Master Thesis

The possibilities, benefits, and disadvantages of a collective energy management system of cultural squares as an example of climate-neutral urban areas in line with the Clean Energy for all Europeans package

Final Version

20 August 2020

Tolga Kamacı

Supervisors: Dr. F.H.J.M. Coenen, Dr. M.J. Arentsen

MSc. ENVIRONMENTAL AND ENERGY MANAGEMENT

UNIVERSITY OF TWENTE

ACADEMIC YEAR 2019/2020

ABSTRACT

This research aimed to explore the concept of combining the energy management systems of the public and private utility buildings in climate-neutral urban areas, particularly so-called cultural squares. Even though energy management plays an important role in the energy transition in urban areas, management practices are generally limited to individual buildings. To search for a solution to this problem, relevant analytical approaches from the literature were studied to build a framework to assess the technical, management, and governmental aspects of collaborative energy management actions. The primary data of this research were derived from in-depth expert interviews, and the secondary data from the content analysis of the literature and the documents were used to support the primary data. Qualitative and quantitative methods within an exploratory single case strategy were applied to see the potential technical, management, and government benefits based on the analytical framework. Moreover, similar cases were used to understand the benefits which have not yet matured in the main case.

Keywords: collective energy management, climate-neutral areas, energy districts, renewable energy communities.

Table of Contents

List of Tables

List of Figures

List of Acronyms

7SE: 7 Square Endeavour

CEC: Citizen Energy Communities

CO_2: Carbon Dioxide

CSC: Collective Self-Consumption

EnMS: Energy Management System

EV: Electric Vehicles

EU: European Union

GHG: Greenhouse gas

MS: Member States

REC: Renewable Energy Communities

Acknowledgement

During this master's program, I gained extensive knowledge and experience and, on this journey, I received significant support and guidance from many individuals and institutions.

I would like to thank my supervisors, Dr. F.H.J.M. Coenen and Dr. Maarten Arentsen for their valuable guidance and supports throughout the time I spent at the University of Twente.

I am grateful to the Jean Monnet Scholarship Programme for supporting my education in the Netherlands. Also, I am thankful to the Ministry of Culture and Tourism for helping make this dream come true.

I appreciate the assistance of Jeroen de Leeuw and valuable colleagues of Arcadis for providing me an opportunity to explore the Rotterdam Cultural Square as a case study, which was very interesting and best suited to my knowledge and skills.

Finally, I would like to thank my wife and my family for supporting me during the whole year with their constant patience and motivation.

CHAPTER 1. INTRODUCTION

1.1. Background

Climate change is accepted as a global problem that requires an urgent action to mitigate its adverse effects. At the international scale, regulatory regimes for this ambition are mainly shaped by the Kyoto Protocol, the Paris Agreement, the UN's Sustainable Development Goals policy frameworks. In addition to these policy developments and regulations at an international level, the European Union (EU) adopted an integrated package of energy and climate policy with net-zero GHGE target by 2050 to keep global temperature rise below 2°C, and even further to 1.5°C.

At the national level, governments have their own regulatory, financial, educational, and voluntary instruments which are key to create policies for the local territorial level, including in cities. As the cities consume over two-thirds of the world's energy and cause more than 70% of global CO2 emissions (C40 Cities, 2020), which are mostly resulted from the combustion of fossil fuels as the main source of energy, such international policies often have an urban dimension, and cities have a major role in their implementation (European Commission, 2020b). Besides, urban communities themselves are also vulnerable to climate change and abrupt weather occurrences, therefore, to improve resilience against the negative environmental impacts, socially-oriented policies is essential (UNECE, 2011). However, as the areas are urbanized more, the variety of the stakeholders and the complexity of the cities increases.

To cope with these issues, one of the important actions that have to be taken is implementing energy management systems (EnMSs). In an EnMS, the performance of the energy system is monitored, controlled, and optimized within the borders drawn by the end-user. The focus is on monitoring and optimizing appliances and facilities, such as heating, ventilation, and lighting installations, which are relatively high in energy consumption in a building or facility. The EnMSs also provide opportunities for measuring energy consumption. Then, obtained data can be used to perform analysis and optimization procedures and to forecast future consumptions (Smart Energy Collective, 2013).

Although energy management plays an important role in minimizing the undesirable effects of global warming and energy transition, which could be defined as the transformation of an energy mix largely based on fossil fuel to clean and renewable sources (Sciullo et al., 2020), the scope of management practices are generally limited for the individually owned buildings, and the opportunities of collective energy management of the public and private utility buildings in urban areas have not experienced enough and realized yet. However, the concept of combining the energy management systems of different actors will lead to multi-win situations and will help to transform the area into a climate-neutral region.

1.2. Research Objective, Research Question, and Sub-questions

The objective of this research is to explore the possibilities, benefits, and disadvantages of collective energy management systems in climate-neutral urban areas, particularly so-called cultural squares.

To reach this objective, first of all, an analytical framework was built based on four perspectives of organising a collective energy management system. After investigating the four streams - The EU's Clean Energy for all Europeans Package, Climate-Neutral Areas, Energy Districts, ISO 50001 Energy Management System approach - in the literature, it was seen that too much emphasis is placed on benefits of collective action in energy management and therefore, it was decided to focus on only the benefits to see whether the selected main case contains those benefits which were found in the literature.

After that, Rotterdam Schouwburgplein was used as the main case, to assess whether it includes the potential technical, management, and government benefits which were found in the literature. In addition to the main case, similar cases were explored for some of the benefits not found in the main case.

Based on this objective, the **main research question** has been formulated as follows:

What are the technical, management, and government aspects of collective energy management systems in climate-neutral urban areas, particularly so-called cultural squares?

The **sub-research questions** that are used to answer the main question were:

1. What are climate-neutral urban public and private utility building areas, particularly cultural squares?

2. Which possibilities, benefits, and disadvantages from literature are relevant for a framework to assess collective energy management systems for climate-neutral urban areas, and what should this analytical framework contain?

3. What are the technical benefits of collective energy management systems in climate-neutral urban areas based on the framework, particularly cultural square cases?

4. What are the management benefits of collective energy management systems in climate-neutral urban areas based on the framework, particularly cultural square cases?

5. What are the governance benefits of collective energy management systems in climate-neutral urban areas based on the framework, particularly in cultural square cases?

1.3. Research Methodology

The research methodology of this study is based on an analytical framework that was structured from the literature. Firstly, the ideas in four areas - how the EU proposes prosumers and consumers jointly acting together, spatial planning and governing tools of climate-neutral areas and energy districts, and how to integrate different elements of energy in a system - were investigated from scientific papers, the EU's policy documents, reports, and media reviews to learn the possibilities, benefits, and disadvantages of collective energy management systems. After that, based on the approaches and the suggestions on the literature, an analytical framework was built to assess only the benefits of collective energy management of a cultural square in an urban environment that has a climate-neutral target.

Then, Rotterdam Schouwburgplein was selected as a case study to explore whether it includes the benefits of collective action found in the analytical framework. The primary data about the main case study were collected through expert interviews and they were assessed by using the technical, management, and governmental benefits criteria in the analytical framework to see which of them were included in the case. Besides, as the collective action in Rotterdam Schouwburgplein is still in the development phase, the management and governance structures are not matured as the technical part. Therefore, similar cases were used to fill the gaps in the technical, management, and governance benefits.

Finally, based on the knowledge gained from the case assessments according to the analytical framework, recommendations for the energy communities on collective energy management were provided.

Validation of data analysis was done by the triangulation technique. To ensure the validity of the results, a combination of individual interviews, observation, and content analysis of textual material was carried out and several sources were used. Besides, the research was presented to the 7 Square Endeavour (7SE) consortium to validate the results.

1.4. Climate-Neural Cultural Squares

This sub-section will answer the first sub-question by describing the climate-neutral urban areas where public and private utility buildings are located, particularly the cultural squares. First, climate-neutrality will be explained. Then, the specifications of the cultural squares will be introduced. After that, the necessities that should be done by public and private actors located in an urban cultural square will be given.

Climate neutrality is about reaching a balance between the emissions generated and the Earth's natural capacity to absorb them, in other words, reducing emissions to zero is not essentially needed. This should be achieved by reducing the current global emissions as much as possible and using carbon offsets to neutralize the remaining (United Nations, 2020). It represents a multi-win situation that promotes economic competitiveness, improves energy security, and quality of life.

Even though there are some similarities with carbon neutrality, climate neutrality doesn’t concern only carbon dioxide (CO2). CO2 makes up almost 80 percent of the GHG emitted by human activities, but it is not the only one. Besides the CO2, five other gases, which the Kyoto Protocol also limits their emissions, are in the coverage of the climate-neutral actions: methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulphur hexafluoride (SF6) (United Nations, 2020). Therefore, the impact of these other gases is expressed by an equivalent amount of CO2 and taken into account in the calculation of emissions.

On the other hand, cultural squares in urban areas can be defined as large-scale cultural districts that contain various public and private buildings with characteristics such as culture and entertainment, education, restaurants, sports, etc. They attract a high number of people every day therefore it is very convenient to influence the behaviours of visitors and show the positive results of a target. It is important to get the commitment of all the stakeholders in the area to increase the benefits of this influence. Consequently, highly visible cultural squares bring significant benefits to these collective actions to achieve their ambitious goals.

In conclusion, climate-neutral cultural squares, which include public and private utility buildings in urban areas, are the areas that reduce their emission as much as possible and offset the remaining.

These highly visible spots are very suitable to influence the behaviours of visitors and increase the pace to reach climate neutrality.

1.5. Outline

The content is structured as follows: in chapter two, the second sub-question was answered through investigating relevant aspects from literature and introducing an analytical framework to analyse collective energy management systems for climate-neutral urban areas. Chapter three introduced the main case, Rotterdam Schouwburgplein. Third, fourth, and fifth sub-questions were answered in chapters four, five, and six by assessing the technical, management, and governance benefits of collective energy management action in Rotterdam Schouwburgplein and similar cases based on the analytical framework. Finally, in the concluding chapter, the main research question was answered according to the findings in the previous chapters, and recommendations were given.

CHAPTER 2. ANALYTICAL FRAMEWORK

In this chapter, an analytical framework was developed to understand the potential benefits of collective energy management systems for public and private utility buildings in climate-neutral cultural squares of urban areas based on the analogy with:

- The benefits of the EU's approach rules in the Clean Energy for all Europeans package to organize different actors jointly acting together;

- The benefits of spatial planning and governing tools' perspective to realize the government's current ambitions to achieve climate-neutral goals collaboratively with citizens;

- The benefits of governmental tools that are used for coordinating and steering energy districts;

- The benefits of integrating energy in the system of multi-building institutions through the ISO 50001 Energy Management System approach.

2.1. The EU's Clean Energy for all Europeans Package

2.1.1 Introduction

The European Union (EU) sets ambition targets with Clean Energy for all Europeans Package (Clean Energy Package), which is the energy policy framework updated in 2019. Some of these objectives are: achieving at least 32.5% of energy efficiency in energy use, generating at least 32% of the electricity from renewable energy resources, decreasing CO_2 emissions at least 40%, and improving energy performance in the building sector by 2030 (European Commission, 2020a), to meet with Paris Agreement commitments for reducing greenhouse gas (GHG) emissions, to implement the Energy Union strategy, and to contribute the EU's long-term carbon-neutral strategy by 2050. With this new energy rulebook, a significant step was taken towards the implementation of the 'Energy Union' strategy, which aims at building an energy union that gives EU consumers secure, sustainable, competitive, and affordable energy (European Commission, 2017).

Clean Energy Package contains eight main legislative acts: Energy Performance of Buildings Directive, Renewable Energy Directive, Energy Efficiency Directive, Governance of the Energy Union and Climate Action Regulation, Electricity Regulation, Electricity Directive, Regulation on Risk-Preparedness in the Electricity Sector and Regulation on the European Union Agency for the Cooperation of Energy Regulators. Member States (MS) have to transpose these directives into their national law until 30 June 2021.

To organize different actors jointly acting together in the energy transition, new approach rules in the Clean Energy Package include private actors to the current public sector-based system. With these changes, the energy consumers and prosumers are located at the centre of the energy transition with more power that enables them to actively participate in the market (Büscher et al., 2020). This will facilitate private actors for acting jointly together with the public actors in the clean energy transition and will make it easier for them to get into the energy market by producing their energy, storing, or selling it onto the grid.

Nevertheless, the legislative processes on energy communities are in its very early stage. In contrast, the individual PV self-consumption is allowed in all EU MS with a variety of financial support. Some of MS such as Switzerland, France, and, Austria have already started the legislative changes on collective self-consumption (CSC) and energy communities whereas, others, for instance, Netherlands, Denmark, and Sweden have only legislative related to the private grids of CSC (Frieden, et al., 2019).

2.1.2 Definitions

It is important to explain the distinctions and similarities between three collective actions in the Clean Energy Package: collective self-consumption (CSC), renewable energy communities (REC), and citizen energy communities (CEC). They are described in legislations as new types of non-commercial entities that aim primarily to provide environmental, economic, or social community benefits rather than prioritise profit-making (REScoop.eu, 2020).

First, CSC is addressed in the Renewable Energy Directive in two forms:

Renewables self-consumer - “a final customer […] who generates renewable electricity for its consumption, and who may store or sell self-generated renewable electricity, provided that, for a non-household renewables self-consumer, those activities do not constitute its primary commercial or professional activity”,

Jointly acting renewables self-consumers: a group of at least two cooperating “renewables self-consumers […] who are located in the same building or multi-apartment block”.

Next, the two energy communities defined in the Clean Energy Package: CSC in the Electricity Market Directive, and REC in the Renewable Energy Directive. The main **common** properties of them are: they have a legal entity as a community, they are voluntary and open, their primary focus is on providing environmental, economic or social community benefits for their members or the local areas where it operates rather than financial profits, they are governed by specific participants, and they have collective actions. On the other hand, they have **differentiated** with these characteristics: **CECs** don’t have a geographic limitation, medium and large enterprises cannot have the effective control, specific to only electricity, whereas, **RECs**: must be controlled by local members/shareholders, large-sized enterprises are not eligible to participate, should be capable of remaining autonomous, and are only open to renewable energy sources which also includes heat, etc.. Moreover**,** the sale of renewable energy between market participants, which is defined as ‘Peer-to-peer trading’ is defined by the Renewable Energy Directive (Frieden, et al., 2019).

In addition, the legal format of an energy community can be defined in different types of forms on a national level, for instance: Energy cooperatives, Limited partnerships, Community trusts and foundations, Housing associations, Non-profit customer-owned enterprises, Public-private partnerships, and Public utility companies (Caramizaru et al., 2020).

2.1.3. Benefits

The collective actions, which are being supported in the Clean Energy Package, bring several technical, management, and governance benefits to both the public and private sectors.

First, regarding technical benefits, the Clean Energy Package supports decentralised **renewable energy generation** through joint actions between the actors, **network, and energy conversion losses** reduce, which brings **energy independence**, **high-quality service,** and increased energy flexibility. Also, improving **energy efficiency and energy savings** is another area that is focussed on the Package, which has a supportive effect on the transition to clean energy.

In terms of management benefits, one of the important outcomes from the Clean Energy Package is the **legal entity** it brings to the collaborative energy actions, under a variety of different titles. As a result, the energy consumers and prosumers are empowered to become an actor in the **energy market**, and allow them to act jointly together with the public actors in the energy transition by generating, storing, or selling their energy onto the grid. This legal status will also **increase the working efficiency** of the energy communities by reducing procedures and enable them to fully reap the benefits of this collaborative action.

For instance, as a result of the legalization of energy community and implementation of legal requirements by the national governments that allow the energy communities to participate in the energy market actively, it will become possible to **peer-to-peer energy trading** within the community, and surplus energy export to the grid. As a result, while the **energy costs and network investments are decreasing,** it also allows them to gain **financial benefits.**

Besides, fewer network investments are needed as a result of on-site energy generation. As a result of energy savings, using energy efficiently, generating renewable energy on-site, and exchanging energy within the community, the energy demand decreases, so that the distributor doesn't have to invest in the network to increase its supply capacity.

Finally, governance benefits include reduced carbon emissions, high environmental awareness, citizen empowerment, and increased local job opportunities. As a result, national and regional authorities could reach national and international environmental targets. Next, as the MS has to transpose the Clean Energy Package into their national law, the **environmental awareness** of citizens will increase, which results in a growing number of voluntary formed collaborative energy unions between the private and public actors. Ultimately, the liveability will expand as a result of reduced carbon emissions.

However, they may also put other customers at a financial **disadvantage**. For instance, as a result of reduced power flows from the main grid, the expected grid revenues of the distribution companies will also decrease and transform into an extra cost for customers in other locations in the system (Caramizaru et al., 2020). On the other hand, even the consumers are self-sufficient, it is not likely that they will disconnect completely from the grid, instead, they will continue to use it as a back-up source. That may create in the future a new way of network tariffs which reflects how the grid is used (The European Consumer Organisation, 2019).

2.1.4. Conclusion

For the transition to cleaner and more sustainable energy, the active involvement of citizens have several benefits. Therefore, the energy communities are one of the focussed areas in the EU's Clean Energy Package. Even though it does not specifically focus on public and private actors that acting together to operate large utilities with different technical and management problems, as discussed in this research, there are many resemblances.

Energy communities that the Clean Energy Package introduces are voluntary organisations where no one could be forced to join or stay. Moreover, the effective control of the community couldn't be under a significant shareholder which helps to protect them as non-commercial entities that aim primarily to provide community benefits rather than prioritise profit-making.

There are several benefits of such collective action on energy transition. First, the technical benefits are: renewable energy generation, energy savings, improved energy efficiency, reduced network & energy conversion losses, energy independence, and increased energy flexibility services. Second, the management benefits are: easy to get into the energy market, decreased network investments, energy cost reduction & financial profits, peer-to-peer energy trading within the community. Thirdly, the governance benefits are: the achievement of the national and international energy and environmental targets, raising users' environment awareness, increased local job opportunities, increased liveability, improved quality of life, and improved energy security.

2.2. Climate-Neutral Areas

2.2.1 Introduction

The cities are the main sources of GHGs because of the modification of the land surface by urban development and waste heat from energy use. Especially the buildings sector in cities, which includes residential, public, and commercial sectors, forms an important part. The main energy sources in the building sector, which causes both direct (on-site combustion of fossil fuel) and indirect (demand for electricity and district heat) emissions, are electricity, district heat, and natural gas. Improving the **efficient use of these energy sources and reducing demand through the insulation of the buildings** play important roles in mitigating **the adverse effect of GHGs.** However, despite this great potential, investment in energy-efficient buildings is not yet optimal due to a **large number of individual buildings with fragmented ownership structure,** lack of sufficient investment capacities, information, uncertainty, and risk (UNECE, 2011). For that reason, a collective institutional system is needed to manage investments, information, incentives, and initiatives while moving towards the energy-efficient buildings.

Moreover, there are several other reasons to reduce the cities' climate footprints. Firstly, most of the urban areas are increasingly exposed to **extreme weather conditions** which may have negative effects on human health, physical capital, and natural habitats (IPCC, 2018). Also, due to the depletion of critical fossil fuels, which plays an important role in the modern economy, it is necessary to move from fossil fuels to fossil-free alternatives to achieve **energy security**. Besides, **air pollution** linked to the **burning of fossil fuels** that comes from vehicles, power stations, and factories often causes health problems and damages the natural world, through acid rain and smog. Next, taking **energy consumption reduction** actions also brings **economic benefits**, such as: **saving energy costs,** increase the adaptations to energy price fluctuations, **create employment, boost the building sector as a result of the increase in insulating buildings, brings innovations in adapting to changing market conditions** (United Nations, 2020).

Therefore, an **urban strategy** for climate neutrality is essential to mitigate climate change and improve the adaptation capacities of the cities. Such a strategy begins with getting a firm **commitment** from the highest level of a country, city, or community. Then, the current situation is **analysed** by calculating emissions and analysing their sources. According to the results, priorities and **targets** are set, and the outline is developed in an **action plan** that includes reducing GHG emissions as much as possible, using trade-off methods to offset the remaining emissions such as investing in environmental projects around the world in order to balance out the rest of the carbon footprints. and becoming resilient to the adverse effects of climate change (UNECE, 2011). Next, while the plan is being **implemented**, the process is **monitored** regularly. After the implementation of the actions completed, the **cycle** starts all over again to continuously search for ways to improve the strategy (United Nations, 2020).

2.2.2. Governmental Tools

National and regional governments use several instruments to achieve their climate-neutral targets, such as regulation (legislation, performance standards), financial and fiscal incentives (subsidies, taxes), capacity-building (technical assistance), and n**ational spatial planning and building regimes** (UNECE, 2011)**. While implementing these measures, k**eeping a **balance** between public and private sector interests, managing the **cooperation** between authorities at different levels, broader **participation of stakeholders** in decision-making processes, and reserving sustainable **funding** sources for climate and energy projects **increase the effectiveness** of **urban governance** (UNECE, 2011).

Especially at the city level, **regional governments** play a crucial role in influencing the energy transition and adaptation of measures because of their proximity to the residents. For that reason, city administrations should move towards climate-neutrality in their activities such as taking energy efficiency measures while renovating public buildings. In this way, they can influence their citizens' and other actors' behaviour through **awareness-raising** (United Nations, 2020). Some cities even have more ambitious climate neutrality targets than at the national level. One of them is Rotterdam in the Netherlands. The Rotterdam Municipality is planning to reduce CO2 emissions by 49% by 2030 compared to 1990 levels and become 100% climate-neutral in 2050 (Rotterdam Municipality, 2019).

The spatial planning of neighbourhoods and communities is one of the contributing factors for urban adaptation and mitigation measures. This **planning practice** focuses several important concerns for **reducing cities' energy and carbon intensities** such as: limiting the uncontrolled expansion of urban areas and car-dependency, providing an integrated system of green spaces, creating integrated energy infrastructure for renewable sources of energy, district heat-cooling-electricity systems, waste-to-energy systems, preserving better standards for energy efficiency in the built environment, and supporting eco-towns or sustainable settlements (UNECE, 2011).

Therefore, urban plans should consider measures aimed at reducing energy demand, and carbon footprints. For instance, legal requirements should be made for granting **building permits** for residential projects that are only spatially optimized to reduce energy demands and contain re-used, recycled, and low-GHG emission construction materials to reduce urban heat island effects. Also, planning permits of the projects with certain levels of energy efficiency could be given faster and higher ratios of incentives could be benefitted. First, demand-driven district heating systems should be developed then, in the longer term, district heating and cooling systems should be integrated. Also, standards for energy efficiency of distribution pipelines should be established (UNECE, 2010).

The taxation system is another powerful governmental tool by changing the energy consumption behaviour of people. Introducing **carbon taxes** on the use of fossil fuels, imposing taxes on the production of energy, and on products that cause environmental damage, This revenue can be used to create incentives and to compensate individuals or companies who invest in climate-friendly alternatives.

Carbon offsets are also an alternative way to neutralize the amount of GHG by funding projects which should cause an equal reduction of emissions somewhere. These kinds of projects raise consumers' awareness, promote sustainable renewable energy projects, and can offer benefits to local communities (United Nations, 2020).

Feed-in tariffs are one of the indirect supporting instruments that increase the development of distributed renewable energy generation. In this tool, the electricity generated from independent renewable producers is bought by network providers at government-controlled rates which are differentiated by the type of energy. As a result, by encouraging the development of renewable sources, it has a positive effect on climate neutrality.

Climate risk assessment is one of the organisational measures that cities can undertake for **improving urban resilience** by investigating the exposure of the city to climate, energy, and environmental risks such as vulnerable locations exposed to heatwaves, energy-inefficient buildings, or key social facilities by using **Geographic Information Systems** (GIS). According to the results of this assessment, an action plan for climate neutrality can be structured (UNECE, 2011).

2.2.3. Benefits

Achieving climate-neutral urban areas bring several technical, management, and governance benefits to both the public and private sectors.

Regarding the technical benefits, governmental tools, such as building permits, **energy efficiency improvement,** and **energy demand reduction are** accepted as important necessities to increase adaptation to climate change and mitigate its adverse effects. Also, with the help of spatial planning tools: district heating and cooling electricity, waste-to-energy, renewable energy generation systems, and energy independence are encouraged.

In terms of management benefits, climate neutrality ensures economic competitiveness through energy cost savings, increasing the adaptations to energy price fluctuations, and changing market conditions.

From the governance benefits perspective, as a result of regional authorities' actions towards climate-neutrality, it is possible to influence their citizens' and other actors' energy consumption behaviour through **awareness-raising.** Besides, changes in the consumption behaviour of the citizens through spatial planning tools, the energy, and carbon intensities in cities reduce, the quality of life and resilience to extreme climate conditions improves in that urban areas. Moreover, the measures that are taken to achieve climate neutrality, will also create employment and boost the building sector encourages moving from fossil fuels to fossil-free alternatives and achieve **energy security.**

2.2.5. Conclusion

Achieving climate-neutral urban areas is mostly an approach adopted by the public sector and spatial planning and other governing tools are mainly used to realize this target. Nevertheless, these tools bring successful results only with an approach that involves citizens. Therefore, there are important analogies to learn from the literature to understand the voluntary cooperation between the private and public actors to steer the transformation into the climate-neutral areas.

Governmental bodies have several important **reasons** to transform their ruling territory into climate-neutral areas. Extreme weather conditions, **air pollution, energy source depletion, energy price fluctuations** are some of them which have negative effects on the environment, economy, and citizens.

Therefore, raising awareness of citizens and implementing urban strategies by using **governmental tools** for climate neutrality is an essential way to mitigate climate change and improve the adaptation capacities of the urban areas. S**ome of the measures which are implemented in that sense are: spatial planning** of neighbourhoods and communities, **building permits,** subsidies, **carbon taxes, and feed-in tariffs. While implementing these measures, it is also important for governmental bodies to keep a balance between the** interests of the public and private sector, manage the cooperation between these actors, and reserving sustainable **funding** sources for the **realization of the** climate-neutral urban areas.

In the end, it is possible to gain several benefits from a climate neutrality target through collective action. Firstly, the technical benefits are: **energy efficiency improvement**, **energy demand reduction,** renewable energy generation systems, and energy independence. Then, the management benefits are economic competitiveness, energy cost savings, adaptations to energy price fluctuations, and changing market conditions. Lastly, the governance benefits are: raising users' environment awareness, influencing the energy consumption behaviour of people, increased local job opportunities, improved quality of life, energy security, and urban resilience to extreme climate conditions, and reduced energy and carbon intensities in cities.

2.3. Energy Districts

2.3.1. Introduction

The EU's Energy Performance of Buildings Directive requires all new buildings to have a high energy performance and are supplied from renewable energy sources (European Parliament and the Council, 2010). This new norm for buildings, called **nearly zero-energy buildings (NZEBs),** could be one of the starting points to sustainable urbanization.

The next step is shifting from individual buildings to the neighbourhood level by forming **energy districts**. While feasibility increases in the district scale, the implementation of the sustainability measures becomes accessible. For instance, some actions can be challenging to implement by **individual buildings** that have high load densities and less roof space. With a **collective approach**, these are balanced with low density and large roof space buildings, and as a result, the district can reach its environmental objectives.

These urban neighbourhoods generally **aim** to generate energy on-site, optimizing energy use, reducing GHG emissions, increasing renewable energy production and resilience to extreme climate conditions, ensuring economic competitiveness and energy independence, and integrating into an urban energy system. The **newly constructed** districts can more easily implement these goals compared to the districts with **existing** buildings and infrastructure. Nevertheless, existing districts can also be retrofitted in the long term by proactive involvement of the stakeholders (Polly et al., 2016).

Even a more ambitious goal is: while reducing CO2 emissions to zero, additionally achieving a local energy surplus. Although there are opposing views that focus should be placed on replication and an upscaling of the energy transition instead of focusing on surplus energy production in the district (Urban Europe, 2020), the European Commission funding programmes within Horizon 2020 are also supporting these kinds of **positive energy districts/neighbourhoods** (PED) concepts.

PEDs are defined as energy-efficient and energy-flexible urban areas with a local surplus production of renewable energy. They require the integration of different infrastructures and stakeholders while improving the social, economic, and environmental sustainability of the urban environment (Urban Europe, 2020). Locally generated **renewable energy** in PEDs will enable a reduction of GHG and ensure economic sustainability. Nevertheless, the local production of renewable energy is highly dependent on **local conditions**. As the space needed for the generation of renewable energy will always be limited in an urban environment, **energy efficiency** should be one of the priorities. Balancing out the needs of both new urban development areas and the existing buildings, the use of energy and mobility by adopting a life cycle approach is essential to reach climate neutrality (Urban Europe, 2020).

Furthermore, **governmental bodies** are operating integrated programmes which address the energy district challenges, for instance, the “Viable Cities” programme in Sweden, "EnergiewendeBauen" research funding initiative in Germany, and the “Natural gas-free neighbourhoods” in the Netherlands. Most of the cities are setting up local **initiatives** that are related to the energy district concept to promote their realisation. (Urban Europe, 2020).

On the other hand, there could also be legal **barriers** for the implementation of energy district projects, such as the difficulties regarding the direct exchange of renewable electricity between households or the legal classification of battery storage systems (JPI Urban Europe, 2020). Besides, in energy districts some other **difficulties** that could come across are; resistance to setting energy goals, measuring the benefits, engaging facilities, arranging the finance and governance structures, and the requirement for the advanced analysis tools (Pless et al., 2018).

Also, due to different planning cultures, ownership structures, and legal frameworks, the **characteristics of the cities** such as density, type of buildings or access to renewable and waste energy, requires different approaches and strategies for the implementation and replication of the energy district concept. For instance, during the design of the energy efficiency measures, various **technologies**, and solutions could be used. Similarly, the production of **renewable** energy is highly dependent on local conditions, and the economic possibility. Moreover, the **involvement** of citizens, city administrations, the real estate industry, energy suppliers, and research institutes have differences between the counties depending on their national legal context (Urban Europe, 2020).

Therefore, to avoid these difficulties during the transformation of urban areas into climate-neutral city districts, the districts should be built up from a **holistic perspective** which involves an environmental, governmental, technical, and social point of view. Besides, **cooperation** between citizens, city administrations, the real estate industry, energy suppliers, and research institutes is essential. Also, raising users' awareness and changing their **energy consumption behaviour** is another important element (JPI Urban Europe, 2020). Moreover, **financing** is one of the important enablers for the development of energy districts. Therefore, the financing requirements of all key stakeholders have to be defined in advance. Also, the **involvement** of the network operators and energy suppliers will have several financial benefits besides their technical contribution to the implementation of energy districts.

2.3.2. Collective Actions in Urban Areas

The amount of fossil-based energies that are consumed in cities can be reduced by decreasing energy demands via saving and efficiency measures, but some energy demand will always be present. Therefore, it is necessary to use renewable sources of energy such as solar, wind, geothermal, etc. for the **remaining energy supply** to decrease the share of fossil fuels and their carbon emissions in **urban energy infrastructure**.

Capital-intensive large-scale renewable installations that require state-regulated activities is one of the options for supplying this remaining energy need. Another option is to shift from a large scale to vertically integrated **decentralized** neighbourhood-scale renewable and low carbon energy generation (**on-site generation**). By promoting local green energy infrastructure, it is also possible to reduce the **energy losses** which occur both during their distribution and the conversion from primary fuels into consumable energies (UNECE, 2011).

District heating and cooling (DHC) systems with co-generation and tri-generation are one of the ways to implement decentralized power generation. As an example of co-generation, **Combined Heat and Power (CHP) plants** integrate the production of power and thermal heat by **utilizing waste heat** from electricity generation and allowing the reuse of this heat for space heating and hot water supply. In addition to heating, cooling is also possible with CHP plants which is also known as **tri-generation**.

DHC networks, a combination of several CHP plants, are a way to increase the benefits of individual CHP plants on a regional scale. These networks can also be supplied from a variety of energy sources such as geothermal and solar heating stations, fuel cells, biomass, etc. to increase **flexibility** and reduce dependency on a single source of supply. Similarly, CHP plants can also work on different fuel mixes, therefore promoting renewable energy sources in district heating and CHP is essential for climate-neutral policies.

Smart grids, the electricity networks integrated with digital technology, are one of the important players to manage the variable generators and loads in distributed energy. Therefore, the

modernization of the electricity grid itself is crucial to support the distributed energy system which is highly dependable on external conditions, such as wind or solar.

2.3.3. Benefits

An energy district approach has several technical, management, and governance benefits. One of the **technical** benefits is the increase in the number of decentralised renewable energy generation systems which also brings reduced network and energy conversion losses, Increased energy flexibility services, resilience to grid outages, and quality assurance. The energy district that gains independence from the grid also enables waste heat recovery and energy sharing within that area. Also because the weather-dependent energy sources are used such as solar and wind in energy generation, the modernization of the electricity grid is needed to manage these decentralised energy supply and demands.

Next, reduced unit costs of purchased products and services are one of the management benefits of energy districts. This collective way of managing energy in district scales also brings design, maintenance costs reduction, and as a result economic competitiveness. Moreover, it is possible to export surplus energy to the grid and gain financial benefits.

Also, in terms of government benefits, the energy districts help to raise the users' environmental awareness in their area in this way influence their energy consumption behaviour. In addition to demand-side management, sector coupling, storage instruments, and **energy flexibility** in energy districts improves the resilience and security of the regional energy system (JPI Urban Europe, 2020). Moreover, in the long term, it contributes to the achievement of national and international energy and environmental targets.

2.3.4. Conclusion

Energy districts are composed of different actors who managed their region’s energy sources and demands. Even though their energy and carbon reduction goals are mostly coordinated and steered by governmental bodies, instead of a bottom-up structure like by private actors, there are valuable analogous that can be learned and used to assess the benefits of voluntary public and private stakeholder structures in energy districts.

To transform urban areas into climate-neutral city districts, strong **cooperation** is essential between public and private actors. With such joint action, achieving energy efficiency and increasing the share of renewable energy is more feasible than an individual building scale. But, due to **different characteristics** of the cities, a unique design is needed for implementation and replication of the energy district concept. Therefore, several countries are operating different integrated **programmes** to build up energy districts from a holistic perspective involving legal, regulatory, and social innovation and their integration into the local eco-system.

During the implementation of these collaborative actions, it is possible to come across some **challenges** which have to be resolved within the stakeholders, such as resistance to setting energy goals, engaging facilities, and arranging the finance and governance structures.

With a well organised energy district approach, several technical, management, and governance **benefits** can be achieved. Technical benefits are renewable energy generation, reduced network and energy conversion losses, energy independency, improved resilience to grid outages, increased quality assurance and energy flexibility services, the direct energy exchange between prosumers, and the modernization of the electricity grid. Management benefits are: reduced unit costs of purchased products and services, design and maintenance costs, ensured economic competitiveness, and surplus energy export to the grid. Governance benefits are: the achievement of the national and international energy and environmental targets, raising users' environment awareness, influencing the energy consumption behaviour of people, improved urban resilience to extreme climate conditions and energy security.

2.4. ISO 50001 Energy Management System Approach

2.4.1. Introduction

Energy is an organization’s major environmental impact, and the energy costs represent a significant part of the organization’s budget, therefore the necessity of an Energy Management System (EnMS) is continuously increasing (Marco Devetta et al., 2018). An **EnMS** is a set of interrelated elements to establish an energy policy and objectives, processes, and procedures to achieve those objectives. Besides, the **ISO 50001 Energy Management System** is an international standard that provides a framework for the implementation of an EnMS (International Organisation for Standardisation, 2018) for developing a policy to use energy efficiently, establishing energy objectives, monitoring energy data and taking necessary actions according to them, and continuously improving energy performance and management (McLaughlin, 2015).

It is estimated that, by implementing the EnMS, there is a 30-40% **energy efficiency** improvement potential with currently available technologies (McLaughlin, 2015). Nevertheless, this **cost-effective energy-saving potential** remains largely untapped especially in the case of **small- and medium-sized** energy consumers. Even though these individual energy consumers have a relatively small consumption, their efficiency improvement potential is usually much higher than that of large energy consumers. As there are a high number of medium-sized energy consumers in any economic sector, **collective efficiency improvement measures** can have a major impact on energy costs and significant beneficial effects on the environment.

2.4.2. Implementation of an EnMS

There are several phases in the implementation of an EnMS in the organisations. Overcoming the lack of information and gaining commitment to improving energy consumption at all levels in the organization are prerequisites.

An analysis of the **current** energy performance and the opportunities are identified with an energy review through an energy audit is generally the first step. The energy data can be collected through typical sources such as energy bills, manual recording of utility meters and sub-meters, or an electronic energy **metering** system (monitoring and targeting [M&T] system), which is beneficial for multi-building facilities (McLaughlin, 2015). According to this data analysis, future energy use and consumption are estimated to gain an overview of the energy behaviour and energy budget of the organization.

Then, identifying the **significant energy uses** (SEUs), which are the largest consumers and those with a good opportunity to improve, is essential for focusing the effort and resources to get the most benefit from time, and money. SEUs for a cultural square can be heating, ventilation, and air conditioning (HVAC) of spaces, lighting, computer systems, and kitchens. In these multi-building areas, categorizing the SEUs according to the size of the buildings can cause difficulties later when trying to develop action plans and performance indicators. For that reason, considering the SEUs according to their energy consumption and improvement opportunities is critical.

Next, **energy baselines (EnBs), which will be used to compare the** historical performance level with future energy use, and **energy performance indicators** (EnPIs), the indicators to check how energy management is performing, are established. These form the basis for monitoring the on-going performance and for taking corrective actions in the event of unexpected results (McLaughlin, 2015).

Moreover, establishing the **critical operating parameters** such as room temperature, refrigeration parameters, hot water boilers, fresh air amounts for different types of buildings in the square, allows to learn more about energy situation and to monitor energy-saving activities more effectively. When these parameters are effectively carried out by the stakeholders, over 10 % of energy savings are possible from this topic alone (McLaughlin, 2015).

On the other hand, while all stakeholders in the cultural square must be aware of the importance of energy consumption, an energy management organization has to be built up, and several people need to be identified and **trained** to use their influence to ensure that those they supervise carry out their role, taking into account the impact on energy consumption.

Based on these, the next step is the implementation of the actions which have visible results that can be generated quickly. After that, the systematic and continuous energy consumption optimisation is launched with the Plan-Do-Check-Act (PDCA) cycle. Finally, the organization applies for the ISO 50001 certification (Javied et al., 2015).

2.4.2. Benefits

The most important technical benefits of following the ISO 50001 EnMS guidance is the improvement of energy efficiency, use, and consumption. Besides, equipment performance improves, and downtimes reduce arising from the better operation.

From the management side benefits, this standard serves as managemental guidance to all kinds of organizations for reducing energy costs and environmental impacts (Therkelsen & Scheihing, 2018). Also, managing energy effectively have several direct benefits such as: reduced exposure to rising energy prices, increased production reliability and production output/yields, (McLaughlin, 2015). Besides to these direct benefits, it brings additional indirect benefits such as: improves comfort levels in buildings including temperature, ventilation, lights, etc., reduces maintenance costs, waste production, and water consumption, ensures compliance with applicable legal requirements (McLaughlin, 2015) and support programs of the governmental bodies, tax deductions, builds a better brand image (Javied et al., 2015) and institutional knowledge, strengthens the connection between team members, and reduce energy-related business risks (Therkelsen et al., 2018).

The most critical governance benefits of implementing the necessities of the standard are the reduced environmental effects of the organisations. Also, as a result of reduced energy and carbon intensities through increasing energy efficiency, urban resilience to extreme climate conditions is improves.

2.4.4. Conclusion

The ISO 50001 Energy Management System approach is principally designed for individual organisations, which are controlled by a single entity, instead of multiple owners. Nevertheless, these organisations, such as **factories or university campuses**, could be composed of different types of buildings in a wide area or even has various branches in different locations and have one energy management system. From these analogies, valuable information was learned and used for analysing the benefits of collective energy management systems for public and private utility buildings in urban areas.

There are several **phases** in the implementation of an EnMS in the organisations and gaining commitment from all decision-makers is the first step for the realization of the system. Analysing the current energy performance, structuring an energy management organization, training participants, identifying the significant energy uses, establishing energy baselines, energy performance indicators, and critical operating parameters, and periodically monitoring the energy system are some of the other important actions have to be taken.

After implementing these measures and achieving the positive results with a Plan-Do-Check-Act sequence, energy management procedures continue its **cycle** to reach a step further in improving energy performance and management of the organisation.

As a result of involving in the standard cycle, several technical, economical and governance benefits could be achieved. Technical benefits are: improvement of energy efficiency, use, consumption, and equipment performance, and reduction in downtimes. Management benefits are: reduced energy and maintenance costs, increased production reliability and production output/yields, improved comfort levels in buildings, reduced waste production, and water consumption, ensures compliance with applicable legal requirements and support programs of the governmental bodies, tax deductions, builds a better brand image and institutional knowledge, strengthens the connection between staff, and reduce energy-related business risks. Governance benefits are the reduced environmental effects of the organisations, reduced energy and carbon intensities, and urban resilience to extreme climate conditions is improves.

2.5 Conclusion

In this chapter, an analytical framework is developed from four literature streams to understand the benefits of collective energy management systems for public and private utility buildings in climate-neutral cultural squares of urban areas.

The similarities that are found from these four areas are shown in **Table 1** below.

Table 1 The analytical framework which is developed from the four literature streams.

Collective energy management systems in climate-neutral urban areas		4 Streams from the literature			
		EU Clean Energy Package	**Climate Neutral Areas**	**Energy Districts**	**ISO 50001 EnMS**
Technical Benefits	1. Energy savings	x			
	1.a. Improved Energy Efficiency	x	x		x
	1.b. Reduced network & energy conversion losses	x		x	
	1.c. Improved equipment performance				x
	2. Renewable energy generation	x	x	x	
	3. Energy independency	x	x	x	
	3.a. Direct energy exchange between prosumers			x	
	3.b. Improved resilience to grid outages			x	x
	3.c. Increased quality assurance			x	
	3.d. Increased energy flexibility services	x		x	
	4. The modernization of the electricity grid			x	
Management Benefits (Benefits for businesses)	1. Easy to get into the energy market	x			
	2. Compliance with applicable legal requirement				x
	3.a. Ensured economic competitiveness		x	x	
	3.b. Energy Cost Reduction & financial profits	x	x		x
	3.c. Reduced unit costs of purchased products and services			x	
	3.b. Reduced design and maintenance costs			x	x
	3.d. Peer-to-peer energy trading within the community	x			
	3.c. Surplus energy export to the grid			x	
	4. Decreased network investments	x			
	5. Reduced energy-related business risks				x
	6. Built a better brand image				x
	8. Built an institutional knowledge				x
	8.a. Strengthened connection between team members				x
	9. International recognition				x
Governance Benefits (Benefits for society)	1. Achievement of the national and international energy and environmental targets	x		x	
	2. Raising users' environment awareness	x	x	x	
	2.a. Influencing the energy consumption behaviour of people		x	x	
	3. Increased local job opportunities	x	x		
	4. Improved energy security	x	x	x	
	5. Increased liveability	x			
	5.a. Improved quality of life		x		
	5.b. Improved comfort levels				x
	6. Improved urban resilience to extreme climate conditions		x	x	x
	6.a. Reduced energy and carbon intensities in cities		x		x
	6.b. Reduced environmental impacts				x

CHAPTER 3. ROTTERDAM SCHOUWBURGPLEIN CASE

3.1. Introduction

The Rotterdam Cultural Square (Schouwburgplein) was used as the main case in this research to explore the benefits of collective energy management systems. In this chapter, Schouwburgplein was described to show all the elements in this cultural square, its building characteristics, stakeholder types, processes, and the procedures that are achieved until today and future targets.

Schouwburgplein is one of the most urbanised areas in the Netherlands. It is composed of residential buildings, two cultural institutions, a cinema, a university, a church, residential houses, offices, several cafes-restaurants, and a shopping area (**Figure 1**). To transform this cultural square into a climate-neutral area, 7 Square Endeavour (7SE) foundation is initiated through bottom-up by public and private actors in this urban area. The 7SE aims to make the Schouwburgplein 100% climate-neutral by 2030 and to apply the lessons learned in Rotterdam to the other cultural squares around the world.

Figure 1 The area of the Rotterdam Schouwburgplein (7SE, 2018)

With an ambitious target of reaching a climate-neutral square, first of all, it is focused on the CO2 neutral energy usage in the area, for example, a transition to a linked CHP system in combination with green electricity. Secondly, adaption to urban heat island effect, downpours, drought, and water scarcity is focussed and implementations such as polder roofs and an underground water buffer are planned for a solution. This research is explored the collective energy actions of the square to reach its CO2-neutral targets.

Up to now, an energy and water strategy and a technical feasibility report have been prepared and found that it is technically possible to make Schouwburgplein climate-neutral by 2030. Next, more detailed research will be performed on sustainability measures, as well as the energy concept will be further modelled. After obtaining the energy model, a business case, which is composed of financing and organizational models, will be developed (7 Square Endeavor, 2019).

3.2. Actors

7SE is composed of several public and private parties. The Rotterdam Theater, de Doelen Concert, and Congress Centre, Municipality of Rotterdam, Regional Water Authority (Schieland en de Krimpenerwaard), Ministry of Infrastructure and Water Management and TNO (the Dutch Organisation for applied scientific research) are the public actors participating in the organization. On the other hand, Amvest (investment manager and real estate developer), Codarts University of the Arts, Arcadis (design, engineering, and management consulting company), Dura Vermeer (construction engineering company), and Manhave (Property management company) are the private stakeholders in the organization.

3.3. Building Structures

The buildings in the square have different functions, varying from restaurants, homes, and the theatre to offices or parking. Their construction years range from the 1950s to 2013s, and a large proportion of them have a monumental status, which means that significant changes in the buildings may not be allowed. The structures located on the square listed below (Arcadis, 2019):

- The Codarts building houses the School of the Arts and is owned by the same organisation. The building is connected to the high-temperature district heating (90°C-70°C) and has a building management system. The general condition of the building is fine.

- The Jan Evertsenplaats, built-in 1958, consists of a high-rise and a medium-rise building section, which has shops on the ground floor. Both parts belong to Vestia, a housing corporation. The buildings are in good condition. The houses are connected to medium temperature district heating (70°C-40°C).

- The Joost Banckertplaats consists of two flats, one ten-high and the other eight-high, and a row of low-rise buildings, which have shops on the ground floor. The buildings, which are currently in reasonable condition, were built in 1958 and are now owned by Amvest. They are connected to high-temperature (90°C-70°C) district heating

- On the Karel Doormanstraat, there is a Manhave apartment, built-in 1958, in which offices, shops, and homes are located. The condition of these buildings is in good condition and connected to a high-temperature district heating system.

- De Doelen accommodates the Rotterdam Philharmonic Orchestra and a congress and concert centre. The building dates from 1966 and is a national monument owned by the Municipality of Rotterdam and leased to De Doelen Foundation. The condition of the building is reasonably good, and it is connected to the district heating (90°C - 70°C).

-The Hartsuykerflat, built-in 1985, mainly contains houses and ground floor shops. In contrast to the other houses in the area, it is mainly owned by individual dwellers and represented by a board of Association. The buildings are generally in good condition.

- Theatre Rotterdam is designed in 1988, does not have monumental status, and is leased by the Municipality of Rotterdam to the Rotterdam Theatre Foundation. Theatre Rotterdam has a building management system and energy consumption is being monitored. The building is connected to district heating (90°C - 70°C).

- Woonstad residential building is owned partly by a housing corporation and partly by individual dwellers and represented by a board of association in the 7SE.

- The underground car park on the Schouwburgplein is owned by the Municipality of Rotterdam. The general condition of the parking garage is in good condition.

- Pathé, a cinema building, and Pauluskerk, a church, are privately owned two utility buildings, which are not active contributors in the 7SE but may be involved in the collective energy system in the future.

3.4. Energy Characteristics

In the Netherlands, due to the implementation of energy-saving measures and moderate economic growth, the total energy demand will be expected to continue its decline in the built environment. Particularly, a sharp decrease in gas consumption is foreseen because of the 'gas-free neighbourhoods' policies. However, compared to changes in gas consumption, electricity and heat demand will remain more constant.

Also, as a result of being a signatory of Paris Climate Change Agreement, a significant decrease in the price per kWh of renewable energy, agreeing on investment plans for large offshore wind farms, phasing out the coal-fired power stations and natural gas production, increase the larger share of renewable energy in the energy mix to 7.4% in 2018 (CBS, 2019) (**Figure 2**).

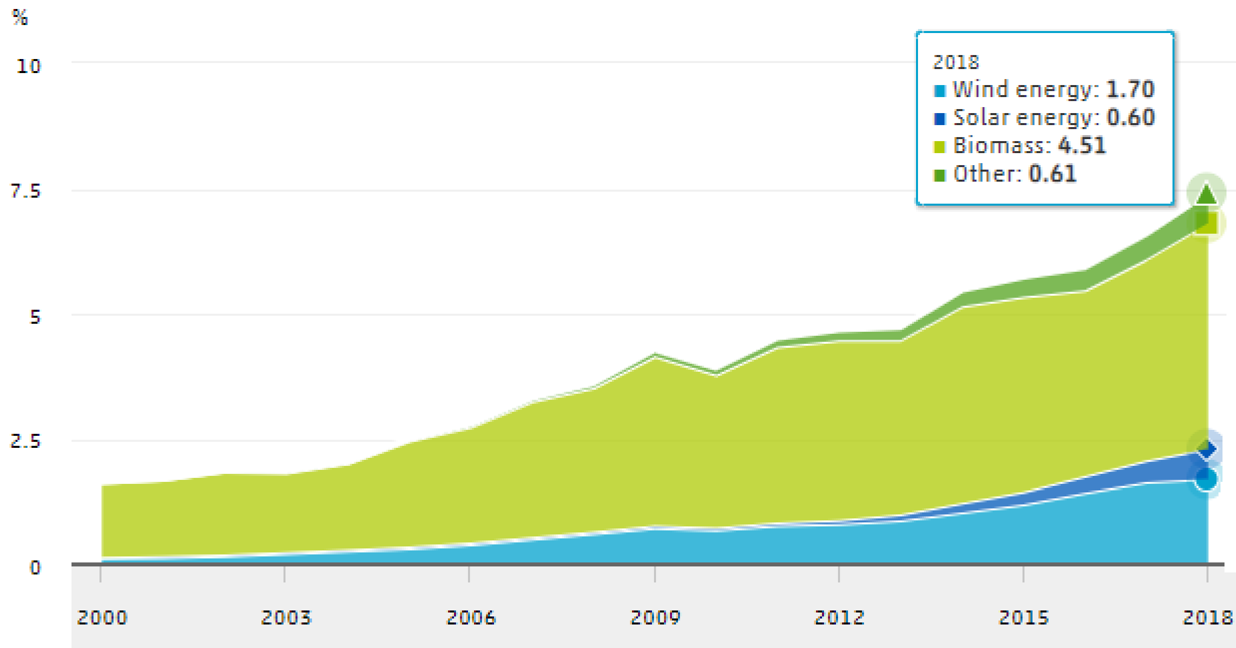

Figure 2 Share of renewable energy in gross final energy consumption in the Netherlands (CBS, 2019).

In Rotterdam Schouwburgplein, most of the heating is provided by a high-temperature (90°C-70°C) district residual heat network from the waste incineration plant in Rotterdam. Even though the square is using a sustainable and economical way of heating (**Figure 3**), this process still creates 26 kg CO2 per GJ (CO2emissiefactoren.nl, 2020). Besides, as the heating is mostly supplied by district heating, the use of **natural gas** is very low in the square, only for cooking and hot water. Also, for cooling and other energy needs, grey electricity is used which emits 0.65kg CO2 per kWh (Arcadis, 2019).

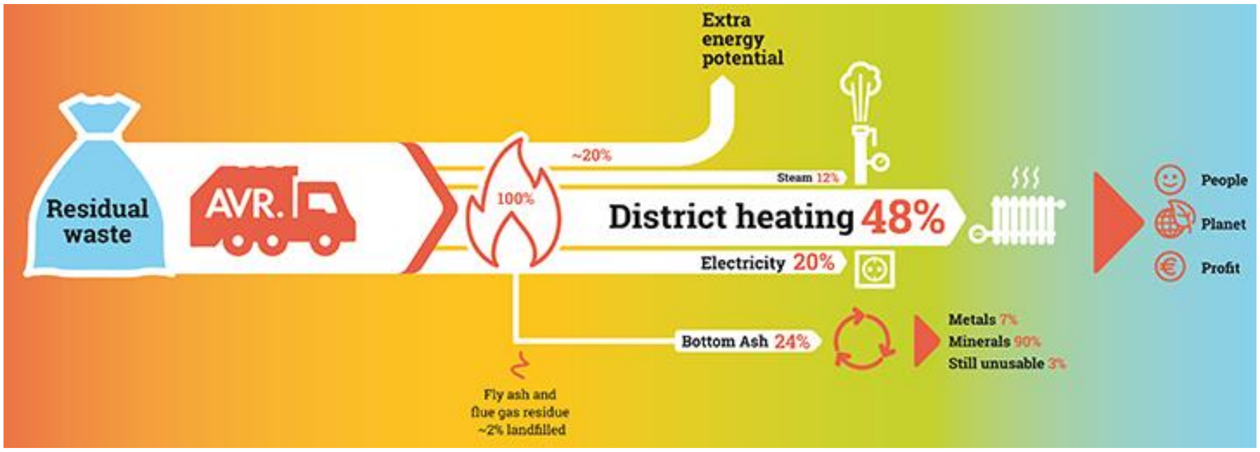

Figure 3 AVR waste incineration plant process (AVR, 2020).

According to the energy strategy plan prepared by Arcadis, a baseline for the total energy demand and CO2 consumption in the square was calculated as 213.000 GJp / 10,3 kton CO2 in 2016, which was formed by 117. 000 GJp / 6,8 kton CO2 (%55) of electricity, 81.000 GJp / 2,6 kton CO2 (%38) of heating, and 15.000 GJp / 0,8 u CO2 (%7) gas demands and CO2 consumptions. In the coming future, it is expected that the autonomous decline in total energy demand at Schouwburgplein will continue in parallel to energy trends in the Netherlands (**Figure 4**) (Arcadis, 2019). However, there is a potential to accelerate the pace of this decline as a result of collective action in the square.

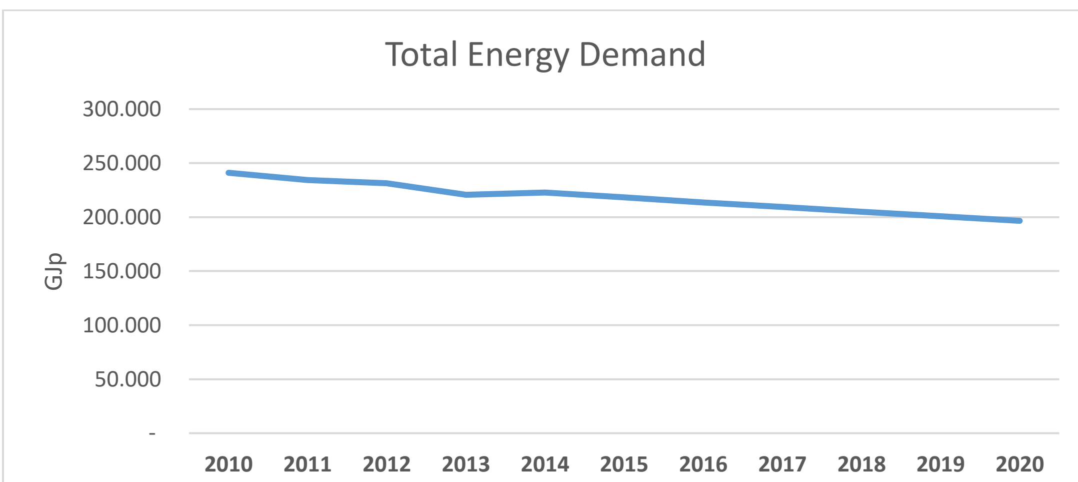

Figure 4 The decline in the total energy demand at Schouwburgplein (Arcadis, 2019).

To take a clear picture, the energy consumption can be divided into sub-components: houses, SME businesses, and 5 large energy users in the area. Schouwburgplein includes about 1,400 apartments, which most of them have an energy label of E or D. The electricity consumption of the houses is 26.000 GJp (%22), and the heat consumption of them is 35.000 GJp (44%). Whereas SME businesses, including all shops, restaurants, small offices, and supermarkets make up 50,000 m2 of the square. Their electricity consumption is 42.000 GJp (36%), and heat consumption is 24.000 GJp (29%). On the other hand, the 5 large energy users in the area, De Doelen, Codarts, Rotterdam theatre, Pathé, and the Pauluskerk, have a 49.000 GJp (%42) electricity, and 22.000 GJp (27%) heat consumption. Although the heat demand of the houses forms the major energy consumption, electricity is the largest energy carrier in the area, partly due to the presence of these major users.

In conclusion, the Rotterdam Cultural Square is a unique case to analyse the benefits of a collective action in energy management with different public and private stakeholders and building characteristics which has a climate neutrality target.

CHAPTER 4: THE TECHNICAL BENEFITS

In this chapter, the potential technical benefits of collective energy management action in the Rotterdam Schouwburgplein case were assessed according to the analytical framework (**Table 2**). Also, similar cases were used to see the technical benefits which have not yet matured in the main case such as direct energy exchange between prosumers.

Table 2 Potential technical benefits of collective energy management

Collective energy management systems in climate-neutral urban areas		**4 Streams from the literature**			
		EU Clean Energy Package	**Climate Neutral Areas**	**Energy Districts**	**ISO 50001 EnMS**
Technical Benefits	1. Energy savings	x			
	1.a. Improved Energy Efficiency	x	x		x
	1.b. Reduced network & energy conversion losses	x		x	
	1.c. Improved equipment performance				x
	2. Renewable energy generation	x	x	x	
	3. Energy independency	x	x	x	
	3.a. Direct energy exchange between prosumers			x	
	3.b. Improved resilience to grid outages			x	x
	3.c. Increased quality assurance			x	
	3.d. Increased energy flexibility services	x		x	
	4. The modernization of the electricity grid			x	

To reach the ambitious targets, the energy plan of the Schouwburgplein was designed based on the Trias Energetica strategy. This strategy, which was developed in 1979 by the study group at TU Delft, is structured on three steps: limiting the energy demand, using energy from renewable sources, and consuming finite (fossil) energy sources efficiently (RVO, 2013) (Figure 5).

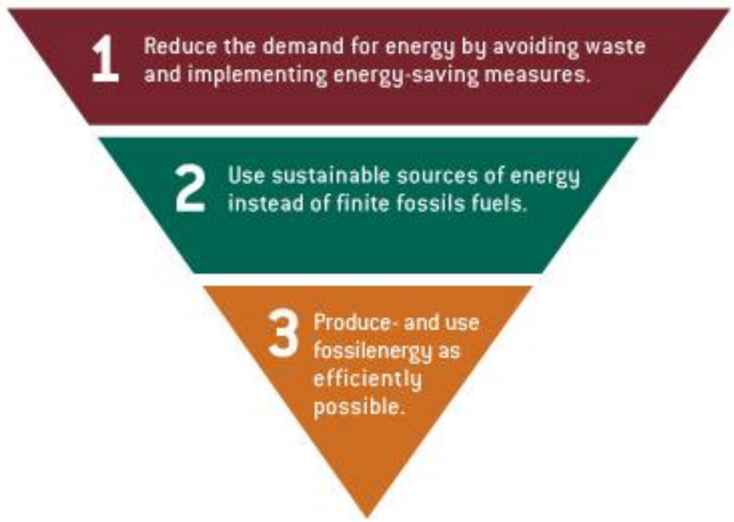

Figure 5 Trias Energetica concept (EURIMA, 2018).

The first action planned to be carried out is to **save energy** and reduce energy demand as much as possible by taking energy-saving measures, improving energy efficiency through installing efficient equipment, and preventing waste energy. For instance, it is planned to recover and exchange the residual heat and to monitor and collectively manage energy flow. In addition, various types of buildings in the square will be insulated with a tailor-made approach and an A-label energy level will be targeted as long as monumental conditions allow. Besides, the installation of a heat recovery system and frequency regulators in the ventilation systems, LED lighting, presence detection, and timer switches are some of the other energy-saving applications that will reduce electricity demand. Also, as a result of increased efficiency, the **equipment performance** will directly improve. For instance. after the insulation of the houses, the load on the heating equipment will be reduced and the working life will be extended. These energy-saving measures are expected to save 50,600 GJp / 2230t CO2 and will have a 21% contribution to reach the target.

Next, for the energy demand that remains after measures have been taken, it is aimed to use as much sustainable energy as possible within the territory of the square. In terms of **renewable energy generation**, it was planned to install solar PV panels on the available roof surface with a capacity of 9,500 GJp / 550t CO2 which would have a 5% contribution to the target. This low contribution is mostly because of the central location of the square with a limited area and physical and legal limitations (such as monumental status) of the buildings. Even though there could be further opportunities to generate sustainable energy also by integrating solar cells in windows and facades, it could not be possible to generate all the electricity needed in the area, therefore the remaining electricity demand will be purchased sustainably.

Energy storage in the square is not included in the initial energy structure design of the project, mainly due to the limited amount of electricity generation. This would have a negative consequence for the square in terms of **energy independence, resilience to grid outages, energy flexibility, and quality assurance**. Nevertheless, in line with future developments in technology, such as increases in the efficiency of PV panels, it could be feasible to store excess electricity later.

Another alternative way to increase flexibility by optimizing solar generation and consumption peaks (**Figure 6**) in the future could be the use of electric vehicles (EV) at the Schouwburgplein car park as a storage unit. However, although the parking area has a large capacity for parking spaces (730+760), the number of charging points (2+10) has to be increased to realize this opportunity.

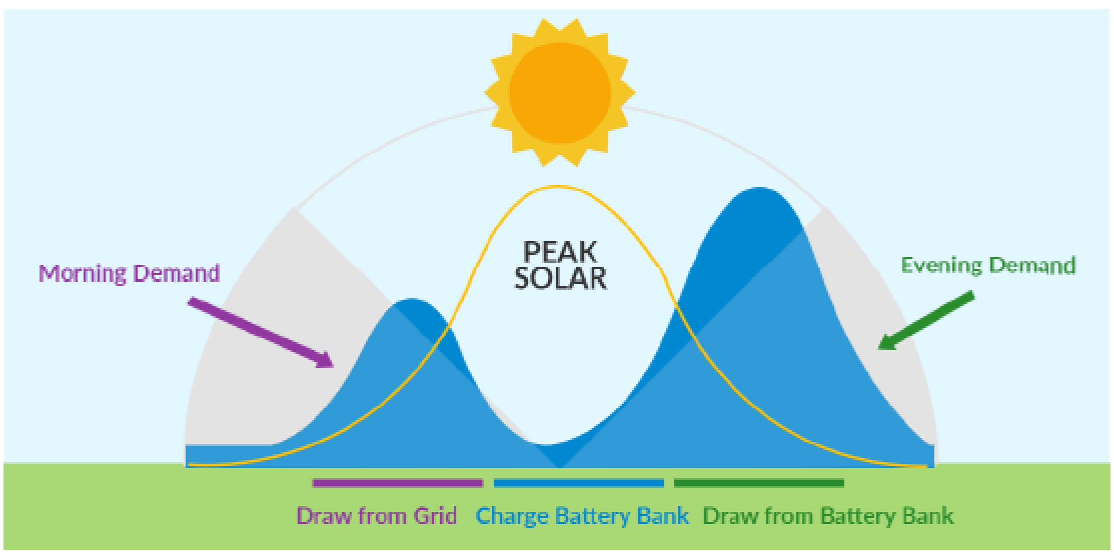

Figure 6 Relation between household consumption, solar generation, and battery usage (The European Consumer Organisation, 2019).

Moreover, used EV batteries could also be preferable for the storage unit to decrease the investment costs sustainably. Even though these second-life batteries could not meet the required specifications for usage in an EV anymore, they could be used for storing renewable power generated in the square while investing less capital per battery (McKinsey & Company, 2020).

Also, the variable nature of renewable energy production and the fluctuating energy demand in the square might create an additional challenge for the energy infrastructure. For instance, solar PV panels on the available roofs generate energy during daytime and summer, but energy demand is highest in the evening and colder periods of the year in the Netherlands. These might bring a need for the energy network operators to **modernize the electricity grid** for grid stability.

The existing high-temperature residual district heating is planned to transform into a **heat and cold storage (CHP) system**. This sustainable alternative system stores heat in the ground in summer to heat in the winter and vice versa, with a collective heat pump and will be enough to supply necessary heat (45°C) and cold (16°C) demand to the square. The efficiency of this system has a COP (coefficient of performance) of 4 (1 amount of electrical energy needed to produce 4 amount of thermal energy). Since the heat pumps will electrify the current district residual heating from the waste incineration plant, it will have an impact on the grid which might need extra capacity even if some of the electricity will be generated by solar panels (The European Consumer Organisation, 2019). Nevertheless, if such a transition to an on-site heat and cold energy supply, it will be possible to prevent the **energy losses during the conversion and the distribution** of the current energy system.

The CHP system is a proven technique and becoming more and more common in energy districts. Even though it may be technically challenging to install a linked CHP system in the Schouwburgplein, it is planned to develop a cyclical process in which supply and demand will be compatible with each other. As a result, the energy can be used simultaneously when it is generated, and the load on the energy infrastructure reduces.

Another difficulty of using this type of low-temperature heating system are the high insulation need for buildings and the need for changes in existing heating equipment. But since the construction of some buildings dates back to 1950, in all cases a similar renovation process is needed for them. For that reason, if their renovation plans are aligned with the climate-neutral targets of the project, realizing these improvements will become financially feasible.

In addition, a secondary heat source will be needed for the **peak demands** of the high energy-consuming institutions or a possible **power shortage** in the region. Infrared heating is considered an alternative for a secondary source, but due to architecture or monument status of some of the buildings in the square, there may not be a chance to make major changes in their structures. Therefore, it will be beneficial for the square to use its existing energy infrastructure for a backup system, which also increases its **energy security**.

In addition to the CHP system, sewage heat recovery, and bio-digester system are planned to be built and green gas from wastewater treatment plants is going to be utilized, which in total help to save 20,100 GJp / 685t CO_2 and will have a 6% contribution.

On the other hand, to supply the **cold** demand, which is mainly formed by cultural institutions and shops, a CHP system will be the most efficient way of cooling with a COP of 20. Besides, an innovative way is also planned to cool the buildings using rainwater which is stored in the polder roofs and underground. The water stored by these methods will also improve the **climate resistance** of the region. Nevertheless, this method will not be sufficient for cooling, but it can be used as a secondary source.

After implementing these fundamental steps, various information can be collected from energy usage data through monitoring energy as transparent as possible. Using this data, it will be possible to see residents' energy use behaviour and manage the square's energy supply and demand. It is foreseen that installing building monitors for dwellings and SMEs and establishing energy management systems for large users will save 16,600 GJp / 730t CO_2 and will have a 7% contribution.

Besides, a more efficient and sustainable energy system is aimed at **exchanging** the residual energy between buildings as efficiently as possible. The excessive heat of a building will be used for another building in the square through the linked CHPs. Also, a cold network will be created by connecting different heat exchangers. With this cold network, it will be possible to meet the supply and demand between different buildings, which increases the efficiency of the system, reduces the peak loads and total energy demand.

The **energy management** concept of the Schouwburgplein has not finalised yet, but using a holistic software algorithm capable of controlling different types of energy (district heating and cooling, generated and purchased electricity, natural gas …) and building types (dwellings, offices, cultural institutions …) would be an effective approach to increase the benefits of an energy community in the square. As used in Loenen, a village in the Dutch province of Gelderland, a Community-based Virtual Power Plant (cVVP), can be taken as a model (Loenen, 2020). cVVP is a group of distributed energy generation units (solar panels), controllable loads (heat pumps and charging points for electric cars), and storage systems (electric cars batteries), combined as a single power plant that works on software systems (van Summeren et al., 2020). In this model, energy usage data of the buildings are collected with digital monitoring tools, and accordingly, the energy management software systems control the power within the community, the storage resources, and the grid. Moreover, it optimizes energy supply and demand (**Figure 7**).

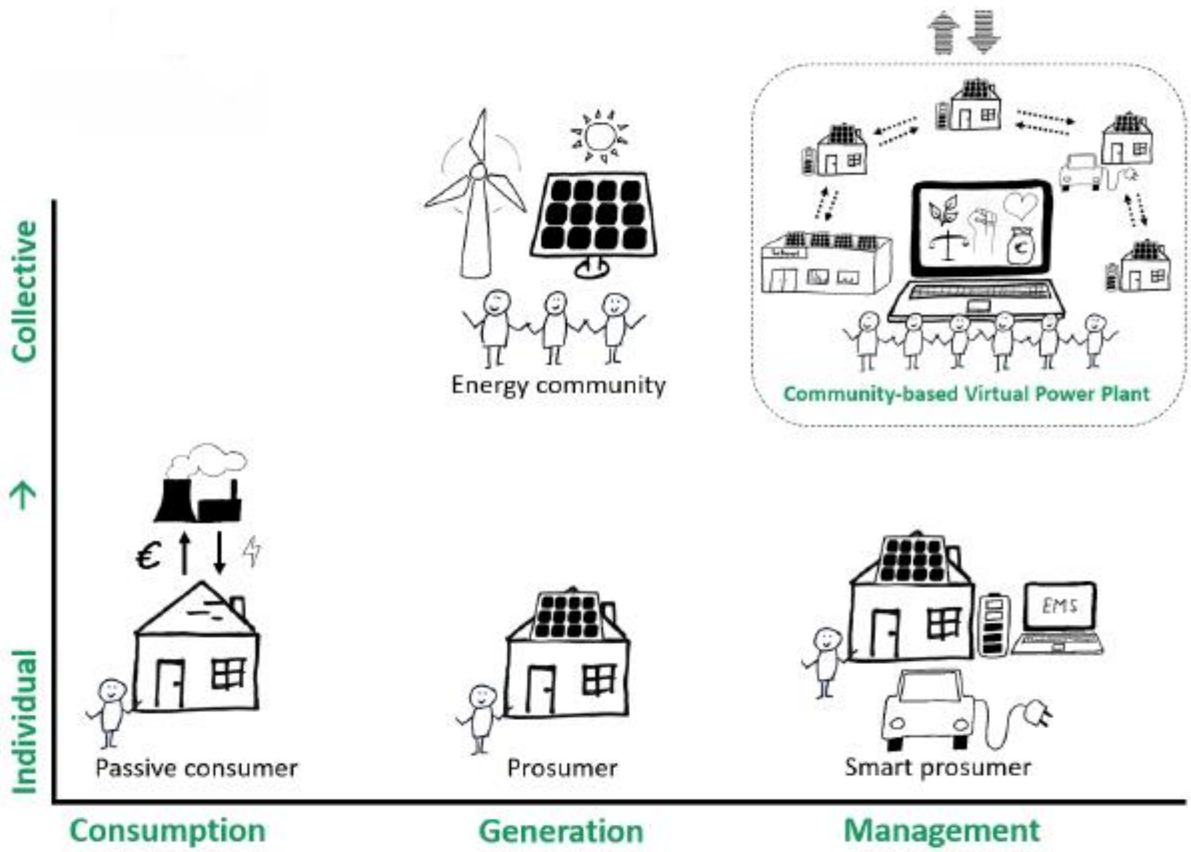

Figure 7 Community-based Virtual Power Plant characteristics (Wieczorek, 2019).

In conclusion, after carrying out saving measures to reduce energy demand, generating energy collectively, and monitoring and managing energy efficiently, it is expected to reduce the **CO2 emission** of the square by 39%. Since it is not possible to generate all the energy needed on site due to its location, the energy that cannot be generated on the square, which corresponds to a 61% of CO2 savings, is planned to be **purchased** in a sustainable and collective way. Even though it is not possible for the square to become **energy independent** with the current technology, it is technically feasible to achieve a carbon-neutral Schouwburgplein by 2030 with collective action in energy management.

CHAPTER 5: THE MANAGEMENT BENEFITS

This chapter will assess the potential management benefits of collective energy management action in the Rotterdam Schouwburgplein case based on the analytical framework (**Table 3**). Similar cases have also been used to see management benefits, which have not yet matured in the main case such as peer-to-peer energy exchanges and decreased network investments.

Table 3 Potential management benefits of collective energy management.

Collective energy management systems in climate-neutral urban areas		**4 Streams from the literature**			
		EU Clean Energy Package	**Climate Neutral Areas**	**Energy Districts**	**ISO 50001 EnMS**
Management Benefits (Benefits for businesses)	1. Easy to get into the energy market	x			
	2. Compliance with applicable legal requirement				x
	3.a. Ensured economic competitiveness		x	x	
	3.b. Energy Cost Reduction & financial profits	x	x		x
	3.c. Reduced unit costs of purchased products and services			x	
	3.b. Reduced design and maintenance costs			x	x
	3.d. Peer-to-peer energy trading within the community	x			
	3.c. Surplus energy export to the grid			x	
	4. Decreased network investments	x			
	5. Reduced energy-related business risks				x
	6. Built a better brand image				x
	8. Built an institutional knowledge				x
	8.a. Strengthened connection between team members				x
	9. International recognition				x

5.1. Organisational

A unique characteristic of the Schouwburgplein project is to include various types of stakeholders from the public and private sectors and various building types with different. A significant number of people are visiting the cultural institutions on the square since the area is located in the centre of Rotterdam and it serves as a testing ground for such bottom-up energy initiation, the stakeholders' **commitment** to reach a climate-neutral square is high. Although this collective action brings several benefits to its stakeholders, a well-designed governing body is essential to prevent delays in implementing energy measures due to the complexity of the organisation structure and to increase the pace of the transformation of the square.

With a participatory model, it could be possible for the building owners to manage their energy system and benefit from the energy exchange and surplus energy export. Even though collaborative energy actions in the Netherlands mostly formed under energy cooperatives, after the transposition of the EU's Clean Energy Package, Schouwburgplein can be entitled as a renewable energy community since it is based on voluntary and open participation of natural persons, local authorities and small or medium-enterprises, its primary purpose is to provide environmental, economic or social community benefits rather than financial profits, and not specific to only electricity, also includes heat and cold (Coibion et al., 2019). According to this entity, Schouwburgplein can **easily get into the energy market**, generate, consume, sell, or store renewable energy, or share it within the community.

Besides gaining an advantage as a legalized entity in the energy market, the energy users of the square will also become **compliant with legislation and regulations** while taking sustainable measures to reach climate-neutral objectives. For instance, the 7SE's Energy Strategy is in line with the objectives of the Climate Agreement, published by the Dutch government in 2019, including reducing GHG emissions by 49% by 2030 compared to 1990 (The government of the Netherlands, 2019). This commitment aims to save CO_2 emissions by implementing energy-saving measures and reducing energy consumption, increasing the share of renewable energy sources to 70% in electricity production, introducing a CO_2 tax, and subsidies for sustainable energy.

All the related public and private actors participating in the project aim to meet periodically and make joint decisions, which **strengthens the connection between** them**.** With the reports, documents, and studies prepared since the establishment of 7SE, significant **institutional knowledge** has been built. Even though it hasn't planned to apply for an ISO 50001 EnMS or similar standards at the end of the energy management cycle, **international recognition** will be achieved by applying the knowledge learned in Rotterdam to other cultural squares around the world.

Another advantage of the project for the stakeholders will be the opportunity to gain a reputation by taking an active role in environmental issues. One of the reasons is the high recognition of the square and the high amount of people visiting it mostly due to the existence of the cultural institutions. The other reason is the importance of the subjects which are highly discussed in the media, such as environmental targets and sustainable cities. Therefore, it is expected that stakeholder’s **brand image** will be improved as a result of their collective efforts to reach climate neutrality.

5.2. Economical

Schouwburgplein will gain **operational cos**t-effectiveness with a target of energy demand reduction and generating local energy as much as possible. Although these efficiency measures will require additional **investments** at the beginning of the project, there are several ways to ensure **economic competitiveness** trough reducing these investment costs, such as by integrating the targeted energy measures with the existing long-term energy maintenance plans of the individual building owners. In this way, these maintenance plans could be harmonized with the climate neutrality target without making duplicate investments. In addition to that, with a collective way of **design and purchase**, it is also possible to **reduce unit costs**. For example, even though every building might need a different degree of insulation, it will be still cost-effective to design, purchase, and implement them under one roof. Also, collectively operated and **maintained** CHP system, by a group of stakeholders which might also include several building owners, will be another economic benefit of this joint action.

Besides, there are several financial opportunities to reduce investment and operational costs, and make the project economically feasible, such as national **incentives** and low-**interest rates.** Thanks to the public actors and consulting firms involved in the project, it will be easier to benefit from such financial advantages and subsidies. In addition to financial opportunities, high investment costs can also be reduced by building a partnership structure with the **energy distributor** company, Eneco. In this way, while building owners still have independence with their energy system, they can benefit financially and technically from the distributor. On the other hand, Eneco will also gain an economical benefit in terms of **decreased network investments** as a result of generating heat and cold on-site and energy-saving measures in the square.

One of the paybacks of these investments will be through a **reduction in energy costs**. In this project, the heating energy is planned to be produced on-site by CHP systems, which consume electricity. This kind of transformation will bring financial benefits due to the government’s gas-free policy that makes the electricity cheaper over time. In addition, by avoiding from the CO2 taxation of the national government and the fluctuations in energy prices due to the developments in global markets, it will be possible to save costs and **reduce energy-related business risks,** thanks to the sustainable way of energy consumption and decreased ratio of dependency to the grid.

Next to these cost-benefits, investments can be payback through **energy trading.** By **exchanging** residual energy within the square, which changes building owners' status from energy consumers to prosumers**,** allows them to gain profit and decrease energy costs. Besides its economic benefits, peer-to-peer energy exchange within the square will also decrease the energy demand from the grid and avoids energy losses. Examples to this kind of community energy markets are continuously increasing, thanks to technological development and environmental awareness. One of these examples is Brooklyn Microgrid, which is an energy marketplace for locally generated, solar energy (lo3energy, 2020). Through blockchain technology and the data platform that they developed; prosumers can transact energy autonomously with consumers in their local marketplace. It allows to manage energy use, load balancing, demand response, and purchase a surplus of energy of a charging station or an EV on the local network. As a result, community members can keep their energy resources local, reduce energy losses, and increase efficiency (Zhang et al., 2017).

Another potential way to **profit** through collaborative action will be exporting the surplus cooling energy generated by the CHP system to close neighbourhoods. When it is considered the temperature increases due to climate change, and the central location of Schouwburgplein surrounded by the businesses, there would be a high possibility to find customers to benefit from this sustainably produced excess cooling energy. Besides, the heating energy generated by the same system will already be guaranteed to be purchased by the building owners. Nevertheless, the business case still in the development phase, and after its completion, it could only be possible to see the financial feasibility of the project.

CHAPTER 6: THE GOVERNANCE BENEFITS

In this chapter, the potential governance benefits of collective energy management systems in climate-neutral urban areas were assessed in the Rotterdam Schouwburgplein according to the analytical framework (**Table 4**). Also, similar cases were used to see the governance benefits which have not yet matured in the main case such as influencing the behaviour of people, the achievement of the local targets, and increased local job opportunities.

Table 4 Potential governance benefits of collective energy management.

Collective energy management systems in climate-neutral urban areas		**4 Streams from the literature**			
		EU Clean Energy Package	**Climate Neutral Areas**	**Energy Districts**	**ISO 50001 EnMS**
Governance Benefits (Benefits for society)	1. Achievement of the national and international energy and environmental targets	x		x	
	2. Raising users' environment awareness	x	x	x	
	2.a. Influencing the energy consumption behaviour of people		x	x	
	3. Increased local job opportunities	x	x		
	4. Improved energy security	x	x	x	
	5. Increased liveability	x			
	5.a. Improved quality of life		x		
	5.b. Improved comfort levels				x
	6. Improved urban resilience to extreme climate conditions		x	x	x
	6.a. Reduced energy and carbon intensities in cities		x		x
	6.b. Reduced environmental impacts				x

The multi-sector cooperation between individual, business, and governmental organisations as in Rotterdam Schouwburgplein is seen essential in the achievement of the **regional, national, and international energy and environmental targets**. As a result of realization of a collective energy management model with a climate neutrality target in Schouwburgplein and replication of similar projects in other areas, the Rotterdam municipality and the Dutch government will gain an opportunity to reach their national target of reducing GHG emissions by 49% and increasing the share of renewable energy sources of the produced electricity to 70% by 2030 stated in the "Climate Agreement". Also, it will be possible for the Dutch government to implement its commitments under the Paris Agreement and the EU's policy objectives in "2030 Climate and Energy Framework" such as at least 40% cuts in GHG emissions, 32% share for renewable energy, and 32.5% improvement in energy efficiency (European Commission, 2016).

An example of this benefit can be seen in the case of LochemEnergie in the Netherlands. To accomplish the local government's renewable energy production policy, the Alderman thought that citizens should be part of this policy. As a result, local citizens set up the LochemEnergie, which has been generating innovative renewable energy projects since 2011. By supporting such collective action, the local government gains benefits to reach its renewable energy goals. Another benefit is the power of the developed knowledge in the community to inspire other local businesses (REScoop.eu, 2013).

To realize the transition to a sustainable energy system, the engagement of the public and private stakeholders in the Schouwburgplein is established under the 7SE foundation. All the parties accept the importance of collective energy management, identified the square as an experimental testing ground to explore the possibilities of the energy transition towards a climate-neutral district and are aware that they will not achieve this on their own.

The current climate emergency requires an urgent action not only from political actors but also from citizens. In Schouwburgplein, all the building owners/users/residents were informed about the sustainable goals of this collective action to encourage them to take an active role in the transition to a climate-neutral square and to **influence their energy consumption behaviour**. A nice example in influencing the behaviour of citizens to act responsibly for the environment could be shown from the city of Växjö, Sweden. Växjö encouraged its citizens to use public transport instead of their fossil fuel-powered cars to reach its fossil-free city target (Wittstock et al., 2019) by investing to city bus lines, such as increasing their frequency, the number of bicycle parking areas at bus stops and providing real-time travel information. Besides, the municipality continues to reinforce its existing cycling infrastructure and building a new bicycle highway.

Next, the residents will be encouraged to make energy efficiency modifications that need to be made in their buildings. After the implementation process, through energy monitoring, their actual energy usage can be compared to the optimal situation and according to this information, residents could see the necessary actions that they can take regarding their energy usage.

Besides the residents of the square, it will be also possible to **raise the environmental awareness** of wider energy consumers who are visiting the cultural institutions in the square. In addition to the Energy Strategy and Feasibility reports, face-to-face meetings, and informational conferences, written and digital communication tools have been using to explain the benefits of such collective action in energy management. Also, the Schouwburgplein project will act as a model for other districts around the world, especially for the cultural squares. The collective energy management techniques, economic, financial, and organisational structures, environmental and social experiences can be applied in similar urban areas.

The climate neutrality objective of the Schouwburgplein will contribute to the **reduction in environmental impacts** and **carbon intensities** of the square. As a result of the energy transition, greening, and water storage in the square, the **liveability** of the area is expected to increase. Also, as a result of the establishment of the efficiency measures such as insulation of the buildings, and decentralization of heating and cooling system, the thermal **comfort** of the residents will increase. Nevertheless, although Schouwburgplein can be easily accessible through sustainable ways such as bicycle routes and public transport stops nearby, an additional study for sustainable mobility will be beneficial to increase the liveability of the area.

The adverse effects of climate change could have more serious consequences in cities and the Rotterdam city is located near the sea and major rivers, therefore by taking the necessary adaptive actions in Schouwburgplein, such as polder roofs and underground water buffers, it could be possible to decrease heat island effect, downpours, drought, and water scarcity, and improve **urban resilience** to extreme climate conditions. In addition, the economic losses of such weather caused issues could be reduced. But more importantly, **the quality of life** for the residents is expected to improve as the city becomes more resilient.

The collective action of energy management of the Schouwburgplein is still in the development phase and therefore some of the benefits found in the analytic framework are not possible to explore in this case. One of them is the increase in the **local job opportunities** as a result of a transition to climate neutrality in such a collective way. According to the National Energy Survey, the employment in the renewable energy and energy efficiency sectors in the Netherlands will increase with 80,000 FTEs by 2020 (The TIR Consulting Group LLC, 2016). Even though it could be difficult to calculate how much of those jobs are only created by the projects that have aims an energy transition, a study estimated that for the districts which composed of a high share of social housing, it is possible to create approximately 800 structural jobs for renovations to establish energy efficiency (The TIR Consulting Group LLC, 2016).

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1. Conclusion

In this last chapter, the thesis was concluded by answering the main research question: What are the technical, management, and government aspects of collective energy management systems in climate-neutral urban areas, particularly so-called cultural squares?

To answer this main research question, firstly the climate-neutral cultural squares in urban areas were defined under the **first** sub-question. Depending on the finding from the literature the climate-neutral cultural squares, where public and private utility buildings with characteristics such as culture and entertainment, education,… etc., are the areas that reduce their emission as much as possible and offset the remaining. These highly visible spots have a significant influence on the behaviours of visitors and have a direct effect on the increase of the pace to reach climate neutrality.

Next, under the **second** sub-question an analytical framework was developed to explore the potential benefits of collective energy management systems for public and private utility buildings in climate-neutral cultural squares of urban areas based on the analogy with four streams from the literature: The EU's Clean Energy for all Europeans Package, Climate Neutral Areas, Energy Districts, and ISO 50001 EnMS approach. The potential technical, management, and governance benefits that are found according to this framework are shown in **Table 2**, **Table 3** and **Table 4**.

In sub-questions 3, 4, and 5, the potential technical, management, and governance benefits of collective energy management action in the main case study was assessed based on the analytical framework, and similar cases were used to see the benefits which have not yet matured in the main case. The Rotterdam Schouwburgplein case was a good example of a collective transformation action formed by a bottom-up approach with stakeholders jointly agreed upon a vision to reduce the climate impact of this energy-intensive cultural square, which is located in the heart of the second largest city of the Netherlands. Its structure was designed to fulfill several requirements to reach climate neutrality by 2030, such as saving energy, generating sustainable energy in the area, and purchasing the remained energy need by collectively and sustainably.

All the stakeholders are committed to the isolation of the buildings, installation of solar panels, implementation of the energy management system, transition to CHP system for heating and cooling, and exchange of residual energy within the square. It was seen that there are several technical, management, and governance benefits of such a collective action in the square to reach climate neutrality.

Regarding the **technical** benefits that have been seen in Schouwburgplein, a significant decrease in energy demand is expected as a result of the implementation of **energy savings** measures, **efficient energy usage**, and prevention of energy losses. Such an increase in efficiency will automatically improve **equipment performance**. For heating and cooling, the current district heating system supplied from an incineration plant will be transformed into a CHP system, which is more efficient and sustainable. With such an on-site heat and cold storage system, it will be also possible to **reduce network losses**. Besides, solar panels will be installed on suitable roofs for the generation **of renewable** electricity as much as possible.

Due to the square location and densely settlement, there are several limitations for the square to become **energy independent**. There is not enough area to generate its energy with current technologies, therefore after implementing energy-saving measures and generating as much as renewable energy as possible, the rest of the energy needs will be purchased collectively in a sustainable manner. Also, due to this limited amount of electricity generation, energy storage is not included in the initial design of this collective energy structure of the project, which could have negative consequences for the Schouwburgplein's **energy independence, resilience to grid outages, energy flexibility, and quality assurance**. Nevertheless, with a holistically designed energy management software, **direct energy exchange** within the square will reduce the dependency on the grid and **increase quality assurance**. In parallel to the active participation in the energy market, there will be a need for the **modernization of the grid**, which in return will increase the **energy security** of the area.

Regarding the management benefits, as the Schouwburgplein collaboration involves several types of stakeholders from the public and private sectors, their experiences, and knowledge in different areas will facilitate the achievement of the climate neutrality target. While the periodic meetings strengthen the **connection between them,** the written reports, documents, and studies built **institutional knowledge.** Also, with an aim to apply the knowledge learned in Rotterdam to other cultural squares around the world, the collaboration will gain **international recognition**. Moreover, stakeholder's **brand image** will be improved as a result of their collective efforts to reach environmental targets in such a visible location.

The collaborative energy actions in the Netherlands are mostly formed under the energy cooperatives to take place in the **energy market**. With the new legal entities that the EU's Clean Energy Package brings, such as renewable energy communities and citizen energy communities, it would be easier for the Schouwburgplein to make the energy transactions within the community or with the grid. Besides, as a result of the climate neutrality objective, the square will become **compliant with legislation and regulations**, such as the Climate Agreement published by the Dutch government in 2019.

Economical savings are another important **management** benefit of this collective action. It is expected that after taking the necessary energy-saving measures, the transition to CO2-neutral energy sources, and purchasing the energy collectively, **the energy cost** of the square will reduce. Also, **unit costs of purchased products** and **services, design, and maintenance costs** are expected to decrease as a result of the joint action in the square. This sustainable way of energy consumption and decreased ratio of dependency to the grid will also protect stakeholders from the possible fluctuations in energy prices, **reduce their energy-related business risks,** and **decrease network investments.** Even though these efficiency measures to reach CO2 neutrality will require a high amount of initial funding, it is possible to ensure **economic competitiveness** through reducing these costs by integrating them with the existing long-term energy maintenance plans of the individual building owners, benefitting from national incentives and low-interest rates, and by building a partnership with the energy distributor company. In addition to the cost-saving benefits, the stakeholders in the Schouwburgplein could gain **financial profits** through **peer-to-peer energy exchange** within the neighbourhood and **surplus cooling energy** export to close surroundings.

Lastly, by collective action in energy management in the square, it is expected to gain several **governance benefits**. First, the **energy consumption behaviour** patterns of the residents are expected to be changed by establishing concrete saving measures. Besides, through written and social information channels, the targets and the progress of the project will be published, and in this way, the **environmental awareness** of people will rise. Also, by realizing the collective energy management model with a climate neutrality target in Schouwburgplein and replication to other areas in the Netherlands, it would be possible to achieve the **regional, national, and international energy and environmental targets.** Moreover, it will increase the pace of **reduction in environmental impacts** and **carbon intensities** of the square, the thermal **comfort** of the residents, and the **liveability** of the area. As a result of the adaptive actions that will be taken within the target, the possible heat island effect, downpours, drought, and water scarcity will decrease, and the **urban resilience** to extreme climate conditions will improve. In addition, the economic losses of such weather caused issues could be reduced and **the quality of life** for the residents is expected to improve.

As the collective action of energy management of the Schouwburgplein is still in the development phase and it is not possible to explore the increase in the **local job opportunities** in this case. Nevertheless, according to the National Energy Survey, the employment in the renewable energy and energy efficiency sectors in the Netherlands will increase with 80,000 FTEs by 2020 and it is possible to create approximately 800 structural jobs for renovations to establish energy efficiency in the districts which composed of a high share of social housing.

In conclusion, after assessing the main case study and similar cases according to the analytical framework which was built by exploring the similarities in the literature, managing energy through a collaborative action in which public and private actors acting jointly together in an urban area bring several technical, management, and government benefits. Especially, if this area has a climate-neutral target and includes cultural institutions that have an important number of visitors, then the benefits of such a joint action are expected to rise.

7.2. Discussions and Recommendations

Due to the COVID-19 pandemic outbreak, difficulties encountered in expert interviews, and accessing documents, therefore it was aimed to support the case study through desk research. Besides, even though it was possible to see most of the benefits of collective energy management in the main case study, similar cases are also explored for the unmatured benefits. To conclude, three recommendations are given on technical, management, and governance issues for future energy communities in this sub-section.

First, the Trias Energetica and its enhanced version Trias Territoria are effective strategies that can guide communities through their journey to achieve sustainable energy. Adopting these technical philosophies as a starting point and adapting them according to the characteristics of the urban area and the existing available technology will provide significant benefits in reducing energy consumption, generating sustainable energy, utilizing the residual flows within the surroundings, and purchasing the remaining energy demand in a sustainable manner.

Second, due to the complexity of the organisation, which can be composed of public and private actors with different building functions, it would be advantageous to establish a specific governance structure legalized under a renewable energy community. Because of their volunteer nature, these organisations are often managed by stakeholders, and this may cause delays as this volunteer work can be considered a side job. To avoid this problem, having full-time employees in the organisation can increase the pace to reach the targeted actions. Also, although there are many actors with different skills, experience, and networking in these collaborative actions, it can take time to make decisions due to the difficulty of meeting all stakeholders and a large number of different ideas. Therefore, it may be a good idea to keep the cooperation management small, which can be changed periodically between stakeholders.

Third, numerous individual buildings with different functions, and divided ownership structure in cities, are some of the biggest challenges of acting together in energy management. However, as can be seen from the Schouwburgplein case, such collaborations can be organised by institutions that have functions such as cultural, educational, … etc. Therefore, it would be beneficial for the governmental bodies to encourage these institutions, which are the meeting point of the citizens, to take a pioneering step to benefit from a collective energy management system in their region. To do this, it is important to transpose the EU's Clean Energy Package into their national laws as soon as possible. Besides, to reach more people and keep the attention alive, activities such as festivals could be organised regularly which also allows the developers an opportunity to present the project to the public.

REFERENCES

7 Square Endeavor. (2019). *7 Square Endeavour's energy concept proves to be feasible | 7 Square Endeavor*. http://www.7square-endeavour.nl/EN/2020/02/17/7-square-endeavours-energy-concept-proves-to-be-feasible/

7SE. (2018). *Informatie 7 Square Endeavour*.

Arcadis. (2019). *Feasibility Study Energy System Theatre Square*.

AVR. (2020). *Waste Inciniration Plant Process*. https://www.avr.nl/en/process-results

Büscher, T., Holtermann, A., & Lang, M. (2020). *Clean energy*. Clean Energy for All Europeans. http://www.twobirds.com/en/news/articles/2019/global/clean-energy-for-all-europeans---an-overview

C40 Cities. (2020). *Why Cities?* https://www.c40.org/why_cities

Caramizaru, A., Uihlein, A., European Commission, & Joint Research Centre. (2020). *Energy communities: An overview of energy and social innovation.* https://op.europa.eu/publication/manifestation_identifier/PUB_KJNA30083ENN

CBS. (2019). *Share of renewable energy* [Webpagina]. Statistics Netherlands. https://www.cbs.nl/en-gb/news/2019/22/share-of-renewable-energy-up-to-7-4-percent

CO2emissiefactoren.nl. (2020). *List of emission factors*. CO2 Emissiefactoren. https://www.co2emissiefactoren.nl/lijst-emissiefactoren/

Coibion, A., Schulz, T., & Losch, R. (2019). *Clean Energy Package adopted*. Linklaters LLP.

EURIMA. (2018). *Trias Energetica*. https://www.eurima.org/energy-efficiency-in-buildings/trias-energetica

European Commission. (2016, November 23). *2030 climate & energy framework* [Text]. Climate Action - European Commission. https://ec.europa.eu/clima/policies/strategies/2030_en

European Commission. (2017, March 8). *Energy union* [Text]. Energy - European Commission. https://ec.europa.eu/energy/topics/energy-strategy/energy-union_en

European Commission. (2020a). *Clean energy for all Europeans package* [Text]. Energy - European Commission. https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en

European Commission. (2020b). *Climate adaptation in cities* [Text]. European Commission. https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/priority-themes-eu-cities/climate-adaptation-cities_en

European Parliament and the Council. (2010). *Energy Performance of Buildings Directive*. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02010L0031-20181224&from=EN

Frieden, D., Tuerk, A., Roberts, J., d'Herbemont, S., & Gubina, A. (2019). *Collective self-consumption and energy communities* (p. 23). Compile Consortium.

IPCC. (2018). *Global Warming of 1.5 ^{o}C*. https://www.ipcc.ch/sr15/

Javied, T., Rackow, T., & Franke, J. (2015). Implementing Energy Management System to Increase Energy Efficiency in Manufacturing Companies. *Procedia CIRP*, *26*, 156–161. https://doi.org/10.1016/j.procir.2014.07.057

JPI Urban Europe. (2020). *White Paper on PED Reference Framework for Positive Energy Districts and Neighbourhoods*. https://jpi-urbaneurope.eu/ped/

lo3energy. (2020). *Brooklyn Microgrid | Community Powered Energy*. Brooklyn Microgrid. https://www.brooklyn.energy

Loenen. (2020). *Stichting Duurzame Projecten Loenen*. https://duurzaamloenen.nl/

Marco Devetta, E. C., Līga Žogla, Aiga Barisa, M. R., Toma, M., & Stiff, G. (2018). *Energy Management System Guidebook For Local Authorities*. Compete4secap. compete4secap.eu

McKinsey & Company. (2020). *Electric vehicles, second life batteries, and their effect on the power sector*. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/second-life-ev-batteries-the-newest-value-pool-in-energy-storage

McLaughlin, L. (2015). *ISO 50001: Energy management systems: a practical guide for SMEs*. ISO.

Pless, S., Polly, B., & Zaleski, S. (2018). *Communities of the Future: Accelerating Zero Energy District Master Planning*. 17.

Polly, B., Kutscher, C., Macumber, D., Schott, M., Pless, S., Livingood, B., & Geet, O. V. (2016). From Zero Energy Buildings to Zero Energy Districts. *National Renewable Energy Laboratory*, 17.

REScoop.eu. (2013). *REScoop Best Practices Report 1.pdf*.

REScoop.eu. (2020). *Energy Community*. REScoop.Eu. http://www.rescoop.eu/

Rotterdam Municipality. (2019). *Rotterdam Sustainability Compass*. https://www.010duurzamestad.nl/wat-wij-doen/GRO-duurzaamheidskompas-V18.pdf

RVO. (2013). *Trias Energetica*. https://www.rvo.nl/sites/default/files/Infoblad%20Trias%20Energetica%20en%20energieneutraal%20bouwen-juni%202013.pdf

Sciullo, A., Wierling, A., Arrobbio, O., Gilcrease, G. W., Gregg, J. S., Henfrey, T., Padovan, D., & Schwanitz, V. J. (2020). *Collective Action Initiatives in the Energy Transition. Supporters of a strong sustainability paradigm?* 14.

Smart Energy Collective. (2013). *An introduction to the Universal Smart Energy Framework.*

The European Consumer Organisation. (2019). *The Future Of Energy Consumers*.

The government of the Netherlands. (2019). *Climate Agreement*.

The TIR Consulting Group LLC. (2016). *The Third Industrial Revolution*.

Therkelsen, D. P., & Scheihing, P. (2018). Establishing a platform to harmonize ISO 50001 energy performance improvement measurement and verification protocols. . . *ENERGY MANAGEMENT*, 12.

Therkelsen, Dr. P., Siciliano, G., & Scheihing, P. (2018). *Establishing a Platform to Harmonize ISO 50001 Energy Performance Improvement Measurement and Verification Protocols (Presentation)*. 17.

UNECE. (2010). *Action Plan for Energy-efficient Housing*.

UNECE. (2011). *Climate Neutral Cities* (p. 98). United Nations Economic Commission For Europe. https://www.unece.org/fileadmin/DAM/hlm/documents/Publications/climate.neutral.cities_e.pdf

United Nations. (2020). *An UN Guide to Climate Neutrality*. https://unfccc.int/climate-action/climate-neutral-now/resources-and-frequently-asked-questions#eq-1

Urban Europe. (2020). *EUROPE TOWARDS PED*.

van Summeren, L. F. M., Wieczorek, A. J., Bombaerts, G. J. T., & Verbong, G. P. J. (2020). Community energy meets smart grids: Reviewing goals, structure, and roles in Virtual Power Plants in Ireland, Belgium and the Netherlands. *Energy Research & Social Science*, *63*, 101415. https://doi.org/10.1016/j.erss.2019.101415

Wieczorek, A. J. (2019). *Community based Virtual Power Plant*. Interreg North-West Europe. https://www.nweurope.eu/media/8549/cvpp-valorisation-tue_anna.pdf

Wittstock, B., Goerke, J., & Blumberg, M. (2019). Understanding the contribution of cities to a carbon neutral society. *IOP Conference Series: Earth and Environmental Science*, *323*, 012072. https://doi.org/10.1088/1755-1315/323/1/012072

Zhang, C., Wu, J., Long, C., & Cheng, M. (2017). Review of Existing Peer-to-Peer Energy Trading Projects. *Energy Procedia*, *105*, 2563–2568. https://doi.org/10.1016/j.egypro.2017.03.737