ANALYSIS OF FUTURE URBAN ENERGY SYSTEMS BASED ON OFFICIAL STRATEGIES AND POLICIES: THE ROLE OF BIOENERGY

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SUMMARY: The percentage of people living in urban areas is expected to continue growing and in order to create sustainable cities, energy systems need to be modernized. EU-level targets, national energy strategies as well as strategies of selected case cities include significant aims for increasing energy production from renewable sources and reduction of greenhouse gas emissions. Analyzed municipal climate and energy strategy documents were noticed to be to a great extent based on upper-level targets, although the scope and specificity of plans varies. Increasing the utilization of bioenergy was a common aim for all the case cities. Often mentioned bioenergy technology routes are involving e.g. transport biofuels, centralized and decentralized CHP production and small-scale heating systems.

1. INTRODUCTION

The importance of cities is growing since the share of urban population is increasing both worldwide and in the EU. In Europe, 71% of the population lives in urban areas and the corresponding percentage value worldwide is 52%. (Population Reference Bureau 2013) In addition to population growth, also the exhaustion of fossil fuel reserves and concerns about climate change cause a need for a transition in urban energy systems. Bioenergy is among the potential renewable energy technologies that can contribute to reduction of greenhouse gas emissions also in cities if utilized sustainably.

Various binding and non-binding energy targets and strategies have been drawn up, for instance, by the European Commission and national governments to develop and retain sustainable energy systems and sufficient security of supply. Also, most major cities have established their own climate and energy strategies that rest upon corresponding European Union (EU) and national-level guidelines. In this paper, the strategies and targets of the European Union and related national political documents from selected case countries Finland and Germany are presented with the focus on bioenergy. Development of urban energy systems and especially bioenergy projects are described based on a literature review. In total, ten case cities are selected from Finland and Germany for a detailed review. The development of the energy systems in the selected case cities is analyzed based on the municipal energy and climate strategies. Especially bioenergy related targets and strategies are assessed.

2. TARGETS OF THE EUROPEAN UNION AND NATIONAL ENERGY STRATEGIES

2.1 Energy related targets of the European Union

Upper-level targets and strategies guide the directions of development in cities. The European Union has defined strategies for the development of its energy sector. Binding targets for the year 2020 are set in the Third energy package established in 2007.(Directive 2009/28/EC) The latest update in 2014 is the policy framework for climate and energy in the period from 2020 to 2030. New numerical targets are to reduce greenhouse gas (GHG) emission by 40% compared to 1990 and to increase the share of renewable energy sources in final energy consumption to at least 27%. Contrary to the targets of the Third energy package, the targets of the latest policy are defined only at EU level and not separately for each member state. (European Commission 2014)

A target for increasing the share of energy from renewable energy sources in overall final gross energy consumption to 20% by 2020 is defined in Directive 2009/28/EC. Furthermore, the Directive includes a goal for the transport sector to reach a 10% share of renewable energy in energy consumption. In addition, the Directive obliges GHG emissions to be reduced by 20% compared to the level of 1990 by the year 2020. (Directive 2009/28/EC)

To reach the 20% share of renewable energy sources, individual targets have been set for each Member State. National objectives are set based on the countries' existing energy mix and potential for utilization of renewable energy sources. Individual targets for Finland and Germany are 38% and 18%, respectively. (Directive 2009/28/EC)

Energy efficiency and energy saving policies are considered as effective methods for increasing the share of energy from renewable sources to achieve the overall targets. (Directive 2009/28/EC) The aim for all Member States is a 20% improvement in energy efficiency by 2020 compared to 2005. In addition, the Directive 2009/28/EC obliges all Member States to establish national renewable energy action plans in which they define separate targets for different sectors, set out measures on how to achieve the targets and evaluate the expected gross final energy consumption by taking into account the impact of energy efficiency and energy saving methods. (Directive 2009/28/EC)

The EU's long-term energy strategy is defined in a document "Roadmap for moving to a low-carbon economy in 2050" published in 2011. The fundamental purpose of the roadmap is to provide information on measures that assist on cutting the greenhouse gas emissions by 80% compared to the levels in 1990 by 2050. (European Council 2011)

2.2 National renewable energy action plans of Finland and Germany

The most significant documents defining national energy and climate policies in Finland are the "Long-term Climate and Energy Strategy" and the "National Renewable Energy Action Plan", and in Germany the "Energy Concept" and the "National Renewable Energy Action Plan". National Renewable Rnergy Action Plans (NREAPs) are compiled obligated by the European Commission, hence the documents from all member countries contain the same type of information and are easily comparable. Therefore the National Renewable Energy Action Plans of case countries Finland and Germany were chosen for further analysis.

According to their NREAPs, both Finland and Germany have planned to significantly increase electricity production from renewable energy sources obligated by the European Commission. Total renewable energy production fulfils the targets in 2020, as can be seen in table 2.1 (note: 2005 is used as a base year and production amounts are estimates for 2015 and 2020).

Table 2.1: Electricity production from renewable energy sources in Finland and Germany in 2005 and estimates for 2015 and 2020 **(**Federal Republic of Germany 2010, Ministry of Employment and the Economy 2010)

	2005		2015		2020		Change 2005-2020	
	Finland (GWh)	Germany (GWh)	Finland (GWh)	Germany (GWh)	Finland (GWh)	Germany (GWh)	Finland (%)	Germany (%)
Hydropower	13910	19687	14210	19000	14410	20000	3,6	1,6
Geothermal energy	0	0,2	0	377	0	1654		826900,0
Solar Energy	0	1282	0	26161	0	41389		3128,5
Wind Energy	150	26658	1520	69994	6090	104435	3960,0	291,8
Biomass	9660	14025	9880	42090	12910	49457	33,6	252,6
Total	23730	61653	25620	157623	33420	216935	40,8	251,9

According to table 2.1, utilization of biomass for power production is expected to increase clearly both in Finland and Germany by 2020. In Finland, power production from biomass has traditionally had an important role especially due to the strong pulp and paper industry. The increase of 3250 GWh is planned to occur via greater use of solid biomass such as woody biomass. (Ministry of Employment and the Economy 2010) In Germany, biomass had a minor role in power production in 2005, but by 2020 the amount of annually produced biomass based electricity is expected to have grown by 35 000 GWh. Numerical targets for 2020 for utilization of solid biomass, biogas and bio liquids are set in the NREAPs. To relate the scope of the national bioenergy targets to city levels, targets are allocated to the case cities based on their population numbers (tables 2.2 and 2.3).

Table 2.2: Estimated final consumption of solid biomass, biogas and bio liquids in 2010-2020 in Finland and allocation of targeted changes to the case cities (Ministry of Employment and the Economy 2010) (Population numbers (European Commission 2013, Tilastokeskus 2013))

	Finland			
	Total (GWh)	Biomass (GWh)	Biogas (GWh)	Bio liquids (GWh)
2010	68565,7	35447,0	388,9	32729,8
2020	96297,1	53682,2	967,8	41647,1
Change in 2010-2020	27731,4	18235,2	578,9	8917,3
Change per capita	0,005110	0,003360	0,000107	0,001643
Targets allocated to cities (change 2010-2020 in GWh)				
Espoo	1332,5	876,2	27,8	428,5
Joensuu	1126,5	740,8	23,5	362,2
Tampere	930,4	611,8	19,4	299,2
Turku	380,6	250,2	7,9	122,4
Vaasa	338,9	222,9	7,1	109,0

Table 2.3: Estimated final consumption of solid biomass, biogas and bio liquids in 2010-2020 in Germany and allocation oftargeted changes to the case cities **(**Federal Republic of Germany 2010) (Population numbers (European Commission 2013, Destatis 2014))

	Germany			
	Total (GWh)	Biomass (GWh)	Biogas (GWh)	Bio liquids (GWh)
2010	179581,8	104909,0	25621,8	49051,0
2020	245166,8	128680,8	45128,0	71358,0
Change	65585,0	23771,8	19506,2	22307,0
Change per capita	0,00081	0,00030	0,00024	0,00028
Targets allocated to cities (change 2010-2020 in GWh)				
Berlin	2749,1	996,4	817,6	935,0
Freiburg	177,6	64,4	52,8	60,4
Hamburg	1412,5	512,0	420,1	480,4
Munich	1130,7	409,8	336,3	384,6
Wuppertal	279,3	101,2	83,1	95,0

On a national level, both Finland and Germany intend to increase especially biogas production (tables 2.2 and 2.3). The percentage increase is 148.9% in Finland and 76.1% in Germany. In Germany, the absolute growth is approximately on the same level for solid biomass, bio liquids and biogas. In Finland, clearly the biggest absolute growth is expected for solid biomass.

Descriptions of bioenergy plans in NREAPs reveal that Finland aims at increasing usage of wood chips in CHP production and separate heat production to 25 TWh/a by 2020. Small-scale usage of wood for heating is targeted to stay on 12 TWh. In 2020, the use of biofuels in transportation is aimed to be 7 TWh. Use of agricultural and natural biomasses is planned to be increased. Target for the use of both pellets and recycled fuels is 2 TWh for each. (Ministry of Employment and the Economy 2010)

Also Germany aims for significant growth in CHP production. By 2020, the target is to double the share of electricity produced with CHP plants to 25%. In the NREAP, the demand for biomass in 2020 is expected to be 880 PJ of final energy and 1400 PJ of primary energy consumption. Domestic biomass could account at the most for 1000 PJ of primary energy. It is suggested, that the gap between demand and supply can be compensated for example by cultivation of new energy crops. Utilization of residues and by-products that do not compete with food industry are promoted for bioenergy production. Biogas should be utilized more in CHP production and for fuel production and 200 million m^3 of natural gas could be replaced by biomethane. In the heating sector, it is estimated that local biomass or biogas–based heating systems will partly replace biomass furnaces in households so that their share of bioenergy will decrease. In the traffic sector, 173 ktoe of biomethane is estimated to be demanded by the 500000 gas vehicles that should be in traffic by 2020. In total, the consumption of bioethanol will be 857 ktoe and consumption of biodiesel 4443 ktoe in the traffic sector in 2020. **(**Federal Republic of Germany 2010)

2.2 Common climate and energy strategies and targets of the municipalities

In addition to national and EU-level strategies, cities have also voluntary commitments and memberships of alliances of municipalities. The European Commission initiated "Covenant of Mayors" after the establishment of the Third Energy package in 2008. "Covenant of Mayors" is a movement that supports and promotes regional actors in the Member States in their actions in climate protection. The aim is to meet or even exceed the targeted 20% reduction in CO_2 emissions by 2020. All cities that participate in the movement submit a sustainable energy action plan in which measures for reaching the objectives are described. Furthermore, special actions performed are listed as benchmarks of excellence. Of the case cities, Tampere, Espoo, Turku, Berlin, Hamburg, Munich and Freiburg im Breisgau have joined the "Covenant of Mayors" movement. The CO_2 reduction targets of the case cities participating in the Covenant of Mayors are: Espoo 28%, Tampere 30%, Turku 20%, Berlin 40%, Freiburg im Breisgau 20%, Hamburg 40% and Munich 47%.(Covenant of Mayors 2014)

The Finnish Ministry of Employment and the Economy administers several programs on energy efficiency. In the municipal sector, there are two programs for the time period 2008-2016, one for smaller and one for bigger municipalities. The core target of both agreements is to reduce energy consumption by 9% during the stated time period. All the Finnish case cities have signed an energy efficiency agreement with the Ministry of Employment and the Economy. (Ministry of Employment and the Economy 2014)

All the German case cities, Berlin, Freiburg im Breisgau, Hamburg, Munich and Wuppertal are members of Climate alliance, an European network of 1600 cities and municipalities from 24 European countries. The member cities are voluntarily committed to reduce their CO_2 emissions by 10% every five years and halve their per capita emissions by 2030 from the level of 1990. (Climate Alliance 2014)

3. DEVELOPMENT OF URBAN BIOENERGY SYSTEMS

3.1 Experiences of implemented bioenergy projects

Experiences from different kinds of bioenergy projects in European cities are described in various articles. (e.g. Madlener et al. 2007, 2008) (Athonis et al. 2013) The analyzed articles present projects related to large-scale bioenergy cogeneration plants and introduction of B30 biodiesel in the car fleet. Additionally, an article about the development of two urban waste management systems is included in the analysis. (Johnson et al. 2011) Several driving forces, risks and challenges and success factors of bioenergy projects were discussed in the analyzed articles (figure 3.1).

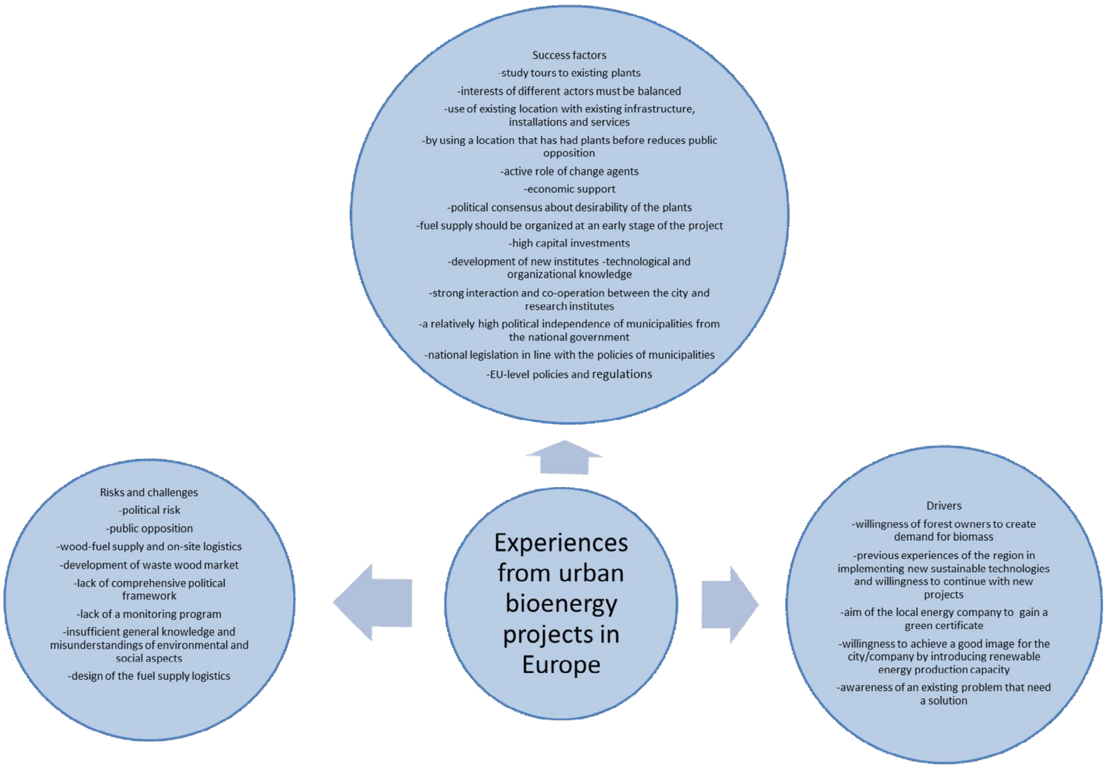

Figure 3.1: Driving forces, risks and challenges and success factors of the analyzed bioenergy projects (Madlener et al. 2007, 2008) (Athonis et al. 2013) (Johnson et al. 2011)

According to the summary in figure 3.1, economic support and political will to carry out the project are among the success factors, whereas political risks and a lack of a comprehensive political framework were noticed to be barriers for successful implementation of bioenergy projects. Following a strategy that favors the introduction of new sustainable plants that contribute to the creation of a green city image is also mentioned as one of the driving forces behind many projects. Suitable independency of the city in decision making is mentioned to be favourable for the creation of innovative solutions, but municipal policies should be in line with national legislation. Higher level targets, for example the policies of the European Union, are also assumed to support the development process. In addition, co-operation between the city and research institutes contributes to the introduction of innovative solutions. Various other factors are mentioned as well, but the existence of political and legislative frameworks seems to be an important aspect for drivers, success factors as well as risks and challenges.

Figure 3.1 summarized the experiences from four bioenergy related projects but it does not contain a complete collection of drivers, risks and challenges and success factors. The obligation to reach binding upper-level targets is not mentioned in the analyzed articles, but it can be considered as one of the most important driving forces behind the implementation of renewable energy projects. Furthermore, technological risks must be taken into account, especially when introducing modern bioenergy technologies. Also risk of demand may be determining: for instance, demand for district heating production may decrease significantly if heat pumps and ground heat systems continue to become more common and if energy efficiency of buildings improves notably. In the electricity sector, changes in production capacity in other regions and countries from the same market area affect electricity demand and prices and must therefore be anticipated when contemplating new investments. Security of fuel supply can be critical to profitability of bioenergy plants and therefore adequate feedstock capacity, preferably nearby the plant, could be listed as a success factor.

3.2 Planning of municipal energy systems

The relationship between centralized and decentralized strategic energy planning of Danish cities is analyzed in Sperling et al. (2011). It is stated that involvement of municipalities and other local actors is required to enable the planned increase in decentralized energy production. According to the article, municipal energy plans can be used for evaluating the focus areas and ambitions of the cities in energy planning, whereas conclusions on implementation can be drawn by comparing the focus areas and corresponding institutional frameworks. Synergies between cities should be supported and sub-optimization avoided by central coordination. However, the policies and legislation should be flexible enough so that municipalities implement the most suitable actions of the national focus areas. The article by Sperling et al. (2011) describes Danish cities, but the same features were present also in analyzed Finnish and German municipal energy strategies. As a conclusion, it can be stated that policies and municipal strategies are crucial for the development of bioenergy production in cities.

To evaluate the energy future of Finnish and German cities, five case cities were selected from both countries. By analyzing the energy strategies of the case cities, this report aims to provide guidelines for urban energy system development and to identify the most popular future technologies for energy production.

3.3 Selection of case cities

Considerations for the selection of the case cities were geographical diversification and relatively high population numbers. For comparison, cities with various population numbers were selected. The focus was on forerunner cities that are most likely among the first ones to adopt new energy technologies. Selected case cities were Espoo, Joensuu, Tampere, Turku, Vaasa, Berlin, Freiburg im Breisgau, Hamburg, Munich and Wuppertal whose population numbers can be seen in table 3.1.

Table 3.1: Selected case cities and population numbers (Tilastokeskus 2013, Destatis 2014)

Town	Population number on 31 December 2013
Espoo	260753
Joensuu	220446
Tampere	182072
Turku	74471
Vaasa	66321
	Population number on 31 December 2012
Berlin	3375222
Freiburg im Breisgau	218043
Hamburg	1734272
Munich	1388308
Wuppertal	342885

The case cities have drawn up and published a broad variety of documents that are related to energy system development. Furthermore, energy companies and other local actors have also their own strategies. The most relevant document from each city was selected for further analysis. The relevance of the documents was justified by their validity, the responsible bodies involved and by the subject of the document (Table 3.2).

Table 3.2: Analyzed climate and energy strategy documents with titels freely translated into English

City	Strategy document
Espoo	Climate Strategy for the Helsinki Metropolitan Area to 2030
Joensuu	Climate Programme of Joensuu 2013
Tampere	Climate and Energy Strategy of Pirkanmaa
Turku	Energy Strategy of Southwest Finland 2020
Vaasa	Energy Strategy and Action Plan of Ostrobothnia 2010-2020
Berlin	Energy Concept 2020
Hamburg	Masterplan Climate Protection
Freiburg im Breisgau	Climate Protection Strategy of the City of Freiburg
Munich	The Integrated Climate Protection Concept of Munich and five participating communities Baierbrunn, Gräfelfing, Kirchheim bei München, Schäftlarn and Unterföhring
Wuppertal	Energy efficiency and Climate Protection in Wuppertal - Report and Action Plan 2009-2020

The analyzed documents include energy concepts, climate protection plans and action plans on climate, energy and energy efficiency that are drawn up by the city administration or mandated by the city.

4. RESULTS AND DISCUSSION

The common ultimate target of the strategies is to contribute to the achievement of the national and European Union-level targets and to reduce GHG emissions. The analyzed documents contain various general targets that are common for many of the strategies. Some of the targets of the analyzed cities are higher than the national level and some cities aim at becoming forerunners in implementing of modern energy solutions.

All the analyzed case cities plan to increase renewable energy production. Production capacities of wind power, photovoltaic, solar thermal systems and heat pumps are aimed to grow. Energy efficiency is planned to be increased especially in municipal buildings but also in other new buildings and buildings that are renovated. In the transport sector, bicycle and pedestrian traffic are promoted and usage of public transport is targeted to be increased. Electric vehicles are planned to become more common and some of the cities plan to set an example by introducing electric vehicles in municipal services.

Targets and plans related to bioenergy were collected in more detail from the analyzed documents. Four cities have announced numerical targets for increasing bioenergy production (table 4.1).

Table 4.1: Numerical targets of the case cities related to bioenergy (Karg et al. 2013, Pirkanmaan liitto 2013, Suck et al. 2011, Timpe at al. 2007)

	Current situation	Target	Change
Tampere	Produced bioenergy in Pirkanmaa in 2012: recycled fuels 0 GWh/a, wood and other biomass 3238 GWh/a	Produced bioenergy in Pirkanmaa in 2020: recycled fuels 800 GWh/a, wood and other biomass 4600 GWh/a	Percentual change between 2012 and 2020: 42% in wood and other biomass
Berlin	Production of bioenergy in Berlin in 2008: 268.5 GWh/a of electricity and 731.6 GWh/a of heat	Reference scenario in 2020: electricity from biomass 732 GWh/a or 1184 GWh/a, heat 1785 GWh/a or 3140 GWh/a. Decentralized energy production from biomass 340 GWh/and 201 GWh/a biomass-based zone heating networks. Target scenario for 2020: electricity from biomass 920 GWh/a or 1221 GWh/a, heat 2946 GWh/a or 3730 GWh/a. Decentralized energy production from biomass 715 GWh/a and 236 biomass-based zone heating networks	Percentual change between 2008-2020 in electricity 173-355% and in heat 144-410 %
Freiburg im Breisgau	Bioenergy production in electricity sector in 2005 6,4 GWh/a	Reference scenario for 2020: bioenergy production in electricity sector 7,8 GWh/a. Scenario "Focus city" for 2020: bioenergy production in electricity sector 103 GWh/a	Percentual change between 2005 and 2020 in bioenergy -based electricity production 22-1509 %
Munich	Current electricity production: 9 GWh/a from waste, 8.5 GWh/a from biogas, 37.5 GWh/a from woodchips. Current heat production: 60 GWh/a from waste, 140 GWh/a from wood, 12.5 GWh/a from biogas	Electricity production in 2030, scenario 1: 9 GWh/a from waste, 22 GWh/a from biogas, 37.5 GWh/a from wood chips, scenario 2: 9 GWh/a from waste, 63 GWh/a from biogas and 37.5 GWh/a from wood chips. Heat production in 2030, scenario 1: 60 GWh/a from waste, 230 GWh/a from wood and 30 GWh/a from biogas, scenario 2: 60 GWh/a from waste, 320 GWh/a from wood and 93 GWh/a from biogas.	Percentual change until 2030 in electricity production: waste 0%, biogas 159-641%, wood chips 0% and in heat production: waste 0%, wood 64-129%, biogas 140-644%

Table 4.1 reveals that the increase in bioenergy production in the case cities is planned to be significant. However, most of the cities have various scenarious whith clearly different bioenergy production amounts, and hence the level of actual increase is difficult to assess.

The specificity of bioenergy targets in the cities' strategies varies among the case cities. Some cities itemize the potential of various technologies in electricity, heat and transport fuel productions, whereas others only mention bioenergy production as one of the possible climate-friendly energy production methods. Bioenergy-related technologies found in the case cities' strategies are listed in figure 4.1 (note: it is illustrated in how many strategies each technology is presented). Waste-to-energy technologies are also included in the figure even though only one fraction of waste is biodegradable. CHP production in considered in cases where it is mentioned to be based on renewable energy production.

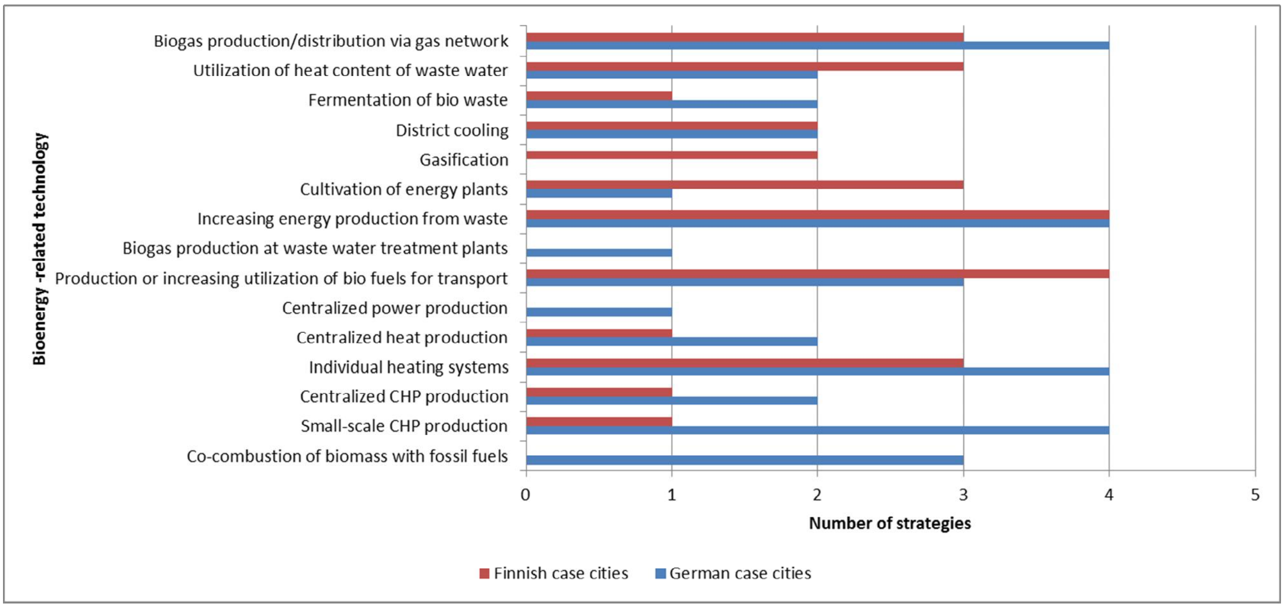

Figure 4.1: Bioenergy-related technologies found in the analyzed strategies of the case cities (Anderson et al. 2007, Brendel 2009, Bürgerschaft der freien und Hansestadt Hamburg 2013, City of Joensuu 2013, Karg et al. 2013, Pirkanmaan liitto 2013, Suck et al. 2011, Timpe at al. 2007, Uitamo 2011, Wasberg et al. 2012)

It can be seen from the figure 4.1 that the most popular bioenergy-related technologies in the Finnish case cities' strategies are energy production from waste and biofuels for transportation. Almost as popular are biogas production, utilization of heat content of waste water, cultivation of energy plants and individual heating systems. In the German cities' strategies, the most often mentioned measures are related to biogas production, energy production from waste, individual heating systems and small-scale CHP production with biomass. Popular actions also include biofuels for transport and co-combustion of biomass with fossil fuels. The biggest differences between the Finnish and the German case cities lie in the cultivation of energy plants, small-scale CHP production and co-combustion of biomass with fossil fuels.

It can be concluded from the strategies, that the case cities have planned to utilize bioenergy mainly for transport fuels and for heat or CHP production. On the other hand, it was noticed that many of the strategies were rather general, hence the planned role of bioenergy in the city's future energy mix was not clearly explained. In addition, the scope of the energy strategies varies, and some bioenergy-related plans may be found in some other strategy documents of the municipalities. For example, in some cities transportation-related targets may be listed in a separate transportation strategy instead of energy strategy.

5. CONCLUSIONS

Planned development of energy systems in the analyzed case cities was noticed to be mainly based on the EU's renewable energy, energy saving and carbon dioxide emission reduction targets even though some of cities have set themselves higher targets. Especially the desire to achieve or maintain a reputation of being a forerunner city by introducing eco-friendly and low-carbon strategies was noticed to be an important driver for setting high targets. The scope of the strategies depends on what kinds of actors are involved. In cities with private energy companies and little co-operation between the city council and the local energy company, targets may mainly be limited to energy consumption reductions in municipal buildings and municipal actions, as well as information campaigns. Instead, in cities with municipal energy companies or plentiful co-operation between the city and the local energy companies, energy and climate strategies often include concrete measures such as construction of new power plants or distribution infrastructures.

Most strategies are based on targets for reductions of carbon dioxide emissions and improved energy efficiency, and producing renewable energy is seen as a tool for emission reductions. Therefore, for example, the attractiveness of additional utilization of bioenergy depends rather heavily on how the carbon neutrality of bioenergy usage is defined.

Only four of the ten analyzed case cities have set numerical targets for additional bioenergy usage. However, national targets, both in Finland and in Germany, include plans for significant growth in biomass, biogas and biofuel consumption in order to reach the targets defined in Directive 2009/28/EC. Consequently, cities can be assumed to have also pressure to introduce new bioenergy production capacity.

Most popular bioenergy-related applications in the cities' strategies were noticed to be related to utilization of biofuels, biogas production or distribution via gas network, energetic utilization of waste and small-scale heating systems. The specificity of bioenergy-related targets was noticed to be low hence it is difficult to evaluate the future role of bioenergy. Especially small-scale heating systems and CHP production are planned to represent decentralized solutions. However, also centralized CHP production and district heating are promoted and the current plants are mainly fossil fuel-fired, thus utilization of bioenergy is planned also for centralized energy production as a partial replacement for fossil fuel usage. Since the plans of the cities were rather general, potential technologies are also difficult to evaluate. Nevertheless, since there are high renewable energy production targets and also the role of bioenergy is planned to be significant at least on the national level, it can be assumed that the circumstances are also favourable for introduction of modern bioenergy technologies.

The analyzed documents describe urban energy system development only from one perspective. Municipalities have only limited decision power over energy related issues and also the interests of municipalities may change as a consequence of changes of upper-level decision-making bodies or policies. Also, other actors, such as energy companies and developers of technologies affect the development of urban energy systems heavily.

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