



ENERGY STRATEGY AARHUS

The road to the fossil-free energy system of the future

2021-25

AFFALDVARME
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Energy Strategy Aarhus – The road to the fossil-free energy system of the future
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OUR FUTURE ENERGY SYSTEM IS A JOINT EFFORT

Aarhus is undergoing a rapid development. There is an inflow of residents, and more people are living and working in our city. Simultaneously, we are in the process of a historic green transformation of the whole society. Overall, Denmark will reduce its CO₂ emissions with 70% in 2030. But Aarhus is more ambitious and exploits the potential in the green transition to create attractive sustainable growth and thereby becoming a CO₂-neutral city in 2030. The transformation of society is both necessary and at the same time a huge business opportunity. Together, we create an attractive climate-friendly framework that can attract companies and investments to Aarhus, and it is our hope, that this will inspire other cities in their transition journey.

In this progressive and value creating climate effort, the energy sector plays a key role. It is a critical and crucial transformation task when electricity, heat, transport, and industrial energy consumption must shift to 100% renewable energy. It places unprecedented demands on our joint energy system for cross-sectoral coupling. At the same time, we must ensure that the transition happens at a pace where the energy infrastructure does not impede or delay the green transition. The future integrated energy system is complex, and the transition is calling for a joint effort focusing on the entire energy value chain, which has not been seen before. No one can solve the task alone.

The four large energy utility companies in Aarhus and Aarhus Municipality have decided to enter a collaboration on strategic energy planning to share the social responsibility and rise to the challenge collectively. With 'Energy Strategy Aarhus', we have entered a public-private partnership to prepare the city's energy system for the future. A preparation, where we ensure the green transition cost-effectively, with due diligence, and with an eye for the development of new innovative solutions that can

benefit both the city's utility companies' business as well as the, the citizens, and companies.

With 'Energy Strategy Aarhus', we have set a direction and developed a platform for our transition. We pledge to contribute and handle the task in joint responsibility and commence the initiatives and the most important parts of the strategy that lie within our own core areas. We will involve other partners and actors when further action is necessary.

Taking a joint responsibility for the city's green transformation provides us with several advantages. Both for society in general and for the individual utility companies. All actors have investments in plants and infrastructure and face additional large investments in the near future. Through 'Energy Strategy Aarhus' we create a common direction and representation of interest, which minimizes risks and increases the possibility of optimizing our own operations and create added value for our owners. This will also help us get to the forefront when it comes to new green and efficient technologies as well as to develop new business opportunities. Hereby we create the basis for lower energy prices and a higher security of supply. This makes the individual utilities more robust in a future with increased uncertainty and increased competition and helps to ensure lower living and production costs for citizens and companies in Aarhus in the long run.

'Energy strategy Aarhus' is our common proactive strategy for a cohesive energy system, which sets a common direction for a timely green transition.



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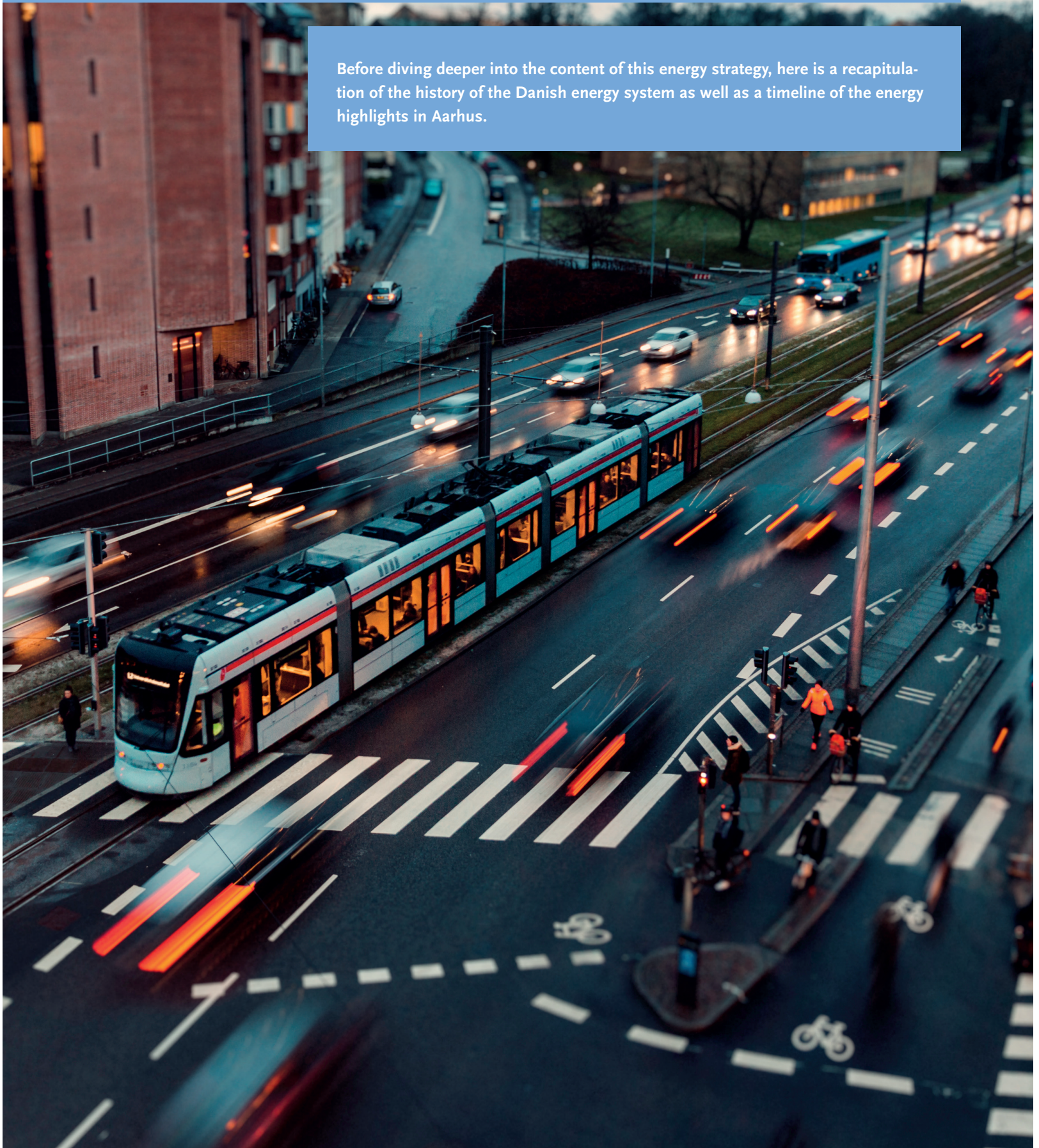
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THE DANISH ENERGY MODEL

Before diving deeper into the content of this energy strategy, here is a recapitulation of the history of the Danish energy system as well as a timeline of the energy highlights in Aarhus.



Building on 40 years' experience

The rethinking of the Danish energy system took its start in the wake of the 1970's oil crisis. Until then, the Danish energy production had relied almost entirely on imported oil. The need to be self-reliant teamed up with the wish to be more environmentally friendly and climate conscious.

During the following 40 years, Denmark began constructing a domestically sourced energy supply, upscaling the use of renewables and making the entire system more energy efficient. Through clearly defined ambitious targets, Denmark has changed the structure of the energy system to be holistic and integrated, yet fully reliable.

One coherent system

An important aspect of the Danish Energy Model is focusing on interactions among sectors and systems establishing synergies between them, as opposed to focusing on individual components and concepts. Public-private cooperation, coupled with stable political and regulatory frameworks, has fostered important innovation and breakthroughs in energy concepts. The Danish Energy Model has a threefold foundation: Energy efficiency, renewable energy and system integration/development including electrification.

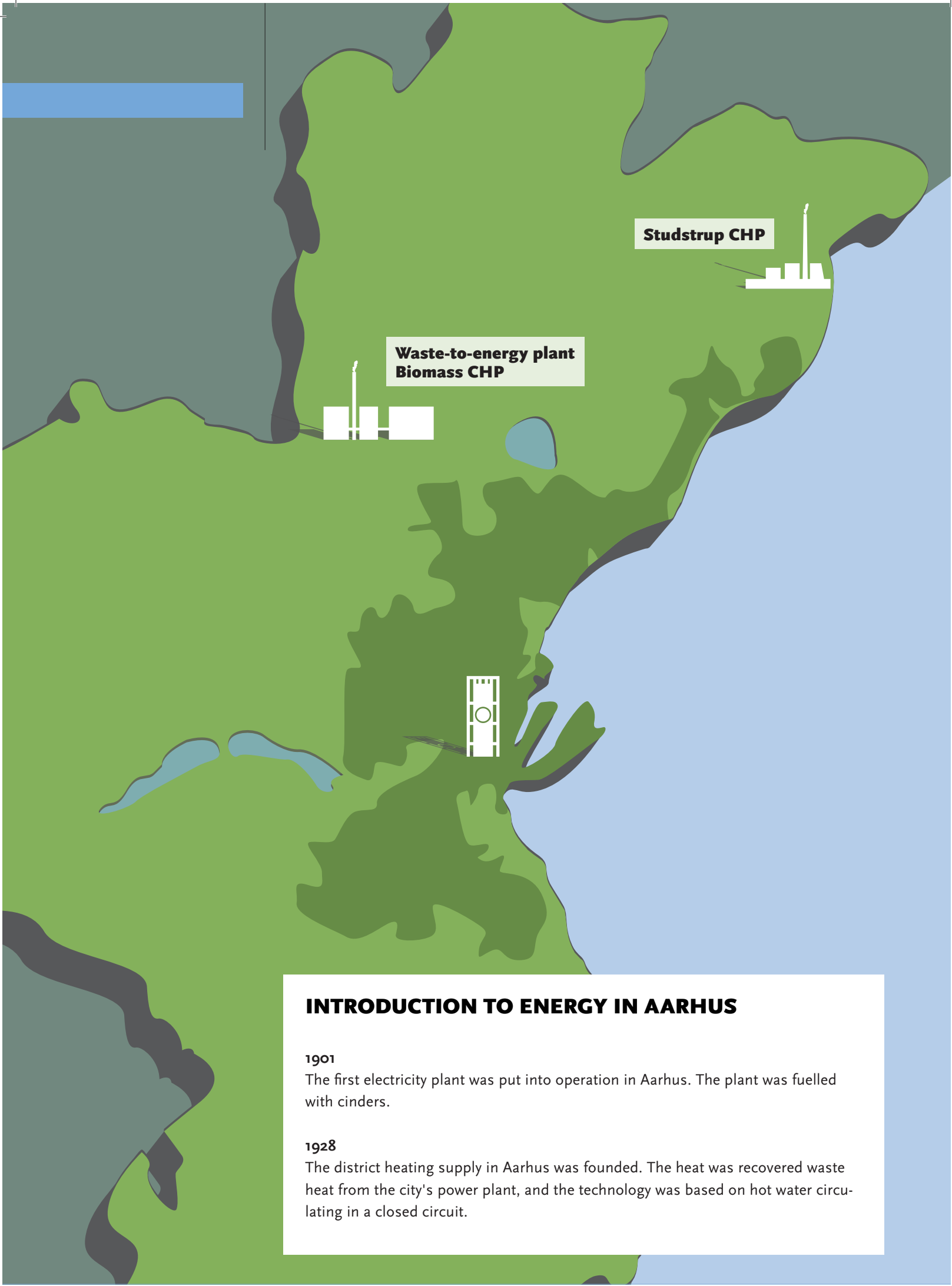
The coherent integration of all three is essential, as the sectors support each other. Making the energy system efficient makes it possible to meet energy demands with renewables that would otherwise initially be disproportionately expensive. An integrated system is able to balance the use

of renewables, from wind and sun, with conventional combustion-based sources, ensuring security of supply. Additionally, it is crucial that the system is supported through a power exchange with the neighbouring countries. Also, the extended use of combined heat and power and district heating has allowed Denmark to integrate large proportions of wind into the energy system, e.g., in electrified heat production.

Teaming up supply and demand structures

The Danish Energy Model concentrates on renewables and energy efficient technology, as well as increasing energy consciousness and altering consumer behaviour. Incentivized to reduce energy consumption through initiatives, such as improved energy standards for buildings, public campaigns to promote energy savings in households and energy saving agreements with industry, the energy policy is well rooted in the everyday lives of Danish citizens and businesses. Danish environmental and energy taxes also contribute to a better reflection of the environmental costs of production, use and disposal in consumer prices on energy.

(Source: Danish Energy Agency)



Studstrup CHP

**Waste-to-energy plant
Biomass CHP**



INTRODUCTION TO ENERGY IN AARHUS

- 1901**
The first electricity plant was put into operation in Aarhus. The plant was fuelled with cinders.
- 1928**
The district heating supply in Aarhus was founded. The heat was recovered waste heat from the city's power plant, and the technology was based on hot water circulating in a closed circuit.

1934

The first waste incineration plant in Aarhus was built.

There was a need to expand the power plant and the incineration plant was built next to it as it was now possible to produce long steam pipes for the desired pressure, and economically, more waste would mean more steam for the power plant instead of increased transport costs to disposing the waste.

The produced heat was utilized in a boiler plant that supplied steam to the power plant.

1948

During and after the war, the district heating network was only slowly expanded, but in 1948 the expansion took off. Heat was to be supplied to an even larger part of the city. In addition to large property complexes, residential areas also became potential customers as the houses were close together and the plant's profitability required as many customers as possible.

1950's

District heating got competition from cheap oil that made the oil boiler attractive to villa owners

1968

The power plant in Studstrup was put into operation.

1970's

The oil crisis in 1973 meant that district heating once again became attractive to homeowners with oil boilers. But it was especially the government's initiative to make Denmark independent of OPEC (Organization of the Petroleum Exporting Countries) that had an impact on the development.

1978

The waste incineration plant in Lisbjerg was put into operation. The recovered heat was used for district heating. Agreement between Aarhus Municipality and several consumer-owned district heating plants was established.

1985

The power plant in Studstrup was converted into a combined heat and power plant, and distribution of heat to Aarhus started.

1994

The waste incineration plant in Lisbjerg was converted into a combined heat and power plant.

2015

The combined heat and power plant in Studstrup was converted to use wood pellets instead of coal.

2017

A biomass CHP in Lisbjerg fueled with wood chips and straw from local farmers was put into operation.

2019

A sea water heat pump was put into operation by the harbour

2020

The Waste and District Heating Company in Aarhus was separated into a company owned by the municipality.

The 4 largest energy companies and the City of Aarhus reached a milestone in their cooperation with the signage of this Energy strategy

STRATEGY AND RECOMMENDATIONS

The vision of our joint energy cooperation is to:

“co-create the cohesive energy system of the future as a prerequisite for the attractive, sustainable, and modern city without fossil fuels”

We do that by

- Develop and apply proactive, long-term, coordinated, and cost-effective energy investments as the prerequisite for a wise and timely green conversion.
- Develop and apply market-based solutions that put us at the forefront of technology development and new business models and create a reduced climate footprint also outside Aarhus.

Our challenges

- To fulfil the vision, there are several challenges that we must take into account and overcome. The following list is not exhaustive, but lists the main challenges as we see them now:
- Over the next 10 years, the energy system must contribute to making Aarhus CO₂-neutral'
- 'We need to ensure power and charging options for electric cars, but we do not know to what extent'
- 'For the next 30 years, we must find green fuel for those parts of the transport sector that are not electrified'
- 'We need to find the right technology mix in district heating in relation to electrification, waste incineration, biomass cogeneration, carbon capture and cheap renewable energy storage'
- 'We need to create a better understanding among citizens, that more people will become neighbours to local cheap renewable energy production plants'
- 'We must integrate wind and solar energy, but also maintain security of supply in the future, when the wind does not blow, and the sun does not shine'
- 'The increasing energy needs of the larger building stock requires a more efficient energy infrastructure or intelligent buildings and smart grids'
- 'We do not yet have the tool to optimize and maintain Aarhus' infrastructure below and above ground as an asset in the green transition while at the same time do this in a cheap and efficient way with least possible inconvenience to citizens.
- 'We need to have a better overview and systemic understanding of sectoral coupling, so the consequences for the whole energy system by adjusting a single process is made visible and is a naturally part of our decision-making processes'
- 'We lack a long-term forward-looking regulatory and planning framework, which promotes market-driven solutions and the most cost-effective green conversion'

Strategic focus areas

The work of strategic energy planning and the preparation of the 'Energy Strategy Aarhus' has helped to identify where we must strive to succeed with our vision, and what it takes. This is extremely valuable insight as the task of the transition and development of the energy system is so extensive and requires such a prompt action that time, investment, and energy needs to be focused on the right initiatives. We therefore recommend 10 strategic focus areas that are particularly important for the conversion of the energy system in Aarhus. Our work in the coming years with implementation of the energy strategy in practice will happen with the commencement of a series of actions and projects that promote the 10 strategic focus areas.



The strategic focus areas are

1. Develop our unique potential for energy parks of the future
2. The electricity grid as a focal point - also as a solution for the transport of the future
3. District heating as a prerequisite for an efficient energy system in the urban community
4. Greater robustness and security with increased local energy production
5. Data as a source of increased value creation and effective interaction
6. Punctual and cost-effective development and maintenance of infrastructure through a strengthened collective model
7. Urban planning secures space for the energy system of the future
8. Joint efforts on necessary framework conditions
9. Joint innovation as a catalyst for local development
10. Strong partnership as an important cornerstone of the transition

1 - DEVELOP OUR UNIQUE POTENTIAL FOR THE ENERGY PARKS OF THE FUTURE

The two large combined heat and power (CHP) plants in Aarhus are strategic positions of strength and will remain crucial for a future energy system relying on renewable energy. Here we can create coherent solutions that in a beneficial way include the existing energy facilities and infrastructure in new technologies and features, and simultaneously contribute to exports and jobs. Besides large-scale energy production, we also have the potential to capture and exploit CO₂ (also called Carbon Capture and Utilization) on commercial terms, through balancing fluctuating electricity from wind and sun, large scale storage and utilization of surplus energy. One of the possibilities is to use the captured CO₂ to produce liquid fuels as a substitute for fossil fuels in the heavy transport. We therefore continue to work strategically and ambitiously with the development of the CHP plots in Studstrup and Lisbjerg, just outside the city of Aarhus but within the municipal border of Aarhus.

We do this because it is necessary to create solutions that on a large scale compensates for CO₂ emissions within the transport sector. But also, because it is unrealistic that we with the current initiatives can reduce our CO₂ emissions to a level which prevents the global temperature level from rising more than 1.5 °C. If the 1.5 °C goal is to be achieved, there will be a need for negative CO₂ emissions. Carbon Capture can therefore play a crucial role in the sustainable energy system of the future.

Specifically, it means that we have established a joint task force across Aarhus Municipality, AffaldVarme Aarhus (waste and district heating company owned by the Municipality of Aarhus) and Ørsted, which initially will work with developing an Energy park at Studstrup. This work will be integrated into AffaldVarme Aarhus' work with a new Climate-Heating Plan (Kli-

maVarmePlan) and in Ørsted's development plans for the plot of Studstrup.

What we are monitoring

- Progress in development of energy parks and regulatory test zones.
- Demonstration projects and whether the learning achieved is activated in relevant places.
- Number of CO₂ tonnes captured.
- Number of TJ fossil-free fuels for transport produced.

2 – THE ELECTRICITY GRID AS A FOCAL POINT - ALSO AS A SOLUTION FOR THE TRANSPORT OF THE FUTURE

The electricity grid plays a central role to the future renewable energy system, where most of the energy will come from wind and solar energy. Electrifying the transport sector and securing options for charging are some of the most important instruments in the green transition. This applies, among other things, to a timely roll-out of charging infrastructure for electric cars and electric-based transport in general, so lack of charging options is not a reason for opting out of choosing electricity as the next choice of transport. There are various issues related to electrification of transport, depending on whether we are looking at charging in the center of Aarhus, where many do not own their own parking space, or residential suburbs where the electricity grid has a low voltage (10 kV) and is challenged by many individual charging stations, or e.g., shore power for ship traffic.

We are therefore working proactively with charging solutions for the transport sector.

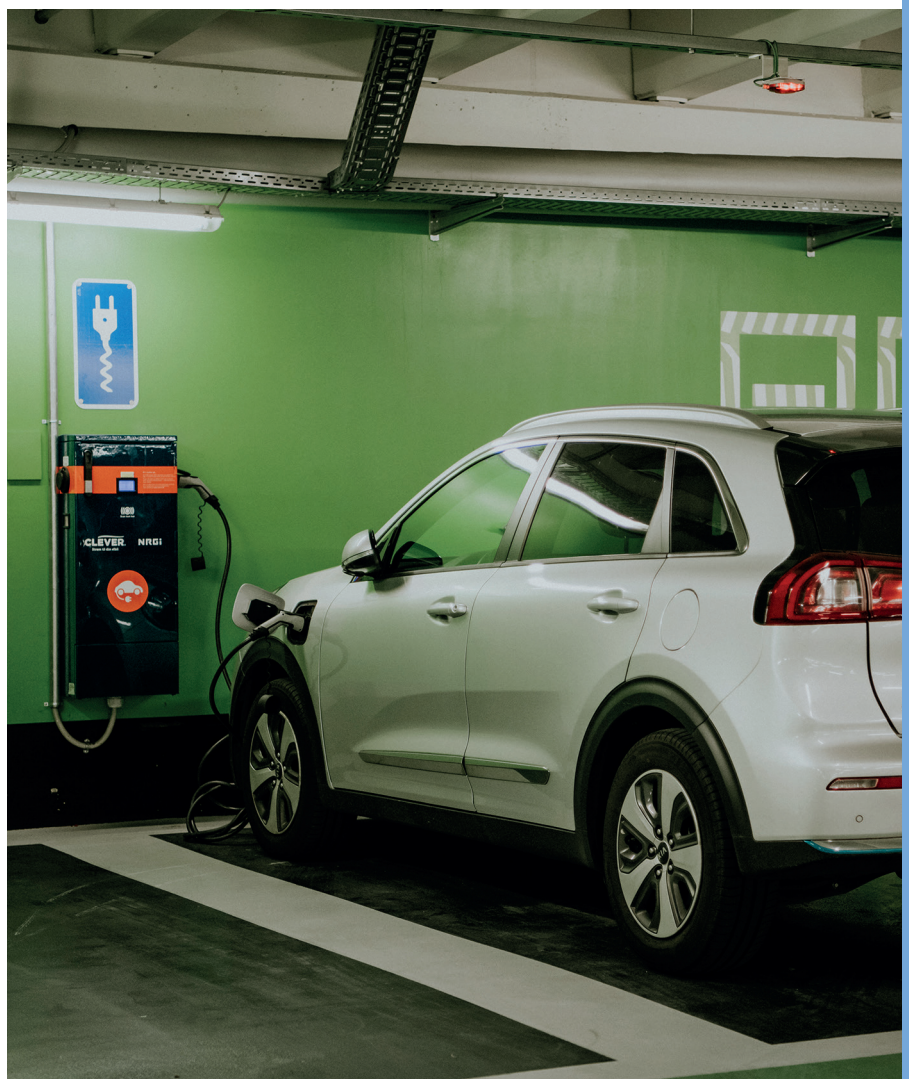
We do this because the roll-out of infrastructure is a prerequisite for getting more people to choose electric transport. Especially in the city centre there is a need of a coordinated effort, so we do not end up with e.g., 4,000 charging stations and none ultra-charging stations close to the city. The space in the city centre is limited and we must make smart system choices that balance the need between lightning chargers and slower charges placed locally, so the citizens of Aarhus can charge their car, whatever their needs. In addition, the electricity grid in Aarhus faces major renovations and there are socio-economic savings opportunities by preparing charging infrastructure at the same time with the renovation and upgrade of the electricity grid.

Specifically, it means that we initially focus on the city centre, including zoning and regulatory road map development for

charging solutions. It requires cooperation between municipality, local grid companies, charging operators and national actors.

What we are monitoring

- The number of electric and plug-in hybrid cars compared to the national average.
- The degree of utilization of public charging points.
- Public charging infrastructure in relation to the number of electric cars.



3 – DISTRICT HEATING AS A PREREQUISITE FOR AN EFFICIENT ENERGY SYSTEM IN THE URBAN COMMUNITY

Today, 95% of the citizens in Aarhus are supplied with green and cheap district heating. The district heating system is very flexible and has an important potential for synergies with other parts of the energy system. For example, utilization of large amounts of fluctuating wind and solar power to produce heat, and to co-generate heat and electricity at CHP plants when the wind is not blowing, and the sun does not shine. District heating can utilise energy from a wide variety of energy sources, which in addition to wind and sun, is biomass, waste, gas, water, geothermal energy, and surplus heat from industry. In that way, district heating ensures that we can harness the energy of society effectively and that nothing is wasted. The district heating system in Aarhus also contributes to address a range of societal tasks, including incineration of waste and substantial CO₂ reductions during the last 10 years.

We can see that the district heating system is an important piece of the puzzle in a cost-effective green conversion of the entire energy system in Aarhus, and we therefore give the area great focus the following years.

We do this because the district heating system in Aarhus is facing major decisions regarding new production facilities and development of the district heating network towards 2030 and because we want to maximize the interaction of district heating with the rest of the energy system and the society in a cost-effective way.

Specifically, this means that Affaldvarme Aarhus prepares a new Climate-Heating Plan, which is the strategic basis for development of the district heating system in Aarhus towards 2030. The Climate-Heating plan will be of great importance for future investment decisions, not least for the electricity and district heating systems and the future energy parks in Lisbjerg and Studstrup.

What we are monitoring

- Percentage distribution of production of different energy resources for district heating.
- Flexible electricity consumption in the heat supply.
- That the used biomass comes from sustainable production.
- Establishment of new important societal functions, which the district heating system contributes to optimize (e.g., waste management, carbon capture, large-scale storage, fossil-free fuels for transport, wastewater management, etc.)



4 – GREATER ROBUSTNESS AND SECURITY WITH INCREASED LOCAL ENERGY PRODUCTION

We will need a vast expansion with solar power plants and wind power in the green transition. Fortunately, the price of producing electricity from renewable energy has dropped quite significantly in recent years, so that green power today is competitive with power from coal. By increasing local energy production, we help to solve this task. Simultaneously, we help to ensure greater robustness in the overall system and decrease the cost of transporting energy over long distances. The socio-economic production cost of offshore wind turbines today is 1/3 higher than solar cells and land-based wind turbines. There is often local resistance to the establishment of wind and solar power plants on land.

We are therefore making it a focus area in the coming years.

We do this because we contribute to reduce the total cost of the green transition when we in Aarhus plan for, and invest in, land-based solar and wind power. As a big city (in Danish standards), we would also like to take a co-responsibility for getting renewable energy plants placed in our municipality.

Specifically, this means that AffaldVarme Aarhus, KONSTANT (NRGI) and DINEL (AURA Energy) and Aarhus Municipality establish a joint working group, that strives at supporting the establishment of local renewable energy plants in Aarhus corresponding to at least half of the potential that is laid out in the municipality of Aarhus' thematic plan for wind and solar power.

What we are monitoring

- How large a share of the potential for local electricity production has been converted into concrete wind and solar cell projects.
- Production capacity (MW) for installed wind and solar cell capacity.
- Share of energy consumption covered by local renewable energy resources.



5 – DATA AS A SOURCE OF INCREASED VALUE CREATION AND EFFECTIVE INTERACTION

There is a great untapped potential to create value of energy data and for Aarhus as a large-scale test and demonstration city. As an example, databased and digital solutions in the building stock can ensure that our investments in the operation, maintenance and expansion of both buildings and the electric and district heating grids, takes into account where the investment provide the greatest energy efficiency and CO₂ savings combined. Data can also be used for flexible management as well as for buildings as storage for the whole energy system. Finally, data can be used in several other areas, e.g., management of energy production and storage, intelligent charging of electric cars versus large investments in expansion of the electricity grid, etc. Aarhus Municipality and the energy utility companies agree to prioritize data as a common area of development the next four years.

We do this because we want to develop our energy system to become more digital, data driven and smarter to succeed with creating the sector couplings, energy efficiencies and the flexibility we want and need if we are to succeed with a cost-effective green transition.

Specifically, this means that we are investigating what potential synergies can occur when we use data across our organizations to enhance the efficiency of the energy system in Aarhus. In addition, we have a continued focus on developing projects such as 'Energy leap Aarhus' (Energispring Aarhus), where the plan is to identify and implement profitable energy savings totalling 4 million m² building mass. This will take place via a network involving public and private building owners, administrators, and interest groups.

What we are monitoring

- Joint digitization projects across energy companies in Aarhus, and their outcome.
- Collaboration on common data platforms and utilization of data for optimization and integration.



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6 – TIMELY AND COST-EFFECTIVE DEVELOPMENT AND MAINTENANCE OF INFRASTRUCTURE THROUGH A STRENGTHENED COLLECTIVE MODEL

There must be significant investments and reinvestments in the energy infrastructure in Aarhus towards 2030 to ensure the supply of the green transition and of the many new citizens and businesses. There is a need for a stronger model on how we together can expand and maintain the energy infrastructure in a cost-effective way and make the inconvenience to the citizens of Aarhus as small as possible. In addition, we must avoid overinvesting in one specific sector or type of infrastructure, as we have not examined the cross-sector solutions. A concrete effort can e.g., be in district heating areas where the heating capacity is being challenged by rising urban growth and densification of the city. Here it is interesting to investigate whether the power grid and boosting of district heating temperature with heat pumps is an economically attractive solution instead of larger district heating infrastructure. Another effort is to investigate smart transmission routes to infrastructure (electricity, heating, water, fiber, etc.) in special hot spots in Aarhus, where changes occur frequently, and where it is expensive to dig. It is also relevant to look at the municipality's opportunity to demand better coordination of digging in the city, so nuisances are minimized. This is an area of development that we prioritize during the next four years.

We do this because it is important to coordinate infrastructure projects across supplies to achieve the greatest possible economic, environmental, and practical gains.

Specifically, it means that we are establishing a working group across Aarhus Municipality, AffaldVarme Aarhus, KONSTANT (NRGI) and DINEL (AURA Energy), which analyses the economic and practical potentials and prepares basis for decisions on concrete efforts, which are then sub-

mitted to relevant decision makers with the purpose of initiation.

What we are monitoring

- Savings generated through coordinated infrastructural planning.
- Development work around e.g. smart guideways / infrastructure channels on selected hotspots in Aarhus.
- Electrification - measured as sales of electricity for transport, heating, industry, and production of biofuel / CCUS (carbon capture, utilization and storage).

7 – URBAN PLANNING SECURES SPACE FOR THE ENERGY SYSTEM OF THE FUTURE

Massive investments are being made in urban development in Aarhus these years. To secure space for new energy systems, it is important that urban planning contemplates the energy of the future early in the planning process. It requires us to think and plan in new ways and in new partnerships with energy companies, investors, and developers in the city. We will need more areas and a new design of the city space for a much larger proportion of transformer stations and energy plants in the future. It is e.g., five times as expensive to retrofit electric cables for electric car charging, compared to laying empty conduit pipes when building. Aarhus Municipality expects, along with the strategic energy planning in 2020, to adopt a new theme for the municipal plan “Restructuring to green energy” as a first step along the road to green transition. We believe that there is still a need for knowledge building, practical experiences, new business models, etc.

We do this because a cost-effective green transition is also about making Aarhus ready by incorporating and preparing for the energy system of the future in current investments.

Specifically, it means that during the next four years, we will select and prioritize work with energy in urban planning. That means, as we develop, mature, and build projects, we will from a municipal standpoint, support an arrangement where the entirety of the future energy system is incorporated. We will continuously collect knowledge and test new solutions in selected urban areas in collaboration with external actors. New solutions can e.g., be low temperature district heating, building integrated solar cells, batteries, preparation for electric cars, and energy communities.

What we are monitoring

- Experiences from demonstration areas, solutions elsewhere and new development in technology.
- Necessary changes in legislation that can ensure the necessary basis for requirements for urban developers and contractors, etc.
- The degree of knowledge and incorporation of future needs in comprehensive and local plans.

8 – JOINT EFFORTS ON NECESSARY FRAMEWORK CONDITIONS

The framework conditions that apply to today's energy system, do not all fit into a world without fossil fuels, which challenge the green transition. For the collective efforts in strategic energy planning to succeed, there is in selected areas a need to change some of the framework conditions. Wherever possible, we will stand together in a coordinated joint representation of interests because it strengthens the weight of our arguments. It helps to ensure that we reach our goals in a timely and cost-effective way.

We believe that there is still a need for knowledge building around common interests to ensure the necessary framework conditions for the green transformation of the energy system in Aarhus.

We do this because it is crucial to get those framework conditions changed that have been formed in another time and prevents a timely and cost-effective conversion of the energy system.

Specifically, it means that we continuously examine the framework conditions that limits our opportunities locally. We make a communication plan and initiate common interest representation via relevant industry associations, directly to authorities, the media, and other bodies.

What we are monitoring

- Inquiries, presentations, and the like from the parties regarding the strategic energy planning in Aarhus to national decision-makers, stakeholders, influencers and the press and not least what results it has created.

9 – JOINT INNOVATION AS A CATALYST FOR LOCAL DEVELOPMENT

New solutions are needed when we as city must complete the largest restructuring of the overall energy system in history. Innovation is crucial, when transport, industry, electricity, and heating must be based on 100% renewable energy by 2050 - and when an increased electrification of transport and the heating sectors is expected simultaneously. We will enforce and initiate projects in the coming years, which can provide value for Aarhus, and explore new business areas for energy companies and other corporations.

We do this because a dedicated effort regarding innovation opportunities can attract financial resources to Aarhus. Through test areas and regulatory test zones, we can help create new solutions, new business areas for the energy companies as well as promote the creation of new local businesses and future local energy jobs.

Specifically, it means that we are persistent in our cooperation on strategic energy planning, and we will work for dedicated test sites and possibly regulatory test zones in Aarhus, where we can develop and mature some of tomorrow's solutions. The steering group in strategic energy planning decides which innovation applications and projects should be initiated.

What we are monitoring

- The number of demonstration projects, their progress, and actual results.
- The number of collaborative projects around the development of an intelligent supply system.

10 – STRONG PARTNERSHIP AS AN IMPORTANT CORNERSTONE OF THE TRANSITION

Our cooperation has already demonstrated value and shown that we must stand together in order for the green transition to succeed. We will maintain but also strengthen our cooperation on strategic energy planning in Aarhus, especially around the implementation of the concrete initiatives leading to the results. There will be initiatives outside our own core areas that must be strengthened if we are to realize our vision.

We take responsibility for strengthening them and involve other partners with the required specialist knowledge and business interest to help carry the load.

We do this because no one can create the solutions alone. Both because the overall task is far too large and complex, but also because sectoral links are crucial and thus it will be in the interplay between the partners that new solutions are co-created.

Specifically, it means the organization around strategic energy planning in Aarhus continues, and the secretariat

service and the jointly decided efforts and projects will continue to be co-financed. The steering group will annually evaluate our progress with fulfilling our vision and strategic 2030 focus areas, along with an assessment of the general development that affects our work.

That way we can react timely and change strategies and level of ambition when necessary, and provide value for the utilities, the citizens of Aarhus, and the green transition.

What we are monitoring

- That the steering group is presented with annual progress reports for 'Energy Strategy Aarhus', including the status of initiated actions/projects and decides on the necessary adjustments.
- That the project group and working groups deliver the agreed gains at the agreed time and within the given framework.



AARHUS' ENERGY-DNA

Today, Aarhus has several characteristics, which are of great importance for our opportunities for further developing the local energy system. Some characteristics are a great advantage, others a challenge, but overall, they form the basis for development in the years to come:

- The vast majority of energy consumption in Aarhus is for electricity and heating in buildings (34 %), as well as for transport (36%). The industry uses a limited share (8%) of the total energy.
- Most of the energy is produced by burning biomass, waste and oil; and very little is produced on solar and wind locally in Aarhus (3% of electricity consumption).
- The degree of electrification today is low (cf. previous point).
- The district heating system is large and well developed, and 95% of Aarhus have district heating.
- The district heating is green because it has converted from coal to biomass.
- Aarhus has one of the largest waste incineration plants in Denmark, that both produces electricity and district heating, while also handling the waste that cannot be recycled.
- The electricity grid in Aarhus is aging and is facing a major re-investment in the coming years, both because of age and because the energy system must be able to deliver far more electricity for i.e., transport and heat supply in the future.
- The industry's energy consumption is from fossil fuel and is centered at the harbor of Aarhus.
- The energy consumption of transport is from fossil fuel, and passenger transportation by car uses most energy.
- Aarhus has a large and dense building stock, which provides an opportunity to activate buildings large-scale in relation to energy efficiency, flexible consumption, building-integrated solar cells etc.
- Aarhus is a small city with a limited area, also for energy facilities. That will be a challenge because the energy system of the future will need space for more transformer stations for electricity, charging infrastructure for electric cars, decentralized district heating systems, new energy infrastructure etc.
- Aarhus is undergoing a very favorable development, and massive investments are being made in new urban areas, companies etc. Growth and urban densification increase energy demand and challenge the existing energy infrastructure.
- We have a large local university and a number of innovative companies that can contribute to innovation.
- We have several energy locations with strong infrastructure, for example at Studstrup and Lisbjerg, which has good potential for development and innovation.
- Today, a lot of electricity is produced at the combined heat and power plants in Studstrup and Lisbjerg, and therefore electricity imports to Aarhus are limited. In the future, electricity consumption in Aarhus will increase at the same time as the production of the cogeneration plants is partially replaced by cheap electricity from solar and wind power. Aarhus will have to import large amounts of electricity in the future.

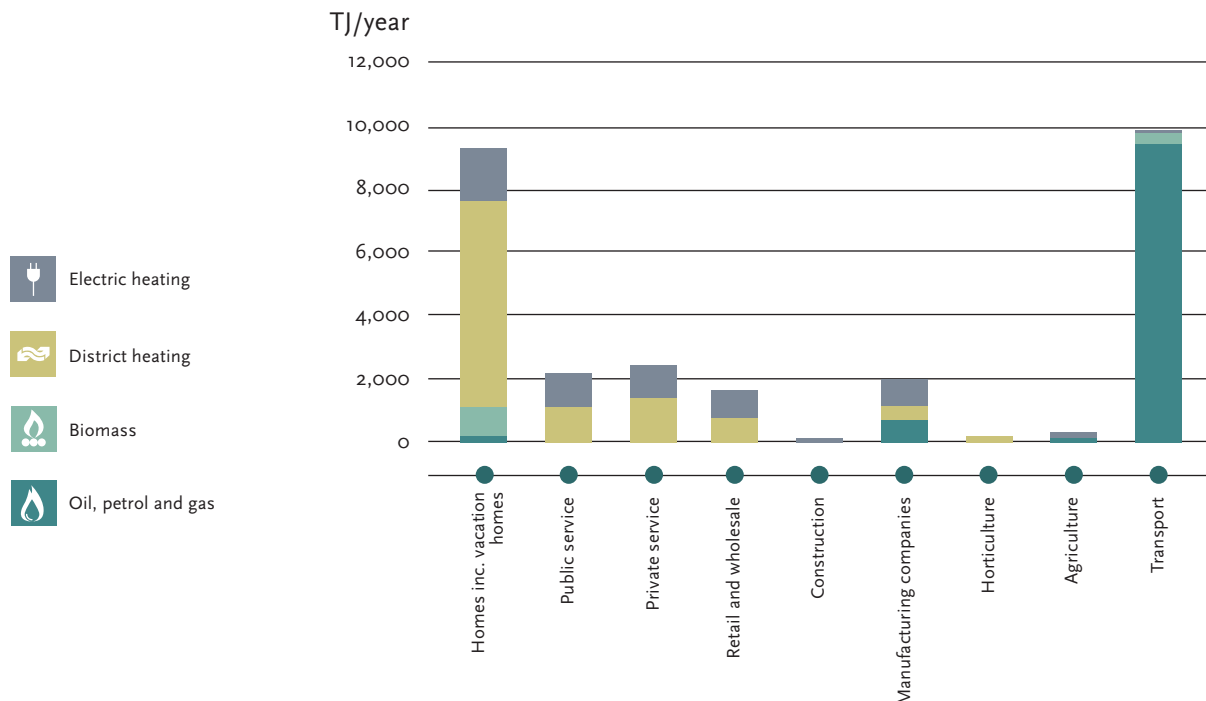
- Aarhus is the regional capital of a business region with a global position of strength within green technology. It provides good opportunities for increased development, exports, and jobs.
- We have a deep harbor with international traffic and high cargo capacity, which allows shipping of products in and out of Aarhus. In the future it could e.g. be locally produced liquid transport fuels in the form of electro fuels.



GRAPHS AND DIAGRAMS

Below you can find a number of graphs and diagrams showing carbon emissions, energy production, and energy consumption across sectors and sources.

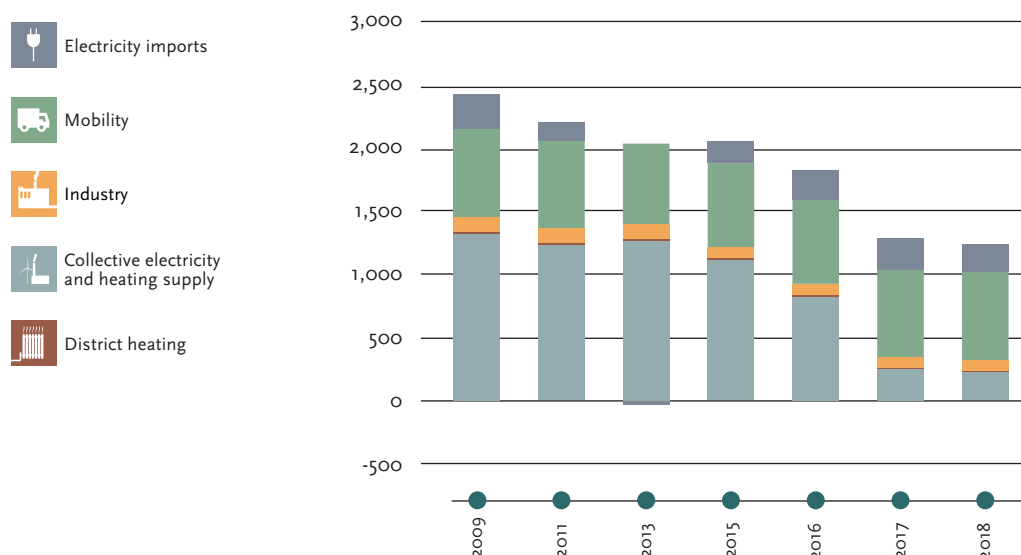
The Energy Consumption in Aarhus

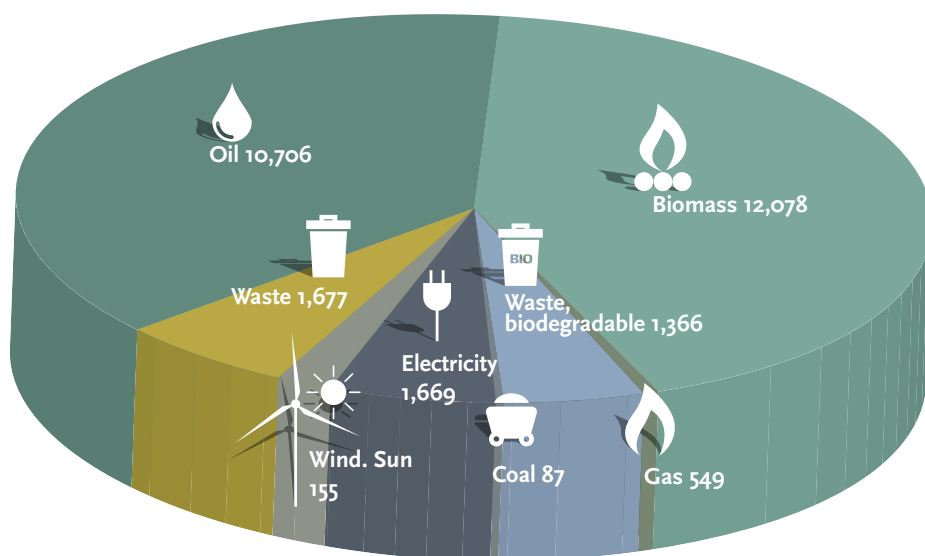


Energy consumption in Aarhus divided into sectors and fuels calculated in Tj / year (terajoules per year). The total energy consumption in Aarhus is 27,900 Tj / year (2018 data). The largest energy consumption is related to electricity and heat in buildings, which account for 34% (9,500 Tj / year) of the total energy consumption in Aarhus and for the transport sector, which accounts for 36% (9,950 Tj / year) of total energy consumption. The industry today accounts for 8% (2150 Tj / year) of the total energy consumption in Aarhus.

Source: Plan Energy, 2018.

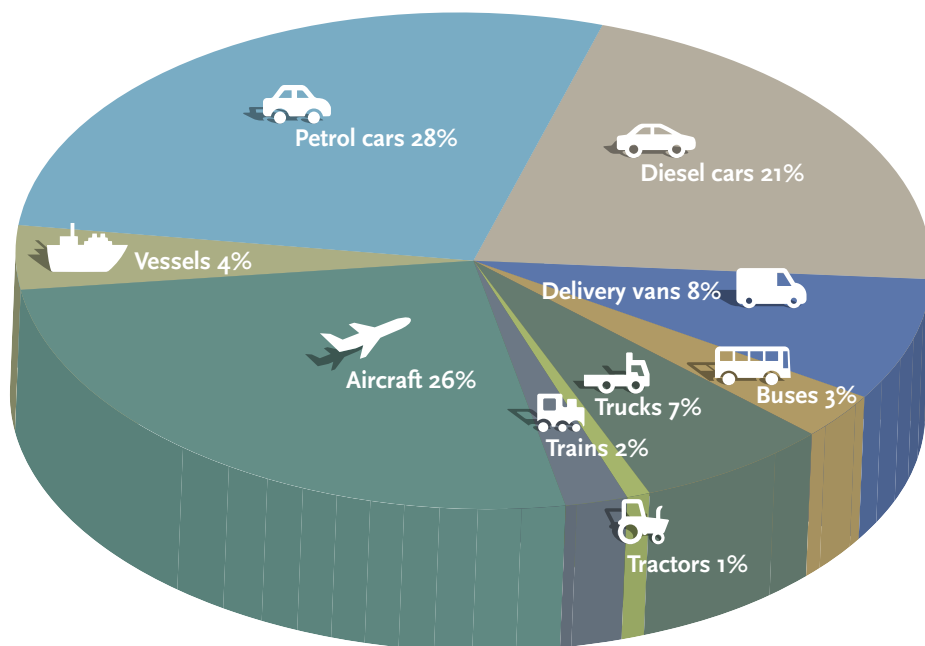
CO₂ emissions, tons. Aarhus as society.





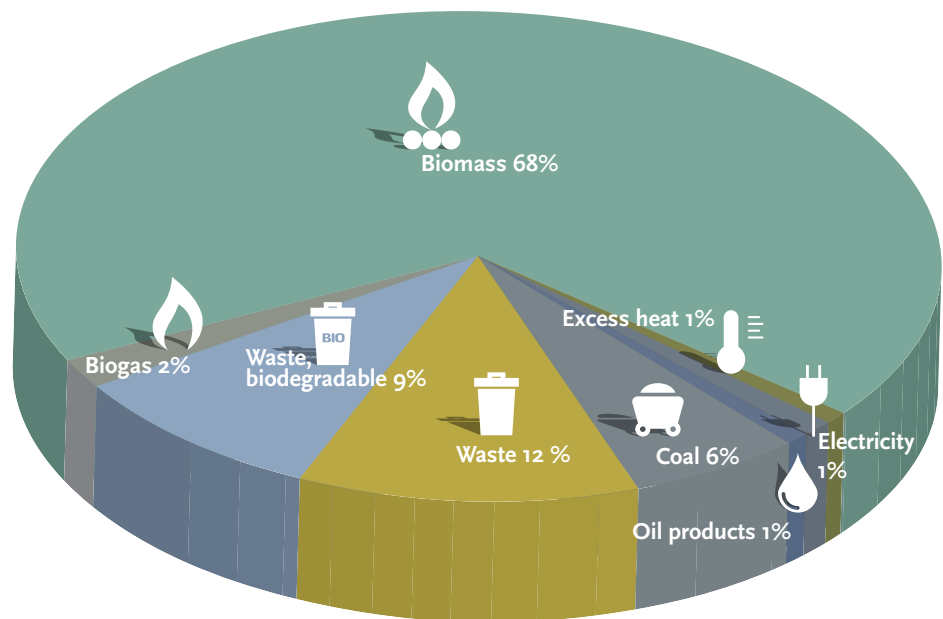
Consumption of fuels in Aarhus' energy supply today. The electricity and heat supply has traditionally been based on waste and coal, but coal has been successfully converted to biomass in Aarhus. Fuel consumption for electricity and District heating is therefore today primarily linked to the use of biomass and waste. The transport sector remains primarily supplied with fossil fuels.

Source: Plan Energy 2018

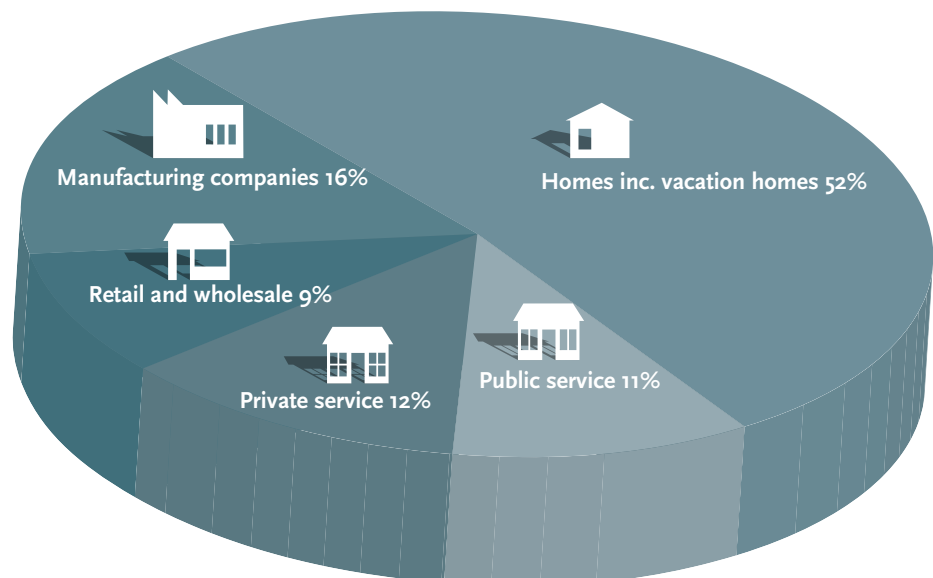


Grouping of energy consumption for transport in Municipality of Aarhus.

Source: Plan Energy 2018.



Fuel distribution for district heating production in Aarhus Municipality.
Source: Plan Energy 2018



The buildings' energy consumption in Aarhus Municipality [estimated for 2018]. Consumption consists primarily of district heating and electricity, but part of the energy consumption in especially manufacturing is used for process purposes. Source: PlanEnergy, 2018 'Energy accounts 2017 for Aarhus Municipality'.



