

THE AMSTERDAM GUIDE TO ENERGETIC URBAN PLANNING

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Abstract

The City of Amsterdam has ambitious goals as to become climate neutral. This will only be possible through a structured approach to both new and existing neighbourhoods.

Following steps from the New Stepped Strategy - as used in the Rotterdam Energy Approach and Planning (REAP) - and using the methodology of Energy Potential Mapping (EPM), the Amsterdam Guide to Energetic Urban Planning (in Dutch: Leidraad Energetische Stedenbouw, LES) must become the manual that will support urban area (re)development towards energy neutrality.

The Guide clarifies local Amsterdam energy potentials, both natural and anthropogenic, and gives an extensive overview of measures and data to be used for the sustainable provision of electricity, heat and cold. This is presented in a very tangible manner, practical to urban planners, architects, housing corporations, developers, public institutions and politician.

The Amsterdam Guide has been tested on two sites, one to be newly constructed and another to be redeveloped, and the incremental approach proved worthwhile, enabling energy neutrality in both cases. The Guide has incited discussions on both short-term actions and long-term visions needed to facilitate real climate neutrality in the city of Amsterdam.

Keywords: sustainable urban planning, New Stepped Strategy, Rotterdam Energy Approach and Planning, Energy Potential Mapping, energy neutrality

INTRODUCTION

Urgency

In spite of some discussion caused by inaccuracies in their 2007 reports, the general conclusions by the IPCC [2007] still stand and are widely supported. The climate is changing at an unprecedented rate and mankind is one of the major causes as acknowledged.

Although the earth receives almost 9000 times more energy from the sun than that mankind needs, energy is becoming a huge problem. Western societies heavily rely on energy, fossil fuels in particular. The Netherlands for instance produces less than 4% of its energy by means of sustainable sources [CBS, 2008]. The rest is fossils and a bit of imported nuclear energy. As Mackay [2009] demonstrated, it is very difficult to establish a society fully run on renewables. However, Cullen & Alwood [2010] showed that most of the energy we use is lost as non-functional waste energy. So the initial demand can be reduced by more effective usage, such as by low-exergy means [Stremke et al., 2011].

Although estimates of resources fluctuate, it is apparent to both energy experts and oil companies that the end is coming near. We have passed peak oil [ITPOES, 2010]: these days we consume more oil than can be produced. That this is a literally dangerous situation was demonstrated by the two gulf wars and recent turmoil around gas from Russia (first: Ukraine disconnected, second: Belarus threatening to halt the throughput of Russian gas). Apart from this international perspective and its influence on the price of energy, few people from the West understand how dependent they have become on energy, and that a collapse in the provision would have devastating effects to everyday life.

Last but certainly not least, the western appetite for energy is severely limiting the opportunities of developing and emerging regions to catch up in prosperity. As figure 01 indicates, western countries owe their prosperity to limited use of energy in other parts of the world. Needless to say this situation deviates strongly from the equity goals posed by the Brundtland Committee in 1987.

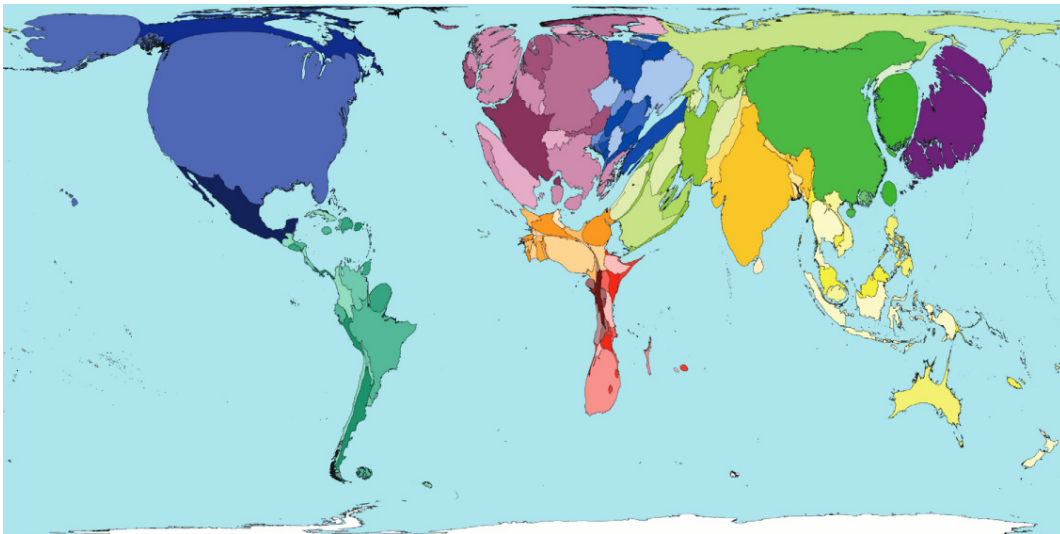


Figure 1: Developed countries above the equator infest on other regions for energy... Countries and the area of land respective to the amount of fuel they consume [Dorling et al., 2009, downloadable from www.worldmapper.org]

The abundance – until now – and relatively cheap and easy access to fossil energy has made the world lazy and inactive to search for local possibilities that would avoid demand from alien energy in the first place. We need to learn this again: planning and designing in such a way that local resources are optimally seized before any demand is posed upon other areas.

How can an urban area become energy neutral ? To accelerate this transition planning and design are crucial aspects to consider. Urban planners are in need of planning tools that bridge the gap between mapping, planning, zoning and designing on one hand and understanding of spatial implications of energy, technical energy data, energy solutions and energy scenarios on the other hand.

Climate-neutral ambitions

10 September 2008 the Amsterdam municipal council decided that as of 2015 new construction projects need to be climate-neutral. This means that projects need to comply with the definition of climate-neutral building (see section 1.3), with a 9.0 - 9.5 score of the Dutch EPL (energy performance on location). This council decision implies that energy will become an integral part of area development, a challenge and opportunity as cooperation between projects and connection with the surroundings offers added value at various scale levels.

The Amsterdam approach to climate-neutral building aims at project development and the contribution authorities can make therein. Agreements can be made, for instance, on the thermal insulation rate as well as energy consumption and generation. The ambitions can only be realised through a structured approach to both new and existing neighbourhoods.

Definitions

In Amsterdam, 'climate neutral' is defined as "building without use of fossil resources for the building-related energy demand" [Ontwikkelingsbedrijf Amsterdam, 2009]. This encompasses heating and cooling, hot tap water, ventilation and lighting, all ingredients of the energy performance of a building, however approximately half of all energy used in buildings. The other half is user-related (predominantly from user appliances).

In terms of the Amsterdam definition of climate neutral, critical connotations can be made, as the term actually implies a net zero effect on the climate, including all emissions with an influence on the climate, not just carbon dioxide (CO₂), yet also nitrous oxide (NO_x), water vapour, chlorine-fluorine-carbons (CFCs), methane (CH₄), ozone (O₃) etc. Through the avoidance of fossil fuels for building-related energy demands, emission of carbon dioxide, and a great deal of methane, nitrous oxide and water vapour is avoided, but not everything. Usage of biomass – provided it is replanted – may be considered as climate- or carbon-neutral, but the technical means to enable this may not be as such. The story is slightly different when using solar energy, wind and geothermal heat. These sources produce no CO₂ and their equipment for energy conversion will be energetically earned back within a certain time-frame, leaving no climate marks on the planet.

In this sense the Amsterdam definition rather equals energy neutral than climate neutral. Also carbon-neutral would describe the aim better than climate-neutral. Perhaps even better would be 'fossil energy free': avoiding any use of fossil fuels in building-related energy consumption.

This said, the official objective of the city is clear through its own definition of climate neutral, and we can proceed how to achieve it.

METHODOLOGICAL BASIS

The Amsterdam Guide to Energetic Urban planning is founded on methods previously developed: Energy Potential Mapping (EPM) and the Rotterdam Energy Approach & Planning (REAP), which in its turn is based on the New Stepped Strategy. All of them will be discussed in this chapter.

Energy Potential Mapping

The foundations for the method of Energy Potential Mapping (EPM) were laid during the Grounds for Change project [Noorman et al., 2006], where new perspectives were sought for a sustainable energy system in the Northern Netherlands (provinces of Frisia, Groningen and Drenthe). This region traditionally had provided the country with energy – peat in the 19th and early 20th century, mineral oil since the 1950s and natural gas since 1960. and is de methodiek van energiepotentiekaarten ontstaan. The design team of Grounds for Change [Roggema et al., 2006] introduced a cartoonesk way of charting potentials in the region for energy harvest.

The method of EPM was significantly improved and provided with a scientific approach through a study for the new environmental plan (POP) of the province of Groningen [Dobbelsteen et al., 2007]. Based on rudimentary information from topographic, climatic, geophysical and infrastructural maps, various new GIS-based maps were produced for potential production of renewable fuels, power generation, heat and cold potentials and even possibilities for carbon sequestration. Figure 2 clarifies the method developed.

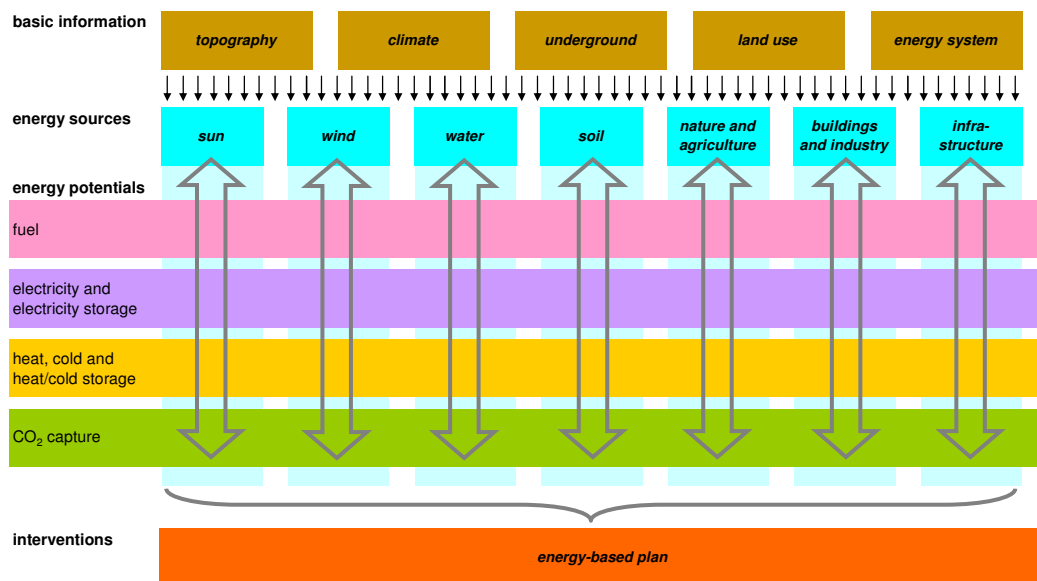


Figure 2: Method of Energy Potential Mapping, graphically clarified [Dobbelsteen et al., 2007]

After the POP Groningen report, EPM was further enhanced and tested at other scales through the EPM studies for expansion plans of Almere, Schiphol Airport and Hoogezand-Sappemeer [discussed in Dobbelsteen & Broersma, 2010]. For Schiphol and Hoogezand-Sappemeer the outcome was newly presented in stacked maps, depicting energy potentials at

various heights and depths, as shown in figure 3, which enabled calculations of the maximum yield to be reapt. In the case of Hoogezand-Sappemeer, the energy produced would potentially exceed the demand, which is important as the new development then could also serve older parts in town.

Energy Potential Pile - De Groene Compagnie (DGC)

Energy Potencies

DGC
(700ha)

Sun
9640 MWh_{pr}/ha 6750 GWh_{pr}

Wind, 100m
228 MWh_e/ha 160 GWh_e

Wind, 30m
56 MWh_e/ha 5 MWh_e/turby

Waste, households
1,7 MWh_(e + th)/ha 1,2 GWh_(e + th)

Residual heat
Kappa
2x 70 GWh_{th}

Biomass
Nature maintenance 4,7 MWh_{pr}/ha
Forest maintenance 18,9 MWh_{pr}/ha
Maintenance DGC 2,4 GWh_{pr}
Eggfarm 1,1 GWh_{pr}
Maintenance surroundings 20 GWh_{pr}

Underground upto -50m
vertical heat exchange (HE)

Aquifers
heat/cold storage

Geothermal, -3000m
105 °C

Energy demand 3000 households:
10,6 GWh_{th}
26,5 GWh_{th}

Applied

PV op roofs 12 GWh_{pr}
Solar collectors on roofs 25 GWh_{th}

Wind, large turbines
160 GWh_e

Wind, turby's 39 GWh_e
(theoretic max.)

Waste, incineration 1,2 GWh_(e + th)

Residual heat
Kappa 140 GWh_{th}
Jansen Wijhe 15 GWh_{th}

Biomass
Maintenance DGC 3,1 GWh_{pr}
Chickens manure gasification 1,7 GWh_{pr}
Maintenance surroundings (radius 10km) 20 GWh_{pr}

Suitability underground HE
very suitable
suitable

Suitability for aquifers
very suitable
suitable
unknown
restriction area

Geothermal
gas drill point

Figure 3: Energy potential map for the expansion plan of Hoogezand-Sappemeer, depicting energy potentials at various heights and depths, enabling calculations of the total energy yield possible [Broersma et al., 2010]

A last development in the EPM range are the heat maps made for the Netherlands [Broersma et al., 2010], focusing solely on heat and cold demand and supply, and meant to feed a national website, which will serve the realization of better exchange of energy in the built environment, or even the spatial planning of new developments.

The New Stepped Strategy

Since the end of the 1980s, approaches to sustainable building have often followed the 'Trias Energetica' [Lysen, 1996], or three stepped strategy:

1. Reduce the demand
2. Use renewable energy
3. Supply the remaining demand cleanly and efficiently

The Trias Energetica forms the guideline for a logical, environmentally conscious approach. However, in the period it has been in use it has not led to the progress required. In particular the extent of penetrated renewable energy technology, step two, is minimal. Mainly in the Netherlands one mainly concentrates on step 3, after limited efforts with step 1 and skipping step 2. No wonder the Dutch are still relying on non-sustainable energy for 96% of their demand.

That step 2 is often neglected and so little use is made of sun, wind and other renewable energy sources has a lot to do with the step abruptly following a sub-optimal reduction in energy demand and with the fact that an important intermediate step is not explicitly mentioned in the Trias.

This is the reason why, the New Stepped Strategy (NSS) [Dobbelsteen, 2008] was presented as a substitute for the Trias Energetica. This strategy adds an important intermediate step between the reduction in demand and the use of renewable sources, and it incorporates a waste stream strategy, inspired by the Cradle-to-Cradle philosophy [McDonough & Braungart, 2002]. The former last step, implying hence accepting the use of fossil fuels, is abolished. Thus, the New Stepped Strategy is as follows (depicted by figure 4):

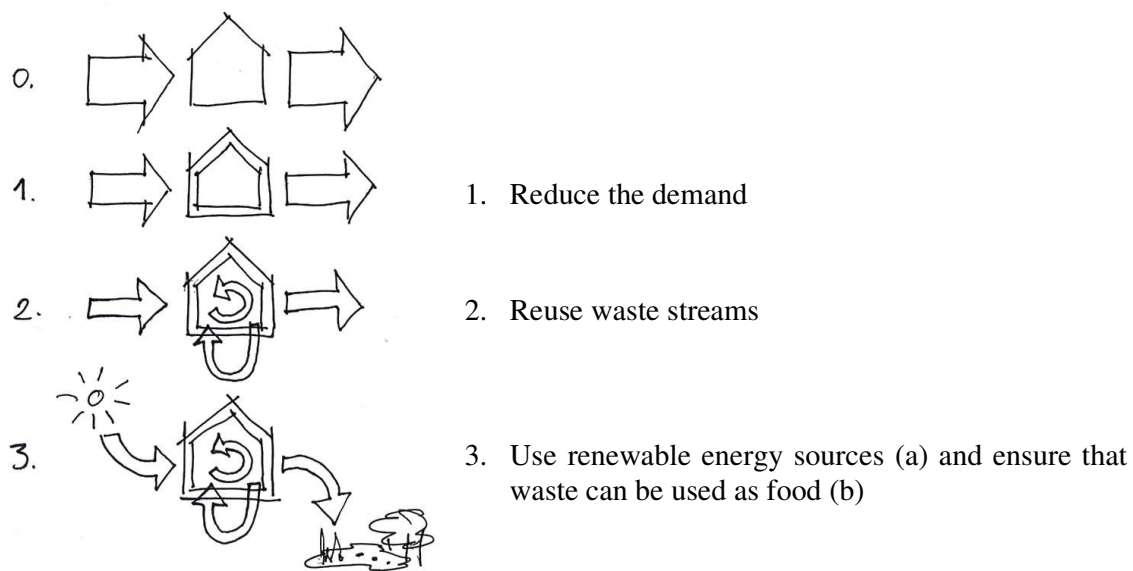


Figure 4: Principle of the New Stepped Strategy [Dobbelsteen, 2008]

The Rotterdam Energy Approach & Planning (REAP)

Based on the New Stepped Strategy, a team of people from the City of Rotterdam, architects and TU Delft [Tillie et al., 2009a] developed the Rotterdam Energy Approach & Planning (REAP) for a structural approach to urban areas. Therefore, the three steps of the NSS were not only connected to buildings yet also to clusters or neighbourhoods, districts and the entire city. Figure 5 graphically clarifies the principle of REAP method.

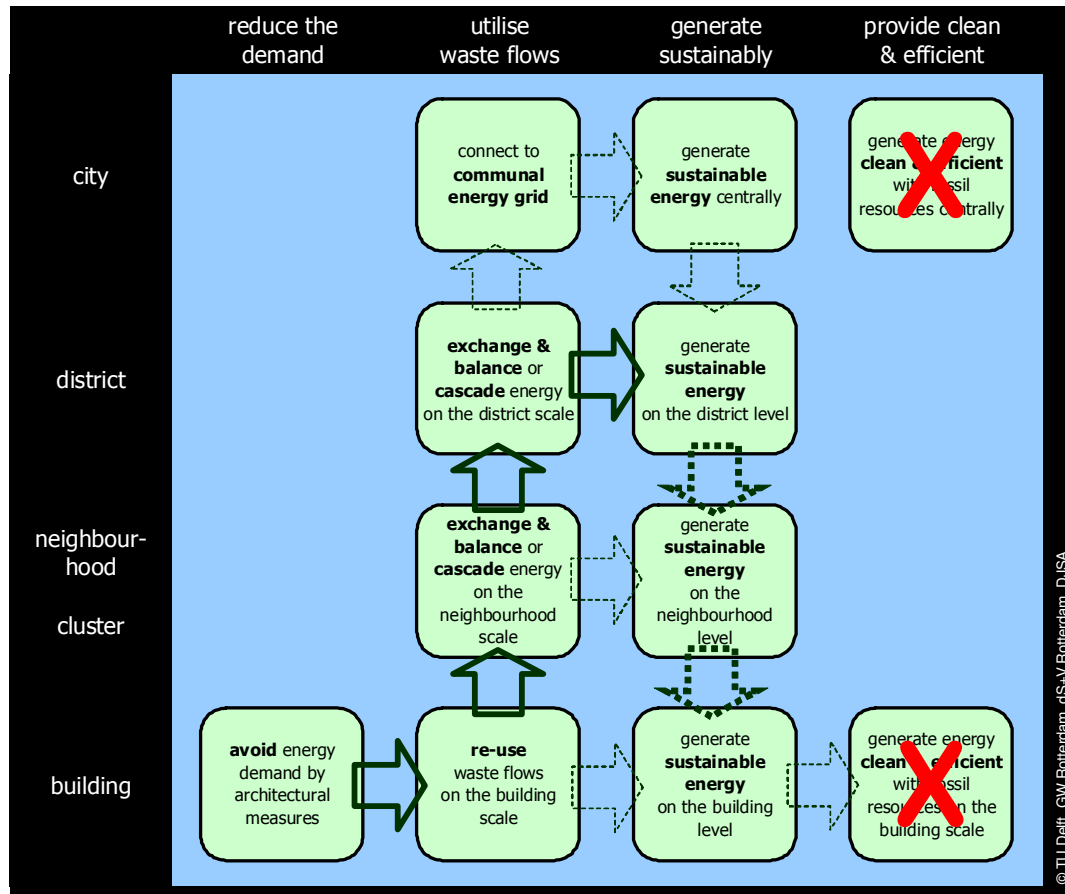


Figure 5: Principle of REAP for urban areas: the New Stepped Strategy that starts with buildings but expand to neighbourhoods and district for optimal balancing of supply and demand before the question of sustainable generation is tackled [based on Tillie et al., 2009a]

REAP was tested on, or actually evolved with a study of, the district of Hart van Zuid ('heart of south'), for which the City of Rotterdam wanted to explore the possibility to become carbon neutral. The largest harbour city of Western Europe has the ambition to become 50% carbon neutral by 2025, so interventions in the existing urban landscape will be necessary. REAP demonstrated that Hart van Zuid could become carbon neutral without devastating demolition of existing building, however with smart exchange of waste energy streams from different urban functions, as well as some additions of greenhouses, green facades and roofs.

The essential novelty in the REAP method is the explicit step of exchanging, balancing and cascading of waste energy in an urban context (figure 6). Earlier approaches had neglected this yet unrepeat energy potential in cities.



Figure 6: Urban functions have totally different energy patterns for heat (W), cold (K) and electricity (E). This image shows that a logical connection between specific functions can be made that require heat or cold, since the generation of cold produces waste heat, which can be used elsewhere but usually is emitted into the air [Tillie et al., 2009a]

Since its presentation in a Dutch and English language book [Tillie et al, 2009a], it was handed to the Dutch minister of the environment, got coverage on national tv and radio, was published in a scientific journal [Tillie et al., 2009b] and inspired other cities to work accordingly. One of them was the city of Amsterdam.

THE AMSTERDAM GUIDE

Amsterdam Guide to energetic urban planning (in Dutch: Leidraad Energetische Stedenbouw, LES) must become the manual that will support urban area (re)development towards energy neutrality [Kürschner et al., 2011].

Outline of the Amsterdam Guide

The Guide clarifies the local Amsterdam energy potentials, both natural and anthropogenic, and gives an extensive overview of measures and data to be used for the sustainable provision of electricity, heat and cold. This is presented in a very tangible manner, practical to urban planners and architects, housing corporations and project developers, public institutions and politician. Figure 7 gives an overview of measures (in simplified icons) in the Amsterdam Guide, divided between heat and cold versus electricity, with the potential improvement of energy performance added.

Overzicht maatregelen LES



Figure 7: Overview of the Amsterdam Guide to energetic urban planning, according to the New Stepped Strategy and with a division between measures (simplified in icons) for heat and cold (thermisch) versus electricity (Elektra); big printed numbers and percentages below are the potential improvement in energy performance

Amsterdam potentials

The Amsterdam Guide commences with an inventory of all energy potentials of the city, in accordance with the method of Energy Potential Mapping. Thus the booklet gives all potentials of natural energy sources and anthropogenic functions that produce waste streams. This latter is of course necessary for the second step of the New Stepped Strategy.

Factsheets

Where REAP was merely a method for an approach to energy-neutral or carbon-neutral cities, the Amsterdam Guide is presented as a handbook, guideline for urban planning within the objectives of the Amsterdam climate goals. The method is set within the municipal managerial system of PLABERUM (translated in English: 'planning and decision making of spatial measures') and gives practical data regarding financial and technical-spatial measures. Figure 8 gives apart of the overview of measures of thermal energy.

Toolbox LES: Maatregelen thermische energie

blz.	icoon	naam	rendement	plaberum	schaal	ruimtebeslag	combineert met
37		compactheid	10-40 %	1 2 3 4			
38		orientatie: zontoetreding	10-15 %	1 2 3 4			
39		optimale hoogte	10-30 %	1 2 3 4			
40		bruikbare dakvorm	max 100 %	1 2 3 4			
43		programmatische balans	max 100 %	1 2 3 4			
44		stadswarmte	40-100 %	1 2 3 4			
45		bio wkk	max 50 GJ/won.	1 2 3 4			
48		zonnecollectoren	1,5 GJ/m2	1 2 3 4			
49		WKO	3.900 GJ/doublet	1 2 3 4			
50		warmte wisselaar	max 35 GJ/won.	1 2 3 4			
51		stadskoude	40-100 %	1 2 3 4			

94 Gemeente Amsterdam

Figure 8: Overview of the Amsterdam Guide to energetic urban planning, according to the New Stepped Strategy and with a division between measures (simplified in icons) for heat and cold versus electricity; figures in the column 'rendement' are the potential improvement in energy performance

Measures are presented in factsheets, of which figure 9 gives two examples, one for heat and cold, one for electricity. These factsheets are meant to be practical and helpful for urban planners and other stakeholders involved in the process of making Amsterdam climate neutral.

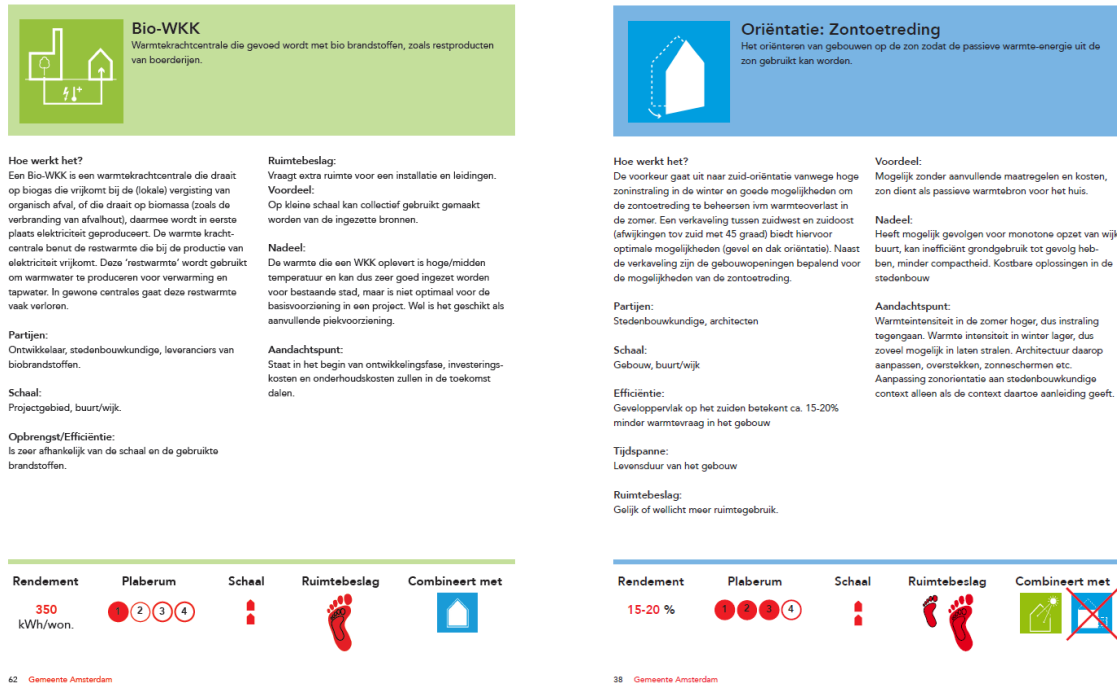


Figure 9: Two examples of factsheets within the Amsterdam Guide, on the left hand side bio CHP for heat production and on the right hand side solar access for power generation

Case studies

The Amsterdam Guide has been tested on two sites, one to be newly constructed (in northern Amsterdam) and another to be redeveloped (in western Amsterdam). With a mixed team of urban planners, energy experts from energy companies, housing corporations, project leaders and the authors presentations were given about the Amsterdam Guide about how to use it, showing what options planners have. After that each group worked on of the areas in an iterative design process planning and energy options were tested in the design and a reality check was performed directly with the stakeholders at the table. After this an energy performance was calculated via an excel sheet of the Amsterdam Guide. The outcome was direct feedback in the ongoing process. This incremental approach proved worthwhile, enabling energy neutrality in both cases. The Guide has incited discussions on both short-term actions and long-term visions needed to facilitate real climate neutrality in the city of Amsterdam. Both urban areas could be made energy-neutral according to the steps of the Amsterdam Guide.

Implementation

Before being finally presented, the Amsterdam Guide was discussed with a response group of

people who would have to work with it or who had profound knowledge of the matter. These meetings were used to improve the model. The concept version of the booklet was presented and discussed with the Amsterdam alderman for spatial planning, and finally it was presented early 2011 to colleagues of the departments of spatial planning and environmental & building regulations, hence the people who need to work with it in practice. The response to this was positive and everyone was asked to test the model in concurrent projects and get back with comments or suggestions for improvements.

DISCUSSION AND PERSPECTIVE

The Amsterdam Guide to energetic urban planning, just as REAP, so far have only been theoretic, though practical, methods that could help urban development towards energy, carbon or climate neutrality. Useful as they may seem, the proof is in tasting the pudding, so ongoing projects within the cities of Amsterdam and Rotterdam will have to show whether the models actually work.

In Rotterdam a REAP follow-up study recently started to investigate not just the technical consequences, yet also the legal, strategic, social and spatial consequences. The test-case this time will be a real project to be elaborated by the municipality, giving it a proper meaning and insight to: What energy scenarios are possible at this local level; what are the building blocks used, to make combinations between scenarios; what are the back up systems and what are the legal, spatial and social consequences.

In Amsterdam, several areas are under study, paving the way for a new approach according to the Amsterdam Guide. The year of 2011 will provide the first findings of working according to the method, inevitably leading to necessary improvements to version 2.0, expected late 2011.

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