Energetic Urban Planning –
A novel approach to carbon-neutral cities

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Summary

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 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.

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.

The paper will discuss the Amsterdam Guide, its methodology, the cases studied, as well as future perspectives and considerations.

Keywords: New Stepped Strategy, Rotterdam Energy Approach & Planning (REAP), the Amsterdam Guide to Energetic Urbanism, Energy Potential Mapping, carbon-neutrality

1. Introduction

1.1 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 1 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.

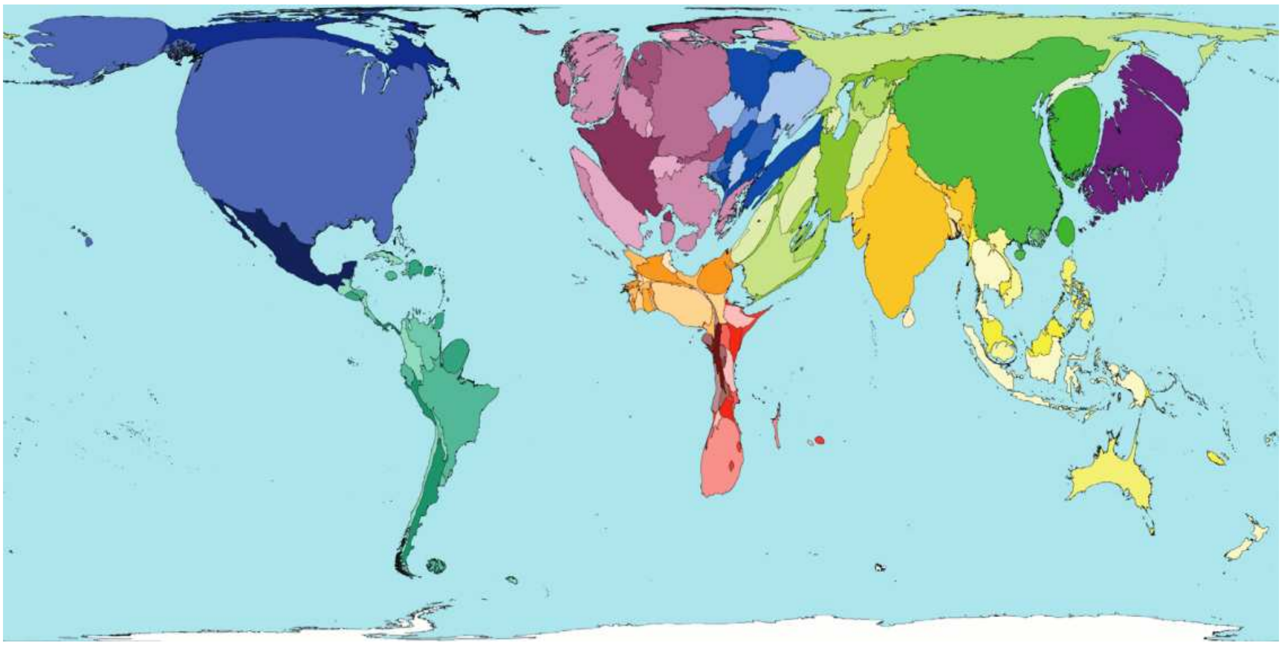


Fig. 1: *Developed countries above the equator infest on other regions for energy… Countries and the area of land respective to the amount of fuel they consume [Dorling et al., 2009, downloadable from www.worldmapper.org]*

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.

1.2 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.

1.3 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 (CO_2), yet also nitrous oxide (NO_x), water vapour, chlorine-fluorine-carbons (CFCs), methane (CH_4), ozone (O_3) 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 CO_2 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.

2. 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.

2.1 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.

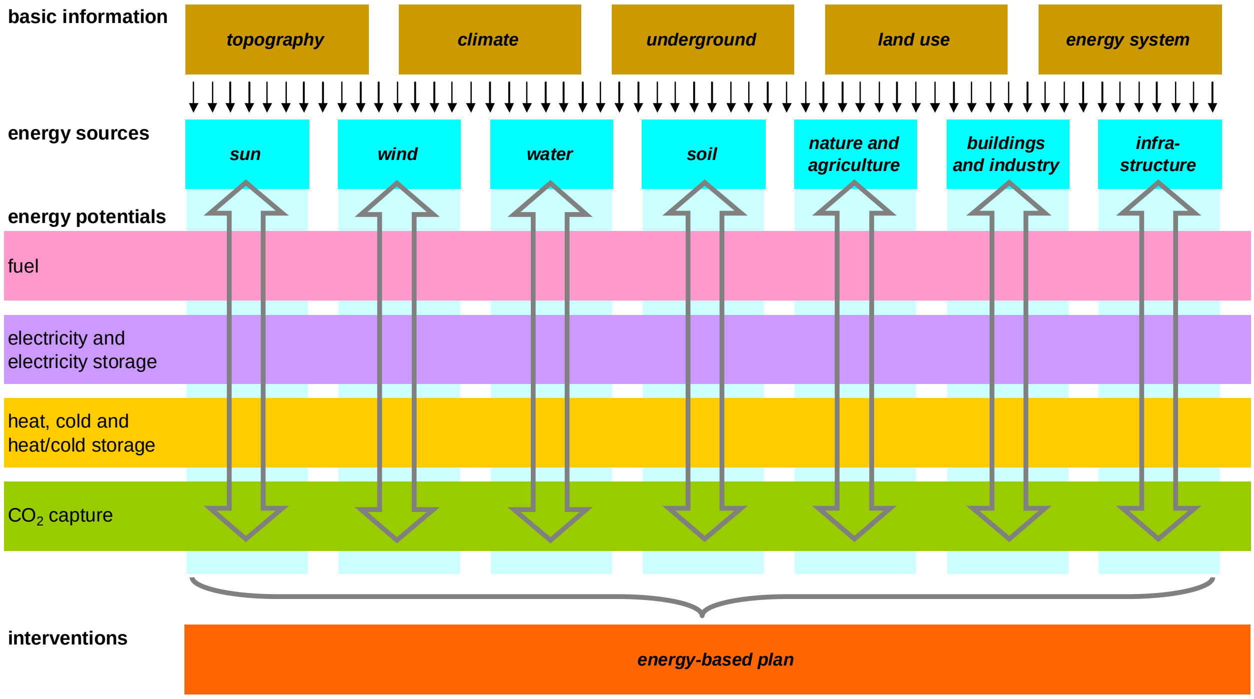


Fig. 2: *Method of Energy Potential Mapping, graphically clarified [Dobbelsteen et al., 2007]*

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.

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.

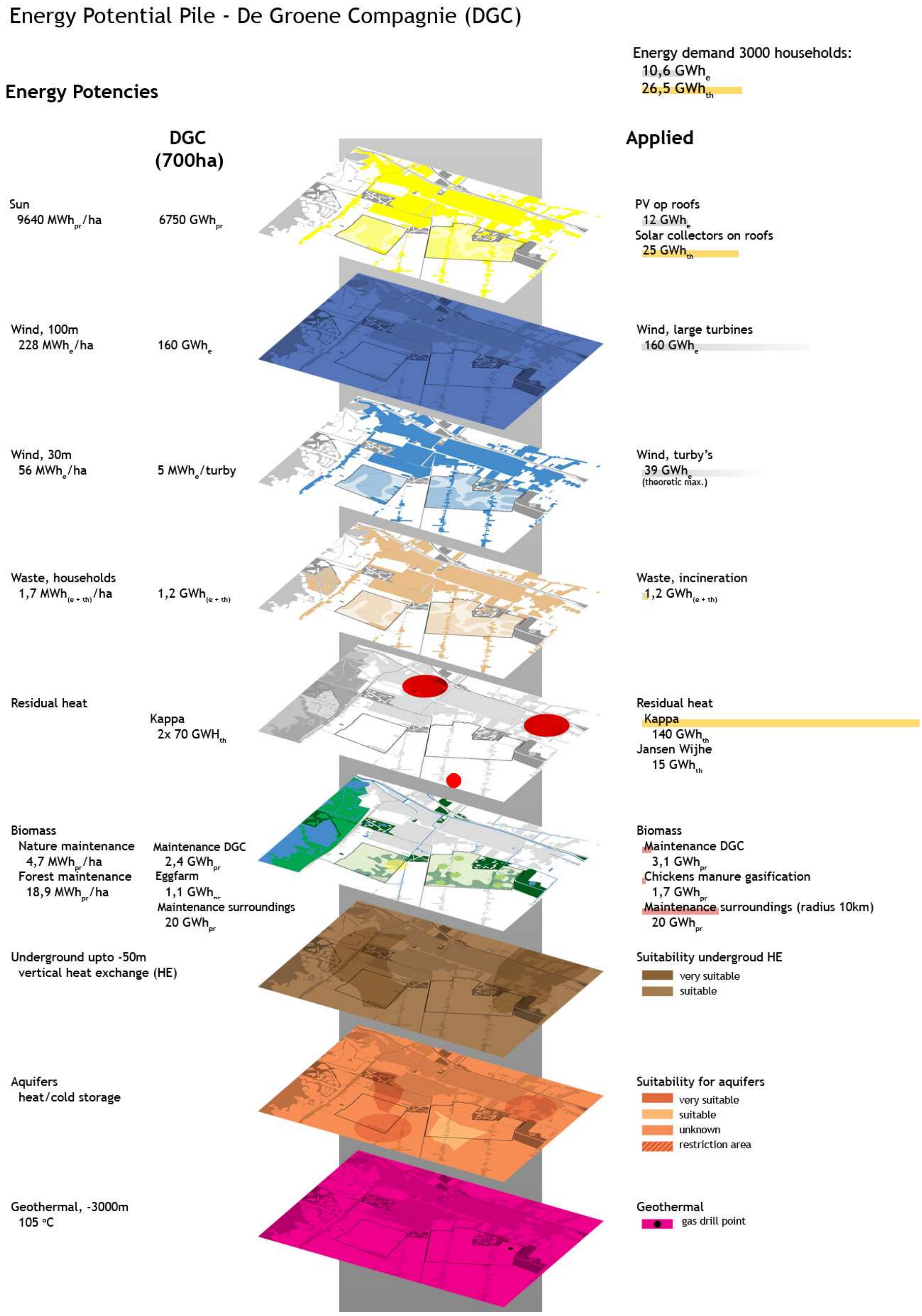


Fig. 3: *Energy potential map for the expansion plan of Hoogezand-Sappemeer, depicting energy potentials at various heights and depths, enabling calculations of the total energy yield possible [Broersma et al., 2010]*

2.2 The New Stepped Strategy

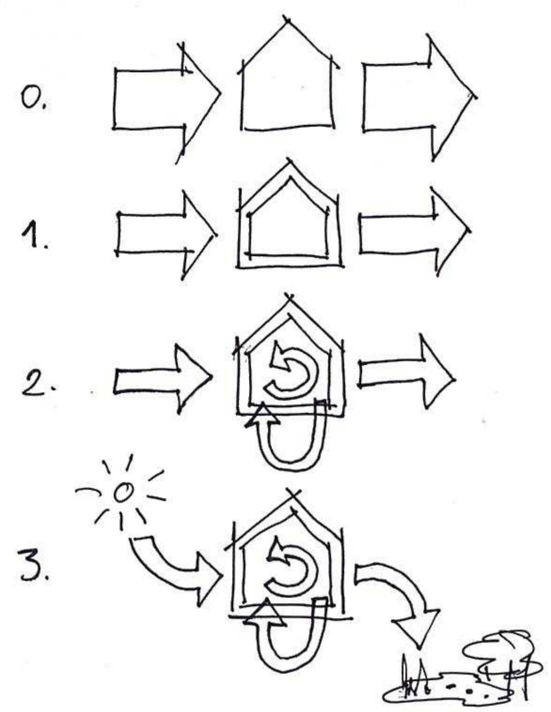
Since the end of the 1980s, approaches to sustainable building have often followed the 'Trias Energetica' [Lysen, 1996], or three stepped strategy:

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):



1. Reduce the demand

2. Reuse waste streams

3. Use renewable energy sources (a) and ensure that waste can be used as food (b)

Fig. 4: *Principle of the New Stepped Strategy [Dobbelsteen, 2008]*

As can be seen, the NSS has a new second step that makes optimal use of waste flows– waste heat, waste water and waste material – not only for each individual building but also on a city wide scale. The addition in step 3 (really 3b) concerns waste that can not be processed in our technical waste processing cycle and so must be returned to nature. This can only be done if the waste is safe (non-toxic) and if it can form nutrients for micro-organisms.

The old step 3 of Lysen will continue to be necessary for the coming years of transition, however eventually this will no longer be possible or desired.

2.3 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.

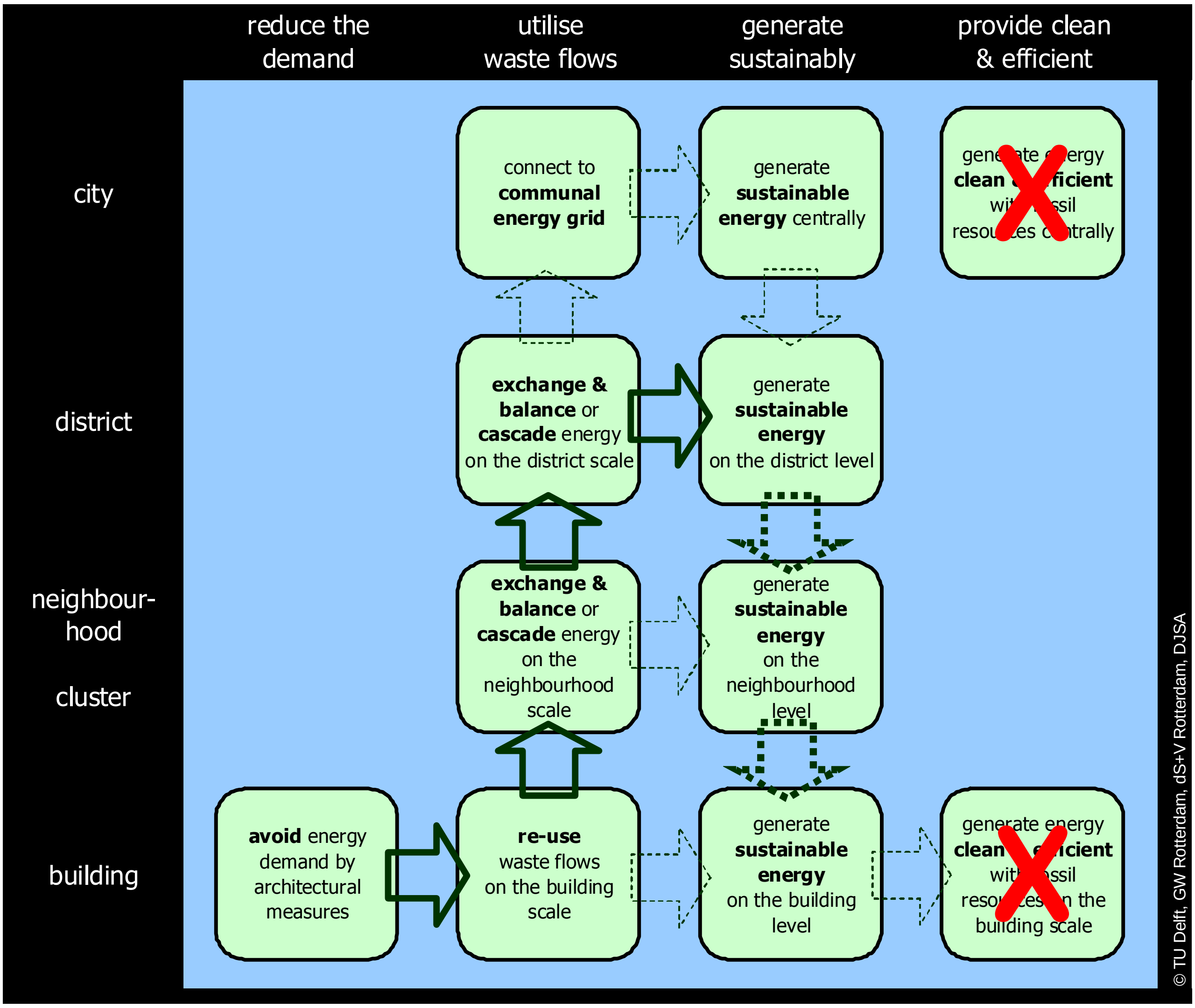


Fig. 5: *Principle of REAP for urban areas: the New Stepped Strategy that starts with buildings but expand to neighbourhoods and district for optimal balancing of supply and demand before the question of sustainable generation is tackled [based on Tillie et al., 2009a]*

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 unreapt energy potential in cities.

Fig. 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.

3. The Amsterdam Guide

Amsterdam Guide to energetic uirban 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].

3.1 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.

Fig. 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 (blue) versus electricity (green); figures in red are the potential improvement in energy performance*

3.2 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.

3.3 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.

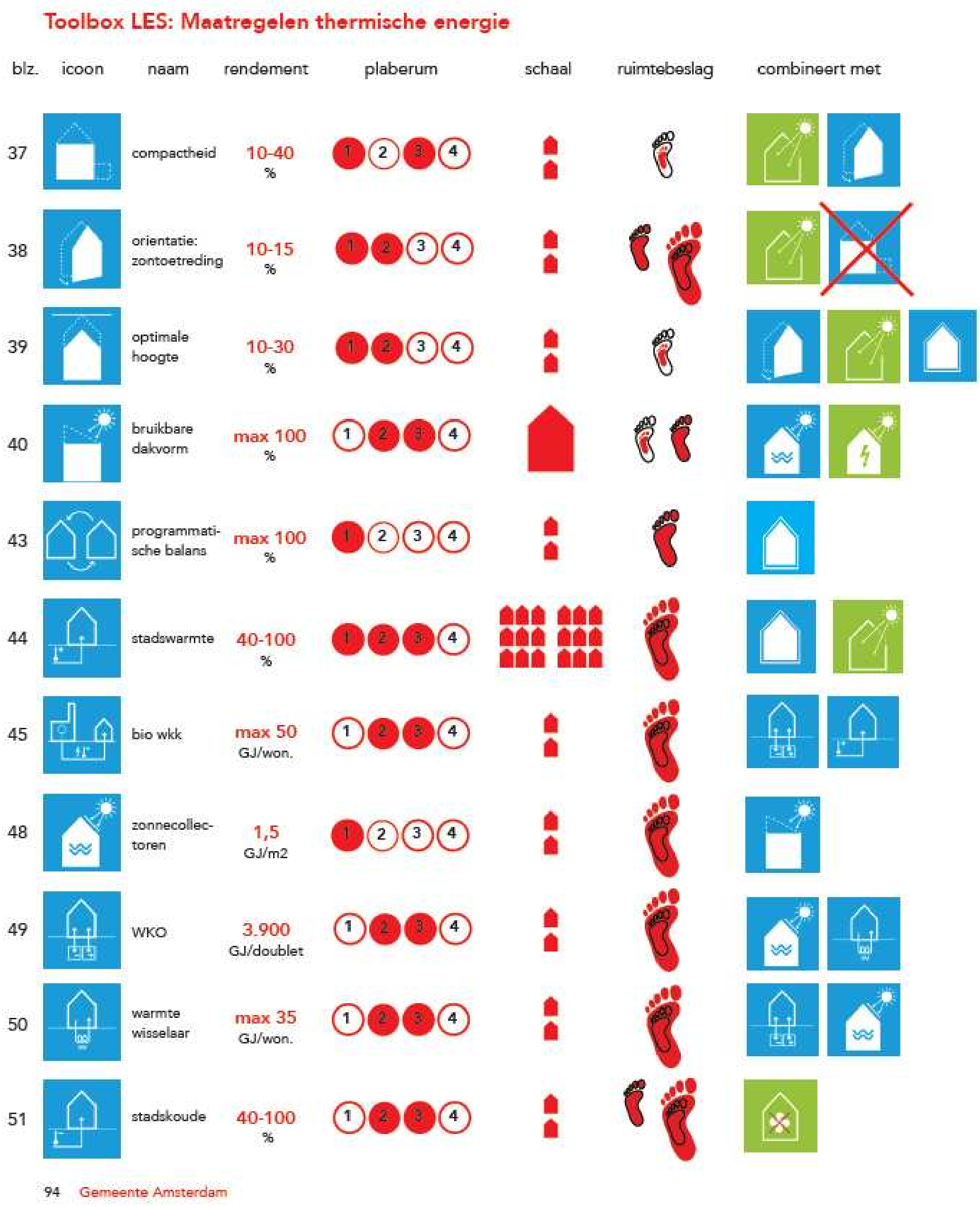
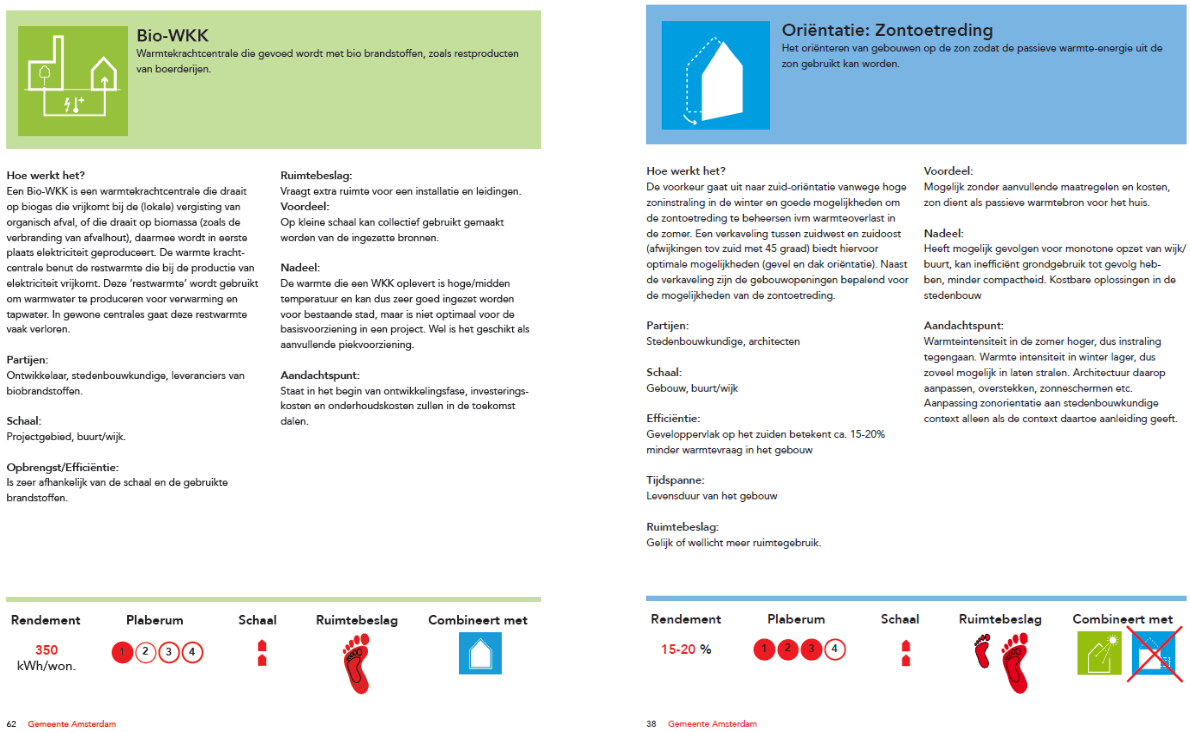


Fig. 8: *Overview of measures and their consequences in the Amsterdam Guide*

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.



Bio-WKK
Warmtekrachtcentrale die gevoed wordt met bio brandstoffen, zoals restproducten van boerderijen.

Hoe werkt het?
Een Bio-WKK is een warmtekrachtcentrale die draait op biogas die vrijkomt bij de (lokale) vergisting van organisch afval, of die draait op biomassa (zoals de verbranding van afvalhout), daarmee wordt in eerste plaats elektriciteit geproduceert. De warmte kracht-centrale benut de restwarmte die bij de productie van elektriciteit vrijkomt. Deze 'restwarmte' wordt gebruikt om warmwater te produceren voor verwarming en tapwater. In gewone centrales gaat deze restwarmte vaak verloren.

Partijen:
Ontwikkelaar, stedenbouwkundige, leveranciers van biobrandstoffen.

Schaal:
Projectgebied, buurt/wijk.

Opbrengst/Efficiëntie:
Is zeer afhankelijk van de schaal en de gebruikte brandstoffen.

Ruimtebeslag:
Vraagt extra ruimte voor een installatie en leidingen.
Voordeel:
Op kleine schaal kan collectief gebruikt gemaakt worden van de ingezette bronnen.

Nadeel:
De warmte die een WKK oplevert is hoge/midden temperatuur en kan dus zeer goed ingezet worden voor bestaande stad, maar is niet optimaal voor de basisvoorziening in een project. Wel is het geschikt als aanvullende piekvoorziening.

Aandachtspunt:
Staat in het begin van ontwikkelingsfase, investerings-kosten en onderhoudskosten zullen in de toekomst dalen.

Rendement	Plaberum	Schaal	Ruimtebeslag	Combineert met
350 kWh/won.	1 2 3 4			

62 Gemeente Amsterdam

Oriëntatie: Zontoetreding
Het oriënteren van gebouwen op de zon zodat de passieve warmte-energie uit de zon gebruikt kan worden.

Hoe werkt het?
De voorkeur gaat uit naar zuid-oriëntatie vanwege hoge zoninstraling in de winter en goede mogelijkheden om de zontoetreding te beheersen ivm warmteoverlast in de zomer. Een verkaveling tussen zuidwest en zuidoost (afwijkingen tov zuid met 45 graad) biedt hiervoor optimale mogelijkheden (gevel en dak oriëntatie). Naast de verkaveling zijn de gebouwopeningen bepalend voor de mogelijkheden van de zontoetreding.

Partijen:
Stedenbouwkundige, architecten

Schaal:
Gebouw, buurt/wijk

Efficiëntie:
Geveloppervlak op het zuiden betekent ca. 15-20% minder warmtevraag in het gebouw

Tijdspanne:
Levensduur van het gebouw

Ruimtebeslag:
Gelijk of wellicht meer ruimtegebruik.

Voordeel:
Mogelijk zonder aanvullende maatregelen en kosten, zon dient als passieve warmtebron voor het huis.

Nadeel:
Heeft mogelijk gevolgen voor monotone opzet van wijk/buurt, kan inefficiënt grondgebruik tot gevolg heb-ben, minder compactheid. Kostbare oplossingen in de stedenbouw

Aandachtspunt:
Warmteintensiteit in de zomer hoger, dus instraling tegengaan. Warmte intensiteit in winter lager, dus zoveel mogelijk in laten stralen. Architectuur daarop aanpassen, overstekken, zonneschermen etc. Aanpassing zonorientatie aan stedenbouwkundige context alleen als de context daartoe aanleiding geeft.

Rendement	Plaberum	Schaal	Ruimtebeslag	Combineert met
15-20 %	1 2 3 4			

38 Gemeente Amsterdam

Fig. 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*

3.4 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), 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. Both urban areas could be made energy-neutral according to the steps of the Amsterdam Guide.

3.5 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.

4. 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.
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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