Research plan

Essay on the underlying theories and methodoligies of the proposed research

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Introduction

Because of the expected growth of the city's population, accelerated by a global trend of urbanization, it is expected that more facets that form the city will either voluntarily or forcibly intertwine with other functional demands because of an increasing pressure on land-use (Tillie et al., 2014; Hocks et al., 2018).
Historically, the task of densification and intensification of the urban fabric has been tackled by architects, civil engineers and planners. However, this has happened at the cost of significant amounts of energy and material. Simultaneously the intensification of the fabric has not prevented the city's energy infrastructure from becoming overly stressed and the city is now only able to sustain itself by consuming vast amounts of resources from rural areas around the globe without creating a reverse flow of valuable resources (Ferrão & Fernández, 2013).

> *"The world's cities occupy just 3 per cent of the Earth's land, but account for 60-80 per cent of energy consumption and 75 per cent of carbon emissions."*
>
> (UN, n.d.)

This makes the global urban region one of the most, if not the most potent domain through which significant reductions of greenhouse gassed (GHG) can be accomplished. Therefore, the energy infrastructure, which crucial to the existence of cities, and a major shareholder within the environmental balance of the city, will take centre stage in this research, because the modern city has become increasingly dependent on its existing energy infrastructures (Belanger, 2016; Burns & Kahn, 2005; Edwards, 2002). Rnergy is produced in fossil fueled centralized power plants and transported over long distances by means of overhead power cables and district heating networks.

The increasing demand for energy and a desire to fulfil this need with renewable energy, has the potential of occupying vast amounts of land in rural areas (Hocks et al., 2018; Stremke & Van den Dobbelsteen, 2012). This sparks the debate whether the urban region itself should instead be able to fulfil its own energy demands, rather than occupying large amounts of ecologically important hinterland. Embedding a renewable, resilient and sustainable energy production network within the city limits is not simply a matter of feasibility and practicability, but rather one of integration (Zanon & Verones, 2013) and is therefore one of the crucial tasks at hand for planners, politicians and architects. This thesis will take centre stage in the research into 'The city of the future'.

Research questions
To explore this theme and demarcate a specific field of research within this theme the following research question is proposed:

> *How can sustainable energy systems be integrated in urban areas through spatial planning and design?*

By placing this thesis within an environment of adjacent research fields, the possibility presents itself to embed the problem statement within both a theoretical and practical framework. In so doing, the following subquestions are proposed to allow for a theoretical embedding of this thesis.

1. *To what extent can a decentralized approach to energy production and storage improve the resilience of future energy networks?*
2. *What renewable energy production and storage methods are suitable in urban areas and what are the spatial implications of these methods?*
3. *What are the opportunities for integration with public life and urban design?*

The following research plan dives in to the planning and procedures involved in the proposed thesis.

Method
The third question will be the central question in the position paper. The first and second question will be covered in the research booklet as they are more geared towards analysing hard data on production systems and network theory. Together, the first two subquestions with the position paper, will be able to asnwer the main question. This is further explained in the research structure.

1. Problem statement

> *"As of 2011, more than 52% of the global population lives in urban areas. In 2006, urban areas accounted for 67–76% of energy use and 71–76% of energy-related CO2 emissions. By 2050, the urban population is expected to increase to 5.6–7.1 billion, or 64–69% of world population"*
>
> (IPCC, 2015. p. 25)

The cities of today account for an enormous amount of rural land use (Ferrão & Fernández, 2013). This exploitation of vast amounts of land, is necessary to provide the desired amount of food, energy, materials, etc. for the non-rural areas. With an ever-growing global population and an ever-growing amount of urban residents, the pressure on production is inescapably going to increase, with an extremely uneven emphasis on consumption within cities. This means that the city is going to rely progressively more on rural production and the providence of the non-urban areas, if today's production methods remain identical. This is especially true for the strongly centralized production of our energy.

Energy, since the industrial revolution, has been a vital condition for modern life within urban areas. Coal, gas and oil provided vast amounts of energy which could be converted to energy in centralized sites within- or far outside the city limits due to the instatement of intricate distribution infrastructures. This subterranean process has caused for urban societies to dissociate from the actual production process that facilitated their daily lives Belanger, 2016).

Fossil fuels are finite, and therefore the production systems together with the global population will have to attune to renewable production methods to be able to sustain the increasing energy demand, as well as to comply with the environmental goals of Paris 2050.

The shift towards a sustainable, renewable and robust energy system will require an enormous effort, possibly radically changing the way we perceive land-use today.

> *"The sheer quantity of renewable energy that needs to be generated to sustain humanity may require us to regard, at least conceptually, every landscape as an energy landscape"*
>
> (Stermke & Van den Dobbelsteen, 2012, p. 4)

If control of the energy network is not reclaimed, 'The City of the future' is likely to fail in becoming less dependent off of fossil fuels and the accompanying energy systems that have been in place since the second industrial revolution. In so doing the lands used and exploited by the world's urban areas will have to be reorganized and reenvisioned. Through this, the global cityscapes are able to steer clear from an imminent energy unconscious society, and seek to find oppor tunities to become increasingly more self-reliant.

2. Relevance

Much of the realm of energy infrastructure, even though it supports modern life for all urban citizens, lies secluded in the realm of engineering and policy making. The modern engineer is predominantly concerned with effectiveness and exactitudes. It is therefore that the modern energy system has been able to support such an extreme intensification of the global urban regions. A result of this continuous expansion of the systems that support urban life, is that infrastructure has come to be measured by performance, rather than the extent to which it benefits public life (Belanger, 2016). As a result, it becomes almost unthinkable that one should question the very basic fundaments on which modern life is build. Energy was and still appears abundantly available, and abundant it was designed to be.

A growing need to change to renewable sources of energy is challenging the existing system (Alanne & Saari, 2006; Mehleri et al, 2013). The way the grid is designed relies heavily on the energy concentrated in fossil fuels, which after conversion can be transported over long power lines. The sheer size of the challenge ahead can already be grasped when one compares the amount of energy that is captured in fossil fuels versus the amount of land that is needed to produce that energy sustainably (Hocks et al., 2018). On top of that there is an increasing economic pressure exerted on the energy system (Tillie et al., 2014)

> *"As prices climb and energy costs make up an increasingly large share of the cost of living, urban energy metabolism will go from being just an environmental virtue to a core determinant of urban economic competitiveness."*
>
> (Troy, 2012, p. xi)

This means that the durability of the existing fossil fuel fired system is reaching its expiration date. It is therefore paramount that professionals look for alternatives which can deal with the challenge of a robust and sustainable system. Much of this debate covers the question of 'who' is able to respond to these challenges. This ranges from the individual building (in the case of net-positive architecture) to full urban self-sustainability (urban metabolism) (Yigitcanlar & Dizdaroglu, 2014).

> *"Climate change and energy saving are challenging the city and the territorial organization. Innovative spatial and urban planning methods and procedures are required, and new approaches and instruments must be elaborated and applied in order to shift from the building scale to the urban and territorial ones. In fact, while energy saving and emission control measures are usually applied to single buildings, plants and technological systems, the urban and territorial scales are not fully considered.."*
>
> (Zanon & Verones, 2013, p. 10)

The questions of 'who', 'where' and 'how', are therefore of the upmost importance to explore. This process is kick-started by the decreasing cost of renewable energy technologies. Simultaneously clean energy production is identified as one of the promising economic recovery strategies after COVID-19 (European Commission, 2020), which will in turn allow for a higher chance of feasibility in future projects. The question of 'where' is especially important in densely populated cities and regions such as the Netherlands, as the human habitat coincides increasingly more with production landscape (Tillie et al., 2014). The challenge of the spatial organisation of the consequences of a renewable energy system is therefore one of the most important tasks of architect and planners (Hocks et al., 2018; Zanon & Verones, 2013) and will therefore take centre stage in the architectural elaboration of this thesis.

3. Theoretic framework

At the base of this framework for the research lies the broader field of 'infrastructure planning'. This is not an official title for a research field, however it is found to be the most appropriate representation of what belanger (2016) calls 'the system'/urban metabolism. It is found to have the best capabilities to draw analogies with adjacent fields of research. Infrastructure as an activity and as artifact is a well-documented field.

An overlay of this field is created through the notion of network-thinking which deals with the way we organize our infrastructure. This directly deals with resilience but also circularity as more connections are drawn between nodes in the network, ergo "activities" in the network. The research field of network thinking goes back to Baran (1962) when he identified the three main structures of networks: Centralized, Decentralized and distributed. His terminology echoes through in modern literature concerning the organization of the imminently changing renewable energy network.

Together they incubate the research field which shall be appropriated. It is given the title of 'infrastructure design', but it should be stressed here that the title is to a degree flexible.

The full width of these research fields, will be further discussed in the research. Simultaneously it will be discussed how these fields of research can engage in complex strategies that are required for climate adaptation.

This an important notion and condition for the following research as it imposes several limits to the research. It is therefore that the framework is framed by the term 'Adaptation'. As complex activity is prone to not be able to produce one all-covering answer.

3.1 Criteria

In the light of this thesis, an additional framework is needed to support the selection of a suitable renewable energy production method. This is due to the specific impact of distinct energy production technologies. For example, smell, sound, size, safety, amongst other characteristics. Due to a proposed decentralized approach, the system of choice must be able to deal with the requirements of the specific scale of the city (Center, Suburban or periphery). Therefore a grading framework is required to score the suggested production methods within selected criteria. This is executed at the hand of the multi criteria analysis proposed by Cristóbal (2012). On top of this the notion of life cycle shall provide insight into the durability that is involved with architectural intervention. If for example a technique has life cycle of 15 years, than the point can be made that the envelop and the additional program need to be flexible to accommodate adaptations. The result of the criteria analysis shall be discussed in the main body of the research.

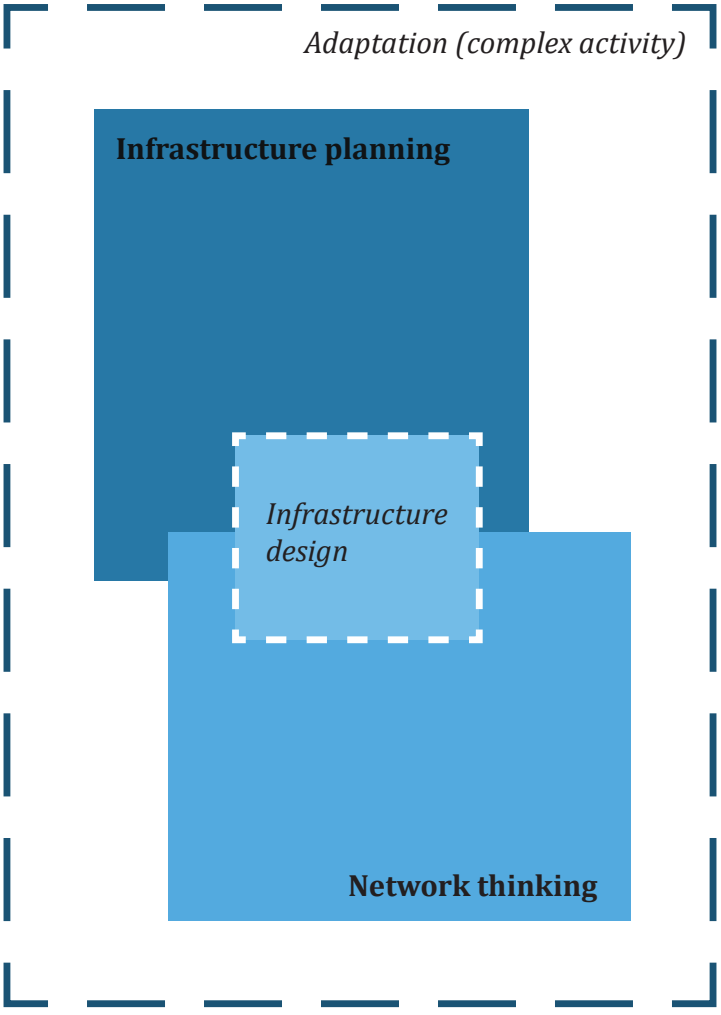

Figure 2: Theoretic framework

4. Methods

The research as will be proposed in this research plan embodies a variety of methods which will be further elaborated on in the research thesis. The research plan will predominantly occupied with the 'what' and 'when' of the methodological framework. This will be done at the hand of variety of key-literature items that have on their turn elaborated on specific elements of the research process.

In the field of qualitative research methods, both within and outside of the realm of design, two frameworks have been identified. The main framework is given through the Qualitative research cycle by Hennink et al. (2020). This framework is supplemented by the Design research methodology of Blessing & Chakrabarti (2009).
Similarly in the field of design research methods (meaning research for design and vice versa), two frameworks have been identified, which deal with the creation of a design assignment from research from two different perspectives. Why these different perspectives are important will be elaborated on further along the research. Important to mention here is that they are not mutually exclusive, and have their own application and purpose. The frameworks at hand are Constructive design research as described by Koskinen et al. (2011) and the Five-step approach by Stremke et al. (2012). The latter is specifically interesting within this field of research, being the imminently changing energy infrastructure, because of the role of design in long term strategies (like climate adaptation strategies).

The research is split up into 4 parts as informed by the frameworks mentioned above. These are the following:

4.1 Research design

The first step of the research consists of the formulation of the assignment. This is kickstarted by the identification of relevant research topics. In the case of this thesis, the topic of 'renewable energy infrastructure' in the broad sense of the word was identified. As this covered a wide variety of topics at a variety of scale levels the topic had to be dissected into manageable parts.

This allowed for the problematization of specific scales of the infrastructure networks. Being a scale which has the potential to be integrated into the fabric of the city; i.e. an architectural assignment.

To look into the relevance of this topic, a literature study was initiated. The literature should then be able to verify the first hypotheses that was formulated during the assembly of the research topic. Through the clarification of the research topic, the field of energy infrastructure was found to be a widely discussed topic, but it was not yet covered on the scale of architecture. This lead to the study of precedents which shall likely become part of the case studies in the research thesis.

4.2 Data collection

The second step of the research consists of the broad exploration of the research field within- and adjacent to energy infrastructure. As the role of architecture in this field of research was found to be not yet part of the discussion, it was believed that a strong theoretic underpinning of the research would be required. This would allow for the identification of relevant subthemes which would be able to deal with the scale of architecture.

The elaboration of the theme at hand is mainly done through a literature study covering a broad variety of adjacent research fields. For this specific research already several themes are identified to be paramount to be able to answer the main question.
These are: identification and assessment of possible renewable energy production and storage methods, selection of framework to grade the available systems for application in urban environments, and the appraisal of (programmatic) hybridization opportunities.

4.3 Analytic cycle

The third step of the research consists of the assessment of the collected data. In this section the main line of reasoning will be formulated. This is assisted by the exploration of studies that already started to deal with (programmatic) hybridization of energy infrastructure. In so doing, together with data collected in the previous data cycle, the theoretic underpinning of the main research question is expected to be adequately explored.

To conclude the analytic cycle additional bodies of research are employed. This is for example done through secundary assingments like '*The historic development of the power plant*'. This will be elaborated on in the research booklet. These assignments are identified to supply further insights into the (architectural) history and future of the energy network.

4.4 Informing design

To conclude the research method the topic of 'design' is briefly touched upon. Although the research does not practically deal with the outcome of the design process, it is however believed that a preliminary definition of the relationship between design and research should be in place. This is already suggested in the introduction of this chapter. This is for example crucial for the selection of the 'building blocks' (as mentioned in the Data cycle paragraph) of the research.
In this case the research is intended to be both capable of supplying a 'program by research' scenario as well as a 'program by scenario' situation, as input for the design assignment. This distinction is further elaborated upon in the thesis.

4.5 Process

How the research leading up to design phase is given shape in a practical sense is shown in the figure on the next page. It outlines the proposed research tasks at hand and how they relate to the proposed research questions and the overall process.

4.6. Process structure

	Phase	Description	Tasks	Output	Question	Schedule
						[Note that the scale is not necessarily 1 week]
	Research					
	Research design	Demarcation field of study. Validating the theme. Preliminary main research question. Crucial to this stage that one can already identify the to-be used research methods as it will influence the type of sources one should look for (qualitative, quantitative/empirical, literature).	1. Formulation of research question	Research plan		1
			2. Problem statement	Research plan		1
			3. Relevance	Research plan		2
			4. Selecting data collection methods (qualitative, quantitative)	Research plan		2-3 [P1 pres.]
			5. Preliminary theoretic framework	Research plan		
			6. Architectural position	Position Paper	Position essay	
				Research plan		3
	Data cycle	Data collection is part of all the cycles, however one should now be concerned with bringing in as much data to broaden one's view. By developing an understanding of the found data, preliminary conclusions can be drawn. This is crucial to be able to start to verify the hypothesis.	7. Literature review	Research plan, Position paper, Research booklet	Q1, Q2, Q3	1-6
			8. Elaboration of theoretic framework	Research plan, Research booklet	Q1	2-4
			9. Research of energy production methods	Research booklet		
					Q2	5
	Analytical cycle	Categorization of the data. The assessment of the data and literature found in the previous cycle, should enable the author to deduce new information. Further research might still be necessary to be able to fully deal with the problem at hand. Either way it shall have implications for the approach to this research topic in the future.	10. Case studies and history of power plant	Research booklet		
			11. Elaboration on *Energy landscape*	Research booklet	Q2, Q3	
			12. Elaboration on *Energy humanities*	Research booklet	Q2, Q3	4
			13. Energy/location mapping	Research booklet		
			14. Data assessment	Research booklet	Q1, Q2, Q3	3-6
			15. Validation of hypothesis	Research booklet, Position paper	MQ, Q3	
			16. Reiterating on literature review	Research booklet, Position paper		
			17. Conclusion (Q3 - Position paper)	Position Paper (Q3)	Q3	6 [P2 pres.]
			18. Conclusion (Main question)	Research booklet (MQ, Q1, Q2)	MQ (Q1, Q2)	
			19. Recommendations	Research booklet, Position paper		6

Figure 3: Research steps in table

5. Research structure

The diagram summarizes the most important facets for the research. The input is the personal fascination supported by relevance and a first indication of the validity of the research topic. First, the Research plan is drafted. This plan outlines the upcoming research and demarcates the literary and disciplinary boundaries. The theoretic framework, which is one of the crucial parts of this plan, determines how these themes are going to be grounded in the wider body of research – anchor points. It is influenced by the position paper as it shall confirm the appropriate precision of the theoretic framework. In this specific field of research the position of the author should be highlighted, because within adaptation and mitigation policies, multiple strategies are possible. A specific strategy will have to be adopted. This will be covered in the position paper

In this case the authors personal architectural position on this matter is very relevant. It is influenced by the preliminary conclusions of the research booklet.
The research booklet will predominantly dive into 'what', 'how' and 'where' to be able to explain the practical consequences of the strategy. The data will be categorised and conclusions can furthermore be deduced. The whole structure is kept in place by the method which is discussed in this research plan. This indicates 'when' and 'where' a research task should happen. The three sources of output (Research Plan, Position paper, Research booklet) are the most important products of the research. The research plan lays the foundation, and the position paper together with research booklet will add to this the main results of the research (Literature, Site analysis, Position essay, etc.)

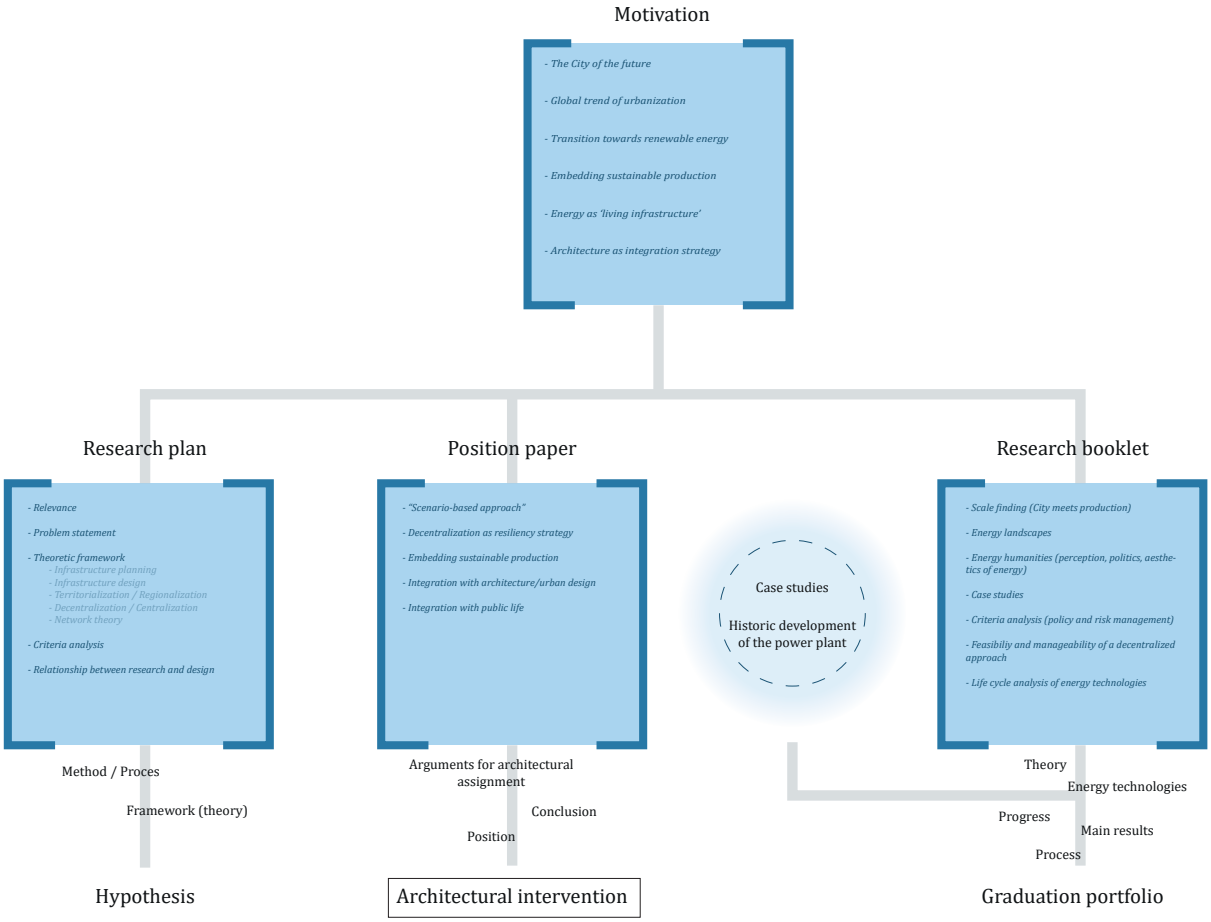

Figure 4: Research structure

6. Precedents

Uppsala power plant
The traditional power plant is seriously challenged in the Uppsala power plant proposal by BIG architects. The power plant has two different cycles. In winter time the plant will be fully operational feeding the district heat networks. Simultaneously educational activites will take place where visitors can get a glimpse of what the production process entices. In the summer, the plant will be largely turned off, allowing more people within the dome. Perhaps even allowing for festivals and large groups of tourists to visits.

By doing this, the Uppsala power plant start to challenge the traditional borders between energy production and public life. Especially in the case of heat production where we will see production occur close to city centers, this approach is perhaps increasingly more required to merge these two worlds.

Source: https://big.dk/#projects-upp

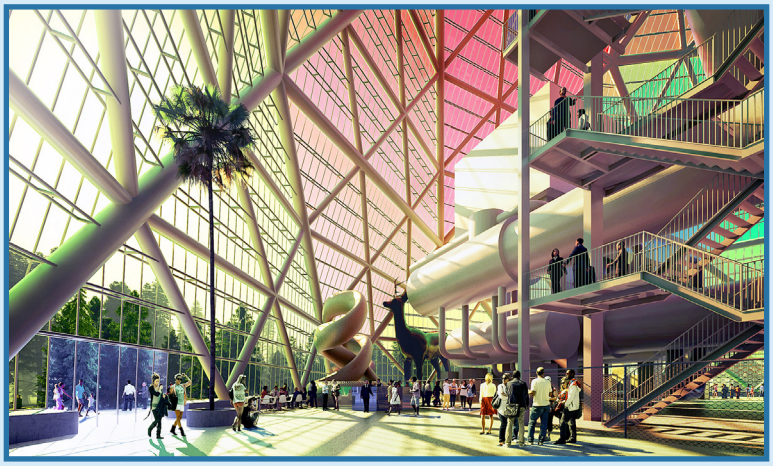

Figure 5
BIG - UPP: Uppsala power plant
Interior render
https://big.dk/#projects-upp

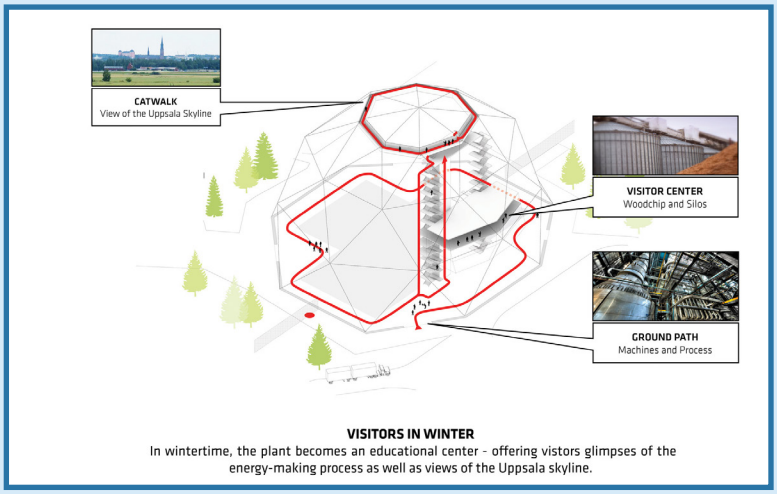

Figure 6
BIG - UPP: Uppsala power plant
Public program scheme
https://big.dk/#projects-upp

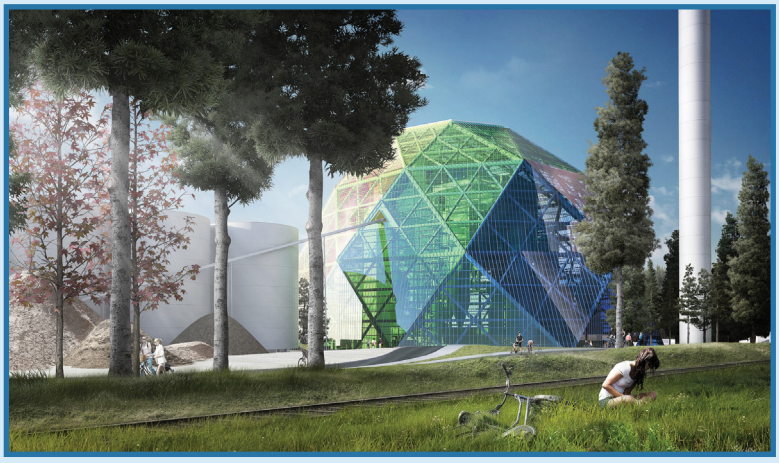

Figure 7
BIG - UPP: Uppsala power plant
Exterior render
https://big.dk/#projects-upp

Energy Cathedral

The Energy cathedral is part of the 'Central Innovation District' proposal for the center of The Hague by UN studio. 'The Energy cathedral combines a pedestrian overpass and a geothermal heat plant in the center. Together with additional program they form the artifact. The architecture is complimented with a lighting program, depicting the hot and the cold side of the thermal well deep under ground. As building heating requirements is one of the major stakeholders in the energy balance of buildings in cities at the latitude of The Hague, these plant are expected to occur more and more within cities. Combining the function of energy production with other neccessary program within the city therefore makes all the more sense.

Source: de Boer, H., Hinterleitner, J., Berkers, M., Buitelaar, E., Cavallo, R., Daamen, T., Gerretsen, P., Harteveld, M., Hooijmeijer, F., Van der Linden, H., & van der Wouden, R. (2020). De stad van de toekomst. Tien ontwerpvisies voor vijf locaties, verbeelding voor een vierkante kilometer stad (2e druk). BNA Onderzoek.

Figure 8
UN Studio - Energy cathedral
Functional diagram
https://www.archdaily.com/907063/unstudio-designs-a-city-of-the-future-for-the-hague

Figure 9
UN Studio - Energy cathedral
Exterior render
https://www.archdaily.com/907063/unstudio-designs-a-city-of-the-future-for-the-hague

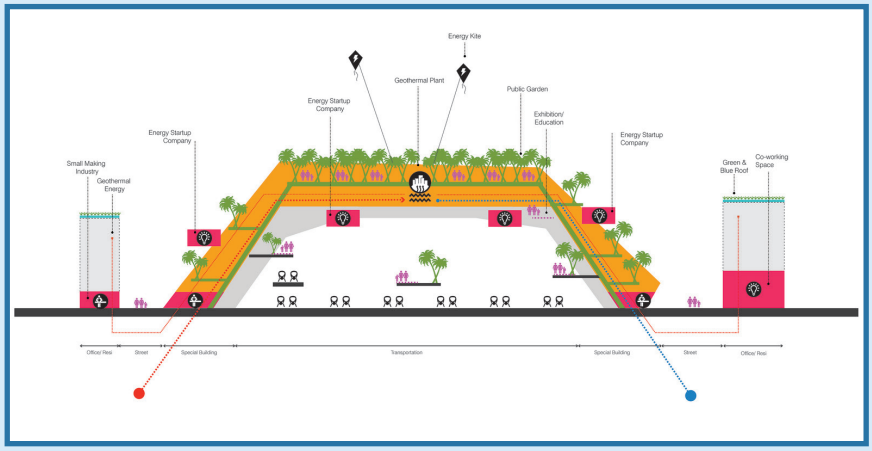

Figure 10
UN Studio - Energy cathedral
Project overview
https://www.archdaily.com/907063/unstudio-designs-a-city-of-the-future-for-the-hague

7. Timeline

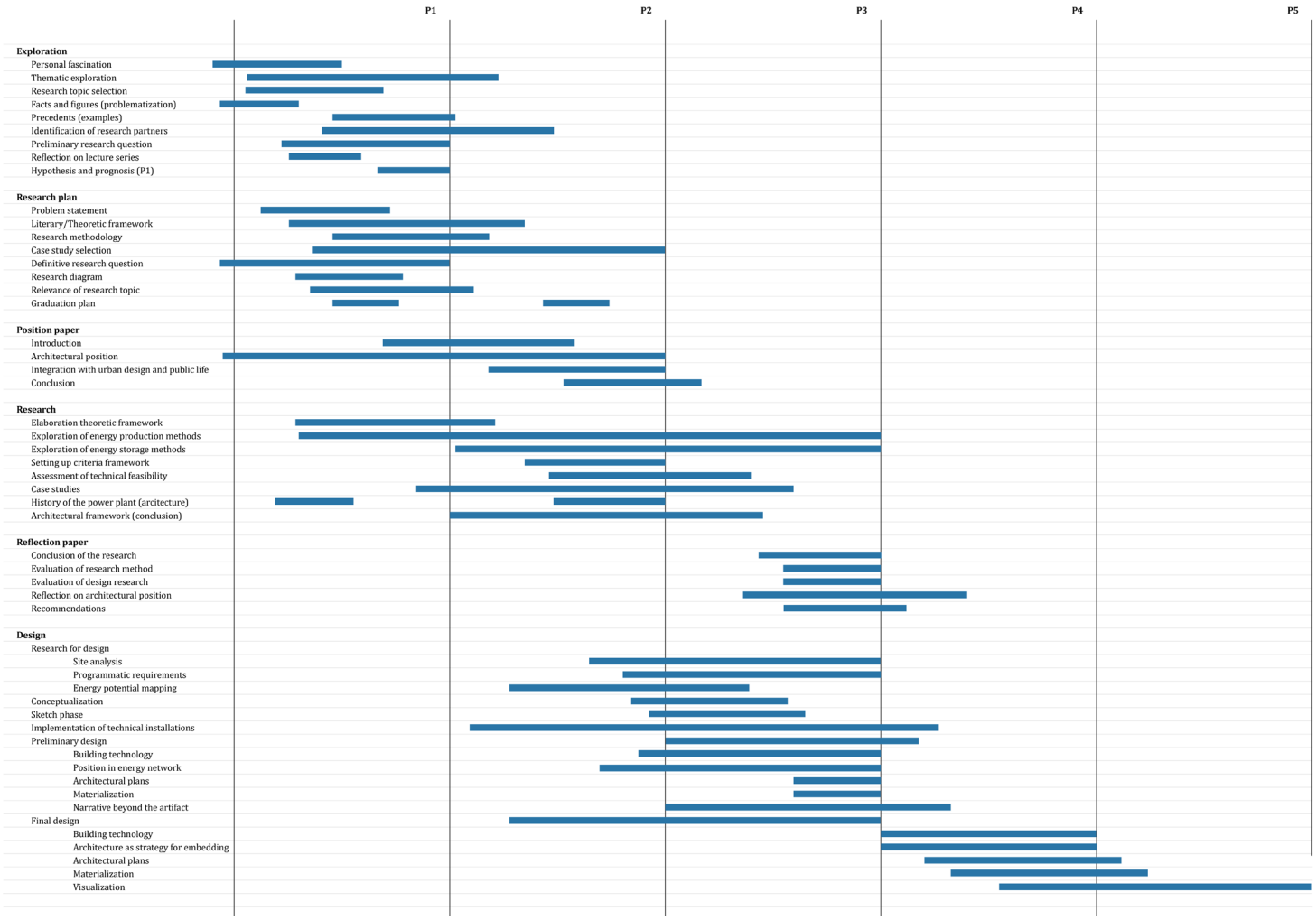

Figure 11: Graduation timeline

8. Self-assessment

The self-assesment section of this research plan was written as a review of the lecture series provided in the course: AR3A010 - Research plan. This course is part of the graduation program of the Msc Architecture, urbanism and building sciences. The lecture series served as preperatory course for this Research plan. In the lecture series a varity of research related topics take center stage. From research methodology, to theoretic frameworks and philosophy. The highlights from this series in relation to theme of the research are discussed in the following chapter.

Recap on the theme
The research proposed in the research plan dives into the problem of creating sustainable, renewable and robust energy systems for the world's urban environments. The cities of today have relied heavily on the fossil fuel fired energy systems to allow for a reliable grid which propelled the growth and densification of the global urban areas (Fahy, 2020). The transition towards a more efficient energy system is a task of great complexity. One crucial component of this transition is the conversion to a more sustainable and renewable energy production system. The embedding of this development within the built environment, is the challenge at hand.

Hypothesizing
The to-be addressed research question dwells within an erratic field of research. This poses some severe implications for the research process. Contrary to research resulting in a contemporary designed solution, the envisioned research trajectory will require a certain degree of 'supposition' or scenario planning. This does not imply that the research problem is obscure for that matter, however the research will not lend itself to be fully conclusive. Rather, it shall project opportunities which individually can become exemplary for the conclusion of the research. This also means that a strong interaction between design and research is likely, as to achieve a research by design scenario. Through this, the hypothesis can be invigorated.

Historic approaches
To reach a deeper understanding of how research in a more conceptive domain can take shape, one has the opportunity to turn to a variety of research methods. A metaphysical approach, literature- and theoretical analysis, as well as a more historicizing substantiation, amongst others. The latter can underpin the line of reasoning by providing relevant precedents through which similarities can be drawn. In light of this research, this can be performed by drawing an analogy with for example: *Oil spaces: The global petroleumscape in the Rotterdam/The Hague area* (Hein, 2018). The theme of the historic development of the systems that have allowed society to function the way it does today, is carefully considered in the light of oil by Hein (2018). The same can be achieved on alternative scales of the energy system by analysing phenomena that have affected the energy production system or the effects thereof over time. This, on its turn can provide relevant starting points for the design brief.

This historicizing approach towards understanding our society today, is valuable concerning the research topic as it might unfold an intrinsic understanding of the theme and provide valuable leads.

Theoretic approaches
The example of aiming for a metaphysical substantiation, is likely going to be able to establish an understanding of how innovation and maybe at an underlying level, creative thinking, influences our abilities to anticipate the future. The studio research and the conclusion, which will follow after the research plan is provided, are in this sense responsible for providing the reasoning through which a 'springboard' can be created. Which on its turn can lead to instances exemplary of the conclusion and hypothesis. The concept of 'the springboard' is a term that is perhaps best represented by conditions as 'speculation', 'assumption' and even 'scenario thinking'. This is relevant because of the lack of maturity within the field of research employed in this research.
The metaphysical approach can support the research in the following scenario. Suppose for example that the topic of inquiry would be an architectural typology and it would furthermore require two research components. On the one hand it would require an historic understanding of the development of said typology over the past decades, while on the other hand it requires an understanding of the current state of the research field. This would furthermore lead to a contemporary design proposal, seeking further improvements on the line of development that has existed for the past decades. This can perhaps be considered to be a more traditional approach to architectural research. If this is the case, the question should be asked if architectural research is still able to provide valuable answers if the development of the research field is less clear or less homogenous? This is where the case of the 'speculative problem' comes in, as stated by Bergson (1998). Suppose that there is existing research and historic precedents but a new typology is suggested by the conclusion. Architecture is then required to fulfil the role of being the source of a scenario based designed solution. According to Heidegger, we should then consider the resources of whatever technological application lies ahead to be directly 'available', as to be able to employ them in the desired solution (Blitz, 2014).

> *"One might just as well say that all truth is already virtually known, that its model is patented in the administrative offices of the state, and that philosophy is a jig-saw puzzle where the problem is to construct with the pieces society gives us the design it is unwilling to show us."*
>
> (Bergson, 1998 p. 36)

The methods of architecture are in a way not much different from the abovementioned 'truth finding'. It is not concerned with reinventing the elementary components of life. Rather, architecture is concerned with reiterating on what exists to come up with an increasingly more appropriate designed solution. Similarly, drawing on the metaphor of the jig-saw puzzle, architecture may as well have to face the reality of obscurity. The ideal solution is not readily available. This is crucial for understanding the speculative problem, because it deals with obscurity as well, but as Bergson suggests, this is also found to be inherent to solution finding.

> *"a speculative problem is solved as soon as it is properly stated. By that I mean that its solution exists then, although it may remain hidden and, so to speak, covered up: the only thing left to do is to uncover it. But stating the problem is not simply uncovering, it is inventing."*
>
> (Bergson 1998 p. 37)

This means that even though the solution might be speculative it might still have value because of the line of reasoning that was applied to arrive at the end point.
Together, the research methods discussed in the course can, for different reasons, support the research of the theme discussed in this research plan.

9. Annotated bibliograhy

Alanne, K., & Saari, A. (2006). Distributed energy generation and sustainable development. *Renewable and Sustainable Energy Reviews,* 10(6), 539–558. https://doi.org/10.1016/j.rser.2004.11.004

Main body – Broad research on the decentralization of energy production and its implications. Both pro's and con's are involved in this study to also indicate where the problems for a full incorporation of decentralized production lie. Also the article pairs well with network-thinking as described in chapter 4. theoretic framework.

Baran, P. (1962). *On Distributed Communications Networks*. Defense Technical Information Center. https://doi.org/10.7249/P2626

Theoretic framework – Perhaps one of the founders of network-thinking. Resilience in systems are created through the amount of connections between nodes. Also the article includes a very in-depth 'failure analysis' to see where critical limits are likely to be exceeded (for example with nodes that have less than 3 connections). Mentioned in Belanger (2016) as an essential example of network-thinking, it creates a very compendious introduction of the study hereof.

Belanger, P. (2016). *Landscape as Infrastructure*. Taylor & Francis.

Theoretic framework – One of the key-literature items. Major contributor to theoretic framework. Very broad elaboration of all themes and theories which are involved in understanding the infrastructure planning methods of today. Interestingly, Belanger doesn't offer a clear-cut conclusion but opts to remain pragmatic, offering a variety of insights into the statement: Landscape as infrastructure

Bergson, H. (1998). *The Creative Mind: An introduction to Metaphyics.* Dover Publications.

Self-assessment – Part of the mandatory readings for the lecture series and equipped here to explain the thought process that can help address the proposed thesis. Architecture like philosophy is also not concerned with finding 'absolute truths'. Rather, it keeps reinventing itself to come up with an increasingly more appropriate solution.

Blessing, L. T. M., & Chakrabarti, A. (2009). DRM, a Design Research Methodology. Springer Publishing. https://www.springer.com/gp/book/9781848825864

Method - Blessing and Chakrabarti are motivated to find a more common language for design research. The main point is that design research is performed by different professionals from different backgrounds, ergo there is a great variety of terms that are being used. Blessing and Chakrabarti propose a set of common terms and methods to provide a more general framework. This was adopted in combination with another source to make the research plan more insightful and more transferable for non-familiar readers.

Blitz, M. (2014). Understanding Heidegger on Technology. The New Atlantis. Retrieved on 14-10-2020 from, https://www.thenewatlantis.com/publications/understanding-heidegger-on-technology

Self-assessment – Heidegger is perhaps one of the most influential philosophers of the 20th century. His works on: Die Frage nach der Technik (1954), and Die Technik und die Kehre (1962), are amongst the most influential works on philosophy behind modern technology. He argues for a philosophy through which technique doesn't take over life, it is there to support it. Because the study of Heidegger is outside of the scope of this research, an internet article on his works was opted for to get a basic understanding of his point of view. Also it describes Heidegger's point of view on 'innovation', which shall become an important part of the proposed design agenda in this thesis.

Burns, C. J., & Kahn, A. (2005). S*ite Matters: Design Concepts, Histories, and Strategies* (1st edition). Routledge.

Introduction - *Site matters,* is an essay bundle concerned with the discussion around the importance of site-conditions. Already in the introduction of the bundle the discussion commences by opening with the debate on whether 'site' is a fixed and limited condition. Further on the bundle dives into what should be considered when taking into account 'site' and context. Whit what should the architect be concerned? Should the architect be concerned with infrastructures for example, or is it merely his task to fulfil the wishes of the client.

Cristóbal, J. R. S. (2012). *Multi Criteria Analysis in the Renewable Energy Industry*. Springer Publishing.

Theoretic framework - Cristóbal provides a very extensive theory on Multi criteria analyses within the field of energy systems. Often with the construction of renewable energy systems, public money is involved. As this cannot be spend without accouting for feasibilty and functionability, studies likes these are very important as they can support choices made within specific design assignments. The framework with the three categories of criteria is adopted in the Research booklet.

Edwards, P. (2002). Infrastructure and Modernity: Scales of Force, Time, and Social Organization in the History of Sociotechnical Systems. *Modernity and technology*, 185–225. https://www.researchgate.net/publication/256684632_Infrastructure_and_Modernity_Scales_of_Force_Time_and_Social_Organization_in_the_History_of_Sociotechnical_Systems

Introduction - An almost essay-like work concerned with the role of technology, infrastructure, etc., on society. This piece is specifically interesting as source of inspiration for the Position paper as it is essentially a plea for a "non-mirco view" of our shared systems and infrastructures, as it would, according to Edwards, always fail in explaining the bigger picture.

European Commission. (2020, july). Powering a climate-neutral economy: An EU Strategy for Energy System Integration (COM (2020) 209). https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2020:299:FIN

Introduction – Providing hard data to create an introduction to the problem statement

Fahy, D. (2020). Energy Humanities: Insights for Environmental Communication. *Environmental Communication*, 14(5), 712–716. https://doi.org/10.1080/17524032.2020.1758377

Main body – The article provides an introduction to the field of energy humanities. It states that the global population has become disconnected from the infrastructure that supports our urban regions. Architecture, as it is perhaps the most visible object on space is capable of altering this course of disassociation.

Ferrão, P., & Fernández, J. E. (2013). *Sustainable Urban Metabolism*. Amsterdam University Press.

Problem statement – The article provides a broad understanding of the concept of urban metabolism. Metabolism has a strong tendency to steer towards circularity which is not the topic of this essay, however the problem statement is a shared one.

Hein, C. (2018). Oil Spaces: The Global Petroleumscape in the Rotterdam/The Hague Area. *Journal of Urban History*, 44(5), 887–929. https://doi.org/10.1177/0096144217752460

Self-assessment – Case study

Henn, R. L., & Hoffman, A. J. (2013). *Constructing Green*. Amsterdam University Press.

Relevance – Broad description of the problem statement and possible directions to arrive at future solutions

Hennink, M., Hutter, I., & Bailey, A. (2020). *Qualitative Research Methods* (2nd edition). SAGE Publications. https://uk.sagepub.com/en-gb/eur/qualitative-research-methods/book242878#preview

Method - Together with Blessing and Chakrabarti these form the two key sources for the research structure. Hennink et al. specifically was used to create the process chart at the and of the Method chapter. For legibility all the task and expected end results were shown in the chart on said page. Hennink et al. provide a very elementary overview of the tasks at hand as to 'design' a suitable research structure. However, addition were made to this structure, as in its general form it was found to be too elementary to encorporate in a literal sence.

Hocks, B., Hugtenburg, J., Kuijers, T., Sijmons, D., Wijnakker, R., Stermke, S., & Vermeulen, M. (2018). *Klimaat, energie en ruimte*. Posad Spatial Strategies. Retrieved from, https://www.rvo.nl/sites/default/files/2018/03/180221_Ruimtelijke_verkenning_Energie_en_Klimaat_LQ.pdf

Introduction / Relevance – Broad elaboration on the spatial impact of renewable energy production techniques

Koskinen, I. K., Zimmerman, J., Binder, T., Redström, J., & Wensveen, S. A. G. (2011). Design research through practice: from the lab, field, and showroom. Morgan Kaufmann Publishers, Inc. https://doi.org/10.1016/B978-0-12-385502-2.00015-8

Method – Critical review of 'research by design', provides interesting anchor points to

Intergovernmental Panel on Climate Change. (2015). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Retrieved from, https://www.ipcc.ch/report/ar5/wg3/

Problem statement – Factual statement to support the problem statement

Mehleri, E. D., Sarimveis, H., Markatos, N. C., & Papageorgiou, L. G. (2013). Optimal design and operation of distributed energy systems: Application to Greek residential sector. Renewable Energy, 51, 331–342. https://doi.org/10.1016/j.renene.2012.09.009

Main body / relevance – Article with a broad overview for the challenges ahead for sustainable energy production for the city of the future.

Stremke, S., & van den Dobbelsteen, A. (2012). Sustainable Energy Landscapes. Amsterdam University Press.

Theoretic framework – One of the key literature items. Very broad exploration of how spatial planning and energy infrastructure planning have been- and should be organised. Also it offers a wide body of theoretic anchor points which shall have an exemplary function for this thesis. Mainly, however this article is able to deal with the main body of this thesis as it very practice oriented with numerous case studies.

Stremke, S., Van Kann, F., & Koh, J. (2012). Integrated Visions (Part I): Methodological Framework for Long-term Regional Design. European Planning Studies, 20(2), 305–319. https://doi.org/10.1080/09654313.2012.650909

Method - A key literature item to understand the way the proposed research can support a strategy for future designed solutions. As mentioned before, climate adaptation doesn't not come with a fixed set of solutions. It is therefore important to gear the research to provide the proper 'handles' to be able to produce distant futures or scenarios for which a designed solution can be approached.

Tillie, N., Klijn, O., Borsboom, J., & Looije, M. (2014). Stedelijk metabolisme: duurzame ontwikkeling van Rotterdam. Mediacenter Rotterdam.

Main body / relevance – Major provider of case study material. Example of how research from a planning point of view can deal with this thesis.

Troy, A. (2012). The Very Hungry City. Amsterdam University Press.

Main body – Rich collection of case studies and reference projects. Although very much written through a subjective and more experience-driven lens, it provides useful tying points indicating practical problems and dilemmas that are encountered in sustainable planning practice.

United Nations. (n.d.). Goal 11: Make cities inclusive, safe, resilient and sustainable. United Nations Sustainable Development. https://www.un.org/sustainabledevelopment/cities/

Problem statement – Factual statement to support the problem statement

Yigitcanlar, T., & Dizdaroglu, D. (2015). Ecological approaches in planning for sustainable cities: A review of the literature. Global J. Environ. Sci. Manage, 1(2), 159–188. https://doi.org/10.7508/gjesm.2015.02.008

Relevance – The article reviews the relevant literature concerning environemtal issues that are challenging the city, and furthermore researches possible solutions for planning sustainable cities. The article takes a close look on the interplay between the (natural) environment and human activities. As it is believed that they spark certain environmental effects which can be both opportunities and threats for the future sustainable city. The conclusion proposes a new conceptual approach to sustainable urban development. The diversity of sources sited in this article was furthermore a valuable source of new information.

Zanon, B., & Verones, S. (2013). Climate change, urban energy and planning practices: Italian experiences of innovation in land management tools. Land Use Policy, 32, 343–355. https://doi.org/10.1016/j.landusepol.2012.11.009

Relevance – Article with a critical stance on urban energy consumption in a European context. It seeks to find the integration of spatial planning with sustainability planning. Therefore it is a useful precedent and is likely to be able to broaden the view of the main body.