



LUDWIGSBURG

University of Stuttgart
Institute of Energy Economics and
the Rational Use of Energy

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Summary of Key Findings



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Integrated Climate Protection and Energy Strategy for Ludwigsburg

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City of Ludwigsburg

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1 Introduction

Against the background of the present climate change, finite resources, increasing energy prices, the dialogue regarding energy supply security and the efforts for sustainable management of nature and environment, the City of Ludwigsburg decided to develop an integrated climate protection and energy strategy, the so-called Overall Energy Strategy Ludwigsburg. The City of Ludwigsburg commissioned the Institute of Energy Economics and the Rational Use of Energy (IER) of the University of Stuttgart for this work. The IER involved the DIALOGIK GmbH Stuttgart for work on specific topics. The Overall Energy Strategy also included an expert panel made up of members from the administration, academia, public utilities, and energy relevant institutes, who on the one hand contributed to the foundations during the development of the measures, and on the other hand served as the committee for the expert participation for stakeholders.

1.1 Status Quo in Ludwigsburg

Ludwigsburg is a mid-sized city with approximately 87,200 inhabitants distributed across 12 city districts. Ludwigsburg's city structure is characterised on the one hand by the building density, which is expressed in the high population density of 2,012 inhabitants per km² with concentrations in the city centre, north, east, south and west of the core city, and on the other hand as the spatial settlements noticed through the traffic flows. Especially due to vocational training and commuter traffic, there is a large amount of traffic coming daily into the core city from the surrounding communities. On the other hand, there are also many commuters travelling outwards into the regions of Stuttgart and Heilbronn. Nonetheless, the passenger car density in Ludwigsburg is far below the state average due to the excellent integration and connections with the public transportation of greater Stuttgart, and the household size is slightly lower than the average in Baden-Württemberg. The employment structure is comparable to the national although there is a significantly larger share of other services in Ludwigsburg. Amongst other reasons, this is due to fact that the headquarters of many of the regional services are located in Ludwigsburg.

▪ Large district city with 87,207 residents (2008)
▪ constitutes 12 city districts
▪ Density: 2,012 ppl/km ² (State: 301 ppl/km ²)
▪ Households (2006): 44,350 – Household size: 2.1 (State: 2.2)
▪ Employed: 42,876 (23% in productive commerce (State: 33%)
23% in Trade/Transport/Food (23%)
54% in other services (43%)
▪ in-commuters: 31,231 – out-commuters: 19,569 – netto: 11,662
▪ Passenger car density: 488 per 1,000 ppl (State: 524 per 1,000 ppl)

1.2 City Development Strategy

Since the beginning of 2004, Ludwigsburg has been putting a City Development Strategy into action under the slogan „Opportunities for Ludwigsburg“.

The Ludwigsburg city council decided at a meeting on the 28th of June, 2006 which principles and strategic objectives would govern the 11 thematic areas of the City Development Strategy. These

thematic areas included economy and employment, and mobility and energy, amongst others. The guiding principle for the thematic area of energy was reviewed during the development of the Overall Energy Strategy and a slight modification was made. This guiding principle for the thematic area of “Energy” for the City Development Strategy for Ludwigsburg has been revised and approved by the local council and states: Energy management will be sustainable. This will be achieved by saving energy and using energy efficiently, placing greater emphasis on adopting renewable energy and increasing capacity building in this area. This will have benefits for the general climate development and the local air quality. Energy security will increase, growth in the local and regional economy will be promoted and job security in a progressive field will be created. The 7 strategic goals for the thematic area of energy are the foundation of the measures and recommended action in the Overall Energy Strategy. Within one of the strategic objectives, a call for the development and implementation of an Overall Energy Strategy is explicitly expressed.

Strategic objectives:

1. **Landmark projects** are implemented in the field of renewable energy, especially efficient equipment and examples of energy saving measures in new and existing buildings.
2. The **optimisation of energy** is an important foundation for building plans and also for routine city building plans.
3. The **Overall Energy Strategy** is implemented and regularly monitored and developed further for its performance.
4. The **independent and decentralised energy supply** from the city utility reinforces the regional form.
5. **Intensive publicity und consultation opportunities** for citizens and commerce are a natural part of the sustainable use of energy.
6. The options for **renewable energy carriers, energy services and innovative energy technologies from the region** are extensive and an important **location factor** for Ludwigsburg.
7. Through integrated city and transport planning, behavioural changes and alternative engine technologies, significant **energy savings in transport** are achieved. Thereby also considerably reducing the noise and toxic pollutant impact in the city.

Through the participation in the EU Project „Sustainable Now“, Ludwigsburg has committed itself to adhere to the 20 / 20 / 20 targets of the EU, i.e. by 2020 the share of renewable energy of the gross domestic consumption in the EU should be 20%, 20% of the primary energy demand should be saved from a previously agreed upon forecasted energy demand development, and the CO₂ emissions should be reduced by 20% compared to 1990.

1.3 Methodology – 6 Steps to Success

To ensure the continuous further improvement of the City Development Strategy (CDS) (Chapter 1.1), a management system for the administration of Ludwigsburg was developed. This should ensure that the principles and strategic objectives are pursued or modified when necessary. The management system is a reiterative process, which runs its course every two to four years. The process includes five steps: 1) reviewing the local situation; 2) further development of the strategic objectives; 3) resolving principles and objectives in the 11 theme areas; 4) implementation of the CDS master plan; 5) reporting and evaluation. The relevant objectives and measures of each theme area are bundled in the working level of the administration for each master plan (e.g. the Energy Master plan).

The comprehensive method used for the City Development Strategy served as the foundation for the development of the Overall Energy Strategy for Ludwigsburg and the analysis of the four areas of heating, electricity, industry and transport in relation to energy efficiency and climate protection. The methodology is divided into clear „*Modules*“. The idea is that the measures and solutions (strategies) will be developed and assessed based on the comprehensive analysis of the current situation and

structure (Status Quo). The information gathered for the Status Quo included discussions with important stakeholders in Ludwigsburg, as well as the City administration and the City utilities of Ludwigsburg, and the climate protection and energy agency of Baden-Württemberg, who are concurrently developing a climate protection strategy for the neighbouring city of Kornwestheim. During the development of the Overall Energy Strategy for Ludwigsburg, the expert participation met eleven times between July 22, 2009 and October 20, 2010.

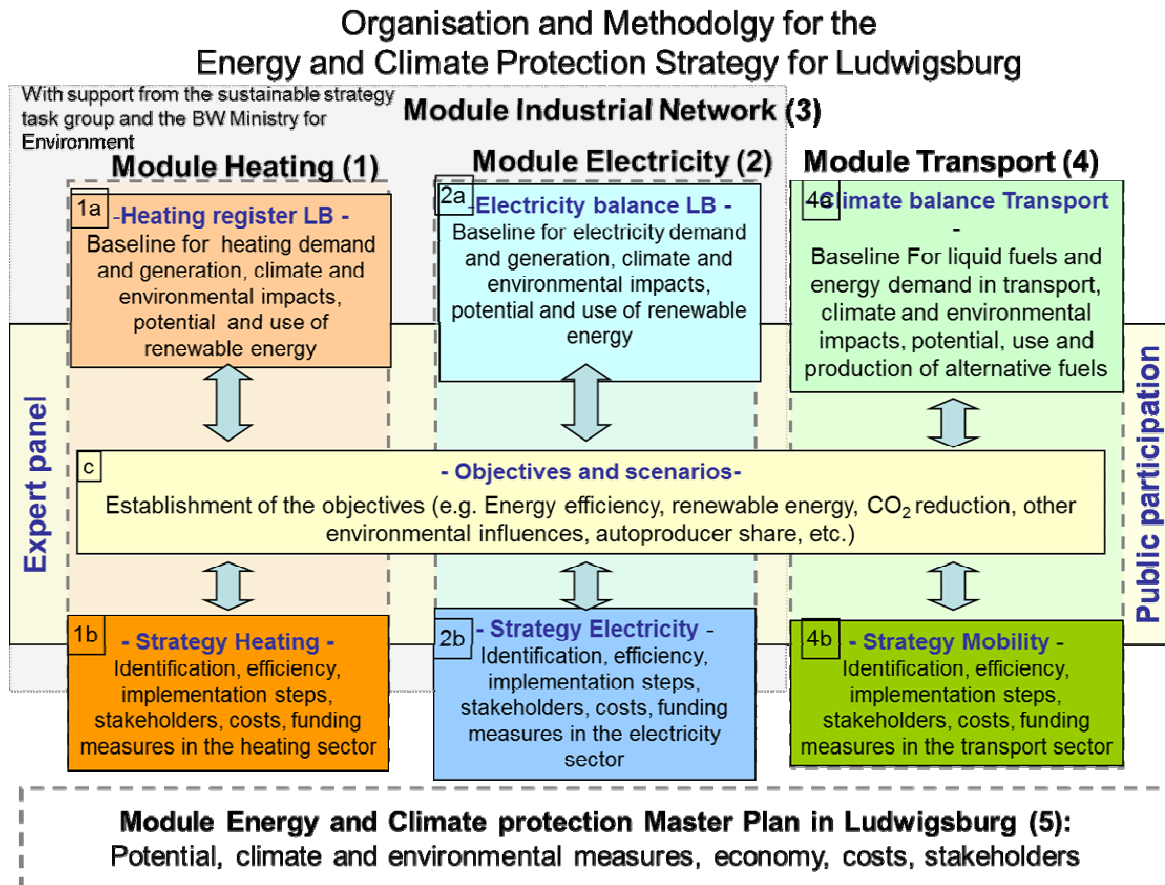
Secondly, a plan was made for the measures and development steps for climate protection, sustainable energy use, security of supply and regional value added in Ludwigsburg. The following package of measures was considered:

- Energy savings and rational energy use: Building insulation, heating exchange, passive energy technologies, lighting, energy saving household appliances, urban planning, information distribution events about energy savings, etc.
- Potential and use of renewable energy: Bio-energy, solar energy, wind und hydropower, geothermal, heat pumps, heat recovery, combined hot/chilled water and steam power, waste management, waste water and landfill gas use, etc.
- Optimisation of the generation structure, adoption of new energy technologies: power plants and heating supply (based on fossil and renewable energy carriers), local and district heating networks, gas networks, air conditioning, process optimisation, etc.

The work and, in particular, the development and assessment of the measures was developed as a discursive process in conjunction with experts from the City (administration, utilities, expert participation) and the citizens. For this, a workshop was held with experts in the form of a Round Table and an Energy Futures Conference was held with public participation. Further activities, which were already prepared during the strategy development and included the dissemination of information and possible actions, consisted of the participation at the public information event on October 14, 2009 at Schlößlesfeld. Furthermore, the public relations in the area of climate protection were strengthened with the introduction of the Overall Energy Strategy on April 15, 2010 in Ludwigsburg at the „Third Climate Protection Meeting“ of the economic development for the Stuttgart region.

The Ludwigsburg city council also participated in these processes. Initially, the board of the Economic, Culture and Administration proposed and resolved to engage the IER Stuttgart in July 2009. In May and July 2010, the city councils participated at the Round Table and the Energy Futures Conference. In August 2010, intermediate information for the city council on the progress of the Overall Energy Strategy was provided, after which a workshop report was presented on October 27, 2010.

The structure and work distribution of the Overall Energy Strategy is represented in the following figure:



Building on the development of the different areas, the overview illustrates the opportunities and barriers to achieving the objectives for climate protection in the three E's (energy savings, energy efficiency, and (renewable) energy) in the City, heating, electricity and transport sectors. The analysis of the overall energy system offers the advantage that the many measures and technologies can be compared with regard to their efficacy and cost-effectiveness.

All together there are 6 steps leading to success for the integrated climate protection and energy strategy for Ludwigsburg and are documented in the following sections:

- Step 1 – Status Quo
- Step 2 – Expert and Public Participation
- Step 3 – Measures
- Step 4 – Integrated Scenario Analysis
- Step 5 – Action Plan
- Step 6 – Continuation: Monitoring, Evaluation and Follow-up#

Status Quo The status quo in Ludwigsburg was determined through six sub-tasks. In addition to compiling a list of existing activities in Ludwigsburg with relevance to climate protection, establishing an energy and CO₂ balance for 2007, assessing questionnaires about energy use for households in the Schlöblesfeld suburb and analysing the heating demand in the Oststadt suburb on a city block level, installing an energy efficient network in the Weststadt suburb, and cooperating with the Mörike secondary school, a detailed analysis of the possible contribution of renewable energy in Ludwigsburg was undertaken. With regard to the existing activities, Ludwigsburg can already boast several achievements and awards in the field of energy and climate protection, such as 2nd place in competition for national capital cities for climate protection in the

category for local authorities of up to 100,000 citizens, or the successful certification according to the European Energy Award (EEA).

1.4 Energy and CO₂ Balance 2007

The balance sheets were elected to follow the territorial principle, i.e. the emissions resulting from energy use in the city are attributed to the city ("bubble principle"). One exception is electricity use, where the polluter pays principle was followed, for which emissions from power plants providing electricity to the city will be attributed to the city although the energy conversion takes place outside of Ludwigsburg. Another exception is the consideration of traffic from the motor vehicle stock ascribed to Ludwigsburg, where the national German average kilometres travelled and specific fuel consumption values differentiated by type of motor vehicle and engine design were applied.

Using this methodology, the actual final energy demand in Ludwigsburg for 2007 was around 2,244 million kWh/a (= GigaWatt-hours GWh/a). The majority of the final energy is attributed to households at 45%, followed by transport with 28%. When adjusting for outdoor temperatures and the values are adapted to the long-term weather conditions of the average year, the final energy demand in Ludwigsburg increases to 2,398 kWh/a, since 2007 was a warm year in comparison to the long-term average.

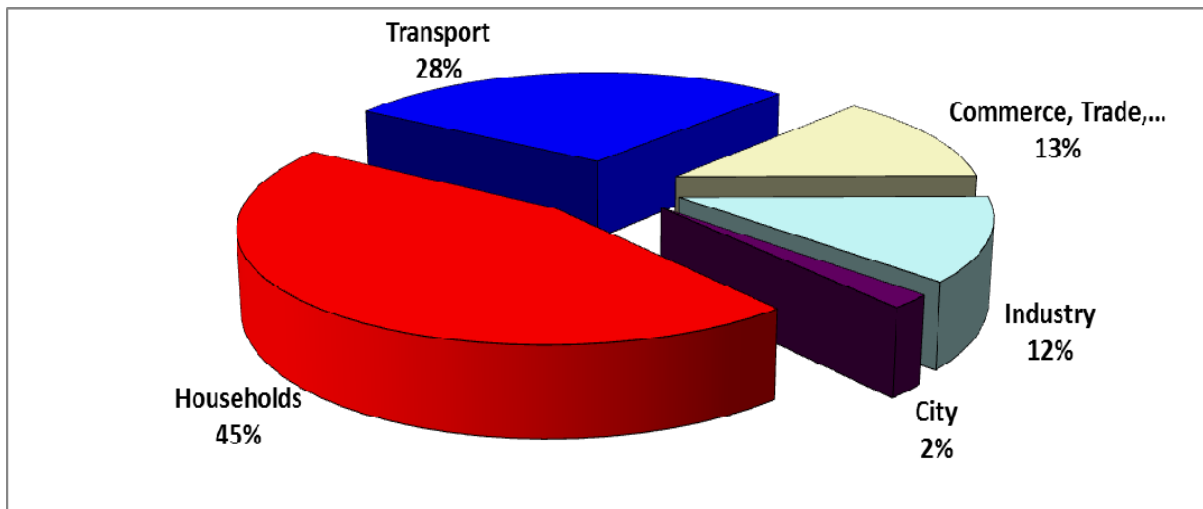


Figure 1: Final energy demand by sector in Ludwigsburg 2007

When including the additional energy required to service Ludwigsburg with electricity and district heating, the actual final energy demand increases slightly to 2,316 million kWh/a. Liquid fuels and fuel oil are each responsible for approximately a quarter of this energy demand, while natural gas accounts for 29% and electricity supply for 18%. Renewable energy contributes about 3% of the final energy demand in Ludwigsburg. If the renewable energy supplied through the imported electricity supply were included, this share would increase by 2.5% giving Ludwigsburg a share of 5.7% of final energy from renewable energy in 2007.

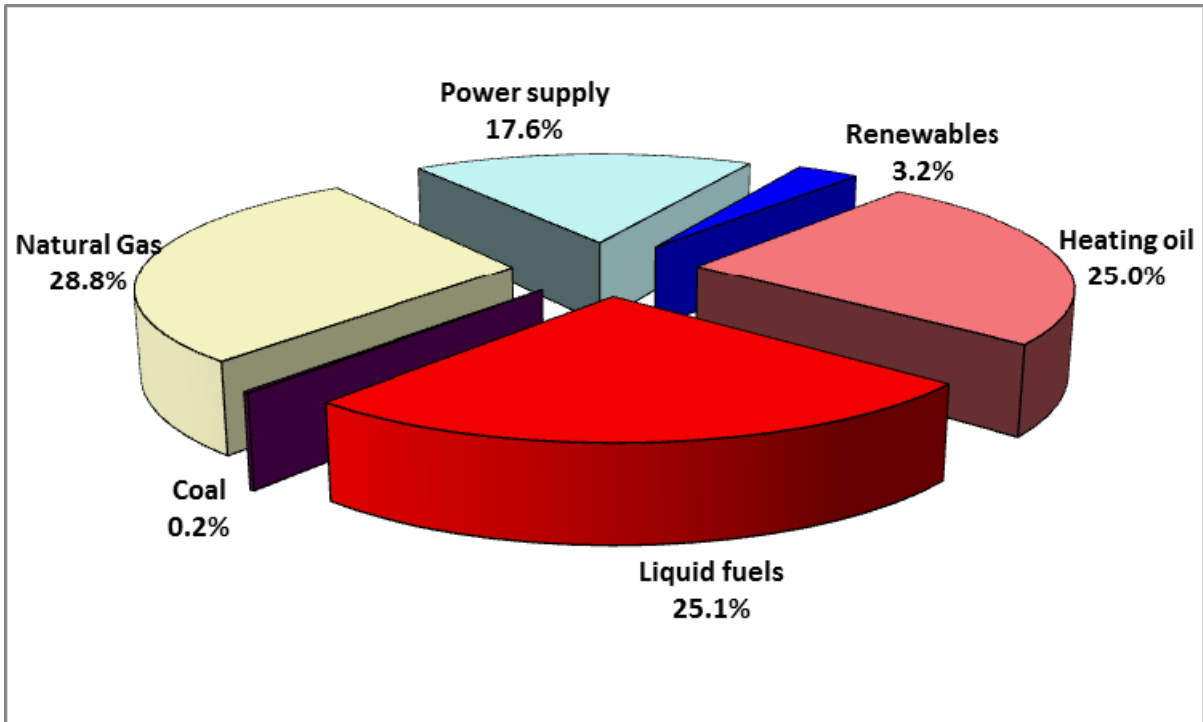


Figure 2: Energy demand by energy carrier in Ludwigsburg 2007

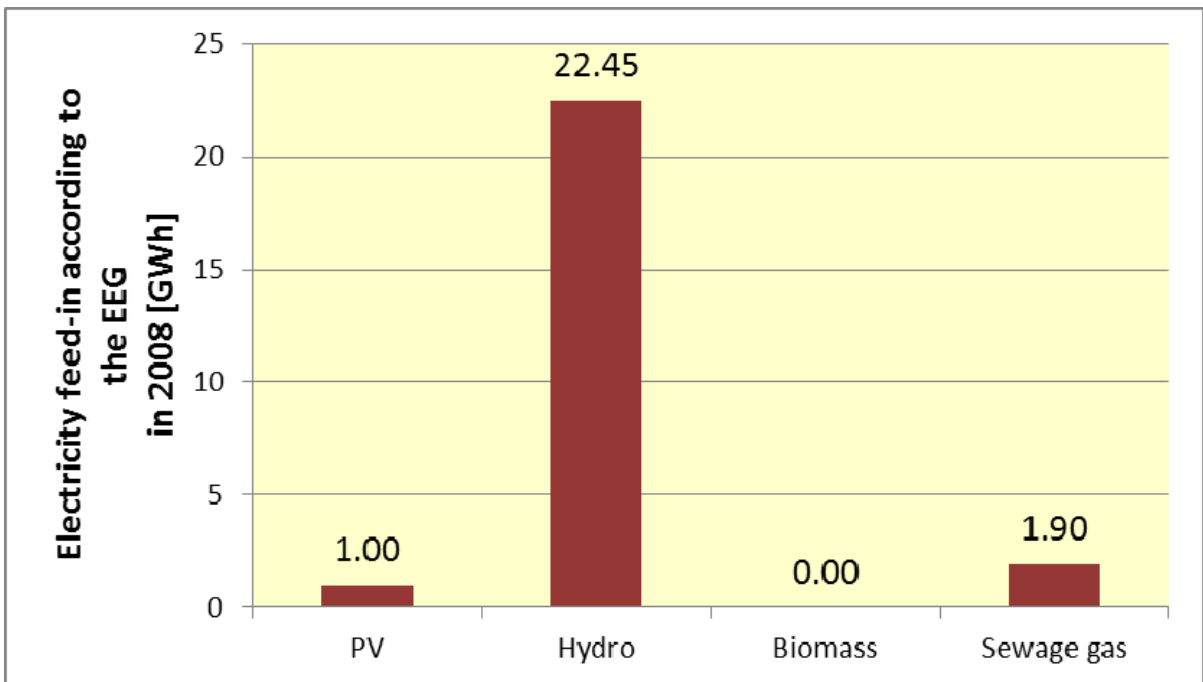


Figure 3: Electricity generation from renewable energy in the City of Ludwigsburg in 2008 /EnBW 2009/

Up to 2008, there was no feed-in of electricity generated from biomass in the City of Ludwigsburg. Since 2010, an extensive feed-in of electricity generated from the new wood-fired cogeneration plant (Operator: SWLB). All together, the wood-fired cogeneration plant generates annually approximately 10 GWh of electricity from wood. Furthermore, 48 GWh of district heating is available for customers of the city utility. Annually, 42,000 tons of wood chips from the region are utilised for the cogeneration plant /Brochure SWLB/.

Figure 4 depicts the contribution of the individual renewable energy carriers to the heating supply in 2008. In total, the heating supply based on renewable energy carriers in Ludwigsburg amounted to around 6.1 – 9.5 GWh. For the latter value, an estimated (potential) use of wood for wood fuel at a capacity of less than 1 MW accounts for approximately 3.4 GWh. With an overall heating demand of about 906 GWh /Kempe et al. 2009/, this corresponds to a share of about 0.7 – 1.0%. The largest share is attributed to heating generation from wood with about 3.6 to 7.0 GWh. This share increases from 51 to 55 GWh as the wood-fired cogeneration plants commissioned starts up.

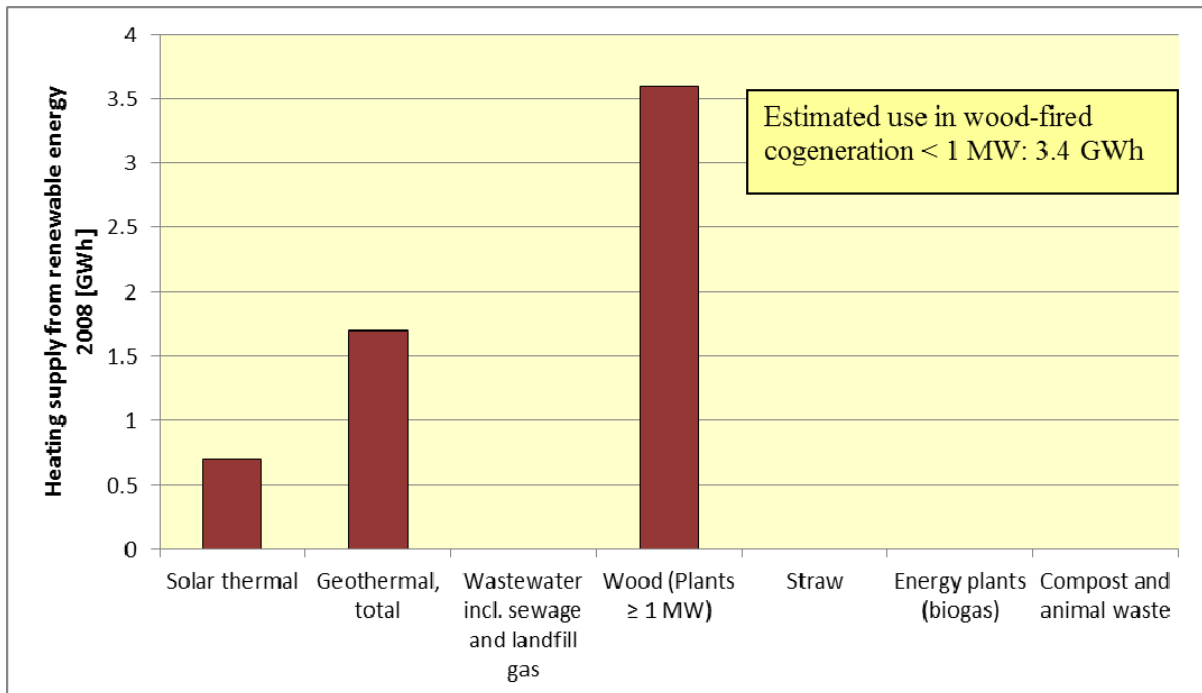


Figure 4: Heating supply from renewable energy in the City of Ludwigsburg in 2008 /Blesl et al. 2008/, /Solarbundesliga 2009/, /Ministry of Environment Baden-Württemberg 2008/, /Kohler 2008/, /Skaletz 2006/, /van Helt 2008/

In the transport sector, renewable energy will be used by mixing the conventional liquid fuels with bioenergy. Their share was 7.4% in 2007. In accordance with the biofuel share law resolved on January 1, 2007, this share should increase to a minimum of 8.0% by 2015.

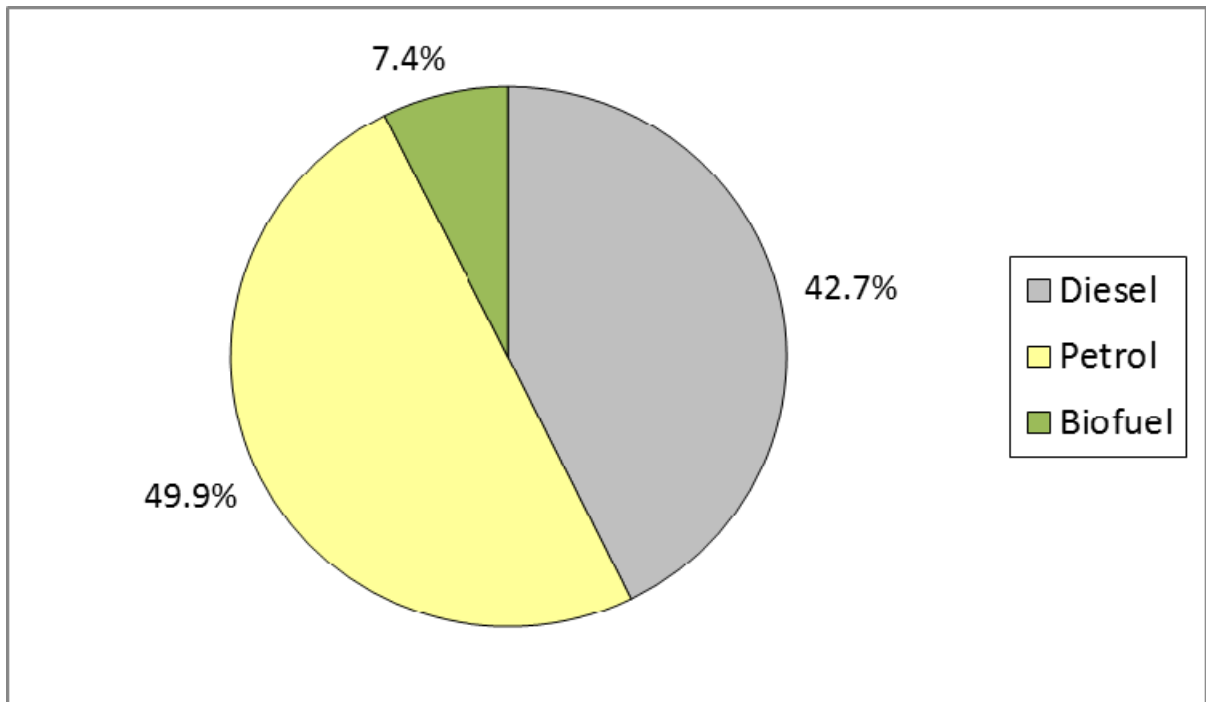


Figure 5: Share of renewable energy in final energy demand for transport in 2007 in Ludwigsburg

The energy related CO₂ emissions attributable to Ludwigsburg were calculated from examining the development of the energy demand and using energy carrier specific emission factors. A total of 539,000 t CO₂/a were emitted in Ludwigsburg in 2007. This averages 6.2 t CO₂/capita/a. In comparison to the average for the state of Baden-Württemberg (6.6 t CO₂ per capita and year), Ludwigsburg already performs slightly better, but in comparison to the national German average (9,2 t CO₂ per capita and year), Ludwigsburg emits much less on average. If the weather conditions are taken into consideration, then the emissions values for Ludwigsburg such that a total of 576,000 t CO₂/a were recorded for 2007. The dominant sectors remain with households responsible for 45% of the actual emissions and transport responsible for 28%.

The actual CO₂ emissions in Ludwigsburg in 2006 totalled 592,000 t CO₂/a.

The energy related CO₂ emissions according to energy carriers shows that liquid fuels are accountable for a share of 28% and fuel oil for a share of 29%. Natural gas follows with a share of 20% and electricity with a share of 18%. Attributing the CO₂ emissions resulting from generating the district heating to the consumption of district heating yields a share of 4.4%.

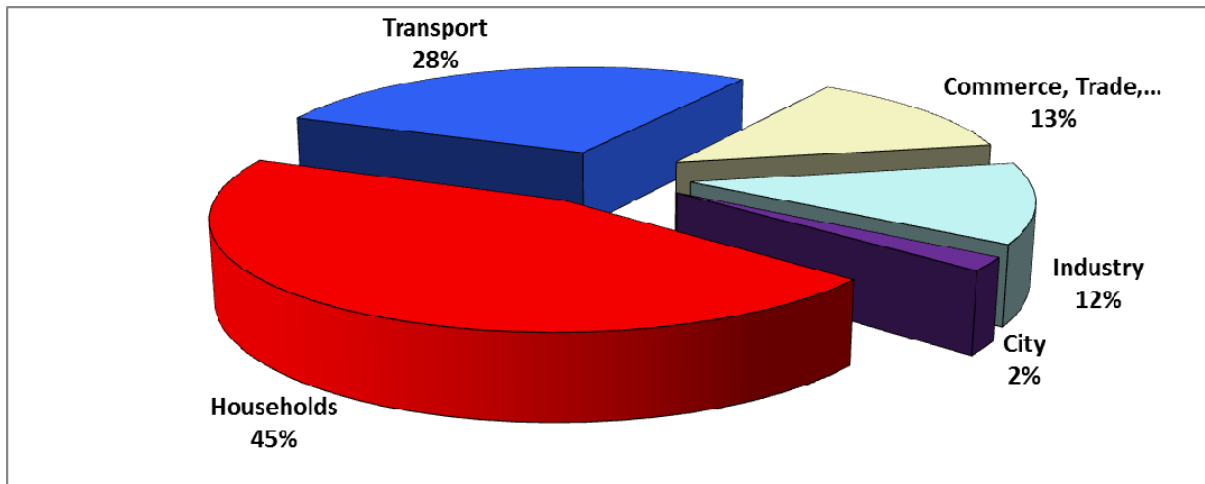


Figure 6: Energy related CO₂ emissions by sector in Ludwigsburg 2007

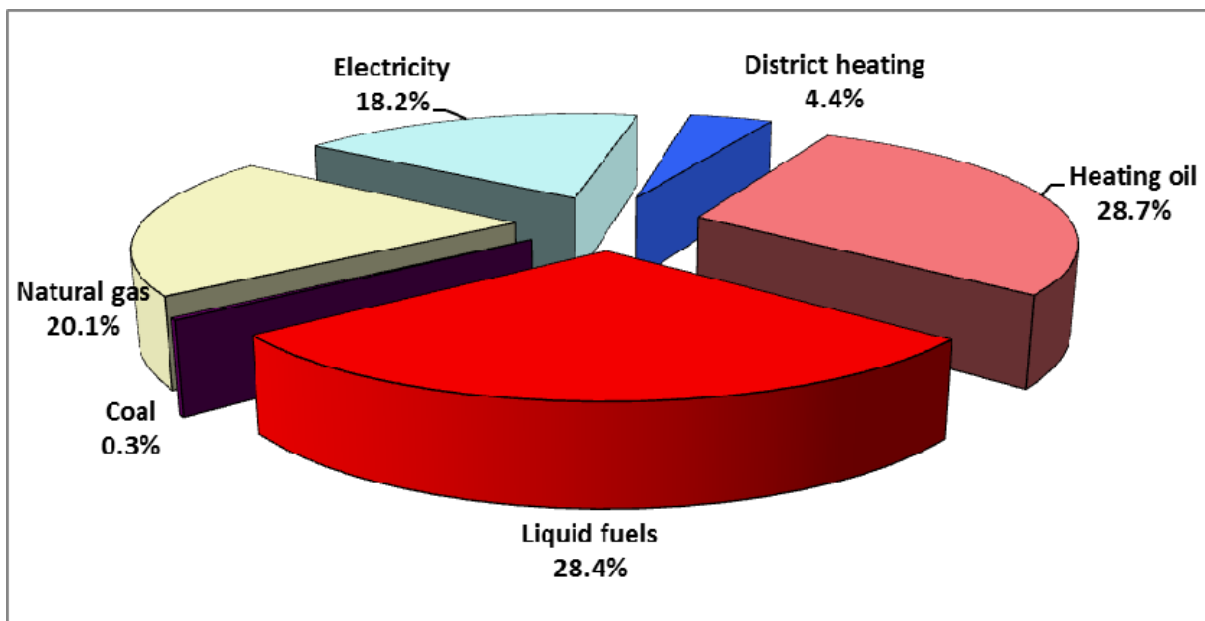


Figure 7: Energy related CO₂ emissions by energy carrier in Ludwigsburg 2007

The CO₂ emissions in Ludwigsburg were reduced even further with the commencement of the wood burning power plant. This measure alone reduced the emissions by 18,000 t such that the emissions level achieved 521,000 t CO₂/a and around 6.0 t CO₂ per capita and year.

Renewable energy potential

The goal of the potential analysis was to determine the scope for renewable energy for electricity and heating generation for the City of Ludwigsburg. The analysis showed that renewable energy has significant potential to contribute to electricity generation in Ludwigsburg. Renewables could account for over 160 GWh (= million kWh) if wood potential appraised for the city area is extended to include the greater region. This could cover around 38% of today's electricity demand in Ludwigsburg. Photovoltaics would play the major role followed by biomass (regional level) and hydro power use. If a 20% reduction in the overall electricity demand by 2025 is assumed due to the implementation of energy efficiency measures, then renewable energy could have a share of 47% in the City of Ludwigsburg. The potential to use renewable energy for heat generation in Ludwigsburg totals around 350 GWh_{th} (wood on a regional level). This would cover almost 39% of today's

heating demand in Ludwigsburg. Solar thermal will play the most significant role followed by wood use and surface geothermal heat collected through geothermal probes and collectors. If a 40% reduction in the overall heating demand by 2025 is assumed due to the implementation of energy efficiency measures, then renewable energy could have a share of 64.5% in the City of Ludwigsburg for the heating demand.

**Expert
and
public
participation**

The work progress and, in particular, the development and assessment of the measures and steps towards implementation of climate protection, sustainable energy use, security of supply, and regional value added in Ludwigsburg were developed as a discursive process together with experts from the city (administration, utilities, expert panel) and the community. Aside steering the project through the expert panel, a round table with experts and a community forum were carried out at the Future Conference on Energy. Involving the participation of the community, business and interested associations at an early stage leads to stronger support in the long term for the Ludwigsburg community and their institutional groups since the measures are developed in collaboration with the community as well as the expert panel. Transparency and acceptance for decisions made in Ludwigsburg provide the community to have a stronger identification with and responsibility for the Overall Energy Strategy and its implementation.

2 Catalogue of Measures

Building on the discussions from the expert participation, the Round Table and the Energy Futures Conference, the measures recommended by IER Stuttgart were further developed and brought into a final format. The current catalogue of measures should serve as a „road map“ for the implementation of climate protection, sustainable energy use, security of supply and regional value added in Ludwigsburg. It should describe and prioritise energy and climate protection activities in Ludwigsburg. At this point, it has not yet been considered if financial constraints may hinder the implementation of the recommendations from the catalogue of measures. In this respect, this currently acts as an idealistic concept.

The catalogue of measures is divided into five areas: (1) Overarching measures, (2) Heating, (3) Electricity, (4) Mobility and (5) Renewable energy generation. The individual measures are classified and labelled accordingly with an abbreviation (O – H – E – M – R). Furthermore, each measure is assigned to the revised strategic objectives from the City Development Strategy for Ludwigsburg.

2.1 Theme Area „Overarching measures“

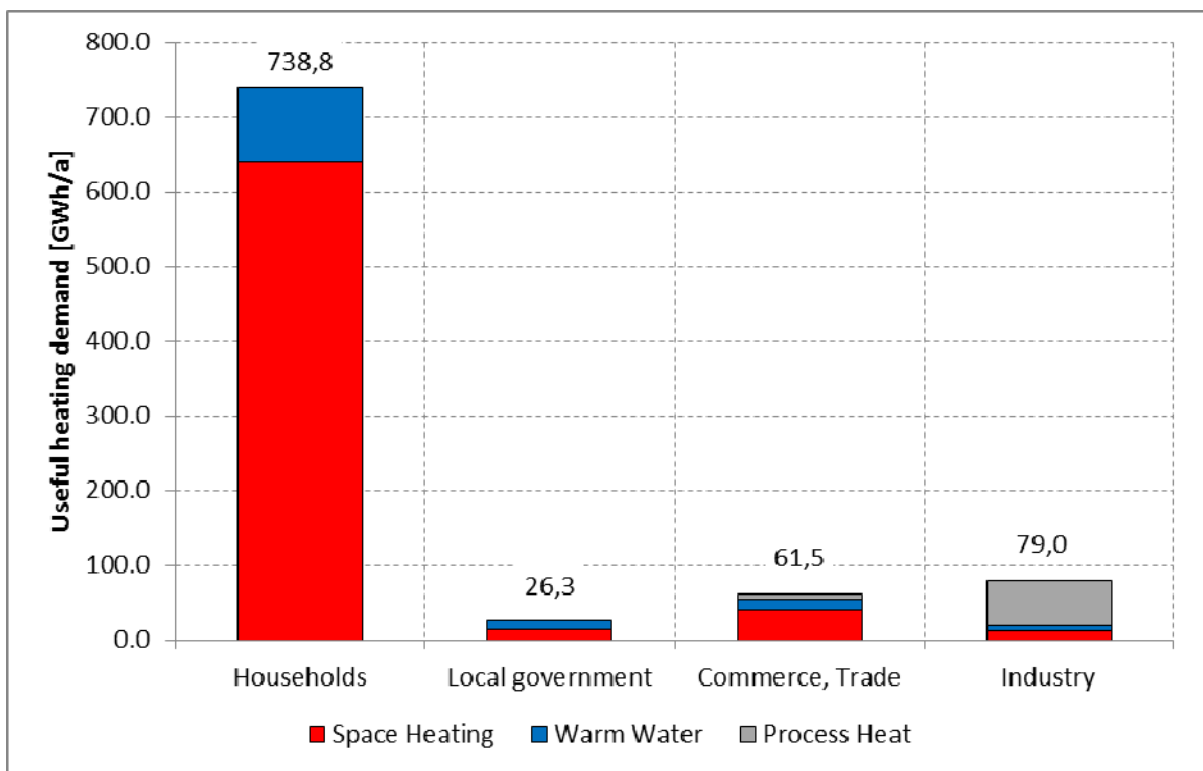
There are seven measures in the theme area of „Overarching measures (O)“ and can be found in Appendix A-5. The short description of a sample of these measures, the related effort and the classification to the revised strategic objectives from the City Development Strategy (CDS) is as follows:

O-01 Communication und public relations	New/Extension
<p>The public relation work is the cornerstone of the climate protection work for the City and other stakeholders. The various target groups in Ludwigsburg should be brought closer to the topic and motivate them to participate.</p> <p>The overall strategy for the public relations would be offered in collaboration with other bodies (e.g. LEA, Energetikom, consumer advice centres, and environmental groups). The public relation work is broadly conceived. It supports and markets the measures of the Overall Energy Strategy through media coverage, a dedicated website (in coordination with existing websites!) and, for example, action events.</p> <p>The model projects will be introduced with a virtual energy map, brochures, and a model project course. The numerous measures in the city are bundled under the unified „brand name“ for easier communication. The existing information and advice and financial offers will be more prominently advertised and made known. All stakeholders will exchange information and implement a coordinated strategy.</p>	
Recommended action: 12 und 13	Average annual costs: 25,000 €
Strategic objective of the CDS theme area „energy“	
11.5 Intensive public relations and counselling services	

O-05 Financing mechanisms for climate protection	New
<p>In times of budget constraints, the required financial investment required for the climate protection measures, which pay for themselves in the mid to long-term. The implementation of the measures can nonetheless be accomplished with the use of financial mechanisms. For example, larger projects can be granted to contracting companies (e.g. SWLB), while smaller projects can be financed with internal city fund through intracting. In addition to the citizen stocks, a climate protection stock trust can be set up, where the energy saving measures can be financed through payments by citizens and paid back over time through the energy savings.</p> <p>The City will use the intracting/contracting model for energy retrofits of their assets. Over and above the accompanying public relations, this will give the contracting market a boost. The SWLB as energy service provider will offer contracting for energy savings.</p>	
Recommended action: 1	Start-up funding per year: 2,300,000 €
Strategic objective of the CDS theme area „energy“	
11.2 Energy optimisation	

2.2 Theme area „Heating“

Within the framework for practical action, guidelines were documented for the development of a Heating Atlas for Ludwigsburg to measure the heating demand for households, commerce, trade and services, industry and the City using an approximation method. According to this method, Ludwigsburg has an overall useful heating demand total of around 900 GWh/a. The largest share is attributable to the residential buildings for space heating and warm water (82%). Herewith, heating is the main use of energy in Ludwigsburg.



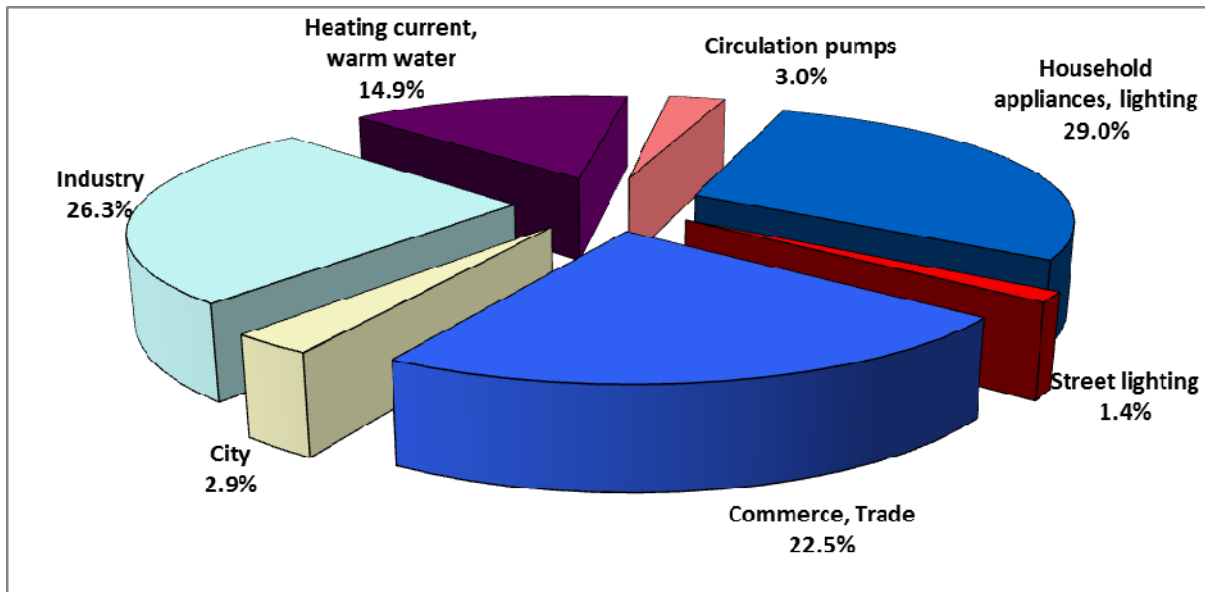
There are four measures in the theme area of „Heating (H)“ and can be found in Appendix A-5. The short description of a sample of these measures, the related effort and the classification to the revised strategic objectives from the City Development Strategy (CDS) is as follows:

H-01 Energy management of City buildings	Extension
<p>There is significant potential for energy savings and emission reductions in City buildings. With energy management, the energy consumption in City assets is recorded by asset in a central energy accounting log and publicised on an annual basis in an energy report. The energy data in the form of absolute values and as information about consumption in comparison to the previous report as well as to benchmarks with comparable buildings will be delivered to the operators and facility managers of the buildings on a monthly basis for self-monitoring. Through on-site training, the facility managers will be sensitised to energy savings. Significant energy savings can be realised through no or low investment measures, such as regulating existing settings and controls as well as changes in behaviour. Furthermore, a strategy for an energy retrofit for City buildings will be prepared. Energy optimisation will be carried out with new City building projects. The City energy management will be extended by 2 additional positions and equipped with relevant software.</p>	
Recommended action: 5, 12 und 16	Average annual costs: 170,000 €
<p>Strategic objective of the CDS theme area „energy“ 11.2 Energy optimisation</p>	

H-03 Ludwigsburg Energy Agency – LEA	Extension
<p>Through neutral, holistic as well as commission and trade independent energy advisers, building owners can take advantage of energy and money saving solutions for retrofits and new building plans. Suitable financing schemes from public funds can be organised, and information gaps and scepticism can be dismantled. The retrofit rate can be increased in Ludwigsburg through intensive, coordinated application of advising services. Appropriate investments will additionally reinforce the regional economy. LEA is developing an advising service together with their advising network that will allow building owners to access free or low-cost on-site advice. This is based on the Bafa consultations and goes over and above the proposal from LEA for the “Building consultation for energy at home” for 100€ plus taxes. In order to ensure on-site advising is carried out effectively, LEA developed an appropriate retrofit strategy specific to the building typology in Ludwigsburg. Advising will integrate implementation opportunities subject to available funding. LEA, together with Energetikom, advises the City of Ludwigsburg regarding energy strategies for construction sites and plans for new buildings or retrofits. Energetikom advises in the field of industry and commerce.</p>	
Recommended action: 22	Average annual costs: 150,000 €
<p>Strategic objective of the CDS theme area „energy“ 11.5 Intensive public relations and counselling services</p>	

2.3 Theme area „Electricity“

Just over 19% of the energy consumption in Ludwigsburg comes from electricity (Section 1.4). The electricity consumption in Ludwigsburg to a total of about 430 mil kWh/a is largely consumed by households, followed by industry and commerce, trade and services.



There are five measures in the theme area of „Electricity (E)“ and can be found in Appendix A-5. The short description of a sample of these measures, the related effort and the classification to the revised strategic objectives from the City Development Strategy (CDS) is as follows:

E-01 Street lighting	Continuation / Extension
Further savings are possible for electricity demand from street lighting in Ludwigsburg (incl. traffic lighting, and tunnel and parking lot lighting). The following package of measures is applicable: <ul style="list-style-type: none"> - Optimised planning with low Watt lighting and the greatest possible distance between lighting points (incl. dismantling lighting points where possible) - Use of efficient lighting with high luminous efficacy (high pressure sodium lamps for yellow light and halogen lamps for white light) - Continuous renewal of the lighting status (low Watt, use of mirror optics, maintenance-friendly lighting) - Investigation and testing of new technologies (e.g. LED) 	
Recommended action: 2	Start-up funding per year: 50,000 €
Strategic objective of the CDS theme area „energy“	
11.1 Landmark projects	
11.2 Energy optimisation	

E-05 Industrial network	Extension
10 Ludwigsburg businesses came together for the pilot plans for the „model area Weststadt“ to exchange experiences with energy saving measures as well as initial and detailed consultations for energy saving potential. The consultations show a (usually economic) realisable savings potential of about 8%, which shows the significance for the industrial network. The involved businesses took part in regular experience exchange meetings („energy efficiency table“) in the form of presentations and information. The industrial network will be extended upon gradually to include further / other Ludwigsburg businesses in order to exploit additional savings potential, whereby the City will co-finance for another 2 years (10% of the costs for the initial consultation and 20% for the detailed consultation).	
Recommended action: –	Once off start-up financing: 140,000 €
Strategic objective of the CDS theme area „energy“	
11.1 Landmark projects	
11.5 Intensive public relations and counselling services	

2.4 Theme area „Mobility“

The mobility in Ludwigsburg is characterised by passenger car and freight truck traffic. Over a quarter (28%) of the CO₂ emissions in Ludwigsburg result from are the mobility of the citizens of Ludwigsburg.

	Motor vehicle stock		Driving profile		Energy consumption		CO ₂ emissions	
	1000	%	mil km	%	TJ	%	1000 t	%
Motorcycles	3537	6.6%	9.82	1.3%	12.5	0.6%	0.89	0.6%
Passenger cars	47,440	88.4%	676.79	90.3%	1,738.3	76.8%	119.08	77.9%
Trucks	1,781	3.3%	45.88	6.1%	317.1	14.0%	20.31	13.3%
Trains	0.567	1.1%	10.36	1.4%	129.5	5.7%	8.28	5.4%
Busses, etc.	0.336	0.6%	7.04	0.9%	67.3	3.0%	4.31	2.8%
Total	52,758.90	100.0%	749.89	1.00	2,264.7	1.00	152.87	1.00
			thereof:					
			Petrol		1,130.1	49.9%		
			Diesel		966.2	42.7%		
			Biofuels		168.4	7.4%		

There are eight measures in Appendix A-5 that show how the energy demand in the Ludwigsburg transport sector can be reduced. The following short description of a sample of these measures gives an overview of the status, the related effort and the link to the revised strategic objectives from the City Development Strategy (CDS).

M-01 Bicycle and pedestrian network plan 2020	Extension
A safe, comfortable and user-friendly bicycle and pedestrian network is a fundamental prerequisite so that the citizens of Ludwigsburg can become aware of alternatives to driving cars. For this, network gaps should be systematically closed and existing bicycle and pedestrian paths should be made more comfortable. E.g. two-way bicycle traffic should be allowed on one-way streets, crossing main roads should become easier, new bike lanes should be built on roads with heavy traffic and other deficiencies should be eliminated. In addition to the construction, human resources should also be provided for the concepts and planning.	
Recommended action: 10	Average annual costs: 435,000 €
Strategic objective of the CDS theme area „energy“	
11.7 Energy savings in transport	

M-02 Mobility management for businesses	Extension
Mobility management for businesses should reduce passenger car traffic (commuting to and from work and for work) and should be organised more efficiently. Information, advising and proposals should support co-workers in changing their relationship and behaviour to mobility by eliminating mobility related shortcomings as well as improve operations and partnerships. Targeted restrictions of passenger car use increase the effectiveness of support measures, but are not popular.	
The City currently secures and supports companies that have developed and implemented their own mobility plans. This includes, amongst others start-up support for employee surveys, initial discussions and consultations through external planning offices, the production of information	

material, carrying out workshops and action campaigns, and counselling capacities in the City administration („Mobility manager“). Experiences, e.g. from Dresden and Munich, have shown that mobility management in businesses could save 28% of passenger car kilometres in 10 years, which markedly reduce mobility costs for the businesses and the employees.

One goal of the step-by-step plan to introduce electro mobility in Ludwigsburg is to also use electric vehicles in the commercial sector.

Recommended action: –	Average annual costs: –
Strategic objective of the CDS theme area „energy“	
11.5	Intensive public relations and counselling services
11.7	Energy savings in transport

2.5 Theme area „Renewable Energy“

Starting points to increase the use of renewable energy are offered through almost all areas in Ludwigsburg, beginning with the use of geothermal energy, solar energy to wind energy . Merely through the use of hydropower, the available potential is already utilised in Ludwigsburg.

There are eight mapped out measures in the theme area of „Renewable Energy (R)“ and can be found in Appendix A-5. The short description of a sample of these measures, the related effort and the classification to the revised strategic objectives from the City Development Strategy (CDS) is as follows:

R-01 Geothermal energy use	New
Surface geothermal systems (geothermal collectors and probes together with heat pumps) provide a heat supply for freestanding houses and apartment buildings and, in part, a heat supply for the commercial, industrial and public sectors. The technology has been in use for several years and is reliable over a long period of time. Soil is typically used as the source of heat, but geothermal collectors can be placed about 0.5 to 2 m under the ground and geothermal probes are limited to a depth of 115m. As an alternative to soil, ground water can also be used as a heat source.	
Recommended action: 3 und 6	Start-up funding per year: 55,000 €
Strategic objective of the CDS theme area „energy“	
11.6	Renewable energy carriers, energy services and innovative energy technologies

R-03 Solar local heating island + building retrofits	New
Large solar thermal units affiliated with a seasonal heating storage have thus far typically been implemented in newly developed areas. The innovation project “solar local heating island Ludwigsburg” stipulates that a heating island be implemented in the existing building stock. The energy optimisation of the building stock should include solar assisted local heating generation. As a part of the building retrofits, large area solar collectors should be installed on roofs. In order to attain a solar fraction of 35% – 40%, a seasonal heating storage should be used. A possible city district that could be used would be one that is not already connected to the SWLB district heating network.	
Recommended action: 8	Costs dependent on the scope of the measures
Strategic objective of the CDS theme area „energy“	
11.1	Landmark projects
11.4	Independent and decentralised energy supply
11.6	Renewable energy carriers, energy services and innovative energy technologies

2.6 Classification of measures

The previously mentioned measures and their classification in relation to the revised strategic objectives from the City Development Strategy show the range of possibilities to save energy, use energy more efficiently and increase the use of renewable energy in Ludwigsburg. The overall classification of the measures yields the role the City has to play, such as 1) responsibility for own implementation, 2) initiating and conceptualisation and 3) implementation support, and the required costs to the City and the citizens, as well as the CO₂ reduction potential.

A prerequisite for the implementation and continuation of the Overall Energy Strategy in Ludwigsburg is the designation of a person to be responsible for the overall coordination. It is logical to establish this within the Department for Sustainable Urban Development. With the funding made available from national government, the position for a Climate Protection Manager could be realised. The responsibilities of the climate protection manager are summarised in Section 3.

It should be noted that the classification of the measures are obtained from the previously described organisation of the measures. However, with the actual implementation, there may be variations with a lower or higher financial volume available for the individual measures. Herewith, there may also be differences in the realisable CO₂ reduction potential. Therefore, the classification of the individual measures is described in the perspective of the reviewers regarding optimal cost efficiency.

From the scientific point of view, there are measures that can be implemented, which have lower or even negative CO₂ reduction costs such that aside from reducing the CO₂ emissions there is also an additional economic advantage. All the listed measures essentially comply with the reviewer criteria although their implementation in many cases does not financially benefit the City, yet the CO₂ reduction costs are portrayed as such. Exceptions are the measures for E-Energy – smart grid of the future (E-03), and the introduction of innovative public transport systems (M-05), which have not yet shown to be market mature from the pilots, as well as the three measures for Bicycle and pedestrian network plan 2020 (M-01), Saving energy = Saving money (E-04) and Electro mobility / Solar mobility (M-06)

It is possible to combine climate protection efforts with increasing the quality of life and the economic standing in Ludwigsburg at least in the mid-term. One measure, the “Ludwigsburg requirement” (H-04), takes a special role since it clearly shows that surpassing the building standards than required by EnEV is only achievable with higher additional costs. The introduction of the “Ludwigsburg quality seal” could serve as the first step to embed energy efficient construction in the mind-set of the population.

Classification of the measures Of the 32 measures assessed, 11 measures were shown to have negative specific CO₂ reduction costs, i.e. money is saved in addition to the reduction in greenhouse gas emissions. A further 10 measures are close to being cost-effective and 3 measures are characterised with very high CO₂ reduction costs, but typically have a leading role as possible implementation options at an early stage. On top of the CO₂ reduction costs are also the costs to the city for the implementation of measures and the contribution gained from the value added through the addition of the measures, which are an important part of the assessment criteria.

Qualitative savings potential of individual measures		Savings potential of individual measures in relation to the overall potential (CO ₂) of the demand
●●●●●	very high	> 3%
●●●●	High	0.5% to 3%
●●●	Medium	0.1% to 0.5%
●●	Low	0.03% to 0.1%
●	very low	Under 0.03%
Not quantifiable		For flexible measures
Qualitative efficiency of start-up costs		Absolute efficiency of the start-up costs (avoidance costs from the perspective of local government)
●●●●●	extremely high	< 0 €/tCO ₂
●●●●	very high	0 to 15 €/tCO ₂
●●●	High	15 to 30 €/tCO ₂
●●	Medium	30 to 50 €/tCO ₂
●	Low	Over 50 €/tCO ₂
Not quantifiable		For flexible measures
Contribution to Value Added		Indicators
●●●●●	very high	Creation / maintenance of jobs, establishment of new firms, increased innovation and technology advancements
●●●●	High	
●●●	Medium	
●●	Low	
●	None	

The measures in the following table are weighted with the scale given in the table above resulting in an assessment from the perspective of the reviewers, whereby within the objectives, the measures are listed in order of priority beginning with the most important measure. In doing so, the contribution of the individual measures towards making efficient use of start-up costs was weighted more strongly than both the other criteria in order to take into consideration that local government is currently working under budget constraints. Furthermore, the individual measures were classified by the revised strategic objectives from the City Development Strategy. The most important difference between the individual measures is that a classification of the measures was undertaken, where they were differentiated into „INVESTMENT MEASURES FOR TECHNICAL IMPLEMENTATION“ and „IMPLEMENTATION SUPPORT“.

Measures	Efficiency of start-up costs (Local government)	CO ₂ saving potential	Contribution to Value Added	Stakeholders	CDS Objectives
Investment measures for technical implementation					
Use of financing instruments (Intracting, Contracting) for climate protection measures (O-05)	●●●●●	●●●●●	●●●●●	City	11.2
Reduction of the electricity demand for street lighting through optimised planning and use of efficient lighting (E-01)	●●●●●	●●●●●	●●	City	11.1 / 11.2
Verification of locations for wind energy use (small and large units) in cooperation with the region and companies (R-04)	●●●●●	●●●●●	●●	City, SWLB	11.4 / 11.6
Increasing information and advice offered for further distribution of geothermal use for households (R-01)	●●●●●	●●●●	●●●	City, Citizens	11.6
Increased use of car sharing in the city administration in combination with the use of environmentally friendly engines (M-03)	Not quantifiable	Not quantifiable	●	City, Stadtmobil	11.1 / 11.7
Establishment of a market study for the use of heat from waste water (R-06)	●●●●●	●●●	●●	SEL, SWLB	11.2 / 11.4 / 11.6
Setting up a contracting programme to increase the exchange of circulation heat pumps (E-02)	●●●●	●●●●	●	SWLB, Citizens	11.4
Further extension of the heating network to connect additional users (H-02)	●●●●	●●●	●●	SWLB, Citizens, Business	11.4
Increased use of electric vehicles / solar vehicles with passenger cars, busses, scooters and bicycles as well as extension of the infrastructure (M-06)	●●●	●●●●	●●●	City, SWLB	11.1 / 11.7
Implementation of a landmark project for solar energy use in Ludwigsburg (R-05)	●●●	●	●●●●	City, SWLB, Citizens, Business	11.1 / 11.4 / 11.6
Introduction of innovative public transport systems (M-05)	●	●●●●●	●●●●	City, Citizens	11.1 / 11.7
Development of a pilot project for a solar local heating network for existing buildings in combination with building renovations (R-03)	●●●	●	●●●	SWLB, City, Citizens	11.1 / 11.4 / 11.6
Construction of a communal biogas unit to use biogas (R-07)	●●●	●	●●	Agriculture, SWLB	11.4 11.6

Bicycle and pedestrian network plan 2020 – Conceptualise and implement (M-01)	●	●●●	●●	City, Citizens	11.7
Future-oriented planning and design of the city streets (M-08)	Not quantifiable	Not quantifiable	●	City, Citizens	11.1 / 11.7
Increased energy generation from waste water plants (R-08)	●	●●	●	SEL	11.6
Completion of a model project for households to improve the coordination between energy demand and supply through smart grids (E-03)	●	●	●●	SWLB, Citizens	11.1 / 11.4
Implementation support measures					
Motivate experts through further training and education opportunities to interdisciplinary thinking (O-07)	Not quantifiable	Not quantifiable	●●●●	Chambers for Trade and Architects	11.1 / 11.2
Preparation of an overarching strategy for communication and public relations (O-01)	Not quantifiable	Not quantifiable	●●●	City	11.5
Support for energy and climate protection knowledge and measures in schools (O-02)	●●●●●	●●●●●	●●●	Schools, City	11.2
Organisation of a solar roof and solar areas programme (R-02)	●●●●	●●●●●	●●●●●	City, LEA, Citizens	11.5 / 11.6
Support for energy management of city buildings (H-01)	●●●●●	●●●●●	●●	City	11.2
Facilitate the combination of public transport and bicycle transport through the introduction of a Combi-Ticket (M-04)	Not quantifiable	Not quantifiable	●	City, VRS, Citizens	11.7
Organisation of an energy saving programme (advice, consumption measurements, financing) for households, starting with lower income households (E-04)	●● / ●●●●●	●●●	●●●	LEA, SWLB, Citizens	11.1 / 11.4
Extension of the regional Energetikom centre of excellence (O-03)	Not quantifiable	Not quantifiable	●●●●	Energetikom	11.1
Development of a Ludwigsburg climate adaptation strategy (O-06)	Not quantifiable	Not quantifiable	●●●●	City	11.1
Extension of the industrial network "Model area Weststadt" to all Ludwigsburg businesses (E-05)	●●●	●●●●●	●●●●●	Energetikom, Business	11.1 / 11.5
Expansion of mobility management for businesses to further organisations (M-02)	●●●●	●●●●●	●●	City, Business	11.5 / 11.7

Continuation of the climate protection cooperative on the regional, state, national and European levels (O-04)	Not quantifiable	Not quantifiable	●●	City	11.5
Expansion of the Ludwigsburg Energy Agency – LEA through on-site advisory services and building specific renovation plans (H-03)	●●	●●●●	●●●●●	LEA, Citizens	11.5
Establishment of a mobility advice for citizens at a mobility advisory centre, in the internet and in schools and pre-schools (M-07)	●●●	●●●●	●●	City, LEA, Citizens	11.5 / 11.7
Development of ownership in Ludwigsburg for building renovations and new building standards (H-04)	●	●●●●	●●●●●	LEA, Citizens	11.1 / 11.2

Scenario analyses

Building on the round table discussions with the experts and from the Future Conference on Energy with the community, the proposed measures were developed further and brought into a final format. An integrated scenario analysis was carried out to estimate the future development of energy demand and the energy related CO₂ emissions for Ludwigsburg. This shows that climate politics on the European and national level also influence the energy and climate politics for Ludwigsburg and serve as a means to restructure the energy demand and supply towards a more climate friendly structure. The task of the Ludwigsburg stakeholders and the City of Ludwigsburg is to support and accelerate this process, for which an abundance of thematically overarching measures exist in the areas of heating, electricity, transport and renewable energy. In general, the aim is to start today using the available capital and manpower to reduce the current energy demand and increase the range of renewable energy in the future. It is about investing in a climate compatible future.

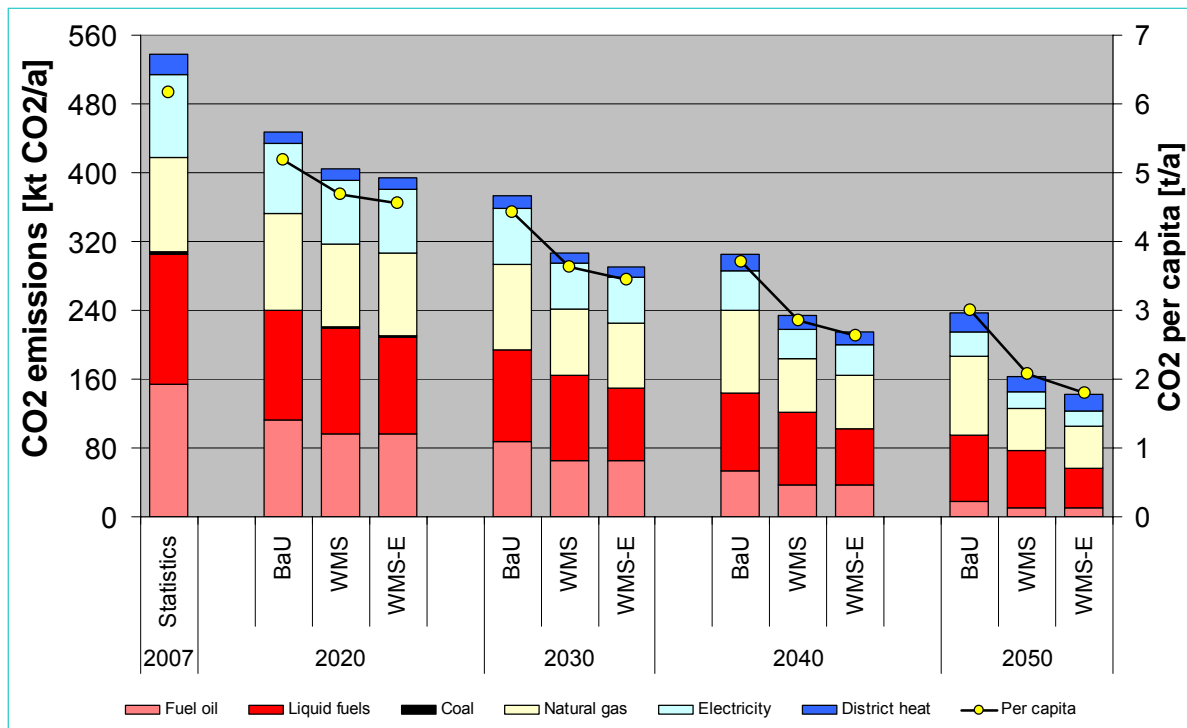


Figure 8: Energy related CO₂ emissions by energy carrier in Ludwigsburg in the Business as Usual (BaU) scenario in comparison with the scenario with measures (WMS) and with electromobility (WMS-E)

3 Recommended action

Climate politics on the European and national level also influence the energy and climate politics for Ludwigsburg and serve as a means to restructure the energy demand and supply towards a more climate friendly structure. The task of the Ludwigsburg stakeholders and the City of Ludwigsburg is to support and accelerate this process, for which an abundance of thematically overarching measures exist in the areas of heating, electricity, transport and renewable energy. In general, the aim is to start today using the available capital and manpower to reduce the current energy demand and increase the range of renewable energy in the future. It is about investing in a climate compatible future. Of the 32 measures assessed, 11 measures were shown to have negative specific CO₂ reduction costs, i.e. money is saved in addition to the reduction in greenhouse gas emissions. A further 10 measures are close to being cost-effective and 3 measures are characterised with very high CO₂ reduction costs, but typically have a leading role as possible implementation options at an early stage. Involving the participation of the community, business and interested associations at an early stage leads to stronger support in the long term for the Ludwigsburg community and their institutional groups since the measures are developed in collaboration with the community as well as the expert panel. Transparency and acceptance for decisions made in Ludwigsburg provide the community to have a stronger identification with and responsibility for the Overall Energy Strategy and its implementation.

Implementation of the guiding principles for the thematic area of energy from the City Development Strategy are carried out from a scientific point of view through measures which have proven low or even negative CO₂ reduction costs since not only CO₂ emissions are reduced, but they also show an economic advantage. Further important criteria to evaluate the measures are the costs, which will arise for local government through the measures and the contribution of the measures towards the regional value added. An evaluation scale was used to assess the measures by these criteria:

Recommended action Taking into consideration the current budget restrictions in the city administration, it can be assumed that is not likely that all recommended measures can be implemented although they are cost-effective. Nonetheless, a climate protection programme is presented for Ludwigsburg with a recommendation for short and medium term actions through which a significant share of the calculated CO₂ reductions can be achieved. The recommendations are divided into two categories: (1) investment measures for technical implementation and (2) implementation support measures.

Investment measures for technical implementation In the category of investment measures for technical implementation the following short and medium term starting points will be particularly meaningful, according to the evaluators:

1. Using Intracting, a financial mechanism should be made available to enable the renovation plan to realise energy efficient measures gradually in new or old city buildings or in street lighting.
2. The plan to renew and improve energy use in street lighting should be done over time such that old lighting infrastructure, as an example, should be replaced with new technology.
3. The use of biogas, wind, waste water and geothermal energy should be assessed for possible implementation during event or project related surveys (e.g. new construction of buildings or areas, redevelopment of areas), and if found to be economic, these should be implemented.
4. The city vehicle fleet should be transferred step-by-step to the car sharing pool of the Stadtmobil, whereby a stronger visibility should be made in the Ludwigsburg suburbs.
5. The Ludwigsburg-Kornwestheim city utility should promote demand side management (promotion of the demand for energy saving measures) as its own area of business.

6. The heating network, which currently supplies the central, southern, eastern, western and northern suburbs, should gradually be further extended such as to achieve an area-wide supply of district heating for the core of the city in Ludwigsburg. As a first step, the extension in the Weststadt suburb should be scrutinised and implemented as soon as possible.
7. When replacing heating systems in newly constructed buildings or city areas, the supply should be derived from renewable energy (e.g. wood and/or solar, through district, local or waste heating, or from a building CHP unit).
8. The construction of a solar local heating island in the existing building stock should be begun in one suburb which cannot be connected to the SWLB district heating network.
9. Electric mobility should be promoted and extended in Ludwigsburg through the acquisition of hybrid and electric vehicles and electric scooters for the city vehicle fleet, hydro busses for the city traffic and the introduction of Pedelecs for company cars within the city administration to be used for the delivery of goods or for rental to tourists or commuters.
10. A network plan for 2020 should be developed and implemented for the bicycle and pedestrian network.

Implementation support measures

In the category of implementation support measures, the following starting points are particularly important, according to the evaluators:

11. To optimise the energy consumption in residential buildings, commercial operations or industrial processes, the affected subsectors and consultants should be offered further training and continued education to integrate a holistic and general trade thinking.
12. The existing energy report on the energy and water consumption of the city buildings and vehicle fleet, the associated costs and the realised measures should be published at shorter intervals.
13. The measurable and accessible data regarding energy carriers from renewable sources should be made publicly available via internet and other central places in the city.
14. The topic of energy and climate should be covered in the Ludwigsburg schools for grades 9 and 10 during the general coursework and coupled with audits at the school and at home as well as field trips relevant to the topic of energy.
15. To stimulate the construction of the solar thermal and photovoltaic units, the city should embark on a solar roof campaign.
16. An additional position as energy manager of city buildings should be advertised as soon as possible.
17. The attractiveness of public transport should be increased through the improvement of comfort, offers and the public transport tariff system.
18. The programme planned to offer energy efficiency advice to lower income households by the Ludwigsburg district should be contributed to by the state administration for Ludwigsburg, the ARGE unemployment fund from the Ludwigsburg district and the Ludwigsburg Energy Agency (LEA).
19. The Energetikom should be further supported in their unique role.
20. The City of Ludwigsburg should continue to review and partake in regional, national, and EU-wide funding opportunities and competitions.
21. The cooperation between the City of Ludwigsburg, Energetikom, LEA and the universities should be further strengthened.
22. The City of Ludwigsburg should continue to cooperate closely with the LEA and broaden the opportunities for energy consultations to the citizens of Ludwigsburg.
23. As a first step towards the Mobility Information System for Ludwigsburg (MIL), the use of the car pooling exchange for the city employees of MobiCar should be intensified in 2011 in order to establish the car pooling community.

24. The meetings of the expert panel to the Overall Energy Strategy should continue.
25. To ensure that the Overall Energy Strategy is implemented, the City of Ludwigsburg should allocate adequate staff.

Outlook

The **25 points** of the programme will enable Ludwigsburg to **halve the per capita emissions** by **2030** in relation to 1990 and to limit the per capita emissions in the **long-term** to a level of **2 t CO₂ per capita and year**. Aside for the commitment of financial resources, which will amortise over time, the deciding factors will be the dedication of the stakeholders in the city community as well as ensuring that the city administration has the means to further drive the process. The corresponding **environment** needs to be established.