Urban energy planning in Tartu

[PLEEC Report D4.2 / Tartu]

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PLANNING FOR ENERGY EFFICIENT CITIES

Deliverable 4.2 / Tartu

Urban energy planning in Tartu

20 January 2015

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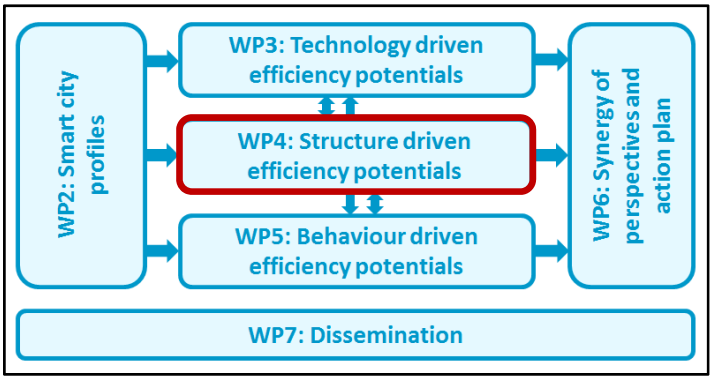
Abstract

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

The Estonian planning system allots the main responsibilities for planning activities to the local level, whereas the regional level (county) is rather weak. That implies a gap of cooperation on the regional level, leading to dispersed urban development in suburban municipalities and ongoing urban sprawl in the vicinity of Tartu. This development appears contrary to the concept of "low-density urbanised space" as formulated in the National Spatial Plan "Estonia 2030+" (NSP) as the central spatial development concept for Estonia and also to a compact and intensive city development as formulated in the Master Plan of Tartu.

Since Tartu has no relevant big industries, the main employers are the municipality and the university, energy related challenges occur from transport and residential (district) heating. The modal split shows big differences between journeys within Tartu and journeys between Tartu and its vicinity. While the first shows a high share of public transport and walking, the latter includes a high share of car use, especially in work related travelling. This is closely related to the issue of ongoing urban sprawl and increasing car ownership. Although the Tartu City Transport Development Plan 2012-2020 points very clearly at the weaknesses in the transport system of Tartu, the plan is not addressing cross-border issues, like e.g. regional commuting.

The highest share of emissions is allotted to energy production. In terms of energy sources Estonia is very much dependent on imports like oil and gas and the Estonian electricity production is to more than 90 % based on Estonian oil shale. Thus, efforts towards higher energy efficiency – at least on the national level – are rather driven by ambitions to decrease fuel dependency than merely efficiency objectives. That illustrates the need for a transition of the energy supply and generation system in Estonia from two forces: decreasing fuel dependency and a shift to an increasing use of renewable resources.

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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

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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.

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 (Fertner et al., 2014). Second, a field trip to Tartu was planned, beginning with discussions at the joint meeting in Turku 25th – 28th March 2014 between researchers and representatives of the cities. Following that, the field trip to Tartu was organized, combining study tour and interviews with key stakeholders (see Table 1). The interview guide can be found in Deliverable Report 4.1 (ibid.).

Table 1: Field study agenda in Tartu, 5-6th June 2014

Thursday, 5th June 2014			**Hosts / interviewee**
10:00	12:00	Study tour in the city	Jaanus Tamm, Kaspar Alev (City of Tartu)
		Lunch	
13:00	16:30	Urban, Transport and Energy Planning	Department of Urban Planning, Land Survey and Use, City of Tartu: Mati Raamat, Indrek Ranniku, Jaanus Tamm, Kaspar Alev
Friday, 6th June 2014			
09:00	10:30	Energy supply	Fortum Tartu: Riho Kõks, Margus Raud

The main documents which were used as sources to draw a picture of the energy and transport policy in Estonia on the national level are:

- National Spatial Plan "Estonia 2030+" (NSP) (Ministry of the Interior, 2013)
- National Renewable Energy Action Plan (NREAP) 2020 (Ministry of Economic Affairs and Communications and Ministry of the Environment, 2010)
- Estonian Environmental Strategy 2030 (Ministry of the Environment, 2007)

On the regional level the Tartu County Development Strategy 2014-2020 (Tartu Maavalitsus Konsultatsiooni- ja koolituskeskus Geomedia, 2012) is only marginally included. Currently Tartu is preparing a Sustainable Energy Action Plan (SEAP) within the EU's "Covenant of Mayors" movement which is supposed to be approved by mid of 2015.

On the local level the main documents which were examined in terms of urban planning and energy and transport policy are:

- Development Strategy "Tartu 2030" (Tartu City Government, 2006)
- Master Plan of Tartu (2006) (City of Tartu, 2006)
- Tartu City Transport Development Plan 2012-2020 (Tartu City Government, 2011)

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

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team, 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 Tartu

Tartu is located in the centre of Southeastern Estonia, about 185 km southeast of the capital Tallinn. Tartu lies on the Emajõgi ("Mother river"), which is now planned to be used for a district cooling plant.

With about 100,000 inhabitants Tartu is the second largest city in Estonia. The municipality's area is roughly 40 km^2. The University of Tartu is the oldest university of Estonia, it was founded in 1632. Thus, Tartu is considered as the intellectual centre of Estonia which is also reflected by the 20,000 students enrolled in either the University of Tartu or the Estonian University of Life Sciences[1], both located in Tartu.

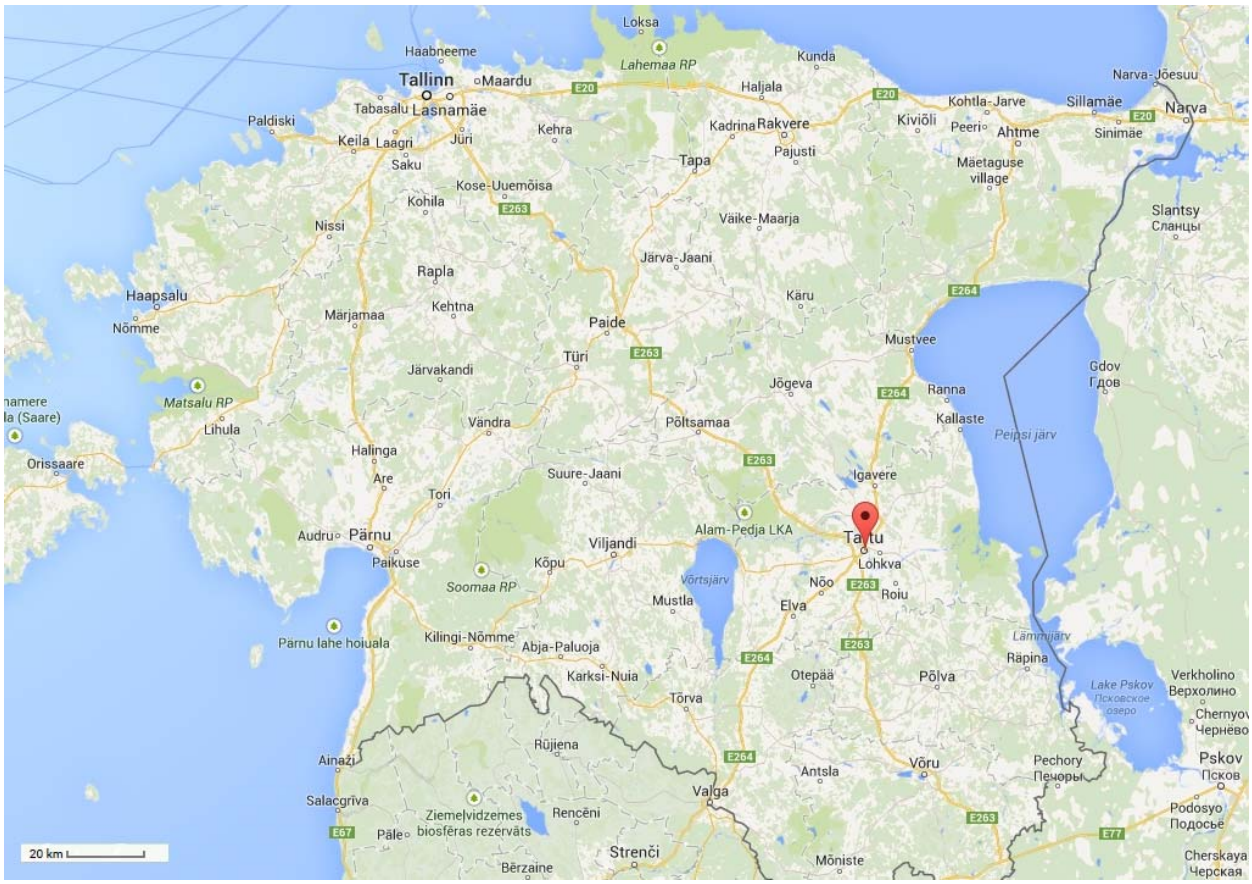

Figure 1: Location of Tartu in Estonia (google maps)

As Tartu is situated between Latvia and Russia it is part of the so-called Tallinn – Riga (Latvia) – Pskov (Russia) triangle (Ministry of the Interior, 2013).

Tartu is seen as "second city" behind Tallinn in Estonia.[2] The main employers are the universities and the municipality (incl. hospital); furthermore Tartu serves as regional centre with public services and as commercial centre.

1 see www.studyinestonia.ee (July 2014)

2 Interview with Department of Urban Planning, Land Survey and Use, City of Tartu, 05.06.2014

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Table 2: Tartu key numbers (Giffinger et al., 2014)

Key parameter	Count	Year
Inhabitants	97,847	2014
Households	42,082	2014
Household size	2.33	2014
Number of dwellings	35,602	2014
Inhabitants per dwelling	2.75	2014
Number of residential buildings	8,617	2014
Number of dwellings per residential building	4.13	2014
Administrative area in km²	38.8	2013
Settled area in km²	28.81	2013
GDP per capita in Euro	17,000 (national)	2011
Average annual household net income in Euro	12,000	2012

Estonia is divided into 15 counties, each county consists of urban municipalities (‘*linnad*’) and rural municipalities (‘*valdade*’). Tartu is part of Tartu County (‘*Tartu maakond*’ or ‘*Tartumaa*’).

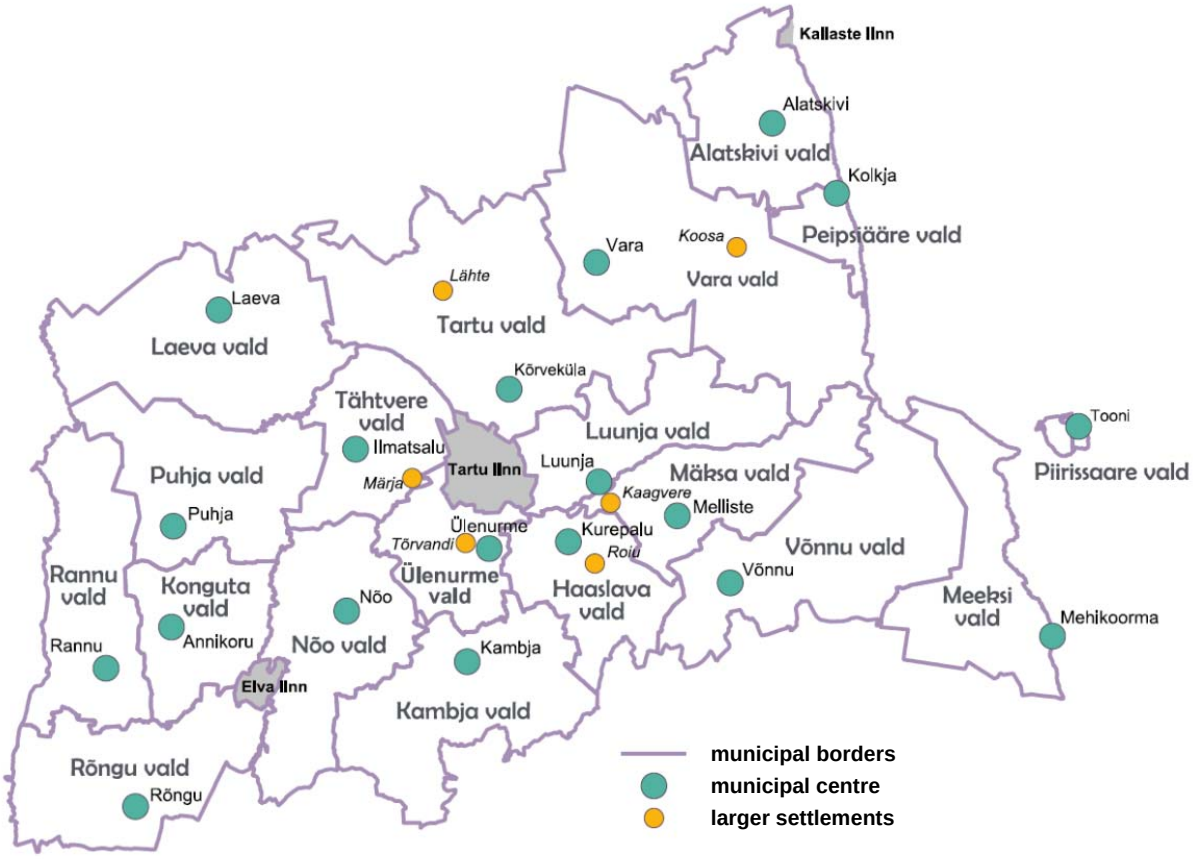

Figure 2: Tartu in Tartu County (Tartu Maavalitsus Konsultatsiooni- ja koolituskeskus Geomedia, 2012, p. 28)

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Population

The average population density of the city is about 2,500 inhabitants/km^2. The following maps illustrate that dense settlement areas are rather concentrated within the municipal boundary of Tartu, but also that less dense settlements continue beyond the city's municipal area.

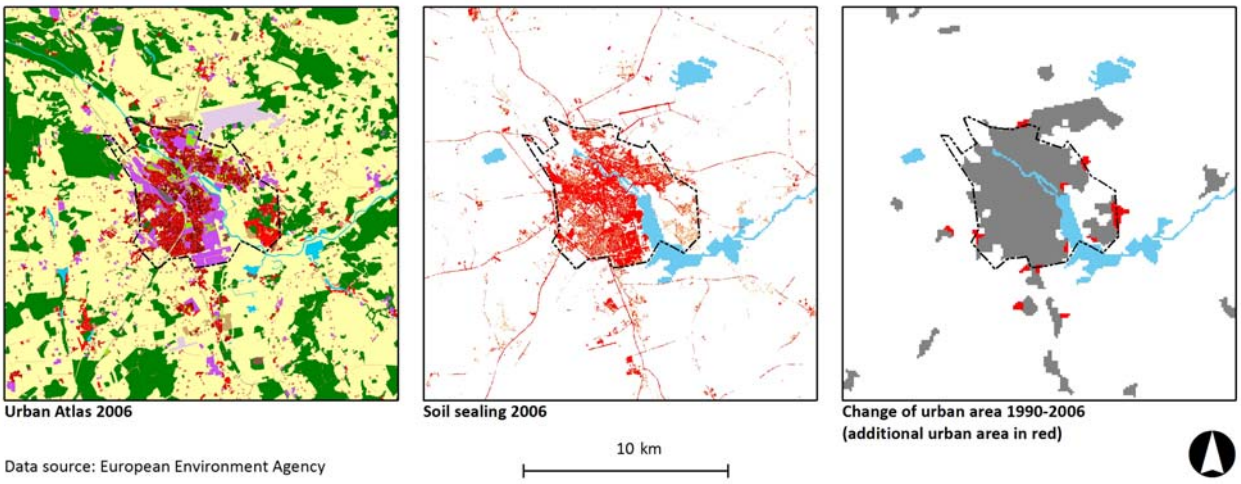

Figure 3: Land use in Tartu area 2006

The district Annelinn (Figure 4, #16) has by far the highest population of all districts of Tartu with more than one quarter of the city's population living there and a population density about twice as high as the average of Tartu.

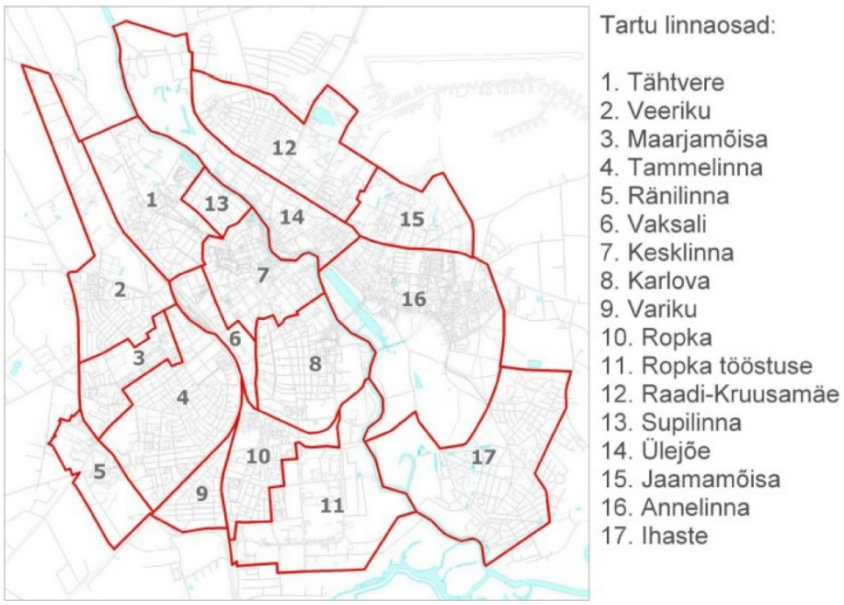

Figure 4: Tartu city districts (Tartu City Government, 2011)

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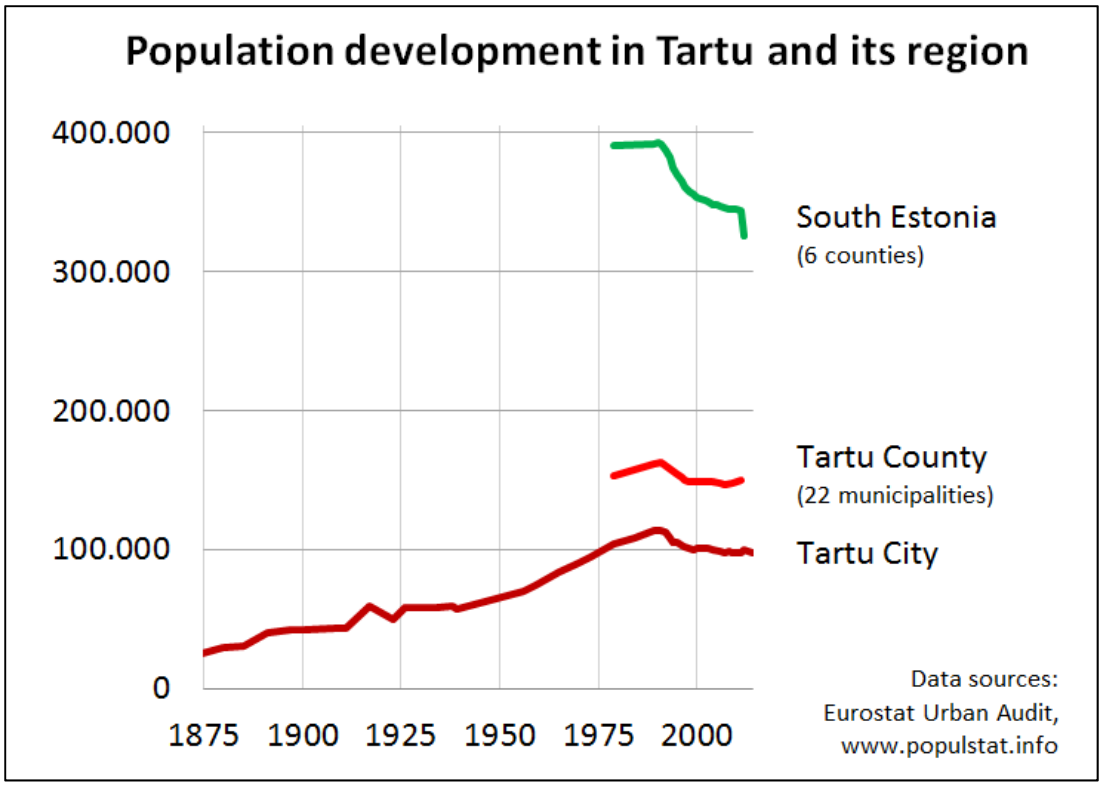

Figure 5: Population development in Tartu and its region 1875-2014

During the Soviet period Tartu was an instantly growing city, the population almost doubled up to about 114,000 inhabitants in 1990, due to immigration from other Soviet republics and natural population growth. After the independency of Estonia in 1991 the population decreased, even though the natural growth is positive, down to about 101,000 inhabitants in 2000 and about 98,000 inhabitants in 2014.

Tartu County, which consists of Tartu and 21 other municipalities in its surroundings, gained however a little in population in recent years. Seen in a regional perspective this means a further concentration of population in and around Tartu while the rest of Southern Estonia lost on average 25 % in population since 1991.

Economy

Tartu is an administrative and service centre, also including trade and tourism, in Southern Estonia. Within the municipality, the service sector has by far the most employees, and many of those work in public administration. Compared to Estonia in general Tartu has only relatively few employment in industry, however, the construction sector is stronger represented.

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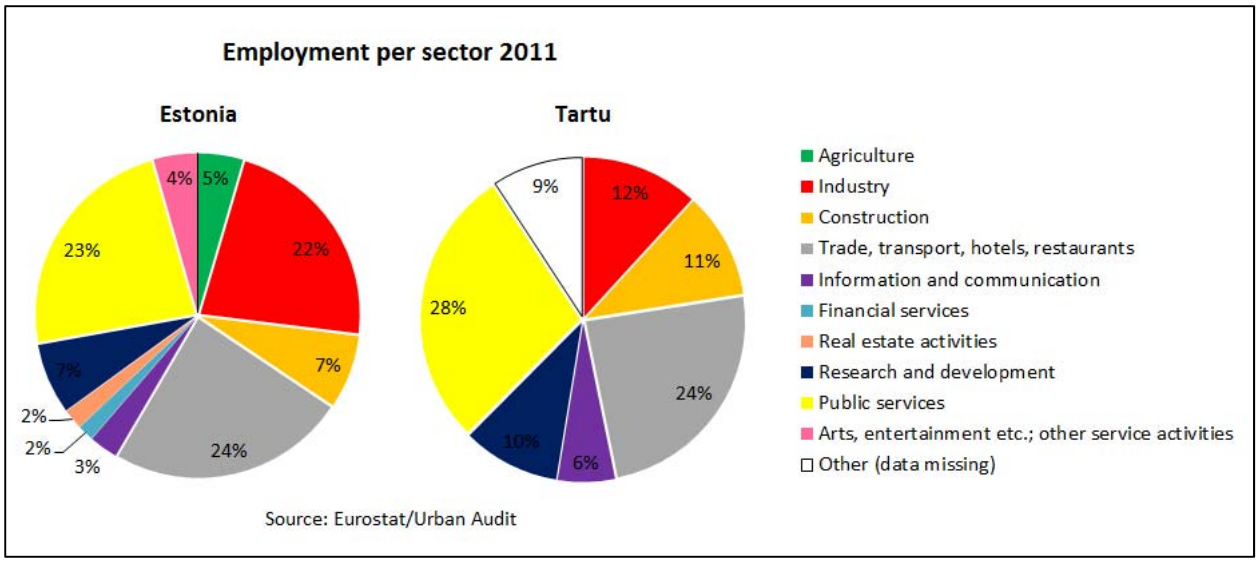

Figure 6: Employment per sector in Estonia and Tartu, 2011

Tartu is also an employment centre in the region, offering more jobs than there are economically active persons living in the city. With about 3,500 employees, the University of Tartu is one of the largest employers.

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4 Historical urban development

Today's appearance and layout of the city started to develop after the great fire in 1775, after which the town's borders were shifted in 1787. Tartu basically lost its fortress and more than two thirds of the wooden houses were destroyed by the fire. The reconstruction plan intended a well-planned construction of the town, including the straightening of the medieval street grid. Besides the New Town Hall and the Stone Bridge, which became the architectural dominants of the market square, the new University building became another compositional landmark next to the Town Hall.

Figure 7: Tartu Town Hall Square, 1925 (via Wikimedia Commons, http://commons.wikimedia.org/wiki/Tartu)

Furthermore the outskirts of the town started developing, mainly along the descending roads heading outside the city, along the old valley of Emajõgi.

About one century later, in the 1870s, the number of business enterprises and industries increased remarkable in Tartu, coming along with the permanent abolition of the medieval guild system and the implementation of the new Russian town law in 1877.

In the second half of the 19th century Tartu's population increased from 12,600 to 40,600 due to immigration, of mainly Estonian rural workers, from the hinterlands of the town.

In 1876 the railway line between Tartu and Tapa in Northern Estonia was completed and by the end of the 19th century Tartu was also connected to Riga (Latvia) via railway. This was an important milestone in the city's development: On the one hand it facilitated further and faster trade connections, on the other hand it affected the development of Vaksali district (Figure 4, #6), where Tartu's main train station is located, remarkable. The opening of the railway connection between Tartu and Pskov (Russia) in 1931 increased the importance of Tartu in railway traffic significantly.

In the 1920s the city territory expanded again notably due to the incorporation of the surrounding manors and their land (see Figure 9). (City of Tartu, 1999, pp. 4–7)[3]

Estonia became independent after World War I. Prior to that Tartu was part of the Russian Empire. But again in 1940 Estonia was annexed into the Union of Soviet Socialist Republics (USSR).

During World War II large parts of Tartu were destroyed, including the centre on both sides of Emajõgi. Many of the green spaces in the city remain from former stone buildings, which were destroyed in the war, their ruins were removed, but not rebuild or replaced by new buildings.

After the war a major Soviet bomber base was constructed on Raadi Airfield northeast of Tartu. For this reason Tartu became a 'closed city' for foreigners for several decades. The air base was closed in the 1990s.

In 1956, during the period of Nikita Khrushchev, instead of "architectural excesses", like the neo-Classicist "Illusioon" ("Komsomol") cinema and dwellings in the city centre and on Riia Hill, only "box-shaped buildings with the most essential standard details" were allowed to be built. These standards came up "in order to more rapidly satisfy the need for new flats". By this means about 25,000 m^2 of new living space was built every year and about 70 % of the residents of Tartu moved into these apartments between 1960 and 1990. (Salupere, 2013, p. 44)

Residential building construction was concentrated on the edges of the town. The biggest new residential area was the "city's bedroom" in Annelinn district (Figure 8, #16). The construction of prefabricated Soviet-style blocks began in the late 1970s.

Figure 8: Annelinn district (field work, June 2014)

The residential building construction came along with establishing of the district heating system in Tartu in the 1970s.

Across the river from Annelinn a new industrial district was built in the southeast corner of the town. Furthermore, due to the needs of speed and saving money many of the stone houses in the city centre were elevated by one storey, which was simply added by lifting the roof. (Jauhiainen, 2003a, p. 39; Salupere, 2013, p. 45)

The incorporation of areas of Soinaste Village, the Tuberculosis Sanatorium, the university and surrounding collective farms in 1962 marked the first post-war expansion of the city border. Figure 9 illustrates that in the 1960s and 1970s the city expanded especially across

[3] Based on a translation of Martin Kukk, student at the University of Copenhagen; see Annex 1 for full version of the translated chapter.

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the river towards southeast (Annelinn and Ihaste district) as well as towards northwest (Tähtvere, Veeriku and Ülejõe district).

The constructional development of the town during the Soviet period since 1976 was mainly guided by Tartu's general plan; the plan determined the town's border how they are until today. (City of Tartu, 1999, pp. 4–7)[4]

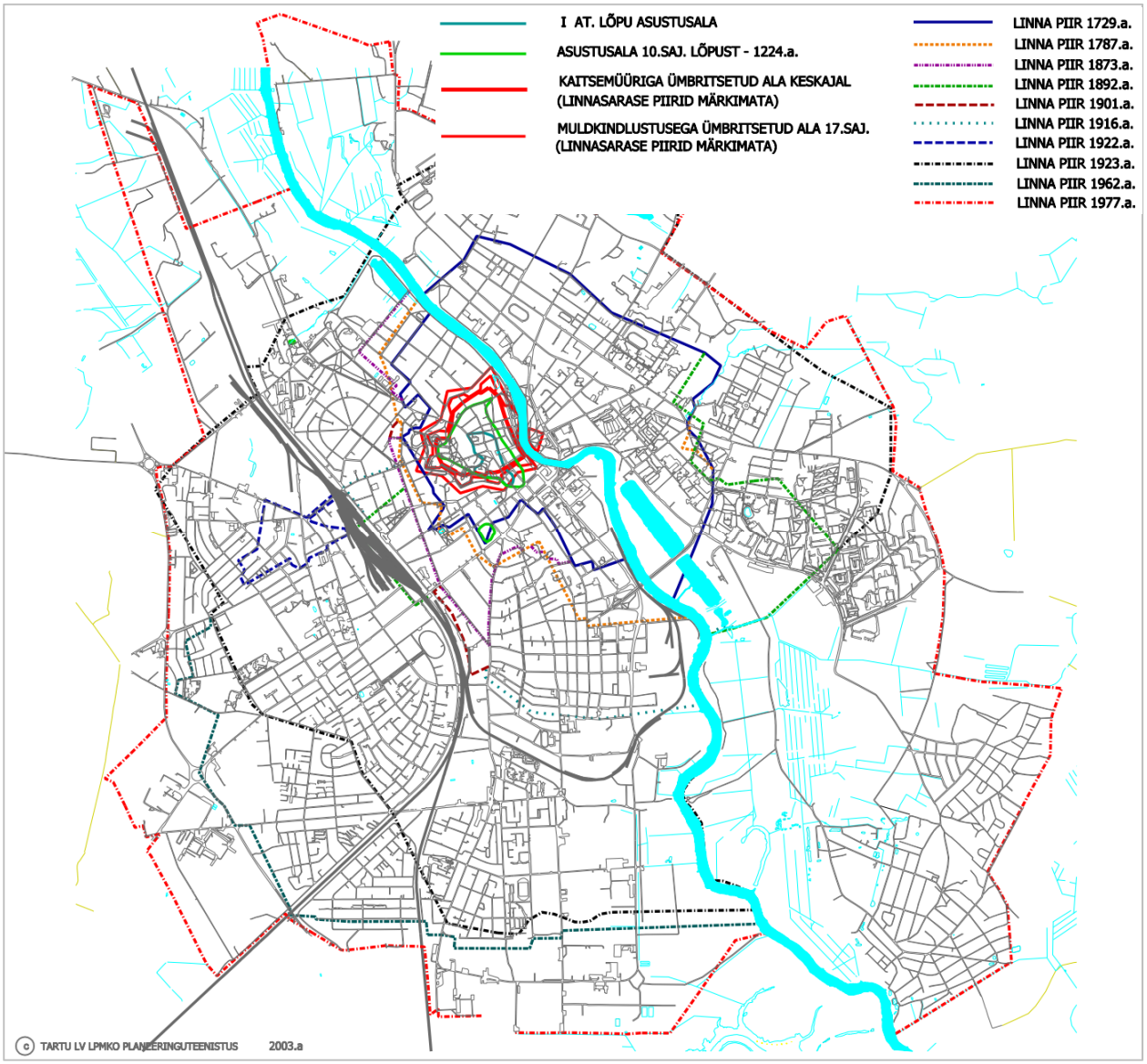

Figure 9: Urban and territorial development of Tartu until 1977 (City of Tartu, 2003)

The last twenty years of the Soviet period, between 1970 and 1990, were characterised by a 'building boom' of residential buildings, health and educational institutions, more than in the previous 200 years together, as well as production space and related administrative buildings and leisure facilities. (Jauhiainen, 2003a, p. 36)

During the Soviet period a number of 'experimental' industrial enterprises came up in Tartu, leading producers with the right to create new products. This generated "more gener-

[4] Based on a translation of Martin Kukk, student at the University of Copenhagen; see Annex 1 for full version of the translated chapter.

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ous financing, higher wages, the construction of showy buildings, and also export to foreign countries". (Salupere, 2013, p. 45)

Towards the end of the Soviet period Tartu gained a noteworthy share of about 10 % of the Estonian SSR's industrial production, especially due to machine and equipment building, and light industry. Estonia's independency in 1991 was followed up by the closure of many industries and hence the loss of a large number of jobs.

The historical urban development of Tartu is hence, among others, strongly related to its socialist background and the former influence of the Soviet Union. Urban planning was particular relevant as towns played an important role in the organisation of the economic development during the socialist period. Thus, urban planning was part of the organisation of the society and subject of hierarchical planning practices entailing particular land-use patterns (e.g. suburban neighbourhoods, industrial areas in the outskirts). (Jauhiainen, 2003a, p. 36)

Nowadays' urban structure of Tartu reflects a town following "the socialist pattern of a town built partially before the socialist period, reorganised during socialism, and redeveloped after socialism". (Jauhiainen, 2003a, p. 40)

5 Evolution of national and local energy planning

5.1 Overview of the Estonian planning system

The legal basis for the Estonian planning system is the Planning Act of [2003]. The Estonian planning system is basically organised in four planning levels:

- national level,
- regional level (15 counties),
- local level (215 municipalities)
  - general plan (master plan) and
  - detailed plan.

The main planning document on the **national level** is the National Spatial Plan "Estonia 2030+" (2013).

Figure 10: The 22 municipalities of Tartu County with Tartu municipality in the centre

On the regional level Estonia is divided into 15 counties with a **county plan** for each. The current plan for Tartu County is more than 10 years old and therefore does not include many up-to-date issues. In 2013 the drafting process for a new county plan started, implying the aim to establish more connections between national, county and local plans.

The county level with the county plan has actually the weakest competences as it operates in-between the competences of national ministries and local governments.

Regarding the allocation of planning competences the main responsibilities for planning activities are hold on the **local level** at the 215 municipalities. Municipal areas in Estonia are quite narrow confined, and thus, the local planning competences have a very limited scope of action, tied to the municipality's core territory.

The main planning instrument is the master plan (former 'general plan') for the city. It has to be approved by the county and with the neighbouring municipalities. In Tartu there are four different plans resp. planning layers outlining the city's planning objectives and principles:

- conditions for buildings (Tartu linna arengukava 2013-2020),
- functional zoning for land use (Arengustrateegia Tartu 2030; Tartu linna arengukava 2013-2020),
- transport (Tartu linna transpordi arengukava 2012-2020; Tartu linna liiklusohutusprogrammi rakendusplaan 2011-2015) and
- open space (Arengustrateegia Tartu 2030; Tartu linna arengukava 2013-2020; Tartu linna välisõhus leviva keskkonnamüra vähendamise tegevuskava),

The outlined Estonian planning system, with a weak county planning and a strong local planning but in combination with the limited territorial scope of local planning, implies a significant gap of cooperation on the regional level, potentially leading towards dispersed developments in neighbouring municipalities.

Thus, under the current conditions, without guidelines from the national or county level the municipality has no control over development of settlements around the city.

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5.2 National energy policy

On the national level Estonia has three documents forming the national energy strategy:

- National Development Plan of the Energy Sector until 2020 (2009)
- National Renewable Energy Action Plan (NREAP) 2020 (2010)
- Development Plan of the Estonian Electricity Sector until 2018 (2009)

The basis for these sector-specific development plans within the sphere of the environment is the Estonian Environmental Strategy 2030. Furthermore the National Spatial Plan (NSP) "Estonia 2030+" directs the integrated development of settlement structure on national and regional level as well as infrastructures (e.g. transport and energy) in Estonia, while considering regional specifications.

Figure 11: National policies on energy and spatial planning

National Spatial Plan "Estonia 2030+" (2013)

The central concept of the NSP is the concept of "**low-density urbanised space**", which is supposed to integrate compact cities, suburbs and traditional villages equally and thereby meeting the requirement of compact urban space as well as preserving the values of low-density settlement characteristics of Estonia. Low-density urbanised space is intended to combine the advantages of living in the countryside with the availability of high-quality services of cities and an urban lifestyle in people's daily activity space, in order to fight urban sprawl. The regional centres are named by the national plan. A basic requirement is good mobility facilities. (Ministry of the Interior, 2013, p. 13f)

But the NSP does not include specific principles e.g. for the development of new housing or land use related to transport infrastructure in order to achieve the proclaimed spatial concept.

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Thus, in reality the concept is not working very well, since strong **urban sprawl** is an ongoing challenge. One reason is the very expensive land; owners keep the land but don't build; which makes densification very difficult.[5]

Regarding **energy policy** the NSP points out the following relevant aspects in order to influence energy consumption:

- shaping settlement,
- entrepreneurship and
- decision making concerning transport.

The Estonian energy policy emphasises the importance of **reducing dependency on imported resources** as well as to ensure **security of energy supply**. A more **decentralised regional energy production** shall improve the overall energy security as well as the better exploitation of local energy resources (wind, solar, biomass, earth heat). Furthermore integrated energy-production solutions, e.g. combined heat-power-production, shall be introduced more.

Currently Estonia is able to supply its full demand of **electrical energy** (see also Rudi, 2010). But the present electricity production (see Figure 12), mainly based on oil shale, is not supposed to be competitive enough in the long term (e.g. due to environmental charges). Thus, the **share of other (renewable) energy sources** shall be increased and in order to trade energy more extensively with other EU countries the infrastructure is to be developed. Mentionable is that even the construction of a nuclear power plant on the north coast of Estonia is considered.

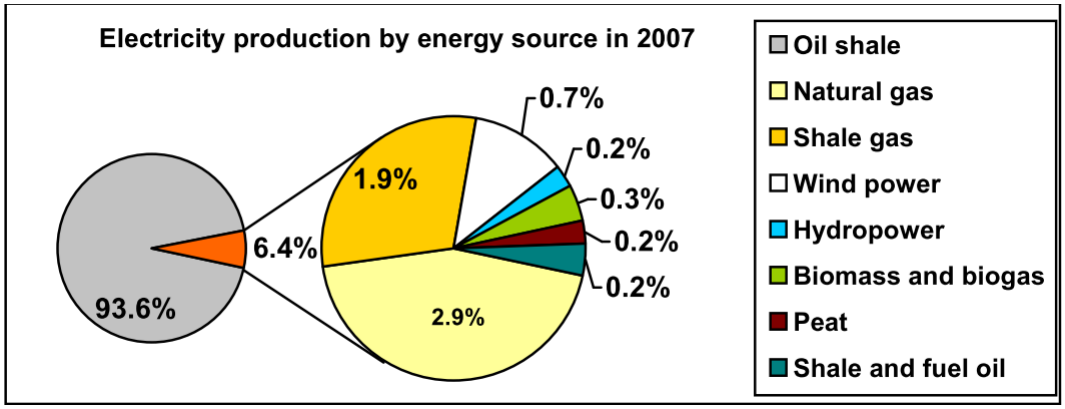

Figure 12: Electricity production by energy source 2007 (Ministry of Economic Affairs and Communications, 2009, p. 13)

Heat energy is currently produced from local fuels (wood, peat, other biomass) or imported fuels (gas, liquid fuels, coal). The share of local fuels in heat energy is supposed to be increased.

Furthermore the NSP emphasises the relevance of **settlement structure, compactness of urban regions and multi-functionality** as important preconditions for efficient supply and use of heat energy.

Regarding **engine fuels** Estonia is depending on imports. Both to reduce fuel dependency and to ensure energy safety, the use of more energy efficient modes of transport (public transport, cycling, walking) and producing fuels from oil shale are seen as important measures. (Ministry of the Interior, 2013, p. 43ff)

[5] Interview with Department of Urban Planning, Land Survey and Use, City of Tartu, 05.06.2014

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In order to achieve that, "fast, affordable, high-quality, convenient and safe connections", including various and sustainable modes of transports need to be provided within the daily activity spaces (see Figure 32, p. 40) and between the different centres in the settlement system. A well-functioning ticketing system, improving the linkage between different modes of transport (e.g. Park & Ride) as well as joining the pedestrian and bicycle paths into regional networks shall contribute to that. (Ministry of the Interior, 2013, pp. 31–34)

The main goals in energy policy summarised in the NSP are

- increase energy efficiency of buildings: this area holds high potentials for the cut of heat energy requirement by 30-60 % and to decrease the demand for electrical energy by up to 20 % (tougher requirements for thermal resistance of buildings needed);
- energy savings in manufacturing sector;
- cohesive and user-friendly public transport (decrease fuel dependency).

Estonian Energy Strategy

The **National Renewable Energy Action Plan** (NREAP) 2020 is part of the "roof strategy" of the energy sector, the National Development Plan of the Energy Sector until 2020. The NREAP gives an overview of the expected gross final energy consumption of Estonia in heating and cooling, electricity and transport up to 2020 (see Table 2).

Table 2: Expected gross final energy consumption of Estonia in heating and cooling, electricity and transport up to 2020 taking into account the effects of energy efficiency and energy saving measures 2010-2020 (Ministry of Economic Affairs and Communications and Ministry of the Environment, 2010, p. 5f)

	2005	**2010**		**2015**		**2020**	
	Base year	*Reference scenario*	*Additional energy efficiency*	*Reference scenario*	*Additional energy efficiency*	*Reference scenario*	*Additional energy efficiency*
Heating and cooling	1,615	1,592	1,572	1,637	1,577	1,698	1,579
Electricity	738	829	829	896	884	951	938
Transport	746	789	789	886	868	954	934
Gross final energy consumption	3,098	3,210	3,190	3,419	3,329	3,602	3,451

Based on that, the expected changes by 2020 – taking into account the effects of additional energy efficiency and energy saving measures – are summarised as follows in the NREAP:

- **final energy** consumption will **increase by 8.4 %** compared to the average final energy consumption from 2005 to 2008;
- **electricity** consumption will **increase by 28 %** compared to the average of 2005 to 2008 (not including the energy sector);
- **heat** consumption will **decrease by 15 %** compared to the average of 2005 to 2008 (not including the energy sector);
- **fuel** consumption will **increase by 12.4 %** compared to the average of 2005 to 2008 (not including the energy sector),
- **motor fuel** consumption of will **increase by 16 %**;

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- **industrial sector** energy consumption will **increase by 24 %**, in **agriculture** by **17 %**, in the **transport sector** by **13 %**, and in the **business and public service sectors** by **2.5 %** compared to the average from 2005 to 2008;
- **household** energy consumption will **decrease by 1.7 %** compared to the average of 2005 to 2008;
- energy consumption in the **energy sector** will **decrease by 3 %.**

Referring to the Renewable Energy Directive 2009/28/EC the national overall target for Estonia is to increase the share of renewable resources from 18 % in 2005 up to 25 % in 2020.

The NREAP splits the overall 25 % target for 2020 as follows:

- 17.6 % renewable electricity (RES-E)
- 38.4 % renewable heating and cooling (RES-H&C)
- 9.9 % renewable transport (RES-T)

These goals will fulfil the overall binding target for 2020 but they are remarkable below the actual potentials in Estonia. (European Renewable Energy Council, 2011, p. 43)

The **Estonian Environmental Strategy 2030** (Ministry of the Environment, 2007, p. 20f) identifies the major problems in national **energy production** in connection with prioritising, on the national level, of power engineering based on oil shale and concentrated in one geographical area (Narva):

- concentration of pollution;
- large losses in the transmission of electric energy;
- considerable vulnerability of the system in emergency situations;
- inhibition of the development of renewable energy sources.

Regarding **energy consumption** the major problems are related to the continuous use of inefficient (out of date) machinery and technologies:

- large energy consumption of buildings;
- losses in transmission and distribution of energy;
- considerable energy-intensity of economy;
- increased demand for energy.

In terms of **transport,** urban sprawl, insufficient development of public transport and alternative energy sources as well as the functioning of Estonia as a cheap transit corridor has entailed

- increasing number of cars and, accordingly, increasing use of land;
- increasing pollution of ambient air;
- increasing amount and chances of realisation of environmental risks;
- unsatisfactory use of environmentally sustainable energy sources and fuels.

Referring to the above named major problems in the areas of energy and transport the Estonian Environmental Strategy 2030 (Ministry of the Environment, 2007, p. 30ff) names the following objectives and indicators to meet these challenges:

- production of energy in an amount that meets the consumption needs in Estonia, based on different energy sources, enable electricity production for export;
- by 2015 the relative share of **oil shale in the production of electricity** amounts to **less than 90%**;
- by 2015 the relative share of **electricity produced on the basis of renewable energy sources** and consumed in Estonia will increase to at least **8 %**;

- by 2020 the relative share of **electricity produced in combined heat-power-plants** (CHP) and consumed in Estonia will increase to at least **20 %**;
- keeping the network losses in the distribution network at the level of 8 % at least until 2015;
- keeping the network losses in the transmission network at least at the level of 3 % until 2015;
- reducing the Estonian power stations' own consumption at least to the level of 9% by 2015.

In Estonia exist four types of environmental taxes: pollution taxes, energy taxers, transport taxes and resource taxes. Resource taxes include mineral resources extraction charge, water abstraction charge, fishing charge, forest stand cutting charge and hunting charge. (European Environment Agency (EEA), 2011, p. 12)

The EU Industry Roadmap (European Renewable Energy Council, 2011, p. 43ff) criticises the current draft law in Estonia regarding changes in the support scheme for the FiT (feed-in tariff) in the electricity sector. The draft aims to set the FiT in accordance to the market price: the higher the market price, the lower the FiT. Furthermore the current support scheme does not distinguish between different technologies, thus, the use of renewable energy sources is not economical. Also the complicated licensing process for heating and cooling systems is remarked.

The special role oil shale has also as a strategic energy resource in the Estonian energy policy, makes it even more difficult to shift to the use of renewables.

In order to exploit the full potential for increasing energy efficiency in buildings, tougher requirements for thermal resistance of buildings are needed. (Ministry of the Interior, 2013, p. 50)

The main **driver for Estonian energy efficiency policies**, especially regarding the change to the use of renewables (woodchips), oil shale or peat as local resources, is apparently to reduce dependency on imported resources (e.g. Russian gas) as well as security of energy supply, also in order to increase economic competitiveness.

Since Estonia is planning to join the "Central European synchronous area" the network connections with Russia are to be made controllable and especially the networks with the Baltic Sea Region shall be strengthened. (European Environment Agency (EEA), 2011, p. 6; Ministry of the Interior, 2013, p. 43ff)

5.3 Municipal energy policy

The **Development Strategy "Tartu 2030"** as a basic strategic document for the long-term development of the city addresses future challenges for the city's development in various fields of actions.

Among others, the strategy focusses on necessary changes related to urban structure: An identified obstacle towards more sustainable transport flows is to zone the urban space in combination with automobile-oriented transport respectively separation of transport modes. Instead, urban space should be organised rather district-centred and by these means attracting the use of public transport as well as an integrated use of transport modes.

Thus, on the one hand high-rise and dense construction in the city centre shall be avoided, but on the other hand, in terms of intensifying land use, industrial areas are to be restructured. Furthermore residential, industrial and recreational areas in the environs of Tartu shall be connected with Tartu. (Tartu City Government, 2006, pp. 27, 37)

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Regarding public transport the development strategy formulates very concrete goals: *"The capacity of public transport will be increased – from one third of the whole transport today to the half of the whole transport. In the year 2030 half of the public transport vehicles are environment friendly. From one fifth to one quarter of all the rides are made by bicycle."* (Tartu City Government, 2006, p. 39)

Furthermore the development strategy includes various goals regarding energy planning, e.g. the better integration of waste as resource in energy cycles and the completion of the district heating system.

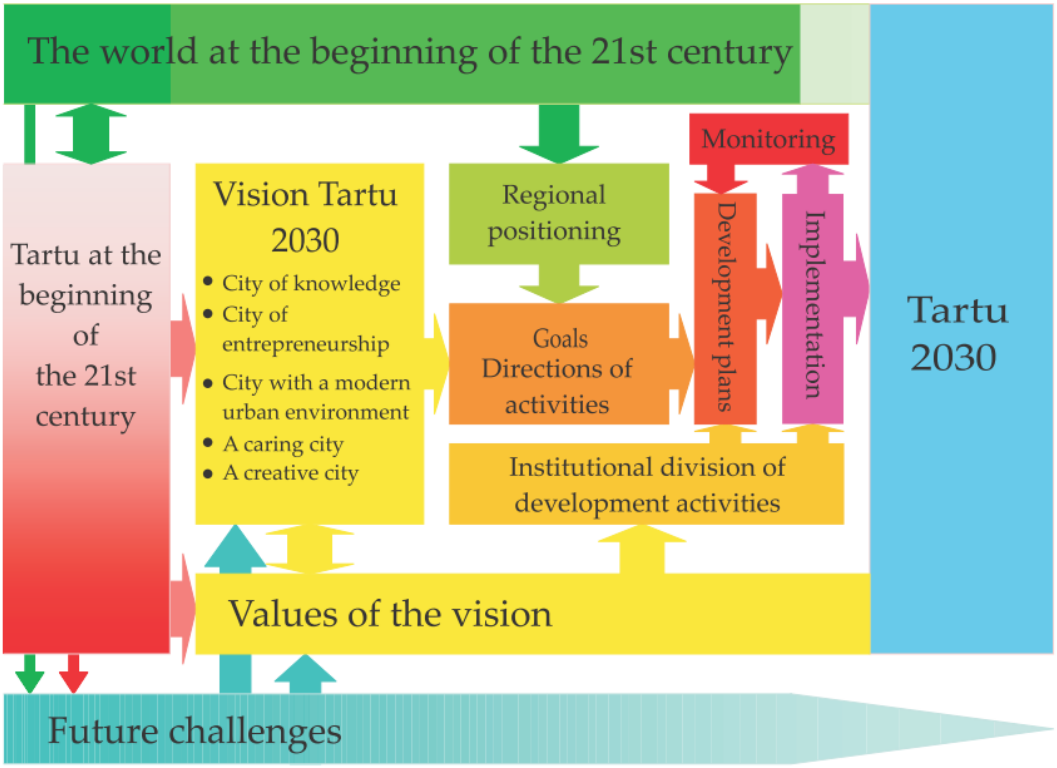

Figure 13: Model of the development of Tartu 2030 (Tartu City Government, 2006, p. 29)

Beyond the objectives and strategic directions formulated in the Development Strategy "Tartu 2030" the document also emphasises the importance of how planning competencies and responsibilities are administered and in which way the different actors are involved. Thus, the Development Strategy "Tartu 2030" interlaces the formulated objectives for the city's developments with the required planning model and implementation process.

Figure 14: Local policies on energy and spatial planning

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Considering the Estonian planning system the main responsibilities are strongly tied to the local self-government, but at the same time strategic questions about the regional positioning of Tartu come up. Not only the City Council, the City government and its administration are in charge of the implementation of the city's strategy; it also demands the contribution of the state and state agencies, public institutions, private companies, non-profit organisations and the public.

The implementation of the municipal policy, drafted by the Development Strategy "Tartu 2030" is carried out by means of general planning (Master Plan of Tartu), budget strategy, development plans (Tartu City Transport Development Plan), sectorial development plans and the plans of activities of city administered institutions (see chapter 6.1, p. 22). These documents are supposed to form an integral system as a basis for the cross-sectoral and integrated regulation of urban development in Tartu.

6 Management of urban planning and energy today

6.1 Main planning documents of Tartu

In this section the main content of the previous and the current Master Plan of Tartu and of the current Transport Development Plan is summarised.

The main regulatory principles for the development of the city are settled in the Master Plan. The Master Plan is also the only instrument to set regulations. Until the 1990s the development of the city was solely guided by national ministries and there were no possibilities to direct urban planning on the local level.[6]

6.1.1 Previous Master Plan of Tartu 2012 (1999)

The previous Master Plan for the City of Tartu until the year 2012 ("Tartu linna üldplaneering aastani 2012") was approved and adopted by the Municipal Council of Tartu in 1999. Changes in the administrative territory, war damages and socio-economic changes induced the need for a general plan with new development principles. Furthermore the conditions of possessing and managing residential space, the demographic and economic situation as well as the requirements for the transportation system had changed (City of Tartu, 1999). Not least the changes in the legal system enforced the design of a new master plan (Jauhiainen, 2003a, p. 42).

The Master Plan was supposed to direct the territorial as well as the social and economic development of the city. In this sense the Master Plan's objective was the determination of *"the trends of purposeful and balanced development [of] the four main functions of the city – working, living, moving and resting – based on realistic economic possibilities"*. Therefore the Master Plan was also supposed to provide the framework for the long-term spatial-economic development of the city as well as a basis for investments. (City of Tartu, 1999)

The main principle of the Master Plan was sustainable development; priority was given to the social needs of the inhabitants, followed by the support of economic development. Intensification of land use was seen as major precondition in terms of sustainability and economic constraints. (Jauhiainen, 2003a, p. 42)

[6] Interview with Department of Urban Planning, Land Survey and Use, City of Tartu, 05.06.2014

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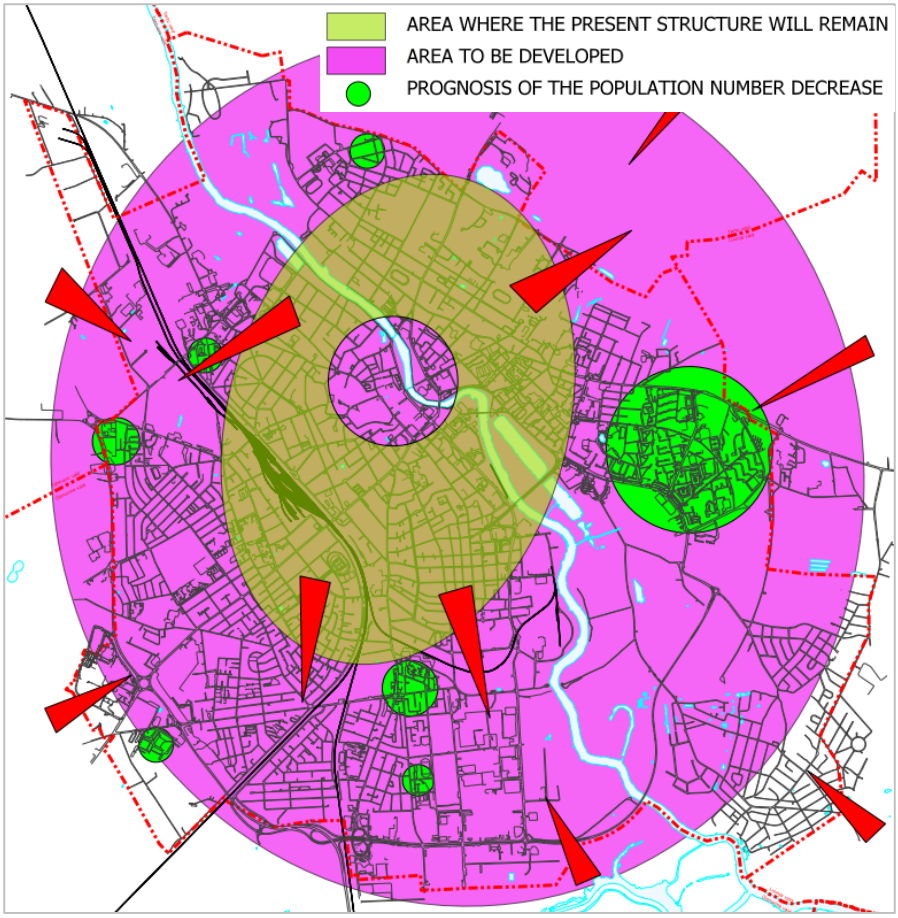

Figure 15: Extensive development – developmental building to empty areas (City of Tartu, 1999)

The Master Plan examined two alternatives for the territorial development of Tartu, an extensive development, directing the city's development mainly on underdeveloped areas, and an intensive development, directing the city's development mainly on built-up areas. Both alternatives where based on parts of the city where the population is supposed to decrease, the main decrease is projected for Annelinn district. The principle of the extensive alternative is to expand the immediate range of the city, whereas the principle of the latter is a sustainable use of the existing land resources, buildings and the structure of urban development. The Municipal Council approved the policy of the intensive development. (City of Tartu, 1999)

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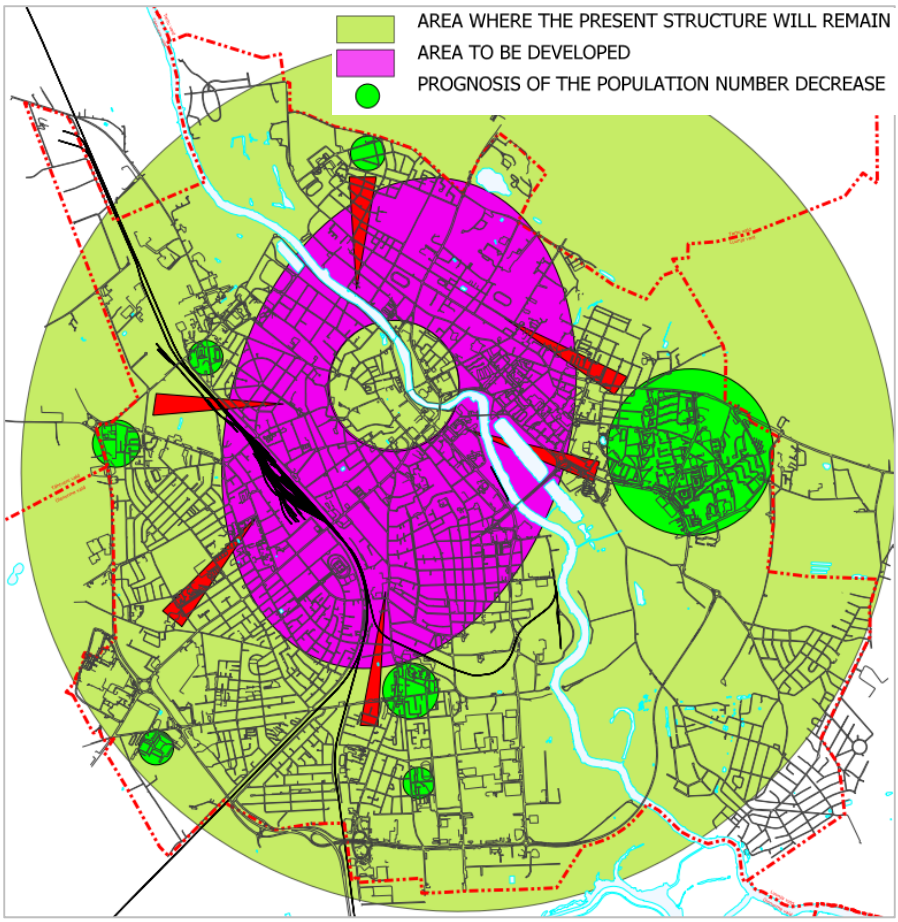

Figure 16: Intensive development – raise of the present quality of the city environment (City of Tartu, 1999)

6.1.2 Current Master Plan of Tartu (2006)

The current Master Plan for the City of Tartu ("Tartu linna üldplaneering") was approved in 2006, which was rather soon after the previous Master Plan from 1999.[7]

The Master Plan includes spatial development principles for Tartu, illustrated by diverse maps addressing various fields of the development of the city like housing, distribution of the population, city centres, energy, heat and water supply, transport routes, cultural heritage, green spaces etc.

Also, the current Master Plan includes a zoning for land use covering the whole city area (Figure 17), but in more detail than the previous Master Plan. Beyond functional zoning it includes detailed information about building regulations in different land use zones on a block level (City of Tartu, 2006).

[7] The municipality names three reasons for that:
1. The land reform was not completed at the time of the previous master plan.
2. Meanwhile legislation has significantly changed and the previous plan did no longer meet the new requirements.
3. The energy company Fortum got monopoly on heat production in Tartu and – referring to the new real estate developments – It was necessary to modify the existing planning conditions.

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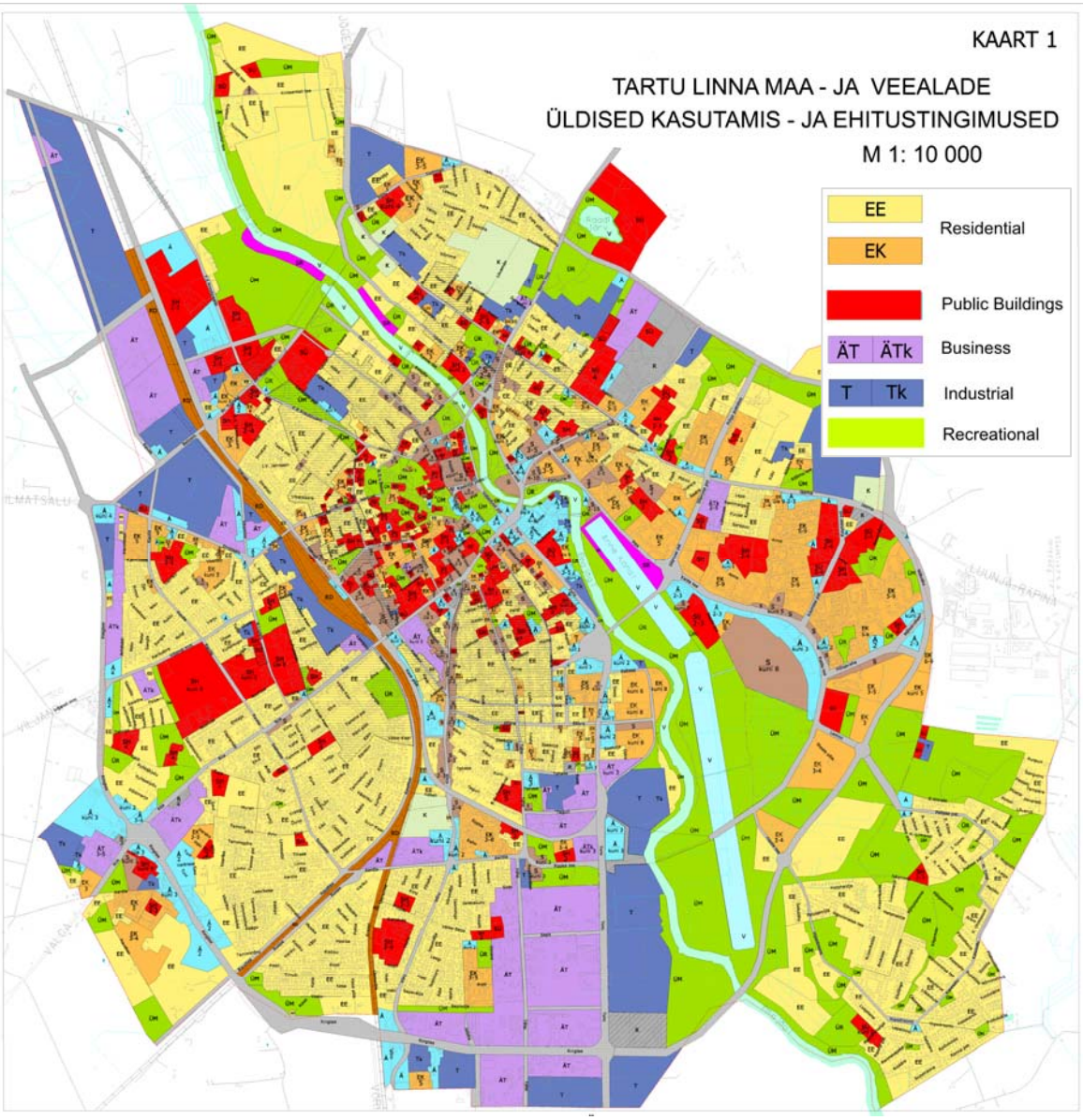

Figure 17: Tartu, zoning for land use (City of Tartu, 2006, http://www.tartu.ee/kaart/)

Contrary to the principle of compact and intensive development, which was set up by the previous (see chapter 6.1.1) and also the current Master Plan[8], under the current Master Plan new residential areas are mainly planned in the outskirts of the city, especially in Ülejõe district (Figure 4, #14), in the Ujula-Kvissentali settlement and also in Jaamamõisa (#15), Ihaste (#17) and Ränilinn (#5) district (City of Tartu, 2006, p. 22f; Tartu City Government, 2011, p. 15). By these means also the concept of low-density urbanised space as set up in the National Spatial Plan is thwarted.

The work on a new Master Plan for Tartu is to be started in autumn 2014. The city planners emphasize the need to develop the Master Plan in cooperation with the county.[9]

8 Interview with Department of Urban Planning, Land Survey and Use, City of Tartu, 05.06.2014
9 Ibid.

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Figure 18: Single-family-housing in Ihaste district (field work, June 2014)

6.1.3 Tartu City Transport Development Plan 2012-2020 (2011)

In November 2011 the Tartu City Transport Development Plan 2012–2020 was approved by the city council. The Transport Development Plan was initiated by the city council's decision no. 73, 20.05.2010, and was set up to specify the goals of the city's sectorial development documents as well as to create a basis for the development and financing of the transport system. The plan is primarily supposed to be a practical tool to enable long-term transport planning and to develop sustainable transport policy.

Goals of the Transport Plan

The Transport Development Plan addresses problems of motorisation as well as the transportation system of Tartu: "*Car usage has consistently grown while at the same time the use of public transport has decreased.*" The plan was drafted according to the motto of the Baltic Biogas Bus project ("Working together on climate-neutral public transport"), where the main objectives were to introduce a biogas bus in the public transport system of Tartu and to increase the use of public transportation. (Tartu City Government, 2011, p. 4)

Furthermore, the Transport Development Plan emphasises the strong interrelations between transport and other sectors and thus the necessity to implement the goals cross-sectorial by handling transport planning as integral part of city planning.

As the transport plan is guided by the goal to create a compact city and multifunctional space to reduce people's needs for movement, it's directly referring to the **relevance of urban structure to transport**. *"The needs and habits of movement thus depend on the spatial structure of the city and the connections between the locations of interest. A significant influence on the habits of movement is exerted by the transportation system, which creates links between different points and shapes possible types of connections and habits."* (Tartu City Government, 2011, p. 17)

Furthermore, in order to reduce private car use the transport plan aims for new **transport and taxation policies** on the one hand and on raising attractiveness of alternative modes of transport on the other hand.

The following three main principles – pointing at urban structure – are mentioned in the transport plan:

- To facilitate new developments in the vicinity of existing central locations (accessibility of basic everyday services, social infrastructure, leisure possibilities);
- To facilitate developments in the vicinity of existing transport grids to ensure accessibility of existing public transport ("transit oriented development");
- To ensure education facilities for children near their residence.

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Modes of transport in Tartu

As main causes for increasing needs for movement are mentioned the ongoing establishment of workplaces (industrial parks) separated from residential areas and the development of shopping centres in the outskirts of the city. (Tartu City Government, 2011, p. 11ff)

Figure 19 shows the distribution of types of movement total and for workers in Tartu. The combined share of walking and cycling is already quite high (45 % resp. 37 %). In the total distribution walking has the highest share compared to all other modes of transport in the city, which shows, that the city basically has a compact structure and provides short distances for everyday requirements.

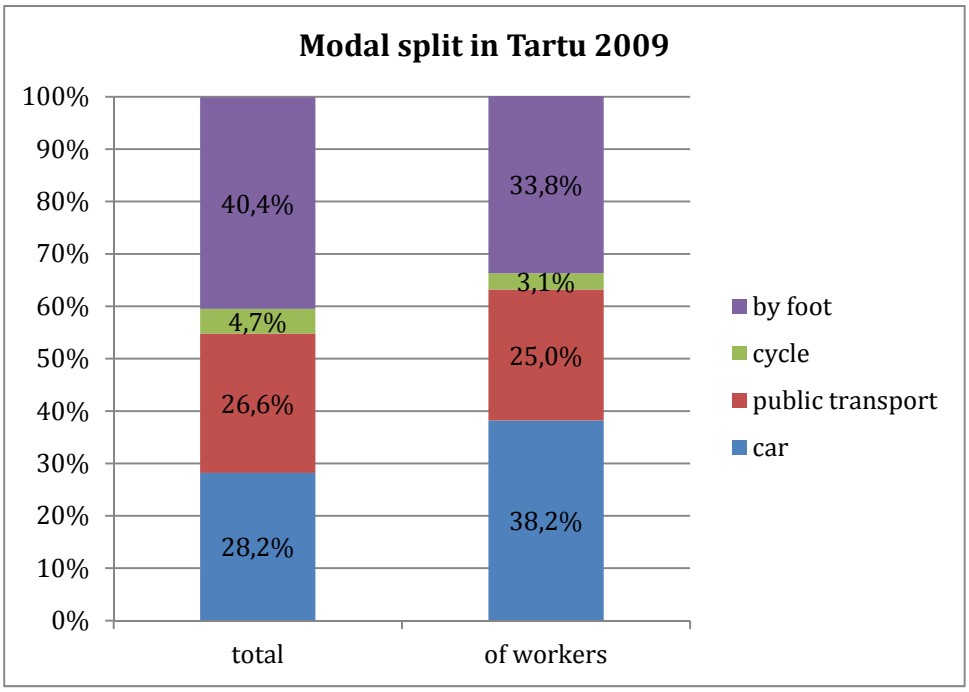

Figure 19: Modal split in Tartu 2009[10] (Tartu City Government, 2011, pp. 17, 21)

But a closer look at the workers' distribution shows a remarkable higher share of car use than in the total distribution. One reason might be a deficit in convenient accessibility of workplaces by public transport or foot/cycle.

The transport plan furthermore mentions as one important limiting factor of car use that only approximately half of the population of Tartu above 18 has a driving licence.

Furthermore car ownership in Tartu (comparable with Tallinn) is still about 20 % below the Estonian average, with about 27,000 registered private cars in Tartu in 2011 (population 97,600) (eurostat, 2014; Statistics Estonia, 2011). Though, Figure 20 shows the constantly increasing number of registered cars in Tartu since 2008. That could be either an indicator that car ownership and driving licence is yet not affordable for many people or that it's not necessary for everyday life in Tartu.

[10] Survey of Movements of the Inhabitants of the City of Tarty and the Neighbouring Local Governments ("Tartu linna ja lähiomavalitsuste elanike liikumisuuring") 2009 (including Tartu and the nearest rural municipalities)

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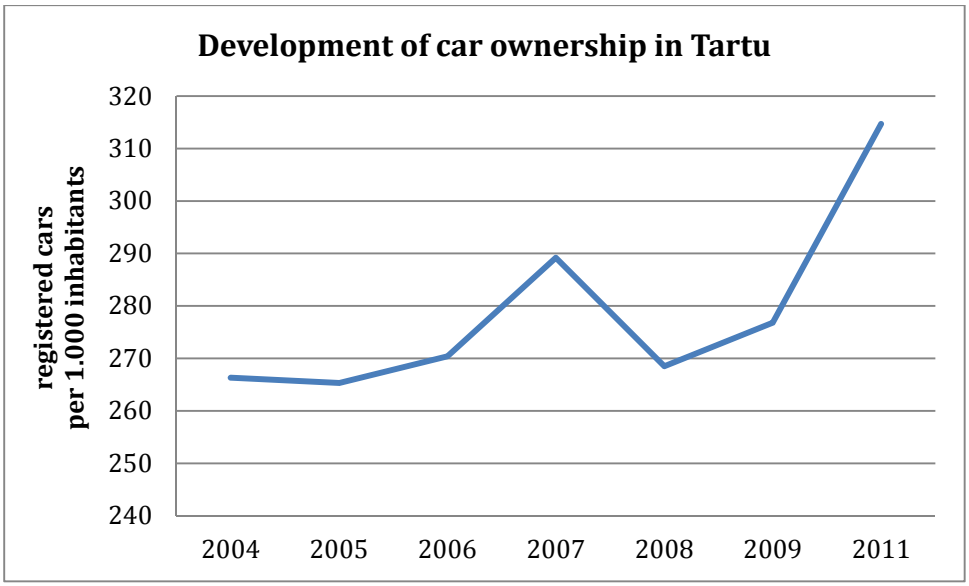

Figure 20: Development of car ownership in Tartu 2004-2011(eurostat, 2014)

From an energy point of view the high share of walking, cycling and public transport in Tartu is an asset of the city. A comparison between Eskilstuna and Tartu[11] reveals that Eskilstuna is more ambitious in relative terms (increase of public transport from 8 % in 2006 to 16 % in 2020), but starts at a much lower level as the share of public transport in Tartu[12] is already about one quarter (Groth et al., 2014; Tartu City Government, 2011).

The situation in Swedish Eskilstuna and Estonian Tartu seems very different. In Estonia the ongoing catch up with European standards of car ownership is a strong driver, making it difficult to keep or even increase the high share of public transport further. In Sweden increasing the use of public transport from the low level seems not in conflict with car ownership *per se*, since public transport may be increased not as an alternative to *own* but to *use* your car.

Transport planning across borders

A major deficit of the Transport Development Plan is its limitation to the city area. Transport relations in a regional or even national context are only marginally mentioned. This is probably caused by the limited scope of action of the local government, but anyway it manifests a remarkable lack of coordination of cross-border planning demands like transport.

But keeping in mind that the main initiative for the transport plan was only to introduce a biogas bus in Tartu and to increase the use of public transport, the final document has a gained a much far-ranging perspective in order to address the whole transport system as integral part of urban planning.

In order to achieve the set up goals for the transport system the Transport Development Plan highlights the necessity to improve the cooperation between the different national and local organisations as well as the involvement of stakeholders in the decision making

11 The figures for Eskilstuna and Tartu are taken from different sources and can therefore only be taken as indicative in terms of the dimension.

12 The figures for modal split in Tartu originate from different sources which are difficult to compare as the reference years and reference areas differs resp. are not always clearly defined.
Especially regarding the modal split in long distance commuting only few relevant statistical data is available for Tartu.

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processes. Highly essential is the cooperation with the neighbouring local governments. (Tartu City Government, 2011, p. 61ff) In fact these cooperations are not very well developed, there's no established process to coordinate planning between the municipalities and the county plan is too weak to assume coordination.[13]

6.2 Transport planning

As illustrated above a major challenge lies in the work related transport (commuting) both within the city area and in the functional urban area.

Cycling

The former Master Plan (1999) implied no relevant changes in transport planning. For example cycling is quite a new topic. First in 2001 a master plan on bicycle paths as key measure to establish cycling as an issue of city policies was implemented, not least because of very active bicycle organisations in Tartu. The plan however, did not create projects mainly due to lacking knowledge.[14]

In 2006 a report about bicycle traffic, which was also a tool for designers of streets, concluded that there's a need to account better for the needs and habits of cyclists regarding routes and bicycle stands. The current city government policy aims to install 100 km of biking paths within four years.[15]

Commuting and work place locations

The workplaces in Tartu are mainly concentrated in the city centre (ca. 29 %) and in an important industrial area in Ropka district (Figure 4, #10) with about 10 % of the workplaces. On the other hand in Annelinn district are only about 10 % of the workplaces, but more than 25 % of the population lives there. (Tartu City Government, 2011, p. 20ff)

These proportions cause remarkable needs for movements to work. The type of transport people chose to go to work highly depends on the distance and the accessibility of different modes of transport; these vary a lot across the districts.

The highest share of car use to work is in Ihaste district (Figure 4, #17) which has also the longest average distance between home and work (see Figure 21). But besides the long distance there is particularly a poor accessibility of public transport in Ihaste, as Figure 22 shows. Furthermore there're mostly single-family-houses in Ihaste, which indicates a rather affluent population with a probably higher rate of car ownership.

Connecting Figure 21 and Figure 22 with each other attests obviously an interrelation between the accessibility of efficient public transport and the share of car use for the travel to work.

Furthermore the figures and the comparison between the districts reveal that primarily not only the distribution proportion between workplaces and residents or the distances are determining, but rather the accessibility of public transport and probably also the level of income (car ownership) of the inhabitants.

[13] Interview with Department of Urban Planning, Land Survey and Use, City of Tartu, 05.06.2014
[14] Ibid.
[15] Ibid.

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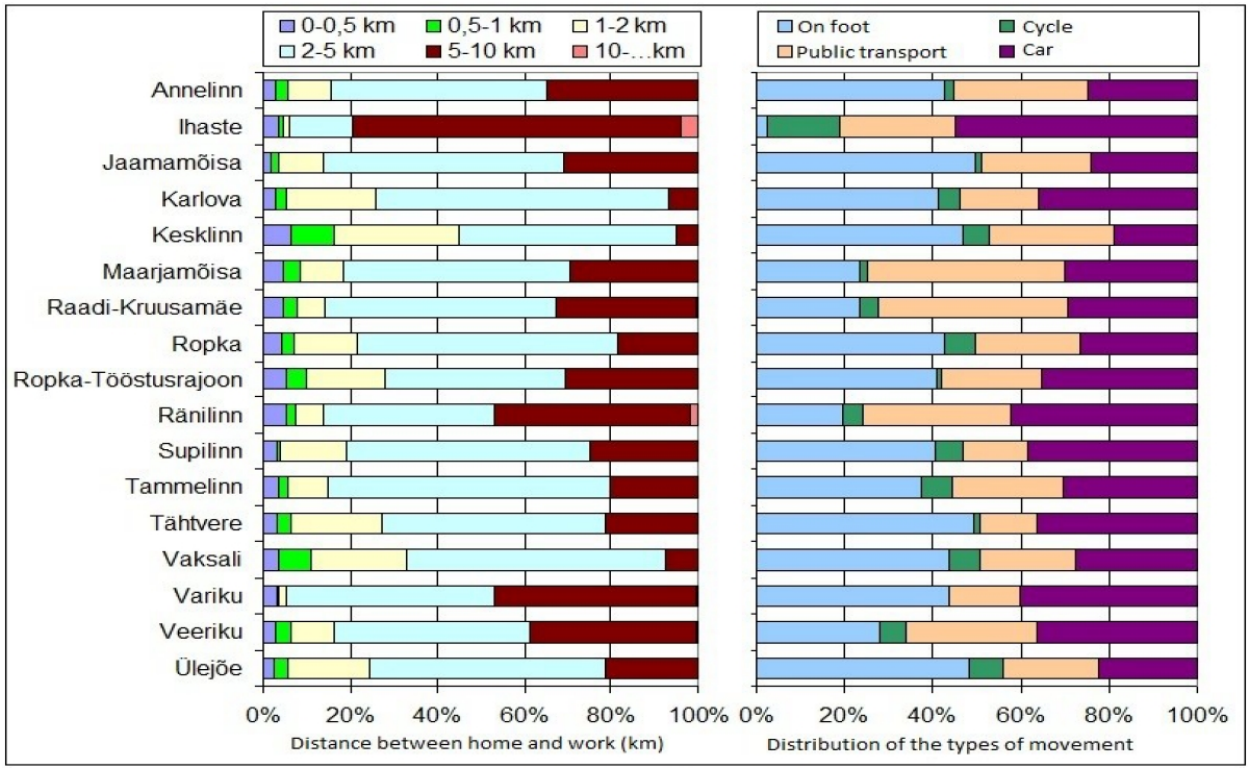

Figure 21: Distance between home and work and model split in Tartu by city district

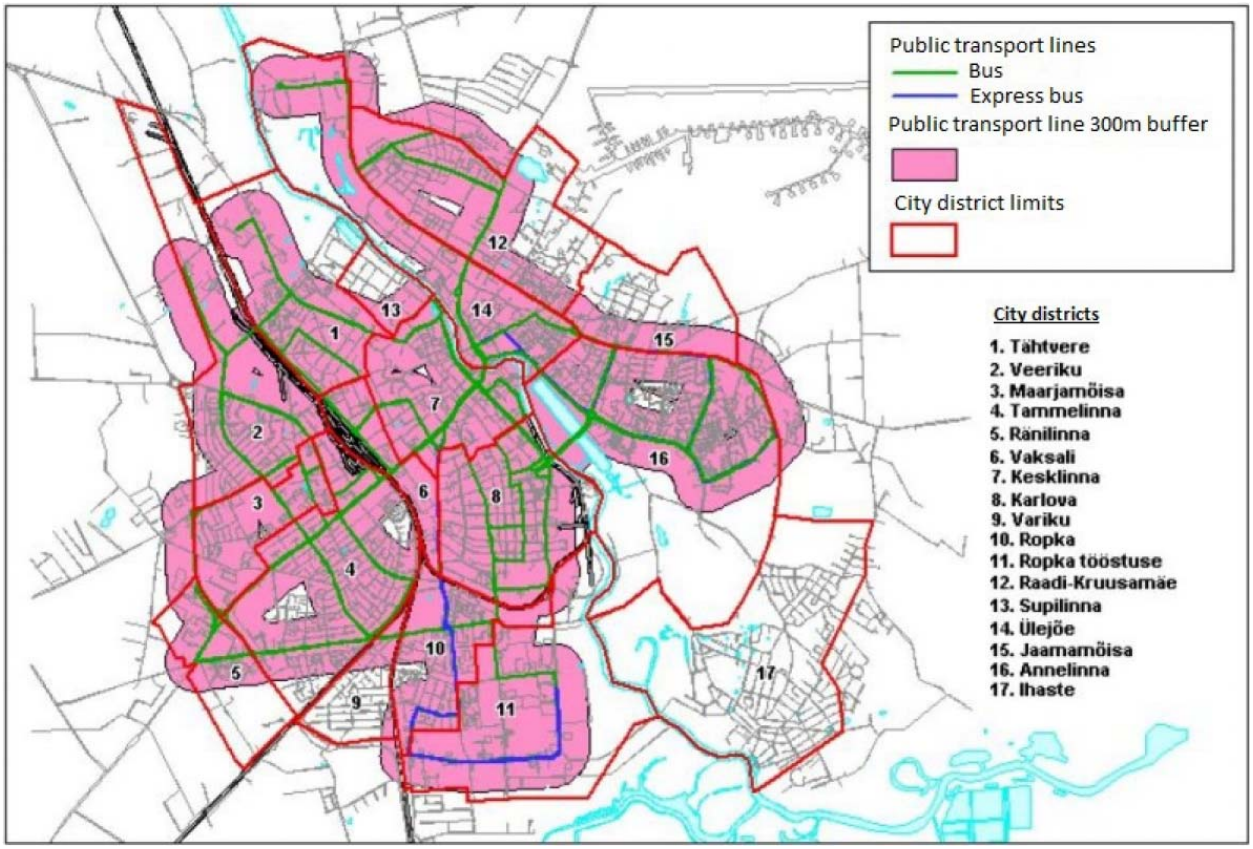

Figure 22: Public transport accessibility within 300 m

Figure 23 draws a different picture regarding all journeys to work, not only within Tartu and its vicinity (see Figure 19). These show a remarkable higher share of car usage and a remarkable lower share of public transport, compared to the journeys in Tartu. Further-

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more the share of journeys to work by car increased between 2008 and 2011 from 45 to 55 %, while the share of public transport decreased from 25 to 13 %. This indicates that public transport is hardly competitive compared to car use, at least not for journeys outside Tartu. Considering there're 6,500 workers commuting out of Tartu and about 16,300 workers commuting into the city in 2011 these cause a remarkable volume of car traffic. (eurostat, 2014)

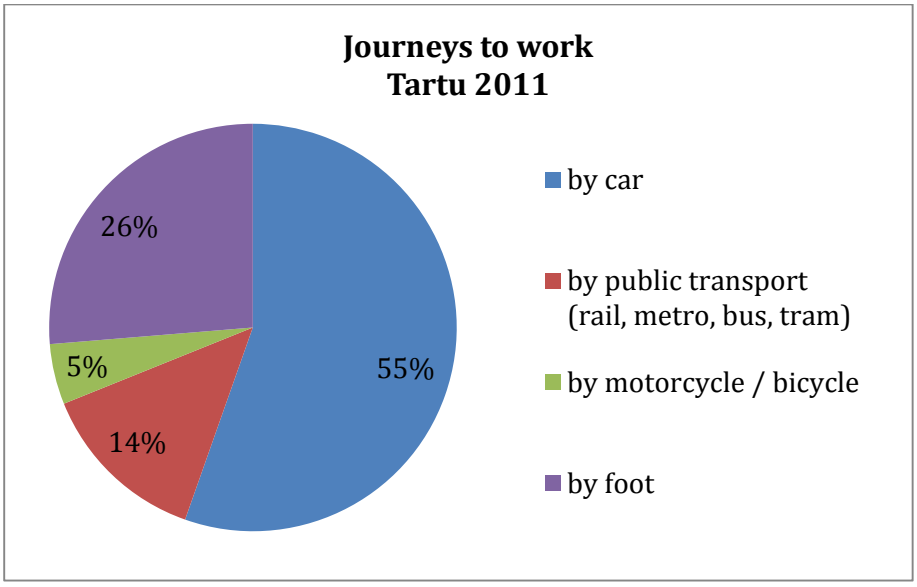

Figure 23: Journeys to work, Tartu 2011 (eurostat, 2014)

Thus, not only home-work-relations within Tartu and its vicinity, but also regional commuting demands a critical view in terms of the city's energy efficiency.

Nevertheless, even the figures from 2009 (Figure 19) and 2011 (Figure 23) are hardly comparable as they look at different reference areas. A tendency towards a decreasing share of public transport can be recognised.

The role of railways

The railway routes in Estonia are already quite well developed, about 80 % of the population lives in the vicinity of railway routes. But due to the rather poor quality of the railway connections, especially regarding speed, accessibility and convenience, too few people use the railway for regional or long distance travel or prefer the bus connections. Thus, currently the railway is not competitive to other modes of long distance transport (Ministry of the Interior, 2013, p. 35).

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Figure 7. *Basic structure of the transport network in Estonia in 2030.*

The backbone of Estonia's transport network is provided by railway services of a significantly improved quality. In the provision of external and internal connections, the role of harbours and airfields is important as well.

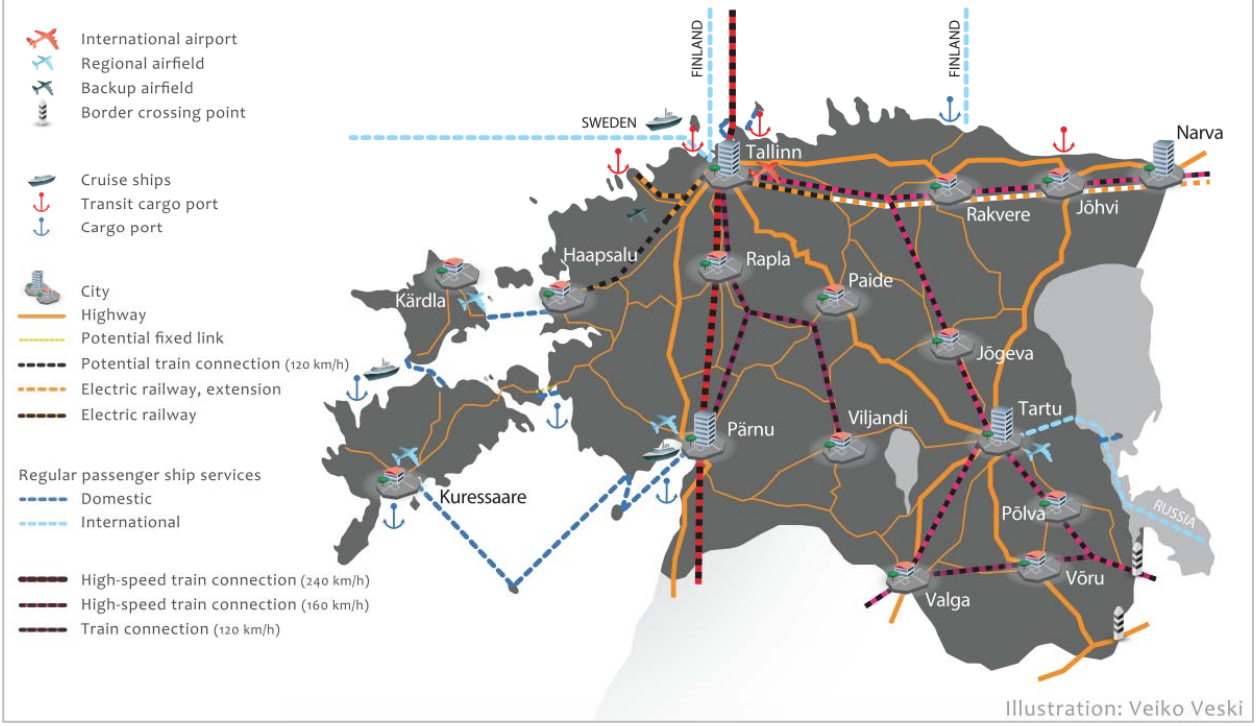

Figure 24: Basic structure of the transport network in Estonia in 2023 (Ministry of the Interior, 2013, p. 32)

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6.3 Energy planning

The major company for energy supply in Estonia is Fortum Eesti AS. Fortum is located in three cities: the administrative centre in Tallinn and two production plants (CHP) in Pärnu and Tartu.

Heat supply in Tartu is since the 1970s mainly carried out by district heating (CHP). Furthermore in 2012 geothermal energy was introduced (heat pumps).

Figure 25 shows business and residential energy consumption in Tartu. Almost half of the energy in business consumption is allotted to electricity, about 40 % to district heating and the rest to fossil fuels. In residential consumption by far the highest share (about 55 %) is allotted to district heating, while electricity's and fossil fuels' share is less than a quarter each. Fossil fuels include mainly gas and oil, which is also used for heating, especially in single-family-houses, or cooking.

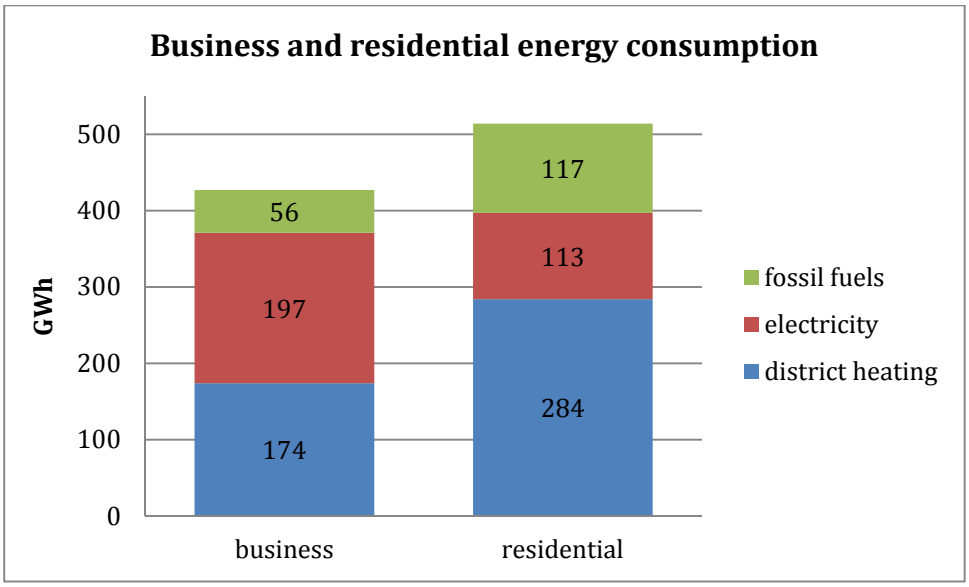

Figure 25: Business and residential energy consumption (Presentation City of Tartu, 05.06.2014)

The total distribution of energy use by sectors in Tartu (see Figure 26) shows that by far the highest share (50 %) is allotted to heating and cooling. Transport and electricity both have a share of about 25 %.

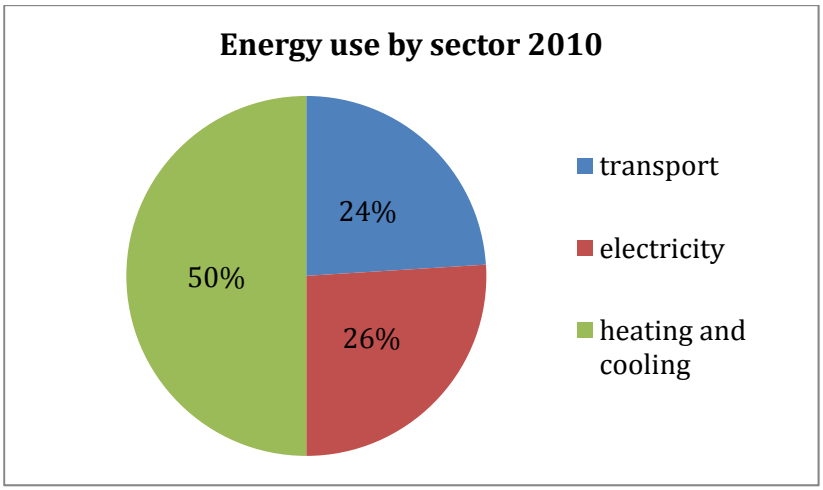

Figure 26: Energy use by sector 2010 (Presentation City of Tartu, 05.06.2014)

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In accordance to this picture the highest share of emissions (more than 70 %) is allotted to energy production, only about 12 % to transport and the rest, with less than 10 % each, to agriculture, waste and industry (see Figure 27). That reveals a probably high potential to reduce emissions caused by heating and cooling as well as electricity production, as these are the biggest energy consuming sectors.

About 75 % of the housing stock in Estonia is multiple-unit buildings. At the same time Estonia uses two to three times more energy in buildings than the Nordic countries. That reveals the low quality of the building stock in terms of energy efficiency. (Lewis et al., 2013, p. 29) Thus, building refurbishment is one of the most urgent issues in order to decrease energy use in households.[16]

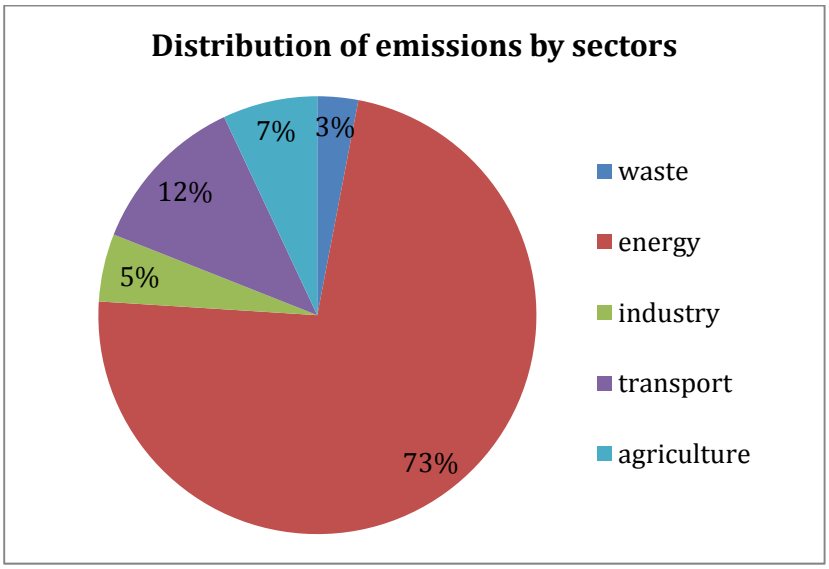

Figure 27: Distribution of emissions by sectors (Presentation City of Tartu, 05.06.2014)

The residential energy consumption of the **Supilinn** district (Figure 4, #13) should be mentioned particularly. The old **wooden house residential district** in the historical centre of Tartu is characterised by detached, mostly two-storey wooden buildings with gardens and yards, mainly built in the late 19th and early 20th century. With regard to the physical condition and technical facilities of the houses, Supilinn is among the worst neighbourhoods in Tartu (Jauhiainen, 2003b, p. 48). About 80 % of the apartments have no hot water. Also, although the surrounding districts are connected to district heating, Supilinn isn't and there are no plans about changing that in the current Master Plan (see Figure 31). About 80 % have no central, gas or electric heating. Heating is mostly wood based. From an energy perspective especially the conditions in terms of heat insulation of the buildings are quite critical regarding residential energy consumption. Furthermore, the property situation of these houses causes difficulties to improve the physical structure of the district.

[16] In order to implement energy efficiency measures in multiple-unit residential buildings built before 1993 the KredEx model as an alternative to the state-funded grant scheme was set up. KredEx aims to improve the financing possibilities for investments in energy efficiency; it combines a loan of the Council of Europe Development Bank (CEB) and a grant of the European Regional Development Fund (ERDF). (Lewis et al., 2013, p. 29)

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Contrary to other parts of Tartu the residents do mainly rent, but not own the apartments, hence there're hardly ambitions to renovate the buildings.[17] (Jauhiainen, 2003b, p. 46f)

Figure 28: Wooden house residential district Supilinn (field work, June 2014)

District heating

Until 2013 the city was divided into two regions for district heating, run by two companies. Today the sole responsibility for district heating supply in Tartu is carried out by Fortum Tartu.

The first district heating power plant close to the centre was inaugurated in the 1970s. It has just recently been replaced by a new CHP plant northeast outside the city borders (see Figure 29). The CHP plant is mostly fuelled by woodchips (since 1994) and peat; gas is only added in the peaks of the cold season. Thus, the Fortum district heating plant is quite competitive measured by the price per delivered energy. Furthermore Fortum runs some heat plants. The largest one is situated in the southern part of the city.[18]

[17] At the same time it has to be considered that the current housing conditions make living in Supilinn affordable for less well-off people. Renovating the buildings would probably lead to higher rents and could cause a gentrification process.

[18] Interview with Fortum Tartu, 06.06.2014

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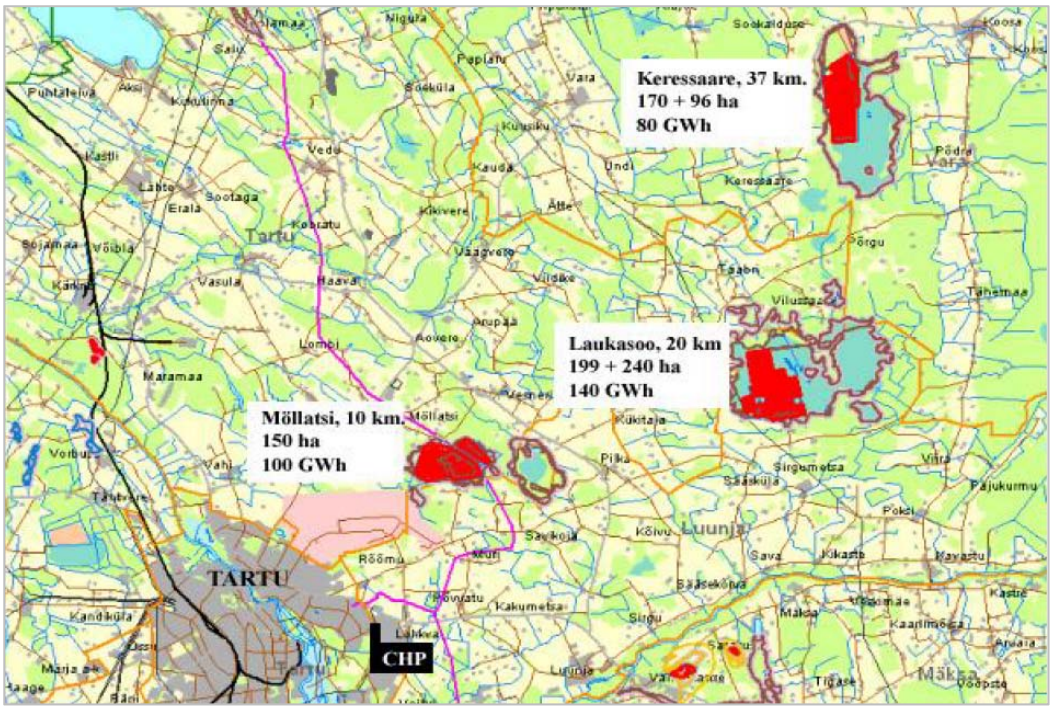

Figure 29: CHP plant and peat production of Fortum Tartu (Presentation Fortum Tartu, 06.06.2014)

Figure 30: New combined heat-power-plant (CHP), Tartu (field work, June 2014)

In the 1970s every house in the city centre had its own oil boiler. At the same time the district heating system in Tartu was established in the 1970s.

In the 1990s individual gas stations were the favoured energy supply of private households; but as the district heating network was already developed, the city intervened on behalf of the running energy company because it would have become too expensive to keep the network.

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Currently about 90 % of the apartment houses are connected to district heating; but less than 5 % of the single-family-houses[19] are connected.

If available, residents have the option of choosing gas rather than district heating, since gas is available in most areas as energy source for cooking. However, in several single family housing areas, neither gas nor district heating is available; in these areas electricity is used for cooking and air-to-air heat pumps and wood furnaces for heating.

In appointed district heating zones it's compulsory to connect, unless the energy demand of a house is less than 40 kW/m^2/yr or is supplied in an environmentally cleaner way of heating (e.g. ground heating, solar panels). Though, connecting houses to district heating is always negotiated.

The former Master Plan (1999) included an energy development plan for Tartu city (district heating, electricity) and assigned district heating areas. This was prior to the implementation of the national District Heating Act in 2003 which enables municipalities to establish district heating zones which make connection to district heating compulsory. The current Master Plan (2006) includes further areas in the district heating system (see Figure 31). In order to include these new areas the city had to establish stricter regulations in district heating zones, since the energy companies refused to expand the network due to its high costs (long distance pipes).

The district heating network is based on draft plans by Fortum, but the assignment of the zones is carried out by the municipality.

The new Master Plan of Tartu (work to be started in autumn 2014) shall again include the extension of the district heating area, incl. new land use schemes.[20]

[19] The share of the single-family-houses (ca. 7.000) is about 20 % of the total housing stock in Tartu (City of Tartu).

[20] Interview with Department of Urban Planning, Land Survey and Use, City of Tartu, 05.06.2014

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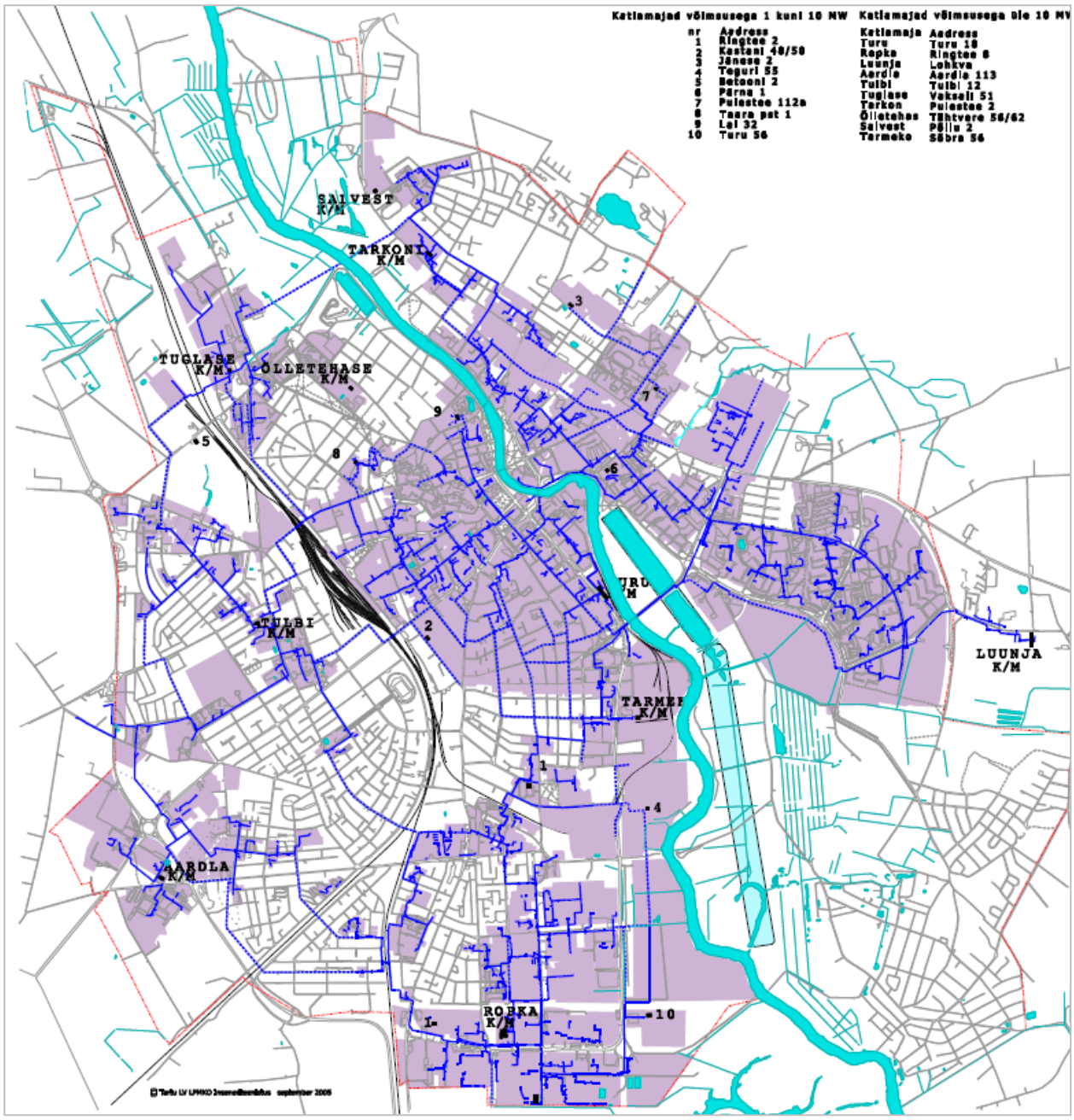

Figure 31: Areas supplied by district heating (City of Tartu, 2006)

The efficiency of the Tartu district heating system has been increased due to monitoring of the water temperature and refurbishment of the tubes in the streets. Energy losses could be contained to about 20 % between 2000 and 2013.

Additional to the district heating system a district cooling system is to be introduced in Tartu. At the premises of the old CHP plant, plans are being prepared for a cooling system using water from the river. Cooling will be offered warehouses and other large public buildings, consuming energy by cooling machines.[21]

[21] Interview with Fortum Tartu, 06.06.2014

Electricity

Electricity in Tartu is not directly supplied by Fortum. The Fortum CHP is driven by the heat demand; the electricity is a residual and sold to the national grid system (two national electricity companies, one on high voltage main grid and one on distribution grid).

The national grid system is connected with Russia, Finland, Lithuania, Latvia and Sweden. Estonian power is produced on oil shale in Narva. The only criteria for selling, buying and distributing power is the price, not CO_2 emissions.

Additionally to the electricity production in Fortum's CHP plants the use of sun power and wind energy was introduced in 2013 in Tartu. [22]

Renewables

94 % of the Fortum fuel is bio-fuel, of which about 70 % is woodchips and 30 % peat. Bio-fuels have been used since 1994. Fortum owns three peat sites from which peat is extracted. In wintertime about 40 lorries transport the peat to the plants, of which about 25 lorries are for the new plant.[23]

However, peat is not considered as renewable fuel, neither by the EU nor by Estonian law. Furthermore currently there's no program running to replace the harvested peat or wood.

6.4 Urban sprawl

Following the current Master Plan for Tartu new residential areas are mainly planned in the outskirts of the city. This can be seen critical as increasing population in the outskirts causes a higher need for movements, e.g. to reach work places in the city centre; furthermore the actual development of the population is arguable, which makes long-term planning of the required transportation system very difficult.

Moreover, Tartu has to face the challenges of urban sprawl since former farming land in the vicinity of Tartu is progressively transformed into housing, business and industrial areas, basically only accessible by car (Tartu City Government, 2011, p. 15f). These factors increase car usage even more as long as no competitive public transport system exists.

The latest phase of suburban development has been ongoing since the late 1990s. This was also caused by big gaps between issued master plans, which far overestimated demands, and actual establishment of suburban settlements (Gauk and Roose, 2011). The study (Gauk and Roose, 2011) addresses changes in land and energy use in Tartu's suburban area. It shows that since the second half of the 2000s more compact housing types became popular in the suburban zone, but still about 60 % of new residential constructions were single-family-houses in 2008.

Figure 32 shows that the main hubs for commuting are a few county centres. Furthermore it shows that the daily commuting distances are quite far, up to 30 % of the workers commute from outside the urban region. Between 2000 and 2010 the number of daily commuters in Estonia increased by more than 30 % (Ministry of the Interior, 2013, p. 23).

This underlines the processes of economic restructuring and urban dispersion (urban sprawl), also Tartu has to face. The mapped commuting patterns are quite difficult to serve with public transport since they're rather scattered, thus it requires a flexible public transport system, e.g. also combining different modes of transport, in order to reduce car use.

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[22] Ibid.
[23] Ibid.

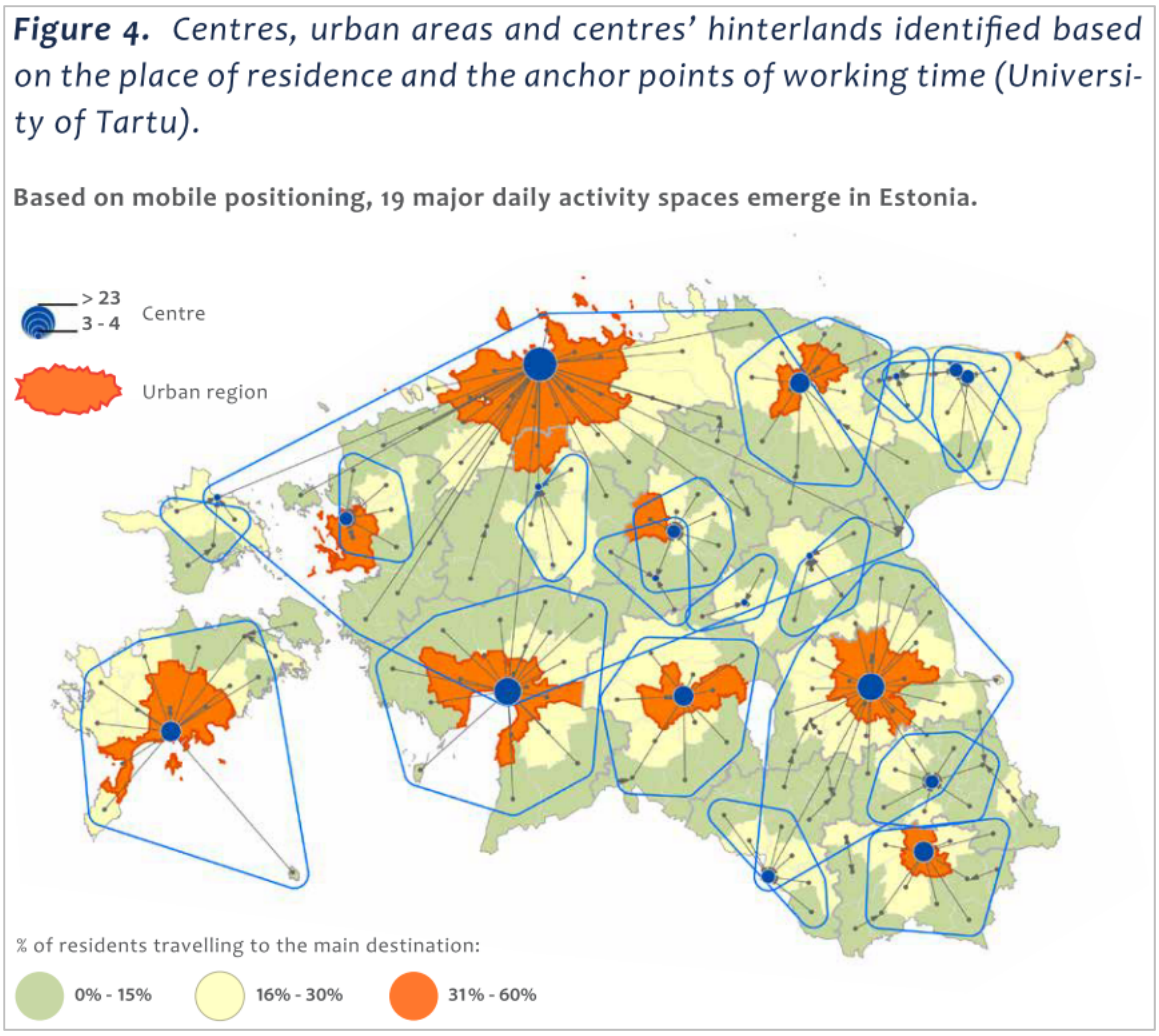

Figure 32: Daily activity spaces in Estonia, 2010 (Ministry of the Interior, 2013, p. 24)

To make matters worse, the competences for planning activities are hold by the local governments and tied to the core city territory as municipal areas are quite narrow confined (see Figure 33). The city has no control about planning activities in neighbouring rural municipalities (see chapter 5.1).

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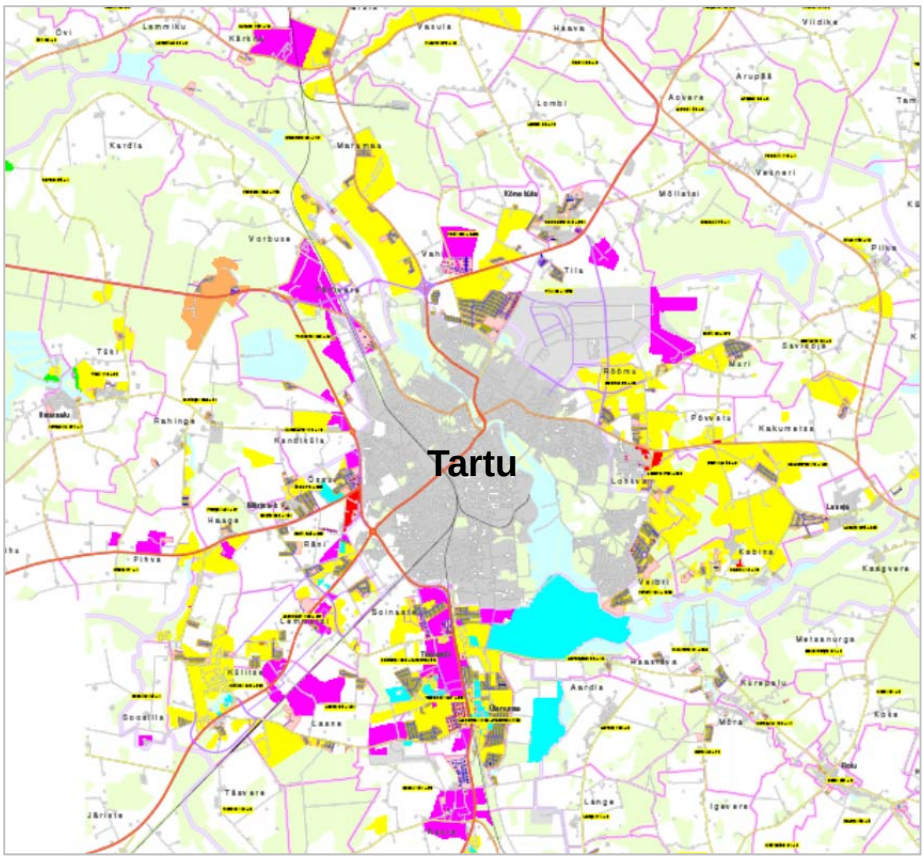

Figure 33: Municipal borders (grey) vs. actual settlement area of Tartu (Metspalu, 2007)

The current planning legislation and allocation of planning competences undermines planning efforts addressing issues with relevant and far-ranging impacts on transport. However, an inevitable precondition to control urban sprawl is to overcome the lack in coordination of planning activities between neighbouring municipalities by strengthening regional cooperation, either by strengthening the counties' planning competencies or by extending the municipalities' scope of action. (Tartu City Government, 2011, p. 16f)

Urban density and spatial organisation are seen as the determining factors in order to influence energy consumption. *"[T]o shift the policy focuses of local master plans and to better cope with the issues related to suburbanization, a policy response on a variable geographical scale is required, integrating local development initiatives and cooperation between different levels of administration."* (Gauk and Roose, 2011)

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7 Pilot projects

7.1 Pedestrian and bicycle bridge across the railway

The City of Tartu is divided into three parts by the river and the railway running through the city. Crossing the river is rather well organised with 5 bridges in the city centre and a sixth bridge in construction in the south-east part of the city.

The railway crossings on the other hand are only a few and wide apart from each other. The largest problem to cross the railway is between the central district and Veeriku district in the eastern part of the city. These two districts are divided by the railway station with many spare railway lanes. The barrier created by the railway is up to 320 m wide with as many as 25 parallel railway lines.

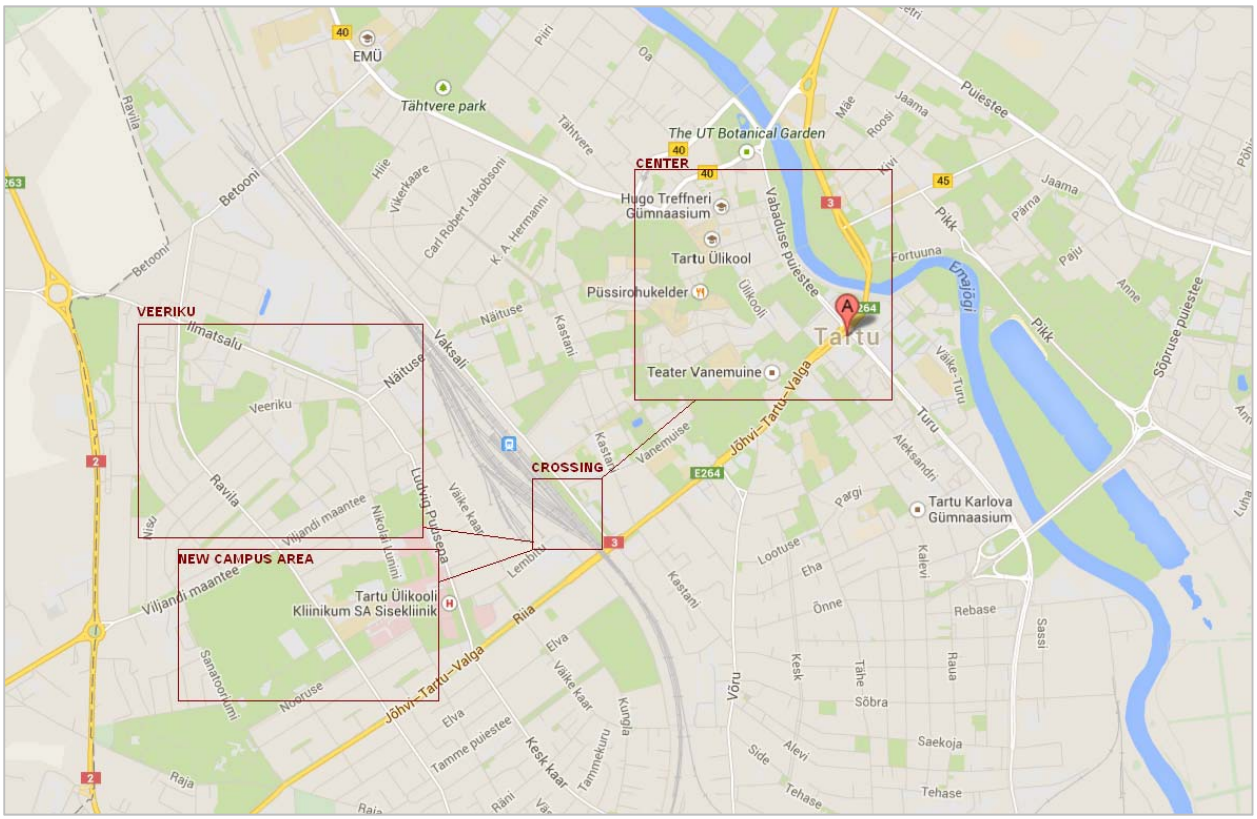

Figure 34: Location of the railway crossing

Tartu University is currently constructing its new campus and additional buildings to its hospital in the Veeriku and Maarjamõisa district in the south-east part of Tartu. The new campus includes Biomedicum, Chemicum, Physicum and Technology Institute. The activities that used to take place in the centre of the city in university's historical buildings have been moved to the new buildings, which creates extra demand for better pedestrian and cycling lanes to cross the railway.

The city government is currently preparing a project for the construction of a pedestrian and cycling bridge or a tunnel to cross the railway. It is planned to build the bridge between Lembitu street on the Veeriku side and either Vanemuise and/or Tiigi street on the centre side of the railway.

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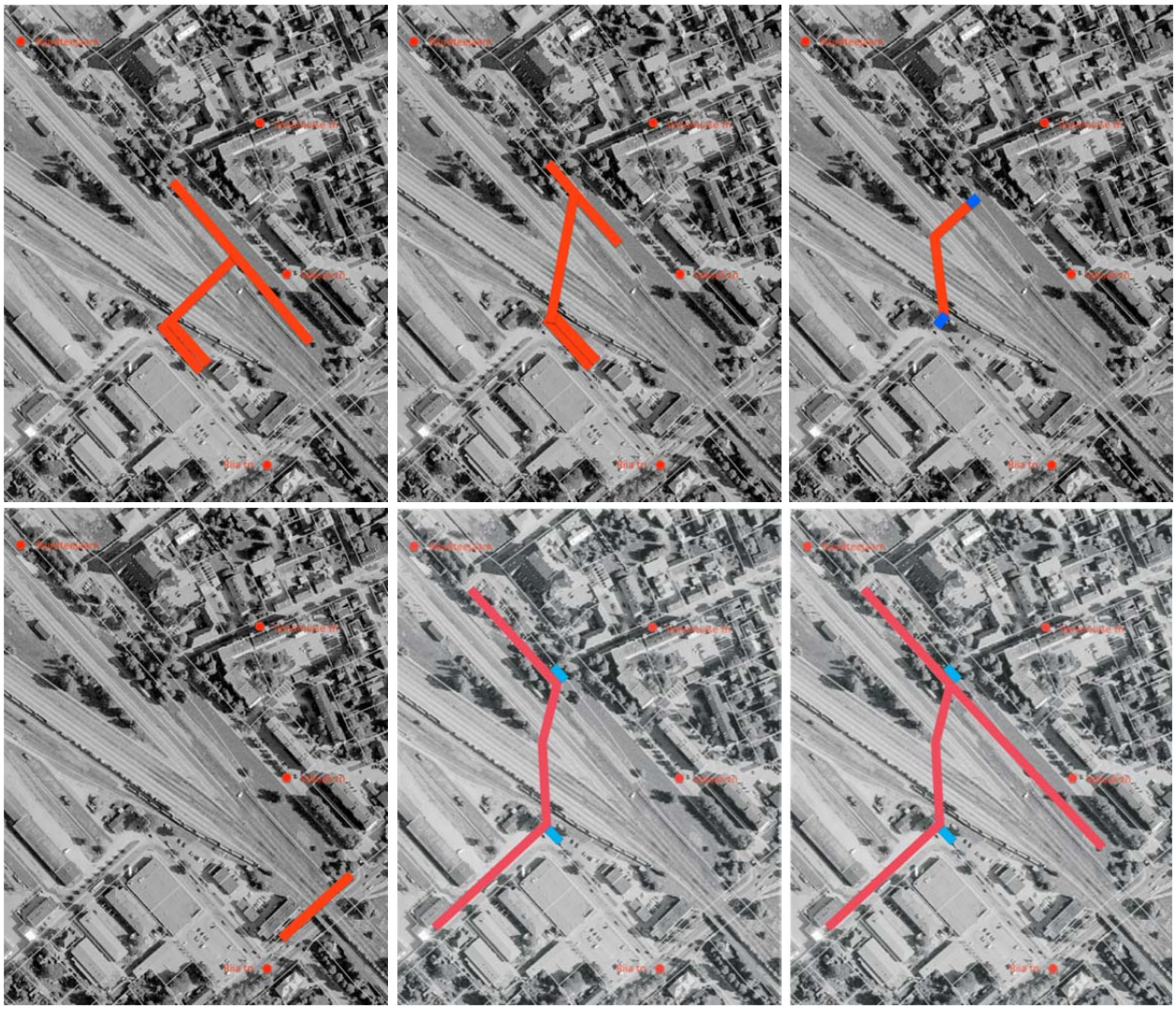

Figure 35: Alternatives 1-6 for position the pedestrian/bicycle bride (City of Tartu)

Currently the city has drafted 6 different positions (see Figure 35) for a bridge or a tunnel to cross the railway. These 6 positions will be put on public display and a public discussion to enable citizens to bring in their opinions.

When one of the solutions is selected an initial draft design of the construction will be produced. The bridge or a tunnel has to be in compliance with Estonian standards and the crossing itself with all roads and lanes leading to it have to be at least 6 m wide.

The draft sketch will be followed by a feasibility study to assess the financial feasibility and evaluate the effects on traffic and environment. Until now no strict time line for constructing the crossing is set. The draft sketch will also give the city government a better picture about how streets leading to the crossing will have to be reconstructed. This will determine the final costs of the project and provide a timeline for the necessary investments.

7.2 District cooling station

District heating in Tartu is organised by Fortum Tartu AS, a part of the Finnish Fortum Group. The group has experienced success with district cooling in a number of northern European cities and is planning to offer the service in Tartu. Their preliminary research has shown that a number of requirements are fulfilled for a better than average organisation of district cooling:

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- The city centre is densely constructed;
- the city centre will become even more dense in time;
- the construction density will provide for high power density of ca 7 kW/m (average: 1,8-5,5 kW/M);
- Fortum is an owner of ground plot right next to the river;
- the river water can be used for cooling during the autumn-winter-spring months and the water can be used for cooling the turbo compressors providing cooling during the summer months.

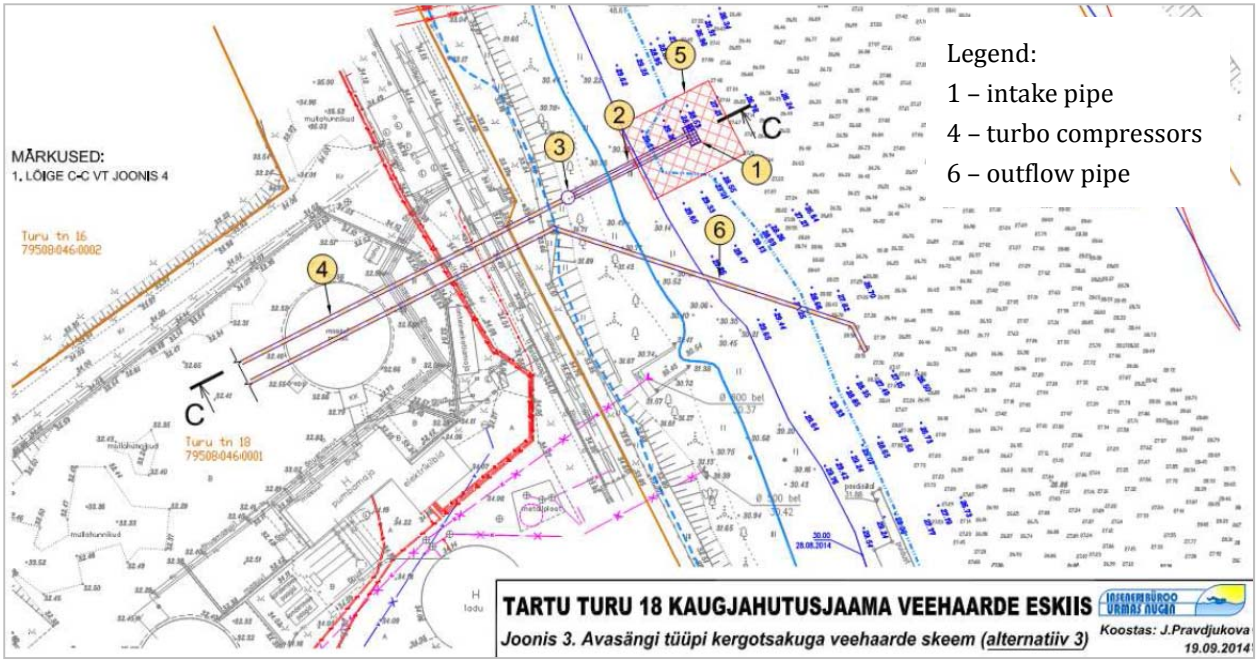

Figure 36: Technical conception of the district cooling station (City of Tartu / Fortum Tartu AS)

The benefits of district cooling will first of all be energy efficiency. The city centre includes mostly public buildings including a water sports centre, a theatre, three shopping centres with a fourth in construction, a youth sports centre a science centre and a number of office buildings (see Figure 37). Currently all the buildings have their own local cooling devices. The different buildings have different use intensity and peaks that provide a possibility for high optimisation of the district cooling system. The efficiency for district cooling system can be 3 times higher than the best local cooling devices can provide.

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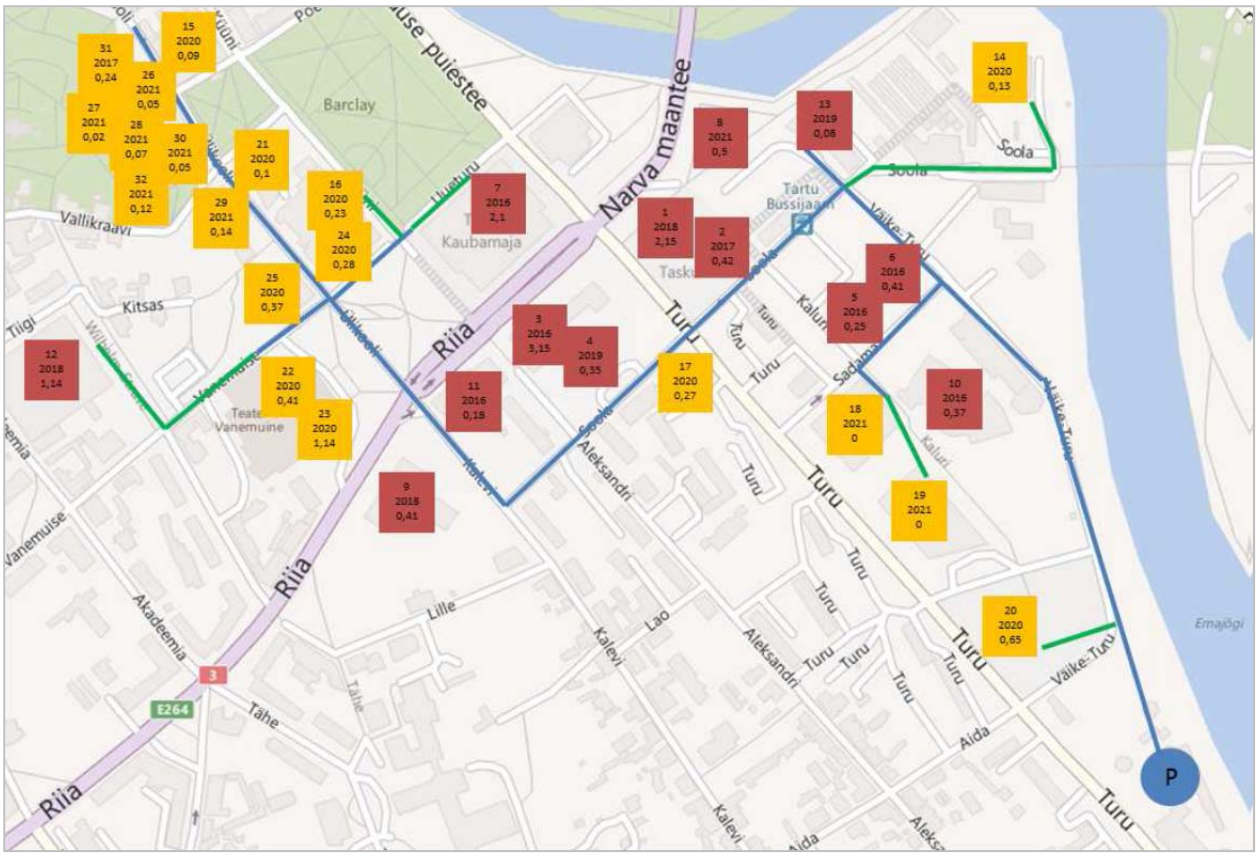

Figure 37: Potential clients for district cooling (City of Tartu / Fortum Tartu AS)

The results of environmental impact research show a low impact on the river and surrounding areas. As Emajõgi is a home for carp there are strict restrictions on affecting the river:

- The water temperature must not increase more than 3 degrees in the out flow area.
- The water temperature must not exceed 28 degrees in the out flow area
- The water temperature must not be higher than 10 degrees during replication period.

Results of the research show that:

- The water directed back to the river is on average 4.4 degrees warmer than intake water.
- The district cooling system will use about ca 0.18 % (436 m^3/h) of the water.
- Worst case scenario is that the water temperature will increase by 0.09 degree in the out flow area.
- For decreasing the effects on temperature the out flow pipe should be situated in the more rapid flow area in the centre of the river.

Table 3: Environmental effects of the district cooling station (City of Tartu / Fortum Tartu AS)

	Unit	Local cooling	District cooling	Savings	Savings
Energy usage	GWh/y	6,0	1,8	4,2	70 %
Primary energy	GWh/y	24	7	17,2	71 %
CO_2 emissions	T/y	8500	2500	6000	71 %

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Table 3 shows the expected savings in energy usage, primary energy consumption and CO_2 emissions induced by the shift from local cooling to a district cooling system. The savings are estimated with about 70 %.

7.3 LED public lighting

The main goal of the project is to reduce energy consumption in public lighting and to improve the road safety in the city. The project was initiated by the Department of Communal Services of the City of Tartu. The primary driver to initiate the project was the ever-rising electricity prices and the need to ensure safe night-time lighting in an urban environment.

The initial plan is to upgrade lighting first in the streets with most intensive traffic and after testing the new lighting system to replace gradually all the city's conventional public lighting.

The results of the first phase (energy consumption, dimming chances) show that LED lighting meets the intended goals; it is therefore planned to move forward with this project in the near future.

Street lighting of Tartu in figures:

321 km lightened roads

227 km air cables and 126 km underground cables

ca 11,500 luminaires

151 switchboards

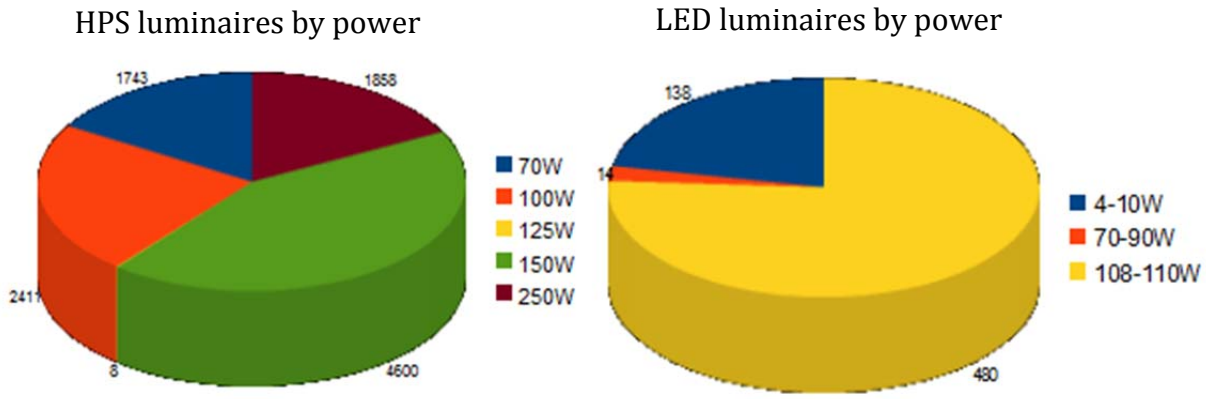

Figure 38: Types of luminaires

Figure 39 shows that the main expenditures of the city for public lighting are induced by the electricity consumption, thus, here lies a high potential for optimisation.

Year	Electricity	Maintenance	Repairing	Total
2012	585 000,00 €	145 000,00 €	92 700,00 €	822 700,00 €
2013	595 000,00 €	99 600,00 €	80 000,00 €	774 600,00 €
2014	720 000,00 €	112 850,00 €	70 000,00 €	902 850,00 €

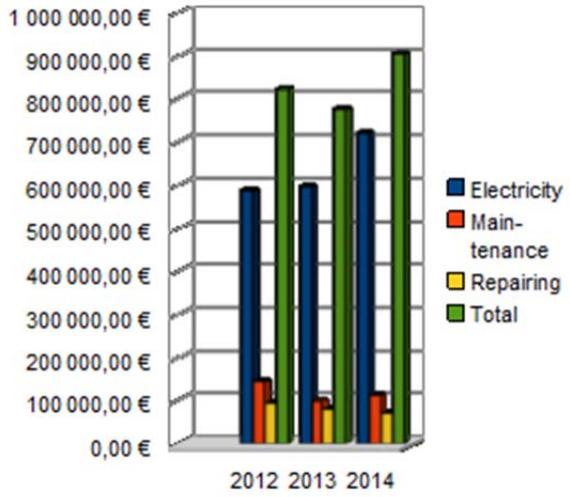

Figure 39: Expenditures on electricity

The objective of the project is to decrease the environmental impact of public lighting in Tartu and the development of an intelligent street lighting network. Acquiring new energy efficient LED streetlights enables to reduce energy consumption and GHG emissions, while improving traffic safety and security of citizens in the city; low energy consumption of LED luminaires enables to have more lighting for the same costs and energy consumption. LED lighting enables better uniformity of pavement, the establishment of a lamp based control system enables to reduce operational (dimming) and maintenance costs.

In the first phase 470 pre-dimmed luminaires plus 20 radio-controlled luminaires were installed. The second phase is currently in implementation, 450 radio-controlled luminaires shall be installed.

	HPS (regular)	HPS (electronical ballast)	LED (regular)	LED (radio-controlled)
Power	250W	250W	110W	110W
Consumption of 1 luminaire	1061 kW	713 kW	314 kW	less than 300 kW
Consumption of 450 luminaires	477,45 MW	320,85 MW	141,3 MW	135 MW
Savings from street lighting (lighting class ME4)	0	33,00%	70,00%	more than 70%
Expenditures on electricity	66 843,00 €	44 919,00 €	19 782,00 €	18 900,00 €
Savings €	0,00 €	21 924,00 €	47 061,00 €	47 943,00 €

Figure 40: Comparison of different lighting systems

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Figure 41: LED and HPS luminaires in Riia street

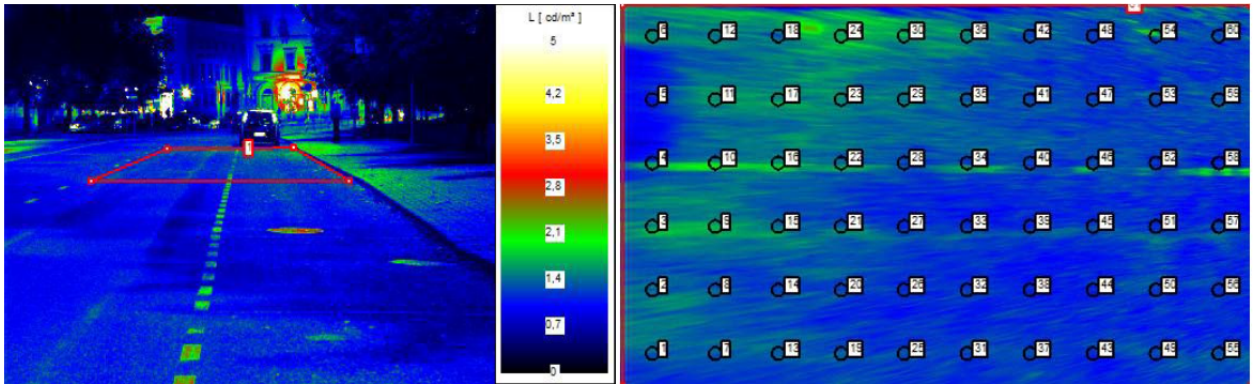

Figure 42: Uniformity of the pavement luminance, Vabaduse Alley, new LED (107,6W, Philips Selenium, luminous flux 9348 (lm, efficacy 88lm/W, colour rendering index 4000K)

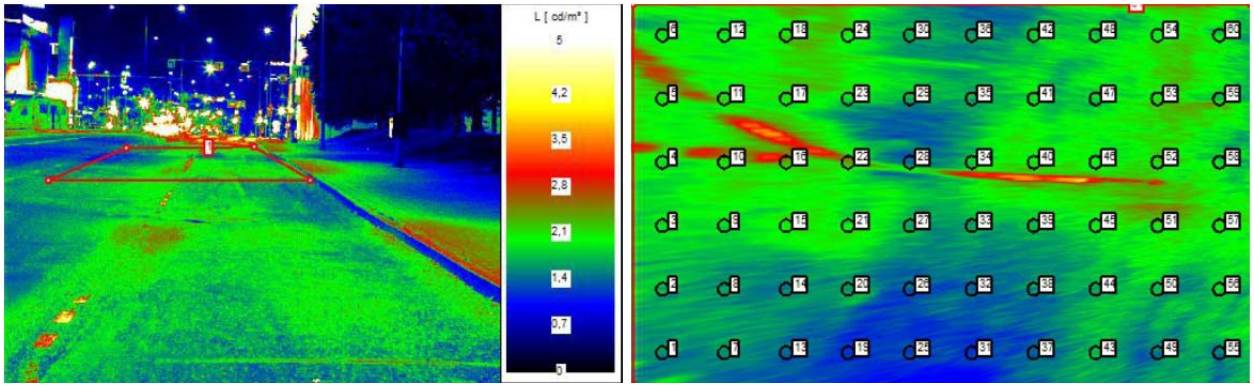

Figure 43: Uniformity of the pavement luminance, Vabaduse Alley, HPS (250W)

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Figure 44: Dimming in Vabaduse Alley, 107 W LED 100% (left) vs. 107W LED 20% (right)

The testing of the LED lighting shows that the street environment is still secure as well as colour and rendering of the lighting is good. Furthermore it's possible to save more than 70 % of energy. As the uniformity of the pavement is better in the case of LED lights, it is possible to increase the distance between the poles and decrease the power consumption of luminaires. LED lighting makes it possible to improve the security of the city and does not shed light on areas with low traffic density.

8 Summary of urban energy planning in Tartu

The main goals regarding national transport and energy policies are formulated in

- the National Spatial Plan "Estonia 2030+" (NSP)
- the National Renewable Energy Action Plan (NREAP) 2020 and
- the Estonian Environmental Strategy 2030.

These documents show a clear vision of the objectives which are pursued on the national level, but at the same time the documents lack to formulate concrete measures that put the specified development principles into action.

"**Low-density urbanised space**" is the central spatial development concept, described in the NSP. It aims to combine the concept of compact urban space with low-density settlement characteristics in Estonia. Furthermore the NSP focuses on reducing energy dependency on imported resources as well as ensuring security of energy supply, which shall be achieved by regional energy production and increasing the share of renewable and local fuels.

Thus, efforts towards higher energy efficiency – at least on the national level – are rather driven by striving to decrease fuel dependency than merely efficiency objectives.

The main strategic and planning documents on the local level are

- the Development Strategy "Tartu 2030"
- the Master Plan of Tartu (2006)
- the Tartu City Transport Development Plan 2012-2020

The Development Strategy "Tartu 2030" sets up a strategic vision for the city's development up to 2030, including goals and directions of activities. By these means the Development Strategy "Tartu 2030" interlaces the formulated objectives for the city's developments with the required planning model and implementation process.

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The Master Plan of Tartu and the Tartu City Transport Development Plan formulate a concrete concept with goals, measures and plans for the city's development. The documents point the necessity to involve "all relevant stakeholders" out, but do not mention concrete alliance groups. Hence, besides the current main actors shaping the urban development of Tartu, which are the municipality and its administration and the main energy supplier Fortum Tartu, purposeful alliances should be figured out.

Contrary to the concept of a compact and intensive city development, as formulated in the NSP and the Master Plan, the concrete development tendencies of the Master Plan operate not in accordance to that, by e.g. planning new residential areas in the outskirts of the city. Thus, the actual development of Tartu is characterized by ongoing **urban sprawl**. As one reason is named high land values which cause land immobility.

Regarding questions of energy efficiency and transport especially the Transport Development Plan highlights current weaknesses in the transport system and draws a clear picture of the goals for the development of the transport system in Tartu.

Though, the Transport Development Plan points the weaknesses in the city's transport system and partly across the city border out, but the measures address only the city scale and not aspects of e.g. regional commuting, which is actually the bigger problem.

The outlined missing links arise, among others, from the following aspects contradicting integrated efforts towards increasing energy efficiency:

One obstacle is caused by the Estonian planning system in combination with the municipal structure: The main responsibilities for planning activities are held on the **local level**, whereas the regional level (county) is rather weak. Estonia has 215 municipalities[24] and the territory of the municipalities is quite narrow confined, thus, the local planning competences have a very limited scope of action, tied to the core city territory.

This constellation implies a problematic gap of cooperation on the regional level, leading to dispersed urban development in suburban municipalities. Furthermore, due to the rather small municipalities their interests excess reasonably its municipal borders; that causes contradicting interests and developments between neighbouring municipalities, but misses a coordination level at the same time.

Similarly demands of regional positioning and integrated planning within the functional urban area (as e.g. mentioned in the Development Strategy "Tartu 2030") can be hardly addressed neither fulfilled.

Another aspect is the extensive **privatisation**, which took place especially in the housing market, in Estonia. Most of the houses and apartments are privately owned and there is a lack of housing organisations taking responsibility of common issues, such as decisions about the heating system. It is for example not mandatory to connect to the district heating network, which implies uncertainties for the energy suppliers in decisions about the extension of the district heating network. Thus, the aspect of privatisation is considered as one of the main limitations to policy implementation. Decisions are taken too close to each property and, hence, lack the broader planning perspective covering a functional entity.

One major problem in Tartu is regional commuting, which includes short distance commuting due to ongoing urban sprawl and far-distance commuting, e.g. to Tallinn. This is also caused by the national concentration on Tallinn as the capital, providing diverse employment possibilities, while the main employers in Tartu are the municipality and the univer-

[24] Currently a reform to join local governments (municipalities) up to a minimum amount of inhabitants (e.g. 5,000) is in process.

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sity. At the same time transport planning within the city region becomes exceedingly problematic due to the outlined planning framework. A lack of available data on regional commuting is just another hint for a planning gap on the regional level.

9 Perspectives for thematic report (D4.3)

There are two central aspects regarding the case of Tartu, which are interesting and relevant to examine further regarding the question of energy efficient urban planning:

1. The concept of "low-density urbanized space"
2. The limited influence of the municipality/planning on household decisions

The first aspect is the **concept of "low-density urbanized space"**, which is outlined in the National Spatial Plan "Estonia 2030+" (NSP) and – as a principle for urban development – also transferred into the previous and current Master Plan of Tartu. This concept aims to combine the principle of compact urban space with the low-density settlement characteristics in Estonia. By these means the requirements of a sustainable (compact) urban form shall be met and at the same time the historically evolved Estonian settlement structures are considered. Contrary to this concept the actual development tendencies show however an ongoing **urban sprawl**[25] in the vicinity of Tartu. Responsible causes seem the following:

- The planning system in combination with the spatial confines of the municipalities causes
  - a gap of cooperation on the regional level, leading to dispersed urban development in suburban municipalities;
  - contradicting interests and developments between neighbouring municipalities;
- High land values, which cause land immobility.

A second relevant aspect for further examination is the **limited influence of the municipality on household decisions** due to a high private ownership. That makes e.g. refurbishment or connection to the district heating network a subject of negotiation. Thus, **privatisation** is considered as one of the main limitations to policy implementation.

The first mentioned aspect illustrates very well that questions of energy efficient urban planning are not tied to the core city level, but require a wider perspective taking into account the regional urban system ('functional urban area').

Both drafted aspects show, that the actual possibilities of the municipality to include energy issues in urban planning or to control urban development at all are very much related to the framework of the planning system and the local power relations. These determine the scope of action in terms of the **territorial scope** (municipal area) as well as the **planning competence** (vs. e.g. private property rights).

Although there's already a first approach of explanations for the outlined gaps in energy efficient urban planning in Tartu, the question – if there're might be further obstacles – needs to be closer examined.

An interesting aspect in Estonian energy policy is the fact that the driving force is not energy efficiency but fuel independency, which stands for an economic or social (secure energy supply) objective and probably causes policy related **goal conflicts**. This is also reflected in

[25] This raises an additional question: At what point do we consider urban form as sprawled? Can we apply a general pattern or do we have to include historical and regional specificities (e.g. a culture of remote single-family-houses in Finland or Estonia vs. a tradition of compact city structures in the UK)?

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the fact that national energy related documents lack to formulate concrete energy efficiency measures affecting urban energy policy. Also, urban planning in Tartu has to deal with a different commitment to energy efficiency or sustainability than for example in Eskilstuna.

Hence, the framework within which urban planning in Tartu has to act is not favouring efficiency related efforts in urban planning. Urban planning is '**locked-in**' the framework of the planning system and the local power relations. Therefore it's necessary to explore appropriate possibilities that enable integrated energy efficiency measures within the given framework and to control urban development.

Potentials to investigate lie e.g. in the involvement of stakeholders and the facilitation of alliance-building as well as in the targeted use of incentives (e.g. to connect to district heating …).

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10 Figures and tables

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Annex 1. Translation of text on historical development of Tartu

The following text is a translation of chapter 1.3 of the Master Plan of Tartu 2012 (Tartu linna üldplaneering aastani 2012, City of Tartu, 1999), describing the town's historical development.

Translation was conducted by Martin Kukk, student at the University of Copenhagen.

1.3 The town's territorial development

Within the current area of Tartu laid a complex system of valleys and gorges in pre-quaternary period. The largest of these were Raadi-Jaama gorge and Raadi-Maarjamõisa gorge, which also border the old town of Tartu. The old valley of Emajõgi is thought to be emerged during the muraavino[26] era, by which time the above-mentioned gorges were already filled with glacial sediments. Due to the effect of the melting water from the glacial a terrain of gulches, flood valleys and sand hills was compiled during the late ice age in the area of old town.

The oldest archaeological findings from the areas of Tartu originate already from the Mesolithic era and were found in 1997 from Ihaste, from the area of the Hipodroom Street. Younger stone-age and bronze-age stone axes are found from many sites from the old river bank in the area of the town. A late stone-age burial ground was discovered in 1911 in Karlova Park.

Natural conditions were the decisive factor when deciding on the location of Tartu. Namely, the higher boulder clay ridges permitted a passage across the bogs of Pärnu County, the marshy basin of Võrtsjärve and the lowlands of Peipsi only in the areas of Tartu and Viljandi. Furthermore, the easternmost of the three ancient trade routes ran along the boulder clay ridges of northern part of Tartu County and crossed the river Emajõgi from the place of today's Tartu. The settlement was established on the narrowest part of the old river valley, where excellent conditions for building a fortress on a hill and for establishing a port place occurred and ample quantities of spring water for every day needs could be found.

Based on archaeological findings, it is estimated that the ancient Estonians established a wooden fort on the South-East plateau of Toomeneemiku during the 5-6th century. A more permanent type of settlement was established on the plateaus' Eastern and Northern side by the end of the first millennium latest. Water barriers surrounded the fortress. Findings with relation to the earliest settlement are obtained nearby the intersection of Jakobi and Munga Street, it seems to reach the line of Kitsa Street from the South side. By the side of Emajõe, the Viking-time settlement reaches the centre of the quarters in places between Rüütli, Küüni and Ülikooli Streets. During the period in question, smithies were located under the fortresses' Northern slope. In the course of the archaeological excavations during the second half of the 1980s two unique Norelund-type Scandinavian bronze pendants made here during the second half of the 10th century were found from the cultural layer of these smithies. These findings refer to cultural bonds with Scandinavian countries. In the beginning of the second millennium, the area of ancient Tartu increased notably. The archaeological findings from the old town suggest that the reason for it lays in the evolvement of the settlement, which was able to mediate trade between the towns of Old-Russia and the lands by the Baltic Sea basin. Considering the above, the war expedition of the Russian prince Jaroslav Smart in the year of 1030, with the help of which Tartu went down in

[26] *Muraavino* – It was not possible to translate this term since no other sources referring to it could be found.

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written history as Jurjev, becomes more understandable. It seems that in this period the entire plateau of Toomemägi was already taken into use. The settlement could have been bordered by Lai Street from the North side and by the contemporary Vanemuise Street from the South side. From the East side, the cultural layer containing wheel-thrown pottery typical for this period reaches in places the centres of the quarters between the streets of Rüütli and Kompanii. Traces of the settlement from the second half of the younger Iron Age are also found from the area of the main building of Raadi manor's, from the south side of Fr. R. Kreutzwald Street 54 in Tähtvere and also from the middle parts of the quarter between the streets of Vanemuise, Pepleri, Tiigi and Akadeemia. It is presumed that a road network connecting the hinterland with the center emerged by the end of the period in question. Tartu and Otepää were the major centers of the ancient Ugandi county.

Tartu (Tarbatu) was conquered by stronghold crusaders in 1224. A bishop's castle made of stone was built instead of the wooden fortress of the ancient Estonians during the 13th century. The largest cathedral of the Baltic lands dedicated to Peter and Paul was built nearby the castle. Tartu was the centre of the diocese and the future hanseatic city. The town was now named German-like Dorpat. Even after the German conquest, Tartu was still a wooden town with few stone houses and churches, which borders did not completely coincide with the area bordered by the protection wall in 14th century. An ample amount of facilities related to handicrafts were found during the archaeological excavations from the cultural layer of the town's centre belonging to the period under question. Blacksmithing, tannery and bone working were dealt with at the foot of the castle. The production was liquidated at the market in Town Hall Square, where special row stores with workshops located. The social organisation and the statute of the town were probably significantly different in the beginning of the middle ages from that of subsequent times. Archaeological studies show that the wooden road pavements of Lossi, Rüütli and Lai Streets were already established before the German conquest. The streets parallel to Emajõgi and the streets in intersection with these occurred in the course of the planned establishment of the medieval town basing the process on the examples of German towns and on the main directions of traffic. The road network surrounding the town was formed of old Pihkva road, which had its starting point at Karja gate and of Riga, Viljandi, Otepää, Narva and Tallinn, Alevaküla, Kastre and Tähtvere roads. The roads joined before entering town's gate, forming fields and squares where already in the 16th century postal stations may have located (on Riga Hill and in Jüri Valley, for example). The length of Tartu's town wall was 2.1 kilometres and it surrounded an area of 27.6 ha in size, where citizens' houses, churches, monasteries and other important public buildings were located. St John's Church completed in the beginning of the 14th century is also located in the town's centre. During the archaeological excavations in the 1980s, relics of Pre-Christening-era Christian sanctuary were found from the cultural layer of St. John's Church. It is thought that already 5,000-6,000 people lived in Tartu during the first half of the 15th century. The prosperity of Tartu during the Middle Ages was based on successfully mediating the trade between German commercial centres and mainly towns of Pskov and Novgorod. Main trade routes passing through the town were the roads of Narva-Riga and Tallinn-Pskov and river roots with Pskov and perhaps with Pärnu. It is likely that the barges were already used in Tartu during the hanseatic period and also that annual fairs were held.

We still do not know much about the suburbs i.e. slums of Tartu during the medieval and modern period. Metropolitan Isidoros, who travelled through Tartu in the first half of the 15th century, praised the town's size, its fancy stone houses and plentiful gardens in his travelogues. But the citizens' garden plots were located in the suburbs. It is also presumed, that a Russian freight yard was located on Holm (an island between the rivers of Koolujõe

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and Emajõgi). Stoneware findings dated from 14-16th century, near the Northwest corner of present-day nightclub "Atlantis" from the cultural layer above silt-layer, confirm the existence of a medieval settlement in this area. One of the medieval suburbs was probably also located a bit farther at Ülejõe Borough. We know from the oldest plans, that a street network opposite to Koolujõe river, similar to modern network was already established by the 17th century. In the area of Tuule Street, the St. George's leprosy hospital and an execution site (so called Kaagimägi) were located. The most comprehensive archaeological studies of the cultural layer of suburbs are conducted in the areas located south of the town wall. From the cultural layer exposed during the aggravation works for the construction of contemporary Market Hall (Kaubahall) and Post Office (Postimaja), data about the medieval road network, large yards surrounded with upright piles, the way of building houses and about water management systems from medieval times was obtained. It is likely, that the medieval settlement continued even farther alongside the former Alevaküla Road (Kalevi Street). From the quarter between the streets of Vallikraavi, Ülikooli and Kitsas, traces of a brick-nave, made of Devon-era clay, were found during the 1997-1998 archaeological excavations. The cultural layer of Tartu's mediaeval and modern period suburbs with relevant findings is also identified close by to Narva Street, in the area of former Veterinary Institute, in front of Narva 89, at Kivi Street, at the western side of Põik Street, on the shores of Koolu river, in the area between Turu Street and Emajõgi and also in the area of Pepleri and Veski Streets. The historical data about Tähtvere, Raadi and Ropka manors also already dates back to the 16th century.

Tartu was held by Russia during the Livonian war in 1558-1582. The Kingdom of Poland got possession of the town up to 1625 with the treaty of Jam Zapolsky (except for the short Swedish rein in the years of 1600-1603). Both Russian and Polish authorities dealt in some extent with renovating and repairing the town's fortification. According to a building revision compiled by Polish authorities in 1590, 71 building plots of town's 276 were empty and 16 were either destroyed or the buildings on the plots were destroyed. During the Swedish rein many administration and church institutions were established and in 1632 a university – Academia Gustaviana – was founded. The Swedes started to renovate Tartu's fortification belt during the second half of the 17th century by modifying Toomemäe's belt of bastions. Still, the town was conquered already in 1704 by Peter the First's troops during the Great Northern War.

Tartu was severely damaged during the Great Northern War. Russians started destroying the town systematically in 1708. The defence walls were blown up, churches and houses were arson and citizens were deported to Russia. The opportunity to return to home did not come until 1714, by which time many decided not to seize it. Arduous work of reconstructing the town began. Still in 1735 only 69 houses were in the town and only 8 made of stone. The municipality rule was re-established in 1719. The border of citizens' common property reached the grounds of medieval leprosy hospital - approximately the line of current Jänese Street - in northeast by the year 1729. In South, the border reached the later Lina Street and in the West the grounds were more or less bordered by the town fortifications. In northwest the grounds of common property also covered the area of Supilinn Suburb, reaching the line of current Meloni Street. The tradition of old names continued also after the Great North War. For example, written resources refer to Kivi Street at Ülejõe Borough, to Holm, Narva, Jaama, Luunja and Kastre Roads and to other former names.

The reason for shifting the town's border in 1787 was the great fire in 1775, after which Tartu was conclusively removed from the list of fortress towns. The fire destroyed over two thirds of the town's wooden houses. The reconstruction plan envisaged the straightening of the medieval street network and well-planned construction of the town. New Town

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Hall and Stone Bridge became the architectural dominant of the Market Square, providing the square with complete and clear-cut spatial effect. Tsar Paul the First donated the area of former entrenchments in Toomemäe to the University of Tartu in 1799, its re-opening in 1802 created favourable conditions for further development of the town. The main building of the university became the second compositional node of the town next to the town hall building. The complex of the university buildings in Toomemäe augmented this further. The centre of the town got the classicistic appearance still observable today. New stone buildings were also built by Narva and Riia Streets. Green space around the town's centre was developed and several new squares were created (The Square of Barclay de Tolly, the surroundings of the Stone Bridge, Auriku Street and others). The outskirts of the town were also developing. The suburbs mainly emerged by the roads descending along the side of the old valley. In contrast, the streets were designed unnaturally across the old valley and they often headed straight up the slope of the valley. In higher positions around the outskirts of the town, in the areas of Veski, Tiigi and Puiestee Streets and elsewhere were windmills. In south, Lower-Karlova up to Rebase Street belonged to the town. The buildings at Ülejõe Borough reached Jaama Street and Juudaoja. In west, the town was bordered by Veski Street and in northeast by Piiri Street. It is interesting to compare the banks of current Emajõe to the old riverbanks. The river was more winding and partitioned, with many pits deeply penetrating the riverbank. Many bonds were connected with the river by now long gone creeks. One of the former creeks that had its start from the springs of Toomemäe was located when archeologically studying the building pit of the contemporary Market Hall in the second half of the 1980s. New numbers were given to plots of the entire city in 1785, they were valid until 1941 (first mentioned on the city plan of reviser O.G Dreyer in 1787). Numbers were also given to the boroughs: I - the town's centre, II - the southern suburb and III - Ülejõe Borough.

During the 1870s the proportion of industry and the number of business enterprises increased notably. The machine era had begun. The guild-system originating from the middle ages was permanently abolished in 1877 and new Russian town-law came into force in Baltic provinces. The transition from labour- to capital-rent and more frequent incidents of buying farmstead in perpetuity brought along the emergence of the rural workers class moving to the towns. Majority of the immigrants were Estonians moving from the hinterlands to town. In 1851, 12,627 people lived in Tartu, according to the population census of 1897 this number had been increased to 40,664. Kastani Street up to Võru Street became the town's western border in the 1870s. The completion of Tapa-Tartu railway in 1876 and connecting the town with Riga via railway by the end of the century, affected particularly Toometaguse-Vaksali Borough and the area between the streets of Filosoofi and Kastani. Wooden suburbs arose mainly around Tähe Street and Karlova manor, but also at Ülejõe in the area of yeast factory and Narva Street and in the area of Puiestee and Jänese Streets. Market squares were established between Peetri and Maarja Streets. Streets in Ülejõe Borough developed in the direction of cemeteries that were established on the lands of Raadi manor after the countrywide order in 1773 to stop burying the deceased in town churches and in cemeteries surrounding them. Trading had gathered around Henning Square, where the roads to hinterlands had their start. Timber, meat, food, hay, fish and Jewish markets located on both sides of the river in the town center near the port. In the end of the 19th century Supilinn Borough with structural planning and dwellings by the side of the plot developed below Tähtvere. The wooden houses on Lepiku Street, genuinely preserved to this day, were built before the I World War (designed by architect Fr. Kangro). A land area bordering Riga Street, the railway and approximately today's J. Tõnissoni Street was incorporated with the town in the end of the century. A little piece of marshy grassland on the

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left bank of the river, opposite to Kuu Street was also incorporated. Tartu had become an Estonian town, although the municipality was held by Germans till the end of the Tsarist era. Tartu became the centre of national movement in 1860s.

During the years of Russification, in 1893-1918, the official name of the town was Jurjev. The territorial expansion of Tartu continued also in the beginning of the 20th century. The grounds of the slaughterhouse and new boroughs in the area of Kastani and Veski were added in 1901. Karlova Suburb and a new borough formed from the lands of Tähtvere manor and Purde farmstead between the streets of Savi, Tööstuse, Näituse and Kastani were added to the town in 1916. At that time the architectural focus shifted from the low floodplains by the river to the area of Riga, Aia and Pepleri Streets, where many presentable buildings were built (the "Vanemuise" clubhouse, the German Theatre, an university building, the Estonian Students Society building and others). The trials of designing the national form were particularly pronounced in the works of the architects K. Burman, A. Perna and G. Hellat at that time.

Veeriku Borough was added to the town in the early years of the Republic of Estonia and with the nationalisation of the nearby manors and their lands in 1923, the territory of the town increased more than two-fold, amounting to 2149 hectares. The territory of the town was divided into town's, have-not's, church's, state's, university's and private properties. The architects A. Soans and A. Eichhorn designed a borough of factories and private houses in 1923 to the lands of Ropka and Bishop's manor. The possibility for it occurred because of the existence of vacant land, which was also used for building a railway branch. In the same year, architect E. Kuusik designed Tamme garden-town, which was developed to become a residential area with deep plots and streets with rich greenery. Based on the plans of the architect A. Matteus a new borough with modern architecture emerged on the lands of Tähtvere manor in 1930s. Taara Avenue with its peaceful surroundings was constructed in 1932. During the pre-war period the banks of Emajõgi were also insured and new groves and green spaces were established there. During the 1930s most of the marketplaces located on the riverbank were abolished. The importance of Tartu in railway traffic increased significantly after the opening of the Tartu-Pskov railway in 1931. 60 300 people lived in Tartu in 1938. The geometrical centre of Tartu's commercial territory shifted towards south by 130 meters between the years of 1913-1935. It is worth noting, that similarly the borders of Tartu's ancient settlement reached further from the southern side than subsequent town centre surrounded by the medieval protective wall.

Tartu lost over half of its buildings during the II World War. The town's centre on both sides of Emajõgi was destroyed, also the buildings by Riia and Aia Streets and especially extensively by Tiigi Street. To replace the destroyed south side of the Town Hall square a series of buildings with classicist facades were constructed in the 1950s, which still engage with the general concept of the preserved buildings (authors I. Jaagus and A.Matteus). The Town Hall square was widened a bit from the western side. Green areas were designed on both sides of the river to replace the destroyed quarters. Riga Street became the main artery passing through the town. Võidu Bridge was completed in 1957. Reconstruction of Tiigi Street started in the end of the 1950s. Free layout of the standard buildings differed entirely from the historical town's structure. Residential quarters with similar buildings were completed in the 1960s in the areas of Turu, Soola, Raatuse and Pärna Streets. Private homes were built on vacant sites in Tähtvere, Tammelinn, around the highway to Räpina, in the areas of Kruusamäe and Võru Streets and elsewhere. The first post-war expansion of town borders occurred on the 28th of December 1962 on the basis of fixed legislation. Areas of Soinaste Village's, the Tuberculosis Sanatorium's, the university's and surrounding collective farms' were merged with the city. During the second half of the 1960s the ground

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layout of Ihaste Horticultural Cooperative was completed. In the 1970s the general plan of Annelinn was prepared by the design organisation "Estonian Project." The base material for the private home district New-Ihaste was prepared in the 1980s. The main document that guided the constructional development of soviet-era Tartu since 1976 was Tartu's general plan, which determined the town's border valid to the present day.

The historical development of Tartu's territory is introduced by the scheme "The formation of town Tartu and its territorial development". (see Figure 9, p. 13)

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