FLEXPOSTS

FLEXIBLE ENERGY
POSITIVITY DISTRICTS

PED IMPLEMENTATION STRATEGY FOR AALBORG EAST

Gemeente Leeuwarden
New Energy Coalition
Green Hub Denmark
Aalborg Universitet
Hanzehogeschool Groningen University of Applied Sciences

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Authors	Kristian Olesen & Jelena Nikolic
With contributions from	Sarah Meyer, Alex Søgaard Moreno, Rasmus Nedergård Steffansen, Lasse Schytt Nørgaard, Ivar lyhne, Poul Thøis Madsen & Søren Løkke
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DISCLAIMER

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Aalborg East 2045

The calendar shows the year 2045. We are in Aalborg East, and when we move around in the district, we are in the middle of a National Test Centre for Renewable Energy and Sustainable Solutions. Citizens and businesses radiate a sense of pride because their district is the first major urban area in Denmark, and one of the first in Europe, to have achieved the European accreditation of a Positive Energy District (PED).

Aalborg East has undergone a major transformation, and today the district is known as an area where the energy flows are optimally utilized around the clock. Energy is actively shared across homes, industry, and educational and health institutions, and everyone feels part of a harmonious and sustainable energy balance. All residences are supplied with sustainable district heating, and the sun's rays are utilised on the rooftops. When there is a need to supplement the energy from the sun, the power is obtained from a small, local wind farm and from a larger wind farm outside the district. On the roads, electric buses are running, which are free to hop on and off, and citizens are, hence, less dependent on their own cars.

Aalborg East's recognition as a PED is largely due to a partnership between local businesses, with the Port of Aalborg and the local business network at the forefront, leading the sustainable transition. The municipality and the state have followed suit by removing several of the administrative and logistical barriers that previously prevented businesses from investing in sustainable solutions. Also housing associations have far better opportunities for making sustainable choices. New favourable conditions for installing solar cells on roofs and a new system for sharing energy flows have contributed to making the dream of establishing a PED in Aalborg East possible.

Figure 1: AI generated image of Aalborg East in 2045

Developing a Positive Energy District

The European Union has established the goal of developing 100 Positive Energy Districts in 2025 as a stepping stone towards realising wider goals of transitioning European societies towards climate neutrality and 100% renewable energy in 2050. Positive Energy Districts (PEDs) are defined as urban districts, which on an annual basis produce more energy than they consume. PEDs should rely on 100% renewable energy and contribute to build liveable urban communities.

We propose that Aalborg East becomes one of these 100 European PEDs by establishing Aalborg East as a PED demo site with the ambition of developing Aalborg East into a full PED by 2045.

We believe that the PED concept has significant potential, if we apply the concept to larger urban districts and at the same time integrate the districts into larger energy systems, allowing renewable energy flows to travel freely in and out of the district. PEDs should be dynamic entities, which build on each districts' strengths, rather than isolated autonomous entities aiming at self-sufficiency.

Figure 2. A PED should not be seen in isolation, but rather as a network of interconnected PEDs throughout Denmark

Aalborg East's Energy Balance

As a mixed-use suburban area Aalborg East holds great potential for becoming a PED. The district offers a variety of housing options, including single-family homes, terraced houses, and apartment blocks, providing a balance of owner-occupied and rented accommodations. Home to approximately 20,000 residents, the district fosters engagement and community-spirit. Additionally, Aalborg East is home to larger industries like the Aalborg Portland cement factory, the Port of Aalborg, and a cluster of businesses in the wind power industry. Aalborg University's main campus and a new university hospital can also be found in the district. All these functions contribute to a thriving and dynamic suburban environment.

In Aalborg East, most private homes, public buildings, and offices get their heating from the city's district heating system. This system mostly uses waste heat from the Aalborg Portland cement factory and the waste incineration plant, Nordværk. If we look at the heat production/consumption balance in isolation, Aalborg East can already be considered a PED today.

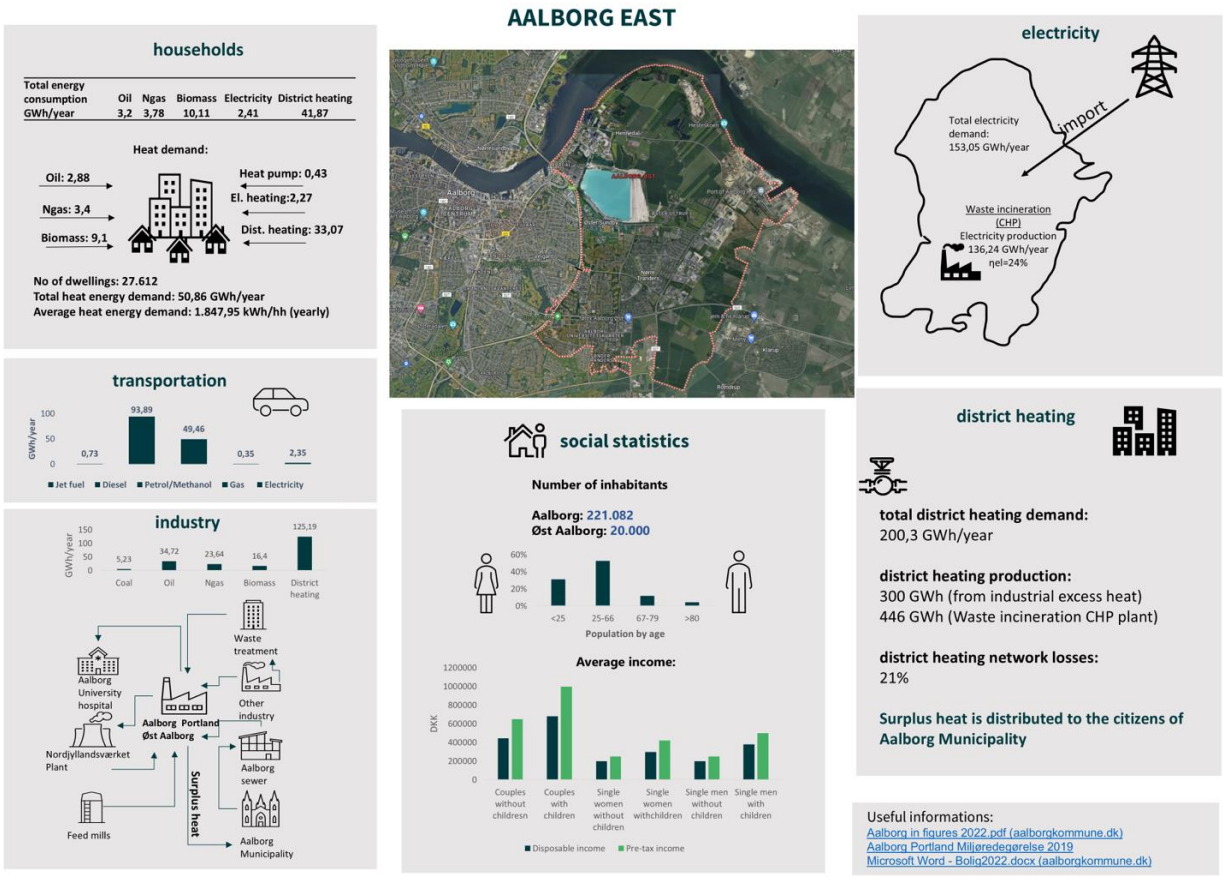

Figure 3. Area passport of Aalborg East demonstrating energy profile of the district

Most of the electricity used is, however, produced outside of the district at the power plant Nordjyllandsværket, located across the fjord. Today, Aalborg East uses significant amounts of fossil fuels, mostly in the transport and industrial sectors. In the district, the share of renewable energy in the total energy mix is only 28% (biomass and waste). The greatest challenge of developing Aalborg East into a PED will therefore be to increase the local electricity production and promote the transition towards 100% renewable energy.

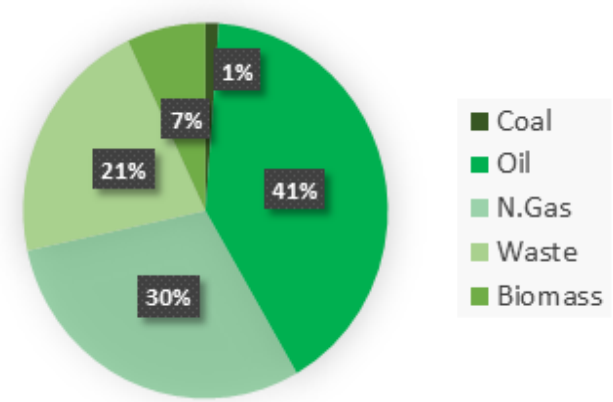

Figure 4. Annual fuel consumption of Aalborg East today.

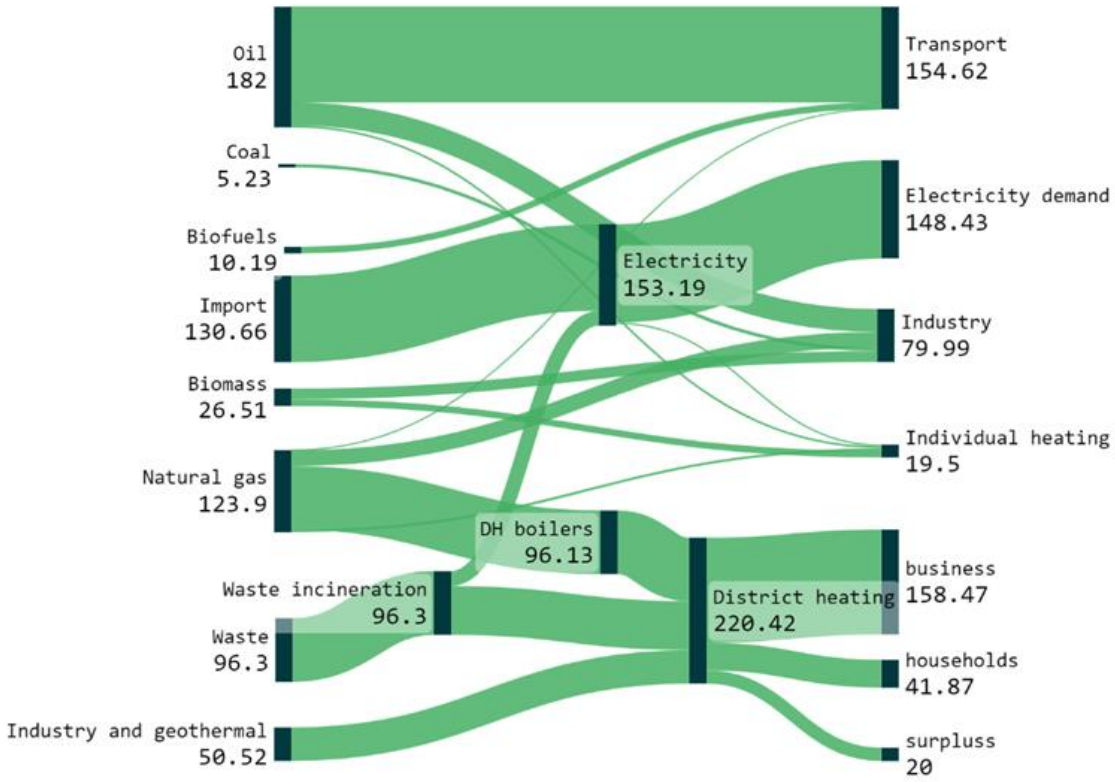

Figure 5. Sankey diagram of the energy system in Aalborg East. The diagram illustrates how energy is used and transformed in the district.

Read more about the energy scenario for Aalborg East.

Energy Scenario for Aalborg East 2045

The energy scenario for Aalborg East has been developed with the transition of the national energy system in mind, together with broader national and global sustainability and climate goals. Furthermore, it is important that the development of a future PED in Aalborg East is done in a way that balances cost-effectiveness with practical implementation. As such we propose a mix of energy efficiency measures and investments in new renewable energy infrastructures in the district.

We propose that Aalborg East in 2045 will rely on a combination of technologies like thermal storage, heat pumps, waste heat from industries, energy from waste incineration, local wind, and solar panels. In our vision of developing Aalborg East into a PED, we seek to exploit the locally available renewable energy sources and use new technologies to meet future energy needs.

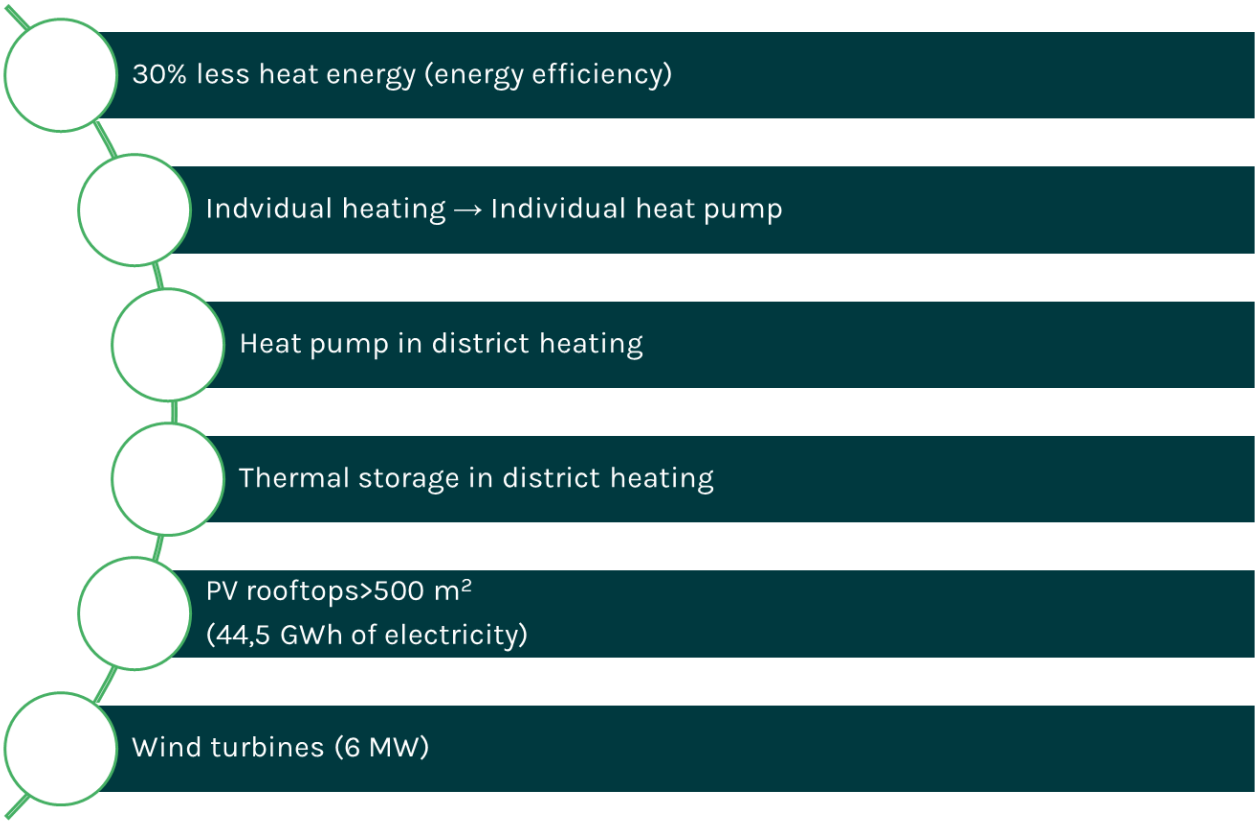

Figure 6. Outline of technological requirements for transforming Aalborg East into a PED in 2045

In 2045 Aalborg East will rely on 100% renewable energy. However, to meet its share of decarbonization at the national level, Aalborg East will only be able to produce around 20% of its electricity demands within the district boundaries. The energy required must be produced in other parts of the country, with more adequate weather and technical conditions. However, if we assume that each district in Denmark will strive to achieve national goals, and thus to achieve the PED concept, it can be expected that the necessary energy will be generated from renewable energy sources.

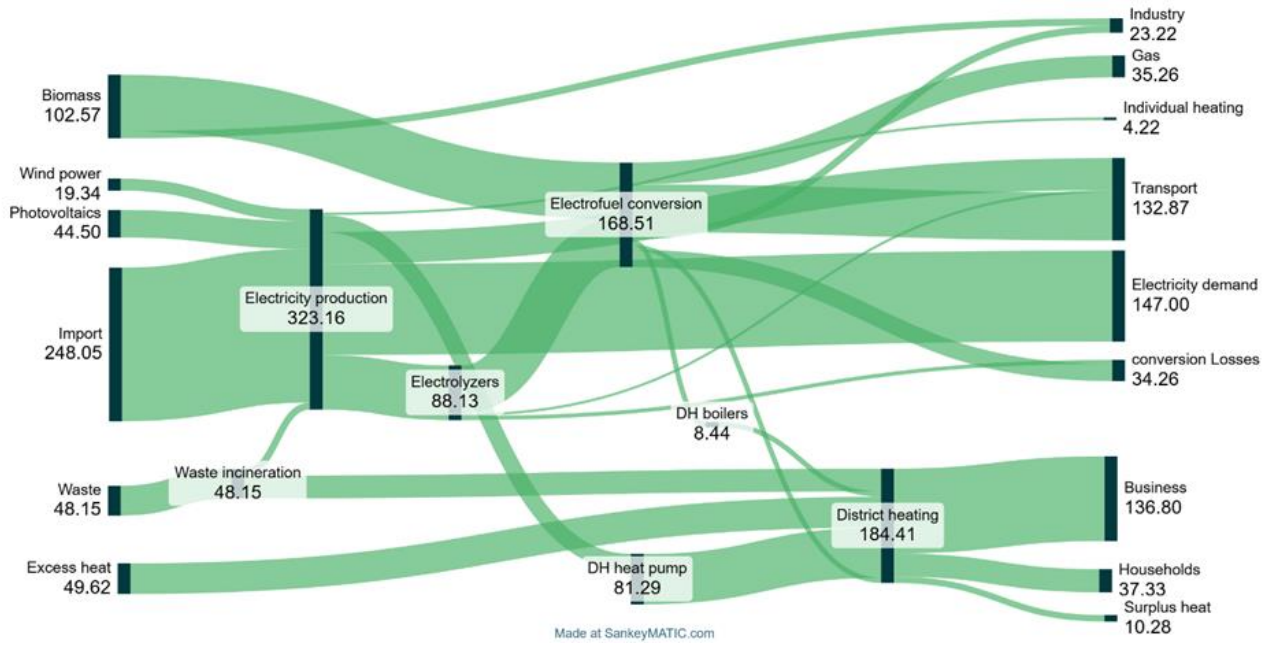

Figure 7. The energy balance of future energy system in Aalborg East in 2045.

Read more about the energy scenario for Aalborg East.

Sustainability perspectives

It is important to take wider sustainability perspectives into consideration when implementing PEDs, as there is a risk that optimising the energy balance at district level will result in sub-optimisation at a larger scale. A key question to explore in a PED implementation process is therefore how much of the district's energy demand should be covered by local (internal) production and external production. In other words, investments inside the PED should only be pursued, if the investments cannot be placed better somewhere else outside the PED. In addition, it is important that the PED is established in a way that the PED contributes to achieve wider policy goals of climate neutrality and transition towards 100% renewable energy sources at city and national levels.

In the energy scenario for Aalborg East 2045, we have adopted the principle that emphasis should first and foremost be on improving the energy efficiency and reducing the energy demand. Second, investments in local energy production should be 'sensible' and not land use consuming, which is why the scenario only includes solar panels on rooftops. In addition, we expect that local energy production from wind turbines amounting to 6 MW can take place within the district, whilst the remaining energy demand most be covered by renewable energy produced outside the district, such as offshore wind farms.

We believe that ensuring sustainable energy solutions for energy-intensive industries should be a national priority. In this context, **strictly adhering to the PED concept is not essential**, especially in areas like Aalborg East that include more than just residential homes. Rather, the production of e-fuels and hydrogen to meet future energy demands in industry and transportation should be done locally wherever it is practical and justified. Here, Aalborg East could be play an important role in the future. The energy transition should aim to solve existing challenges without creating new ones. Therefore, maximizing the use of available renewable energy resources should be a priority in every part of the country.

Read more about the sustainability perspectives in energy scenario for Aalborg East

Economic benefits of implementing a PED

Developing Aalborg East into a PED could play an important role in building up a National Test Centre for Renewable Energy and Sustainable Solutions in the district. Several larger businesses within the wind power industry are already located in Aalborg East today, and the brand of Aalborg East as a PED could potentially help attract new businesses within the wind power or related sectors to the district. Acquiring European recognition of a PED may increase the brand value of the district, leading Aalborg East to become a destination and a place to visit for public authorities and businesses seeking to establish a PED in their local contexts.

As demonstrated in our strategy, the investments of developing Aalborg East into a PED are minimum. All the investments outlined in the scenario for Aalborg East 2045 are expected to be necessary to support the transition towards carbon neutrality and a 100% renewable energy system, with or without PED ambitions. What our scenario for Aalborg East 2045 demonstrates is how Aalborg East can contribute to these overall policy goals by developing into a PED.

Figure 8: AI generated image of Aalborg East in 2045

Read more about the economic benefits of developing Aalborg East into a PED.

Important stakeholders for realising a PED

The development of a PED should be a local innovation process engaging a range of different stakeholders. Realising a PED in Aalborg East requires active involvement and support from public administrations, private actors, and the local community. In Aalborg East there are already strong community networks and an active business network, which can be mobilised to support the vision of establishing a PED. In addition, there are stakeholders such as the Port of Aalborg, Nordværk, and Himmerland Housing Association, who already have experience with projects seeking to promote a sustainable transition. These actors could therefore be mobilised to champion the PED vision.

A first step in the PED implementation strategy would be to build knowledge and awareness of the PED concept among key stakeholders in Aalborg East. Through interviews and workshops, we have explored the initial interests in establishing a PED among the main stakeholders in Aalborg East.

The hope is that this initial interest and increased awareness of the PED agenda could lead to the formation of a PED-network, that is a group of stakeholders actively pursuing the idea of developing Aalborg East into a PED. Rather than establishing a new network, we suggest that the PED-network is hosted within one of the existing networks in the districts, such as the 9220 Business Network.

Today, the business network already unites key stakeholders in Aalborg East, including the Port of Aalborg, Himmerland Housing Association, and other larger businesses in the district. As our vision for implementing a PED in Aalborg East mainly relies on investments from businesses (energy efficiency measures and installation of PVs) and residences (energy efficiency measures and installation of individual heat pumps), these stakeholders groups play an important role in realising a PED in the district.

Figure 9. Stakeholder analysis of PED implementation in Aalborg East

Read more about the stakeholder analysis for Aalborg East.

Barriers and Potentials for Realising PEDs

The PED concept is new in a Danish context. Currently, there are no official plans to develop PEDs in Denmark. This implementation strategy is therefore the first of its kind in Denmark.

Denmark's highly integrated district heating system with high shares of renewable energy represents a unique starting point for realising larger policy agendas of climate neutrality and transition towards 100% renewable energy by 2050. As district heating areas often will be larger than the typical size of PEDs, especially in the larger cities, it may not be as apparent what PEDs have to offer in comparison with other European countries. In addition, Denmark only has limited experiences with implementing Energy Communities – another related European policy concept, which seeks to promote local energy production at district level. One of the greatest barriers for implementation of PEDs in Denmark is therefore that the concept is unknown, and that there only are a few initiatives, which could help demonstrate what establishing a PED could mean in a Danish context.

In addition, there are some regulatory barriers which until now have prevented the extensive sharing of energy flows between buildings envisioned in the PED concept. If an entity (housing block, company, public entity) wants to sell excess electricity, e.g. from solar panels to its neighbours, a separate energy company must be established to manage the transaction to the grid. However, new legislation taking effect from mid 2025 is expected to facilitate an easier and less bureaucratic sharing of excess electricity among neighbours. This new legislation could potentially help pave the road for PED implementation in Denmark.

Read more about the barriers and potentials for implementing PEDs in Denmark and in Aalborg East here: Barriers and Potentials for PEDs

	Barriers	Potentials
Regulatory	No legal option to demand that new housing areas are connected to the district heating network. Barriers for establishing energy communities. Barriers for sharing locally produced renewable energy across households and buildings.	District heating as non-profit.
Structural	Neighbourhood scale not aligned with district heating or political-administrative boundaries. Focus on centralised production in district heating networks. Neighbourhood scale produces ambiguities about who should lead the development of PEDs. National energy policy favours big scale solutions	Adopting sustainable urban planning principles can reduce energy demand. Experiences with planning at neighbourhood scale in Aalborg East.
Technical	Risk of sub-optimisation.	Possibilities for local energy production, flexibility, and security. Possibilities for increasing local renewable energy production.

Figure 10: Overview of the main barriers and potentials for implementing a PED in Aalborg East

Towards Aalborg East as a PED

Developing Aalborg East into a PED is a long-term process. The measures and investments for realising the vision should therefore be implemented gradually. The first step in the PED implementation strategy is to improve the energy efficiency in the district. In the first few years, we can look forward to a reduction in household energy consumption, setting the stage for a brighter, more sustainable future. Though it may take time to realize this change fully, such a measure not only reduces consumption but also enables the achievement of thermal comfort and improvement of the quality of life of the PED residents.

In parallel with improving energy efficiency, installation of solar panels can be started. In the first years this will happening mainly in public institutions, serving as a good example to be followed by other actors. Also in the first years, once planning is in place and the necessary bureaucratic procedures have been completed, the installation of wind turbines can proceed.

In 2035 when the energy production from solar panels exceeds households' energy demands, a heat pump and thermal storage will be installed in the district heating system to increase the flexibility of the energy system.

By 2045, a significant drop in energy usage is expected. All buildings with large rooftops, over 500 square meters, will be equipped with solar panels. Additionally, Aalborg East will take advantage of its ability to set up wind turbines. In 2045 Aalborg East stands out as a pioneering PED, playing a crucial role in Denmark's mission to significantly reduce carbon emissions. With its innovative design and sustainable practices, this vibrant community is a shining example of how to create a greener world for generations to come.

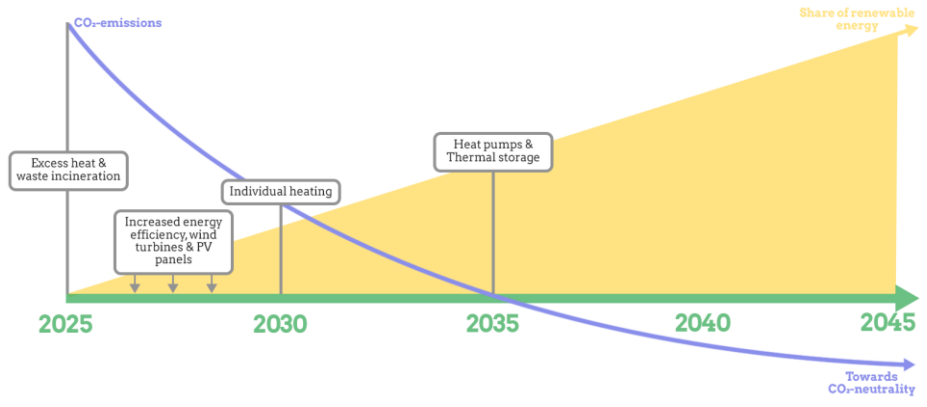

Figure 11: Timeline for developing Aalborg East into a PED

About the implementation strategy

This implementation strategy has been prepared as part of the FLEXPOSTS research project, financed by Innovation Fund Denmark under the JPI Urban Europe programme 2022-2025. In the project an interdisciplinary group of researchers from Department of Sustainable and Planning at Aalborg University has collaborated with Green Hub Denmark on developing an energy scenario and implementation strategy for realising a PED in Aalborg East by 2045.

More information about the project can be found here: https://greenhubdenmark.dk/en/flexposts/