Residential Energy Transition
of Amsterdam Nieuw West neighbourhoods

Katerina Panteli_4516397
Mentors: MSc Siebe Broersma
Dr.-Ing. MSc Thaleia Konstantinou
Delegate of examiners: Dr. Ad Straub
BACKGROUND

CITY-ZEN PROJECT

Energy urban planning approach for fully sustainable and energy (carbon) neutral smart cities

Demonstration projects
- Grenoble
- Amsterdam (Nieuw-West)

EU ENERGY GOALS

Carbon emissions reduction 80-95% by 2050
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NEEDED STRATEGIES FOR
• Smartifying e-grid
• Heat network expansion
• Residential retrofit
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PROBLEM STATEMENT

There are several existing strategies to deal with the retrofit of different residential typologies. Moreover, for Amsterdam Nieuw West there is not a clear structured approach for residential retrofit interventions referring to different scales.
MAIN OBJECTIVE

The main objective is the development of a stepped methodology, to define a roadmap that leads to the goal of the energy transition and CO2 emissions reduction of residential neighbourhoods in Amsterdam Nieuw West, through the suitable combinations of energy systems and retrofit measures on the timeline until 2050.
The main objective is the development of a methodology, starting from city scale, to define the roadmap that leads to the goal of the energy transition and CO2 emissions reduction of residential neighbourhoods in Amsterdam Nieuw West, through the suitable combinations of energy systems and retrofit measures on the timeline until 2050.

This roadmap constitutes a useful tool for the municipality of Amsterdam, to help give more unified solutions for the energy transition of neighbourhoods of the city, to achieve the energy targets.
RESEARCH QUESTION

Which is the methodology leading to the design of a roadmap that helps to define which energy systems and retrofit measures should be applied where and when, on residential neighbourhoods of Amsterdam Nieuw West until 2050, for achieving their energy transition and CO2 emissions reduction?
SUB-QUESTIONS

• Which are the current energy demands and potentials of Amstedam city?

• Which are the future energy goals until 2050?

• Which are the suitable energy systems and the retrofit measures that can be applied on building, neighbourhood and district scale?

• Which residential typologies exist in Amsterdam Nieuw West neighbourhoods and which are their ownership and energy characteristics?

• Which neighbourhood should get which combination of energy systems and retrofit measures and when?

• Which are the decision points of the roadmap for the different neighbourhoods in Amsterdam Nieuw West with retrofit interventions on timeline?
RESIDENTIAL ENERGY TRANSITION

01  FUTURE ENERGY GOALS

02  RESIDENTIAL BUILDING STOCK IN THE NETHERLANDS

03  RESIDENTIAL RETROFIT CASE STUDIES

04  RETROFIT MEASURES & ENERGY SYSTEMS

05  EXISTING ENERGY URBAN PLANNING METHODOLOGIES

06  SET ENERGY URBAN PLANNING METHODOLOGY STEPS
### Future Energy Goals

Overview of Amsterdam’s & European Commision’s energy goals

#### EU2020 to 2050

<table>
<thead>
<tr>
<th>Comparing to 1990</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
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<tr>
<td>Energy reduction</td>
<td>20%</td>
<td>27%</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Share of renewables</td>
<td>20%</td>
<td>27%</td>
<td>-</td>
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<tr>
<td>CO2 reduction</td>
<td>20%</td>
<td>40%</td>
<td>60%</td>
<td>75%</td>
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</table>

... the cities don’t no how to achieve the goals yet...

... a methodology leading to the roadmap for energy transition should be developed today in order to reach this targets in 2050...
LITERATURE REVIEW

01 FUTURE ENERGY GOALS
02 RESIDENTIAL BUILDING STOCK IN THE NETHERLANDS
03 CASE STUDIES
04 RETROFIT MEASURES & ENERGY SYSTEMS
05 EXISTING ENERGY URBAN PLANNING METHODOLOGIES
06 SET ENERGY URBAN PLANNING METHODOLOGY STEPS
# RESIDENTIAL BUILDING STOCK IN THE NETHERLANDS

## Residential typologies

<table>
<thead>
<tr>
<th>Region</th>
<th>Construction Year Class</th>
<th>Additional Classification</th>
<th>SFH Single-Family House</th>
<th>TH Terraced House</th>
<th>MFH Multi-Family House</th>
<th>AB Apartment Block</th>
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<tr>
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<td><img src="NL.N.MFH.05.Gen" alt="Picture" /></td>
</tr>
</tbody>
</table>

Generic building types in the Netherlands (source: http://webtool.building-typology.eu/#bm)
RESIDENTIAL BUILDING STOCK IN THE NETHERLANDS

Total primary energy demand for Heating and DHW (kWh/m²) After retrofit ambitious standard

<table>
<thead>
<tr>
<th>Construction year class</th>
<th>Single-Family House</th>
<th>Terraced House</th>
<th>Multi-Family House</th>
<th>Apartment Block</th>
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<td>43.8</td>
<td>40.7</td>
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<td>1992...2005</td>
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</tbody>
</table>

Total primary energy demand for Heating and DHW (kWh/m²) per typology (source: http://webtool.building-typology.eu/#bm)
LITERATURE REVIEW

01  FUTURE ENERGY GOALS
02  RESIDENTIAL BUILDING STOCK IN THE NETHERLANDS
03  CASE STUDIES
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05  EXISTING ENERGY URBAN PLANNING METHODOLOGIES
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CASE STUDIES
Residential energy retrofit on different scales

PIJNACKER, OOSTLAND
From district to city scale
Basic principles
• Energy Potential Mapping
• Small scale heat networks supported by local sustainable sources
• Future connection to DHN

WIJK VAN MORGEN, KERKRADE
from building to neighbourhood
Basic principles
• Passive House standard
• Exploitation of solar energy
• Repeatable renovation concept for a whole neighbourhood

TRUMPINGTON, CAMBRIDGE
From building to district
Basic principles
• A feasible and reproducible retrofit strategy same typology
• Achieve “A” energy label
LITERATURE REVIEW

01 02 03 04 05 06

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RETROFIT MEASURES & ENERGY SYSTEMS

Basis of categorizing

REDUCE + REUSE EXCHANGE CASCADE + PRODUCE = ENERGY BALANCE

SUN EARTH WIND WATER WASTE BIOMASS

HEATING COOLING DOMESTIC HOT WATER ELECTRICITY

RENEWABLE ENERGY SOURCES ENERGY NEEDS
# RETROFIT MEASURES & ENERGY SYSTEMS

List of measures by literature review

<table>
<thead>
<tr>
<th>REDUCE</th>
<th>REUSE EXCHANGE CASCADE</th>
<th>PRODUCE</th>
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<tr>
<td>Exterior walls insulation</td>
<td>Waste heat recovery for district heat network</td>
<td>Photovoltaic’s (PVs)</td>
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<tr>
<td>Roof insulation</td>
<td>Waste heat recovery for building heating</td>
<td>Solar Collectors (SC)</td>
</tr>
<tr>
<td>Ground floor/basement ceiling/basement wall insulation</td>
<td>Energy exchange between building zones</td>
<td>Photo Voltaic Thermal systems (PVT’s)</td>
</tr>
<tr>
<td>High-performance windows</td>
<td>Energy exchange between buildings</td>
<td>Heat pumps (ground source, air, water or waste heat)</td>
</tr>
<tr>
<td>Energy efficient lighting</td>
<td>Energy cascade</td>
<td>Deep Geothermal systems</td>
</tr>
<tr>
<td>Shading systems - Solar protection</td>
<td>Smart appliances (dishwasher, clothes washer &amp; dryer, Refrigerator, water heater)</td>
<td>Aquifer Thermal Energy Storage (ATES)</td>
</tr>
<tr>
<td>Efficient mechanical ventilation system (with heat recovery)</td>
<td>Road collectors with ATES</td>
<td>Waste-to-energy district heating plant</td>
</tr>
<tr>
<td>Shower heat exchangers</td>
<td>District heating boiler fuelled by electricity, biogas, wood pellets, wood chips (usually as backup heating systems)</td>
<td>Combined Heat and Power (CHP) system fuelled by biogas or biomass</td>
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<tr>
<td>Smart meter</td>
<td>Wind turbines</td>
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## RETROFIT MEASURES & ENERGY SYSTEMS

**Catalogue of measures for this project**

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<th>DISTRICT</th>
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</table>
RETROFIT MEASURES & ENERGY SYSTEMS

Proposed energy systems for Amsterdam city

Existing energy systems’ application scenarios

1st scenario

2nd scenario

District Heat Network (D.H.N)

Small scale heat network with ATES

Zero On the Meter (NOM)

All-electric

Green gas
RETROFIT MEASURES & ENERGY SYSTEMS

Application requirements of energy systems

- Favourable solution when there is heating network near
- High heat demand
- Easier to convince one owner / big corporation

District Heat Network (D.H.N)
Small scale heat network with ATES
Zero On the Meter (NOM)
All-electric
Green gas
District Heat Network (D.H.N)

Small scale heat network with ATES

Zero On the Meter (NOM)

All-electric

Green gas

- Excess heat from buildings like offices, supermarkets, hospitals and supermarkets in the neighbourhood
- Heating and cooling demand in equilibrium
- Well-insulated dwellings with integrated floor and/or wall heating
- Preferable in case of big buildings & not too high heat demand
- Easier to convince one owner / big corporation
RETROFIT MEASURES & ENERGY SYSTEMS

Application requirements of energy systems

- Low-rise dwellings because of the suitable roof area
- Well-insulated dwellings with low heat demand
- Possible for individual home owners & for big corporations
RETROFIT MEASURES & ENERGY SYSTEMS

Application requirements of energy systems

- Preferable for high rise dwellings since low rise are possible for NOM
- Well-insulated dwellings with low heat demand
- Possible for individual home owners & for big corporations

District Heat Network (D.H.N)  Small scale heat network with ATES  Zero On the Meter (NOM)  All-electric  Green gas
RETROFIT MEASURES & ENERGY SYSTEMS

Application requirements of energy systems

- District Heat Network (D.H.N)
- Small scale heat network with ATES
- Zero On the Meter (NOM)
- All-electric
- Green gas

- Can be injected into the natural gas grid
- A suitable solution in the case historic buildings that have strict restrictions for any modifications
- Possible in case of big buildings with multiple owners.
RETROFIT MEASURES & ENERGY SYSTEMS

Important variables for applying the suitable energy system

- Ownership
- Retrofit time before or after the energy system application
- Average heat demand
- Existing district heating in neighbourhood
- Storeys number (2 levels or higher)
- Heating and cooling need proportion in the neighborhood
- Excess heat from non-residential buildings
LITERATURE REVIEW

01 02 03 04 05 06

FUTURE ENERGY GOALS
RESIDENTIAL BUILDING STOCK IN THE NETHERLANDS
CASE STUDIES
RETROFIT MEASURES & ENERGY SYSTEMS
EXISTING ENERGY URBAN PLANNING METHODOLOGIES
SET ENERGY URBAN PLANNING METHODOLOGY STEPS
ENERGY URBAN PLANNING METHODOLOGIES

Basis of retrofit steps

TRIAS ENERGETICA

1. Minimize the energy demand
2. Use of sustainable energy sources
3. Use of fossil fuels only if necessary

THE NEW STEPPED STRATEGY APPROACH

0. 0 standard building
1. 1 reduce energy consumption
2. 2 reuse waste energy streams
3. 3a renewable energy production for remaining demand
3b waste = food

[Dobbelsteen, 2008]

THE REAP METHODOLOGY

City ➔ District ➔ Neighbourhood ➔ Building
Retrofit in stages

Minor -> 30% energy savings 1-3 energy retrofit measures

Moderate -> 30%-60% 3-5 energy retrofit measures

Deep -> 60%-90% Holistic retrofit approach - Package of measures

nZEB -> 90% + Addition of renewable energy technologies
ENERGY URBAN PLANNING METHODOLOGIES
Energy Potential Mapping (EPM)

ENERGY DEMAND MAPS
- ELECTRICITY
- GAS

ENERGY POTENTIAL MAPS
- SUN
- GEO
- WIND
- WATER
- WASTE
- BIOMASS
- WASTE HEAT
ENERGY URBAN PLANNING METHODOLOGIES

Energy Potential Mapping (EPM)

ENERGY DEMAND MAPS
- ELECTRICITY
- GAS

ENERGY POTENTIAL MAPS
- SUN
- GEO
- WIND
- WATER
- WASTE
- BIOMASS
- WASTE HEAT

THE ENERGY MASTER PLAN
Transition to self-sufficient city regions by means of an approach to local energy potentials
ENERGY URBAN PLANNING METHODOLOGIES

City-Zen stepped methodology

Step 1: Map the present
Step 2: Map the near future
Step 3: Envision the future
Step 4: Define desired future
Step 5: Select energy systems
Step 6: Define roadmap
Step 7: Re-calibrate and adjust
LITERATURE REVIEW

01 FUTURE ENERGY GOALS

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03 CASE STUDIES

04 RETROFIT MEASURES & ENERGY SYSTEMS

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ENERGY URBAN PLANNING METHODOLOGY STEPS

Leading to energy transition of residential areas

Step 1  Map the present
Step 2  Define future energy targets
Step 3  Strategy for selecting energy systems
Step 4  Roadmap design
Apply steps on city scale

**Step 1** Map the present
- Step 1a Energy demands
- Step 1b Energy potentials

**Step 2** Define future energy targets
- Step 2a Future scenario for natural gas and electricity use
- Step 2b Desired future heat demand

**Step 3** Strategy for selecting energy systems
- Step 3a Develop scenario for dividing the main heat systems through the districts of Amsterdam
- Step 3b Main heat systems ratio in each district
- Step 3b Classify energy systems

**Step 4** Roadmap design

Amsterdam city
## ENERGY URBAN PLANNING METHODOLOGY STEPS

Leading to the roadmap final design

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
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<tbody>
<tr>
<td><strong>Map the present</strong></td>
<td><strong>Define future energy targets</strong></td>
<td><strong>Strategy for selecting energy systems</strong></td>
<td><strong>Roadmap design</strong></td>
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<tr>
<td><strong>Step 1a</strong></td>
<td><strong>Step 2a</strong></td>
<td><strong>Step 3a</strong></td>
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<td>Future scenario for natural gas and electricity use</td>
<td>Develop scenario for dividing the main heat systems through the districts of Amsterdam</td>
<td>Define suitable energy systems in 2050 for each neighbourhood</td>
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<td><strong>Step 1b</strong></td>
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<tr>
<td>Energy potentials</td>
<td>Desired future heat demand</td>
<td>Main heat systems ratio in each district</td>
<td>Describe energy systems and retrofit measures leading to 2050 vision</td>
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<tr>
<td><strong>Step 1c</strong></td>
<td><strong>Step 3c</strong></td>
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<tr>
<td>Energy potentials</td>
<td>Develop decision-making diagram for on-site interventions on appropriate time</td>
<td>Define the interventions on timeline</td>
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</table>

### Amsterdam Nieuw West neighbourhoods

- **Step 1a** Site determination inside Amsterdam Nieuw West
- **Step 1b** Buildings description & Energy demands
- **Step 1c** Energy potentials

- **Step 2a** Desired future heat demand
- **Step 2b** Low and high temperature heat potentials & technologies for each system

- **Step 3a** Set variables for selecting the suitable energy system
- **Step 3b** Set priority criteria for on-site interventions
- **Step 3c** Develop decision-making diagram for on-site interventions on appropriate time

- **Step 4a** Define suitable energy systems in 2050 for each neighbourhood
- **Step 4b** Describe energy systems and retrofit measures leading to 2050 vision
- **Step 4c** Define the interventions on timeline
ENdergy urban planning methodology steps
Leading to energy transition of residential areas

Step 1
Map the present

Step 1a
Energy demands

Step 1b
Energy potentials

Amsterdam city
STEP 1  MAP THE PRESENT

1a Energy demands

Average gas demand

How was it mapped out?
This map shows the average gas consumption per square metre (m²) of floor area for each urban block, which is determined using the average consumption of all the gas connections within an urban block or cluster. In principle each dwelling has a single connection, while a business might have several. The data is grouped by function and per 5 connections.
STEP 1  MAP THE PRESENT

1a Energy demands

Average electricity demand

This map shows the average electricity consumption per m² of floor area for each urban block, which is determined using the average consumption of all the connections within an urban block or cluster. In principle each dwelling has a single connection, but a business might have several. The data is grouped by function and per 5 connections.
STEP 1  MAP THE PRESENT

1a Energy demands

Electricity

4 595 566 161 kWh/year

16.5 PJ/year

Natural Gas

788 716 193 m³/year

1 m³ = 9.796 kWh

7 704 968 489 kWh/year

1 kWh = 3.6 * 10⁻⁹ PJ

27.7 PJ/year

STEP 1  MAP THE PRESENT

1b Energy potentials

Solar potential from PV panels on roofs

Total potential = 3.75 PJ + 0.26 PJ = 4.01 PJ

How it was mapped out?
This map was produced with the aid of the Zonatlas (Solar Atlas). Combining weather data, solar insolation, the pitch of roofs and the incidence of shade makes it possible to give a highly accurate indication of the suitability of roofs for the collection of solar energy. The map is an adaptation of the map in the Zonatlas and indicates the potential per m$^2$ of built-up land.
The detailed inset for Amsterdam-Southwest was copied directly from the Zonatlas and shows the suitability of each roof for the collection of solar energy.

Solar potential per year in kWh per m$^2$ of surface area
- 1 to 22
- 22 to 38
- 38 to 56
- 56 to 96
- 96 to 100

## STEP 1  MAP THE PRESENT

### 1b Energy potentials

Renewable sources potentials & energy production technologies

<table>
<thead>
<tr>
<th>Source</th>
<th>Potential Type</th>
<th>Technology</th>
<th>Potential</th>
<th>Available Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUN</td>
<td></td>
<td>PV panels on roofs</td>
<td>4.01 PJ</td>
<td></td>
</tr>
<tr>
<td>WIND</td>
<td></td>
<td>Wind turbines</td>
<td>1.78 PJ</td>
<td></td>
</tr>
<tr>
<td>DOMESTIC WASTE</td>
<td>Waste incineration</td>
<td>1.18 PJ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOMASS</td>
<td></td>
<td>Biomass treatment</td>
<td>0.06 PJ</td>
<td></td>
</tr>
<tr>
<td>RESIDUAL HEAT</td>
<td>Supermarkets, Offices, Hospitals, Datacenters</td>
<td>1.90 PJ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EARTH</td>
<td></td>
<td>Open loop thermal energy storage - ATES system</td>
<td>111.9 PJ available</td>
<td></td>
</tr>
<tr>
<td>WATER</td>
<td></td>
<td>Closed loop thermal energy storage - GSHP system</td>
<td>8.40 PJ</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deep geothermal system</td>
<td>9.36 PJ available</td>
<td></td>
</tr>
</tbody>
</table>

ENERGY URBAN PLANNING METHODOLOGY STEPS

Leading to energy transition of residential areas

Step 1
Map the present

Step 1a
Energy demands

Step 1b
Energy potentials

Step 2
Define future energy targets

Step 2a
Future scenario for natural gas and electricity use

Step 2b
Desired future heat demand

Amsterdam city
### STEP 2 DEFINE FUTURE ENERGY TARGETS

#### 2a Future scenario for natural gas and electricity use

<table>
<thead>
<tr>
<th></th>
<th>2017 (PJ)</th>
<th>2050 Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity use</td>
<td>16.5</td>
<td>Remains the same</td>
</tr>
<tr>
<td>Natural gas use</td>
<td>27.7</td>
<td>Not used anymore</td>
</tr>
</tbody>
</table>

- **Assumption:** Demand reduced because of using smart appliances
  - But, an amount needed for heat pumps’ operation
STEP 2  DEFINE FUTURE ENERGY TARGETS

2b Desired future energy demand for heating

Cooking demand = Gas demand * 5% = 1.4 PJ
Losses = Gas demand * 5% = 1.4 PJ

Space heating demand = Gas demand * 70% = 19.5 PJ
DHW heating demand = Gas demand * 20% = 5.5 PJ

Gas boilers of 90% efficiency

Overall Heat demand reduction by 60%

Space heating demand reduction by 77%
ENERGY URBAN PLANNING METHODOLOGY
Stepped methodology leading to energy transition of residential areas

**Step 1** Map the present
- Step 1a Energy demands
- Step 1b Energy potentials

**Step 2** Define future energy targets
- Step 2a Future scenario for natural gas and electricity use
- Step 2b Desired future heat demand

**Step 3** Strategy for selecting energy systems
- Step 3a Develop scenario for dividing the main heat systems through the districts of Amsterdam
- Step 3b Main heat systems ratio in each district
- Step 3b Classify energy systems
STEP 3  STRATEGY FOR SELECTING ENERGY SYSTEMS

3a Develop scenario for dividing the main heat systems through Amsteram districts

Heat potentials exceed the current heat demand giving the possibilities for multiple renewable energy technologies to be used.

Such low amount of Biomass offered for Green gas production that can be used only for transport.
STEP 3  STRATEGY FOR SELECTING ENERGY SYSTEMS

3a Develop scenario for dividing the main heat systems through Amsterdam districts

PJ

Current Heat Demand and Potentials (PJ)

2050 Heat scenario (PJ)

- Low Temperature
- High Temperature

Domestic waste is expected to be reduced close to zero until 2050

Potentials fulfilling the remaining need for Space heating & DHW
STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

3a Develop scenario for dividing the main heat systems through Amsteram districts

Resulted electricity demand for heat pumps connected to LT systems

Electricity produced from renewable sources fully covers the electricity need for heat pumps.
STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

3b Main heat systems ratio in each district

Map of gas demand

Regional warmtenet 2015-2040

Amsterdam Centrum as a possible area of D.H.N. exention because of the high concentrated heat demand

Source: Gemeente Amsterdam. (2016). Naar een stad zonder aardgas
### STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

#### 3b Main heat systems ratio in each district

<table>
<thead>
<tr>
<th>Amsterdam district</th>
<th>Heat demand 2050</th>
<th>H.T. or L.T. Heat Systems</th>
<th>Percentage</th>
<th>Heat Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrum</td>
<td>1.5</td>
<td>High Temperature</td>
<td>50%</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low Temperature</td>
<td>50%</td>
<td>0.7</td>
</tr>
<tr>
<td>Oost</td>
<td>1.2</td>
<td>High Temperature</td>
<td>80%</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low Temperature</td>
<td>20%</td>
<td>0.2</td>
</tr>
<tr>
<td>Zuid</td>
<td>1.5</td>
<td>High Temperature</td>
<td>50%</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low Temperature</td>
<td>50%</td>
<td>0.7</td>
</tr>
<tr>
<td>West</td>
<td>1.5</td>
<td>High Temperature</td>
<td>80%</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low Temperature</td>
<td>20%</td>
<td>0.3</td>
</tr>
<tr>
<td>Nieuw-West</td>
<td>1.2</td>
<td>High Temperature</td>
<td>50%</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low Temperature</td>
<td>50%</td>
<td>0.6</td>
</tr>
<tr>
<td>Westpoort</td>
<td>0.7</td>
<td>High Temperature</td>
<td>30%</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low Temperature</td>
<td>70%</td>
<td>0.5</td>
</tr>
<tr>
<td>Noord</td>
<td>1.2</td>
<td>High Temperature</td>
<td>50%</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low Temperature</td>
<td>50%</td>
<td>0.6</td>
</tr>
<tr>
<td>Zuidoost</td>
<td>1.2</td>
<td>High Temperature</td>
<td>45%</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low Temperature</td>
<td>55%</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**Total heat demand 2050**: 10.0

**Total H.T. Heat potential**: 4.0

**Total L.T. Heat potential**: 6.0
STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

3b Main heat systems ratio in each district

Covering the total Heat demand of 10 PJ in 2050
In reality the energy systems are mixed in the districts of Amsterdam
### STEP 3  STRATEGY FOR SELECTING ENERGY SYSTEMS

3c Classify energy systems

<table>
<thead>
<tr>
<th>Low Temperature Heat</th>
<th>High Temperature Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small scale Heat Network ATES</td>
<td>NOM (up to 2 floors)</td>
</tr>
</tbody>
</table>

- **Small scale heat network with ATES**
- **Zero On the Meter (NOM)**
- **All-electric**
- **District Heat Network (DHN)**
ENERGY URBAN PLANNING METHODOLOGY
Stepped methodology leading to energy transition of residential areas

Step 1 Map the present
- Step 1a Energy demands
- Step 1b Energy potentials

Step 2 Define future energy targets
- Step 2a Future scenario for natural gas and electricity use
- Step 2b Desired future heat demand

Step 3 Strategy for selecting energy systems
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Step 4 Roadmap design

Amsterdam city

Step 1a Site determination inside Amsterdam Nieuw West
Step 1b Buildings description & Energy demands
Step 1c Energy potentials

Amsterdam Nieuw West neighbourhoods
STEP 1  MAP THE PRESENT
1a Site determination inside Amsterdam Nieuw West

DISTRICT HEAT NETWORK

BOUNDARY CONDITION
Site restriction because of the project time limit
STEP 1  MAP THE PRESENT
1a Site determination inside Amsterdam Nieuw West

AMSTERDAM NIEUW WEST DISTRICT

NEIGHBOURHOOD COMBINATIONS

Buurt 4 Oost
Buurt 5 Noord
Buurt 2
Buurt 3
Buurt 5 Zuid
Slotermeerr Zuid
Noordoever Sloterplas
Slotermeer-Zuidwest
Het Nieuwe Meer
Sloterpark
Slotermeer-Noordoost
### Typologies map

- **Gallerijflat appartement block**
- **Portiekflat appartement block**
- **Rowhouse**
- **Multifamily house**
- **Semi-detached house**
- **Detached house**

### Data extraction

#### Year of construction

<table>
<thead>
<tr>
<th>Area</th>
<th>Neighbourhood</th>
<th>Building block number</th>
<th>House typology</th>
<th>Additional classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slotmeer-Zuidwest</td>
<td>Buurt 4 Oost</td>
<td>18937</td>
<td>Apartment bloc</td>
<td>Portiekflat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18938</td>
<td>Apartment bloc</td>
<td>Portiekflat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18939</td>
<td>Apartment bloc</td>
<td>Portiekflat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19067</td>
<td>Apartment bloc</td>
<td>Gallerijflat</td>
</tr>
</tbody>
</table>

#### Use surface m²

<table>
<thead>
<tr>
<th>Use surface m²</th>
<th>Electricity kWh/m²</th>
<th>Gas consumption m³</th>
<th>Gas m³/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>2804</td>
<td>33</td>
<td>59808</td>
<td>21</td>
</tr>
<tr>
<td>2804</td>
<td>32</td>
<td>55056</td>
<td>20</td>
</tr>
<tr>
<td>2804</td>
<td>44</td>
<td>58703</td>
<td>21</td>
</tr>
<tr>
<td>6498</td>
<td>45</td>
<td>146382</td>
<td>23</td>
</tr>
</tbody>
</table>

#### Gas CO₂ emissions kg

<table>
<thead>
<tr>
<th>Gas CO₂ emissions kg</th>
<th>Gas consumption kWh</th>
<th>Heat demand kWh</th>
<th>Heat demand kWh/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>106458</td>
<td>584264</td>
<td>525838</td>
<td>188</td>
</tr>
<tr>
<td>98000</td>
<td>537842</td>
<td>484058</td>
<td>173</td>
</tr>
<tr>
<td>104491</td>
<td>573470</td>
<td>516123</td>
<td>184</td>
</tr>
<tr>
<td>260560</td>
<td>1430006</td>
<td>1287009</td>
<td>198</td>
</tr>
</tbody>
</table>
STEP 1  MAP THE PRESENT

1b Buildings description & Energy demands

Year of construction

Housing corporations

Electricity demand kWh

Gas demand m³ per m²
STEP 1  MAP THE PRESENT

1c Energy potentials

Aquifer Thermal Energy Storage System

Existing D.H.N. with rest heat from buildings

Vertical heat exchange - Ground Source Heat Pump

Solar potential on roofs

Solar potential per year in kWh per m² of surface area

- 1 to 22
- 22 to 36
- 36 to 56
- 56 to 86
- 86 to 108
STEP 1 MAP THE PRESENT
3D heat map_Data visualisation

Average heat demand per m²
Building levels
Housing corporations
District Heat Network
### ENERGY URBAN PLANNING METHODOLOGY

Stepped methodology leading to energy transition of residential areas

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Map the present</strong></td>
<td><strong>Define future energy targets</strong></td>
<td><strong>Strategy for selecting energy systems</strong></td>
<td><strong>Roadmap design</strong></td>
</tr>
<tr>
<td><strong>Step 1a</strong> Energy demands</td>
<td><strong>Step 2a</strong> Future scenario for natural gas and electricity use</td>
<td><strong>Step 3a</strong> Develop scenario for dividing the main heat systems through the districts of Amsterdam</td>
<td><strong>Step 4a</strong></td>
</tr>
<tr>
<td><strong>Step 1b</strong> Energy potentials</td>
<td><strong>Step 2b</strong> Desired future heat demand</td>
<td><strong>Step 3b</strong> Main heat systems ratio in each district</td>
<td><strong>Step 4b</strong></td>
</tr>
<tr>
<td><strong>Step 1c</strong></td>
<td><strong>Step 2a</strong> Desired future heat demand</td>
<td><strong>Step 3b</strong> Classify energy systems</td>
<td></td>
</tr>
</tbody>
</table>

#### Amsterdam city

- Step 1a: Energy demands
- Step 1b: Energy potentials
- Step 1c: Buildings description & Energy demands
- Step 1c: Energy potentials

#### Amsterdam Nieuw West neighbourhoods

- Step 1a: Site determination inside Amsterdam Nieuw West
- Step 1b: Buildings description & Energy demands
- Step 1c: Energy potentials
- Step 2a: Desired future heat demand
- Step 2b: Low and high temperature heat potentials & technologies for each system
- Step 3a: Develop scenario for dividing the main heat systems through the districts of Amsterdam
- Step 3b: Main heat systems ratio in each district
- Step 3b: Classify energy systems
STEP 2 DEFINE FUTURE ENERGY TARGETS

2a Desired future heat demand

Data collected from site analysis

<table>
<thead>
<tr>
<th>Nieuw-West_Slotteermer neighb.</th>
<th>Heat demand kWh 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buurt 4 Oost</td>
<td>5504688</td>
</tr>
<tr>
<td>Buurt 5 Noord</td>
<td>15962339</td>
</tr>
<tr>
<td>Slotermeer Zuid</td>
<td>15962339</td>
</tr>
<tr>
<td>Buurt 5 Zuid</td>
<td>24676013</td>
</tr>
<tr>
<td>Noordoever Sloterplas</td>
<td>10734521</td>
</tr>
<tr>
<td>Buurt 3</td>
<td>29793499</td>
</tr>
<tr>
<td>Buurt 2</td>
<td>12289597</td>
</tr>
<tr>
<td></td>
<td>114922996</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heat demand PJ 2017</th>
<th>0.41</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat demand PJ 2050</td>
<td>0.10</td>
</tr>
</tbody>
</table>
STEP 2 DEFINE FUTURE ENERGY TARGETS

2b Low and High Temperature heat potentials & technologies for each energy system

Data collected from site analysis

<table>
<thead>
<tr>
<th>Nieuw-West_Slotteermer neighb.</th>
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</thead>
<tbody>
<tr>
<td>Heat demand PJ 2050</td>
<td>0.10</td>
</tr>
</tbody>
</table>

L.T. Heat Potential  | 0.04 |
H.T. Heat Potential  | 0.06 |

A bigger percentage is considered for High Temperature heat since the District Heat Network already passes through 4 out of 7 neighbourhoods

<table>
<thead>
<tr>
<th>Low Temperature Heat</th>
<th>High Temperature Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small scale Heat Network</td>
<td>NOM (up to 2 floors)</td>
</tr>
<tr>
<td>ATEs</td>
<td>GSHP</td>
</tr>
<tr>
<td>Rest heat from buildings</td>
<td>PVT</td>
</tr>
<tr>
<td>PVT</td>
<td>PVs</td>
</tr>
</tbody>
</table>
## ENERGY URBAN PLANNING METHODOLOGY

Stepped methodology leading to energy transition of residential areas

<table>
<thead>
<tr>
<th>Step 1</th>
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### Step 1a
- Energy demands

### Step 1b
- Energy potentials

### Step 1c
- Site determination inside Amsterdam Nieuw West
- Buildings description & Energy demands
- Energy potentials

### Step 2a
- Future scenario for natural gas and electricity use
- Desired future heat demand

### Step 2b
- Low and high temperature heat potentials & technologies for each system

### Step 3a
- Develop scenario for dividing the main heat systems through the districts of Amsterdam
- Set variables for selecting the suitable energy system

### Step 3b
- Main heat systems ratio in each district
- Set priority criteria for on-site interventions

### Step 3c
- Classify energy systems
- Develop decision-making diagram for on-site interventions on appropriate time

Amsterdam city

Amsterdam Nieuw West neighbourhoods
STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

3a Set variables for selecting the suitable energy system

- Ownership
- Retrofit time before or after the energy system application
- Average heat demand
- Storeys number (2 levels or higher)
- Excess heat from non-residential buildings
- Existing district heating in neighbourhood
- Heating and cooling need proportion in the neighborhood
STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

3b Set priority criteria for on-site interventions

Prioritise

- Are there lots of the same buildings near? (Yes/No)
- Is the total energy use for heating high? (Yes/No)
- Is the energy use for heating high? (Yes/No)

Start

Low priority

Yes

No

Low priority
STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

3c Develop decision-making diagram for on-site interventions on appropriate time

Prioritise

Low priority

No

Yes

Are there lots of the same buildings near?

Low priority

No

Yes

Is the total energy use for heating high?

Start

Is the energy use for heating high?

Yes

Social rental/one owner?

No

Yes

Are there buildings with excess heat? AND Is there equal need for heating and cooling in the neighbourhood?

No

Yes

Is there District Heat Network in the neighborhood?

No

Yes

Connection to District Heat Network (assuming 50% energy reduction)

No

Yes

Are the building blocks up to 2 levels high?

No

Yes

Retrofit in stages

Yes

Retrofit in stages

Small scale Heat Network connected to ATES

Retrofit in stages

NOM

All-electric
# ENERGY URBAN PLANNING METHODOLOGY

Stepped methodology leading to energy transition of residential areas

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<td>Step 3b</td>
<td>Step 4b</td>
</tr>
<tr>
<td>Energy potentials</td>
<td>Desired future heat demand</td>
<td>Main heat systems ratio in each district</td>
<td>Describe energy systems and retrofit measures leading to 2050 vision</td>
</tr>
<tr>
<td>Step 1c</td>
<td>Step 3c</td>
<td>Step 4c</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop decision-making diagram for on-site interventions on appropriate time</td>
<td>Define the interventions on timeline</td>
<td></td>
</tr>
</tbody>
</table>

### Amsterdam city

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- Step 3c: Classify energy systems

- Step 4a: Define suitable energy systems in 2050 for each neighbourhood
- Step 4b: Describe energy systems and retrofit measures leading to 2050 vision
- Step 4c: Define the interventions on timeline
STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS
4a Define suitable energy systems in 2050 for each neighbourhood

Selection of suitable energy system for each neighbourhood for 2050 final vision

- Social rental/one owner?
  - Yes: Are there buildings with excess heat? AND Is there equal need for heating and cooling in the neighbourhood?
    - Yes: Is there District Heat Network in the neighborhood?
      - Yes: Connection to District Heat Network (assuming 50% energy reduction)
        - Yes: Retrofit in stages
          - Yes: Small scale Heat Network connected to ATES
          - No: NOM
        - No: Retrofit in stages
          - Yes: Retrofit in stages
          - No: All-electric
    - No: Are the building blocks up to 2 levels high?
      - Yes: Retrofit in stages
      - No: Retrofit in stages
      - No: Retrofit in stages
STEP 4 ROADMAP DESIGN

4a Define suitable energy systems in 2050 for each neighbourhood_Buurt 3

Rowhouses of private ownership

Social rental (one owner)?
- Yes
  - Are there buildings with excess heat? AND Is there equal need for heating and cooling in the neighbourhood?
    - Yes
      - Is there District Heat Network in the neighborhood?
        - Yes
          - Connection to District Heat Network (assuming 50% energy reduction)
            - Yes
              - Retrofit in stages
            - No
              - Small scale Heat Network connected to ATES
        - No
          - Retrofit in stages
    - No
      - Are the building blocks up to 2 levels high?
        - Yes
          - Retrofit in stages
        - No
          - Small scale Heat Network connected to ATES

- No
  - Are there buildings with excess heat? AND Is there equal need for heating and cooling in the neighbourhood?
    - Yes
      - Is there District Heat Network in the neighborhood?
        - Yes
          - Connection to District Heat Network (assuming 50% energy reduction)
            - Yes
              - Retrofit in stages
            - No
              - Small scale Heat Network connected to ATES
        - No
          - Retrofit in stages
    - No
      - Are the building blocks up to 2 levels high?
        - Yes
          - Retrofit in stages
        - No
          - All-electric

NOM
STEP 4 ROADMAP DESIGN
4a Define suitable energy systems in 2050 for each neighbourhood_Buurt 3

Social rental (one owner)?

Yes → Are there buildings with excess heat? AND Is there equal need for heating and cooling in the neighbourhood?

Yes → Is there District Heat Network in the neighborhood?

Yes → Connection to District Heat Network (assuming 50% energy reduction)

Yes → Retrofit in stages

No → Small scale Heat Network connected to ATES

No → Retrofit in stages

No → Are the building blocks up to 2 levels high?

Yes → Retrofit in stages

No → No

No → No

No → Retrofit in stages

No → All-electric
4a Define suitable energy systems in 2050 for each neighbourhood_Buurt 3

Social rental (one owner)?

Are there buildings with excess heat? AND Is there equal need for heating and cooling in the neighbourhood?

Yes

Are the building blocks up to 2 levels high?

Yes

Retrofit in stages

No

Is there District Heat Network in the neighborhood?

Yes

Connection to District Heat Network (assuming 50% energy reduction)

Retrofit in stages

No

Retrofit in stages

Small scale Heat Network connected to ATES

NOM

All-electric
STEP 4 ROADMAP DESIGN
4a Define suitable energy systems in 2050 for each neighbourhood_Buurt 2

Social rental (one owner)?

Are there buildings with excess heat? AND Is there equal need for heating and cooling in the neighbourhood?

Yes

Are the building blocks up to 2 levels high?

Yes

Retrofit in stages

No

Is there District Heat Network in the neighborhood?

Yes

Connection to District Heat Network (assuming 50% energy reduction)

Retrofit in stages

No

Retrofit in stages

Small scale Heat Network connected to ATES

NOM

All-electric
4a Define suitable energy systems in 2050 for each neighbourhood_Buurt 4 Oost

STEP 4 ROADMAP DESIGN

Are there buildings with excess heat? AND Is there equal need for heating and cooling in the neighbourhood?

Are the building blocks up to 2 levels high?

Is there District Heat Network in the neighborhood?

Connection to District Heat Network (assuming 50% energy reduction)

Retrofit in stages

Small scale Heat Network connected to ATES

No

Retrofit in stages

Social rental (one owner)?

NOM

All-electric

Yes

Retrofit in stages

Multistory dwellings of social rental
STEP 4 ROADMAP DESIGN

4a Define suitable energy systems in 2050 for each neighbourhood

- **D.H.N**
  - Multistory dwellings of social rental

- **NOM**
  - Rowhouses of both private ownership & social rental

- **NOM**
  - Rowhouses of private ownership

- **NOM possible**
  - Rowhouses & semi-detached houses of private ownership

- **All-electric**
  - Multistory dwellings of social rental

- **L.T. with ATES**
  - Multistory dwellings of social rental

- **D.H.N**
  - Mostly rowhouses & few multistory dwellings both of social rental
4b Describe energy systems and retrofit measures leading to 2050 vision_Buurt 3

<table>
<thead>
<tr>
<th>PRINCIPLES</th>
<th>STEPS AND FEATURES</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0. EXISTING SITUATION</td>
<td>Features: • 124 multifamily and rowhouses, some for social rental and some of private ownership • poor energy performance</td>
<td>Heat demand H 14363 MWh/y CO2 2908 tCO2eq/y</td>
</tr>
<tr>
<td>1. DEMAND REDUCTION</td>
<td>Insulation: • roof, walls, roofs • high performance windows Installation efficiency: • Smart appliances • change heating system • efficient mechanical ventilation with heat recovery • shower heat exchangers</td>
<td>Remaining heat demand H 3591 MWh/y CO2 727 tCO2eq/y</td>
</tr>
<tr>
<td>2. HEAT PRODUCTION</td>
<td>• Transition to NOM energy system • Individual GSHP with horizontal heat exchanger • Heat pump is used with GSHP system, the electricity used is produced by renewable sources</td>
<td>Remaining heat demand &amp; Electricity demand for heat pump with COP = 6 H 0 MWh/y CO2 0 tCO2eq/y E 599 MWh/y</td>
</tr>
<tr>
<td>3. ELECTRICITY PRODUCTION</td>
<td>PV on roofs: • 9 m2 per roof</td>
<td>Remaining heat &amp; Electricity demand H 0 MWh/y E -60 MWh/y</td>
</tr>
</tbody>
</table>

Zero On the Meter (NOM)
## STEP 4 ROADMAP DESIGN

### 4b Describe energy systems and retrofit measures leading to 2050 vision_Buurt 3

<table>
<thead>
<tr>
<th>PRINCIPLES</th>
<th>STEPS AND FEATURES</th>
<th>RESULTS</th>
</tr>
</thead>
</table>
| **0. EXISTING SITUATION** | Features: • 45 multistory dwellings of social rental • poor energy performance | Heat demand
H 15430 MWh/y
CO2 3124 tCO2eq/y |
| **1. DEMAND REDUCTION** | Insulation: • roof, walls, roofs • high performance windows Installation efficiency: • Smart appliances • change heating system • efficient mechanical ventilation with heat recovery • shower heat exchangers | Remaining heat demand
H 3858 MWh/y
CO2 781 tCO2eq/y |
| **2. HEAT PRODUCTION** | • Transition to All-electric energy system • Individual GSHP with horizontal heat exchanger • Heat pump is used with GSHP system_the electriciy used is produced by renewable sources | Remaining heat demand & Electricity demand for heat pump with COP = 6
H 0 MWh/y
CO2 0 tCO2eq/y
E 643 MWh/y |
| **3. ELECTRICITY PRODUCTION** | PV on roofs: • 25 m2 per roof | Remaining heat & Electricity demand
H 0 MWh/y
E -21 MWh/y |
**STEP 4 ROADMAP DESIGN**

4b Describe energy systems and retrofit measures leading to 2050 vision_Buurt 2

<table>
<thead>
<tr>
<th>PRINCIPLES</th>
<th>STEPS AND FEATURES</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0. EXISTING SITUATION</td>
<td>Features: • 22 multistory building blocks of social rental • poor energy performance</td>
<td>Heat demand</td>
</tr>
<tr>
<td></td>
<td>H 12289 MWh/y CO2 2488 tCO2eq/y</td>
<td></td>
</tr>
</tbody>
</table>

| 1. DEMAND REDUCTION | Insulation: • roof, walls, roofs • high performance windows Installation efficiency: • Smart appliances • change heating system • efficient mechanical ventilation with heat recovery • shower heat exchangers | Remaining heat demand |
|                     | H 3072 MWh/y CO2 622 tCO2eq/y |         |

| 2. HEAT PRODUCTION | • Local heat network • Collective ATES using waste heat from offices and supermarkets • SC if heat demand is not covered • Heat pump is used with ATES system_the electricity used is produced by renewable sources | Remaining heat demand & Electricity demand for heat pump with COP = 6 |
|                   | H 0 MWh/y CO2 0 tCO2eq/y E 512 MWh/y |         |

| 3. ELECTRICITY PRODUCTION | PV on roofs: • 40 m² per roof | Remaining heat & Electricity demand |
|                          | H 0 MWh/y CO2 0 tCO2eq/y E -8 MWh/y |         |

Small scale heating network connected to ATES system
## STEP 4 ROADMAP DESIGN

### 4b Describe energy systems and retrofit measures leading to 2050 vision_Buurt 4 Oost

### District Heat Network (D.H.N.)

#### 0. EXISTING SITUATION
- Features:
  - 35 multistory building blocks of social rental
  - poor energy performance
- Heat demand:
  - $H = 10899$ MWh/y
  - $CO2 = 2206$ tCO2eq/y

#### 1. HEAT PRODUCTION
- Collective District Heat Network is used
- Remaining heat demand:
  - $H = 0$ MWh/y
  - $CO2 = 1103$ tCO2eq/y

#### 2. DEMAND REDUCTION
- Insulation:
  - roof, walls, roofs
  - high performance windows
- Installation efficiency:
  - Smart appliances
  - change heating system
  - efficient mechanical ventilation with heat recovery
  - shower heat exchangers
- Remaining heat demand:
  - $H = 0$ MWh/y
  - $CO2 = 278 -> 0$ tCO2eq/y
  - Year 2020 -> 2050
**STEP 4  ROADMAP DESIGN**

**4c Define the interventions on timeline**

This tool will be applied every 5 years

1st time_ Heat demand > 300 kWh/m²
2nd               > 250 kWh/m²
3rd               > 200 kWh/m²
4th               > 150 kWh/m²

Selection of suitable energy system for each neighbourhood

**Prioritise**

- Low priority
  - No
  - Are there lots of the same buildings near?
    - No
    - Start
      - Is the energy use for heating high?
        - Yes
          - Social rental/one owner?
            - Yes
              - Are there buildings with excess heat? AND Is there equal need for heating and cooling in the neighbourhood?
                - No
                - Are the building blocks up to 2 levels high?
                  - Yes
                    - Retrofit in stages
                  - No
                    - Retrofit in stages
              - Yes
                - Is there District Heat Network in the neighborhood?
                  - No
                    - Retrofit in stages
                  - Yes
                    - Connection to District Heat Network (assuming 50% energy reduction)
                      - Yes
                        - Retrofit in stages
                      - No
                        - Retrofit in stages
                - Yes
                  - Connection to District Heat Network (assuming 50% energy reduction)
                    - Yes
                      - Retrofit in stages
                    - No
                      - Retrofit in stages
          - Yes
            - Retrofit in stages
        - No
          - NOM
    - Yes
      - Retrofit in stages
Retrofit in stages

- Minor -> 30% energy savings → 1-3 energy retrofit measures
- Moderate -> 30%-60% → 3-5 energy retrofit measures
- Deep -> 60%-90% → Holistic retrofit approach - Package of measures
- nZEB -> 90% + → Addition of renewable energy technologies

STEP 4  ROADMAP DESIGN

4c Define the interventions on timeline

Heat demand > 300 kWh/m²

2017  2020  2025  2030  2035  2040  2045  2050

2. Decide which buildings need:
   a. Connection to District Heat Network (covers fully the heat demand)
   b. Minor Retrofit -> 20 % energy reduction

1. Prioritise
STEP 4 ROADMAP DESIGN

4c Define the interventions on timeline

1. Prioritise

2. Decide which buildings need:
   a. Connection to District Heat Network
   b. Minor Retrofit -> 15% energy reduction
   c. Moderate Retrofit -> 45% energy reduction in total

Heat demand > 250 kWh/m²

2017 2020 2025 2030 2035 2040 2045 2050

200 kWh/m²
STEP 4 ROADMAP DESIGN

4c Define the interventions on timeline

1. Prioritise Heat demand > 200 kWh/m²

2. Decide which buildings need:
   a. Connection to District Heat Network
   b. Minor Retrofit -> 15% energy reduction
   c. Moderate Retrofit -> 45% energy reduction in total
   d. Deep Retrofit -> 75% energy reduction in total
STEP 4  ROADMAP DESIGN
4c Define the interventions on timeline

1. Prioritise

Heat demand > 150 kWh/m²

2017  2020  2025  2030  2035  2040  2045  2050
STEP 4 ROADMAP DESIGN

4c Define the interventions on timeline

Heat demand > 100 kWh/m²
STEP 4  ROADMAP DESIGN

4c Define the interventions on timeline

Remaining need to be covered by renewable sources
STEP 4  ROADMAP DESIGN

4c Define the interventions on timeline_Final vision

Heat demand is fulfilled by local renewable sources when all systems are applied.
CONCLUSIONS

Answering the research question

The methodology leading to the design of a roadmap that helps to define which energy systems and retrofit measures should be applied where and when, on residential neighbourhoods of Amsterdam Nieuw West until 2050, for achieving their energy transition and CO2 emissions reduction, is organised in a 4-step energy urban planning approach to be applied on both city and neighbourhood scale.

- Total heating demand reduction by 60% for the entire city of Amsterdam and up to 75% for Amsterdam Nieuw West district by 2050.
- The solutions in several neighbourhoods vary due to the different features of each building block.
- The heating demand and the electricity need for operating the systems can be fully covered by renewable sources by 2050.
- The classified energy systems for neighbourhoods of Amsterdam are 1) DHN, 2) Small-scale heat network connected to ATES system, 3) the transition to All-electric and 4) NOM.
- The result of the systems on-site applications cannot be presented as a specific blueprint.
- The developed stepped methodology can be used for retrofitting other neighbourhoods of Amsterdam and results a promising methodology for further implementations in other cities of the world.
FURTHER RESEARCH

- Interviewing the owners and asking the energy suppliers about future plans, for giving more detailed and accurate solutions.
- The actual time consumption of each retrofit stage.
- The changes needed for using the methodology in other cities, that can be based on different future energy goals of other cities, local energy demands and potentials that must be collected.