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Interrelation Between Urban Planning and Geothermal Energy Use. Exploring Challenges and Potential Synergies in Reykjavík Capital Area

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ABSTRACT

Population growth and development of housing, services, and economic activities are determinant for levels of energy consumption. In terms of geothermal energy production and distribution, the allocation of settlements, determined in the land use planning system, can have a great influence on the overall energy system and energy distribution. Land use planning, settlement structure and urban design are closely linked to societal factors, ruling ideologies and political priorities. The consideration of essential infrastructure in terms of energy and resources is an important factor in this development, but synergies with energy systems and urban planning at the strategic level is often lacking and consequently infrastructure for energy distribution is often taken for granted, neither considering existing infrastructure or future programmes. Furthermore, the timeline for strategic decision making follows a different timeline than energy harnessing which can present challenges for matching energy supply and demand. In this paper the effects of new priorities in urban planning (in terms of urban densification and land use allocations) on distribution systems for geothermal energy will be presented, taking Reykjavík capital area as a case study through the following research questions: How do changes in priorities in land-use planning and a new paradigm of sustainable urban development affect infrastructure planning? Can greater synergies can be created between urban planning, energy use and distribution?

1. INTRODUCTION

1.1 Comprehensive planning and sustainability

In terms of meeting climate targets and promoting sustainability-led development comprehensive planning holds a key role. Decisions regarding land allocation, major infrastructure and services are based upon regulations set out in land use plans, as well as political strategies for future development of the municipality or the region.

The need to give greater weight to the environment in land use planning is generally accepted throughout the westernized world. The effects of unrestricted urban growth (urban sprawl) based upon the principles of incremental planning, whereas undeveloped areas are built upon in response of demand, are now recognized as given rise to various issues such as overexploitation of natural resources, ecosystem destruction, environmental pollution and large-scale climate changes. Furthermore, recent examples of extreme weather conditions have shown that the conventional urban fabric is not well suited to deal with extreme climate evens, such as heavy rain, heat or draught.

This requires a change in paradigm for planning urban areas, calling for a more strategic, comprehensive approach. The development of planning, in order to manage development and allocate land to its best use has developed over time and several planning styles and approaches have coexisted during the last century. The writings of the first “fathers of planning”, or the planning theorists derive from the turn of the 20th century (e.g. the Ebenezer Howard, Osborn, and later Le Corbusier Parker and Unwin. The industrialised cities of the 19th century had grown at a tremendous rate dictated by economic forces and resulted in poor and unhealthy living conditions for their inhabitants. The evils of urban life for the working poor were becoming increasingly evident as a matter for public concern. Around 1900, theorists began developing urban planning models to mitigate the consequences of the industrial age, by providing citizens, especially factory workers, with healthier environments, ensuring access to fresh air, light and basic infrastructure, but also calling for social improvement. The development of the planning tool and the planning profession has developed over time, reflecting societal issues and economic development.

Randolph (2004) lists four basic approach to planning in his book Environmental Land Use Planning and Management. The incremental approach, or what Lindblom (1959) called the “science of muddling through”, is based on acting within the limitation to information and power, making the best decisions available at the time, often within short time perspective. It is the most established alternative to rational-comprehensive approach, where the pros and cons of each option is carefully weighted and compared by professionals, based upon optimization of the sum of the different aspects. Participatory approach aims at encompassing different stakeholder perspective, where the process is of prime importance with the aim of involving the public into decision making. Finally, the advocacy planning approach recognizes the power struggle that can arise in decision making on planning, whereas the planners act as mediators between different interests. In additions to those categories above, environmental or sustainable planning has become an established concept. In parallel, other instruments have been developed to ensure environmental consideration of development and planning, namely that of Environmental Assessment (Environmental Impact Assessment of projects and Strategic Environmental Assessment of plans and programmes) that is required by legislation in most countries (EU, World Bank etc.). When conducted to its full potential EIA establishes a framework to consider two level of inquiry: the technical environmental aspect and its wider embedding in sustainable development, including socio, political economic aspects of the planning and decision-making process.

It can be claimed that this change in emphasis constitutes a new planning paradigm based upon the principles of sustainable urban development. This change has been reinforced by decision-makers at the strategic level, such as international treaties committing to change in established "way of doing things". The aims is to reduce CO2 emissions, but to achieve this a change in attitude and heightened awareness by different actors is needed, i.e. decision makers, the public and the practitioners (energy companies, planners and practitioners etc.) that the challenges of sustainable development need to be addressed and changes are needed in the way of designing the urban fabric.

1.2 Energy and urban infrastructure

Energy and urban infrastructure. Urban infrastructure is a concept that encompasses engineered facilities, utilities and systems. It is essentially intertwined in the context in which it is placed, and the society it is made to serve. It is therefore highly dependent upon economic growth, societal and demographic changes. With the demands on sustainable development and a change in societal use of limited natural resources and CO^2 emissions and other pollution, the subject of renewable energy resources is central to the discussion. There is an intrinsic relationship between urban planning and sustainable energy and infrastructure. Issues such as urban compactness, related mobility and transportation effects and possibilities for distribution of energy and other infrastructure. With this regard scale and context is of crucial importance. It is often assumed that compact urban settlements are more advantageous for both energy provision and sustainable urban infrastructure. However, this assumption is essential based technical optimization of energy savings and those aspects need to be balanced with other considerations, such as architecture, quality of living etc.

In a study made by Malekpour et al (2015), literature on strategic planning on urban infrastructure over the last century was reviewed. The hypothesis for the study is that strategic planning of public infrastructure is in a central position to operationalise environmental sustainability visions due to their significant impacts on the environment. The findings reveal how the scholarly paradigms for infrastructure planning have transformed over time, from optimization (based upon criteria of effectiveness and specialist expertise) to sustainability planning using the criterion of sustainability when making strategic choices. However, according to the study, incremental planning has been the dominant approach for decades and it stands in the way for adopting the sustainability approach for infrastructure planning. Among the conclusions from the overview are that a limitation to applying the lessons and principles from sustainable planning to urban infrastructure is that much of the literature on strategic planning for sustainability is lacking in practical application and is more aspirational than embedded in planning practice.

2. ENERGY DISTRIBUTION AND SUSTAINBLE PLANNING IN REYKJAVIK

2.1 Geothermal district heating in Reykjavík

The distribution of essential urban infrastructure in the city of Reykjavík is assembled in the hands of Veitur, a public company with own board and decision-making authority. The company provides Reykjavík city with district heating, drinking water, electricity and wastewater services. Furthermore, the company provides services to neighbouring municipalities in the south and the west of the country, and distributes hot water to 73 % of Iceland's population (Figure 1). The district heating company Hitaveita Reykjavíkur was established in 1946 (became part of Veitur), but the first distribution services have been in place since 1930.

Figure 1: Veitur's geographical distribution area. Veitur, 2019.

The first geothermal boreholes in Reykjavík were drilled to increased flow from the geothermal field, 1930. The water was collected and led to a primary school in the central Reykjavík. The neighbouring homes followed, as well as the hospital and an indoor swimming pool.

These boreholes are still in use and provide hot water to a part of the city. In the following years boreholes at Reykir outside Reykjavik were harnessed and ensuing more effective technic of deep holes pumping multiplied the capacity of the system and municipalities around Reykjavík were connected to the hot water supplies.

In 1990 a system of combined electricity and warm water powerplants at Nesjavellir and Hellisheiði were constructed, where hot fresh water is a byproduct of the operation and now provides hot water for a large part of the capital area (figure 2).

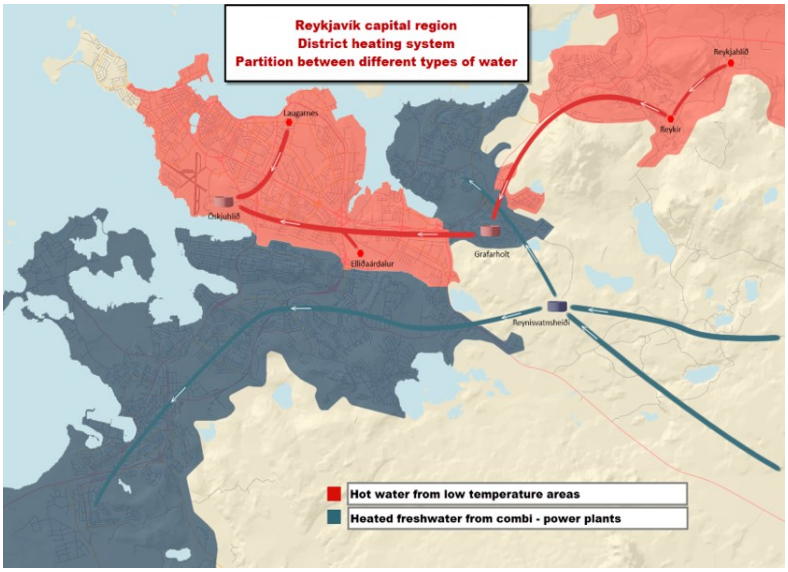

Figure 2: Sources of hot water distributed in the capital area. Veitur, 2019.

2.2 New planning paradigm : sustainable planning

The urban framework of Reykjavík City is characterized by eras of demographic changes and urbanization of the country in the 50s and 60s that coincided with the rise in automobile ownership. The resulting urban pattern is a consequence of high car dependency and urban sprawl. Around the year 2000 it was decided politically to develop Reykjavik and the Capital Area with urban densification to fulfill the criteria for sustainable planning, less car dependency and better possibilities for public transport and other modes of transport such as walking and cycling and minimize CO^2 emissions.

Urban densification is the politically mandated goal in Reykjavik‘s comprehensive plan 2010 – 2030, that was adopted 2013, both identifying certain areas as development areas, but also enhancing densification in other areas of the city. Strict limits were imposed to prevent urban sprawl with the goal to work towards a 90/10 ratio in building densification, meaning 90% of new construction will be in within urban areas of the city.

This strategy was further enhanced in the capital areas regional plan, where the 8 municipalities present a common vision for the development of the capital areas, focusing on containing new settlements within the current boundaries of the urban area and focusing new development in regional centres that would enable public transportation.

2.3 Effects of district heating system on the urban fabric

The district heating for residential use for 73% of the population calls for effective distribution system that calls for sound technical and safety solutions, but as the capital area has grown resulting in increasing pressure on urban land, land use conflicts have arisen.

Although the distribution systems are mostly in place, there is need to maintain and strengthen the system, and move a larger part of the urban area to use heated water from the combined power plants that is available in abundance from the power plants east of the city. The distribution infrastructure require space with surrounding safety zones where buildings are restricted, but also disturbance during construction and maintenance. Furthermore, the pump stations entail noise pollution and traffic from heavy service vehicles.

It is important to keep in mind that the history of harnessing geothermal water is interlinked with the urbanization in Reykjavík, and this can be seen both in the urban fabric and place names. An example of this is Laugavegur, a road that led from the early settlement in Reykjavik to the hot springs, which still is the main street in the city.

Another issue of importance is that there are 54 boreholes in the capital region, with temperatures 70 – 130 °C. These were originally on the outskirts of the town, but as the capital areas has expanded, their location is within the urban area. An example of this are the boreholes in Laugarnes, that were the first ones to be harnessed and used for residential heating in the city and were placed on the city’s outskirts but is now interwoven in the urban fabric (figure 3).

Existing energy and urban infrastructure is frequently overlooked by the city authorities in making strategic decisions on land use, and this can result in situations that are both costly and time consuming to solve. Since the focus on urban densification was introduced, those situations have emerged more frequently.

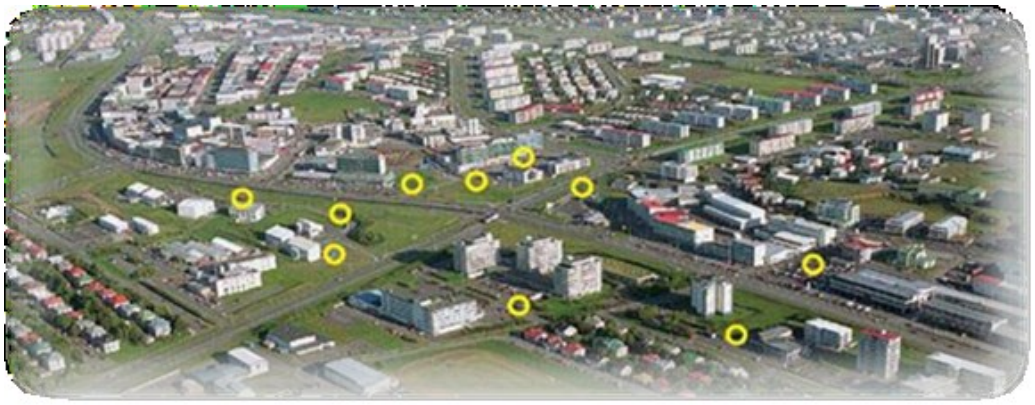

Figure 3: Location of boreholes in Laugarnes. Veitur, 2019.

Figures 4 and 5 show the location of the boreholes on Veitur's Geographical Information System and the priorities of the city council on development areas for urban densification which covers the geothermal area. Connection to the boreholes there are pipes and pumping stations that need to be considered in new development proposals. Currently the city is proposing a large profile housing project within the area, as well as installing a rapid transport network along the main road.

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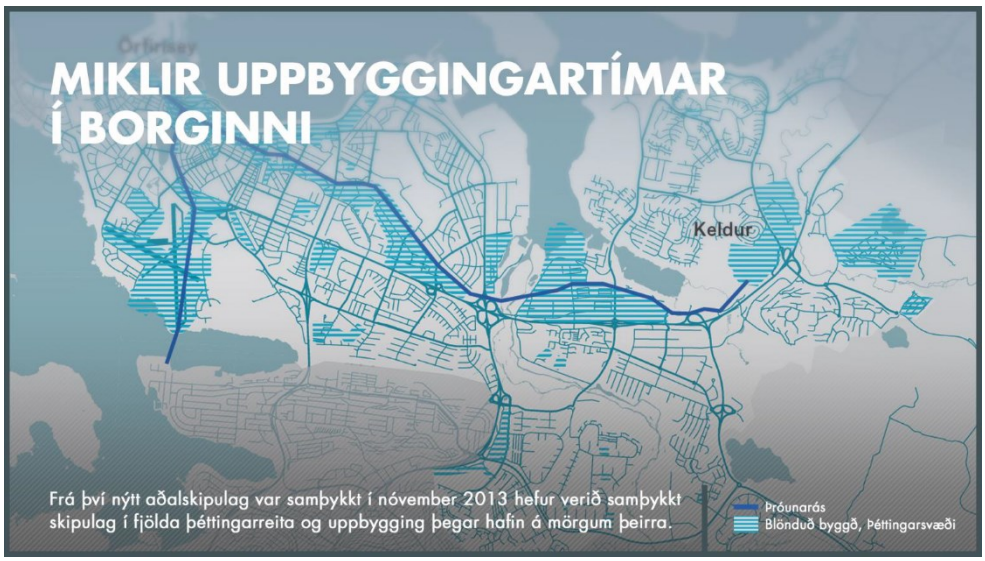

Figure 4: Development areas identified for urban densification. Presentation by the mayor of Reykjavík, 2nd March 2018[1].

[1] https://reykjavik.is/sites/default/files/dbe-loka-lodauthlutanir-og-ny-byggingarsvaedi-2mars2018.pdf

Figure 5: Location of boreholes in central Reykjavík. Source: Geographical Information System for Veitur.[2]

3. DISCUSSION: SUSTAINABLE PLANNING AND RESILIENCE OF URBAN INFRASTRUCTURE

The change in paradigm in Reykjavik city planning in in line with the international development in planning and is furthermore a direct outcome and sign of political commitment towards reducing CO^2 emissions and promoting sustainable lifestyles. Urban densification is a key element in the sustainable planning practices and it is assumed that the higher density will also have positive effects on energy use, better use of existing urban infrastructure.

However, results of literature review in the energy sector (Kammen and Sunter, (2016), Kruger and Kolbe (2012), Malekpour et al (2015), Pasqualetti et al. (2010)) identify the challenges of adapting energy systems to new priorities and that "[S]ound knowledge of energy resource demand and supply including its spatial distribution within urban areas is of great importance for planning strategies addressing greater energy efficiency" (Krüger and Kolbe, 2012). Kammen and Sunter (2016) highlight that energy systems of cities are increasingly vulnerable to the effects of climate change and extreme weather such as storms, flooding and sea level rise, "but also to natural and human-induced disasters". It is important that decision regarding changes in land use take those aspects into account, and that decisions are based upon sound knowledge and a comprehensive review of all factors involved and minimize risk rather than enhancing them.

Urban infrastructure is a multifaceted concept that goes beyond a set of engineered facilities, utilities and systems. It is a result of several factors in its specific context, including economic growth, political priorities and behavioral patterns, as well as technical solutions, and needs to be open to change and adpatation. An aspect that is identified in Malekpour's review of strategic planning for sustainability is lacking in practical aspects of implementation, knowledge that is held by the infrastructure companies which hold an overview of the whole process from decision making to construction.

It is of core importance that decisions taken by the distribution companies take full account of the context in which they operate. Land use planning and planning theory can provide lessons regarding comprehensive approach, stakeholder engagement and solving conflicting interest. At the same time it is important that planning for sustainability ensures that the basic, important functions of the city are withheld, included and planned for in the best way. A strategy for how urban infrastructure is addressed in new development is an important component to ensure comprehensive planning. .

According to Pasqualetti et al (2010), there is often a tendency to think that for solving environmental problems finding a silver bullet is needed, often involving technical solutions. Experience shows that a more thorough commitment is needed involving several aspects, referred to as "head" (education), "heart" (motivation) and "hands" (action). This appears also to be the case of inclusion of urban infrastructure in the planning for sustainability in Reykjavik. A silver bullet in form of technical "fix" will not solve the challenges ahead to solve conflicting interests, but a persistent process based upon the principles of transparency. This process must built upon bilateral understanding of each others' work, willingness to share and cooperate, and production of results that reflect those values. Considerations of urban infrastructure systems at early stages of the planning process can result in efficient use of resources, minimise negative impacts in forms of delay, risks and financial costs and ensure the resilience of those systems.

REFERENCES

Kammen, D.M., and Sunter, D.A.: *City-integrated renewable energy for urban sustainability.* https://gspp.berkeley.edu/research/featured/city-integrated-renewable-energy-for-urban-sustainability.

Krüger, A, and Kolbe, T.H.: Building analysis for urban energy planning using key indicators on virtual 3D city model – the energy atlas of Berlin. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* Volume XXXIX-B2, (2012). XXII ISPRS Congress, Melbourne, Australia.

[2] https://lukor.or.is/lukor/

Malekpour, S, Brown, R.R., Haan, F.J.: Strategic planning of urban infrastructure for environmental sustainability: Understanding the past to intervene for the future. *Cities,* **46** (2015), 67-75.

Pandit, A., Minné, E.A, Li, F., Brown, H., Jeong, H., .James, J-A. C. Newell, J.P, Weissburg, M., Chang, M.E., Xu, M., Yang, P., Wangh, R., Thomas, V.M, Yu, X., Lu, Z.: Crittenden, J.C. Infrastructure ecology: an evolving paradigm for sustainable urban development. *Journal of Cleaner Production,* **163** (2017), 19–27.

Pasqualetti, M.A., Tabbert, M.K. and Boscamp, R.L.: The Silver Bullet Myth of Sustainable Energy Savings. *The Electricity Journal,* **23** (2010), 72-78.

Randolph, J. 2004. *Environmental Land Use Planning and Management*. Island Press. Washington, DC.

Vandevyvere, H. and Stremke, S: Urban Planning for Renewable Energy Future: Mythological Challenges and Opportunities from a Design Perspective. *Sustainability,* **4** (2012), 1309-1328.

Weber et al, Urbanisation and Land Use Management in the Arctic: An Investigative overview in *Northern Sustainability: Understanding and Addressing Change in the Circumpolar World* (2017), Fondahl, G., and Wilson, G. (ed). Springer.