Urban energy planning in Turku
[PLEEC Report D4.2 / Turku]

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PLANNING FOR ENERGY EFFICIENT CITIES

Deliverable 4.2 / Turku

Urban energy planning in Turku

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SEVENTH FRAMEWORK PROGRAMME

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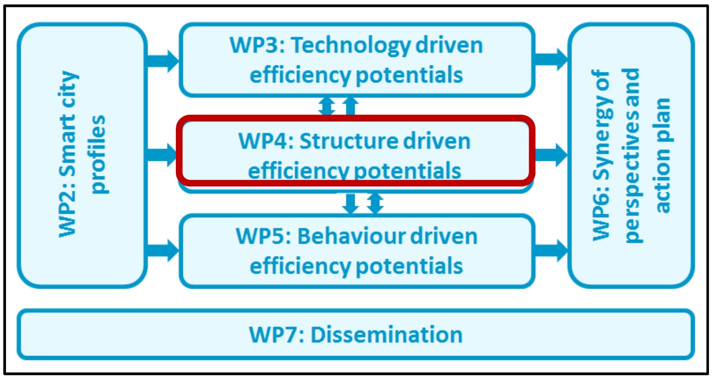
Abstract

Main aim of report

The purpose of Deliverable 4.2 is to give an overview of urban energy planning in the 6 PLEEC partner cities. The 6 reports illustrate how cities deal with different challenges of the urban energy transformation from a structural perspective including issues of urban governance and spatial planning. The 6 reports will provide input for the following cross-thematic report (D4.3).



WP4 location in PLEEC project

Target group

The main addressee is the WP4-team (universities and cities) who will work on the cross-thematic report (D4.3). The reports will also support a learning process between the cities. Further, they are relevant for a wider group of PLEEC partners to discuss the relationship between the three pillars (technology, structure, behaviour) in each of the cities.

Main findings/conclusions

Since industrialisation, Turku has been an important industrial town in Finland and still is. Today, after considerable restructuring of the industrial sector, most jobs (79 % in the city of Turku) are within services. Besides its economic base, Turku also is experiencing a change in the former prevailing urban sprawl, characterising urban development since the 1950s. The city is densifying and promoting sustainable urban development, though at a regional scale with several growth centres. Its future development is envisioned in the "Structure model 2035", focusing on more compact urban development along public transport corridors. From the case report three issues arise which might be of considerable interest in a broader context of the PLEEC project:

1. Working with energy efficient regional urban structure (e.g. regarding urban sprawl) in a low density country and on a voluntary cooperative basis
2. Keeping the industrial base in a city facing deindustrialisation and aiming for energy efficiency
3. Decentralisation of energy supply enables new forms of settlements with the example of Skanssi

Activities carried out including methodology used

All 6 reports are based on workshops (Stoke-on-Trent, Turku), field work (interviews with stakeholders) in the cities, the analysis of local reports as well as close contact with our city partners. This is more described in the methodology chapter.

The PLEEC project

Energy efficiency is high on the European agenda. One of the goals of the European Union's 20-20-20 plan is to improve energy efficiency by 20% in 2020. However, holistic knowledge about energy efficiency potentials in cities is far from complete. Currently, a variety of individual strategies and approaches by different stakeholders tackling separate key aspects hinders strategic energy efficiency planning.

For this reason, the PLEEC project – "Planning for Energy Efficient Cities" – funded by the EU Seventh Framework Programme uses an integrative approach to achieve the sustainable, energy–efficient, smart city. By coordinating strategies and combining best practices, PLEEC will develop a general model for energy efficiency and sustainable city planning. By connecting scientific excellence and innovative enterprises in the energy sector with ambitious and well-organized cities, the project aims to reduce energy use in Europe in the near future and will therefore be an important tool contributing to the EU's 20-20-20 targets.

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Table of Content

1 Introduction

This is one of six case-studies in the PLEEC project, the goal of which is to describe how cities deal with climate planning and strategies. In focus are relations between 'the urban' and energy and key climate measures. By 'urban', we mean the structure of the city, its density and the cohesion between the built environment and the infrastructure. Along with this, we examine relations between the city and other cities, i.e. the urban system in a regional context. Finally, we discuss urban issues concerned with managing a city's infrastructure, its energy systems and services.

Turku is one of the main urban centres of Finland with about 300,000 inhabitants in the urban region an important centre in Northern Europe. The population of Turku has more than doubled since the 1950s. We will give an overview of Turku's development in chapter 3.

2 Methods

The case-study was elaborated in three tiers. First, a template on content was discussed between the researchers at the backdrop of the first data collected about the six cities (see Fertner et al. 2014). Second, a field trip to Turku was planned for 24-25 March, combining study tour and interviews with key stakeholders (see Table 1). The dates were chosen in combination with the PLEEC general project meeting in Turku 26-28 March 2014.

Table 1: Interviews conducted in Turku 24-25th March 2014

Date/time	Topic	Host/Interviewees
24 March, 15:00	General urban development	Risto Veivo, Development Manager, Climate, Environment Policy and Sustainable Development, City Development Group, City Administration, City of Turku
25 March, 9:00	Urban planning, Skanssi Project	Oscu Uurasmaa, City Planning Architect, Skanssi Project, Urban Planning/ Environmental Division, City of Turku
25 March, 11:00	Energy production and supply, district heating, electricity grid	Antto Kulla, Development manager, Oy Turku Energia - Åbo Energi Ab + 2 colleagues (one from electric grid, one from district heating)
25 March, 13:00	Transport planning	Jaana Mäkinen and Juha Jokela, Traffic & Transportation office, Urban Planning / Environmental DivisionCity of Turku
25 March, 15:00	Regional planning and development	Aleksis Klap, Natural resource planner, Regional Council of Southwest Finland

Turku was the first case where interviews were conducted. We decided therefore to be a rather big team for the talks to have a joint experience how the questions and topics we have chosen would work with the interviews. The interviews were conducted by Christian Fertner, Juliane Große (both University of Copenhagen), Roberto Rocco (TU Delft) and Jari Hietaranta (Turku University of Applied Sciences). The interview guide can be found in Deliverable Report 4.1 (ibid).

Important written sources for this report were several scientific articles on energy and urban development in Turku and Finland as well as documents from the national level especially related to energy policies and documents from the regional and local level related to urban and transport planning and local energy supply.

Due to the complexity of urban affairs and the wide diversity of the six cities, the research was oriented more towards a phenomenological understanding than positive comparison on fixed parameters. At one of the Skype meetings between the Delft and Copenhagen teams, it was decided to delay the comparative study until the six case-study reports have shown what is possible and reasonable to compare.

3 Overview of Turku

Turku (Swedish: Åbo) is located at the south-western coast of Finland at the mouth of the Aura River (Aurajoki). Turku was settled and founded as a town in the 13th century and is therefore Finland's oldest city. From 1809-1819 it was also the first capital of Finland. Furthermore the first university of Finland was founded in Turku in 1640. Turku is Finland's historical centre for culture and education.

Figure 1: Southwest Finland and the location of Turku in Finland (Wikimedia Commons)

Today Turku is the capital of the region Southwest Finland (also known as *Finland Proper*; Finnish: Varsinais-Suomi, Swedish: Egentliga Finland) and has about 300.000 inhabitants in the urban region (11 municipalities), whereas most people, about 180.000, live in the municipality of Turku. The city is bilingual, with Swedish speakers accounting for approximately 5% of the population (Central Administration of the City of Turku 2013).

Turku is an important university town, due to the presence of different universities and universities of applied sciences, and has about 40,000 students living there. In 2011 Turku was the European Capital of Culture.

Table 2: Turku key parameters (Giffinger et al. 2014)

Key parameter	Count	Year
Inhabitants	180,225	2012
Households	97,346	2012
Household size	1,85	2012
Number of dwellings	108,151	2012
Inhabitants per dwelling	1.67	2012
Number of residential buildings	17,868	2012
Number of dwellings per residential building	6.05	2012
Administrative area in km²	245	2012
Settled area in km²	75	2012
GDP per capita in Euro	29,300	2012

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3.1 Population development

Although Turku has a long history back from the 13th century, population growth first accelerated during the 19th century in line with industrialisation. Until the Second World War most development still followed the compact urban development laid out by a grid plan in 1828 (see section 4.2). Since however, population has tripled, whereas most of the increase did not take place in the inner city or the municipality of Turku, but in the suburban municipalities (see Figure 2). The municipality of Turku is stagnating or only growing slowly in population numbers since the 1970s; the suburban municipalities have taken over most growth since then.

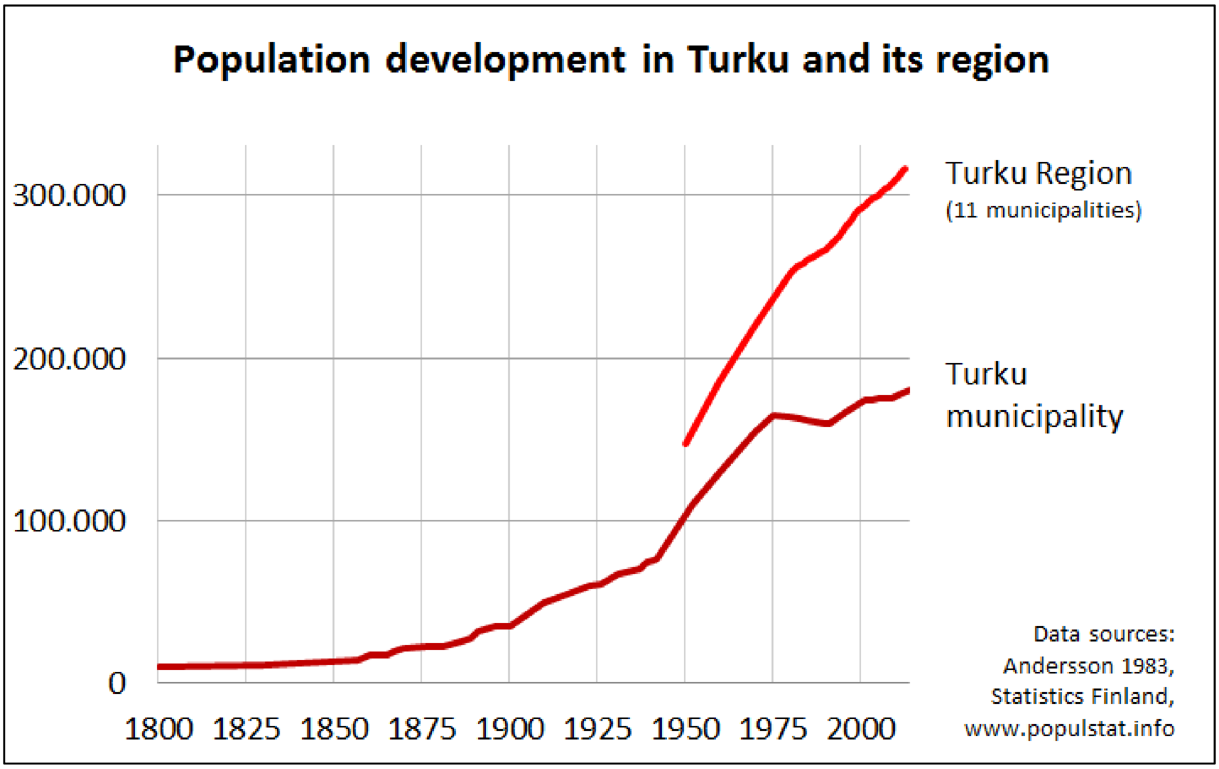

Figure 2: Population development in Turku and its region

3.2 Economy

Since industrialisation, Turku has been an important industrial town in Finland and still is. Although industry does not fill very much in total employment in the city itself (see Figure 4), the region, including the industrial town of Salo about 50 km east of Turku, still has a significantly higher proportion of jobs in industry than in Finland in average (Hanell and Neubauer 2005).

However, as many other places in Europe the industrial sector is in transformation or decay. This could be seen most lately in 2012 when Nokia closed its production plant in Salo. Part of it was taken over by Orion Oyi, a pharmaceutical company, establishing a logistic centre in Salo with about 100 employees. This is however considerably less than the 1,000 employees, which have worked at Nokia before (Virki 2012).

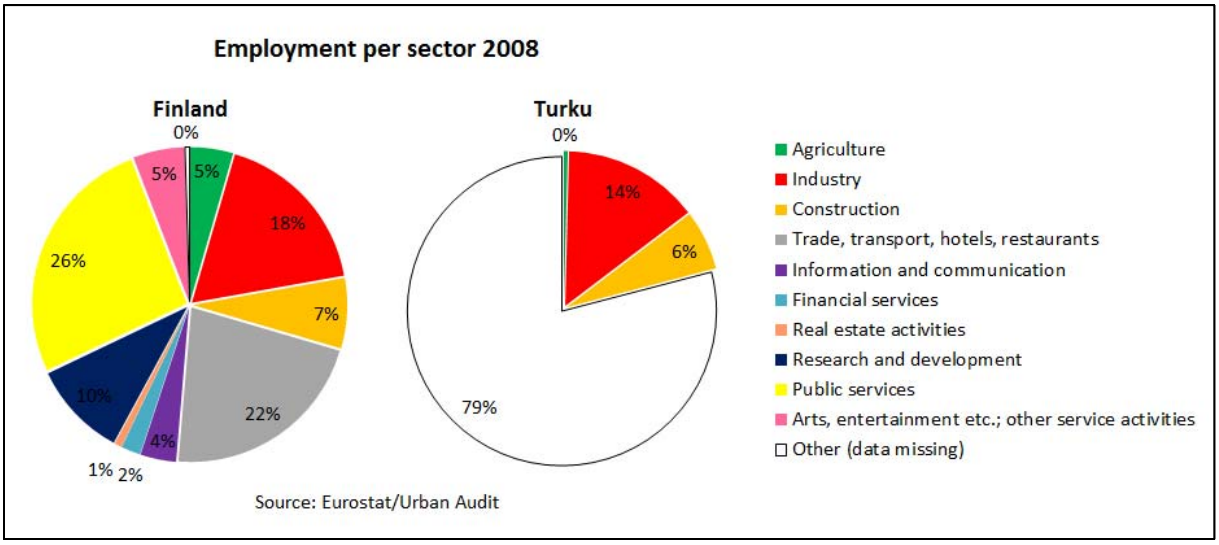

Figure 4: Employment per sector in Finland and the city of Turku, 2008 (Data: Eurostat/Urban Audit)

With its harbour the city of Turku has still industrial characteristics. Besides cruise ferries using it as base, also a Shipyard is located there. After several years of an unknown future for the shipyard, it was recently taken over by the German shipbuilder Meyer Werft, including a new order for cruise vessels, expecting to have a direct employment effect in the city of at least 12,000 man years (City of Turku 2014b).

Figure 5: Meyer Turku Shipyard (Photo: City of Turku)

Despite a significant industrial sector, most of the jobs are within services – alone in Turku 79 % of all jobs are in the third sector. The most important sectors providing employment in the region are commerce, industry, construction and health and social services. Significant employers in Turku include STX Finland, Bayer Schering Pharma and Wallac. The employment rate in the Turku region has been approximately 70% in recent years. (Central Administration of the City of Turku 2013)

Today, approximately one-third of the 150,000 jobs in Turku's urban region are located in the centre of Turku, while the rest are located elsewhere in the urban region (City of Turku 2012)

Figure 6: Kupittaa business district in Turku, by Koiranaama, (Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Kupittaa_business.jpg)

3.3 Regional setting

Turku is the main city in South-western Finland. Helsinki is 160 km to the East, about 2 hours by car. There is some commuting between the two cities, however, the distance and time limits the numbers. Figure 8 shows also that compared to Helsinki and Tampere, commuting distances are shorter and less in number around Turku. Despite the rather dispersed urban form of the city (see section below), it seems to perform well compared to its Finish neighbouring cities.

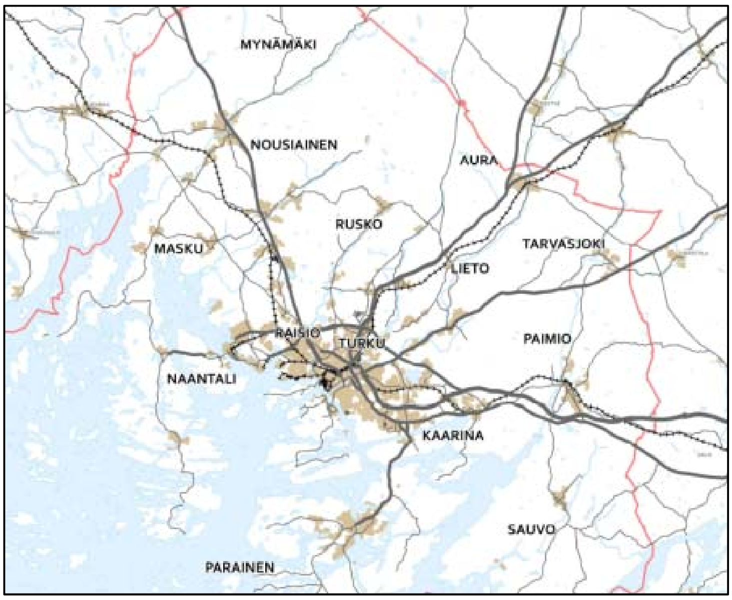

Figure 7: Turku region (RM35 2012)

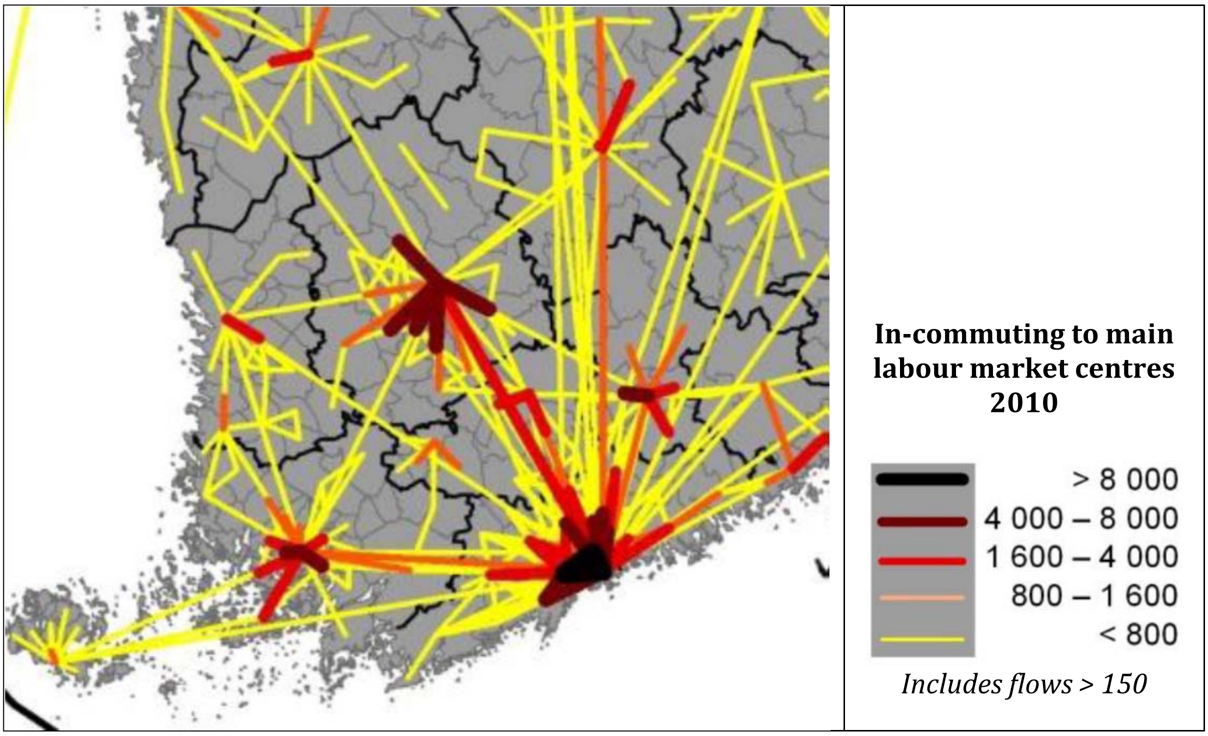

Figure 8: Commuting pattern in Southern Finland in 2010 (Roto 2012, p. 11) – Turku is the node on the Southwestern coast, Helsinki on the southeastern coast and the node to the north is Tampere, the second biggest city in Finland.

3.4 Current land use and urban form

The surface area of the municipality Turku is 306.37 km², of which 245.67 km² is land, 3.46 km² is inland water and 57.24 km² is sea water. The greatest distance (45 km) in Turku is in the north-south direction (City of Turku 2013). Due to its elongated shape, the core urban area is in the southern parts of the city. The core urban area of the City of Turku is the area between the airport and Hirvensalo (City of Turku 2012).

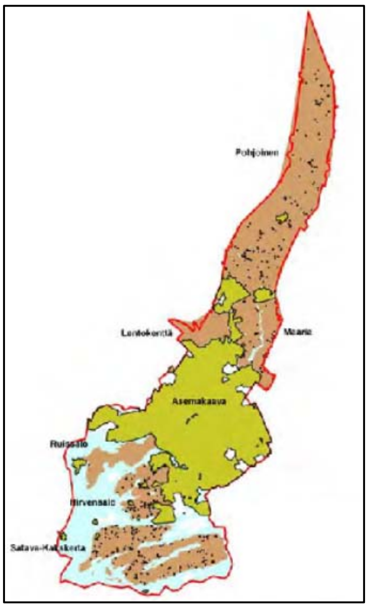

Figure 9: Location of housing in the City of Turku(City of Turku 2013)

The urban form is essentially influenced by Turku's neighbouring municipalities, of which Raisio and Kaarina in particular are an integral part of the urban structure of Turku. The political aim is to obtain a zone of city centre jobs, housing and services in this area. It is also intended to secure the same aim in the direction of Naantali (City of Turku 2013). Approximately 70% of the total population of the urban region live in Turku's core urban area (Naantali-Raiso-Turku-Kaarina zone) (City of Turku 2012).

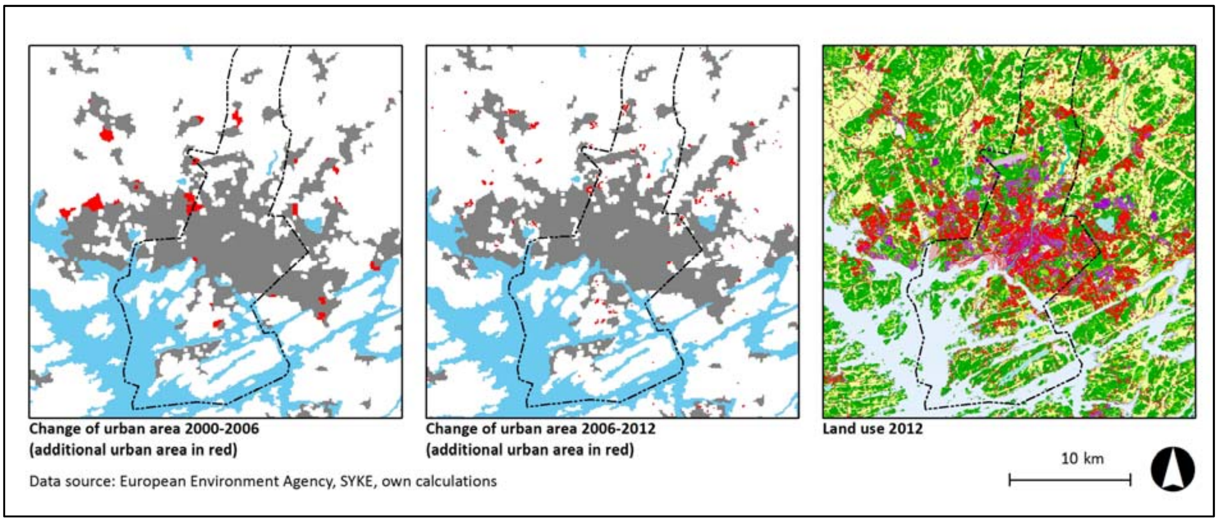

Figure 10: Urban land use change in Turku between 2000 and 2012. Transformation of open space to urban area seems to have slowed down between 2006 and 2012. The municipal boundary is indicated as dotted line. (Data source: EEA/SYKE)

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, 41). This kind of urban structure generally implies an increased need of transportation (Clark 2013;Næss 2006;Stead 2001) and therewith increased energy use for transportation.

4 Historical urban development

Andersson (1983) identified four Phases of urban development of the city of Turku which will be used to structure this chapter. A final section on the most recent development is added.

4.1 Pre-industrial city (1300-1827)

Turku was established around 1300 at a road crossing along the river Aura. The main roads and waterways determined the directions of growth. Urban growth was characterised by a continuous and dense urban structure, however, without a particular town plan.

In the 17th century the town was considerably expanded when the Crown granted fields to local merchants. These areas were sufficient for the town's building needs up to the 19th century.

First planning measures can be traced to the 17th century, mainly related to fencing the town and the protection of fire by the creation of broad streets. All planning from 1634-1721 followed a rigid grid pattern, paving the way for the grid-plan tradition in Finland at that time.

During the great fire of 1827 a large part of the city, mainly consisting of wooden houses, was destroyed. This tremendous destruction allowed however to rebuild the city by a general plan.

Figure 11: The great fire of 1827, painting by Gustaf Wilhelm Finnberg, via Wikimedia Commons, http://commons.wikimedia.org/wiki/File%3ATurun_palo_1827.jpg

4.2 1828 town plan – Engel's grid plan

Johann Carl Ludwig Engel was architect and general intendant for building and construction in Finland from 1824. He was involved in the planning and architecture of several other Finish cities as e.g. Helsinki and Jyväskylä (Junecke 1959). In 1828 he prepared a new town plan for Turku to rebuild the city after the Great Fire. Engel's plan followed a rigid grid system, which was partially already laid out in the 18th century. The area covers the urban core, as the city was still relatively small and compact.

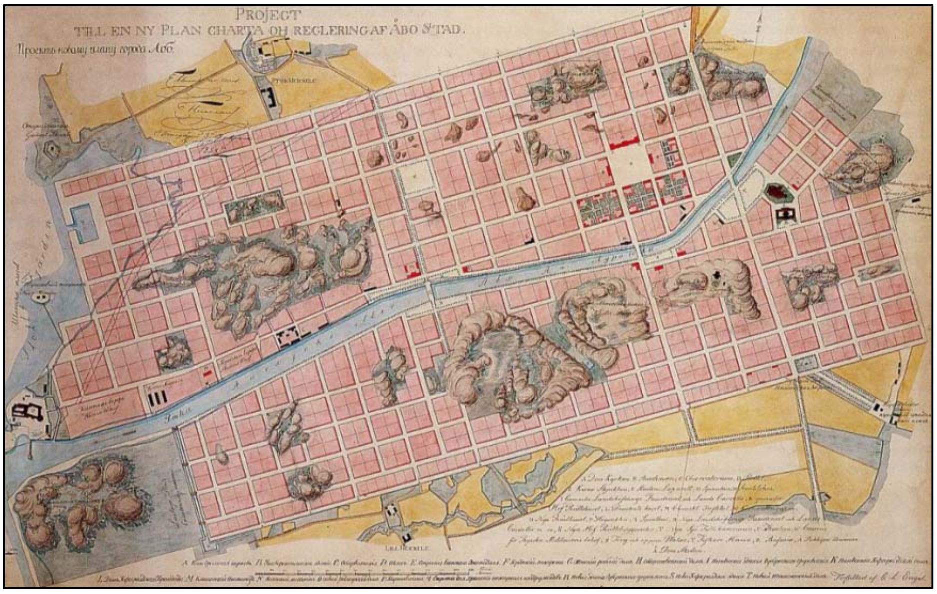

Figure 12: Engel's grid plan from 1828 (Hintsanen 2014)

4.3 Start of 1900: suburbs

With the establishment of horse- and later electric powered streetcars around 1900, the city started to grow into its suburbs. The first suburbs were adjacent to the grid city because of transport limitations. The General plan from 1920 (see Figure 14) shows the extension of the city to the Northwest.

Figure 13: "Turku Horse tram 1890" by Unknown via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Turku_Horse_tram_1890.jpg

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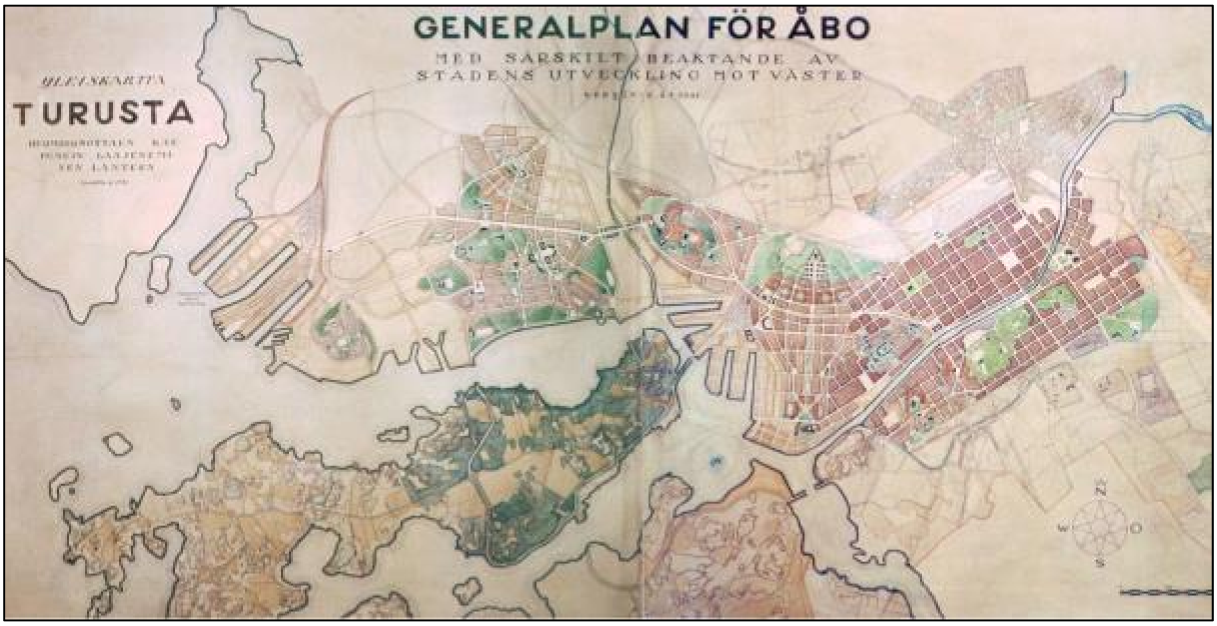

Figure 14: General plan 1920 – away from the grid (Salonen 2014)

4.4 Dispersion after WWII

Although considerable extension of the city took place in the first half of the 20th century, the extent of the city as we know it today mainly took place in the decades of rapid growth after 1950. In about 30 years the population of the city doubled to 160,000 and the region grew to 250,000. Figure 15 shows the expansion of the urban area in this time.

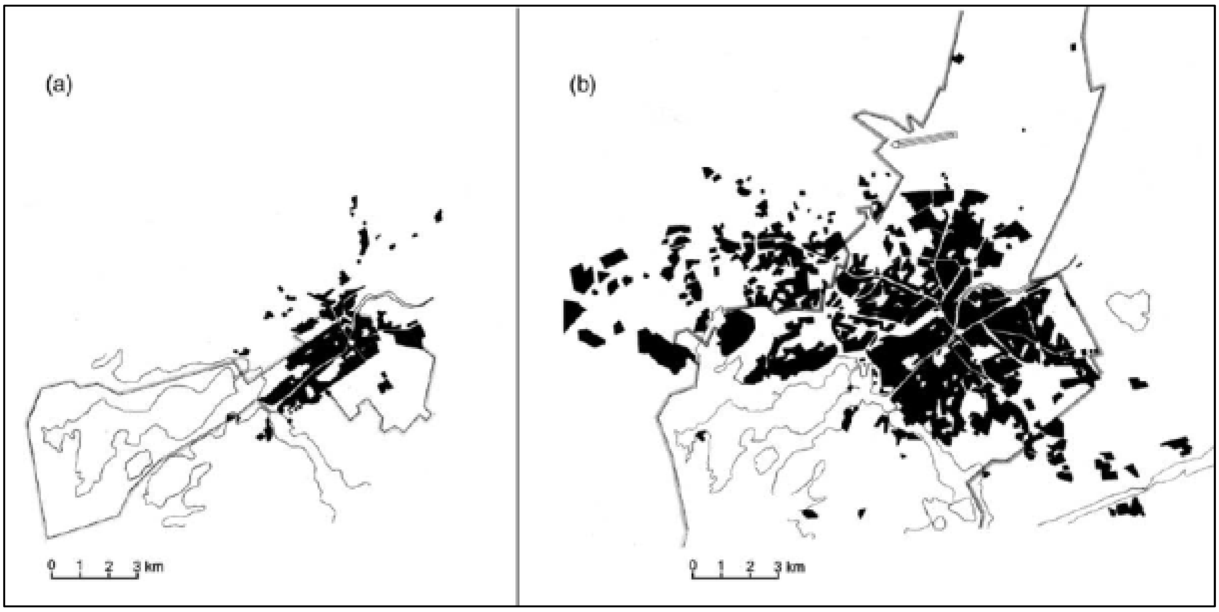

Figure 15: Expansion of Turku's settlement areas 1920 (a) – 1975 (b) (Andersson 1983)

Andersson (1983, p. 212) names four causes for this development:

- The post-war settlement activity
- The spread of the motor car
- The building of suburbs, which later grew into the mass construction of vast housing estates and
- Patterns of land ownership and the policy adopted by the city council regarding building land

Opposite to the development of the first suburbs, the new development areas were not necessarily adjacent to the existing urban area. Turku's tram network was abandoned in 1972, when the system was substituted by bus service. The historical tram service covered mainly the city centre. The new, dispersed located suburbs were car dependent or served by busses.

4.5 Recent development

The population of the Turku region has spread since the 1980s, but at the same time, it has concentrated in the region (Vasanen 2009). This means however often the fill-in and development of areas in the suburbs and some densification. The population however gets more evenly distributed in the urban area, which indicated the growing importance of sub-centres in the neighbouring municipalities, independent from the old city centre.

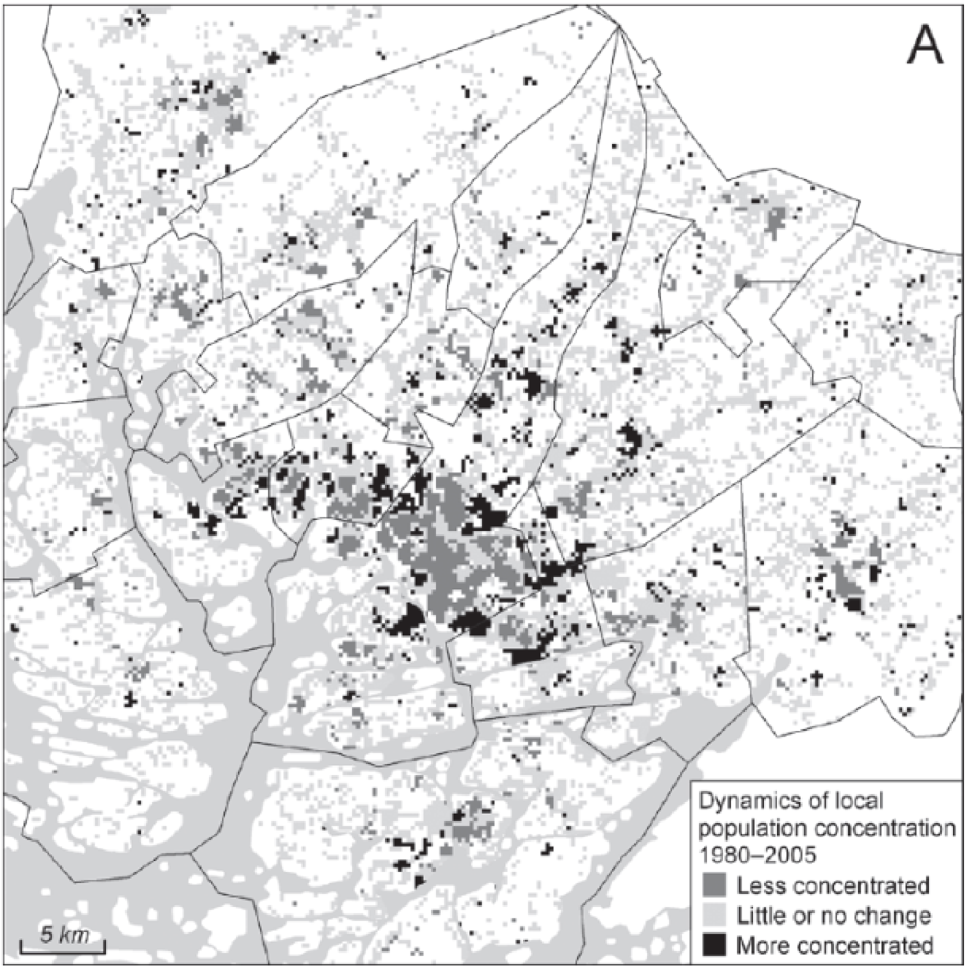

Figure 16: Changes in population distribution from 1980 to 2005 (Vasanen 2009)

The Urban Zone project coordinated by the Finnish Environment Institute studied the zonality of the community structure. The zoning carried out in the project covers the impact areas of the largest urban regions in Finland (including Turku). The project also studied the development of the urban areas between 1985 and 2010. Urban regions are divided into core and border areas and the surrounding rural area. The community structure is further divided into pedestrian, public transport and private car zones (Ristimäki, Tiitu, Kalenoja, Helminen, & Söderström 2013).

There has been development in urban regions that can be partly interpreted as fragmentation of the community structure and partly as compacting. Two obvious changes have taken place in urban regions. The population of urban areas in urban regions has increased while the population of rural fringe areas has decreased. In urban regions, the population is distributed across an increasing area and urban areas are expanding. The growth of the urban areas has also made the car zone considerably bigger. (Ristimäki et al. 2013)

The urban areas have grown at a strong rate in terms of area in the Turku urban region during 1985–2010. The population is increasingly concentrating in urban areas, and the fringes outside the urban areas have become car zones. The public transport zone has concentrated in the core area (within 10 km from the city centre). The use of bicycles is highest in the public transport zone. (Ristimäki et al. 2013)

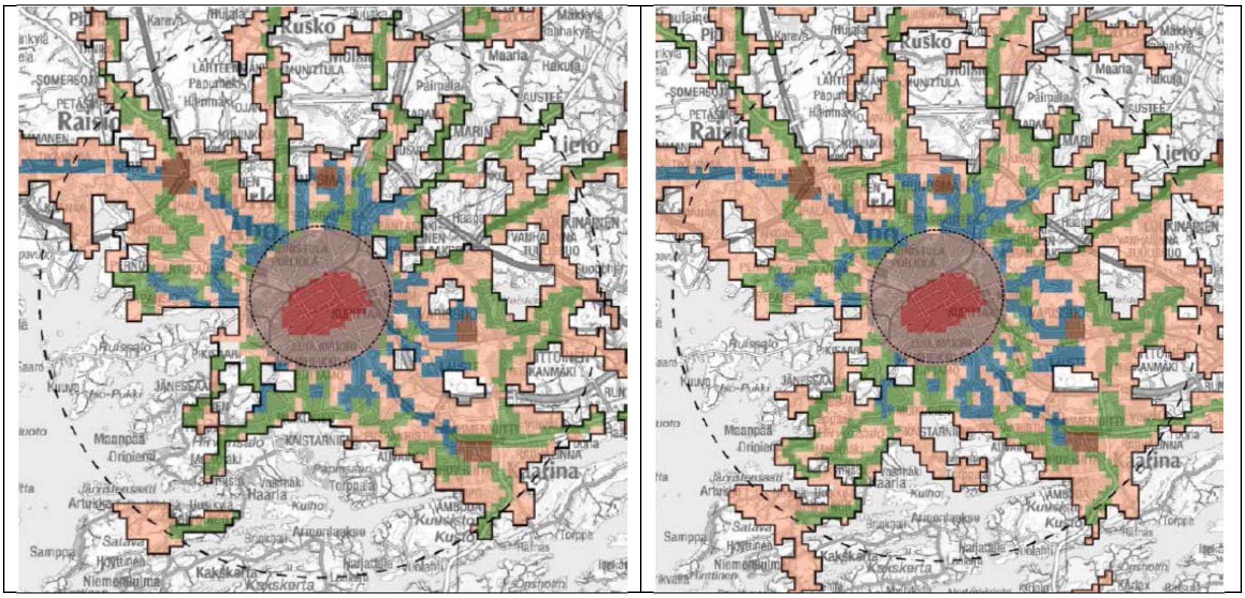

Figure 17: Community structure zones in 1990 (left) and 2010 (Ristimäki et al. 2013).

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5 National framework and constraints for urban and energy planning in Finland

In this chapter we describe national conditions, constraints and policies, influencing urban and energy level at the local level in Finland. First we describe briefly the Finnish planning system and National Land Use Guidelines, as well at the territorial government organisation. Afterwards the Finnish energy production and consumption is presented followed by the current objectives and measures related to energy efficiency and sustainability.

5.1 Turn towards a market-oriented Planning System in the 1990s

According to Hentilä and Soudunsaari (2008, p. 4-5) the Finnish planning system can be categorized as being particularly Scandinavian as opposed to "Napoleonic", "Germanic" and "British" families. This is because of the Finnish planning system's focus on local self-government and tripartition into national, regional and local levels, albeit the Finnish tripartition is rather hierarchically binding ("the plans on the higher level steer the lower plans", ibid, p. 11). Moreover, Scandinavian planning is typically focusing on the local level, which, especially after the reform of the Land Use and Building Act in 2000, characterises Finland in particular with its comprehensive local self-government and participatory planning (ibid).

THE FINNISH PLANNING SYSTEM

	POLICY INSTITUTION	POLICY INSTRUMENTS	
	Planning authority	**Type of plans**	**Legal effect**
NATIONAL LEVEL	Council of State	*Alueidenkäyttötavoitteet* (National Land Use Guidelines)	Advisory guidelines
REGIONAL LEVEL	Regional councils	*Maakuntakaava* (Regional plan)	Binding
LOCAL LEVEL	Municipal councils	*Yhteinen yleiskaava* (Joint master plan)	Optional
		Yleiskaava (Master plan)	Binding
		Asemakaava (Detailed plan)	Binding

Figure 18: The Finnish Planning System (Hentilä and Soudunsaari 2008)

The roots of the reform can be found in the development in the beginning of the 1990s, where Finland underwent an "exceptionally deep" economic depression, which turned out to become a turning point in Finnish planning. Within a rather short period of time, municipalities started to review their relationship to the private sector, methods in administration and organisation in favour for an incremental and project-based planning.

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This turned out to have a major impact on local land-use planning; "The local plan is not made as a proactive regulative statement to guide future urban development, but rather as a reactive document whose primary function is to provide the judicial legitimation for development decisions made elsewhere." (Mäntysalo 1999, p. 179) The perspective on cities in general shifted to a more positive focus, seeing them as growth engines in their region. The 'Regional Cities programme' and the 'Centres of Excellence programme' started during the 1990s where effectively supporting this development (Jørgensen and Ærø 2008).

5.2 National Land Use Guidelines focusing on climate change

According to the Land Use and Building Act, National Land Use Guidelines "must be taken into account and promoted" on all three planning levels (Ministry of the Environment 2009, p. 4). On the national level Land Use Guidelines are made "on demand", and are divided into general and specific guidelines, which must be involved on the levels seen in Figure 19. It is important to note that Land Use Guidelines are jurisdictionally implemented through regional plans – thus the Guidelines could be perceived as a "national plan" without legal power.

The revised version from 2008 is in particular interesting, as it responds to climate change in specific. Key issues are "the regional and urban structure, the quality of the living environment, communication networks, the energy supply, the natural and cultural heritage and the use of natural resources" (Ministry of the Environment 2009, p. 4). This translates into an increased focus on coherent urban structures thereby reducing traffic volumes, enhancing sustainable means of transport, energy savings, promotion of district heating, wind turbine areas in regional plans, siting of new waste incineration plants, and turning Helsinki into a "metropolis" relying heavily on public transport, especially railways (Ministry of the Environment 2009, p. 7).

Consideration of the general and special guidelines

	General guidelines	Special guidelines			
		In land use	In land use planning	In regional planning	In the regional land use planning
Work of the state authorities	■	■			
Regional land use planning	■	■	■	■	■
Local master planning	■	■	■		
Local detailed planning		■	■		

Figure 19: The relation between general and special guidelines on the different administrative levels. (Ministry of the Environment 2009)

Regarding the urban pattern, the Guidelines state that "The regional structure will be developed as a polycentric and networking entity based on good transport connections" and that "The regional structure in southern Finland will mainly be based on rail connections between Helsinki and the other urban centres.", although a new motorway and an airport are being planned (Ministry of the Environment 2009, pp. 13-15). In general the amendments from 2009 are focusing on reducing car traffic through cycling and walking and by placing service, workplaces, leisure and residential areas nearby each other or public transport.

5.3 Local government organisation in Finland and Turku

Finland is divided into 19 regions (FI: maakunta), 70 sub-regions (seutukunta) and 320 municipalities (kunta). The regions however have no self-governing authority. They are joint regional councils where the region's municipalities have to take part. The regions focus mainly on regional development and have to prepare a regional plan for a desired future development, including main activities to reach the goals and how to finance those (Jørgensen & Ærø 2008). Also, the regional councils are responsible for implementing the EU Structural Fund programmes (Localfinland.fi 2015).

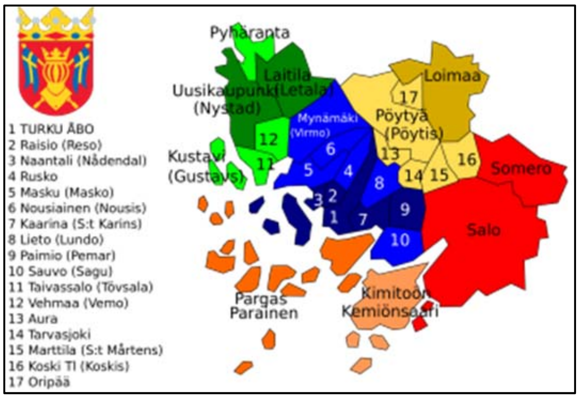

Figure 20: Municipalities in the region Southwest Finland

Municipalities in Finland have extensive self-government (Vasanen 2009). This includes the right of the local elected council to control, guide and implement land use planning, but also the need to compete for good tax payers. Also, the recently reformed Finnish land use legislation, which even increases the municipalities' potential to influence their land use, has made planning one of the key instruments for inter-municipal competition in urban regions. The increasingly polycentric urban pattern is supposed to be mostly an outcome of the fragmented municipal structure in the urban region (Vasanen 2009).

The differences in the amount of population in municipalities are huge, ranging from an island municipality with 500 inhabitants to the City of Helsinki with a population well over 500 000 (Committee on Spatial Development in the Baltic Sea region 2000). In the last 10 years an ongoing voluntary merging of municipalities is taking place – mainly to increase efficiency and lower costs for public service provision, reducing the number by more than 100 to currently 320 municipalities.

Table 3: Municipalities in Finland by size class, 2013 (Source: Statistics Finland)

Size class	Count	Population	
		2013	% (2012-2013)
Helsinki	1	612,664	1.4%
100,000 – 300,000	8	1,409,531	1.2%
50,000 – 100,000	11	737,132	0.3%
20,000 – 50,000	35	1,073,072	0.3%
10,000 – 20,000	48	686,147	-0.1%
5,000 – 10,000	77	556,296	-0.5%
1,000 – 5,000	126	367,992	-0.9%
< 1,000	14	8,436	-0.2%
Finland	**320**	**5,451,270**	**1.6%**
Turku municipality		182,072	1.0%

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5.4 General energy situation in Finland

Because of a high proportion of energy-intensive branches, low population density, cold climate and a “fragmented regional structure”, Finland’s energy consumption per capita is rather high compared to other industrialised countries. (Haukkala 2014, p. 53).

5.4.1 Energy production

Finland is high ranking within the EU in terms of using renewables in the energy production, where especially wood fuels are contributing. Nuclear and coal-fired power plants are main sources for electricity production, and industrial heating predominately comes from biomass produced in the pulp and paper industry (Haukkala 2014, p. 53). Since Finland is fully integrated in the Nordic wholesale market for electricity, Denmark and Finland are primary energy producers in dry years, whereas “good water years” ensure electricity production in hydroelectric facilities in e.g. Sweden and Norway. This enables better utilisation of reserves and adjusting in favour of hydroelectricity (Ministry of Employment and the Economy 2014, pp. 26-27).

Deregulation of energy production in the 1990s and carbon taxes

In June 1995, Finland's Electricity Market Act removed the licensing requirements for constructing power plants and selling electricity directly to ultimate customers. The law also made it easier to import and export electricity and has mandated transmission access. (Lynch 2003)

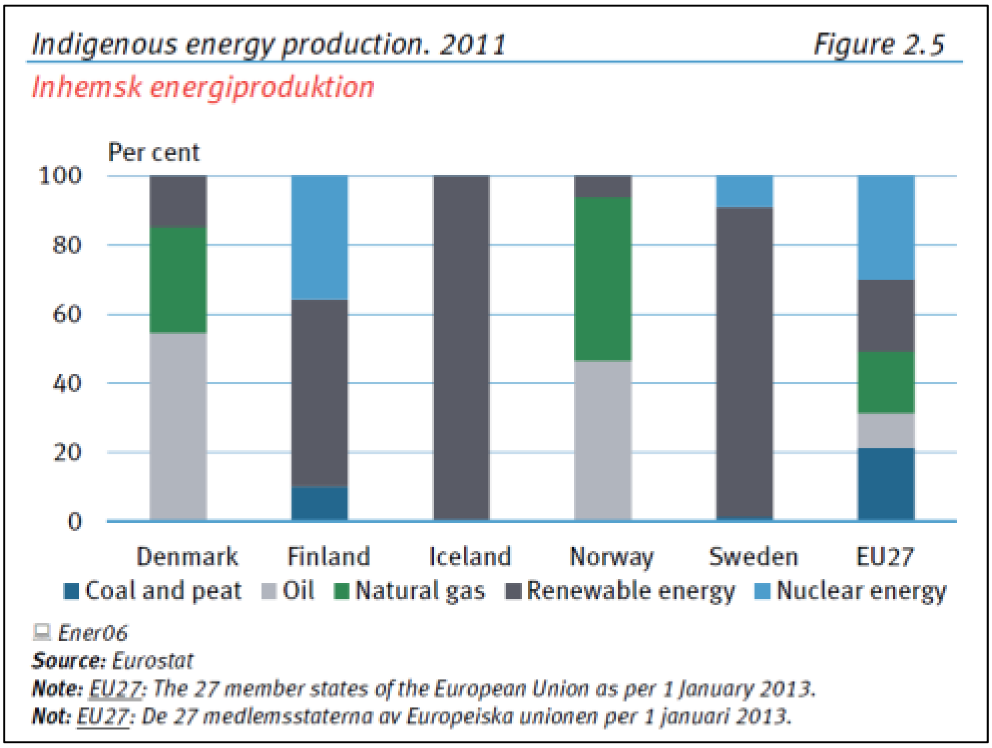

Figure 21: Domestic energy production in the Nordic countries in 2011 (Nordic Council of Ministers 2013)

The graph shows the different situations the countries are in and also gives some hints regarding potentials for renewable energy production. E.g. Sweden has a very high share of renewable energy coming from the high potential for water power due and biomass

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(trees). Both are clearly related to topography [geographical features]. Denmark on the other hand has only little biomass capacity and almost none for water power. On the other hand Denmark has natural gas resources in the Nordic sea and of course a lot of wind power. Finland on the other hand produces about a third of its energy by nuclear power. Finland's main renewable energy source is wood fuels.

5.4.2 Energy consumption

In May 1997, Finland adopted an energy strategy that includes 'promoting a competitive energy market' and 'diversifying energy supplies'. The strategy also emphasized energy efficiency, use of renewables, and reduction of carbon dioxide emissions. In 1990, Finland became the first country in the world to institute a carbon tax; the tax on district heating is based on the carbon content of the fuel. Finland also has a tax on electricity usage (Lynch 2003).

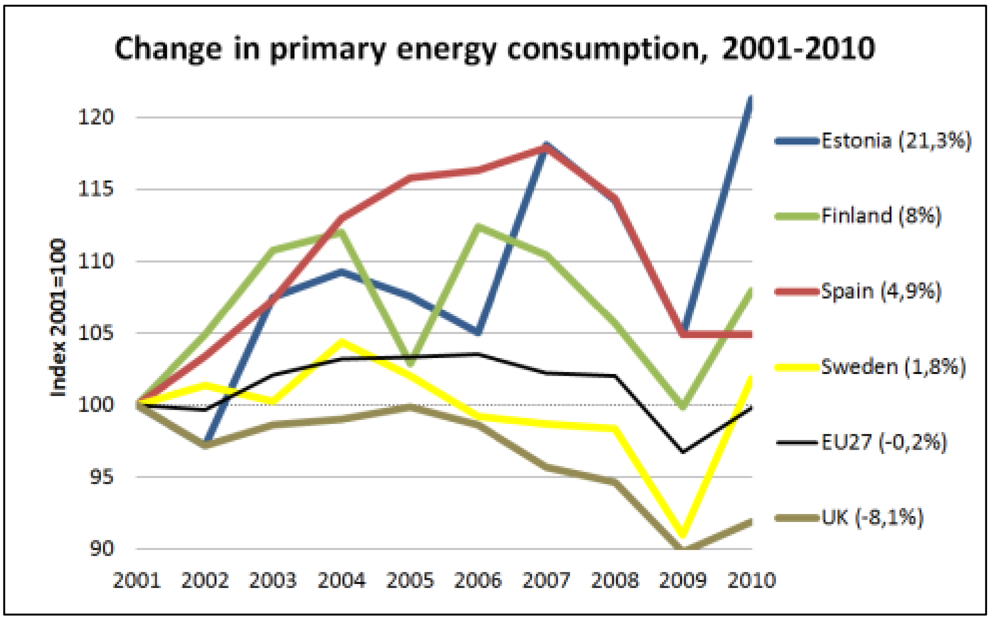

Figure 22: Primary energy consumption 2001-2010 (in "Tonnes of oil equivalent") in PLEEC countries (Eurostat 2013, Table nrg_ind_335a)

Out of the five 'PLEEC-countries', only the UK reduced its total primary energy consumption since 2001. Although the financial crisis reversed some of the increase, energy consumption in Estonia, Finland and Sweden increased strongly in the last year of data availability.

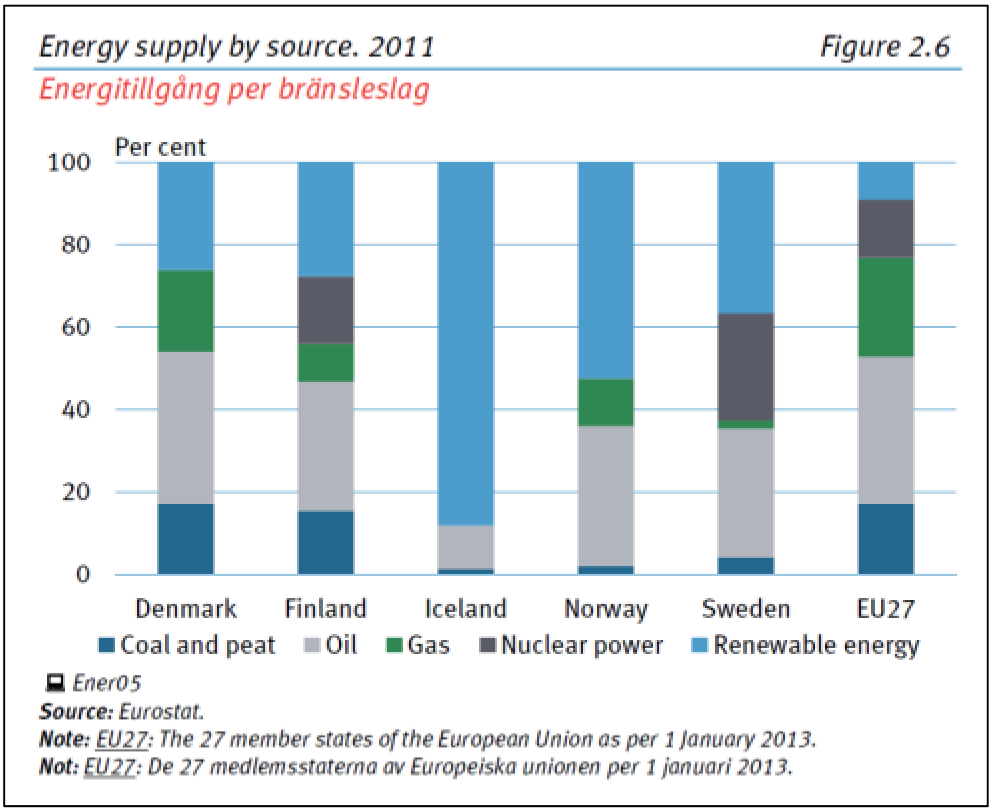

Figure 23: Energy supply in the Nordic countries in 2011 (Nordic Council of Ministers 2013)

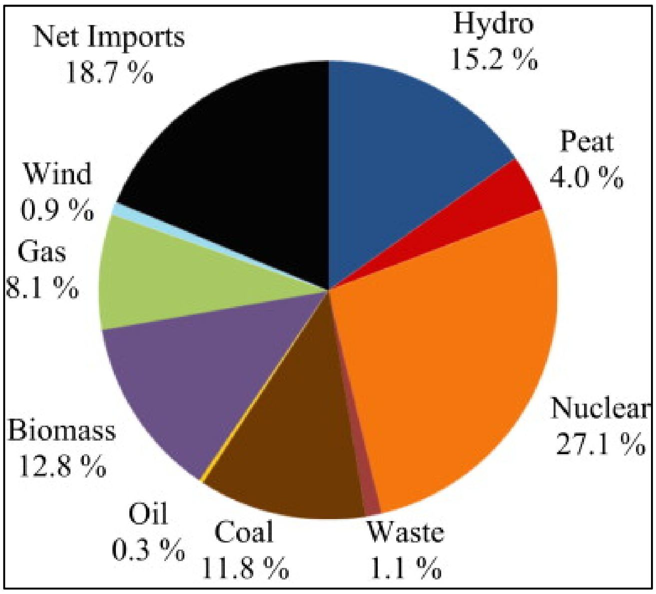

Figure 24: Electricity supply by source in 2013 (Ochoa & Gore 2015)

5.4.3 Greenhouse gas emissions

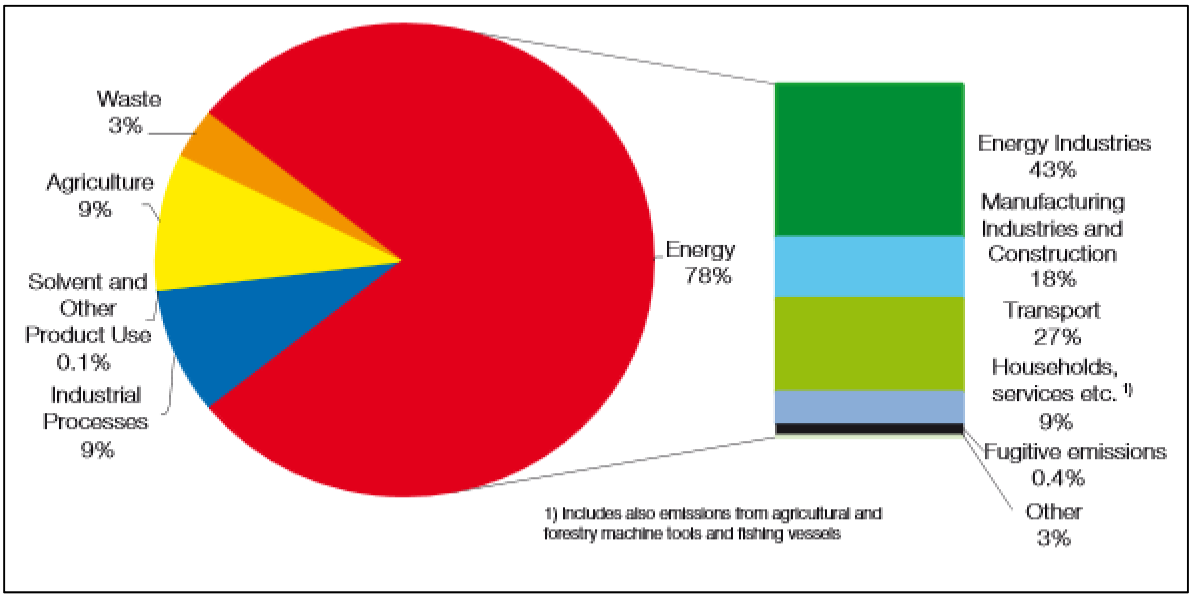

Figure 25: Finland's greenhouse gas emissions 2012 was around 68 million CO_2 tonnes, excluding LULUCF (Land Use, Land use change and forestry) (Ministry of Employment and the Economy 2014).

On average in the period of 2008-2012, Finland decreased its greenhouse gas emissions by 4% compared to 1990, even though the country experienced a growth in GDP of 48% in the same period of time. Compared to 1990, especially waste handling, heating of buildings and the pulp and paper industry have decreased CO2-emissions, whereas oil and metal refining as well as district heating production have increased.

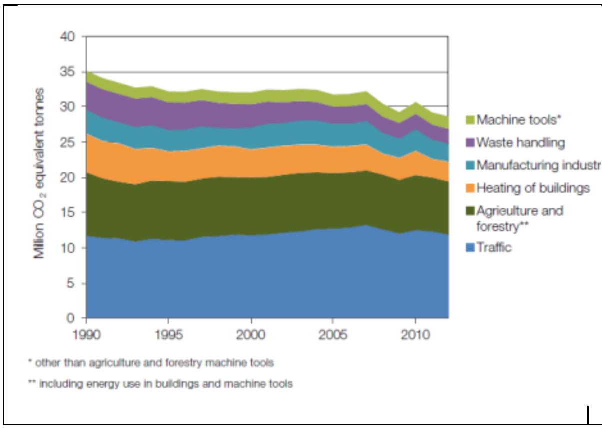

Figure 26: Non-emission trading sector's greenhouse gas emission in Finland (Ministry of Employment and the Economy 2014).

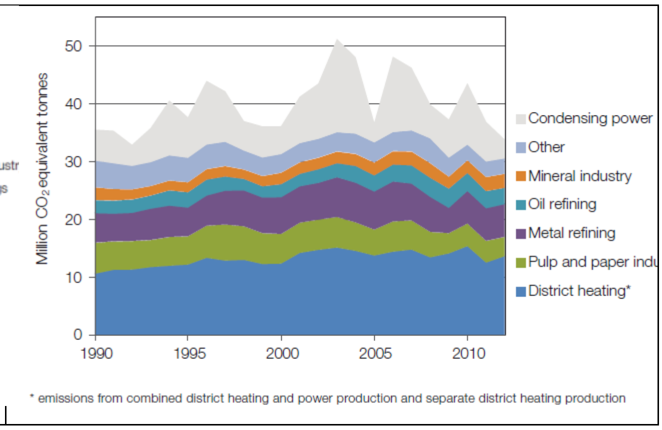

Figure 27: Emission trading sector's greenhouse gas emission in Finland (Ministry of Employment and the Economy 2014).

5.5 National policy goals and measures in energy

Targets for 2020	The EU	Finland
Reduction of greenhouse gas emissions [1)]	-20%	EU-level target
ETS emissions [2)]	-21%	EU-level target
Non-ETS emissions [2)]	-10%	-16%
Share of renewable energy sources in final energy consumption	20%	38%
Share of biofuel in transport fuels	10%	20%
Improving energy efficiency [3)]	+20%	EU-level target

[1)] base year 1990
[2)] base year 2005
[3)] in comparison to development as estimated in 2007

Figure 28: 2020 Targets for the EU and Finland (Finnish Government 2013)

Finland is obligated to the EU's goal of reducing Co2 emissions with 80-95% by 2050(Ministry of Employment and the Economy 2014, p. 21). The goal of the Energy Strategy of 2008 is to decrease energy consumption by 37 TWh (Finnish Government 2013) and increase the share of renewable energy to 38 per cent by 2020, in line with the obligation proposed by the European Commission for Finland. This is a challenging obligation, and its attainment fundamentally depends on having final energy consumption enter a downward trend. Finland's natural resources would facilitate the additional use of renewable energy, but in order to realise this, the current subsidy and steering systems must be rendered more effective, and structures changed. Indeed, meeting such an obligation would require an intense increase in the use of wood-based energy, waste fuels, heat pumps, biogas and wind energy. As a new promotional method, a cost-effective feed-in tariff system, operating on market terms as far as possible, will be introduced.

5.5.1 Measures

Within the different sectors, measures such as regulations, taxes, promotion programmes and so forth have been introduced and amended in the past couple of decades. Here is a brief outline of some selected measures:

Residential sector

Building codes for energy efficiency
Energy efficiency in buildings has been regulated since 1976 through national building code, and has continuously been tightened and updated for the past couple of decades. As of 2012, a so called "E ratio" is calculated for buildings (applies only to new buildings), which takes into account building type and favours buildings heated by district heating and renewable energy. Existing buildings' energy consumption is steered through energy audits, subsidies, voluntary agreements and energy advice, and new legislation regarding building renovations is coming (as of Oct. 2012) (Motiva Oy 2012, p. 27).

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Promotion of energy efficient heating Höylä agreement: since 1997 promoting energy efficiency in oil-heated single-family dwellings. Höylä III (2008-2016) strengthens the promotion of energy efficiency and introduces promotion of biofuel oils and solar-power and provision of advice and information to energy end-users. The latter is ensured through consumer energy advice, travel guidance and renovation advice (Motiva Oy 2012, pp. 27-28). Promotion of energy efficiency in oil-heated single-family dwellings/oil-heating systems. Promotion of biofuel oils, solar-powered heating.
Energy Efficiency Agreement, property sector 'Operational programme' for Associations owning rental housing
EuP Directive, Energy Star Energy labelling of white goods, electronics etc.
Energy advice Consumer energy advice, travel guidance, renovation advice

Transport

Transport tax "Transport tax is directed at the procurement and availability of the vehicle (when buying a new car and an annual tax for owning one), as well as its actual use (fuel taxes)" (Motiva Oy 2012, pp. 28).

In general most legislation comes from the international level, and is adopted nationally. However the national level is responsible for taxation which is a powerful tool. Mobility management is being strengthened through different programmes improving the link between regional and national mobility strategies, including walking and cycling strategies. The industrial sector is still highly dependent on voluntary agreements (Motiva Oy 2012).

5.5.2 Energy and Climate Roadmap 2050

In the Energy and Climate Roadmap 2050 (Ministry of Employment and the Economy 2014) four main scenarios for 2050 are being taken into consideration:

1. Stable and quick **growth**
2. **stagnation**,
3. intense energy/resource **save,**
4. structural/technological **change**

All are based on the "Low Carbon Finland"-research project (Ministry of Employment and the Economy 2014, p. 14).

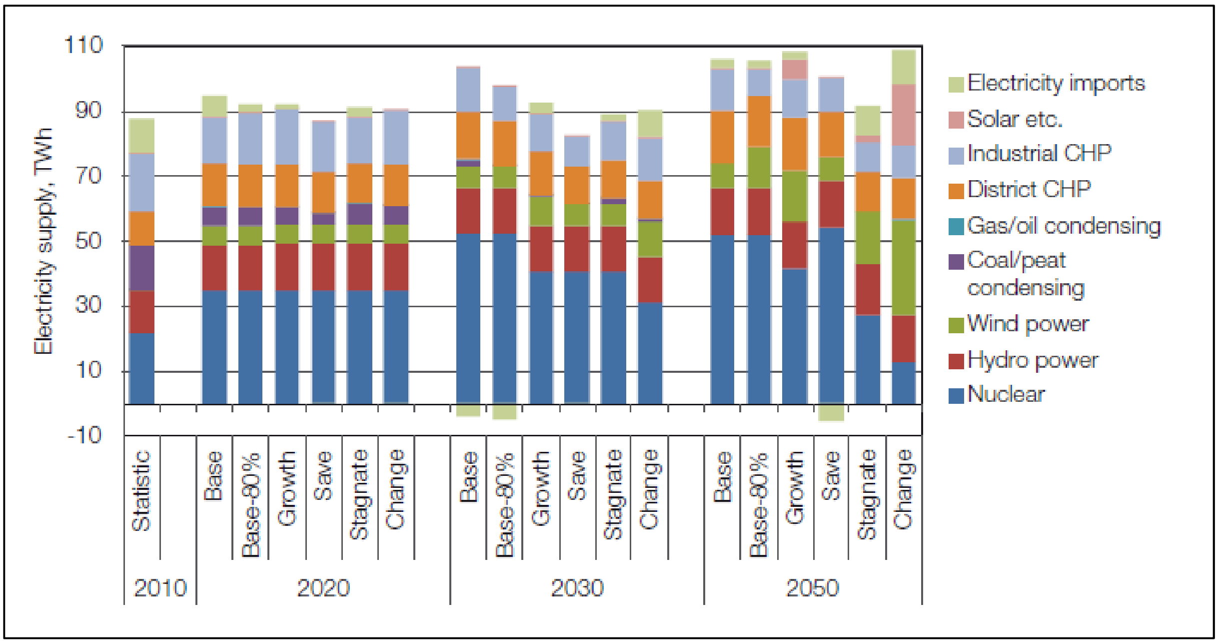

Figure 29: Structure of electricity supply in the Low Carbon Finland scenarios (Ministry of Employment and the Economy 2014)

Regarding self-sufficiency, the roadmap foresees that domestic energy sources will increase from today's 35%/53% to up to 65%/80% in 2050 (the latter number indicates the international calculation method, which includes nuclear power as a "domestic energy source") (Ministry of Employment and the Economy 2014, p. 23).

A barrier for creating a network of production for electricity through hydroelectric and wind energy solutions is that of the competition of the surrounding Nordic neighbours as well as the EU's internal market and state subsidy legislation (Ministry of Employment and the Economy 2014).

Wood is a particular sustainable source of energy that is being focused on in the Roadmap. In particular it is mentioned that there will be an increased need for transport as most supply is located in eastern Finland, whereas the biggest demand is in Southwestern (i.e. Turku) and Southern Finland (Ministry of Employment and the Economy 2014, pp. 32-33).

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6 Management of urban planning and energy today [energy management and governance]

The city of Turku is working with a range of strategies, programmes and plans with sustainable urban development. Furthermore, several relevant documents are development at the regional level, which means by the Region of Southwest Finland (e.g. the recent Regional Strategy), but through a cooperation of the municipalities located in the city region (e.g. the Regional Structural Model 2035). Table 1 summarizes the most important current documents.

Table 4: Main programmes and plans in urban development and planning

Finnish name	Name	Spatial scope	Adopted	Programme / Plan perspective
	Climate and Environment Programme	City of Turku	2009	2009-2013
	Roadmap for climate, energy and resource wisdom	City of Turku	Planned for 2015	2040
Yleiskaava 2020	General Plan for Turku	City of Turku	2001	2020
Yleiskaava 2029	General Plan for Turku	City of Turku	Planned for 2017	2029
	Transport Plan for Turku	City of Turku	2010	
Rakennemalli 2035	Regional Structural Model 2035	City-region of Turku	2012	2035
Varsinais-Suomen maakuntastrategia	Southwest Finland Regional Strategy	Southwest Finland	2014	2035+ (Programme for 2014-17)
Varsinais-Suomen liikennestrategia 2035+	Southwest Finland Transport Strategy 2035+	Southwest Finland	2014	2035+

In the following sections we will discuss some of the plans and documents by presenting general development goals, current general plans for the city and the region and the state of plans for electricity and heating.

6.1 General development goals

6.1.1 Overall strategy of the city

The central document which guided sustainable development in Turku in the recent years was the Climate and Environment Programme 2009-2013. The overall objectives are to reduce CO2 and turn towards renewables as energy sources (City of Turku, 2009). The programme focuses on emissions in general as well as the electricity and heat supply. Figure 30 shows the share of GHG emissions by source.

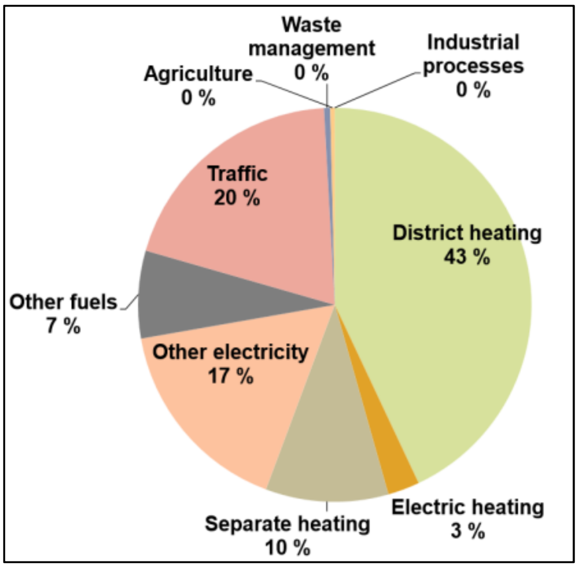

Figure 30: GHG emissions Turku, 2010. Per inhabitant: 7.8 tonnes. Total: 1.378 t. Co2-eqv. (Veivo 2012)

Emissions goals:

- Reduction of CO_2-emissions: 2020: -20% in total / -30% per inhabitants (compared to 1990)
- CO_2-emissions cut per person: 2020: 30% (compared to 1990)

Electricity goals:

- 2013: 100% of purchased electricity comes from renewables
- Only electricity produced by renewables should be procured

Heat goals:

- 2020: At least 50% of district heating comes from renewables
- Increase of renewable energy sources in heat production
- Sustainability criteria in public tenders from 2013

The environment programme also includes the climate and energy programme and public transport programme, based on an agreement between the City Council political groups. The programme also takes sustainable development budgeting into consideration. Furthermore, in conjunction with the Aalborg Commitments (follow-up of the "Aalborg Charter of European Sustainable Cities and Towns Towards Sustainability"), Turku has committed to comprehensively promote sustainable development, with regard to controlling climate change by developing and following "a strategic and integrated approach to mitigate climate change and work toward a sustainable level of greenhouse gas emissions" (City of Turku, 2009).

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As a follow-up to this programme, the city adopted a strategy in 2014 leading to the development of a **Roadmap for climate, energy and resource wisdom** which is planned to be adopted by the city council during 2015. One of the main aims is to be carbon neutral by 2040. However, the city is also explicitly focusing on economic growth, but intends to combine this with the climate and environmental goals under the headline of 'green growth'.

6.1.2 Urban development goals for transport and urban form

A main concern of planners in Turku is changing the modal split in favour of cycling, walking and public transportation. In cases of transport and zoning plans, CO2-calculations are made, but according to the planners these calculations mostly make sense on a broader scale, e.g. whether they should densify the city centre or develop the suburbs – and not when comparing two different neighbourhoods. Energy is in general of less interest compared to other planning related themes (Mäkinen 2014).

As written above, the Climate and Environment Programme (City of Turku, 2009) also includes transport issues, by setting a couple of particular goals for transport as well as urban form:

Transport

- Community decentralization will be restricted
- Growth in share of motor traffic will be restricted. Development of a public transport which is fluid, pleasant and reasonably priced
- Zoning will promote use of public transport
- Zoning will promote a community structure supporting other sustainable ways of travelling
- Waste transport logistics will be eco-friendly
- 50-80 charging stations for electrical cars, spring 2015 (Turku.fi 2015d)
- Bus Rapid Transit system in discussion

Urban form

The urban form is being altered through an intensified focus on densifying the central boroughs and limiting urban sprawl:

- Community decentralization will be restricted
- Zoning will promote use of public transport: new development areas are situated next to public transportation lines in the regions' structural land use plan (Mäkinen 2014)
- Zoning will promote a community structure supporting other sustainable ways of travelling
- Concentrating new developments along energy infrastructure (Kulla 2014)

Even though the objectives for the city of Turku is to limit urban sprawl and focusing on developing the central areas (80%) the split up municipal structure around Turku makes it next to impossible to reach. The other municipalities simply have other interests than pursuing this strategy of densification (Mäkinen 2014).

In a study conducted by Siemens and the City of Turku (WBCSD urban 2011), further proposals were elaborated to reach these goals:

- Green logistics – supply chain bundling, smaller vehicles etc.
- Traffic Management – Park'n'ride, signage etc. to guide cars, fee in congested areas, car/bike sharing
- Light rail system (see also section **Error! Reference source not found.**)
- Smart Grid – matching supply/demand of electricity
- Skanssi and Linnakaupunki to be build "energy smart" especially through new technological solutions (Turku.fi 2015b)

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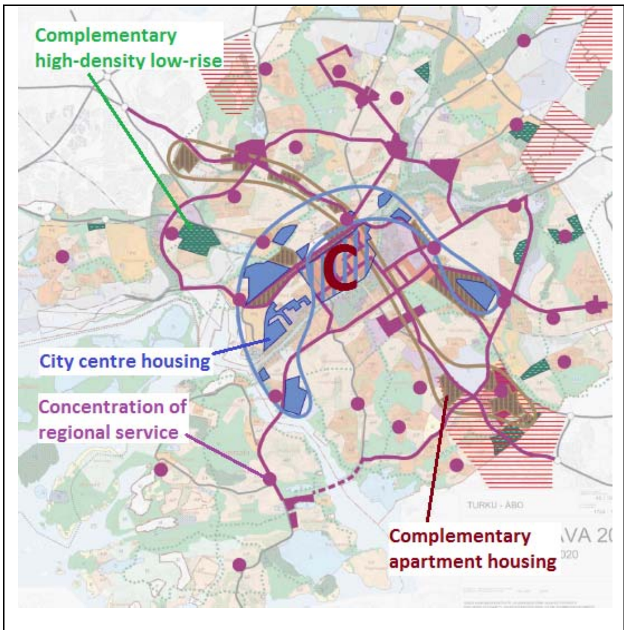
6.2 Current and new master plan for the City of Turku

The current general plan was adopted in 2001. Some of the main objectives were to limit the growth in person traffic ("persontrafik"), expanding the central area nearby the grid, the centre periphery and regional centres and enhanced cooperation with the surrounding municipalities.

The central area was meant to expand and being rebuilt in former industrial areas with dense housing and work places. Housing and service development in the fringe area should be placed nearby selected major intersections/hubs and public transport. These hubs should be equipped with a good level of possibilities for light traffic such as cycling and walking.

Figure 31: Current urban development plan of City of Turku

Technology industries are placed along the Helsinki motorway, central industries along main arteria roads, reservations are made for industry around the airport, port and the railway station.



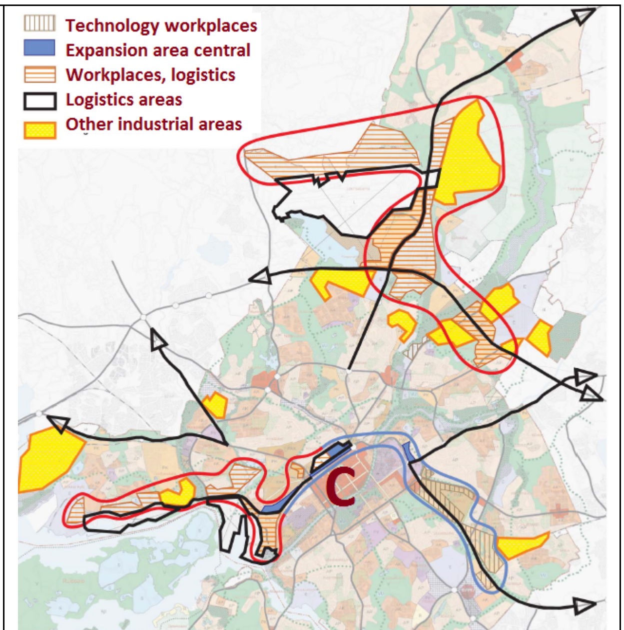


Figure 32: Housing plan	Figure 33: Plan for workplaces. E.g. technology is placed next to the Helsinki motorway

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In 2013 work on new plan started. A draft should be ready by 2015, while the final proposal is expected by 2017. The new general plan has a 12 years plan perspective (2017-2029), which is considerably shorter than the previous. A core element in the new plan is the discussion of a future city model (see Figure 34). However, these models are long term visions which the 12 years-period of the plan can only be a stepping stone to. The preferred model is the growth corridors model, while dispersed growth is planned to be avoided.

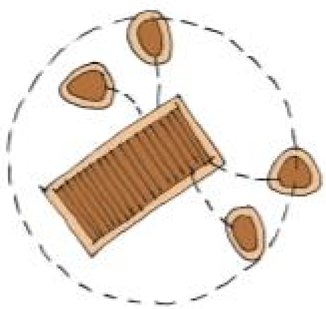		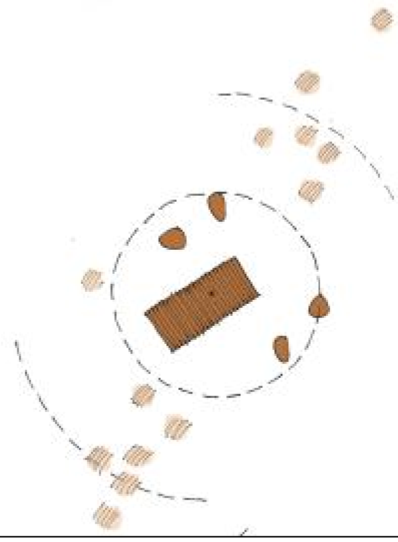
Growth centres	Growth corridors (with emphasis on public transport routes)	Dispersed growth

Figure 34: Considered future city models for Turku, http://www.turku.fi/yleiskaava2029

6.3 Regional Structural Model 2035 (adopted in 2012)

The Structural model 2035 for the Turku Urban Region (RM35, 2012) is a common land-use strategy for 14 neighbouring municipalities in Southwest Finland. The plan was developed out of the national municipality reform (NEW BRIDGES 2011). It is a follow-up to previous initiatives on improving regional service structures (PARAS project). The planning process started in 2010; the plan was finally adopted in 2012.

The Structural model presents a vision for long-term development of the region as well as main guidance to achieve those. It counts with a growth of 75 000 inhabitants until 2035. The overall objective underlines improvements to the competitiveness and attractiveness of the city-region and the mitigation of climate change. The strategy aims to have common targets for all significant land use activities such as housing, business, service provision, mobility and transport in connection to the network of urban green areas (NEW BRIDGES 2011).

The key objective of the structural model is to create a shared insight into the main long-term guidelines of the urban region's community structure. The structural model also aims to promote a sustainable urban structure and increase the appeal and competitiveness of the region. The model guides land use planning at the general level and it functions as the starting point of the regional land use plan and general plan (RM35, 2012). The structural model for the Turku urban region is given legal standing through land use planning.

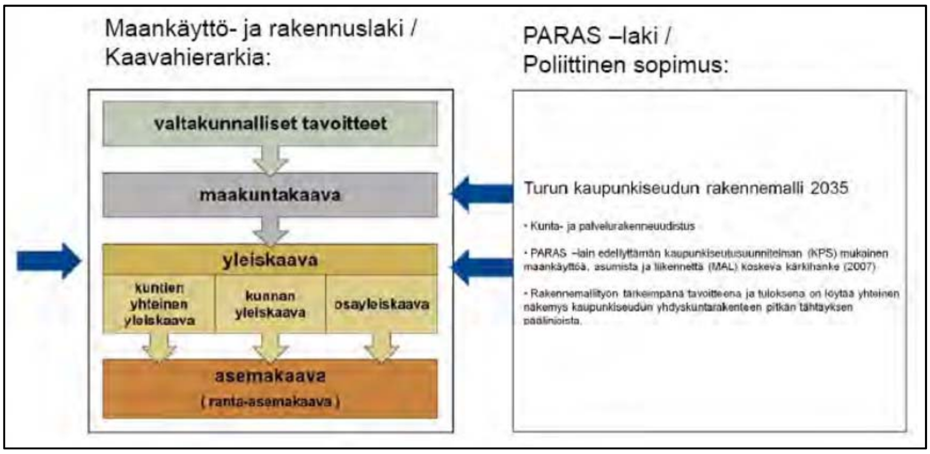

Figure 35: Joining of the structural model to the land use planning system. The RM35 relates to regional as well as city planning (two arrows going to the left) (City of Turku 2013, p. 14).

The principles of the structural model are largely the same as the regional land use plan for the Turku urban region and the regional land use plan for Southwest Finland. The common objectives are compacting the area structure, supplementary construction of underutilised areas, renovation of old areas, conserving the cultural landscape and implementing green networks (RM35, p. 65).

The population of the area covered by the structural model is approximately 324,000. The population has spread to the neighbouring municipalities in recent decades, and the focus of population growth has also been on them. Jobs and services, however, are concentrated in the central city, Turku. This has resulted in longer distances to services and increasing private car traffic (RM35 2012, p. 4).

6.3.1 Land use

The regional land use plan area of the Turku urban region is comprised of Naantali, Raisio, Turku Kaarina, Rusko, Lieto, Piikkiö and Paimio. An urban zone extending from Naantali via Turku to Piikkiö is marked in the regional land use plan for the urban region. A significant part of land use, housing, jobs and services are located in this area. "The aim is to strengthen the central axis and the surrounding central zone of the urban region further by increasing housing and jobs in the vicinity of the existing centres and existing public utility services." The value of the central axis as a public transport route is also associated with its development (City of Turku 2013).

The objectives of the regional land use plan can be seen clearly in the General Plan 2020, which emphasises compacting the regional structure in particular. The impacts of the regional land use plan on the city functions (compacting and broadening the area structure) define the direction of the city's growth. With regard to the energy use of the city, the regional land use plan has an impact on energy efficiency and traffic solutions. Compact and dense housing provides opportunities for functional public transport (Aarnio 2013).

Land use planning promotes sustainability and climate change control. It is important to find ways to implement the structural model in the land use policy. In practice, this concerns land acquisition in the areas, the prices of undeveloped land remaining stable, controlling the increase in the prices of land and housing, decreasing dispersed construction, sufficient supply of plots and timely construction, as well as promoting the utilisation of areas that are favourable in terms of the community structure (RM35 2012).

Outside the core urban area, construction will be concentrated in centres, which will be developed as self-sufficient areas in terms of services and jobs and with mixed functions. The structural model points out new residential areas for fringe area zones with service cooperation potential: Maaria-Ilmarinen (Turku-Lieto), Varissuo-Littoinen (Turku-Kaarina-Lieto) and Tikanmaa (Raisio-Naantali). In these growth zones, real estate investments can be made in joint service needs and financial savings can be achieved (Aarnio 2013).

A mixed area structure is promoted in land use to decrease the need for mobility and to increase vitality. The compaction of the structure will be focused in the vicinity of services, jobs and public transport (City of Turku 2013). Land use planning will support pedestrian traffic and cycling as well as bus traffic trunk lines and light rail.

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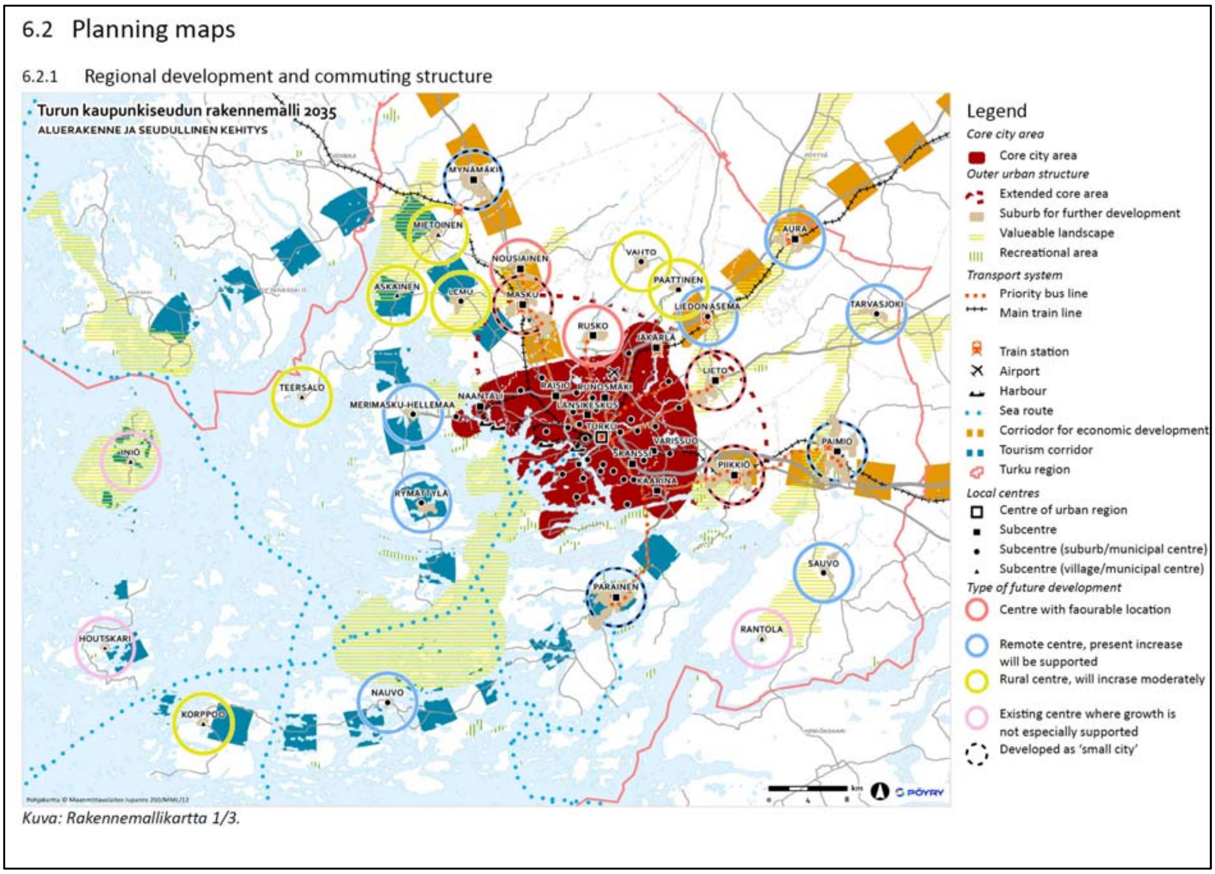


Figure 36: Regional structure of the employment area and regional development (RM35 2012, p. 20, translated)

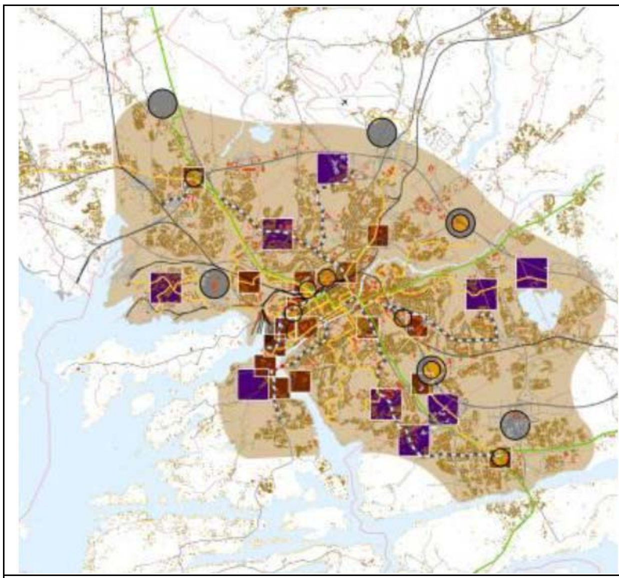
6.3.2 Alternatives for future growth

The national land use objectives have been the starting point of the structural model work. Both share the same objective: a functional regional structure and defragmenting the community structure. The functionality and comfort of the community structure, on the other hand, influence the ability of the urban region to cope in the competition over residents and jobs (RM35 2012, p. 5).

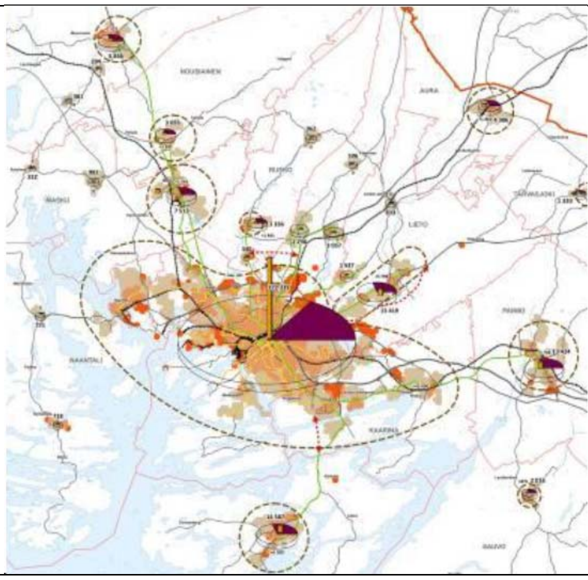
The urban region is planned as a functional entity. Land use and the traffic system are planned in a mutually supplementary way in order to achieve a functional community structure. Compacting and supplementing underutilised areas defragment the community structure (RM35 2012, p. 7).

A city axis running from Naantali to Piikkiö via Turku is specified in the regional land use plan for the Turku urban region, with the majority of land use, housing, jobs and services located in it. The structural model aims to strengthen the central axis and central zone further. The development of a multi-centre area is supported outside the core urban area (RM35 2012, p. 65).

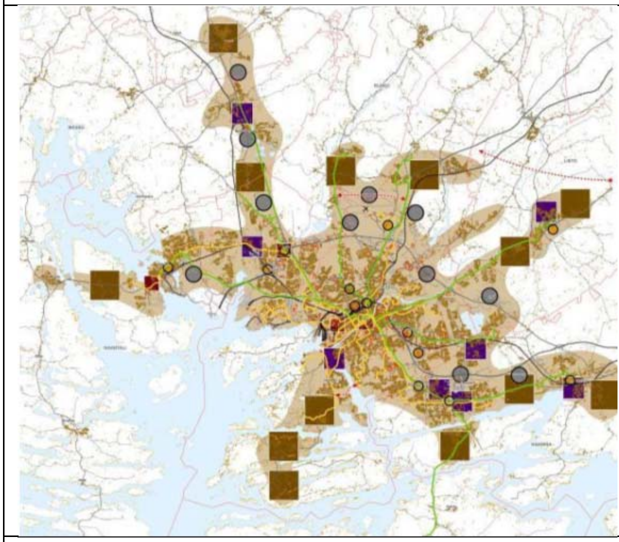
Opportunities for growth in the Turku urban area have been studied in the structural model. Four alternatives were prepared to investigate the possible growth directions and opportunities for compaction.



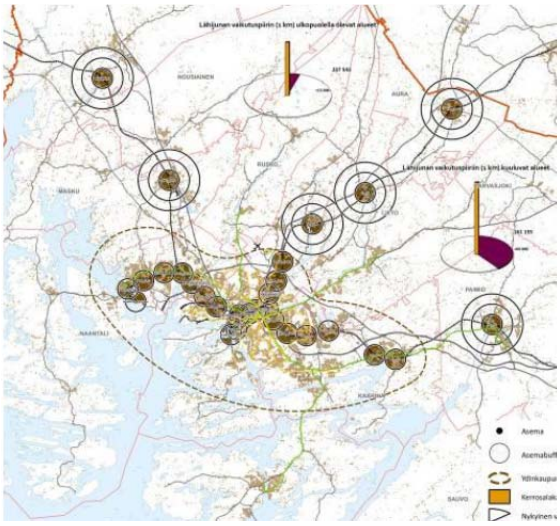
"The Snail"



"The Net"



"The Octopus"



"Pearls"

Figure 37: Four alternatives for future urban growth of the Turku urban region (RM35 2012, p. 10-11)

"The Snail"

In the Snail alternative, the growth of the urban area is directed either to the core urban area comprised of Turku, Raisio and Kaarina or somewhat more extensively, following the urban zone between Naantali and Piikkiö. Services are concentrated in the core urban area or the centre of Turku (Aarnio 2013).

The benefits of this solution include the competitiveness of the urban region, an efficient public transport system and the possibility of a comprehensive pedestrian and bicycle traffic network. In addition to efficient traffic, the Snail model is energy-efficient and climate-friendly, with growth mainly taking place within a distinct zone. The services are easily accessible, and there is clear development potential for the retail sector (Aarnio 2013).

"The Net"
In this model, growth is distributed among the core urban area comprised of Turku and its neighbouring municipalities and the municipal centres of the surrounding region. In the Net model, the volume and distances of car travel increase, but on the other hand, the pedestrian and bicycle traffic network can be developed at the local level. The model benefits the self-sufficiency of municipalities outside the centre and growth in supply, but includes the risk of the retail sector aiming to locate between the centres next to traffic routes (Aarnio 2013).

"The Octopus"
In this model, growth is focused on land use areas extending like tentacles from the core urban area parallel to main traffic routes. In this model, the possibility of providing a pedestrian and bicycle traffic network decreases. There will be less pedestrian and bicycle traffic, and the focus is on increasing car traffic. The Octopus model is the least energy-efficient of the models (Aarnio 2013).

"Pearls"
In this model, growth is focused along railway lines. The model emphasises the competitiveness, comfort and safety of the urban region and the quality of the living environment. The fragmentation of housing involves the risk of increasing car traffic. The model has potential for energy efficiency and climate friendliness, provided that growth is clearly focused on zones. In this case, the preconditions for an efficient public transport system and pedestrian and bicycle traffic exist. Due to the good traffic connections, the availability of services is also good. The risk is major retail units being located in the areas between the centres next to traffic routes (Aarnio 2013).

6.3.3 Infrastructure and transport

Infrastructure
The land use solutions of the structural model are based on compacting and supplementing the existing structure by utilising the existing infrastructure. This solution has economic advantages as it can increase the efficiency of previous investments in infrastructure. Naturally, the maintenance of existing infrastructure results in maintenance and renovation costs. The new areas will have an impact on them through changes in capacity and utilisation rate. However, a compact community structure minimises the amounts and maintenance needs of new external network structures. In a dense urban structure, providing and maintaining services incurs lower costs than in a fragmented one (RM35 2012, pp. 68-70).

Transport
The *Turun Seudun joukkoliikenne 2020* report has investigated scenarios for public transport in the Turku region. The aim is that in 2030, the volume of passengers using public transport is 50% higher per population than the current level. Turku has been an increasingly passenger car-focused area for a long time (Aarnio 2013). The structural model supports the Turku Region Public Transport 2020 Development Plan (RM35 2012, p. 2).

Implementing the traffic solutions and projects recorded in the structural model will require further planning in many respects. The urban region traffic system task force comprised of several parties is responsible for further planning. Increasing traffic volumes with growth will also require investments in developing the traffic system (RM35 2012, pp. 66-70).

Energy use

Compacting the core urban area and developing the traffic networks will improve energy efficiency and reduce greenhouse gas emissions. The energy efficiency of the community structure depends on the density of construction. The dominance of high-rise blocks, compact construction and centralisation all decrease energy consumption. Emissions reduction in energy consumption is largely dependent on the method of energy generation. Decreasing greenhouse gas emissions requires improving the energy efficiency of the building stock in terms of both new construction and renovation (RM35 2012, pp. 68-60).

Compacting and strengthening the core urban area facilitates functional public transport connections and improvement in pedestrian zones, which supports the sustainable development of the entire urban region. In terms of emission reduction, the structural model solution is a better solution than the fragmentation of the urban region into areas that are weak in terms of service offering. With regard to climate impacts, the essential thing is to start the implementation of the structural model from measures that defragment the community structure (RM35 2012, pp. 68-69).

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6.4 Heating and electricity supply

Turku Energy is owned by the City of Turku and has the overall responsibility for energy management, the physical network ('network asset management') and its planning in Turku. Today half of the electricity consumed in Turku is produced at the Naantali power plant (will be replaced in 2017), and the other half comes from the national grid. Whereas Turku Energy has monopoly on electricity, this is not the case with (district) heating, which makes it possible to create local alternatives (Kulla 2014).

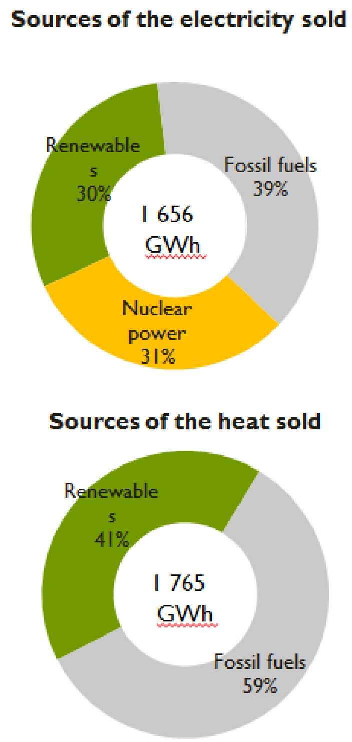

Figure 38: Source of electricity and heating (Turku Energia 2014)

Turku Energia has been an independent company since 1995, but is owned by City of Turku. Turku Energy is responsible for district heating, and supplies neighbouring municipalities albeit other actors also have the possibility of joining the market. They have monopoly on electricity production and are not covering other municipalities. District heating/cooling and electricity is currently produced by a share of 41% and 30% renewables, respectively. The district heating network in Turku is quite comprehensive, and accounts for 90% of the heating market. Thus it is the most common form of heating in Turku, used in almost all suburbs and urban areas.

Turku Energia prefers new developments along existing power lines and district heating infrastructure as well as those planned in their five year plan. Plans for new district energy infrastructure primary focus on the big heating/cooling consumers (big companies or production facilities), while smaller consumers play a minor role for the decisions where the main pipes will be located (Kulla 2014).

6.4.1 District heating/cooling

The heat for the district heating system is mainly generated at the CHP plant in Naantali, Turku's waste incineration plant (which however will get closed) and the bio heat station. The heat is distributed to customers via hot water circulating in the district heating network (Community Structure 2035, 136.)

Heat is generated using a variety of fuels in Turku: coal, refinery gas, waste, wood, biogas and oil. Production takes overall economic efficiency and environmental impacts into account. Combined heat and power production, for example, cuts fuel consumption by one-third. (Community Structure 2035, 136.)

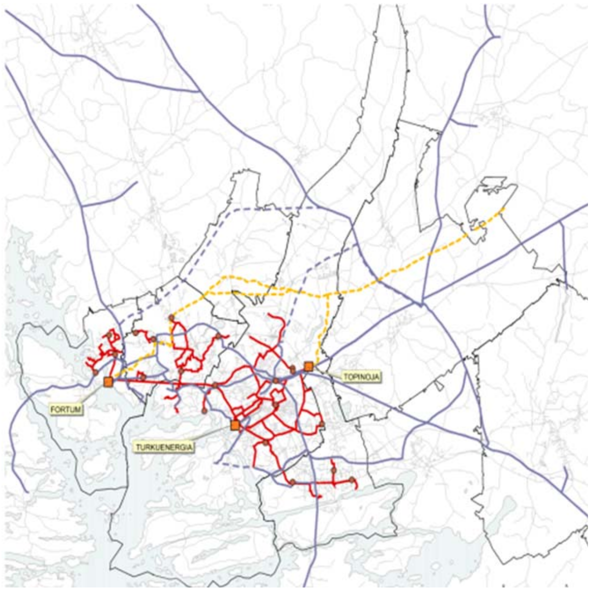

Figure 39: District heating network

There will be changes in the energy generation solutions in the region when the Naantali power plant is replaced by a new plant in 2017. The new plant will also be a combined heat and power plant. The new multi-fuel power plant can be fired with biofuels, coal or high-quality waste. The aim is to use domestic biofuel as much as possible. (*Turun Sanomat* 10 February 2014.)

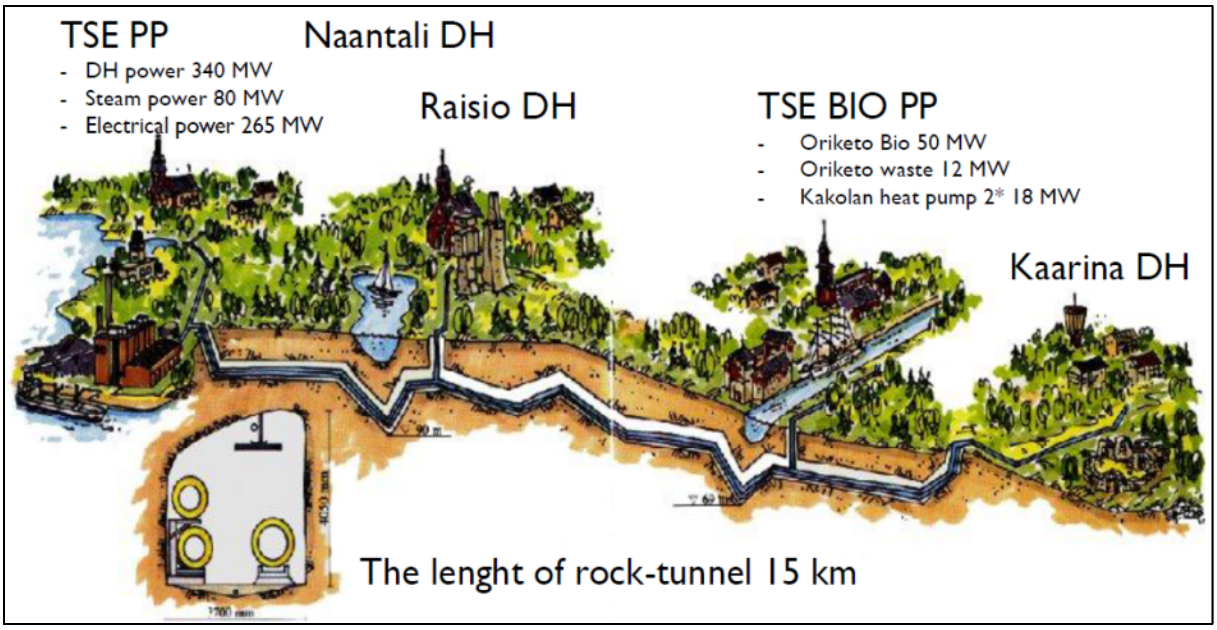

Figure 40: District heating network in Turku. 600 km pipeline, 4900 delivering points, 200.000 customers (Kuivanen 2014)

In 2009 the Kakola heat pump was put into service. This heat pump has increased the use of renewables to more than 30% of the total heat production and a new heat pump is on its way (Turku Energia 2014). The Oriketo bioheating plant, which is using wood chips (renewable), produces approximately 20% of the district heating in Turku (UBC Comission on Environment 2015).

It would be more economically feasible to connect the Skanssi area to the existing district heating system, but since it should work on an experimental level related to "smart city" planning, this solution was not chosen (Kulla 2014).

Turku also has a district cooling network, which was one of the first in Finland. It was opened some 10 years ago. Whereas district heating and cooling can be produced at the same place, the infrastructure consists of different pipes – the ones for cooling are bigger (Kulla 2014).

6.4.2 Electricity

The share of wind power will increase to 10% in 2020. In 1998 the Hyötytuuli wind power production company was founded. It is a collaboration between several major Finnish energy companies, including Turku Energia. In 2003, Turku Energia and two other energy companies bought "Eastern Norge Svartisen", a Norwegian hydro power plant (Sundström 2003). Waste incineration was abolished due to environmental concerns of the existing incineration plan – now Turku's waste is incinerated in Stockholm.

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6.5 Transport planning

Turku has a rather high proportion of people cycling and walking compared to the other PLEEC-cities. The level of cars is on average, and the usage of public transportation is rather low. Parking fees are rather high, which might be the reason why cycling and walking is high (Giffinger et al. 2014).

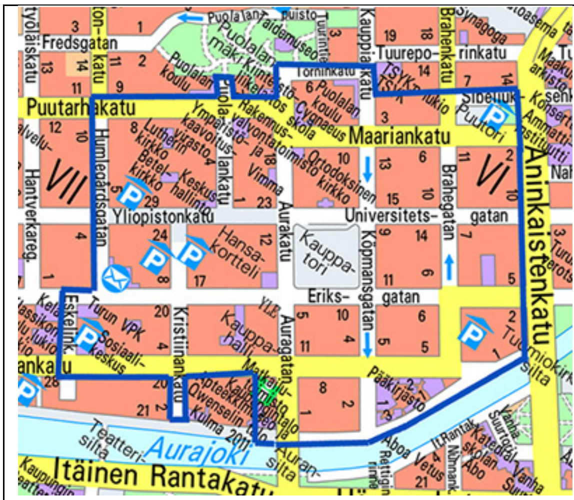

Figure 41: Parking in Turku. 3€ and 1,5 €/h inside and outside the blue marking, respectively (Turku.fi 2015c)

As previously mentioned, the planners in Turku are very devoted to changing the modal split. The starting point for sustainable transport is good, since Turku citizens are already the second least car driving in the bigger Finnish cities. Also, the share of public transport increased in recent years and exceeded the political goals (Veivo 2014).

However, there are also some aspects which have to be drawn attention to. For example the new development area Skanssi (see also section 7.1) is situated next to a highway. This might, despite its good connection by bicycle paths and potentially the new light rail (see also section 7.2) undermine the goal of reduced car use. Also parking space in the city can contradict that idea. According to the city of Turku, it is impossible to imagine parking spots only for local residents with the argument that “the streets are for everyone” (Turku.fi 2015a).

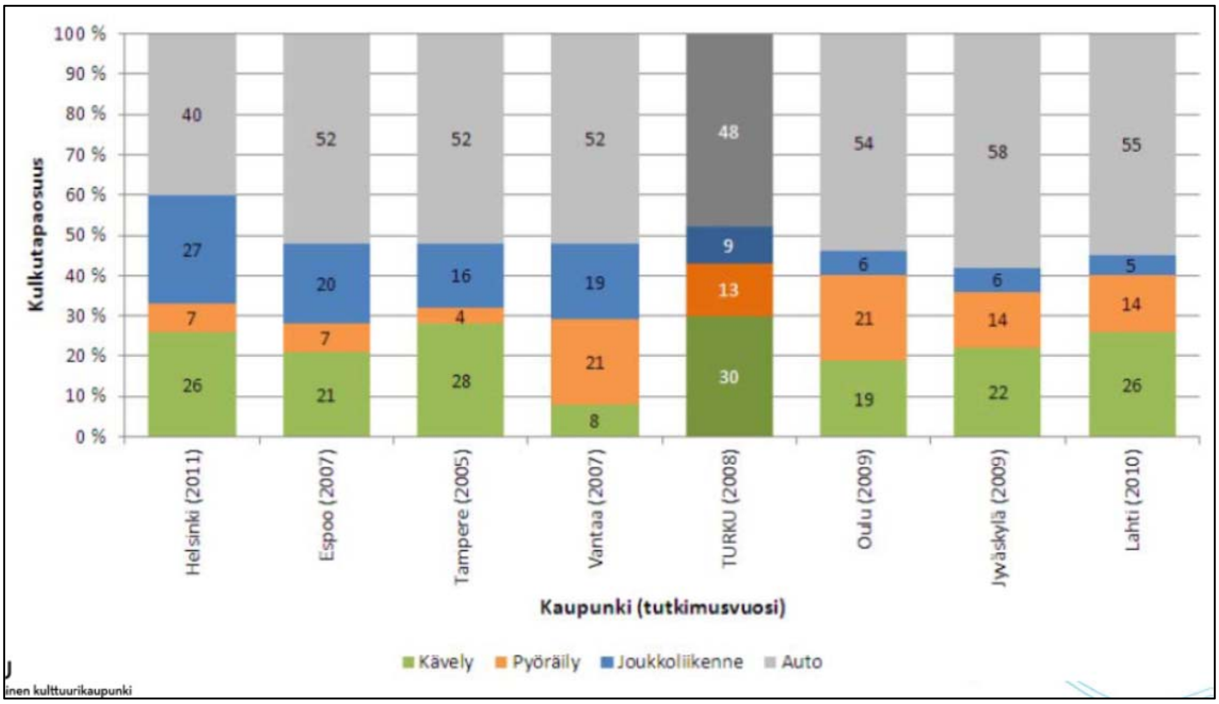

Figure 42: Modal split in Finnish cities (green=walking, orange=cycling, blue=public transport, grey=car); Turku has the highest share in walking (City of Turku 2014a)

Another issue is the modal split in the surrounding areas. Although Turku municipality has a majority of trips done by public transport, walking or cycling, this changes when looking at the suburban municipalities. Here the car share is about 60 % in the central areas and 80 % in the peripheral areas of the Turku region (Laaksonen 2011).

Figure 43: Shopping centre "Mylly" in Raisio, suburb of Turku, by Jarteq via Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Raisio_Mylly_01.JPG

This pattern is not only relevant for commuting, but also for other kinds of travel needs. For example a research project dealing with children's mobility patterns in the suburbs of Turku shows that car transport is the major form of transport for many people living there – in affluent as well as less affluent suburbs, while active transport (walking and cycling) plays only a minor role (Fagerholm and Broberg 2011).

6.5.1 Transport planning in the Regional Structural Model

In the Regional Structural Model 2035 (see section 6.3), transport and mobility is an important issue, especially regarding the future community and service structure. The traffic system is developed as part of the development of land use and service network. An increasing use of sustainable means of transport is expected to reduce greenhouse gas emissions from traffic (City of Turku 2013, p. 162).

The aim is to control the growth in distances travelled and the volume of passenger car traffic through community and service structure planning. The preconditions for public transport, pedestrian and bicycle traffic will be improved. The traffic system solutions made aim to implement the targeted community structure and objectives. The aim is a mixed pedestrian network for short distances and a public transport network based on municipal and regional centres. Population growth will also increase traffic volumes and investments outside the centre of Turku (Aarnio 2013).

With regard to public transport, the aim is to establish trunk lines on regional main lines. In practice, traffic will be operated as bus and rail traffic. The rest of the area is served by regional main lines with short intervals and regional lines with less frequent service. The suburban zone will be developed with the aim of increasing the population of the public transport zone sustainably (City of Turku 2013).

In order to make public transport attractive, the pricing of tickets is suggested to remain competitive and development supposed to take place throughout the travel chain (stops, passenger information, etc.). The City of Turku has launched the Public Transport Plan 2020 for the development of public transport.

6.5.2 Cycling

In Turku's Climate and Environment Programme (see section 6.1) cycling is included in the category "light transportation", and is pursued to comprise 55% in 2013 (52 % in 2008) and over 66% by 2030 in the modal split. In order to achieve this objective, a programme for pedestrians and bicycle transport should have been completed by 2010 (status unclear to the authors) and a downtown cycle network will be realized at the latest in 2015. The network will be implemented faster through "utilizing lighter implementation options" (City of Turku 2009).

Currently the official Turku homepage does not contain any information of such, and cycling is categorized under "Sports and Outdoor Activities", indicating that cycling is not considered a "serious" means of transportation. Also, only 300 meters of cycle path is completely separated from other traffic (Giffinger et al. 2014). The problem for the planners in the city centre is that they have to choose between car parking and cycle paths, whereas the cycle paths outside the city centre obviously are easier to plan for (Mäkinen 2014).

The share of cycling is also strongly related to local weather conditions, with significantly higher numbers in the summer time. However, the potential is big in the central area of Turku, since many people live within cycling distance to it. (Mäkinen 2014)

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6.5.3 Bus and light rail

In the Climate and Environmental Programme it was projected that the first trunk bus routes would operate in 2011 and that a common regional public transport organisation would be put in action in 2012. The Föli collaboration ("Turku Region Traffic") between Turku and five other municipalities was founded on 1 July 2014 (Föli.fi 2015). Today the regional bus routes connect the suburbs and satellite towns with central Turku, but are especially prevalent along the east-west corridor Kaarina-Turku-Raisio-Naantali. The planned light rail's second phase (to Raisio and Kaarina) will most likely thin out the existing regional bus routes. The local bus routes are more connecting the north-south corridor and inside of Ring road 40, reflecting the municipal borders.

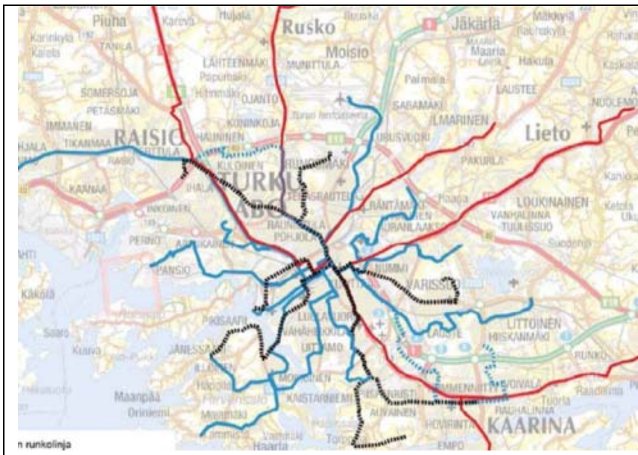

Figure 44: Trunk bus/main line (blue), Tram (black), regional bus (red)

Currently a new light rail is planned in Turku (see also section 7.2). They are currently (as of spring 2014) investigating potential users and how it will affect other modes of transportation, e.g. the car. According to Jaana Mäkinen from the city administration, the general perception of public transport is much better than that of e.g. cycling – which probably is a generation issue (Mäkinen 2014). The price of public transport in Turku is low compared to e.g. Jyväskylä (Giffinger et al. 2014), so if the price stays low after the improvement, there might be potential for changing the modal split. Also, since the transport performance of public transportation currently is rather low (10 mio. passenger-kilometres), compared to other PLEEC-cities.

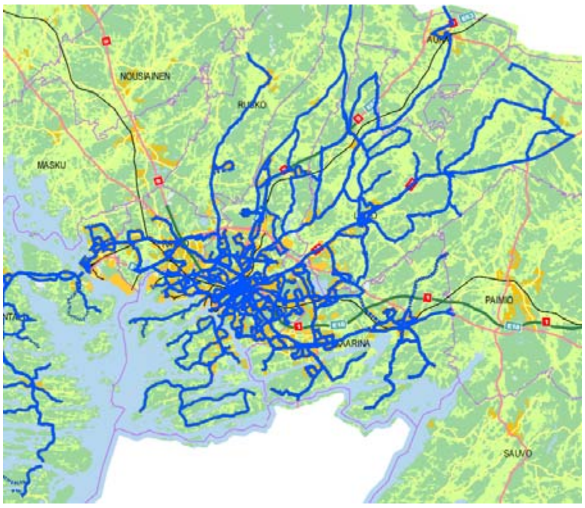

Figure 45: All bus routes in Turku, not including neighbouring municipalities (Opaskarrta.turku.fi 2015)

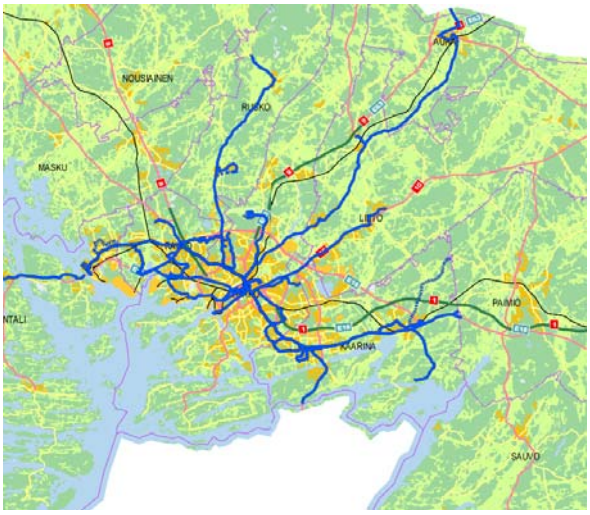

Figure 46: Regional bus routes in Turku (Opaskarrta.turku.fi 2015)

6.5.4 Rail

The railway lines towards Helsinki and Tampere pass through some of the suburbs/satellite towns, but without any stations. In the Regional Transport System Plan, it is proposed that the regional train lines should be reinstated and old stations should be reopened (Laaksonen 2011). Even though there is a railway line to e.g. Naantali today, it is not operated. The three stations in Turku are Turku, Turku Port and Kupittaa. The current lines are only single-track, including the line to Helsinki until Karis which is about half way.

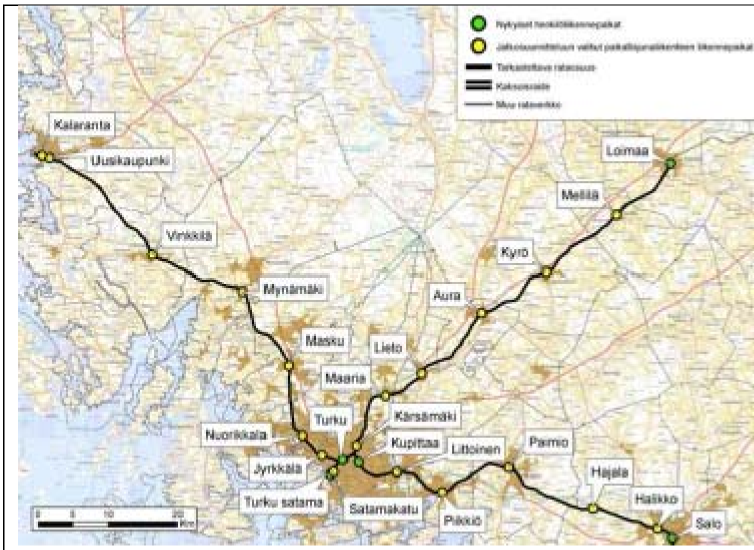

Figure 47: Current railroad network w/stations (green) and proposed stations (yellow) in the Regional Transport System Plan

7 Pilot projects

7.1 Skanssi – integrating energy supply and demand within a new district

Skanssi is a new development southeast of the city centre of Turku. It will be developed in close cooperation between Siemens and the City of Turku, along with another new development, Linnakaupunki (Castle Town). Skanssi is located between motorway 1 (Turku-Helsinki) and regional road 110.

7.1.1 Background, aims and ambitions

Skanssi is an area of varying terrain, covering about 85 hectares. There is existing building stock and a large shopping centre in the area. The aim of the planning of the Skanssi area is to realize a sustainable district (Turku.fi/skanssi 2015). The district is being planned for approximately 8,000 residents. Diverse user groups will be taken into account in the planning of the area (City of Turku 2014c). The area is scheduled for completion by 2030.

Skanssi serves the purpose of attracting new tax payers to the already growing municipality, but is also perceived as an avant-garde sustainability project, which potentially could give Siemens new knowledge and business opportunities and Turku a positive image. Skanssi is a greenfield development, but is "filling the gap" in the regional urban structure. The area will be connected by public transport; also the new light rail is projected to pass through, and is situated in cycling distance to city centre (approx. 5 km, cycle paths on almost the entire stretch). Skanssi is a pilot project for an integrated energy supply and demand system, and is, by and large, meant to operate self-sufficiently.

Figure 48: Aerial photo of the Skanssi area (left) and Vision (right), www.turku.fi/public/default.aspx?contentid=438438&contentLan=2&culture=en-US&nodeid=23#

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Skanssi, is planned to be sustainable and meet modern lifestyles, consisting of:

- “A versatile cityscape”
- “A flexible structure”
- Traffic-calmed living
- Sufficient district size
- Reducing private car traffic
- Promoting walking, cycling and public transport

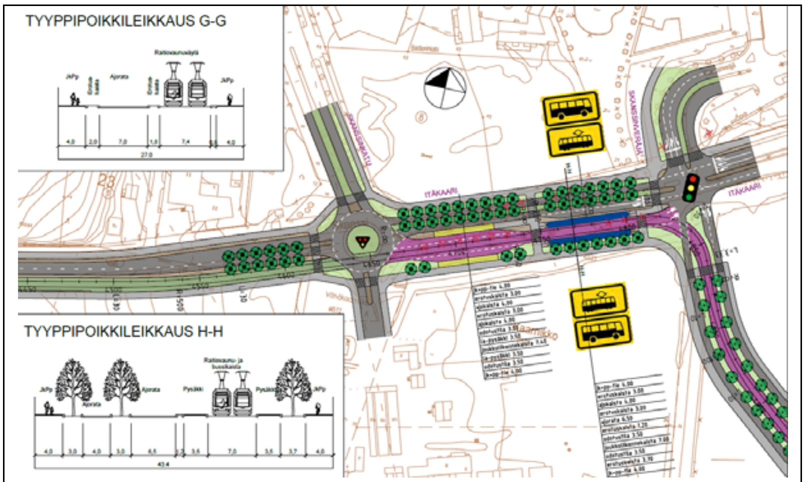

Figure 49: The light rail stop next to Skanssi Shopping Mall (Siemens & City of Turku 2012)

The built-up environment of the area will combine sustainable energy and traffic solutions, a functional community structure, the opportunities provided by IT and new types of services. (Turku.fi/skanssi 2015) The aim is a smart district that is comfortable and vital in spite of the new technologies (City of Turku 2014c).

7.1.2 Planning aspects

A main aim in Skanssi’s development is to apply solutions to decrease energy consumption and carbon dioxide emissions, but it also contains objectives in relation to social and biological sustainability. Practical measures include:

- Favouring public transport and functional pedestrian and bicycle traffic routes
- Supporting renewable energy sources, e.g. utilising solar power in buildings
- Aiming for a diverse urban structure (Turku.fi/skanssi 2015)

Surveys carried out in the area make up the foundation of the planning work. These include a nature survey, construction feasibility survey, technology survey, school needs survey, land use planning economics survey and traffic-related surveys. A student competition has been organised for the planning of the green areas, and various other types of student work will be carried out in the area. The results of the survey work will also be utilised in other planning by the City of Turku. (Turku.fi/skanssi 2015)

The planning solutions aim for cost efficiency and take life cycle costs into account. The suitability of various evaluation methods (LEED, BREEAM, Green City Index, PromisE) for setting the objectives is investigated during the planning (Turku.fi/skanssi 2015). The plans have been edited based on geological surveys to be more cost efficient. The future maintenance costs of the area have been minimised through efficient traffic routes and the resource-efficient planning of recreational areas (City of Turku 2014c)

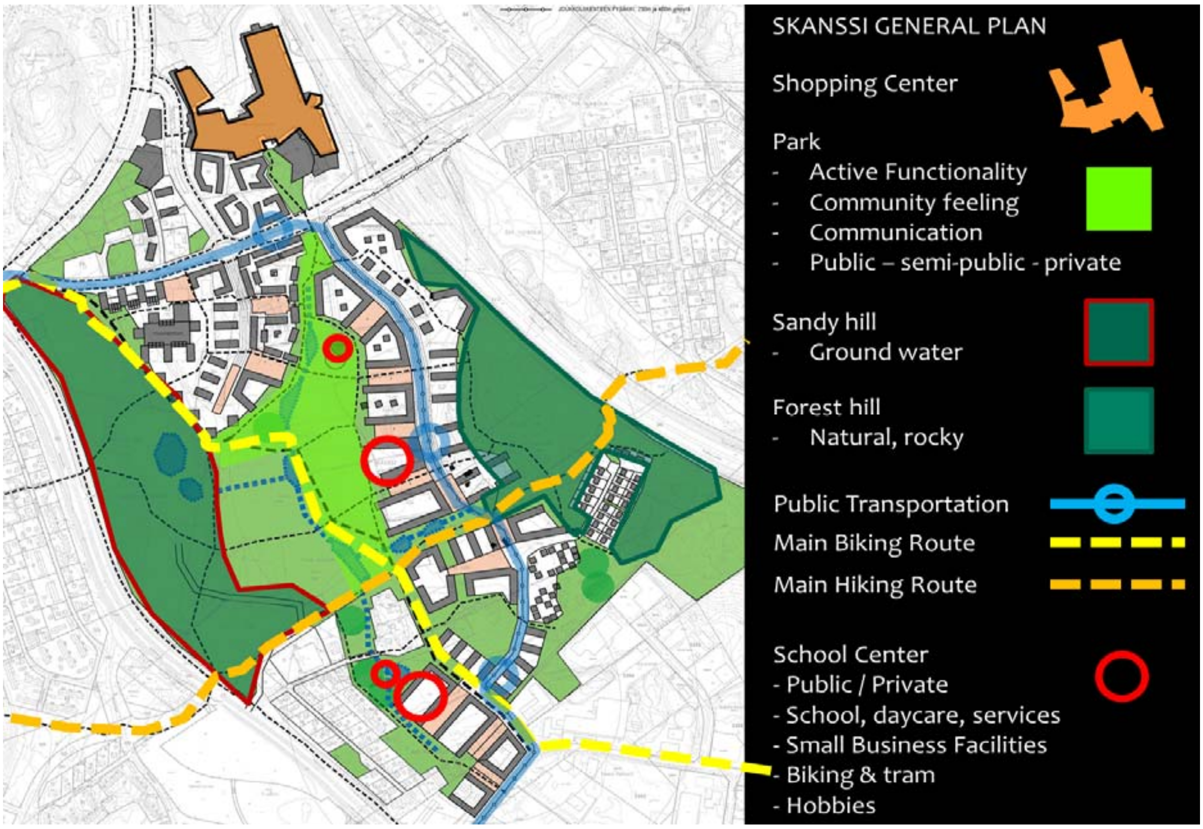

Figure 50: Three light rail stops and a north-south cycle route are planned (City of Turku & Siemens 2013)

7.1.2.1 Traffic

Main goals for the traffic planning include:

- Parking may not "control the city space" and external traffic should be kept away
- ICT solutions for consumers and traffic
- 25% less parking compared to other new developments (normal=0,5/household)
- Charging stations for electrical cars are important
- Making alternatives to the car more attractive
- Flexible public transport

(City of Turku & Siemens 2013)

The public transport solutions are a key to sustainable traffic, and they are supposed to be in use when the buildings are completed. However, the public transport trunk network requires a minimum of 5,000 residents in the area, as well as services (Turku.fi/skanssi 2015). The needs of the tram line network are also taken into account in planning. A system of jointly-owned cars is planned for the area. Large parking lots will be avoided. Another goal is to create extensive car-free recreational areas with safe pedestrian routes. (City of Turku 2014c)

7.1.2.2 Energy

In terms of energy, the overall objective is to focus on:

- Smart energy network, smart grid
- Local energy production
- “Smart Distribution Network”
- Continuous monitoring, documentation of results
- Encouraging and informing residents about sustainable habits

The heating system in the area will have its own system which allows to lower the temperature in the pipes and use intelligent optimisation based on “heat consumption profiles”, geothermal heat utilisation, solar power, district cooling, processing of surplus heat, small CHP plants etc. (Vaittinen 2014). The system will be connected to the existing district heating at a special exchange (DH), which can be used as a backup.

Turku Energy works with Skanssi in four phases; 1) specifying two-way DH network, 2) planning the network and pre-study of local production, 3) building the network, and 4) building local renewable production pilot plants (Vaittinen 2014).

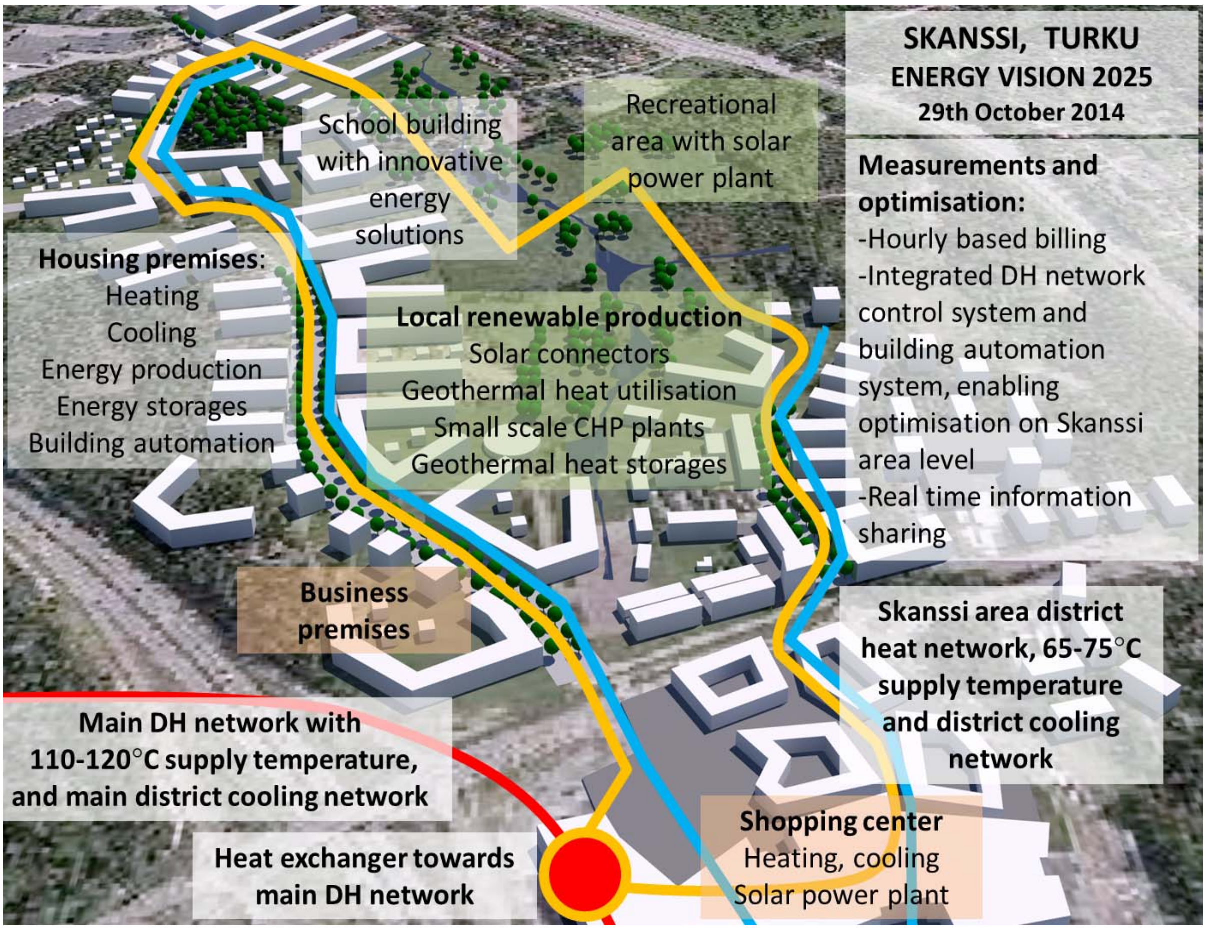

Figure 51: The vision for energy procurement in Skanssi 2025 (Vaittinen 2014)

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7.1.3 Stakeholders and their effective participation and roles

Siemens see their involvement in the Skanssi development as a business opportunity, a possibility of benchmarking midsized European cities. Siemens is a leading sustainability actor and has vast knowledge about it.

The area is planned in interaction with the residents. A working group with students and pensioners, people living nearby and those considering moving in has been established to support the planning of the district. Moreover, diverse insights are collected to support the planning work through public events and workshops. (Turku.fi/skanssi 2015)

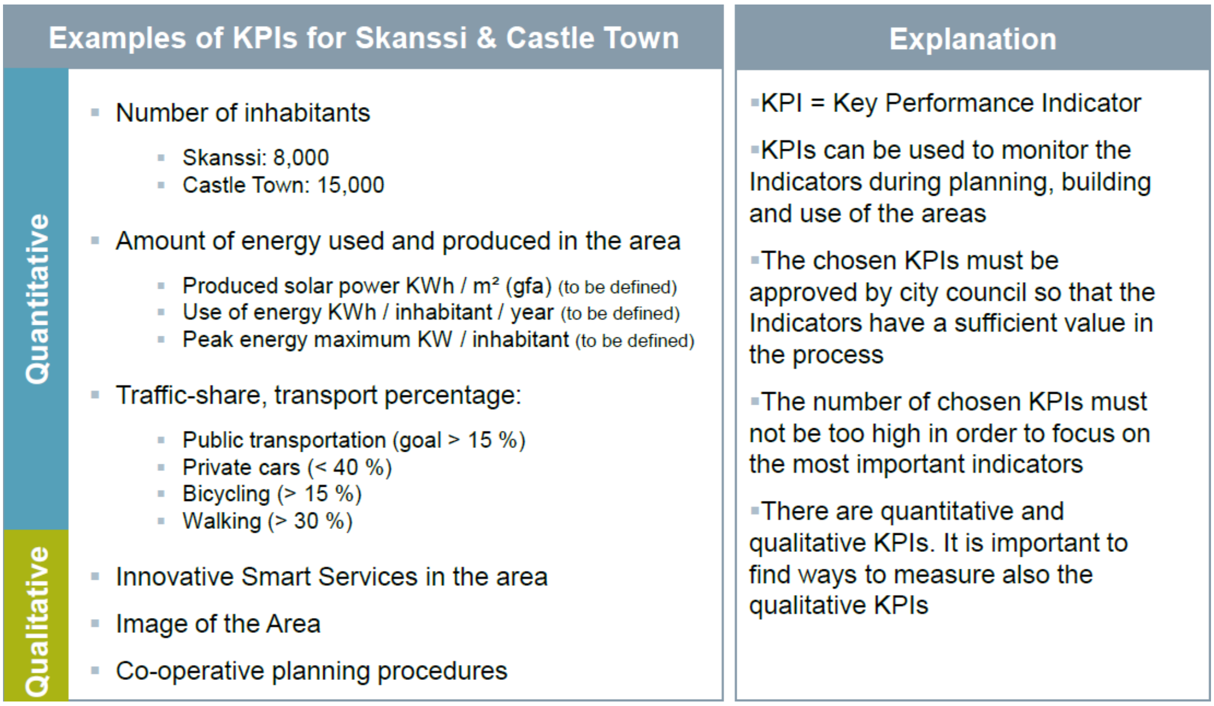

Figure 52: Key Performance Indicators for Skanssi (and Linnakaupunki) (City of Turku & Siemens AG 2013)

7.1.4 Success and structural effect on energy consumption

According to Siemens and City of Turku, cities of tomorrow have to leave the current values and ideas of materialism, and physical structures underpinning congestion, high energy consumption and centralized "physical" services (City of Turku & Siemens AG 2013). Skanssi, as a new urban development following these ideas, should be a part of a

- polycentric city structure,
- self-containing districts,
- intelligent transportation,
- modal integration,
- "inter-device" communication,
- highly mobile knowledge-based society,
- integrated communities
  (City of Turku & Siemens AG 2013)

For instance a central objective is to underpin an alternative modal split in the area compared to the rest of the city. Since the area is situated between two major roads leading to Turku city centre, public transport will however have a challenge competing with the car.

It is stressed that policies are important for the project to succeed, and not just market based initiatives and voluntary agreements. For the Skanssi area Siemens and City of Turku have established certain 'Key Performance Indicators' (KPI) as a tool for measuring the boroughs success to ensure the realization of the goals.

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7.2 Planned light rail – shift to public transport

The light rail is still in the planning phase and was in 2014 limited to three main lines in the first phase, from the main square (Kauppatori) to Runosmäki, Skanssi and Varissuo. In the beginning of 2015, it will be decided whether the project should continue, based on feasibility analyses (Turunraitiotie.info 2015).

The Impact Study from 2012 analysed routes to Runosmäki, Varissuo, Linnakaupunki and Kukkola, where a detailed evaluation of ecological and economic effects of a light rail transport system implementation was carried out:

- from a technology provider perspective
- to support further planning and funding discussions with different stakeholder groups.

Benefits of a light rail included:

- Additional capacity without building additional road lanes in transport corridors where more buses can no longer fulfil the transport demand.
- Can be adjusted to changing passenger numbers; therefore a transport mode which increases accessibility of the city centre without increasing congestion.
- Can be developed in stages from a street-bound tram to a Pre-Metro operated fully on its own right-of-way.
- Permanence of physical infrastructure gives citizens and businesses confidence in long-term availability of the service and makes location decisions easier.

7.2.1 Background, aims and ambitions

Turku's tram network was operated from 1890 until its final closure in 1972, when the system was substituted by bus service. The historical tram service covered mainly the city centre.
The new light rail is for Turku a part of their strategy of becoming sustainable through "green growth" and being a beacon for others. Siemens see themselves as a sustainability beacon, and see the project as business opportunity as well as a way of strengthening their position (Siemens AG and City of Turku 2012).

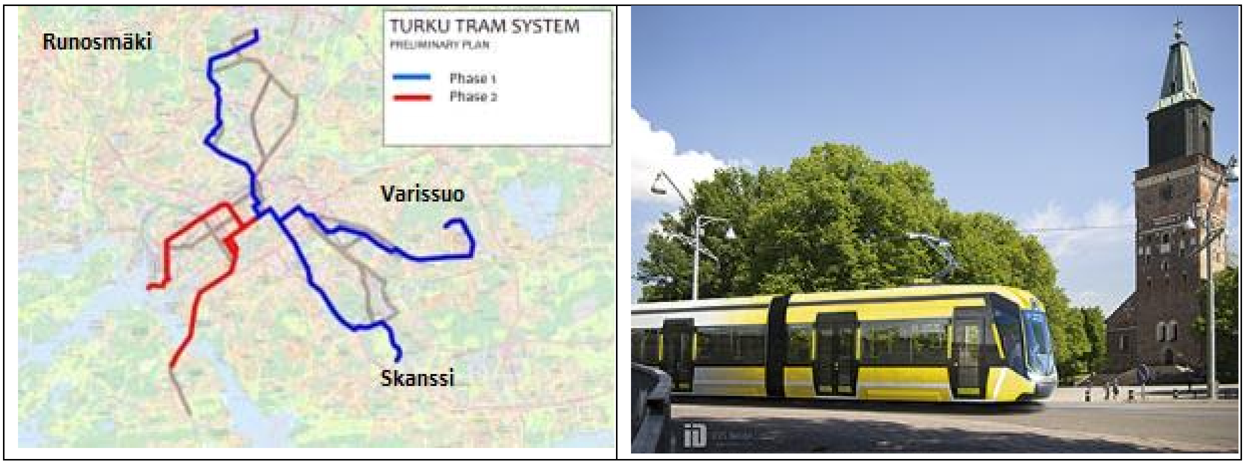

Figure 53: Planned routes for a new light rail system and illustration of a new light rail (Siemens AG & City of Turku 2012)

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7.2.2 Planning aspects

In the Impact Study, light rail is described as an attractive means of transportation because of its visibility, accessibility, regularity, possibility of independent trajectory, passenger volumes, and physical structures which ensures long-term operation. This aside, increased real estate value and retail revenue, and environmental advantages such as reduced carbon footprint and improved air quality in the city are key factors (Siemens AG & City of Turku 2012). In the Impact Analysis' conservative estimate, the total value of real estate along the lines is expected to increase by ~ EUR 480-850 mio.[1] (Siemens AG & City of Turku 2012).

The light rail is planned to have several intermodal nodes, where commuters are meant to utilize the possibility of combining light rail, bus and train.

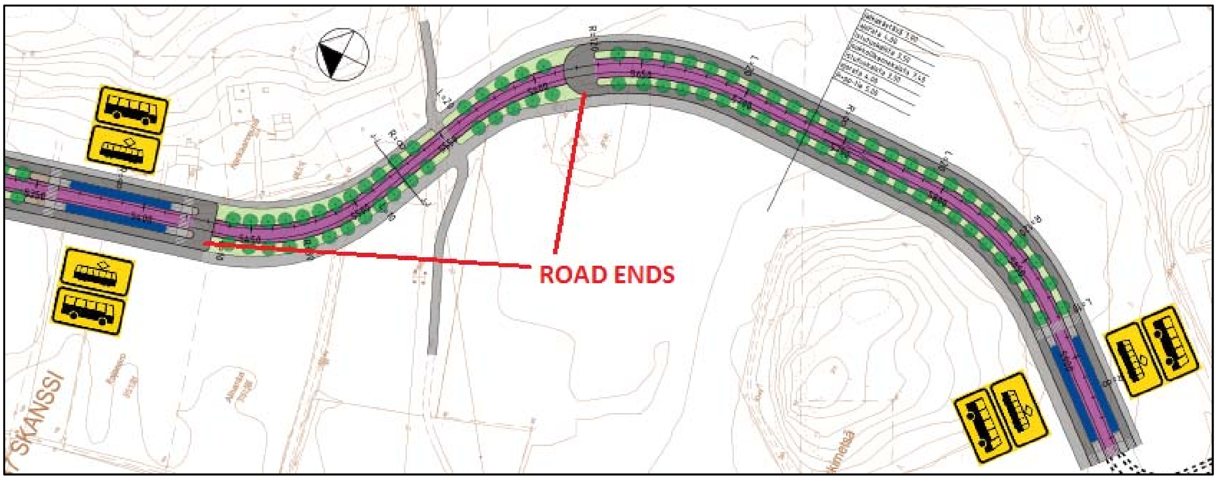

Figure 54: In Skanssi, the light rail will have prerogatives, and will be able to drive through the area, whereas streets for cars are designed as cul-de-sac roads (Turku et al. 2015)

7.2.3 Stakeholders and their effective participation and roles

For the City of Turku, the planning of the light rail is perceived as a strategic project being part of more general and comprehensive aims of urban development.
Siemens is part of the work about the Impact Analysis and the general cooperation between them and the City of Turku regarding the sustainability project.

Table 5: Expected cut in emission if the light rail is implemented (Siemens AG & City of Turku 2012)

Emissions	2025	2035
CO2 emissions	7%	11%
PM exhaust emissions	4%	8%
PM non exhaust em.	3%	7%
NOx emissions	8%	12%

[1] This analysis is based upon the trajectory, i.e. the corridor of the future light rail, not on where the actual stations be located (and therewith the real accessibility of the light rail).

7.2.4 Success and structural effect on energy consumption

In the Impact Study, three different scenarios were studied: 1) business-as-usual scenario with no light rail, 2) isolated system with light rail implementation but no accompanying policies, 3) integrated solution with light rail implementation and tailored policies for city and public transport development.

The 'integrated solution' is the alternative with the biggest impact:

- A reduction of 8 to 13% of traffic emissions can be reached in 2035.
- In a conservative scenario the total value of real estate in the city is projected to increase by approximately 480 – 850 million € in 2035.
- City capture of total value increase 6 - 7%.
- In addition to quantified impact: forward looking city image, accelerated city development and improved economic and socio-economic climate.

The main tailored policies accompanying the integrated light rail solution are:

- Integrate land use and traffic planning.
- Cooperate with all stakeholders: citizens, local business, public transport suppliers, NGO's etc.
- Give priority to public transport via traffic management.
- Stable project funding, negotiations with real estate investors early in the process

(Siemens AG & City of Turku 2012; Leskinen, Ahtiainen, & Brandt, 2014).

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7.3 Turku Masterplan RM35 – compact city development and polycentricity?

The Masterplan RM35 was introduced and described in detail in section 6.3. In this section we focus on its relation to energy issues and a more general evaluation of the RM35 as a tool for change and implementation.

7.3.1 Background, aims and ambitions

In order to prevent the fragmentation of the urban region, the regional land use solution must be of a compacting and supplementary nature while benefiting the existing infrastructure. With regard to land use, services must be produced cost efficiently and sustainably (RM35 2012)

7.3.2 Planning aspects

The detailed planning aspects of the RM35 where presented in section 6.3. Here we only want to have a closer look at the style of the main map, the 'Regional development and commuting structure' map (Fi: *Yössäkäyntialueen aluerakenne ja seudullinen kehitys*). In the map different centres are depicted (see Figure 55 with legend), proposing a – despite the strong urban core – a polycentric structure. Three transport axes are identified as corridors for urban/economic development. Two of the axes (east and northeast) are following the train lines, while the third one (northwest) is following the main highway and only in the part closest to the urban centre connected to the rail line. The strongest centres (red circles) are intended to be close to the existing urban area.

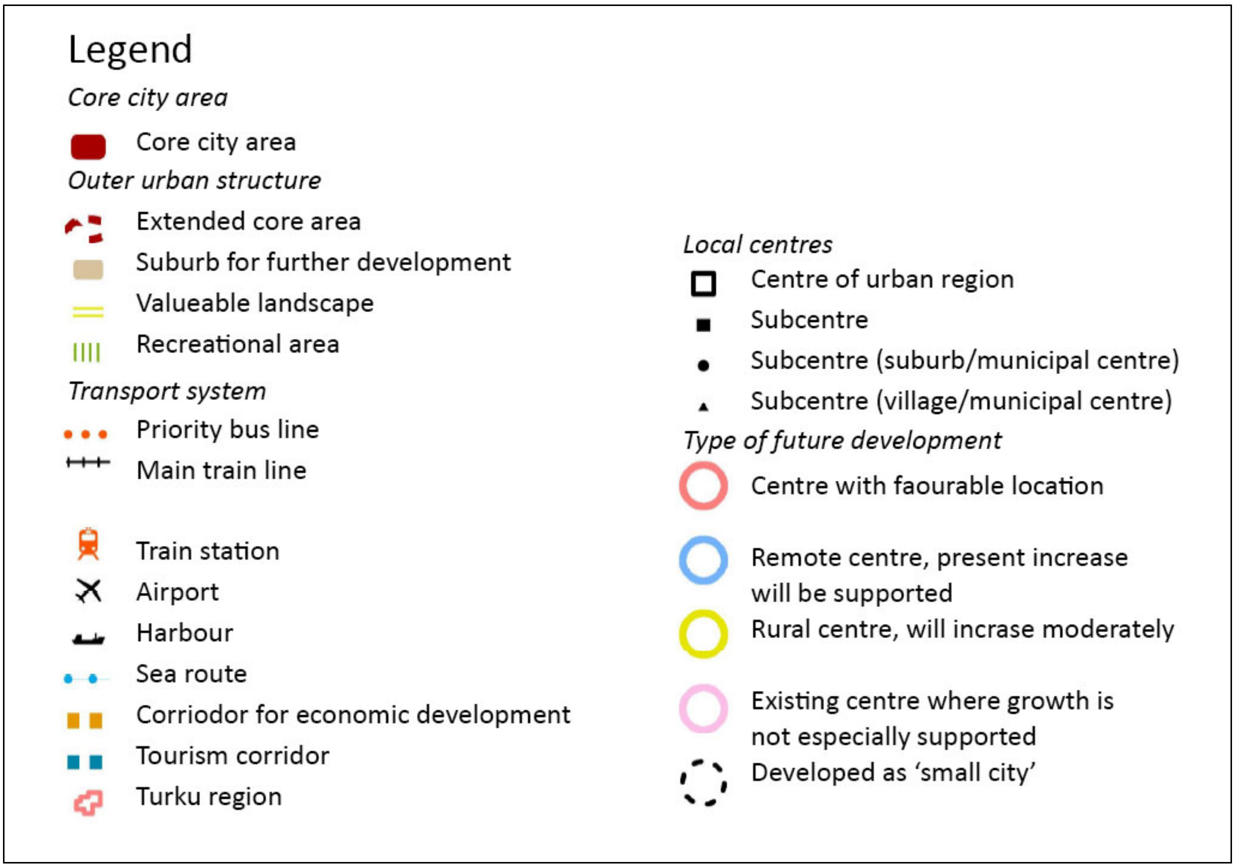

Figure 55: Legend from the Regional Structure Model 2035 (see section 6.3 for full map)

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7.3.3 Stakeholders and their effective participation and roles

The RM35 is a voluntary cooperation between the municipalities of the region, which is the normal – but challenging and not always successful – way in regional development as Finnish municipalities enjoy a broad autonomy in land use planning. The RM35 is not legally binding, but is expected to have great significance as it has attracted broad acceptance between the municipalities (NEW BRIDGES 2011).

The planning process emerged from the NEW BRIDGES project where stakeholders and politicians from the region where already involved to discuss future development. The planning process was rigorous scheduled and kept transparent (NEW BRIDGE 2011). The Steering Group which consists of high level municipal politicians, city administrators and regional level actors has coordinated the whole process and the regional council play an important role to coordinate the process (Veivo 2014). *"Individual residents as well as local stakeholders from different municipalities and regional authorities have had several opportunities not only to comment on but also to direct and evaluate the plan through the stakeholder meetings and public hearings organised"* (NEW BRIDGES 2011).

7.3.4 Success and structural effect on energy consumption

The Turku urban region is expected to grow in population in the coming decades (+75,000 by 2035). A vision for the urban development of the region is therefore an important step-stone to secure energy efficient development and avoid urban sprawl. The model is especially focusing on nodes for urban development which should be connected by high quality public transport. However, the current plan allows development in many centres and the future transport need of such a polycentric structure is not yet known. Also, the RM35 is a general picture while it is up the municipalities to make detailed plans. An ongoing coordination and adaptation of the plans between the municipalities will therefore be a decisive factor for the successful implementation of the plan.

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8 Summary of urban energy planning in Turku

Since industrialisation, Turku has been an important industrial town in Finland and still is. Today, after considerable restructuring of the industrial sector, most jobs (79 % in the city of Turku) are within services. Besides its economic base, Turku also is experiencing a change in the former prevailing urban sprawl, which characterised urban development since the 1950s. The city is densifying and promoting sustainable urban development, though at a regional scale with several growth centres.

Finnish municipalities have extensive self-government and a wide range of possibilities to steer its development, while Finnish regions play a coordinating role. However, the city of Turku and its neighbouring municipalities agreed on a joint vision for the region's future development, the "Structure model 2035", focusing on more compact urban development along public transport corridors. This is especially important in the light of future population increase in the region, driven by rural to urban migration in Finland.

The city owns its own energy company (Turku Energia) selling electricity, heat and cooling (district energy). Public transport is organised by the Turku Region Traffic Authority, a cooperation between Turku and its neighbouring municipalities.

The city has a strong focus on climate and environment, which culminated in the adoption of an Environment Programme in 2009. Currently the city is working on a follow-up programme, incorporating however an even broader perspective under the header of "resource wisdom". Also other Finnish cities are working on such programmes.

However, economic growth plays an important role for the city and the city is promoting itself as a gateway in the Baltic Sea. Growth is intended to be 'green', and the city aims a being carbon-neutral by 2040. A key challenge will therefore be how this intended growth can be sustainable especially when it should be coupled with stable or even increasing welfare.

The city opens up for pilot projects, e.g. in the area of Skanssi, where new energy system solutions will be tested (opposing the traditional district heating system). However, also Skanssi is built on green fields (which though could be called in-fill from a regional perspective) and close to an existing highway which will make car travel easy. The city is also working on improving public transport (e.g. with a planned light rail) as well as conditions for bicyclist. These measures are however mainly focused on the urban core.

9 Perspectives for thematic report (D4.3)

There are three issues arising from the Turku case which could be relevant in a broader context for the thematic report

1. Working with energy efficient regional urban structure (e.g. regarding urban sprawl) in a low density country and on a voluntary cooperative basis
2. Keeping the industrial base in a city facing deindustrialisation and aiming for energy efficiency

3. Decentralisation of energy supply enables new forms of settlements with the example of Skanssi

Energy efficient regional urban structure – compact city and polycentricity
Turku has experienced extensive urban growth since the 1950s (like many other European cities). While the municipality of Turku is stagnating since the 1970s, the city region has grown further, resulting in large urban area and a dispersed settlement structure in the fringe (though possibly less dispersed than other Finnish city regions). The urban structure cannot be changed in the short-term, however, long term strategies can stop a further dispersion and increase density in particular areas which could reduce energy use for transport in the future.

The "Structural model 2035" is thereby a good case how to deal with this challenge, outlining different scenarios for the urban development and transport structure of the region.

A key challenge might also be the traditional low density in Finland. Similar to Estonia, the urban structure is much dispersed and long-commuting distances are normal. However, the current trend to move to the bigger cities can also be a chance to work on that, because, as one interviewee said, "Finland is finally urbanizing".

Industrial base and energy efficiency – integration in sustainable planning
Despite industry has lost most of its importance in the city, it seems still an important sector for the city and not least for the wider region. In an energy perspective, industry is though important, e.g. as big customer of the district heating system, which makes district heating in some areas feasible. Example of many places are knows where such synergy effects are exploited. However, industrial development can also be seen as a hamper for the sustainability goals of the city. The waste incineration plant in Turku was closed down, also because its old technology did not fit with the general goals of environmentally friendly development in the city. A sustainable industrial development has therefore also been seen in the light of new, renewable energy sources and how these are distributed.

The question here is the 'spatial' aspect or how this topic can be related to urban planning, meaning the planning or restriction of functions on particular locations.

Decentralisation of energy supply enables new settlement structures
The main energy distribution system for heating in Turku, district heating, is, because of its infrastructure demands closely related to urban form and density (of users). However, new technology can impact this relation. New energy efficient housing is demanding so little energy that it makes traditional district inefficient. Besides that, renewable energy in the form of electricity also enables different heating technologies to be sustainable. In sparsely populated areas, different forms of individual heat pumps can be applied. In a more urban context, as for example in the area of Skanssi[2], cluster solutions with a decentralised, low-energy heating grid for a specific area/district can take advantage of energy efficient (or even energy producing) housing and still organise it

[2] Another example for cluster solutions of a decentralised heating grid is the new urban development of Vinge in Frederikssund, Denmark, about 30 km northwest from Copenhagen. This case was discussed during the PLEEC Energy Efficiency Forum in Copenhagen, 29 October 2014 (see www.pleecproject.eu).

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around a bigger entity to ensure energy security. However, the closeness to the central district heating system is less important, while the internal structure of the particular area (suppliers and users of energy) is more important. Together with new transport solutions this can change the spatial conditions for sustainable urban development, especially regarding new developments.

10 Lessons and links to other PLEEC work packages

The case study report illustrates several interesting general tendencies which should be discussed in the broader context of PLEEC. These tendencies could be illustrated with several gradients:

Investment size	Small	⟷	Big
Finance models	Private	⟷	Public
Time perspective	Short term	⟷	Long term
Energy management	Individual	⟷	Collective
Energy system	Decentral	⟷	Central
Energy supply	Local/Regional	⟷	Regional/Global
Energy paradigm	Reducing demand	⟷	Increasing renewables
Socio-technical focus	Behavioural	⟷	Technical
…	…	⟷	…

Not all of those are gradients only, sometimes both 'ends' ca be with the same system. The concrete choice though is subject to contextual issues and no general best solution can be recommended. E.g. in the new urban development of Skanssi, a decentralised heating system is planned, opposite to the existing central district heating system which almost all buildings in Turku are connected to. For the existing buildings the system is efficient, however, for new low-energy (or even zero-energy) housing, the traditional district heating systems cannot be run cost-efficient because of the low heating demand. So in the context of new buildings a decentralised, partially independent system is an advantage, while this is not the case for the existing built-up area in Turku.

Many of these gradients also have a structural dimension, meaning that they are very strongly related to the historical path of the city and the current setup of the energy planning and governance system. A significant change might therefore also make a structural change necessary. In PLEEC's WP6 we should therefore also include an extensive discussion of the context, when discussing good (and bad) practices. Only then we can discuss the transferability of solutions and the lessons to learn.

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11 Figures

12 References

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