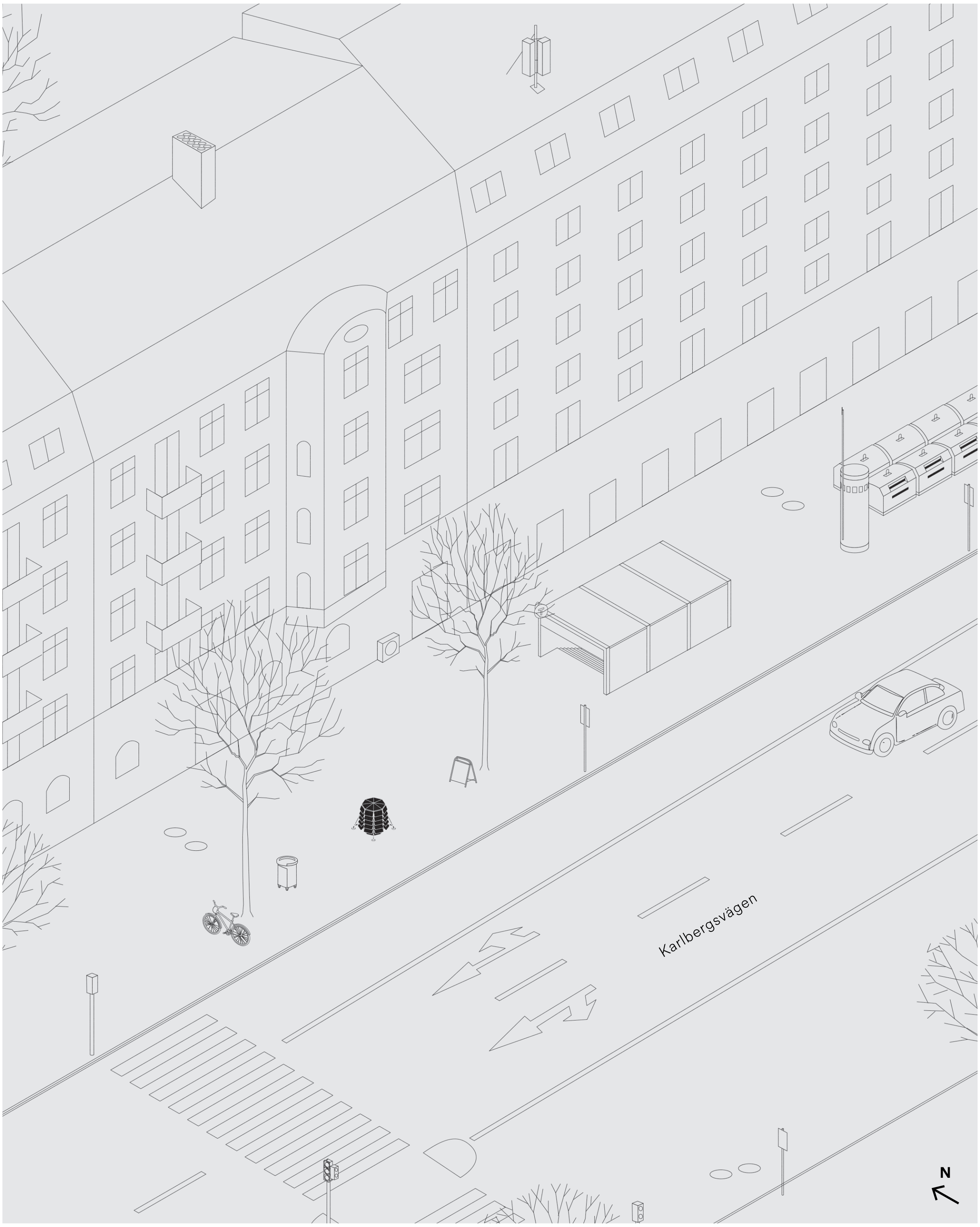
- More prominent placement in the streetscape.
- Dynamic lighting, making it a kinetic character.
- The external shell layers of metal panel and meshes to provide both cooling and an sculptural expression.
- Arrangement of internal components in a radial configuration to make it more ornamental.
- Question permanence versus temporarily of these infrastructure with its structural legs witch makes it look ready to take of at any moment.

← Composite digital image, Karlbergsvägen 28

↓ Key for Inserted Objects in Image

The image shows how the replacement and addition of new infrastructure could shift how we perceive our common urban spaces. The buildings are more static than the support structures that appear like mushrooms on our streets.

1 Dimming Street Light
2 Surveillance Cameras
3 Distribution Cabinet
4 Manhole Cover
5 Electric AC/DC Cabinet



CONTEXT

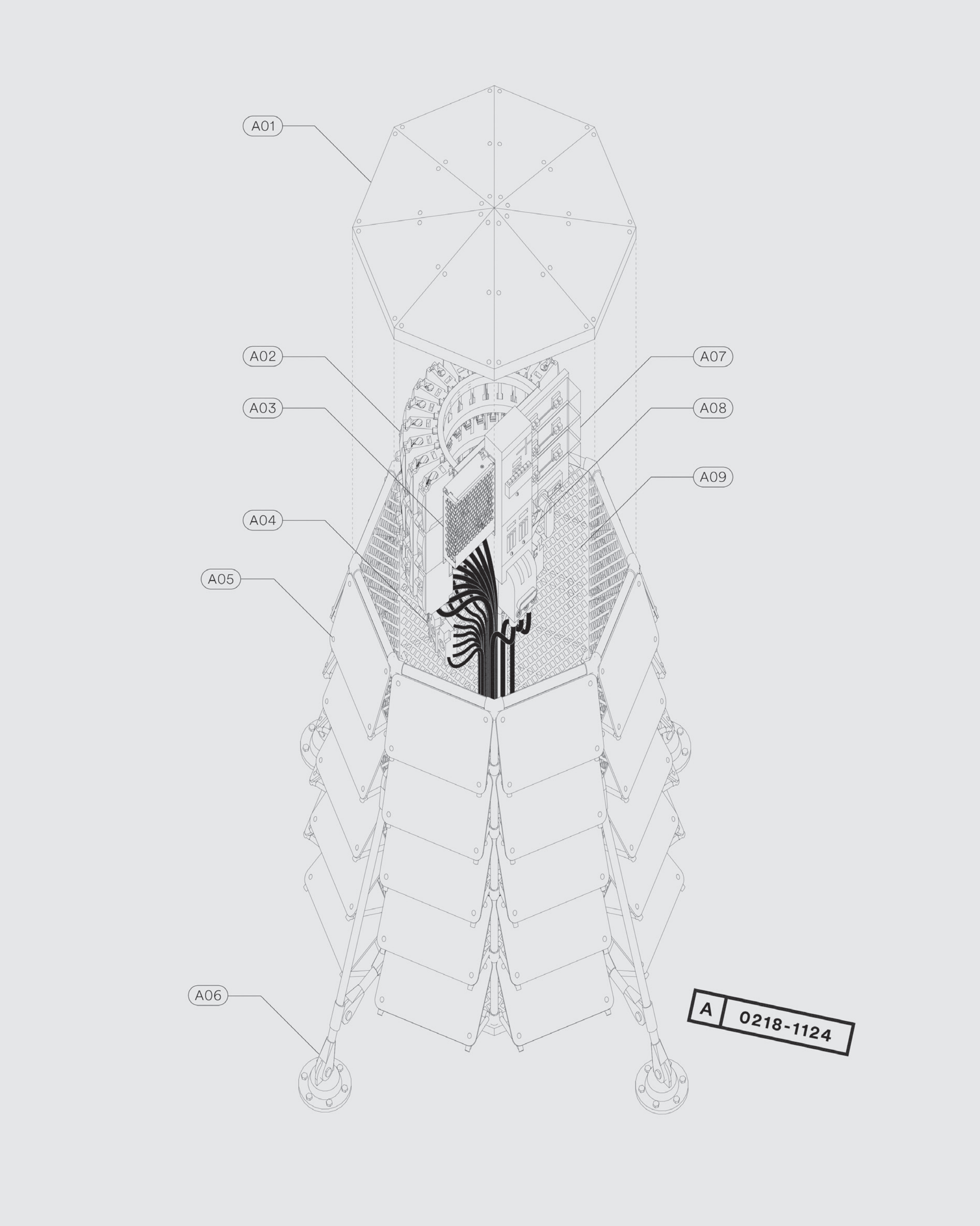
The electric cabinet example is situated on the curb of Karlbergsvägen near the Odenplan subway and train station, designed as a sculptural object. The electric cabinet becomes one of many similarly scaled objects that function like street furniture. Its neighbours includes trash bins, sandwich boards, poles with signs, outdoor seating areas, strawberry stands, and more. Traditionally, electric cabinets have been seen as a necessary evil, often relegated to less conspicuous positions to minimize their presence. However, to emphasize their importance, this electric cabinet is now placed prominently towards the street. Together with its sculptural appearance it becomes a more distinct part of the street's layout and helping to define the street space.

Site Axonometric, Karlbergsvägen 28 ↑

Digital Detail Image of Electric Cabinet ↗

Elevation of Electric Cabinet, ↑
Karlbergsvägen 28

Detail Exploded Axonometric ↗
of Electric Cabinet



ELECTRIC CABINET COMPONENTS

A01 Riveted Bent Stainless Steel Roof
A02 Fuse Disconnect Switches
A03 AC/DC Converter
A04 Ground Line
A05 Stainless Steel Panels
A06 Base Feet
A07 Circuit Breaker
A08 Main Breaker
A09 Metal Mesh Lining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MEDIUM:
MEDIUM VOLTAGE SUBSTATION

In a small space in Vasastaden, created by a 1960s building set back from the street, a new transformer station is placed among the old trees. The transformer station is equipped with two iron-core transformers that reduce the electricity from 10,000 volts AC to 400 volts, the same voltage that end users such as apartments and offices receive, allowing the electricity to be further distributed to electric cabinets.

New transformer stations are held to high standards of energy efficiency, and this station's shape is dictated by that requirement. Its tapered top creates a chimney effect, making it easy to exchange heat from the transformers' excess heat to minimise heat loss as much as possible.

The design strategy is applied to the transformer station's basic structure by dividing it into 6 segments, each containing different components: two transformers and four cabinets with switchgear. The loadbearing steel framework also uses this radial arrangement to form the structure, which is then covered in corrugated transparent polycarbonate and corrugated stainless steel.

The wave-like neon sign alludes to the sinus curve of each electrical phase. The façade's design language mirrors the characteristic heat sinks of the transformers.

By actively shaping the structure's layers and alternately concealing and revealing different parts, it reveals its structural systems. The foundations feet protrude beneath the corrugated metal highlighting its small details, and the network of steel tubes, connections, and cross-braces is visible through various cutouts in the corrugated steel facade. The circular cutout that frames the transformers is not only a design highlight but also the central component of the system.

The structure can be compared to the Tempietto di San Pietro in Rome, highlighting the similarities in how both structures encapsulate and celebrate significant elements. The Tempietto celebrates the divine, while the substation celebrates electricity. Each is crafted to create a distinctive expression that fosters a unique relationship with its observers, transforming it into a local landmark.

The design proposal of the electric cabinet addresses the following:

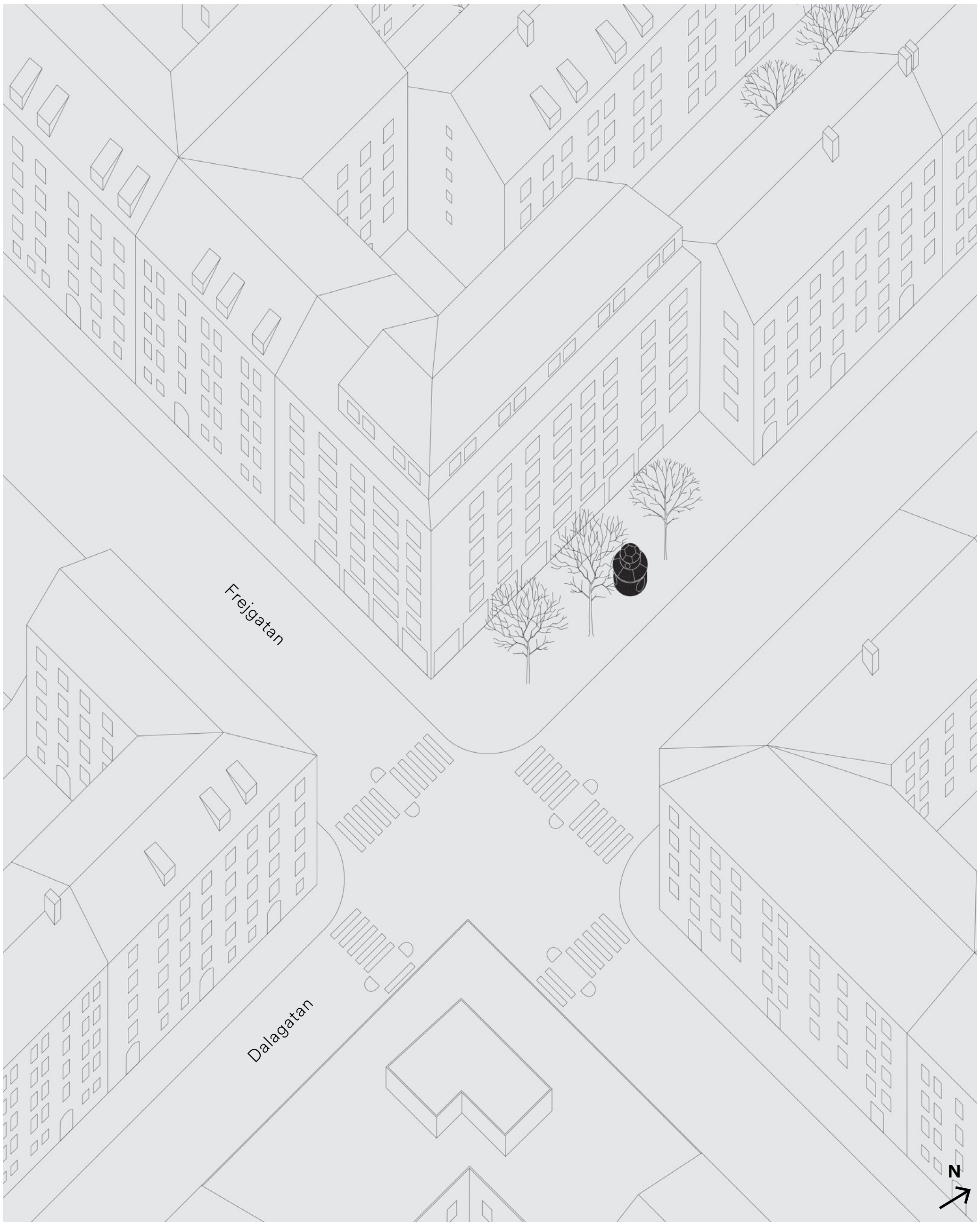
- Framing of the internal systems.
- Highlighting the beauty of the loadbearing structure through the framing of joints, cross-braces and feet.
- Relation between structure and infrastructure in terms of expression. (Heat sinks on transformers almost look like corrugated metal.)
- Alluding to electric concepts. (Sinus wave of three phase electricity and lightning bolt.)
- Outer shell of structure shape derives from placement of internal components to provide efficient operation.
- Characteristic expression creating local landmark
- The circular cutout becomes a display window with the details on the inside as something interesting for passer-bys to look at.

← Composite digital image, Dalagatan 29

↓ Key for Inserted Objects in Image

The image show how several objects in the streetscape will be replaced due to them being worn out or technological shifts. One of them being the in-depth studied medium voltage substation. If the replaced objects are more consciously design they can shape how we preceptive our urban spaces, with a more mindful relationship to the supports structures around us.

1 Medium Voltage Substation
2 Illuminated Billboard
3 Volvo 240 Converted into Electric
4 Illuminated Signs
5 Night Dimmed Street Light



CONTEXT

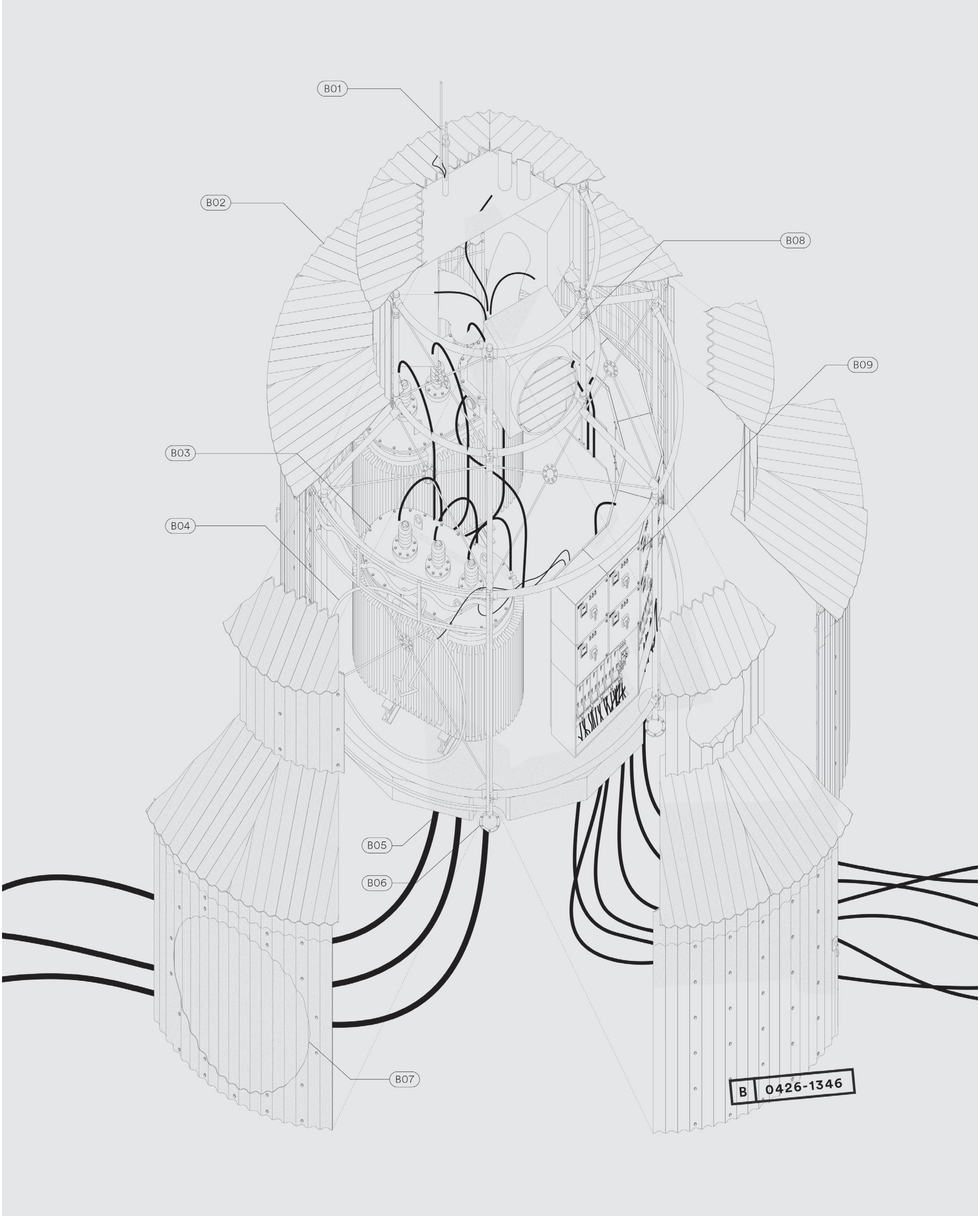
Placed in a small pocket park, the substation is subordinate to the buildings around it. It rather has the same scale as the other tin cans around it, cars, advertising columns and the entrances to buildings.

Site Axonometric, Dalagatan 29 ↖

Digital Detail Image of Medium Voltage Substation ↗

Elevation of Substation, Dalagatan 29 ↑

Detail Exploded Axonometric of Substation ↗



ELECTRIC CABINET COMPONENTS

B01 Telecommunication Antennas & Warning Light
B02 Corrugated Stainless Steel
B03 10 000 V to 400 V Transformer
B04 Red Neon Light
B05 Concrete Slab Foundation
B06 Steel Frame Foot
B07 Corrugated Polycarbonate Sheet
B08 Ventilation Fan
B09 Switchgear


ORRTULL
5 STJÄRNIG
TRYGGHET
LARM

LARGE:
ENERGY STORAGE FACILITY

On a leftover slope on the outskirts of the inner city, an energy storage facility is placed where it would have otherwise been difficult to construct housing or office buildings. The facility is designed to make the electrical grid more robust and stable by alleviating load during peak energy consumption periods. When more energy is produced than consumed, electrical energy can be transformed into hydrogen using an electrolyzer, allowing it to be stored in tanks over an extended period. This hydrogen can later be converted back to electricity using a fuel cell when the grid is under strain. Additionally, the stored energy can be utilized in the event of war or crisis to supply power to nearby Karolinska Hospital.

The facility consists of three main parts: one section stores energy in lithium-ion batteries on a daily cycle, which can be quickly charged and discharged as needed. Another section contains pressurized hydrogen tanks, and the third section houses large cryogenic tanks where hydrogen is cooled to below -253 °C, turning it into liquid form which achieves a high energy density per volume.

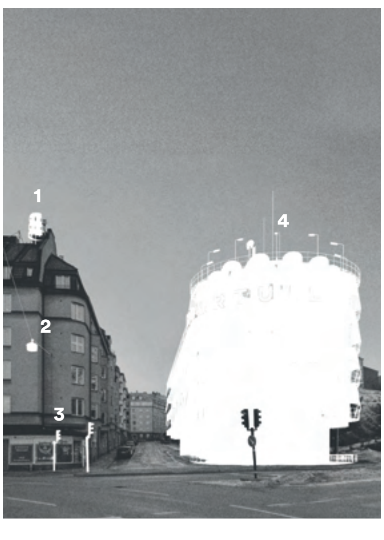
In addition to these three main systems, there are various support systems essential for the facility's operation, such as transformers, switchgear, ventilation, fire protection, computers, and measurement equipment.

The design proposal of the electric cabinet addresses the following:

- The loadbearing structure and climate envelope becomes infrastructural, has the same expression as the infrastructural systems and is made out of standard part.
- Relating in height and size to neighbouring buildings to fit in with the logic of the city while being undoubtedly infrastructural.
- Rational placement of components in a grid.
- The interconnections between components become ornamental and part of the architecture.
- The technical systems should be visible, facilitated thorough highlighting rhombic flat-glass cutouts in the facade and allowing components to stick out through the building's envelope.
- Opposite to conventional infrastructure architecture, incorporate a public function in the bottom floor to activate the street and not be a closed of structure.
- Having different appearances during night/day, lights up at night/more reflective opaque during the day.
- Treating the internal systems with the same dignity as the facade.

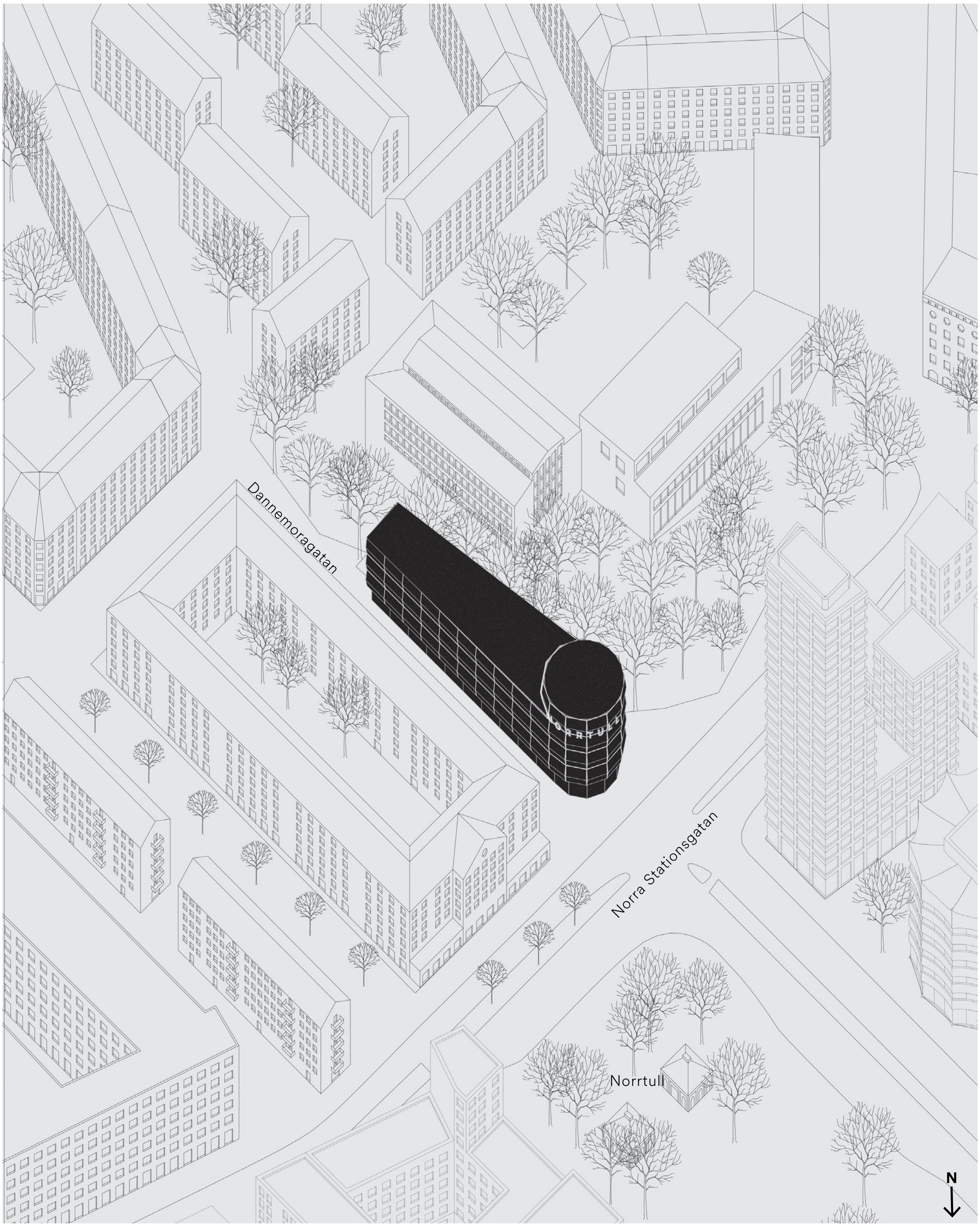
← Composite digital image, Dannemoragatan 21

↓ Key for Inserted Objects in Image



The image show that new infrastructure will appear in our cities and explores how they should relate to its surrounding.

1 Mobile Antenna
2 Street Light
3 Traffic Light
4 Energy Storage Facility

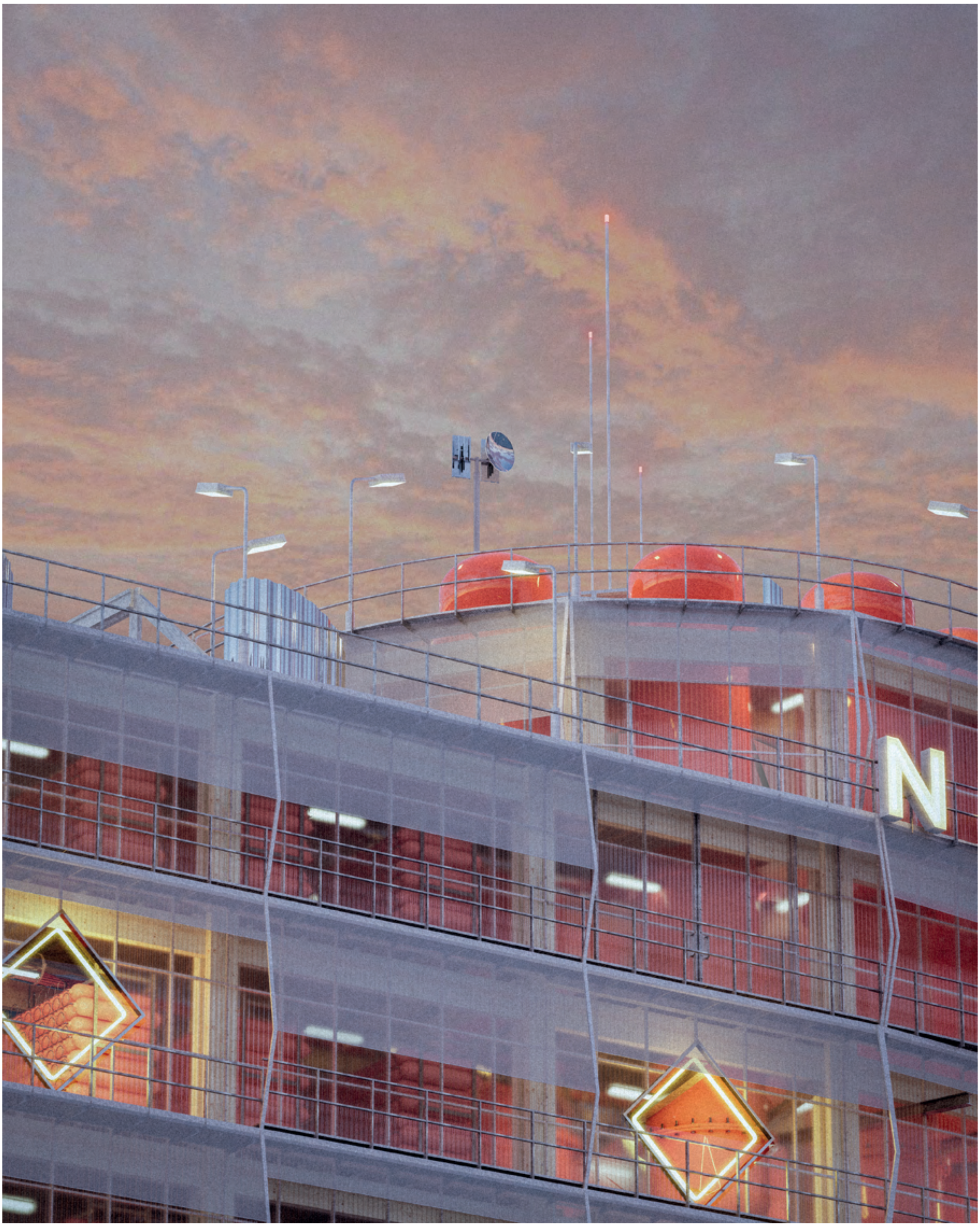


CONTEXT

Placed on a piece of land difficult to fit offices or residential building. The urban placement of the facility is necessary to reduce losses in transmission. 100 000 residents live within 5 kilometres of the facility making it (and other checkpoints in Stockholm) a strategic placement.

Site Axonometric, Dannemoragatan 21 ↑

Digital Image of Exterior ↗


N

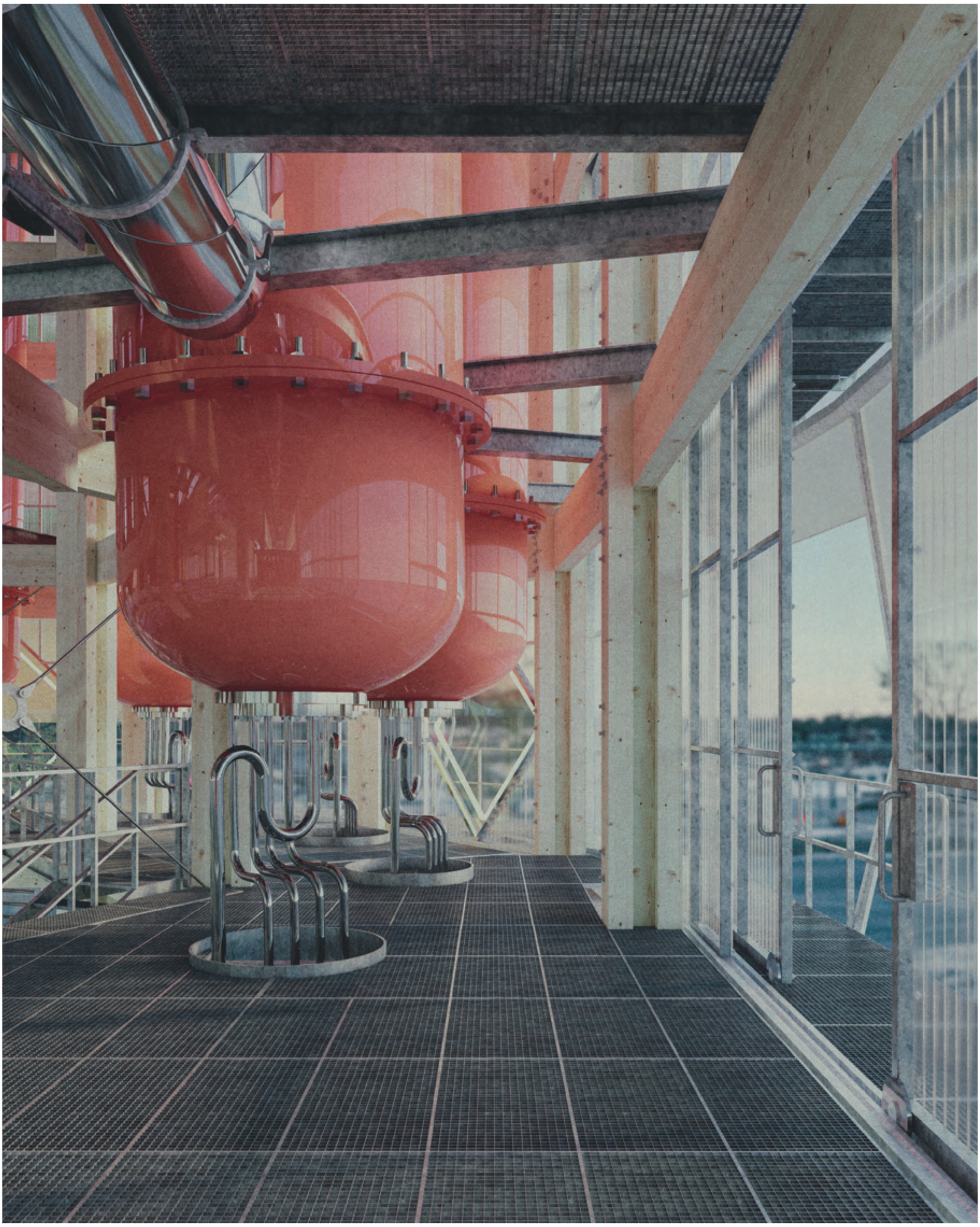
Digital Image of Interior, Floor 2 ↖

Axonometric Section of Storage Facility ↗

ENERGY STORAGE
FACILITY COMPONENTS

C01 Floodlight
C02 Galvanized Railing
C03 Awnings
C04 Corrugated Polycarbonate Sheet
C05 Grating Walkways
C06 Neon Light
C07 High Voltage Transformer
C08 Metal Truss
C09 Cable Ladder
C10 Ventilation Duct
C11 Gluelam Wood Pillar and Beam System
C12 Glass Cut-out
C13 Cross Brace
C14 Concrete Frame

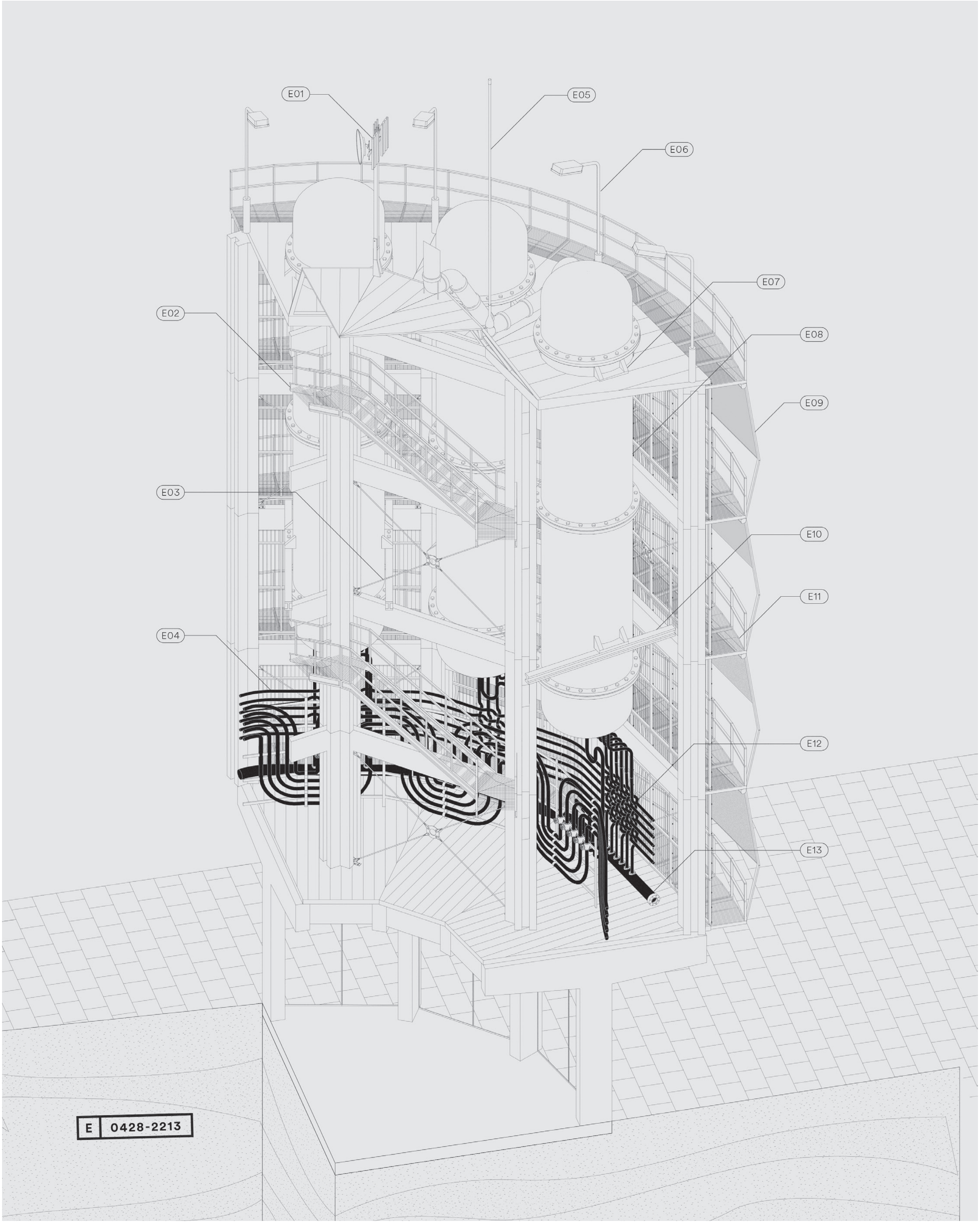

NORRTU



East Elevation of Storage Facility (Previous Page) ←

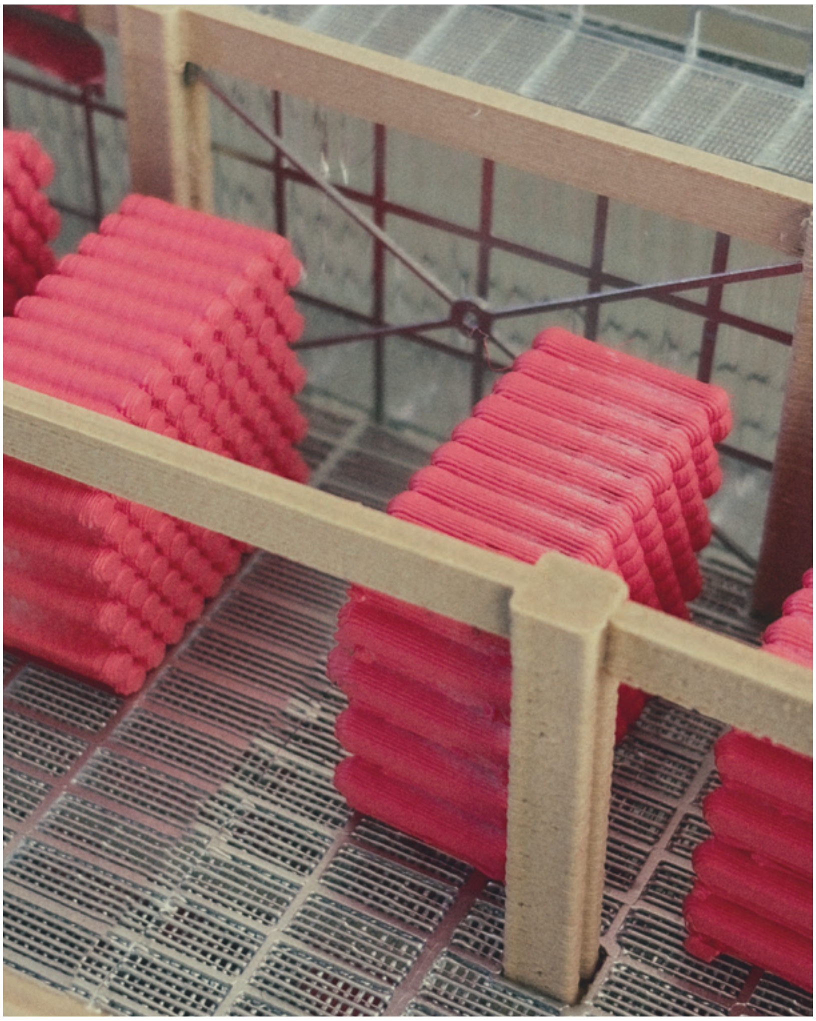
Digital Image of Cryogenic Hydrogen Storage Tanks, Floor 3 ↖

Axonometric Section of Cryogenic Hydrogen Storage Tanks ↗



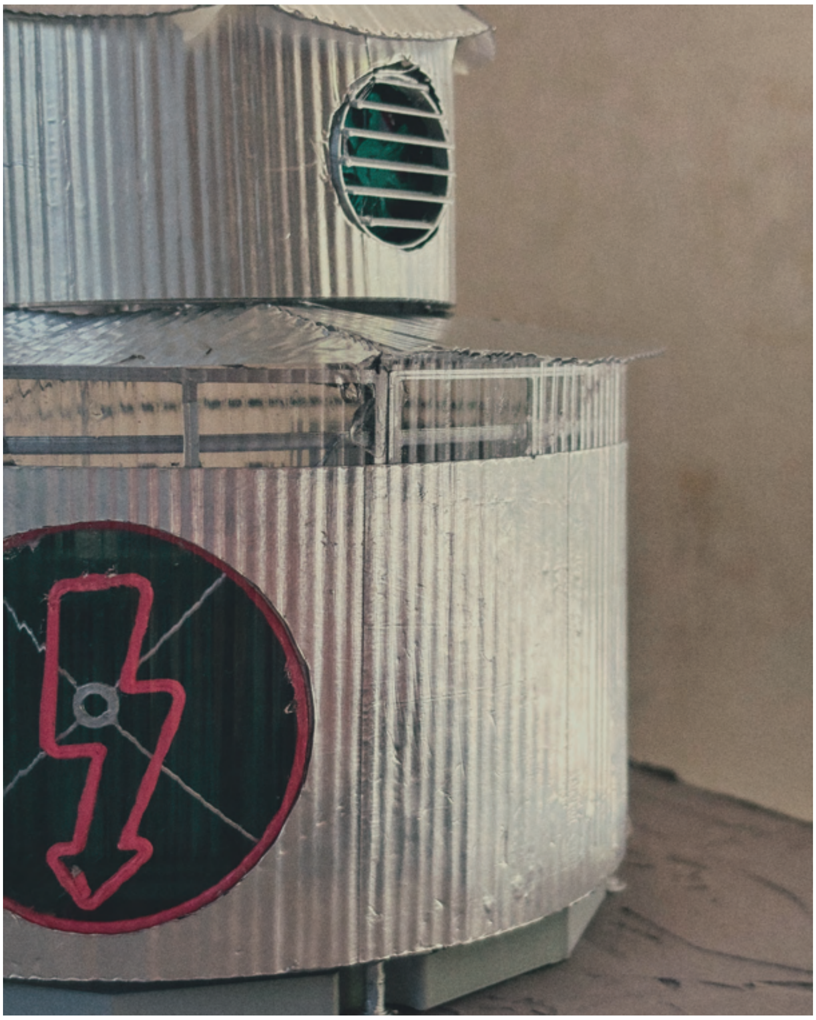
ENERGY STORAGE
FACILITY COMPONENTS

E01 Mobile Antenna
E02 Grating Staircase
E03 Cross Brace
E04 Incoming Hydrogen Pipes
E05 Radio Antenna
E06 Flood Lights
E07 Hydrogen Tank Suspension
E08 Cryogenic Hydrogen Tank
E09 Awnings
E10 Suspension Beam
E11 Grating Walkways
E12 Distribution Pipes
E13 Outgoing Hydrogen Pipes



PHYSICAL MODEL

The production of physical models was used as a tool to try the different design strategies in actual built form. The models were built in parallel to the development to the design proposals and thus helped making design decision.



↖ Model Photo, High Pressure Hydrogen Tanks From Above

↑ Model Photo, Exterior of Storage Facility

← Model Photo, Facade Layers Loadbearing Structure and Hydrogen Tanks Behind

↑ Model Photo, Electric Cabinet

↗ Model Photo, Internal Structure of Substation

→ Model Photo, External View of Substation

DISCUSSION

An infrastructure architecture of love and affection represents an expansion of the architect's role and engagement. It involves a deliberate focus on designing elements that are typically architecturally overlooked and instead elevate these structures on the architectural agenda. This approach focuses on caring about all parts of a structure, from the technical systems, the "guts" of the building, to the more commonly visible floors, walls and façades. Traditionally, these systems have been organized by other professions and were not seen as architectural concerns beyond concealing them as much as possible.

Infrastructure architecture should not merely act as an outer shell, it must be meticulously designed from the inside out as a cohesive whole. This approach resembles the attentiveness of a cabinet maker who cares about all details of their creations, even the interior of a drawer. The design strategy "System Layers" exemplifies this by integrating all of the structure's layers, loadbearing, spatial, and technical, into the architecture. As a result, infrastructure not only fulfils a utility function but also enhances aesthetic value, allowing the architecture to be infrastructural and the building to articulate a coherent language of standard parts and various assemblies planned in detail.

Infrastructure is deeply woven into the fabric that forms the foundation of our society and can be a powerful tool used by authorities to influence public opinion, as described by Keller Easterling. This raises crucial questions about the kind of future we envision. Will electricity flow freely through society, or could it become a limited resource?

Infrastructure is not a singular object, it is a network of interconnected systems that manifest through architectural structures across cities and countryside. New green infrastructure policies will lead to the installation of vast expanses of solar panels and extensive energy networks, which will encroach upon communal urban spaces. This demands a conscious decision about how we engage with these new infrastructures to ensure that their expansion is not merely the result of political will and that cities are not just outfitted with industrial objects bought "off the shelf." The introduction of a post-carbon aesthetic of poetic pragmatism thus becomes a democratic imperative.

Infrastructure is not a platform for individual expression, it is a reflection of our collective values. Democratising infrastructure means making these systems easier to understand and relate to, integrating human-centric values to render them more approachable through the use of robust materials and meticulous detailing across all scales.

The design strategies articulated in the thesis aim to infuse urban infrastructure with an emotionally resonant expression, transforming these typically utilitarian structures into interactive, pedagogical, and approachable elements that are distinctly infrastructural. By meticulously focusing on detailing, the design proposals strive to embody love and affection, ensuring that every interaction with these structures, whether catching a bus, departing the city, or enjoying breakfast on a balcony, evokes a sense of connection and care. The deliberate use of standard parts in the structures introduces a dialogue on temporary permanence and future nostalgia, echoing the enduring qualities of historical architecture while inviting reflections on the transient nature of modern infrastructure. This thoughtful placement and design not only enhance daily urban experiences but also aim to cultivate a deeper emotional engagement with the built environment, enriching routine encounters and fostering a lasting appreciation for the infrastructural landscape.

While infrastructure cannot be intentionally designed to evoke affection immediately, affection is something that develops over time. Its impact can be assessed by our response to its absence. If the loss of these infrastructural elements would be profoundly felt, it would indicate that the architecture has successfully cultivated a sense of affection.

Temples such as the small Tempietto di San Pietro in Rome is an architecture that celebrate a God, in the same way the proposed medium voltage substation on Dalagatan can become a monument to celebrate the transformation of voltages. Just as art museums celebrate art and libraries celebrate literature, infrastructure should celebrate its own existence and utility. This approach advocates for an architecture that is visually lighter and paves the way for a future liberated from the burdens and architectural associations of heavy fossil fuels. It transforms infrastructure from utilitarian sheds to characteristic and lovable structures, elevating their presence in the urban landscape.

↗ Electric Cabinets on Torsgatan, Stockholm

BIBLIOGRAPHY

LIST OF REFERENCES

Barthes, R., (1993). *Camera Lucida : reflections on photography* (New ed.). Vintage

Condorelli, C., Wade, G., & Langdon, J. (2009). *Support structures.* Sternberg Press

Easterling, K., (2016). *Extrastatecraft : the power of infrastructure space*. Verso.

Frichot, H., Carbonell, A., Frykholm, H., & Karami, S. (2022). *Infrastructural love : caring for our architectural support systems*. Birkhäuser.

Fuller, R., & Snyder, J. (2008). *Operating manual for spaceship earth* (New ed.). Baden, Switzerland: Lars Müller.

Hallerdt, L,. (1992). *Stockholms tekniska historia, del V: Ljus kraft värme* Stockholmsmonografier

Ménard, R., (2023). *Énergies Légères : usages, architectures, paysages.* Pavillion De L'Arsenal

Metel, P., (2023). *Stockholms elnät i förändring : En flermetodsforskning om nätstationers utformning och placering i det offentliga rummet.* [Dissertation, Stockholms universitet]. Retrieved from https://urn.kb.se/resolve?urn=urn:nbn:se:su:diva-221018

Miller, M., (2017). *Systems Thinking & Architecture.* Medium. https://medium.com/mk-ink/systems-thinking-e648240c4138

Rosa, H., (2021). *Resonance.* Polity Press

studio*ser.* (2022). *Monte. Verso un territorio per l'anzianità.* studioser. https://studioser.ch

Venturi, R., Scott Brown, D., & Izenour, S. (1977). *Learning from Las Vegas : the forgotten symbolism of architectural form* ([Rev.ed.]). MIT P.

IMAGE SOURCES

All drawings and images by the author unless referenced here.

Baxter, W. (2009). A wind turbine on Blackcleuchedge Moss [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:A_wind_turbine_on_Blackcleuchedge_Moss_-_geograph.org.uk_-_1225240.jpg

Campagne, O (2023) Les Toits [Image insertion]. Pavillion De L'arsenal.

Dallegret, F. (1965). Anatomy of a dwelling [Illustration]. Socks. https://socks-studio.com/img/blog/dallegret-06-b.jpg

Ellgaard, E. (2010). Kraftledning Stockholm 2010 [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Kraftlening_Stockholm_2010.jpg

Ellgaard, E. (2014). Forsmarks kärnkraft 2014 [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Forsmarks_kärnkraft_2014.jpg

Hogger, S. (2022). Monte bench and well [Photograph]. Studio SER. https://estudioser.adiosestudio.com/wp-content/uploads/2021/03/221205_studioser_Monte_Sven-Hogger_web-13-768×1024.jpg

Jonckheere, S. (2018) BACCHUS (F1) I [Digital print] Stijn Jonckheere. https://freight.cargo.site/t/original/i/622748b520fbaa7463647f8be09862aea6100e3a02f009ce254c23555e6bc72d/stijn-jonckheere-artist-artwork-print-drawing-bacchus-F1-1.jpg

Ljungdahl, D. (1896). Brunkebergsverket 1896h [Painting]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Brunkebergsverket_1896h.jpg

Pelican. (2017). Small small shrine [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Small_small_shrine_(32539242512).jpg

seier+seier. (2008) Sigurd Lewerentz, florist, 1969 [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Sigurd_lewerentz,_florist,_1969_(2348583304).jpg

Tubaist. (2004). Olidan [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Olidan.jpg

Teenage Engineering. (2023). Field Series [Digital image]. Teenage Engineering. https://teenage.engineering/_img/6294d419c14df3000431f0c8_original.jpeg

Unknown author. (1890). Telefontornet i Stockholm [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Telefontornet_1890.jpg

Unknown author. (1903) Katarinastationen 1903 [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Katarinastationen_1903.jpg

Unknown author. (1903). Kronobergsstationen 1903 [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Kronobergsstationen_1903.jpg

Unknown author. (1903). Tulestationen 1903 [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Tulestationen_1903.jpg

Unknown author. (1903). Vartaelverket 1903 [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Vartaelverket_1903.jpg

ACKNOWLEDGEMENTS

This thesis was made possible by the immense support and guidance of:

Daniel Norell

The Before and After Building Studio

Colleagues of What!

Friends and family

Maija

ELECTRIC CITY:
AFFECTIONATE MANIFESTATIONS
OF ELECTRIC INFRASTRUCTURE

RIKARD MURGÅRD, 2024

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