

# THE CITY-ZEN APPROACH FOR URBAN ENERGY MASTER PLANS ADDRESSING TECHNICAL OPPORTUNITIES + NON-TECHNICAL BARRIERS

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## Abstract

European cities and municipalities usually have considerable goals in becoming more energy self-sufficient, but are often not on track towards their short-term (e.g. EU2020) targets. The pathways to move forward in the transition towards a sustainable built environment however are complex to outline. Cities use different and often fuzzy methods to define sustainable measures, actions and interventions.

Several layers of influence can be distinguished that either allow for or obstruct sustainable interventions in the built environment. This paper describes the City-zen approach which serves to define both short and long term sustainable interventions within a broader urban Energy Master Plan; stake holder wise both from top-down and bottom-up perspectives. These layers of influence are implemented to define barriers and opportunities for interventions.

The Delft method of Energy Potential Mapping (EPM) already structurally exposes the geographical-physical and technical layers into local layers of energy potentials. This technical-spatial quantification of demand, reduction potential and renewable supply forms the first analytical step of the approach..

However, other layers may affect the realisation of this technical potential on a non-technical and non-quantifiable level. Technically feasible interventions have to be assessed on barriers and opportunities on economic, social and political-legal levels and to take away barriers, strategic interventions have to be defined.

To develop a full Energy Master Plan in the next steps, the future has to be envisioned in different scenarios followed by defining future targets and goals. A roadmap can finally be created combining interventions on a timeline, both on the technical and strategic level.

Abbreviations: **CHP**: Combined Heat and Power; **City-zen**: City Zero (carbon) ENergy; **COP**: Coefficient of Performance; **DHW**: Domestic Hot Water; **EMP**: Energy Master Plan; **EPM**: Energy Potential Mapping; **EC**: European Commission; **EU**: European Union; **EU2020**: Europe 2020 strategy; **FP7**: EU/EC Seventh Framework Programme; **LES**: Leidraad Energetische Stedenbouw (Amsterdam Guide to Energetic Urban Planning); **MUSIC**: Mitigation in Urban Areas: Solutions for Innovative Cities; **PV**: Photovoltaic; **REAP**: Rotterdam Energy Approach & Planning; **SEAP**: Sustainable Energy Action Plan; **SREX**: Synergy between Regional Planning and Exergy; **STEP-UP**: Strategies Towards Energy Performance and Urban Planning; **TRANSFORM**: TRANSFORMAtion agenda for low carbon cities.

## 1. Introduction and background

European cities are both required and willing to speed-up the transition towards a sustainable energy system in the built environment, for reasons that can be assumed well-known. Many cities commit themselves to targets and goals such as the EU2020 targets. 'Sustainable energy action plans' and 'transformation agendas' are made to direct to the cities with technical and strategic actions towards these goals. These documents however often only address relatively short-term goals within the energy transition.

Furthermore, cities generally have a limited influence on certain conditions: proposing incentives or standards for the industry, building codes etc. (Kloppenborg, 2014). Although the national level is key to address these questions, they are often heavily influenced by international developments; such as European Union (EU) processes and politics that, however, represent a level of complexity that few cities in Europe can match. In addition, city budgets are limited and manpower is often insufficient in terms of competencies, mandates and organisational support to deal with identified challenges.

This means that cities and city planners can only limitedly influence the transition.

City governments are however able to direct towards desired developments and facilitate processes. Long-term future goals and perspectives can be set out; subsidies can be given and pilot projects initiated to raise awareness of solutions and challenges and boost energy saving measures or energy producing technologies.

The complexity of these issues does not enable a simple strategy and demands for a structured approach to define actions suitable for the city both short and long term, and acceptable to its citizen: Rogers *et al.* (2008) for example state that there should be a higher degree of public participation in local energy planning.

The EU project City-zen aims to provide methodologies and tools to cities and their citizens to realize and boost the transition towards 2020 and beyond. As part of this project, the authors are developing a theoretical framework and methodology to address the above described issues, not only for and from city planners' point of view, but also to be of used by other stakeholders: citizens. This involves not just making technical and economic aspects accessible, but taking into account social and societal aspects as well.

Furthermore, the efforts to continuously improve energy performance requirements for new buildings will have a limited impact, as the majority of buildings present in 2050 will already have been built today (assuming an average build rate of 1% per annum). Therefore, special attention will be given to refurbishment other systemic measures to improve the current building stock.

The transition to a fully renewable energy system has a significant effect on the communities involved. Although there are numerous examples of successful individual renewable energy projects, there are also issues. An example of this is the mind-set towards wind turbines. In several countries, local opposition to these is significant. Neighbouring countries the Netherlands and Germany provide contrast here, as 51% of the 63.000 MW of German installed land wind power is owned by citizens (either fully owned or a partial stake in a turbine/park) (Nestle, 2014), whereas about 10-15% of the 250 MW of installed wind capacity in the Netherlands is operated by cooperatives (Wind-works, 2015), matching equally divergent public opinions on both sides of the border. Based on German and French experiences however, Jobert *et al.* (2007) suggest a solution to improve on acceptance can be influenced in the key areas of visual impact, ownership, information and participation, by involving the right stakeholders.

A transition also involves significant investments, which in the present economic climate is not likely to originate with a single or few parties. Furthermore, even though a 'Manhattan Project' type of high cost transformation over a very short period of time may result in a renewable energy system with highly attuned components, a limited workforce and manufacturing capabilities make this an unlikely event for large urban areas. From an investor's point of view therefore Wüstenhagen and Menichetti (2012) emphasise the importance of strategic choices.

## 2. Transition methodologies

The aim of tackling the discrepancy between urban renewable energy targets and implementation is not new. Various initiatives and methodologies with similar goals and with different levels of usability already exist. A few of them, with aspects of particular interest and suitability for integration in the City-zen framework, will be discussed next, starting with general instruments and ending with more integrated approaches.

The **REAP** (Rotterdam Energy Approach & Planning) methodology improves on the *Trias Energetica* and its successor the *New Stepped Strategy* by including spatial scales, ranging from the individual building, through neighbourhoods and districts, to the city and beyond. This provides a basic framework that facilitates energy exchanging and cascading, and therefore implicitly includes energy networks and their opportunities. (Tillie *et al.*, 2009)

**LES** (Leidraad Energetische Stedenbouw, or the Amsterdam Guide to Energetic Urban Planning) builds upon the REAP methodology by additionally providing a catalogue of technical measures, tied to the local energy atlas (Dobbelsteen *et al.*, 2011).

Although REAP makes it possible to choose those interventions that are the most efficient throughout these scales and can be used to both make immediate decisions and construct a long term vision, and LES provides a catalogue of means to achieve these, they do not include the temporal scale of a transition methodology.

The **Covenant of Mayors** is *the mainstream European movement involving local and regional authorities, voluntarily committing to increasing energy efficiency and use of renewable energy sources on their territories* (Covenant of Mayors, 2015). By committing, these cities aim to meet and exceed the European Union 20% CO<sub>2</sub> reduction objective by 2020, for which **Sustainable Energy Action Plans** (SEAP) are made. These SEAPs range from simple documents with a few goals to more elaborated ones with specific interventions.

**STEP-UP** is *an energy and sustainable city planning programme that aims to assist cities enhance their sustainable energy action plans and integrate energy planning into their sustainable city planning* (STEP-UP, 2015). The nine step methodology developed revolves around providing enhanced SEAPs, essentially producing a detailed localised manual on how to achieve EU2020 targets. As the STEP-UP defined future is relatively near (and therefore all the stakeholders known), and the EU2020 goal limited, specific interventions can be defined. A more distant timeline is not taken into account.

The same applies to the European **TRANSFORM** project (TRANSFORM, 2015), in which a framework for Transformation Agendas was developed, for cities to improve on their existing energy policies (e.g. SEAPs). It can be seen as a small transformation cycle to check and monitor if a city is on track towards their initially set targets. It focuses on the short-term and helps to define short-term actions.

The **MUSIC** project aims to catalyse and mainstream carbon and energy reduction in the urban context (MUSIC, 2015). MUSIC takes on the urban sustainability issue from a multi actor perspective, using a transition management approach. Strong focus is given to social sustainability and the interaction between the many different actors over the course of the transition period. This result in four types of interventions: orienting, agenda-setting, activating and reflecting. There are similarities with the TRANSFORM project, both in the cyclic nature of the interventions, ending with a recalibration phase, and the inclusion of a GIS based Decision Support Tool (DST).

The **five-step approach** (Stremke, 2012) as developed for the SREX (Synergy in regional Planning and Exergy) research project (SREX, 2011) serves to develop robust long-term energy visions for regions.

A focus in this approach is that critical uncertainties are taken into account by developing long-term visions for different scenarios and abstracting the most robust interventions for an integrated vision. The successive steps and the questions behind them are: Step 1: Present conditions: How does the present region function and how can it be evaluated in comparison with other regions? Step 2: Near future developments: How will the region change in the near future? Step 3: Possible far futures: What kind of possible long-term developments are expected in the study region, and at which locations? Step 4: Developing integrated visions: How can a possible future be turned into a desired future? Step 5: Identifying spatial interventions: Which possible interventions should be implemented? In the last step, the interventions that are found in many of the different scenarios are considered robust and therefore fit in short term visions. Local stakeholders are involved in a final adjustment cycle of the developed visions. The *five-step approach* defines visions for city-planners.

In 'urban planning for renewable energy futures: methodological challenges and opportunities from a design perspective', Vandevyvere and Stremke (2012) propose an analytical framework to address the challenges of renewable energy based planning. 2 levels of analysis are proposed: environmental assessment and integrated sustainable evaluation, with for example social, economical, policy/process realms, which complement each other. Herman Dooyeweerd already identified 15 law spheres, from determinative to normative, in the multimodal system theory. Almost all of these spheres concern sustainable development is concluded and a *multidisciplinary framework* is needed to properly assess these layers, such as socio-cultural, economical, juridical.

Although not a transition method in itself, the Delft method of **Energy Potential Mapping** (Broersma *et al*, 2013) facilitates energy based planning, and within City-zen it provides the basis with which the Energy Atlas (mentioned below) can be built. EPM focuses on the strong spatial relation between sinks (demand) and sources (supply) in a fully renewables based energy system, and investigating which types of energy are involved (heat/cold, electricity and fuels). The resulting spatially quantified data can be applied towards local and regional energy based planning, as shown in the Oostland study below.

### 3. Methodological framework of the City-zen Approach

Sustainable development in the built environment requires a transformation process over a longer period of several decades or more. To direct and speed up this process, strategic approaches and long term visions help city planners to set targets and appoint directions to get there. But citizens and other stakeholders must also be able to find the best solutions for the improvement of their energy systems, not only because they are willing to, but also because their contributions will often be a necessity to get to the cities' set targets. This is part of the goal of the City-zen approach: to increase the usability of such a theoretical framework which enables more participation of different stakeholders not only top-down yet also bottom-up; from city planners to citizen. For city planners the City-zen approach must also contribute to, and improve the outline of the path towards the set targets over the period of time that the roadmap covers by defining individual, but coherent interventions at technical and strategic levels.

To define a theoretical framework for energy master plans for cities, several approaches, methodologies and projects on energy planning have been studied so far. As a basis, some of the steps of the theoretical framework of the SREX five-step approach (SREX, 2011) have been adapted.

Even though the five-step approach mainly focuses on technical measures in integrated visions, both TRANSFORM and STEP-UP do show that measures on the strategic level (often to remove barriers) are equally important. Vandevyvere's study also stresses the importance of a multimodal system analysis to achieve integrated sustainability. We refer to these modals as 'layers of influence'.

Within the City-zen approach the basis of the five-step approach will therefore be expanded addressing non-technical barriers and opportunities at 4 levels (the condensed modals Vandevyvere refers to). The local stakeholders involved may not be able to significantly influence technological development, but can change the political, legal, social and economic situation, thus accelerating the transition to renewable energy. As Figure 1 shows, a division can be made between 'hard' aspects summarised in the energy atlas, and 'soft' aspects, to which societal mapping relates.

The energy atlas uses the Energy Potential Mapping method mentioned earlier in order to spatially quantify renewable potentials, combining these with present and future demand (reduction potentials) and the energy systems present. Societal mapping will augment this atlas with the barriers and opportunities on the social, political and legal layers. The implicit temporal component of these two categories is the identification of these barriers, and which opportunities will be additionally unlocked if these are removed, which can subsequently be made explicit as interventions.

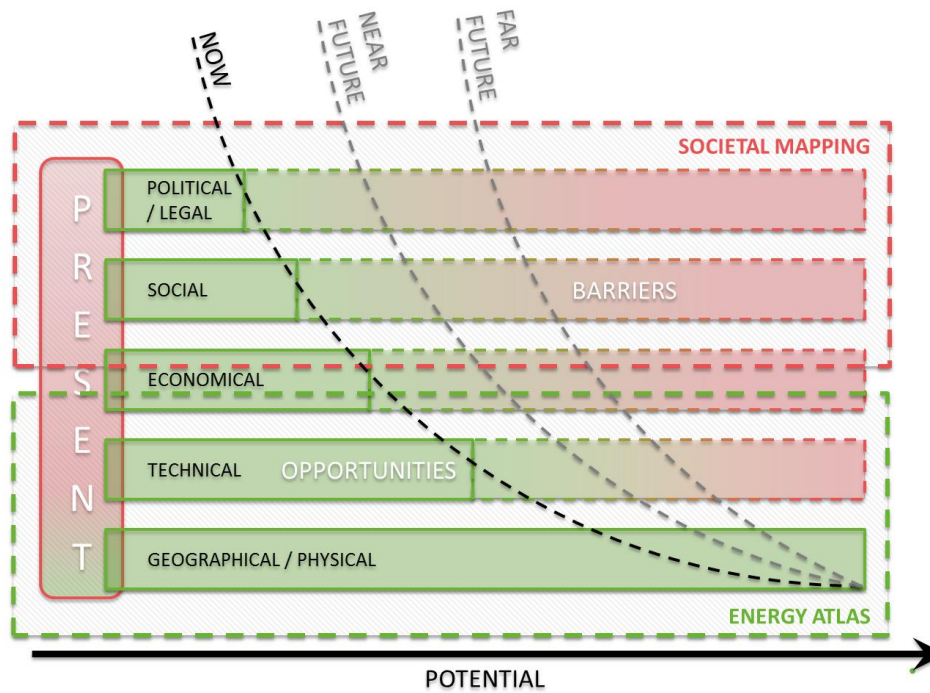


Figure 1 Diagram visualising the analysis of the present system in layers of influence, showing opportunities and barriers for the present and (near) future

In order to facilitate the step from potentials to actions, a City-zen catalogue of measures will be introduced in which these layers are integrated. Measures will not only technically be assessed but also at the political/legal, economic/financial and social levels. This will result in new measures (being solutions for barriers) at these non-technical levels. With this, the catalogue will contain sustainable energy measures both on a technical and a strategic (non-technical) level. Finally, strategies will be integrated in the City-zen approach to define the right and most suitable interventions from this catalogue for the city and its stakeholders and a roadmap towards a future vision.

#### Used terms

In the context of this paper, **measures** can be technologies, legal instruments, social models and many more generic devices, which during the project will be collected in the *City-zen Catalogue of Measures*. Assigning an area, budget and a period of time in which to apply these turns them into **interventions**. Realised projects (both within and outside of City-zen) with exemplary value are considered **case studies**, which are collected in the *Atlas of Case Studies* and may serve as both local and international inspiration for a city's vision and the roadmap that leads to it.

**Scenarios** refer to socio-economic projections and other external influences that affect the city, the **vision** is a set of long term targets and indicators of the city's choosing (rather than being a specific blueprint) that it aims to achieve, the **roadmap** connects the present with this future vision (and will be elaborated, with specific interventions, in the near future, while providing more a general direction in the far future) and **milestones** are future actions at set intervals where progress is evaluated and the roadmap adjusted accordingly.

### 3.1 The framework of the City-zen approach

The basics behind the various (successive) steps and elements of the City-zen framework and methodology will be explained in Figure 2. As the City-zen approach is part of a European FP7 project that won't be finished until 2019, the methodology is under construction and still needs to be expanded, tested and improved.

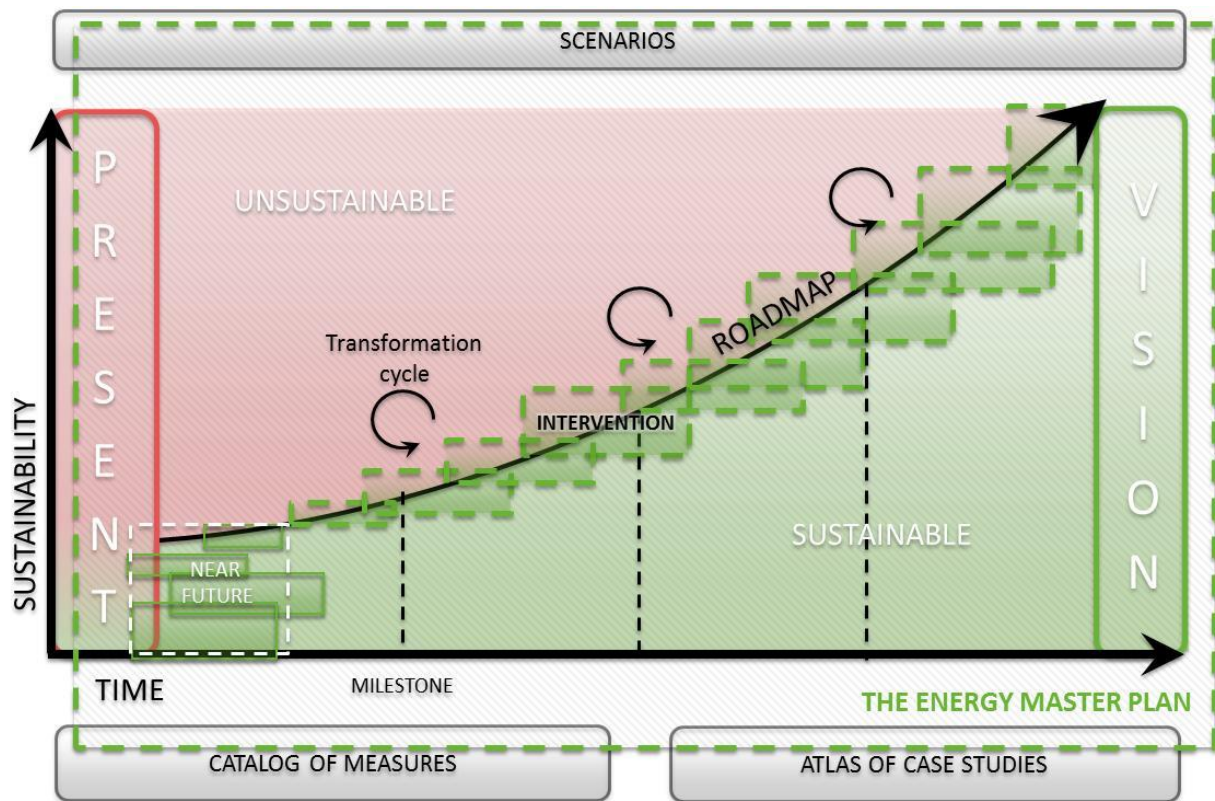


Figure 2 City-zen approach framework

### Step 1 Map the present and near future

The first step involves mapping the present and near future in several layers of influence: making an energy atlas and mapping the society as schematically shown in Figure 2. The length of the supply chain of the current energy system should be considered when assessing its sustainability and resilience. A gas based power plant may for example get its natural gas from a distant source in another country, something that occasionally applies to more renewable wood pellet based CHP plants as well.

Next follow the sub-steps of mapping the present and near future:

#### 1.1 Collect data on the geographical-physical environment

In order to build the energy atlas, the available data on the city's climate, infrastructure, including the existing energy system, energy usage (patterns), built environment and underground needs to be collected. A high detail level for each layer (for example energy demand or roof photovoltaic potential) is desirable but not required, and individual layers can always be improved upon at a later moment. If suitable, the influences of the social, legal and economical layers may be included in these layers. An example of this is the influence of risk zoning on wind turbine placement potential, a regulatory issue with a strong spatial effect.

#### 1.2 Map and analyse the technical energy potentials

The base data collected in 1.1 can be used to project various renewable energy techniques and other interventions in order to determine both the technical maximum potentials and their geographic spread of a city: the energy atlas. For the sub-steps 1.1 and 1.2 the EPM methodology will be applied, with some additional information of 1.3 and 1.5. Adding any information still missing or increasing its resolution will be a first strategic step to be taken by the city government.

#### 1.3 Analyse and map the economic system and financial barriers and opportunities

This step involves exploring those local and national economic and financial aspects that impede realisation of the maximum technical potentials explored in the energy atlas, and interventions that may increase this realisation. Examples may be changing municipal taxation schemes, vouching for investment loans or providing temporary subsidies.

#### 1.4 Analyse the social environment

The main question here is which local stakeholders will be involved in the transition process, either directly or indirectly and what their mind-set is. Although social changes may have the longest temporal horizon, these may be accelerated significantly by identifying key actors and actively engaging them.

#### 1.5 Analyse the political and legal environment

As with 1.3, this step will both have local and national aspects, and may either identify room for local measures or issues that need to be raised on the national agenda. Calculating the unrealised technical potential resulting from these barriers may provide incentive for national politics to address them. Both the

legal environment and the responsibilities of the governmental stakeholders involved need to be mapped as these may differ significantly between cities and countries.

## 1.6 Map the near future

This last part involves cataloguing ongoing and planned projects within the city.

### **Step 2** Determine scenarios

A range of possible far futures can be illustrated with the help of regional, national and international scenario studies, which will have an effect on the city. Conversely the city itself has a limited influence on them, therefore they provide the future environment that the city's vision will be based in.

### **Step 3** Select potentially suitable measures

Available measures (either single techniques, for example PV panels or combinations like solar district heating, but also legal, financial and social measures) will be collected from the Catalogue of Measures, useful references to The Atlas of Case Studies may provide additional inspiration here, showcasing built examples.

### **Step 4** Create a vision

The ambitions for the city can be defined by setting targets, goals and milestones (rather than a specific blueprint) in a future vision. Indicators (for example the share of renewables, the amount of CO<sub>2</sub>-exhaust, exergetic efficiency or the resilience of the energy system) need to be defined in order to allow tracking progress towards this vision (see also step 6). If the set targets are ambitious, the temporal horizon for the vision may be distant (for example 2065), in order to provide a suitable time frame to achieve them.

### **Step 5** Define the roadmap

Various strategies and approaches can be used to define suitable interventions over time, both on the strategic (i.e. processes) and the technical level. The various stakeholders involved will have different temporal horizons (political changes versus social ones for example, the former may be months to years whereas the latter may take a generation), which needs to be taken into account when defining these interventions. Because at this step the present, near future and desired far future are known, back-casting principles can be used to formulate a pathway between these, which will provide the actual steps – focusing on a detailed palette of interventions for the near future, while defining more general directions for later periods.

### **Step 6** Re-calibrate and adjust

Outside of the effects of planned interventions, both the environment and the actors can change over time, which may result in a deviation from the roadmap. To counter this effect, progress needs to be monitored, and at set intervals (milestones) compared to the targets set using the indicators defined in step 4.

Developing the **roadmap**, which can be seen as an extended version of a SEAP, is the most important and difficult part of the methodology. An essential aid here is the use of the *Catalogue of Measures* together with the *Atlas of Case Studies*. The roadmap will mainly be developed for city-planners, whereas the *Catalogue* will be designed to also be useful for and usable by citizens and other stakeholders. In here the different layers of influence will get an important place as well. Each technical measure may have barriers or opportunities in either the technical, economic, social or political/legal field. Strategic actions will remove the barriers, so subsequently new technical measures can be implemented.

Single approaches can be applied for different measures, to define whether or not a measure is suitable and if so, where and when the measure fits in a city and with these local interventions can be defined.

Considering these factors, shaping an intervention involving a district heating expansion could consist of the following steps:

- Map heat demand by end use (domestic hot water and space heating) and (current) temperature level
- Map building energy efficiency levels and current heating systems (block heating being particularly attractive)
- Map ownership (to identify housing corporations, collectives and larger companies)
- Map planned renovations
- Map planned road/sewer works

This would not only highlight areas of interest, but also provide a time table. The *Catalogue of Measures* will include these steps for each measure, allowing cities to simply collect the desired data and subsequently formulate suitable local interventions and finally a roadmap.

In order for the roadmap to achieve the maximum gain in CO<sub>2</sub> reduction per euro spent, the short and long term impacts of each measure have to be considered, therefore providing comparative insight in their benefits.

An essential part of this is understanding the supply chains involved in both the present day situation and the available measures, including extraction and generation, transport, distribution and final conversion. Making the right short term investments may drastically reduce the amount of funds required over the next 50 years to reach the goals set in the vision. Furthermore, investments in measures that are less favourable in the



short term may actually reduce the ability to achieve CO<sub>2</sub> reduction in the long term, or be highly dependent on measures taken at a larger scale, outside of local control.

There may for example be tension between investments (and the associated recovery period) in district heating networks (transport and distribution) and large scale improvements of thermal insulation (reducing the amount of final conversion needed). In this case the generation sources will have to be considered, as well as which quantities they will be able to supply 50 years from now. Industrial residual heat for example is at present largely dependent on a supply of fossil fuel sources, so if a decline is expected and local renewable heat sources may only be able to supply at lower temperatures, perhaps the network temperature will need to be adjusted.

Another example is in the application of heat pumps for space heating and domestic hot water (DHW). Assuming a current supply chain using natural gas (Amsterdam), given an average COP of 2.5 and retaining a small gas fired boiler for DHW, the short term effect will be changing the physical location of most of the associated CO<sub>2</sub> exhaust from individual houses to large power plants outside of the city (electricity in the Dutch national grid is at present predominantly generated by fossil fuels (CBS, 2015)). However, if this electricity mix expected to increasingly change towards (local) renewables, even this remote CO<sub>2</sub> exhaust will drastically be reduced, therefore making the earlier change in local conversion technology a significantly more sustainable one in the long term.

#### **4. Related projects**

As both the City-zen methodology and framework are still under development, no specific results from the applied City-zen approach can be shown yet. For this reason, this chapter showcases two existing studies and projects in order to explain some of the steps or principles that can be found in the City-zen approach.

##### **4.1 Oostland**

For the Dutch region of Oostland (near Rotterdam), an urban energy study was carried out in 2013 (Broersma, 2014), in order to start a regional energy atlas (of demand and renewable supply potentials). This 'catalogue of energy potentials' served as a base document, containing principles for defining suitable interventions for the local energy system. For the city of Pijnacker, an Energy Master Plan was proposed, which included a roadmap for a future district heating network as shown in the next figure. The level of detail for this roadmap was basic, outlining self-contained building blocks and future connecting and upgrading principles rather than defining an explicit time line.

A study of the local energetic characteristics of Pijnacker revealed heat demand in the built environment predominantly fell in the low and mid-temperature ranges, the majority related to horticulture. Fortunately, several potentially suitable sustainable sources were also identified in the area, which could be connected to demand areas using small scale district heating networks. Several of these are already present in the area and more are planned. As all rely on separate, single sources, both with limited resilience and expansion capabilities, it would be valuable to eventually interconnect them, creating a larger, more resilient multisource network in the process. This will also make it far easier to eventually connect new sources that may not be financially feasible at present but may become so in the future. A fixed temperature will have to be chosen for the main network, the exact level of this however depends on the present and expected future types of demand, using heat pumps to increase temperature level in small island subsections where necessary. The network has to be strategically dimensioned to cater for future throughput though. If the required temperature for the majority of demand lowers even further (refurbishment of energy inefficient older homes and the addition of well insulated new homes), the network temperature could in the future be changed to follow suit.

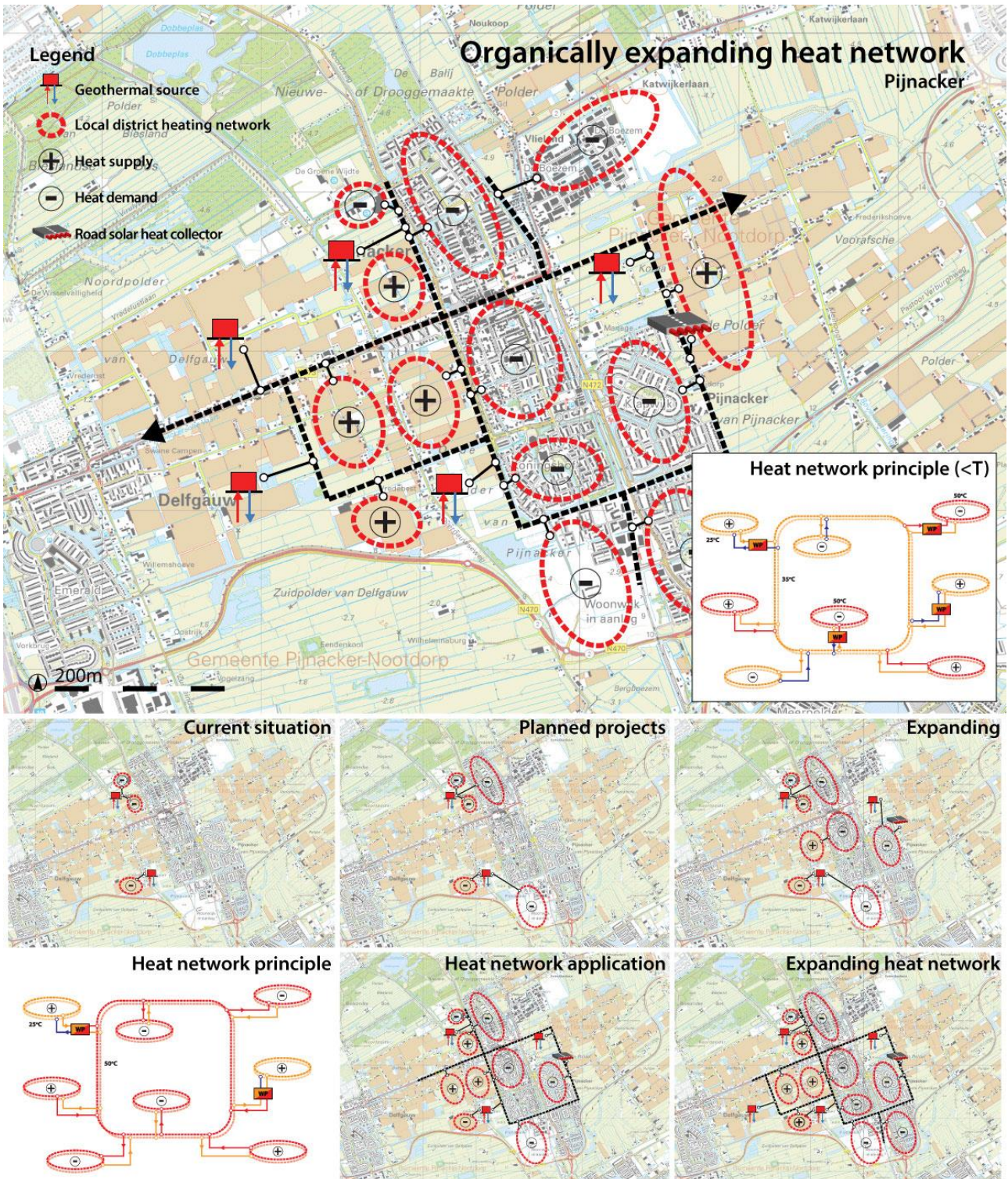


Figure 3 concept for an organically expanding district heating infrastructure for a self-sufficient Pijnacker (Broersma, 2014)



## 4.2 Sustainable Amsterdam

The City of Amsterdam recently published their Sustainable Agenda (Municipality of Amsterdam, 2015), adopted by the municipal council in March 2015. This agenda can be seen as a S.E.A.P. for the current governmental period (2014-2018) with clear targets, actions, budget and a timeline, as summarised in the visual roadmap below.

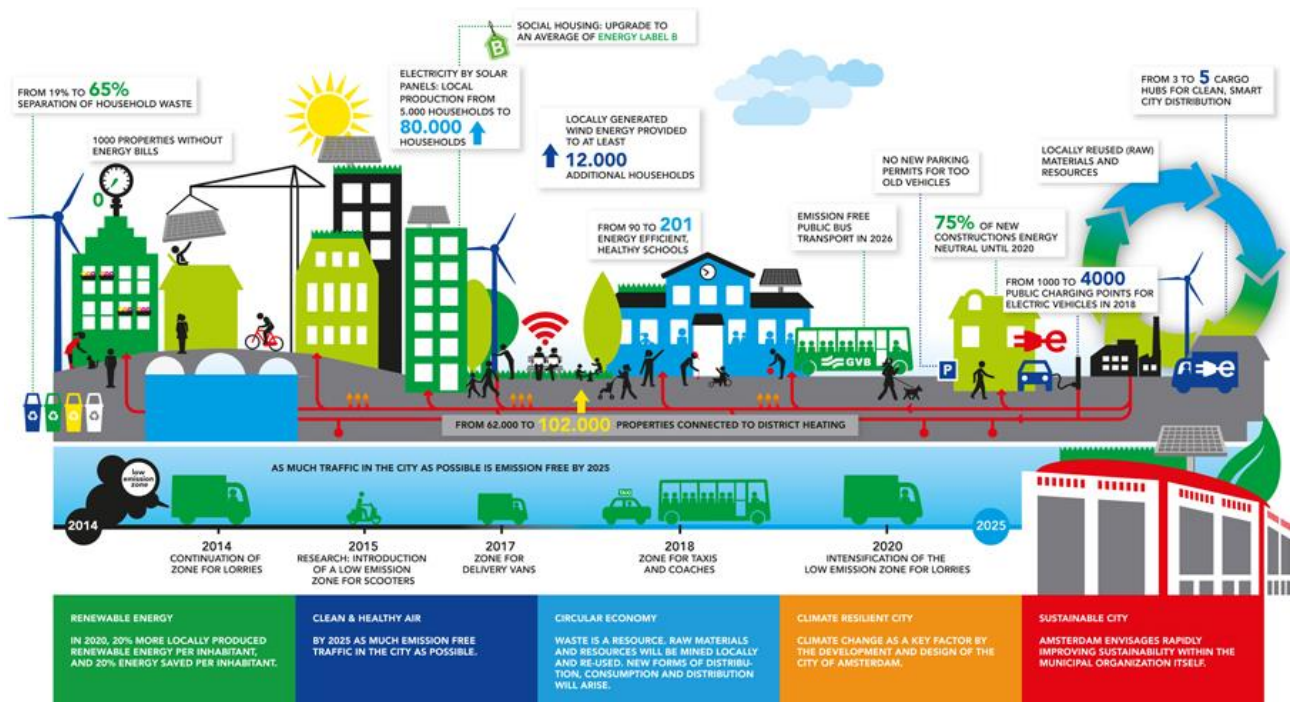


Figure 4 Amsterdam SEAP overview

The report does not explain the methodology used to define the specific interventions, however several steps coincide with the City-zen methodology, e.g. mapping energy demand, CO<sub>2</sub> emissions, renewable energy potentials and to a certain extent, stakeholder mapping.

## 5. Conclusion, discussion and outlook

The majority of the steps of the City-zen methodology are more or less present in many of the subject related studies, several of which being described in this paper. City-Zen however aims to combine provision of a broad, long term urban energy transition methodology focusing on not just using opportunities, but identifying and removing barriers. As the name implies, active public participation is an integral component both from social acceptance and financial investment points of view. Furthermore, existing buildings are emphasised, as these form the majority of most cities' building stock, and therefore an important opportunity to increase urban sustainability.

As an important part of City-zen is to not just provide long term sustainability goals but also a *roadmap* leading to these, the various parts of the methodology will be enhanced and refined over the next years in order to provide practical implementation tools and strategies for the stakeholders involved.

During the City-zen project, a more extensive long term roadmap towards fully sustainable partner cities Amsterdam and Grenoble will be developed (guided by the authors), applying the elaborated City-zen methodology and in return help evolve practical matters. As different cities have different goals, what exactly 'fully sustainable' is, needs to be decided locally, as described in step 4. The Sustainable Agenda of Amsterdam that was mentioned before, will in this case serve as a list of 'near future' plans (step 1), rather than be modified into a long term roadmap, as the latter will most likely cover 2050 and beyond.

In order to be able to build these roadmaps, sets of generic principles and approaches need to be defined in the Catalogue of Measures, for which both City-zen partners and past projects (for example other FP7 ones and the REAP, LES, SREX and Oostand studies) will serve as input.

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