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Delivering of a PED project

How mixes of policy instruments can help to understand the delivering of a PED project

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Abstract

The IPCC reports of the last few years indicate upcoming and already on-going effects of climate change (IPCC, 2021). Positive energy districts (PED) are focussed on lowering these greenhouse gas emissions through turning urban districts into renewable based energy positive areas, changing energy production, efficiency and flexibility. This research will analyse how different mixes of policy instruments should develop a PED. The policy instruments analysed were categorised within three different policy phases, formation, adoption and implementation. The policy instruments used in the different policy phases will be analysed with theory and through a questionnaire conducted with different PED projects. Both theory and practice agreed upon the importance of nodality and organisational policy instruments within the formation and adoption phase. However, within the implementation phase the instruments were highly explorative and still searching for a best way to deliver. Future implementations were presented but did not feel truly understood; theory might be further than practice within the implementation phase. Furthermore the political context of the different cases influenced the power of the local governments. Future research could be able to find which mixes of instruments are best suited within the implementation phase.

Introduction

1.1 Background and relevance

The latest report of the United Nations Intergovernmental Panel on Climate Change stated in 2019 that there are only eleven years left to save the planet before an irreversible climate change is triggered (IPCC, 2019). Concerning this IPCC report the changes to the planet are already irreversible but there is still time to change the overall outcome of climate change (IPCC, 2021). From 1750 onwards, concentrations of greenhouse gases have continued to increase in the atmosphere, unequivocally caused by human activities (IPCC, 2021). This has warmed the atmosphere, oceans and land causing widespread changes to the atmosphere, ocean and biosphere (IPCC, 2021). The IPCC measured that in 2019 the atmospheric CO2 concentrations were higher than at any time in at least 2 millions years (high confidence) and concentrations of methane and nitrogen were higher than at least the last 800.000 years, this conclusion is categorised as very high confidence (IPCC, 2021). The increase of these greenhouse gases causes global surface temperatures to rise at an unprecedented rate. The temperatures of the last 2000 years are depicted within Fig. 1.

These temperatures are reconstructed through paleoclimate archives, materials that preserve evidence of past changes in climate change (grey line) and observations (black line).

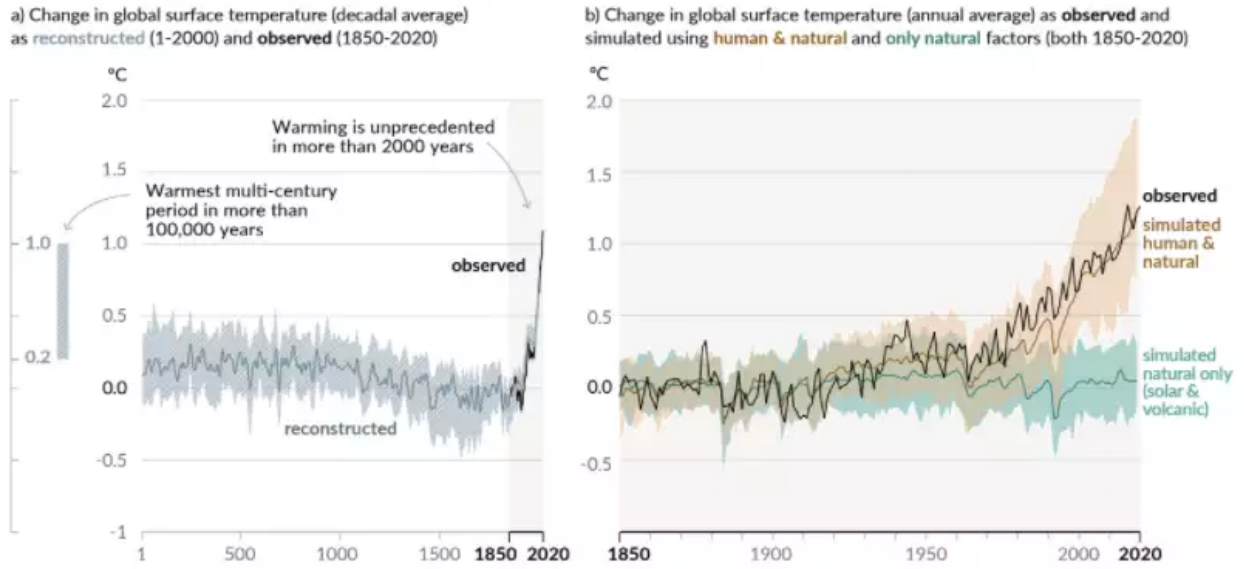

Figure. 1: History of global temperature change and causes of recent warming.

Human induced climate change can have huge implications for life on earth. Extreme weather, loss of biodiversity and sea level rising are only some of the impacts it has. Already, climate change is affecting weather and climates in all regions across the globe (IPCC, 2021). Evidence of observed changes extremes are already in, such as heat waves, heavy precipitation, droughts and tropical cyclones (IPCC 2021). To challenge climate change and its related issues, we need to decrease the emission of greenhouse gases and return earth to a more stable state (IPCC, 2021).

Globally the use of energy represents the largest proportion of human induced greenhouse gases, with energy used in industry (24,2%), transport (16,2%) and energy used in buildings (17,5%) of the global greenhouse gas emission (Our World in Data, 2020a). To diminish the greenhouse gas emission of this large contributor the European Union has set new emission targets to become the first climate neutral continent by 2050 (European Commission, 2020). The European Commission proposed in September 2020, as part of the European Green Deal, to raise the 2030 greenhouse gas emission reduction target to at least 55% compared to 1990 (European commission, 2020). The European Green Deal calls for supplying clean, affordable and secure energy where renewable energy sources play an essential role (The European Green Deal, 2019). Next to the energy transition concerning the sources another important pillar is building and renovating in an energy and resource efficient way, especially where the building stock is highest, cities.

Cities have become the centre of social economies and human activity, since 2007 there are more people living in urban areas than rural areas (Our world in data, 2021b). These urban areas are increasingly important in the reduction of carbon emission and are essential for global carbon emission reduction (Mao et al. 2019). Especially because in urban areas, mainly through rapid economic development, energy consumption and emission is still rising (Mao et al. 2019). Different European projects are conducting energy projects and policies to reduce energy consumption and emission within European urban areas. Within this setting, Positive Energy Districts (PED) has emerged as a central concept to support the European energy transition and thereby reaching the legally binding climate goals of 2030 and 2050 (Paris Agreements of 2015). PED projects are energy-efficient and energy-flexible districts, groups of buildings, which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy (Bossi et al. 2020).

Next to the importance of urban areas as centres of social and economic and human activity, thinking on a smaller scale also grew in importance in another way. Increasing evidence was found that the battle against climate change should not only be fought on the macro level (national/international) but also on the local level. Local authorities are required to be an active part of energy transformation concerning demand and supply (Saheb et al, 2019). Furthermore, a somewhat smaller scale such as districts/neighbourhoods can be considered as an “optimal” scale to accelerate sustainability, small enough to innovate quickly and big enough to have meaningful impact (Ecodistricts, 2013). Also, these smaller scale districts or neighbourhoods are aiming to become more environmentally conscious and are looking for an option to contribute. De Groote and Rapf (2005) even conclude that local communities have a key role to play towards a more sustainable energy system, due to the fact that buildings account for 40% of energy consumption and emission. To include the community and lowering overall energy consumption and emission of private property, blockchain technology could play a role. Especially the management of renewable energy sources and energy autonomy of communities can be altered through the use of blockchain technology.
When developing such positive energy districts, the government benefits from a good policy design. Many efforts of governments and citizens to create a better world have failed due to poor policy design (Howlett, 2018). This failure of noble efforts, often due to complexity, has led to a greater appreciation of difficulties of designing public policy and the importance to correctly understand the nature of policy instruments and their governance context (Howlett, 2018; Lester and Goggin, 1998). If the complexity of an issue is high, it becomes more importance to understand the different policy instruments in the policy

mix (Howlett, 2018). Therefore, to make public energy transition projects more successful and to overall lower greenhouse gas emission, it is important to understand policy instruments and its governance context. A policy instrument is a technique that governmental authorities use to execute their power to ensure support and effect or prevent social change (Verdung, 1998). The different policy instruments will be analysed in three different policy design phases using the phase model, which consists of the formation, adoption and implementation phases. Through understanding the different policy instruments and policy mixes used in different phases a clearer policy design can be achieved, possibly leading to a higher number of successful energy projects and overall leading to lower emission of greenhouse gases.

Research on policy design, policy mixes and policy instruments has been done extensively by many researchers, such as Howlett (2018), Anderson (2004) and Parsons (1996). Furthermore, Bossi et al. (2021) performed research on the delivering of a PED project. However, the combination of these two academic fields of study has not been done before. Researching how mixes of policy instrument in different policy phases can deliver a PED project could therefore be seen as a perusing a research gap. The results therefore might validate these theories found in academic literature and give insight into a new academic pathway. This is useful to the scientific community as it provides new knowledge to the rapidly changing scientific subject of the energy transition.

The necessity of reaching the climate goals is evident, but it remains unclear on how to best achieve these goals. The PED concept seems to be a promising strategy, but can it be applied everywhere? The concept of PED and the PED program is still in an exploratory phase searching for best mix of instruments. It remains unclear whether the program as a whole can be considered a feasible solution concerning the overall climate goals. This study will try understand the use of mixes of policy instrument into different project phases delivering a PED project.

1.2 Research framework and outline

The main goal of this research is to get insight into mixes of policy instruments throughout different project phases within a PED project, reaching congruence between the project goals and the sufficient mix of policy instruments. To analyse this the following research question is put central in this study:

> "How can mixes of policy instruments support the delivering of a PED project?"

The following sub-questions have been formulated that will provide a substantiation for answering the main research question:

1) Which mix of policy instruments are described by literature to support the delivering of PEDs?
2) Which mix of policy instruments, in practice, are used in the delivering of a PED project?
3) How do theory and practice on mixes of policy instruments relate to each other?

Theoretical framework

This chapter introduces the theoretical framework that underlies the current study. First the concept of policy design thinking gets discussed followed by the concept of policy instruments. Secondly, the different policy phases are explained through the phase model. Thirdly, the PED concept is researched followed by a policy template, which is a combination of all theories used within the theoretical framework.

2.1 Policy design

Policy design thinking holds that policy making is fundamentally based upon constraint actors attempting to match policy goals with policy means in a process of applied problem solving. Identifying problems and matching solutions to them, it involves finding policy goals to policy deliberation and discourses and using policy tools to attain those goals (Howlett et al. 2009). Overall policy can be described as: ”A purposive course of action or inaction followed by an actor or set of actors in dealing with a problem or matter of concern” (Anderson, 2014). This definition by Anderson (2014) focuses more on what is actually done instead of what is proposed and therefore differentiates it from a only a decision to policy as something that evolves over time. Public policies are developed by public bodies and officials but can be influenced by nongovernmental actors and factors (Anderson, 2014). When facing public problems there is the need for governmental intervention. This notion of ‘public’ presumes that there is a certain domain/sphere that is not purely individual (private), but held in common (Parsons, 1996). This public dimension of human activity is regarded as requiring governmental or social regulation or at least common action (Parsons, 1996). Overall the focus on realising policy design thinking has always been intended policy outcomes by consciously matching goals and means (Howlett & Mukherjee, 2015). This appropriate combination, well thought out and constructed (designed), can be seen as a policy design. Policy design can be described as: *“The deliberate and conscious attempt to define policy goals and to connect them to instruments or tools expected to realise those objectives”* (Howlett et al. 2015, 292).

To reach the set objectives, governments need tools for governing to influence society and thereby solve societal problems (Vabo & Røiseland, 2012). The tools can even been seen as an important component in all democracies in order to link democratic participation to societal change (Idem), in this sense it could be said that an empty toolbox of policy instruments means that democracy itself is failing (Hood and margetts, 2007; Vabo & Røiseland, 2012). Solutions (policy instruments) should be aligned with the public problem. Public policy instruments are a set of techniques, which governmental authorities use to execute their power to ensure support and effect or prevent societal change (Vedung, 1998). For policy makers it is crucial to have a good overview of the generic forms of these instruments, because choosing the appropriate combination of policy instruments is of high importance in giving effect to policy ambitions (Vedung, 1998). The design study can generate better and improved ways to construct policies and aim to maximise, or even optimal, results are achieved from the expenditures of scarce government resources (policy instruments) (Howlett, 2018).

Concerning Howlett (2014), a distinction can be made between the new and old policy design approaches. Where the old policy design can be categorised as a single instruments design straightforward means-to-end approach (Hood 1893). The latter is a more comprehensive perspective on policy design, it views policy design as an interactive mix of goals and instruments (Howlett & Lejano, 2013). The old policy thinking, revolving around Tinbergen (1952), was that most effective policy truly consists of a 1-to-1 goals means to end ratio, where one instrument fully addresses one policy goal (Knudson, 2008; Geet, 2021). Within this research we will tend to new policy design thinking, because the energy transition is a complex issue and cannot be dealt with by a single instrument that has a multitude of problems and solutions. Therefore, as Tinderbergen (1952) already anticipated, this research acknowledges that maintaining the 1-to-1 ratio is not doable because comprehensive policy goals do require mixes of policy instruments also a policy design should be understood as a mix of interrelated goals and instruments that are deployed throughout the policy process (Howlett, 2014). Even, in practice, picking the 'best' instrument in a particular public problem can be quite problematic. There is no 1:1 correspondence between the problem and the fitting policy instrument and/or a multitude of instruments could solve the same problem (Howlett, 2018). This study aims to understand the mixes of policy instruments shed light on the 'right' mix of mutually supportive instruments.

2.2 Policy instruments

Policy instruments, as discussed above, are the tools which governments use to find solutions to their issues. In practice policy instruments mixes are the real tool which governments use to operate. In the current government system policymakers are increasingly asked to come up with innovative solutions to complex policy issues (Howlett, 2018). To deal with this increased complexity it is important to understand singular policy instruments. Because, understanding the singular instruments of governance increases in importance when the complexity of the problem at hand is increasing (Howlett, 2018). Within this research the NATO-model will be used to analyse the policy instruments.

2.3 Categorising policy instruments

Numerous scholars attempted to identify the different instruments and classify them into meaningful categories (Gunningham et al. 1998; Howlett, 2009). One of the more influential categorisations is the NATO-model by Chrispopher Hood (1986), who proposed that all policy tools used, belong to one of four categories of governing resources: "their information in their position as a central policy actor ('nodality'), their legal powers ('authority'), their money ('treasure'), or the formal organisation available to them ('organizational') or 'NATO'". These four types of policy instruments can be used both as detectors, used by governments to get information, and as effectors to influence society (Vabo & Røiseland, 2012). Each of the governing resources will be described in more depth below.

Nodality-based instruments are mainly based on sending and receiving information. This nudging is performed from the government's position to traffic information on the basis of having "the whole picture"; this status is given through their respective size and amount of (expertise) information compared to other societal actors (Vabo and Røiseland, 2012). Nodality equips governments with a strategic position from which to dispense and draw information for no other reason than it is the (knowing) centre (Kuehnhanss, 2018). This power is only limited through credibility and how governments spend their resources (Kuenhnhanss, 2018). Examples of the nudges and nodality tools are presented in Table 2.1.

Authority-based instruments give governments the ability to force societal actors, typically expressed in laws and regulations (Hood and Margetts, 2007). Authority implies the legitimacy of legal or official power whereby authoritative rules are often followed by negative sanctions such as, demands, prohibitions, guarantees and judgement (Vabo & Røiseland, 2012). Furthermore, authorization refers to the process of giving an organisation or person permission to do something. Recognising the authorisation of non-state actors is one of the principal regulatory activities of the government (Freiberg, 2018). The authorization tool is one the first of regulatory tools employed by governments. Nowadays, with the movement of decentralisation of state in regulations and increase in private actors in regulations, systems of certification and accreditation (also authority tools) have grown in importance (Freiberg, 2018).

Treasure-based instruments are related to the many economical tools governments have at their disposal. Via treasure tools governments can finance certain actions or behaviour (Hood & Margetts, 2007). Therefore, the government can confine everything that can be freely exchanged, as rewards as well as fines. These tools are also referred to as *carrots* either rewarding someone or letting them pay which will make something cheaper in terms of money, effort, time or other valuables to steer certain actions (Vabo & Røiseland, 2012). It is important to note that the treasure tool differentiates from authority because addressees are not obliged/bound to take the involved measure (Verdung, 1998).

Finally, organizational-based instruments are administrative reforms about the organisations that comprise the infrastructure of government and involve the design and deployment of organizational policy tools. The organizational tool, at the core, is about the treatments/physical power the governments possess (Hood and Margetts, 2007), in forms of individual skills, properties and equipment, denoting governments own capabilities and capabilities to act (Vabo & Røiseland, 2012). One could argue that the organisation is a precondition for the other three categories of policy tools (Verdung, 1998; Hood & Margetts, 2007; Vabo & Røiseland, 2012). This makes sense because governments obviously need organization to develop and employ policy instruments. It is expected that new organizational policy tools will, eventually, result in different policy outcomes (Lægreid, 2018). Organizational tools are sometimes referred to as 'forgotten fundamentals' of government activity and policymaking (Salamon, 2001). However, they are a key aspect of government action, enabling them to be capable and physical to act directly and using their own power.

The NATO-typology is, mostly, based on the notion of a hierarchical government, that the national and subnational governments are separated from society and that policy instruments bridge this gap (Vabo & Røiseland, 2012). However this notion of a hierarchical government and a gap between society and government is highly challenged. The (new public) governance is understood as a shift from hierarchical to a governing style through different networks, including the inclusion of market and civil society (Vabo & Røiseland, 2012). Within this research, as of most scholars, we acknowledge this shift towards a less hierarchical management and governing. However, the governments still play an essential role in public policy making and service delivery and that governance networks therefore still need to be anchored in a hierarchical government (Vabo & Røiseland, 2012; Baker and Stoker, 2011). Due to that conclusion, this research will analyse both substantives as procedural instruments. There will not be a distinction between the two when analysing policy instruments in different project phases. However it is important to acknowledge its differences due to the change in government style, these differenced will be explained

shortly below. Furthermore, the research by Vabo and Røiseland (2011) concluded that the hierarchical based structure of the NATO-framework, despite the different context of the modern era, still applies.

Within policy design thinking policy instruments are often categorised in substantive and procedural instruments. Substantive policy instruments are those directly providing services or goods to members of the public or government (Howlett and Giest, 2013). The substantive policy instruments are based on a more traditional way of governing and heavily influenced by economists (Howlett, 2018). They were designed as a more command and control approach to regulations or subsidies which would determine price quantity or other characteristics of goods and services provided by public or private enterprises (Howlett, 2018). Procedural instruments act to indirectly "guide or steer policy processes in the direction government wishes through the manipulation of policy actors and their interrelationships" (Howlett, 2000). A procedural component entails all the processes and activities necessary to coordinate the activities of policy actors in charge of making decisions, administrating the alternatives and formulating (Howlett, 2016, 2011). Their outcome is less direct; they do not directly deliver goods and services but do tend to affect the delivery of these goods and services. It intends to modify or alter the nature of the policy process at work (Howlett, 2000). The aim of their taxonomy of substantive and procedural policy instruments was both a better description but also prescription. Table 2.1 presents a taxonomy of substantive policy instruments based upon Hood (1986). Although it is important to understand the difference between substantive and procedural instruments no differentiation is made in the data analyses.

Taxonomy of basic policy instruments

		Resources Used			
		Nodality	Authority	Treasure	Organisation
General principle Governing use	Substantive (Effectors and Detectors)	Advice Training Reporting Registration	Regulation Self-regulation Licencing Census-Taking	Grants User charges Loans Tax credits Polling	Administration Public enterprises Policing Consultants Record- keeping
	Procedural (Positive and Negative)	Education Advertising Training Misleading (information and propaganda)	Treaties Advisory committees commissions Banning groups and associations	interest group funding/ creation research Eliminating funding	Hearings Evaluations Institutional bureaucratic reform Administrative delay Information suppression

Table 2.1, Based upon: Howlett (2011); Howlett and Giest (2013)

2.4 Policy congruence

Recent policy design thinking has recently focussed on the need of various parts of mixes to be integrated and coordinated for maximum effectiveness (Cashore and Howlett, 2007). Policies are composed of several elements and correspondence across these elements is required if policy goals are to be integrated successfully with policy means (Cashore and Howlett, 2007). This includes the principle of congruence, "the ability of goals and instruments to work together in a uni-directional or mutually supportive fashion" (Howlett and Rayner, 2007). Design literature has recognized that correspondence across the elements (goals, objectives, settings, instruments logic, mechanisms and calibrations) is required if policy goals are to be integrated successfully with policy means (Cashore and Howlett, 2007). Where older policy design thinking assumed all combinations of all policy instruments were possible due to unlimited degrees of freedom from policymakers. Empirical studies however, show that this can only be found in highly specific cases and is quite rare (Thelen, 2003). More present policy design thinking takes into account the spatio-temporal complexities, meaning these studies 'match' design to both spatial and temporal contexts (Howlett, 2011). This newer policy design thinking includes the principle of congruence of reaching agreement between the policy goals and policy means and their more fluid form (Howlett, 2011).

2.5 Contextual aspect of policy instrument choice

Concerning Vanesa Weyrauch et al. (2016): "Context is the complex environment that influences how policy decisions take place as the result of simultaneous interactions between various stakeholders. As mentioned in paragraph above also policy design is influenced by spatial and temporal contexts. Within this paragraph the influence of different layers of governments and government policy choice are discussed.

The relation between supranational, national and sub-national legislations can alter the capability of local governments to implement their preferred instruments. In some systems, national set targets are further allocated to the provinces (sub-national governmental organisations) through specific national processes (Somanathan et al. 2014). As for example in France, where European targets are adopted into national goals, leading to all regions over 50,000 inhabitants are required to prepare 'Climate and Energy Territories Plans' to meet these goals and to illuminate adaptation needed (Somanathan et al. 2014). These different layers of government can either assist or limit the capabilities of local governments depending on the interaction between the governance levels (Somanathan et al. 2014). Sub-national efforts could even, in situations of lacking national political momentum, attempt to compensate for this with locally founded projects (Schreurs, 2008).

A research by Hughes and Urpelainen (2015) found that the choice of policy instruments in the energy sector depends on the interests of industry, public demand for climate change policies and the institutional capacities of governments. They found that for example differences in electoral institutions within democratic settings could also affect outcome. As Bailey and Rupp (2005) also conclude, institutional factors and national policy styles are key factors in accepting new environmental policy instruments. Next to the influence of political systems the local context and aims is also of importance. Many studies suggest that city (and regional) planning is highly contextual and process orientated (Mirakyan and De Guio, 2013).

2.6 Policy instruments throughout the policy process

To understand the use of different policy instruments we used the NATO-model but to understand the use of these different policy instruments within a project we will use the Phase model. In general, policy making is often explained through the policy cycle, meaning different stages within a policy cycle in a project. Harold Laswell proposed the initial policy cycle in 1956, which consisted of seven stages: intelligence, promotion, prescription, invocation, application, termination and appraisal (Chapman et al. 2016). These stages have somewhat stood the test of time in public policy theory. However, it is now generally agreed that there is no termination phase because the process is cyclical and therefore the termination phase does not make all that much sense (Chapman et al. 2016). Within the public policy making theory there is general agreement that the policy process begins with agenda setting (problem identification) and ends with evaluation before beginning anew (Howlett et al. 2003). Table 2.2 gives an overview of accepted models and shows the phases differ slightly depending on the assessors' choice of terms (Chapman et al. 2016). Models help understand decision making in distinctive yet partial ways; it helps to analyse processes which in reality are more intertwined and interconnected (Morgan, 1997). The phase model is both in science and in policy practise the generally most accepted and respected model (Anderson, 1979).

Selected overview of policy cycle stages.

Author	Howard (2005)	Howlett and Ramesh (2003)	Jann and Wegrich (2007)
	Agenda setting or problem identification Analysis of policy issue(s)	Agenda setting	Agenda setting: problem Analysis of the policy issue(s) recognition and issue selection
Policy cycle stages	Formulation of policy responses decision to adopt a specific policy response	Policy formulation Public policy decision making	Policy formulation and decision making
	Implementation of the chosen policy evaluation of policy	Policy implementation Policy evaluation	Implementation Evaluation and termination

Table 2.2, Adopted from: Chapman et al. 2016

The Phase model suggests that decision making is the succession of different situations in the formation, adoption and implementation and evaluation of a policy (Crosby and Bryson 1992;Teisman, 2000). To analyse the decision making process and to categorise the use of policy instruments into different phases this research will use the Phase model, consisting of the theoretical distinction of the three phases, formation, adoption and implementation.

Using a model such as the phase model the researcher must be aware of the fact that reality does not reflect the assumption of the model (Teisman, 2000). The phase model provides a theoretical basis of

understanding the policy making process. The different phases are all interlinked and overlap in practice; they are not necessarily performed in a predetermined order (Mirakyan and De Guio, 2013). Planning in a shared-power situation hardly ever follows a structured sequence through the different phases. It is important to understand that, especially in practice, policy can be understood and examined as a combination of several processes that are interrelated. Therefore it might be difficult to distinguish between the different phases, however they still can be conceived as distinct components that are determinants for government action (Sato, 1999). Furthermore, when using the Phase model there is, or at least should be, one actor whose decision supersedes the one ot the others so it could determine the problem and the policy (Teisman, 2000). Although the Phase model acknowledges the existence of wicked problems (Rittel and Webber, 1973) in the sense that they have no definite formulation, cannot be solved immediately and are unique, the phase model still assumes they exist and should be known before a search for solution can begin (Teisman, 2000). In the next section the different phases of the phase model are explained more in-depth.

2.6.1 Formation phase

The formation phase refers to the process of generating options on what to do about the public problem. Policy options that might help resolve the issue are identified, refined and formalised (Howlett, 2009). Furthermore an initial feasibility assessment of policy is conducted but the formation efforts are moved towards the next phase. Formulating the course of action entails this phase of the model (Howlett, 2009), exploring the various options or alternative courses of actions available for addressing the problem (Howlett, 2009, Jones, 1984). This exploration leads to measuring the merits and risks of the various options, narrowing down what policy-makers are willing to accept before the options move towards a more formal 'policy analysis'.

The formation phase of policy making and deciding on feasibility of the different options can be set, regarding Howlett (2009), into four different phases: appraisal, dialogue, formation and consolidation.

- The appraisal phase is based on generating and receiving input on policy problems and solutions. From a multitude of sources such as, research reports, expert testimony, stakeholder input or public consultation (Howlett, 2009).

- The dialogue phase facilitates communication between policy actors that have different views on potential solutions and issues. Proving both formal and informal opportunities for discussion or invitations to express their different perspectives. The formal, more structured, settings tend to privilege experts input and frustrate new participants, while informal settings engage actors from a lesser-established organisation tend to add energy and enthusiasm to the dialogue on policy options (Hajer, 2005).

- The formation phase sees the public officials contemplate the evidence on various policy options and draft proposals on which options, if any, will proceed to the next phase (Howlett, 2009). This feedback/result can take the form of draft legislation or regulations but could also identify a certain framework for public and private actors to further discuss a more specific action plan (Howlett, 2009).

- The consolidation phase provides policy actors, who are displeased by the recommendation of the formation phase, the opportunity to provide feedback on the recommended option(s). Policy actors can support the recommendations, come around and join the consensus or continue to dissent from the recommendations.

2.6.2 Adoption phase

The adoption phase is a policy process where the options that have been debated and examined within the previous phase are approved as an official course of action. The adoption usually produces some kind of formal/informal statement of intent on the authorised public actor to take, or not to take (Howlett, 2009). It comes down to choosing from the limited set of alternatives provided by the formation phase. This decision can be 'positive', in the sense that they, once implemented, can alter the situation in some way. Or they can be 'negative' in the sense that they will do nothing to the public problem (Howlett, 2009). This process of selection is not a technical exercise but is highly political; it recognizes that the decision creates winners and losers when an instrument is regarded 'positive' or 'negative' (Howlett, 2009).

The most prominent actors within this stage are actors that occupy formal office of government, which have both power by vote and by voice (Howlett, 2009). Other actors, non-state actors, can however influence the choices made via lobbying activities and through these persuade and encourage policy actors to make certain choices (Howlett. 2009). These actors, however, only have a voice and no vote.

2.6.3 Implementation phase

When a decision is made towards a course of action this now must be put into practice. This phase of putting policy decisions into action is called the implementation phase (Howlett, 2009). While policy decisions identify the means to pursue their goal, the policy choices within the implementation phase need to attain results.

Policy implementation often relies on civil servants and administrative officials to manage and establish necessary actions. However, non-governmental actors can also be included and this is done more and more through the years (Howlett, 2019). The implementation phase is actually the process of doing everything to ensure that the formulated policies take effect, to apply it to the target population (Anderson, 2014). This implementation process is not a routine, nor a very predictable process (Anderson, 2014). The process of implementation appears to be routine, actions like processing requests, writing reports, collecting information, and so forth. Nonetheless, the consequences of implementation for the content of a policy, and its impacts and degree of success, are just as important as the formation and adoption phase (Anderson, 2014). If implementation fails then all that preceded phases were pointless as well.

The paragraphs above on policy design, policy instruments and the phase model provide a theoretical basis for this research. This understanding of building a policy design and the understanding of different policy instruments helps understand the importance of this process and how this should be applied within the concept of PED. Understanding instruments and categories of instruments provides a theoretical understanding on how to reach congruence between policy goals and policy means. Furthermore, these paragraphs provided the theoretical basis for the policy template presented in table 2.5.

2.7 PED and the local energy transition

In the European union there is no definition in terms of legal framework towards the energy transition on a district level. Definitions such as 'zero-energy' and 'energy community' do exist but possess no legislative power (Shnapp et al. 2020). Nevertheless, there are numerous (policy) instruments that are able to support citizens, communities and authorities to develop such districts (neighbourhoods) and communities (Shnapp et al, 2020). Many of those instruments and programs however have been focussed on the concept of integrated renewable energy systems in buildings (Lindholm et al. 2021). Projects such as Net-zero energy building (Panagiotidou and Fuller, 2013), Zero Emission building (Lund et al. 2013) and Positive energy building (Kolokotsa et al. 2011) focus only on the different energy relations towards a singular building. The PED projects however focuses on an entire district of a city and is therefore better equipped to manage the renewable energy demand and supply because this can be unevenly distributed throughout the district, which allows for a more strategic installation of renewable energy systems and energy storage (Lindholm et al. 2021).

Moreover, evidence shows that the battle against climate change should not only be dealt with on a macro level (Global, national) but also on a local level. Local authorities are required to be an active part of energy use and production needed for the survival and well being of their citizens (Saheb et al, 2019). On a local level the district scale can be considered as an "optimal" scale to accelerate sustainability, small enough to innovate quickly and big enough to have a meaningful impact. (EcoDistricts, 2013). Furthermore, The applications and findings from the neighbourhood and district level could have potential implications for future energy policies (Shnapp et al, 2020). Also comparing the district/neighbourhood approach to individual energy neutral houses it has a better performance, due to its better management of energy demand and generation and a higher level of flexibility. Districts are, in contradiction to single buildings, able to have different energy generating resources because of their bigger size. However, the scale of the operation, moving from singular buildings to districts, also increases the complexity of the energy performance assets and design factors (Erzen, 2017). So the importance of the neighbourhood level lies in its ability to innovate quickly and its innovation to have a meaningful impact. Furthermore its transition could potentially influence future energy policies and has some scaling advantages and disadvantages concerning individual buildings. Therefore current European energy projects are often focussed on districts/neighbourhoods (Lindholm et al. 2021), as are the PED projects.

The simplest definition of the PED is that the district generates more renewable energy than it consumes on an annual basis (Lindholm et al. 2021). The program on positive energy districts (PED program) is conducted by joint programme initiative (JPI) urban Europe, which is a knowledge hub for urban transition, and the Strategic energy technology (SET) plan action 3.2, which assists to boost the transition towards a climate neutral energy system through the development of low-carbon technologies in fast and cost-competitive way (Bossi et al. 2021, Urban Europe, 2021, European commission, 2020). The Program was established in October 2018 with the mission to bring about 100 urban districts or neighbourhoods in Europe by 2025 with the clear commitment towards sustainability, liveability and going beyond carbon neutrality by becoming energy positive. This was the foundation of PED and positive energy neighbourhoods (PEN's). These districts should be developed and also provide solutions concerning urban district renewal (Urban Europe, 2021).

The PED program can be seen as a contribution to current policies on achieving the goals of reducing Europe's carbon footprint. Managing cities' ambitions towards sustainable urban development, with cities contributing to 70% of global CO2 emission. Furthermore, according to EU directive 2010/31, buildings in the EU account for 17,5% of the total energy consumption (Our World in Data, 2020a). The PED framework believes that urban areas should therefore play a leadership role in driving global action to address it. Energy performance of buildings was usually done individually, the PED strategy however applies an integrated strategy for building renovation, energy efficiency and local energy production of renewable energy sources (RES) in a locally connected holistic way (Monti et al. 2016). The key concept of PED is that the district produces a surplus of renewable energy, a PED district is described as follows:

"Positive Energy Districts are energy-efficient and energy-flexible urban areas or groups of connected buildings which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require integration of different systems and infrastructures and interaction between buildings, the users and the regional energy, mobility and ICT systems, while securing the energy supply and a good life for all in line with social, economic and environmental sustainability" (Urban Europe, 2021, Bossi et al. 2020).

The PED concept is, schematic, depicted in Fig. 2.1. It illustrates the geographically distinct area, all within the circle, and the electricity grid and district heating outside of this area. This example is a PED autonomous which is, as other forms of PED's, explained further beneath the image.

PED Autonomous.

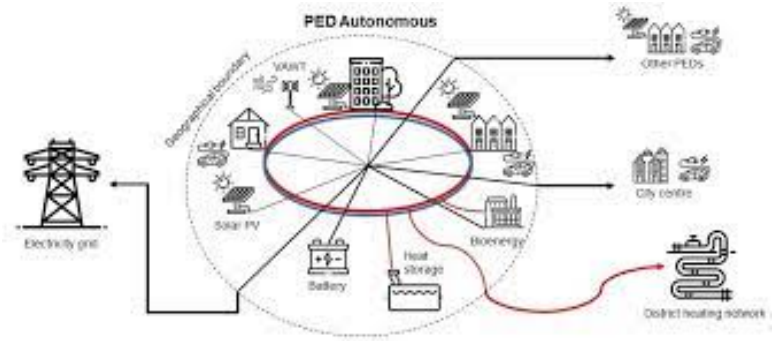

Figure 2.1, Adopted from Lindholm et al. (2021).

Three different PED concepts were developed in a PED definition workshop organised by the European Energy Research Alliance (EERA) joint Programme Smart Cities (Wyckmans et al. 2020)

- PED Autonomous - a district with clear geographical boundaries that is completely self-sufficient energy wise. The entire energy demand of the district is covered within the district generated by renewable energy. However, there is no import of energy. The district is able to export the surplus energy to the external grid (Fig. 2.1).
- PED Dynamic - a district with clear geographical boundaries that had an onsite generation of renewable energy, annually, which is higher than its demand. The district can openly interact with the external electricity grid as well as district heating and gas networks.

- PED Virtual - a district that allows the implementation of "virtual" renewable energy systems and energy storage outside its geographical boundary. However the combined renewable energy generation inside the district and the virtual renewable energy systems should be higher than the annual energy demand of the district.

These different PED concepts also present new challenges concerning management of energy systems. The production of RES have undergone massive changes and development in recent years. Mainly due to a rapid increase of volume as a result of privatisation, unbundling of the energy sector and boosted financial incentives and energy policy incentives (Andoni et al. 2019). This increased generations units of RES create new challenges concerning balancing the energy supply and ensuring the stability of the energy network (Monti et al. 2016). As shown above the different PED concepts all interlink in new ways to the existing electricity network, making managing it even harder. This challenge, concerning Monti et al. (2016), calls for improvement of communication and information structures at the community level. Where districts should be seen as complete units with their own local energy source management where they can sell their excess energy and buy more energy when needed. This philosophy relates to the PED concept of being energy efficient within the district. However the problem concerns the fragile supply of RES. Due to its unpredictability and its dependency on weather conditions RES are not stable. Furthermore, it adds complexity to operating the electricity systems, with its unpredictability of supply (Andoni et al. 2019). With the energy system becoming more active, decentralised, complex and multi-agent with an increasing number of actors and possible actions an altered energy system is needed (Andoni et al. 2019).

As mentioned earlier, the PED is not only an algorithm for calculating the input and output of energy. It rather is a framework that takes into account, economic, cultural and climate-related diversity of European countries and cities. The framework outlines the three most important functions of urban areas in the context of their urban and regional energy system. Concerning energy, the three main pillars consist of energy production, efficiency and flexibility, which are further explained below. Guided by principles concerning quality of life, inclusiveness, sustainability and resilience and security of energy supply (Urban Europe, 2020).

The first energy pillar of the PED framework should be to rely on renewable energy only, the energy production function. Furthermore, preferably the energy will be produced and locally and regionally will enable sustainable reduction of greenhouse gases and ensure economic viability (Urban Europe, 2020). However, the local production of renewable energy is highly context dependent on the local and regional availability of RES. The PED's also encourage the use of waste heat (Urban Europe, 2020).

Secondly, energy efficiency is one of the priorities in order to utilise the renewable energy availabillity. The energy efficiency function is based on reduction of energy consumption in the PED: "balancing out the needs of the different sectors, building infrastructure, the use of energy, settlement typology, as well as transport and mobility." For example, mixed-use settlement could be an effective instrument to minimise transportation costs. Also "grey energy" and resource efficiency will be other important aspects within this energy function (Urban Europe, 2020).

Lastly, energy flexibility is of high importance because urban areas are the largest consumers of energy. The PEDs need to make sure that they act in the most beneficial manner towards the energy system (Energy flexibility function). This is done through actively contributing and balancing of the regional energy systems with the optimal benefit for regional energy systems in mind via demand side management, sector coupling and storage. Furthermore, it is important to manage the interactions between urban districts and regional energy systems on how to best use RES (Urban Europe, 2020).

When developing PEDs, the context of the urban area's is very important. The density, type of buildings, available local renewable energy resources and many more variables can alter the course of action. The conceptualization of the PED concept is a work in progress, meaning, there is no predefined or guaranteed prescription for success (JPI Uban Europe, 2021). Furthermore, JPI Urban Europe (2021) conducted a survey with 62 PEDs and found that stakeholder involvement, integrated technology and funding/ business models where labelled highest as success factors by the individual projects.

2.8 Building a PED policy template

Within the next paragraph this research will try to build a theoretical basis of policy instruments used in energy transition projects and placed in the corresponding phase. As mentioned before, the strategy of energy transition projects in urban areas differ from one another. Analysing the theoretical basis concerning policy instruments and putting them into the corresponding phases will present an overview of theoretically sound instruments. This template, presented in table 2.5, will present a theoretical framework that can later be tested against the gathered data.

2.8.1 Formation phase

Within energy projects their seems to be inconsistency between energy policy tools and energy policy goals (Chapman et al. 2016). Their study found that there is a clear disconnection between issue identification, policy formulation (tool selection and target setting). Policy tools rewarded renewable energy generation that were not concerned with the potential impacts on society (Chapman et al. 2016). The energy policy documents did mention ideals regarding societal fairness but in reality no policy tools were in place to realise these aspirational goals. This misalignment shows the importance of a strong formation phase, which aims to identify issues and provide a range of possible solutions. Reaching congruence between policy goals and means.

Including the social aspect in energy transition projects starts, according to Urrutia-Azcona et al. (2020) with new organisational structures. The first step is the creation of a local group headed by the local authority, providing stability in the process. They should map and engage key local stakeholders, including representatives from all quadruple helix branches (government, industry, academia and citizens) (Wyckmans et al. 2019). To get more information a pre-analysis must perform a literature review at the city level, delving on existing policies, regulations, strategies, and plans, complemented by semi-structured interviews with experts and surveys on citizens perception (Urrutia-Azcona et al. 2020). When all stakeholders are engaged and the city's information is gathered, the next step should be to organise working groups. These working groups perform strategic city diagnostics, scenarios and city vision generation, strategic plans and action plans (Urrutia-Azcona et al. 2020). To get an in-depth analysis of

external factors a project could also conduct a PESTLE (political, economic, social, technological, legal, environmental) analysis (Urrutia-Azcona et al. 2020).

Another feasible strategy is to use experiences and best practice from other cities and regions (Mirakyan and De Guio, 2013). Several associative networks and internet platforms have been established, such as EERA-JPSM, where cities can collaborate either long term or on a project base relation and share their experiences. Transferability of different projects is of great importance within the. With a central planner approach and the use of (mostly) open data the level of transferability is higher (Mainzer et al. 2015). These initiatives tend to also be an additional motivation for other cities to also perform sustainable development measurements (Mirakyan and De Guido, 2013). However, using insights from other projects is not always applicable due to the specific context of the different cities. To determine the context of your own projects different tools can be used, for example, perform a strength, weakness, opportunity and threats (SWOT) analysis to determine which lessons can be adopted and which might nog fit (Terrados et al. 2007). Or use soft system mythology (SSM), to define the context of the problem and the relevant objectives for the different stakeholders (Neves et al. 2009). Other studies implement an OSTM-TRIZ based approach to analyse the initial situation, define the problem and goals while taking into account the existing or the potential solutions (Mirakyan et al. 2009).

Next to determining local context it is important to assess the energy system within the district. This could be performed via energy system modelling. Mirakyan and de Guido (2013) propose a list of quantitative methods and tools to analyse this, ranging from simulation, linear optimization to physical counting. The general purpose of energy models are, predict or forecast the future, to explore the future (scenario analysis) or to look back from the future to the present ("backcasting") (van Beeck, 2000). Specific purpose of the models is often energy demand models, energy supply models, impact models and appraisal models (van Beeck, 2000). Concerning Urrutia-Azcona et al (2020), these modelling actions are needed to enhance a carbon emission baseline which is crucial to perform further strategies and projects towards energy transition.

All information gathered within the formation phase can be bundled into a city background information package (CBIP). Once all the information is gathered, a foresight exercise could be conducted. The strategic city diagnosis must be supported by the contribution of local stakeholders, which are organised in thematic working groups (city visioning- and expert workgroups). These will provide critical topics and main input for scenarios (Urrutia-Azcona et al. 2020). All suggested scenario's from working groups should be developed, by local steering groups, into workable scenario's. These workable scenarios should be put out to the working groups and start discussion towards a preferred 'master scenario" (Urrutia-Azcone et al. 2020). These "master scenarios" now need to be envisioned into reachable goals and integrated within the municipal planning and strategies (Urrutia-Azcona et al. 2020).

2.8.2 Adoption phase

Within the adoption phase the different participants preferences and possible solutions towards the issue are taken into consideration and a preferred solution is chosen. Economic benefit has long been the singular measurement criterion of energy and environmental planning and decision making (Greening and Bernow, 2004). However, energy planning is complex and multidimensional, the sub-optimal single criterion solutions do not always support the long-term sustainable development targets (Mirakyan and

De Guido, 2013). Furthermore, the tools and methods used within the adoption phase should support the decision-making procedure, which involves different stakeholders with varying interests, angles and opinions. The conventional economic methods have, from this group decision perspective, numerous limitations. This due to the fact it is unable to deal with varying interest, angles and opinions (Mirakyan and De Guio, 2013). In contradiction to this singular approach the multi-criteria approach is able to with multiple different options and therefore better support the decision-making procedure. The multi-criteria decision making methods can be used to identify a set of Pareto optimal solutions. When using multi-criteria decision analysis (MCDA) methods it is highly important that the formation phase, the defining of objectives, is done properly because these goals are can significantly influence the results when using MCDA (Bond et al. 2008). In the context of energy planning the MCDA method is not just there to define the 'best' plan. It can support the understanding of the multi-criteria complex situation that supports interactive planning and learning. Furthermore, it helps people systematically consider, apply value judgement and document the value and alternatives of each recommendation (Mirakyan and De Guido, 2013). Some examples of MCDA software tools are, DECISIONARIUM global space for decision support (Decisionarrium, 2021) and Decisions-deck project (Decision Desk, 2021).

The approach by McKenna et al. (2018) compares the use of existing optimization models in combination with MCDA framework to allow structured alternative formulation and an overarching participatory approach to the problem with the integration of key stakeholders. The MCDA framework is also used in PED projects, because these projects have a multitude of objectives, energy efficiency, energy production and energy flexibility in combination with social and cultural values. The MCDA framework represents a formalised framework, which draws on a variety of methods to provide transparent and systematic support in complex decision making (Stewart, 1992). MCDA seeks to find an optimal solution amongst a theoretically infinite number of alternatives, with for example, multi-objective mathematical programming methods (Mckenna et al. 2018). Also methods which seek a sort of a finite set of alternatives under consideration of the decision maker which are under consideration of decision makers subjective preferences (Mckenna et al. 2018). The subjectivity and uncertainty surrounding the alternatives make an uncertainty or sensitivity analysis indispensable (Mckenna et al. 2018). MCDA is able to combine different policy instruments such as, workshops and energy models to formulate a certain decision. This combination of instruments is depicted within Fig. 2.2 below, indicating the interaction between information from workshops and the data from the energy model.

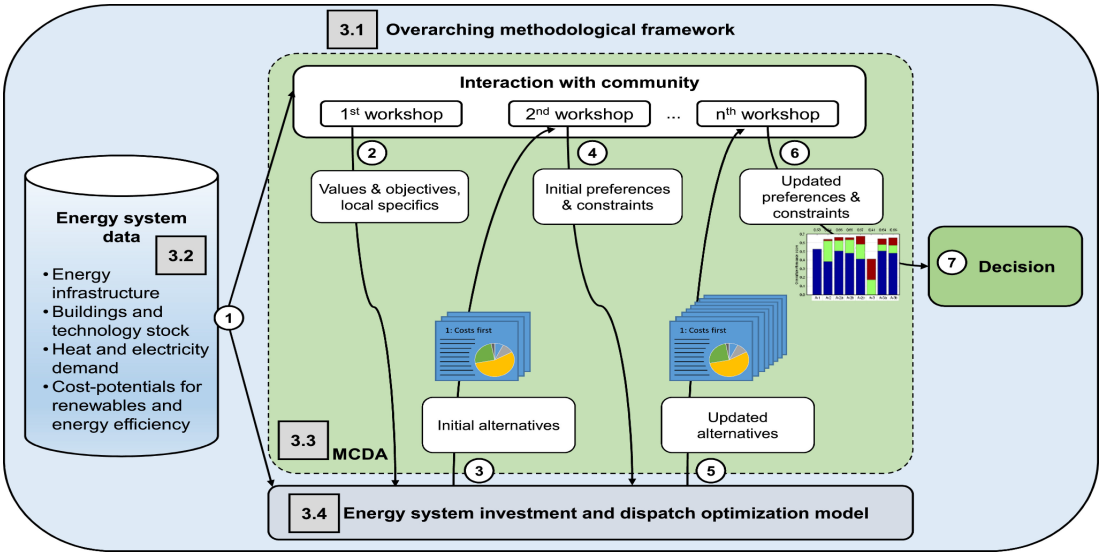

Figure 2.2, MCDA Framework (McKenna et al. 2018).

Within the example above the citizens engagement is perceived valuable in reaching a decision. This citizen engagement should create a sense of ownership adopted within their own district, positively influencing the success of a PED project through higher local impact and citizen trust (Bonsón et al. 2016). Citizen engagement has significant importance in relation to the success, development and implementation of PED (Fatima et al. 2021). Concerning JPI Urban Europe (2021) individual PED cases stated that the highest contributing factor to a successful PED project was stakeholder involvement. The recruitment of citizens may form a challenge, but this could be resolved through extensive promotion and reaching out to citizens via various channels, such as social media, and provide motivation for participation (Fatima et al. 2021). Moreover, citizen interaction should also give room to mention feedback, not only interaction for the sake of interaction. Experts should be ready to modify their plans based upon comments of citizens. Furthermore, they should use a different formats. Common formats such as presentation, discussions, workshops and working groups. But also informal formats such as exhibitions or more event-like formats which create more awareness, emotional impact and create more discussions with local residents (Fatima et al. 2021). The earlier citizens are engaged within the process the higher the project's success (Fatima et al. 2021), meaning, they should be engaged within the formation phase providing local information and preferences. But also should be engaged within the decision making process and therefore these instruments relate to both the formation as the Adoption Phase.

Coming to a long-term sustainable decision it is important to include and engage citizens as well as other stakeholder included in the quadruple helix perspective (government, industry, academia and citizens). This interaction leads to the broader framework identifying opportunities to become more sustainable. Innovation playgrounds provide these different stakeholder to connect with one another. They can develop and test urban prototypes and beta projects, get help mature their ideas through crowd-solving, crowd-funding and match-funding. Furthermore, they can receive assistance developing business models (Wyckmans et al. 2019). These innovation playgrounds are based on co-creation of knowledge by

stakeholders and require flexibility in terms of direction and format to allow the entrance of new/different stakeholders (McCormick and Hartmann, 2017).

2.8.3 Implementation phase

After the choice of the direction the plan should be developed. This 'master plan' is embodied by actual projects and programs, which should satisfy the proposed conditions of previous phases. The methods and tools used within this phase can highly differentiate depending on the projects and the needs of investors or planners (Mirakyan and De Guio, 2013). Especially within the implementation phase both geographical and political differences between regions can alter the instruments choice (Mirakyan and De Guio, 2013).

A study done by Mao et al. (2019) researched policy instrument implementation within low carbon pilot and model city in China, from 2008 to 2014. Their research analysed the effectiveness of these policy instruments on a low-carbon city. Translating their results on the use of policy instruments in a low carbon city from towards a NATO typology classification resulted in table 2.3

Policy instruments researched

Instrument	Amount	Percentage	Type
Regulations	28	56%	Authority
Taxation and user fees	10	20%	Treasure
Information and persuasion	7	14%	Nodality
Assistance	3	6%	Treasure
Voluntary Organisation	2	4%	-
Public enterprises	N/A	0%	Treasure
Direct provisions	N/A	0%	Authority
Auction of property rights	N/A	0%	Treasure
Family and community	N/A	0%	-
Market	N/A	0%	Treasure

Table 2.3 Adapted from Mao et al. (2019).

As shown in the table, the regulation (Authority) policy instruments is heavily favoured within these projects and makes up 56% of total use. Also financial Assistance in terms of loans and subsidies are used and taxation and used fees which combined make up for 26% of the amount of instruments used. Information and persuasion made up 14 % but, notably, did cover all six outcome criteria of the study. Some of the instruments were based on a voluntary basis and had no government involvement, these do not suit the public policy making instruments of the NATO typology. The low carbon city construction is mainly dominated by governments direct manipulation and intervention (Mao et al. 2019) with the use of regulatory instruments complemented with market based means. Furthermore, the study found that the higher the amount of authority based instruments, the higher the policy completion degree (Mao et al. 2019). The reason could be that prescription driven enforcement instruments are more powerful and able to prioritise. Furthermore, these tools are clear and definite to implement which could automatically lead to higher degree of use by policymakers (Mao et al. 2019). The study also found that the best mix of policies was between compulsory instruments and mixed instruments on a ratio of 2:1, meaning, a combination of two regulations and one information, taxation and user fees or assistance is the best mix (Mao et al., 2019).

These results are in line with China's top down approach to reducing carbon emissions. Furthermore the Chinese local governments are more accustomed to compulsory regulatory policy instruments (Mao et al. 2019). So the dominant use of the authority driven policy tools within China might therefore not be a generalizable and transferable strategy. However, other nations such as Germany and Japan also mostly used regulatory policy instruments within their energy related policy making (Hughes and Urpelainen, 2015). Within the German case the IEA-CCD recorded nine major policy packages, including mostly regulatory policies in addition to taxes and subsidies. A similar structure of policymaking was observed within the case of Japan (Hughes and Urpelainen, 2015). The choice of policy instruments is not solely based upon the political system but also on the interest of industry, public demand for climate change policies and the institutional capacities of government (Hughes and Urplelainen, 2015).

Another study done by Kern et al. (2017) researched the types of instruments used in the energy transition in both Finland and the UK between 2000 and 2014. Their analysis found that policy mixes are increasingly complex, with a variety of goals and different types of instruments. As shown in the table below both Finland and the UK heavily relied on regulatory and treasure based instruments to meet EU targets. To reach these targets they had to introduce additional policies into an already crowded space (Kern et al., 2017).

The historical timeline of policy instrument implementation of both the UK and Finland is depicted below in Fig. 2.3 and Fig. 2.4, these figures provide some insight on which policy instruments were used instead of displaying only the instrument category. These figures are summarised within table 2.4.

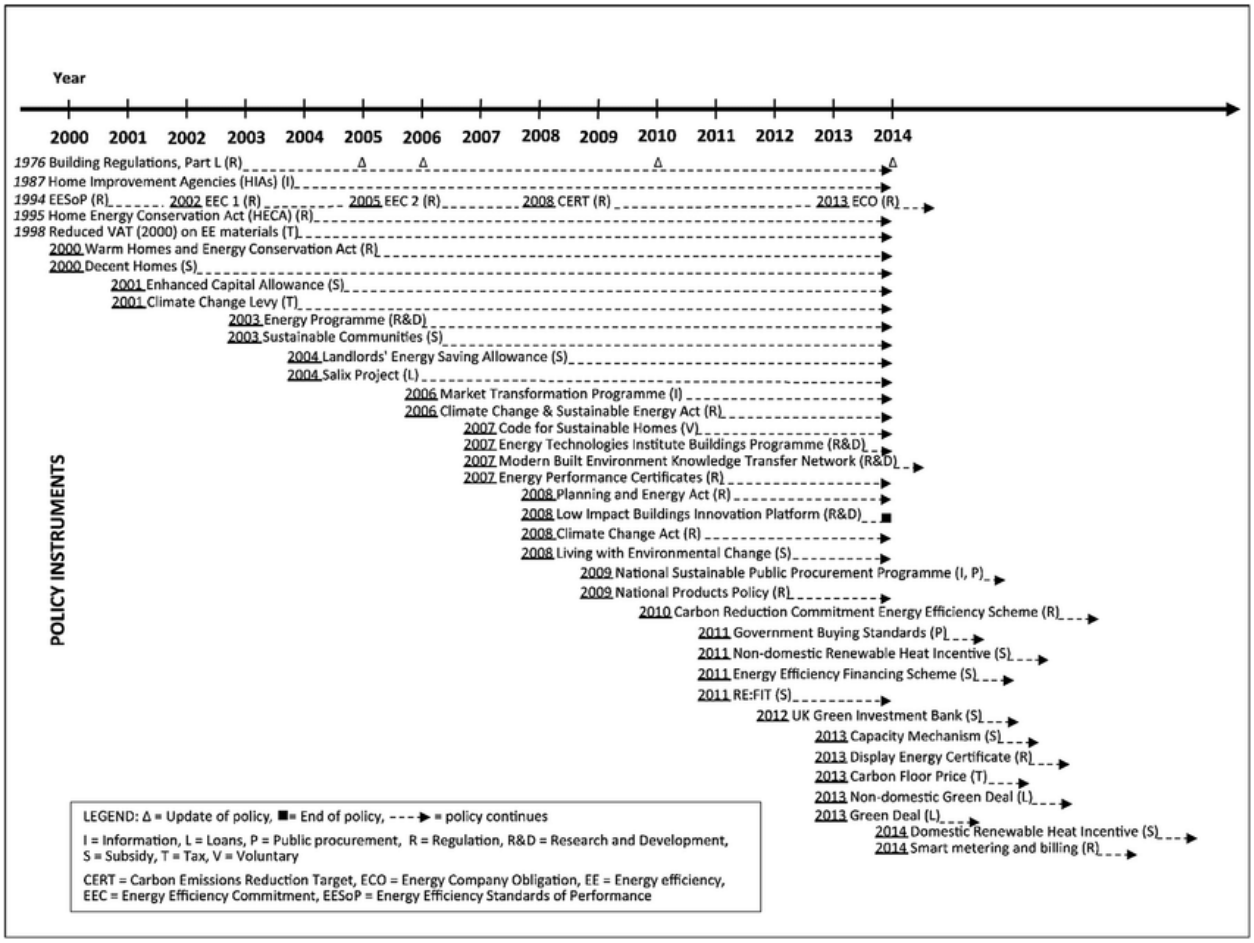

Figure 2.3: The development of the UK policy instruments for building energy efficiency 2000-2014 (kern et al. 2017).

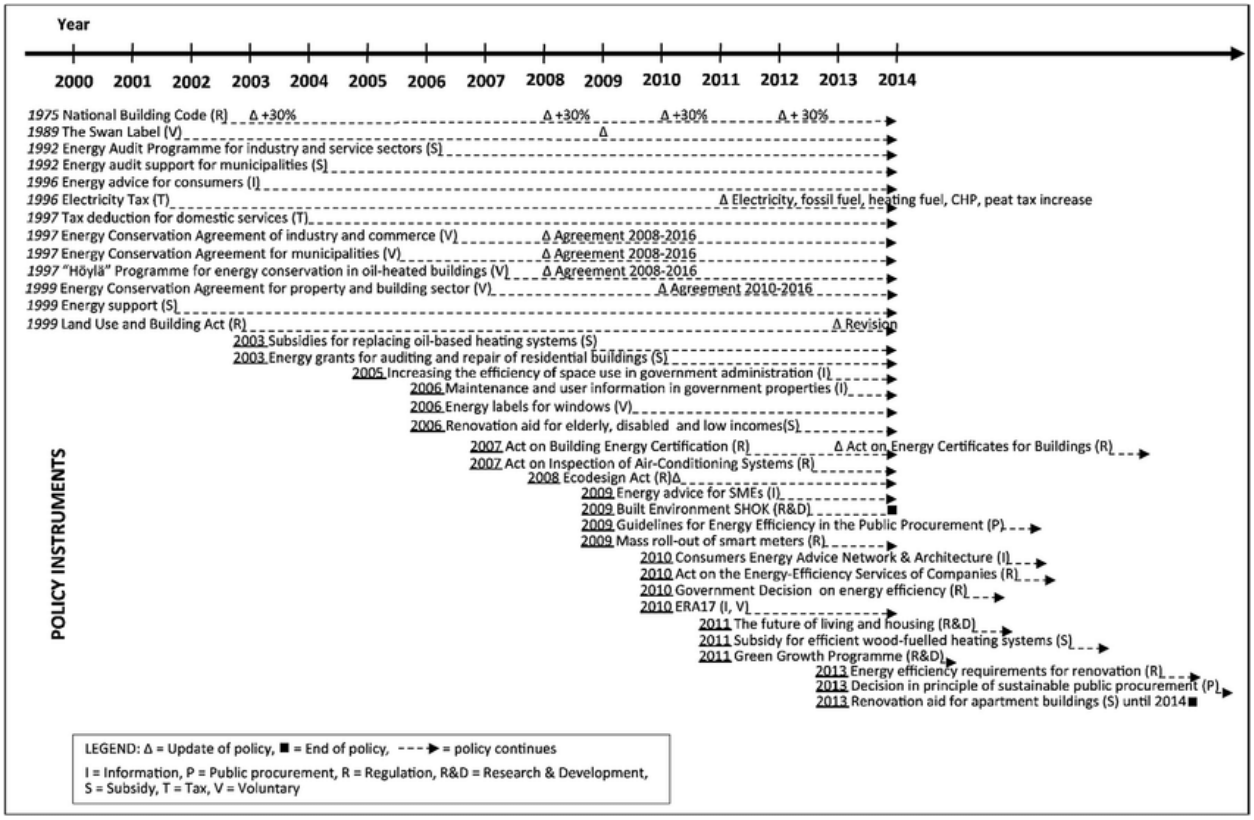

Figure 2.4: The development of the Finish policy instruments for building energy efficiency, 2000-2014.

Summary of types of instruments in Finland and the UK placed between 2000-2014.

Type of instrument	Instrument	Finland	UK
Treasure	Subsidy	8	11
	Loans	0	3
	Taxation	2	3
	Public procurement	2	2
	Research and development	3	4
Authority	Regulations	9	12
Information	Information	6	3
	Voluntary measures	6	3

Table 2.4, Adapted from Kern et al. (2017).

2.8.4 Energy flexibility

As discussed in paragraph 2.3, PED's three important pillars in PED are energy production, efficiency and flexibility. Most implemented instruments within this paragraph were based upon energy production and efficiency. However, concerning energy flexibility also numerous new instruments have potential.

As mentioned earlier, the management of the electricity grid is increasingly challenging as energy systems are becoming more active, decentralised, complex and multi-agent, with an increased number of actors and possible actions (Andoni et al. 2019). Especially within a PED structure where energy is locally produced from a multitude of energy sources the management of the grid can be become problematic. These challenges require advanced communication and data exchanges through the power system which become increasingly challenging from a central management and operational level. Early research and start up initiatives indicate that blockchain is a potential solution to some challenges faced by the energy industry (Andoni et al. 2019). Block chain technology also fits well with the three main objectives of the future energy systems, as stated by the EU and UK, decarbonisation, decentralisation and digitalization, with a shift to empower consumers.

Within the current energy market structure small player participation is excluded and actions to active prosumer participation have proven insufficient (Andoni et al. 2019). Early blockchain initiatives were able to build a platform for completely decentralised energy trading (Andoni et al. 2019). Concerning Marschall (2016) from Deloitte, these blockchain transactional digital platforms are able to reduce operational costs, increase efficiency, fast and automated processes, increased transparency and the possibility of reducing capital requirements for energy firms. This is also depicted within the difference between Fig 2.5 and Fig 2.6. Some examples of implementation of blockchain based policy instruments, mostly based on management, are stated below:

- Automation, meaning block chains could improve control of decentralised systems (Andoni et al. 2019). The adoption of local energy marketplaces enabled by local peer to peer (P2P) trading of energy, can significantly improve behind the metre activities. The energy self-consumption and self-production, which can influence tariffs and revenues, as also displayed within Fig. 2.6 (Andoni et al. 2019). This could also be applied to the concept of PED, the district arranging its own production and consumption without a central party. This could lead to potentially having overall cheaper energy.
- Grid management on blockchain technology could assist the management of the decentralised networks, flexibility services and asset management (Andoni et al 2019). Blockchain can achieve integrated flexibility trading platforms and optimise flexible resources which otherwise lead to expensive network upgrades and through this influence revenues and tariffs for network use (Andoni et al. 2019). Difficulties with renewable energy, distributing energy when it is needed to where it is needed, is more easily managed within a more local energy grid in contradiction towards a national energy grid.
- Sharing of resources, blockchain could offer charging solutions for sharing resources between multiple users. For example, sharing EV charging infrastructure (Dal Canto, 2016) or common centralised community storage, as also shown in Fig. 2.6
- Trading and markets, blockchain-enabled and distributed trading platforms can alter the energy market, such as wholesale market management (Andoni et al. 2019), commodity trading

transactions and risk management. There are also blockchain systems being developed concerning green certificate trading. Other benefits can be automated billing, more competition, security, identity management and an increase in transparency (Andoni et al. 2019).

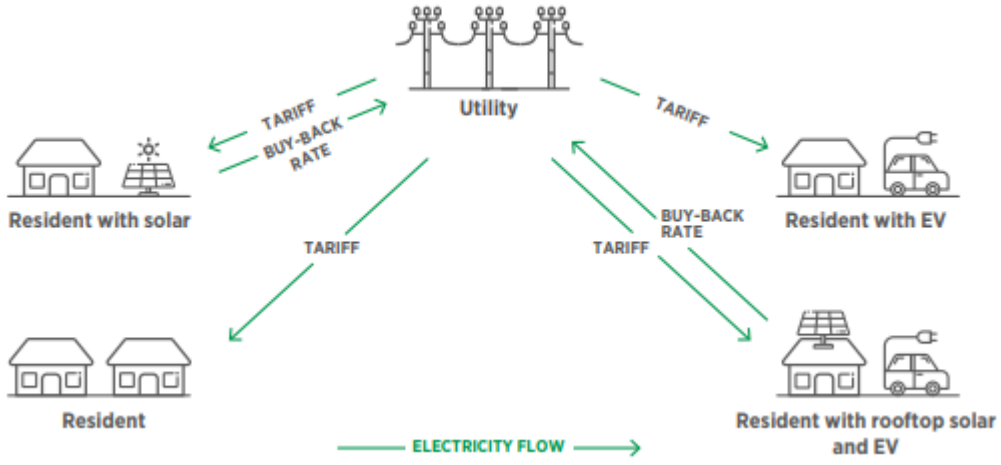

Figure 2.5: Traditional trading model of energy. Source: ((IRENA, 2020) adapted from Liu et al. 2019).

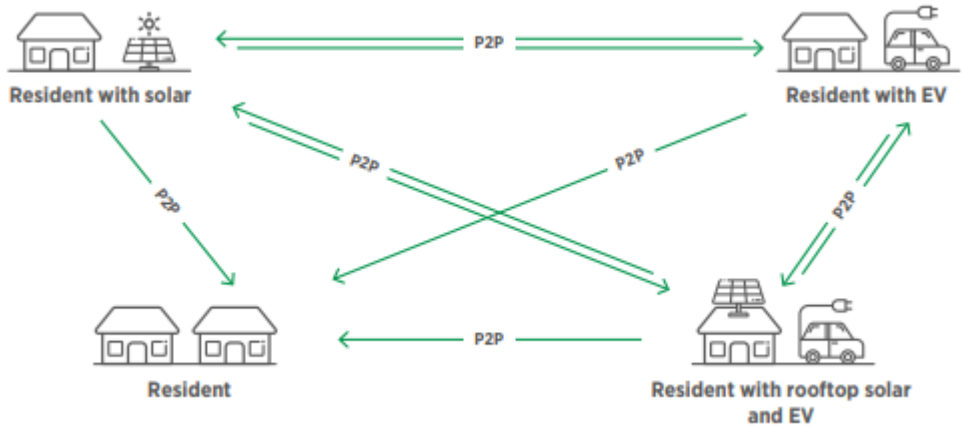

Figure 2.6: Structure of P2P electricity trading model. Source: ((IRENA, 2020) adapted from Liu et al. 2019).

2.9 Policy instrument template

Combining the literature from policy instruments, policy phases to the actual used policy instruments in energy transition project resulted in the Policy Instrument Template (Table 2.5) below. It indicates which instruments, theoretically, should be considered when a delivering a PED projects.

Table 2.5: Policy instrument Template.

Phase:	*Instrument resource:*	*Instrument description:*	*Examples:*
Formation	Organizational	Foundation of local group headed by local authority	**Flexens** (European committee of regions, 2021).
Formation	Nodality	A pre-analysis delving on existing policies, regulations, strategies, and plans.	**Semi-structured interviews with experts** (Urrutia-Azcona et al. 2020). **Surveys on citizens perception** (Urrutia-Azcona et al. 2020). **Literature review at the city level** (Urrutia-Azcona et al. 2020).
Formation	Nodality	Strategic foresight diagnosis	**SWOT** (Terrados et al. 2007) **SSM** (Neves et al. 2009) **OSTM-TRIZ** (Mirakyan et al. 2009).
Formation	Nodality	Learn From other examples	**European energy research alliance Joint programme smart cities (EERA JPSM)** (EERAJPSM, 2021).
Formation	Nodality	Energy models	**Energy plan** (Lund and Munster, 2006),(Lund, 2005), (Lund, 2007). **Simapro** (Manisch et al. 2006). **Anylogic** (Hodge et al. 2011).
Formation	Nodality	An in-depth analysis of external factors	**PESTLE analysis** (Demirtas et al. 2021).
Formation	Organizational	Organising of working groups of Different stakeholders help deciding on:	- **strategic city diagnosis** - **scenario's and city vision generation** - **strategic plan and action plan**
Formation	Nodality	workshops	**City visioning workshop (**Urrutia-Azcona et al. 2020). **Expert workshops (**Urrutia-Azcona et al. 2020).

Adoption	Nodality/Organizational	MCDA	**DECISIONARIUM** (Decisionarrium, 2021). **Decision-deck** (Decision Desk, 2021).
Adoption	Nodality	Learning Workshops	**Interviews, mock-ups, forecasting, participatory design methods, storyboards, future workshops, brainstorming and experience prototyping** (Wyckmans et al. 2019).
Adoption	Nodality/Organizational	Innovation Playgrounds	**Climathons and Participatory Mapping** (Mee et al. 2021).
Adoption	Nodality/Organizational	Urban living labs	**Amsterdam institute for advanced metropolitan solutions** (Amsterdam institute for advanced metropolitan solutions, 2021).
Implementation	Authority	Regulations	**Act on the energy efficiency services of companies**, 2010 (Kern et al. 2017). **Smart metering and billing,** 2014 (Kern et al. 2017).
Implementation	Authority	Energy management	**Automation** (Andoni et al., 2019). **P2P-marketplace** (Liu et al., 2019). **Sharing resources** (Andoni et al., 2019). **Trading and markets** (Andoni et al., 2019).
Implementation	Treasure	Subsidy	**Subsidy for efficient wood-fuelled heating systems**, 2011 (Kern et al. 2017). **Energy Efficiency Financing Scheme**, 2011 (Kern et al. 2017).
Implementation	Treasure	Loans	**Green Deal, 2013** (European Commission, 2021).
Implementation	Treasure	Taxation	**Carbon Floor Price, 2013** (Kern et al. 2017).
Implementation	Nodality	Information	**Market transformation Programme, 2006** (Kern et al. 2017).
Implementation	Nodality/ Organizational	Information	**Consumers Energy Advice Network & Architecture, 2010** (Kern et al. 2017).

2.10 Conceptual model

Fig. 2.7 is the conceptual model used in this study. The conceptual model presents which policy instruments are congruent to the ambition to deliver positive energy district. The conceptual model illustrates the relation between the theories used within the theoretical framework and how these theories assist in answering the research question. The NATO-typology provided understanding of categorisation and understanding of the different policy instruments. The phase model gave insight into the different phases within a policy process. Combining these two theoretical concepts led to the basis of the policy template, which was filled with numerous theories concerning the energy transition and PED theory. Building the policy template was of high importance because this allows for comparison with the actual developed PEDs. The policy instrument template illustrates the policy instruments which should be congruent with the policy goals. The model helps to understand how to reach congruence between policy instruments (right mix of policy instruments) and policy goals (reduction of emission through implementing the 'best' PED projects). Although a perfect congruent scenario seems unfeasible to reach, understanding how it works should improve the outcome.

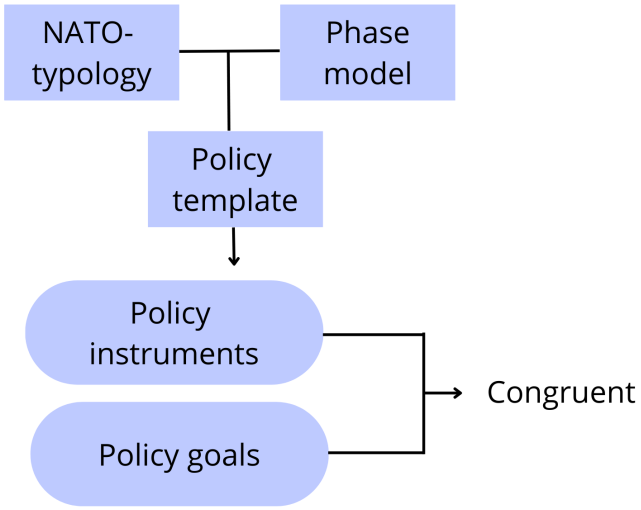

Figure 2.7: Conceptual model

Methodology

The previous chapter outlined the theoretical backbone of this research to give academic meaning to the analysis. Within this chapter the methodological approach is presented. This chapter will give insights in the research design, the study design, selection of cases, data analysis methods and ethical considerations. A well-structured research design is of high importance, as Clifford et al. (2016) argued, to produce convincing and meaningful results. This chapter on methodology is designed to inform the reader on the research strategy of this study to answer the main research question.

3.1 Research design

The aim of this study is to understand how mixes of policy instruments can help deliver a PED project. By doing so, the study looks at gaining knowledge on how different policy instruments within the policy phases alter the delivery of a PED project. Aiming to illustrate on how these differently categorised policy instruments relate to the delivering of a PED project. To analyse how this is done, this research conducts a case study methodology. Case studies are often criticized for less objectivity, representative significance or robustness compared to other approaches such as standardized surveys or archival data research (Yin, 2003); Gog, 2015). However, this research is exploratory in nature and presents results via "storytelling", which according to Cog (2015) is a more reasonable approach when the causal relationships between the observed phenomena are just in the explanatory phase. The essence of a case study is that it seeks to highlight a decision or a set of decisions, why they were made or how they were implemented and with what result (Schramm, cited in Yin, 2014). As mentioned earlier, this study aims to develop an empirical understanding of how mixes of policy instruments are used to deliver a PED project. A case study fits well with this aim because it offers the possibility to gain integral knowledge on a specific process in practice (Clifford et al. 2016). Moreover, the phenomenon of a PED is a rather new concept and its application in relation to the use of different policy instrument in different phases is a new, explorative approach.

To understand and build the research design, the researcher must be aware of the different philosophical worldviews (ontologies) that influence the practice of research. The entire research design is a combination of interaction between philosophical worldviews (Ontologies), selected strategies of inquiry and research methods and how we can require knowledge of the world around us (Epistemology). Merriam (2009) recognizes four primary epistemological perspectives: postpositivist, constructivist, postmodern/poststructural and the critical approach. The postpositivist approach is focussed on observing and measuring reality, while the interpretive approach is designed to analyse multiple realities, descriptions, and experiences of the population (Merriam, 2009). The postmodern/poststructural approach deconstructs previous truths and perspectives, while the critical approach is designed to strengthen and identify emancipatory information (Merriam, 2009).

This research exemplifies an epistemological, constructive perspective, as the primary objective is to gather data on all the respondents' worldview. Constructive epistemology assumes that truth is a construct of group dynamics and is always dependent on context and never value-free. There are no right or wrong answers and there could be a multitude of truths. The constructivist

approach is appropriate for doing qualitative research because the benefit of using qualitative data lies in the ability to understand what is important to people (Silverman, 2010) and in this case, what people believe are important policy instruments in delivering a PED project. Overall, the importance of qualitative research is that it provides rich, contextual information that often cannot be gathered through quantitative research designs (Merriam, 2009); qualitative research looks beyond data and numbers to provide meaning and context. A constructive epistemological perspective provides research with a framework for predicting, describing, empowering and deconstructing population-specific worldviews, increasing the base of knowledge that leads to improved understanding of the purpose behind qualitative research (Merriam, 2009).

3.2 Case selection

The selection of the cases was based on their relevance to the research objective, meaning that the cases were selected on the basis of level of completion (at least implementation phase), as the aim is to analyse formation, adoption and implementation phases and data on all three phases are needed. Furthermore, the cases were ambitioned to be from different geographical areas because geographical features are of influence on policy instrument choices (Mirakyan and De Guio, 2013). Purposeful sampling was done to provide the research with the best information rather than random statistical sampling as is often used in quantitative studies (Cornelissen, 2012). The evidence gathered in this study is therefore less representative of the entire population, but can provide information for other empirical cases (Cornelissen et al. 2012). The cases were selected from the PED Booklet (Urban Europe, 2020), which consist of 61 PED cases around Europe. A meeting was held with prof. Christoph Gollner and prof. Silvia Bossi, who co-authored the PED Booklet and are conducting research on the use of PED. They provided contact details of the different PED projects and provided data on the selection of the different cases. The selected cases are described and represented in Table 3.1.

Table 3.1 Selected cases

Country:	City:	Neighbourhood:	Inhabitants:
Ireland	Limerick	'Georgian Neighbourhood'	≈5000
Sweden	Lund	Brunnshög	≈ 40.000
Portugal	Evora	Évora city center - Valverde - The industrial and - commercial park	4738 450 0
Spain	Bilbao	Zorrozaurre	≈ 15.000
Finland	Helsinki	-	-

3.3 Data collection process

To retrieve the data, the following methodological research methods were used. First, a literature research was conducted that provided insight into policy design, instruments and policy phases. In addition, literature review helped to understand PEDs in relation to policy instruments. This combined understanding led to the policy template that provided a framework to help compare the gathered data. This theoretical framework was compared with the data collected to draw conclusions between theory and practice.

Secondly, this research conducted an extensive questionnaire to gather primary data, this questionnaire can be found in appendix A. The qualitative based questionnaire consisted of a multitude of open-ended questions and encouraged participants to describe/explain their own answers. As mentioned above, other researchers provided contact details. Via e-mail, the different cases were asked to participate in this study, stating the purpose of the research and the voluntary nature of the questionnaire. A total of twelve cases were selected to potentially participate in the study. Due to non-response, only five cases were eventually researched. The questionnaire enabled numerous "interviews" to take place at the same time across multiple countries. Also the cost of someone participating in a survey is typically lower than in a qualitative interview, which theoretically increases the response rate of the selected cases. Moreover, the questionnaire offered participants the opportunity to express their feeling/meaning in their answers, hence the choice of this research method. However, the questionnaire did not provide the researcher with the non-verbal communication that an interview can provide. An interview with audio recording can provide contextual pauses and the interviewer's responses are even more extensive (Lindh‐Åstrand et al., 2007). Although the questionnaire did not include these features, it is more suitable than a quantitative approach. Quantitative research approaches often tend to make the characteristics of people and communities meaningless, because they cannot be put to numbers (Choy, 2014). The qualitative questionnaires provided the research with both extensive context driven data.

Lastly, a desk research was conducted. The desk research provided secondary data on the five selected cases, which enriched the selected data. The desk research was mostly based on national or local policy documents, such as the Integrated Energy and Climate Plan of Finland or the Energy Targets of Ireland.

The use of multiple methods in a qualitative research to develop a comprehensive understanding of a phenomenon can be referred to as triangulation (Carter et al. 2014). Triangulation increases the validity of the research, creates a more in-depth picture of the research problem and uses different ways to understand a research problem (Carter et al. 2014).

3.4 Data Analyses

The data gathered from the questionnaires and desk research is categorised using the NATO-typology discussed within the theoretical framework. All individual policy instruments are sorted via their policy phase and policy resource. This provides a individual policy template concerning each case, which are displayed within chapter 4. These different policy templates were first tested against the theoretical policy template in table 2.5 providing certain narratives on the

mixes of instruments suggested by theory and used in practice. The next step was to compare the individual policy templates determine the influence of context between the cases. With the foundation of the theoretical framework this research was able to better understand which mixes of instruments, based on their instrument category, are most dominant or absent in the different policy phases.

3.5 Ethical considerations

In a case study involving human "subjects", it is of great importance that they are protected with special care and sensitivity (Yin, 2014). Especially in qualitative research, the researcher must be aware of his position. Therefore, it is important that certain ethical considerations are made to protect the participants (Orb et al. 2001). To achieve this special care and sensitivity, informed consent was obtained for the study, meaning that subjects were informed on the nature of the case study and made aware of the voluntary basis of their participation. Furthermore, the privacy and confidentiality of the participants was protected. In the opening of the questionnaire, participants were informed on the aims of the study, alerted on their anonymity and provided with the researcher's contact details.

Results

This section will describe the results found in questionnaire and policy document analyses. The theoretical policy template design used in the theoretical framework has the same framework as within the results. These criteria are based upon the policy phases and the NATO-typology scheme. The results will be presented in the same way as the policy template is based upon.

4.1 Limerick - Ireland

Limerick is a lighthouse city project which is, in cooperation with CityxChange, striving for developing a framework with supportive tools to enable a common energy market supported by a connected community (Urban Europe, 2020). The Limerick City and County Council (LCCC) are leading the implementation and testing of 11 demonstration projects under the headings of integrated planning and design, common energy market, and community exchange (Urban Europe, 2020).

The Limerick PED project, and other Irish energy transition projects, are backed by a strong foundation of legislative instruments (Climate adaptation strategy, Climate action Act and Environmental impact assessment). The country development plan and Climate Adaptation Strategy make sure the local government keeps updating their plans, with the legally binding aspect of climate change, the national program (RSES) also makes sure local governments oblige to this. The local government also cooperates with community representatives and sectoral interests to set the strategic agenda of their plans and strategy. The implementation instruments range from treasure to authority. Aiming to reach a multitude of different stakeholders, for example private and publicly homeowners. Within these different projects the following instruments were identified as used within the PED projects in Limerick. There was no consideration of using blockchain technology based instruments.

Phase:	**Policy name:**	**Policy Resource:**	**Description:**
Formation	Country development plan	Authority	There is a legal requirement to prepare a development for a municipal area every 6 years. The format and process for the preparation of the plan is set down in law - Planning and Development Act 2000 as amended and associated regulations. Climate change is a mandatory objective to be included in the plan
Formation	Regional transportation land use study	Nodality	Mid West Area Strategic Plan
Formation	Climate Adaptation Strategy	Authority	Climate adaptation strategies are now a requirement in Ireland and all local authority had to prepare one by 2020
Formation	Strategic policy committee	Nodality	This group is made of representatives of the elected council, community representation and sectoral interests and is used to set the strategic agenda of the local authority
Formation	National Planning framework and regional strategies	Authority	These are overarching government strategies that each local authority is obliged by law to have due regard to in the preparation of their plans and strategies.

	(RSES)		
Formation	Limerick 2030	-	- Establish the Limerick Unified business Portal - disseminate the message to generate momentum and signal to other stakeholders who are taking the lead on business across the City *(Organizational)*. - Build broad stakeholder support for the Economic and Spatial Plan through its advocacy in public forums and in engagement with Central Government (Nodality*)*. - Put in place the structures to allow the public, business and voluntary sectors to work together in the delivery process: a joined up collective approach *(Organizational)*. - Commence the necessary studies and assessment to allow the revision of the transport strategy for the City building upon the smarter travel principles and seeking to ensure an integrated public transport, vehicular and cycling/pedestrian strategy *(*Nodality *)*. - Identification of several key development projects *(Authority)*. - More information can be found: (Limerick, 2021).
Adoption	Public expenditure code	Authority	The Irish government requires that projects are subject to the criterias set out in the code depending on the capital value of the project.
Adoption	Decarbonisation zone designation	Authority	The Climate Action Act requires each local authority to designate a decarbonisation zone in which projects are to be trialled and tested to achieve a 50% in CO2 by 2030.
Adoption	Environmental Impact Assessment / Natura impact assessment	Authority	All projects in Ireland are subject to screening for environmental impacts and depending on results of the process and including proximity to protected sites further assessment may be required
Adoption	Planning consent	Authority	Most developments including local authority's own developments are subject to an approval / consultation process depending on their size and scale
Adoption	Citizen innovation - Open calls	Authority	a process of public calls for innovation to address the challenges of implementing the PED the successful parties must have community involvement and have a number of other stakeholders involved
Implementation	Living city initiative	Treasure	tax incentive for the refurbishment of historic building with a focus on owner occupier who can set off the entire cost of a building refurbishment against income tax over 10 years
Implementation	sustainable energy agenda Ireland grants	Treasure	Home energy grants, Electric vehicle Grants, Community Grants, Research funding, Business Grants
Implementation	H2020 - +Cityxchange project		Limerick is part of the +cxc project and is ireland's first lighthouse city
Implementation	An Taisce Environmental Education Unit - Green Schools	Nodality	education programme for schools in the area of environmental sustainability

Implementation	Citizen observation	Nodality	The 3D model enables the Limerick community to visualise the energy use and carbon emissions across their city. Alongside energy consumption data, the platform will provide real-time information on renewable energy generation and storage (Limerick, 2021). : This is a digital platform for increased citizen understanding, ownership and active participation including interactive mapping which will be put in place, enabling a 2- way dialogue regarding the aims, goals, motivations and ambitions of the communities with the urban authorities (Urban Europe, 2020).
Implementation	Regulatory Sandbox	Nodality	Examples of solutions that are to be trialled are peer-to-peer trading, integrated energy system optimisation/balancing between electricity, thermal, and liquid fuels, EV integration, demand response/flexibility and new markets for delivery of consumer-driven decentralised energy systems (Urban Europe, 2020).
Implementation	Flexible Mapping tool	Nodality	This crowd-sourced mapping app is a flexible and open tool which can be used by participating groups as part of an Innovation Playground. It allows people to share knowledge about a particular location, to observe and identify specific features of an area, or to collaborate on sense-making as part of the +CityxChange project (Limerick, 2021). Innovative ideas developed by citizens, entrepreneurs, creatives and other organisations will be prototyped and piloted in specially designated Innovation Playgrounds. Successful prototypes will enter in a third stage via crowdfunding campaigns that will not only be used as funding mechanisms but also as market validation tools and user feedback processes.
Implementation	Typology of energy supply	Authority	Heat Pump System: Replace Fossil Fuels: for example, install an air to air heat pump to replace gas or oil boilers. Solar thermal: Incorporate building integrated renewables: for example, solar thermal to produce Domestic Hot Water supply and/or PV to provide electricity to the building.

4.2 Lund - Sweden (Lund-Northeast - Brunnshög)

The site Brunnshög is located in the northern part of the city Lund, the Brunnshög district has the vision to become a world-leading environment for life, innovation and research. The government is landowner

and energy supplier and can have a strong impact on the built environment. Within the district of Brunnshög a large low temperature district heating system is build. From 10-1-2022 no other PED implementations are present. Furthermore there is no interaction with local citizens, this could change when newly constructed houses are built in the near future.

National Legislations, in the form of Planning and Building Act of 2014, prevent municipalities from setting specific demands regarding technical standards to project developers making it harder to force emission reduction measures on project developers. Within the project the following instruments were identified and used. There was no consideration of using blockchain technology based policy instrument.

Phase:	**Policy name:**	**Policy resource:**	**Description:**
Formation	LundaEko II	Nodality	Lund's program for environmental sustainability
	Focus areas	-	Lund have 4 focus areas
	Focus area 2: Smarter Lund	-	Lund should be leading within innovation and environment
	Brunnshög vision		The vision for the development of the city district Brunnshög (the PED area)
Adoption	Agreements between municipality and contractor	Organizational	Agreement between contractor and municipality has to be reached because within the planning and building act of 2014 it prevents the municipality from making specific demands of their development partners regarding technical standards (Planning and building Act, 2018). Municipalities and contractors therefore must reach an agreement, such a tool is necessary because of the lacking top down directive (Clevenger, 2020).
Implementation	Low temperature district heating	Authority	A large-scale low temperature district heating network is being established, where heat from the research facilities MAX IV and ESS (European Spallation Source) will be recovered. The first deliveries of LTDH started in September 2019 and the grid will in title be 6,5 km long. The waste heat from the facilities will be more than enough to provide heating to the whole area. See COOL-DH project (Urban Europe, 2020).
Implementation	Energy technologies used	Authority	Photovoltaic, Heatpumps, Districts heating system, waste heat, Solar terminal (Hedman et al. 2021).

4.3 Évora (Portugal)

The city of Évora is part of a lighthouse project of POCITYF which is a smart city-orientated project which major goal is to deliver a set of PED's. The project is heavily focussed on the mixed urban environments, with a strong emphasis on cultural and historical protected areas. The improvements must be conducted with this in mind and to deliver in a sustainable and citizen-driven manner. The project will be carried out along 4 Energy Transition Tracks (EET), within the following three different zones:

- Zone 1 (Évora city centre), being an UNESCO World Heritage Site, represents a challenge in terms of deploying solutions; the numerous public buildings will be the source of the solution.
- Zone 2 (Valverde) is a small rural village consisting of 200 buildings, mostly residential, all connected to the LV grid. Valverde has been an innovation hub in what concerns energy-oriented projects of POCITYF and will take the next step in becoming a positive generating energy performance.
- Zone 3 (The industrial and commercial park) forms a different challenge and is mostly based on the implementation of ICT infrastructure,

All project had a different aim. Within zone one the instruments were heavily related to citizens engagement and local values. Where zone two was a test site for new instruments and zone three provided the opportunity to use more technical ICT instruments. Overall, the following instruments were identified as used within the PED projects in Évora. There was no consideration of using blockchain technology based instruments.

Phase:	**Policy name:**	**Policy resource:**	**Description:**
Formation	S.W.O.T. analyse	Nodality	During the SWOT analysis, technical and innovation experts on energy transition participated in the process of identifying strengths, weaknesses, opportunities, and threats, along with city representatives and relevant city experts.
Formation	Decode and clustering process	Nodality	an internal city process, which was performed with the support of the technical and city experts. This process led to the definition of key objectives that could be addressed by a versatile energy transition strategy covering aspects such as energy, mobility, ICT, waste, citizen engagement, and specific solutions for historic cities.
Adaption	Decision Support tools	Nodality	Design-based Value Mapping for Communities.
Adaption	Identifying relevant solutions	Nodality	The specific solutions have been carefully selected by the local ecosystems after long *discussions*

			among the local authorities, energy and technology providers, the citizens, and research organisations, with a view to select the most appropriate ones addressing city needs and linking those to supportive frameworks, i.e., policies and initiatives, as described in previous sections (Girourka et al, 2020).
Adaption	Understanding value of solutions	Nodality	Participants in the survey were asked to describe the value proposition for each solution along with a linkage to potential addressable market needs (Maas et al, 2020).
Adaption	Market research	Nodality	A market research was then conducted to explore market needs and trends and verify that the solutions identified have the potential to become sustainable business cases (Maas et al, 2020).
Implementation	Renewable energy generation (8)	Authority	PV (crystalline silicon) glass//PV canopies//PV skylights//Roof integrated PV systems//PV roofing shingles//Community Solar Farm.
Implementation	Fostering Energy related Innovations (3)	Organisational	Smart cloud for innovative start-ups//Acceleration Programs (i.e., Pocifest).
Implementation	P2P energy trading	Authority	Peer to Peer energy transactions/trading
Implementation	Gamification Platforms	Nodality	Gamification platform to be used for fostering the interaction with energy users in the different types of building at the different energy blocks, creating tailored strategies for disseminating information, promoting challenges and competition based on communities to leverage the impact on energy reduction strategies without compromising comfort levels.

4.4 Bilbao (Spain)

The Bilbao PED project is centred around the neighbourhood of Zorrozaurre, which is an island within the river Nervión. Fig (4.1) shows the island and a conceptual build environment on it. The Bilboa PED project is part of the ATELIER programme (which stands for Amsterdam Bilbao citizen driven smart cities) is a project which forms part of the European Smart Cities and Communities lighthouse programme, creating and replicating positive energy districts.

The Bilbao project aims to try new technologies, new financial and business models which help to promote innovative projects in energy. However, the key ambition remains the creation of PED with a strong and proactive involvement of citizens to increase their energy awareness and energy efficient behaviour and support to play an active role as prosumer. The implemented outcome is, development of geothermal system, an e-mobility hub, smart grid and demand/response offers (International strategies, 2020). They attempt reaching this goal using the following policy instruments:

Fig 4.1 Impression of Zorrotzaurre island after the redevelopment (Climate adapt, 2021).

Table 4.4

Phase:	**Policy name:**	**Policy resource:**	**Description:**
Formation	Workshop 1: (Neighbour LH/FW cities participating in SCC/PED projects)	Nodality	The first Innovation Atelier was held in June 2020. The aim was to draw on the experience of other Basque smart-city projects (Lighthouse and Fellow cities) to pool knowledge, experiences and best practices from their H2020 projects, and thus identify potential collaboration opportunities.
Formation	Energy system modelling (ESM)	Nodality	LEAP
Formation	Energy characteristics		energy characterization of building stock (Enerkad, 2019).
Formation	Workshop 2:	Nodality	Financing energy saving: experiences and alternatives (Martin et al. 2020).
Formation/Adaption	Strategic Stage	-	Step 1, Foundation of a local partnership towards the smart zero-carbon city (organisational). step 2, City information gathering (city background - Information package). Step 3, Strategic city diagnosis (visioning taskforce set-up) Step 4, Strategic planning (Scenarios

			generating and preferred vision) Step 5, Strategic plan and action plan. Step 6, integration of (Step 5) into municipal planning.
Formation/Adaption	Multiple criteria decision analysis (MCDA)	Nodality	To facilitate the definition and evaluation of various future alternatives or scenarios that can guide the transition process of the city in question towards the desired low-carbon future.
Adaption	Quadruple helix methodology - Innovation Ateliers	Organizational/Authority	In the ATELIER smart city project, the design of new participatory mechanisms is based on the Quadruple Helix methodology, an inter-sectoral approach where governance, academia, industry, and citizens build up new decision-making processes.
Adaption	Two-way governance mechanism	Organizational/Authority	The Two-Way Governance mechanism has been developed naturally by combining elements from both the top-down and bottom-up models, combining the highest level, perspectives and demands (EU legislation,) plus citizen driven co-creation or solutions. This innovative instrument combines interdisciplinary and transdisciplinary working mechanisms that structure the generation of urban communities, definition of strategic visions, co-implementation of innovative energy systems, integration of ICT tools, empowerment of communities working as prosumers, etc.
Implementation	Energy efficiency instruments	Authority	district heating based in low temperature geothermal energy (5th generation district hearing), photovoltaic panels
Implementation	Smart ICT implementation	Authority	a smart-grid, increased e-Mobility capacity, smart street furniture and smart lighting systems
Implementation	Energy flexibility	Authority	Smart metering devices, Smart Building Energy Management Systems (smart BEMS) and an overarching Energy Management System (EMS) that will aggregate BEMs and other smart district consumption (public services, storage systems, heat pumps, EV operators, etc.)

4.5 Helsinki (Finland)

Helsinki is part of the lighthouse project mySMARTlife and aims to make the city more environmentally friendly by reducing CO2 emission and increasing the share of renewable energy. The PED projects within Helsinki are part of the bigger Carbon-neutral Helsinki project which aims to cut co2 emission by 80% by 2035 (Urban Europe, 2020). The interventions include innovative technological solutions in connection with energy refurbishments of buildings, usage of renewable energies, clean transport and supporting ICT solutions (Urban Europe, 2020). The PED projects are focussed on the so-called high performance areas in four different districts.

The project's technical actions are carried out within the first three years with a monitoring period of two extra years. The results and lessons learned will be integrated within other districts within the city (Urban Europe, 2020) The main objective on energy efficiency is to reduce consumption by 10% in initial piloting period and expand learnings to further energy efficiency improvements (Urban Europe, 2020). The project's aim is heavily based on buildings, because heating of buildings causes half of Helsinki's emission and emission from buildings can be reduced to up to 80%. Within these different projects the following instruments were identified as used within the PED projects in Helsinki. There was no consideration of using blockchain technology based instruments.

Phase:	**Policy name:**	**Policy resource:**	**Description:**
Formation	Technical and comprehensive study	Nodality	VTT Technical Research Centre of Finland has performed a comprehensive technical and cost-efficiency study on suggested renovation measures for particular type of apartment buildings– information table embedded as pop-up clickable feature onto the model 136 Merihaka apartment buildings
Formation	Property specific or regional opportunities	Nodality	Property-specific or regional opportunities for storing energy (electricity and heat) will be examined, as will the cost effects of these opportunities. Based on the results, objectives will be set for using the storage to increase the demand response level and as reserve power, and an operating plan will be prepared.
Formation	Collecting of extensive data	Nodality	The City of Helsinki has collected extensive data on buildings' energy information for open source use in the Energy and Climate Atlas as an integral part of the 3D City Model. (Link to the model (https://kartta.hel.fi/3d/atlas/#/)
Formation	Mobility plans	Nodality	Mobility plans and other smart transport plans will be implemented for the City organisation, subsidiary communities and companies. The City and HSL, together with entrepreneurs, will survey the needs of companies and the opportunities for reducing traffic and making it more efficient.
Formation	Including of residents - Agile prototyping	Organizational/Nodality	The residents are given opportunities to influence and participate in the development of new Smart & Clean solutions in an economically sustainable manner. - Helsinki uses in kalasatama (Zone 2) agile prototyping to harvest ideas from citizens.

Adaption	Developing flexible regulations	Regulatory/organisational	By developing the regulations on land use planning, the selection of methods that support carbon-neutrality can be expanded. The regulation collection for land use planning will include regulations which are related to the use and production of renewable energy and energy efficiency, which cannot be expected to become outdated soon and which will facilitate flexibility regarding plot conveyance and the further planning and implementation stages, as well as various trials and new technologies to help achieve the objectives.
Adaption	Energy surveys	Nodality	The status of the actions identified in the energy surveys of the last years will be examined and both the unimplemented and feasible actions will be projected. The documentation of the survey implementation will also be developed.
Adaption	Setting, policies, objectives and procedures	Regulatory	Policies, objectives and procedures will be set for facility projects with conflicting interests related to energy efficiency and the utilisation of renewable energy, i.e. costs, profitability, protection values, architectonic solutions and the cityscape.
Adaption	General and common guidelines to support renovation	Regulatory	Descriptions of technical concept solutions will be prepared for different types of projects: buildings of different ages and types, renovations of different types; lifecycle calculations, such as MOBO, will be used here. • Target level for energy conservation or the E value • The implementation measures for heat recovery from ventilation and sewage •Adoption of renewable energy, such as solar panels •Demolition will be examined for unprotected locations where the price of the renovation would be close to the price of a new building.
Adaption	Development of road map of building control	Regulatory	A road map or service path will be prepared for the development of building control in all stages of a construction project to enable energy efficient construction: • The Buildings and Public Areas Division will work on the development in its own processes; for example: the environmental management model.
Implementation	Strengthening through environmental criteria.	Regulatory	The commitment and competence of the actors responsible for construction and maintenance will be strengthened in terms of the low emission levels, energy efficiency and lifecycle impacts of the construction projects and existing buildings and in terms of the environmental criteria used in procurements.
Implementation	Great Energy efficiency	Regulatory	Great energy efficiency will be sought in the renovations of the City's own housing production, and actions for making the buildings more energy efficient will be implemented where they are viable in terms of lifecycle costs
Implementation	Education	Nodality	a. The amount of environmental education in early childhood education and schools will be increased. b. The skills related to the mitigation of climate change and to circular economy will be strengthened in school curricula and in schoolwork, in general. Teachers' knowledge will be expanded.

Implementation	Carbon Ego	Organizational/Nodality	One practical idea in development is an App “Carbon ego” to be used in the daily life of a citizen to follow their own carbon footprint. There will be functions like “challenges” to create social activities around the app.

Discussion

Within the following paragraph the results of the research and the implementation of these results will be discussed. This will be done in the following way, first the results concerning the use of different instruments within different project phases will be discussed. Followed by discussing the importance of contextual factors within instrument choice.

5.1 Phases and instruments

Within all cases the formation and adoption phase seem well established, a clear set of targets and objectives was set. Which is important concerning the European parliament, striving for more transparent policy making and to counter the existing inconsistencies between issue identification and policy formulation (Chapman et al. 2016). Most cases consist of targets concerning energy use or greenhouse emission targets, except for Lund which is striving to become a world-leading environment for life, innovation and research, which seems rather vague and subjective.

When analysing the used policy instruments in the formation and adoption phase between the theory, policy instruments template in Table 2.5, and practice a multitude of similarities arise. Within the formation phase the cases show that information is key, most used instruments within this phase are used to extract information (Nodality instruments). Instruments such as S.W.O.T analysis, energy modelling and in-depth analyses of external factors were suggested in theory and used in the cases. However, these instruments are mainly based on economic and ecological factors and are often the dominant choice in energy related projects in contradiction to the social factors (Chapman et al. 2016). Although these instruments of Nodality were heavily based on economic and ecological factors, the PED cases initiated new organisational structures to include local stakeholders and retain local context and opinions on the projects. Organisational structures such as unified business portal (Limerick), 2 way governance (based on triple helix approach, (Wyckmans et al. 2019) Bilbao)) and Agile prototyping (Helsinki) gave citizens and other stakeholder an organisational structure to express and influence the PED project. As suggested by the research of JPI Urban Europe (2021), stakeholder involvement is the highest success factor in PEDs projects. The use of Nodality and organizational policy instruments within the formation and adoption phase is confirmed by both theory and practice.

It was expected that within the adoption phase authority based instruments would be dominant because it these ultimately approve the official course of action (Howlett, 2009). In this phase the decision concerning implementation alternatives has to be decided, eventually by a (local) governmental authority. However, as the theoretical framework already suggested, before this decision is reached theoretically strong PED projects do consist of further information gathering and interaction with the stakeholders. Decision assisting instruments such as MCDA and forms of interaction, (Table 2.5), should assist in the decision making process, assisting finding the optimal solutions amongst the infinite number of theoretical solutions in these complex issues (Mckenna et al. 2018). Within the Limerick case the community involvement is assured via the legislation planning consent. The Evora case used decision support tools to identify relevant solutions (nodality) and understanding the value via survey (nodality) among stakeholders, as suggested by Mckenna et al. (2018). Within the Bilbao project, MCDA (nodality) was used in combination with a two-way government, implementing both top down as bottom up

solutions into the mix concerning the decision. Within the Lund and Helsinki cases the adoption phase seems somewhat different. Within the Helsinki case the authoritative policy instruments make decision making quite straightforward, regulatory based road maps with clear set steps. Within the Lund case the national legislations are limiting the power of the local government to implement technical requirements. Both cases are building a new district that might explain their lacking interaction with other stakeholders, because there may not be as many present or/and it may be hard to identify future residents. Although authority based instruments remain dominant in practice, within most cases the decision making process is influenced by the use of nodality based instruments, as theory suggested.

The implementation phase of the projects can be seen as the 'master plan' embodied by the actual projects, which should fulfil the proposed targets of the previous phases. In contradiction to expectations the implementation phase practice moved away from theory. Where theory suggested that a mix of treasure and authority based instruments is most applicable (Mao et al. 2019; Kern et al. 2017). In practice only the Limerick case was dominated by instruments that are both treasure and authority based, leading towards an energy transition both publicly and privately (Verdung, 1998). Furthermore, they communicated their results via nodality instruments such as Citizen observation, flexible mapping they translate these results back to and with the stakeholders. In contradiction, the other cases are more focussed on regulatory instruments to implement RES, heavily focussed on implementing these on public property. For example, within the case of Helsinki, the city only consists of 11% public property and therefore misses 89% of the buildings to cut emission because they do not include private property. Treasure based measures, heavily used by Chinese cities and Finland and the UK energy transition policy design (Mao et al. 2019; Kern et al. 2017), are able to influence people's decision making through financial incentives and work well within more liberal systems (Verdung, 1998; Vabo & Røiseland, 2012). The treasure-based instruments seem lacking in most of the PED cases, while these are able to create incentive for private property owners to support the delivering of a PED. Furthermore, the implementation phase consists of rather new and future orientated instruments, regulatory sandbox, p2p energy markets. These instruments were not implemented yet but were based on finding potential future solutions. Instead of implementing the best carbon emission diminishing instruments they implemented testing instruments to find out which are the best instruments. The PED cases are labelled as lighthouse projects and therefore they aim to shed light upon the uncertain future of the energy transition via testing a multitude of instruments. Therefore, especially within the implementation phase, it remains undoable to pinpoint the best instruments concerning reaching congruence between the project's goal and a mix of instruments. The results of these future orientated instruments should be shared and made publicly for all future projects to see. Such a platform, as EERA-JPSM might prove beneficial for future projects and assist in building a toolbox concerning applicable mixes of instruments. Only within the Bilboa project, Table 4.4, the projects looked to draw upon former experiences from such a platform.

The PED cases seem to show that there is no 'best practice' mix of policy instruments reached yet, especially within the implementation phase. All cases show experimental instruments, focussed on future implementation instruments. Within Limerick they use regulatory Sandbox, in Evora they implemented fostering energy related innovations, P2P energy trading, gamification platforms, in Bilbao they are striving for smart ICT implementations such as smart metres and in Helsinki they implemented Carbon ego. Most of these implementations, especially concerning P2P trading, are not implemented yet but are mentioned as future implementations. With the use of a blockchain network these things could be

implemented, however, all cases argued they did not consider using blockchain technology and were unaware why this was never considered. It seems that the theory concerning blockchain technology might be ahead of practical implementation or practical awareness.

5.2 Contextual factors

Contextual factors, as suggested by theory, have influence on policy instrument choice in delivering PED projects. The Limerick PED project, and other Irish energy transition projects, is backed by a strong foundation of legislative instruments (Climate adaptation strategy, Climate action Act and Environmental impact assessment). The country development plan and Climate Adaptation Strategy make sure the local governments keep updating their plans and include climate change measures. The national program (RSES) also makes sure local governments oblige to this. This strong foundation of authority-based instruments provides local governments with a structure and guides them into the 'right' direction of implementing just carbon diminishing instruments. This allocation of responsibility from national to more local governments can improve the transition because local governments are able to better pinpoint local opportunities and barriers (Somanathan et al. 2014). In contradiction to the Limerick case is the case of Lund. Their national legislations, in the form of Planning and Building Act of 2014, prevent municipalities from setting specific demands regarding technical standards to project developers. In this way the local government is not able to force certain emission reduction measures upon the project developers, making it more difficult to control/limit future emission. As mentioned by Somanathan et al. (2014) other layers of government can either assist or oppose local governments.

Local context also influence PED cases in another way. All the different cases in this research are part of a bigger program which all consist of slightly differentiated goals and means. The different programs consist of POCITYF, CityxChange, MySmartLife and ATELIER which all have a central niche to their program and influencing the project within it. The city of Évora cooperates with the POCITYF organization focuses on the energy transition but also on the preservation of historical inner cities. Therefore, the Évora case had an extensive formation and adoption phase with interaction between local authorities, energy and technology providers, the citizens, and research organisations which should lead to the best possible solutions concerning local barriers and opportunities. They even tested solutions on their value's via the Maslov value pyramid theory, participants in the survey were asked to describe the value proposition for each solution along with a linkage to potential addressable market needs, which should foster user adoption of energy efficiency related solutions (Maas et al. 2020). Compared to other cases the Évora case used more nodality instrument. The case of Bilboa is part of the ATELIER program, which aims to strengthen local innovation ecosystems through removing legal, financial and social barriers. This is shown through their focus on new business models via instruments based on authority and organisation, their new participatory mechanism based upon Quadruple helix principles (Table 4.4) and Two-way governance (Table 4.4). This provides the local government with a tool to combine top down EU legislation with bottom-up models. As the programs consist of (slightly) different goals the instruments used within the cases also differentiate. Therefore, reaching congruence within a single case is possible however a generalizable congruent situation between delivered PEDs and 'a' mix of instruments is hard. However, reaching congruence in new policy design thinking means that are more fluid and are able to differentiate (Howlett, 2011).

Conclusion

This study aimed to analyse the best mix of policy instruments to develop a PED project. The theoretical framework, mostly based upon the NATO-typology and phase model, provided a theoretically sound instrument template able to test the cases and allow for validation of findings. Combining PED theory and policy design theory led to the policy template in table 2.5. The comparison between the policy template and the data provided from the cases has shown certain narratives within the delivering of a PED. Within the Formation phase theory and practice are mostly aligned, leading to a high use of nodality and organizational based instruments. Within the Adoption phase the cases were aware of the importance of including stakeholders within the decision making process. Within the implementation phase cases were heavily differentiated, which was expected due to different political and program based context. Different cases had lesser or more assistance from their national/supranational governance influencing the project positively or negatively. Furthermore, the local context of their overarching programs differentiated the goals of the different project from focusing on local heritage, reaching new business models or strengthening local innovation ecosystems. Differentiated policy goals led to the use of different policy means (instruments) to reach a congruent situation. Furthermore, the cases used (future) explorative instruments aiming to find which instruments are the best to implement instead of implementing the best instruments. Overall this research argues there is no 'true' best mix of policy instruments to develop a PED. However, both theory and practice aligned on the use of policy instruments within the formation and adoption, which increases the understanding towards delivering of a PED project.

This research was conducted in a time where COVID-19 restrictions affected everybody's life. However, by doing a questionnaire, as a data collection method, it was not necessary to come in direct contact with people, which limited the influence of the pandemic. The assessment is done on the basis of interpretation of the author. It could be that some disagree with the policy category given to certain instruments. Another limitation of this research is the non-differentiations between procedural and substantive policy instrument. Mainly due to limited time and resources this extra different categorization is not included in the research. A more diverse categorisation could have led to 'richer' findings.

The reflections in the previous section implied certain limitations implying there is opportunity for future research. To limit the researchers bias the same research could be conducted by others or a multitude of different researchers. Furthermore, the findings of the research also imply opportunities concerning future research. As the research concluded, the implementation phase was full of instruments that were based on finding the 'best' instruments instead of implementing the 'best' instruments. Future research could focus on these newly found implementation instruments. Furthermore, a quantitative study could be performed focussing on actual emission cutting rates of instrument mixes. This research helped understand policy mixes in delivering a PED project, however the search for the 'best' mix of instruments concerning the delivering of a PED remains a challenge.

References:

Anderson, J. E. 2014. *public policymaking*. 8th ed. Stamford: Cengage Learning.

Andoni, M., Robu, V., Flynn, D., Abram, S., Geach, D., Jenkins, D., McCallum, P. and Peacock, A. (2019). Blockchain technology in the energy sector: A systematic review of challenges and opportunities. *Renewable and Sustainable Energy Reviews*, 100.

Bailey, I. and Rupp, S. (2005). Geography and climate policy: a comparative assessment of new environmental policy instruments in the UK and Germany. *Geoforum,* 36(3).

Baker, K. and Stoker, G. (2011). Imperative policy making, metagovernance and democracy. Essex: ECPR Press.

Bond, S. D., Carlson, K.A. and Keeney, R.L. (2008). Generating objectives: can decision makers articulate what they want?. *Management Science*, 54,56-70.

Bonson, E., Perea, D and Bednarova, M. (2019). Twitter as a tool for citizen engagement: An empirical study of the Andalusian municipalities. *Gov. inf. Q*, (36) 480-489.

Bossi, S., Gollner, C and Theierling, S. (2020). Towards 100 Positive Energy Districts in Europe: Preliminary Data Analysis of 61 European Cases. *Energies,* 13 (22).

Boza-Kiss, B., Moles-Grueso, S. and Urge-Vorsatz, D. (2013). "Evaluating policy instruments to foster energy efficiency for the sustainable transformation of buildings", *Current Opinion in Environmental Sustainability,* 5 (2), 163-176.
choy
Burger, C., Kuhlmann, A., Richard, P. and Weinmann, J. (2016). Blockchain in the energy transition, a survey among decision-makers in the German energy industry.

Cashore, B. and Howlett, M. (2007). Punctuating which equilibrium? Understanding thermostatic policy dynamics in Pacific Northwest Forestry. *American Journal of Political Science*, 51(3)

Carter, N., Bryant-Lukosius, D., DiCenso, A., Blythe, J. and Neville, A.J. (2014). The use of triangulation in qualitative research. *Oncol Nurs Forum*.

Chapman, A., McLellan, B. and Tezuka, T. (2016). Strengthening the Energy Policy Making Process and Sustainability Outcomes in the OECD through Policy Design. *Graduate School of Energy Science*, Kyoto University.

Choy, L.T. (2014). The strengths and weaknesses of research methodology: Comparison and complimentary between qualitative and quantitative approaches. *IOSR Journal of Humanities and Social Science*, 19(4).

Clevenger (2020). Urban Experimentation in Support of Sweden's Sustainability Transition.

Commission E. (2009). Strategy for sustainable development. Retrieved on 20-10-2021 from http://europa.eu/legislation_summaries/environment/sustainable_development/l28117_en.htm.

Connolly, D., Lund, H., Mathiesen, B.V. and Leahy, M. (2010). A review of computer tools for analysing the integration of renewable energy into various energy systems
Applied Energy, 87,1059-1082

Cornelissen, J., Gajewska-De Mattos, H., Piekkari, R. and Welch, C. (2012). Writing up as a legitimacy seeking process: alternative publishing recipes for qualitative research. *Qualitative Organizational Research: Core Methods and Current Challenges*, 185.

Crosby, B.C. & Bryson, J.M. (1992). Leadership for the common good: tackling public problems in a Shared-Power World. 1ste edition.

Dal Canto, D. Enel. Blockchain: which use cases in the energy industry, CIRED 2017
Glasgow, Round table discussion.

Delacourt, S. and Lenihan, D.G. (2000). Collaborative Government: Is there a Canadian Way? *Toronto: Institute of Public Administration of Canada,* (6).

Demirtas, O., Derindag, O.F., Zarali, F., Ocal,O. and Aslan, A. (2021). Which renewable energy consumption is more efficient by fuzzy EDAS method based on PESTLE dimensions? *Environmental Science and Pollution Research* (2021)

EcoDistricts. (2013). EcoDistricts Protocol. Retrieved on 6-6-2021 from: http://ecodistricts.org/wpcontent/uploads/2013/03/EcoDistricts_Protocol_Executive_Summary_ISSUE_6.242.pdf

Energy Cities. (2021). Energy Efficiency Watch 4: Making the implementation of the Energy Efficiency Directive a reality. Retrieved on 10-10-2021 from: https://energy-cities.eu/project/energy-efficiency-watch-3/.

European Energy Research Alliance Joint Programme Smart Cities. (2020). Collaboration. Retrieved on 22-12-2021 from: https://www.eera-sc.eu/external-ccollaboration.html.

European Commision. (2019). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS The European Green Deal. Retrieved on 10-10-2021 from: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1576150542719&uri=COM%3A2019%3A640%3AFIN.

European Commision. (2021). The European Green Deal Investment Plan and Just Transition Mechanism explained. Retrieved on 23-12-2021 from: https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_24.

Fatima, Z., Pollmer, U., Santala, S.S., Kontu, K., and Ticklen, M. (2021). Citizens and Positive Energy Districts: Are Espoo and Leipzig Ready for PEDs? *Buildings*, *11*(3), 102

Freiberg, A. (2018). Authority tools: pervasive, persistent and powerful. 1ste edition. New York

General data Protection Regulation (2021). General Data Protection Regulation. Acced on 4-5-2021 from: https://gdpr-info.eu/

Gog, M., 2015. Case study research. International Journal of Sales, Retailing & Marketing, 4(9), pp.33-41.

Gohari, S., Ahlers, D., Nielsen, B.F. and Junker, E. (2020). "The Governance Approach of Smart City Initiatives. Evidence from Trondheim, Bergen, and Bodø." *Infrastructures*, 5 (4), 31.

Greening, L.A. and Bernow, S. (2004). Design of coordinated energy and environmental policies: use of multi-criteria decision-making. *Energy policy,* 32, 721-735.

Hajer, M. A. (2005). 'Setting a stage: A dramaturgy of policy deliberation'. *Administration and Society*, 36 (6), 624-647.

Hedman, A., Rehman, H.U., Gabaldón, A., Bisello, A., Seifried, V.I., Zhang, X., Guarino, F., Grynning, S., Eicker, U., Neumann, M., Tuominen, P. and 1 and Reda F. (2021) "Iea Ebc Annex83 Positive Energy Districts," 11(130), 130–130.

Hood, C. (1986). *The Tools of Government* . Chatham: Chatham House Publishers.

Hood, C. and Margetts, H.Z. (2007). The tools of government in the Digital Age. Basingstoke: Palgrave Macmillan.

Howard, C. (2005). The policy cycle: A model of post-Machiavellian policy making? Aust. J. Public Adm. 64, 3–13.

Howlett, M. (2011). Designing Public Policies: Principles and Instruments. New York: Routledge

Howlett, M. (2014). From the 'old' to the 'new' policy design: design thinking beyond markets and collaborative governance. *Policy Sciences*, 47(3), 187–207.

Howlett, M. (2000). Managing the "hollow state": Procedural policy instruments and modern governance. *Canadian Public Administration*, 43(4), 412–431.

Howlett, M. (2009). Governance modes, policy regimes and operational plans: A multi-level nested model of policy instrument choice and policy design. *Policy Sciences*, *42*(1), 73-89.

Howlett, M. (2018). The context and Components of policy Design: Governance modes and policy regimes. *Routledge handbook of policy design*, 20-34.

Howlett, M. and Lejano, R. P. (2013). Tales from the crypt: The rise and fall (and rebirth?) of policy design. *Administration & Society*, 45(3), 357–381.

Howlett, M. and M. Ramesh. (1995). Studying Public Policy: Policy Cycles and Policy Subsystems. Toronto: Oxford University Press

Howlett, M. and Ramesh, M. (2003). Studying Public Policy: Policy Cycles and Policy Subsystems, 2nd ed.; Oxford University Press: Don Mills.

Howlett, M. and Rayner, J. (2007). Design principles for policy mixes: Cohesion and coherence in 'new governance arrangements'. *Policy and Society*, 26(4), 1–18.

Howlett, M., Mukherjee, I. and Woo, J. J. (2015). From tools to toolkits in policy design studies: the new design orientation towards policy formulation research. *Policy & Politics*, 43(2), 291–311.

IPCC. (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

IDA (2021). IDA's Energy Vision 2050, A Smart Energy System strategy for 100% renewable Denmark. Retrieved on 10-12-2021 from: https://vbn.aau.dk/ws/portalfiles/portal/222230514/Main_Report_IDAs_Energy_Vision_2050.pdf.

European Commision. (2021). Strategic Energy Technology Plan. Retrieved on 25-5-2021 from: https://ec.europa.eu/energy/topics/technology-and-innovation/strategic-energy-technology-plan_en#key-action-areas.

Jann, W. and Wegrich, K. (2007). Theories of the Policy Cycle. In Handbook of Public Policy Analysis: Theory, Politics, and Methods. Press: New York, NY, USA, 2007; pp. 43–62.

Jordan, A., Wurzel, R.K.W. and Zito, A.R. (2010). ' new' instruments of environmental governance: patterns and pathways of change. *Environmental Politics*, 12 pp. 37-41
Kern, F., Kivimaa, P. and Martiskainen, M. (2017). Policy packaging or policy patching? The development of complex energy efficiency policy mixes. *Energy Research & Social Science*. (23).

Knudson, W. A. (2008). The Environment, Energy, and the Tinbergen Rule. *Bulletin of Science, Technology & Society*, 29(4), 308–312.

Kolokotsa, D., Rovas, D., Kosmatopoulos, E. and Kalaitzakis, K. (2011). A roadmap towards intelligent net zero- and positive-energy buildings. *Solar Energy*, 85, 3067–3084.

Lægreid, P. (2018). Designing Organizational Tools,Tool Choices as Administrative Reforms. 1ste edition. Routledge

Lester, J. P. and Goggin, M. L. (1998). "Back to the Future: The Rediscovery of Implementation Studies*." Policy Currents,* 8 (3),1–9.

Limerick (2021). Interim Review and Update of the Limerick 2020 plan. Retrieved on 10-12-2021 from: https://www.limerick.ie/sites/default/files/media/documents/2021-06/volume-6-limerick-2030-plan-interim-update.pdf.

Lindholm, O., Rehman, H.U. and Reda, F. (2021). Positioning Positive Energy Districts in European Cities. Buildings, 11, (19).

Lund, H., Marszal, A. and Heiselberg, P. (2011). Zero energy buildings and mismatch compensation factors. *Energy Build*, 43, 1646–1654.

Maas, N., Georgiadou, V., Roelofs, S., Lopes, R. A., Pronto, A., and Martins, J. (2020). Implementation framework for energy flexibility technologies in Alkmaar and évora. *Energies*, *13*(21), 5811.

Manfren, M.P., Costa, C.G. (2011). Paradigm shift in urban energy systems through distributed generation: methods and models. *Applied Energy*, 88, pp. 1032-1048

Mao, Q., Ma, B., Wang, H. a Bian, Q. (2019). Investigating policy instrument adoption in low-carbon city development: A case study from China. *Energies*, *12*(18), 3475.

McCormick, K. and Hartmann, C. (2017). The Emerging Landscape of Urban Living Labs: Characteristics, Practices and Examples. Governance of Urban Sustainability Transitions (GUST), Deliverable 3.3.2. Retrieved from http://www.urbanlivinglabs.net.

Mckenna, R., Bertsch, V., Mainzer, K. and Fichtner, W. (2018). Combining local preferences with multi-criteria decision analysis and linear optimization to develop feasible energy concepts in small communities. *European Journal of Operational Research*, (268).

Merriam, S. B. (2009). Qualitative research: A guide to design and implementation. San Francisco, CA: Jossey-Bass.

Mingers, j. and Rosenhead, J. (2001). Multimethodology – Mixing and matching methods Rational analysis for problematic world revisited (2nd ed.), Wiley, Chichester.

Mirakyan, A., Lelait, L., Khomenko, N. and Kaikov, I. (2009). Methodological framework for the analysis and development of a sustainable, integrated, regional energy plan—a French region case study. EcoMod., Ottawa

Monti, A., Pesch, D., Ellis, K. and Mancarella, P. (2016). Energy Positive Neighborhoods and Smart Energy Districts: Methods, Tools, and Experiences from the Field; Academic Press: London, UK; San Diego, CA, USA; Cambridge, MA, USA; Oxford, UK.

Morgan, G. (1997) Images of organisation. (2nd edn.). London: Sage.

Neves, L.P., Dias, L.C., Antunes, C.H. and Martins, A.G. (2009). Structuring an MCDA model using SSM: a case study in energy efficiency. *European Journal of Operational Research*, 199, 834-845

Orb, A., Eisenhauer, L. and Wynaden, D. (2001). Ethics in qualitative research. *Journal of Nursing Scholarship*, 33 (1),93

Our World in Data. (2021a). Emission by sector. Retrieved on 12-28-2021 from: https://ourworldindata.org/emissions-by-sector.

Our World in Data. (2021b). Number of people living in rural and urban areas , World, 1960-2020. Retrieved on 10-11-2021 from: https://ourworldindata.org/grapher/urban-and-rural-population

Panagiotidou, M., Fuller, R.J. (2013). Progress in ZEBs-A review of definitions, policies and construction activity. *Energy Policy*, 62, 196–206.

Parsons., W. (1996). Public policy making: an introduction to the theory and practice of policy analysis. Edward Elgar Publishing Ltd

PwC global power & utilities (2021). Blockchain - an opportunity for energy producers and consumers?. Retrieved on 4-5 from https://www.pwc.com/gx/en/industries/assets/pwc-blockchain-opportunity-for-energy-producers-and-consumers.pdf

Rad, F.D. (2010). Application of local energy indicators in municipal energy planning: a new approach towards sustainability. ACEEE Summer Study, Asilomar (CA, USA): Lund University

Saheb, Y., Shnapp, S. and Paci, D. (2019). From nearly-zero energy buildings to net-zero energy. EUR 29734 EN, Publications Office of the European Union, Luxembourg.

Salaj, A.T. and Loewen, B. (2020). Keeping Up with Technologies to Act Responsively in Urban Environment, *International Academic Conference on Places and Technologies*, (7),13-22.

Salamon, L. M. (2001). The new governance and the tools of public action: An introduction. Fordham Urb. LJ, 28, 1611–1674

Schreurs, M. A. (2008). From the Bottom Up: Local and Subnational Climate Change Politics. *The Journal of Environment & Development*,17, 343–355

Shnapp, S., Paci, D. and Bertoldi, P. (2020). Enabling Positive Energy Districts across Europe: energy efficiency couples renewable energy, EUR 30325 EN, Publications Office of the European Union, Luxembourg.

Silverman, D. (2010). *Doing Qualitative Research: A Practical Handbook*. 3rd Edition, Sage Publications, London.

Somanathan, E., Sterner, T., Sugiyama, T., Chimanikire, D., Dubash, N.K., Essandoh-Yeddu, J., Fifita, S., Goulder, L., Jaffe, A., Labandeira, X., Managi, S., Mitchell, C., Montero, J.P., Teng, F., and T. Zylicz, T. (2014). National and Sub-national Policies and Institutions. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Stewart., T.J. (1992). A critical survey on the status of multiple criteria decision making theory and practice. *Omega*, 20 (5,6), pp. 569-586

Teisman, G.R. (2000). Models for research into decision-making processes: On phases, streams and decision-making rounds. *Public Administration*. Retrieved from http://hdl.handle.net/1765/10260

Thelen, K. (2003). "How Institutions Evolve: Insights From Comparative Historical Analysis." In Comparative Historical Analysis in the Social Sciences, edited by Mahoney, J. and Rueschemeyer, D. 208–40. Cambridge: Cambridge University Press.

Terrados, J., Almonacid, G. and Hontoria, L. (2007). Regional energy planning through SWOT analysis and strategic planning tools. *Impact on renewables development Renewable and Sustainable Energy Reviews*, 11, 1275-1287.

Tinbergen, J. (1952). On the Theory of Economic Policy. North-Holland Publishing Company, Amsterdam.

Urban Europe (2021). Positive energy districts. Retrieved on 25-5-2021 from: https://jpi-urbaneurope.eu/ped/

Urrutia-Azcona, K., Tatar, M., Molina-Costa, P. and Flores-Abascal, I. (2020). Cities4ZERO: Overcoming Carbon Lock-in in Municipalities through Smart Urban Transformation Processes. *Sustainability*, 12(9)

Vabo, S.I. and Røiseland, A. (2012). Conceptualizing the Tools of Government in Urban Network Governance. *International Journal of Public Administration*, 35, 934-946.

Van Beeck, N.M.J.P. (2000). *Classification of energy models*. Tilburg: Tilburg University, Faculty of Economics and Business Administration.

Van Geet, M. (2021). 'Policy design and infrastructure planning: finding tools to promote land use transport integration'.

Vedung, E. (1998). Policy instruments; typologies and theories. In M. L. Bemelmans-Videc, R. C. Rist, & E. Vedung (Eds.), Carrots, stick and sermons (pp. 21-59). New Brunswick, New Jersey: Transaction Publishers.

Villamayor-Tomas, S., Thiel, A., Amblard, L., Zikos, D., Blanco, E. (2019). Diagnosing the role of the state for local collective action: Types of action situations and policy instruments, *Environmental Science & Policy*, (97), 44-57.

Weyrauch, V., Echt, L. and Suliman, S. (2016). How to make strategic decisions to promote a better interaction between knowledge and policy.

Yin, R.K. (2014) Case study research, design and methods 5th edition, SAGE publications

Yikui-Liu, Y., Lei, W. and Li, L. (2019). Peer-to-peer (P2P) electricity trading in distribution systems of the future. *The Electricity Journal*, 32(4).

Appendix A: Questionnaire

PED projects and policy instruments

Start of Block: Default Question Block

Dear participant,

Thank you for taking the time to fill in this questionnaire.

This survey aims to analyse the policy instruments European cities use in the planning and delivery of Positive Energy Districts. More specifically, the study focuses on the instruments that are deployed in the stages of policy formation, adoption and implementation.

The survey consists of 7 questions and will take approximately 15 minutes to complete.

The data gathered in this survey will be made anonymous and is only accessible for the researchers. If have any questions regarding this survey, the research or have additional information that you are willing to share. Feel free to send an e-mail to j.j.lijster@student.rug.nl

Page Break

Introduction

This survey consists of two opening questions and three main questions, which address the use of policy instruments in the formation, adoption and implementation phase. Furthermore, this research aims to illustrate if blockhain technology is present in energy transition projects.

Please name the **country** in which the PED project you are involved with is located?

_____

Please name the **city** in which the PED project you are involved with is located?

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Formation phase

The formation phases comprises of the stages of agenda setting and policy formulation. During the formation phase, understanding is developed regarding the nature, scope, urgency of societal problems and possible courses of action or solutions are identified to address the problem. Exploring the various options or alternative courses of actions available for addressing the problem. This phase is all about search for information, design and evaluation of the different alternatives that are designed.

Governents can use a variety of policy instruments to support processes of policy formation. One can for example think of Long Term Visions, Policy Strategies, Policy Plans, Policy Framework, Workshops, Scenario Studies, Policy Plans, GIS analysis, SWOT-analysis, Cost Benefit Analysis, Life Cycle Assessments, Stakeholder Engagement Tools, Working Groups, Commisions, Agent-Based Simulation, Business Cases, Think Tanks, Advisory Committies, Spatial Planning/Urban Planning Instruments, etc.

Please list the policy instruments your city is using/ has used during the formation phase of the Postive Energy District development and give a discription of each instrument.

	Please list the instruments used in your city in the formation phase of the PED development	Please provide a description of each listed instrument.
	Instrument name (1)	Instrument description (1)

Policy instrument 1 (1)		
Policy instrument 2 (2)		
Policy instrument 3 (3)		
Policy instrument 4 (4)		
Policy instrument 5 (5)		
Policy instrument 6 (6)		
Policy instrument 7 (7)		
Policy instrument 8 (8)		
Policy instrument 9 (9)		
Policy instrument 10 (10)		

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Adoption phase

During the adoption phase policy actors individually or collectively deliberate and prioritize between possible alternative courses of action or solutions to address a certain problem and agree on a preferred alternative. This prioritizing between different possible alternatives can be shaped through different styles of decision making, bargaining, persuasion, command or majority building.

Governents can use a variety of policy instruments to support processes of policy adoption. One can for example think of Multi-Criteria Decision Aid tools, Feasibility Studies, Cost Benefit Analysis, Business Cases, Political Deliberations, Environmental Impact Assessment, Campaigns, Competitions, Advertising, Research Projects, Decision Support Instruments, Enforcement (use of legislative power).

Please list the **policy instruments** your city is using/ has used during the **adoption phase** of the Postive Energy District development and provide **a discription** of each instrument.

	Please list the instruments used in your city in the adoption phase of the PED development	Please provide a description of each listed instrument.
	Instrument name (1)	Instrument description (1)

Policy instrument 1 (1)		
Policy instrument 2 (2)		
Policy instrument 3 (3)		
Policy instrument 4 (4)		
Policy instrument 5 (5)		
Policy instrument 6 (6)		
Policy instrument 7 (7)		
Policy instrument 8 (8)		
Policy instrument 9 (9)		
Policy instrument 10 (10)		

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Implementation phase

The implementation phase refers to the actual action that is carried out to address a problem at hand. Whereas the first two phases are mainly focussed on proving the right arena to come to a set of policy alternatives and objects, the policy implementation phase is al about devoting efforts, knowledge and resources to give effect to the adopted policy goals. Instruments used in the implementation stage are often more tangible than those used in the other phases because it is directly focused on addessing a policy issue and not towards the organizatin of the decision making process.

Governents can use a variety of policy instruments to support processes of policy implementation. One can for example think of Building Codes, Implementation Strategies, Direct Grants, Land Use Regulation, Tax Incentives, Stakeholder Support Materials, Financial Schemes, Quality Targets, Educational Programs, Development Projects, Regulations, Funds etc.

Please list the **policy instruments** your city is using/ has used during the **implementation phase** of the Postive Energy District development and **provide a discription** of each instrument.

	Please list the instruments used in your city in the implementation phase of the PED development	Please provide a description of each listed instrument.
	Instrument name (1)	Instrument description (1)

Policy instrument 1 (1)		
Policy instrument 2 (2)		
Policy instrument 3 (3)		
Policy instrument 4 (4)		
Policy instrument 5 (5)		
Policy instrument 6 (6)		
Policy instrument 7 (7)		
Policy instrument 8 (8)		
Policy instrument 9 (9)		
Policy instrument 10 (10)		

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Blockchain technology

According to the Euopean Union the future energy system should be all about **decarbonistation, decentralization** and **digitalization.** This focus provides challenges mostly concerning decentralization and digitalization, the current power grid has difficulties dealing with prosumers and arranging supply and demand within local/regional levels. Blockchain technology could provide solutions concerning these future problems.

Blockchains are shared and distributed data structures or ledgers that can secure and store digital transaction without using a central point of authority. All network members have access to the records chain and are able to check if transactions are valid, which leads to transparent and trustworthy, tamper-proof records. This allows for a local energy market were prosumers and consumers of energy can buy and sell energy locally.

The following questions are aimed to assess the status of blockchain technology use in energy transition projects.

Does the projects use or considered using blockchain technology?

- ○ Yes (1)
- ○ No (2)
- ○ What does blockchain technology mean? (3)

If yes, could you explain what kind of blockchain technology was used or considered using and how this is done?

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We thank you for your time spent taking this survey.

Press next to definitively submit the survey or go back to check and revise your answers.

End of Block: Default Question Block