Energy Programme 2050

Creating an energy system that meets the power and material challenges of a Climate Positive Uppsala.

The municipal council reached a final decision on 2018-05-28, section 109, for this activating strategic document.

About Energy Programme 2050

Energy Programme 2050 is a municipal-wide policy document that describes Uppsala municipality's vision for the long-term development of the energy system in Uppsala. The goal is to transform the local energy system in order reach the municipality's climate positive target. The aim is to create a more environmentally, socially, and financially sustainable energy system which is itself better connect it to other public works and infrastructure. The purpose is to increase the overall resource efficiency, sustainability and the degree of robustness of the system.

Uppsala municipality's goals for resource efficiency, health, the environment and climate, rural and urban development, more job opportunities and environmentally-driven business development, civil preparedness, as well as the strengthening of ecosystems, are all foundations of the programme. The programme expands and builds upon the Municipality's 2016 Master Plan. The Energy Programme is a cornerstone in the efforts to make *Uppsala Fossil-Free and Renewable in 2030 and Climate Positive in 2050.*

<u>The Energy Programme's desired end states are:</u>

- Interconnected public works and infrastructure providing synergy gains
- A resource-efficient energy supply with high utilization of local resources and closed material circuits
- An available, safe, equitable and integrated energy system

<u>The Energy Programme's implementation strategies:</u>

- Everyone has a responsibility and a role in creating a Climate Positive Uppsala
- Research, innovation and business development help Uppsala find its way forward
- Area planning and development that promotes new solutions
- Urban planning for energy supply to the transportation system
- Coordinated development of local energy production and Climate Positive infrastructure
- Follow-up and development through modelling and climate road maps

Each strategy has corresponding tactical actions.

Background

The municipality's energy investigation, climate road map with impact assessments, and work within the scope of the 2016 Master Plan show that a continued step-by-step development of the energy system will not meet the municipality's Climate Positive target. These documents show that there is a need for a major systemic change and identify opportunities connected to this kind of change. The investigations and the Master Plan also show that when the municipality takes a more active role in collaboration with other stakeholders, there is a great opportunity to bring about a shift that can lead to success in development goals many areas beyond energy and climate. An Energy Programme is a political instrument for achieving this change.

Legal Requirements

The Municipal Energy Planning Act (1977:439) states that each municipality must have a current plan for the supply and use of energy. Energy Programme 2050 constitutes the municipalities plan in accordance with the law. It replaces the 2001 Energy Plan.

Development of Energy Programme 2050 and Its Implementation

Uppsala municipality is not the only stakeholder responsible for the development of the energy system and energy sector in Uppsala. Consensus and collaboration are necessary locally, nationally and internationally. This Energy Programme provides a basis for lifting the importance of the local energy system and defining the municipality’s active role concerning energy issues. The programme is an invitation to collaborate, but also identifies individual and shared responsibility related to the local energy system.

The previous energy investigation, climate road map, and now the work on formulating the Energy Programme have taken place with the participation of a wide range of stakeholders. Representatives from the public sector, industry, academia and civil society have participated in its formulation and continue to participate. This has provided a successful forum for collaboration in the implementation phase which is now under way. The final chapter of the Energy Programme consists of six implementation strategies and corresponding tactical actions. Collaboration is at the heart of all of these strategies.

The programme focuses on the municipality's work to develop the local energy system. The strategies and actions in the programme directly relate to the municipality’s own organization including municipal owned companies. The programme is specifically relevant for the municipal executive board, rural and urban planning department, public works and municipally owned companies. The municipal executive office is responsible for the internal coordination of the programme. The tactical actions are prioritized and resourced in the municipal council's annual “Objectives and Budget” and are a part of ongoing municipal operations and responsibilities. Several other municipal programmes are of major importance for the implementation.

Programme Evaluation and Revision

Progress and evaluation of Energy Programme 2050 and its strategies is conducted every four years. The tactical actions are followed up on an on-going basis throughout the implementation as well as annually and on completion. Results and lessons learned from the tactical actions are fed back into the strategy areas for further development, as well as for the development of the tactical actions. The relevance, of all politically adopted programmes as well as their implementation, is followed up annually.

Contents

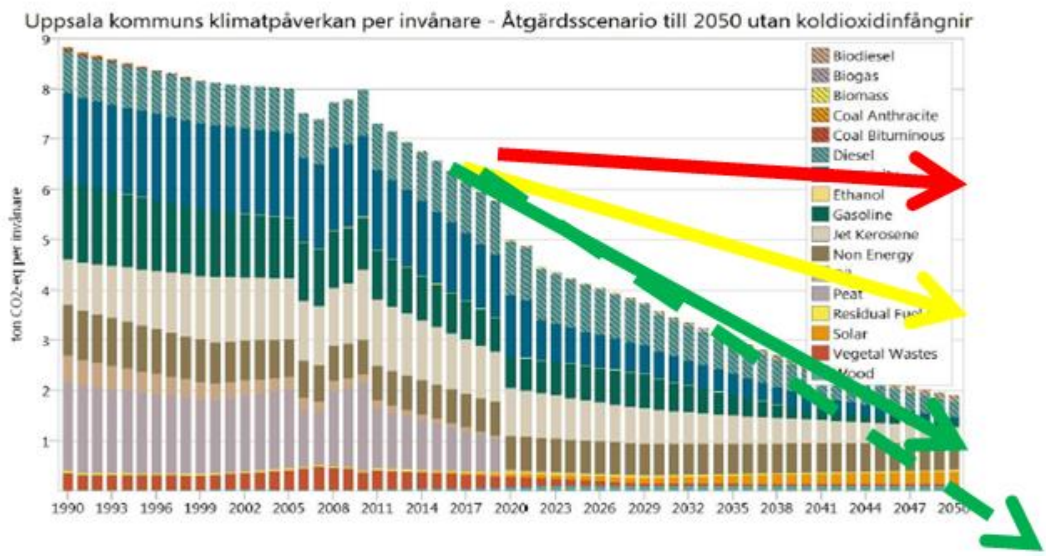
1 Why an Energy Programme?

The energy system and its continued development are crucial for Uppsala municipality's objectives for resource efficiency, health, the environment and climate, sustainable travel, rural and urban development, more job opportunities and environmentally-driven business development, civil preparedness, as well as the strengthening of local ecosystems. The Energy Programme is a cornerstone in the efforts to make *Uppsala fossil-free and renewable in 2030 and climate-positive in 2050.* The programme expands and builds upon the 2016 Master Plan. The goal of the programme is to transform the local energy system itself and better connect it to other public works and municipal infrastructure.

1.1 The municipality’s climate and development goals cannot be reached with the current energy system

Emissions of greenhouse gases from heating, electricity usage, transportation fuels currently constitute the largest share of Uppsala's climate impact. Emissions from local energy production have decreased significantly over the years, and will continue to decline in the near future. Climate impact from the transport sector is the main source of climate impact locally. The second biggest climate impact, which is increasing, is the impact from long-distance journeys made by Uppsala's residents with overnight stays elsewhere. A smaller share emanates from emissions from farmland and livestock farming.

From 2013 to 2015, Uppsala municipality together with the Uppsala Climate Protocol evaluated the development[1] of the municipality's climate impact based on the current energy system, figure 1.



[1] Road map for a climate-neutral Uppsala (2015).

Figure 1: Schematic image of actual (1990–2010) and modelled (2012–2050) future climate impact from Uppsala municipality in a potential action scenario. The arrows represent this and other scenarios. These are explained below.

The results of the assessment showed that unless significant efforts are made beyond what is currently taking place in respect to climate and energy policy, as well as investments and technological development – at a local as well as a national level – the impact on the climate would only decrease marginally by 2050. (Reference scenario, red arrow in figure 1)

The municipality, local businesses and other organizations actively engage in climate change mitigation. Despite these efforts, the reduction in emissions by 2050 will not be sufficient to achieve the necessary low greenhouse gas emissions. Current developments are judged to be insufficient for many other social goals. (Stakeholder scenario, yellow arrow in figure 1)

Alternative scenarios were analyzed to find future measures and system solutions that will enable low emission levels to be achieved. The conclusion is that not even a complete transition to renewable and climate-friendly forms of energy, together with dramatic energy efficiency improvement in all sectors of society, will be sufficient. (Unbroken green arrow in figure 1)

In one report for the Master Plan, "Energy System 2050 in Uppsala Municipality" (also called Energy 2050 Report), the analysis is extended and it states that a development based on the conventional systems will probably not be sufficient to achieve the municipality's goals.

Therefore, it follows that there is a need to identify transformative and system-changing measures for the current energy system. It is vital that efforts that lead to massive reductions in greenhouse gas emissions also strengthen the municipality's potential for achieving the other development goals related to good health and living standards, as well as attractiveness for individuals, industry and research.

1.2 A well-developed energy system is essential for goal fulfilment

There are opportunities for developing the energy system that could result in low or even negative greenhouse gas emissions[2]. The Energy 2050 Report for the 2016 Master Plan points out that a potential prerequisite is that the energy system with its associated stakeholder structure undergoes a major change. In particular, local publicly funded stakeholders need to take more active responsibility during the transition period. The study also shows that long-term investments in sustainable energy supply support sustainable business development. (Broken green arrow in figure 1)

At the same time, a pronounced development of the energy sector is currently taking place, which in many cases envisages a shift in such a desirable direction. The ongoing transformation is driven by a combination of active international and national climate policy, technological developments and new stakeholders and business models. The municipality has an important role to play in all these areas in order to fully influence a desirable development for society.

[2] Negative emissions mean, for example, carbon capture and storage i.e. greenhouse gases are removed from the atmosphere.

1.3 Beyond conversion from fossil fuels to renewables for cyclical solutions

There is an obvious risk that short-term solutions to achieve the 2030 goals may delay or impede adjustments needed to achieve the 2050 goals. It is not enough to think that bio-fuels will replace fossil fuels. The focus will need to be extended to see solutions in materials flows, embedded emissions (in products) and waste energy, in order to achieve the goal of climate-positivity.

1.4 Power and storage – key issues for the energy system

The transition to a completely renewable and resource-efficient energy system accessible to all requires a balanced mix of all types of sustainably produced renewable and recycled energy sources, along with extensive improvements in efficiency and reduced energy usage.

Today, we see that capacity constraints, especially in the electrical grid, are a challenge for the municipality in respect to achieving growth targets. A transition to a renewable and resource-efficient energy system will not automatically solve the power problem, which in Sweden is particularly challenging during the winter.

A combination of reduced energy usage, on demand flexibility, energy storage and power efficiency would even today significantly improve our energy system. These measures are imperative for the future energy system. This will require an ever closer integration between different parts of the energy system, as well as other public works systems and infrastructure that have traditionally been more or less disconnected from one another.

In order to even out differences in supply and demand, local-national, day-night and summer-winter, distribution networks for electricity, gas, steam, heating and cooling are essential. Together with energy storage, the different distribution networks create a robust framework for energy system.

1.5 Socioeconomic risks

When planning construction and infrastructure decisions, social costs and social benefits need to be investigated and evaluated. This includes energy and materials usage and the environmental and climate impact of various alternatives. The analysis framework must be kept at an overarching level to identify the effects of actions on the choice and design of systems. There is an assumption that, in the future, new technologies in the energy sector and other technical systems will be developed. Therefore, a holistic approach is required to avoid financial and technical sub-optimizations at the system level.

If, in the future, a significant number of energy users were to disconnect from the traditional grid-based energy and district heating systems, it would entail a number of risks to the energy system. This off-grid trend is already happening to some extent with district heating in the city. Taking this off-grid trend to its extreme would result in energy system being less efficient in terms of balancing power loads over time and between different parts of the system. In addition, this could potentially mean that the cost of maintaining large, technical systems (i.e. district heating, electrical grid, water and sewage lines, etc.), which are built to supply a large part of society, will be carried by a diminishing group of users. Such cost distortions, as well as differences between urban and rural conditions, are aspects the municipality takes in to consideration with the implementation of Energy Programme 2050.

2 Energy Programme 2050's aim and scope

2.1 The aim of the Energy Programme

Energy Programme 2050 has the following aims:

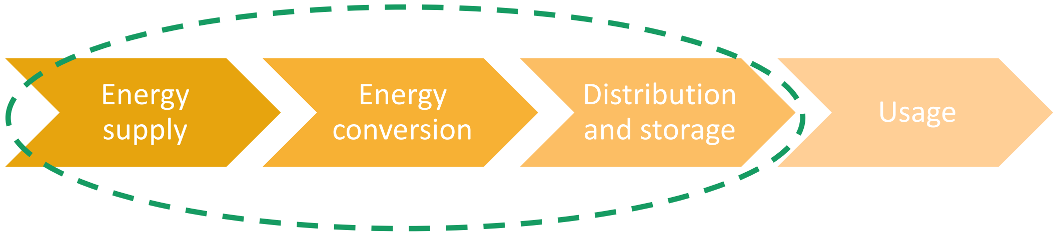
- Presenting objectives and implementation strategies for Uppsala Municipality's future energy system, including energy connected to the transport system.
- Visualizing and strengthening the energy system's connections to other public works and infrastructure systems for increased common good.
- Prioritizing the inclusion of long-term Climate Positive solutions in planning and implementation from the outset.
- Clarifying the municipality's leadership and coordination role in transforming the energy system as well as inviting all relevant stakeholders to participate and perpetuate development.

The programme is used to communicate the municipality's vision of the future energy system and thus provides a basis upon which all stakeholders and residents to act. Energy Programme 2050 provides a framework for the municipality to develop and implement initiatives to achieve the desired end states.

2.2 The scope of the energy system and the programme

The Energy Programme includes energy for both stationary perspective (all energy that is linked to a physical site such as real estate property, businesses, industrial processes, households, etc.) and mobile perspective (public transport, cars, trucks, agricultural and building machines, etc.) purposes. Flights, ferries or the like are not included here, but they must be considered in the overall picture. The programme aims to provide an overarching framework for how the energy system itself can be integrated into the geography of Uppsala, with rural areas, suburbs and a central city. There is a focus on a circular economy development in city districts and rural centers. Energy Programme 2050 primarily refers to the energy aspects of the local energy system, but has a broad environmental perspective.

Energy systems are often illustrated by the following chain. The chain begins with an energy source, which is converted to energy and then distributed or stored until finally consumed at end use.



Energy Programme 2050 encompasses the entire chain, but focuses on the first three steps of the chain. The aim is to create a more integrated energy system with stronger connections to other technical systems. Enhanced energy efficiency at the user level is a prerequisite for achieving the desired end states of the Energy Programme, as well as other goals. Objectives and measures for improving efficiency at the user level for both stationary and mobile purposes can be found in other municipal policy documents.

3 Desired End States for the Energy System

By 2050, Uppsala's energy system will be characterized by the following states:

Desired End State 1: Interconnected public works and grid infrastructure create synergy gains

Uppsala's various technical and organic supply systems are interconnected, where this leads to positive synergies or other benefits: the energy system, the transport system, water, sewage, residual products, materials flows and materials requirements, food and nutrients. Energy resources are optimized as far as possible in time and space to secure other societal functions. Public works and grid infrastructure systems cooperate with, and intentionally support, the long-term sustainable use of ecosystem services.

Desired end state 2: A resource-efficient energy supply with high utilization of local resources towards a circular economy

Uppsala's energy system is a supply sector but also important part of the circular economy. This system can integrate tributaries from other systems and closed material cycles. Renewable resources and material cycles, with a high level of local and regional supply and production, contribute to an energy system that is Climate Positive.

Desired end state 3: An available, safe, equitable and integrated energy system

Uppsala's energy system consists of a large number of small and large production units for different types of energy carriers (electricity, hot/cold water, steam, gas, solid and liquid fuels, etc.). Local systems where multiple manufacturers and/or users share flows and storage capacity interact with centralized infrastructure. Energy carriers are not locked into linear flows between production and use in parallel systems, but rather can be stored, converted and eventually used in other forms and for other purposes.

Objectives: What will Uppsala look like in 2050 and how did we get there?

The following is a description of a future in which the Energy Programme's desired end states have been achieved and the energy system contributes to the municipality's environmental vision. How this happened and what the outcome was is also described. First a general description, followed by a description of each desired end state.

In 2050, Uppsala is a Climate Positive municipality. This was achieved by making a number of choices and investments in the public works and grid infrastructure systems. How these systems are managed and used is also critical to its success. In addition to transforming the energy and transport systems, climate positivity was achieved by reducing emissions from materials flows and, where possible, by creating solutions with negative emissions. Uppsala's citizens, businesses and organizations **act in an environmental and energy-conscious manner**, while the public works and grid system and financial control instruments are designed to **facilitate this**. A vibrant countryside, several suburbs, and a multi-node city means that people are closer to more amenities.

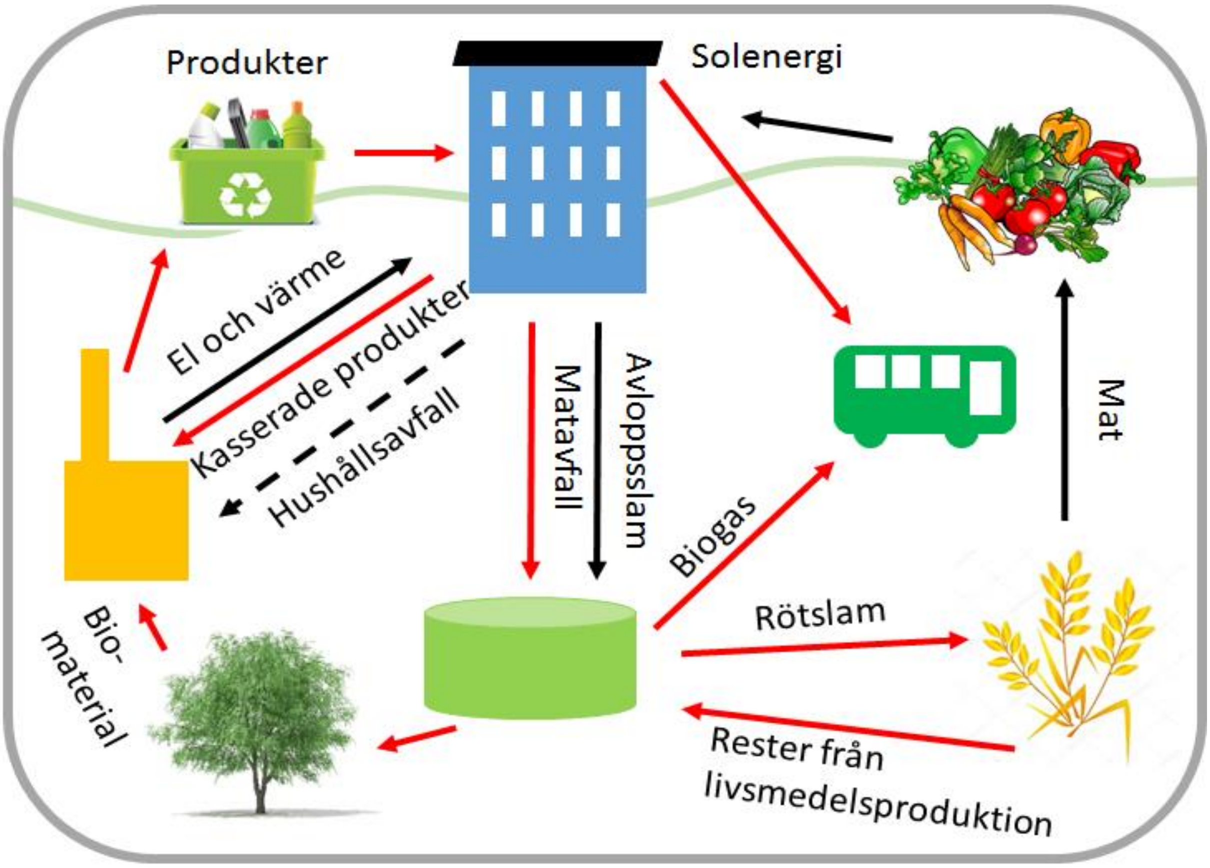


Figure 2: Schematic sketch of many, but not all possible local flows in Uppsala relevant to the Energy Programme. The current system is indicated by black arrows, future, new or reinforced system by red arrows and weakened connections by dotted arrows.

After considerable improvements in energy and power efficiency, the demand for energy in the different sectors of society is minimized in 2050. Variations in energy usage across days and seasons have decreased. In other words, the energy needs of the society (in terms of electricity, heating, cooling, fuels, etc.) have decreased to the lowest point possible without compromising the individual's quality of life or society's functions in general. At the same time, the quality of life for future generations has been maintained at the same level or has improved compared to today. That efficiency has been fully implemented has been a prerequisite for achieving a high degree of self-sufficiency.

Important aspects of the development required to achieve the desired end states are:

- The municipality has been an active party in the transformation.
- Improvements to energy and power efficiency have continued at a high pace in all sectors.
- Demand flexibility and power management have become well established for both electricity and heating.
- Energy networks for cogeneration, district and block heating, as well as cooling, form the cornerstone of the municipality's energy system. The current networks have been upgraded and maintained. New buildings have been installed with the new generation of low-temperature district heating with interactive management by the customer. The new generation of more economical technology has allowed continued expansion of district heating and increased opportunities for utilizing waste heat.
- The expansion of local and small-scale solutions has continued at an increasing pace, originating from city nodes and urban areas and through utilization of energy networks.
- Energy carriers have become less limited to certain types of energy sources and applications – different types of storage and crossover flows are common. A hydrogen system has been fully developed. Gasification technologies are common.
- The circular economy has ensured that waste heat and other residual flows have been taken care of. Basically, all materials have a residual value and are reused. New combinations of industrial materials and energy have been established. Bio-based raw materials dominate.
- Automation and information technologies have been developed for optimized energy use and power management for the energy system, while also facilitating energy and climate-conscious behavior from local residents.

Desired end state 1: Interconnected public works and grid infrastructure create synergy gains

3.1

Uppsala municipality has grown while the energy sector has undergone a transition. The energy sector is thus also a supply sector for other technical systems. The energy system harnesses, converts and distributes residual flows from other sectors such as materials, surplus heat and surplus electricity. It acts as energy storage. The energy system has become more local and at the same time more coordinated. Energy resources are optimized, as far as possible, in time and space to secure other societal functions, such as public transport.

Traditional examples of how existing connections and interactions between energy systems and other societal functions can interact are biogas production in waste water treatment plants and land-based industries' production of solid forest fuels and energy crops. Residual materials from food production are also used for biogas production. New connections have been established in multiple areas.

A number of areas will be considerably different from an energy perspective in 2050. This development takes place in the interplay between the energy sector and public works and grid infrastructure systems, and is driven only partly by the development of the energy sector itself. The systems for materials, energy and water are extensively interconnected.

<u>A bio-based and circular economy</u>

- Social systems cooperate with, and intentionally support, the long-term sustainable use of ecosystem services. More and more of the materials we use to build society come from biological raw materials. In order not to deplete our habitat, a completely different level of circular thinking is required. Local and regional cycles form the foundation, and rural and urban areas are interconnected by technical systems.
- Land-based industries are a fundamental source of different types of materials with a high energy content, but the Climate Positive and ecologically sustainable agricultural system places completely different demands on the recycling of nutrients for fields and forests. Closed circuits in the food industry, where energy harnessed as part of the process, is a key issue. Phosphorus and nitrogen circulate locally and regionally.
- In order to meet climate goals, carbon dioxide is also extracted from the atmosphere, in so-called carbon sinks. It occurs naturally in plants, but can also be accelerated through crop selection or technical systems that convert atmospheric carbon as a raw material for energy, soil improvement or materials.

<u>Industrial symbiosis and combined processes.</u>

- Materials flows lack sharp demarcations between what is considered to be resources with a value and what is considered residual products. There are systems and space for cost-effective cycles, so that materials retain a large part of their value throughout the entire life cycle. Different stakeholders use each other's residual flows to create benefits and eliminate residual flows.
- Processes that produce multiple benefits in parallel from biomass, such as bioplastics, soil improvement materials, animal feed, biofuels and surplus heat have been developed. Materials combinations are a central part of the circular economy. Plants for

this are located both in rural areas of Uppsala (near raw materials) and in urban areas (close to concentrations of energy) in order to optimize the overall system with regard to efficient use of materials, energy and transports. Products are manufactured to some extent by 3D printers for different materials. Materials that have been circulated locally and regionally.

Steps to increase synergies

The potential for strengthened connections is greatest where an unnecessary “high-value” energy carrier, such as electricity, is used even though other options are available: For example, local surplus heat. Both the design and operation of systems need to be reviewed so as not to make synergies as well as materials and energy recovery impossible, because the systems are not interconnected. Examples of desired development are lowering the temperature in district heating systems in order to more easily utilize residual heat streams.

Urban and area planning are important tools for society to create a common objective at an early stage, and where technical sectors and residents are affected and involved in the development of built-up areas.

With the right conditions, there is a wide range of synergies that can be achieved through the interconnection of technical systems. Examples of systems whose connections to one another need to be strengthened are water and sewage, agriculture and forestry, transport and fuel, electricity and heating, recycling, construction, and food supply.

The key to successful integration is that the systems can communicate and exchange information so that the systems can autonomously prioritize and optimize operations. Implementation requires a common platform that ensures operational reliability and protection against external disruptions, as well as user integrity and data security.

Figure 4: The waste hierarchy describes the order in which different methods for reducing and managing waste should be used.

3.2 Desired end state 2: A resource-efficient energy supply with high utilization of local resources towards a circular economy

Efficiency and reduced energy intensity, which in earlier periods primarily have been translated into increased prosperity rather than reduced energy use, have shifted to more substantial reductions. All energy is used efficiently within the municipality. It is achieved, for example, through high energy performance buildings and solar collectors for electricity and/or heating that are integrated into the building. Energy production and energy storage are integrated into the infrastructure of the transport sector. Noise barriers and weather protection are equipped with solar cells. Small-scale, vertical axis wind turbines are used on unused surfaces that are part of the traffic infrastructure. Energy-efficient alternatives are used for travel and transportation. The national energy sector, including fuel, is completely converted to renewable energy resources.

By 2050, only renewable energy resources will be used in Uppsala municipality, many of which will have local and regional origins, and others will be of Nordic origin. The fundamental principle will be investments in solar and wind power, as well as forest fuels and energy crops in the municipality and neighboring municipalities. Circular economy prevails and biogas is produced from sewage sludge and food residue. The residual energy can be used for heating.

Fossil fuels in the transport sector will be phased out in 2030. This will take place in 2020 for the municipality's own fleet of vehicles and in 2030, for procured transport services. This phasing out process has been partly driven externally by rapid technological developments, but also through systematic work among local stakeholders such as procured vehicle and transport services with a clear climate profile.

There has been a more extensive infrastructure added to traditional energy carriers, including networks for bio and hydrogen gas, which work both as a supply system and as energy storage.

Energy crops and forest fuels, as well as wind and sun, have the greatest potential for the local production of electricity, heat and fuels. The realization of this potential has required many stakeholders to take action and collaborate, including the municipality.

However, a significant part of the local renewable energy potential consists of energy sources that are not continuously available (intermittent) such as sun and wind, which cannot be controlled to meet demand. This will require major changes for flexible use and storage, which is developed under desired end state 3.

Important aspects of Uppsala's energy system in 2050:

It will be important for the future energy system that energy sources, energy carriers and cycles are used optimally. This is critical to ensure availability, especially during the winter, and to contribute to the overall climate and development goals. In order for this to be possible, well-functioning storage and distribution systems for electricity, gas, heating, cooling and other energy carriers are necessary.

Bioenergy, in the form of forest fuels, energy crops and residual products from agriculture, plays a prominent role in the municipality's energy system. The big challenges have been deciding

- which conversion processes are most suitable,

- where processing should be located, in city district nodes, suburbs or existing block and district heating plants, in order not to increase the overall transport needs, as well as
- at what rate withdrawals and nutrient feedback should take place to create a long-term sustainable system.

The technology for large-scale gasification of biomass has been developed and tested in Uppsala.

Bio-refineries are a collective term for integrated processes for producing different benefits from biomass. For example, it can be used for fuel, animal feed, fertilizer, bioplastics and heating. The technology was commercially established at the beginning of the century, but it was limited to liquid fuels and animal feed. In the 2020s, the technology developed quickly to produce several different products from an integrated process. A few plants of different types and sizes will deliver biomaterials and energy within the municipality.

Solar energy accounts for at least 10-15 percent of electricity usage. Building integration is obvious in the construction phase – different types of solar solutions include roof and wall materials, weather protection, etc. The targets for solar energy in the Environment and Climate Programme of 30 MW (2020) and 100 MW (2030) respectively were followed by further targets by 2040, 2050 and 2070 in the Energy Programme. Solar energy is used extensively.

Wind energy is practically completely developed in large parts of the areas indicated in the municipality's wind farm map since the beginning of 2010. At the time, land-based wind power was already one of the cheapest sources of power, and technical development has continued right up to 2050. Historical conflicts between wind power and air travel and housing have steadily declined due to increased automation and technological development, which reduced the disruption from wind power.

Hydrogen is not a naturally occurring source of energy, but is established because it is efficient for storing electricity for long periods. Hydrogen also functions as a transport fuel in the fuel cell vehicles that became more common in the 2020s. It is used above all for trucks and buses.

The water and sewage system contributes even more to the energy supply as a result of the potential for further heat recovery and biogas production being fully realized.

Organic by-products (excluding agriculture) from households and industry are still an important raw material for biogas production and nutrient recycling for the agricultural sector. Biogas fills an important function not only as an energy source, but also as an energy store to meet peak consumption and disruptions in other parts of the energy system.

Materials flows need to be reduced and circulated throughout society as a whole to achieve the stipulated climate and environmental goals. An increasing proportion of what has historically been regarded as waste is given a financial value and the amount that is ultimately spent on incineration is decreasing. This requires a significant shift at several levels in society, from households to producers and recycling companies, as well as for district heating.

Other cycles, in addition to those already currently in use, have been largely completed through the recycling of utilities such as heating and materials that historically represented residual flows. In order to utilize the full potential of recirculated water in the district heating and waste water systems from industry and properties, solutions for low-temperature district heating have been implemented. Lower heat consumption, partly due to climate change but to a greater extent due to more efficient technology, also reduces the need for primary heating production.

3.3 Desired end state 3: An available, safe, equitable and integrated energy system

In 2050, the energy system consists of a large number of small and large production units for different types of energy carriers such as electricity, hot/cold water, gas, solid and liquid fuels. Energy carriers are used directly in-situ, stored for the future or delivered to another user depending on demand. In addition, there are local systems where multiple producers and/or users share the flow and storage capacity to reduce the burden on more centralized infrastructure. Decentralization tendencies with users who disconnect from the communal infrastructure have been avoided.

Larger systems, such as central production facilities and distribution systems for electricity, heating, gas, etc., now act as buffers and equalizers at peak consumption at the local level. The systems can be used with higher efficiency. The balancing of power over time and between users that was previously only a matter for electricity and district heating networks is now also partly local, which leads to increased robustness in the systems.

Energy carriers are not locked into linear flows between production and use in parallel systems, but can be stored, converted and ultimately used in forms other than in which it was originally produced. Electricity from solar cells can be converted into gas on days when production exceeds consumption, and gas can be used as fuel for the transport sector, or stored and then converted to electricity when demand exceeds production. Energy storage is an area that has developed considerably during the period and stores of different types and sizes are integrated at different levels in the system.

At a national level, the energy system was renewable in 2040 and climate neutral in 2045. Denmark became fossil free by 2035 and Finland became climate neutral by 2050. This means that imports of electricity, for example, from other parts of the Nordic region do not have to result in a poorer performance in respect to the climate.

The following figures exemplify a cross section of the development of electricity and heating from essentially one-way systems to integrated systems.

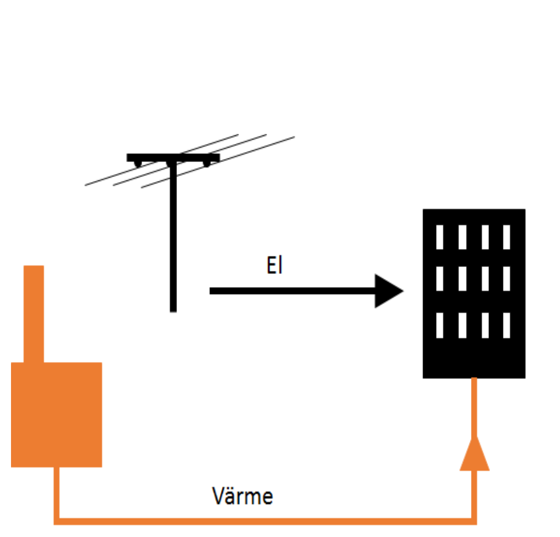


Figure 5a: A simplified model of the current linear energy system

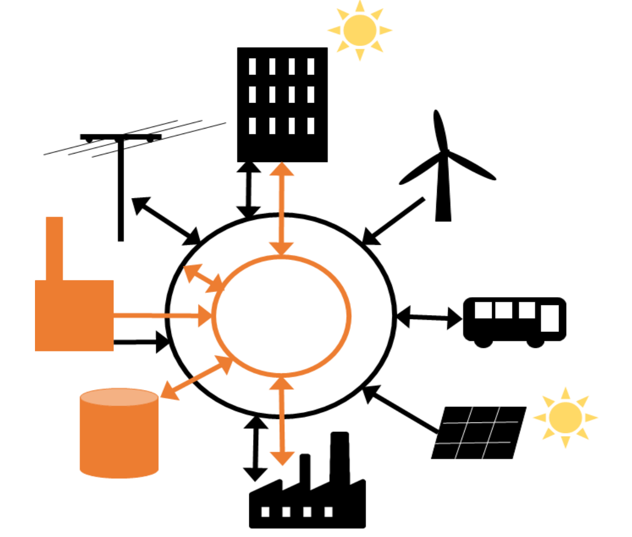


Figure 5b: A simplified model of the future integrated and circular energy system

The former, essentially one-way, system with large-scale energy production and where energy for different purposes is delivered from producers to consumers in disconnected systems. In Uppsala, the linear system is not as clear. This is mainly due to cogeneration and accumulators in Vattenfall's plants and the utilization of waste heat from, among other things, Uppsala Vatten och Avfall's (Uppsala Water and Waste) purified waste water.

The Energy Programme will promote a development from the essentially one-way direction to the integrated energy system, where more stakeholders can be both producers and consumers. Figure 5b illustrates the built-up environment (12 o'clock) that uses electricity and heating, but also supplies waste heat from sewage, and electricity from solar cells when there is an excess. Transport and associated infrastructure (3 o'clock) integrate energy production, for example solar panels in noise barriers. Storage of energy is also available in hot water accumulators or phase change materials (8 o'clock). All of these are parts of the local system, with the link to the national grid represented as one point (11 o'clock).

This integration of different forms of energy, technical solutions and stakeholders who can switch between producer and consumer at different times, leads to different forms of renewable and distributed energy resources[3]. The various forms can interact to fill important functions with the overall system to create a robust energy system.

Steps for increased energy availability, integration and security

Through increased flexibility in the energy system, energy will be used where and when, in the right form, it will provide the best benefit at a marketable and economically affordable price for the majority of users. Flexibility and integration create a technically and organizationally robust system which is a requirement for an available energy supply, and especially for society's critical functions.

Flexibility in the use of energy means that end users can increase and decrease their use of energy when needed. The end user may be an industry, another commercial enterprise or a private household. Depending on when an adjustment is needed, it may be appropriate for different end users to contribute with their flexibility.

As individual households generally have very little influence, it will be necessary for a larger number of households or properties to allow, for example, the heating system to be controlled centrally by a so-called aggregator. It is carried out in order to even out power peaks, such as when an electric car is charging at night or when heating systems can be turned down in the morning, to maintain balance in the energy system.

The transport sector's need for new types of energy in particular, is currently an important issue, as is the ability to charge vehicle batteries and produce fuel. Fuel can be gaseous or liquid and come from different processes and raw materials including electrolysis for hydrogen production. Production can be carried out at times when there are no capacity shortages.

Energy storage in different forms and at different levels will be a necessary complement to flexibility of use. At times when users are not able to adjust their power consumption, energy

[3] Distributed Energy Resources (DER) include, but are not limited to, improved energy efficiency, demand flexibility, energy storage and local energy production.

must still be available. This means that energy storage options must be available. Electricity can be stored in batteries for later use, but can also be stored in the form of heat in accumulator tanks.

Buildings may have “built-in” heat storage with heavy structural materials or new phase change materials, PCM. This creates major inertia in the building's temperature fluctuations.

Fuel for the transport sector comprises stocks ranging from a few days to a number of seasons, and batteries in electric vehicles constitute short-term storage if they can be charged at night for daytime use.

Allowing *energy flows to switch between different energy carriers* always enables the right form of energy to be made available when demand occurs. Electricity can, for example, be converted into fuel, mainly hydrogen or methane, which can be used in sectors other than electricity generation, if needed. This also means that a process of separate and decentralized solutions *reduces* the entire system's ability to optimally provide energy flows where the benefit is greatest. An example of effective centralized systems is the development of integrated district heating and electrical power systems and their key functions for energy storage and flexibility.

Technologies already currently exist for integrated solutions. The challenge is to find models for regulating the energy sector to enable commercial stakeholders, the municipality and private individuals to jointly develop their respective roles and functions. The municipality and other public stakeholders will have an important role to play in implementing solutions that have a lower, short-term financial return than commercial stakeholders would need. This has happened in the past, specific examples include the expansion of district heating or converting the public transport system to renewable fuels, and constitute a natural platform for steering development in the desired direction.

4 Changed conditions create opportunities

This chapter outlines the current conditions and challenges, as well as trends that are relevant to the Energy Programme.

Uppsala is a municipality experiencing strong growth. The Master Plan takes anticipates 120,000 new inhabitants and 70,000 additional jobs by 2050. That future makes it necessary to plan attractive areas with the efficient use of resources. Both buildings and infrastructure are something that will last for a long time. It is important to do things right from the beginning and not to incorporate unnecessary barriers to future solutions. For example, the new neighbourhoods will mean an overall increase in total energy demands. Therefore, these must be built with a high-energy performance and a high degree of energy recovery, as well as local electricity and heat production. Power requirements will also increase. It is therefore necessary to control energy use to avoid short-term and high consumption levels of electricity and heating – power peaks.

In Uppsala, Vattenfall has systems with accumulators for district heating and district cooling that take care of daytime fluctuations. It is a form of energy storage. Energy storage is an opportunity that needs to be developed and used in the future energy system. Although, energy production consists essentially of renewable or recycled energy, power reduction is crucial for achieving the goals. Reduced power consumption leads to a lower total cost for distribution systems and increases the capacity in the networks. Reduced power consumption enables more users to be connected and increased local energy production, within both existing and new areas. This applies especially to the electrical power system.

In addition to what is happening within the municipality, such as population growth and political policies relating to climate targets, energy and climate issues are also affected by a number of external trends and factors. The following section describes some of the external factors that have a major impact on the design and implementation of the Energy Programme.

1. The ongoing transformation of the transport sector.
2. New roles and stakeholders to solve common challenges
3. Local production provides increased security of supply
4. Energy and power efficiency is a prerequisite for this transformation
5. Integrated energy systems create flexibility
6. Beyond 2030 – a renewable energy system, but what happens next?

4.1 The ongoing transformation of the transport sector.

In the transport sector, different renewable fuels, and most recently electrification, have increased rapidly. Nevertheless, these still represent only a small proportion of the total energy use, diesel and petrol dominate. In the short term, electrification entails battery operated bicycles, light vehicles and public transport in scheduled traffic travelling short distances. In the long term, the transport system will be converted to run on electricity.

Battery technology is constantly evolving and will be able to achieve a greater operating range with better life-cycle performance from a sustainability perspective. Another aspect of electrification is the development of electric roads. The definition of electric roads brings together different technical systems with more or less continuous power supply, for example cables with current collectors. Electric roads along with electrical power supply through fuel cells would facilitate electrification, especially for heavier vehicles in the fleet, such as buses and lorries. Electrical power supply through hydrogen fuel cells are currently on the market for both light and heavy vehicles.

However, it is not likely, or desirable, that the entire vehicle fleet be electrically powered by 2050. Climate and environmental problems will not be solved by electric vehicles, even if local emissions of harmful particles and nitrogen oxides, as well as noise, are reduced. The increased need for electrical energy and electrical power will be significant. A mix of different powertrains will be necessary to reduce vulnerability and create redundancy. Especially for community-critical transport. Other proven renewable fuels for internal combustion engines such as biogas will therefore continue to play an important role. Ethanol, which is currently on the way out for various reasons, and other biofuels also need to be developed. Biofuels are needed both as a main source of fuel, and as auxiliary fuel for hybrid electric vehicles.

A combination of biofuels, electricity and fuel cells means that local energy resources are used as well, and the vulnerability to disruption of individual types of energy is reduced. The overall social perspective must be retained that takes into account primary energy, energy conversion, infrastructure, land use, materials usage and recycling in terms of energy carriers, vehicles and infrastructure for the entire system as a whole when these alternatives are introduced. Balance must be achieved between the use of local resources, preparedness and reduced vulnerability, as well as minimizing the risk of sub-optimization.

Other trends in the transport sector are automation and mobility as a service, although they are still in the early stages.

4.2 New stakeholders and roles to solve the common challenges

There is a growing focus on the users in the energy market. Focus on users does not mean that all, or even most, energy users will actively participate directly in different business models. On the other hand, different types of stakeholders and solutions, visible as consumer products or embedded in other services, will provide support to energy users and energy suppliers. A so-called aggregator is a collective term for a type of third party stakeholder that assembles many smaller stakeholders to facilitate, for example, small-scale energy production, demand flexibility and other energy services, and thus contributes to transformation processes.

Information and communication technology, as well as automation provide new opportunities to aggregate many different stakeholders and real-time feedbacks in the energy system. In a future energy system, information will flow between stakeholders so that they can jointly decide to keep the energy system in balance. One prerequisite is good access to communication, measurement data and a common platform for sharing the information. With such innovative systems, there are associated risks for information security and customer integrity. It is therefore necessary to raise awareness among energy users about the benefits and risks associated with sharing data, as well as setting strict requirements for technical systems and suppliers.

In the future, some of today's energy users will own their production capacity, such as home owners with their own solar cell facilities. For these so-called prosumers, new opportunities and challenges will arise as the proportion of self-produced energy increases in relation to what is delivered from major centralized systems.

A key issue regarding the future energy system is what new types of stakeholders will lead the transformation and what the role of citizens will be in the future. The municipality plays an important role in setting up common frameworks and investing in new technologies that have not yet been fully commercialized. Current legislation and standards do not always allow for the emergence of new technology and business models that promote a more efficient energy system. The municipality also plays a role in influencing regulatory frameworks, legislation and standards.

4.3 Local production provides increased security of supply

Energy supply based on local energy sources can provide increased security of supply if properly designed. This applies to electricity, heating and transport systems. The goal is not self-sufficiency for its own sake, even if many other benefits such as local jobs can be created, as certain types of energy sources can contribute to greater climate benefits and resource efficiency if they come from other places. Hydroelectric power is an example of a resource for large-scale storage and high power consumption during the winter, which contributes to the functioning of the entire energy system. Other sources of energy that are characterized by significant economies of scale need to be jointly planned at a national and regional level.

A higher degree of locally produced and distributed energy in various forms is an advantage, as it reduces the risk of disruptions that affect entire systems at the same time. When almost all houses have solar energy solutions, and storage also exists in the local systems, power failures do not need to cause the same complete and immediate outages that they do today. If biogas and hydrogen are available locally and regionally, community-critical transports can be maintained even during external disruptions.

Biomass in natural cycles, as well as from multifunctional cultivation that produces plant protein and energy carriers from the same land use, need to have the conditions to grow. In the long term, it means more waste heat from society's different processes, as well as from local materials conversion of biomass and recycling of materials rather than direct incineration.

As renewable forms of energy such as solar and wind become a significant part of the total energy supply, the need for new solutions to match production and demand increases. As the power supplied to the system becomes uneven and relatively difficult to calculate, innovation and development regarding regulation of demand is required. Through real-time feedback, load management can be used if parts of the energy demand can be flexible and consumption takes place when there is a good supply of energy. It also requires inertia in the system for this to work smoothly and a key issue is to continue to find different ways of storing energy. It is already currently done with everything from accumulator tanks for hot water and underfloor heating that provide storage in the building, to various smaller battery solutions.

Within the electricity sector, there are rapid technological developments within energy storage where commercial solutions that provide benefits to power grids and users are introduced.

4.4 Energy and power efficiency is a prerequisite for this transformation

Energy efficiency has the potential to create a system with reduced vulnerability and lower energy demands. It is important to take a comprehensive view. Government building regulations and voluntary environmental certifications have currently focused strongly on purchased energy and not the total energy requirements of the building. These are two different things and may lead to sub-optimization when implementing measures at the system level.

Important measures are those that reduce power peaks and power requirements in general, it will become even more significant the greater the proportion of local and renewable energy is. Power management is a major area that is undergoing rapid developments, where small-scale local solutions, such as private DC networks, need to interact with different types of energy storage and with network owners and Svenska Kraftnät at the national level.

However, efficiency and reduced energy intensity (kWh/Swedish krona), which are steadily improving, have not fully resulted in reduced energy use, but rather in greater comfort such as larger and warmer homes and productivity. The energy usage of the industrial sector is levelling off, but production is increasing. There is a high risk that automation of the transport sector will result in an increase in demand for the transportation of both people and goods.

In order to achieve the adopted goals, it is necessary that the trend of improvements in load management leading to increased energy use is broken and that savings and automation in the future will result in a real reduction in energy consumption.

Efficiency improvements in the transport and energy sectors must be weighed against the total energy consumption from a lifecycle perspective, which requires a wider systemic approach. For example, it is rarely more effective from an energy and climate perspective to prematurely demolish buildings or scrap vehicles that have a high energy consumption. The impact on the climate from materials means that new buildings and vehicles begin their life cycle with a significant debt in terms of materials, energy and climate impact, regardless of how little energy they use during their life or their impact on the climate during operation.

4.5 Integrated energy systems create flexibility

Increased integration of the energy system creates redundancy in both supply and use. Specific examples of this may be to use surplus electricity to produce hydrogen that can be used both as a fuel and for storing energy. The energy can then be returned to the system when demand exceeds production. The district heating system can be optimized to further facilitate recovery of residual heat from other processes. This can be done, for example, by low-temperature district heating.

The interconnection between historically independent systems such as electricity, forest fuels and the transport sector offers great opportunities to exchange energy sources and energy carriers to handle peaks in demand and production seasons.

There is a risk that many diverse technical systems will be put next to or on top of one another without achieving optimization of climate and other benefits for the energy system as a whole. This risks hampering the development of large structural systems where the costs and benefits are shared by all.

At the same time, a development of more integrated energy systems is taking place where needs and assets can be coordinated both across larger geographic areas and between forms of energy. The opposite trend is also evident, with examples of autonomous solutions where smaller areas can be completely self-sufficient, independent and disconnected from the overlying networks. Disconnection from the communal district heating network is already occurring and to some extent is likely to increase. If this happens, the network's ability to utilize waste heat and the system's potential for efficient energy supply will decrease.

4.6 Beyond 2030 – a renewable energy system, but what happens next?

The period after 2030, when the energy system has been converted to renewable energy sources, will be characterized by qualitatively different issues. Consideration must now be given to the changes that the transformation entails.

The climate focus shifts to choice of materials and systems

When the overall climate goal is added to the energy goals, the largest source of greenhouse gas emissions will be manufacturing, transportation and reuse of materials.

How to integrate renewable and recycled energy and materials flows to ensure maximum use of resources and achieve more complete cycles is a key issue in the energy and climate endeavours. This applies to both bio-based materials and the recycling of existing fossil materials.

Through the emergence of different types of bio-based energy combinations and biorefineries, a higher degree of materials recycling and increased use of more bio-based materials will be achieved, ensuring greater climate benefits. A prerequisite for achieving Uppsala's energy and climate goals is that such industrial facilities are located in the municipality. They will become a natural part of energy production and supply, together with other recycled energy and materials flows. The municipality has extensive rural areas and consequently has space for such facilities. It also presents an opportunity to convert major, existing energy production facilities. The prerequisite is that more opportunities for energy distribution are created for electricity, other energy sources and materials flows. In such a scenario, the maintenance and development of the networks will be of fundamental importance.

A concrete example is plants for biochar. The main product, biochar, provides a number of benefits: a climate-positive carbon sink that results in negative emissions, soil improvement and better run-off water management. At the same time, gas for electricity and/or heating production can be produced.

Plastics, both bio and fossil-based, can be recycled through chemical transformation, instead of energy recovery. Through chemical transformation, difficult materials can also be recycled. Such plants also provide waste heat. The need for plants for heat generation alone, by incinerating biomass and waste, can therefore be reduced.

Residual materials that are currently being used for energy recovery will in the future increasingly be recycled regionally or nationally. This also applies to things that we do not currently consider to be economically or technically possible to treat other than through incineration. The need for waste incineration, energy recovery, as the final step in the materials flow decreases correspondingly. District heating based on waste incineration at the present level should therefore not be taken for granted when the three current waste-fired plants successively need to be replaced for reasons of age after 2030. Planning for the oldest waste-fired boilers needs to commence in the near future. The waste-fired boilers are fuel-flexible.

During the journey towards becoming a climate-positive municipality, a number of choices of systems need to be made which go beyond the energy sector, but which still will have an important impact on the energy sector. Examples include the balance between private cars and public transport and the need for continuous electricity supply or stationary charging. Other examples of choices concern the development of systems for water utilization, separate systems for different types of waste water and food waste with closed-circuits, as well as how nutrients for the food sector can be linked to real-world cycles.

5 Implementation strategies

This chapter describes the strategic areas that have been identified for the achievement of the Energy Programme's desired end states.

In order to transform the energy system, six different strategies and related tactics have been developed. These interact and reinforce one another. There is a need for both a physical and a psychological transformation – what we as individuals and society believe in achieving and why this is important. Step-by-step changes alone are not enough; instead, more transformative or system-altering solutions are necessary to achieve the goals.

Uppsala municipality like many other municipalities has previously shouldered a great responsibility when it comes to energy issues through municipal energy companies. This was most evident in the 1960s and 70s when oil central heating boilers in private homes were replaced with the much more efficient district heating system. In the forthcoming transformation, the municipality once again will play an active role and use all its roles and capacities.

The following describes the six implementation strategies and the corresponding tactics. It is followed by the policy documents that support, and can further support, development, as well as continued collaboration in established collaborative arenas.

The tactics will be included in the municipality's planning, budgeting and follow-up efforts.

<u>The Energy Programme’s implementation strategies:</u>

1. Everyone has a responsibility and a role in creating a climate-positive Uppsala
2. Research, innovation and business development lead the way
3. Area planning and development that promotes new solutions
4. Urban planning for energy supply to the transport system
5. Coordinated development of local energy production and climate-positive infrastructure
6. Follow-up and development through modelling and climate road maps

5.1 Everyone has a responsibility and a role in creating a climate-positive Uppsala

The municipality has a responsibility to set goals, stipulate requirements and drive developments in the desired direction. Areas where the municipality has great resources and influence, as well as initiatives with great potential to achieve a restructuring effect in the short as well as the long term, will be prioritized.

One prerequisite for success is that other organisations, and individuals, in a position to drive developments do this.

The municipality's role is to take responsibility for the vision, as well as to assume overall responsibility for system-level optimization and to invite all stakeholders to get actively involved. The municipality is taking the lead where commercial operators do not have the capacity to fully develop climate-positive solutions at the pace required.

The municipality collaborates with stakeholders locally, regionally and nationally, as well as internationally. Citizens, businesses, academia, associations and public organisations will shape the work together. The key message is that the scope of the transformation is such that everyone will be affected in some way and therefore must also be given an opportunity to influence the process. Transparency and clear communication are particularly important for consolidating a common goal for everyone in society.

It is essential that there are networks and arenas where stakeholders can meet and drive issues forward based on a common interest. The Uppsala Climate Protocol will be the primary platform for raising new issues, running joint projects and following developments. Regular dialogue and communication initiatives are a prerequisite, where the Public Climate and Energy Advisors and the Regional Energy Agency play key roles in reaching individuals as well as small and medium-sized companies and organisations. Together, organisations can create dialogue and build up knowledge about the choices individuals make that are important for resource and energy efficiency.

Tactics:

1. **The municipality shall** work to ensure the best design of instruments and funding in order to support opportunities and eliminate obstacles to local and regional development. This will be done in close dialogue with national and international stakeholders.
2. **Uppsala collaborates** to increase the presence of bio-based and circular economy within the municipality.

Policy documents:

- Uppsala’s Policy for Sustainable Development
- Uppsala’s Environment and Climate Programme
- Uppsala’s Master Plan
- Regional Development Strategy – RUS
- The County Council Energy and Climate Strategy

Established collaborations:

The Uppsala Climate Protocol's fourth protocol period commencing in the autumn of 2018 coincides with the start of the Energy Programme 2050 and will be an important arena for development and implementation.

The Uppsala Business Protocol extends its activities to contribute to initiatives and collaboration for the strategic goals, implementation strategies and tactics of the Energy Programme.

5.2 Research, innovation and business development lead the way

Research and development are important components of the implementation process. New technologies need to be tested on a commercial scale. Stakeholders need to find their roles in the future energy system. At the same time there is inherent inertia in existing structures. Transformation requires that new solutions are considered, and the municipality plays an active role in supporting that transformation One prerequisite is that national control instruments, rules and standards are reviewed to facilitate new solutions.

In urban planning and socio-technical systems, there are a number of critical choices required to achieve a climate-positive Uppsala in 2050. To do this in a systematic and generally accepted manner, close collaboration with universities, energy companies and innovation stakeholders is required.

Additional development of the work on innovation in public sector operations contributes to the development of business and the municipality's activities, which benefits residents in different ways. In climate-driven business development, Uppsala has good opportunities to increase business and export in collaboration with the universities. The Climate Protocol can also contribute positively in respect to this.

It is a priority to promote business development and innovation environments in Uppsala that include a transformation of the energy sector. Sweden and the EU prioritize these issues, which means that there are good opportunities for seeking external funding for development, demonstration and research projects. Support is available for both investigating and initiating innovative solutions in urban as well as rural development projects. Uppsala works actively with participation in regional, national and international initiatives and partnerships, including funding, which makes possible initiatives that the municipality would find it difficult to run on its own.

Uppsala has a considerable advantage in that it is home to two distinguished universities, Uppsala University and SLU. Applied research and development locally is beneficial to all parties. The large student population can provide important impetus in the transformation process.

A key area for achieving sustainable development is to achieve synergies between urban and rural areas. In Uppsala, there is both extensive rural areas and a major city, which is a challenge but, above all, an opportunity.

<u>Tactics</u>:

1. **Uppsala collaborates** to develop a research and development platform for synergies between urban and rural areas, which takes advantage of the fact that Uppsala has both a major city and extensive rural areas, as well as access to considerable research at Uppsala's two universities.
2. **Uppsala collaborates** to create Living Labs, with Uppsala's large student population, where new technologies can be tested in practice, while being used to challenge established patterns and make future generations aware of how transformation can be implemented at the household level, as well as what is required at the societal level.
3. **Uppsala collaborates** to identify and develop opportunities for industrial symbiosis, i.e. That different stakeholders utilize each other's residual flows to create benefits and

transform residual flows into resources. **The municipality shall** in its business development efforts and in the establishment process create systems for enabling more industrial symbiosis in Uppsala.

4. **Uppsala collaborates** to develop gasification technologies and establish biomass combines. Different local raw materials and recycling of materials form the basis for the production of different products or utilities including energy production or utilization of waste heat in block and district heating networks. **The municipality shall** work with academia and businesses to ensure the local establishment of materials conversion industries, such as biorefineries.

Policy documents:

The Uppsala Municipality Business Programme supports innovation as well as environmentally and climate-driven business development.

The municipality's directive to the owners of the municipal companies states that they shall systematically test and implement new environmental and energy technologies. This will be carried out in test beds in collaboration with Stuns, as well as through municipal procurements.

Established collaborations:

Uppsala municipality collaborates with a number of innovation platforms. Uppsala Innovation Centre and Green Innovation Park are current examples.

Stuns is Uppsala’s foundation for innovation, where Stuns Energi is the part that drives developments in energy and environmental technology. The foundation is run by the municipality, the region, the county administrative board, the universities and the Uppsala chamber of commerce. The municipality initiates a dialogue concerning how operations can be developed to support the Energy Programme's strategic goals and the aforementioned tactics.

The collaboration between Uppsala municipality, Uppsala University and the Swedish University of Agricultural Sciences (SLU) is extensive and ongoing in a number of different areas. It is a long-term partnership for knowledge development and business development.

5.3 Area planning and development that promotes new solutions

In the planning of areas for major transformation or new construction, energy issues are integrated in all phases of the work, from directives and project planning at the Detailed Master Plan (FÖP) and programme levels to construction and management. Sectoral action plans will provide guidance on how this should be carried out. The action plans shall:

- specify quantifiable targets with a bearing on the Energy Programme for areas,
- specify methods to ensure goal fulfilment in different planning phases,
- specify methods for evaluating the needs of compensatory measures outside the area boundary,
- specify possible combinations of technical and organisational solutions for different planning situations,
- overall promote innovation and resource efficiency in all technical supply systems.

Developing system integration and local systems is done first in new and densely populated residential areas. This applies to both new urban nodes and prioritized rural areas. Existing infrastructure and technical supply systems in such areas are often lacking, or are only partially developed. This makes the potential to establish resource-efficient, innovative and integrated systems particularly beneficial.

Creating the prerequisites for new, coordinated solutions for social service systems becomes critical. This entails a need for early planning to increase coordination and integration. The municipality's role is to lead the planning – and to be responsible for the collaboration with and between energy companies, developers and other stakeholders.

Planning will take a holistic perspective. Existing structures will be integrated and given the right conditions. The plans reserve space for plants that are required to enable functional systems, and for energy exchange, energy production and reuse, as well as for water, transport and material flows.

The land allocation process for selling the municipality's own land for construction purposes is a powerful tool for achieving the desired effects. By allowing the process to be clear and using it to clarify the municipality's goal of becoming a climate-positive municipality, it provides stakeholders with an opportunity to contribute. The process strongly contributes to the fulfilment of the municipality’s goals by shifting to renewable energy, renewable and non-toxic materials, reusing residual energy and materials, as well as managing power peaks. It also provides a level of quality and sustainability for projects that are built on land not owned by the municipality.

Prior to 2030, it is important to highlight the connections between individual stakeholders in order to demonstrate the significance of integrated planning, where developers and suppliers of energy technologies in the power and heating sectors are expected to contribute with innovation and development.

The municipality has a role in identifying places where various sectors need to cooperate, and also in convening stakeholders to cross-sectoral processes.

The expansion of Bergsbrunna as a new part of Uppsala, will entail around 30,000 new homes. The planning of Bergsbrunna has already commenced.

Tactics:

1. **The municipality shall,** as part of its obligation in the agreement on new cities with the state, in a Detailed Master Plan develop and respond to the goals, challenges and strategic choices that are described in the Energy Programme. As part of this, a developed climate model for Uppsala will be necessary to integrate into the urban development process in order to provide continuous follow-up of and feedback on goal fulfilment.
2. **The municipality shall** develop processes with structures and tools that enable the efficient treatment and integration of many different sustainability aspects in the planning process – energy issues, climate impact, waste and materials management, run-off water, mobility and transports and ecosystem services to mention but a few.
3. **The municipality shall** develop the planning process for city nodes and urban areas, as well as integrate it into the ongoing physical planning process to promote resource-efficient, innovative and sustainable technical supply systems.
4. **The municipality shall** develop an action plan for increased joint laying of technical infrastructure. In particular, so called multi conduits are to be evaluated and tested. This applies to existing, ongoing expansions of urban areas as well as new urban areas.
5. **The municipality shall** actively support and define requirements for reduced energy usage and climate impact from the construction process, both in terms of its own operations and as part of the urban development mandate. This can be accomplished through the increased use of wood materials, phasing out of fossil plastics, use of concrete and steel with a lower climate impact, as well as fossil-free transportation and industrial machinery.
6. **The municipality shall, in conjunction with interested** stakeholders, develop system solutions for water supply as well as waste and sewage management that are less transport dependent, as well as aim for a high degree of energy autonomy (self-sufficiency) for both stationary and mobile purposes.
7. **Uppsala collaborates** to create opportunities for energy-positive local and regional production and distribution of food. **The municipality** develops initiatives within the scope of the Rural Development Programme.

Policy documents:

The Waste Plan (Refuse Collection Plan), the Water and Sewage Plan, the Rural Programme, the Environment and Climate Programme, infrastructure plans and siting plans in the Urban Planning Board’s area, (forthcoming) guidelines for sustainable urban planning at the area level.

Established collaborations

Collaboration with Sweden Green Building Council in the development of a guide for sustainable urban development and an eco-certification model at the district level. Further collaboration within the scope of the DECODE project – Community design for conflicting desires – which develops dialogue formats to better manage different interests. It operates within Vinnova's Challenge-Driven Innovation area. Uppsala is participating in the Gottsunda project.

5.4 Urban planning for energy supply to the transport system

Publicly funded vehicle fleets, such as buses and refuse vehicles, have historically been a powerful driving force and enabled the introduction of new fuels such as biogas, ethanol and FAME/RME. Now the public vehicle fleets should play a similar role in the run-up to electrification and the continued development of biofuels. Social planning is needed for the transformation to be economically sustainable for society and financially feasible for businesses.

Charging infrastructure for private cars is estimated to be expanded by commercial stakeholders without extensive activity from local community stakeholders. It mainly builds on existing structures and does not require large or coordinated investments. On the other hand, society in conjunction with commercial stakeholders play a role in the electrification of heavy vehicles, as well as the continued expansion of biogas and hydrogen as sources of fuel.

The electrification of the transport system can take place in different ways with different consequences for the energy supply: power demand, amount and type of materials use, urban environment, economy and accessibility – all of which must be balanced to achieve the best results at the system level. The target year for a mainly electrified transport system is 2030.

The vulnerability of the current transport system up to the point when a predominately electrified system is in place, lies in a dependence on fossil fuels on a global market, as well as increased competition for sustainable biofuels. The vulnerability in the future, when large parts of the transport system is expected to be electrified through either direct, continuous feed or via charging, will be dependence of power supply. That the transport infrastructure itself generates energy and maintains energy storage, for example as hydrogen but also through other methods, will be a new important component in planning transport infrastructure. An expanded system for electrical power via fuel cells and hydrogen, together with biogas, ethanol or other renewable fuels, ensures reduced vulnerability and a robust system. Functions that are critical for society are given particular consideration.

Tactics:

1. Electrification of the transport system

   A. **The municipality shall** pursue active planning for electrification of the transport sector, focusing on common solutions for multiple modes of transport, especially heavy vehicles. At the municipal and regional level, as well as in collaboration with the national level. It concerns both direct feed, charging and hydrogen fuel cells.

   B. **The municipality shall, together with the regional public transport authority**, jointly plan appropriate infrastructure for how parts of the public transport system can be electrified so as to support the electrification of other modes of transport, especially heavy vehicles. Electrification systems will be selected for minimum power consumption and materials usage.

   C. **The municipality shall**, in its investigation of a tramway system, also review the possibility of an open system in order to have a future infrastructure that can be used by both public transport and freight.

D. **The municipality shall** work for the development and financing of the electrification of the transport system as well as self-generated energy and energy storage to be included in the planning at the county level and in the county traffic infrastructure plans, as well as the national infrastructure planning and in other ways.

2. Development and interplay between biofuel, hydrogen and electricity

   A. **The municipality shall, in conjunction with interested** stakeholders, develop a comprehensive plan for the best use of renewable fuels and electricity, as well as combinations of these at different stages, before, during and after full-scale electrification.

   B. **The municipality shall, in conjunction with the region and other interested** stakeholders, maintain and develop society's investment in biogas and ethanol as a distributed fuel.

   C. **Uppsala collaborates** for the expansion of a hydrogen system, including local production, energy storage and vehicles.

   D. **The municipality shall, on their own behalf and in conjunction with the public transport authority, the Swedish Transport Administration and other interested** stakeholders, plan to integrate energy production and energy storage into the transport system infrastructure.

3. Development of municipal traffic control measures, especially environmental zones

   A. **The municipality shall** work to ensure that municipalities have the power to determine more control measures for transports.

   B. **The municipality shall**, as soon as possible, apply the new regulations for environmental zones in support of the municipality's energy, climate and environmental goals, as well as for a healthier and more attractive municipality.

   C. **The municipality will** seek ways to include biogas as a permissible fuel in the highest environmental zone (zone 3).

Policy documents:

The municipality's policy documents, the Mobility and Traffic Strategy and the Energy Programme, jointly cover the issue of the energy infrastructure for the transport system.

The Waste Plan (Refuse Collection Plan), the Water and Sewage Plan, the Rural Programme, the Environment and Climate Programme, infrastructure plans and siting plans in the Urban Planning Board's area, the Noise and Clean Air Programmes as well as (forthcoming) guidelines for sustainable urban planning at the area level.

Established collaborations:

Biogas Öst is an association that promotes the development of biogas in Mälardalen. Their members comprise companies, municipalities and research institutions. Biodriv Öst is a partnership that promotes sustainable and renewable fuels in Mälardalen. Both organisations play an important role in the ongoing work on strategies and tactics.

5.5 Coordinated development of local energy production and infrastructure

Investing in new technology and solutions means that any stakeholder usually has to take a risk. The municipality can be a test bed or co-finance critical infrastructure that is not currently produced by commercial providers. Another option is to invite new stakeholders to develop new solutions. Critical infrastructure that no commercial provider undertakes to implement may, at least initially, be part of the municipality's responsibility in terms of both financing and implementation, including operation and ownership, wholly or partially. This is especially true in the interfaces between traditional and new systems, where individual stakeholders cannot provide all the features that would be required to achieve targets set at the system level.

Despite the fact that the transformation of the energy system is in progress, and has come a long way in many respects, such as converting from fossil fuels to renewables, both in district heating and in the electricity sector, more needs to be done. The municipality will play a prominent role in coordinating and supporting early implementation of climate-positive infrastructure in instances where commercial providers do not currently do this at the rate required for the fulfilment of goals.

For a couple of decades, the municipality has been working to establish block heating systems in urban areas in order to develop an efficient systemic way of replacing individual oil boilers and electric heating, and introducing biofuels and solar heating. The prevailing market situation has resulted in limited success. Since 2009, the municipality has collaborated with Bionär Närvärme AB, which means that there are now block heating systems in five urban areas, as well as Vattenfall's block heating in Storvreta. Difficulties persist for further expansion and new more concrete efforts are needed to make additional progress.

Geo-energy is solar heating (essentially) that is stored in the ground. Geo-energy is utilized with system technology for geothermal heating, borehole storage and aquifer storage. The development of system technology is ongoing and established technology currently exists with heat pump systems that combine solar energy for plant operation and energy storage in boreholes, for a more or less renewable local system. Geo-energy is part of the energy system within the municipality's geographic area. In central Uppsala, protection of the city's water supply – groundwater intake – on the other hand means that geothermal energy cannot be built. Extended district heating supply is also the reason why geothermal facilities with borehole wells are not a viable alternative.

The municipality will produce a development plan for energy distribution (heating, cooling, electricity, gas)[4].

Tactics:

1. The interplay of energy efficiency, power, storage and waste heat
   A. **Uppsala collaborates** to reduce both energy and capacity requirements locally and regionally. This is achieved both through improved energy efficiency and

[4] The Master Plan’s tactical measure no. 17 in the municipal executive board’s operational plan for 2017–19 and 2018–20.

power efficiency, as well as through power management and control, and preparedness in local production.

B. **Uppsala collaborates** to create a more flexible and open network that connects small and large-scale energy producers.

C. **The municipality collaborates** with other stakeholders to develop seasonal storage and backup power solutions.

D. **Uppsala collaborates** to survey what additional potential is available for using waste heat that is currently not used. **Uppsala collaborates** to create a local power market for heating and electricity.

E. **The municipality shall, together with energy companies and other interested** stakeholders, introduce and develop technologies with low temperature heating systems – in both the city (district heating) and the urban areas (block heating).

2. <u>Expansion and development of the block heating system</u>

A. **The municipality shall** develop and apply more effective and concrete methods to promote the expansion of block heating solutions. These include the construction and ownership of the network. Early planning by the Planning and Building Board, the Traffic and Community Environment Board and clear directives to the municipality's companies form the basis for the expansion of the block heating systems. In existing built-up areas, the municipal companies shall connect to existing block heating systems or initiate and contribute to the creation of such facilities.

B. **The municipality shall, together with other stakeholders**, develop renewable energy production for block heating systems and other new technologies for materials flows and energy production in urban areas.

3. <u>Solar energy and wind power</u>

A. **The municipality shall** develop municipal geographic goals for the production of solar electricity for 2040, 2050 and 2070. Goals for 2020 and 2030 already exist. The municipality shall develop additional goals and initiatives for <u>solar heating</u>.

B. **Uppsala collaborates** for the next leap forward in volume and technology in the utilization of solar energy, such as solar parks and building-integrated solar systems, for both electricity and heating.

C. **The municipality shall** develop larger plants on its own properties and land to further drive development.

D. **The municipality shall** monitor developments for the opportunity to expand wind power, and maintain talks with other stakeholders.

4. <u>Capture and use carbon and carbon dioxide, especially the development of biochar</u>

A. **Uppsala collaborates** to identify, highlight and develop different technologies for carbon and carbon capture, focusing on usage and new products of carbon and carbon dioxide. The carbon binding should take place locally, for example in agriculture and in the city's green areas.

B. **Uppsala collaborates** for the development of pyrolysis plants with materials supply and the use of its products, especially biochar, synthetic gas and waste heat. **The municipality shall** investigate the prerequisites for the production of biodiesel in Uppsala municipality and also construct a pilot plant[5].

C. **The municipality shall**, for its part, develop the use of biochar in their own operations: tree care, park activities and the like, run-off water management, own land, own land for agriculture, sewage treatment. To that end, the municipality will collect biomaterials from its own operations, as well as from municipal waste disposal, for the production of biochar.

D. **The municipality**, in cooperation with research and industry, will develop a model for local climate compensation concerning, for example, biochar.

Policy documents:

The Water and Sewage Plan, the Waste Plan, the Business Plan and directives to the owners of Uppsala Vatten och Avfall as well as directives to the owners of the municipal property-owning companies, the Tree Plan, Park Plan, the Run-Off Water Programme, siting plans within the Urban Planning Board's area, (forthcoming) guidelines for sustainable urban planning at the area level, as well as policy documents for municipally owned land.

Established collaborations:

The municipality and Vattenfall have a partnership agreement for strategic collaboration for sustainable energy systems.

The municipality and Bionär Närvärme AB have a partnership agreement for strategic collaboration to develop and promote block heating solutions in Uppsala municipality's smaller urban areas.

The municipality collaborates with other municipalities and energy companies in the counties of Uppsala, Västmanland, Sörmland and Gotland through the Mälardalen AB Energy Agency. The municipality initiates a dialogue concerning how operations can be developed to support the Energy Programme's desired end states and the aforementioned tactics.

Uppsala municipality participates in the EU project, Solarcharge 2020, which develops and evaluates solutions for power management and optimization of electric vehicle charging with locally produced solar electricity. An important interim goal is to design specifications of requirements for future infrastructure solutions. The project is run in collaboration with Uppsala parking companies, the university and businesses.

Uppsala municipality participates in a research project led by KTH on biochar 2017–2020, which develops and evaluates biochar through pyrolysis and waste heat. Uppsala's part is to

[5] The Municipal Executive Board's Operational Plan 2018–2020

evaluate biochar/pyrolysis at the system level, i.e., at the geographic level. This is carried out using Uppsala's climate and energy model in the LEAP modelling programme.

5.6 Follow-up and development through modelling and climate road maps

The Energy Programme will be followed up every four years.

An overall goal of the periodic reviews of the Energy Programme is to update the programme based on changing conditions, both within the municipality and in the wider world. These conditions include, but are not limited to, technology development, energy market issues, the municipality's growth rate and new challenges related to this, as well as political decisions and goals at the municipal, national and global levels.

Uppsala's energy system is modelled on the current situation and with different scenarios for long-term developments, integrated into modelling of the climate impact from Uppsala. This is carried out in LEAP, a modelling programme from the Stockholm Environment Institute. It is the cornerstone of the follow-up, evaluation and planning of the Energy Programme and the municipality's climate goals and endeavours. The model is called the *Uppsala Climate Model*. In addition to the energy system, the climate model also includes the long-distance travel of Uppsala residents, as well as the climate impact of non-energy activities such as agriculture, animals and industrial processes.

The Uppsala Climate Model has been developed since 2010 in cooperation with SLU and the Uppsala Climate Protocol. It was last used for the Uppsala Climate Protocol’s *Roadmap for a Climate-Neutral Uppsala* (2015), and for the report, Energy 2050. For more information, see chapter 1.

Uppsala municipality and the Uppsala Climate Protocol will work on a new climate roadmap, *Roadmap for a Climate-Positive Uppsala*. The Energy Programme's strategic goals and implementation strategies with tactical measures will be modelled for the target scenario. The Energy Programme is thus followed up and will keep developing. This is carried out to ensure that it develops in the right direction and at a sufficiently high pace.

Modelling will be developed with more components to be able to evaluate and develop the energy system based on the Energy Programme. Above all, the following modelling development will be made:

- indirect climate emissions from production and transport of construction materials
- gasification of biomaterials, pyrolysis with other technologies as well as biochar usage,
- the power issue by adding larger storage systems
- the power issue by introducing time resolution and load curves from energy production,
- geographical breakdown in urban and rural areas, as well as Bergsbrunna and Södra staden with Ulleråker separately.

The Climate Protocol participates in the research programme *Mistra Carbon Exit* 2017–2020. The programme has the same goals as the Climate Protocol – achieving climate positivity in the mid-century, especially with a focus on transformative solutions in buildings, transport and infrastructure. The work carried out in Mistra Carbon Exit will be an integral part of the Roadmap for a Climate-Positive Uppsala).

6 Appendices:

6.1 Uppsala municipality's environmental vision, goals for sustainable development and programmes with significance for the energy system

Uppsala municipality's overall ambition is to be a fossil-free successful municipality that contributes to global ecological recovery and well-being.[6]

The Energy Programme should be implemented without compromising other goals for sustainable development in the municipality. This section summarizes and analyses how the Energy Programme relates to other programmes and policies.

The ecological framework

The municipality's programme for environmentally sustainable development is The Ecological Framework (2014). The framework's overall priorities are:

- Effective resource utilization and cyclical thinking.
- Renewables and climate-efficient energy sources and materials.
- A society that is free of toxic substances where health and the environment go hand in hand.
- Biodiversity and the natural and cultural environment are developed, promoted and used sustainably.

The ecological framework for sustainable development brings together the municipality's various environmental programmes. The Energy Programme is based on and supports the following:

- The Environment and Climate Programme
- The Waste Plan
- The Water Programme
- The Run-Off Water Programme
- Action Programme against Noise and Air Pollution
- The Conservation Programme

Policy for sustainable development and the Sustainable Development Goals

Uppsala municipality's Sustainability Policy describes how the municipality will work to achieve sustainable development. The municipality shall be a guiding force – this involves taking an active role – for sustainable development globally, nationally, regionally and locally.

Uppsala municipality's Sustainability Policy supports the 17 Sustainable Development Goals and the 2030 Agenda. They were adopted by the world’s heads of state at the UN Summit in September 2015 as an action plan for sustainable development.

The developmental goals and the 2030 Agenda aim to eradicate poverty and hunger, bringing about human rights for all, achieving gender equality and ensuring lasting protection for the

[6] Municipal council, 2015

planet and its natural resources. The Global Goals are integrated and indivisible, balancing the three dimensions of sustainable development: economic, social and environmental.[7]

The goals that have a direct impact on the Energy Programme's areas of focus include: Affordable and Clean Energy" (Goal 7); Industry, Innovation and Infrastructure (Goal 9); Sustainable Cities and Communities (Goal 11); Responsible Consumption and Production (Goal 12); Climate Action (Goal 13); Life on Land (Goal 15) and Partnerships for the Goals (Goal 17).

Uppsala municipality's climate goals

The municipality's climate goals are in line with the assessments of the UN Intergovernmental Panel on Climate Change (IPCC) in its 5th Assessment Report (2013) and the 2015 Paris Agreement, but with an earlier target date. The earlier target date has two purposes. Firstly, to show the need for a climate policy with greater safety margins. Secondly, to take responsibility for historical emissions.

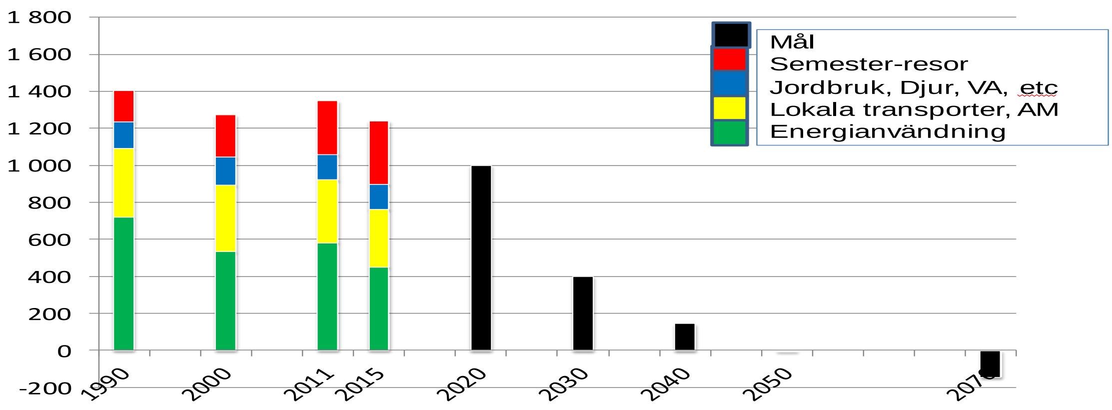


Figure 3: Historic values for climate impact in absolute terms (thousand tonnes of CO_{2e}) and Uppsala's goals.

The overall climate goals are as follows:

- By 2030, Uppsala's local energy use is fossil free and renewable.
- By 2050, Uppsala is climate-positive for total emissions[8]

The local emissions that are included in the goal for 2030 include energy production and distribution, energy use and transportation. In the total emissions goals, emissions are added from non-energy related emissions from agriculture and industry within the municipality's borders, as well as the long-distance travel by Uppsala residents outside the municipality.

The goal of a climate-positive Uppsala also recognized a responsibility for emissions from the production of goods that are transported to Uppsala. These emissions are currently not included

[7] Government Offices of Sweden (Regeringskansliet), 2017

[8] The goals in terms of climate positivity are specified as reducing the overall emission of greenhouse gases in Uppsala in absolute terms, compared to 1990 by: 90% no later than 2040, by 100 % by 2050 and by more than 110 % by 2070.

in the emission calculations for Uppsala. The largest of these items is considered to be construction materials and food.

The Environment and Climate Programme 2014–2023

The Environment and Climate Programme focuses on the climate challenge and an environment free of toxic substances. The programme has milestones for how heating and transport should be converted to renewable energy, how solar energy will be expanded and how energy efficiency will be accelerated. There are also milestones for non-toxic procurement, materials selection, organic food, sustainable construction and management, as well as environmentally-driven business development. The target dates in the Environment and Climate Programme are 2020, 2023 and 2030.

The milestones in energy and transport lay the foundation for, and constitute a prerequisite for, the Energy Programme's long-term target date. As with the other milestones, continuous interaction between the Environment and Climate Programme and the Energy Programme is required for the goals to be achieved.

The Energy Programme interacts with the municipality's other plans and programmes

In addition to the policy documents, there are several other programmes and plans that to a greater or lesser extent concern energy issues.

In particular, the Master Plan emphasizes the importance of designing the energy system to enable utilization of waste heat flows, integration with waste systems and sewage systems, as well as the use of solar energy in both buildings and large-scale plants. Large scale systems for power grids and district heating are supplemented with smaller local systems and local cycles. Adjacent properties and facilities will balance the loads between them. This is especially true in new and densely populated areas, such as city nodes and prioritized urban areas. The link between urban and rural is emphasized. Energy and materials use and its climate impact, in production, distribution and disposal will decrease, materials flows will be better managed, and circuits will be closed.

The Rural Programme emphasizes that “Increased self-sufficiency in food, water and energy is important for meeting future societal challenges and an increasingly uncertain world”. The Business Programme has the goal of creating 70,000 new jobs in the municipality by 2050. This is something that the transformation of the energy system will both contribute to and benefit from.

In relation to transport and mobility, there is a Bicycle Programme and a Public Transport Programme. The Master Plan has goals for sustainable travel and the municipality is working systematically within this area. A Mobility and Traffic Strategy is under development. Local electricity and heating production will in the near future be largely fossil-free, excluding energy recovery from fossil plastics. The remaining use of large amounts of fossil fuels locally is in relation to travel and transportation. Therefore, transport goals and plans are important for the Energy Programme's goal fulfilment.

The Energy Programme and the Mobility and Traffic Strategy will jointly deal with the issue of the choice of electrification systems and strategies for biofuels, as well as the energy supply to the transport system.

6.2 Appendix: Organisations currently participating with the Energy Programme

Municipal bodies

The Municipal Administrative Office	**The Urban Planning Administration**	**Companies**
Ecological Sustainability	Real Estate	Fyrishov
Business Development	Strategic Planning	Industrihus
Security and Preparedness	Traffic and Society	Skolfastigheter
		Sportfastigheter
		UKFAB
		Uppsala Parkering
The Labour Market Administration	**The Administration for Environmental Affairs**	Uppsala Vatten
Energy and Climate Advice	Water and Waste Water, Health and Area Protection	Uppsalahem

Public and private agencies/organisations

Akademiska Hus	InnoEnergy	Svensk Solenergi
Biogas Öst	KTH	Svenska kraftnät
	Lantmännen	Teknikföretagen
Carbonext	The County Administrative Board	
E.On	NCC	Bionär
Eneo	Ramböll	Upplands Energi
	Region Uppsala, the regional office	Vattenfall: R&D Business development
Energikontoret Mälardalen	Region Uppsala, the Public Transport Authority	Vattenfall värme Uppsala
Energimyndigheten	Rise	Vattenfall Distribution
FerroAmp	STUNS	Researchers at the Swedish University of Agricultural Sciences
Heby municipality	Sustainable Innovation	Researchers at Uppsala University

	Sweco	Researchers at KTH

6.3 Glossary and terminology

Biochar	Organic material that is heated without an oxygen supply to the extent that the material's volatile substances are released. The remaining product is biochar.
Biogas (or biomethane)	Gas formed by digesting organic matter under acid-free conditions. During digestion, both methane and carbon dioxide are formed. To be able to use the gas for vehicles, the carbon dioxide must be separated out.
Biorefinery	A plant that separates different fractions of substances from the original raw material (biomass).
Power	The consumption of energy per unit of time.
Demand flexibility	The ability to vary the demand for electricity over a period of time, which is used to release electricity at certain times of the day in order to move it to other periods, thus spreading usage over time.
Energy intensity	Energy use in relation to economic activity (usually GDP)
Renewable	In energy contexts, an energy source that can be recreated or is naturally replenished (e.g., biomass, solar/wind).
Intermittent	Not continuously available, used in energy contexts most often in connection with renewable power generation. Wind and sun are intermittent sources of power.
Conductive charging	Cord charging or power supply.
LEAP	Long-Range Energy Planning, modelling tool for energy systems and greenhouse gas emissions, etc.
PCM	Phase Change Materials. Utilizes the relatively large amount of energy that is released or used at phase conversion, solid to liquid form, liquid to gaseous form, for example ice to water
Prosumer	End user/consumer who also has the possibility of supplying energy to the system and thus both produce and consume energy on different occasions.
Urban node	Strategic and demarcated areas in a city that interconnect neighbouring areas with regard to, for example, energy.
The Uppsala Climate Protocol	A network of companies, organisations, the public sector, universities, environmental associations and the municipality that collaborate and inspire each other to contribute to the geographic climate goals and to the development of Uppsala.
Hydrogen gas	Energy-bearing gas which can be used as fuel in fuel cells for the production of electricity. The electricity can in turn be used for the propulsion of vehicles (fuel cell vehicles) or for power supply in stationary applications.

Greenhouse gas	Gas that traps heat from solar radiation in the atmosphere, which means that it is not reflected away from the earth's surface. This contributes to a gradual increase in the average temperature on the surface of the planet.
Master Plan	Master Plan, planning document specifying the long-term physical planning in a municipality