INTELLIGENT INFRASTRUCTURES: ANATOMY OF THE METU CAMPUS

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ABSTRACT

INTELLIGENT INFRASTRUCTURES: ANATOMY OF THE METU CAMPUS

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Designed and constructed with the ambition of generating “a small city” in the 1960s, Middle East Technical University (METU) Campus is facilitated with a sophisticated infrastructural design. This thesis focuses on the complex infrastructural systems, needs, and problems of the campus. The goal is to re-investigate the university campus as an early model for modern, sustainable, and liveable urban environments. This thesis provides documentation and representation of campus infrastructure from campus scale to the architecture of a selected building. Infrastructural inquiry of the campus and its architectural anatomy enable to reconsider the campus as a living organism with continuous flows, operative systems, and networks of activities. This architectural experiment blurs the distinctions between infrastructure and architecture and redefines the METU Campus as a collection of a new type of physical, social, and natural infrastructures. This contextual research is supported by a conceptual design proposal for the intelligent urban development and transformation of the campus, buildings, and the infrastructure. Infrastructure is reconsidered in this proposal in the light of recent technological developments, social transformations, and environmental challenges of the “Information Age”. The aim is to transform the early conceptions and the vision of the campus, which was modern, hygienic, and rational into intelligent, circular, and responsive environments.

Keywords: Infrastructure, Modern Campus, METU Campus, Intelligent Cities, Circular Urbanism

ÖZ

AKILLI ALTYAPILAR:
ODTÜ YERLEŞKESİNİN ANATOMİSİ

Ağırsoy, Ömer Faruk
Yüksek Lisans, Mimarlık
Tez Yöneticisi: Prof. Dr. Ayşen Savaş

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1960'lı yıllarda “küçük bir şehir” kurma hedefiyle tasarlanıp inşa edilen Orta Doğu Teknik Üniversitesi (ODTÜ) Yerleşkesi, gelişmiş bir altyapı tasarımı ile oluşturulmuştur. Bu tez, yerleşkenin karmaşık altyapı sistemleri, gereksinimleri ve sorunlarına odaklanmaktadır. Üniversite yerleşkesini çağdaş, sürdürülebilir ve yaşanabilir kentsel ortamlar için erken bir örnek olarak yeniden ele almayı amaçlamaktadır. Bu tez, yerleşke ölçeğinden başlayarak seçilen bir yapının mimarisine kadar yerleşke altyapısının belgelenmesini ve temsilini üretir. Yerleşkenin altyapısal araştırması ve mimari anatomisi, yerleşkeyi sürekli akışlar, işleyen sistemler ve etkinlik ağları ile canlı bir varlık olarak yeniden ele alır. Bu mimari deney, altyapı ve mimari arasındaki ayrımları azaltır ve ODTÜ Yerleşkesini yeni bir tür fiziksel, sosyal ve doğal altyapılar topluluğu olarak yeniden tanımlar. Bu bağlamsal araştırma, yerleşkenin, yapılarının ve altyapısının akıllı kentsel gelişimi ve dönüşümüne yönelik kavramsal bir tasarım önerisi ile desteklenmektedir. Bu öneride altyapı, “Bilgi Çağı”ndaki teknolojik gelişmeler, sosyal dönüşümler ve çevresel zorluklar ışığında yeniden ele alınmaktadır. Amaç, yerleşkenin modern, hijyenik ve akılcı olan kavramları ve vizyonunu akıllı, döngüsel ve duyarlı ortamlara dönüştürmektir.

Anahtar Kelimeler: Altyapı, Modern Yerleşke, ODTÜ Yerleşkesi, Akıllı Şehirler, Döngüsel Şehircilik

To my beloved family

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TABLE OF CONTENTS

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

ABBREVIATIONS

2D Two-dimensional

3D Three-dimensional

BAS Building Automation System

BIM Building Information Modeling

BMS Building Management System

CAD Computer-Aided Design

CHP Combined Heat and Power

CPS Cyber-Physical System

ICT Information and Communications Technology

IoT Internet of Things

IT Information Technologies

GIS Geographic Information System

HVAC Heating, ventilation, and air conditioning

METU Middle East Technical University

SCADA Supervisory Control and Data Acquisition

CHAPTER 1

INTRODUCTION

This thesis is a part of collaborative studies on the Middle East Technical University (METU) Campus initiated by the Getty Conservation Institute Keeping It Modern-METU Faculty of Architecture Building Project, and it mainly focuses on the experimental infrastructure of the METU Campus.[1] This thesis dwells on the issue raised in the final report of the METU-GETTY Keeping it Modern Conservation Management Planning Project, particularly focusing on the infrastructural aspects of the campus design, and highlights its social aspects (3.5 Infrastructural Notes).[2] METU Campus and its infrastructure are analyzed to understand the complex infrastructural challenges of campus environments. Taking the report as a starting point, this research aims to extend and develop the infrastructural issues. The strong interrelation between the architectural, mechanical, landscape, and social infrastructure of the METU campus is studied through the conceptualization and the production of space in terms of technological, social, and environmental issues.

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[1] The foundation of this research is based on the discussion about the author's studio project called "Living with the Infrastructure" in 2017-2018 Arch401-402 Architectural Design Studio courses given at the METU Department of Architecture. The study benefited from the sustainability discussions in Arch301 Studio in Fall 2016 and infrastructural discussions and lecture notes of Arch492 Landscape Research Course in Spring semester of 2016. Preliminary studies of thesis started with the papers submitted to Arch513 and Arch504 Courses. The research is further developed with Arch505 Advanced Architectural Design Research, Arch 524 Architecture and Different Modes of Representation, and Arch571 Directed Studies courses conducted by Prof. Dr. Ayşen Savaş in the Master of Architecture Program at METU. This thesis also benefited from the discussions and outcomes of the Arch505 Advanced Architectural Design Research and TU Delft Complex Projects collaborative design and research studio in the Fall Semester of 2021 entitled "Modern Campus | Campus Utopias" course which was held by Ayşen Savaş (METU), Esther Gramsbergen (TU Delft), and Yağız Söylev (TU Delft) and the author is contributed the studio course as a research assistant.

[2] Ayşen Savaş, Bengisu Derebaşı, İpek Gürsel Dino, Sezin Sarıca, F. Serra İnan, and Şahin Akın, eds., "Research and Conservation Planning for the METU Faculty of Architecture Building By Altuğ-Behruz Çinici, Ankara, Turkey," *Keeping It Modern Project Report, Getty Foundation,* 2018, 325–27, Retrieved from https://www.getty.edu/foundation/pdfs/kim/metu_arch_res_cons_plan.pdf.

1.1 Background Information:

Social transformation, environmental changes, and emerging technologies in the so-called "information age" are leading to a new technological and social revolution that would eventually reshape the ways and patterns of production and consumption as well as living conditions and the built environment.[3] This constant transformation is altering physical, digital, and biological processes and how and where people work, live, study, produce, and leisure irreversibly.[4] Current and upcoming architectures are also defined by these three main drivers of change. This challenging context gives infrastructure an essential role for the necessary developments of urbanization and societies. The infrastructure of intelligent and sustainable cities becomes a critical discussion in architectural studies and constitutes the main research topic of this thesis.

Social: Extreme urbanization and increasing population create cultural, economic, demographic, and environmental challenges. According to the UN Department of Economic and Social Affairs report, projections show that the world's population will be about 9.8 billion in 2050.[5] In that time, around 70% of the world population expected to be live in urban areas.[6] In addition to growing population density in urban areas, shifting social needs become more apparent within collaborative and connected living and working environments. Increasing expectation of wellbeing and comfort levels of contemporary society in the urban environments necessitates more careful and detailed planning for the cities. On the other hand, growing awareness about social justice, egalitarian society, equality raises the significance of universal design principles and equal distribution of resources and opportunities to

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[3] Klaus Schwab, *The Fourth Industrial Revolution*, 1st Ed. (Geneva:Switzerland: World Economic Forum, 2016), 7, https://doi.org/10.1017/CBO9781107415324.004.

[4] Ibid., 12.

[5] United Nations Department of Economic and Social Affairs Population Division, "World Population Prospects: The 2017 Revision, Key Findings and Advance Tables" (New York, 2017), 7.

[6] United Nations Department of Economic and Social Affairs Population Division, "World Urbanization Prospects: The 2018 Revision" (New York, 2019), 10.

all citizens. Urban sprawl, population growth, and social needs require more space and infrastructure, which leads to an exponential increase in the ecological footprints of cities. Yet, they also put a vital significance on infrastructure for providing equal access and opportunities to the society.

Environmental: Population growth, social shifts, and urban sprawl also lead to some environmental problems. Increasing carbon emissions, fossil fuel usage, water contamination, wildfires, scarcity of natural energy resources, and recent production and consumption habits of society are raising the effects of global climate change. According to IEA, if the significant energy and emission measurements are not taken, the average global temperature is expected to increase by 2.7°C until 2100.[7] Therefore, as the recent pandemic is approved, efficient use of natural resources/assets becomes more critical to dealing with natural and environmental problems.

Increasing environmental challenges give great responsibility to the building industry and architecture. According to IEA, the buildings are responsible for 30% of total energy use and 37% of global CO_2 emissions.[8] Within this discussion, “sustainability” is an important term re-emerging in architecture within the discussion of “environmental consciousness” in the last decades. It becomes an integral part of contemporary architectural production and discourse. Nesbit states that “environmental ethics” became essential for creating a sustainable relationship between nature and the built environment.[9]

Lim argues that “sustainability” discussions in current architecture mainly focus on the increasing energy demands of individual buildings. Still, plot-based solutions are

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[7] International Energy Agency (IEA), *Energy Technology Perspectives 2017*, Energy Technology Perspectives (OECD, 2017), 19, https://doi.org/10.1787/energy_tech-2017-en.

[8] International Energy Agency, “Energy Technology Perspectives 2020” (Paris, 2020), 159, Retrieved from https://www.iea.org/reports/energy-technology-perspectives-2020.

[9] Kate Nesbitt, “Theorizing a New Agenda for Architecture:,” *An Anthology of Architectural Theory 1965 - 1995*, 2013, 61.

neither sufficient for the needs of a building nor create generative networks within the city, which eventually ends up with passive systems.[10] On the other hand, active sustainability principles aim to generate productive physical and organizational networks and infrastructures within the city by providing a seamless connection between the different scales of the built environment. This approach promotes infrastructures to host multiple functions for the needs of the community to fulfill all "Circles of Sustainability"(ecological, economic, cultural, political)[11]. Therefore, infrastructures increase both the productivity and environmental performance of urban environments by providing a better connection between natural resources/forces and urban networks.

Technological: Emerging technologies with the developments of the "Industry 4.0",[12] which is referred to as "digital revolution" bring a lot of potentials and opportunities as well as challenges and problems to city planning and architectural production in the 21st century. This transformation enables individualization and optimization[13] in production processes of spatial formations, which increases quality, resource, and time efficiency, performance, flexibility, and productivity. [14] New

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[10] C. J. Lim, *Inhabitable Infrastructures: Science Fiction or Urban Future?*, 1st Ed. (New York: Routledge, 2017), 273, https://doi.org/10.4324/9781315652207.

[11] Paul James, *Urban Sustainability in Theory and Practice: Circles of Sustainability* (Oxon: Routledge, 2015), 14.

[12] The term "Industry 4.0" is first introduced in the 2011 Hannover Expo in Germany within the scope of "High-Tech Strategy 2020 for Germany" initiative. German Federal Ministry of Education and Research collaborated with a research group known as "Industrie 4.0 Platform". The group published their final repot in 2013 which designates the German ideals on the future of industry in terms of securing the "competitiveness and productivity" of the German manufacturing industry. The aim was to develop strategies for the future of production within the conditions of upcoming technological shifts and developments. However, the issue of discussion was valid and taken into consideration globally and extend the term into other states and disciplines. These developments and strategies are also crucial within the scope of this study to understand technological potentials in architecture.

[13] Heiner Lasi, Peter Fettke, Hans Georg Kemper, Thomas Feld, and Michael Hoffmann, "Industry 4.0," *Business and Information Systems Engineering* 6, no. 4 (August 1, 2014): 239–42, https://doi.org/10.1007/s12599-014-0334-4.

[14] Henning Kagermann, Wahlster Wolfgang, and Johannes Helbig, "Securing the Future of German Manufacturing Industry: Recommendations for Implementing the Strategic Initiative INDUSTRIE 4.0.," *Final Report of the Industrie 4.0 Working Group* (Frankfurt, 2013), Retrieved from https://www.acatech.de/wp-content/uploads/2018/03/Final_report__Industrie_4.0_accessible.pdf.

additive and subtractive manufacturing techniques such as 3D and 4D printing provide opportunities for fast prototyping, nonstandard, programmable, and responsive materials.[15] Robotics, nanotechnology, alternative energy systems, biotechnology, new materials are also other technologies that may help to make architecture and urbanization more sustainable.[16]

One of the most prominent outcomes of the recent technology is the digital transformation which creates another level of intelligence for the built environment. The Internet of Things (IoT) enables objects to communicate with each other and their environment. With the help of live data collection infrastructures, sensors, and networks, new IoT technologies make cities and buildings more connected and responsive.[17] Computational technologies ease the analyzing natural and artificial environments and enable parametrization of control, design, and production processes to deal with multi-dimensional problems.[18] Collected information and big data can be processed with artificial intelligence to create both real-time and long-termed solutions for the needs of the built environment. Cyber-Physical systems (CPS) combine digital and physical processes to enable completely autonomous processes.[19] However, these technologies require some digital and physical networks and intelligent infrastructures to create a seamless connection between society and the built environment. Understanding the new technologies and the necessary infrastructures are essential within the scope of this study to understand the potentials of technology in architecture.

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[15] Skylar Tibbits, "4D Printing: Multi-Material Shape Change," *Architectural Design* 84, no. 1 (January 2014): 116–21, https://doi.org/10.1002/ad.1710.

[16] Schwab, *The Fourth Industrial Revolution*, 7.

[17] Georgios Lilis, Gilbert Conus, Nastaran Asadi, and Maher Kayal, "Towards the next Generation of Intelligent Building: An Assessment Study of Current Automation and Future IoT Based Systems with a Proposal for Transitional Design," *Sustainable Cities and Society* 28 (January 1, 2017): 473–81, https://doi.org/10.1016/j.scs.2016.08.019.

[18] Arzu Gönenç Sorguç and Semra Arslan Selçuk, "Computational Models in Architecture: Understanding Multi-Dimensionality and Mapping," *Nexus Network Journal* 15, no. 2 (2013): 349–62, https://doi.org/10.1007/s00004-013-0150-z.

[19] Lasi, Fettke, Kemper, Feld, and Hoffmann, "Industry 4.0."

In different eras, architects also look for innovative technologies as sources of inspiration. Particularly after the 20th century, production technology has been a salient topic of discussion in architectural production and discourse. Banham explains that there were many visions, ideals, manifestos, and utopias that emerged for creating alternative approaches for the future of architecture and urbanization in "the First Machine Age."[20] Most of the ideals and the search for new architectures, styles, and efforts tried to be grounded on the latest technological developments. Architects searched for methods to rationalize their design through creating metaphors between architecture and engineering solutions, living space, and machines[21] for the sake of "functionalism" or "rationalism".[22] Subsequent styles of modernism High-tech and Metabolist movements in recent history also aimed to promote advanced technologies, production, infrastructural developments via structural expression and transparency. By introducing their own infrastructural interpretations, all these different attempts had great ideals to create or change the cities, ideology, or lifestyles of their society.[23]

This new challenging and dynamic context of ongoing technological, environmental, and social transformations also necessitates new architectural and urban solutions and requires a new understanding of infrastructures both for the existing and new urbanizations. The built environment must adapt these transformations to serve the current needs of the city and society with the modern and up-to-date spaces, infrastructure, and technologies. As stated by Antonio Sant' Elia, "Every generation must build its own city".[24]

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[20] Reyner Banham, *Theory and Design in the First Machine Age*, 2nd Ed. (New York: Praeger, 1967).
[21] Le Corbusier and Frederick Etchells (transl.), *Towards a New Architecture* (New York: Dower Publications, 1986), https://doi.org/10.2307/3191562.
[22] Banham, *Theory and Design in the First Machine Age*.
[23] Lim, *Inhabitable Infrastructures: Science Fiction or Urban Future?*, 26.
[24] Antonio Sant'Elia, "Manifesto of Futurist Architecture," in *Futurist Manifestos*, 1914.

1.2 Scope of Topic: Infrastructure

Infrastructure is an essential premise for contemporary cities to cope with the effects of technological and environmental transformation in relation to contemporary urbanization trends and the growing demand for natural resources. Infrastructure is considered fundamental for civilization.[25] Edwards explains that:

> “Nevertheless, the fact is that mature technological systems — cars, roads, municipal water supplies, sewers, telephones, railroads, weather forecasting, buildings, even computers in the majority of their uses — reside in a naturalized background, as ordinary and unremarkable to us as trees, daylight, and dirt. Our civilizations fundamentally depend on them, yet we notice them mainly when they fail, which they rarely do. They are the connective tissues and the circulatory systems of modernity.”[26]

Cities are a collection of continuous movements, flows of people, networks of resources, objects, and information. Although they seem stagnant, these networks actually allow the city to perform well and actively with the help of infrastructures. Infrastructures are essential for habitable urban environments. Therefore, different studies create metaphors between the infrastructure of the city and the anatomy of living organisms. In her descriptive book about the infrastructure of cities entitled “The Works: Anatomy of a City”, Kate Escher states that:

> “All cities, big and small, rely on a vast array of interconnected systems to take care of their citizens' most basic needs: keeping water bubbling through the pipes, traffic moving on the streets, power flowing to businesses and

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[25] Paul N. Edwards, “Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems,” in *Modernity and Technology*, ed. Thomas J. Misa, Philip Brey, and Andrew Feenberg (Cambridge: MIT Press, 2003), 185–225.

[26] Ibid., 185.

> homes. Largely invisible and almost always taken for granted, these are the basic building blocks of urban life…
>
> …Like the essential systems that keep a human body running, each of these is vital to the functioning of the metropolis. And as with any lesson in anatomy, these complex systems—while interdependent are best studied discretely."[27]

Banham also represents the mechanical services of the building with the title "Anatomy of a Dwelling".[28] Mitchell also creates a metaphor between cities and living organisms:

> "At the dawn of the twenty-first century, then, cities possessed all of the crucial subsystems of living organisms: structural skeletons; input, processing, and waste removal networks for air, water, energy, and other essentials; and multiple layers of protective skin. Even more importantly, the existence of artificial nervous systems was enabling cities to sense changes in their internal and external environments and respond, like organisms, in intelligently coordinated fashion."[29]

Therefore, this anatomical analogy between the infrastructure of the built environment and living organisms is used in the title of this thesis to emphasize infrastructural investigation.

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[27] Kate Ascher, *The Works: Anatomy of a City* (New York: The Penguin Press, 2005), vii.

[28] Reyner Banham and François Dallegret, "A Home Is Not a House," *Art in America* 2 (1965): 71.

[29] William J. Mitchell, "Intelligent Cities," *UOC Papers* 5, no. 5 (October 5, 2007): 4, Retrieved from http://uocpapers.uoc.edu.

1.2.1 Infrastructure in Architecture

Infrastructure has become a re-emerging topic of architecture between the architecture-technology discussions and architectural practice within the last century. Recent urban and infrastructural perspectives shifted the infrastructural discussions beyond single architectural buildings to urban forms that work as networks and systems. This thesis searches for means, scales, and ways of looking at urban environments from an infrastructural perspective and filter.

Shane argues that a city can be considered as a combination of enclaves (self-centric system, places of statis, physical assets) and armatures (infrastructures, space of flow, linear networks).[30] The infrastructural research of this thesis claims that there is not a direct split between those. A building can also be considered as an armature that hosts continuous flows of people, resources, and information. The mobility space can also be investigated as an enclave that can produce alternative cultures and meanings.[31] This kind of binary distinction understanding is not always valid for both conceptualization of space and the production of infrastructure. On the contrary to the belief that infrastructural works were considered merely as a duty of engineering,[32] the definition of the infrastructure does not prioritize the issue as a technical problem.[33] Infrastructures are part of the built environment, yet they are also co-creating the conditions and facilities of the liveable environments. Contemporary infrastructural approaches considered infrastructure a "socio-technical" issue by referring to the multidisciplinary nature of infrastructural

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[30] David Grahame Shane, *Recombinant Urbanism: Conceptual Modeling in Architecture, Urban Design, and City Theory* (Chichester: Wiley, 2005), 154–230. Grateful to Gizem Deniz Güneri Söğüt for highlighting the significance of the terms "enclaves and armatures"

[31] Ole B. Jensen, "Flows of Meaning, Cultures of Movements – Urban Mobility as Meaningful Everyday Life Practice," *Mobilities* 4, no. 1 (March 2009): 139–58, https://doi.org/10.1080/17450100802658002.

[32] Katrina Stoll and Scott Lloyd, "Performance as Form," in *Infrastructure as Architecture: Designing Composite Networks*, ed. Katrina Stoll and Scott Lloyd (Berlin: Jovis, 2010), 4.

[33] Edwards, "Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems," 188.

developments.[34] They require a strong interrelation between engineering, social, spatial, economic, natural, and urban factors and generate contextual and environmental solutions to urban problems.[35] Therefore, architects should have an essential role in infrastructural projects and developments. As Banham points out:

> "…the history of architecture should cover the whole of the technological art of creating habitable environments, the fact remains that the history of architecture found in the books currently available still deals almost exclusively with the external forms of habitable volumes as revealed by the structures that enclose them."[36]

In the article named "Infrastructural Urbanism", Stan Allen also argues that, since the architects shifted their focus on the semiotics signs, images, and surfaces by calling the post-modern discussions, they lost the sense of "instrumentality" and "materiality" of architecture. By referring to Robin Evans, he states that:

> "As Robin Evans has remarked, a building was once "an opportunity to improve the human condition;" now it is conceived as "an opportunity to express the human condition."[37]

He mentions that this focus shift distanced architects from participating in the actual technical and social issues of the built fabric in the name of infrastructural problems of the cities. He reminded the problem with the following words:

> "Land surveying, territorial organization, local ecologies, road construction, shipbuilding, hydraulics, fortification, bridge building, war machines, and

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[34] Ibid.

[35] Ying-Yu Hung, Gerdo Aquino, Charles Waldheim, Julia Czerniak, Adriaan Geuze, Alexander Robinson, and Matthew Skjonsberg, *Landscape Infrastructure: Case Studies by SWA*, ed. The Infrastructure Research Initiative at SWA, 2nd Ed. (Basel: Birkhäuser, 2013), 15, https://doi.org/10.1515/9783034615853.

[36] Reyner Banham, *The Architecture of The Well-Tempered Environment* (Chicago: The University of Chicago Press, 1969), 12.

[37] Stan Allen, "Infrastructural Urbanism," in *Points + Lines: Diagrams and Projects for the City*, 1st Ed. (New York: Princeton Architectural Press, 1999), 50.

> networks of communication and transportation were all part of the traditional competence of the architect before the rise of disciplinary specialization."[38]

By referring to Modern city plans, he states the fact that architects have lost their impact over infrastructural developments. In those times, architects were designing all the technical infrastructures, where the cities and roads were built, even the airport had to be located. He proposed that architects should redirect their focus on the actual problems and discussions of urban environments by reclaiming their role in the infrastructural developments as in the previous eras.[39] Since they require integration and collaboration of different disciplines, architecture as multidisciplinary practice in nature can consolidate these developments:

> "Architecture is uniquely capable of structuring the city in ways not available to practices such as literature, film, politics, installation art, or advertising. Yet because of its capacity to actualize social and cultural concepts, it can also contribute something that strictly technical disciplines such as engineering cannot"[40]

Starting with the broad definition of infrastructure, this thesis also investigates the possible design tools, approaches, and architect's role for the emerging infrastructural needs and requirements of the building complexes. The infrastructural requirements of the urbanizations are continuously evolving with the aforementioned challenges. Urban environments necessitate new networks that work together in collaboration with the other natural and artificial systems. Information, energy, transportation, natural and social life require new interconnected networks of digital, mechanical, and social infrastructures. There is an emerging interest and need for intelligent infrastructural systems. Architects should be aware of these challenges and should actively participate into these developments.

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[38] Ibid., 52.
[39] Ibid.
[40] Ibid., 54.

1.2.2 Intelligent Cities and Infrastructures

Within this context, in the early 1990s, smart/intelligent city concept is emerged[41], which aims to provide a new level of synergy between the different components of the cities. The purpose is to generate new networks between economy, people, governance, mobility, environment, and living[42] to make cities and buildings more "intelligent, interconnected and efficient".[43] Of course, there are many different definitions and approaches for the concept,[44] "intelligent city" use the benefits of technological developments to provide a higher quality of spaces and services and a clean environment for urban users.[45] Due to the strong emphasis on environmental issues, sustainability also becomes an integral part of intelligent city developments.[46]

This concept emphasizes infrastructure again as a vital issue in this transformation for intelligent city proposals.[47] The city with cognitive abilities works as a responsive network with intelligent buildings[48] through intelligent infrastructures. Infrastructure

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[41] Maria-Lluïsa Marsal-Llacuna and Evan Mark Segal, "The Intelligenter Method (I) for Making 'Smarter' City Projects and Plans," *Cities* 55 (June 2016): 127–38, https://doi.org/10.1016/j.cities.2016.02.006.

[42] Rudolf Giffinger and Gudrun Haindlmaier, "Smart Cities Ranking: An Effective Instrument for the Positioning of Cities?," *ACE: Architecture City and Environment* Año IV, no. 12 (2010): 7–25, Retrieved from http://hdl.handle.net/2099/8550.

[43] Doug Washburn and Usman Sindhu, "Helping CIOs Understand 'Smart City' Initiatives," *Growth* 2 (2010): 2, Retrieved from https://www.forrester.com/report/Helping-CIOs-Understand-Smart-City-Initiatives/RES55590.

[44] Taewoo Nam and Theresa A. Pardo, "Conceptualizing Smart City with Dimensions of Technology, People, and Institutions," in *Proceedings of the 12th Annual International Digital Government Research Conference on Digital Government Innovation in Challenging Times - Dg.o '11* (New York, New York, USA: ACM Press, 2011), 282–91, https://doi.org/10.1145/2037556.2037602.

[45] Hafedh Chourabi, Taewoo Nam, Shawn Walker, J. Ramon Gil-Garcia, Sehl Mellouli, Karine Nahon, Theresa A. Pardo, and Hans Jochen Scholl, "Understanding Smart Cities: An Integrative Framework," *Proceedings of the Annual Hawaii International Conference on System Sciences*, 2012, 2289–97, https://doi.org/10.1109/HICSS.2012.615.

[46] Ibid.

[47] Francesco Paolo Appio, Marcos Lima, and Sotirios Paroutis, "Understanding Smart Cities: Innovation Ecosystems, Technological Advancements, and Societal Challenges," *Technological Forecasting and Social Change* 142, no. December 2018 (2019): 1–14, https://doi.org/10.1016/j.techfore.2018.12.018.

[48] T Derek and J Clements-Croome, "What Do We Mean by Intelligent Buildings?," *Automation in Construction* 6 (1997): 398.

constructs the new conditions and systems of smart cities and architecture by combining physical and digital infrastructures.[49] Digital systems are utilized to structure and process the data and generate multi-dimensional solutions[50] for environmental and infrastructural problems. Intelligent cities will also regulate the internal and external conditions of the systems to optimize environmental performance and usage of natural resources.[51] By establishing a critical distance to the marketing provisions of the smart cities, this thesis searches for real potentials of intelligence and architectural solutions rather than material products.

This constant transformation and discussion of infrastructure, sustainable and smart cities highlight the importance of evaluating existing environments in addition to new ones. Increasing environmental awareness and scarcity of natural resources puts a lot of pressure on the adaptation of existing cities and architecture within these changing conditions. Several architectural concepts and methods/terms emerged to focus on this possible transformation of existing architectures, such as adaptive reuse, retrofit, refurbishment, renovation, conservation, etc. All of them particularly focus on the re-evaluation of the existing structures, cities, and environments and particularly on the infrastructural and environmental performance of existing architectures. METU Getty project is one of the recent examples of a conservation project. This thesis also concentrated on the METU Campus and particularly its infrastructure is studied to understand and discuss the sustainable and intelligent transformation of the existing environments.

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[49] Keith Bowers, Volker Buscher, Ross Dentten, Matt Edwards, Jerry England, Mark Enzer, Ajith Kumar Parlikad, and Jennifer Schooling, “Smart Infrastructure: Getting More from Strategic Assets,” 2018, 2, Retrieved from https://www-smartinfrastructure.eng.cam.ac.uk/files/the-smart-infrastructure-paper.

[50] Sorguç and Selçuk, “Computational Models in Architecture: Understanding Multi-Dimensionality and Mapping.”

[51] Rui Yang and Lingfeng Wang, “Multi-Objective Optimization for Decision-Making of Energy and Comfort Management in Building Automation and Control,” *Sustainable Cities and Society* 2, no. 1 (February 2012): 1–7, https://doi.org/10.1016/j.scs.2011.09.001.

1.3 METU Campus and Infrastructure:

Designed in the 1960s by Behruz and Altuğ Çinici, METU Campus is a glorious/successful example of the architectural and urban design of the post-war era of Turkish Architecture. The METU campus was listed with the iconic buildings of Modernism in 2017. With its highest ambition of design qualities in different scales, it was presented as a great example representing the "ideals of Modernity" in Turkish Architecture.[52]

The campus was not just designed to provide educational facilities but also to accommodate social and collective activities to build a new university.[53] The idea of university campus design is considered as a self-sustaining environment which was very successfully "engineering the space, nature, and society".[54] From the master plan to the architecture of single buildings, accommodation units to landscape design, METU Campus almost has all the features/facilities and necessary infrastructures to be considered as "small city." Holistic design and construction provide a strong consistency between architecture, structure, landscape and the infrastructure of the buildings and the campus. Although there are ongoing research and theses about the architectural or urban qualities of the campus, there is very little information about the campus infrastructure. Therefore, the architecture and infrastructure of the METU campus give inspiration for this research and provide a perfect case study.

METU Campus has a unique and experimental infrastructural design in different scales, from campus scale to individual space. The strong definition of the architectural, mechanical, landscape, and social infrastructure of the METU campus

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[52] Ayşen Savaş, "METU Campus," *Brownbook Magazine*, 2018, 71. See also the Getty webpage

[53] Güven Arif Sargın and Ayşen Savaş, "'A University Is a Society': An Environmental History of the METU 'Campus,'" *Journal of Architecture* 21, no. 4 (May 18, 2016): 602–29, https://doi.org/10.1080/13602365.2016.1192429.

[54] Ibid.

makes the campus a great example that provides a delicate balance between engineering(hard infrastructure) and societal needs(soft infrastructure). Mechanical infrastructures to pedestrian-oriented urban mobility, landscape design to the central heating system, underground service tunnels (gallery) to rich public facilities, METU Campus has a lot of innovative and significant infrastructural design principles and applications. All the infrastructural facilities on the campus are built and managed by METU. It can be claimed that infrastructure allowed the campus to function well for many years.

The infrastructure of the campus should be understood in different ways, scales, times, and contexts. METU, as a modernity project[55], the campus infrastructure also has modernist preconceptions in different scales. The relationship of campus infrastructure with modernity, time, territory, topography was essential to understand context, conceptualization, and production of spaces and infrastructures. Although this study aims to provide a framework for the infrastructure of the campus in general, it mainly focuses on the “hard infrastructure”, and it will evolve to be part of the following research that will focus on the landscape and social infrastructure of the campus.[56]

1.3.1 Aims and Objectives

Universities are one of the crucial institutions meant to be promoting innovation and production. The METU campus should be prepared for the changing social/digital trends and new disciplines to provide innovative educational and extracurricular facilities. The campus should provide intellectual, social, economic, environmental, and infrastructural networks and integrations. The next phase of the campus will promote togetherness, participation, innovation, environmental awareness,

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[55] Ibid.

[56] Please see the forthcoming master’s theses, about the Landscape of METU Campus and Social Infrastructure of the Campus, supervised by Ayşen Savaş (after 2021).

collaboration, and creativity with non-hierarchic, equitable, and sustainable spaces and infrastructures. Here, the campus infrastructure is an essential tool for the equal distribution of resources and opportunities to campus users.

This thesis provides contextual research supported with a conceptual design proposal for the intelligent and sustainable development of the METU campus and its infrastructure. Research on the infrastructure of the campus can help to understand the complex infrastructural problems of the universities to search for potentials of upcoming infrastructural developments. The design proposal investigates the ways, prospects, and methods to look, understand and re-evaluate existing (legacy) modernist campus infrastructure. Contemporary research areas and multiscalar design methods were investigated to generate intelligent infrastructural networks in METU. This thesis aims to re-investigate how these systems, tools, and methods can affect infrastructural design and construction processes to make campus and its buildings more productive, responsive, interconnected, and environmentally conscious. It searches for infrastructural potentials to protect the campus from environmental challenges, to provide the campus with the necessary technologies, and to participate the society of the campus with the social shifts.[57] Although campus did not have all the complexity of cities in terms of different stakeholders, management, user groups of urban settlements, this kind of implementation and research can work as a preliminary model for sustainable and intelligent redevelopments/implementations of urban environments by considering the university campus again as a “learning laboratory”.[58]

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[57] Three keywords of “protect” “provide” and “participate” is borrowed from the book “Inhabitable Infrastructures: Science Fiction or Urban Future” by CJ Lim, 7.

[58] Savaş, Derebaşı, Dino, Sarıca, İnan, et al., “Research and Conservation Planning for the METU Faculty of Architecture Building By Altuğ-Behruz Çinici, Ankara, Turkey,” 342.

1.3.2 Hypothesis:

The infrastructure of the METU Campus has significant infrastructural aspects and vision that should be mentioned in the conditions of these constant transformations. Forward-thinking conceptual infrastructural design and production of the campus still actively serves the campus's many needs even today and provides a lot of room for current needs and additional requirements. Campus infrastructure has many novel/innovative features and experimental/ noteworthy qualities which can serve as a model for contemporary urbanization and sustainable developments. This thesis claims that the infrastructure of the METU Campus can be defined/re-investigated as an early (precedent) model of intelligent (contemporary) infrastructures.

Although new technologies, systems, and structures require their infrastructure for current needs and specifications, there should be a vision and plan to adapt existing environments. This thesis also argues that the modernity of the campus is created with the help of infrastructure in METU, and it can be a model for the necessary/upcoming developments. Modernist preconceptions (visions, dreams) of the campus can be implemented/ transformed into and sustainable and intelligent environments (utopias) by preserving and promoting similar visions as fundamental in addition to intelligent features. With the understanding of infrastructures change forms not the function,[59] modernist principles of the campus that modern, hygienic, rational can easily evolve into intelligent, sustainable, responsive environments.

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[59] Edwards, "Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems," 204–7.

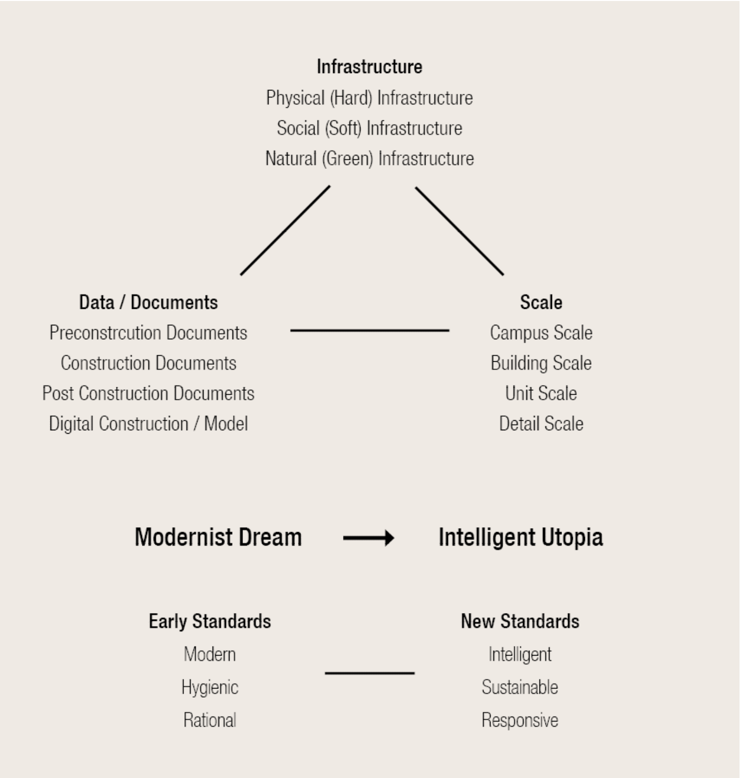
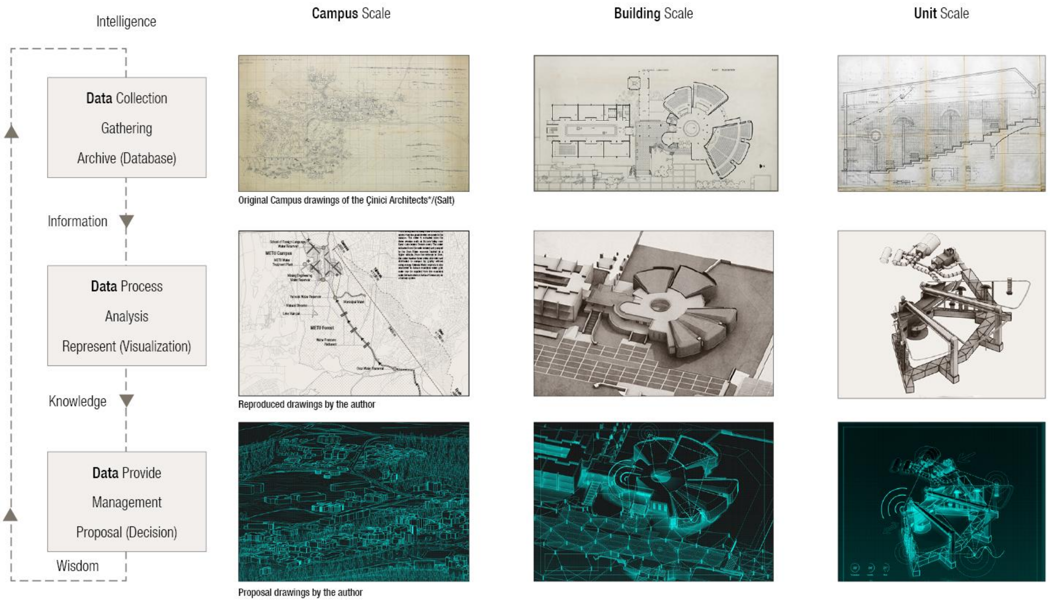


Figure 1.1. Study Diagram

1.3.3 Methodology – Data Collection, Processing and Providing

By accepting the “data” as the most crucial component of the “intelligence”, the organizational process of the intelligent systems provides methodological data management and research strategy for this thesis. Intelligent systems collect and store data, process, analyze, evaluate the collected data to generate information, and provide, distribute information to enable solutions. The methodology of this thesis stems from the exact cognitive process. This thesis aims to collect and archive the data about the campus and its infrastructure, evaluates, processes, analyzes this data to understand and generate information through representation, and provides a proposal for the intelligent sustainable development of the campus infrastructure. This comprehensive approach also proposes an comprehensive alternative model to current smart city initiatives.



Original Campus drawings of the Çinici Architects*/(Salt)

Reproduced drawings by the author

Proposal drawings by the author

Figure 1.2. Methodological Matrix of the study

METU is analyzed to understand the complex infrastructural problems of university campuses. With the understanding of “cities as a collection of infrastructural projects”,[60] this thesis re-investigates the METU Campus as a collection of physical, mechanical, social, and natural infrastructures and spaces. Infrastructural reading of the campus enables not to look at the city through just architecture of static buildings and objects, rather represent them as living organisms with continuous movements, operative systems, networks of social activities. This understanding blurs the distinctions between architecture and infrastructure, makes the campus a complex and multi-scalar infrastructural network that provides necessary social, mechanical, and environmental facilities to the users. Therefore, in this study, the infrastructures of the campus were redrawn, mapped, modeled at different scales, and represented to visualize collected and processed information (data visualization).

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[60] Laila Seewang, “Skeleton Forms: The Architecture Of Infrastructure,” SCENARIO Journal 03: Rethinking Infrastructure, 2013, Retrieved from https://scenariojournal.com/article/skeleton-forms/.

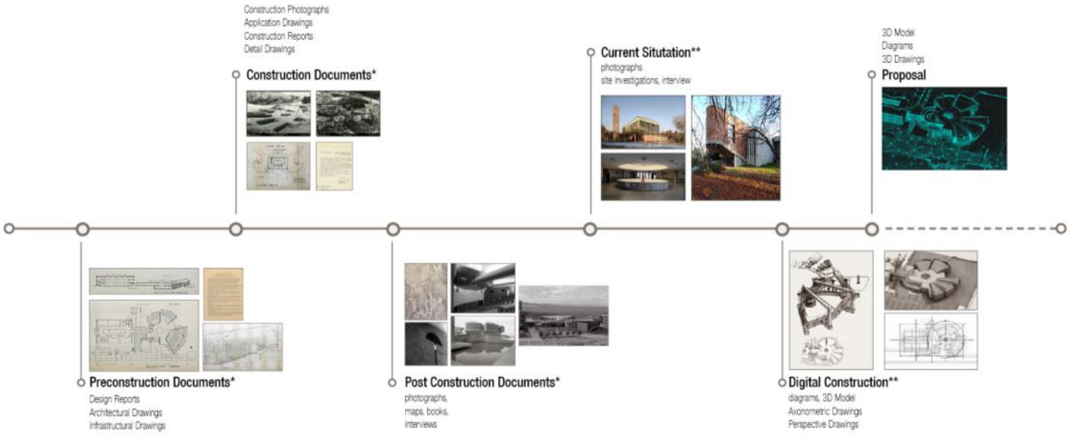

Figure 1.3. Documentation and Representation process of the study

The architectural, mechanical, landscape, and social infrastructure of the METU campus is studied through the conceptualization and the production of space in terms of social, structural, technological, political, spatial relations, topographical, materials, infrastructure, and scales. The existing infrastructure of the campus is analyzed in different scales from city-scale to detail scale (city, campus, building, unit, space) with the help of various preconstruction (architectural and infrastructural drawings), construction (drawings and reports), and postconstruction documents, (drawings, photographs, site investigations, books, and interviews) and visualized with “different modes of architectural representation”[61] (diagrams, axonometric and perspective drawings, and 3D models). Necessary architectural representational tools and methods are explored to understand and evaluate the spatial relationship between visible(architecture) and invisible(infrastructure).

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[61] The phrase is borrowed from the Arch524 Architecture and Different Representation Modes Course which the author is also participated in Fall 2019 semester at METU and produced a video mapping for the “METU: Representing Itself” exhibition. Please also see METU: Representing Itself Exhibitions curated by Prof. Dr. Ayşen Savaş.

The data collected from the evaluation and analysis of the existing situation is used to understand the spirit of first infrastructure and architecture. Initial ideals helped rethink the campus and its buildings with the recent challenges. With the help of analytical research and data, a conceptual project is proposed for the infrastructural development of the campus. This approach provides an opportunity to reveal both potentials and current problems /challenges of the campus and its infrastructure. This thesis suggests increasing synergy between the hard, soft, and green infrastructure in terms of mechanical, digital, social, and ecological processes to generate a sustainable, intelligent campus ecosystem. This infrastructural documentation and research enable to understand the history and existing situation of the campus and its infrastructure deeply and then promote the qualities that are inherited from the original design.

1.4 Outline of the Thesis:

This study is organized around five main chapters to comprise the main framework of this research. First is an introduction and general overview of the topic. This chapter starts with the background information of recent technological, social, and environmental developments and challenges of urbanization and summarizes the case study, research fields, hypothesis, and methodology of the research. The second topic is an inquiry on “infrastructure” in terms of definition, classification, and its meaning for architecture, urban, public space, and intelligence in architecture. The third topic mainly focuses on the infrastructure of the METU Campus; it provides a comprehensive investigation and documentation about the campus infrastructure to the very architectural anatomy of a building. This chapter surveys how these infrastructures work and point out their potentials and challenges. And the fourth section is the re-evaluation of the existing infrastructure of the campus and provides a proposal to generate an intelligent urban environment within the campus. The fifth and last chapter is the conclusion.

CHAPTER 2

INFRASTRUCTURE IN/AS ARCHITECTURE

This chapter focuses on infrastructure and aims to understand the concept of "infrastructure" in architecture. The first part seeks to clarify the term infrastructure through its definitions and classifications. The second part tries to contextualize infrastructure as a spatial concept to understand its significance in relation to urban and architectural studies. Historical progress and the current understanding of infrastructure are extended with some important examples in architectural practice. The broad definition of "infrastructure" is essential for the scope of this study to understand the complexities, potentials, and challenges of the term.

2.1 Etymology – Definition – Classification of "Infrastructure"

infra- + structure (n.)

Latin prefix "infra" meaning "below, beneath, under"

"structure" (derived from the Latin word "structure")

The etymology of the infrastructure is traced back to its Latin origins; it is composed of the Latin prefix "infra," meaning "below, beneath, under," and "structure" (derived from the Latin word "structure"). The origin of the English word is adapted from the French civil engineering term "infrastructure", dating back to the mid-nineteenth century.[62] Will Batt explains the usage of the keyword became widespread in the post-war period:

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[62] Ashley Carse, "Keyword: Infrastructure: How a Humble French Engineering Term Shaped the Modern World," in *Infrastructures and Social Complexity*, ed. Penelope Harvey, Casper Bruun

> "The earliest use documented is in 1927 in the Oxford English Dictionary, wherein the term was used to describe "the tunnels, bridges, culverts and 'infrastructure' work generally" of French railroads. The next frequent appearances are in connection with NATO war mobilization studies in the early fifties. Lord Ismay, first Secretary General of NATO, published a volume in 1954 which devoted a whole chapter to "NATO Common Infrastructure," which referred to all of the "fixed installations which are necessary for the effective deployment and operations of modern armed forces…"[63]

After its emergence in English, the usage and definition of the term "infrastructure" are extended into social, technological, economic, political, and environmental fields and dimensions in different periods.[64] Today, it is widely used to explain both tangible and intangible issues. On one side, the word still has a connection with the materiality of the physical world and spaces; on the other side, it is evolved to explain abstract and organizational concepts.[65]

The term "infrastructure" commonly refers to some physical assets and interconnected systems which also facilitate the needs of society and the standard of living.[66] Fulmer defines the term infrastructure as "The physical components of interrelated systems providing commodities and services essential to enable, sustain, or enhance societal living conditions."[67]

Jensen, and Atsuro Morita (New York, NY: Routledge, 2016), 29, https://doi.org/10.4324/9781315622880.

[63] H. William Batt, "Infrastructure: Etymology and Import," *Journal of Professional Issues in Engineering* 110, no. 1 (January 1984): 2, https://doi.org/10.1061/(ASCE)1052-3928(1984)110:1(1).

[64] Carse, "Keyword: Infrastructure: How a Humble French Engineering Term Shaped the Modern World."

[65] Ibid.

[66] Jeffrey E. Fulmer, "What Is the World Infrastructure?," *PEI Infrastructure Investor* 1, no. 4 (2009): 30–32, Retrieved from https://30kwe1si3or29z2y020bgbet-wpengine.netdna-ssl.com/wp-content/uploads/2018/03/what-in-the-world-is-infrastructure.pdf.

[67] Ibid., 32.

According to Lim:

> "Infrastructure refers to the fundamental man-made structures, networks, services and facilities that support the essential growth of a country, city or industry and is fully dependent by its communities…
>
> …Enabler of socio-economic growth, planning policies and social wellbeing; with coming technological advancement, infrastructure has the ability to adapt landscapes, urban forms and social cultures."[68]

The definition of the infrastructure puts a strong emphasis on continuities and movements in different scales, which is also associated with a set of keywords and concepts such as network, grid, flow, system, process, interconnection, links.

The infrastructure of the city is generally classified under hard and soft infrastructures.[69] Lim states that hard infrastructures are the physical infrastructure of cities to maintain and provide the crucial needs of society which refers to the systems of transportation, energy, sewage, communication, electricity, etc. These infrastructures prevent the city from destructive conditions. However, hard infrastructure is not enough to develop balanced and well-developed urban conditions. On the other hand, soft infrastructure refers to the social infrastructures of cities to maintain the non-physical needs of society that aim to increase living standards in terms of economy, culture, education, recreation, and health.[70]

The definition of infrastructure also outlines the ecological and natural issues "beyond engineering" and technical necessities.[71] Another necessary component of the urban infrastructure is the green infrastructure, defined as an "interconnected network of green space that conserves natural ecosystem values and functions and

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[68] Lim, *Inhabitable Infrastructures: Science Fiction or Urban Future?*, 61.
[69] Ibid.
[70] Ibid.
[71] Pierre Bélanger, "Landscape Infrastructure : Urbanism Beyond Engineering," in *Infrastructure Sustainability and Design*, 1st Ed. (New York: Routledge, 2013), 276–315, https://doi.org/10.4324/9780203120316.

provides associated benefits to human populations."[72] This understanding emphasizes ecological systems and natural solutions to utilize landscape as infrastructure. It aims "…to reformulate landscape as a sophisticated, instrumental system of essential resources, services, and agents that generate and support urban economies."[73] Bélanger states that "Landscape infrastructure is both index and interface that spatially incorporates hard technological systems and soft biophysical processes, by design"[74]

Weinstock describes a more comprehensive explanation for the infrastructure:

> "Infrastructure is the collective term for the systems and spaces of flows that provide the 'services' of the city; its transportation, water, energy, information and communications, waste collection and disposal, public spaces including the 'green' spaces of parks, gardens, open woodlands or nature reserves, and the social programmes of health, education and recreation."[75]

The broad definition of the infrastructure refers to the crucial interrelation between the physical (mechanical, technological, digital), mental (social, cultural), and natural (landscape, green and blue, ecological) needs of cities and societies. Integration and balance between these characteristics generate networks and systems for more sustainable and "livable" urban environments. Infrastructure protects the city from social and natural problems, provides necessary resources, and increases living standards with social, environmental, and engineering solutions.

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[72] M.A. Benedict and E.T. McMahon, "Green Infrastructure: Smart Conservation for the 21st Century," *Renewable Resources Journal* 20, no. 3 (2002): 12.

[73] Pierre Bélanger, "Landscape As Infrastructure," *Landscape Journal* 28, no. 1 (2009): 79, https://doi.org/10.3368/lj.28.1.79.

[74] Bélanger, "Landscape Infrastructure : Urbanism Beyond Engineering," 38.

[75] Michael Weinstock, "System City: Infrastructure and the Space of Flows," *Architectural Design* 83, no. 4 (2013): 21, https://doi.org/10.1002/ad.1614.

2.2 Infrastructure and Architecture

2.2.1 Infrastructure as “Space”/ as Architecture

> “Infrastructures are built networks that facilitate the flow of goods, people, or ideas and allow for their exchange over space.”[76]

Infrastructures as built objects/structures occupy a space with their obvious presence in the city. Infrastructures can be considered as a “form of architecture,”[77] which is a spatial entity fundamental for the development of urban settlements. Throughout the history of cities, developing infrastructure was considered essential for civilizations. Therefore, they have been at the center of construction practice and discussions in different eras. These inquiries spread to various technological, spatial, historical, economic, aesthetic, political fields, and dimensions. Hung states that “a city with a well-capitalized infrastructural system provides for an efficient, fluid operation hence maximizing its productive power and regional influence.”[78]

In the ancient and medieval ages, providing protection was vital for the cities. Humanity used fortification walls as defense infrastructure to protect their city from invasions. Beyond the protection of cities, infrastructure provides necessary living standards for the urban settlements. The Romans effectively used infrastructures to supply resources through transportation, security, economic, amusement infrastructures. Just for the water needs of their cities, Romans built thousands of kilometers of substructures, waterways, channels, drains, wells, fountains, aqueducts, and cisterns.[79] They also utilized the urban space effectively by

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[76] Brian Larkin, “The Politics and Poetics of Infrastructure,” *Annual Review of Anthropology* 42 (2013): 328, https://doi.org/10.1146/annurev-anthro-092412-155522.

[77] Stoll and Lloyd, “Performance as Form,” 4–7.

[78] Ying-Yu Hung, “Landscape Infrastructure: Systems of Contingency, Flexibility, and Adaptability,” in *Landscape Infrastructure: Case Studies by SWA,* ed. The Infrastructure Research Initiative at SWA, 2nd Ed. (Basel: Birkhäuser, 2013), 16, https://doi.org/10.1515/9783034615853.

[79] Lim, *Inhabitable Infrastructures: Science Fiction or Urban Future?*, 165.

associating divergent infrastructures. The Hippodrome in Istanbul is an excellent example of multiuse infrastructures. It is constructed as the primary social space for the events and ceremonies of the great empire, but it also works as a part of the water infrastructure of the city with its cistern underneath the seating places inside the Sphendone. Hence, Romans cleverly used infrastructural developments as way of promotion to consolidate their power.[80]

> "However, the provisions of everyday infrastructures must not be misconstrued with the development of social wellbeing and liberalism. The bathhouses, amphitheater and forum were representative of political and social control centers, giving Rome further surveillance and influence over its people and its new colonies. The greatness of the Roman Empire was a direct consequence of engineering as propaganda, and the aqueduct was the ultimate ingenious political infrastructure. It is indeed because of the aqueduct that great transformations of service infrastructure took place, changing the basic systems from a primitive mode into recognizable modern forms."[81]

Figure 2.1. Aqueduct of Valens, İstanbul, 373[82]

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[80] Ibid., 170.
[81] Ibid.
[82] Retrieved from https://en.wikipedia.org/wiki/Aqueduct_of_Valens on December 21,2021

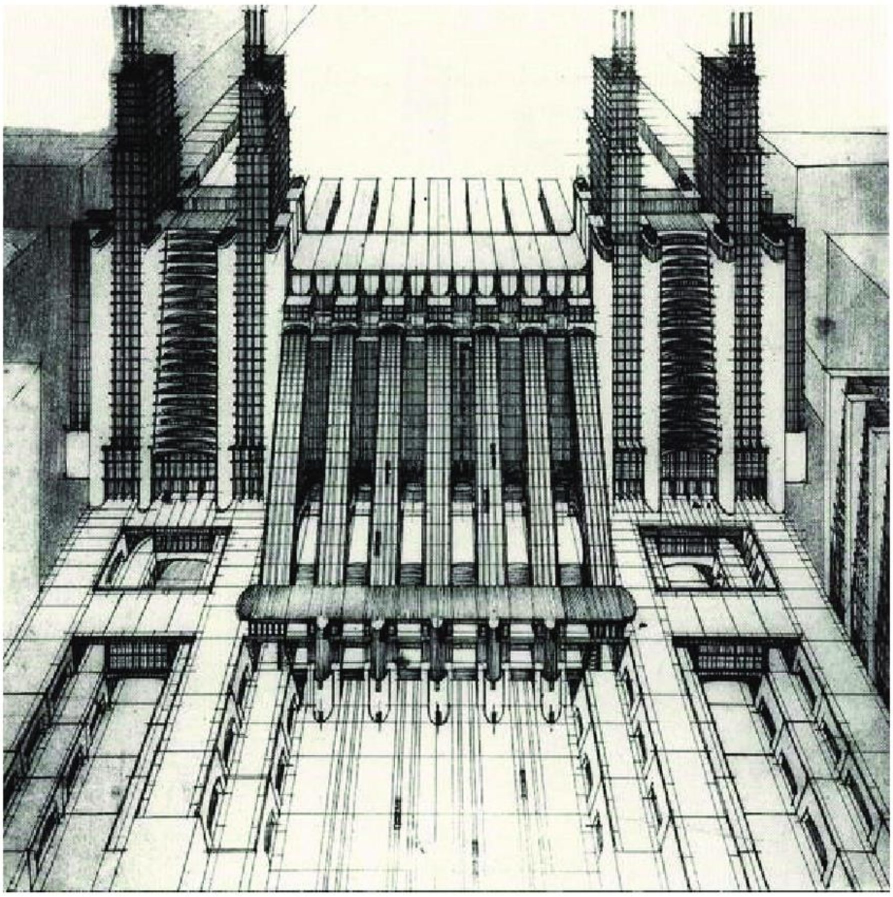

Figure 2.2. La Citta Nuova, Antonweinio Sant Elia, 1914 [83]

The industrial revolution provided new construction techniques and production technologies starting from the 20th century. These functional developments of services, machines, and infrastructures became an important topic of form-function discussions in architecture. “Rational” and “functionalist” approaches have emerged in architecture[84], while Le Corbusier emphasizes the essential services of a house with his famous quote, “House is a machine for living in.”[85] Infrastructures and mechanical services put technical and functional reasons in front of formal or aesthetic ones. Different architects also searched for alternative proposals to

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[83] Weinstock, “System City: Infrastructure and the Space of Flows,” 14–15.
[84] Banham, *Theory and Design in the First Machine Age*, 320–30.
[85] Corbusier and Etchells (transl.), *Towards a New Architecture*.

spatialize their technological and infrastructural ideals. In his well-known work La Citta Nuova, Antonio Sant Elia presented his ideals by uniting technologies of Italian Futurism with cubist geometries and forms.[86] These infrastructural forms and technical approaches aimed to provide pragmatic solutions to spatial design.

Archigram group in the 1960s created a series of inspirational drawings about their ambitious city proposals and futuristic designs again in the different forms of infrastructures. They focused on the diverse social and spatial problems of the cities by providing alternative infrastructural, technological, and architectural solutions.

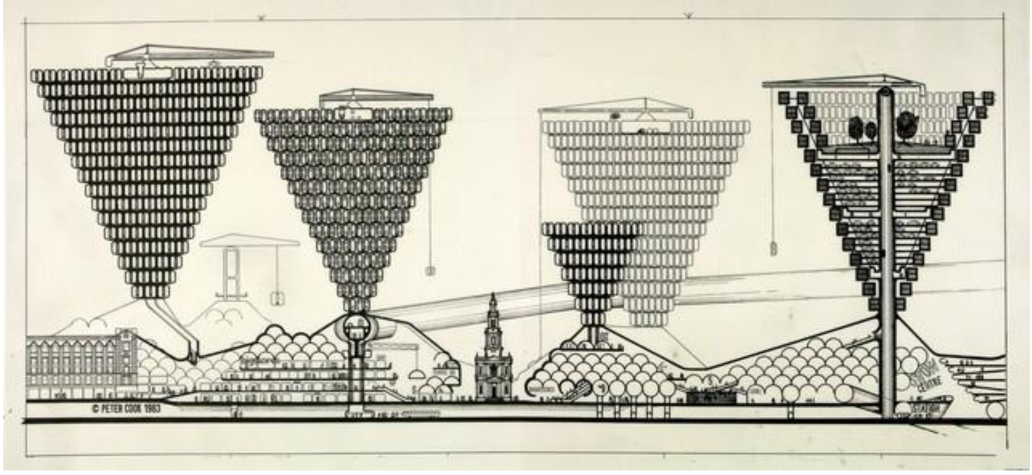

Figure 2.3. Plug-in City, Peter Cook, Archigram, 1964[87]

Like the Archigram group, the Metabolist movement aimed to create cities and architecture in a structural and infrastructural grid with attachable and detachable modules. They developed cities in the form of megastructures. These proposals tried to reorganize cities and spaces as infrastructures by asserting technical, transportation, mobility, and mechanical systems and solutions.

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[86] Banham, *Theory and Design in the First Machine Age*, 127–37.
[87] Retrieved from https://www.archdaily.com/399329/ad-classics-the-plug-in-city-peter-cook-archigram on December 2, 2021

Figure 2.4. A plan for Tokyo, Kenzo Tange, 1960 [88]

These technological and infrastructural approaches also inspired different academic works in architectural discourse. In his renowned essay “A Home is not a House,” Reyner Banham represents how infrastructural services affect social life by invading architectural spaces.[89] He addresses increasing expectations from buildings through their continuously growing mechanical equipment. As CJ Lim exemplifies, this technological and infrastructural demand of critical systems evolved the ways of construction and development of services in architecture:

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[88] Retrieved from https://archeyes.com/plan-tokyo-1960-kenzo-tange/ on December 25,2021

[89] Banham and Dallegret, “A Home Is Not a House,” 70.

> "A visit to a construction site would reveal the extent to which all of our buildings are wired, ducted and plumbed. Networks of cables envelope the inhabited volumes of houses and workplaces, while countless electrical switches hide behind walls and under floors."[90]

Architects of the High-tech era/movement cleverly used technological and infrastructural development on behalf of architectural design. Their products praise technological advancements by expressing the structural and infrastructural qualities of space. They created designs in the form of mechanical services and generated a new architectural machine aesthetic that puts structures and infrastructure on a show in the built environment.

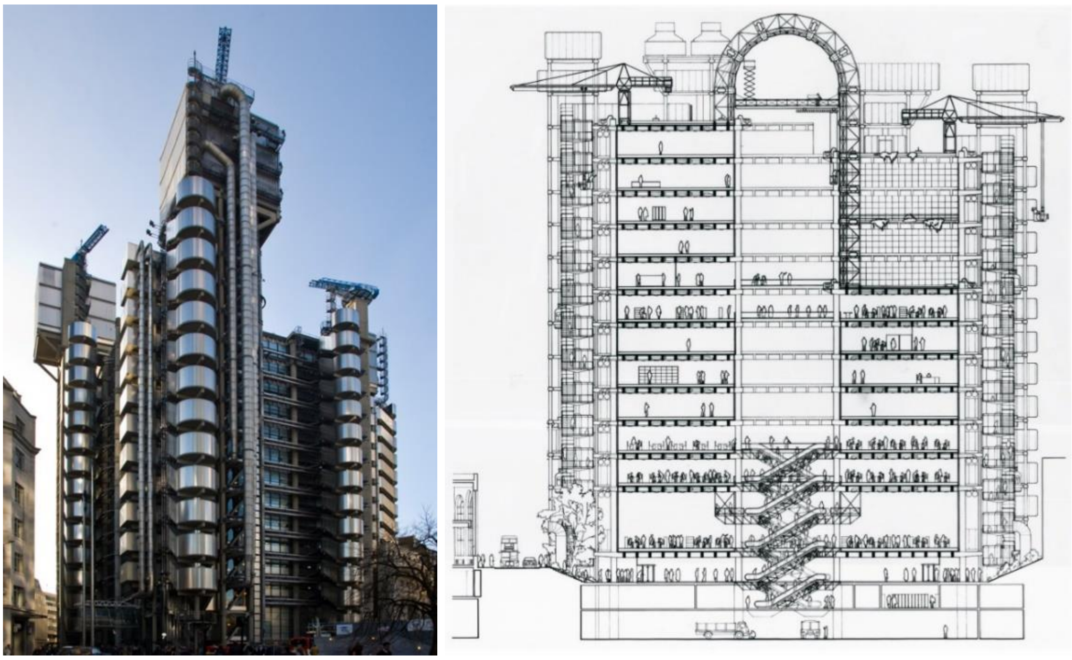

Figure 2.5. Lloyds Building, Richard Rogers, 1986 [91]

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[90] Lim, *Inhabitable Infrastructures: Science Fiction or Urban Future?*, 25.
[91] Retrieved from https://commons.wikimedia.org/wiki/File:Lloyd%27s_building.jpg and https://www.dezeen.com/2019/11/19/lloyds-building-richard-rogers-high-tech-london/ on November 21, 2021

Recently the technology of the buildings is evolving and getting smaller into sensors, and small components of the buildings and the expected capabilities from the buildings are increasing. The cognitive capacity and environmental performance of the buildings are increased with the emergence of smart, sustainable buildings. The EDGE, Amsterdam by PLP Architects is one of the recent products of this transformation. Although the building is not designed and constructed with the help of BIM, the capability and benefits of BIM are fully used for optimization and utilization of the management and maintenance process. The project is developed with a very efficient solar energy system that can generate more energy than it consumes. Also for the thermal energy, two aquifers 130 m below the ground are utilized for the hot and cold water storage to provide thermal conditions in summer and winter. The building is fully developed with a mobile application, thousands of IoT devices, and sensors that collect real-time and long-term data of the building, and it provides users to ensure indoor environment quality, thermal comfort, lighting conditions, flexible work spaces.[92]

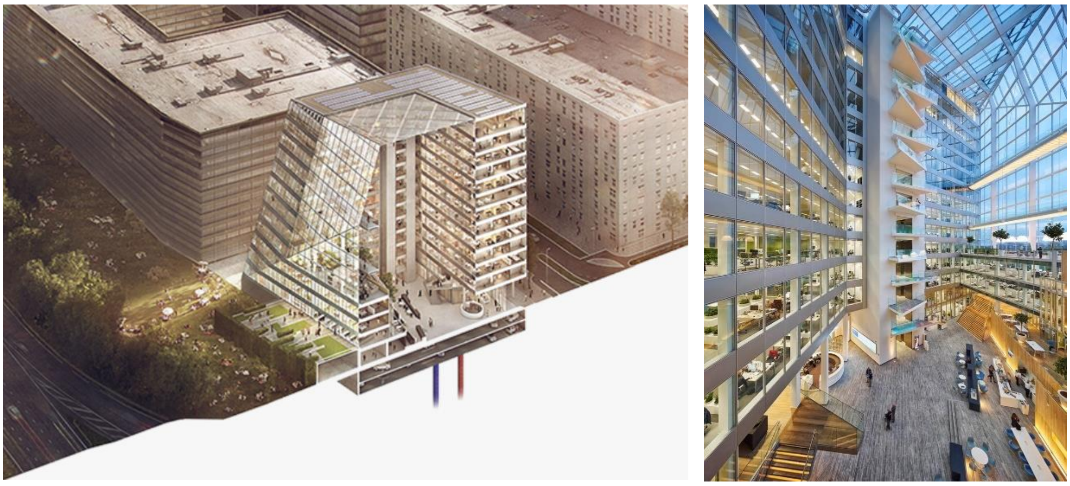

Figure 2.6. The Edge Amsterdam, PLP Architecture, 2015 [93]

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[92] Aftab Jalia, Ron Bakker, and Michael Ramage, “The Edge, Amsterdam Showcasing an Exemplary IoT Building,” n.d.

[93] Retrieved from https://www.plparchitecture.com/the-edge.html on December 10, 2021

2.2.2 Infrastructure as “Public Space”

Recent understanding and advancements of infrastructures have shown that they transform cities into urban ecosystems by creating connections between physical, digital, and biological processes.[94] This ideological change blurred the distinctions between the infrastructure, public spaces, and buildings. On the urban scale, infrastructures can be conceived as “public spaces” that generate contextual, economic, and environmental solutions to urban problems.[95] Considering infrastructure as a “public endeavor” and “integrated design project” in the city provides potential to advance the city by means of environmental, social, and technological design decisions.[96] Therefore, the presence and integration of infrastructures as a public space is substantial for a well-developed urban environment. Lim also explained how the significance of infrastructure is shifted:

> “Fortifications, moats, lagoons, and glacis that have long lost their defensive value still solidly enclose many towns. Walls can still frame and protect a city, but these infrastructures need no longer be made of stone and mortar – city zoning, greenbelts, and floodgates can defend against the contemporary threats of overpopulation, pollution and climate change.”[97]

After the 1970s, in parallel to the increase of environmental concerns,[98] the infrastructural need for security also evolved from political dimensions or technical solutions to environmental issues. This understanding extends the mechanical understanding of infrastructure to cover social and natural fields. High Line in New York is one of the recent products for this mentality shift. It is a remarkable case

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[94] Schwab, *The Fourth Industrial Revolution*, 7.

[95] Hung, Aquino, Waldheim, Czerniak, Geuze, et al., *Landscape Infrastructure: Case Studies by SWA*.

[96] Kelly Shannon and Marcel Smets, *The Landscape of Contemporary Infrastructure* (Rotterdam: NAI Publishers, 2016), 9.

[97] Lim, *Inhabitable Infrastructures: Science Fiction or Urban Future?*, 101.

[98] Bélanger, “Landscape Infrastructure : Urbanism Beyond Engineering,” 20.

study of how old elevated hard transportation infrastructure of railway lines are transformed into a public green space which becomes one of the most vibrant public spaces and infrastructure of New York City.

Figure 2.7. High Line, James Corner Field Operations, Diller Scofidio + Renfro, and Piet Oudolf, New York, 2009 [99]

Contemporary infrastructural theories clustered around the idea of questioning the single-use infrastructures, which separate all the infrastructural facilities for different purposes. Multi-scalar and dimensional characteristic of urban problems necessitates interdisciplinary infrastructural approaches and solutions. Urban infrastructures have capabilities to host multiple functions with meeting the demand of the social, digital, biological, and mechanical needs and resources of the urban future. Multiuse infrastructures aim to solve hard technical problems via integrating or combining with the soft ones. These urban catalysts can generate many potentials and dynamic results from the technical problems and issues with the potentials of architecture.

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[99] Retrieved from https://en.wikipedia.org/wiki/High_Line on November 20, 2021

Decentralization of infrastructures is significant to re-generate symbiotic relationship between the city and its infrastructures. The infrastructural needs of ever-growing cities require a huge amount of space in and around the city. In the past, the development of infrastructural systems was generally based on conventional approaches of separating, excluding, or hiding systems rather than integrating them into the living environment.[100]

This understanding led to the centralization of most of the infrastructural systems outside the city. They covered and polluted a vast amount of natural land, which negatively affected the ecology and climate conditions. In addition, these solutions increase distribution problems and transportation expenses while decreasing functional efficiency. However, reallocation of infrastructures into the city provides economic benefits and increases the availability of resources. Rethinking the decentralized and distributed infrastructural solutions within the planning of constantly growing cities[101] is essential in generating sustainable, resilient, and responsible environments.

Therefore, the design of the infrastructure should be more inclusive for alternative usages and purposes to promote public participation and contextual relationships. Integration of infrastructure within an urban fabric is substantial for self-sustaining environments. The juxtaposition of soft and hard infrastructural systems does not just provide the efficient usage and distribution of natural resources; they also increase the knowledge and awareness about environmental issues. This type of infrastructure can create networks of technical needs by providing public spaces and ecological solutions.[102]

BIG’s Copenhill Project is one of the recent examples of decentralized infrastructures that superimpose “infrastructural facility” with the “public space.”

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[100] Weinstock, “System City: Infrastructure and the Space of Flows,” 21.
[101] Bélanger, “Landscape As Infrastructure.”
[102] Shannon and Smets, *The Landscape of Contemporary Infrastructure*, 9–11.

This infrastructural implementation aimed to blur the distinctions between the hard and soft services of the city. The waste-to-energy plant is located at the very central spot in Copenhagen in the form of the tallest building of the city. This landmark works as an important infrastructure for waste management and power production while providing a public space for recreational and sports facilities like ski and climb.[103] Mountains of trash turned into a mountain of the public park which hosts different recreational facilities. This building becomes the symbol of environmental consciousness arising in Copenhagen about ecological problems and global warming. It also shows that the technology and system of new infrastructures can be harmless to the city and the nature of its closed proximity.

Figure 2.8. CopenHill Energy Plant and Urban Recreation Center / BIG, Copenhagen, 2019, photo by Laurian Ghinitoiu [104]

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[103] "CopenHill Energy Plant and Urban Recreation Center / BIG," Archdaily, 2019, Retrieved from https://www.archdaily.com/925970/copenhill-energy-plant-and-urban-recreation-center-big.

[104] Retrieved from https://www.archdaily.com/925970/copenhill-energy-plant-and-urban-recreation-center-big on April 04, 2021

In the future, buildings should be considered as part of the urban ecosystem producing food, energy, clean air, and water.[105] This can be achieved with the new comprehensive understanding and integrated systems of infrastructural developments. Distributed systems and decentralized infrastructures can have the potentials to generate contextual relationships. Recent urban and architectural studies started to work on the upcoming buildings benefiting from the contemporary technological developments. As the new developments blur the distinctions between the hard, soft, and natural necessities, infrastructure will become not just a part of the city but the urban space itself.

ARUP is one of the companies that focuses on the issue and develops hypothetical concepts. In 2013, they unveiled their conceptual project titled "Urban Building of the Future".[106] The project defines future buildings as an integral part of the urban ecosystem and infrastructure. The feature of the future building is specified as "Flexible Structures, Sustainable Resources, Reactive Facades, Community Integration, Smart Systems." The project aims to meet the ecological concerns about buildings and use contemporary technologies in the building of future. Therefore, they proposed a dynamic system to make buildings more responsive, interconnected, ecologic, efficient, productive, and sustainable. It is adaptable to future changes with replaceable modules. It generates public space and transportation facilities for users interrelated with new infrastructures. Eventually, the definition of the building will transform architecture into infrastructure.

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[105] Josef Hargrave, "It's Alive!" (London, 2013), Retrieved from https://www.arup.com/news-and-events/report-describes-the-future-of-buildings-in-2050.

[106] Ibid.

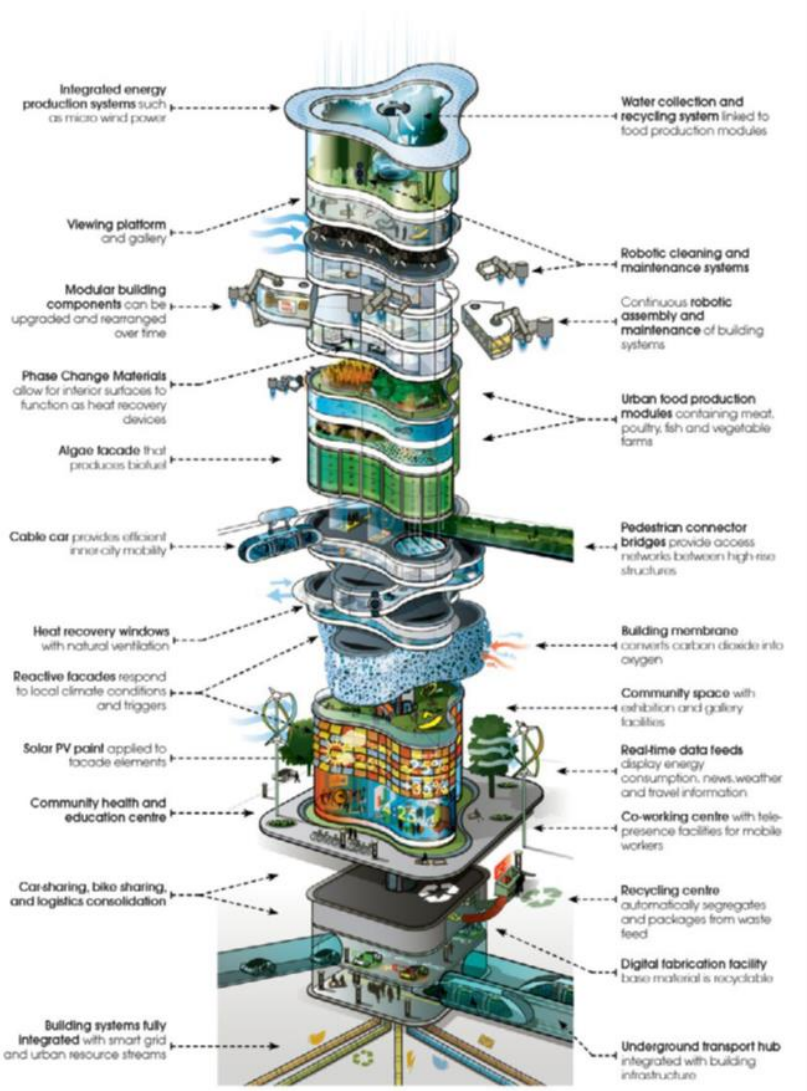

Figure 2.9. ARUP “Urban Building of the Future” [107]

Infrastructure can construct the conditions and systems of smart cities and architecture. Infrastructure can generate intelligent recycling and reuse networks for sustainable environments through renewable energy grids, water collection and purification systems, and waste management plants.

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[107] Ibid.

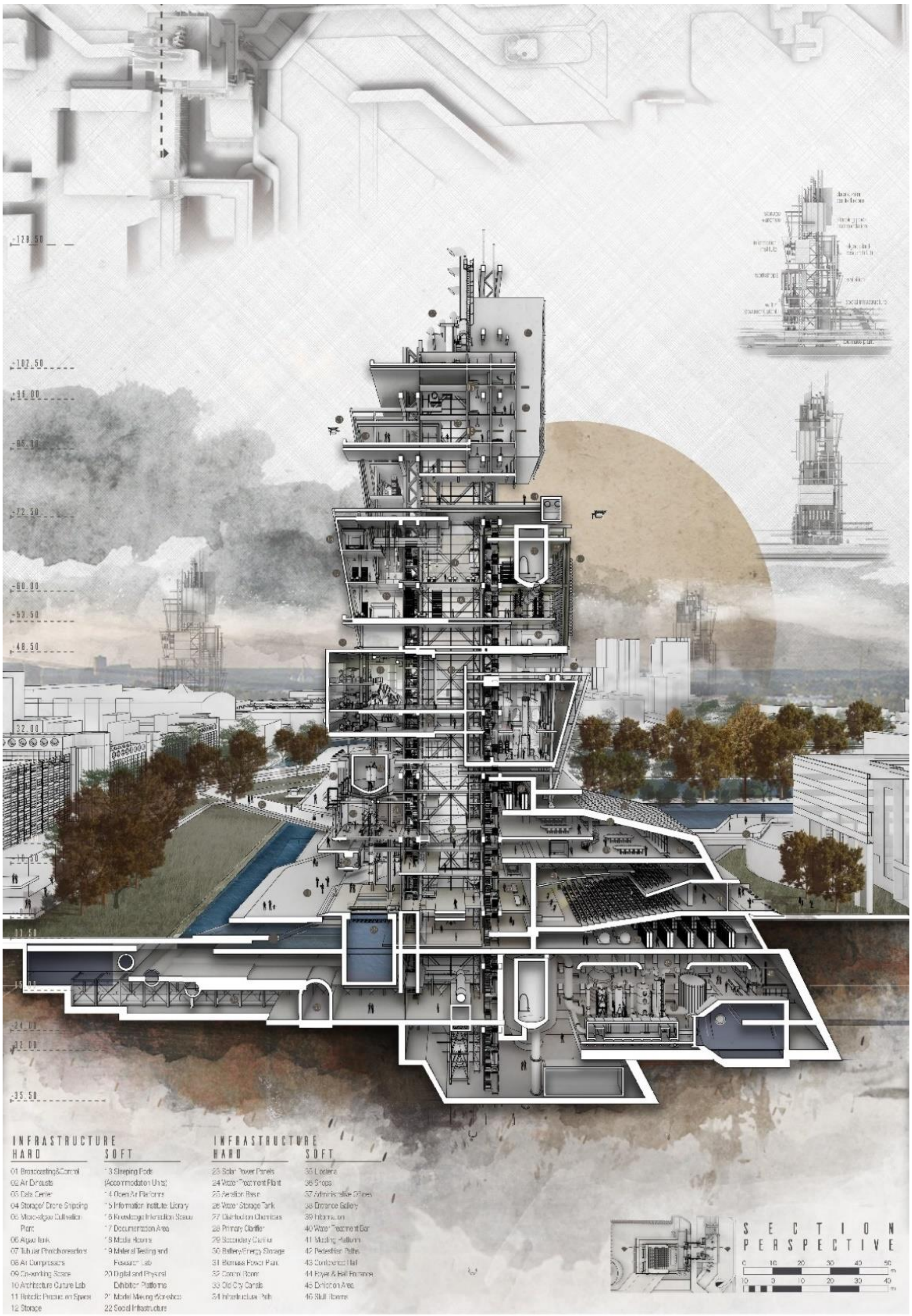

Figure 2.10. “Living with the Infrastructure | Bologna Center of Architecture”, drawn by the author

The graduation project of the author has also proposed an infrastructural project for the city of Bologna. The project deals with the expansion of the city and its indispensable demand for infrastructure. In the city of Bologna, which is famous for its medieval towers, the project introduces a new infrastructural system based on a triad of networks: canals, green, and towers. The building removes all the functions from the ground and investigates controversial ‘architectural spaces and urban typologies’ by superimposing the living environment with the mechanical infrastructure. Experimental urban infrastructure is proposed within the city by juxtaposing hard (technical) and soft (social) infrastructure to create a self-sustaining urban settlement with an aim to increase citizens' awareness about their impacts on the environment.[108]

2.3 Intelligent Cities as Infrastructure (Infrastructure of Intelligence)

The development of technologies and emerging digital systems provide different infrastructural potentials for the spatial structures to deal with the growing environmental and social challenges of cities. “Smart” (“intelligent”) urbanism has emerged as a strategy to ensure livable and sustainable environments for the cities.[109] The “smartness” discourse for the cities has evolved from the “smart growth” movement, which was widely used in the 1990s[110] , and the term “smart city” was first used in 1992[111]. The usage and recognition of the “smart” or “intelligent city”

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[108] The foundation of thesis initiated with this studio project entitled “Living with the Infrastructure” in 2017-2018 Arch401-402 Architectural Design Studio courses given at the METU Department of Architecture held by Ayşen Savaş, Arzu Gönenç Sorguç, Tolga Hazan and Onat Öktem. The author won significant awards with this project, including the METU Chair’s Award, first prize in Archiprix Turkey, Archi-World Academy Award, and the project is presented in exhibitions and digital platforms, including Archiprix International, Young Talent Architecture Awards.

[109] Chourabi, Nam, Walker, Gil-Garcia, Mellouli, et al., “Understanding Smart Cities: An Integrative Framework.”

[110] Nam and Pardo, “Conceptualizing Smart City with Dimensions of Technology, People, and Institutions.”

[111] Marsal-Llacuna and Segal, “The Intelligenter Method (I) for Making ‘Smarter’ City Projects and Plans.”

concepts on a global scale significantly increased after 2009, and it became a global phenomenon.[112] Today, there are many different definitions for the intelligent city, and different variant adjectives are used to define it such as “smart”, “intelligent”, “digital”, “wired”, “ubiquitous”, “knowledge”, “creative”.[113] Similar to interchangeable keywords are all used to define similar strategies for the city, definitions of the concept are also widely varying. Two comprehensive definitions of the smart city are:

> “A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens. Smart city generally refers to the search and identification of intelligent solutions which allow modern cities to enhance the quality of the services provided to citizens.”[114]
>
> “Smart Cities initiative tries to improve urban performance by using data, information and information technologies (IT) to provide more efficient services to citizens, to monitor and optimize existing infrastructure, to increase collaboration amongst different economic actors and to encourage innovative business models in both the private and public sectors.”[115]

As mentioned in the definitions, the purpose of the intelligent city is to generate new networks and synergies between the different components of the city to make cities,

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[112] Maria Lluïsa Marsal-Llacuna, Joan Colomer-Llinàs, and Joaquim Meléndez-Frigola, “Lessons in Urban Monitoring Taken from Sustainable and Livable Cities to Better Address the Smart Cities Initiative,” *Technological Forecasting and Social Change* 90, no. PB (2015): 611–22, https://doi.org/10.1016/j.techfore.2014.01.012.

[113] Nam and Pardo, “Conceptualizing Smart City with Dimensions of Technology, People, and Institutions”; Robert G. Hollands, “Will the Real Smart City Please Stand up? Intelligent, Progressive or Entrepreneurial?,” *City* 12, no. 3 (2008): 303–20, https://doi.org/10.1080/13604810802479126.

[114] Giffinger and Haindlmaier, “Smart Cities Ranking: An Effective Instrument for the Positioning of Cities?”

[115] Marsal-Llacuna, Colomer-Llinàs, and Meléndez-Frigola, “Lessons in Urban Monitoring Taken from Sustainable and Livable Cities to Better Address the Smart Cities Initiative,” 618.

infrastructures, and buildings “more intelligent, interconnected and efficient.”[116] “Intelligent city” aims to use the benefits of technological developments and digital infrastructures to provide a higher quality of spaces, services, and a better environment for urban users to increase conditions of living. “Smart cities strive to increase the competitiveness of local communities through innovation while increasing the quality of life for its citizens through better public services and a cleaner environment.”[117]

The varying definitions of the “intelligent city” enable an extensive framework for intelligent strategies in urban environments, increasing possibilities, potentials, and customization. [118] They offer flexibility for adaptation to a specific context, case, or practice, which is the METU Campus in this study. Although the terms can be used interchangeably, there is a saddle difference between the terms “smart” and “intelligent” in the literature. As stated, “The label intelligent city is usually used to characterize a city that has the ability to support learning, technological development, and innovation procedures.”[119] Therefore, the term “intelligent” is used in this study deliberately instead of “smart” to highlight the university as an institute (infrastructure) of intellectual knowledge and “knowledge society.”[120]

“Intelligence” in the urban context can be considered as a general “metasystem”[121] that can be elaborated in different scales of urbanization. “Smart ecosystem is a conceptual extension of smart space from the personal context to the larger

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[116] Washburn and Sindhu, “Helping CIOs Understand ‘Smart City’ Initiatives,” 2.

[117] F. Appio, M. Lima, and S. Paroutis, “Understanding Smart Cities: Innovation Ecosystems, Technological Advancements, and Societal Challenges,” *Technological Forecasting and Social Change* 142 (2019): 1, https://doi.org/10.1016/j.techfore.2018.12.018.

[118] Hollands, “Will the Real Smart City Please Stand up? Intelligent, Progressive or Entrepreneurial?”

[119] Nam and Pardo, “Conceptualizing Smart City with Dimensions of Technology, People, and Institutions,” 285.

[120] Nam and Pardo, “Conceptualizing Smart City with Dimensions of Technology, People, and Institutions.”

[121] Weinstock, “System City: Infrastructure and the Space of Flows,” 23.

community and the entire city."[122] It can also be translated for the social, political, economic, and environmental components and infrastructures of the urban environments. Weinstock states that:

> "The future city is fully intelligent. It is self-aware and 'conscious' of both itself and its citizens, and able to synchronise the city systems with climatic and ecological phenomena at the regional and local scales. Its spatial patterns are culturally appropriate to its citizens, and it adapts itself to the fluctuations of its flows, and to the emergent phenomena of its cultural practices by expansions, contractions and reconfigurations of its infrastructural systems, its spatial patterns and the morphology of its architecture."[123]

2.3.1 Technology of Intelligence

Technology, especially digital infrastructure, can be considered the primary driver of intelligent urban developments.[124] The most prominent factor of intelligence is the use of Information Technologies and ICT infrastructures to provide advanced solutions and better services for the different challenges of urban environments.[125] Digital Infrastructure enables the communication between things (IoT) with the help of controllers, sensors, and smart networks.[126] This communication mainly increases the cognitive abilities of cities to generate responsive networks between the different urban components through cognitive infrastructures. Smart infrastructure constructs

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[122] Nam and Pardo, "Conceptualizing Smart City with Dimensions of Technology, People, and Institutions."

[123] Weinstock, "System City: Infrastructure and the Space of Flows," 23.

[124] Andrés Luque-Ayala and Simon Marvin, "Developing a Critical Understanding of Smart Urbanism?," *Urban Studies* 52, no. 12 (September 23, 2015): 2105–16, https://doi.org/10.1177/0042098015577319.

[125] Elvira Ismagilova, Laurie Hughes, Yogesh K. Dwivedi, and K. Ravi Raman, "Smart Cities: Advances in Research—An Information Systems Perspective," *International Journal of Information Management* 47, no. January (2019): 88–100, https://doi.org/10.1016/j.ijinfomgt.2019.01.004.

[126] Lilis, Conus, Asadi, and Kayal, "Towards the next Generation of Intelligent Building: An Assessment Study of Current Automation and Future IoT Based Systems with a Proposal for Transitional Design."

the new conditions and systems of smart cities and architecture by combining physical and digital infrastructures.[127] Washburn and Sindhu state that:

> "A new generation of integrated hardware, software, and network technologies that provide IT systems with real-time awareness of the real world and advanced analytics to help people make more intelligent decisions about alternatives and actions that will optimize business processes and business balance sheet results."[128]

Having the components, technologies, or subsystems is not enough to make an urban fabric intelligent. But it is more critical for intelligent cities that these interdependent systems work as an "organic whole."[129] Mitchell explains the 21st century intelligent cities by analogy to living organisms: "cities have all the subsystems that are needed by living organisms: structural skeletons, various layers of protective skins and artificial nervous systems."[130] He provides interesting reading to these city components:

> "The new intelligence of cities, then, resides in the increasingly effective combination of digital telecommunication networks (the nerves), ubiquitously embedded intelligence (the brains), sensors and tags (the sensory organs), and software (the knowledge and cognitive competence)."[131]

Information is the most important premise of intelligence, and "data is the key"[132] for knowledge. Therefore, smart cities have all the technological and social systems

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[127] Bowers, Buscher, Dentten, Edwards, England, et al., "Smart Infrastructure: Getting More from Strategic Assets," 2.

[128] Washburn and Sindhu, "Helping CIOs Understand 'Smart City' Initiatives," 2.

[129] Nam and Pardo, "Conceptualizing Smart City with Dimensions of Technology, People, and Institutions."

[130] Mitchell, "Intelligent Cities," 5.

[131] Ibid.

[132] Bowers, Buscher, Dentten, Edwards, England, et al., "Smart Infrastructure: Getting More from Strategic Assets," 6.

and components to generate knowledge out of the data and information. The structure of the smart city comprises of four layers: sensing layer, transmission layer, data management layer, and application layer.[133] Raw data is collected through physical components and digital technologies (sensors, IoT devices, GPS, GIS, and BIM systems) in the sensing layer.[134] ICT infrastructure and cyber-physical systems connect and transfer the collected data to the management layer.[135] The data management layer is where the collected big data is structured and evaluated, processed, and analyzed to create valuable knowledge and information.[136] The cognitive ability of this layer generates meaning and knowledge through both machine learning and human intelligence out of the provided information and data. The last layer is considered as the application layer, where this knowledge is used for better decisions, management strategies, actions, and services.[137] These strategies are again distributed to subsystems and entities through the transmission layer. In summary, "intelligence" is created through a continuous cycle of collection, processing, distribution, and application of data.

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[133] Bhagya Nathali Silva, Murad Khan, and Kijun Han, "Towards Sustainable Smart Cities: A Review of Trends, Architectures, Components, and Open Challenges in Smart Cities," *Sustainable Cities and Society* 38 (April 2018): 697–713, https://doi.org/10.1016/j.scs.2018.01.053.

[134] Ibid.

[135] Lilis, Conus, Asadi, and Kayal, "Towards the next Generation of Intelligent Building: An Assessment Study of Current Automation and Future IoT Based Systems with a Proposal for Transitional Design."

[136] Silva, Khan, and Han, "Towards Sustainable Smart Cities: A Review of Trends, Architectures, Components, and Open Challenges in Smart Cities."

[137] Ibid.

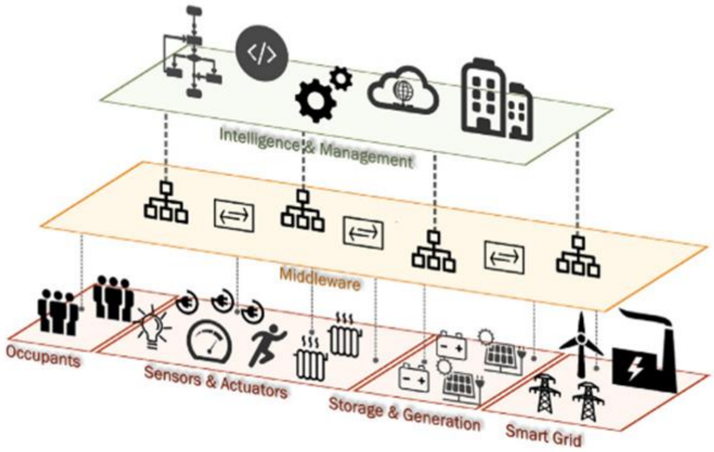

Figure 2.11. The layered approach in the intelligent building system design[138]

This informational structure generated diversified advantages for intelligent cities and infrastructures. First, it provides a two-way flow of energy, information, and communication resources.[139] This multidirectional connection works as a responsive and interconnected network between buildings, infrastructures, people, products, natural, social, and environmental components. With the digital and cognitive abilities, infrastructures are not just providing resources to society; they are also evolved to collect the necessary information to develop better strategies and better decisions for performance, environmental control and resource usage.

As technology can be considered as the core component of smart cities,[140] technology alone is not enough to make a city smart.[141] In parallel to the discourse of infrastructure, smart city developments triggered by technological developments, should be advanced with social, political, economic, and environmental aspects.

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[138] Lilis, Conus, Asadi, and Kayal, "Towards the next Generation of Intelligent Building: An Assessment Study of Current Automation and Future IoT Based Systems with a Proposal for Transitional Design."

[139] Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang, "Smart Grid - The New and Improved Power Grid: A Survey," *IEEE Communications Surveys and Tutorials* (Institute of Electrical and Electronics Engineers Inc., 2012), https://doi.org/10.1109/SURV.2011.101911.00087.

[140] Chourabi, Nam, Walker, Gil-Garcia, Mellouli, et al., "Understanding Smart Cities: An Integrative Framework."

[141] Hollands, "Will the Real Smart City Please Stand up? Intelligent, Progressive or Entrepreneurial?"

Three pillars of sustainability (economic, social, environmental) are considered as an integral part of intelligent urban developments.[142] Therefore, rather than just focusing on techno-utopian features of intelligent urbanism, conceptualizing the different components and challenges of the urban environment is essential for a more balanced understanding of the issue.

As there is no single keyword or definition of intelligent cities, there is also no single set of dimensions produced for the smart cities. Different definitions of smart or intelligent cities provide different dimensions, characters, and parameters of the concept.[143]

Chourabi et al. provided eight critical factors for the smart city: "The eight clusters of factors include (1) management and organization, (2) technology, (3) governance, (4) policy, (5) people and communities, (6) the economy, (7) built infrastructure, and (8) the natural environment."[144] According to Nam and Pardo "Core Components of smart city: technology (infrastructures of hardware and software), people (creativity, diversity, and education), and institution (governance and policy)."[145] Giffinger and Gudrun define the characteristics of the smart city with six dimensions: "quality of life (Smart Living), competitiveness (Smart Economy), social and human capital (Smart People), participation (Smart Governance), Transport and ICT (Smart Mobility), natural resources (Smart Environment).[146]

Consequently, intelligent applications can be considered as an additional layer for cities. This layer implements cognitive abilities and responsive flows and infrastructures for the built environment. While the core components and living

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[142] Marsal-Llacuna and Segal, "The Intelligenter Method (I) for Making 'Smarter' City Projects and Plans."
[143] Hollands, "Will the Real Smart City Please Stand up? Intelligent, Progressive or Entrepreneurial?"
[144] Chourabi, Nam, Walker, Gil-Garcia, Mellouli, et al., "Understanding Smart Cities: An Integrative Framework."
[145] Nam and Pardo, "Conceptualizing Smart City with Dimensions of Technology, People, and Institutions."
[146] Giffinger and Haindlmaier, "Smart Cities Ranking: An Effective Instrument for the Positioning of Cities?"

standards of the city remained, intelligence became available with the technologies, data, social and digital infrastructures. Its parameters can be defined and developed regarding the necessities or premises of a specific urban environment. The primary aim is to make the existing city a more liveable and prosperous place to live. This layer can control environment, social life, and technological infrastructures to increase and improve resilience, connectedness, responsiveness, performance, and efficiency of the built environment.

This intelligence topic examines three of the important components of the intelligent city concept for the sake of this study in terms of technology, environment, and community. In parallel to the conceptualization of this study, these three dimensions provide strategic principles for the number of subtopics. The potential of the technology is already discussed above; the second dimension is the environment, third is the social and human infrastructure. Infrastructure is interrelated with all these dimensions.

2.3.2 Social Ecosystem

One of the most important components of the intelligent city is the community. "Projects of smart cities have an impact on the quality of life of citizens and aim to foster more informed, educated, and participatory citizens."[147] Like the infrastructural discourse, intelligence is also a socio-technical issue, and it cannot be developed without a social layer. Active participation of the inhabitants of the city is crucial for the development and adoption of new technologies. More importantly, the community is a significant component for creating collective intelligence within the information society:

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[147] Chourabi, Nam, Walker, Gil-Garcia, Mellouli, et al., "Understanding Smart Cities: An Integrative Framework."

> “There is a conceptual and practical distinction between digital city and intelligent city. The label intelligent city is usually used to characterize a city that has the ability to support learning, technological development, and innovation procedures. In this sense, every digital city is not necessarily intelligent, but every intelligent city has digital components.”[148]

As knowledge is the most important premise of intelligence, smart urbanism also necessitates the participation of the community in all layers. People are integrated to the initial layer as occupants, the middle layer as infrastructural designers and hardware developers, the data analysis layer as the software and algorithm developers, and the application layer as the managers and controllers. Therefore, the developments always require both hard and soft strategies.[149] Availability and sharing of the data are crucial for intelligent city developments to create an extensive innovation ecosystem to promote social integration and participation and provide collective intelligence.[150]

> “A successful smart city can be built from top down or bottom up approaches, but active involvement from every sector of the community is essential. United efforts create synergy, which allows individual projects to build upon each other for faster progress, resulting in the involved, informed and trained critical mass necessary for transformation of how the entire community carries out its work.”[151]

Since the systems require integration and collaboration of different disciplines, different approaches are generated to search for new solutions to adapt society into

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[148] Nam and Pardo, “Conceptualizing Smart City with Dimensions of Technology, People, and Institutions.”

[149] Appio, Lima, and Paroutis, “Understanding Smart Cities: Innovation Ecosystems, Technological Advancements, and Societal Challenges,” 2019.

[150] Ibid.

[151] Nam and Pardo, “Conceptualizing Smart City with Dimensions of Technology, People, and Institutions.”

the digital revolution.[152] For example, Keidanren (Japan Business Federation) published a report which is called Society 5.0: Co-Creating the Future. The aim of “Society 5.0” is to bring people at the center as the main innovator that actively pioneering this technological transformation. This research focuses on the methods and ways of creating the characteristics of future society which is highly integrated with the emerging digitalization and rapid transformation of technological trends. This highlights the importance of active participation of society in collaborative working processes to increase the awareness and capability of the community for the upcoming developments.[153]

Another critical issue of the smart city is governance, which can be related to the different surveillance, political, institutional, and regulatory issues. As discussed by Chourabi et all, policies are crucial for intelligent initiatives in terms of rules and regulations within a specific in addition to different norms and actions, the behavior of the institutions.[154] “Governance encapsulates collaboration, cooperation, partnership, citizen engagement, and participation.”[155]

2.3.3 Environmental Intelligence

Increasing environmental challenges, scarcity of natural resources, excessive waste, and energy usage, greenhouse gas emissions, global climate change make the environment one of the major discourses and essential components of smart cities. Most of the intelligent city initiatives are developed hand in hand with environmental sustainability, which is mainly referred to as smart sustainable cities.

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[152] Hiroaki Kitano Hiroaki Nakanishi, “Society 5.0 Co-Creating Future” (Japan, 2018), Retrieved from https://www.keidanren.or.jp/en/policy/2018/095_booklet.pdf.

[153] Ibid.

[154] Chourabi, Nam, Walker, Gil-Garcia, Mellouli, et al., “Understanding Smart Cities: An Integrative Framework.”

[155] Nam and Pardo, “Conceptualizing Smart City with Dimensions of Technology, People, and Institutions.”

Sustainable city developments can transform into intelligent cities by implementing an intelligent decision process. Smart systems are used to process the data and create solutions for complex environmental and infrastructural problems. They can regulate the internal and external conditions of the ecological systems to optimize the performance, management, and protection of natural resources.[156] Environmental awareness should be considered at the center of intelligent cities.

2.3.4 Criticism / Challenges of Intelligent Cities

Providing a critical agenda for the smart city is also important for a comprehensive understanding of different aspects. Instead of thinking of smart city developments as an urban utopia that is a savior of all urban problems, they should be recognized with challenges and shortcomings.[157] Relying on only technological developments can generate various problems between different components and stakeholders of the city.[158] Not sufficiently detailed digital transformations can cause different environmental, economic, and socio-political issues.

First, smart cities can amplify social polarization by the gentrification of specific urban environments.[159] Holland also states that most urban problems are not technological; most of the smart city developments fail to answer even the basic sociological or political problems and complexity of cities.[160] Boosting only technological developments can neither solve the fundamental problems of the city and society nor provide equal opportunities to all city components.[161] Developing artificial intelligent systems can gradually substitute humans with machines. Thus,

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[156] Yang and Wang, “Multi-Objective Optimization for Decision-Making of Energy and Comfort Management in Building Automation and Control.”

[157] Hollands, “Will the Real Smart City Please Stand up? Intelligent, Progressive or Entrepreneurial?”

[158] Ibid.

[159] Ibid.

[160] Robert G. Hollands, “Critical Interventions into the Corporate Smart City,” *Cambridge Journal of Regions, Economy and Society* 8, no. 1 (2015): 61–77, https://doi.org/10.1093/cjres/rsu011.

[161] Hollands, “Will the Real Smart City Please Stand up? Intelligent, Progressive or Entrepreneurial?”

it can increase inequality and unemployment[162] and cause economic problems about the distribution of wealth between capital and labor.[163]

> "For instance, despite being a relatively rich country, aided partly through its advanced technological infrastructure, Singapore's poverty level is estimated to be in the region of 25–30 percent of the population. Perhaps even more telling is that during the height of its information technology boom, the city/country became even more polarized.[164]

Therefore, there should be a balance and interrelation between the technology and other necessities of smart developments. Second, since the core component of the smart city developments relies on the data, the critical discussion is how these systems are collecting, using, governing public and private data. These systems can cause surveillance problems because of the monitoring, collection, and usage of personal data. They can be used for dystopian ideals and disruptive features. Cyber security, data privacy, protection, and transparent processes should be supported before diving deep into the technological features.[165]

Third, most smart city developments are promoted, marketed, and handled by corporate companies.[166] Holland states that "it might be argued that beneath the emphases on human capital, social learning and the creation of smart communities, lay a more limited political agenda of high-tech urban entrepreneurialism."[167] These developer ambitions mainly underestimate the complex urban problems into quantitative problems that can be solved with the data and binary solutions in similar

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[162] Ibid.

[163] Erik Brynjolfsson and Andrew Mcafee, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies,* 1st Ed. (New York: W.W. Norton & Company, 2014).

[164] Hollands, "Will the Real Smart City Please Stand up? Intelligent, Progressive or Entrepreneurial?"

[165] Appio, Lima, and Paroutis, "Understanding Smart Cities: Innovation Ecosystems, Technological Advancements, and Societal Challenges," 2019.

[166] Ola Söderström, Till Paasche, and Francisco Klauser, "Smart Cities as Corporate Storytelling," *City* 18, no. 3 (2014): 307–20, https://doi.org/10.1080/13604813.2014.906716.

[167] Hollands, "Will the Real Smart City Please Stand up? Intelligent, Progressive or Entrepreneurial?"

to functionalist urban approaches that emerged before the 1950s.[168] Since the corporate companies dominate the emerging market, developer ambitions can overtake the smart urbanism sector beyond being sustainable.[169] They can overpass the real benefits of the smart cities in terms of social, political, and environmental problems with “technocratic reductionism” to make more profit.[170]

It can be claimed that, mainly because of these factors, smart city developments did not reveal their potential to a full extent yet. As observed from the different smart city initiatives, such as failed promises of Masdar City in Abu Dhabi, cancelled project of Sidewalk Labs in Toronto, underpopulated city of Songdo International Business District in South Korea, ultra-rich development of Eko-Atlantic in Nigeria, they all faced with different problems that are not expected.[171] Although they were very ambitious investments and well-developed technological attempts, they were failed to bring together all components of the city that make it livable. Upcoming smart city projects have a lot of things to learn from the outcomes of these attempts.

As Söderström pointed out, “alternative smart city stories” should be created and promoted to show how smart technologies are utilized for amplifying urban developments, collective thinking, and social networks in contrast to “corporate grand schemes.”[172] Therefore, this thesis aims to promote alternative models and collective approaches for intelligent cities searching for spatial and architectural potentials. University campuses can be an excellent case for such investigation and implementation.

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[168] Söderström, Paasche, and Klauser, “Smart Cities as Corporate Storytelling.”

[169] Hollands, “Will the Real Smart City Please Stand up? Intelligent, Progressive or Entrepreneurial?”

[170] Colin Mcfarlane and Ola Söderström, “City Analysis of Urban Trends, Culture, Theory, Policy, Action On Alternative Smart Cities From a Technology-Intensive to a Knowledge-Intensive Smart Urbanism,” 2017, https://doi.org/10.1080/13604813.2017.1327166.

[171] Zafirah Zein, “Smart Cities of the Future: Eco-Utopia or Dystopian Nightmare?,” March 2, 2020, Retrieved from https://www.eco-business.com/news/smart-cities-of-the-future-eco-utopia-or-dystopian-nightmare/.

[172] Mcfarlane and Söderström, “City Analysis of Urban Trends, Culture, Theory, Policy, Action On Alternative Smart Cities From a Technology-Intensive to a Knowledge-Intensive Smart Urbanism.”

CHAPTER 3

INFRASTRUCTURE OF THE METU CAMPUS

3.1 The METU Campus – Background Information

Middle East Technical University was founded in 1956. The mission of the METU is to provide innovative and modern educational models/methods with different variety of educational facilities for students from all around Turkey and the Middle Eastern region. In that sense, METU can be considered as both the educational infrastructure and model for the near regions. METU started education in the barracks next to the TBMM in 1956, with an emerging need for a new campus for the university. After winning an international architectural competition, Altuğ and Behruz Çinici commissioned to design the new campus in 1961. Constructions of the campus started in 1961 and were primarily completed in 10 years, although some of the structures proceeded to 1980. In addition to academic and educational success in a short period, METU Campus became an outstanding example of the architectural and urban design of the post-war era of Turkish Architecture.[173]

The land of the METU Campus is selected in southwest Ankara adjacent to the Konya and Eskişehir Roads 10 km away from the city center. METU is designed and constructed on a 45 million m^2 vacant land of "Anatolian Bozkır."[174] The buildings occupy 8 million m^2 of this land, and the rest has remained for the green and water. Similar to the other post-war period of university campuses[175], METU Campus is

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[173] Savaş, "METU Campus." See also the Getty webpage

[174] Sargın and Savaş, "'A University Is a Society': An Environmental History of the METU 'Campus.'"

[175] Stefan Muthesius, *The Postwar University; Utopianist Campus and College* (New Haven and London: Yale University Press, 2000).

designed as a self-sustaining settlement that includes all the necessary components of living beyond just educational facilities. The campus is planned for 15000 students and a daily active population of 25000 people with personnel, faculty members, guests.[176]

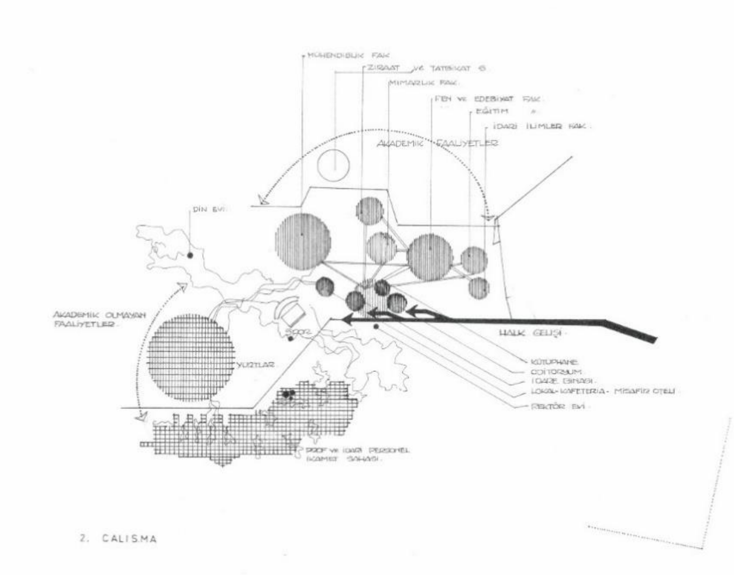

Figure 3.1. “Work” diagram that shows the different zones of the campus[177]

The urban layout and the master plan of the campus are designed in four main zones. The first is the academic zone, where different academic departments are located around a pedestrian alley. The second one is the central zone settled on the East side of the alley, including rectorate, library, cafeteria, and auditorium. The third zone is separated for the accommodation facilities, including the lodgments, dormitories, and social center on the East part of the campus. The fourth zone is the recreational areas where open and closed sports areas are located between the accommodation and academic units. The METU campus embodies academic institutions, educational

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[176] “Report about design decisions and construction process of Middle East Technical University Campus”,Salt Research, “Altuğ-Behruz Çinici Archive - Middle East Technical University” (Ankara, 1961).

[177] Savaş, Derebaşı, Dino, Sarıca, İnan, et al., “Research and Conservation Planning for the METU Faculty of Architecture Building By Altuğ-Behruz Çinici, Ankara, Turkey,” 97.

departments, accommodation units, dormitories and lodgments, a library, cultural centers, museums, open and closed sports facilities, research centers, religious facilities, shopping facilities, medical center, cafeteria, and eating facilities. The campus is planned and constructed to have all the social needs and components of a city.

Creating a new urban settlement on an empty Anatolian Bozkır was not an easy task. Therefore, The METU Campus is facilitated with sophisticated infrastructural design in order to provide necessary resources and living conditions for this new settlement. In 1962, all the developments of mechanical infrastructures are initiated in addition to building constructions.[178] METU constructed all the water, electricity, heating, communication, road, and transportation infrastructures and their subsystems with innovative infrastructural design and meticulous engineering solutions. For the first time in Turkey, all the underground infrastructural facilities, services were designed to be underground. 12 km of underground infrastructural service gallery was constructed to host electricity, heating channels, communication, and water infrastructure.[179] Heating plant and other service and storage facilities located as a new zone in the northwest direction of the campus, below the hill. The central heating system is developed and connected with the buildings with the underground service galleries. Water drilled from the wells near lake Eymir is connected with the campus with 22 km of water infrastructure. The infrastructure of the METU has special significance to enable the existence of the campus, distribute vital resources, and provide a healthy and modern environment for its community.

The third component of creating a liveable environment for the campus is the natural environment. In addition to structural and infrastructural developments, most of the land of the METU Campus is afforested with the efforts of students and staff. Thirty-

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[178] Kemal Kurdaş, *ODTÜ Yıllarım, “Bir Hizmetin Hikayesi,”* 2nd Ed. (Ankara: METU Press, 2004), 65.

[179] Ibid.

three square kilometers of land is planted with trees to provide a green and clean environment for the users of the campus. This effort was praised with the Aga Khan Award in 1995. The large land of the campus now includes forest, lake, archeological settlements, and streams. This forest and natural environment of the campus provide fresh air and recreational areas for both the campus and Ankara city.

With all these facilities, METU Campus is designed and remained as a self-sustaining environment that successfully "engineering the space, nature, and society."[180] It has all the features, assets, and necessary infrastructures to be described as a "small city." A successful and holistic design approach creates a strong consistency between architecture, structure, landscape, and infrastructure of the campus, which provides strong spatial consistency between the architectural, mechanical, landscape, and social infrastructure of the METU campus.

Today METU Campus has more than 27451 students and 2736 academics. It provides education in 218 different educational programs (41 Undergraduate Programs, 108 Master's Programs, 69 Doctoral Programs) in a 45 km^2 area. The campus also has Tekno-park, which includes 444 firms and 9171 research staff. [181] As designed for the capacity of 15000 people[182], the population of the METU Campus is now more than doubled with nearly 35000 population and 45000 daily population.

In addition to this population increase, recent social, technological, and environmental changes and challenges necessitate new methods, needs, and conditions. It is inevitable to rethink the campus and its buildings in these changing contexts/conditions. Understanding the existing and original spirit, characteristics of the campus, and its infrastructure is essential for reconsidering campus infrastructure for the new challenges of the upcoming future. This research may help to read

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[180] Sargın and Savaş, "'A University Is a Society': An Environmental History of the METU 'Campus.'"

[181] METU, "METU at a Glance," 2021, Retrieved from http://ilkbakista.odtu.edu.tr/english/.

[182] Salt Research, "Altuğ-Behruz Çinici Archive - Middle East Technical University."

existing environments and future development of complex infrastructural problems and systems of the urban environments through university campuses. Therefore, this chapter of the thesis aims to extend the infrastructural studies about the METU campus and provide comprehensive readings and alternative connections between the architectural, natural, social, and mechanical systems and infrastructures to achieve technological, intelligent, and sustainable development of the campus.

3.2 Understanding the Concept of Infrastructure in METU Campus

This research investigates the conceptualization and production of the campus infrastructure in terms of different contexts, time, and space in multiple scales. Understanding the scale, time(history), and context of the campus infrastructure is essential to reveal the essential qualities and to investigate potential developments of the infrastructure. Because infrastructures have historical significance, they develop and transform slowly over time. The context is critical to understand the previous conditions and visions in that era to readapt them into recent shifts and technologies. Scale is also significant to generate a general framework to comprehend different relations and networks between the main and subsystems, whole and parts. Understanding the infrastructure is essential to understand how a new city and society has emerged in vacant land.

METU as a "modernity project", campus design and infrastructure also resemble modernist principles and ideals in multiple scales.[183] The modernist preconception of the city that modern, hygienic, rational[184] is obtained/enabled with the necessary

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[183] Sargın and Savaş, "'A University Is a Society': An Environmental History of the METU 'Campus.'"

[184] Sibel Bozdoğan, *Modernizm ve Ulusun İnşası: Erken Cumhuriyet Türkiye'sinde Mimari Kültür* (İstanbul: Metis Yayınları, 2002), 236; Sargın and Savaş, "'A University Is a Society': An Environmental History of the METU 'Campus,'" 609.

infrastructures." As argued by Edwards, infrastructure provides the conditions of modernity:

> "… infrastructures simultaneously shape and are shaped by — in other words, co-construct the condition of modernity. By linking macro, meso, and micro scales of time, space, and social organization, they form the stable foundation of modern social worlds."[185]

In reference to Reyner Banham's article "Home is not a House", Seewang states that "infrastructure acts as the agent between social life and the architecture that accommodates it."[186] Michel Osman also argues the effect of infrastructure and technology on Modernism with the following words:

> "Modernism did not materialize in buildings as the embodiment of an idea about a new society; rather it was constructed through intersections of management with technology and physical infrastructure that operated on the environment and the economy to constrain the errors and deviations endemic to a society invested in growth."[187]

The conceptualization and construction of the campus also have these modernist principles.

METU is an outcome of a particular vision, and it is established with these ideals and principles. The materiality/physicality of this vision is realized on a specific territory with the construction of the campus and infrastructures. It links the vision and territory to establish the new urban fabric:

> "Infrastructures are about the establishment of some strategy or the institution of some normative space. Infrastructures realize specific normativities while

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[185] Edwards, "Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems," 186.

[186] Seewang, "Skeleton Forms: The Architecture Of Infrastructure."

[187] Michael Osman, *Modernism's Visible Hand*, *Modernism's Visible Hand* (Minnesota: University of Minnesota Press, 2018), vii, https://doi.org/10.5749/j.ctt22rbjxn.

> establishing synoptics on territories. They link visions of territories to vision on territories – not always with ultimate fidelity but with a certain objective finality. Infrastructures establish the reality of territories.”[188]

Infrastructures are also site-specific(contextual) spatial entities. In METU Campus, the site and the territory are prepared with the necessary infrastructures before the buildings. Savaş and Sargın mentioned that the infrastructure of the campus tamed the topography of barren land to prepare the conditions of the modern campus and its buildings.[189] The campus infrastructure consolidates the network between campus buildings and general systems to sustain the future urban life with necessary infrastructures. Stan Allen states that:

> “Infrastructure works not so much to propose specific buildings on given sites, but to construct the site itself. Infrastructure prepares the ground for future building and creates the conditions for future events. Its primary modes of operation are: the division, allocation; and construction of surfaces; the provision of services to support future programs; and the establishment of networks for movement, communication, and exchange. Infrastructure’s medium is geography.”[190]

The term “grid” is an important keyword to understand the spatial and infrastructural organization and establishment of the METU Campus. The architectural grid is an organizational instrument of modernism for creating rational design for built environment. The three-dimensional architectural grid of METU Campus is used similarly to Modern predecessors to rationalize the design process by providing a spatial and structural framework for the buildings. It defines consistent cartesian

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[188] Stephen Read and Patrizia Sulis, “Infrastructure as World-Building,” in *Infrastructure as Architecture: Designing Composite Networks*, ed. Katrina Stoll and Scott Lloyd (Berlin: Jovis, 2010), 131–32.

[189] Sargın and Savaş, “‘A University Is a Society’: An Environmental History of the METU ‘Campus,’” 620.

[190] Allen, “Infrastructural Urbanism,” 54.

mathematical reference both for the objects/forms in relation to each other and the spaces in between. The architectural grid of the campus created an organizational layout for the design of the campus in multiple scales, which is flexible for further change, extension, or shrinkage.[191]

On the other hand, the grid is often associated with the infrastructural systems and is particularly used to reinterpret power infrastructure and energy distribution. The infrastructural grid comprises engineering solutions to provide living conditions for the new campus. It distributes the necessary/essential resources through different mechanical systems and components. The similarity between the definition of terms "grid" and "infrastructure" causes the terms to be used interchangeably.

In METU Campus, both the architectural and infrastructural grid is used for the same ambition: to prepare a systematic layout for the new urban conditions. Whereas one is an architectural tool used to regulate campus spaces with similar and consistent design principles, the other is an engineering tool used to provide functionality and services for the campus. By providing a rational system for regulation and further developments, both grids aim to rationalize the construction and services. They provide systematic continuity and organization between different campus scales, landscape, topography, and campus conditions, from city to unit scale.

> "The network of tunnels brought more to the campus than mere technical capacity in that it represented a new instrument in the modernist cognitive world, being utilised first to tame the given barren land, and then to regulate the construction site for further architecture and landscaping. In a similar fashion, both the architecture and landscaping were then overlaid with the infrastructure blueprints so as to complete the envisioned scenario for the METU Project; however, the layout of the main pedestrian walkway, the alley, was designed as the prime instrument for the regulation of the Master

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[191] Francis D. K. Ching, *Form, Space and Order*, *E-Conversion - Proposal for a Cluster of Excellence*, 3rd Ed. (New Jersey: John Wiley & Sons, 2007), 230–37.

> Plan to bring order to what was visible on the surface. If the word ‘tunnel’ was considered a good embodiment of how the land had to be regulated in order to maintain a ‘healthy, ordered and green’ system, the word ‘alley’ was of extreme significance for the same reason”[192]

As Savaş and Sargın explained, the service tunnel is used to tame topography and prepare conditions of site works as the main element of the hard infrastructure. In contrast, the “alley” is the main element of the campus that constitutes the social infrastructure of the campus. Both of them connect all buildings with each other to create a complex urban settlement that both technically and socially works together. Although the first one is under the ground and invisible, this does not make it less important than the other, which is visible on the ground.

These spatial characteristics and physicality of the infrastructure also create the potentials and limits of an urban environment. Infrastructures can provide facilities, yet to a certain extent:

> “… infrastructures act like laws (Winner 1986). They create both opportunities and limits; they promote some interests at the expense of others. To live within the multiple, interlocking infrastructures of modern societies is to know one’s place in gigantic systems which both enable and constrain us. ……Control, regularity, order, system, techno-culture as our nature: not only are all of these fundamental to modernism as Weltanschauung , ideology, aesthetic, and design practice, but they are also (I want to argue) basic to modernity as lived reality.”[193]

The opportunities and limits are essential for the existence of METU Campus and infrastructure for two main reasons. The first one is important in its historical setting.

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[192] Sargın and Savaş, “‘A University Is a Society’: An Environmental History of the METU ‘Campus,’” 620.

[193] Edwards, “Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems,” 191.

The realization of the campus has a specific significance after a period of the problems of international design in Turkey are primarily associated with the unavailability of engineering solutions and immature construction technologies.[194] The infrastructure of the campus also has particular importance that can be thought of as an expression of engineering solutions for an emerging technical university. Innovative qualities of the infrastructural design and development of the campus provided a lot of opportunities in that sense:

> "Since the construction of its first building, the campus had obtained all the necessary architectural tools to be identified as a landmark of Modernism in Turkey. In particular, the construction process illustrated an overarching emphasis on one of Modernity's most basic premises – engineering the society in accordance with the taming of nature. Above all, however, the infrastructure and the architecture with landscaping illustrated how social aspects of modernity could be utilised to overcome some of the shortcomings of modern design attitudes. Perhaps such a complex infrastructure was one of the first implications at that scale due to its immense capacity to include a network of irrigation lines for the landscaping, a complex sewer system, an advanced water purification system and an environmentally friendly central heating system, all of which were encapsulated within a network of tunnels that systematically embraced the entire site."[195]

The second is essential to conceive current conditions and problems of the campus. First campus infrastructure is designed for the 15000 people, and today the population of the campus is more than doubled, which pushes the capacity and limits of infrastructures. Overpopulation and uncontrolled spread of the campus increase the problems about the availability of infrastructures and public amenities.

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[194] Bozdoğan, *Modernizm ve Ulusun İnşası: Erken Cumhuriyet Türkiye'sinde Mimari Kültür,* 317.

[195] Sargın and Savaş, "'A University Is a Society': An Environmental History of the METU 'Campus,'" 620.

The infrastructure of the campus is one of the modern ideals, yet it is a product and outcome of the 1960s. As stated by Read and Sulis, infrastructures have “historical specificity” since they are the outcome of a particular time, vision, and purpose:

> “…They (Infrastructures) are built in specific times and to specific purposes but are then themselves historical and liable to change. They will be products of a certain time in more ways than one: at one level an infrastructure will implement a strategic response to some perceived need or conceived vision; at another, the infrastructure will institute, or consolidate, a structure of places as a network of the generic urban elements we mentioned earlier.”[196]

This time-dependent characteristic of infrastructures requires a continuous need for change and reconsideration. The campus should adapt this transformation to be modern and up-to-date, which also requires new solutions and adaptation of infrastructures for the future of urbanization and societies.

> “Infrastructures are flexible and anticipatory. They work with time and are open to change. By specifying what must be fixed and what is subject to change. they can be precise and indeterminate at the same time. They work through management and cultivation. changing slowly to adjust to shifting conditions. They do not progress toward a predetermined state (as with master planning strategies). but are always evolving within a loose envelope of constraints.”[197]

Stan Allen suggested that infrastructure should change over time, and it has to be ready, stable, and adaptable for shifts.[198] Therefore, this study will evaluate campus’s the existing (legacy) infrastructure and look for the potential compatibility with current needs and expectations.

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[196] Read and Sulis, “Infrastructure as World-Building,” 132.
[197] Allen, “Infrastructural Urbanism,” 55.
[198] Ibid.

3.3 Reading the Campus as a Collection of Infrastructures

Infrastructural reading of the campus enables to investigate the METU campus and architecture through operative systems, continuous flows, networks of social activities instead of steady situations and static buildings. Since the infrastructure can be considered as “Any public asset that provides essential services to citizens.”[199] In a general framework, the infrastructure of the METU Campus is conceived as a producer of “public space” in this study. This understanding reveals a lot of possibilities, flexibilities, interception, and relations in between, which also redefines the boundaries between different scales, topics, disciplines, and territorial conditions. Seewang states that:

> “Viewing the city as a collection of infrastructural projects that mediate natural resources in order to supply urban needs re-frames the concept of “the city” into a complex site of social, political and economic forces.”[200]

The meticulous infrastructural design of the METU campus can be examined on different scales. On the more comprehensive framework, METU itself can be considered infrastructure for education, production, and innovation on a macro scale. The aim of establishing METU was to cultivate young generations to develop contemporary societies in the nation and even for the Middle East countries.[201] However, this scale of the issue is beyond the scope of this thesis. This research mainly focuses on the meso and micro scales of the urban and architectural design of the campus and its infrastructure.[202]

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[199] Steve Cimino and Ellory Monks, “Defined by Our Infrastructure,” AIA Feature, 2017, Retrieved from https://www.architectmagazine.com/aia-architect/aiafeature/defined-by-our-infrastructure_o.

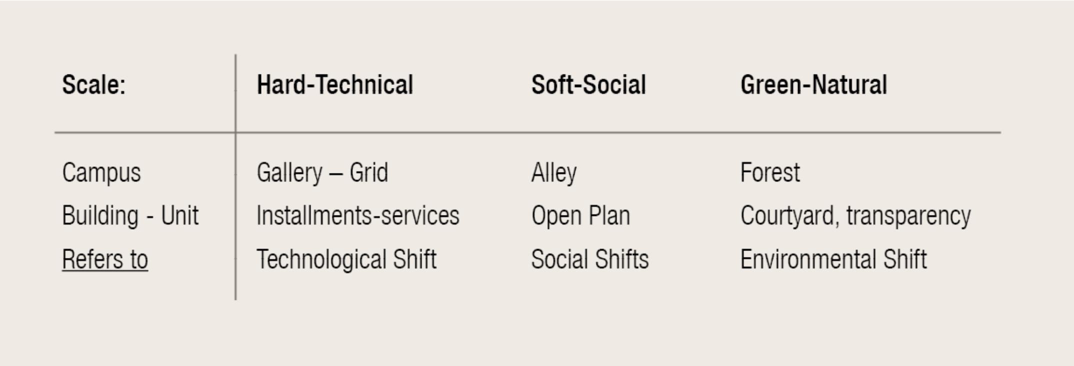
[200] Seewang, “Skeleton Forms: The Architecture Of Infrastructure.”

[201] Sargın and Savaş, “‘A University Is a Society’: An Environmental History of the METU ‘Campus,’” 607.

[202] Issue of “scale” was one of the themes in the joint international architectural design and research studio named "Modern Campus | Campus Utopias" that I participated as research assistant in the Fall 2021 semester and Arch505 and Arch571 courses I attended at METU between the years 2019 and 2020.

On the meso and micro scales, The METU Campus can be re-read/investigated as a collection of hard-technical, soft-social, and green-natural infrastructures and spaces. The design, conceptualization, and production of the campus do not prioritize one onto another. There is a strong balance between the mechanical, landscape, and social infrastructure of the METU campus both in the urban and architectural scales. These qualities make the campus a great example of the combination of hard, soft, and green infrastructures. This triad of infrastructures constitutes the primary research and enables to claim alternative relationships between the infrastructures and the aforementioned technological, social, and environmental challenges.

In general, infrastructures are premises of upcoming urbanization and living conditions on the campus. Hard infrastructure provides the necessary resources and essential services to the buildings. In contrast, the soft infrastructures respond to the users' needs with many social, recreational, cultural, informational facilities. The green one generates a landscape that embraces all the campus and buildings with natural and healthy living areas. It praises nature. On the campus, architectural-urban design and production tools provide similar infrastructural qualities in different scales.



Scale:	**Hard-Technical**	**Soft-Social**	**Green-Natural**
Campus	Gallery – Grid	Alley	Forest
Building - Unit	Installments-services	Open Plan	Courtyard, transparency
Refers to	Technological Shift	Social Shifts	Environmental Shift

Figure 3.2. Classification and Scales of Campus Infrastructure

On campus-scale, the main element of the social infrastructure is the alley, the hard one is the central systems and service tunnels, and the green and blue refers to the forest and lakes. Hard infrastructures embrace the campus from outside the with underground galleries with the advanced design of infrastructures and upper ring-road transportation network. Alley is at the center of campus and buildings, which is the main element that creates social infrastructure and network throughout the academic buildings. Whereas the green is located in between infiltrates between buildings embraces both and connects with the entire campus, which also redefines the boundary of the campus.

In building scale, social infrastructure is provided with the “open plan” as a continuation of the alley into the buildings, which promotes the flexible and dynamic usage of spaces. Technical necessities of hard infrastructure are supplied with careful design and cutting-edge detailing of mechanical services. The landscape is infiltrated into the buildings with courtyards, skylights, and large transparent surfaces, creating visual and spatial continuities between inside and outside, natural and built. This study will investigate the triad of infrastructures and expand them one by one.

Representing the Infrastructures:

Representation was one of the essential tools for the studies about the METU Campus. Starting from 1999, “METU Documented: Representing Itself” exhibition series curated by Prof. Dr. Ayşen Savaş aimed to represent and document METU Campus.[203] In the course entitled “METU Arch524 Architecture and Different Representation Modes” held by her, “representation” is discussed as a way of seeing, learning, and a tool for design. Re-drawing a building is considered as a creative architectural survey, representation, and design tool. This course and exhibitions discussed representation modes and produced all kinds of media from films to photographs, dancing to modeling, music to video mapping. The author is also participated in these courses and exhibitions between 2018-2021 and produced films and drawings for the exhibitions.

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[203] Ayşen Savaş, “The METU Campus Documented V: Representing Itself,” *METU Journal of Architecture* 57, no. May (2019): 285–95.

The outcome of these studies has significant importance for this study for representing the data to survey, represent, and produce information. In this study, diverse architectural representation techniques are used to explore, discuss, and investigate the different components and scales of the infrastructure of the METU Campus.

Digital models and mappings are created by examining a set of pre-construction, construction, post-construction documents. The style used in these drawings is specifically referenced from the style of architects' original blueprint campus drawings in respect to the design of the campus. Although similar drawing styles are used to create different architectural representations, this thesis does not reproduce the original drawings, but extends them. Series of 2D, 3D, perspective, axonometric drawings, diagrams, and models are created to explain and visualize different systems, scales, and flows to reveal advantages, problems, and potentials. The drawings prepared for the intelligent campus proposals were clearly separated from the other visuals in terms of color and drawing technique. Diagrams have a specific significance because they are adapted from engineering solutions to architectural design for rational solutions and systems. "By means of the diagram that these new matters and activities along with their diverse ecologies and multiplicities can be made visible and related."[204] They are used to present both tectonic, engineering, and architectural qualities to show relations.

In this study, the infrastructural investigation of the buildings has been greatly inspired by the article "Home is not a House" written by Reyner Banham and illustrated by François Dallegret. Especially the drawing entitled "Anatomy of Dwelling" is highly inspirational to create "Anatomy of Lecture Halls."

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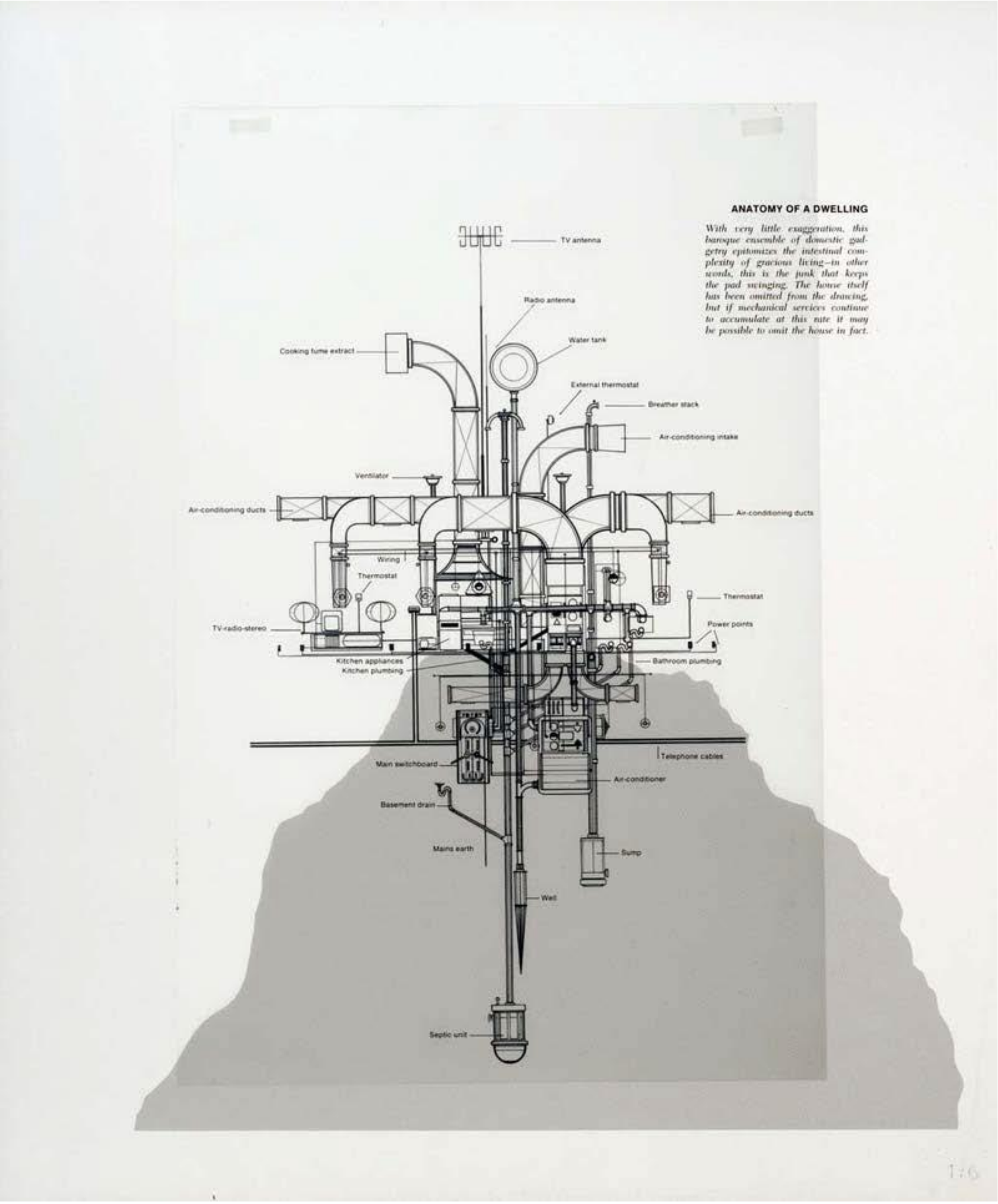
[204] Robert E. Somol, "Architecture without Urbanism," in *Points + Lines: Diagrams and Projects for the City,* 1st Ed. (New York: Princeton Architectural Press, 1999), 138.



ANATOMY OF A DWELLING

With very little exaggeration, this baroque ensemble of domestic gadgetry epitomizes the intestinal complexity of gracious living—in other words, this is the junk that keeps the pad swinging. The house itself has been omitted from the drawing, but if mechanical services continue to accumulate at this rate it may be possible to omit the house in fact.

Figure 3.3 Anatomy of a Dwelling by Reyner Banham & François Dallegret[205]

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[205] Banham and Dallegret, “A Home Is Not a House,” 71.

3.3.1 Infrastructure and/as Engineering: Hard Infrastructure of METU Campus

Hard infrastructures mainly refer to mechanical infrastructures and physical assets. They enable control over the environment[206] and provide essential resources to urban settlements. By regulating resources, controlling topography, protecting, and providing necessary matters, hard infrastructures maintain fundamental standards of living. The hard infrastructures of The METU can be classified and investigated as heating, electricity, water, ICT, and mobility systems.

On campus-scale, the hard infrastructures of the campus constructed the site and enabled the existence and future developments. They established the relationship with the environment, topography, and natural conditions and provided vital resources for the community. They also provide physical networks between the city, campus, and buildings and connect all of them with each other. On a building scale, mechanical services provide living conditions and protect the users from environmental conditions. Therefore, infrastructures have a strong relationship with architecture, environment, and structural solutions.

In his memory book "ODTÜ Yıllarım, "Bir Hizmetin Hikayesi" Kemal Kurdaş gives information about the establishment, developments, and construction of the campus infrastructures. He states that "A modern university must first have sufficient physical facilities to provide the expected services."[207] Therefore, starting from 1962, in addition to all construction schedules, infrastructural developments of the METU Campus have been initiated. The campus is prepared for the new users with the hard infrastructures. Road, electric, heating, communication, wastewater, and sewage services were auctioned in the first half of 1962.[208]

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[206] Edwards, "Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems," 188.
[207] Kurdaş, *ODTÜ Yıllarım, "Bir Hizmetin Hikayesi,"* 29. Translated by the author
[208] Ibid., 69.

In parallel with the construction of METU Faculty of Architecture, road, electricity, communication infrastructures were completed till October 1963. All the infrastructural facilities were constructed in the 1960s, including heating plant and network, disposal facilities, lighting, sewerage, drinking water, and external telephone network. The infrastructural system is designed in a strong relationship with the natural resources and topographic conditions. Also, for the first time in Turkey, a wastewater and sewage treatment plant has been established.[209] These systems enabled the campus to have modern, efficient, civil, and sanitary infrastructures and conditions.

Since such infrastructures are the first example in Turkey, METU had to deal with all these problems. The establishment and construction of the infrastructures are also used as a "learning laboratory".[210] With its novel construction and infrastructural technologies, METU pioneered many innovations in terms of infrastructure in Turkey. One of the most significant of them is the underground service gallery.

Figure 3.4 The hard infrastructures of the METU Campus, redrawn by the author[211]

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[209] Ibid., 65.

[210] Savaş, Derebaşı, Dino, Sarıca, İnan, et al., "Research and Conservation Planning for the METU Faculty of Architecture Building By Altuğ-Behruz Çinici, Ankara, Turkey," 342.

[211] Drawings are re-produced based on the information provided by Barış Yağlı.

3.3.1.1 Underground Service Gallery – METU Tunnels[212]

In the METU Campus, for the first time in Turkey, all the infrastructural networks and services were designed to be underground.[213] 12 km of underground vaulted stone infrastructural service gallery is constructed to host electricity, heating pipelines, communication, and water infrastructure. METU has become the first institution in Turkey to provide underground infrastructure services.[214]

The construction of the galleries was carried out with the road constructions. Infrastructural investigation reveals that tunnels are also designed similar layout with the road infrastructure surrounding the main campus with a ring system. Therefore, roads also serve for the mechanical infrastructure with their complex underside gallery system. The galleries reach the buildings with extended branch lines of the main gallery and feed the campus buildings from the surrounding. This infrastructural design not just overlaps with the other infrastructures and superstructures but also rationalizes services and provides systematic continuity between different campus scales, landscape, and topographical conditions. The galleries connected all the campus buildings with each other and the central infrastructural services.

With the help of original construction photographs and gallery inspections, the cross-section model of the gallery is created for this study. This section model shows both the spatial characteristics, dimensions, and infrastructural services that the gallery hosts. The tunnels mainly carry clean water, electricity, heating pipelines, and IT infrastructure. The scale and dimension of the gallery vary and get larger at the intersection points. Except for these intersection points, the width of the gallery is

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[212] METU Keeping it Modern Getty Report particularly highlights many issues related with METU Tunnels and all the materials has to be used in reference to that report and please also see forthcoming paper about METU Campus Infrastructure submitted to “OverHolland”.
[213] Kurdaş, *ODTÜ Yıllarım, “Bir Hizmetin Hikayesi,”* 65.
[214] Ibid., 71.

mainly between 1.5 and 2 meters, and the height differs between 2 and 2.5 meters. Building extension branches are also relatively narrower than the main gallery. The original galleries were made of stone masonry walls and vaulted concrete. Later additions were constructed with reinforced concrete in a rectangular section layout without vault. It can be claimed that the gallery is an infrastructural masterpiece.

Figure 3.5 The construction of road and service tunnels[215]

Figure 3.6. Photos from the gallery inspection, taken by the author

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[215] Retrieved from METU Library Visual Media Archive, on August 15, 2021.

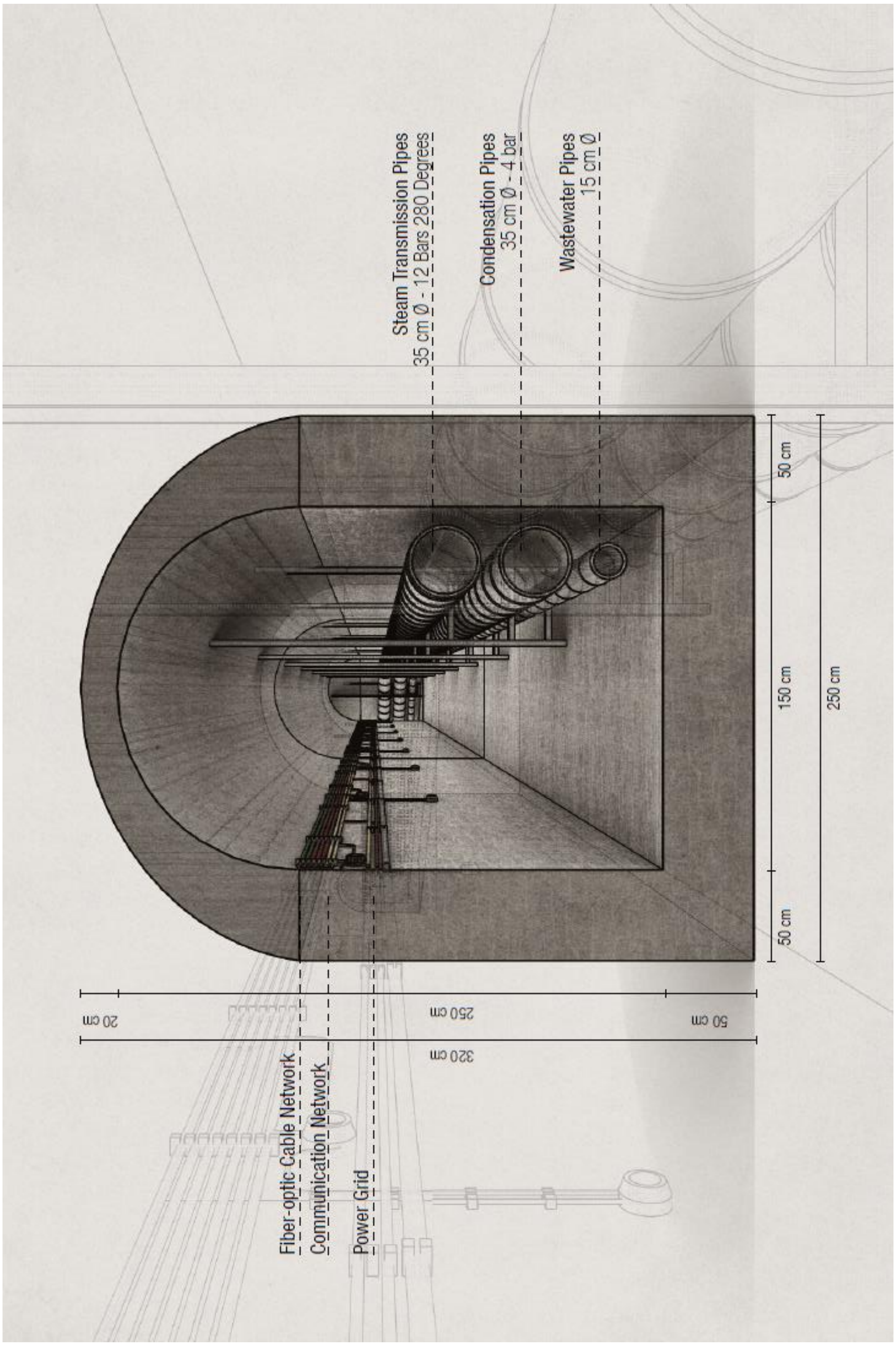

Figure 3.7. Cross-section model of the gallery, drawn by the author

3.3.1.2 Heating Infrastructure

One of the essential components of the hard infrastructure of the METU Campus is the central heating system. The main campus is heated from the central heating plant, where the heat is distributed to buildings through the underground service gallery.

Brief History:

Constructions of the first part of the heating plant, underground gallery, and technical facilities were completed in 1963. The system of the heating plant of the METU Campus was designed by the German firm called SHG, which won the international competition for the heating system. Since such infrastructure was the first example in Turkey, there was no Turkish company that knew how to install the central heating system and steel transmission pipes exported from Germany. The construction of the heating plant is held by the METU according to the specifications and spatial needs that the firm provides. Construction of the heating plant with a height of 7 m and an area of 1850 m^2 was completed in 1963. Underground gallery, transmission pipelines, and the exchangers that connect each building to underground pipes were also constructed. The heating system in the power plant was also completed in that time.[216] However, there was a lack of experienced staff to operate the system since these systems were new in those days. With the help of a retired navy officer, a crew was established, trained, and employed for many years to operate the heating plant. Later with the addition of new buildings on the campus, the need was emerged to increase the capacity of the heating plant. SHG company again won the second international competition. With the addition of a 1000 m^2 area and a 40 ton/h capacity boiler, the capacity of the power plant was increased from 25 tons to 65 ton/h by the SHG, Selnikel consortium in 1968.[217] This system operated served the needs of the campus for more than 50 years, efficiently, clean, and safe.

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[216] Kurdaş, *ODTÜ Yıllarım, “Bir Hizmetin Hikayesi,”* 71–73.
[217] Ibid., 92–97.

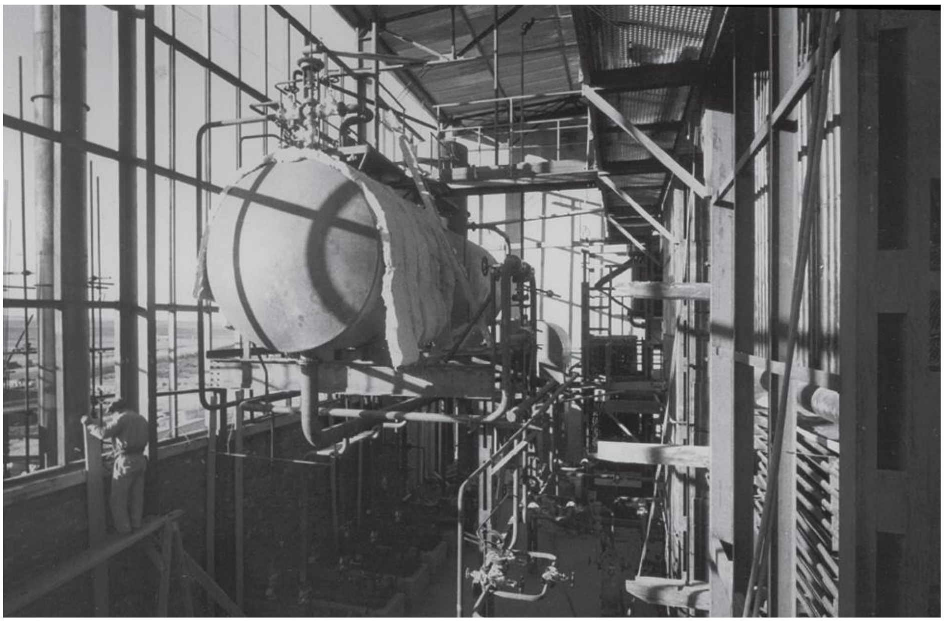

Figure 3.8. Photographs of Central Power Plant[218]

In addition to the central heating plant, 12 km of 2 meters by 2 meters vaulted stone underground service tunnel gallery is designed to hold necessary infrastructures and distribute heat to the buildings. This gallery connects all the buildings in the campus with the heating plant. Transmission lines in the gallery distribute heated steam to the buildings and collect condensated water.[219] As Kurdaş states, since this gallery was the first example in Turkey, there were issues and problems about the construction and isolation of transmission pipelines. The company that Orhan Işık and Paşa Bey established became responsible for developing the system of transmission pipes. Isolation and expansion of steel pipes created many problems because steam and hot water can overheat the lines and tunnels. They found a regional soil called "bebe toprağı (baby soil)" from Nevşehir and mixed it with minerals imported from Italy to create an isolation paste for the pipes. The heating system started to heat METU Faculty of Architecture on 7 November 1963. For

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[218] Savaş, Derebaşı, Dino, Sarıca, İnan, et al., "Research and Conservation Planning for the METU Faculty of Architecture Building By Altuğ-Behruz Çinici, Ankara, Turkey," 324.
[219] Kurdaş, *ODTÜ Yıllarım, "Bir Hizmetin Hikayesi,"* 71.

many years, the system has provided clean, efficient, and comfortable spaces for the students and staff.[220]

The System:

To understand how the heating and water infrastructure of the campus works, an interview was conducted with Yasin Mert, who is the current manager of METU Office of Central Heating and Water Support, on 15 December 2021. Information about the current condition and operational system of the campus water and heat infrastructure was compiled from the information he provided in this interview.

The central heating system of the METU Campus is simply working as follows: The heating plant provides superheated dry steam at 280 degrees with 12 atm pressure in the radiation-type boilers.[221] The heated steam is pumped from the central plant to the campus through steam transmission pipelines in the gallery, which have a 350 mm diameter.[222] The gallery is connected to the mechanical rooms of each building. Steam pipeline reaches the mechanical rooms of the buildings through the gallery and connects with the heat exchangers. Incoming heated steam transfers its energy to the inner heating system of the building in the exchangers and condenses into a liquid. The condensed water is collected with the 4 bar condensation pipelines and returned to the heating plant with the help of gravity. Contrary to the campus settlement, the heating center is cleverly constructed at a lower level from the campus. There is no energy or local pumping system used to return condensed water in the condensation pipes with the help of natural forces and exceptional details in the original design.[223]

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[220] Ibid., 72.

[221] METU Water and Heating Directorate, “Technical Information,” 2019, Retrieved from http://isim.metu.edu.tr.

[222] Savaş, Derebaşı, Dino, Sarıca, İnan, et al., “Research and Conservation Planning for the METU Faculty of Architecture Building By Altuğ-Behruz Çinici, Ankara, Turkey,” 326.

[223] Yasin Mert, “Interview about Heating and Water Infrastructure of METU Campus” (Ankara, 2021).

Internal heating of the buildings is provided from the mechanical rooms of the buildings. Mechanical rooms mainly include heat exchangers, steam pressure reducers, boilers for hot water, and air conditioning systems. The water heated by the steam in the heat exchanger is sent to the internal heating of the building by the circulation pump. It feeds the necessary interior components of the building for heating either with fan-coil, air handling units, or radiators. The heat exchangers can also provide heat for the air conditioners.[224] The diagram explains the basic principle of the central heating system and underground galleries of METU Campus.

Since the buildings were constructed with bare concrete without any thermal insulation, larger and higher spaces required fan-coils for heating. METU was the first application of fan coils in Turkey, which also required unique technical details and solutions. The system of fan-coils was developed by Mechanical Engineer Kevork Çilingiroğlu in collaboration with the Alarko.[225]

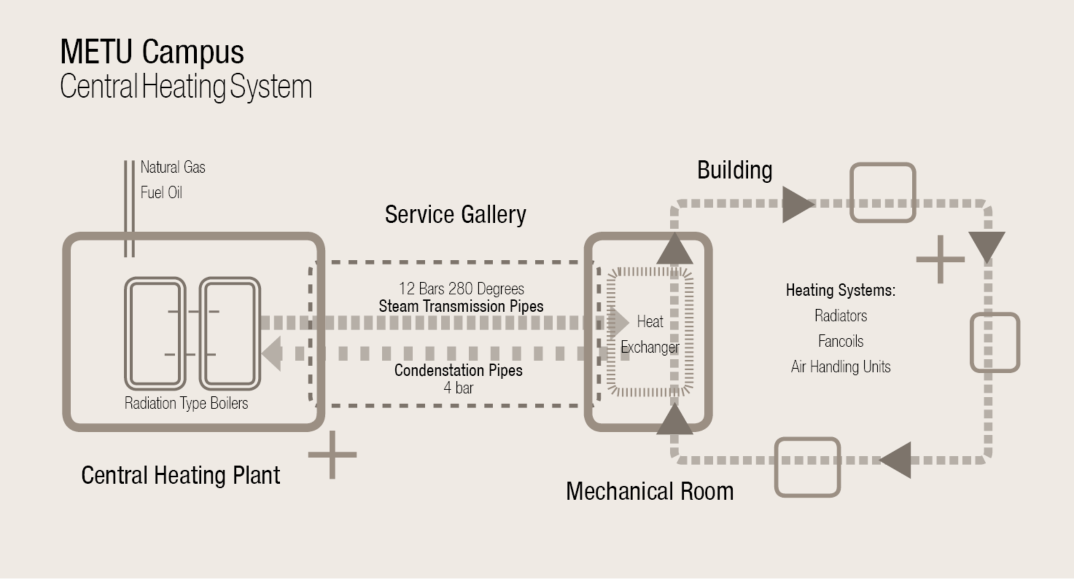

Figure 3.9. Central Heating System of the METU Campus, drawn by the author

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[224] Ibid.

[225] Savaş, Derebaşı, Dino, Sarıca, İnan, et al., "Research and Conservation Planning for the METU Faculty of Architecture Building By Altuğ-Behruz Çinici, Ankara, Turkey," 327.

Recent Condition:

This heating system is still working in full capacity with the same principles. Except for the Technopark and west campus buildings, the main campus is heated from the central heating plant. According to the METU Office of Central Heating and Water Support, since the original 45 ton/h capacity boiler is expired, initial boilers were replaced with two pieces of fully automated radiation type boilers with the capacity of 65 ton/h in 2005(by Selnikel) and in 2014(İsimek). The boilers can run with dual fuel (natural gas and fuel-oil). The original energy resource of the system was fuel-oil; the heating center still has four fuel-oil tanks as a backup system. Today, natural gas is mainly used to generate hot water and steam because it is more efficient and clean compared to fuel-oil. The heating plant meets the need for heating, hot water preparation and steam in winter, and hot water and steam in summer. It operates 11 months in a year and consumes approximately 11.000.000 m^3 of natural gas.[226] Also, in the heating center, pure water is produced by conditioning the water with chemicals. This treated water is used in the boilers of the central heating plant, which increases the lifetime of the boilers and the overall system. With the new developments, there is almost no leakage in the system, and the need for conditioned water is not more than 30 m^3 for a day.

The initial galleries of the campus have been extended, and now METU Campus has a total of 25 km of (11 km main, 14 km secondary) underground service gallery. The original galleries were made out of vaulted stone, and later additions were reinforced concrete. Even the relatively new buildings in the inner campus are also connected to the heating system with additional galleries. The initial design was arranged according to heat around 250.000 m^2 of closed space, but today, the central heating system provides heat and hot water for 620000 m^2 closed area with the addition of new buildings. Therefore, almost double of space and users heated today with the

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[226] METU Water and Heating Directorate, "Technical Information."

first infrastructure of the same pipes and heating center. The original infrastructure was designed with a foresight to meet even this increase.

Figure 3.10. Central Heating Plant and Fuel-Oil Tanks, taken by the author

Efficiency:

There were lots of efforts and renovations made to increase the efficiency of the system throughout the years. All the former tube heat exchangers have been replaced with plate heat exchangers, which operate around 50% more efficiently. With each replacement, the building heating has been transformed into automated systems. Insulation of transmission lines is also very important for the efficiency of the system. In fact, “baby soil” was a very good insulation coat material, some of the soil used to insulate pipelines contained asbestos. Therefore, it has been replaced with rock wool after the new regulations enacted in 2012. The original pipes are still in use for almost 60 years. In addition to the insulation of pipelines and heat exchangers, valves were also insulated with valve jackets to minimize the energy loss in the system. According to the Office of Central Heating and Water Support, although the central heating system increases operating and maintenance costs, it provides a 25 percent advantage over local systems.[227]

Today, all the heating system works fully automated, and they can be controlled both on-site and remotely with the Supervisory Control and Data Acquisition(SCADA) systems 24 hours a day. The system automatically adjusts fuel amounts by analyzing flue gas and weather conditions in the heating plant. It also enables monitoring all the devices for problems and issues in the mechanical rooms and building heating components. System efficiency has been increased significantly with all these automation of systems, software developments, renovation, and insulation works. The energy used to heat 320000 m^2 in the past is now sufficient to heat 620000 m^2.[228] However, the main problem is the excess energy consumption of bare concrete buildings. Since there was no environmental agenda for energy efficiency and consumption in the 1960s, the environmental performances of buildings are weak.

In the 1960s, when the buildings were mainly heated with coal and other primitive energy resources, METU Campus pioneers the central heating systems that provide a clean, safe, and efficient way of heating. The realization of the heating infrastructure was beyond the expectations of that day, it was adapted to new energy resources and automation, and the system is still in operation. Therefore it can be considered as an early model of energy-efficient and clean infrastructural design. With the similar ambition of creating a self-sustaining settlement, circular and sustainable heat and energy models have to be provided in the METU Campus.

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[227] Mert, “Interview about Heating and Water Infrastructure of METU Campus.”

[228] Ibid.

3.3.1.3 Power Infrastructure

METU Campus comprises academic and accommodational units where its community is active in the campus all the time and dependent upon power supply. Power infrastructure is one of the basic premises of the METU to comprise the electricity needs of the whole campus and one of the main components of the hard infrastructure.

The power of the METU Campus is supplied from the High Voltage electrical distribution grid of Ankara. This electricity is distributed from 5 central distribution centers to campus with a medium-voltage (MV) distribution network. A medium-voltage network enables to decrease the power loss and ensures power stability.[229] MV networks connected with the 35 building type transformers with a total power output capacity of 44.520 kVA.[230] The power is stepped down by transformers and transmitted to the buildings with mainly low-voltage networks since they are located close to buildings. The power generally goes to the electrical room of the buildings and distributed to the building from the service panels in electrical rooms.

The total electricity consumption of the campus was 35.032.707,60 kWh in 2019.[231] With the increase of digital technologies, personal devices, and ICT systems, this power need is expected to increase in the coming years. Therefore, the MV distribution grid should be improved for reliability and to meet this growing need.[232] As a backup system, the campus has 38 diesel power generators distributed to buildings in case of any power cuts to provide the necessary power for the buildings.

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[229] Şeyda Ertekin, Ozan Keysan, Murat Göl, Hande Bayazıt, Tuna Yıldız, Andrea Marr, et al., "METU Smart Campus Project (IEAST)," in *International Conference "New Technologies, Development and Applications" Lecture Notes in Networks and Systems*, vol. 76 (Springer, 2020), 292, https://doi.org/10.1007/978-3-030-18072-0_34.

[230] METU Electrical Directorate, "Technical and Statistical Information," 2020.

[231] Ibid.

[232] Ertekin, Keysan, Göl, Bayazıt, Yıldız, et al., "METU Smart Campus Project (IEAST)," 292.

The total power capacity of generators is 21.479 kVA. There are also 170 uninterruptable power supplies with a power capacity of 5.679 kVA in the campus.[233]

Again, the original power distribution network of the campus was designed to be underground. The initial power distribution center of the campus was located on the east side of the library, down from the main vehicle road. It was connected with the electrical distribution grid of the city with a high-voltage overhead power transmission line. Later, this power distribution center was moved to near A1 Gate. The energy is now distributed to the campus from A1 with three main lines. Technopark has also separated from the central campus grid. With the increase of campus population, area, and expansion of technological devices, the capacity and number of transformers and distribution centers area increased throughout the years.

Since most campus buildings are constructed in the same period with similar standards and technologies, investigations done for the power grid of METU Faculty of Architecture can be considered valid for the other inner campus buildings as well:

> "As the building is designed according to standards in practice during 1960s, the electrical design includes grounding systems only for main distribution panels, and the building does not have a lightning protection system. It is not equipped with an earth leakage circuit breaker (ELCB). Lighting fixtures in the building are still active after over 60 years, and half of the switches in use are the originals… … Since there were no fire detection systems in place in the years of construction, fire safety system features manual fire alarm buttons and horns."[234]

Throughout the years, in addition to the improved capacity of the overall campus power grid, the internal electrical grids of the buildings are also enhanced. The capacity and number of power switches, outlets, and sockets increased. Essential

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[233] METU Electrical Directorate, "Technical and Statistical Information."

[234] Savaş, Derebaşı, Dino, Sarıca, İnan, et al., "Research and Conservation Planning for the METU Faculty of Architecture Building By Altuğ-Behruz Çinici, Ankara, Turkey," 326.

educational systems such as projections, cameras, wireless and cabled internet connection networks, and microphone systems are implemented into the lecture rooms, offices, and common areas throughout the entire campus. Also, necessary CCTV and fire detection systems located into some critical buildings of the campus. The exterior lighting of the campus is designed with the campus's overall layout, which is operated and controlled by a central system.[235] "The majority of streetlights at METU campus are conventional Mercury-vapor or Sodium-vapor lamps"[236] Energy efficiency of the lighting is low because of conventional vapor lamps and the absence of motion or lighting sensors on the lighting systems. Today, the Campus has almost no renewable energy sources except for local solar panel implementations in the METU Department of Electrical and Electronics Engineering.[237]

3.3.1.4 The Water Infrastructure

In the first years of METU, necessary water for the construction and campus is provided from the springs at Yalıncak Village. Yalıncak was an ancient Galat City, and springs there were provided 3-4 liters per second for the water needs of the campus.[238] In order to meet the water needs of the new settlement, METU investigated groundwater resources in the campus land at Bursallı Valley near Eymir Lake İncesu Stream creek. Two artesian wells were drilled there in 1963, providing 90 liters of water per second. The system of the campus's water infrastructure was designed by Süleyman Demirel, the former president of Turkey. Construction and the engineering of 22 km of water infrastructure are completed in 10 months before 1964.[239] Although the campus population is doubled in that period, this system is still in operation and provides the drinking and utility water needs of the campus.

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[235] Ibid., 325.

[236] Ertekin, Keysan, Göl, Bayazıt, Yıldız, et al., "METU Smart Campus Project (IEAST)," 294.

[237] Ibid., 293.

[238] Kurdaş, *ODTÜ Yıllarım, "Bir Hizmetin Hikayesi,"* 76.

[239] Ibid., 73–77.

The system:

Information about the water infrastructure of the campus is studied from the master's thesis entitled "Sustainable Water and Stormwater Management for METU Campus", written by Melike Kiraz, supervised by Assoc. Prof. Dr. Emre Alp, and the interview held with the Office of Central Heating and Water Support. That thesis provides detailed information about the water infrastructure of the campus.

The water extracted from the wells in Bursalı Valley is treated and chlorinated in Eymir. Treated water is pumped to the Oran Water reservoir located at a higher altitude. From the reservoir in Oran, the water reaches the campus by gravity.[240] Since the altitude difference is too much, the pressure of the water coming to the campus is reduced in three in three break pressure tanks to prevent excess pressure in the pipes. The incoming water reaches to the three water reservoirs in the campus. The first reservoir is located in Yalıncak, the second one is near Mining Engineering, and the third reservoir is located near the School of Foreign Language. These three reservoirs provide water for all the departments and buildings on the campus according to the necessary pressure levels. The higher altitude reservoir in Yalıncak transfers water to higher buildings, the Mining Engineering depot transfers to the west campus area, and the Preparatory school transfer to the Heating Plant and other facilities. In this way, water is distributed to the whole campus with the help of gravity without using energy. In addition, the Yalıncak Water reservoir is also connected with the ASKİ (Ankara municipal water grid); water can be supplied from the municipal water infrastructure of Ankara if necessary as a backup system. The diagram explains the main water infrastructure of the METU campus in relation to the natural slope of topography.

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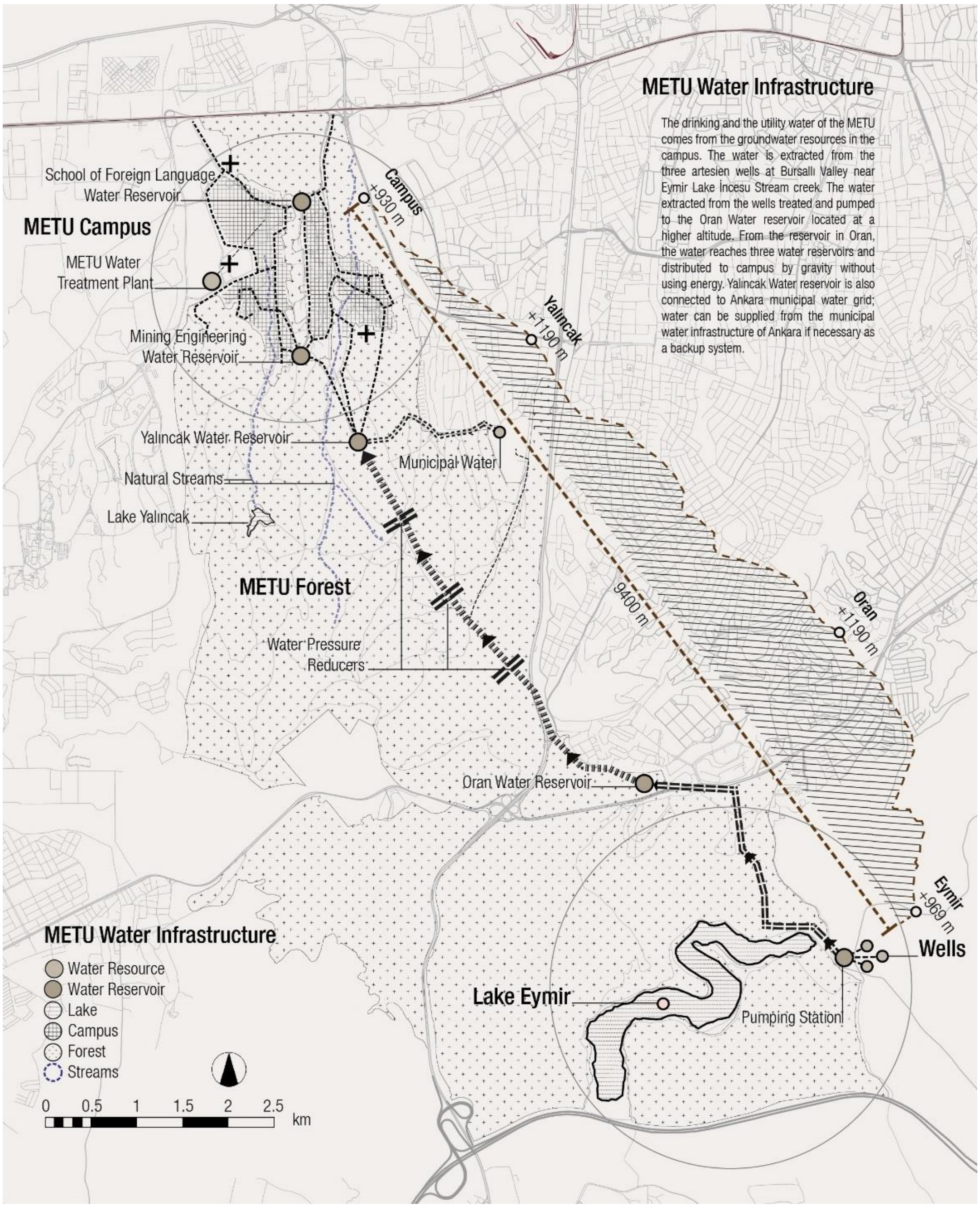
[240] Melike Kiraz, "Sustainable Water and Stormwater Management for METU Campus" (Middle East Technical University, 2018).



The drinking and the utility water of the METU comes from the groundwater resources in the campus. The water is extracted from the three artesien wells at Bursallı Valley near Eymir Lake İncesu Stream creek. The water extracted from the wells treated and pumped to the Oran Water reservoir located at a higher altitude. From the reservoir in Oran, the water reaches three water reservoirs and distributed to campus by gravity without using energy. Yalıncak Water reservoir is also connected to Ankara municipal water grid; water can be supplied from the municipal water infrastructure of Ankara if necessary as a backup system.

Figure 3.11 Water Infrastructure of the METU Campus, re-drawn by the author[241]

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[241] Drawing is created according to drawings provided in the thesis entitled “Sustainable Water and Stormwater Management for the METU Campus” by Melike Kirazlı and according to interview held with the Yasin Mert from the METU Office of Central Heating and Water Support

The quality and conditions of the water are controlled with the samples taken from the pumping station and the last points where the water reaches. Necessary analyses are carried out to measure water conditions and bacteria levels. The entire water infrastructure of the campus can be controlled and observed with the Supervisory Control and Data Acquisition (SCADA) system. Water levels of wells are also monitored.[242] There is no leakage detection integrated into the system; it can be understood from the excessive water consumption values.[243] METU Campus also has a very complex water network for the irrigation of the landscape.[244] There is no distinction between daily use water and irrigation water on campus. The campus landscape is irrigated with the same water from May to August.[245]

The METU Campus also constructed the first wastewater treatment plant in Turkey in the 1960s. The original treatment plant is located on the west campus, close to the A9 gate. The treatment plant has been transformed and extended several times throughout the years. It was finally transformed with the implementation of a Vacuum Rotating Membrane (VRM) bioreactor in 2005 with the supervision of Prof. Dr. Celal Gökçay from the Department of Environmental Engineering at METU. This facility only uses the raw wastewater of west campus dormitories and METU academic village.

The usage of the VRM system is also the first example in Turkey, and the plant is still in operation. It purifies 200 m^3 of wastewater per day. The water purified in the plant is collected in the water reservoir and used for the landscape irrigation of Teknokent.[246] The two inactive waste stabilization lagoons were also renovated to

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[242] Kiraz, "Sustainable Water and Stormwater Management for METU Campus."

[243] Mert, "Interview about Heating and Water Infrastructure of METU Campus."

[244] Sargın and Savaş, "'A University Is a Society': An Environmental History of the METU 'Campus.'"

[245] Mert, "Interview about Heating and Water Infrastructure of METU Campus."

[246] Okan Tarık Komesli, Melis Muz, Selcen Ak, and Celal Ferdi Gökçay, "Prolonged Reuse of Domestic Wastewater after Membrane Bioreactor Treatment," *Desalination and Water Treatment* 53, no. 12 (2015): 3295–3302, https://doi.org/10.1080/19443994.2014.934107.

increase the capacity of this system in 2010. The old ponds are transformed to collect 15000 m^3 of purified water during winters.[247]

The ongoing urbanization around Oran region has significant environmental impacts on Eymir and Mogan lakes. According to the METU Office of Central Heating and Water Support, especially after the covid, with the unauthorized construction of prefabricated buildings, lots of septic pits were opened in the region. The natural and ecological habitats of Eymir and Mogan lakes are affected by these pits. The groundwater resources are also in danger of contamination.[248]

3.3.1.5 Information and Communication Technologies (ICT) Infrastructure

Starting from the establishment of the university, METU has pioneered many innovations in computation and communication. METU was the first university that integrated computation technologies into education in the first years.[249] The first computer was rented in 1965, after the foundation of the computer center in 1964.[250] In the later years, this research expanded and progressed. With the digital turn in the 1990s, METU pioneered to implementation of the web and internet technologies both in campus and the country. In 1993, METU became the first institution in Turkey that establish an internet connection. The first internet connection was provided between Ankara and Washington on April 12, 1993, with a 64 Kbps line.[251] The internet connection of the country was supplied through networks in the METU Campus for many years. Historically and symbolically, the internet connection was

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[247] METU, “METU Technopolis Membrane Water Treatment Plant Will Represent Turkey at Rio +20!,” 2013, Retrieved from http://www.archive2016.metu.edu.tr/announcement/metumetu-technopolis-membrane-water-treatment-plant-will-represent-turkey-rio-20.

[248] Mert, “Interview about Heating and Water Infrastructure of METU Campus.”

[249] Kurdaş, *ODTÜ Yıllarım, “Bir Hizmetin Hikayesi,”* 152–53.

[250] “History | Computer Center,” accessed January 8, 2022, Retrieved from https://bidb.metu.edu.tr/en/history.

[251] Erkan Saka, “Türkiye’de İnternet,” in *Türkiye’de Kitle İletişimi Dün-Bugün-Yarın*, ed. Korkmaz Alemdar, Gazetecile (Ankara, 2009), 957–81.

significant for METU and the country to be upfront for the new ways of information and communication infrastructure.

Prior to that development, METU established the first fiber-optic campus network in 1990. METU pioneered the first radio (1996) and TV broadcast over the internet (1998) and initiated the First Internet-based Distance Education Program (1998) in the country. METU also provided the first wireless network and megabyte Ethernet network in the campus.[252] Throughout the years, in and off-campus connection, capabilities, speed, and reliability of networks have enhanced. Today, the campus has an enhanced data network:

> "METU controls 53,000 user accounts which are served by on-campus 160 servers. All of these servers are stand-alone servers which have been designed for specific purposes. To date, the capacity of these 160 servers has not been shared. More than 75 K emails are being sent or received daily. Currently the METU network serves 2,737,656 online visitors with 3,500 TB download and 1,500 TB upload. The main network feed's band with is 3 Gbps and campus which is equipped with an additional 1 Gbps redundant feed. As shown in Fig. 7(3.21), the whole campus is connected using both single (Yellow), and multiple mode fiber (Red) optics."[253]

However, the network system creates problems from time to time, especially during heavy usage. New digital resources, communication and internet networks should be developed for the future of the campus. In and off-campus connection networks and services should be improved in terms of reliability, security, speed, and stability.

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[252] "The First of ODTÜ | ODTÜ'nün 60.Yılı," accessed January 12, 2022, Retrieved from https://60yil.metu.edu.tr/en/firsts-metu.

[253] Ertekin, Keysan, Göl, Bayazıt, Yıldız, et al., "METU Smart Campus Project (IEAST)," 295.

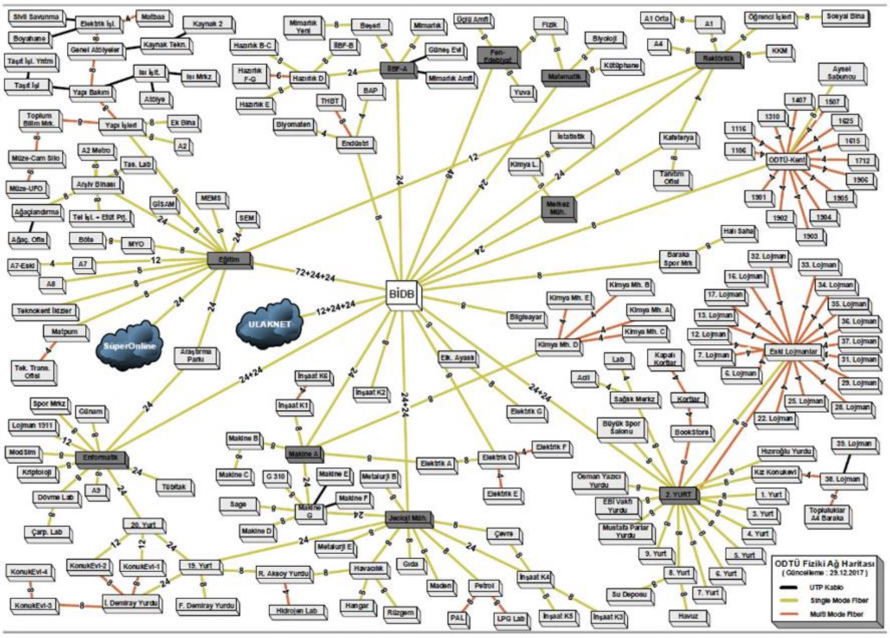

Figure 3.12. Campus Wired Network Infrastructure[254]

Future Agenda: Intelligent Data

Information and Communication Technologies (ICT) network is one of the basic premises of both the new educational methods and the intelligent campus infrastructures. It is essential to increase control over the environmental systems and infrastructures of the campus. They provide digital resources and opportunities to increase sharing and participation through the decentralization of information. They also protect and control critical systems and buildings through digital monitoring. ICT infrastructures provide two-way information flow, which increases interoperability. They enable control and management of systems through data collection.

Information technologies increase the connectedness of the systems, internal and external web services, and networks. The digital connection provides another space

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[254] Ibid., 296.

in the digital environment called “Cyberspace” or maybe “Metaverse” in nowadays. Cyberspace can be considered as the digital public space of cyber people. Web services also enable alternative learning methods over conventional ones. Open course services provide asynchronous educational methods to promote self-learning, which is changing the conventional understanding of lecture hall-oriented educational practices.[255] The recent pandemic also showed how these networks are vital to providing distant education and communication systems. Today, digital networks provide much more accessibility to all kinds of information and resources with up-to-date research and extensive content that a library cannot contain. METU Library also provides a VPN service for remote access to the electronic resources of the library. Library host resources are important to service can be an example for the development of the system, and it can also host sharing digital information and data provided by the campus and its infrastructure. New digital resources and communication and internet networks should be developed for the future of the campus. In and off-campus connection networks and services should be improved in terms of reliability, security, speed, and stability.

One of the first studies about the mapping of the infrastructures of the campus is prepared by the Usul and Dabanlı. The project aimed to transfer all the CAD or print documents of water, natural gas, heating, electricity and communication infrastructures into GIS environment to provide a research, monitoring, analysis and report interface for campus infrastructure.[256]

Collection, management, process, storage, sharing, and analysis of the data is necessary to provide better services and to improve, secure, manage and control campus facilities and infrastructures. Geographic information system (GIS)

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[255] J. Michael Haggans, “Future of the Campus in a Digital World | Center for 21st Century Universities,” accessed January 5, 2022, Retrieved from https://c21u.gatech.edu/blog/future-campus-digital-world.
[256] Nur Usul and Ahmet Dabanlı, “Kent/Altyapı Bilgi Sistemleri: ODTU ve Ankara Örnekleri.,” in *Yerel Yönetimlerde Kent Bilgi Sistemi Uygulamaları Sempozyumu* (Trabzon, 1999), 92.

technologies in campus scale and building information modeling (BIM) for the existing buildings of the campus should be developed to collect and monitor spatial/geographical data for both real-time and long-term solutions.

Data collection devices such as microsensors, controllers, and networks, IoT devices should be increased to understand usage, control, monitor, protection, fault, efficiency, the performance of the buildings services, campus infrastructures, and environmental systems. These data should be integrated and collected with the Building Management Systems (BMS) and centralized control center to provide classified and detailed information and solutions.

3.3.1.6 Transportation – Mobility Infrastructure

METU Campus is designed as one of the best examples of pedestrian-oriented planning. Academic and central campus buildings were built around a pedestrian alley. This design prioritizes pedestrian mobility with 1.5 km of uninterrupted pedestrian circulation space between the campus buildings. The alley not just provides pedestrian circulation but also establishes a space for the social infrastructure of the campus.

On the contrary, the vehicular transportation of the campus completely separated from the pedestrian traffic. Vehicular roads are designed as an external ring-road system that embraces the main campus and provides access and services to the buildings with cul-de-sacs from outside around the academic zone. The service gallery is also constructed with the roads, and the spatial layout is similar. This infrastructural correspondence is an intelligent approach that enables the infrastructural facilities and services to embrace the campus facilities from outside. This planning principle also represents that the infrastructure and architecture overlap in different scales in the campus.

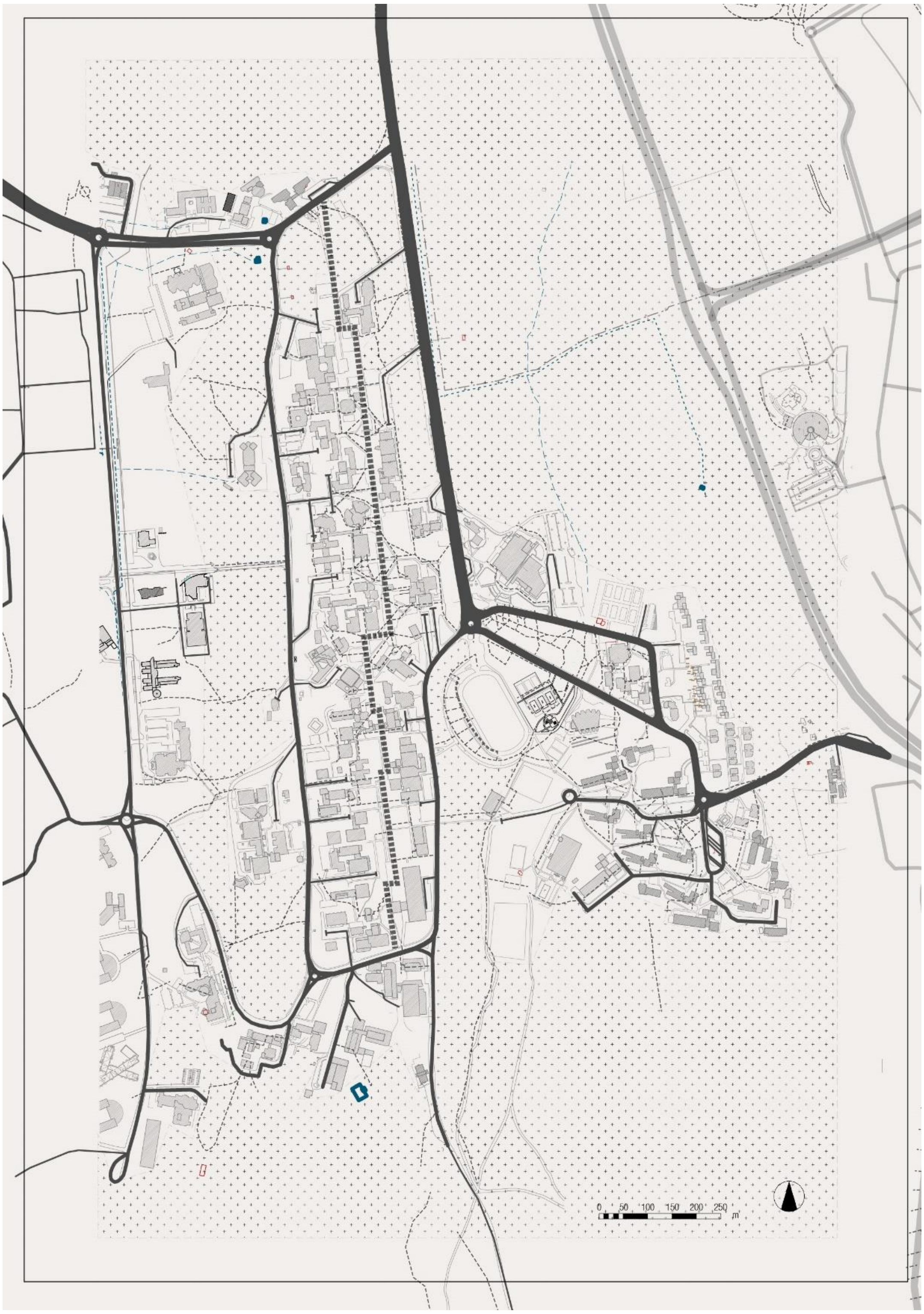

Figure 3.13. Pedestrian and Vehicular Transportation of the METU Campus, drawn by the author

Altıntaşı and Yaman states that: “The campus has a daily population of 30,000 people; most of the population commutes from different parts of Ankara. A significant portion of these commuters use private cars, which generates approximately 14,000 trips per day.”[257] This population requires a well-developed transportation system and depends on different transportation modes:

> “There are a number of different modes of transportation to and from the campus, including dolmuş, buses, services, private vehicles, and pedestrians. According to a recent study, it was found that 41 % of passengers came to campus by public transport, 39 % of them came by private car and 13 % of them preferred to use dolmuş and 7% walked to the campus.13 The same study also calculates the total number of vehicles entering the campus in working hours as 6,491. Following the increase in automobile ownership and use in Ankara, the number of vehicles entering the METU campus nowadays exceeds 15,000 per day (10492 vehicles during the work hours).”[258]

In-campus circulation is mainly provided either with walking or ring system. All the facilities and the zones of the campus were designed according to their proximity. The circulation diagram provided by the architects shows how the campus and its facilities are located to create a walkable campus. (Appendices D) On the other hand, ring busses of the campus also operate around the campus within a defined schedule. Since the buses are old, they rely on fossil fuels, increasing carbon emissions. [259]

Design of the campus facilities in close proximity to each other creates a lot of possibilities for sustainable campus mobility solutions. In that sense, it has a lot of

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[257] Oruc Altintasi and Hediye Tuydes-Yaman, “Best Option for Reducing On-Campus Private Car-Based CO2 Emissions: Reducing VKT or Congestion?,” *Metu Journal of the Faculty of Architecture* 33, no. 1 (2016): 87, https://doi.org/10.4305/METU.JFA.2016.1.4.

[258] Oruç Altıntaşı, “Assessment of Scenarios for Sustainable Transportation at METU Campus” (Middle East Technical University, 2013); Savaş, Derebaşı, Dino, Sarıca, İnan, et al., “Research and Conservation Planning for the METU Faculty of Architecture Building By Altuğ-Behruz Çinici, Ankara, Turkey.”

[259] Ertekin, Keysan, Göl, Bayazıt, Yıldız, et al., “METU Smart Campus Project (IEAST),” 291.

coincidences of recently awarded urban design approach entitled “15-minute city” by Carlos Moreno. Fifteen minutes city focuses on the urban accessibility through closer proximity of essential urban services in 15 minutes by walking or cycling. This proposal aims to provide a human-centered urban design which also less dependent on vehicular transportation.[260] As the original circulation diagram reminds that, METU Campus can be considered as a perfect example of this approach.

On the other hand, an increasing number of individual car ownership in addition to extending the population and surface area of the campus, produces several challenges for the campus. Personal vehicle usage is increasing due to the poor internal and external mobility infrastructures of the campus. “This increase in the vehicular traffic has started to threaten both campus walkability and also increases the carbon output. The lack of sufficient car parking is another problem that the campus faces.”[261] Another issue is that, since the universal design principles were not common in the 1960s, interior and exterior spaces of the campus create some challenges for the users with special needs. Therefore, the campus and buildings have some problems with the universal design of pedestrian accessibility. Accessibility problems should be solved to create equity and access for the entire campus and community.

Detailed information about the transportation infrastructure of campus and sustainable transportation models can be found in the Master thesis entitled “Assessment of Scenarios for Sustainable Transportation at METU Campus” by Oruç Altıntaşı, supervised by Prof. Dr. Hediye Tüydeş Yaman.[262]

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[260] Carlos Moreno, Zaheer Allam, Didier Chabaud, Catherine Gall, and Florent Pratlong, “Introducing the ‘15-Minute City’: Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities,” *Smart Cities* 4, no. 1 (2021): 93–111, https://doi.org/10.3390/smartcities4010006.

[261] Savaş, Derebaşı, Dino, Sarıca, İnan, et al., “Research and Conservation Planning for the METU Faculty of Architecture Building By Altuğ-Behruz Çinici, Ankara, Turkey,” 369.

[262] Altıntaşı, “Assessment of Scenarios for Sustainable Transportation at METU Campus.”

3.3.2 Infrastructure and/as Public Space: Soft Infrastructure of the METU Campus

> “As Foucault has reminded us, techniques are social before they are technical. Hence, to think of architecture as a material practice does not mean leaving questions of meaning entirely behind. Architecture works with cultural and social variables as well as with physical materials, and architecture’s capacity to signify is one tool available to the architect working in the city.”[263]

The METU Campus was designed as a self-sustaining urban settlement. Therefore, it has all academic and accommodation units, social and sports facilities, library, cultural centers and museums, a technopark, research centers, shopping facilities, cafeteria and eating facilities, and a medical center. Availability of these facilities does not just transform the campus into a small-scale city but also constitutes an extensive social infrastructure within the campus. METU Campus provides a variety of rich public spaces and infrastructures for its community.

The most significant public space and the urban element of the campus design is the “alley.” Alley creates main pedestrian circulation space, which is located between the academic and central zones of the campus, and it is designed as a central spine of the campus that conencts all the buildings.[264] The alley is extended in the North-South direction and provides a 1.5 km of uninterrupted pedestrian circulation space between the Foreign Languages and Civil Engineering Departments. It is designed in strong relation with the topography. It is built on the ridge of the hill in the North-South direction and provides vistas to the East and West directions.[265]

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[263] Allen, “Infrastructural Urbanism,” 53.

[264] Sıla Akman, “Conserving And Managing Modern Campus Heritage: ”Alley” as The Spine of METU Campus, Ankara” (Middle East Technical University, 2016).

[265] ODTÜ Mimarlık Fakültesi Mekansal Strateji ve Tasarım Çalışma Grubu, “Orta Doğu Teknik Üniversitesi Ankara Yerleşkesi Mekânsal Strateji ve Tasarım Kılavuzu,” 2016, 5.

Figure 3.14. Continuity of Public Spaces in METU Campus, ODTÜ Ankara Yerleşkesi Mekânsal Strateji ve Tasarım Kılavuzu[266]

There is a very strong connection and continuity between horizontal and vertical circulation systems and interior and exterior circulation patterns of the campus. Starting from the Alley, pedestrian movement not just connects buildings but also extends itself through and into the buildings as pathways, platforms, arcades, corridors, stairs, and galleries. Architectural definition and design of circulation space create seamless continuity in the campus between open, semi-open, and closed spaces. It is articulated with different levels, subspaces, rich materials, water elements, built-in urban furniture, greeneries, and artworks. It provides an interface for all kinds of urban infrastructures. There are other completed and ongoing studies about the alley and public spaces of the campus. Although this thesis is not intended to repeat them, it claims that the public space of the campus is the premise of the social infrastructure of the campus.

The idea of the alley in the METU Campus provides meaning beyond the circulation space. It is the main element that constitutes the social infrastructure in the campus. It is a powerful urban element that connects architecture, nature, and society with each other. "it is not only a pedestrian road but also a recreational and intellectual platform of exchange for the occupants of the university."[267] The design of the alley amplifies interaction, togetherness, and cooperation. Architects explained the alley

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[266] Ibid., 23.

[267] Savaş, "METU Campus," 72.

as a “forum” that is defined as a positive open/public space between the buildings. The term forum also suggests that the aim was to provide cultural and social space where the campus community can become together for different activities, relations, events, and cultural movements.[268] The alley is a perfect example for Jahn Gehl’s statement of “high quality of outdoor areas,” which stimulates optional and social activities in addition to necessary activities:

> “When outdoor areas are of poor quality, only strictly necessary activities occur. When outdoor areas are of high quality, necessary activities take place with approximately the same frequency – though they clearly tend to take a longer time, because the physical conditions are better. In addition, however, a wide range of optional activities will also occur because place and situation now invite people to stop, sit, eat, play, and so on.”[269]

The design of the alley and social spaces of the campus connects architecture and society. It stems from creating a “campus” as a city similar to other educational infrastructures in postwar periods. Here the ambition is not just building structures but initiating an ideology and lifestyle for the new society, described as “engineering society”[270] The term engineering here is critical to understand how this social community created a social infrastructure. It can be said that this ambition has given results. Today, METU has a strong society spirit with its students, personnel, academicians, and graduates, creating excellent social infrastructure extending beyond the physical conditions/boundaries of the campus. This social infrastructure increases the capacity, regional influence, and power of the METU in different educational, institutional, industrial, political, economic fields.[271]

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[268] Salt Research, “Altuğ-Behruz Çinici Archive - Middle East Technical University.”

[269] Jan Gehl, *Life Between Buildings: Using Public Space*, 6th Ed. (Washington, DC: Island Press, 2011), 11.

[270] Sargın and Savaş, “‘A University Is a Society’: An Environmental History of the METU ‘Campus,’” 604.

[271] Ibid., 602.

3.3.2.1 Infrastructure of Resistance

As discussed in the previous sections of the thesis, infrastructures also have political dimensions and significance in the urban context. As Read and Sulis explained, since infrastructural development requires vast investments and comes with enormous expenses, there should also be other motivations to invest. They give examples from the Roman Empire, Napoleon, and Hausman for their developments about transportation infrastructures in the names of boulevards or freeways to boost economy and trade or industrial developments.[272] As CJ Lim mentioned, Romans used hard and soft infrastructures for "social and political stability." They used "engineering as propaganda" for influencing new colonies with social and physical infrastructures such as amphitheaters and aqueducts.[273] Infrastructure gives control, order, surveillance, limits, and power over the territory. Therefore, infrastructures are used not only to provide necessary resources but also to consolidate social networks.[274]

A detailed discussion of the politics of infrastructure is beyond the aim of this study. Still, there are two political things/twists that can be related to the strong relationship between the political issues and social infrastructures of the campus. They can be observed in different scales of the METU Campus.

Firstly, as discussed by Humpfrey, the built environment and the material character of the physical space can create divergent ways of living beyond all the imposed ideologies and design decisions.[275] The design of the public spaces is significant for establishing the community spirit of the METU. This flexible and elaborated design of the campus spaces serves different social, cultural, and political activities.

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[272] Read and Sulis, "Infrastructure as World-Building," 131.

[273] Lim, *Inhabitable Infrastructures: Science Fiction or Urban Future?*, 170.

[274] Edwards, "Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems," 189–90.

[275] Caroline Humphrey, "Ideology in Infrastructure: Architecture and Soviet Imagination," *Royal Anthropological Institute* 11, no. 1 (2005): 39–58.

Surprisingly, the American tradition of campus generated a social infrastructure in METU that became a symbol/pioneer of socialist movements and resistance in the country. In that era, the gallery tunnels of the campus were used as an escape route for political activists and groups to hide from law enforcement officials. Interesting coincidence that both the soft and hard infrastructure of the campus has a vital role in this resistance infrastructure that also led to the suspension of educational facilities on the campus in the previous years.[276]

Second, the METU forest is important to support both social infrastructure for the campus and urban resilience in the city. Just as the walls were used as a defense infrastructure for the security of cities in the early ages, METU Forest can be considered as the contemporary understanding of defense infrastructure that protects the campus by corresponding to recent environmental problems/issues.

Global neo-liberal developments in the post-war era have strong political and economic effects on Turkish politics in the 1950s, and even METU is one of the outcomes of that era. As previously mentioned, the term “infrastructure” is also beginning to be widely used with the construction of NATO war mobility roads in the 1950s.[277] Turkey also benefited extensively from these infrastructural investments. Especially after the 1950s, road constructions began to be perceived as an essential public responsibility in Turkey and became the political instrument of the government officials. It is surprising that this political instrument of roadmaking still remained present in Turkish Politics in the 21st century and became a discussion point to interfere with METU Campus in Ankara. Road infrastructure was used as an invasion ground to interfere with the METU forest in 2015 and became a threat to the campus's integrity. The community of METU showed tremendous resistance against the demolition of the natural assets of the campus. This resistance also showed how the campus constitutes a solid social infrastructure with a sensitive

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[276] Kurdaş, *ODTÜ Yıllarım, “Bir Hizmetin Hikayesi,”* 275–323.
[277] William Batt, “Infrastructure: Etymology and Import.”

awareness about the nature of the campus and its natural assets. As Sargın states that "nature establishes its position to social forces and maintain its political power with spatial patterns."[278] It is an interesting example that shows the power of the politics of infrastructure and how it can be both productive or destructive in the urban context.

3.3.3 Infrastructure and/as Environment:[279] Natural Infrastructure of the METU Campus

METU campus has a tremendous natural environment and assets that include a forest, streams, water resources, lakes, archeological sites within its 45-hectares land. This land comprises 33 million square meters of forest with rich flora and fauna that hosts different species of plants in terms of trees, bushes, grasses, and many wild and domestic animals, including many bird and fish species.[280] The natural environment of the campus generates a green, healthy environment that produces fresh air for both the campus and the city of Ankara. The water need of METU is also provided from the natural groundwater resources of the campus at the Eymir Region. Therefore, the third and largest component of the METU Campus can be considered a natural infrastructure. METU forest is an integral part of the campus infrastructure for three reasons. It provides a liveable environment and natural resources, promotes collaboration and participation, protects the campus and its natural assets from environmental challenges and possible interventions.

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[278] Güven Arif Sargın, "Modernleşme Projesinin Bir İmgelemi Olarak Bozkır Deneyimi: ODTÜ Yerleşkesinin Çevresel Tarihine Giriş," in *ODTÜ Mimari Projeler:1 Yarışma Projeleri 2000-2008*, ed. Ayşen; Savaş (Ankara: METU Press, 2008), 27. Translated by the author of this thesis.

[279] The title is borrowed from Edwards, "Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems," 188.

[280] Directorate of Forestation and Landscaping, "Forest Maintenance and Afforestation Works," accessed January 2, 2022, Retrieved from http://acdm.metu.edu.tr/orman-bakim-ve-agaclandirma-calismalari.

3.3.3.1 Brief History:

The aim of the METU Campus afforestation is one of the premises of developing a natural environment and landscape for the new campus. There is a strong correspondence between the idea of METU Forest, postwar period “utopianist campus planning”[281] principles, and modern city understanding of leaving the ground as green and water. For this reason, in addition to other construction works of the physical properties and infrastructures, plantation works started on 3 December 1961.[282] Providing a natural environment for the new campus was considered as crucial as the other construction works. These efforts have initiated and progressed under the supervision and management of Rector Kemal Kurdaş, Head of the Plantation Directorate Alaaddin Egemen and vice-rector responsible for the afforestation Nuri Saryal.[283] Starting from December 1961, METU planted most of the campus with more than 12 million trees in 8 years.[284] Approximately 33 million trees (10 million coniferous and 23 million broadleaves) planted on the campus until today. This tremendous effort and dedication transformed Anatolian Bozkır into a man-made forest. A huge natural environment has been created in the steppe climate of Central Anatolia, which has become the largest green area in Ankara.[285] With all plantation efforts, The METU Campus Reforestation project was awarded with the Aga Khan Award for Architecture in 1995. The METU Forest was also specified as a “Natural and Archaeological Protection Site” in 1995 by the Ministry of Culture.[286]

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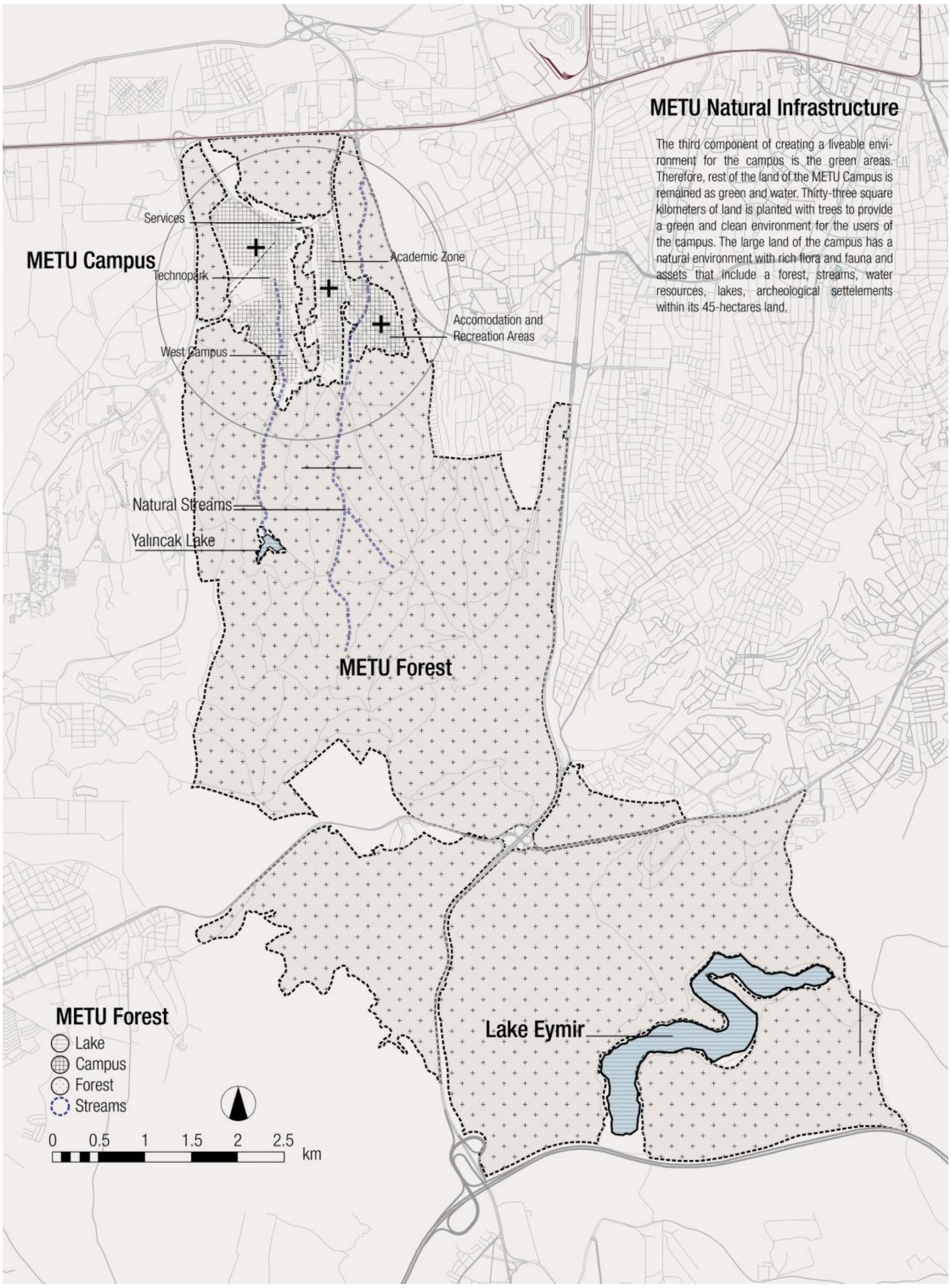
[281] Muthesius, *The Postwar University; Utopianist Campus and College*.
[282] Kurdaş, *ODTÜ Yıllarım, “Bir Hizmetin Hikayesi,”* 123.
[283] Ibid., 131.
[284] Ibid., 130.
[285] Directorate of Forestation and Landscaping, “Forest Maintenance and Afforestation Works.”
[286] Ibid.



The third component of creating a liveable environment for the campus is the green areas. Therefore, rest of the land of the METU Campus is remained as green and water. Thirty-three square kilometers of land is planted with trees to provide a green and clean environment for the users of the campus. The large land of the campus has a natural environment with rich flora and fauna and assets that include a forest, streams, water resources, lakes, archeological settelements within its 45-hectares land.

Figure 3.15. METU Forest, drawn by the author

3.3.3.2 Landscape Architecture and Infrastructure:

In addition to the forest, the greening works progressed for the surrounding of the central campus as well. A natural landscape texture has been created in the campus with plant species resistant to steppe climate conditions.[287] The landscape of the inner campus is also designed by Çinicis. The close proximity of the buildings, roads, and alley is elaborately designed with various natural greeneries that constitutes a strong relationship and continuity between natural and built fabric, nature, and society[288]. Landscape integration into the urban environment blurs the distinctions between architecture and the natural environment, creates visual and spatial continuities between natural and built. The landscape infiltrated into the buildings with courtyards and skylights, became visible with continuous transparent surfaces, and articulated with the specifically designed and located urban furniture. This plantation became so dominant that it even compensated the rigid forms and materials of modern architecture of the campus[289] and created a contrast to the depiction of Ankara as so-called "gray city". The design concept according to natural scenery emerged very clearly in the meticulous landscape and architectural design:

> "We will furnish every inch of the university's land, and around every building, we will build with trees. Even under windows. Every student looking out of the window of a classroom or laboratory will see a tree in front of a window, a grove behind, and the forest of the university far behind. This is making a piece and love with nature and greenery. Our students will grow up with a new culture, and they will be the light and leader for the people of Turkey's barren lands in the future."[290]

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[287] Ibid.

[288] Sargın and Savaş, "'A University Is a Society': An Environmental History of the METU 'Campus.'"

[289] Sargın, "Modernleşme Projesinin Bir İmgelemi Olarak Bozkır Deneyimi: ODTÜ Yerleşkesinin Çevresel Tarihine Giriş."

[290] Kurdaş, *ODTÜ Yıllarım, "Bir Hizmetin Hikayesi,"* 134. Translated by the author

This quote from Kemal Kurdaş briefly summarizes how the natural environment creation is poured a foundation of environmental consciousness in its community. It was not just crucial within the discussions of a sustainable city and green building practices, but also innovative to promote environmental awareness among its community. Especially in the days when the climate problems were not that obvious, nature-oriented design decisions in parallel with creating an environmentalist culture are very visionary and still valid for the current urban practices.

METU afforestation is also a great example of natural infrastructure. Even though the landscape works are not used for the urban problems in the ways that in the contemporary practice of “landscape infrastructure”, plantation strategies helped to protect, maintain and support the forest ecosystem and natural landscape of the campus. METU planted more than 30 different coniferous and broadleaf tree species. This mixed afforestation technique creates a biological diversity that constitutes natural resilience and creates an ecosystem that different kinds of animals and plant species can grow.[291] The land surface is terraced and planted with the groundcover to keep water on the land and prevent soil loss by erosion. This approach reduces drought and improves flora and fauna. The degree of slope and terracing methods are determined according to the wind direction and rain patterns. Long-living and drought-resistant tree species suitable for steppe climate were selected, which facilitated easy maintenance during the growing period and reduced tree losses. Relatively close planting of trees allowed them to benefit from each other’s biotopes. The branches and leaves of the trees provide shade to preserve the rains by protecting the soil from the direct sun and evaporation. The closer relation and mixed plantation developments also increase the communication and networks between the trees, which is an early discovery of current investigation about forest ecosystems.[292]

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[291] Ibid., 128.

[292] Ibid., 136–38. The idea is from the video “Secret Life of Trees: how they talk to each other, BBC, https://www.youtube.com/watch?v=DUqEB_tGHtw

3.3.3.3 Promoting Social Infrastructure:

METU plantation activities also have significant social and political outcomes beyond going green. Firstly it helps to create a solid social infrastructure. The collaborative process of afforestation works initiated a collective community understanding between the different parties in and out of the campus. It establishes a social relationship and communal commitment for the students, academicians, executives, and the personnel of METU and strengthens the community spirit and sharing, which constitutes the social infrastructure of the campus. Beyond the Campus, METU also invited public people, officials, military personnel, embassies, organizations, politicians into the afforestation activities. Moreover, METU donated trees for the greening of schools and mosques throughout Ankara.[293] Participation and contribution of different community groups strengthen social relations and networks. This public intervention also undergirds the loyalty, support, and admiration for the upcoming developments. It promotes the campus and reinforces social and political forces through collective work and sharing.

METU Tree Plantation festivals became a tradition and a great symbol of the greening activities of emerging social infrastructure. It promotes afforestation works beyond compulsory duty and encourages around “joy” through collective celebration and participation. This contemporary understanding fosters the love of green between students and also builds up real awareness about the environment in the minds of its students and society. This approach represents the “hedonistic sustainability”[294] principle that individuals actively participate in environmental challenges, contrary to the conventional pro-consumerist sustainable practices.

In the end, afforestation of the METU campus generated an environmentally conscious society which is an essential component of sustainable environments.

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[293] Ibid., 130.
[294] The concept is developed by the Bjarke Ingels Group (BIG), retrieved from the speech entitled “Hedonistic Sustainability” from https://youtu.be/ogXT_CI7KRU.

Since sustainable developments can not be achieved without participation, human engagement is important for both the establishment and the durability of natural environments.

Although global climate change, urbanization challenges, and scarcity of natural resources were not that obvious in the 1960s, METU forest is one of the early examples of environment-oriented urban design that cultivates both nature and community. It helped to create a culture around environmental awareness. Today with the re-emerging environmental concepts, the significance of this example is becoming more evident.

3.3.3.4 Resilience and Resistance:

The second outcome of the forest is creating urban resistance and resilience within the city of Ankara. The forest of the campus created a micro-climate effect in the region that decreased the hard and rapidly changing conditions of the steppe climate.[295] It still provides a green ecosystem in the southwest of Ankara, which also protects the land from uncontrolled urbanization and enables to development of other university campuses in the region.

Since the campus has a huge and valuable area, and METU forest protects the campus and its natural environment from the outer interventions. METU Forest was listed officially as “National Forest Protection Area” in 1995. Kemal Kurdaş explained how the plantation is also used consciously to protect the campus environment from possible occupations:

> “We knew that one day, Ankara would set its sights on 45 thousand decares of land and would want to share. That’s why we planted this place. We have built the science high school so that we can hold our border from there

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[295] Directorate of Forestation and Landscaping, “Forest Maintenance and Afforestation Works.”

> (Konya Road). We have reinforced the afforestation along the road. We afforested the lake, and we also secured that area…"[296]

It is clear that the territory of the campus is decisively defined with the afforestation works, where the forest works as s defense infrastructure to protect the campus from further interventions.

Today, similar to all urban developments, METU is also under the attack of urban sprawl. Both the population of the campus and the Ankara are increased beyond expectations. This has already caused some problems before and may cause some problems in the future about the infrastructure and the natural resources of the campus. The ongoing urbanization around the Oran region is already threatening the natural habitat of Eymir and natural resources, especially the quality of water.

3.4 Re-reading the Campus Buildings as a Collection of Infrastructure: METU Faculty of Arts and Sciences – Block of Lecture Halls

The meticulous design of the METU Campus and its infrastructure can be examined and continued for the architectural scale as well. General principles and careful intentions of the design maintained between the scales generate a strong relationship and consistency between the social and physical infrastructures and building services. This study focuses on the METU Faculty of Arts and Sciences Block of Lecture (Amphitheatre) Halls Building as known as "Triple Auditorium (Üçlü Amfi)" and its immediate environment to investigate these qualities on an architectural scale.

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[296] Fevzi Gümrah and Sıdıka Kahraman, "Kemal Kurdaş'la Röportaj," *ODTÜ'lü Dergisi* 1, no. 1 (1993): 3–8, Retrieved from https://odtulu.metu.edu.tr/dergiler/1/1.html#p=4. Translated by the author.

Figure 3.16. METU Faculty of Arts and Sciences - Lecture Halls, 1960s[297]

The block of lecture halls building was designed by the architects of the campus Altuğ and Behruz Çinici. Structural works were conducted by Göncer Ayalp, mechanical works were conducted by Celal Okutan, and electrical works were undertaken by Naci Sarısözen. The building has an area of 2200 m^2 in total. The constructions were started at May 1966 and completed almost in 15 months.[298] Therefore, it is one of the buildings that was completed with the first campus development, which has similar architectural, structural, and infrastructural details with the other buildings completed in the same period.

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[297] Salt Research, “Altuğ-Behruz Çinici Archive - Middle East Technical University.”

[298] Ibid. Chart that shows the area, cost, starting and ending dates of construction of METU Campus buildings

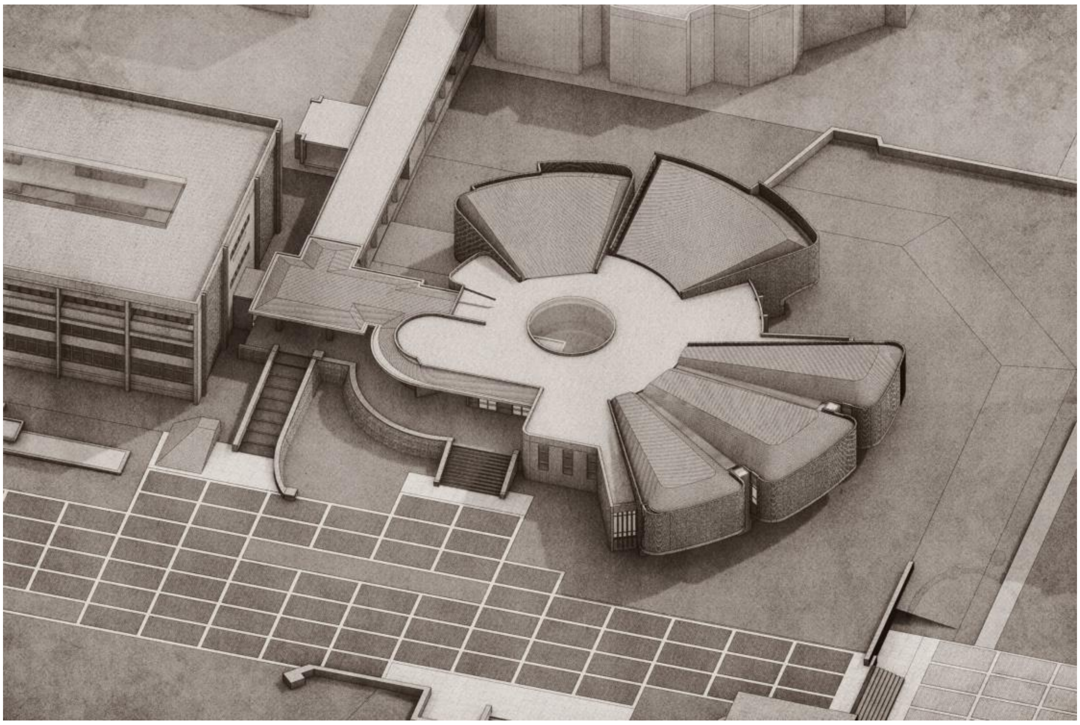

Figure 3.17. Digital Model of the Lecture Halls, drawn by the author

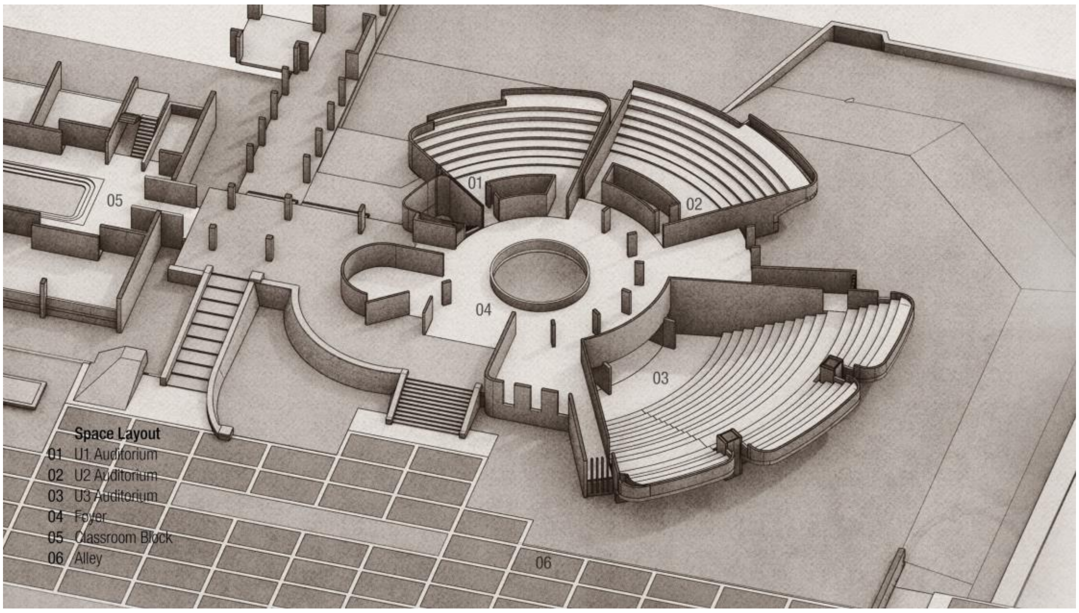

Figure 3.18. Axonometric Plan Drawing of the Lecture Halls, drawn by the author

The lecture halls building was designed as part of the Faculty of Art and Sciences, Department of Physics. It is located at the very center of the campus; the block is surrounded by the library, rectorate, cafeteria buildings, mathematics, and chemistry departments. Department of physics composed of 4 building blocks: laboratory building, classroom buildings, lecture halls, and later addition of classroom building. Lecture halls block is designed in a strong relationship with the alley in the south, classroom block at the east, and the physic laboratories building in the west direction with the complex layout of semi-open, open, and closed spaces.

The building is designed on two floors: ground and basement. It is mainly composed of 3 auditorium-type lecture halls, which are used for all the campus community from different departments and still work for the same purpose. U1 and U2 have 150 people capacity, and U3 has 550 people capacity, which is one of the biggest lecture halls on the campus. The ground floor is composed of lecture halls and a central hall(foyer) that provides access to all lecture halls. The basement floor includes a mechanical room, office room, and wet spaces (Figure 3.18).

The building's primary architectural qualities, materials, conceptualization and production of space, and spatial relations have similar principles with the other campus buildings. It is designed as an open plan layout with large transparent glasses, exposed brick, and concrete usage. Although the materials and conceptualization of spaces are identical, the building also has unique architectural, structural, and infrastructural details and solutions that create variety in unity. Unlike the other campus buildings, it has a circular layout that connects all the amphitheaters with the central circulation space. The building is one of the rare examples of both the orthogonal and radial grid used. It also has an experimental vaulted roof and cantilever in the auditoriums and a glass dome roof in the circulation hall.

The building has a unique infrastructural design and solutions, including new mechanical services, the rotating platform, ventilation systems. Therefore, investigating the soft and hard infrastructures of the building and its relationship with the green is important to extend this study on an architectural scale. The idea is to understand the relationship between hard, soft, and green systems on an architectural scale through reading a building by its infrastructure to understand how the infrastructural systems and mechanical infrastructure are defining the architecture.

3.4.1 Hard Infrastructure of the Building

METU Lecture halls building has a distinctive design in terms of architecture, structure, and infrastructure. Architectural, structural, and mechanical systems of the building have unique and detailed solutions designed to contribute and combine seamlessly. Since the architectural drawings provide information about both the conceptualization and production of space, this study investigates these qualities and relationships in building scale through the original architectural drawings of the Çinici architects, construction progress reports, and correspondence reports.

The original campus and building drawings of the architects provide systematic information about the buildings in terms of structure, services, infrastructures, spatial relations, topography, materials, infrastructure, scale, details, and proportions.

The infrastructural qualities and spatial details can be investigated from preliminary project drawings to the application project drawings. Although the spatial configuration and division remained same in drawings, structural and infrastructural details are added carefully into the drawings regarding architectural design.

3.4.1.1 General Layout - Building Scale:

There is strong consistency and correspondence between the layout of architecture, structure, and infrastructure of the building. The architectural, mechanical, and structural systems of the building are carefully designed and detailed to provide consistency and quality between the different scales of the building.

The infrastructure of the building is mainly composed of heating, ventilation, electric, and water systems. Infrastructures of the building are designed in relation to the spatial layout. The wet spaces, mechanical and electrical rooms are located in the basement floor under the small lecture halls adjacent to each other. Whereas the U3 auditorium extends between the ground and basement floor and provides a connection to both floors. The basement floor of the building is also connected to the laboratory building with a tunnel underside the main arcade reaching to the other buildings.

The mechanical room of the building is connected to the main infrastructural gallery of the campus. It hosts all the necessary components of the mechanical services of the building. Mechanical services are distributed to other spaces from the mechanical room in the building, like the general infrastructural layout of the campus. The main ventilation channels are located under the big hall. Construction photographs also show the construction of the service gallery and the implementation of infrastructural systems during the foundation works.

There are similar spatial qualities between architectural spaces and infrastructures. This correspondence is generated with the meticulous usage of architectural and structural elements of the building. The building has a circular layout that distributes the spaces with a radial grid. Structural system and spatial division of the buildings articulated with load-bearing walls and structural beams extended from the central axis. Other walls are also located on the radial grids with different radius. Also, the circular theme of the design of the building is continued through different architectural elements, infrastructures, spatial layout, walls, corners, beams, edges, and details.

In the architectural design of the building, walls are doubled in parallel to create different kinds of transition spaces such as corridors, openings, or entrance spaces. Visibility and distinction of structural and infill elements are important in the architectural design where the load-bearing systems are separated from the other partition walls. Elongated architectural elements parallel to each other are used to provide transparency and continuity between spaces.

For the infrastructure, the same principles are applied for the creation of mechanical shafts. Walls are duplicated with a secondary parallel wall. The space between walls is designed as a shaft or depots to provide space for the necessary space for the services of the building. Of course, the outer wall is load bearing, and the inner one is mostly produced as nonbearing infill walls to give room for different kinds of infrastructural installation.

Almost all the architectural and structural elements of the building are designed and articulated to have secondary functions for the infrastructural requirements of the building. These secondary functions are also generated in similar principles with the architectural approach. Walls, beams, columns, and floors are articulated, extended, thickened to host multiple functions and different mechanical services of the building. This design approach decreases the strict distinction between structure, infrastructure, and space.

3.4.1.2 Anatomy of Lecture Halls[299] - Visualizing / Representing Infrastructure

> "With very little exaggeration, this baroque ensemble of domestic gadgetry epitomizes the intestinal complexity of gracious living – in other words, this is the junk that keeps the pad swinging. The house itself has been omitted from the drawing, but if mechanical services continue to accumulate at this rate it may be possible to omit the house in fact."[300]

Within the discussion of the thesis, there are some questions emerged about the infrastructure: How to read architectural space by its infrastructure? What is the relationship between hard and soft infrastructures? How can infrastructures

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[299] The title is inspired from the drawing called "Anatomy of Dwelling" in the article "Home is not a House"

[300] Banham and Dallegret, "A Home Is Not a House," 70.

orchestrate the architectural space? How and to what extent can we interfere with the existing architectures?

Here this study is inspired by the article “Home is not a House” written by Reyner Banham illustrated by François Dallegret. “Anatomy of Dwelling” drawing is used as a reference to create drawings of the “Anatomy of Lecture Halls.”

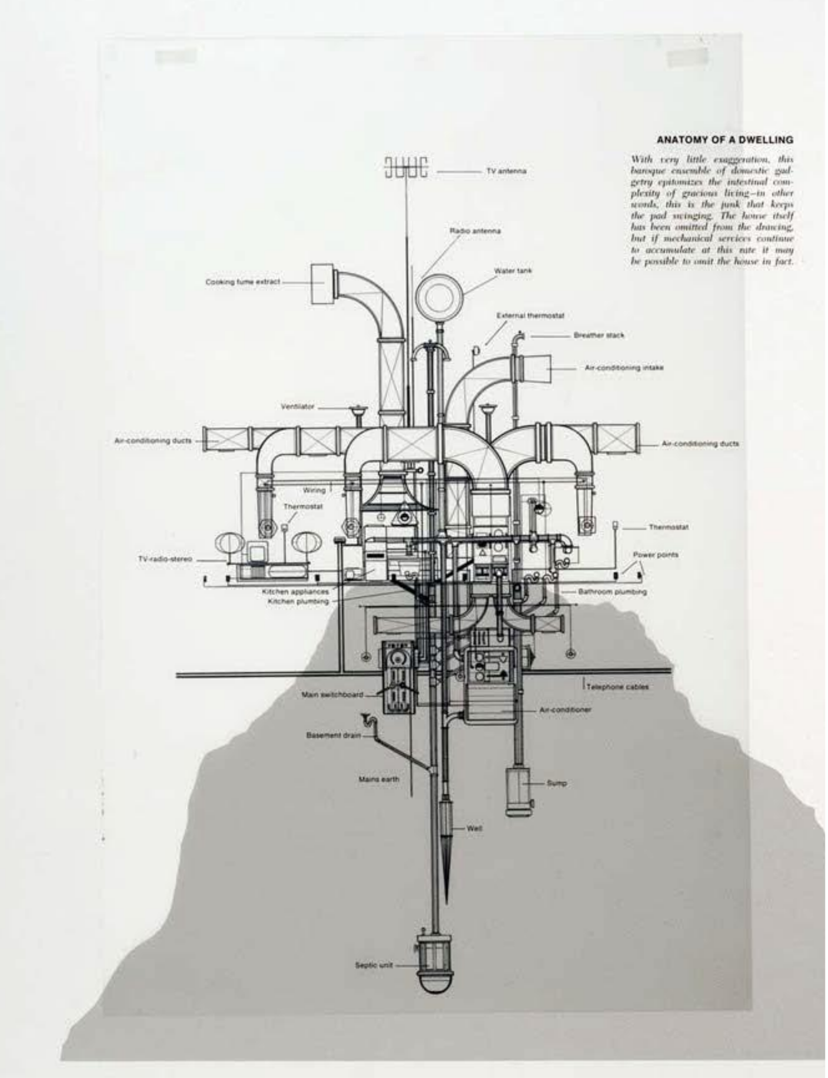

Figure 3.19. Anatomy of a Dwelling by Reyner Banham & François Dallegret[301]

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[301] Ibid., 71.

Digital Construction (re-drawing) of a building is considered necessary to create an architectural survey, representation, and design in this thesis. Remodeling is considered not just a presentation tool that visualizes the current state of architecture; on the contrary, it is a design tool that should control all kinds of interventions into architecture.[302] To research how these systems are interrelated with each other, a detailed digital model of the building is created. The idea is to visualize the meticulous infrastructural design of mechanical services of a building. Series of drawings are created to understand/read the relationship between services and architectural space to make mechanical services visible that work invisible in the background. In other words, the anatomy of the building is represented through a series of x-ray views to investigate the building as a collection of the systems like an organism that facilitate the living environment.

The "Anatomy of Lecture Halls" drawing shows that all these mechanical systems of the building are carefully designed and support the architectural spatial, and structural division of this complex structure. Although the mass articulation of the building suggests strong zoning, the flexibility of the infrastructure allows the open plan layout. The drawing represents that all the architectural and structural elements of the building are designed in a strong relationship to have multiple functions for the infrastructural requirements and articulated to host mechanical services of the building.

The technical infrastructure of the ventilation system, mechanical equipment, service shafts, and electrical grids are actually hidden, but these invisible systems overlap with the structure and spatial division. It can be claimed that this kind of implementation cannot be overcome without strong communication, harmony, and understanding between architects and engineers in different stages of the project process.

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[302] Ayşen Savaş, "METU Arch524 Architecture and Different Modes of Representation" Course, Fall 2018 Lecture Notes, Representation is discussed as an architectural survey method.

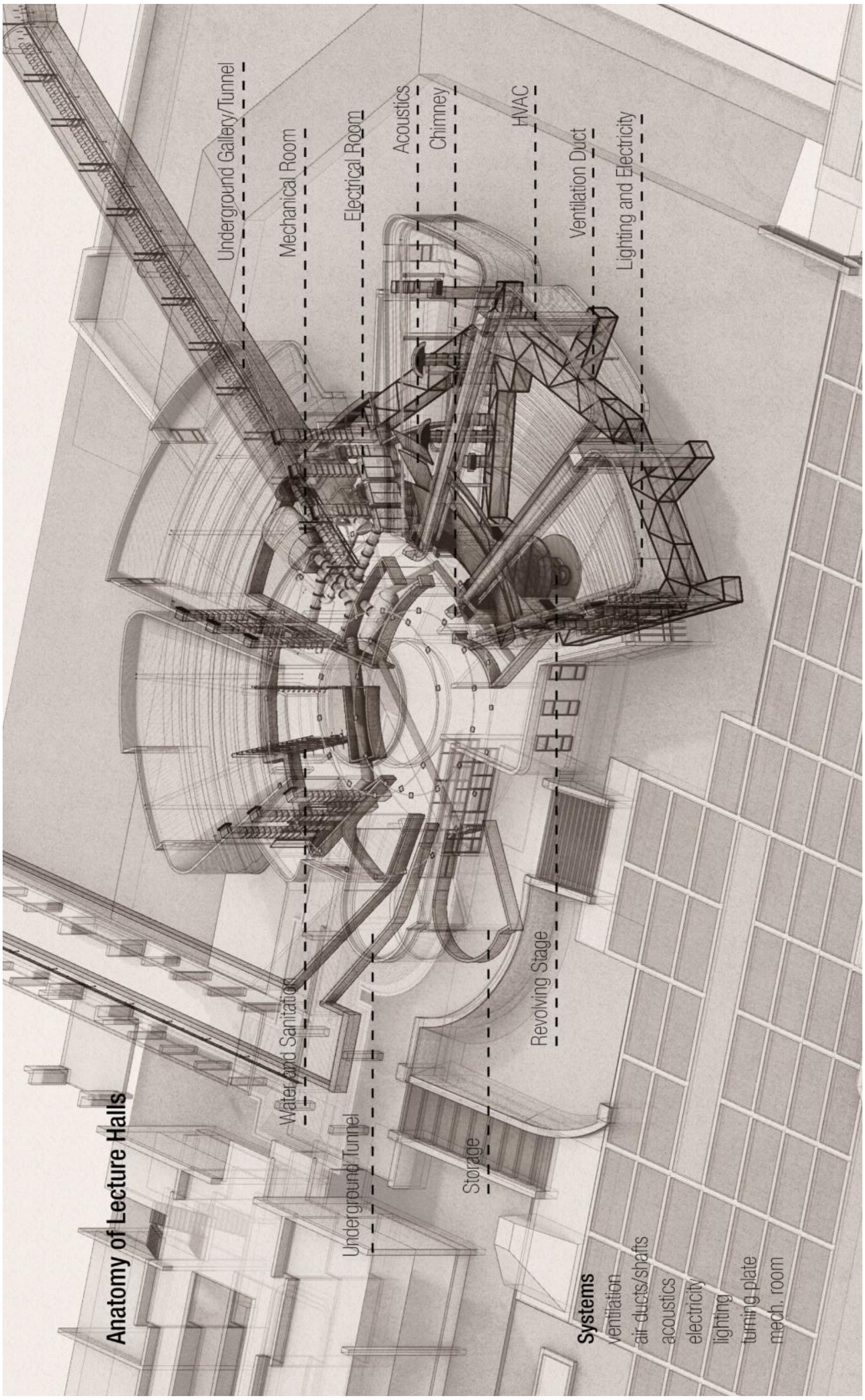

Figure 3.20. Anatomy of Lecture Halls, drawn by the author

3.4.1.3 Unit Scale: U3 Auditorium:

U3 auditorium is the most elaborated space and the biggest hall of this building. The space is approximately 20 meters by 30 meters in size in a symmetrical layout. The huge space of the U3 auditorium is divided by the structural system of columns and beams into three parts which are visible from inside and outside. This long-span roof is covered with three very thin concrete vaults, which are 16 cm thick. This three-partied ceiling is supported with four beams, 100 cm deep. The side beams transferred their load on two shear walls on the sides. On the other hand, the structural load of the inner beams transferred to the two exterior columns that embrace the auditorium. These columns also support the 4-meter cantilever extending from the end of the hall.

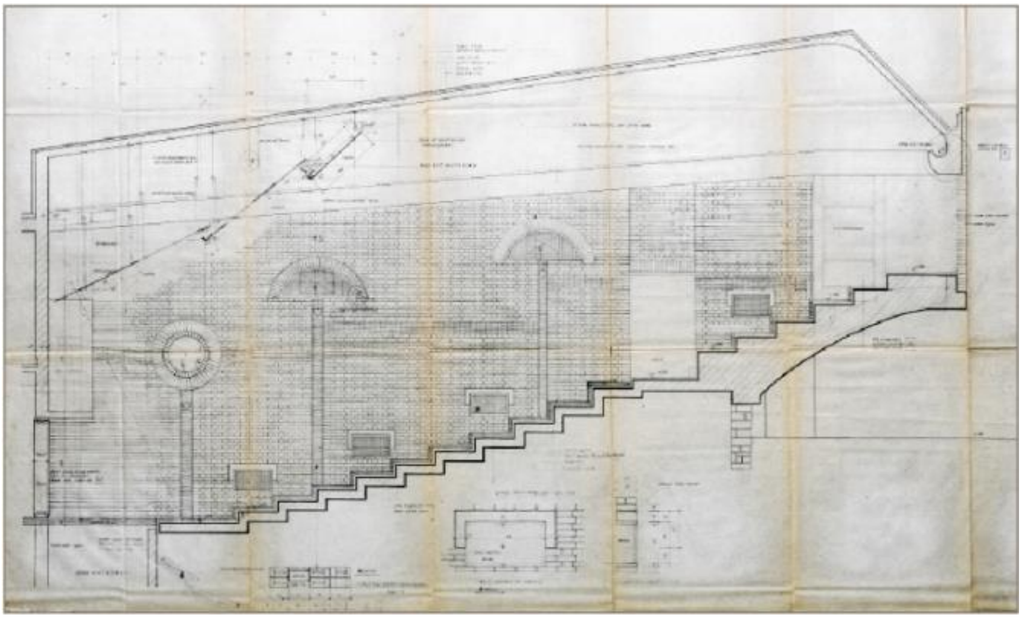

Figure 3.21. Section drawing of the big auditorium[303]

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[303] Salt Research, “Altuğ-Behruz Çinici Archive - Middle East Technical University.”

The separation walls on the sides of the auditorium are doubled to host necessary infrastructures. The outer wall is the exposed concrete shear wall, whereas the inner one is the infill wall constructed with red brick. The space between the walls is utilized as a service shaft for electrical systems and ventilation ducts. The flexibility of the inner infill brick wall was used to the fullest in the space. The brick surface is treated almost like a relief that hosts ornamented air vents, lighting niches, fixtures, electrical switches, and the clock.

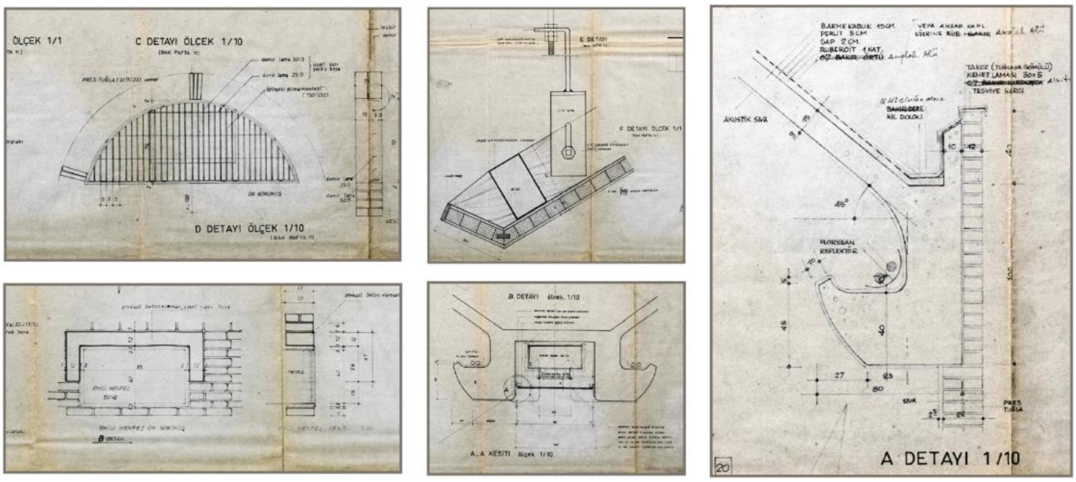

Figure 3.22. Beams and Wall Details[304]

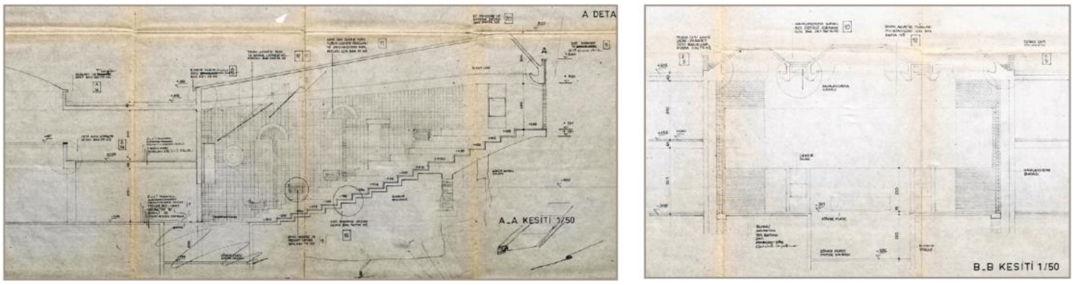

Figure 3.23. Original section drawing of the lecture hall[305]

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[304] Ibid.
[305] Ibid.

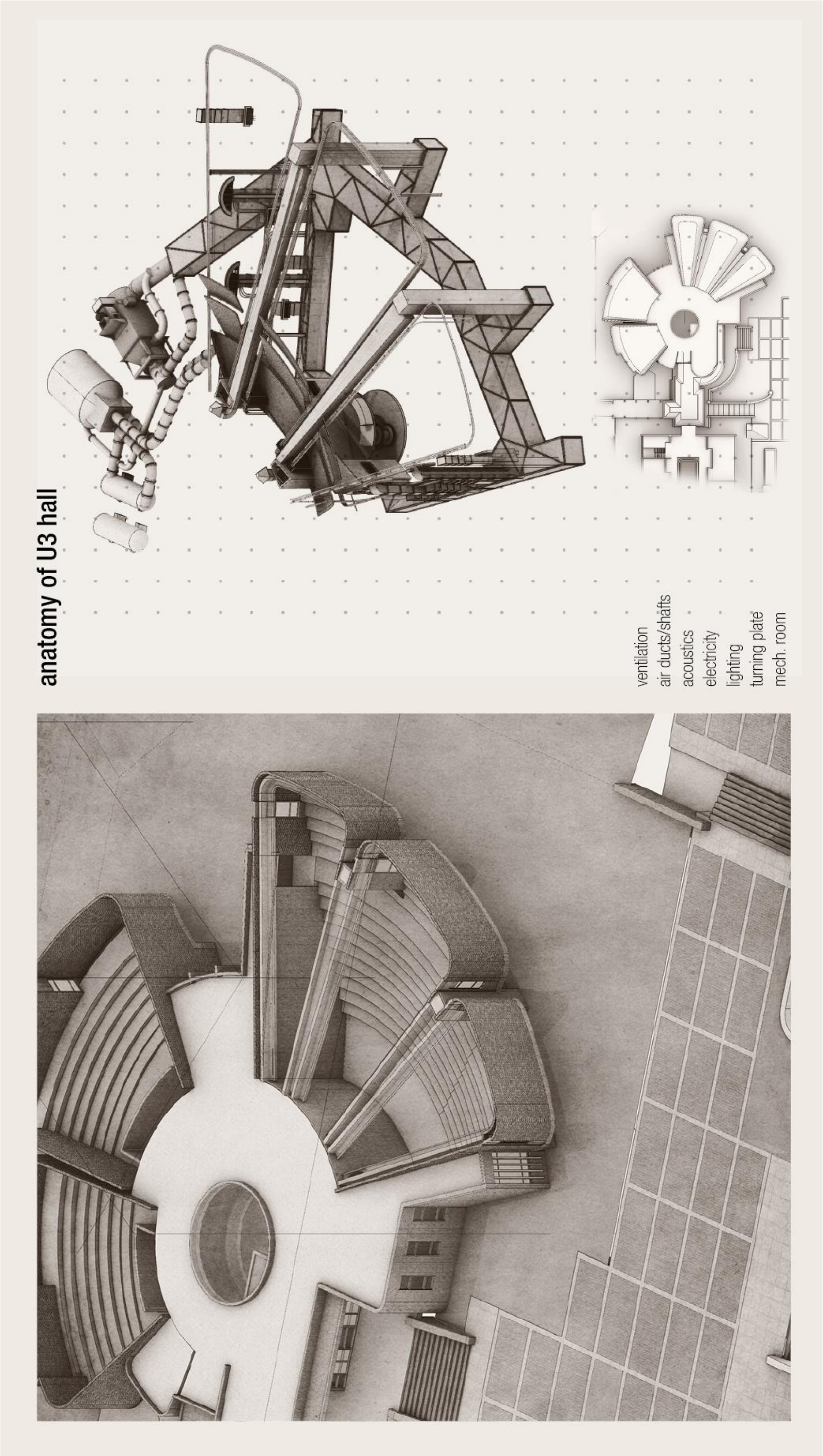

Figure 3.24. Anatomy of U3 Hall, drawn by the author

The division of space is also important for the infrastructure of the building. The hollow design of the columns and beams provides space for the ventilation shafts. Beams are designed in two separated parts to host air supply ducts and outlets. These parts of the beams are also articulated in cross-sections to serve for the electrical system. They are extended inside to create a niche that rotates around the entire area under vaults to provide indirect lighting within the space. Acoustic panels are also located between these beams and create a 3dimensional layout in the space. Therefore, this triple division is used not only for structural reasons but also to distribute mechanical services evenly to the big space.

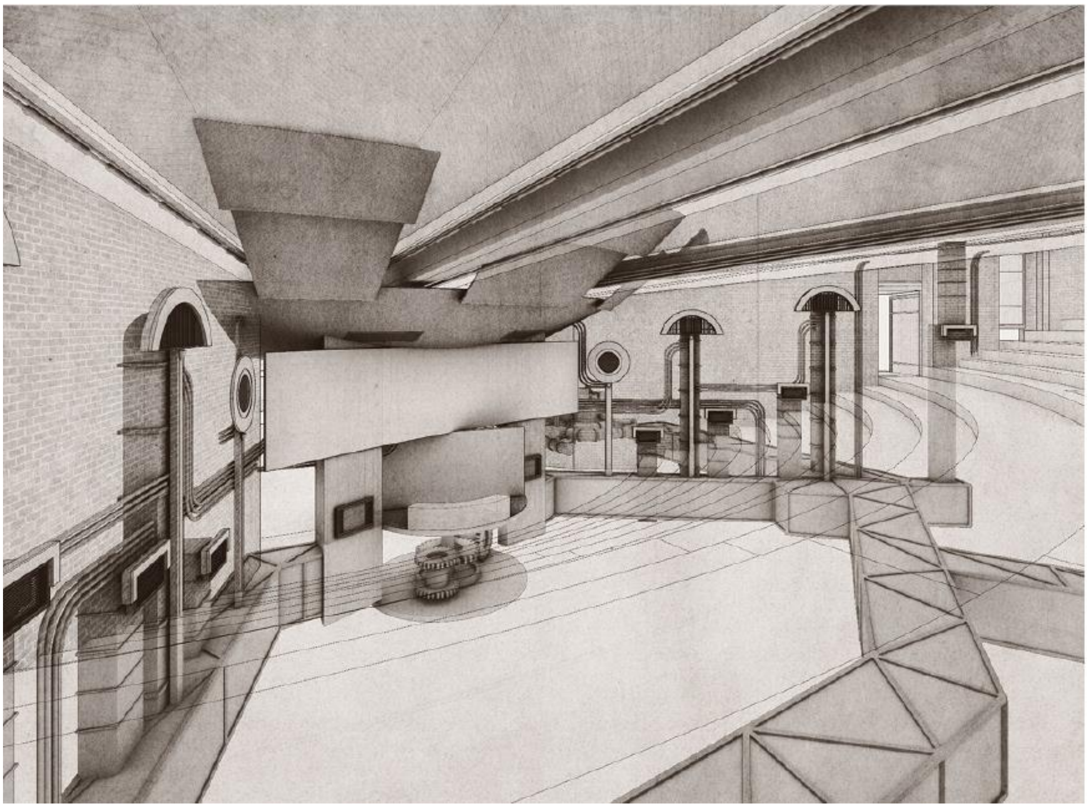

Figure 3.25. X-ray view of the inner space, drawn by the author

The convex stage wall of the auditorium is also duplicated by a concave wall inside. In between, space is used for the fume hood that is connected with the chimney on the roof. These walls, columns, and beam ventilation systems are connected underground with a big ventilation channel extended under the auditorium seating and connected with the mechanical room. This 3-dimensional design of the ventilation system embraces the space from all sides and provides a healthy environment for the space users. This articulation of spatial, structural, and mechanical systems with cutting-edge detailing and materials creates a consistent and coherent whole.

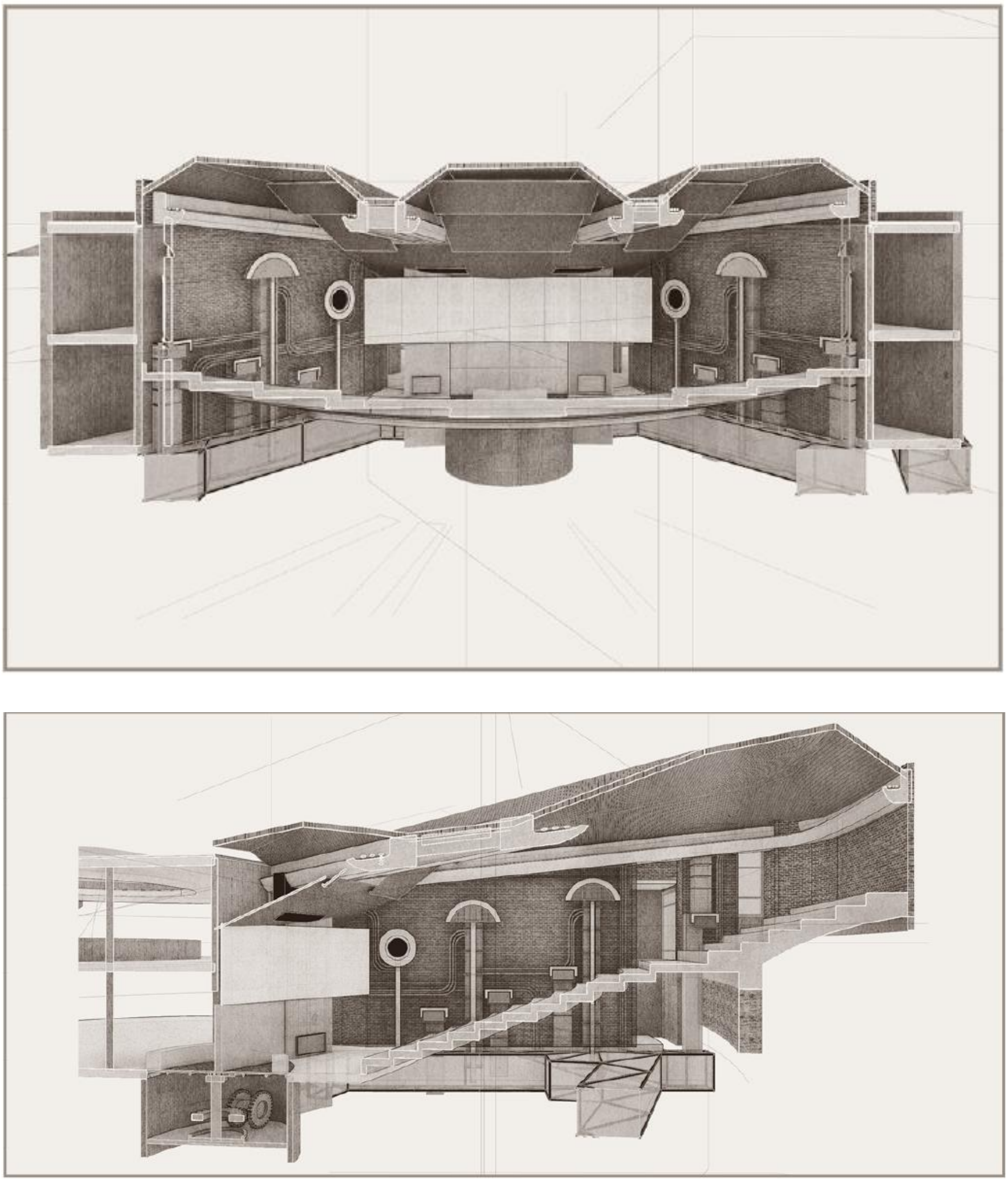

Figure 3.26. X-ray sections of the lecture hall, prepared by the author

The construction reports of the building also reveal the quality and the careful consideration and design of the structures and infrastructures. Architects and the engineers of the building have a lot of knowledge on infrastructure and push all the construction of structural and mechanical works to achieve the best.

3.4.1.4 Detail Scale: Revolving Stage-Platform

One of the most distinctive details of the U3 auditorium is the rotating platform. According to the design report that architects provided, the main aim of the rotating platform is to create spatial continuity between the laboratory building and the auditorium. The lecture hall block is connected with the tunnel in the basement floor, under the continuous arcade that extends to the laboratory building. The experiments prepared in the laboratories can be brought through these tunnels to a big amphitheater to present them in the lectures. (Appendices M) Another reason for this rotating stage is to provide time for the preparation of the following course since this hall is one of the most used spaces of the campus.

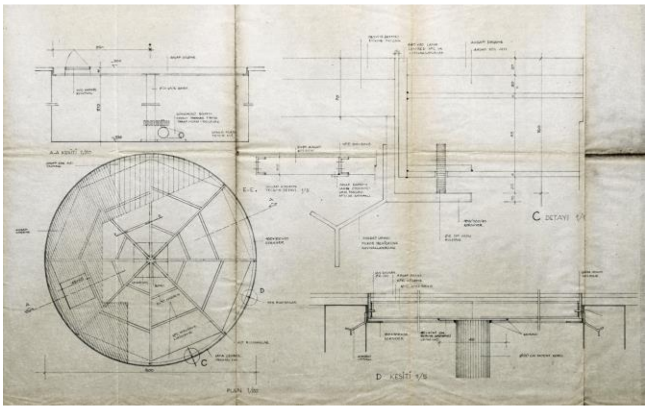

Figure 3.27. Original Drawings of the Revolving Stage [306]

In this study, details of the space and turning plate are discovered and modeled with the help of detail drawings to understand the system behind the rotating platform.

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[306] Ibid.

Stage mechanism has an underground space for its complex system of gear wheel and power engine. The rotating platform is constructed by a local firm with local opportunities. For that period, its usage is very innovative and ground-breaking.

The rotating platform is the headliner of all the infrastructural details in the building. It is an infrastructural component that significantly increases the capability and flexibility of the lecture hall. It is an architectural element that can transform one space into another and create alternative space layouts, and blurs the strict distinction between spaces. Therefore, it is the most complimentary element of the stage of the auditorium. This unique system shows the complexity and creativity hidden in the whole campus design. Infrastructure, which seems to be an engineering work, enhances the architectural design and production.

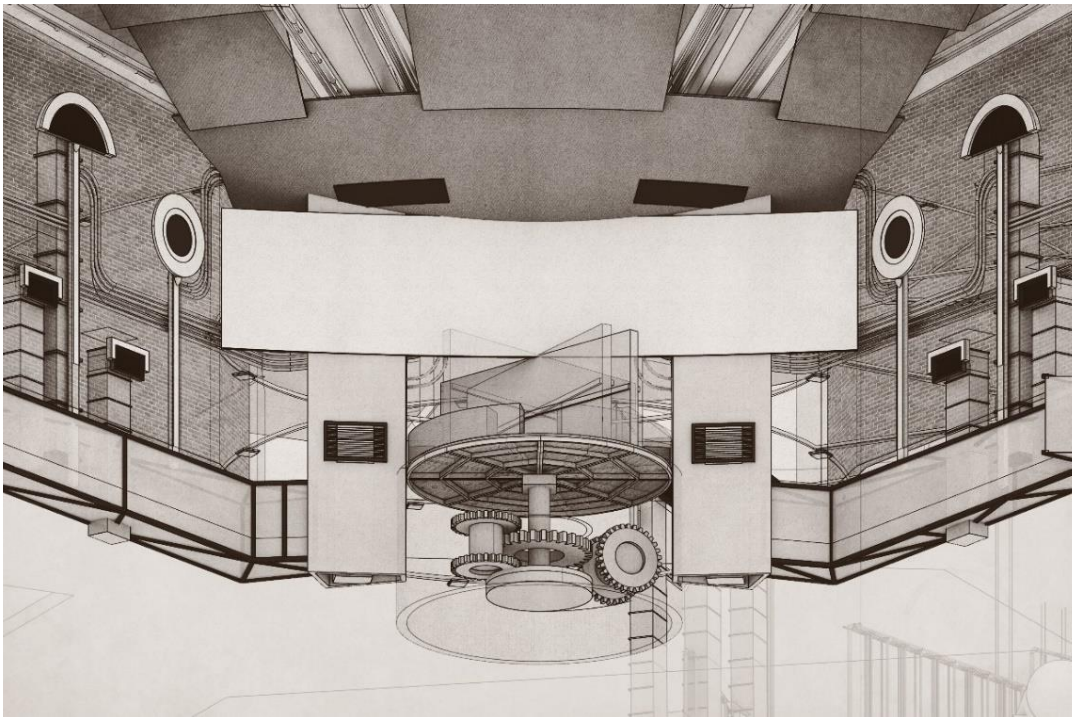

Figure 3.28. Drawing of the Revolving Platform, drawn by the author[307]

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[307] Forthcoming paper with Prof. Dr. Ayşen Savaş particularly focusing on detail of the stage.

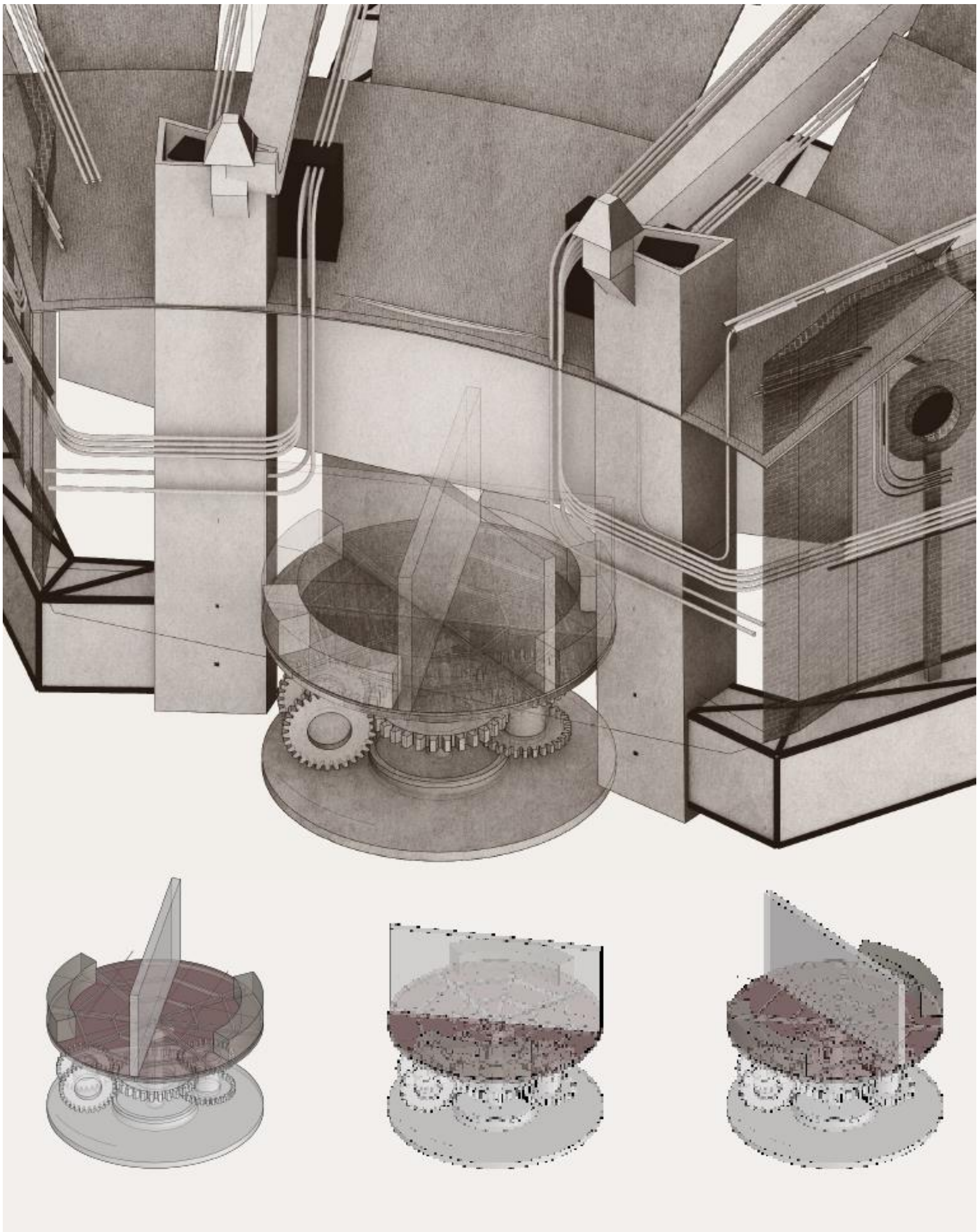

Figure 3.29, Trajectories of Revolving Platform, drawn by the author

3.4.2 Social Infrastructure in Building Scale

> “Architecture acts as a medium for the continuous horizontal exchange between natural and artificial ecologies, internal and external activities.”[308]

The complex circulation system of the campus is the main element that constitutes the architecture of social infrastructure in the campus and buildings. With the help of an open plan, it connects all the architectural spaces seamlessly to each other to provide continuous social networks and public spaces on the campus. Therefore, the social infrastructure of the buildings is provided mainly with the circulation system and “open plan” layout of the campus and buildings. Here the original architectural drawings of the METU Faculty of Arts and Sciences Lecture Halls are transformed into a digital model to understand the conceptualization of space design and thus to reveal the spatial characteristics and social infrastructure of this complex building in terms of circulation space, open plan, and served-servant spaces.

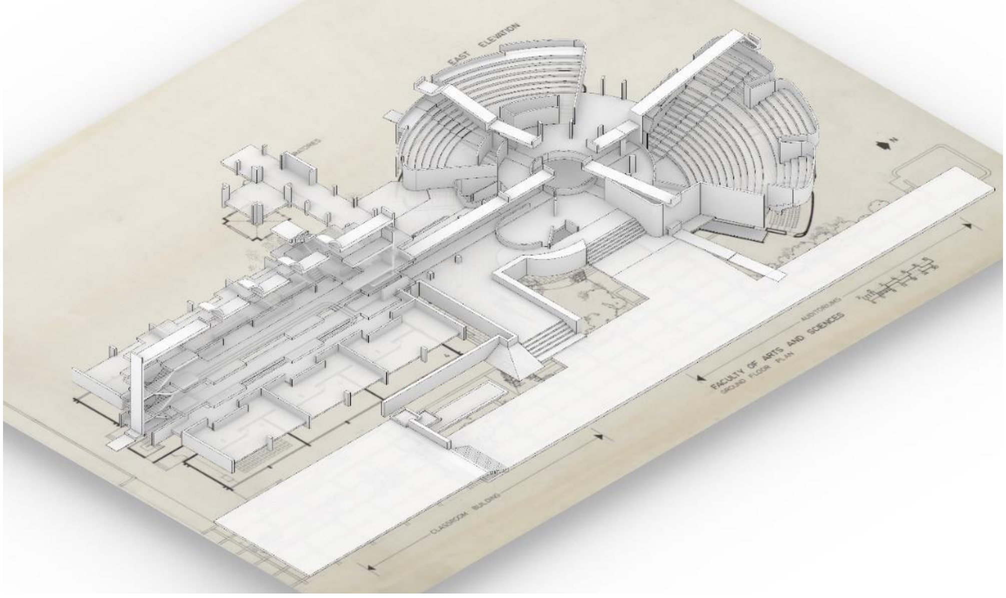

Figure 3.30. Partial Digital Model, drawn by the author.

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[308] Somol, “Architecture without Urbanism,” 142.

Circulation as Space:

All the architectural spaces of the building are connected seamlessly with each other with the complex system of circulation. There is a very strong connection and continuity between horizontal and vertical circulation systems, interior and exterior circulation patterns of the campus and buildings. Starting from the Alley, pedestrian movement extends itself through and into the buildings with the articulated system of circulation pathways, platforms, arcades, corridors, stairs, and galleries. The auditoriums are intentionally separated from each other in the building to allow circulation space to infiltrate in between. With the aid of this permeability, circulation space expands into lecture halls and work as a three-dimensional network that welds all the spaces with each other.

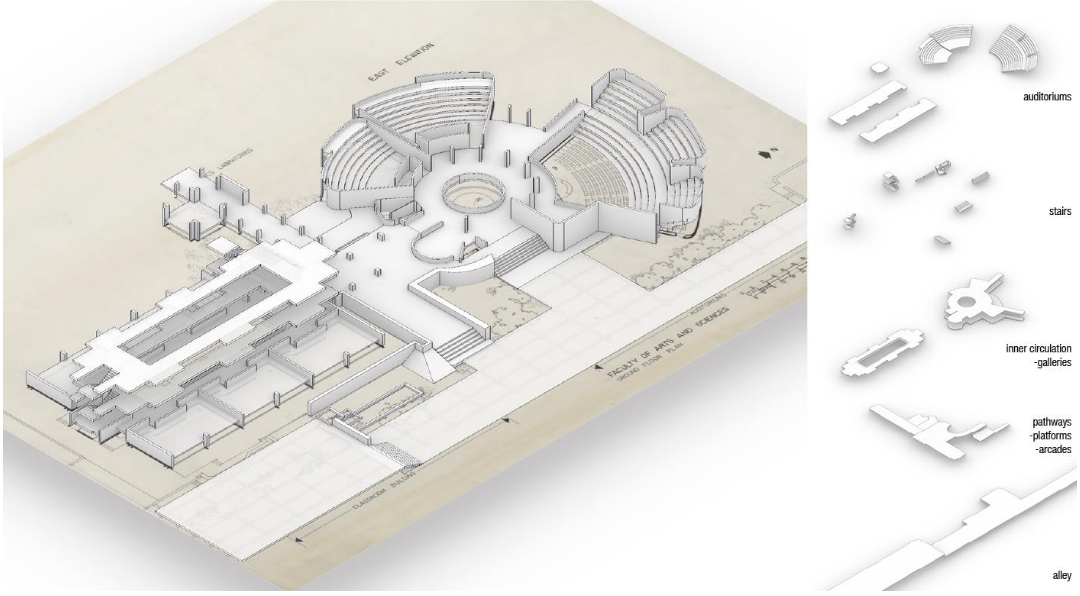

Figure 3.31. Articulation of Circulation Spaces, drawn by the author.

The Open Plan:

Walls are known as the main dividing elements of architectural space that help to control the relationship between outside and inside, lower floor and upper floor, serviced and servant spaces. In this building, they are not used merely to define different functions but also to link them horizontally and vertically. The walls in this building are deliberately designed to suggest movement. Seamless visual and physical continuities from lecture halls to corridors, corridors to outside spaces transform their identity from exterior to interior walls, load-bearing to infill walls, retaining walls to landscape elements. On the other hand, slabs are used to divide the building into different floors/levels. Slabs here articulated to create visual and physical continuities between different floors/levels, open semi-open and closed spaces with galleries, mezzanine floors, eaves, stairs, and clerestories.

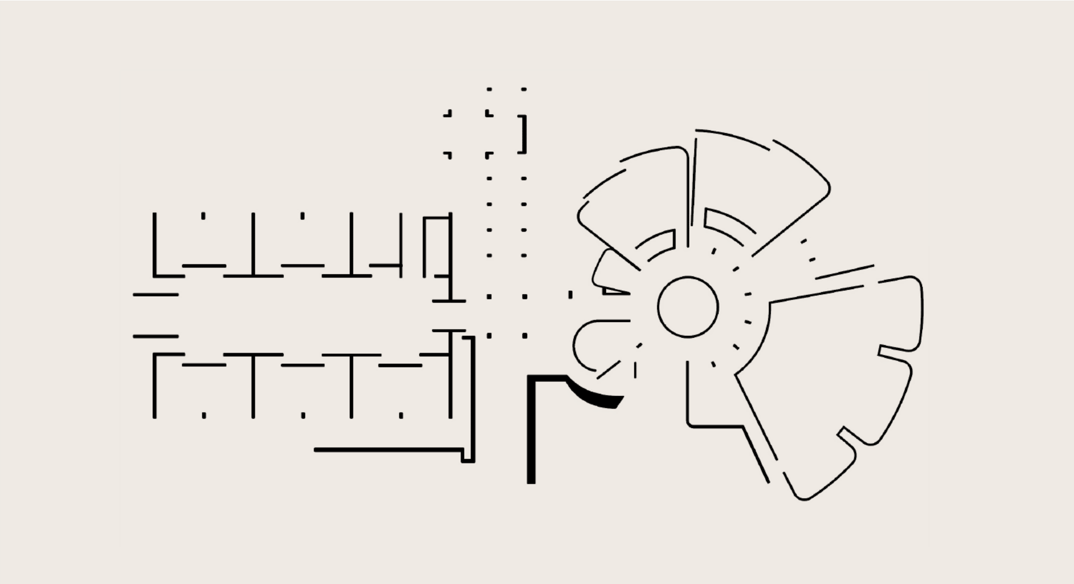

Figure 3.32. Open Plan Diagram, drawn by the author.

The "Open-plan" layout enlarges the impact area of individual functions, dissolves them into each other, and blurs the strong definition and division of spaces and circulation. Open plan layout also creates seamless movements and continuities between interior and exterior spaces with a complex circulation network serving for the rich social life and informal activities.

This continuous flow of spaces into each other helps to read the whole building as a single entity. Although divided into different scale auditoriums, lecture halls, staff rooms, canteens, and laboratories, this complex building transforms into a single volume.

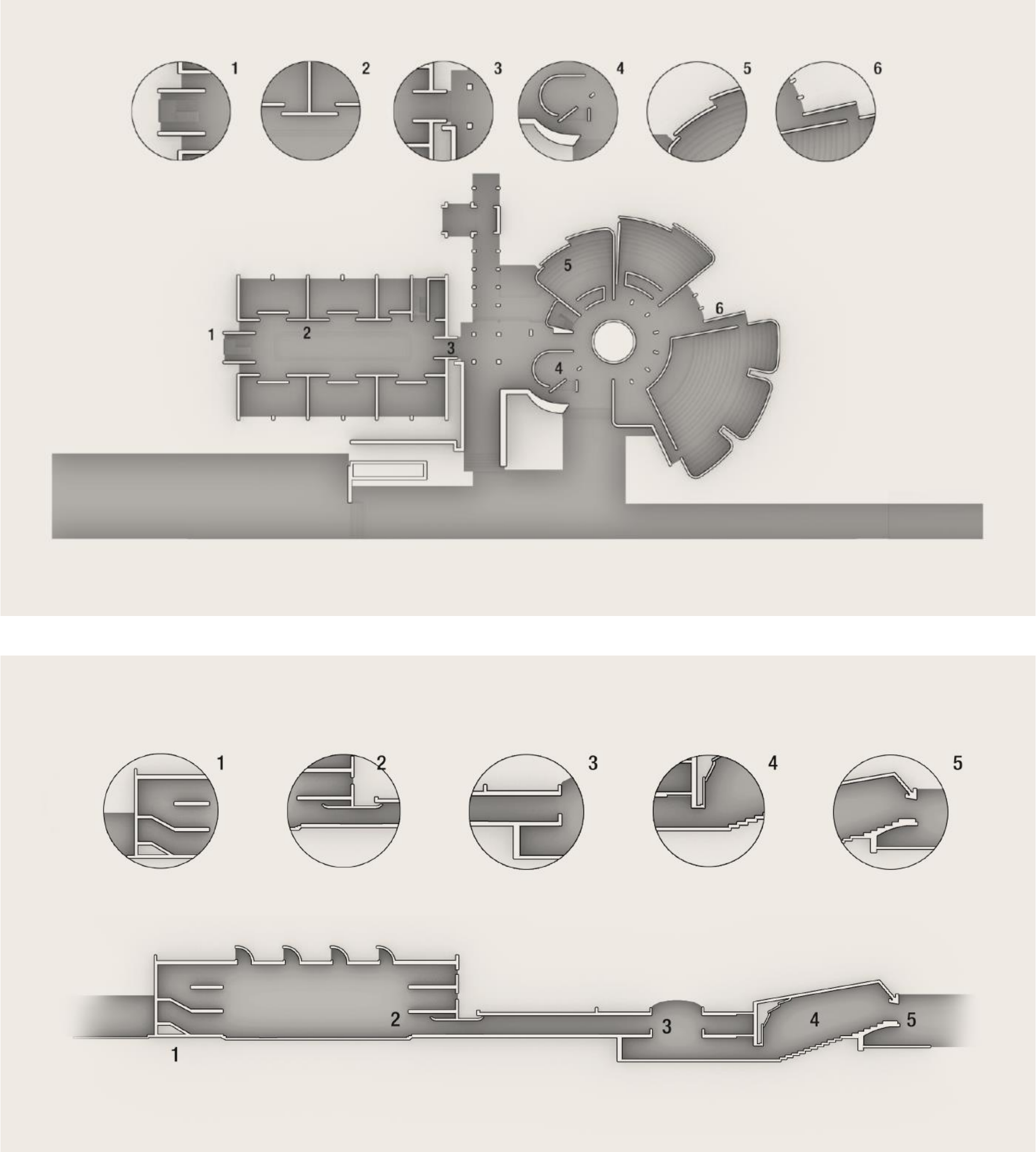

Figure 3.33. Walls and Slabs as Unifying Elements, drawn by the author.

Served Servant Spaces:

The concept of Louis Kahn’s spatial classification system of “served and servant spaces” is descriptive to discuss infrastructure and building services, especially the social infrastructure in the architecture of the campus buildings. The term “served spaces” in this building refer primarily to habitable areas, which can be listed as classrooms, offices, and auditoriums. “Servant spaces” on the other hand, refers to the building services, including the support functions such as corridors, stairs, technical rooms, and wet spaces.

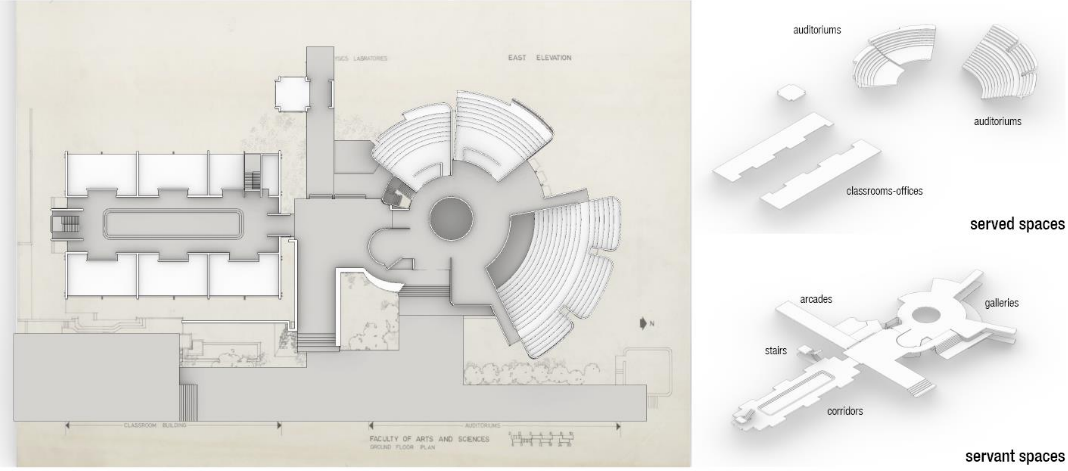

Figure 3.34. Served and Servant Spaces, drawn by the author.

The main characteristic of this building is that there is an intimate relationship between served and servants spaces, a design decision that blurs their strict distinction. Not only in this building but also in all the campus buildings, servant spaces have their autonomous spatial and material identity and capacity to enable the expansion of the main functions and make room for extracurricular activities. In the original functional requirement list, almost sixty percent of the total surface area of the building is reserved as servant spaces. The domination of servant spaces over served ones in the campus design blurs the strict spatial definition of these terms and makes it harder to differentiate which space is “served” and which is “servant”.

This conceptualization and design of the campus buildings reveal that the spaces called “servant” by definition are not designed only for circulation; on the contrary, they are actually designed to serve for extracurricular purposes and activities on the campus. They have the capability to serve for various social events, exhibitions, student presentations, informal meetings, and gatherings. That supports the rich social life of the campus that is strong enough to transform all these relationships in reverse. The campus buildings that are designed to function as educational units are now serving for the social life and informal activities. Lecture halls become part of canteens, and the buildings melt into the Alley to provide a public forum.

Therefore, as originally planned, education, the main function of the campus, takes place no longer in the classrooms but also in the corridors, courtyards, arcades, and entrance platforms. Çinici Architects gave great importance to the social necessities of the campus architecture with an ambition of “engineering a new society”.[309]

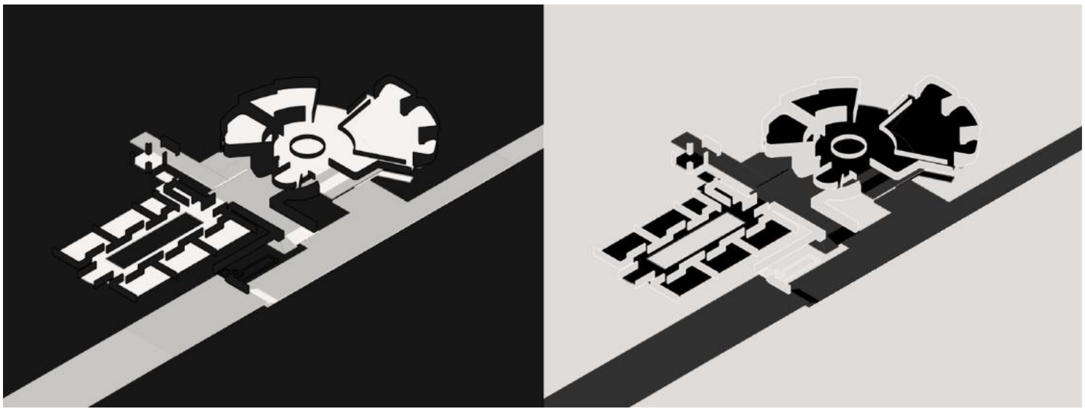

Figure 3.35. Flexible Architecture, drawn by the author.

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[309] Sargın and Savaş, “‘A University Is a Society’: An Environmental History of the METU ‘Campus,’” 604.

3.5 General Overview and Timeline of the Campus Infrastructure

METU Campus was also designed as a self-sustaining campus with all the social facilities, physical infrastructures, and natural assets. However, different analyses about the environmental impact and resource management of the campus reveal that METU consumes a great amount of natural resources, generates a lot of waste, and releases carbon into the environment. METU covers an area of 45000 hectares of land, its population is around 35000 people[310], it has more than 650.000 m^2 of built area[311] The annual energy consumption of the campus is estimated at around 38.000.000 kWh[312], natural gas consumption is 11.000.000 m^3/year[313], water consumption is more than 1.200.000 m^3/year[314] , and food consumption is around 13.200.000 kg/year.[315] In addition, around 14.000 vehicles enter the campus in a day which generates more than 12.000 kg of CO_2 per day.[316] Also, METU generates 2.908.000 kg/year solid waste[317] and releases 56.036.497 kg CO_2 into the atmosphere in a year[318]. Although these numbers alone are not enough to make a deduction, they briefly represent what kind of an urban environment and infrastructural system that campus has.[319]

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[310] METU, "METU at a Glance."

[311] Yeliz Galioğlu, "Quantifying the Ecological Footprint of Middle East Technical University: Towards Becoming a Sustainable Campus" (Middle East Technical University, 2015), 82.

[312] METU Electrical Directorate, "Technical and Statistical Information."

[313] METU Water and Heating Directorate, "Technical Information."

[314] Kiraz, "Sustainable Water and Stormwater Management for METU Campus."

[315] Galioğlu, "Quantifying the Ecological Footprint of Middle East Technical University: Towards Becoming a Sustainable Campus," 76.

[316] Altintasi and Tuydes-Yaman, "Best Option for Reducing On-Campus Private Car-Based CO2 Emissions: Reducing VKT or Congestion?," 99–100.

[317] Ecem Bahçelioğlu, E. Selin Buğdaycı, Nazlı B. Doğan, Naz Şimşek, Sinan Kaya, and Emre Alp, "Integrated Solid Waste Management Strategy of a Large Campus: A Comprehensive Study on METU Campus, Turkey," *Journal of Cleaner Production* 265 (2020): 4, https://doi.org/10.1016/j.jclepro.2020.121715.

[318] Ayşe Merve Turanlı, "Estimation of Carbon Footprint: A Case Study for Middle East Technical University" (Middle East Technical University, 2015), vi.

[319] For detailed information please see the referenced studies here. More research about the sustainability of METU Campus can be found in the websites https://greencampus.metu.edu.tr/tezler/ and http://sustainablecampus.metu.edu.tr/.

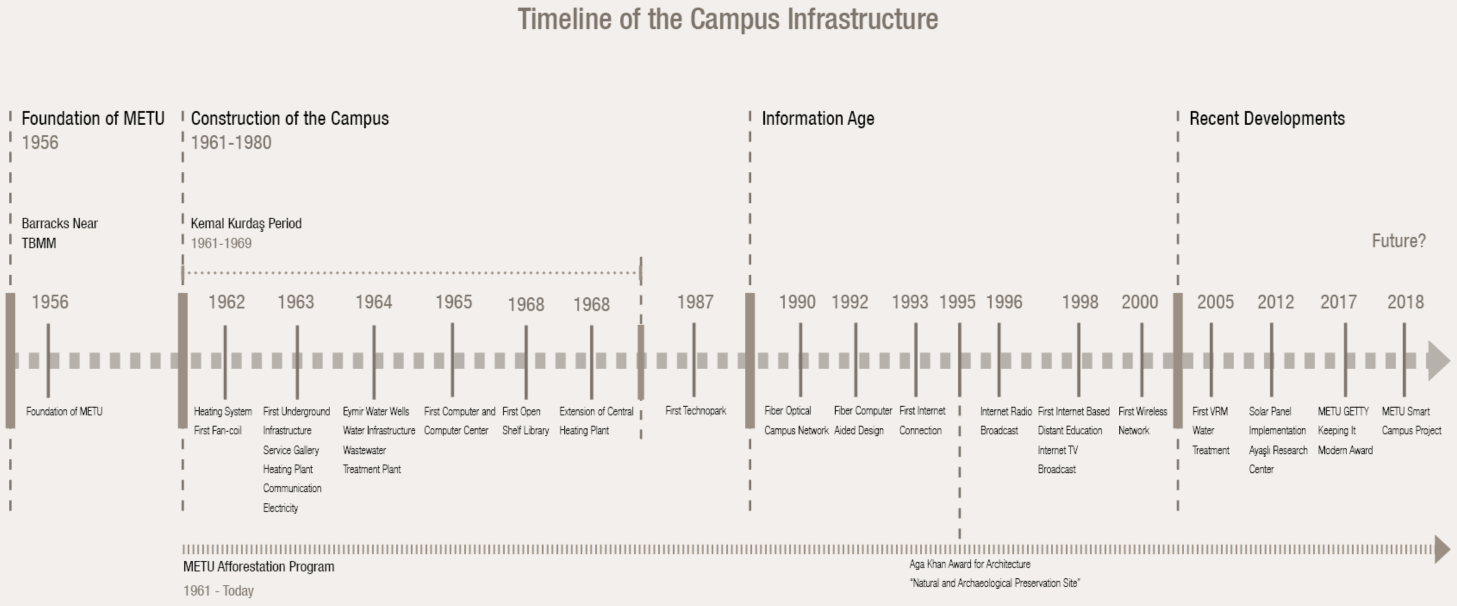

Figure 3.36. Timeline of the Campus Infrastructure, prepared by the author

Information about the infrastructural development of the campus throughout the years is collected in a timeline. The infrastructural investigation revealed that, although the METU campus has a very well-established campus and legacy infrastructure, the connection and collaboration between the infrastructures are not promising. Yet, sustainable and intelligent solutions and implementations are not adequate. Most of the qualities were inherited from the original design, conceptualization, and production of the campus and its infrastructures from the first ten years of campus developments. Except for the digital turn in the 1990s, it can be claimed that very few developments have been taken to improve the urban environment and spatial structure of the campus in 60 years.

In this thesis, understanding the actors of infrastructure is also important for potential development. As represented in the diagram, there are many stakeholders and actors who are effective on the campus and infrastructures. Although the campus infrastructure is operated singlehandedly by the university administration, there are different offices, experts, and people that are effective in the campus facilities. This social network diagram also aimed to represent the actors that might be effective on the campus infrastructures, such as research institutions established on the campus. It can be claimed that interconnected infrastructural networks and developments require close collaboration between the different actors of the built environment. The designers have a critical and central role in developing connections and collaborations between different components, scales, disciplines, stakeholders of the campus.

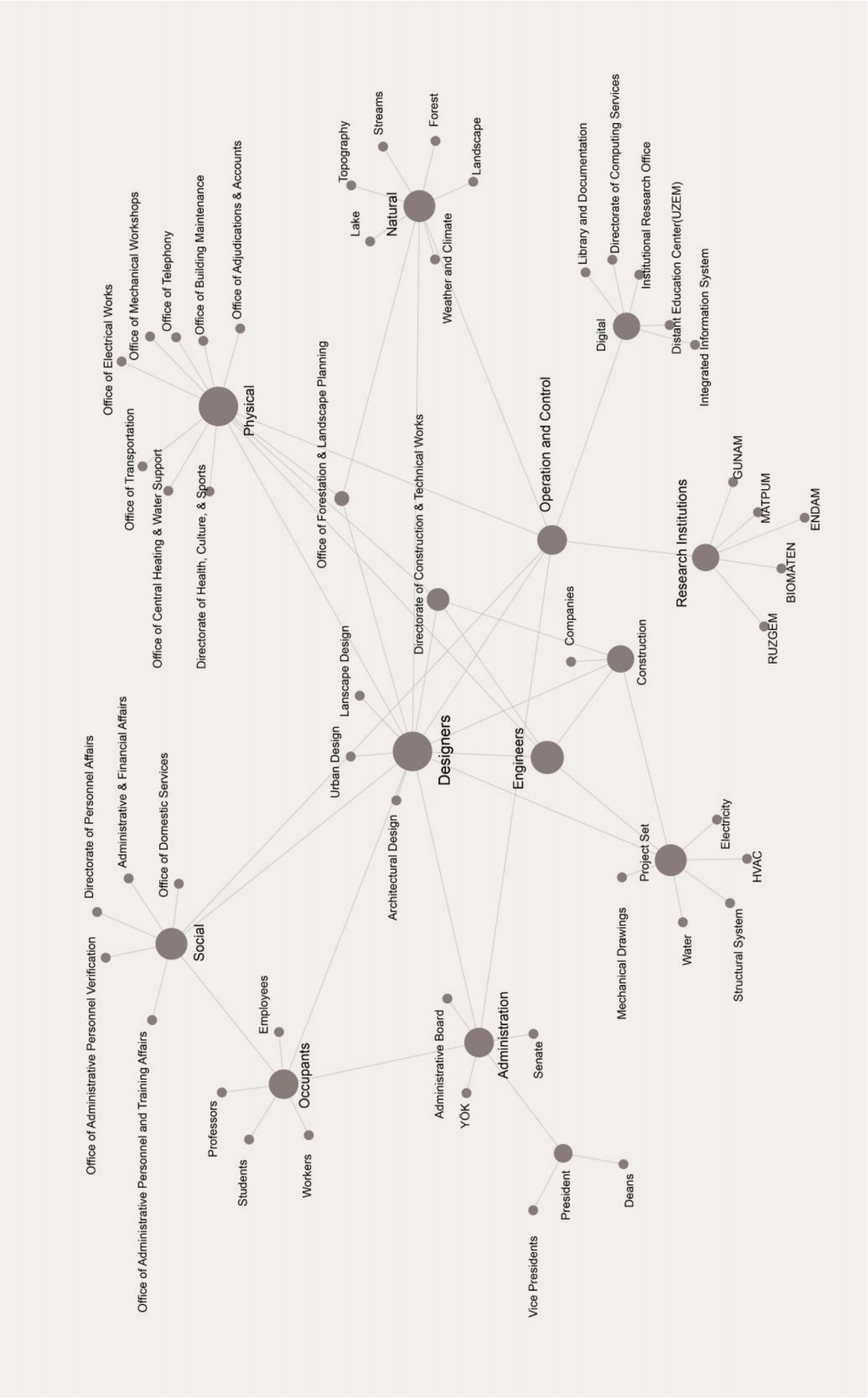

Figure 3.37. Actors of Campus Infrastructure, drawn by the author

CHAPTER 4

AN INTELLIGENT UTOPIA FOR THE METU CAMPUS

> "Every generation must build its own city. This constant renewal of the architectonic environment will contribute to the victory of Futurism which has already been affirmed… and for which we fight without respite against traditionalist cowardice."[320] Antonio Sant'Elia

Shifting social, technological, economic, and environmental trends are completely reshaping physical, digital, and biological processes as well as current architecture, urbanization, and infrastructural requirements of the cities.[321] Within this challenging context, the development of technologies and emerging concepts provide different potentials for the urban fabric to deal with these challenges. "Intelligent" cities have emerged as a strategy to ensure livable and sustainable environments.[322] Understanding the concept/framework and the potentials of "intelligence" in this study is significant to reconsider METU Campus and its infrastructure in these changing conditions and the new challenges of the future. The focus of this chapter is to overcome the emerging infrastructural needs and requirements of the METU Campus with a conceptual design proposal for the intelligent and sustainable development of the campus.

The infrastructural inquiry and documentation about the campus in the previous chapter provided detailed information about the context, history, ideals, technologies, and existing conditions of the campus infrastructure. This architectural research redefines METU Campus as an early example of social, physical, and

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[320] Sant'Elia, "Manifesto of Futurist Architecture."

[321] Schwab, *The Fourth Industrial Revolution*, 12.

[322] Chourabi, Nam, Walker, Gil-Garcia, Mellouli, et al., "Understanding Smart Cities: An Integrative Framework."

natural infrastructure for the emerging (intelligent) urban environments. However, the intelligence of the campus is not dependent on smart technologies. The initial vision, meticulous design of space, and experimental features of the infrastructures provide intelligent characteristics. Most of the infrastructures and architecture of the modern campus were built in 10 years, which generated a great network of social, technical, and ecological infrastructure for the campus and its community. This development can be considered as a modernist dream[323] for that time, and it can be a model for the spirit of a potential "intelligent utopia" for the future campus. This conceptual proposal aims to translate early standards of the modern campus into intelligent urban developments. With the original idea of considering campus development and construction as a "learning laboratory"[324], the campus can be an ideal experimentation ground to research and provide alternative models instead of corporate ideals. It can reclaim the intelligent developments to reconceptualize the issue with theoretical, academic, also material, and practical research to establish better cities.

Since the social, technological, and environmental necessities of the campus are transforming over time, this study approaches campus development as an ongoing process. Beyond the architectural ambitions, the proposal aims to provide a systematic understanding of general principles that can be consistent through different scales of applications and solutions. It points out the different potentials and research agendas for the campus, rather than generating a new smart masterplan. So that, development of individual and local systems can accumulate and contribute to the campus environment over time.[325] Providing bottom-up solutions in relation to the general principles and visions is, in fact, necessary for the overall coincidence about the campus developments. These suggestions aim to benefit from both hard

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[323] Savaş, "METU Campus."

[324] Savaş, Derebaşı, Dino, Sarıca, İnan, et al., "Research and Conservation Planning for the METU Faculty of Architecture Building By Altuğ-Behruz Çinici, Ankara, Turkey," 342.

[325] Stan Allen, "Field Conditions," in *Points + Lines: Diagrams and Projects for the City*, 1st Ed. (New York: Princeton Architectural Press, 1999), 90–135.

and soft strategies. As a result, technological smartness is not developed as an aim in this study; it is considered as another tool for campus developments that can be helpful to interconnect the environment, buildings, social life, and physical infrastructures.

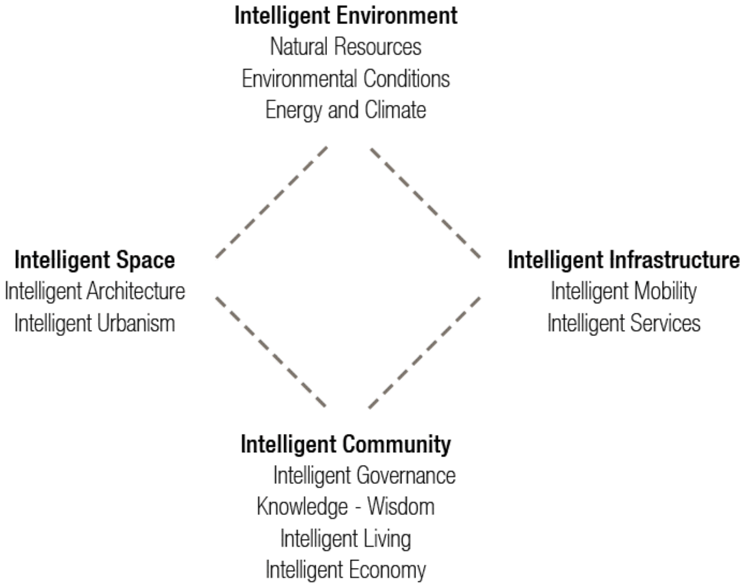

Figure 4.1. Components of Intelligence

4.1 General Framework:

The conceptual proposal provides a general framework and related thematic strategies for campus developments. This proposal stems from the potentials and challenges generated from the investigation on the campus and its infrastructure. It aims to increase efficiency, sustainability, the productivity of the campus with a general conceptual framework and specific suggestions. It builds on the previously mentioned issues, namely social, technological, and environmental. The technological, natural, and social infrastructure of the campus is reconsidered by an investigation of intelligent urban strategies to make campus and buildings more responsive, interconnected, and environmentally conscious. “Intelligent infrastructures” are proposed to maintain the productivity and liveability of the campus, and the primary goal is to achieve “urban intelligence”. Intelligent community, infrastructure, environment, and space are necessary components to generate intelligent urban settlements. Therefore, the primary aim is to increase interrelation between the social, spatial, physical, digital(artificial), and natural infrastructures for the intelligent campus.

This study will point out some of the principles that can be developed for the general framework for intelligent development of the campus and provide some local solutions and bottom-up proposals for the implementations. It conceptualizes the smart, sustainable campus proposals under several topics:

- Intelligent Space, Environment, Community, Infrastructure for Intelligent campus
- Strengthening integration and relationship between physical, social, and natural infrastructures of the campus
- Enhanced “Knowledge Infrastructure” Extensive Data and IT Infrastructure
    - Collecting, processing, and distributing data (GIS, SCADA, and BIM systems)
    - Open Data – Information – Knowledge – Innovation - Wisdom
- Circular and self-sustainable urban environment
    - Circular usage of resources – energy, natural resources, space
- Net-negative energy, carbon, and waste campus
    - renewable energy resources biomass, solar, wind, water,
    - decentralized power production
    - water collection and treatment
- Clean environment, left to green and water, (efficient, sustainable, resilient)
    - Automated and sustainable mobility systems for the car and carbon-free environment

4.2 Integrated Infrastructural Network

METU Campus has all the necessary infrastructure facilities and still managing and operating them.[326] This is a great advantage for developing intelligent strategies on the campus. Increasing the interrelation (correlation) between the social, physical, and natural infrastructures is the first strategy for the intelligent future of the campus. The integrated infrastructure can connect hardware, software, and nature with each other and blurs the line between physical, digital, and biological processes. This change of approach eventually eliminates the distinctions between the infrastructure, public spaces, and buildings on the campus. Integration and cooperation of technological, social, and natural infrastructures and disciplines transform the campus into a responsive, interconnected, and efficient urban ecosystem. All the infrastructure can be part of this urban network that serves for and is served by the campus.

This integration starts with intelligent strategical and circular principles before all kinds of interventions. This circular interrelation generates productive physical and organizational networks and infrastructures within the campus. It provides a seamless connection between the different scales and components of the built environment to create intelligent space, environment, community, infrastructure for an intelligent campus. It enhances environmental conditions, circular and efficient usage of resources, interconnected society, and knowledge in the campus.

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[326] Hung, Aquino, Waldheim, Czerniak, Geuze, et al., *Landscape Infrastructure: Case Studies by SWA.*

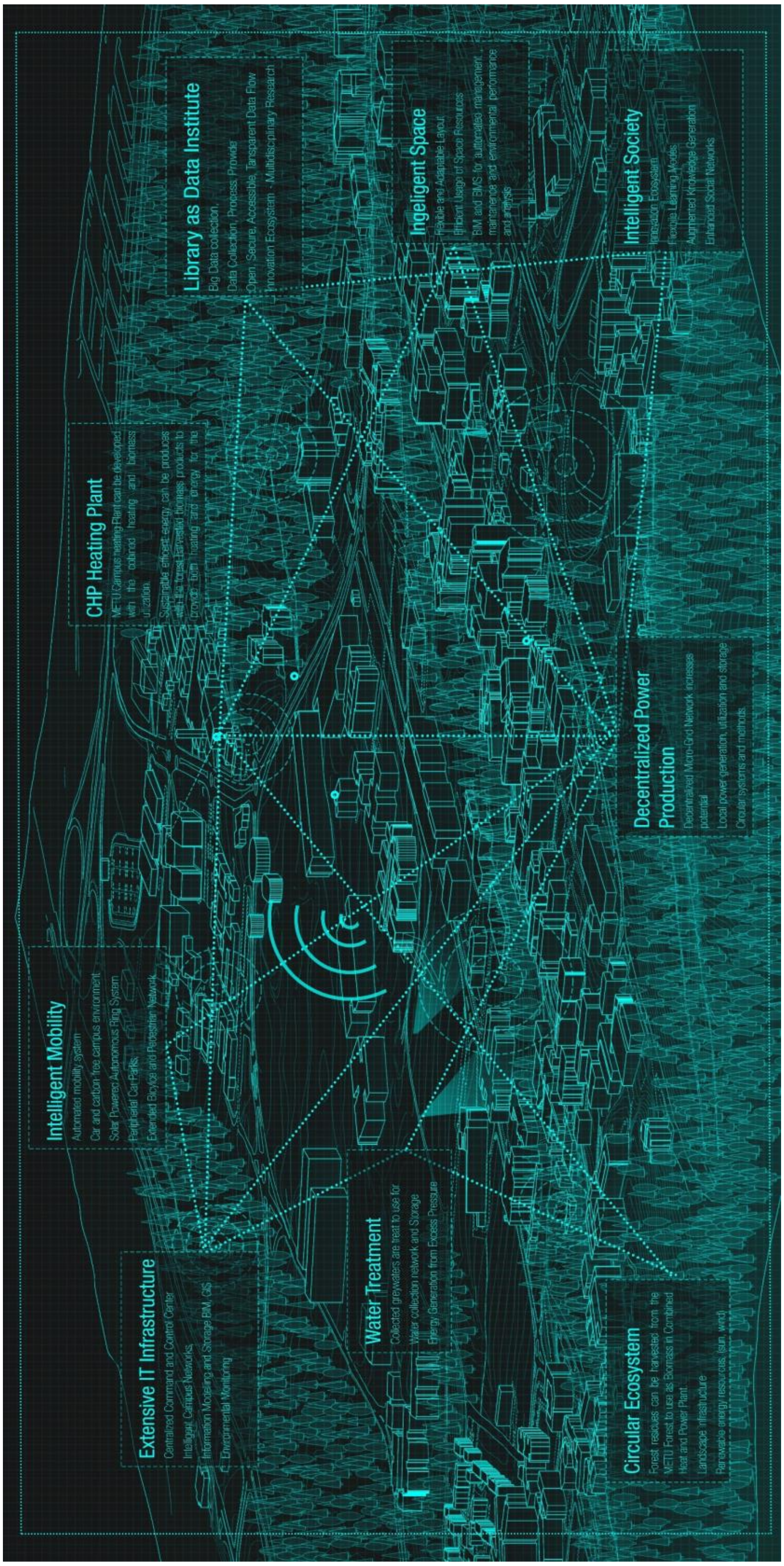

Figure 4.2. Integrated Infrastructural Network, drawn by the author

Integration of networks can be supported with the hybrid system of centralized and decentralized infrastructural networks. Decentralization of infrastructural systems can increase the ability and reliability of distributed infrastructural networks and legacy infrastructures. Therefore, beyond just providing resources, they can also produce, collect, and distribute necessary resources back to the system and nature. The two-way flow between the infrastructure supports integration between natural, artificial (built), and digital systems and infrastructures of the campus. Increased integration creates a symbiosis, synergies, and correlation between the different components of the campus. This intelligent approach can affect the performance of spaces of the campus to be more smart, productive, and environmentally conscious.

Digital infrastructure can amplify these relationships on the campus. There is a need for an intelligent infrastructural network in the campus consisting of sensing, transmission, data management, and application layers of the intelligent urban structure. This network can collect data, process it, provide information, and enable solutions. This collection scheme can be connected with the centralized command and control center to manage, control, and store the data within the supervision of the METU Library.

The centralization of information systems can ease the management, control, and usage of integrated infrastructures. It can digitally enhance interconnection between the different networks and increase the availability and accessibility of data for the inhabitants of campus. This data can be used to generate contextual, economic, and environmental solutions to campus problems. All infrastructural components, transportation, power, green, heating, environmental conditions, ICT, lighting, waste, and water can be detected, controlled, and developed integrally.

4.3 Intelligent Environment and Circular Resources

METU Campus is designed as a self-sustaining settlement. With similar ambition, circular and sustainable energy resources and models have to be provided in the METU Campus. The aim should be a net-zero waste for the self-sustaining, circular campus design. Currently, METU Campus has mainly dependent on non-renewable energy resources except for limited use of local solar panel implementations in the METU Department of Electrical and Electronics Engineering.[327]

The huge land and the forest of the campus provide alternative opportunities to utilize internal energy resources and generate sustainable modes of heating, cooling, energy, and power. The land is capable of working as a productive ground that can supply different kinds of renewable resources, such as biomass, wind, rainwater collection, geothermal and solar energy. They can be utilized as circular resources for the vision of the net-zero energy campus. Harvested forest residues can be utilized as biomass to generate energy. Seasonal heat gain can be stored in underground aquifers to heat campus in winter.[328] Storm and rainwater collection methods can be elaborated to use treated water for landscape irrigation. Ecological solutions can be developed for waste management; waste can be reutilized to use as an energy source and fertilizer. Huge parking lots provide great potential for solar energy production. All the energy produced in the local systems can be shared with the other buildings on the campus. Excess water pressure generated in the METU water infrastructure due to gravity can provide a potential energy generation in the system.[329]

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[327] Ertekin, Keysan, Göl, Bayazıt, Yıldız, et al., "METU Smart Campus Project (IEAST)," 293.

[328] Jalia, Bakker, and Ramage, "The Edge, Amsterdam Showcasing an Exemplary IoT Building."

[329] İ Ethem Karadirek, Selami Kara, Özge Özen, Oğuzhan Gülaydin, Enes Beştaş, Mustafa Boyacilar, Ayşe Muhammetoğlu, Afşin Güngör, and Habib Muhammetoğlu, "Energy Recovery Potential from Excess Pressure in Water Supply and Distribution Systems," *Mugla Journal of Science and Technology* 2, no. 1 (2016): 70–76.

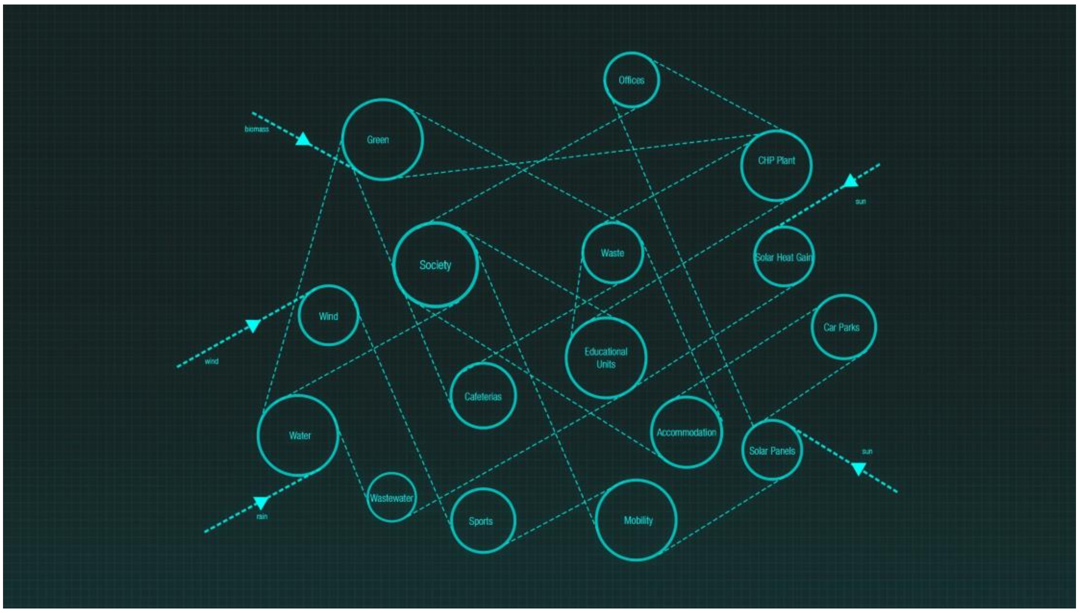

Figure 4.3. Circular Campus, drawn by the author[330]

As the METU Smart Campus Project points out that "METU campus has a great potential for installing combined heat and power systems due to availability of heating center."[331] This development can create both energy and heat for the campus by transforming the heating plant into the Combined heat and power (CHP) systems which are much more efficient than separated energy and heating systems. In addition to developing CHP, it is necessary for this infrastructure to be dependent on renewable energy resources. As suggested, biomass and waste collected from the campus can be reutilized as the main energy resources to achieve circular and sustainable energy production with an aim to achieve zero-waste and net-zero energy campus. As in the old days, it will be relatively easy to switch both the energy resources and equipment thanks to having an interdependent central heating plant and networks.

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[330] Bjarke Ingels, *Yes Is More: An Archicomic on Architectural Evolution* (Köln: Taschen, 2010), 53. This drawing is inspired by the diagrams of the project entitled "Little Denmak" designed by BIG

[331] Ertekin, Keysan, Göl, Bayazıt, Yıldız, et al., "METU Smart Campus Project (IEAST)," 293.

In addition to the transformation of the centralized infrastructure of the campus, decentralized energy generation is important to increase the capacity of renewable energy resources. According to the smart campus project developed for the METU, the power grid of the campus can be developed with micro-grid energy systems.[332] This hybrid energy generation with decentralized systems can also increase the reliability and capacity of renewable energy sources. The distributed network of energy creation and internal energy gain also requires power storage systems over the campus. Hybrid energy storage systems can support the primary power grid. Since the new mechanical systems and equipment are constantly getting more compact and decentralized, they will provide available spaces for energy and data storage within the existing infrastructure.

Water is also another vital resource for the campus. Although METU has its own groundwater resources and great water infrastructure, water recycling is really limited on the campus. The water treatment center and its capacity can be extended to use all the campus greywater, which can decrease the consumption of the campus. Groundwater can be kept as much as possible for future use on such a campus. All the rainwater collected and grey water used in the buildings can be used for one of the most water-consuming activities of the campus, which is irrigation. Different water depots can be implemented to collect, distribute, and use rainwater and stormwater by benefiting from the natural slope of the campus. Groundcover of the campus landscape can also be switched to less water-demanding plants. Water consumption, usage, quality, problems should be controlled with smart meters, environmental monitoring, and control systems.[333]

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[332] Ibid., 292.

[333] Kiraz, “Sustainable Water and Stormwater Management for METU Campus.”

Figure 4.4. Augmented Networks of the campus, drawn by the author.

As the Smart Campus project points out, the development of central control system over the campus power grid provides a lot of potentials to collect data, monitor problems, and increase efficiency by optimization and management. Smart detection sensors and meters have a great significance in the network. IoT devices should be provided to increase control over the infrastructural grid. Digital systems can be extended and utilized to monitor, control, manage natural resources and environmental conditions, which can also provide feedback for the real-time risks in the natural habitat and long-term ecological problems.

The study also suggests, this project and implementation should be developed in collaboration with multidisciplinary teams and experts in these fields. Accepting the fact that an interdisciplinary approach is necessary, this proposal aims to highlight some of the infrastructural, architectural, and spatial dimensions and potentials for the development of the campus. METU hosts different research institutes that can develop renewable energy and resource strategies on the campus, such as the Center for Wind Energy (RÜZGEM), Center for Solar Energy Research and Applications (GÜNAM), Biomaterials and Tissue Engineering Application and Research Center (BİOMATEN), The Center for Energy Materials and Storage Devices (ENDAM), Research and Application Center for The Built Environment (YTM-MATPUM), Ecosystem Implementation and Research Center.

4.4 Library as Information (Data) Institute:

> “Knowledge infrastructures are ‘robust networks of people, artifacts, and institutions that generate, share, and maintain specific knowledge about the human and natural worlds’”[334]

One of the most important characteristics of an intelligent city is the data. Edwards states that creating a knowledge infrastructure can provide many potentials for the cities.[335] Collection, management, and usage of data are crucial for the intelligent campus, infrastructure, and community. Today METU only has smart control systems in the entrance gates and library, which are used mainly for security and control reasons.[336] The purpose of collecting and using data should be much broader, paying close attention to the personal data usage rights. Governance of the data and transparency are critical for how data is collected, processed, and used.[337] Therefore, this proposal also provides a management model for the data usage of the campus, with an aim to increase collaboration, integration, and communication with more transparent data and information flow (data exchange) between the different actors/stakeholders of the campus.[338] The library can have a key role in this development to provide a transparent, accessible, and safe data management model.

METU Library was developed as the earliest example of an open-shelf library system in Turkey that promotes access to knowledge and makes information available for all the campus society. METU Library is also designed separately from the individual departments to increase the capacity and quality of resources.[339] It is designed to be a separate institute that is intended to be more comprehensive than

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[334] Paul N Edwards, “Knowledge Infrastructures for the Anthropocene,” *The Anthropocene Review* 4, no. 1 (2017): 36, https://doi.org/10.1177/2053019616679854.

[335] Ibid.

[336] This idea is highlighted by Barış Yağlı during the discussions about METU Campus with him.

[337] Chourabi, Nam, Walker, Gil-Garcia, Mellouli, et al., “Understanding Smart Cities: An Integrative Framework.”

[338] Ibid.

[339] Kurdaş, *ODTÜ Yıllarım, “Bir Hizmetin Hikayesi,”* 151.

departmental libraries or resources. Such understanding is valid for today, where it becomes hard to distinguish boundaries between the sub-fields and disciplines. With the increase of web technologies, digital resources have become part of academic studies and knowledge. Digital connection develops the campus library system further with the digital resources of the campus. The essence of the library has remained same for providing both digital and printed resources and information about the campus.

New digital resources and analysis, all the informational and communication systems, and data can be regulated under the responsibility of the library as an over-departmental institute. Availability, accessibility, and transparency of the library can work as a model for two reasons. First, data collected from the networks and systems should be shared with the researchers and participants to promote the innovation ecosystem on the campus. This facilitates collaboration among researchers and disciplines and promotes alternative solutions and systems for campus sustainability, intelligence, efficiency, responsiveness, and management. The collective understanding ensures the data is collected for better environments and cities for the sake of new developments and technologies. The administration model for safety and anonymity should be the second implementation to increase the reliability and security of the system to avoid surveillance issues and other shortcomings of smart cities. The shared data should not include any private information but rather general information and crowd data. This approach can stimulate the research and collaboration to generate information from data and knowledge to create intelligence for the community and campus.

4.5 Intelligent Mobility

Transportation is one of the most fundamental human activities; therefore, they are essential infrastructures of urban areas. It is fundamental for both the transportation of passengers and goods. However, the transportation sector is responsible for 23% of global carbon emissions. Road transportation accounts for 73% of this emission, and more than half of it is produced by individual vehicles.[340] Therefore, looking for more sustainable, intelligent transportation modes and solutions should be beneficial for both the campus and the future of the city.

Recent studies about transportation are defining and handling the issue as a “mobility” solution. Transportation refers to the “act of moving goods or people”, whereas mobility focuses on “the ability to move or to be moved.”[341] Therefore, mobility is considered as a basic urban service about equity and access. Handling the issue as a mobility system can play a more significant role in an increasingly urbanized world where environmental concerns are more prevalent. This paradigm shift from hard transportation infrastructure to mobility infrastructure will help not just for transportation needs but also to reveal different values for mobility infrastructures. As Jensen states, transportation is not just a technical facility that can be considered as an “armature”.[342] Instead, he mentions the importance of “re-conceptualizing mobility and infrastructures as sites of (potential) meaningful interaction, pleasure, and cultural production.”[343] The aim is to search for “creating flows of meaning and cultures of movement.”[344]

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[340] Drew Kodjak, “Policies To Reduce Fuel Consumption, Air Pollution, And Carbon Emissions from Vehicles In G20 Nations,” *The International Council on Clean Transportation - ICCT*, no. May (2015): 22.
[341] Jordan Mckay, “Transport or Mobility: What’s the Difference and Why Does It Matter? | Forum for the Future,” 2019, Retrieved from https://www.forumforthefuture.org/blog/transport-or-mobility.
[342] Jensen, “Flows of Meaning, Cultures of Movements – Urban Mobility as Meaningful Everyday Life Practice,” 141–43.
[343] Ibid., 139.
[344] Ibid.

Mobility solutions promote multiuse infrastructure and solutions rather than the strict separation of vehicular and pedestrian infrastructures as hard and soft. The design of mobility infrastructures has the capability to generate synergies with social or landscape networks for the campus. Mobility of the campus can be developed with more sustainable, efficient, safe, environmentally conscious, and smart systems and approaches. Public transportation, walking, sharing, and cycling solutions can be promoted to decrease individual vehicular usage and traffic on the campus. Recently, a cycling route has been constructed on the campus to connect A1, A4, A2, and A7 gates. These solutions should be complemented with bike-sharing solutions. Public transportation, ring, and parking systems should be developed with efficient, renewable resources and intelligent solutions, especially with solar power, to decrease carbon emissions. The ring system can be developed by integrating real-time passenger analysis with the development of the web services; short and long-term data should be collected in multilayered GIS to create intelligent mobility solutions within the campus.[345] Monitoring and optimizing the real-time traffic patterns through sensors can also help to manage traffic congestions and mobility-related problems on the campus. IoT-enabled intelligent mobility solutions can be developed to improve the reliability, speed, customization, and security of mobility systems on the campus.

The design and planning principles of the car-free pedestrian circulation of the alley can be reconsidered to extend for the whole campus in the medium term. The primary aim can be achieving a completely car-free campus by promoting public mobility solutions and sustainable alternatives. Campus mobility can be developed with solar-powered autonomous shuttles/rings and rail systems in addition to extended cycling and walking networks. Except for the necessary services, all the vehicles can park at the car parks at the periphery of the campus, where they can be powered with solar energy and systems.

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[345] Ertekin, Keysan, Göl, Bayazıt, Yıldız, et al., “METU Smart Campus Project (IEAST),” 292.

4.6 Intelligent Space

> "Resources—particularly energy and space— will be managed and allocated in far more sophisticated ways than they are today. The effects upon patterns of space use, building systems and their functionality, and the prospects for long-term urban sustainability, will be profound —often in ways that are, as yet, unimagined."[346]

As Mitchell explains, space should be reconsidered as another resource in the urban environment.[347] This efficient usage of spaces is important to decrease the demand for new buildings and spaces on the campus. Digital transformation can provide a lot of potential in that sense. Both the public space and the individual spaces can be reutilized more effectively through alternative usage scenarios and methods for protecting, improving, managing usage of the spaces that are already constructed rather than consuming resources to build new ones. As stated by Haggans, sustainability cannot be just achieved with the usage of fewer resources and spaces:

> "The most sustainable building is the one that is never built. Unfortunately, most institutions continue to build space they don't need and can't afford to maintain and operate. Even if these buildings are at the cutting edge of sustainable design, institutions are increasing their carbon footprint problem. Having more bricks than necessary is expensive, regardless of how good those bricks are."[348]

Increasing usage of digital technologies, distant education, and online communication modes create another digital environment which is referred as "cyberspace". Recent pandemic proved that developing digital networks also decreases the demand for actual spaces for lecture halls and individual offices.[349] On

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[346] Mitchell, "Intelligent Cities," 7.
[347] Ibid.
[348] Haggans, "Future of the Campus in a Digital World | Center for 21st Century Universities."
[349] Ibid.

the other hand, emerging educational models promote dialog, collaboration, sharing, and participation which is also transforming traditional lecture understanding and spaces to diverse communication grounds between the participants.[350] Therefore, the need for collaborative working and sharing spaces is increasing on the campus.

> "The spatial requirements for campus buildings are being redefined by the emergence of new, more varied learning methods. Less space is needed for traditional lecture theatres, while there is a growing demand for collaborative or trans-disciplinary workspaces, quiet spaces, labs and innovation hubs as well as other types of functional space. There is also a rising demand for spaces that can be transformed on a regular basis, according to ever-changing curricula and the individual requirements of students, departments and industry partners."[351]

Since the learning modes are constantly evolving, being prepared for the new requirements with flexible and adaptable usage of spaces and layouts is crucial.[352] The flexible design of the METU campus and buildings are eligible for this development. The open plan layout provides flexible and adaptable space for alternative usage. They promote social engagement and leave space for uncertain conditions and activities. Contrary to what Banham stated about the constant growth and accumulation of mechanical services[353], it can be seen today that these services of buildings have become more compact and smaller. Especially digital infrastructures, small sensors, and thermal controllers need nothing but small electricity wires and Wi-Fi connections. Shrinkage of mechanical systems of the buildings provides more space for new decentralized systems on the campus and can also help to increase the flexibility of spaces.

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[350] Elisa Magnini, Tom Butler, and Marcus Morrell, "Campus of the Future," *ARUP Foresight* (London, 2018), 12.

[351] Ibid.

[352] Magnini, Butler, and Morrell, "Campus of the Future."

[353] Banham and Dallegret, "A Home Is Not a House," 70.

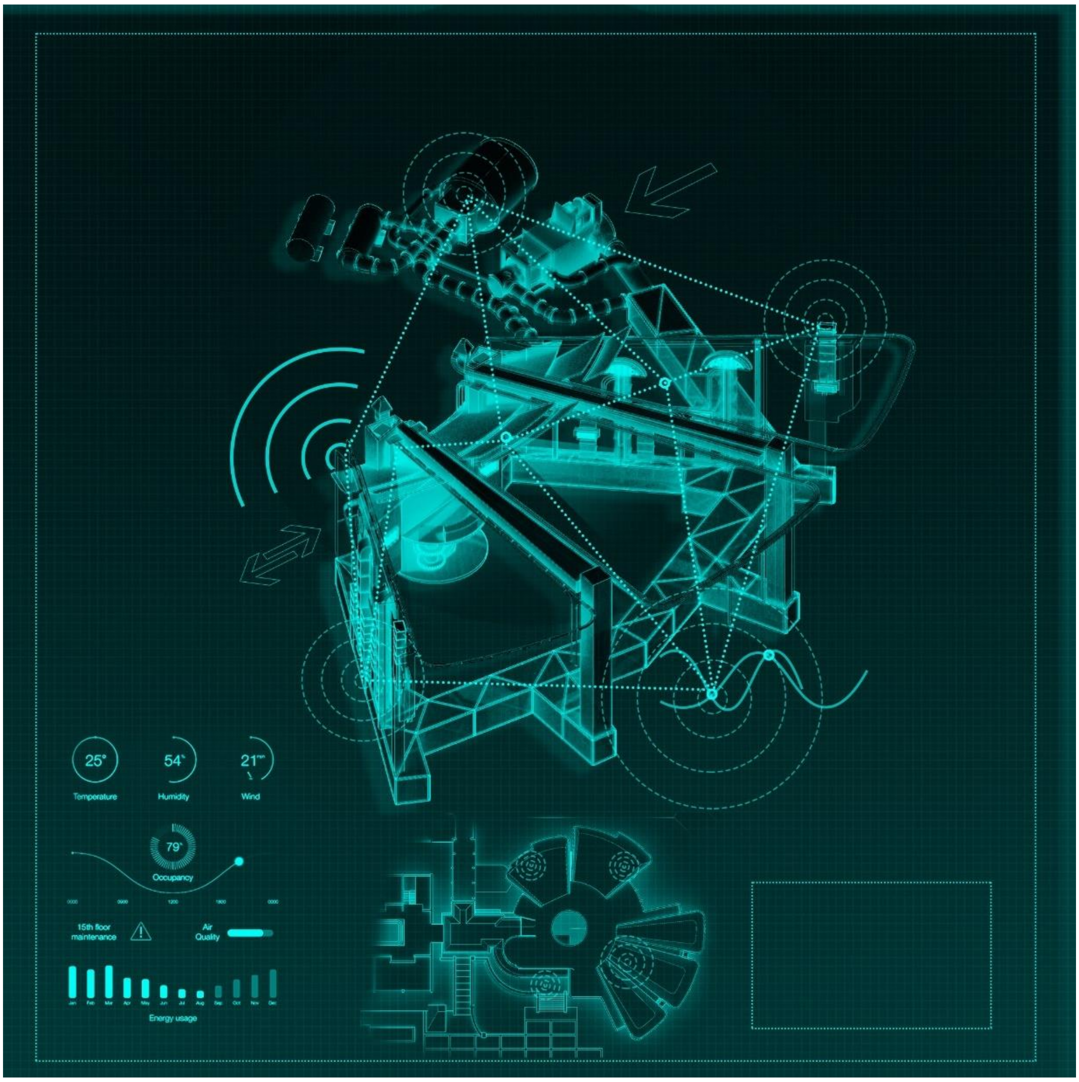

Figure 4.5. Intelligent Space, drawn by the author

Intelligent systems can also facilitate the environmental conditions and efficient usage of space. Digital sensing infrastructures of the spaces can collect the data of campus spaces in terms of density, course information, availability, and the number of occupants. With the integration of BIM and GIS, this data can provide information about the availability of the different spaces of the campus. Most of the spaces can be reutilized as study and co-working areas when there is no lecture. This data can recommend alternative working spaces to the students. Of course, this real-time data can be reutilized for the building automation (BAS) and management systems (BMS) to create more dynamic and responsive spaces. The cognitive ability of the space creates more interactive, adaptive, and responsive spaces. Intelligent infrastructures provide the connection between the systems, components, controllers, sensors, and actuators of the building to provide better conditions for the users.[354] They can increase the quality of space by adjusting environmental performance, temperature, air quality, level of noise, lighting conditions. This also enables to reduce the usage of resources by adjusting energy and performance according to environmental conditions and occupancy schedules.

> "The concept of a distributed building intelligence network extends to linking a number of buildings belonging to a single organisation together, both in terms of communications systems and building automation systems, hence, creating a "virtual building" which maximises both efficiency and effectiveness gains."[355]

Consequently, digital infrastructure promotes, enables, and supports the social, natural, and physical infrastructure of the campus and the relationship between them. They can create seamless digital, physical, and social connections and collaboration with the other buildings of the campus.

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[354] Derek and Clements-Croome, "What Do We Mean by Intelligent Buildings?," 396.
[355] Ibid., 398.

CHAPTER 5

CONCLUSION

The objective of this thesis is to study the complexities of the urban infrastructure of universities through METU Campus. The campus is studied and conceptualized as a collection of mechanical (hard), social (soft), and natural infrastructure, and the study primarily focused on the mechanical one. As the thesis title represents, the infrastructure of the METU Campus and its subsystems are investigated with an intelligent process. This study collected the information (data) about the different scales of the campus and its infrastructure, processed this information through different analyses and visualization methods, and proposed a general framework for the intelligent, sustainable development of the campus. Infrastructural context and spatial definitions are explored and visualized in different scales with different techniques of representation.

The investigation reveals that the METU Campus has a well-developed infrastructural design and production that can be considered intelligent. This intelligence stems from the design and conceptualization of the campus, which provides detailed care and importance to all components and infrastructures of the urban settlement. The METU Campus was established with pioneering technologies of mechanical infrastructure, an enormous natural environment, and integrated design and conceptualization of social spaces. High standards of engineering solutions, rich natural assets, and well-developed public facilities provided with advanced infrastructures that are still in operation. These characteristics are still significant in contemporary architectural and urban discussions and practices.

Infrastructural inquiry of the campus shows that, although this triad of the built environment generates a coherent whole, systematic interrelation and resource/material flows between different infrastructural assets of the campus are relatively weak. There are mischances and potentials to improve the campus in terms of environmental, technological, social expectations, and infrastructural challenges. Therefore, the principles learned from the spirit of the campus are reconsidered with the potentials and challenges of the campus infrastructures to create a conceptual design proposal for the future technological and sustainable development of the campus. The original preconception of the modern campus is evaluated with the emerging challenges of the 21st century to create an intelligent vision for the campus.

The project aims to enhance the relationship between the hard and soft infrastructural networks to achieve a fully self-sustaining campus environment. The proposal seeks for an integrated set of sustainable, digital, engineering, and beyond engineering; environmental and architectural design solutions for possible infrastructural networks that can be implemented in the near and medium-term to increase the productivity of the campus. The aim is to strengthen the social, physical, and natural infrastructures of the campus and interconnection between them to create a circular, intelligent urban ecosystem. Different potentials of integrated, multifunctional infrastructures are promoted to transform the campus and its buildings into more responsive, interconnected, and environmentally friendly environments.

This study is essential for the architectural survey of the built environment and architecture. It can be claimed that digital construction and informational modeling of the existing environments are inevitable to provide the full extent of intelligent implementation. Geographical mapping and re-drawing the urban areas and buildings (digital twins) should be the prime method to archive, survey, analyze, and enable solutions for urban developments. The spatial studies represented that most of the technological challenges can be improved with spatial utilization and developments. By accepting the space as an important resource of the cities, improving efficiency, flexibility, and variety of the urban environment services will generate endless potentials in terms of sustainability, infrastructures, and intelligence.

This methodological process generated an alternative model for studying, representing, adapting, and transforming existing urban environments. This model re-claims/recalls an essential role for the architects and designers in multiscalar and multidisciplinary urban infrastructural developments. By accepting these developments as a socio-technical and spatial issue, providing a comprehensive framework is necessary to answer the different social, environmental, and technological challenges of the city. So that the architects can participate in the actual, technical, material, social issues in the name of infrastructural problems of the urban environment for “an opportunity to improve the human condition.”[356]

Within the core of this study, the “infrastructure” discussion provides infrastructural ways and meanings to look at and understand urban settlements. Since the definition of “infrastructure” refers to both tangible (material) and intangible (theoretical) issues, this research generates many potentials and discussions that go beyond the stylistic or semiological studies of architecture calling for the material problems of urban environments.[357] Similar to the anatomical investigation of the body of living organisms, this infrastructural reading is helpful to understand how urban settlements work, operate, and proceed. Although this infrastructural investigation focuses on how each system and scale work independently, it points out cross-readings and unifying/synergetic potentials between different components and disciplines of the urban settlements. The multidisciplinary nature of infrastructures is helpful for the creation of multifunctional approaches and systems. Infrastructure is able to comprise both abstract and material issues to connect ecological, sociological, political, environmental, technological issues through infrastructural thinking.

Understanding the systematic reasons behind infrastructures and flows of the systems provides a broad understanding for architects. Infrastructural research increases spatial and systematic understanding and capabilities of designers, which

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[356] Allen, “Infrastructural Urbanism,” 50.
[357] Ibid., 52.

creates an awareness of the intricate relationship between architectural and infrastructural knowledge and production. The interdependence of space and infrastructures increases the flexibility of both services and spatial configurations as well as the durability and adaptability of architecture over the years. Since the production of both space and services is getting more complex and multifaceted, this research refers to the importance of close collaboration and communication between different actors and disciplines effective on the built environment.[358] As Banham also states:

> “It would have been apparent long ago that the art and business of creating buildings is not divisible into two intellectually separate parts—structures, on the one hand, and on the other mechanical services.”[359]

As a result of general infrastructural reading on campus, this thesis also claims there is no direct distinction between infrastructure and structures. The infrastructural inquiry reveals that a building can also be considered as infrastructure, and cities can be studied as the collection of infrastructures. This infrastructural study moves the research beyond ongoing “structure, service”, “served-servant”, “enclaves-armatures”, or “form-function” discussions and splits in architecture and urban design. Instead, it searches for the potential connection and integrity between dualities or multiplicities. This provides infrastructural perspective and system thinking to understand the design and engineering behind liveable urban environments and spaces in the Banham words “technological art of creating habitable environments”.[360]

The comprehensive understanding of the “infrastructure” provides a productive theoretical ground for re-conceptualizing “intelligence” for urban environments. Conceptual and instrumental features, in addition to the soft and hard understanding

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[358] Ibid., 55.
[359] Banham, *The Architecture of The Well-Tempered Environment*, 11.
[360] Ibid., 12.

of infrastructure enable both theoretical profoundness and inclusive implementation that can be a model for intelligent urban developments. This overall understanding can be extended into the intelligent city discussions to elaborate studies and knowledge to uncover alternative scenarios without restricting urban developments to only high-tech add-ons.

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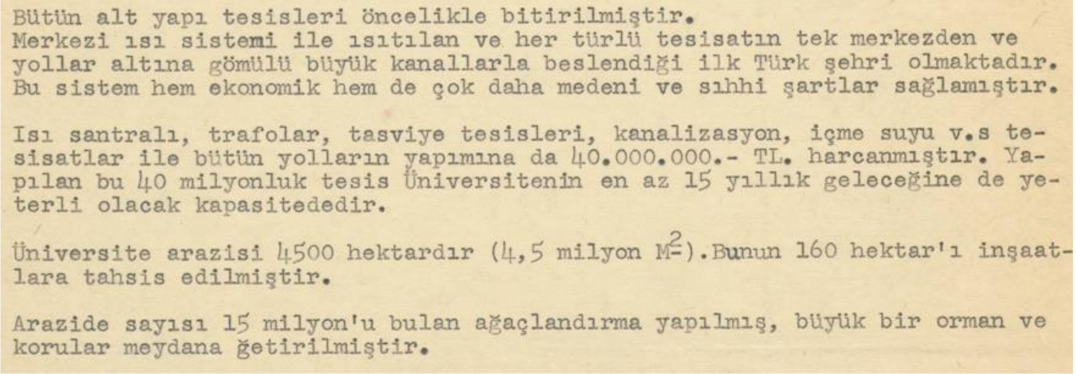
APPENDICES

A. Text contains some information about Middle East Technical University Campus



Bütün alt yapı tesisleri öncelikle bitirilmiştir.
Merkezi ısı sistemi ile ısıtılan ve her türlü tesisatın tek merkezden ve yollar altına gömülü büyük kanallarla beslendiği ilk Türk şehri olmaktadır. Bu sistem hem ekonomik hem de çok daha medeni ve sıhhi şartlar sağlamıştır.

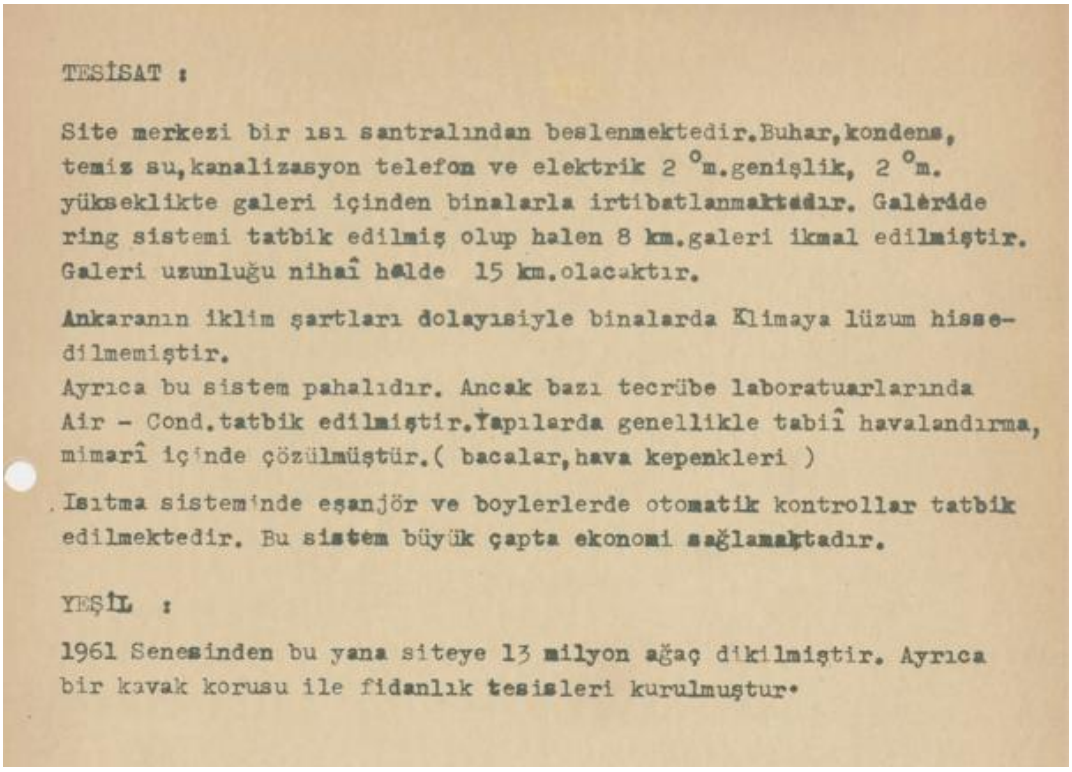
Isı santralı, trafolar, tasviye tesisleri, kanalizasyon, içme suyu v.s tesisatlar ile bütün yolların yapımına da 40.000.000.- TL. harcanmıştır. Yapılan bu 40 milyonluk tesis Üniversitenin en az 15 yıllık geleceğine de yeterli olacak kapasitededir.

Üniversite arazisi 4500 hektardır (4,5 milyon M^2).Bunun 160 hektar'ı inşaatlara tahsis edilmiştir.

Arazide sayısı 15 milyon'u bulan ağaçlandırma yapılmış, büyük bir orman ve korular meydana ğetirilmiştir.

Source: Salt Research, “Altuğ-Behruz Çinici Archive - Middle East Technical University

B. Report about design decisions and construction process of Middle East Technical University Campus



TESİSAT :

Site merkezi bir ısı santralından beslenmektedir. Buhar, kondens, temiz su, kanalizasyon telefon ve elektrik 2 °m. genişlik, 2 °m. yükseklikte galeri içinden binalarla irtibatlanmaktadır. Galeride ring sistemi tatbik edilmiş olup halen 8 km. galeri ikmal edilmiştir. Galeri uzunluğu nihaî halde 15 km. olacaktır.

Ankaranın iklim şartları dolayısiyle binalarda Klimaya lüzum hissedilmemiştir.

Ayrıca bu sistem pahalıdır. Ancak bazı tecrübe laboratuarlarında Air - Cond. tatbik edilmiştir. Yapılarda genellikle tabiî havalandırma, mimarî içinde çözülmüştür. (bacalar, hava kepenkleri)

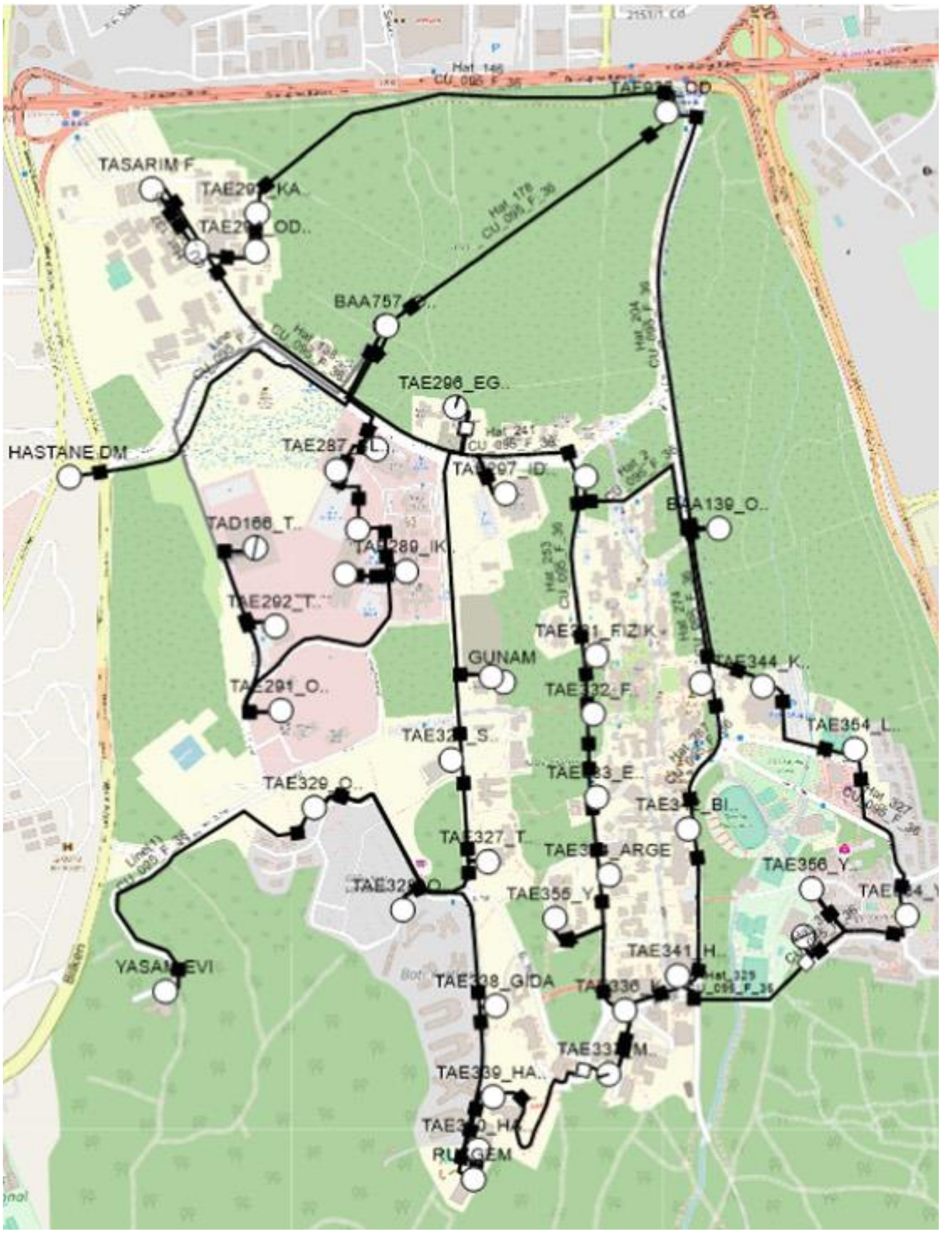
Isıtma sisteminde eşanjör ve boylerlerde otomatik kontrollar tatbik edilmektedir. Bu sistem büyük çapta ekonomi sağlamaktadır.

YEŞİL :

1961 Senesinden bu yana siteye 13 milyon ağaç dikilmiştir. Ayrıca bir kavak korusu ile fidanlık tesisleri kurulmuştur.

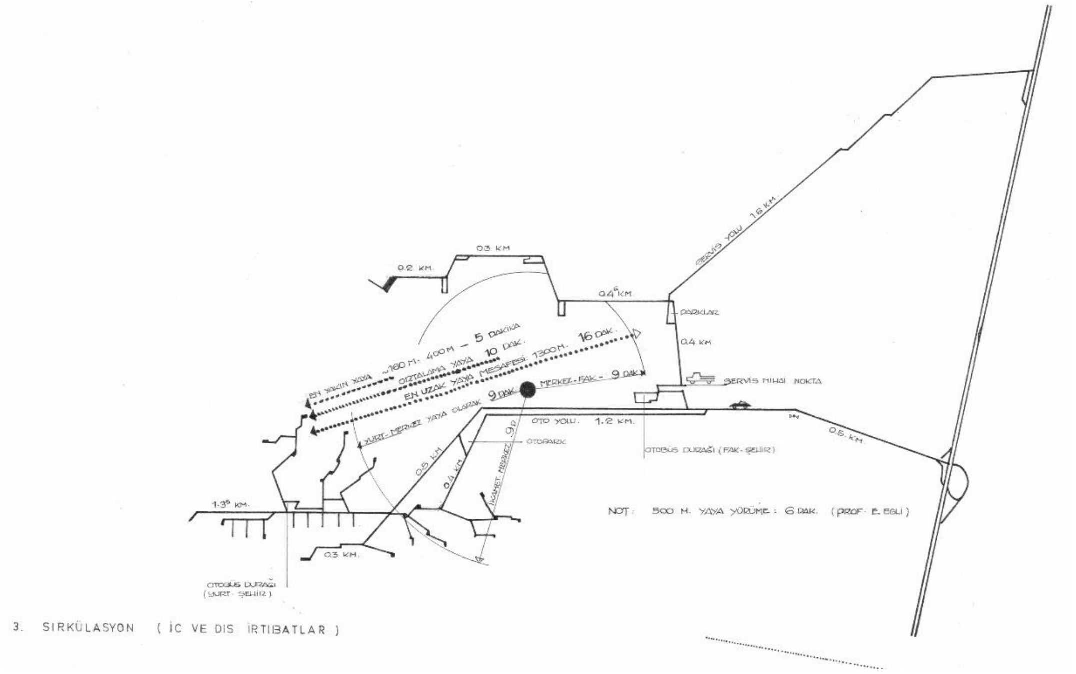
Source: Salt Research, “Altuğ-Behruz Çinici Archive - Middle East Technical University, Report about design decisions and construction process of Middle East Technical University Campus

C. Medium Voltage Distribution Grid of the Campus



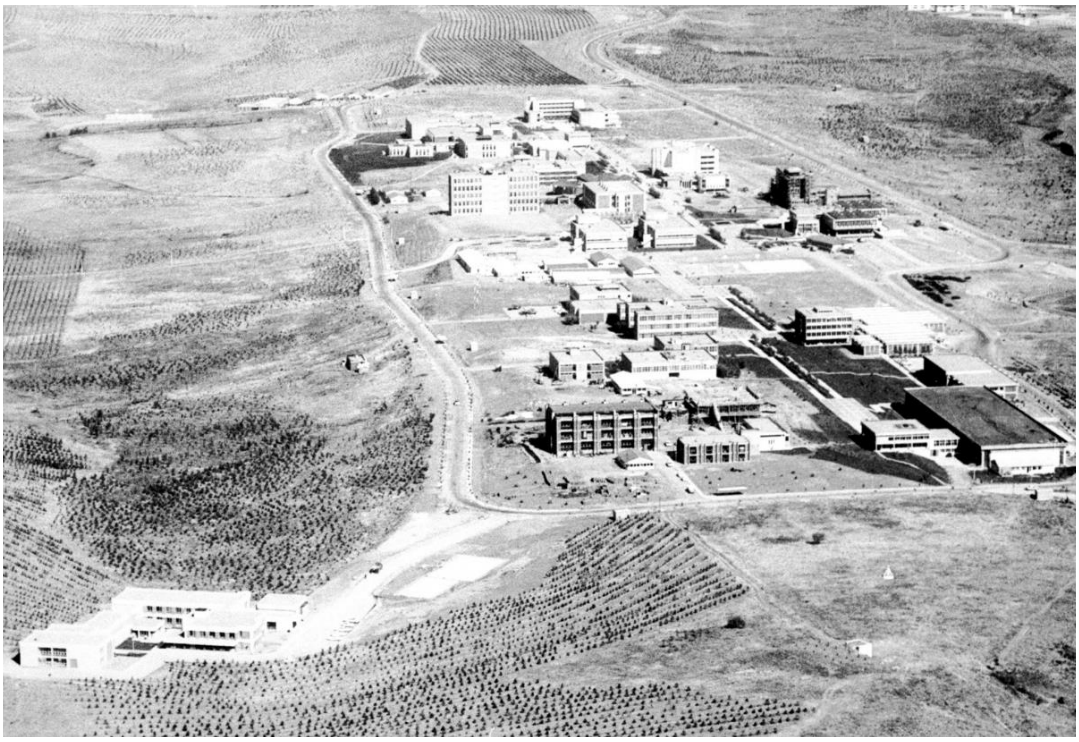
Source: METU Smart Campus Project, 293

D. Circulation Diagram of the Campus



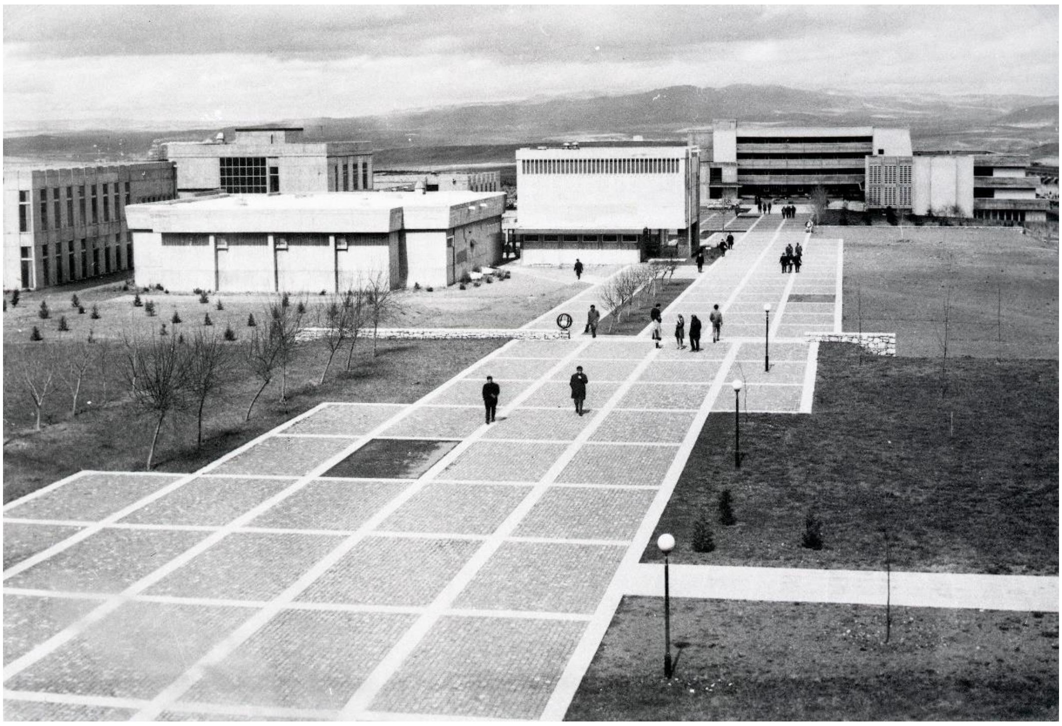
Source: Savaş, Dino, Sarıca, İnan, Derebaşı, Özkan “Research and Conservation Planning for the METU Faculty of Architecture Building by Altuğ-Behruz Çinici, Ankara, Turkey.”, 2018, 97.

E. METU Campus in 1960s



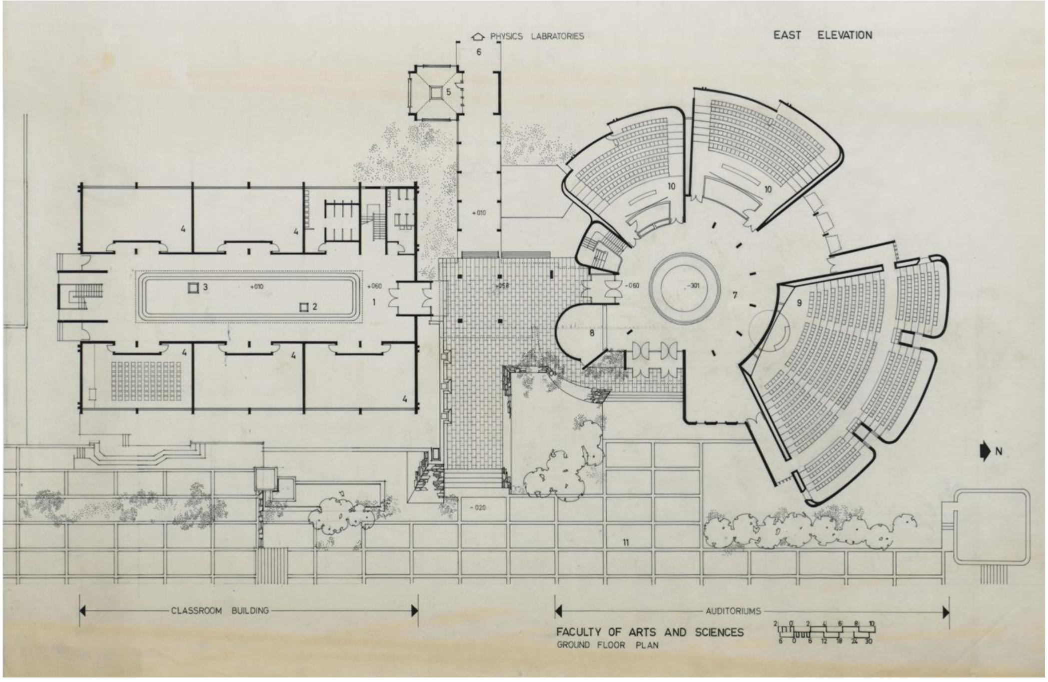
Source: Retrieved from https://archweb.metu.edu.tr/en/campus-map on December 15, 2021

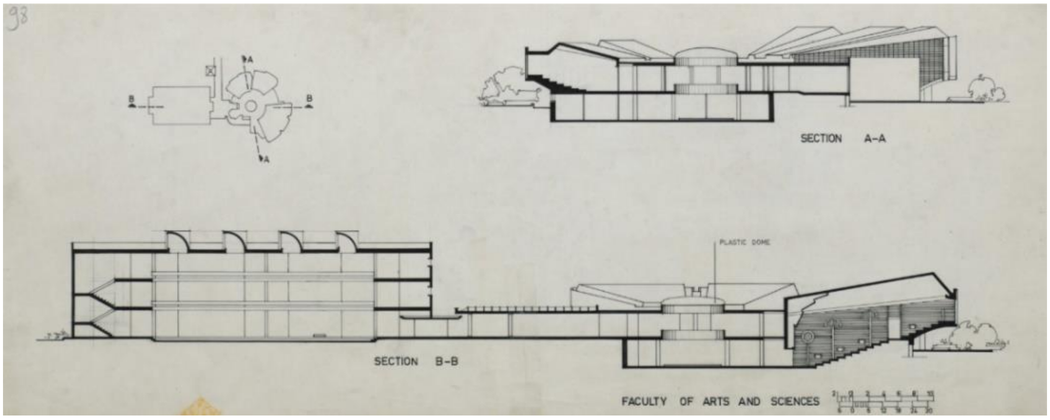
F. Alley of the METU Campus in the 1960s



Source: Salt Research, “Altuğ-Behruz Çinici Archive - Middle East Technical University”

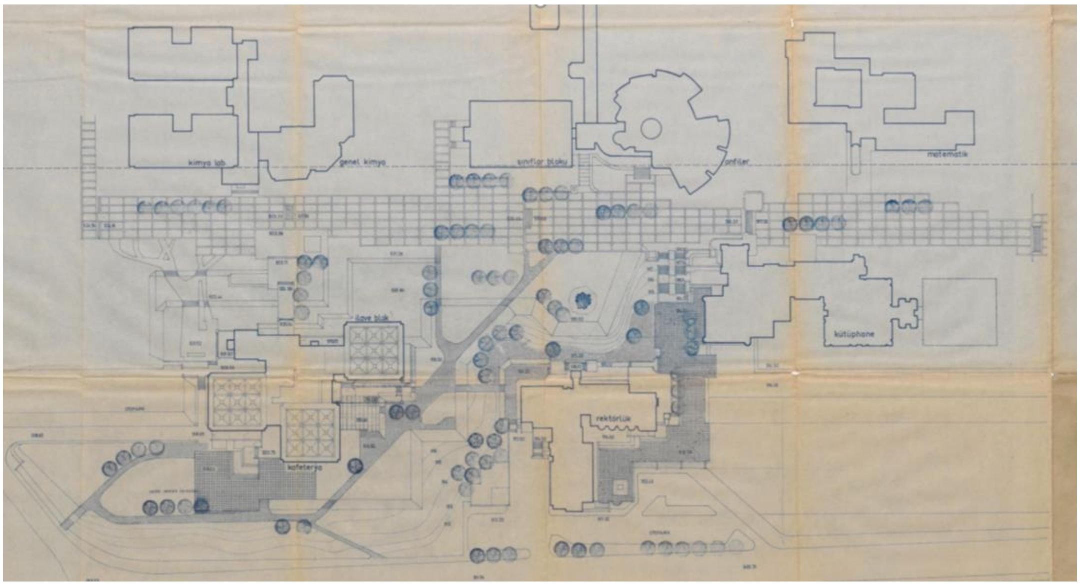
G. METU Faculty of Arts and Sciences, Blocks of Lecture Halls, Preliminary Project Drawings





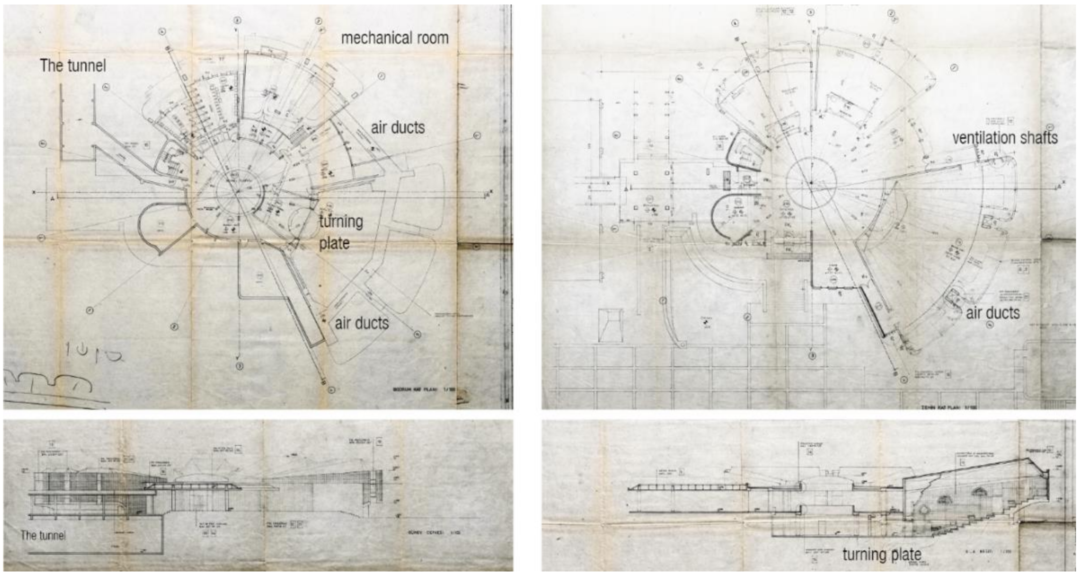
Source: Salt Research, “Altuğ-Behruz Çinici Archive - Middle East Technical University”

H. Site Plan of the Central Zone of the Campus



Source: Salt Research, “Altuğ-Behruz Çinici Archive - Middle East Technical University”

İ. METU Faculty of Arts and Sciences, Block of Lecture Halls, Construction Drawings

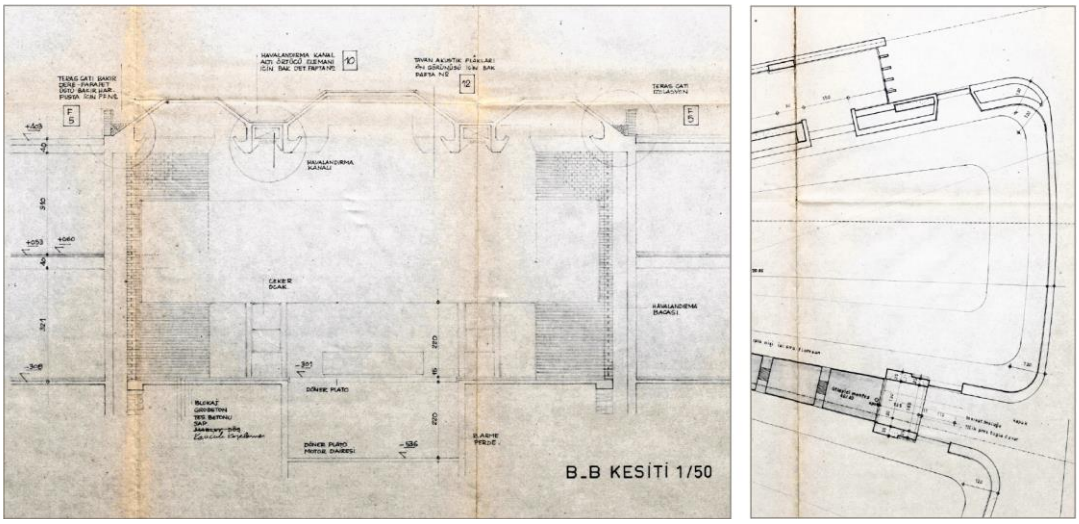


Source: Salt Research, “Altuğ-Behruz Çinici Archive - Middle East Technical University”

J. Construction photographs of the block of lecture halls

Source: Retrieved from METU Library Visual Media Archive, https://ww2.lib.metu.edu.tr/gallery/ on August 15, 2021

K. Big Auditorium Section and Wall Details

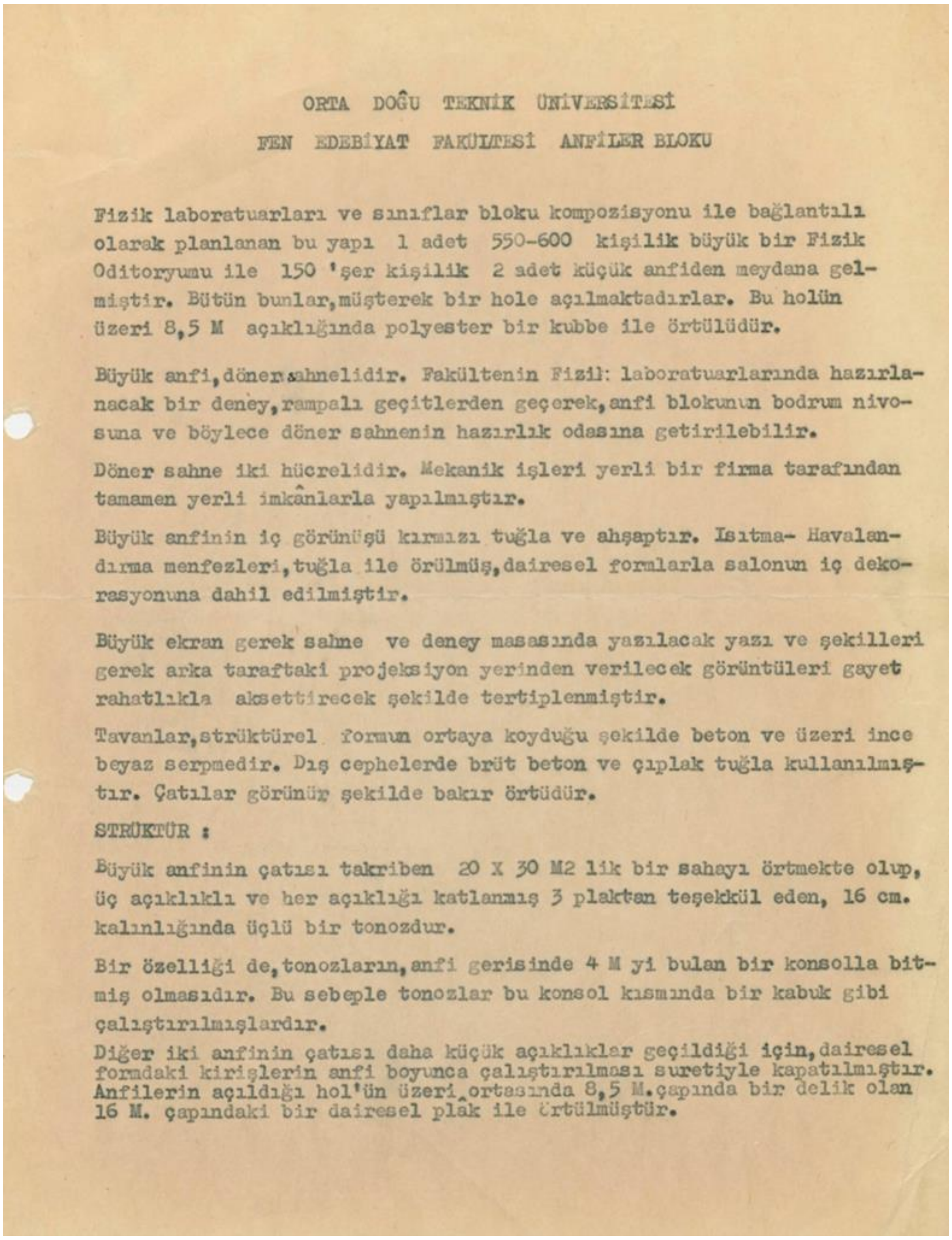


Source: Salt Research, “Altuğ-Behruz Çinici Archive - Middle East Technical University”

L. Photographs of the Lecture Halls

Source: Salt Research, “Altuğ-Behruz Çinici Archive - Middle East Technical University”

M. Faculty of Arts and Sciences, Blocks of Lecture Halls, Reports contains the design decisions of Lecture Halls



ORTA DOĞU TEKNİK ÜNİVERSİTESİ

FEN EDEBİYAT FAKÜLTESİ ANFİLER BLOKU

Fizik laboratuarları ve sınıflar bloku kompozisyonu ile bağlantılı olarak planlanan bu yapı 1 adet 550-600 kişilik büyük bir Fizik Oditoryumu ile 150 'şer kişilik 2 adet küçük anfiden meydana gelmiştir. Bütün bunlar,müşterek bir hole açılmaktadırlar. Bu holün üzeri 8,5 M açıklığında polyester bir kubbe ile örtülüdür.

Büyük anfi,döner sahnelidir. Fakültenin Fizik laboratuarlarında hazırlanacak bir deney,rampalı geçitlerden geçerek,anfi blokunun bodrum nivosuna ve böylece döner sahnenin hazırlık odasına getirilebilir.

Döner sahne iki hücrelidir. Mekanik işleri yerli bir firma tarafından tamamen yerli imkânlarla yapılmıştır.

Büyük anfinin iç görünüşü kırmızı tuğla ve ahşaptır. Isıtma- Havalandırma menfezleri,tuğla ile örülmüş,dairesel formlarla salonun iç dekorasyonuna dahil edilmiştir.

Büyük ekran gerek sahne ve deney masasında yazılacak yazı ve şekilleri gerek arka taraftaki projeksiyon yerinden verilecek görüntüleri gayet rahatlıkla aksettirecek şekilde tertiplenmiştir.

Tavanlar,strüktürel formun ortaya koyduğu şekilde beton ve üzeri ince beyaz serpmedir. Dış cephelerde brüt beton ve çıplak tuğla kullanılmıştır. Çatılar görünür şekilde bakır örtüdür.

STRÜKTÜR :

Büyük anfinin çatısı takriben 20 X 30 M2 lik bir sahayı örtmekte olup, üç açıklıklı ve her açıklığı katlanmış 3 plaktan teşekkül eden, 16 cm. kalınlığında üçlü bir tonozdur.

Bir özelliği de,tonozların,anfi gerisinde 4 M yi bulan bir konsolla bitmiş olmasıdır. Bu sebeple tonozlar bu konsol kısmında bir kabuk gibi çalıştırılmışlardır.

Diğer iki anfinin çatısı daha küçük açıklıklar geçildiği için,dairesel formdaki kirişlerin anfi boyunca çalıştırılması suretiyle kapatılmıştır. Anfilerin açıldığı hol'ün üzeri ortasında 8,5 M.çapında bir delik olan 16 M. çapındaki bir dairesel plâk ile örtülmüştür.

Source: Salt Research, "Altuğ-Behruz Çinici Archive - Middle East Technical University"