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Article

Urban Structure, Energy and Planning: Findings from Three Cities in Sweden, Finland and Estonia

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Abstract
Transforming energy use in cities to address the threats of climate change and resource scarcity is a major challenge in urban development. This study takes stock of the state of energy in urban policy and planning and reveals potentials of and constraints to energy-efficient urban development. The relationship between energy and urban structure provides a framework for discussing the role of urban planning to increase energy efficiency in cities by means of three in-depth case studies of medium-sized cities in Northern Europe: Eskilstuna in Sweden, Turku in Finland and Tartu in Estonia. In some ways these cities go ahead when it comes to their national climate and energy policies and aim to establish urban planning as an instrument to regulate and influence the city's transition in a sustainable way. At the same time, the cities are constantly facing goal conflicts and limitations to their scope of action, which creates dilemmas in their strategic orientation and planning activities (e.g. regional enlargement and increased commuting vs. compact urban development). Finally, considering urban form and spatial structure along with the policy context as well as regional drivers and functional relations is suggested as a suitable approach for addressing the challenges of energy-efficient urban development.

Keywords
climate change; energy efficiency; Northern Europe; sustainable development; urban form; urban planning

Issue
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1. Introduction

In 2008, the European Union (EU) published the 2020 climate and energy package which contained three key objectives: a 20% reduction in EU *greenhouse gas emissions* from 1990 levels, an increase in the share of EU energy consumption produced from *renewable resources* to 20% and a 20% improvement in the EU's *energy efficiency*. Following these "20-20-20 targets", energy has been high on the agenda in urban development issues. Energy is an important element in many visions of future urban development, including sustainable and CO_2-neutral cities, self-sufficiency, regeneration and resilience, but also in more general concepts such as a smart city (Girardet, 2015).

The first planning responses to climate change in urban areas date from the late-1980s/early-1990s. However, an analysis of urban climate change experiments revealed that they are mainly rather recent phenomena and showed that the experiments in Europe were predominantly conducted in the fields of the built environment, urban infrastructure (energy, waste, water) and transport, whereas urban form/planning, adaptation and carbon sequestration played only a minor role accounting for less than 25% of the experiments (Bulkeley & Castán Broto, 2013).

Recently, the proliferation of climate change experiments was reasserted by the European cooperation movement *Covenant of Mayors,* whose signatory cities, almost 6,500 by 2015, voluntarily commit to meet and exceed the EU's 20% CO_2-reduction target by 2020. Relevant examples of local initiatives ('Benchmark of Excellence') from the signatories show a focus on the public sector (municipal buildings, equipment/facilities, public lighting) as well as on local electricity production and transport (Covenant of Mayors, 2015), i.e. much in line with the findings of Bulkeley and Castán Broto (2013).

Hence, cities are already taking an active role in climate change policies. The interrelations between urban structure and energy are a key aspect of these urban climate policies. For decades, thus, development principles in urban planning for urban infrastructure and urban form were influenced by a concern for energy saving and efficiency. Related to these efforts concerning urban structure are initiatives to increase sustainable transport and the share of renewable sources in local energy generation, enhance energy efficiency in buildings, the use of combined-heat-power (CHP) generation and regional product cycles.

This study contributes to the scientific discussion of energy and urban structure by establishing a linkage between the known beneficial influence of urban structure to increase energy efficiency and the role of urban planning to affect urban structure purposefully. Starting point is that urban structure can facilitate efficient use of energy in cities. But, what we observe from the scientific literature and the case studies is that the possibilities of urban planning to influence or change urban structure are limited and that urban structure adapts only slowly to planning measures. However, optimising urban structure by complementing policies, such as the transport system or incentives, is crucial to influence travel behaviour. In our study we, thus, look for 'complementing' policies and aim to conceptualise the scope (fields of action) and key framing conditions (potentials and constraints) for municipal urban planning with an energy-efficiency agenda, especially in transport planning.

Section 2 provides a brief overview of the scientific literature focusing on the relationship between urban structure and energy use, which serves as a framework and 'stepping stone' for the empirical analysis. Section 3 summarises the applied empirical methods and introduces the multiple-case study of three Northern European cities: Eskilstuna in Sweden, Turku in Finland and Tartu in Estonia. The cases are separately investigated in sections 4−6; elaborating on the question, what role can cities—urban planning—play in increasing energy efficiency by working with urban structure? In section 7, we discuss the case study findings from the perspective of three interrelated dimensions of urban energy policy, which leads to the final conclusions in section 8.

2. Urban Structure and Energy—Providing a Framework

The relationship between urban structure and energy use in cities has been investigated by researchers for more than three decades and is being increasingly incorporated in policy-oriented documents from the EU and other institutions. Research ranges from studies which only focus on urban form-related aspects to broader approaches which also consider, for example, socio-economic factors.

This study uses the relationship between energy use and urban structure, with respect to its relevance for urban planning, as a framework for discussing the role of urban planning to increase energy efficiency by affecting urban structure. Urban structure itself is a disputed term. We focus on urban form and the transport system as we consider these to be two major components of urban structure when discussing energy efficiency.

2.1. Urban Form

One of the first in-depth studies to investigate urban structure and its implications for urban energy supply and consumption was conducted by Susan Owens (1986). Owens argues that energy supply, price and distribution shape urban and regional systems (spatial structure); but that in turn, the spatial structure (e.g. land use) determines energy demand and consumption (e.g. transport and district heating) and opportunities for alternative energy systems (feasibility). Owens identifies the energy-efficient characteristics of the spatial structure. The most influential characteristics are compactness, integration of land uses, clustering of trip ends and, at least to some degree, self-contained urban units of variable size and number. Owens describes the 'compact city', the 'archipelago pattern' and the 'linear grid structure' as the basic types of energy-efficient spatial structure.

An adaptation of the pure compact city concept is polycentric spatial structures (decentralised concentration) that appears to provide an answer to the trade-offs of a single compact city (e.g. disadvantages of high density) while keeping its advantages (Holden & Norland, 2005). Also, polycentric spatial structures provide an alternative spatial principle for regions where compact city development is hardly feasible (e.g. sparsely populated regions). Sparsely populated regions such as Estonia or Finland are characterised by dispersed urban settlements and long commuting distances. Polycentric urban regions, however, favour shorter commuting distances (Grunfelder, Nielsen, & Groth, 2015). A review of empirical studies from the Nordic countries (Næss, 2012, p. 41) also shows that "decentralized concentration may be the most energy-efficient settlement pattern at a wider regional scale".

In summary, dense and concentrated cities are considered to contribute reduce travel needs by car (Næss, Sandberg, & Røe, 1996). Newman and Kenworthy (1988) provide empirical evidence that locational factors have a greater impact on energy (fuel) consumption than congestion. Næss and Jensen (2004, p. 37) state that "urban structure makes up a set of incentives facilitating some kinds of travel behaviour and discouraging other types of travel behaviour" and, thus, the structural conditions have relevant potential to influence people's travel behaviour (Næss, 2006). Compact urban structures and concentrated development facilitate and favour the efficient use of energy in cities (Fertner & Große, in press).

2.2. Transport System as a Complement to Urban Form

Studies on the interrelations between urban form and travel behaviour embrace a number of urban concepts ranging from the 'compact city' stressing "the merits of urban containment" (Breheny, 1995, p. 82) to 'decentralisation' referring "to all forms of population and industrial growth taking place away from existing urban centres" (Breheny, 1995, p. 87). This definition of urban structure is related to the conceptualisation of cities in the regional context (e.g. Kunzmann, 2003) and stresses the importance of mobility as an integral part of the urban phenomenon: Urban form not only shapes mobility, mobility also shapes urban form. Mobility as an independent driver is revealed by a study by Rickaby and Steadman (1991) who show that differences in urban form between different compact city models do not have significant implications for energy use in transport; only competitive public transport systems and accompanying policies could induce reductions in energy use. Also Næss (2006) recognises the need to complement transport reducing urban planning with accompanying instruments to achieve significant changes. Likewise, public transport needs to be accompanied by land use and transport planning to restrict car use and direct development towards transit nodes (Anderson, Kanaroglou, & Miller, 1996).

Therefore, it is difficult to clearly verify the relationship between urban structure and travel behaviour. Some critics even consider it as 'weak' or 'uncertain', also due to the importance of socio-economic factors and people's attitudes (Næss & Jensen, 2004). Breheny (1995), for instance, considers the present high mobility levels as a relevant obstacle to inducing significant changes in travel patterns through changes in urban form. Certainly, socio-economic factors influence the effectiveness of energy efficient urban structures, such as actual travel patterns. But the consideration of socio-economic factors implies also the potential to carry out customised and, thereby, effective energy policies (Stead & Marshall, 2001; Stead, Williams, & Titheridge, 2004).

2.3. Energy and Urban Structure

Despite uncertainties, the literature persistently reveals that energy consumption corresponds with urban structure (e.g. Næss, 2006; Newman & Kenworthy, 1988). Accordingly, principles of urban development, notably urban structure, are crucial for energy efficiency. Consequently, policies on urban structure are preferable as an energy conservation strategy. However, tapping the full potential of these policies requires knowledge on how to optimise urban structure by accompanying policies (e.g. transport planning) since functional relations (e.g. transport system, mobility) and policy context (e.g. efficiency of local and national policies) are essential complements in order to constitute energy savings.

The literature, though, provides evidence that the implementation of energy efficiency policies is often limited by the policy context. This frames the potential and constraints for urban planning to affect and facilitate the development of energy efficient urban structure—and is also the issue we particularly look into by means of the case studies.

2.4. The Planning System, National and Local Policies as Complements

In energy planning, a particular role is accorded to municipalities. Brandoni and Polonara (2012) see the importance of municipal energy planning processes especially in identifying the crucial aspects in energy consumption as well as assessing the most suitable energy-saving initiatives and identifying renewable sources that can be more properly exploited in a given local area.

Williams (1999), however, questions the power of the (local) planning system to ensure urban 'intensification' and manage its consequences. Williams considers the process of policy implementation as responsible for the divergence between theory and planning practice. Local policy making takes place within policy regulations from higher tiers of government that determine the range of local options (van Stigt, Driessen, & Spit, 2013). Additionally, the prerequisite of administrative boundaries induces a problem whenever functional relations exceed these boundaries. Thus, decision-making in line with the established government levels is insufficient in, for instance, transport policies since transport widely exceeds administrative boundaries while responsibility for action is likewise contested (Marsden & Rye 2010). A case study of the Gothenburg Metropolitan Area (Lundqvist, 2015) illustrates how the jurisdictional fragmentation of a metropolitan area counteracts the coordination of planning processes and that coordination which is built on administrative boundaries is not sufficient to achieve climate change adaptation.

However, according to Bulkeley and Betsill (2005), solutions remain tied to the local level instead of exceeding the local frame due to the neglect of interactions of economic, social and political processes across different governance levels and systems as well as gaps in cooperation at the regional level and among constituent municipalities (Geerlings & Stead, 2003). Furthermore, Brandoni and Polonara (2012) consider co-ordination at the regional level as fundamental to enable municipalities to concentrate their efforts on their agenda.

To conclude, ambitious and purposeful municipal energy planning requires, on the one hand, policy-wise backup from the national level and, on the other hand, coordination at the regional level. This implies examining governance structures and their influence on urban form in more depth to identify and establish "helpful governance structures" (Schwarz 2010, p. 44).

3. Methods and Introduction to the Cases

The empirical core of this study is conducted as in-depth, multiple-case study (Yin, 2014) of three Northern European cities, which were part of the European project PLEEC—"Planning for Energy Efficient Cities" (Kullman et al., 2016): Eskilstuna in Sweden, Turku in Finland and Tartu in Estonia (see Figure 1). The selected cases are all medium-sized cities (see Table 1), which function as regional centres and each is striving to increase its energy efficiency. In some respects, the cases are therefore representative of medium-sized cities in Europe. They also face similar challenges such as urban sprawl and regional commuting, which are related to their urban structure and their position within the regional urban system. At the same time, the cities are faced with similar potential and constraints to addressing urban structure and increasing their energy efficiency. This supports the intention of this paper to draw some transferable conclusions by using "analogous generalization", which Neergaard (2007, p. 271) defines as the extrapolation of a researched insight (role of urban planning in the three case cities) to new contexts (other medium-sized cities in Europe).

As we look at the role of urban planning in influencing urban structure and energy efficiency, it was important for the choice of the cases that the role of municipal planning in the planning system of each country was comparable. The countries' planning systems are to a certain extent similar as the main competences in spatial planning are allotted to the municipal level, whereas planning on the regional level is rather weak (COMMIN Project Co-ordination, Academy for Spatial Research and Planning, 2015; Smas & Fredricsson, 2015). Also in terms of their planning culture and style—based on a general classification of major traditions of spatial planning in Europe (European Commission, 1997)—all three countries adopt the *comprehensive integrated approach,* while Sweden also shows elements of the *regional economic approach* (ESPON, 2007). The *comprehensive integrated approach* is described as 'framework management' with a "very systematic hierarchy of plans from national to local level" (European Commission, 1997, pp. 36-37). The *regional economic approach* is characterised by wide social and economic objectives (European Commission, 1997). Accordingly,

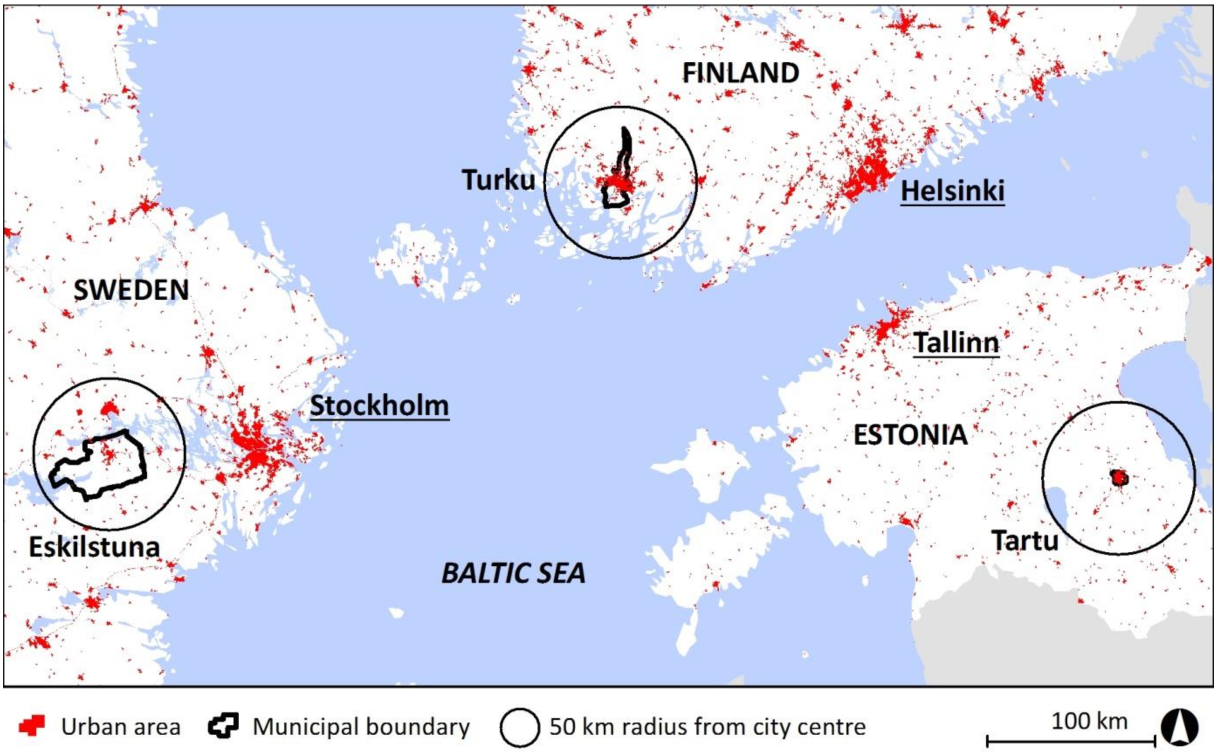

Figure 1. Urban areas in Northern Europe and the three case study cities. Source: European Environment Agency, 2015.

Table 1. Key figures of Eskilstuna, Turku and Tartu. Source: Eurostat, 2016; Giffinger, Hemis, Weninger, & Haindlmaier, 2014).

	Eskilstuna	Tartu	Turku
Inhabitants in the municipality	99,804	97,847	180,225
Inhabitants in the urban region	(99,804*)	150,528	316,634
Administrative area of the municipality in km^2	1,100	39	245
Urban area of the municipality in km^2	51	29	75
Population density in inhabitants per km^2 urban area	1,945	3,396	2,403
Average number of persons per household	2.2	2.3	1.9
GDP per capita in NUTS 3-region in Euro (2012)	35,500	9,300	33,800
PPS per capita in NUTS 3-region in % of EU average (2012)	101%	50%	106%
Final energy consumption per capita in MWh	26.5	13.0	35.3
share of transport in final energy consumption	16%	20%	9%
Level of motorisation - Registered cars per 1,000 inhabitants	450	250	420
GHG emissions reduction target 2020 (SEAP**)	(base 2009) 25%	(base 2010) 20%	(base 1990) 20%
tons CO_2 equivalent/year by 2020	40,873	108,159	293,400
Required average annual GHG emissions reduction *baseline—2020 (CO_2 equivalent)*	-3,716	-10,816	-9,780

Notes: * The administrative area of Eskilstuna can be considered as its urban region (see also Figure 1); ** According to the cities' Sustainable Energy Action Plans (City of Tartu, 2015; City of Turku, 2009; Municipality of Eskilstuna, 2013a).

the *level of comprehensiveness* differs between the three countries; Finland and Estonia show both vertical and horizontal coordination, whereas the Swedish planning system shows mainly horizontal and only weak vertical coordination (ESPON, 2007).

The investigation of the cases is based on the review of related scientific publications and national, regional and local planning documents, as well as field visits and interviews with civil servants and stakeholders in urban development and energy planning in each city.

The reviewed planning documents (see Appendix I) comprise current local planning documents (and selective previous versions or drafts) that address issues of spatial development, transport, climate and energy planning. Planning documents of superordinate levels (regional, national) were included if relevant for local planning.

The fieldwork was conducted between March and June 2014 as part of the EU-FP7 project PLEEC. The interviews were semi-structured; the interviewees were asked about their perception of framing conditions and national energy regulations, the evolution of spatial planning, current transport planning as well as national and local energy policy and the role of regional planning. One to three individuals from the respective department or institution (see Appendix II) participated in each interview. All interviews were recorded and transcribed. The interview transcripts were coded manually or with the assistance of software by using keywords (e.g. "compact", "commuting", "land use") and split into analytical categories (e.g. urban structure, municipal planning, cooperation) (Further information can be found in Fertner, Christensen, Große, & Hietaranta, 2015; Große, Groth, Fertner, Tamm, & Alev, 2015; Groth, Große, & Fertner, 2014).

For each case, we provide an overview of status and practice of urban form and transport. Consequently, we discuss potentials of and constraints on urban planning, while also addressing factors for success such as scope of action, local power relations and leading principles as the baseline for municipal actions to integrate energy issues in urban development.

The effort required to reach their 2020-target for GHG emissions reduction varies according to each city's current baseline: Turku and Tartu need to reduce their annual GHG emissions on average by about 10,000 tons CO_2-equivalent each year, whereas Eskilstuna only needs to reduce by less than 4,000 tons CO_2-equivalent each year (see Table 1).

At first glance, the figures in Table 1 suggest a negative correlation between population density and energy consumption. Tartu shows the highest density and by far the lowest energy consumption per capita, whereas Eskilstuna and Turku show lower densities of the urban area but significantly higher energy consumption per capita. However, a closer look at the figures reveals that other factors, e.g. purchasing power standards per capita (PPS) or car ownership, which is considerably lower in Tartu, also appear to be relevant.

Figure 1 and Table 1 also reveal the differences between the administrative boundaries and the actual urban area of the cities. While the total area of Eskilstuna municipality is much larger than just its urban area, the urban area of Turku significantly exceeds its municipal boundary. In Tartu, the municipal boundary corresponds more or less to the urban area, but signs that it is exceeding its boundaries are already visible.

By means of the case studies, we investigate the question, what role can cities—urban planning—play in increasing energy efficiency by working with urban structure? In particular, we look at the role of urban planning, and its potential and possible constraints to facilitating the development of energy-efficient urban structure.

4. Energy and Planning in Eskilstuna

The Swedish municipality of Eskilstuna, with almost 100,000 inhabitants in 2013 (Eurostat, 2014) and a size of 1,250 km^2, is located about 100 km west of Stockholm and is within Stockholm's commuter belt. Eskilstuna is situated in the county of Södermanland, which is part of the Stockholm-Mälar Region, a polycentric region with about 3 million inhabitants. Eskilstuna marks a former major industrial location in Sweden; since the 1970s, its population has been rather stable at between 90,000 and almost 100,000 inhabitants. Deindustrialisation in the 1970s caused a pronounced decline in the number of jobs, making the city ripe for urban restructuring.

4.1. Urban Form and Transport

Urban densification and connectivity to transport routes facilitated by public transport are generally acknowledged as two main principles of energy-efficient urban development in Eskilstuna. With the current Comprehensive Plan (Översiktsplan 2030, Municipality of Eskilstuna, 2013b), a radical decision was made to abandon the former settlement planning in the attractive coastal area of lake Mälaren (see Figure 2). Furthermore, future urban development will be concentrated within or close to the existing urban cores as well as in connection with public transport links between these cores (Figure 2). Currently, two thirds of the inhabitants live within 3 km of Eskilstuna city centre.

However, with few exemptions, transportation depends on fossil fuels. The design of effective incentives to reduce fossil fuels remains the key challenge, also at the national level. The main transport mode for commuting—as far as to Stockholm—is the private car (Municipality of Eskilstuna, 2012, p. 6).

A key observation in this regard is that energy efficiency policies in Eskilstuna have been developed subordinate to the basic drivers of economic development. Regional enlargement and the chance to enter Stockholm's labour market offered the municipality a way out of a long economic downturn, which lasted from the mid-1970s to the late 1990s, but is also facilitated by increased commuting.

4.2. Potential of and Constraints on Urban Planning—Factors of Success

The main legislative foundations for municipal urban planning are the Planning and Building Act, the Swedish Environmental Code and Sweden's 16 environmental quality objectives (Swedish Environmental Protection Agency, 2013). The latest Planning and Building Act from 2011 gave the municipal Comprehensive Plan a stronger strategic role so that it became

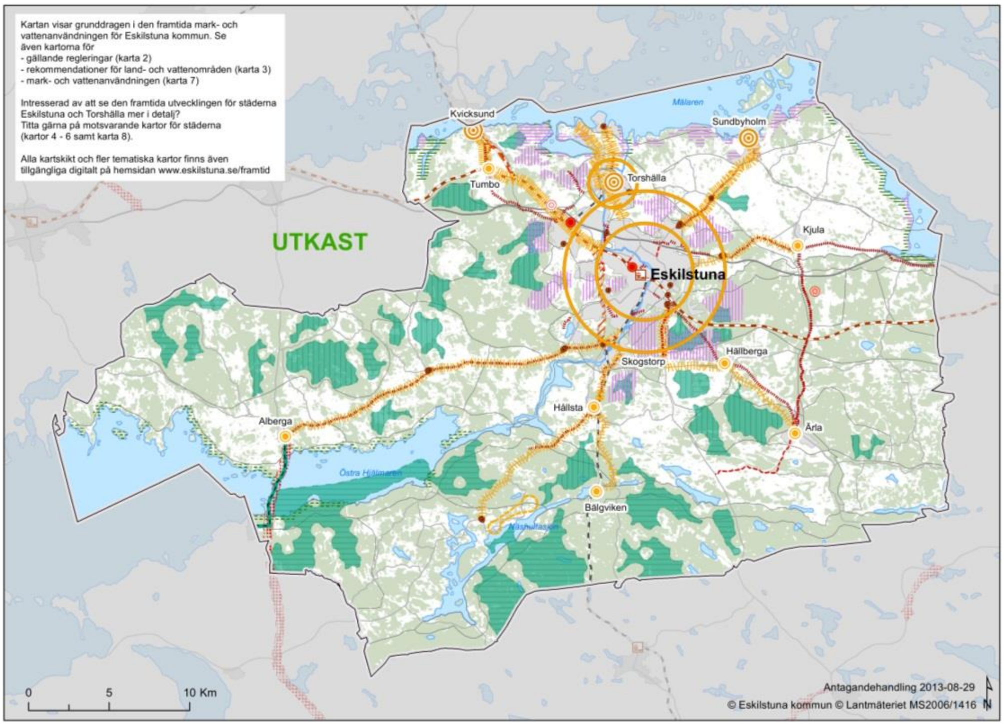

Figure 2. Development concept of Eskilstuna Comprehensive Plan emphasising urban development in the core of Eskilstuna City and along selected transport axes. Source: Municipality of Eskilstuna, 2013b).

a key instrument of sustainable development. The Comprehensive Plan applies a broader perspective including topics such as economic development, regional aspects of transportation and water supply.[1] The core planning documents, Comprehensive Plan, Climate Plan and Transport Plan (Municipality of Eskilstuna, 2012, 2013a, 2013b), as well as the interviews provide evidence that energy efficiency has become an almost omnipresent issue, integrated across sectors and between levels in the municipal organisation.

However, energy and climate policy is carried out in the following two policy arenas in Eskilstuna, which is also emphasised by different planning documents: the municipality acting as a concern ('planning') and the municipality acting as a stakeholder of energy initiatives ('strategy') (Municipality of Eskilstuna, 2013a). The concern is in charge of all decisions regarding municipal planning, services and infrastructure. The municipal climate plans and projects are carried out with a high level of effectiveness by the Eskilstuna municipal concern (municipal services, energy supply, public enterprises, e.g. Eskilstuna Energi & Miljö AB), due to omnipresent 'sustainability thinking'. This is also supported by an annual ranking of all Swedish municipalities in regards to their climate ambitions and plans in which Eskilstuna achieved top positions (MiljöAktuellt, 2015).

The more comprehensive climate strategies that include energy initiatives outside the municipal concern have, however, much greater potential regarding, e.g. CO_2-savings. The concern's share of potential CO_2-emission reductions accounts for only 7% of the city's total. However, the development and implementation of such comprehensive strategies relies on the establishment of partnerships between the municipality and, e.g. private companies, organisations and the public, which operate outside the direct influence of the municipality.

Thus, although the municipal area of Eskilstuna corresponds to its urban region, which provides a much larger territorial scope than in Tartu or Turku, the distinction between the two policy arenas is very relevant for the operational preparation of plans, projects and strategies as well as their final practical effectiveness. Furthermore, particularly in regional transport planning, the municipality depends on the National Traffic Authority due to its responsibility for investments in regional transport networks, whereas the municipality can regulate local public transport by contracting the public transport operators.[2]

However, policies of energy efficiency remain 'second-order' compared to the economically driven 'first-order' development of the regional urban system that comes along with increased transport. The development of the regional urban system with its orientation towards Stockholm's labour market is not questioned by the city authorities; it is taken as a starting point for policies that aim to compensate the effects of commuting such as policies to enhance commuting by train rather than car and the development of a dense urban structure in hub-and-spoke patterns adjacent to public transport lines.

Thus, although the Transport Plan (Municipality of Eskilstuna, 2012) and the Climate Plan (Municipality of Eskilstuna, 2013a) contain measures for sustainable transport, these remain "mild answers to strong trends". This twofold planning strategy—first, matching trends in the outside world and second, setting up hierarchies of sustainability visions (strategy) and goals (plans and projects)—is a major constraint on urban planning in Eskilstuna.

5. Energy and Planning in Tartu

Tartu is the second largest city in Estonia with 98,000 inhabitants (2014) and a municipal area of roughly 40 km². The city is located about 180 km southeast of the capital Tallinn. Tartu has no relevant big industries; the main employers are the municipality (incl. hospital) and the university.

5.1. Urban Form and Transport

Estonia is characterised by a generally low population density with only a few dispersed urban centres. The National Spatial Plan (NSP) "Estonia 2030+" (Ministry of the Interior, 2013) implemented a concept called *"Low-density urbanised space"*, which combines the concept of sustainable (compact) urban space with the low-density settlement characteristics of Estonia. The concept aims to match people's daily activity spaces by applying a polycentric spatial strategy, which is supposed to favour shorter commuting distances (Grunfelder et al., 2015; Ministry of the Interior, 2013). The concept is also adopted in the previous and current Master Plan of Tartu (City of Tartu, 2006).

Although the core city is rather compact, Tartu is facing ongoing urban sprawl and car-dependent commuting from the surrounding suburbs as well as long distance commuting, e.g. to the capital Tallinn, which provides diverse employment opportunities.[3] The modal split shows significant differences between journeys within Tartu and journeys between Tartu and its surroundings. While the former shows a high share

[1] Interview with Eskilstuna Municipality, Town Planning Department, Planavdelningen (översiktsplanerare), comprehensive planning, 07.05.2014.

[2] Interview with Eskilstuna Municipality, Town Planning Department, Planavdelningen (trafikplanerare), Transport and bicycle plan, 08.05.2014.

[3] Interview with City of Tartu, Department of Urban Planning, Land Survey and Use, city planner, planning documents and comprehensive planning, 05.06.2014.

of public transport and walking, the latter involves a high share of car use, especially for work-related journeys. A strong driver for this development is a continuous increase in the number of registered cars in Tartu towards European levels of car ownership (Eurostat, 2014; Tartu City Government, 2011).

5.2. Potential of and Constraints on Urban Planning—Factors of Success

The outlined challenges of regional commuting and urban sprawl require coordinated cross-municipal efforts at the regional level. The Estonian planning system delegates the main responsibility for planning to the 215 municipalities. In the case of Tartu, this implies that the municipality's planning competences are limited to the core city area and do not cover the urban region. This is also reflected in the city's planning documents such as the Master Plan and the Transport Development Plan as they are limited to the municipal boundaries. Similarly, demands for regional positioning and integrated planning within the functional urban area as mentioned in, e.g. the Development Strategy "Tartu 2030" (Tartu City Government, 2006) can be hardly addressed.

However, planning at the regional level (county) is rather weak in Estonia (Roose, Kull, Gauk, & Tali, 2013). Addressing problems that exceed the city scale requires voluntary cooperation between municipalities to, e.g. connect the surrounding settlements by a bus service. But as the municipalities' interests reasonably exceed their municipal borders and may be in conflict, such as the assignment of residential areas in the urban fringe, suburban areas develop dispersed and contradicting.

Regulating urban sprawl requires coordinated action by Tartu and its surrounding municipalities as, both, city planning documents assign new residential areas on the outskirts of the city (City of Tartu, 2006); and zoning for suburban housing in the five surrounding municipalities of Tartu significantly exceeds real demand (Gauk & Roose, 2011). Roose et al. (2013) consider the local governments' lack of experience in land use planning as one reason for urban sprawl.

A planned reform to merge local governments (municipalities) to form geographically and demographically logical entities with a minimum of 5,000 inhabitants may be an opportunity to improve regional and cross-border coordination. The reform, which is supposed to be implemented in 2017, also emphasises the need for cooperation at the county level. Furthermore, a new county plan, the intention of which is to apply a more comprehensive perspective, is currently being developed and is supposed to be approved in late 2016 or early 2017.[4]

A further constraint on municipal energy planning in Estonia concerns a different national commitment to energy efficiency or sustainability than for example in Sweden. In Estonia, energy production is responsible for the highest share of emissions. Estonia is highly dependent on oil and gas imports and more than 90% of its electricity production is based on oil shale (Rudi, 2010). In order to achieve the GHG-reduction target for 2020, the main challenge for Estonia lies in reducing this high share of oil shale, which is responsible for almost 70% of GHG emissions from the energy sector (Roos, Soosaar, Volkova, & Streimikene, 2012). At the same time, local oil shale and peat resources are considered an important replacement for imported resources. Thus, although regional energy production and increasing the share of renewable and local fuels are generally considered relevant measures, national efforts to achieve greater energy efficiency are driven by an ambition to decrease fuel dependency (e.g. Russian gas) and secure energy supply rather than sustainability objectives (Ministry of the Interior, 2013).[5]

6. Energy and Planning in Turku

Turku is the centre of the region of Southwest Finland with a population of about 180,000 inhabitants (2014) in the municipality and 316,000 inhabitants in the urban region. The city is situated on the southwest coast of Finland about 150 km west of Helsinki. It is an important university city with about 40,000 resident students.

Since industrialisation, Turku has also been an important industrial centre. Today, after considerable restructuring of the industrial sector, 79% of the jobs in the city are in the service sector. However, the region still has a significant industrial sector (Hanell & Neubauer, 2005). Approximately a third of the 150,000 jobs in Turku's urban region are located in the centre of the city.

6.1. Urban Form and Transport

The traditional low-density settlement structure in Finland represents a key challenge. Like Estonia, urban settlements are dispersed and long commuting distances are usual.

Turku has experienced extensive urban growth since the 1950s. While the municipality of Turku has been stagnating since the 1970s, the city region has continued to grow resulting in a large urban area with a dispersed settlement structure on the fringe. In recent decades, sustainable urban development has been actively promoted and the city region has densified, albeit with several growth centres at the regional scale

[4] Interview with City of Tartu, Department of Urban Planning, Land Survey and Use, city planner, planning documents and comprehensive planning, 05.06.2014; see also haldusreform.wordpress.com, accessed 15.01.2016.

[5] Interview with Fortum Tartu, Management board and development management, 06.06.2014.

(Vasanen, 2009). Thus, like many other Finnish cities, Turku is urbanising, but is experiencing urban sprawl at the same time, which is inducing regional and car-dependent commuting to as far as Helsinki. This urbanisation trend needs to be taken as a chance towards more energy-efficient urban structures.

According to a study of 240 European cities, Turku is in the group of cities which "are characterised by a higher number of patches, a lower compactness index of the largest patch and a higher area of discontinuous urban fabric" (Schwarz, 2010, p. 41). This kind of urban structure generally implies a greater need for transportation (Clark, 2013; Næss, 2006) and, therefore, increased energy use for transportation.

The case of Turku exemplifies the importance of a regional dimension in terms of urban structure[6], which is at odds with a focus on the local level, particularly in Finland with its comprehensive local self-government and participatory planning (Hentilä & Soudunsaari, 2008). Regional coordination is, therefore, dependent on voluntary collaboration between municipalities. An example of regional coordination for urban development is the "Regional structural model 2035" (City of Turku, 2012), which was set up by Turku and 13 neighbouring municipalities as a common land-use strategy. The Structural model 2035 aims to establish common objectives for all significant land-use activities and focuses on more compact urban development along public transport corridors.

The 'Regional development and commuting structure' map ('*Yössäkäyntialueen aluerakenne ja seudullinen kehity*') depicts different centres (see Figure 3), proposing—despite the strong urban core—a polycentric structure. Densification takes place at the regional scale with several growth centres. The challenge for Turku is to connect growth policies, such as attraction of population and industries, with energy efficiency policies.

6.2. Potential of and Constraints on Urban Planning—Factors of Success

Finland has a fragmented municipal structure, especially in urban areas, and extensive municipal self-government competencies. In the beginning of the 1990s, Finland experienced a deep economic recession, which became a turning point in Finnish planning. Municipalities started to review their relationship with the private sector and their administration and organisation methods in favour of incremental, project-based planning. This turned local land-use planning into a reactive

[6] Interview with City of Turku, Climate, Environmental Policy and Sustainable Development, City Development Group, City Administration, 24.03.2014.

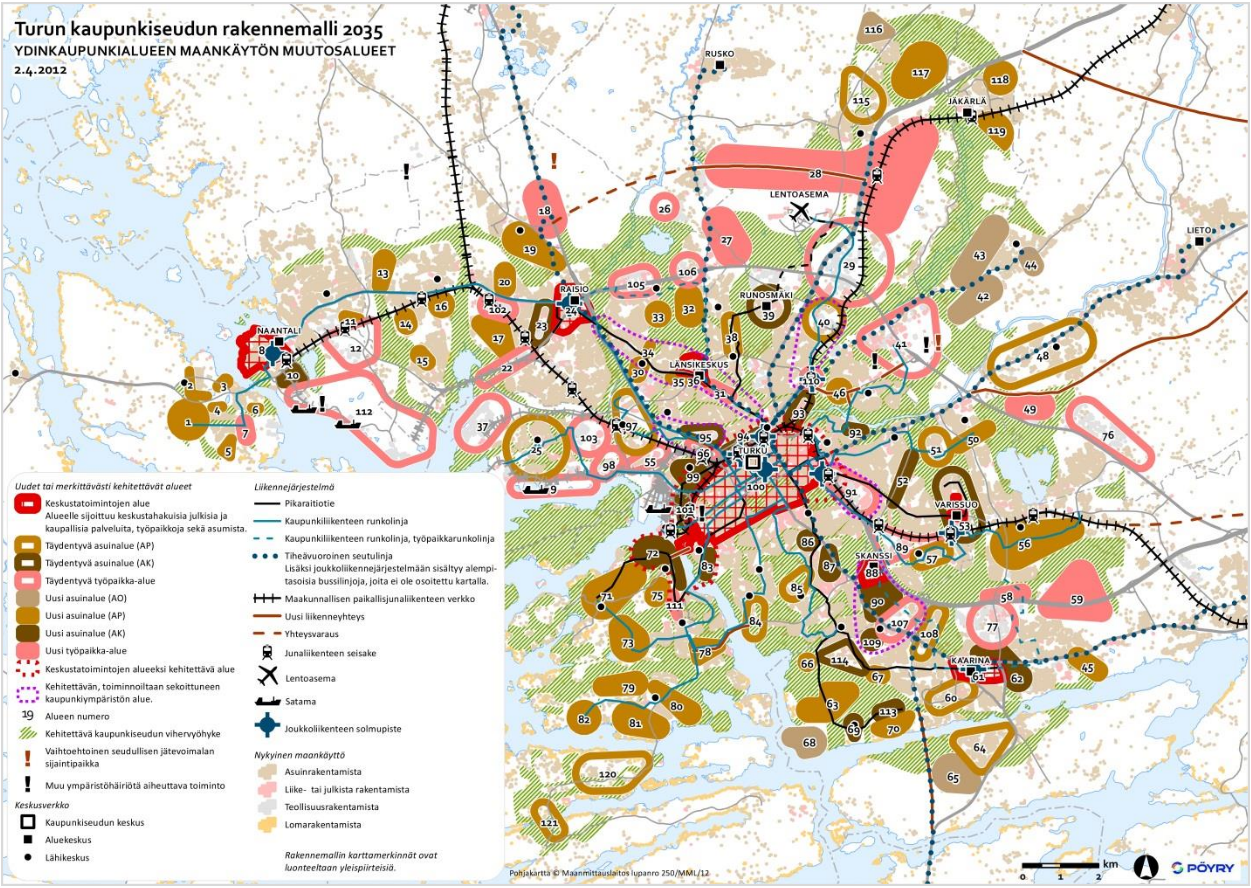

Figure 3. Regional structural model 2035. Source: City of Turku, 2012.

instrument to primarily provide the "judicial legitimation for development decisions made elsewhere" (Mäntysalo, 1999, p. 179).

The Regional structural model 2035 shows that even though the city of Turku aims to limit urban sprawl and focus on developing the central areas (the aim is 80% of the growth within the core), the fragmented municipal structure around Turku represents a major constraint because the surrounding municipalities simply have other interests than pursuing this strategy of densification. Furthermore, for practitioners, energy is, in general, of less interest compared to other planning-related topics.[7] This is also obvious in Turku's "Resource wisdom roadmap", the follow-up programme to the "Climate and Environment Programme 2009–2013" (City of Turku, 2009), which explicitly focuses on economic growth, but intends to combine this with the climate and environmental goals under the headline of 'green growth'.

7. Discussion: Urban Planning towards Energy Efficiency—Addressing Three Dimensions

The literature provides evidence that specific characteristics of urban form promote energy efficiency, but this does not constitute savings or generate specific energy consumption patterns. Increasing energy efficiency requires complementing urban form by accompanying policies, such as organisation of the transport system, which is also illustrated by the case studies.

The cases illustrate the options for and limitations to urban development regarding increasing energy efficiency. In all three cases, a major challenge is to address regional, especially car-dependent commuting, which is a consequence of urban sprawl and regional enlargement, in order to connect with more distant labour markets; also, to prevent further sprawl and stimulate compact and concentrated development of the urban core. An essential similarity and framing condition for the role of urban planning in all three cities is that the main spatial planning competences are allocated to the municipal level, whereas the regional level is rather weak. However, the territorial scope—municipal area compared to respective urban region—differs considerably.

Consequently, in all three cases the urban planning strategy is to focus rather on complementing and optimising the given urban structure by considering those functional relations as well as the policy context than substantially altering urban form, which is not only a difficult but also a long-lasting procedure.

Therefore, based on the knowledge from the scientific literature and the findings from the case studies, we can position urban planning as acting with and within the interrelated dimensions of urban form/spatial structure, functional relations and policy context (see Figure 4). *Functional relations* includes all kinds of urban flows and interactions between the physical urban areas such as the transportation and energy system as well as a city's position in the regional urban system. The *policy context* includes the relevant organising principles such as the planning system, the local power relations and national and local energy policy.

[7] Interview with City of Turku, Climate, Environmental Policy and Sustainable Development, City Development Group, City Administration, 24.03.2014; Interview with City of Turku, Urban Planning/Environmental Division, Traffic & Transportation office, 25.03.2014.

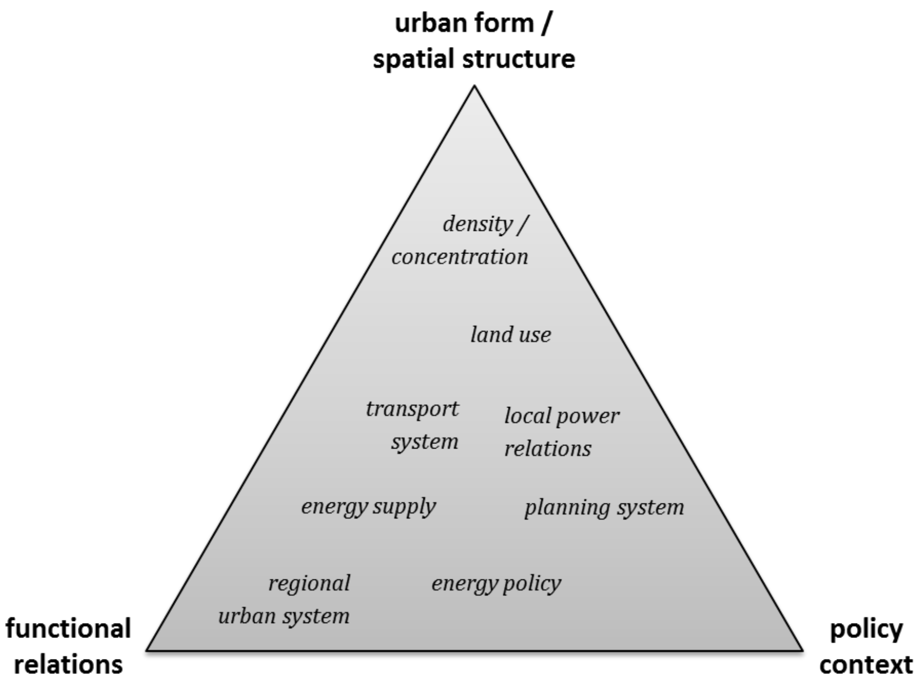

Figure 4. Urban form/spatial structure, functional relations and policy context as interrelated dimensions.

Energy and climate planning is characterised by the interplay of these dimensions; they determine the potentials of and constraints on urban planning and comprise fields of action of urban energy planning.

7.1. Urban Form and Policy Context

All three case studies illustrate how a municipality's scope of action is determined by the policy context:

- through the allocation of planning competences to the national, regional and local level;
- the territorial scope of a municipality, as defined by the municipal boundaries or
- the policy arena in which energy and climate policy is carried out (e.g. coverage of a municipal concern as in Eskilstuna).

The differences between the three cases regarding their municipal area in relation to their actual urban area exemplify the interrelation between urban form and policy context. Eskilstuna municipality comprises its urban region and municipal planning can address urban form in relation to the core urban area and the surrounding regional urban system. Turku and Tartu municipality, however, hardly comprise their urban area. Moreover, municipal planning is bound to the municipal concern. Eskilstuna exemplifies how these boundaries can be purposively adopted in plans of the municipal concern and strategies that are carried out with stakeholders in the entire municipality but outside the municipal concern.

However, strong planning competencies at the local level combined with an urban area that stretches beyond the administrative boundaries, as in Tartu and Turku, constrain municipal planning and imply challenges for coordination at the regional level. Development tasks that exceed municipal borders have to be addressed on a voluntary basis by municipalities.

Consequently, the options for and constraints on urban energy planning are further framed by local power relations—the interplay between municipal planning competences, the involvement of stakeholders as well as coordination between neighbouring municipalities and regional planning bodies. Although these relations are not discussed in-depth in the case studies, their importance is obvious as exemplified by Eskilstuna municipality acting as a stakeholder of energy initiatives that relies upon partnerships, as well as by voluntary regional cooperation as a necessary strategy in Turku and Tartu.

7.2. Urban Form and Functional Relations

The way people travel is not sufficiently explained by the characteristics of urban form. This is confirmed by the case studies, which show that travel patterns are strongly influenced by the position of a city in the regional urban system and the distribution of labour markets. Eskilstuna, for instance, is a small and compact city, which facilitates environmentally friendly transport modes such as public busses or cycling; but the functional relations—regional commuting to Stockholm—go far beyond its urban area. Obviously, functional relations do not necessarily correspond to spatial structure; the high and increasing mobility levels have initiated an ongoing detachment of mobility from the city boundaries (Breheny, 1995). In all three cases, problems of regional and long-distance commuting confirm that energy efficient urban development is not just about 'urban containment,' but is increasingly related to the wider regional urban system. However, the outlined challenges are particularly at odds with the scope of energy policies in Tartu and Turku, which is framed by extensive municipal self-government in combination with restrictive administrative boundaries.

7.3. Functional Relations and Policy Context

Constraints on addressing energy efficiency in urban development may also originate in contradictory leading principles in national or local policies as well as the need to react to trends in the outside world.

The case of Tartu illustrates that the level of commitment to sustainability or the driver behind energy efficiency (e.g. decrease fuel dependency) in national or urban policies determines both the content and the total effect of established objectives and measures—either energy efficiency is a subordinate or a leading principle. Also Jørgensen and Ærø (2007) attest the state a still strong role in urban policy ('national urban policy'). Solving urban problems at the local level requires backing from the state, but the state requires strong stakeholders at the local level in order to conceive and implement its urban policy (Uitermark, 2005).

In the case of Eskilstuna, the problem is not a lack of commitment to sustainability, but a twofold strategy in urban policies, following first-order economically driven policies and downgrading energy efficiency as a second-order policy. This strategy is partly a reaction to trends from the outside world, but this order of priority is also taken for granted and its negative effects are compensated by second-order 'sustainability' policies. Moreover, regional transport planning as compensation policy depends on the National Traffic Authority in Sweden, which constrains efficiency policies even more.

Both cases provide examples of policy trade-offs that originate from goal conflicts, either due to subordinate commitment to energy efficiency or ambiguities in the development strategy. The cases also reveal common discrepancies between functional relations and policy context.

The outlined interrelations between the dimensions of urban form/spatial structure, functional relations and policy context disclose potential areas where to put complementing policies, e.g. organisation of the transport system, purposefully in place to complement urban structure.

8. Conclusion

The aim of this paper is to examine the role cities can play in increasing energy efficiency. The relationship between urban structure and energy use provides a suitable framework for discussing the potential of and constraints on urban planning to increase energy efficiency.

Research provides evidence that compact urban structures and concentrated development facilitate efficient energy use. However, urban structure must not only be viewed from an urban form perspective, but should include considerations of functional relations and the policy context. Thus, urban planning has to act with and within these dimensions.

For example, mobility is a phenomenon that is not sufficiently explained by urban form, but underlies further conditions. Transport patterns are interwoven with land-use, distribution of functions and the positioning of a city in the regional urban system. In terms of sustainable transport, cities encounter their limitations at their borders. Municipal transport planning addresses inner city transport. Increasing (energy intensive) mobility beyond municipal boundaries emphasises, however, the relevance of regional transport planning.

The case studies illustrate that cities have a lot of potential with regards to addressing climate change; but there are quite different possibilities for action, including voluntary cooperation, improved institutionalised regional plans, or even ‘soft’ regional strategies on climate and energy, which may be important as a benchmarking instrument. Moreover, creative use of available tools and instruments as well as providing space for innovative initiatives implies significant potential, but requires concerted interplay between these efforts by engaging the relevant actors and steering by the municipality.

Urban planning can play an influential role, but a major crux lies in acknowledging, enabling and promoting innovations as well as necessary partnerships and cooperation involving stakeholders, local and regional authorities and private actors for long-term strategic policy making and implementation. Besides a (planning) system backing up such strategies, political commitment to sustainable energy development and entrepreneurial spirit of the relevant stakeholders play a crucial role; something the three investigated cities, despite challenges due to the administrative structure, seem to be good examples of.

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Conflicts of interests

The authors declare that there is no conflict of interest.

References

Anderson, W. P., Kanaroglou, P. S., & Miller, E. J. (1996). Urban form, energy and the environment: A review of issues, evidence and policy. *Urban Studies*, *33*(1), 7-35.

Brandoni, C., & Polonara, F. (2012). The role of municipal energy planning in the regional energy-planning process. *Energy*, *48*(1), 323-338.

Breheny, M. (1995). The compact city and transport energy consumption. *Transactions of the Institute of British Geographers*, *20*(1), 81-101.

Bulkeley, H., & Betsill, M. (2005). Rethinking sustainable cities: Multilevel governance and the ‘urban’ politics of climate change. *Environmental Politics*, *14*(1), 42-63.

Bulkeley, H., & Castán Broto, V. (2013). Government by experiment? Global cities and the governing of climate change. *Transactions of the Institute of British Geographers*, *38*(3), 361-375.

City of Turku. (2009). *City of Turku’s Climate and Environment Programme 2009–2013*. Turku, Finland: City of Turku.

City of Turku. (2012). *Turku Master Plan 2035* [Turun kaupunkiseudun rakennemalli 2035]. Turku, Finland: City of Turku.

City of Tartu. (2006). *Master plan of Tartu* [Tartu linna üldplaneering]. Tartu, Estonia: City of Tartu.

City of Tartu. (2015). *Action plan for sustainable energy management 2015–2020 for the city of Tartu* (draft). Tartu, Estonia: City of Tartu.

Clark, T. A. (2013). Metropolitan density, energy efficiency and carbon emissions: Multi-attribute tradeoffs and their policy implications. *Energy Policy*, *53*, 413-428.

COMMIN Project Co-ordination, Academy for Spatial Research and Planning. (2015). COMMIN: The Baltic Sea Conceptshare, BSR INTERREG III B project ‘Promoting spatial development by creating COMon MINdscapes’. Retrieved from http://www.commin.org

Covenant of Mayors. (2015). Benchmark of excellence. *Covenant of Mayors*. Retrieved from www.covenantofmayors.eu/actions/benchmarks-of-excellence_en.html

ESPON. (2007). *ESPON project 2.3.2. Governance of terri-*

torial and urban policies from EU to local level. Final report. Luxembourg. Retrieved from http://www.espon.eu/export/sites/default/Documents/Projects/ESPON2006Projects/PolicyImpactProjects/Governance/fr-2.3.2_final_feb2007.pdf

European Commission. (1997). *The EU compendium of spatial planning systems and policies*. Luxemburg: European Commission.

Eurostat. (2014). Cities (Urban audit). *Eurostat.* Retrieved from http://ec.europa.eu/eurostat/web/cities

Eurostat. (2016). Eurostat database. *Eurostat.* Retrieved from http://ec.europa.eu/eurostat/data/database

European Environment Agency. (2015, August). CORINE land cover version 18. *European Environment Agency*. Retrieved from http://land.copernicus.eu

Fertner, C., & Große, J. (in press). Compact and resource efficient cities? Synergies and trade-offs in European cities. *European Spatial Research and Policy*, *23*(1).

Fertner, C., Christensen, E. M., Große, J., & Hietaranta, J. (2015). *Urban energy planning in Turku* (*PLEEC Report D4.2/Turku*). Copenhagen: EU-FP7 project PLEEC.

Gauk, M., & Roose, A. (2011). Urban energy consumption patterns in Estonia—a mandate of master plans. *Proceeding of the the life cycle management (LCM) conference: Towards life cycle sustainability management*. Berlin: Technische Universität Berlin.

Geerlings, H., & Stead, D. (2003). The integration of land use planning, transport and environment in European policy and research. *Transport Policy*, *10*(3), 187-196.

Giffinger, R., Hemis, H., Weninger, K., & Haindlmaier, G. (2014). *Energy efficiency indicators WP2. Part of deliverable 2.3 'Energy smart city profiles' and deliverable 2.4. 'methodology for monitoring'*. Wien, Austria: EU-FP7 project PLEEC*.*

Girardet, H. (2015). *Creating regenerative cities* (1st ed.). Abingdon, UK: Routledge.

Große, J., Groth, N. B., Fertner, C., Tamm, J., & Alev, K. (2015). *Urban energy planning in Tartu* (Deliverable 4.2/Tartu). Copenhagen, *Denmark*: EU-FP7 project PLEEC.

Groth, N. B., Große, J., & Fertner, C. (2014). *Urban energy planning in Eskilstuna* (Deliverable 4.2/Eskilstuna). Copenhagen, *Denmark*: EU-FP7 project PLEEC.

Grunfelder, J., Nielsen, T. A. S., & Groth, N. B. (2015). Changes to urban form and commuting patterns: trends in two Danish city regions. *Geografisk Tidsskrift-Danish Journal of Geography*, *115*(2), 73-87.

Hanell, T., & Neubauer, J. (2005). *Cities of the Baltic Sea region—Development trends at the turn of the millennium*. Stockholm, Sweden: Nordregio.

Hentilä, H. L., & Soudunsaari, L. (2008). *Land use planning systems and practices Oulu–Skanderborg–Umeå*. Oulu*, Finland:* University of Oulu*.*

Holden, E., & Norland, I. T. (2005). Three challenges for the compact city as a sustainable urban form: Household consumption of energy and transport in eight residential areas in the greater Oslo region. *Urban Studies*, *42*(12), 2145-2166.

Jørgensen, G., & Ærø, T. (2007). Urban policy in the Nordic countries—National foci and strategies for implementation. *European Planning Studies*, *16*(1), 23-41.

Kullman, M., Campillo, J., Dahlquist, E., Fertner, C., Giffinger, R., Große, J., Groth, N. B., Haindlmaier, G., Kunnasvirta, A., Strohmayer, F., & Haselberger, J. (2016). Note: The PLEEC project—Planning for energy efficient cities. *Journal of Settlements and Spatial Planning*, *5*, 89-92.

Kunzmann, K. R. (2003). Creative planning in city-regions. The European city between globalisation, local identity and regional governance. In Ministry of the Environment, Spatial Planning Department (Ed.), *European cities in a global era. Urban identities and regional development: Messages and conclusions* (pp. 44-55). Copenhagen, Denmark: EU2002.

Lundqvist, L. J. (2015). Planning for climate change adaptation in a multi-level context: The Gothenburg metropolitan area. *European Planning Studies*, *24*(1), 1-20.

Mäntysalo, R. (1999). Learning from the UK: Towards market-oriented land-use planning in Finland. *Housing, Theory and Society*, *16*(4), 179-191.

Marsden, G., & Rye, T. (2010). The governance of transport and climate change. *Journal of Transport Geography*, *18*(6), 669-678.

MiljöAktuellt. (2015). *Miljöaktuellts municipality ranking 2015*. MiljöAktuellt Retrieved from http://miljoaktuellt.se/kommunrankingen

Ministry of the Interior. (2013). *National Spatial Plan Estonia 2030+.* Tallinn, Estonia: Ministry of the Interior.

Municipality of Eskilstuna. (2012). Transport Plan for Eskilstuna Municipality. Strategy. Adoption proposal.

Municipality of Eskilstuna. (2013a). Climate Plan for Eskilstuna.

Municipality of Eskilstuna. (2013b). Comprehensive Plan 2030. Adopted by the City Council 2013-08-29.

Næss, P. (2006). *Urban structure matters, residential location, car dependence and travel behaviour* (1st ed.). London and New York: Routledge.

Næss, P. (2012). Urban form and travel behaviour: Experience from a Nordic context. *Journal of Transport and Land Use*, *5*(2), 21-45.

Næss, P., & Jensen, O. B. (2004). Urban structure matters, even in a small town. *Journal of Environmental Planning and Management*, *47*(1), 35-57.

Næss, P., Sandberg, S. L., & Røe, P. G. (1996). Energy use for transportation in 22 Nordic towns. *Scandinavian Housing and Planning Research*, *13*(2), 79-97.

Neergaard, H. (2007). Sampling in entrepreneurial settings. In H. Neergaard & J. P. Ulhøi (Eds.), *Handbook of qualitative research methods in entrepreneurship*

(pp. 253-278). Cheltenham, UK: Edward Elgar.
Newman, P. W. G., & Kenworthy, J. R. (1988). The transport energy trade-off: Fuel-efficient traffic versus fuel-efficient cities. *Transportation Research Part A - Policy and Practice*, *22*(3), 163-174.
Owens, S. E. (1986). *Energy, planning and urban form*. London: Pion Ltd.
Rickaby, P., & Steadman, P. (1991). Patterns of land use in English towns: implications for energy use and carbon dioxide emission. In *Regional science association British section, twenty-second annual conference*. Oxford, UK: Mansfield College.
Roos, I., Soosaar, S., Volkova, A., & Streimikene, D. (2012). Greenhouse gas emission reduction perspectives in the Baltic States in frames of EU energy and climate policy. *Renewable and Sustainable Energy Reviews*, *16*(4), 2133-2146.
Roose, A., Kull, A., Gauk, M., & Tali, T. (2013). Land use policy shocks in the post-communist urban fringe: A case study of Estonia. *Land Use Policy*, *30*(1), 76-83.
Rudi, U. (2010). The future of power generation in Estonia. *International Journal of Global Energy Issues*, *34*(1), 68-77.
Schwarz, N. (2010). Urban form revisited—Selecting indicators for characterising European cities. *Landscape and Urban Planning*, *96*(1), 29-47.
Smas, L., & Fredricsson, C. (2015). Changes and inherent tensions in the Nordic planning systems. *Nordregio*. Retrieved from http://www.nordregio.se/en/Metameny/Nordregio-News/2015/Tensions-in-Nordic-urban-planning/Changes-and-inherent-tensions-in-the-Nordic-planning-systems
Stead, D., & Marshall, S. (2001). The relationships between urban form and travel patterns. An international review and evaluation. *European Journal of Transport and Infrastructure Research*, *1*(2), 113-141.
Stead, D., Williams, J., & Titheridge, H. (2004). Land use, transport and people: Identifying the connections. In K. Williams, E. Burton & M. Jenks (Eds.), *Achieving sustainable urban form* (pp. 174-186). London and New York: E. & F. N. Spon.
Swedish Environmental Protection Agency. (2013). *Sweden's environmental objectives. An introduction*. Swedish Environmental Protection Agency. Retrieved from http://www.swedishepa.se/About-us/Publikationer/ISBN/8600/978-91-620-8620-6
Tartu City Government. (2006). *Development strategy Tartu 2030*. Tartu, Estonia: Tartu City Government.
Tartu City Government. (2011, November 14). *Tartu city transport development plan 2012–2020*. Tartu, Estonia: Tartu City Government.
Uitermark, J. (2005). The genesis and evolution of urban policy: a confrontation of regulationist and governmentality approaches. *Political Geography*, *24*(2), 137-163.
van Stigt, R., Driessen, P. P. J., & Spit, T. J. M. (2013). Compact city development and the challenge of environmental policy integration: A multi-level governance perspective. *Environmental Policy and Governance*, *23*(4), 221-233.
Vasanen, A. (2009). Deconcentration versus spatial clustering: changing population distribution in the Turku urban region, 1980–2005. *Fennia*, *187*(2), 115-127.
Williams, K. (1999). Urban intensification policies in England: problems and contradictions. *Land Use Policy*, *16*(3), 167-178.
Yin, R. K. (2014). *Case study research, design and methods* (5th ed.). Los Angeles, USA: SAGE.

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Appendix I. Reviewed planning documents.

Eskilstuna
Eskilstuna kommun, 2005, Översiktsplan and Fördjupad Översiktsplan för Mälarstranden 2005 (comprehensive plan)
Eskilstuna kommun, 2013, Översiktsplan 2030. Antagen av kommunfullmäktige 2013-08-29 (comprehensive plan, application draft)
Eskilstuna kommun, 2012, Trafikplan för Eskilstuna Kommun. Strategidel. Antagende Förslag (transport plan, application draft)
Eskilstuna kommun, 2013, Klimatplan för Eskilstuna (climate plan)
Länsstyrelsen Södermanlands län, 2012, Klimat- och Energistrategi för Södermanlands Län. Länsstyrelsen Södermanlands län, Nyköping
Regeringskansliet, 2014, The Swedish Energy System

Tartu
City of Tartu, 1999, Master plan of Tartu 2012 (Tartu linna üldplaneering aastani 2012)
Tartu City Government, 2006, Development Strategy Tartu 2030
City of Tartu, 2006, Master plan of Tartu (Tartu linna üldplaneering)
Tartu City Government, 2011, Tartu City Transport Development Plan 2012-2020
City of Tartu, 2015, Action Plan for Sustainable Energy Management 2015-2020 for the City of Tartu (draft)
Ministry of the Environment, 2007, Estonian Environmental Strategy 2030
Ministry of the Interior, 2013, National Spatial Plan Estonia 2030+

Turku
City of Turku, 2009, Climate and Environment Programme 2009-2013
City of Turku, planned for 2015, Resource wisdom roadmap 2040
City of Turku, 2001, General Plan for Turku 2020
City of Turku, 2012, Master Plan for Turku 2035
City of Turku, planned for 2017, General Plan for Turku 2029
City of Turku, 2010, Transport Plan for Turku
City-region of Turku, 2012, Regional Structural Model 2035
Southwest Finland, 2014, Southwest Finland Regional Strategy 2035+ (Programme for 2014-17)
Southwest Finland, 2014, Southwest Finland Transport Strategy 2035+
Ministry of Employment and the Economy, 2014, Energy and Climate Roadmap 2050
Ministry of the Environment, 2009, The future of land use is being decided now - The Revised National Land Use Guidelines of Finland, retrieved from http://www.ym.fi/en-US/Latest_news/Publications

Appendix II. List of interviews.

Eskilstuna, 7/8th May 2014
Eskilstuna Municipality, Town Planning Department, Planavdelningen (översiktsplanerare), Comprehensive Plan, 1,5 h
Eskilstuna Municipality, Cultural Heritage, Culture and Leisure Department, Arkiv och muséer (arkivarie), history of Eskilstuna, 1 h
Eskilstuna Municipality, Municipal Board, Kommunledningskontoret (project manager), Climate Plan, 1 h
Eskilstuna Municipality, Town Planning Department, Planavdelningen/Trafikavdelningen (trafikplanerare), Transport and Bicycle Plan, new parking norms, 2,5 h
Eskilstuna Energi & Miljö AB, district heating, 1,5 h
Eskilstuna Energi & Miljö AB, water and sewage water, 1 h
WSP Environmental, building certification, Eskilstuna indoor swimming hall and arena, 1,5 h

Tartu, 5/6th June 2014
City of Tartu, Department of Urban Planning, Land Survey and Use, city engineer, energy and transport planning, 1,5 h
City of Tartu, Department of Urban Planning, Land Survey and Use, city planner, planning documents and comprehensive planning, 1 h
City of Tartu, Department of Municipal Property, 1 h
Fortum Tartu, Management board and development management, energy supply, 1,5 h

Turku, 24/25th March 2014
City of Turku, Climate, Environmental Policy and Sustainable Development, City Development Group, City Administration, Development Manager, general urban development, 1,5 h
City of Turku, Urban Planning/Environmental Division, City Planning Architect, urban planning and Skanssi project, 1,5 h
City of Turku, Urban Planning/Environmental Division, Traffic & Transportation office, transport planning, 1 h
Regional Council of Southwest Finland, Natural resource planner, regional planning and development, 1 h
Oy Turku Energia - Åbo Energi AB, Development manager, energy production and supply, district heating, electricity grid, 1 h