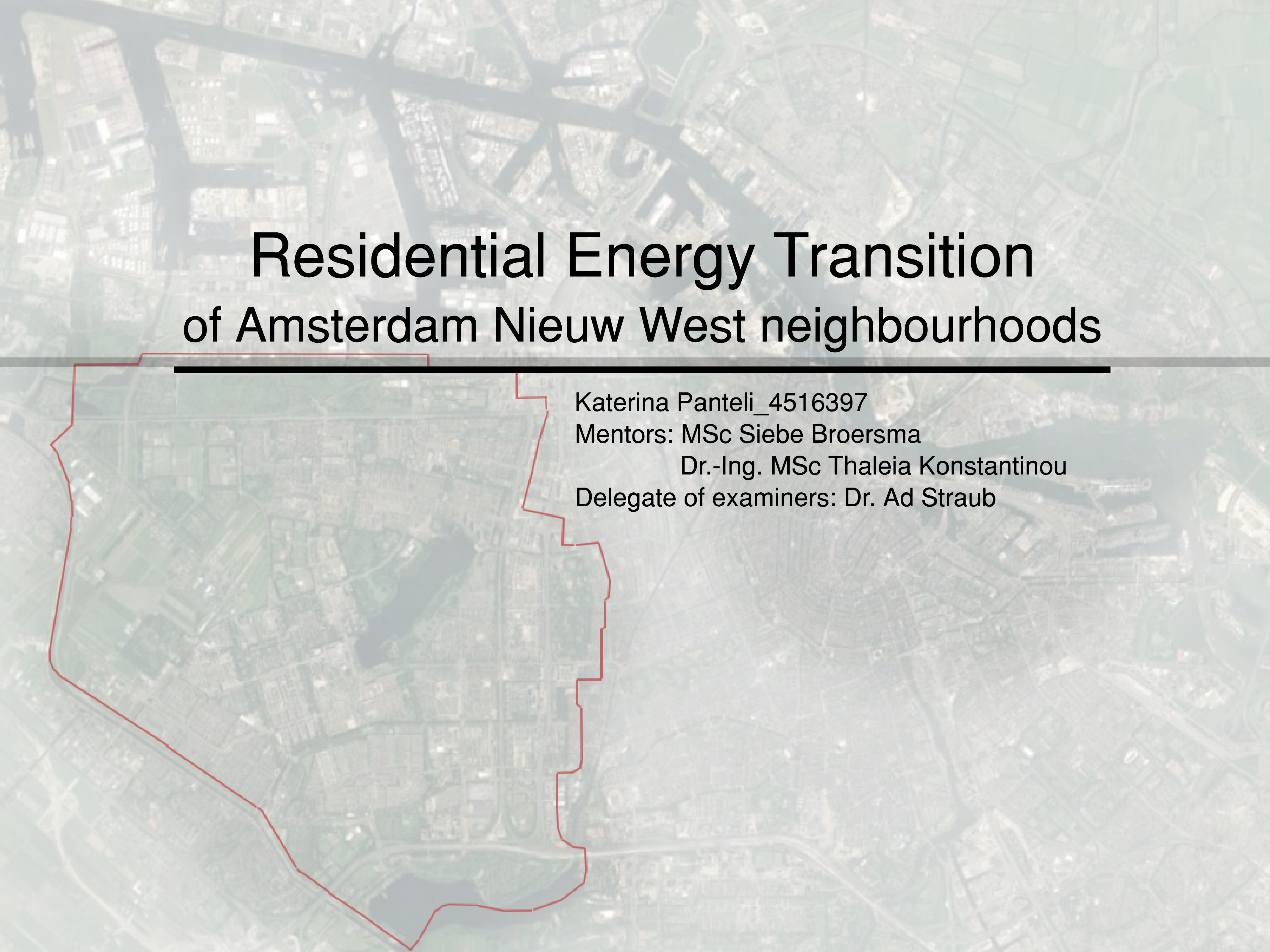

Residential Energy Transition
of Amsterdam Nieuw West neighbourhoods

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

BACKGROUND

CITY-ZEN PROJECT

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

Demonstration projects
- Grenoble
- Amsterdam Nieuw-West

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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

BACKGROUND

CITY-ZEN PROJECT

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Demonstration projects
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EU ENERGY GOALS

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NEEDED STRATEGIES FOR
- Smartifying e-grid
- Heat network expansion
- Residential retrofit

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 CO_2 emissions reduction of residential neighbourhoods in Amsterdam Nieuw West, through the suitable combinations of energy systems and retrofit measures on the timeline until 2050.

MAIN OBJECTIVE

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.

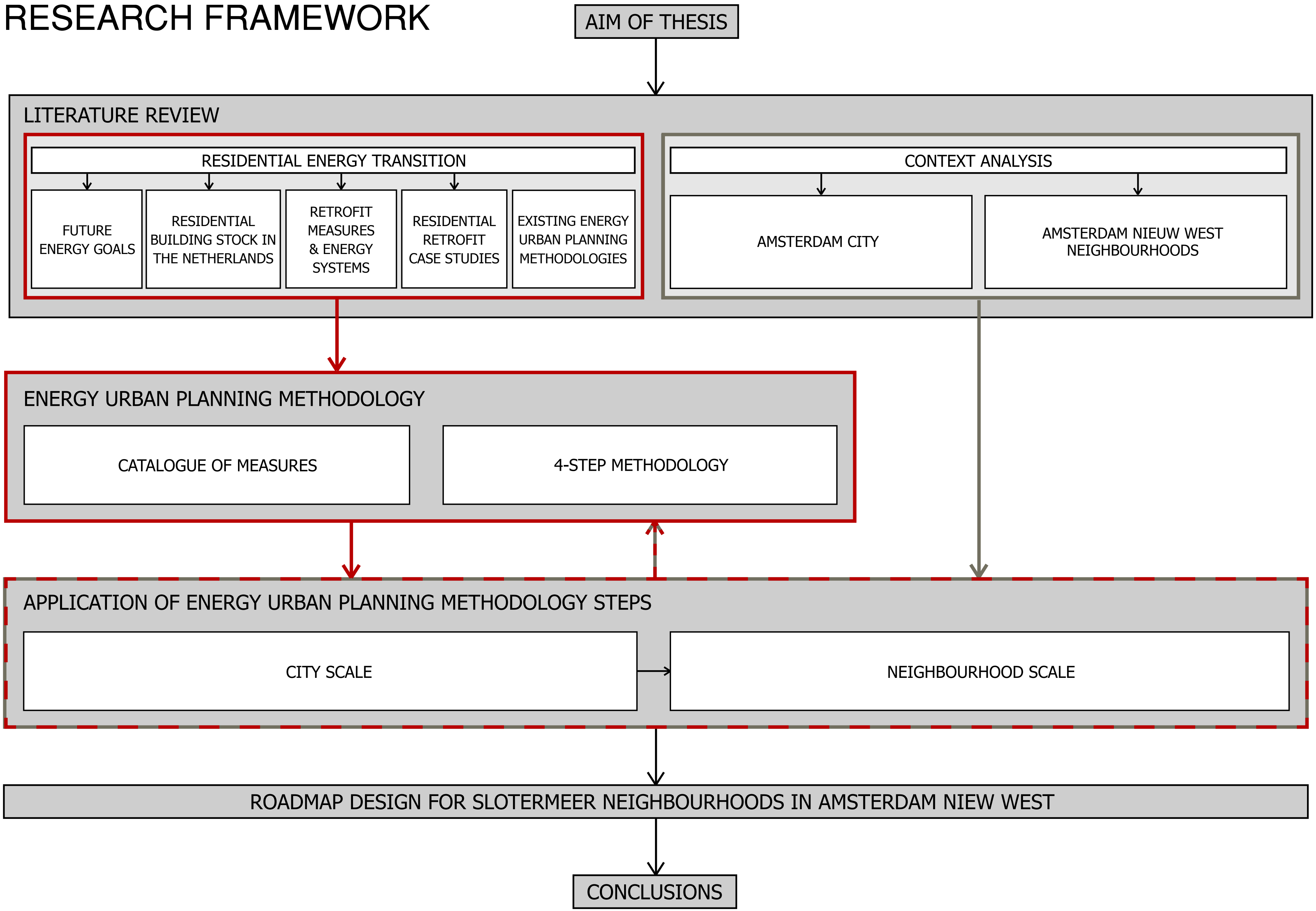
RESEARCH QUESTION

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 CO_2 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?

RESEARCH FRAMEWORK



RESIDENTIAL ENERGY TRANSITION

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

FUTURE ENERGY GOALS

Overview of Amsterdam's & European commision's energy goals

EU2020 to 2050

Comparing to 1990	2020	2030	2040	2050
Energy reduction	20%	27%	-	-
Share of renwables	20%	27%	- 50%	-
CO_2 reduction	20%	40%	60% 75%	80-95% 100%

Amsterdam municipality's goals

... 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	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

RESIDENTIAL BUILDING STOCK IN THE NETHERLANDS

Residential typologies

	Region	Construction Year Class	Additional Classification	SFH Single-Family House	TH Terraced House	MFH Multi-Family House	AB Apartment Block
1	national	... 1964	generic	 NL.N.SFH.01.Gen	 NL.N.TH.01.Gen	 NL.N.MFH.01.Gen	 NL.N.AB.01.Gen
2	national	1965...1974	generic	 NL.N.SFH.02.Gen	 NL.N.TH.02.Gen	 NL.N.MFH.02.Gen	 NL.N.AB.02.Gen
3	national	1975...1991	generic	 NL.N.SFH.03.Gen	 NL.N.TH.03.Gen	 NL.N.MFH.03.Gen	 NL.N.AB.03.Gen
4	national	1992...2005	generic	 NL.N.SFH.04.Gen	 NL.N.TH.04.Gen	 NL.N.MFH.04.Gen	 NL.N.AB.04.Gen
5	national	2006...2014	generic	 NL.N.SFH.05.Gen	 NL.N.TH.05.Gen	 NL.N.MFH.05.Gen	 NL.N.AB.05.Gen

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

Construction year class	Single-Family House	Terraced House	Multi-Family House	Apartment Block
... 1964	48.0	43.8	40.7	41.7
1965...1974	46.2	41.2	36.7	37.0
1975...1991	43.8	39.3	38.2	39.3
1992...2005	43.9	37.5	36.5	35.7
2006...2014	40.9	35.5	33.7	34.8

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

LITERATURE REVIEW

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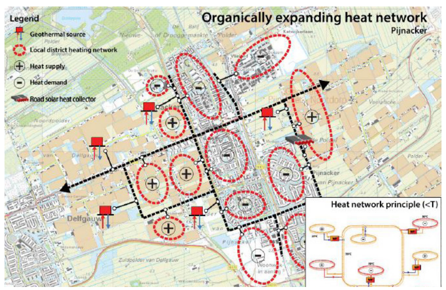
CASE STUDIES

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

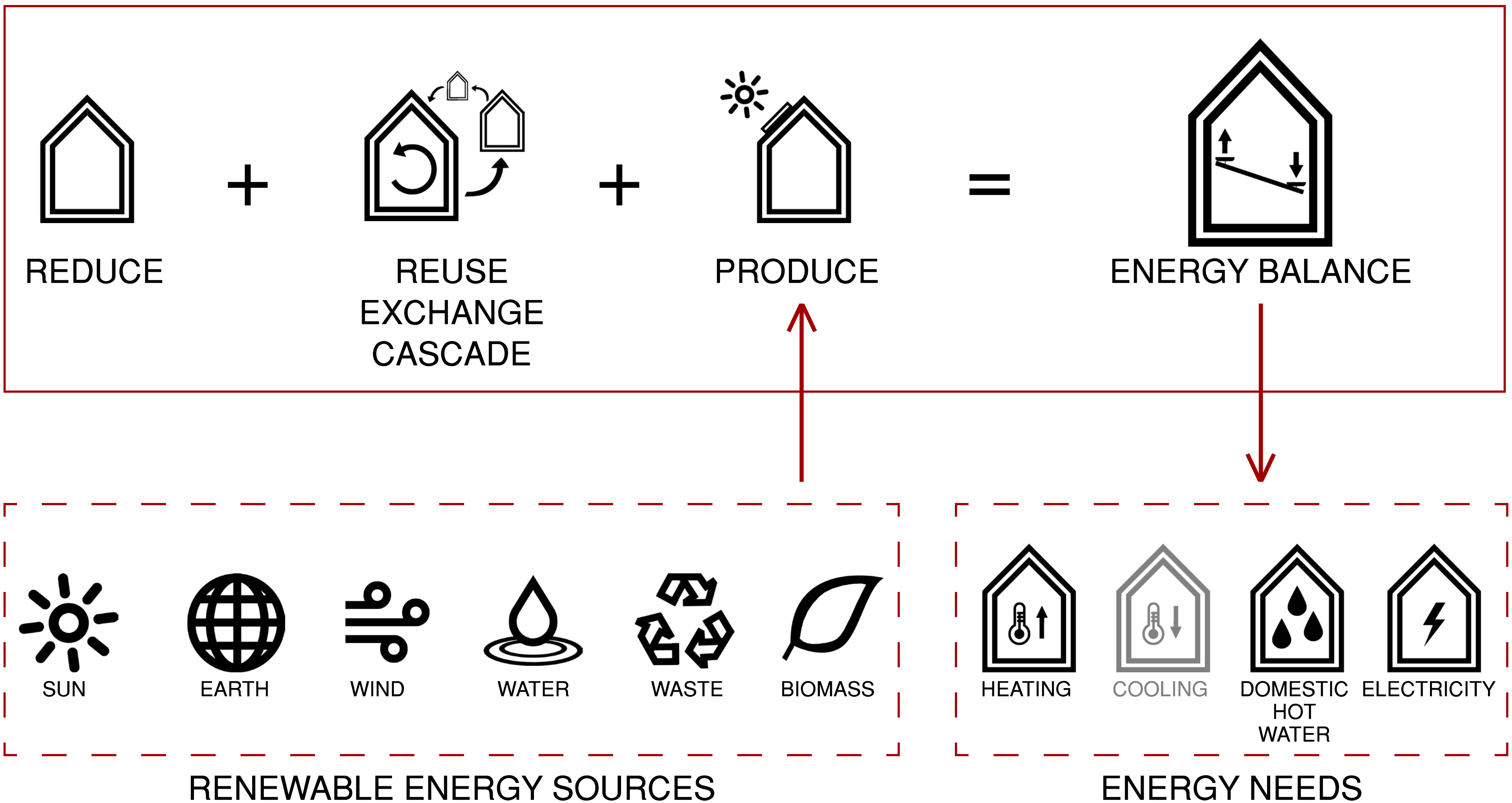
- A feasible and reproduc-ible retrofit strategy same typology
- Achieve “A” energy label

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

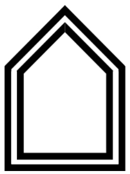
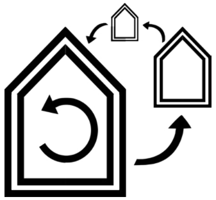
RETROFIT MEASURES & ENERGY SYSTEMS

Basis of categorizing



RETROFIT MEASURES & ENERGY SYSTEMS

List of measures by literature review

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

RETROFIT MEASURES & ENERGY SYSTEMS

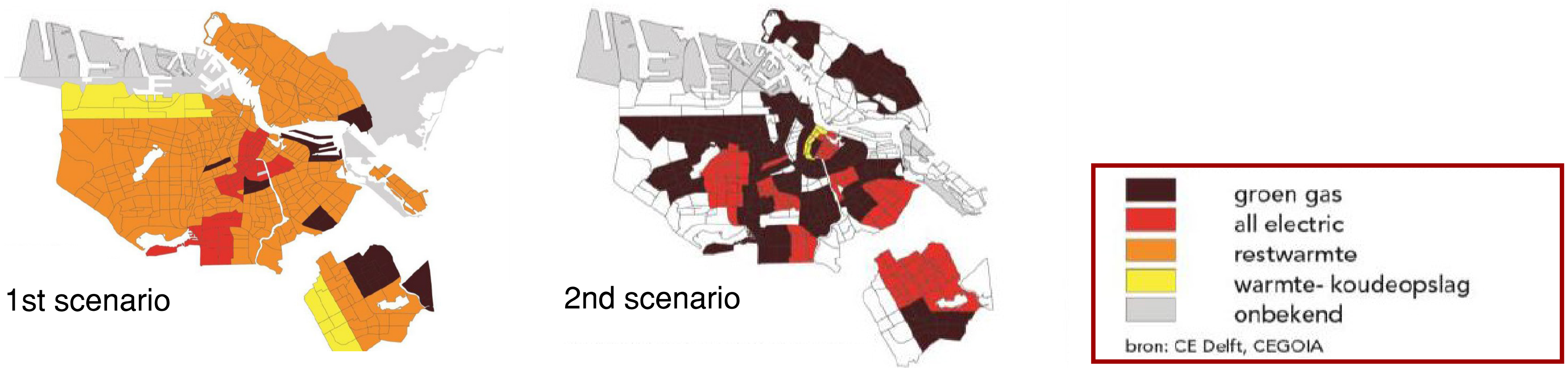
Catalogue of measures for this project

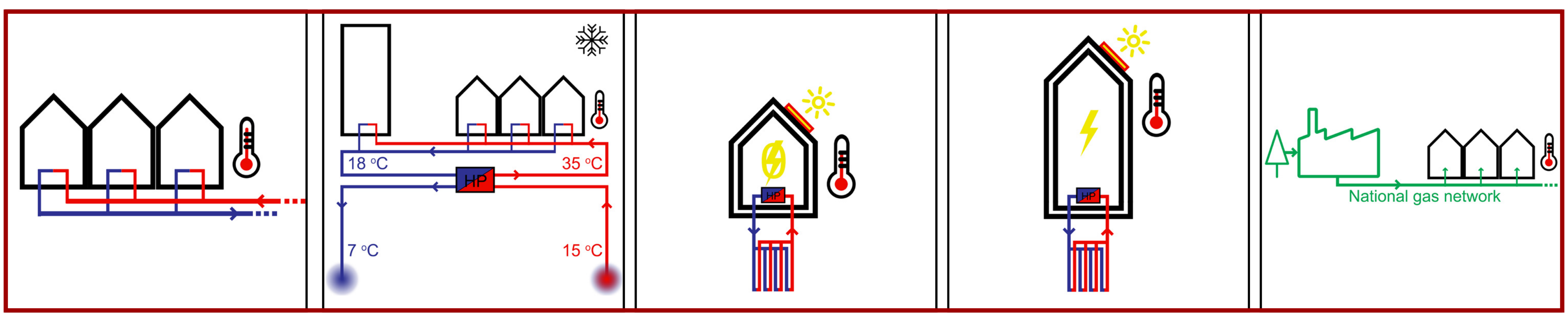
	BUILDING	NEIGHCOURHOOD	DISTRICT
ENERGY SAVING MEASURES			
Exterior walls insulation	✓		
Roof insulation	✓		
Ground floor/basement ceiling/basement wall insulation	✓		
High-performance windows	✓		
Energy efficient lighting	✓		
Shading systems - Solar protection	✓		
Efficient mechanical ventilation system (with heat recovery)	✓		
Shower heat exchangers	✓		
ENERGY EXCHANGE MEASURES			
Waste heat from industrial units			✓
Waste heat recovery for building heating	✓		
Energy exchange between building zones	✓		
Energy exchange between buildings		✓	
Energy cascade		✓	
Smart appliances (dishwasher, clothes washer & dryer, Refrigerator, water heater)	✓		
RENEWABLE ENERGY TECHNOLOGIES			
Photovoltaic's (PVs)	✓	✓	
Solar Collectors (SC)	✓	✓	✓
Photo Voltaic Thermal systems (PVT's)	✓		
Heat pumps (ground source, air, water or waste heat)	✓	✓	✓
Deep Geothermal systems			✓
Aquifer Thermal Energy Storage (ATES)	✓	✓	
Road collectors with ATES	✓	✓	
Waste-to-energy district heating plant			✓
District heating boiler fuelled by electricity, biogas, wood pellets, wood chips (usually as backup heating systems)			✓
Combined Heat and Power (CHP) system fuelled by biogas or biomass			✓
Wind turbines	✓		✓

RETROFIT MEASURES & ENERGY SYSTEMS

Proposed energy systems for Amsterdam city

Existing energy systems' application scenarios

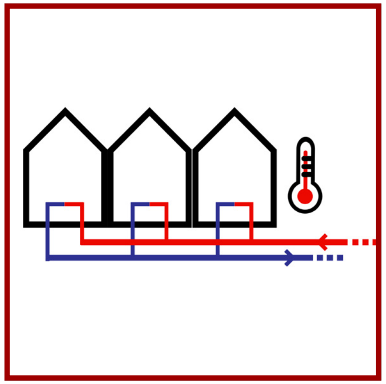




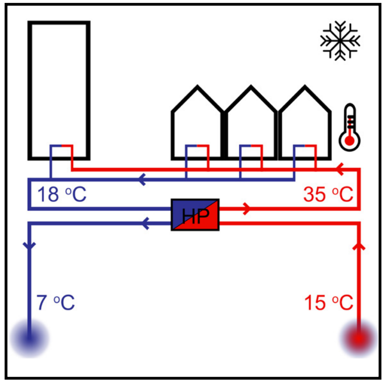
District Heat Network (D.H.N) | Small scale heat network with ATES | Zero On the Meter (NOM) | All-electric | Green gas

RETROFIT MEASURES & ENERGY SYSTEMS

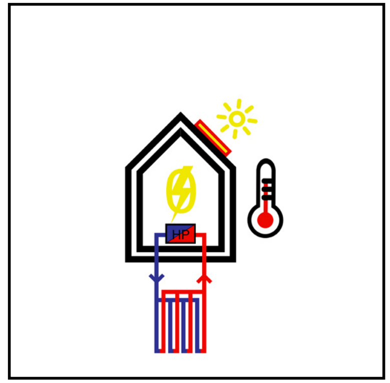
Application requirements of energy systems



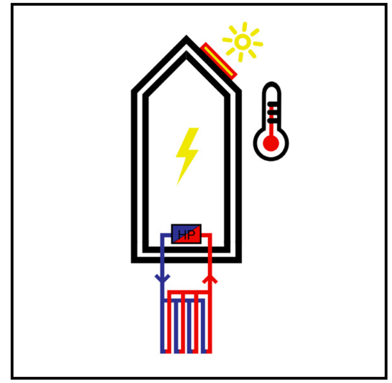
District Heat Network (D.H.N)



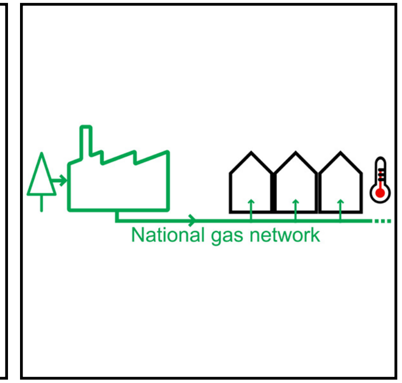
Small scale heat network with ATES



Zero On the Meter (NOM)



All-electric

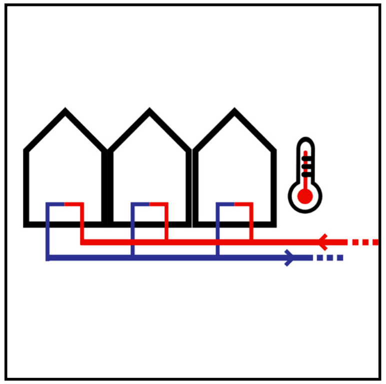


Green gas

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

RETROFIT MEASURES & ENERGY SYSTEMS

Application requirements of energy systems



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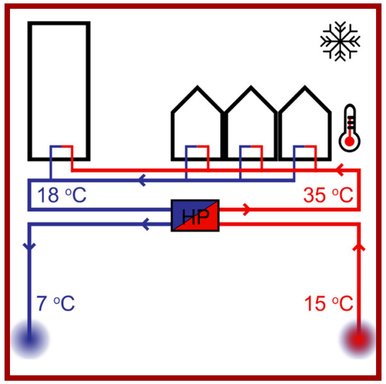
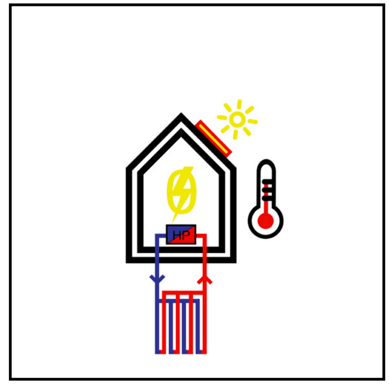


Small scale heat network with ATES



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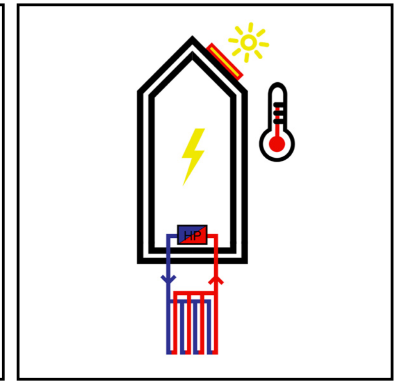

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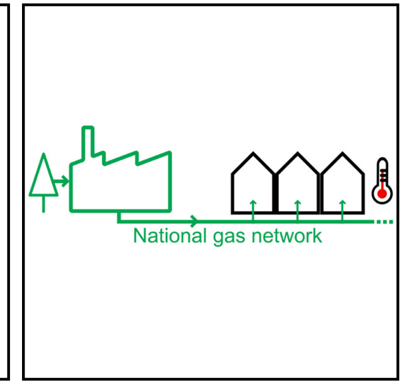
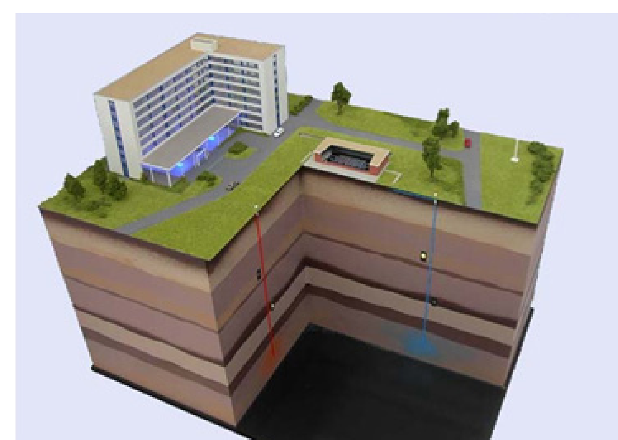


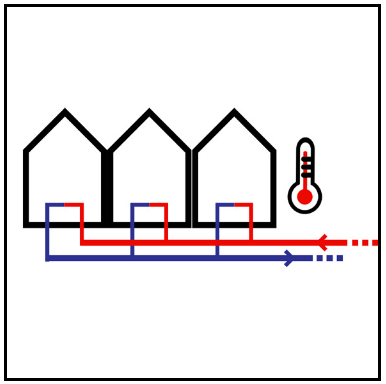
Green gas

- 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



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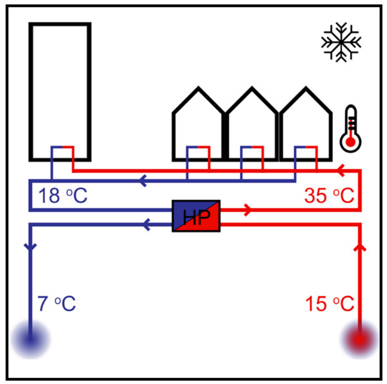
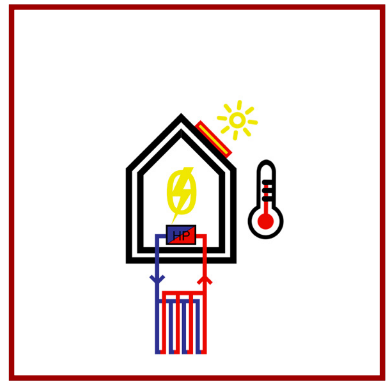


Small scale heat network with ATES



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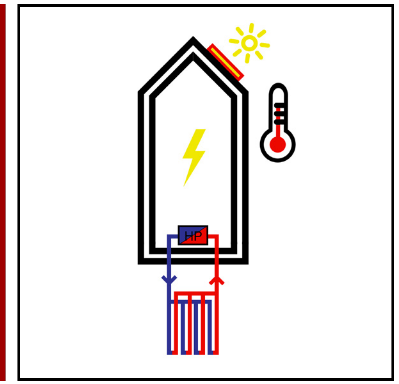
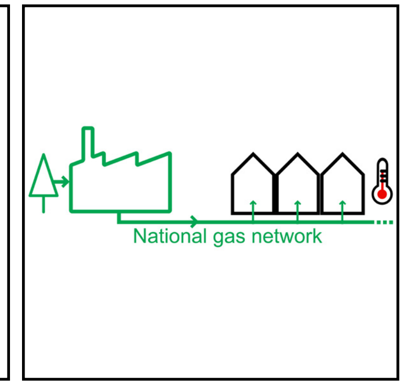


All-electric

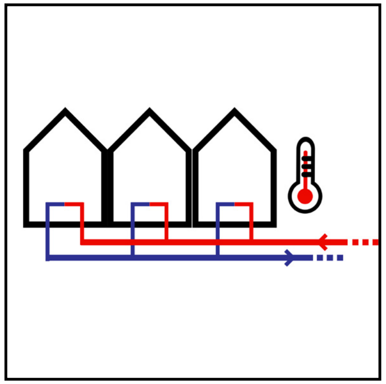


Green gas

- 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



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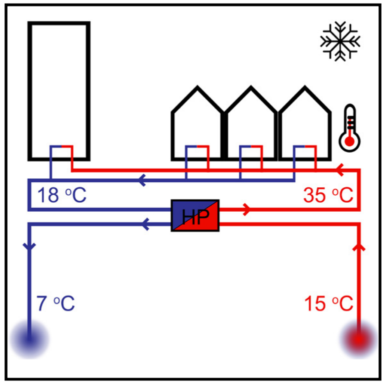
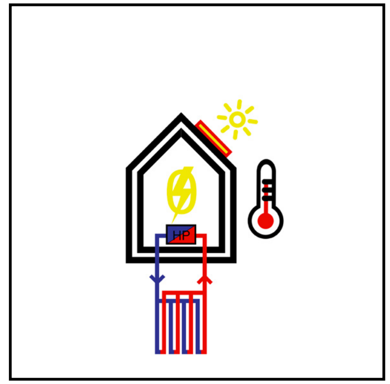


Small scale heat network with ATES



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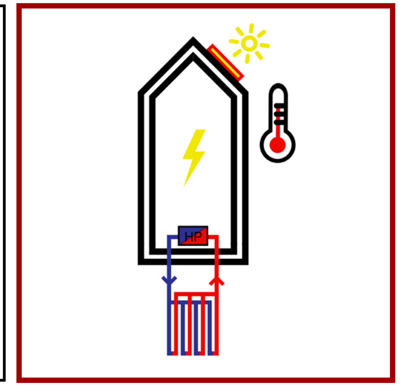
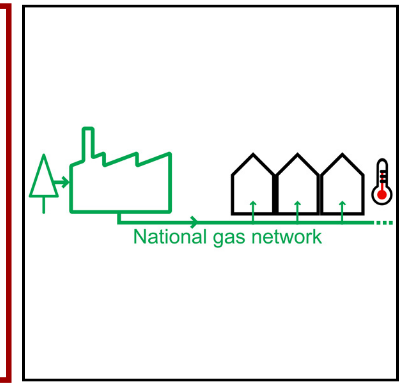


All-electric

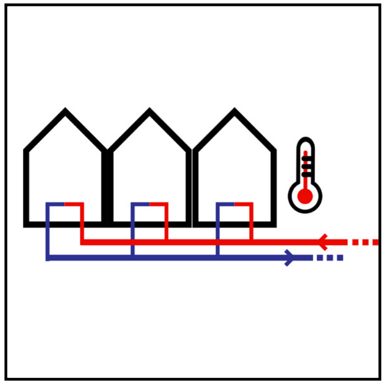


Green gas

- 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

RETROFIT MEASURES & ENERGY SYSTEMS

Application requirements of energy systems



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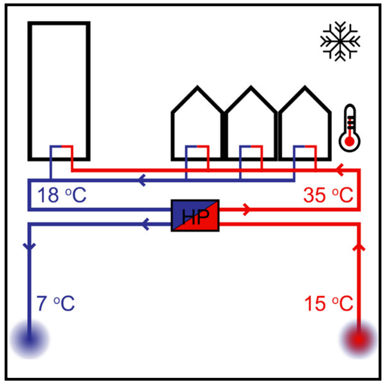
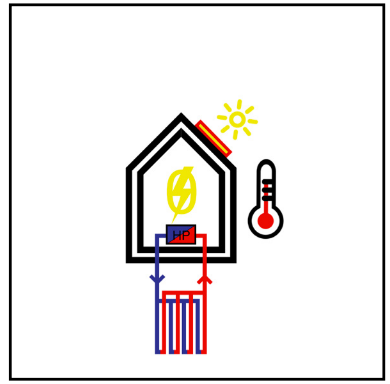


Small scale heat network with ATES



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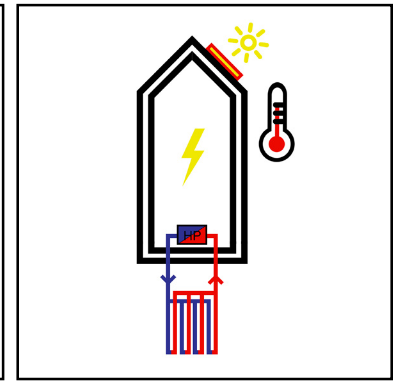
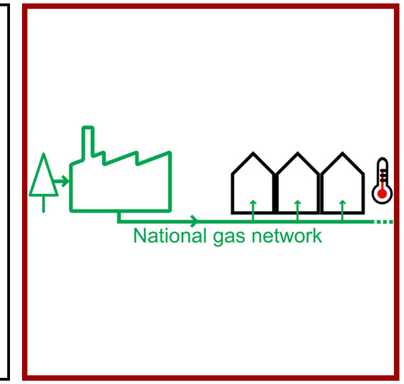
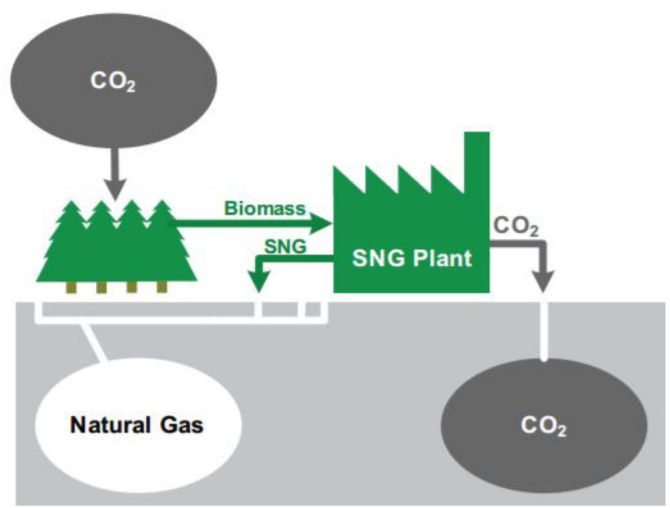


All-electric



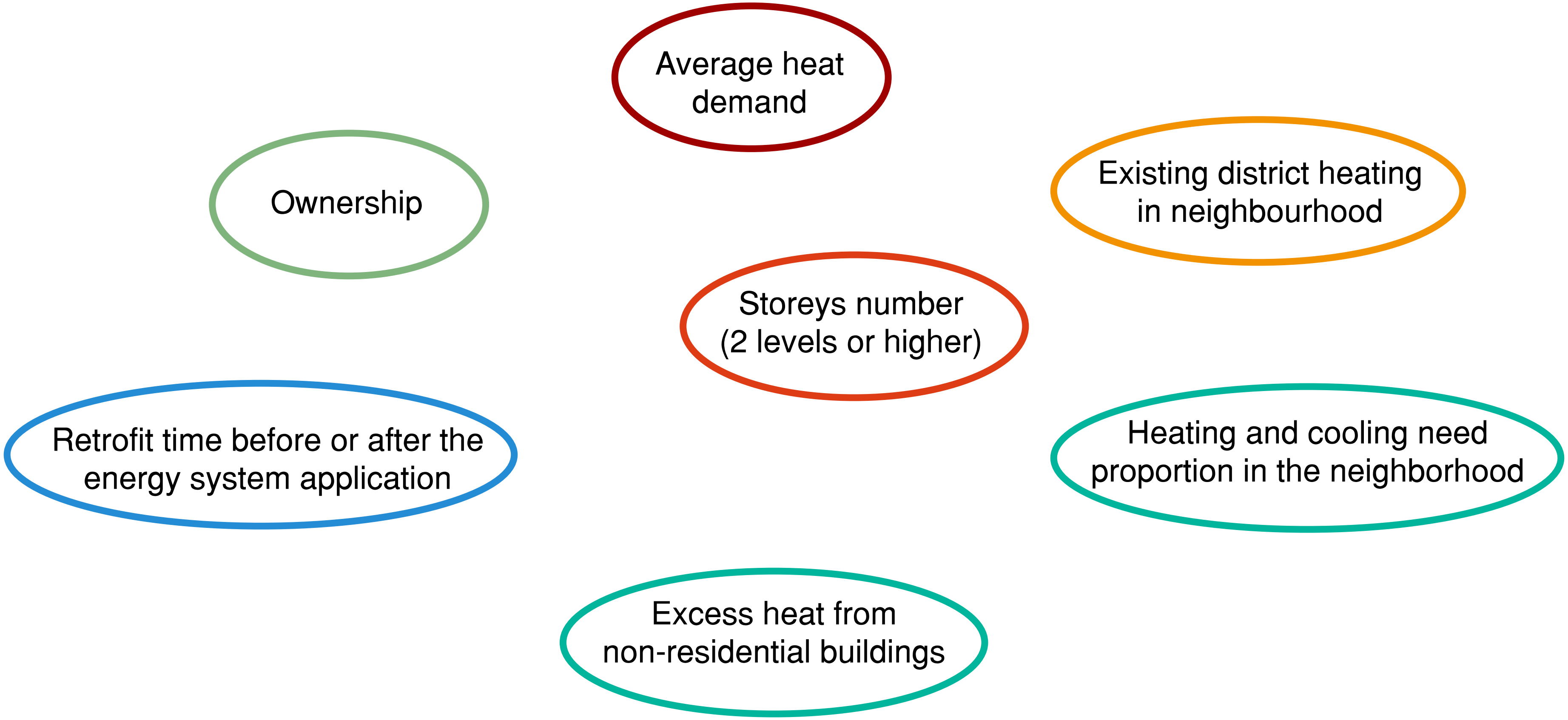
Green gas

- 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



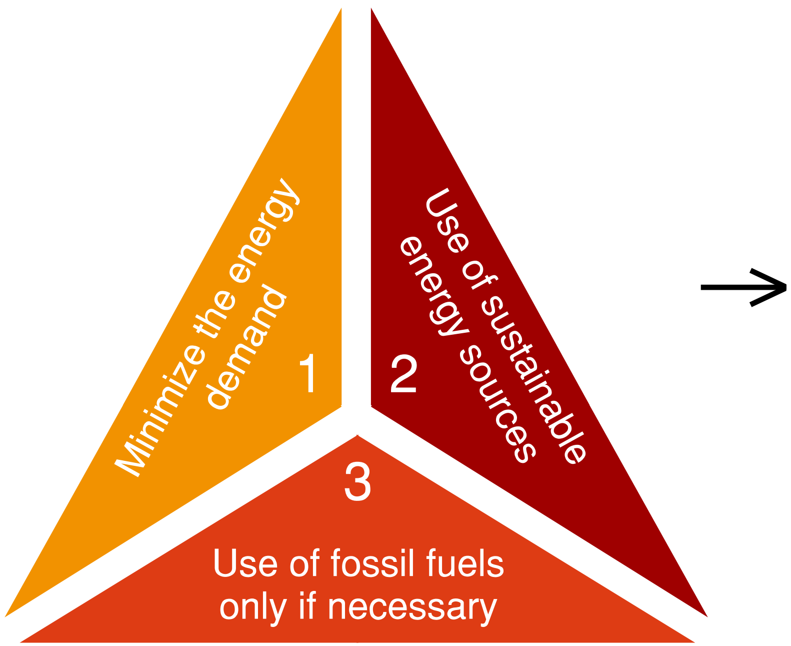
LITERATURE REVIEW

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

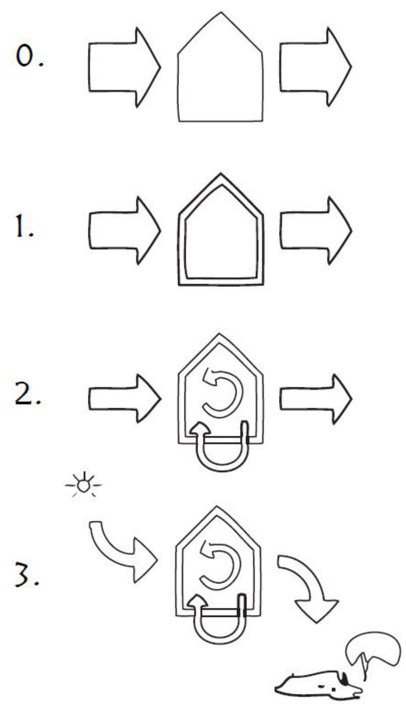
ENERGY URBAN PLANNING METHODOLOGIES

Basis of retrofit steps

TRIAS ENERGETICA



THE NEW STEPPED STRATEGY APPROACH



0 standard building

1 reduce energy consumption

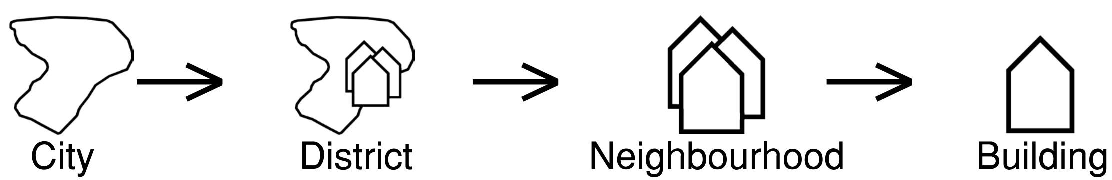
2 reuse waste energy streams

3a renewable energy production for remaining demand

3b waste = food

[Dobbelsteen, 2008]

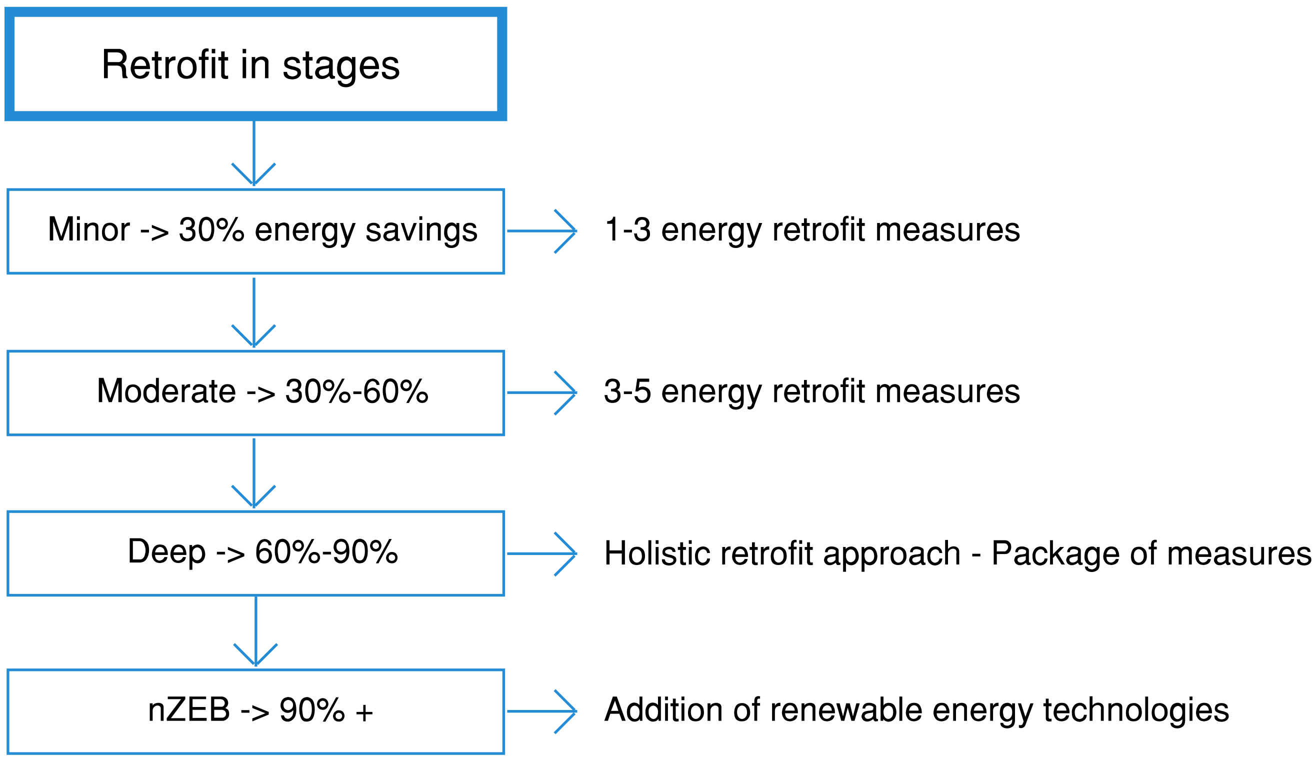
THE REAP METHODOLOGY



ENERGY URBAN PLANNING METHODOLOGIES

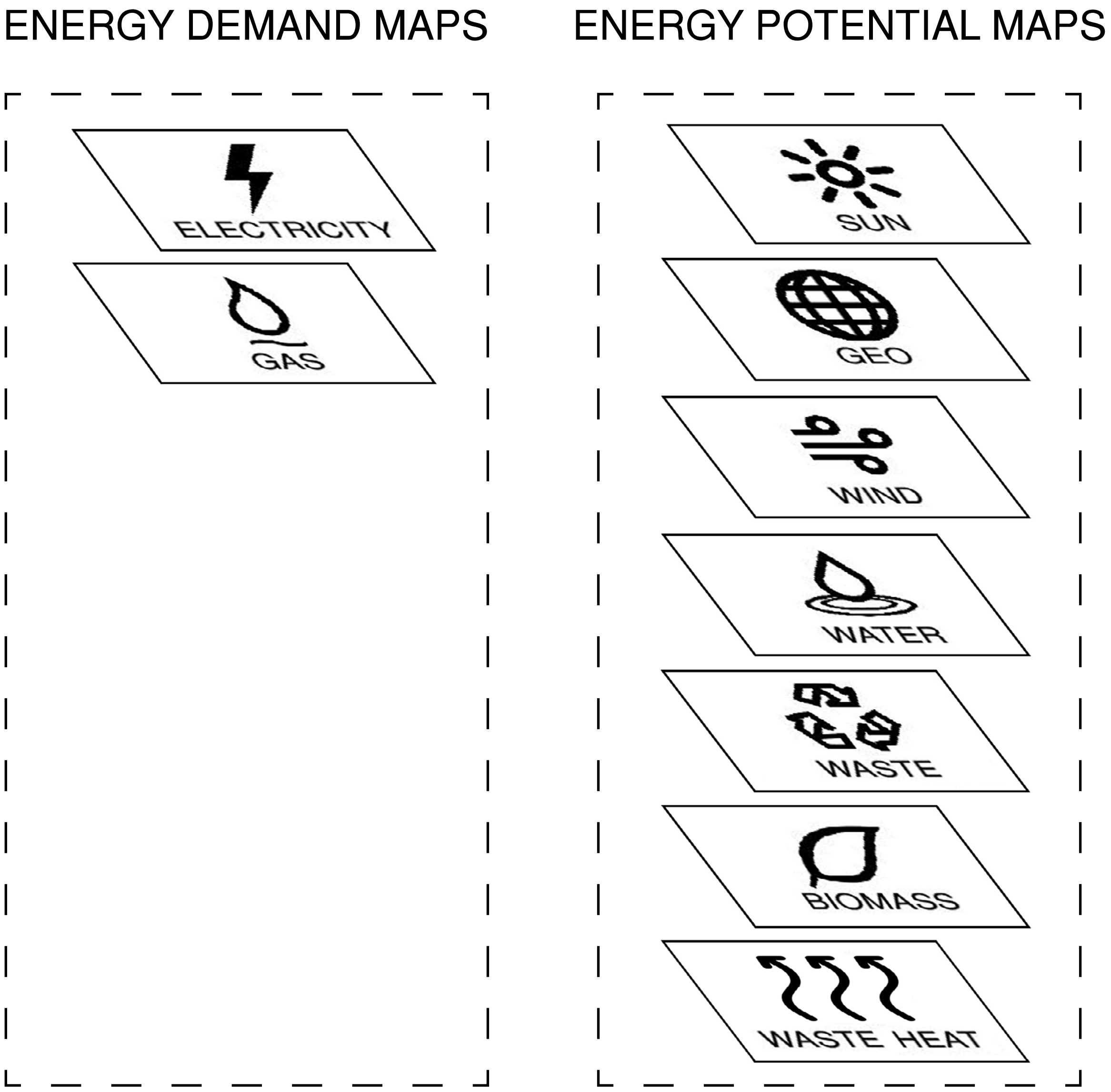
Basis of retrofit steps

EUROPE’S BUILDINGS UNDER THE MICROSCOPE - BPIE MODEL



ENERGY URBAN PLANNING METHODOLOGIES

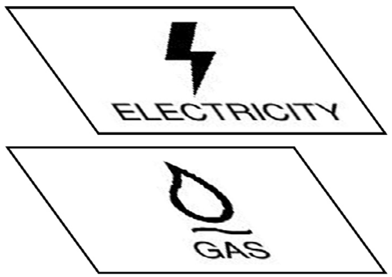
Energy Potential Mapping (EPM)



ENERGY URBAN PLANNING METHODOLOGIES

Energy Potential Mapping (EPM)

ENERGY DEMAND MAPS



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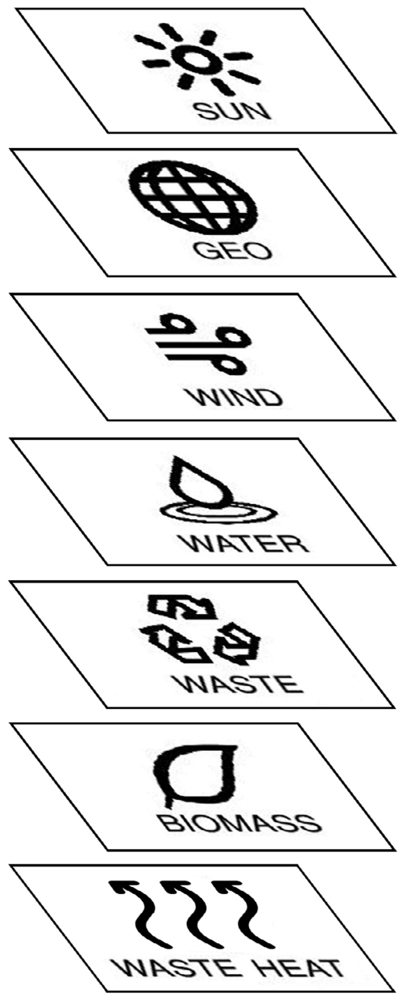
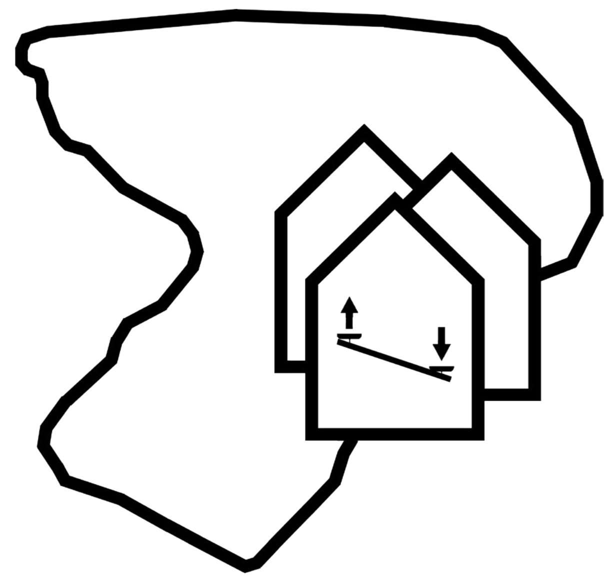
ENERGY POTENTIAL MAPS



→

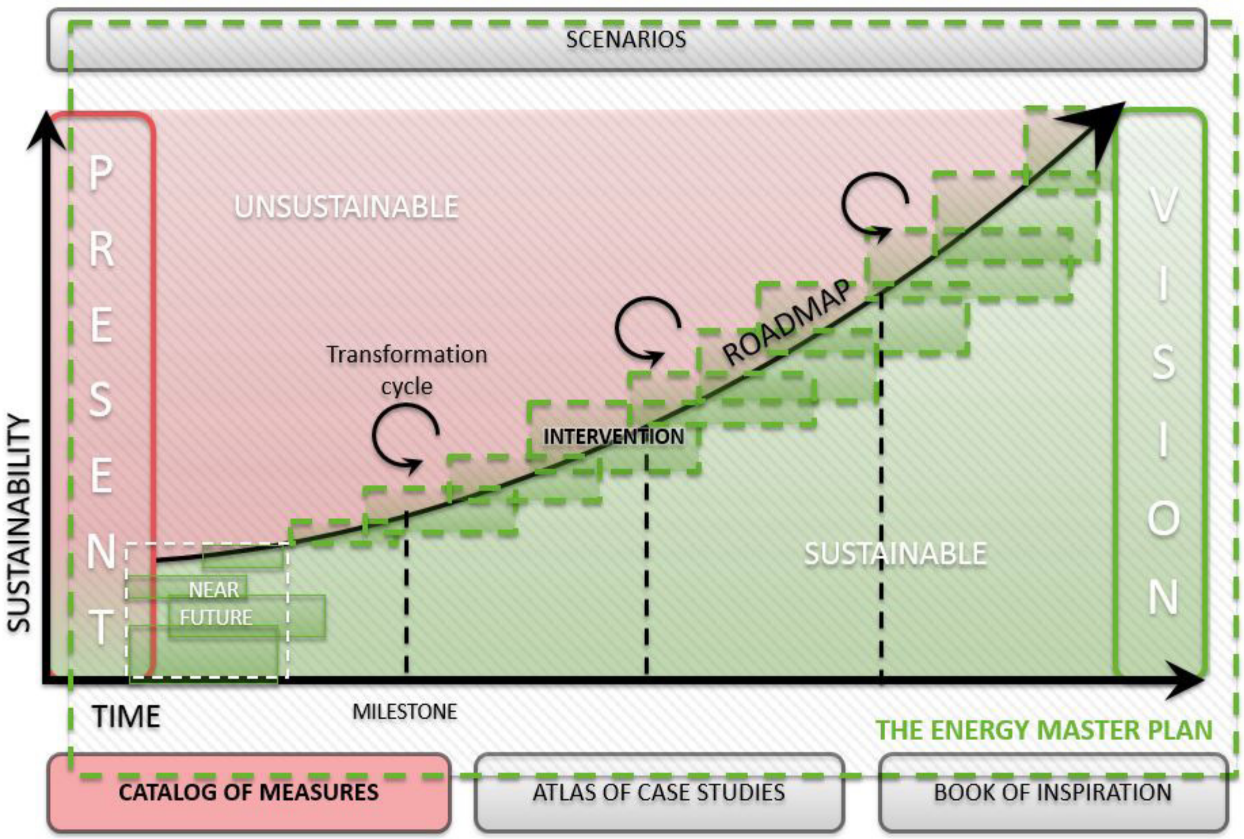
THE ENERGY MASTER PLAN

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	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 METHODOLOGY STEPS

Leading to energy transition of residential areas

Step 1
Map the present

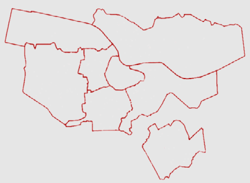
Step 2
Define future energy targets

Step 3
Strategy for selecting energy systems

Step 4
Roadmap design

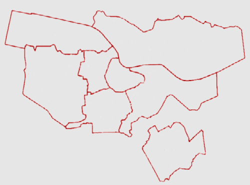
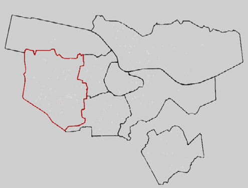
ENERGY URBAN PLANNING METHODOLOGY STEPS

Apply steps on city scale

	Step 1 Map the present	Step 2 Define future energy targets	Step 3 Strategy for selecting energy systems	Step 4 Roadmap design
 Amsterdam city	Step 1a Energy demands Step 1b Energy potentials	Step 2a Future scenario for natural gas and electricity use Step 2b Desired future heat demand	Step 3a Develop scenario for dividing the main heat systems through the districts of Amsteram Step 3b Main heat systems ratio in each district Step 3b Classify energy systems	

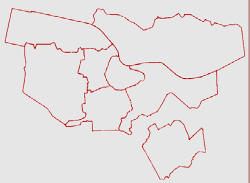
ENERGY URBAN PLANNING METHODOLOGY STEPS

Leading to the roadmap final design

	Step 1 Map the present	Step 2 Define future energy targets	Step 3 Strategy for selecting energy systems	Step 4 Roadmap design
 Amsterdam city	Step 1a Energy demands Step 1b Energy potentials	Step 2a Future scenario for natural gas and electricity use Step 2b Desired future heat demand	Step 3a Develop scenario for dividing the main heat systems through the districts of Amsteram Step 3b Main heat systems ratio in each district Step 3b Classify energy systems	
 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 inter-ventions 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

ENERGY URBAN PLANNING METHODOLOGY STEPS

Leading to energy transition of residential areas



Step 1
Map the present

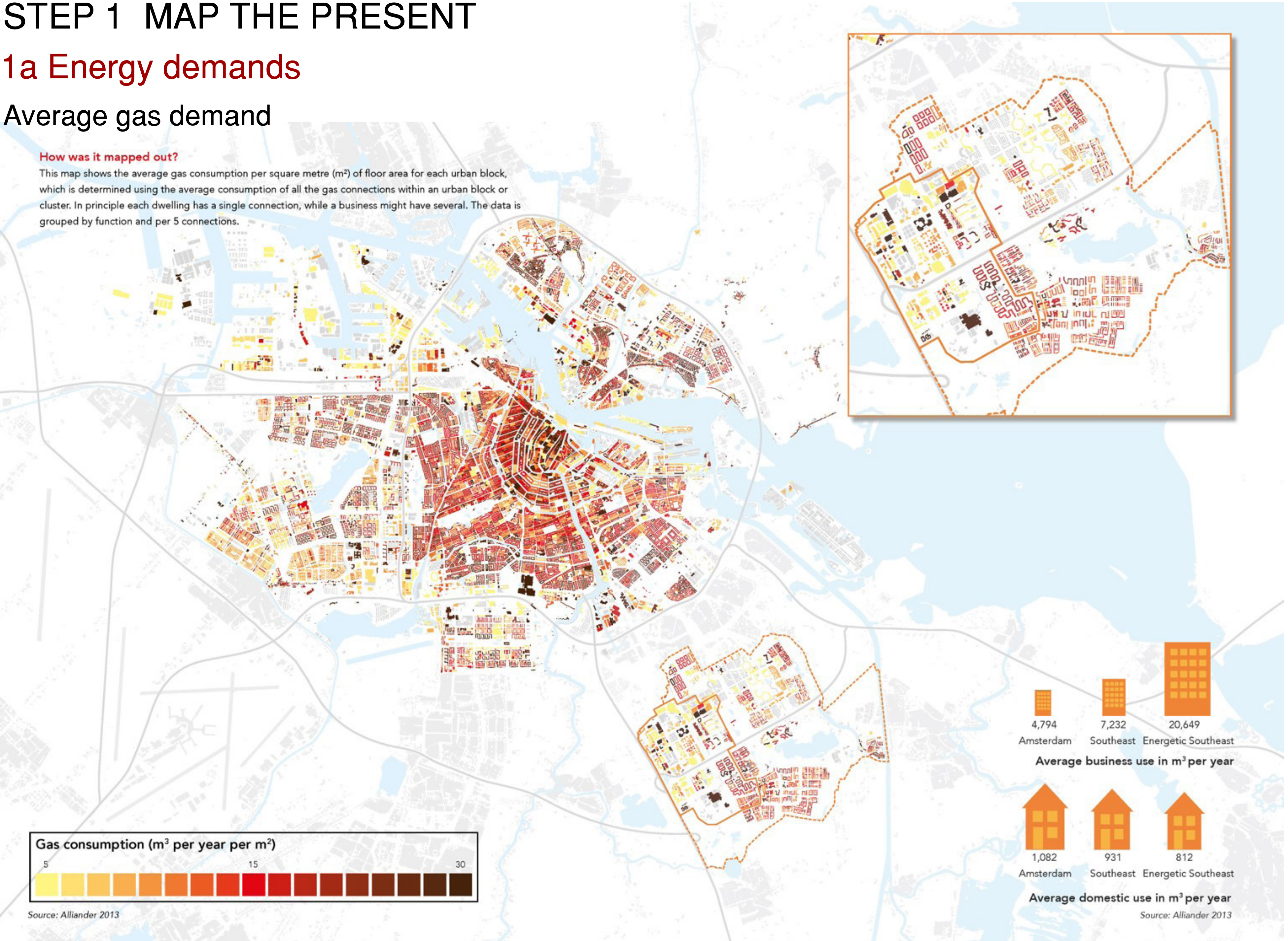
Step 1a
Energy demands

Step 1b
Energy potentials

STEP 1 MAP THE PRESENT

1a Energy demands

Average gas demand

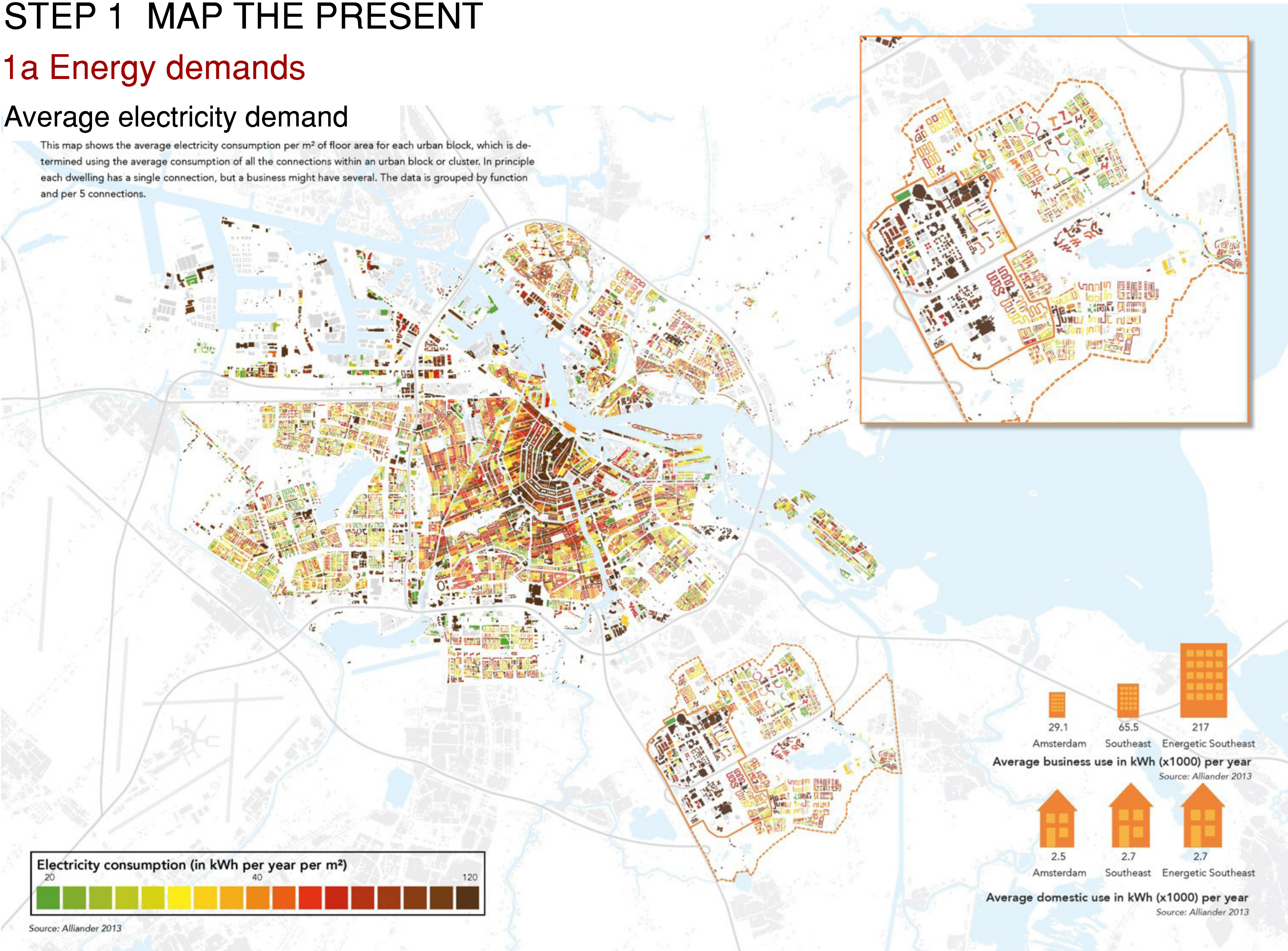


Source: Geert den Boogert, L. H. (2014). Energy Atlas Amsterdam Southeast

STEP 1 MAP THE PRESENT

1a Energy demands

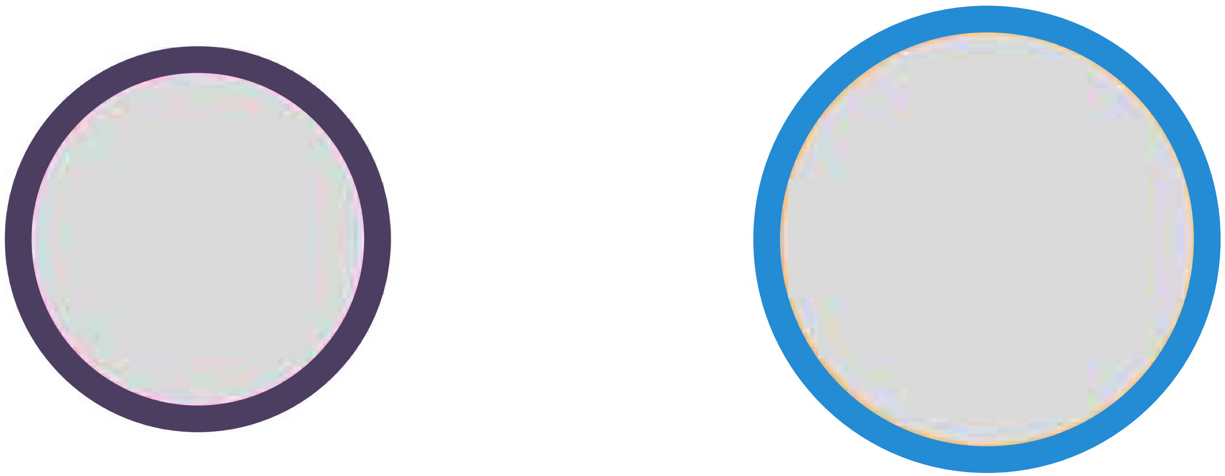
Average electricity demand



Source: Geert den Boogert, L. H. (2014). Energy Atlas Amsterdam Southeast

STEP 1 MAP THE PRESENT

1a Energy demands



Electricity

Natural Gas

788 716 193 m^3/year

↓ 1 m^3 = 9.796 kWh

4 595 566 161 kWh/year

7 704 968 489 kWh/year

↓ 1 kWh = 3.6 * 10^{-9} PJ

16.5 PJ/year

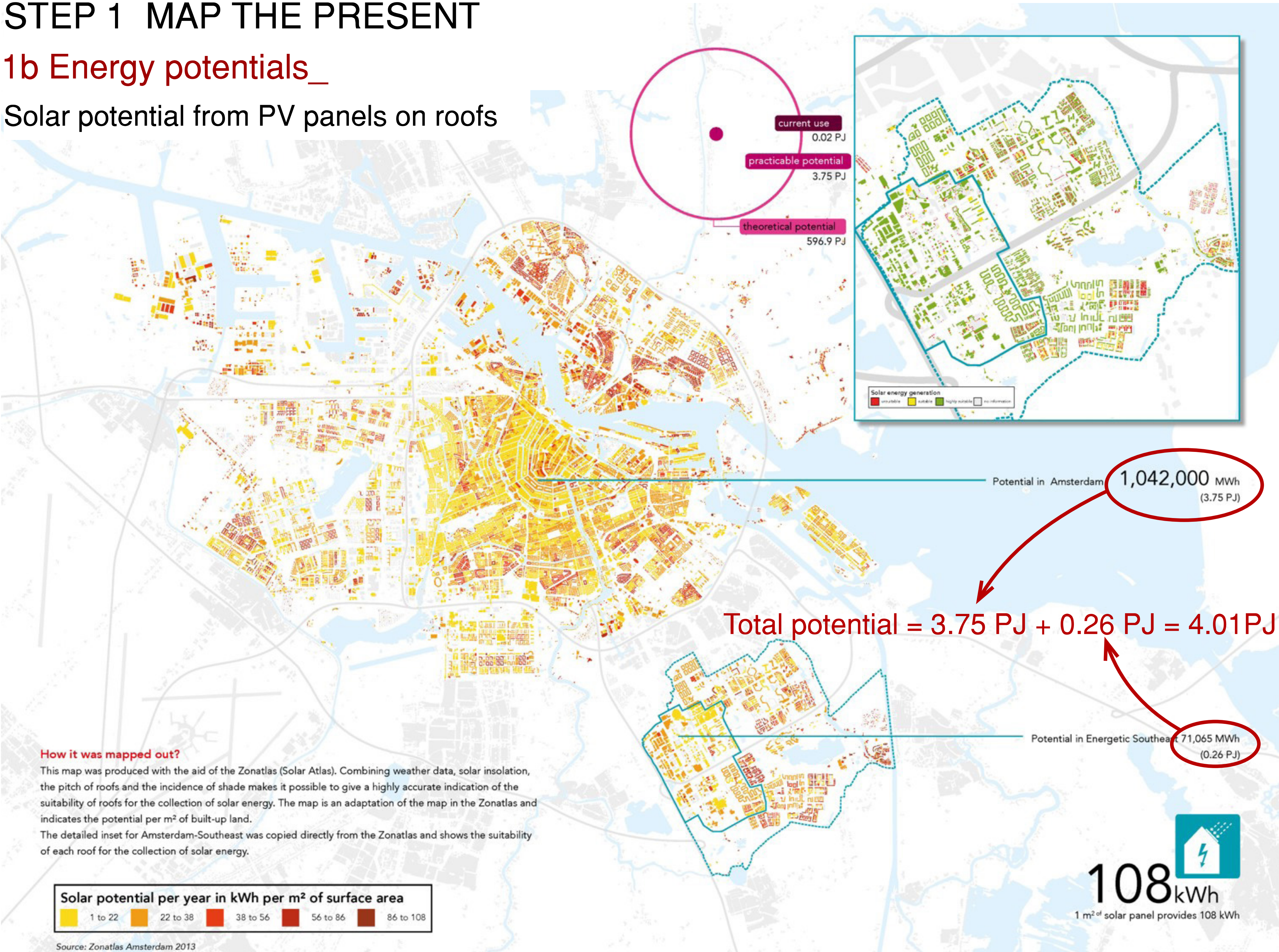
27.7 PJ/year

Source: Geert den Boogert, L. H. (2014). Energy Atlas Amsterdam Southeast

STEP 1 MAP THE PRESENT

1b Energy potentials_

Solar potential from PV panels on roofs

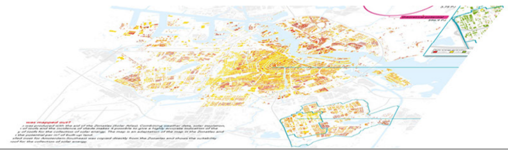
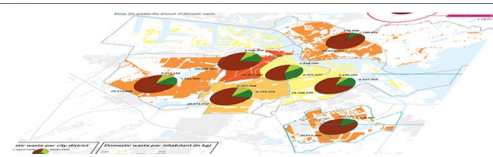
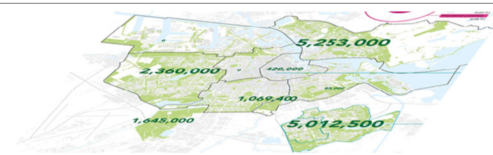
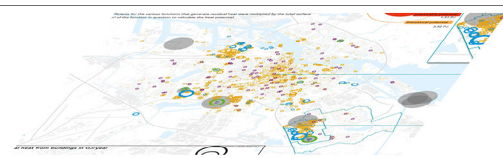
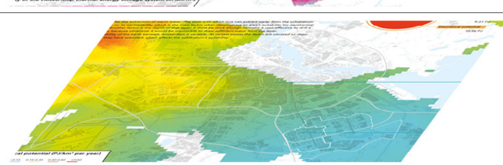


Source: Geert den Boogert, L. H. (2014). Energy Atlas Amsterdam Southeast

STEP 1 MAP THE PRESENT

1b Energy potentials

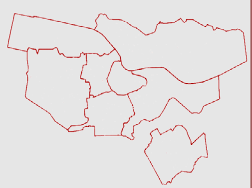
Renewable sources potentials & energy production technologies

SUN	PV panels on roofs		4.01 PJ	ELECTRICITY
WIND	Wind turbines		1.78 PJ	
DOMESTIC WASTE	Waste incineration		1.18 PJ	
BIOMASS	Biomass treatment		0.06 PJ	
RESIDUAL HEAT	Supermarkets, Offices, Hospitals, Datacenters		1.90 PJ	HEAT
EARTH / WATER	Open loop thermal energy storage - ATES system		111.9 PJ available	
	Closed loop thermal energy storage - GSHP system		8.40 PJ	
	Deep geothermal system		9.36 PJ available	

Source: Geert den Boogert, L. H. (2014). Energy Atlas Amsterdam Southeast

ENERGY URBAN PLANNING METHODOLOGY STEPS

Leading to energy transition of residential areas



Amsterdam city

Step 1
Map the present

Step 1a
Energy demands

Step 1b
Energy potentials

Step 2
Define future energy targets

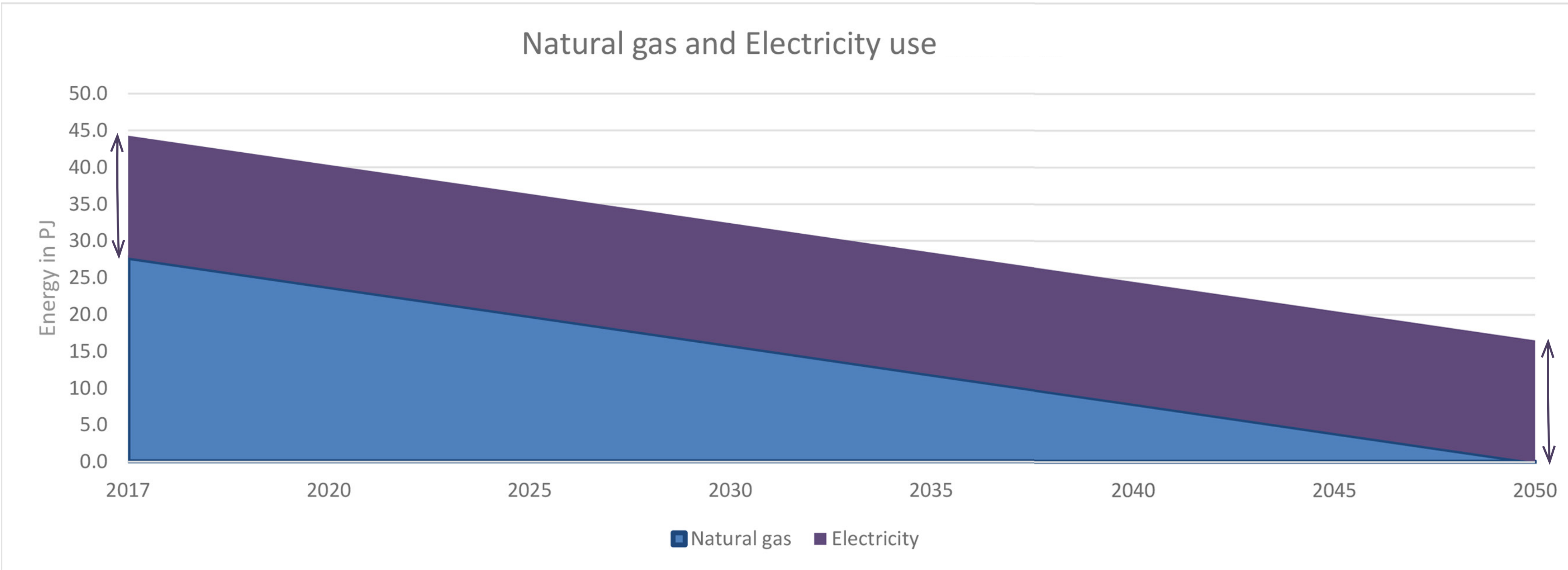
Step 2a
Future scenario for natural gas and electricity use

Step 2b
Desired future heat demand

STEP 2 DEFINE FUTURE ENERGY TARGETS

2a Future scenario for natural gas and electricity use

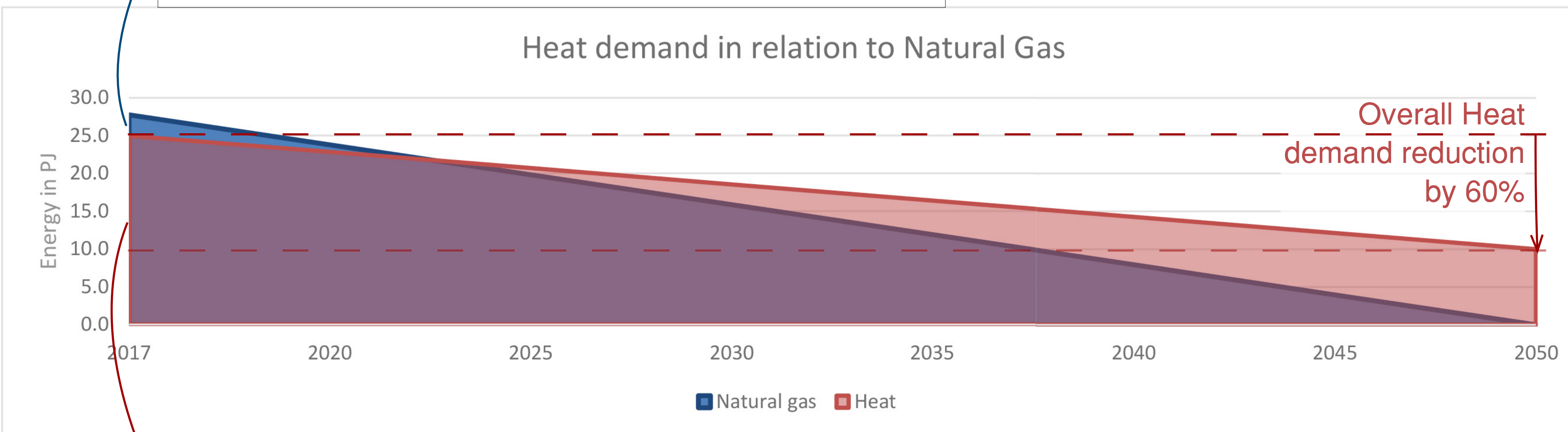
	2017	2050	Assumption
Electricity use =	16.5 PJ	Remains the same →	Demand reduced because of using smart appliances But, an amount needed for heat pumps' operation
Natural gas use =	27.7 PJ	Not used anymore	



STEP 2 DEFINE FUTURE ENERGY TARGETS

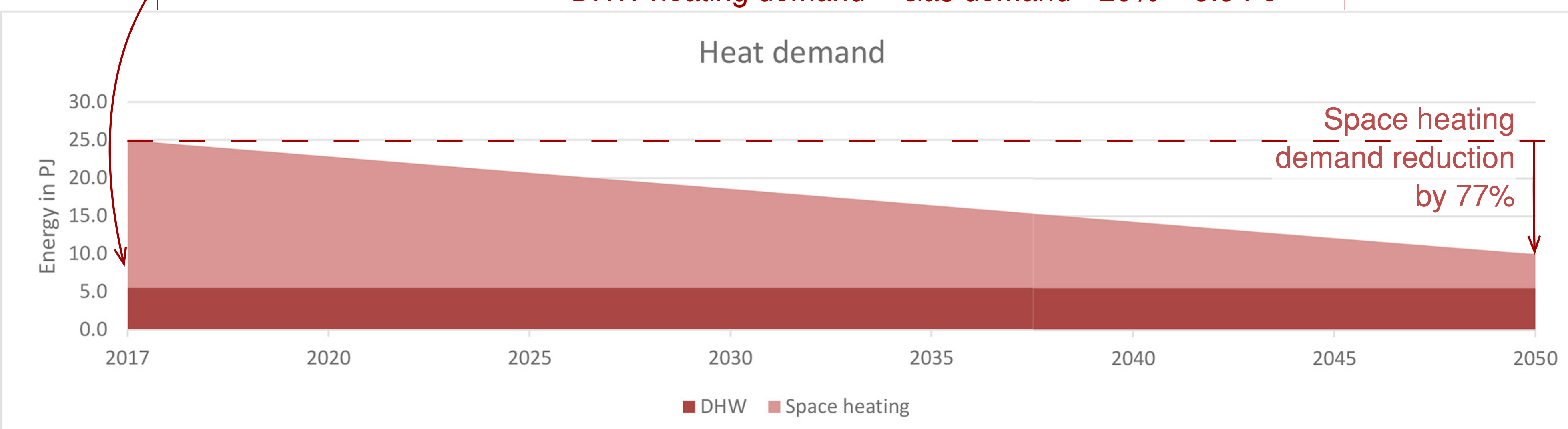
2b Desired future energy demand for heating

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



Gas boilers of 90% efficiency

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



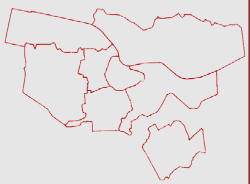
ENERGY URBAN PLANNING METHODOLOGY

Stepped methodology 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



Amsterdam city

Step 1a
Energy demands

Step 1b
Energy potentials

Step 2a
Future scenario for natural gas and electricity use

Step 2b
Desired future heat demand

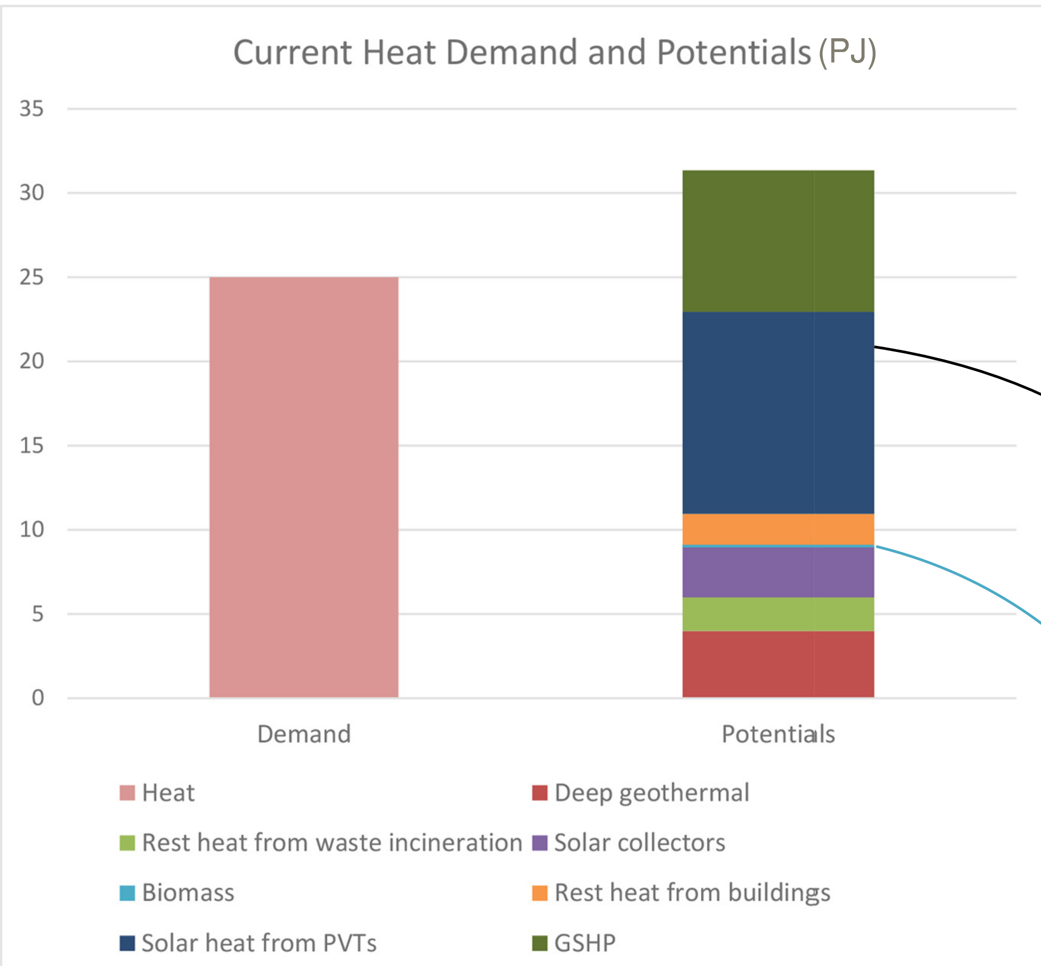
Step 3a
Develop scenario for dividing the main heat systems through the districts of Amsteram

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



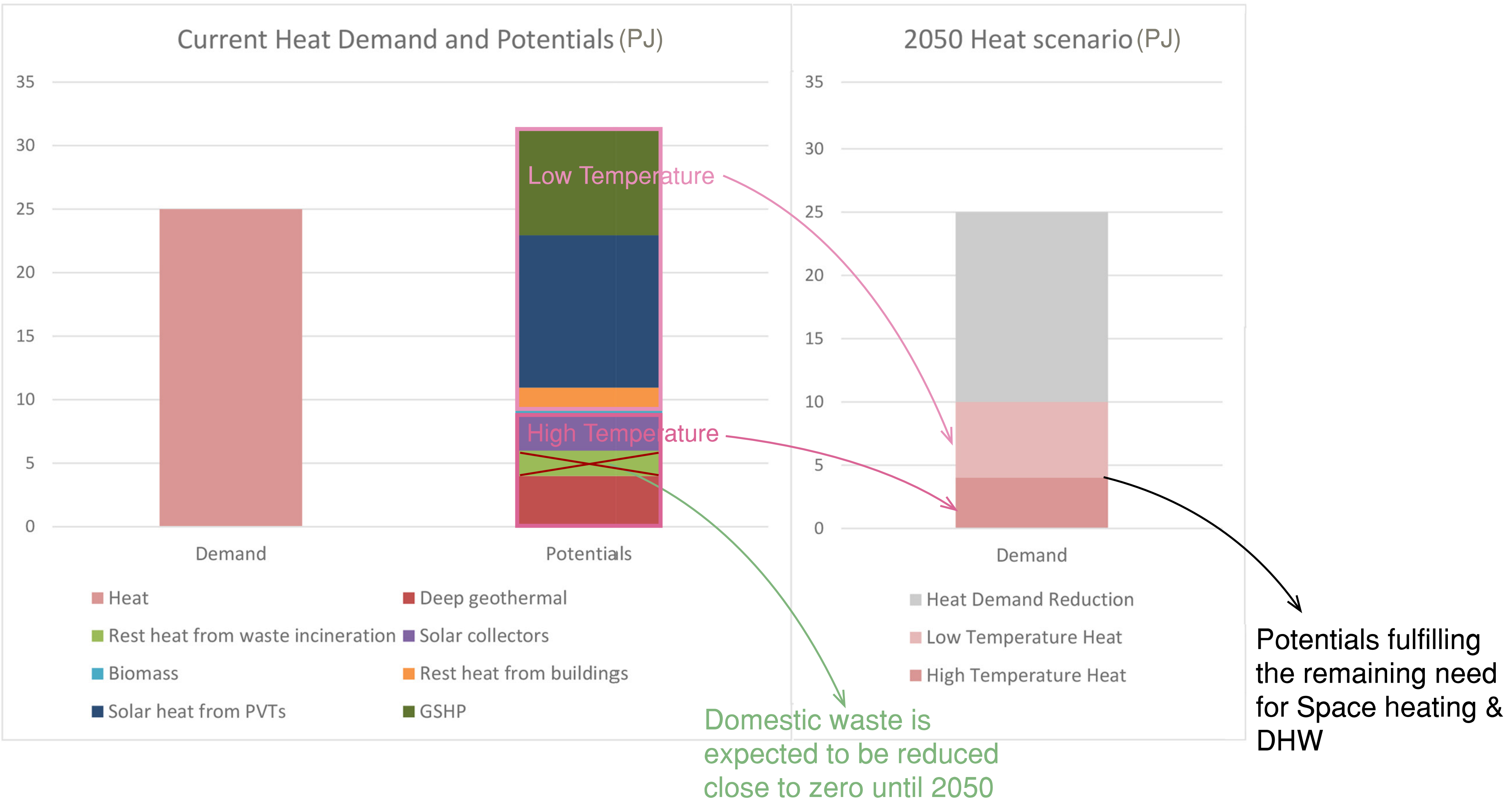
Heat potentials exceed the current heat demand giving the possibilities for multiple renwable energy technologies to be used

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 Amsteram districts

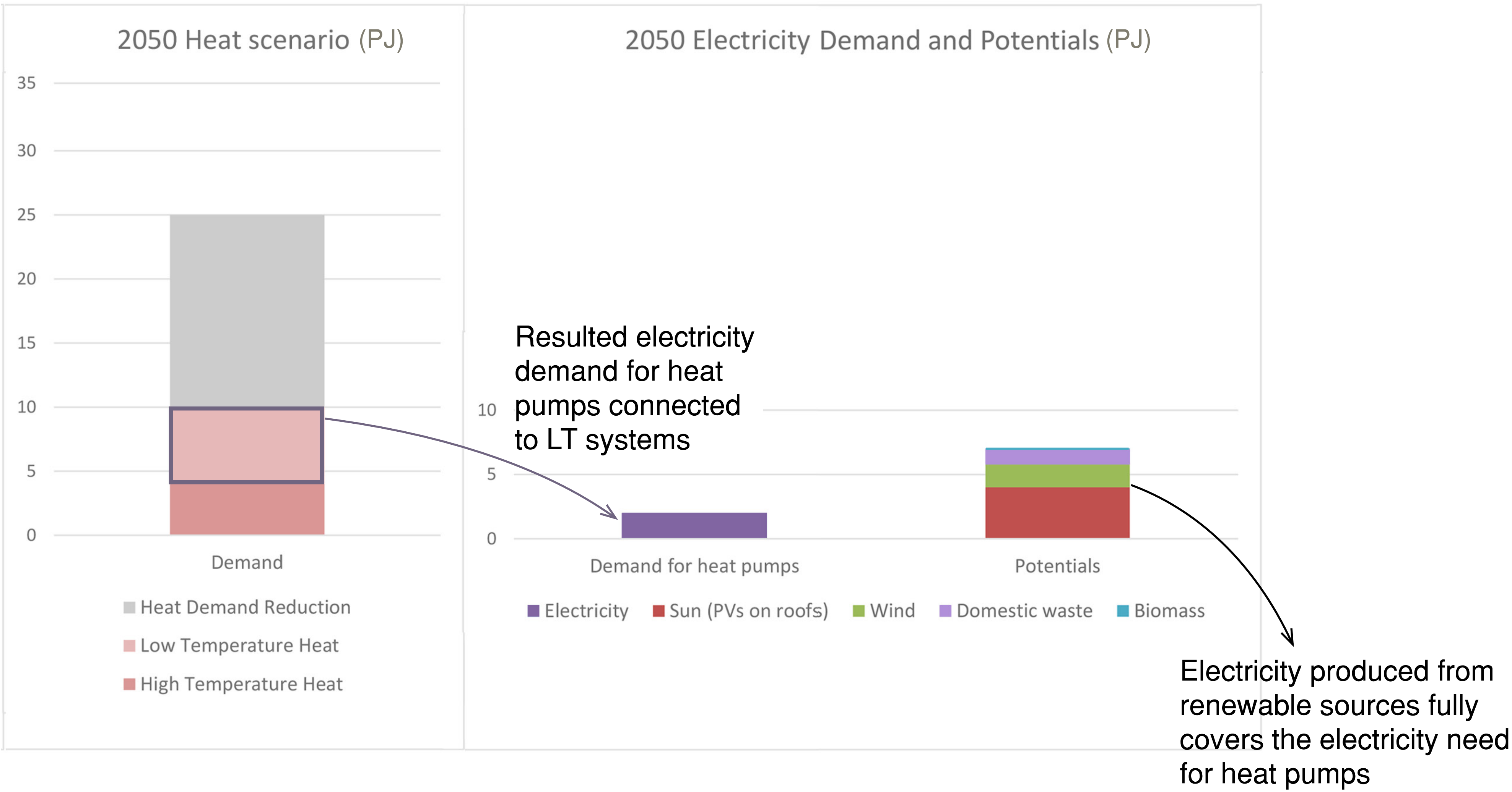
PJ



STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

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

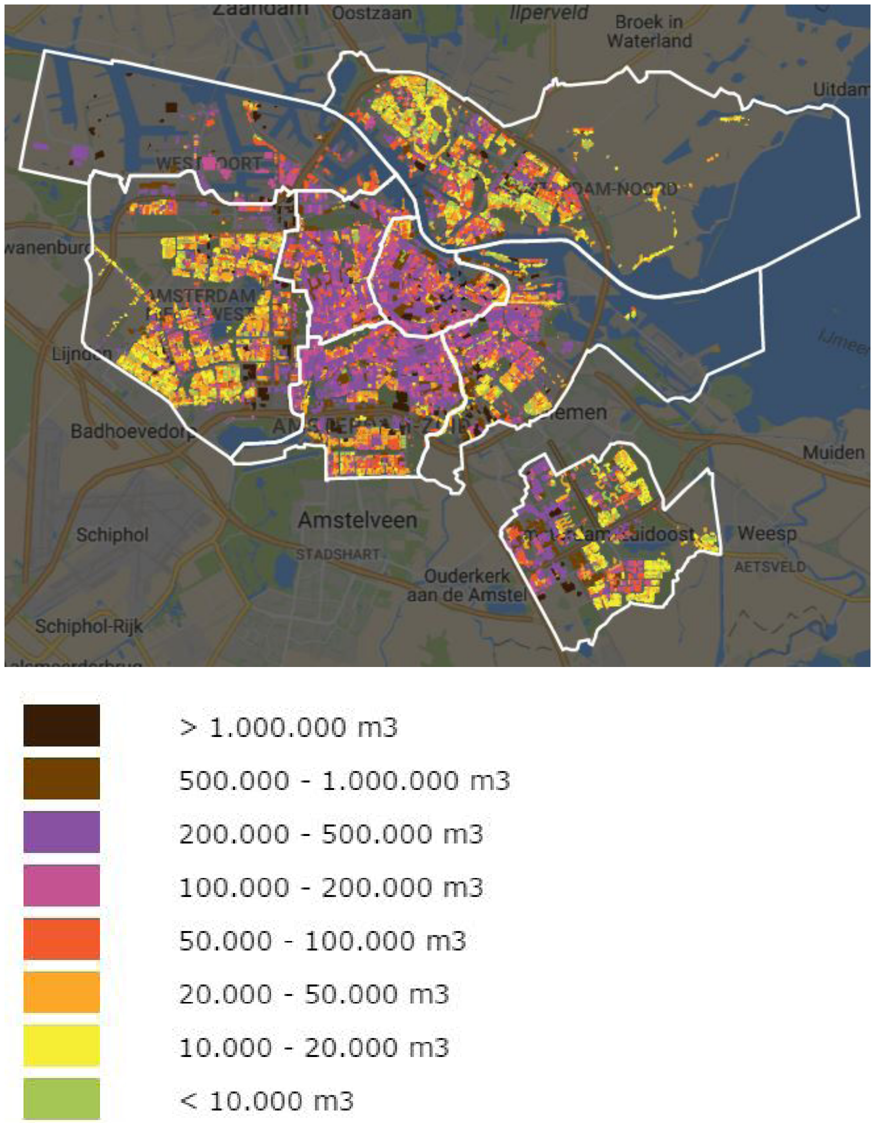
PJ



STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

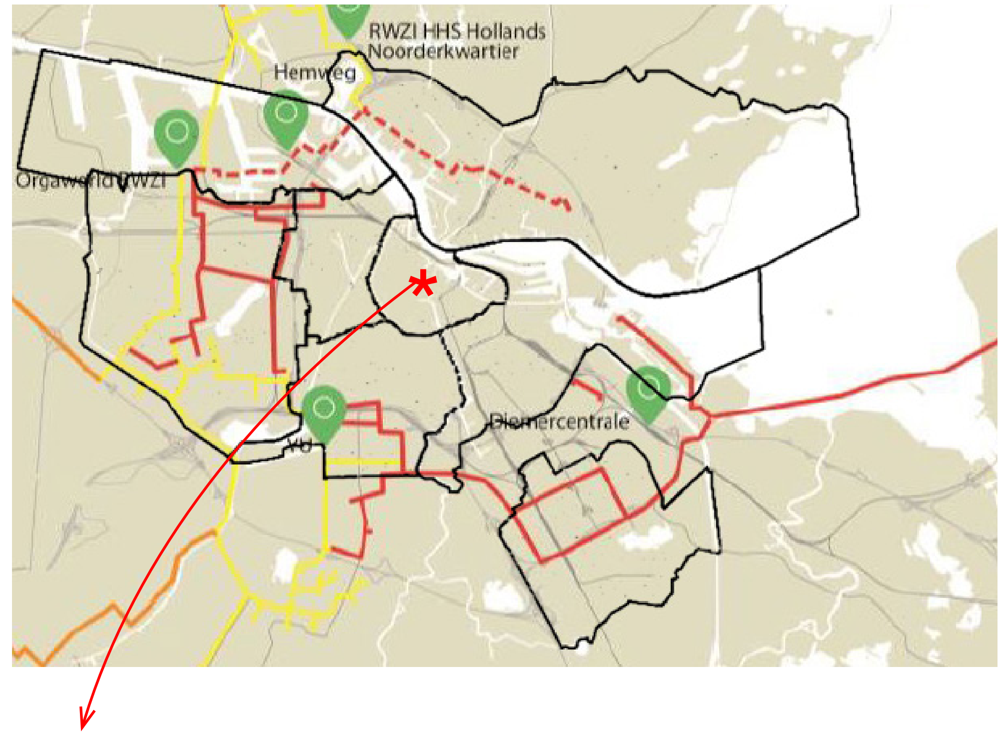
3b Main heat systems ratio in each district

Map of gas demand



Source: http://maps.amsterdam.nl/

Regional warmtenet 2015-2040

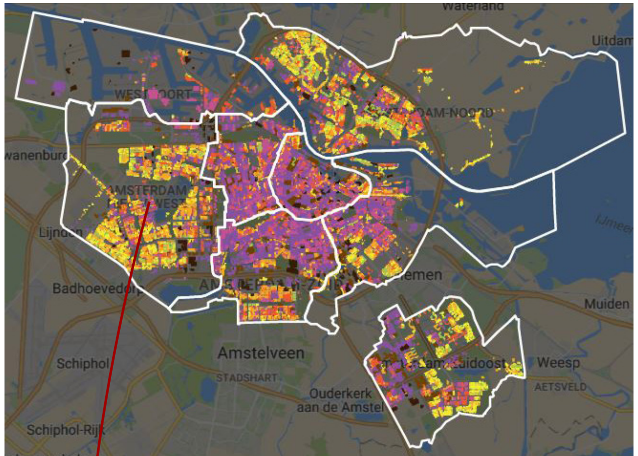


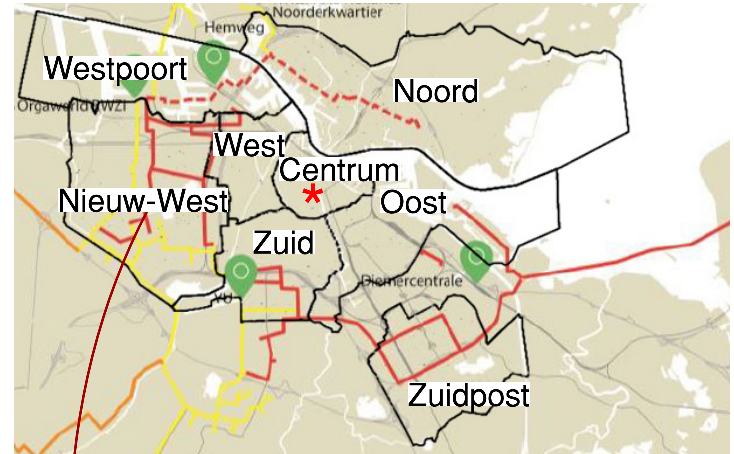
Amsterdam Centrum as a possible area of D.H.N. extention because of the high concentrated heat demand

Source: Gemeente Amsterdam. (2016). Naar een stad zonder aardgas

STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

3b Main heat systems ratio in each district



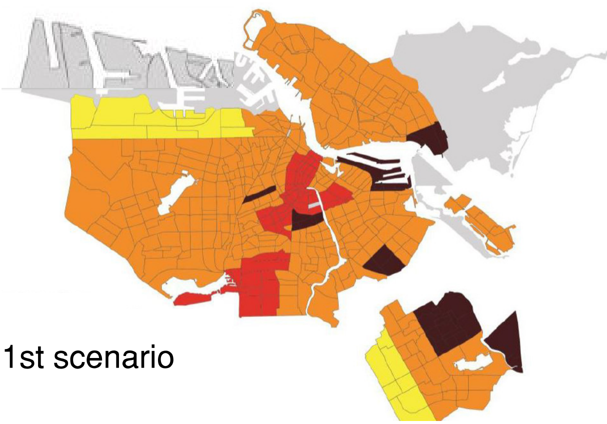


Amsterdam district	Heat demand 2050	H.T. or L.T. Heat Systems	Percentage	Heat Potential
Centrum	1.5	High Temperature	50%	0.7
		Low Temperature	50%	0.7
Oost	1.2	High Temperature	20%	0.2
		Low Temperature	80%	1.0
Zuid	1.5	High Temperature	50%	0.7
		Low Temperature	50%	0.7
West	1.5	High Temperature	20%	0.3
		Low Temperature	80%	1.2
Nieuw-West	1.2	High Temperature	50%	0.6
		Low Temperature	50%	0.6
Westpoort	0.7	High Temperature	30%	0.2
		Low Temperature	70%	0.5
Noord	1.2	High Temperature	50%	0.6
		Low Temperature	50%	0.6
Zuidoost	1.2	High Temperature	45%	0.5
		Low Temperature	55%	0.7
	Total heat demand 2050			**Total H.T. Heat potential**
	10.0			**4.0**
				Total L.T. Heat potential
				6.0

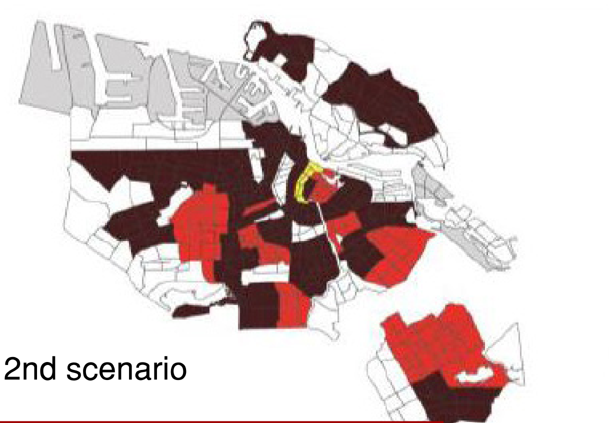
STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

3b Main heat systems ratio in each district

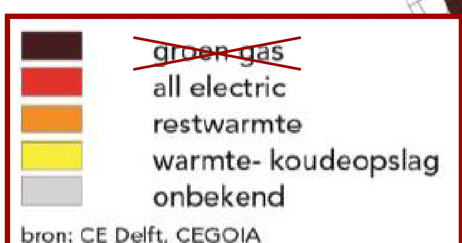
Existing research on energy systems' application scenarios



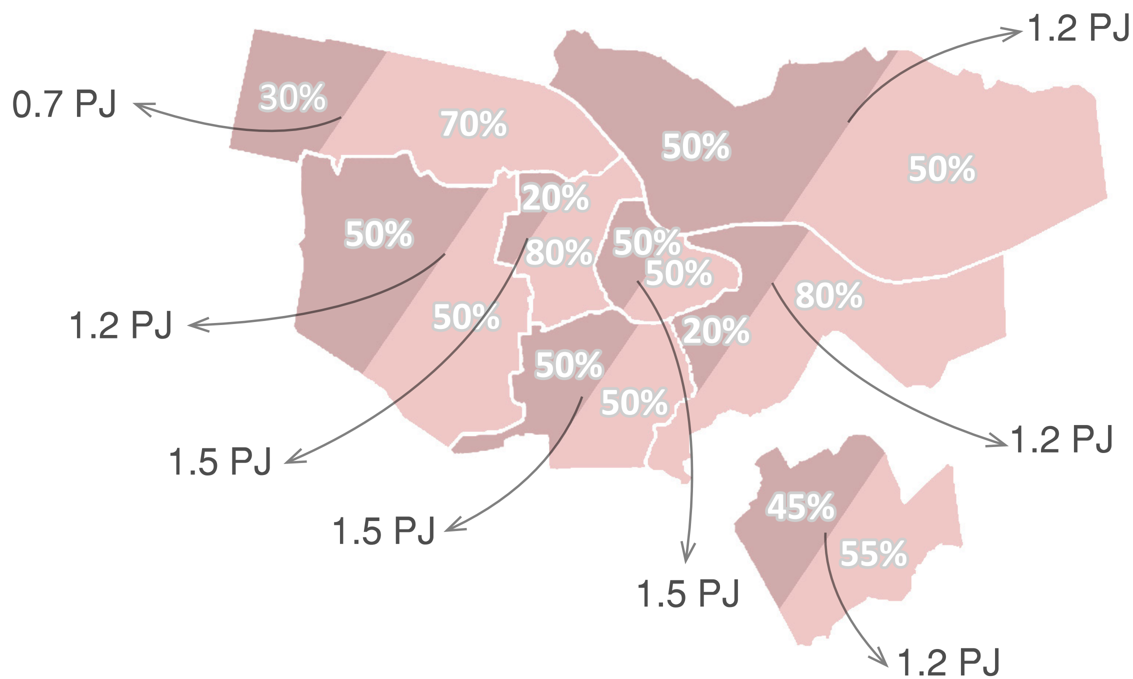
1st scenario



2nd scenario



L.T. and H.T. energy systems ratio covering the future heat demand

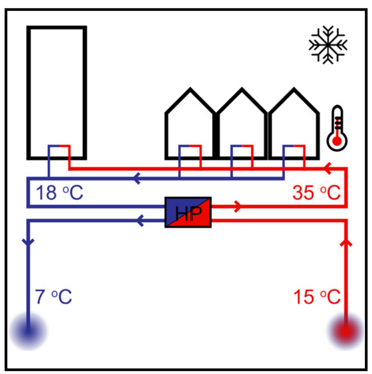
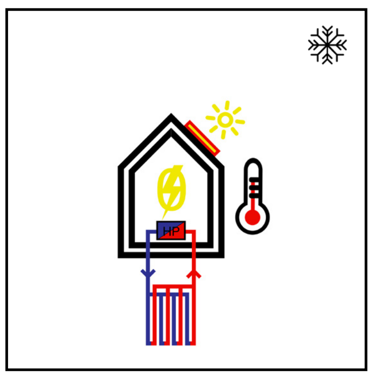
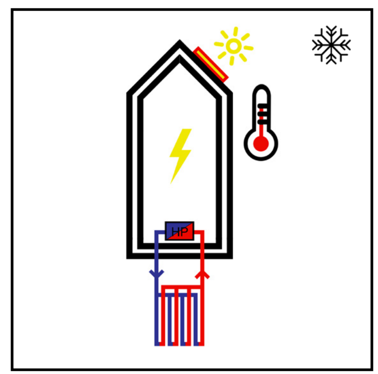
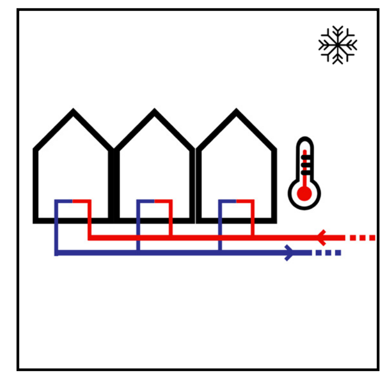


Covering the total Heat demand of 10 PJ in 2050
In reality the energy systems are mixed in the districts of Amsteram

Low Temperature Heat			High Temperature Heat
Small scale Heat Network ATES	NOM (up to 2 floors)	All-electric	District Heat Network

STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

3c Classify energy systems

Low Temperature Heat			High Temperature Heat
Small scale Heat Network ATES	NOM (up to 2 floors)	All-electric	District Heat Network
 Small scale heat network with ATES	 Zero On the Meter (NOM)	 All-electric	 District Heat Network (DHN)

ENERGY URBAN PLANNING METHODOLOGY

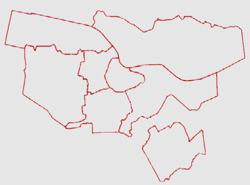
Stepped methodology leading to energy transition of residential areas

Step 1
Map the present

Step 2
Define future energy targets

Step 3
Strategy for selecting energy systems

Step 4
Roadmap design



Amsterdam city

Step 1a
Energy demands

Step 1b
Energy potentials

Step 2a
Future scenario for natural gas and electricity use

Step 2b
Desired future heat demand

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

Step 3b
Main heat systems ratio in each district

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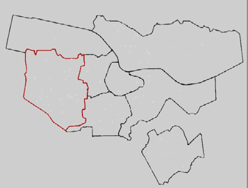


Amsterdam Nieuw West neighbourhoods

Step 1a
Site determination inside Amsterdam Nieuw West

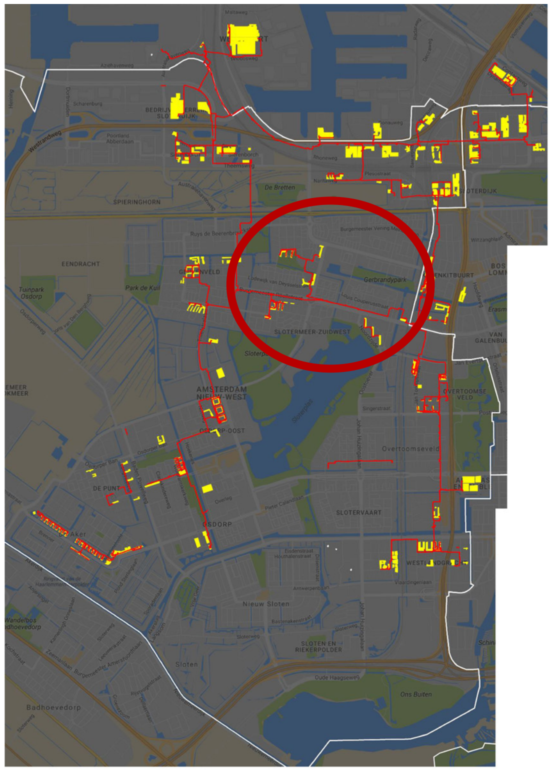
Step 1b
Buildings description & Energy demands

Step 1c
Energy potentials

STEP 1 MAP THE PRESENT

1a Site determination inside Amsterdam Nieuw West

DISTRICT HEAT NETWORK



Source: http://maps.amsterdam.nl/

AVERAGE GAS CONSUMPTION

- > 100 m3
- 50 - 100 m3
- 25 - 50 m3
- 20 - 25 m3
- 15 - 20 m3
- 10 - 15 m3
- 5 - 10 m3
- < 5 m3
- Geen of onbetrouwbare m2

CONSTRUCTION YEAR

- Before 1860
- 1860-1919
- 1920-1945
- 1946-1965
- 1966-1990
- After 1990
- Unknown

BOUNDARY CONDITION

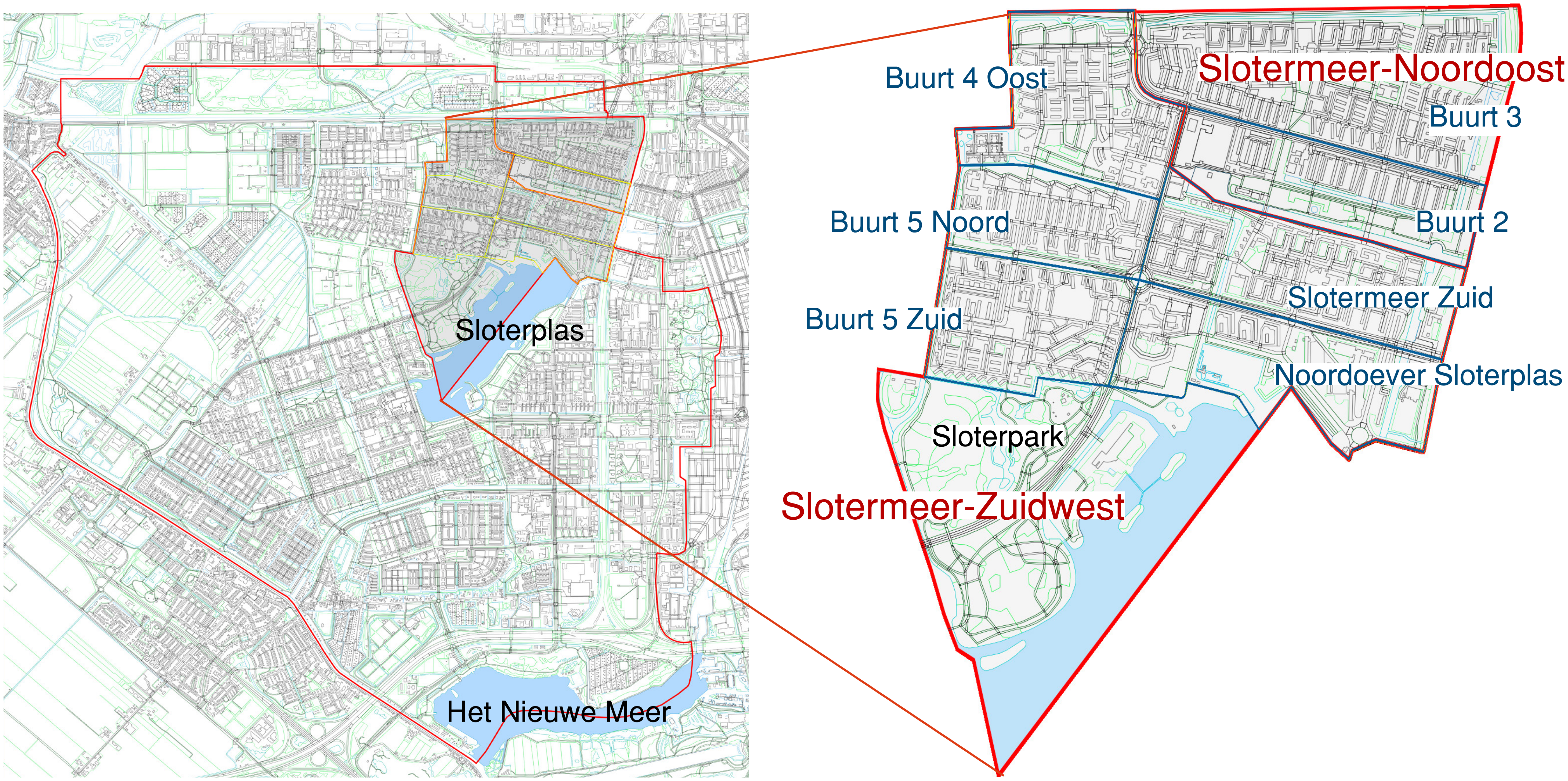
Site restriction because of
the project time limit

STEP 1 MAP THE PRESENT

1a Site determination inside Amsterdam Nieuw West

AMSTERDAM NIEUW WEST DISTRICT

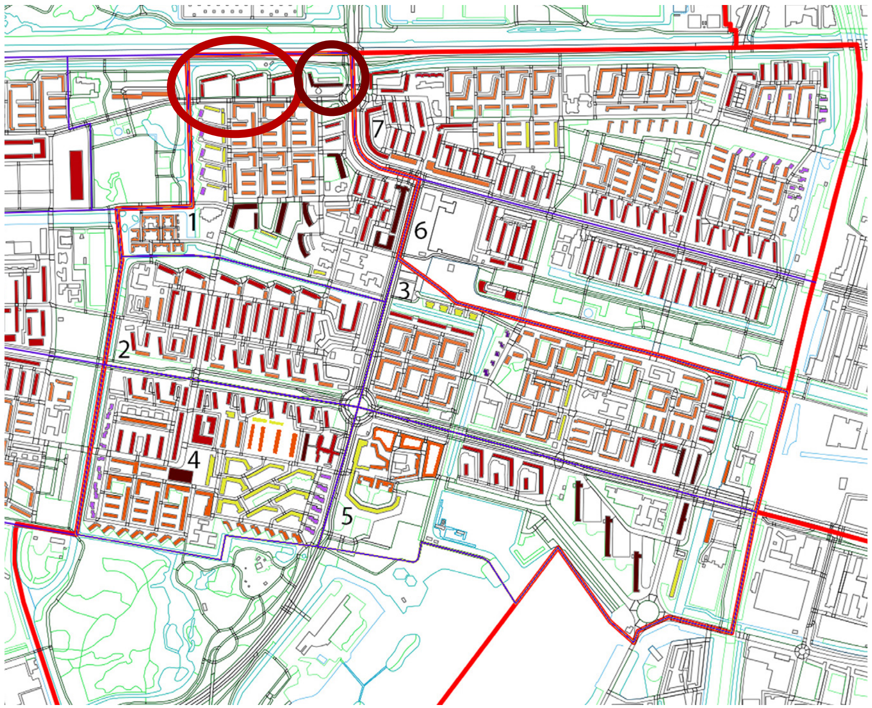
NEIGHBOURHOOD COMBINATIONS



STEP 1 MAP THE PRESENT

1b Buildings description & Energy demands

Typologies map



- Gallerijflat appartment block
- Portiekflat appartment block
- Rowhouse
- Multifamily house
- Semi-detached house
- Detached house

Data extraction

Area	Neighbourhood	Building block number	House typology	Additional classification
Slotermeer-Zuidwest	Buurt 4 Oost	18937	Appartment bloc	Portiekflat
		18938	Appartment bloc	Portiekflat
		18939	Appartment bloc	Portiekflat
		19067	Appartment bloc	Gallerijflat

Year of construction	Storeys number	Type of roof	Electricity consumption kWh
1955	5	sloped	93075
1955	5	sloped	90100
1955	5	sloped	122748
1959	9	flat	290376

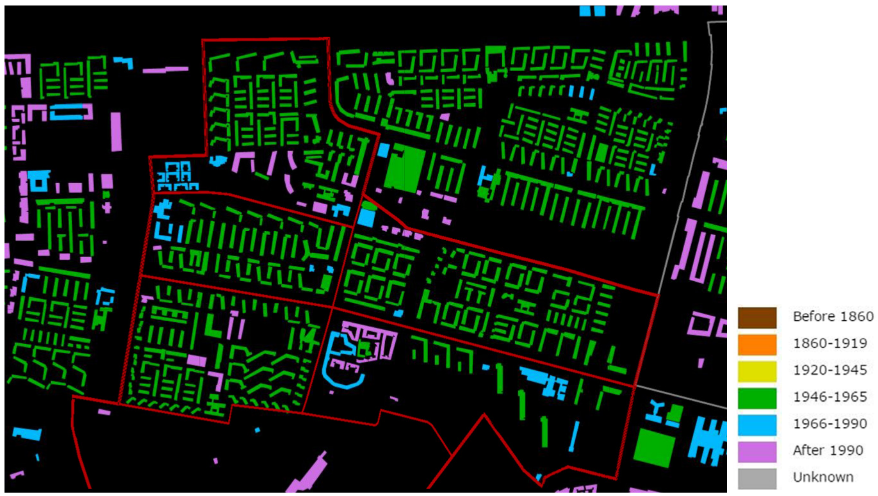
Use surface m2	Electricity kWh/m2	Gas consumption m3	Gas m3/m2
2804	33	59808	21
2804	32	55056	20
2804	44	58703	21
6498	45	146382	23

Gas CO2 emmisions kg	Gas consumption kWh	Heat demand kWh	Heat demand kWh/m2
106458	584264	525838	188
98000	537842	484058	173
104491	573470	516123	184
260560	1430006	1287005	198

STEP 1 MAP THE PRESENT

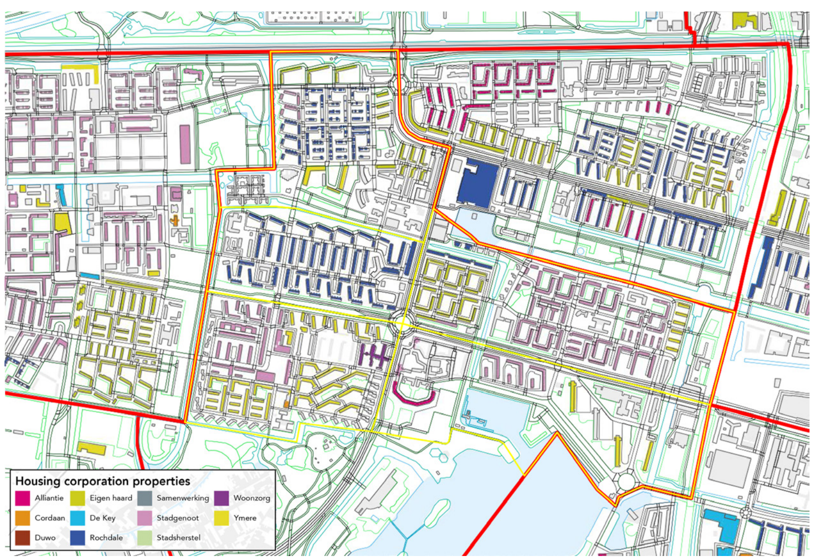
1b Buildings description & Energy demands

Year of construction

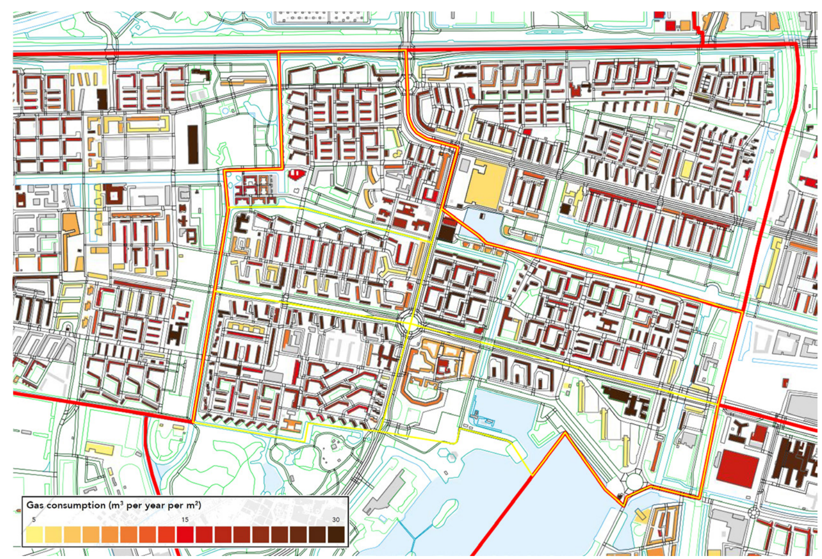


Electrictity demand kWh

Housing corporations



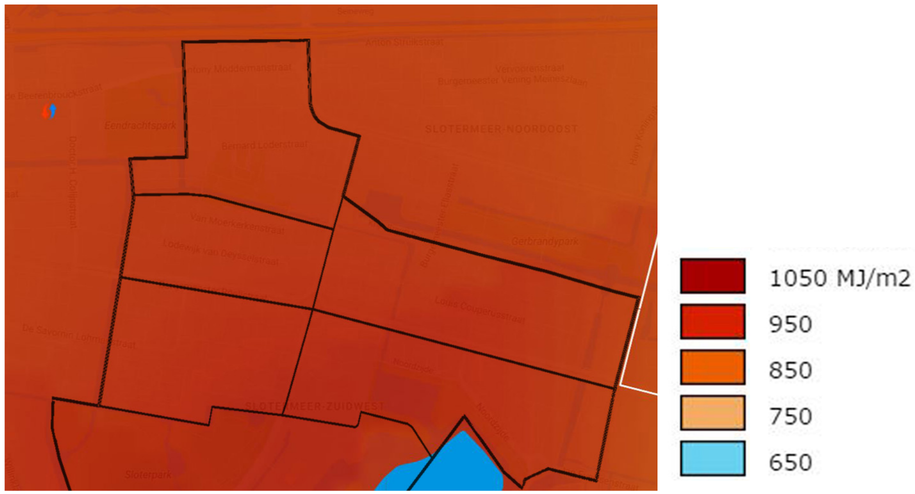
Gas demand m^3 per m^2



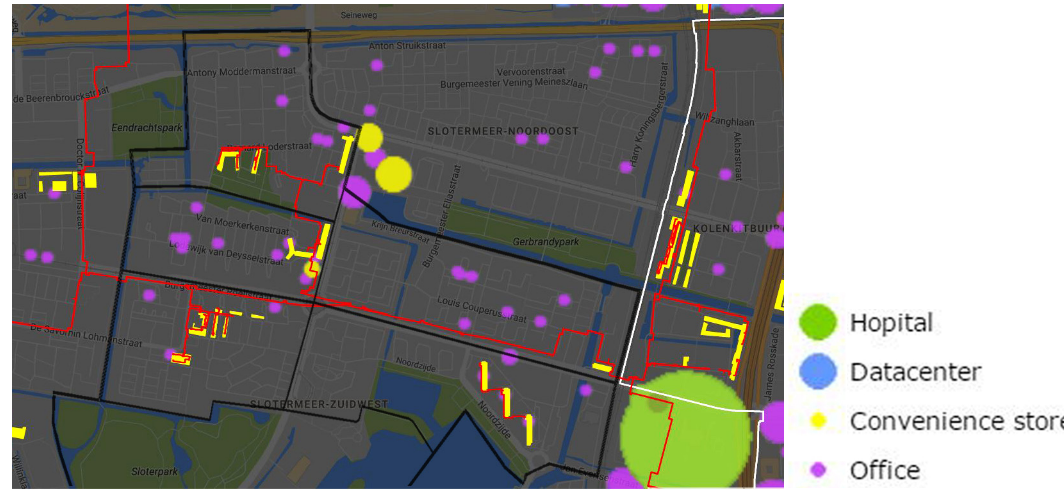
STEP 1 MAP THE PRESENT

1c Energy potentials

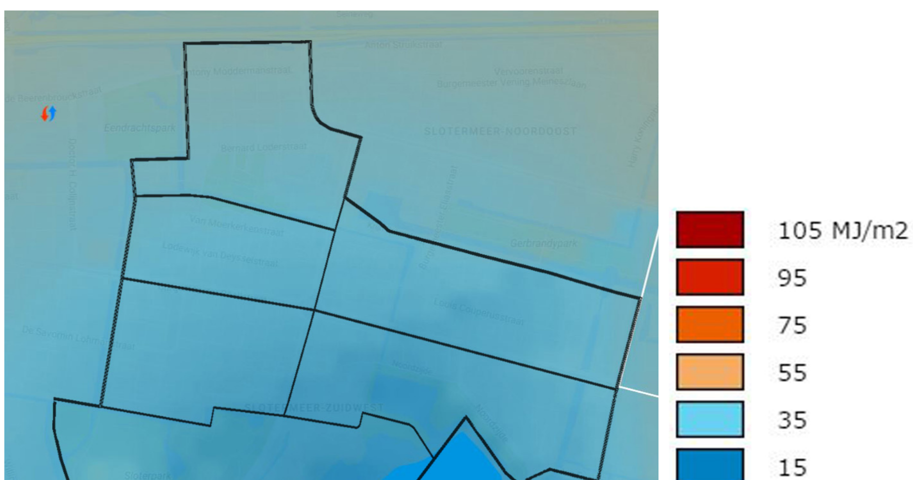
Aquifer Thermal Energy Storage System



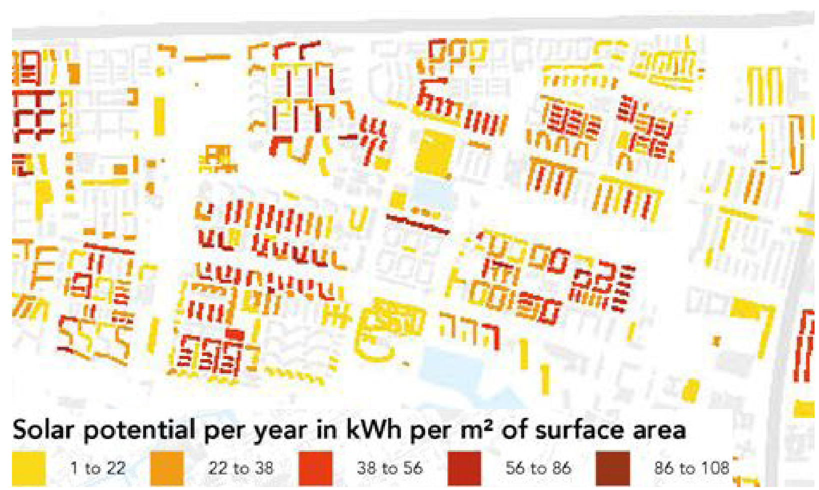
Existing D.H.N. with rest heat from buildings



Vertical heat exhange - Ground Source Heat Pump

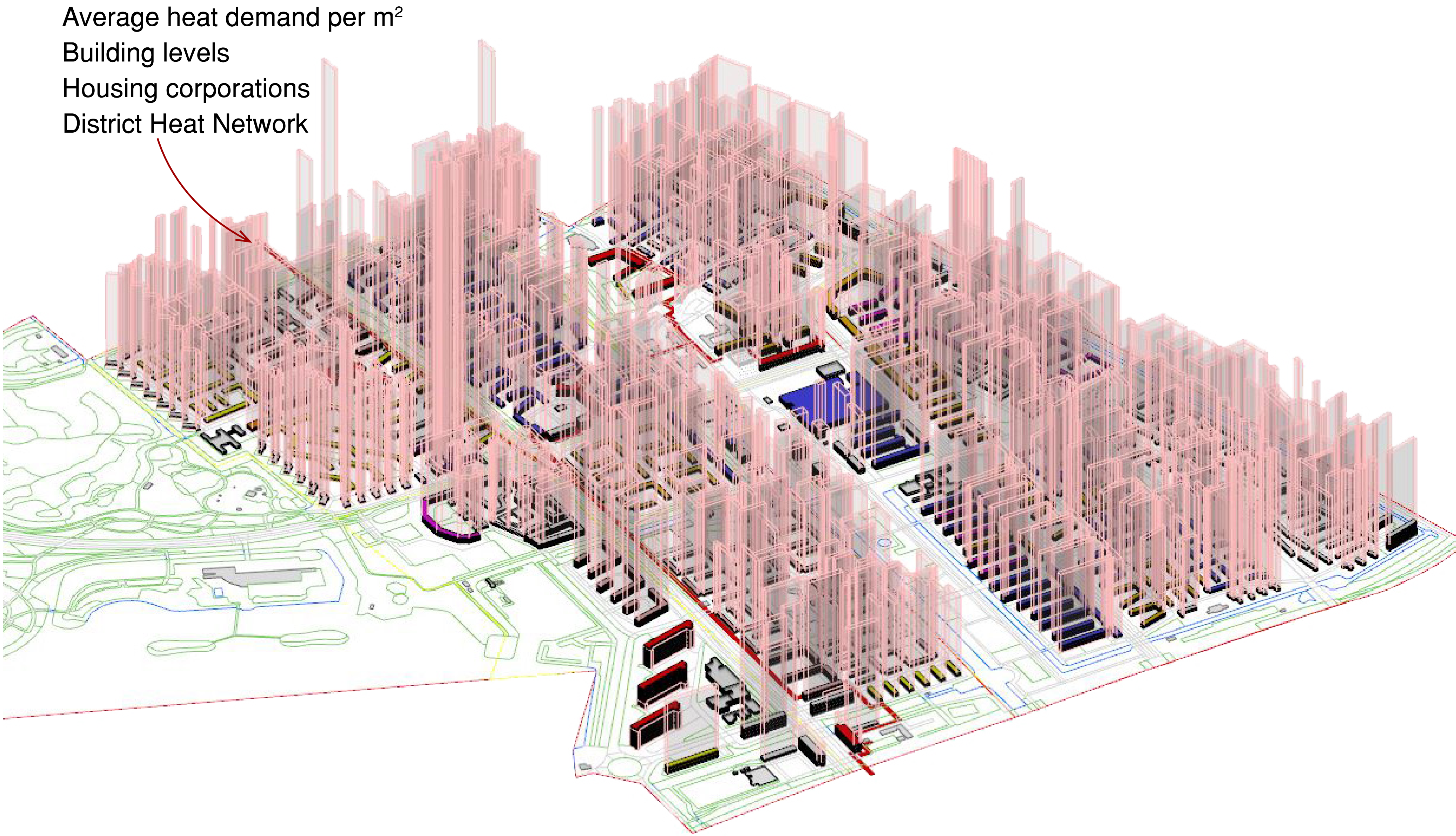


Solar pontential on roofs



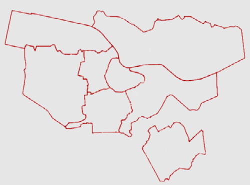
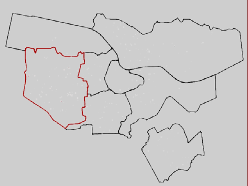
STEP 1 MAP THE PRESENT

3D heat map_Data visualisation



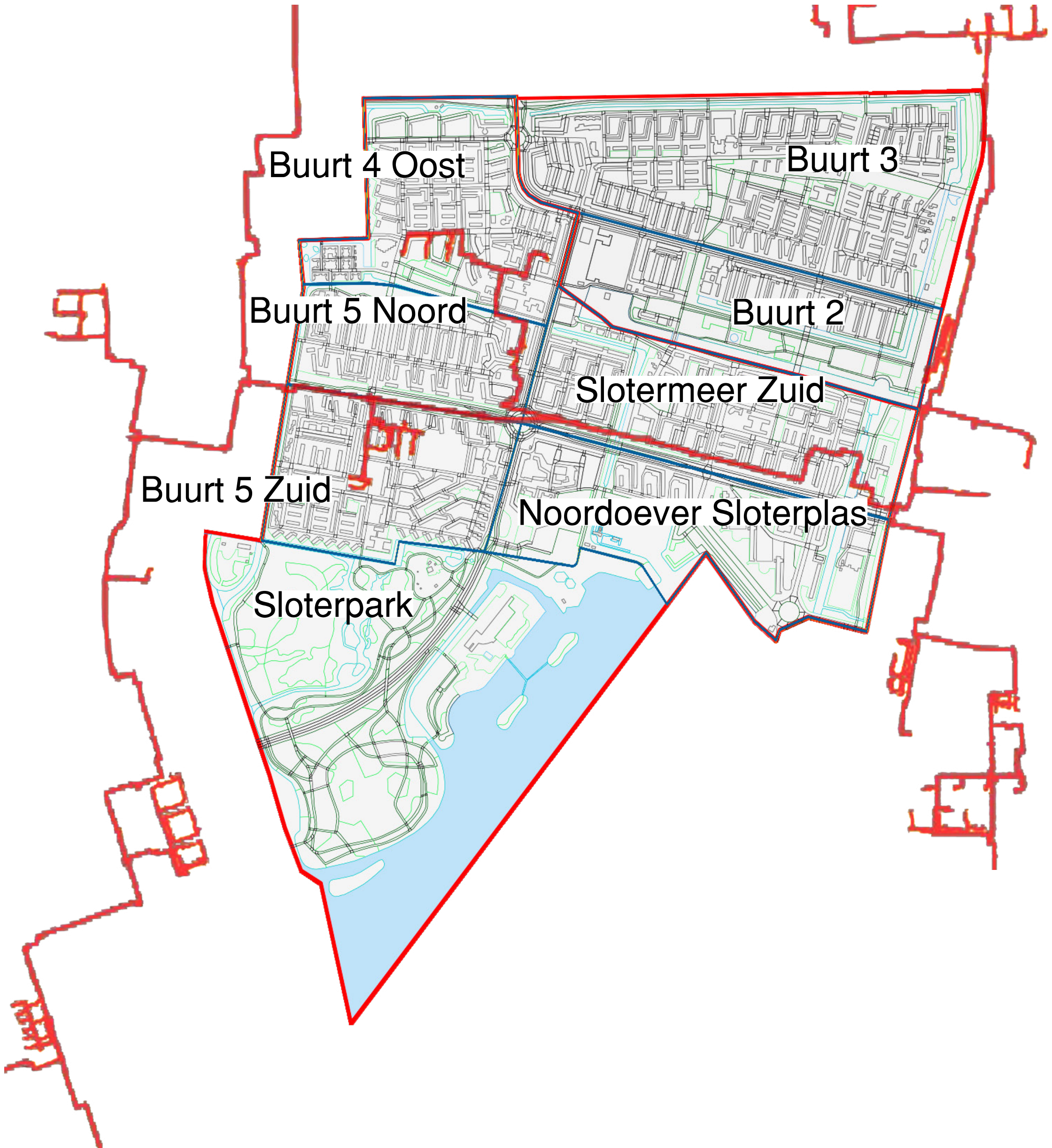
ENERGY URBAN PLANNING METHODOLOGY

Stepped methodology 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
 Amsterdam city	**Step 1a** Energy demands **Step 1b** Energy potentials	**Step 2a** Future scenario for natural gas and electricity use **Step 2b** Desired future heat demand	**Step 3a** Develop scenario for dividing the main heat systems through the districts of Amsteram **Step 3b** Main heat systems ratio in each district **Step 3b** Classify energy systems	
 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 2 DEFINE FUTURE ENERGY TARGETS

2a Desired future heat demand

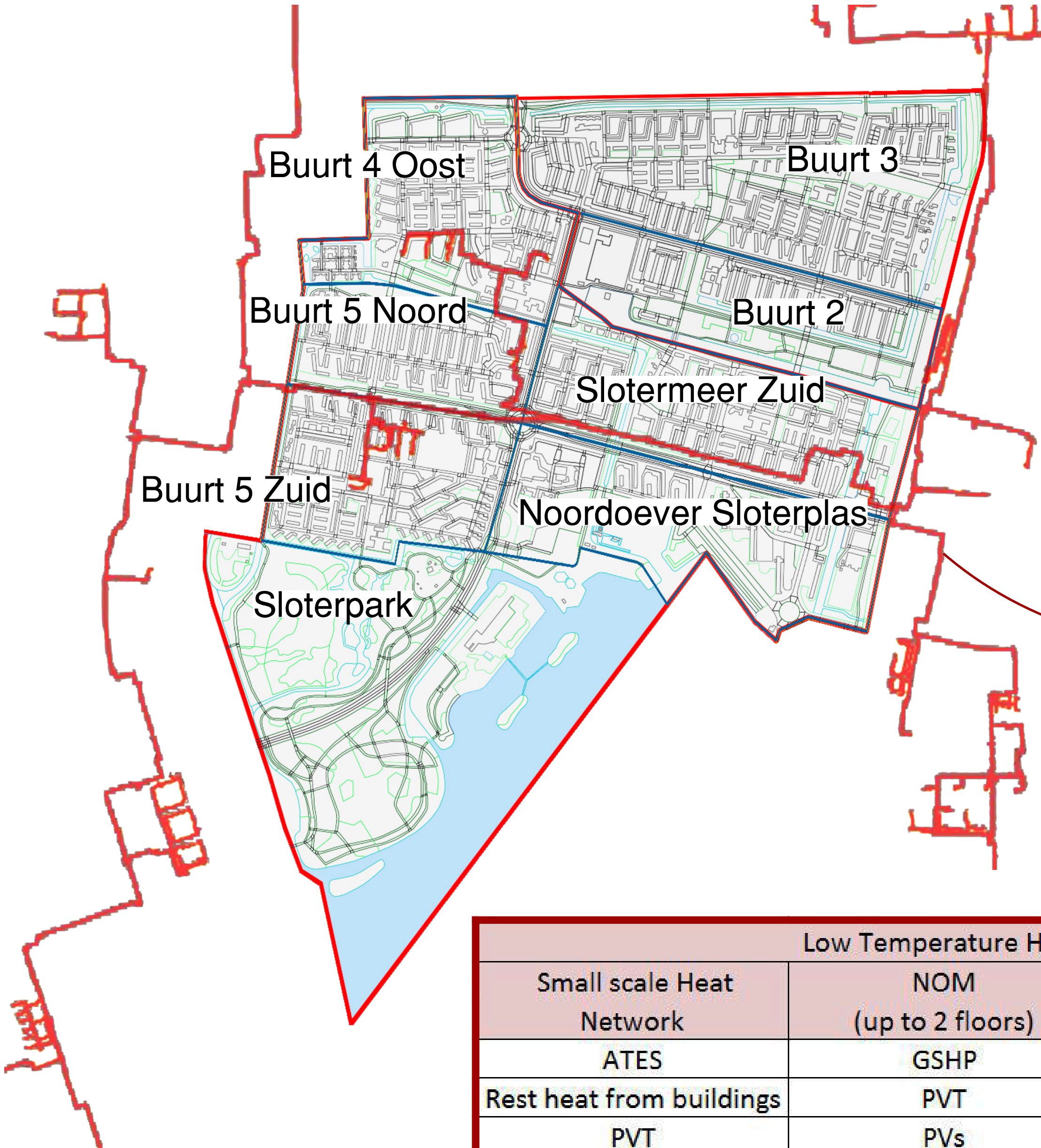


Data collected from site analysis

Nieuw-West_Sloteermer neighb.	Heat demand kWh 2017
Buurt 4 Oost	5504688
Buurt 5 Noord	15962339
Slotermeer Zuid	15962339
Buurt 5 Zuid	24676013
Noordoever Sloterplas	10734521
Buurt 3	29793499
Buurt 2	12289597
	114922996
	Heat demand PJ 2017
	0.41
	Heat demand PJ 2050
	0.10

STEP 2 DEFINE FUTURE ENERGY TARGETS

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



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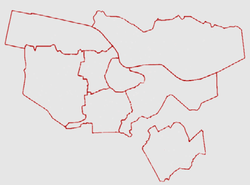
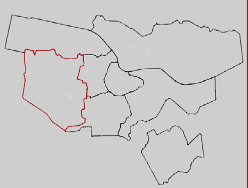
Noordoever Sloterplas	10734521
Buurt 3	29793499
Buurt 2	12289597
	114922996
	Heat demand PJ 2017
	0.41
	Heat demand PJ 2050
	0.10
L.T. Heat Potential	**0.04**
H.T. Heat Potential	**0.06**

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

Low Temperature Heat			High Temperature Heat
Small scale Heat Network	NOM (up to 2 floors)	All-electric	District Heat Network
ATES	GSHP	GSHP	Deep Geothermal
Rest heat from buildings	PVT	PVT	Rest heat from waste incineration
PVT	PVs	PVs	Solar Collectors are possible

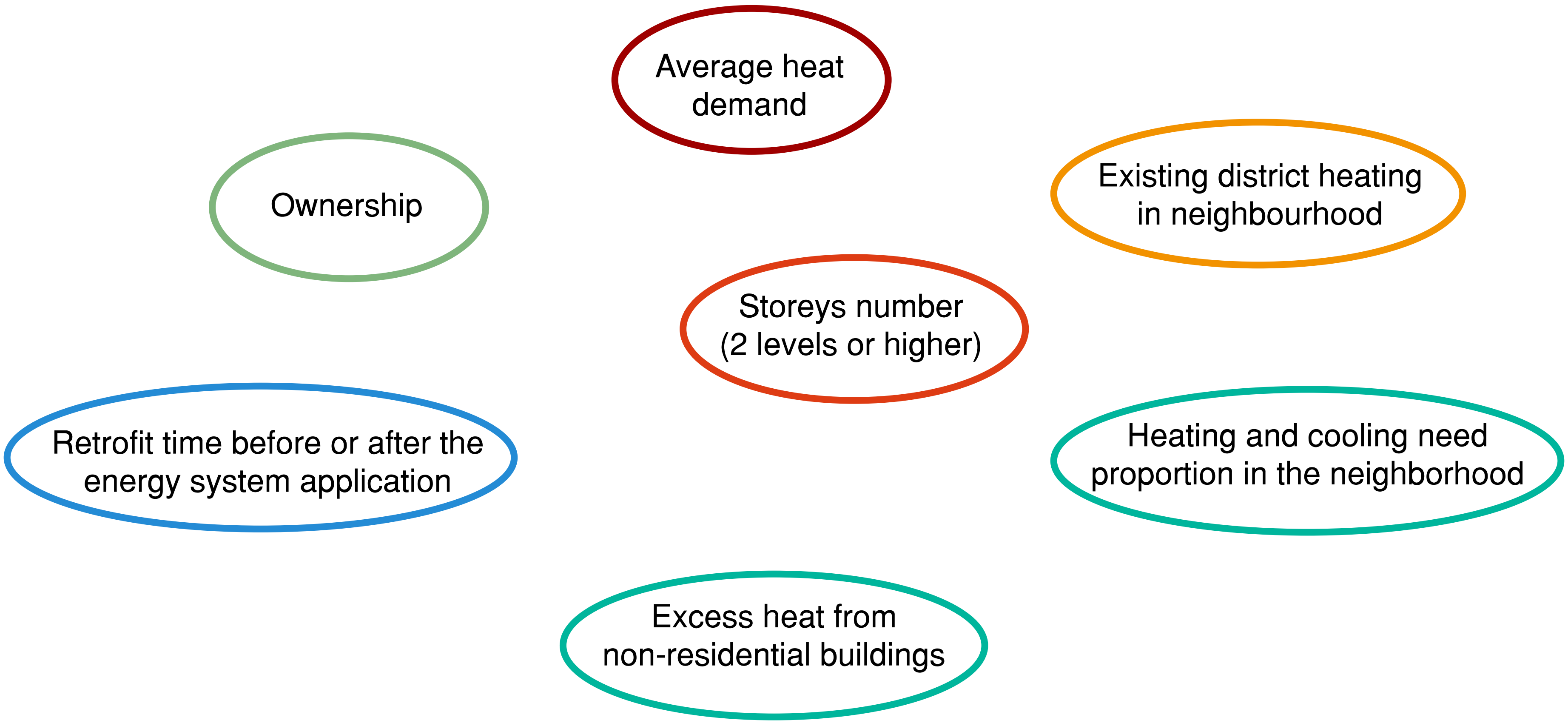
ENERGY URBAN PLANNING METHODOLOGY

Stepped methodology 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
 Amsterdam city	**Step 1a** Energy demands **Step 1b** Energy potentials	**Step 2a** Future scenario for natural gas and electricity use **Step 2b** Desired future heat demand	**Step 3a** Develop scenario for dividing the main heat systems through the districts of Amsteram **Step 3b** Main heat systems ratio in each district **Step 3b** Classify energy systems	
 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 inter-ventions on appropriate time	

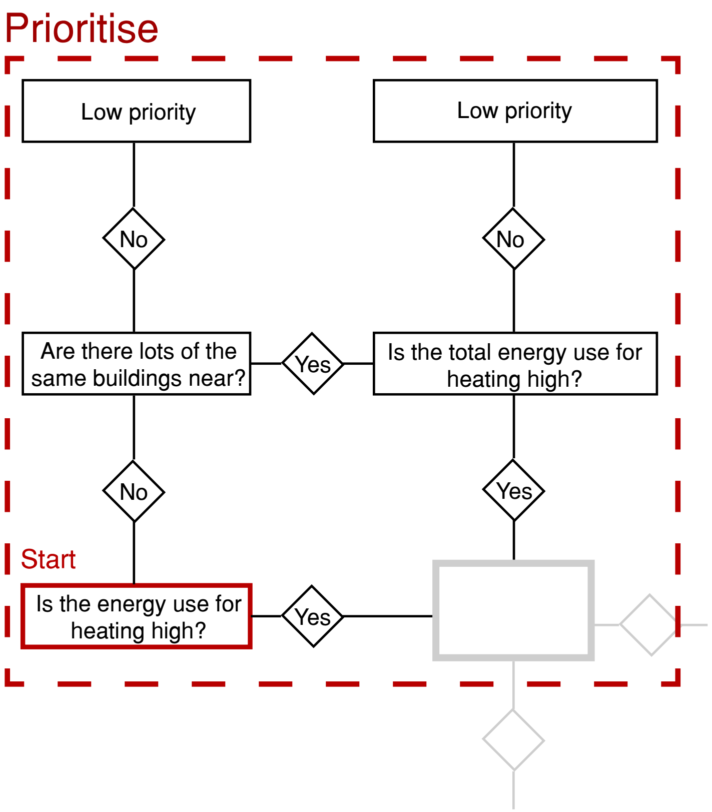
STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

3a Set variables for selecting the suitable energy system



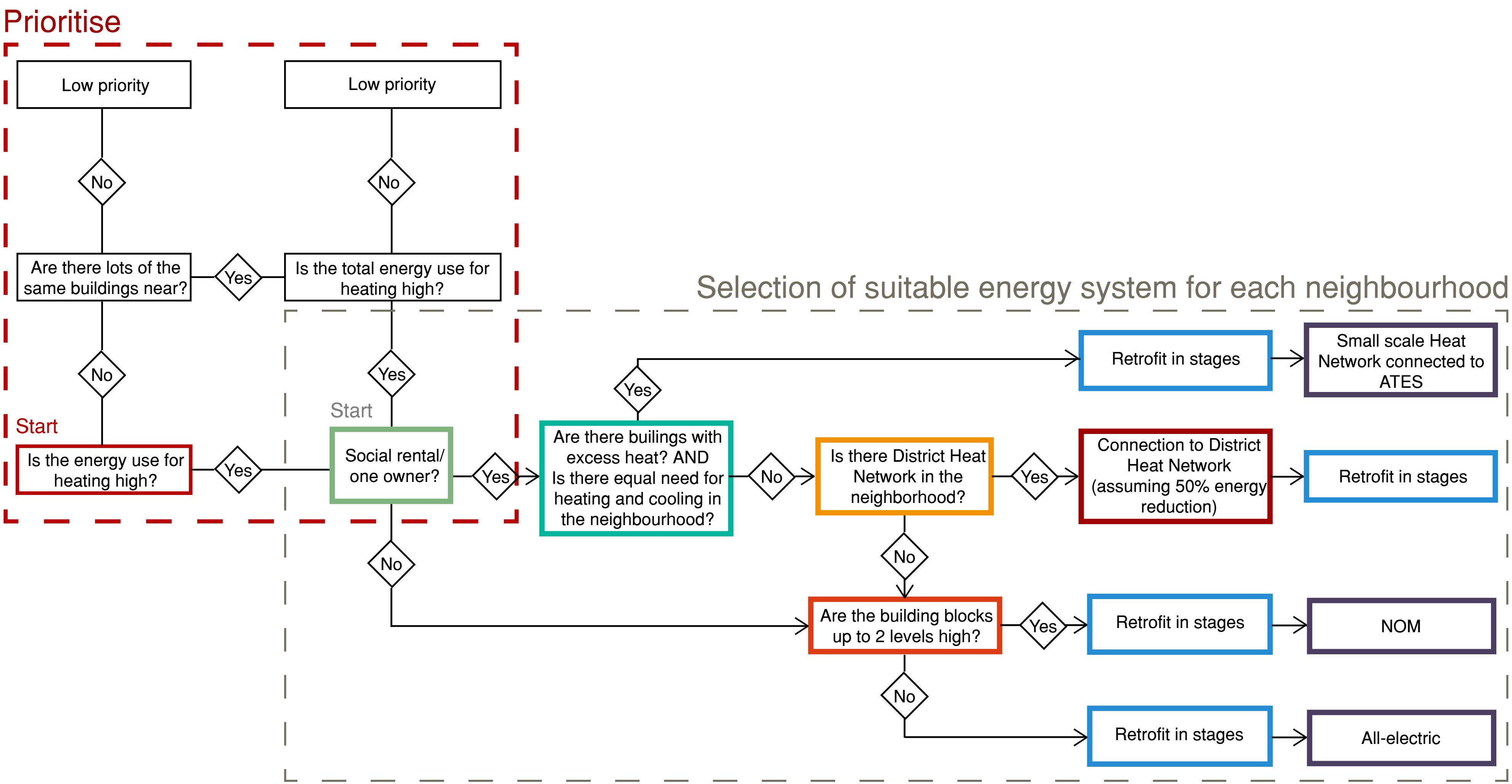
STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

3b Set priotiry criteria for on-site interventions



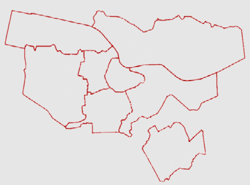
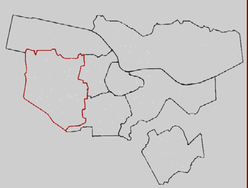
STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

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



ENERGY URBAN PLANNING METHODOLOGY

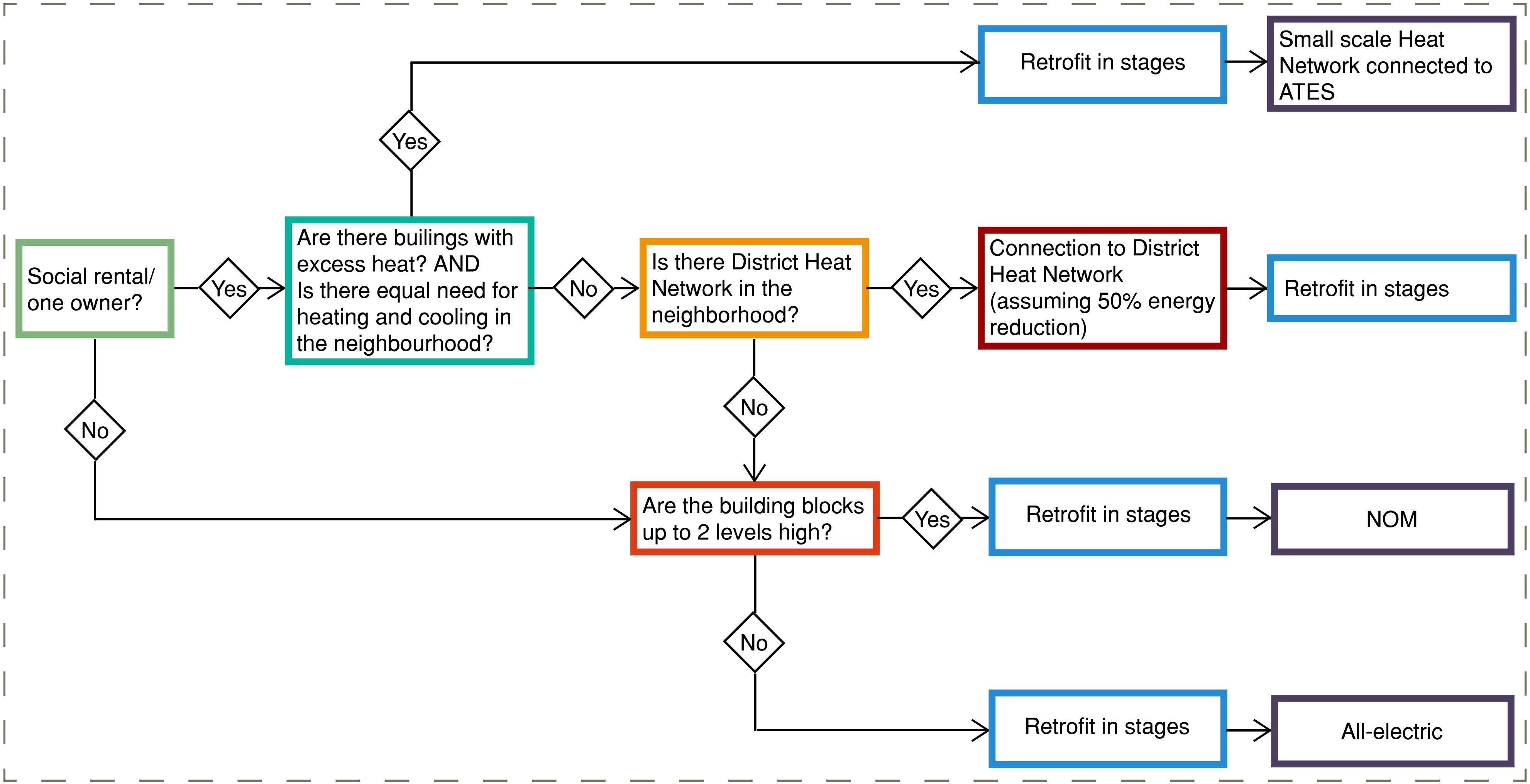
Stepped methodology leading to energy transition of residential areas

	Step 1 Map the present	Step 2 Define future energy targets	Step 3 Strategy for selecting energy systems	Step 4 Roadmap design
 Amsterdam city	Step 1a Energy demands Step 1b Energy potentials	Step 2a Future scenario for natural gas and electricity use Step 2b Desired future heat demand	Step 3a Develop scenario for dividing the main heat systems through the districts of Amsteram Step 3b Main heat systems ratio in each district Step 3b Classify energy systems	
 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 inter-ventions 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

STEP 3 STRATEGY FOR SELECTING ENERGY SYSTEMS

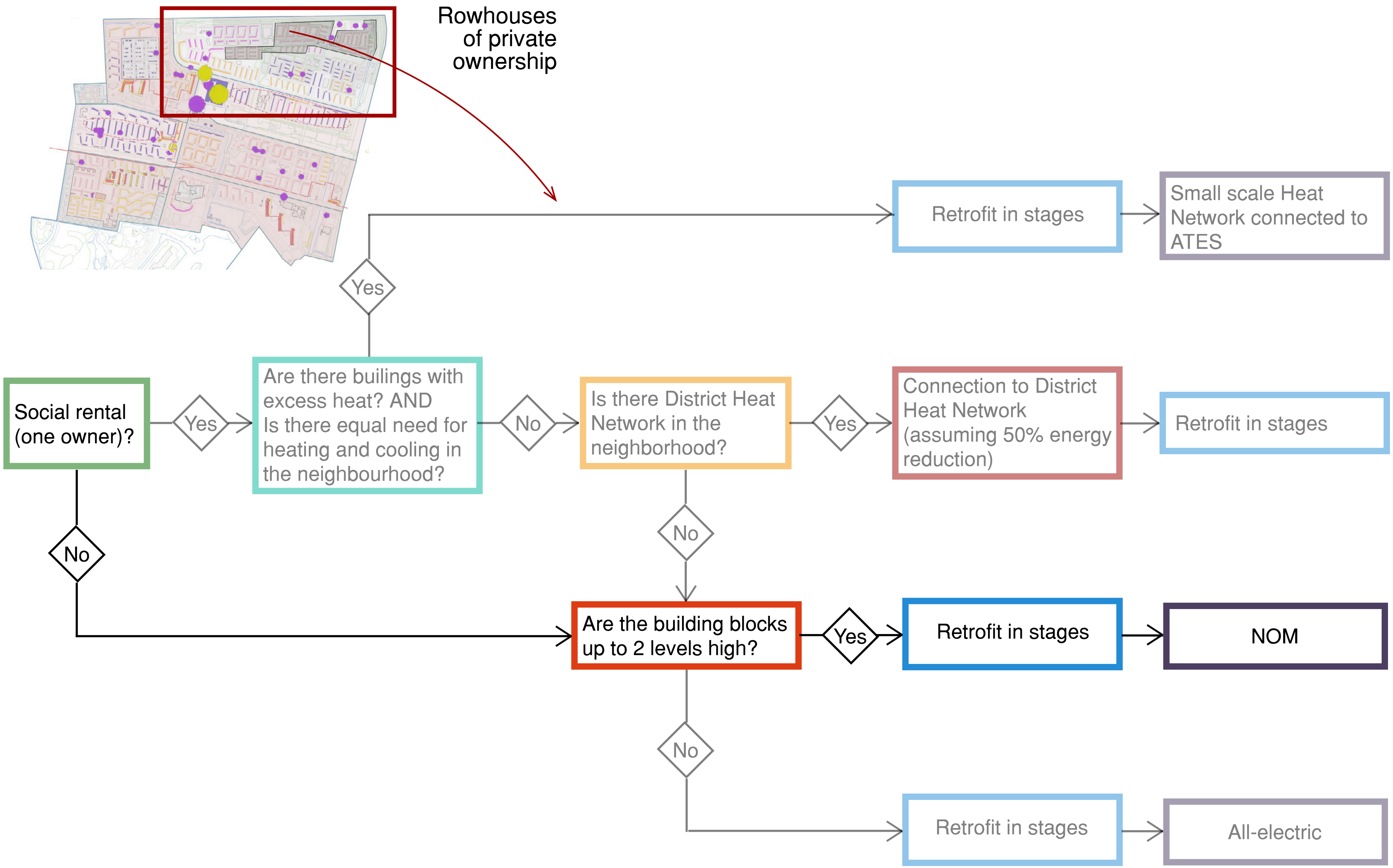
4a Define suitable energy systems in 2050 for each neighbourhood

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



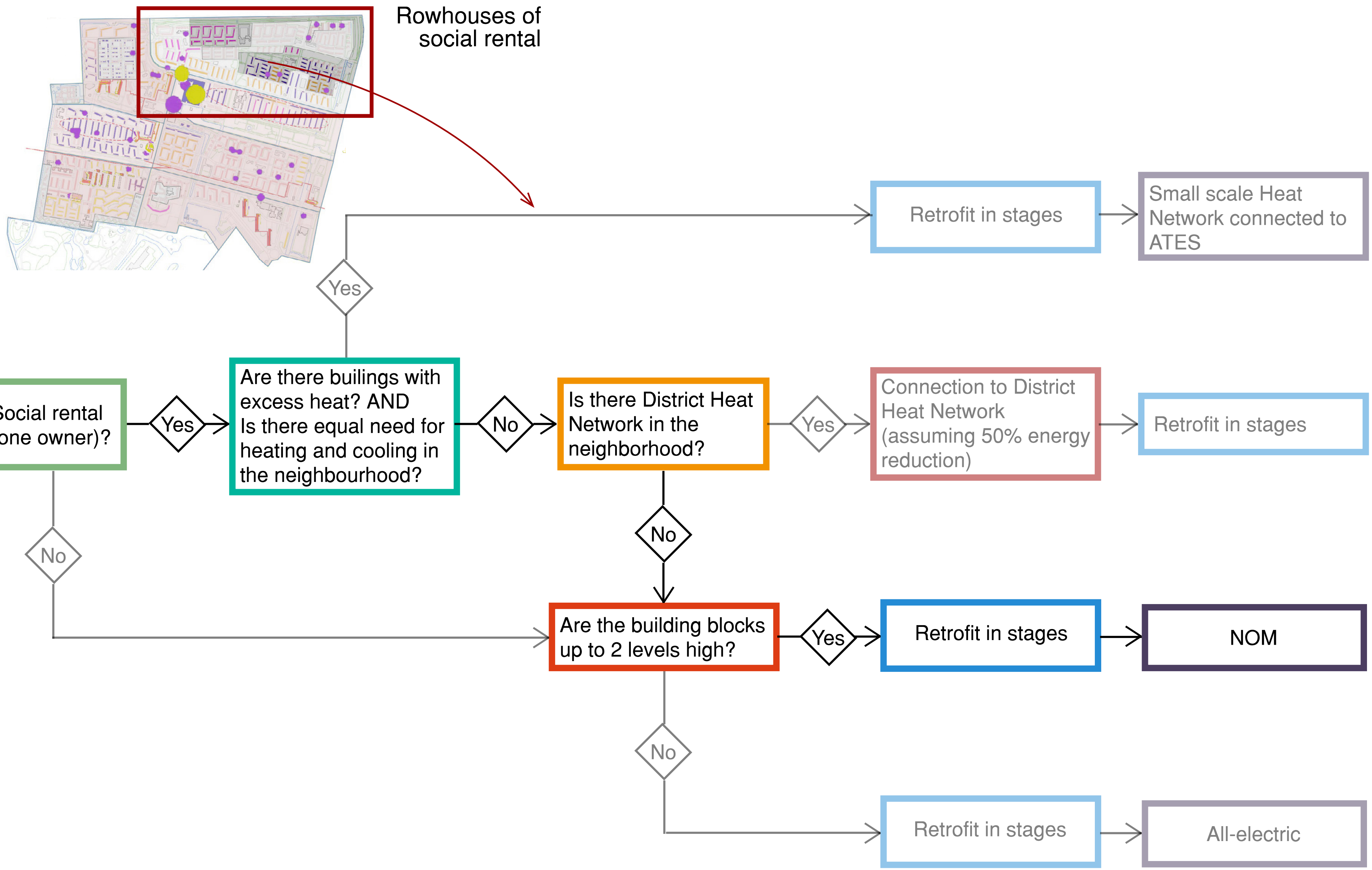
STEP 4 ROADMAP DESIGN

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



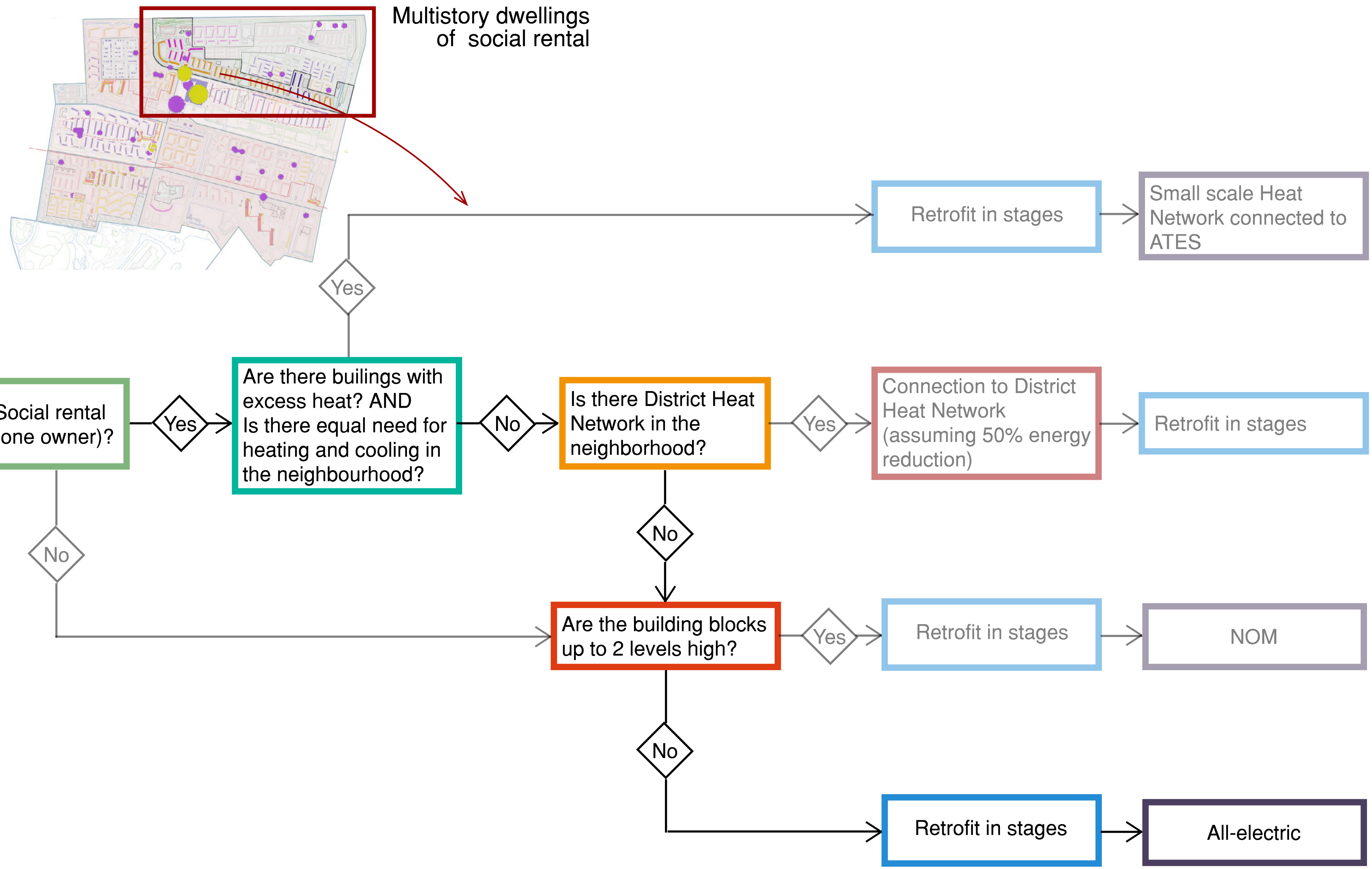
STEP 4 ROADMAP DESIGN

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



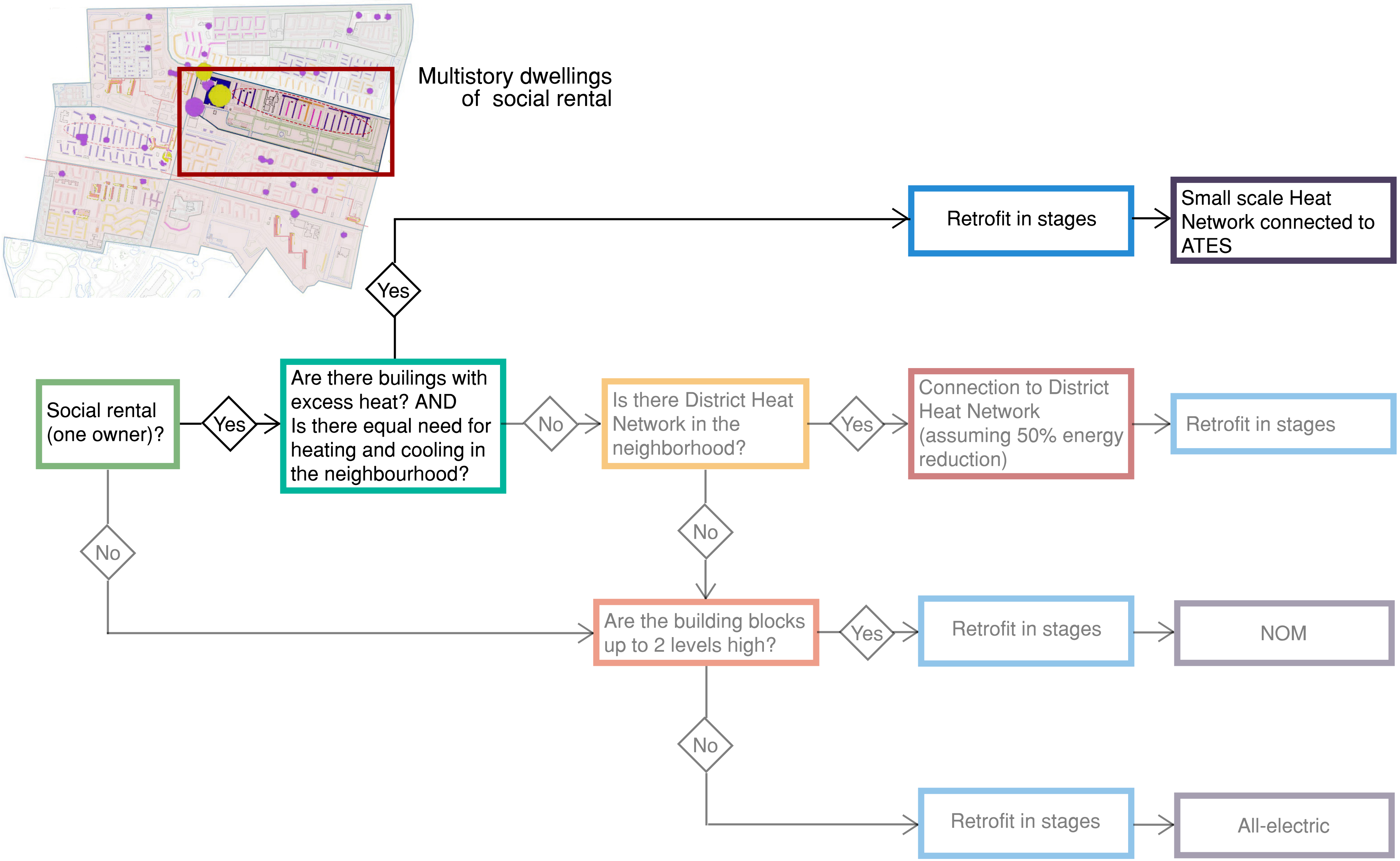
STEP 4 ROADMAP DESIGN

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



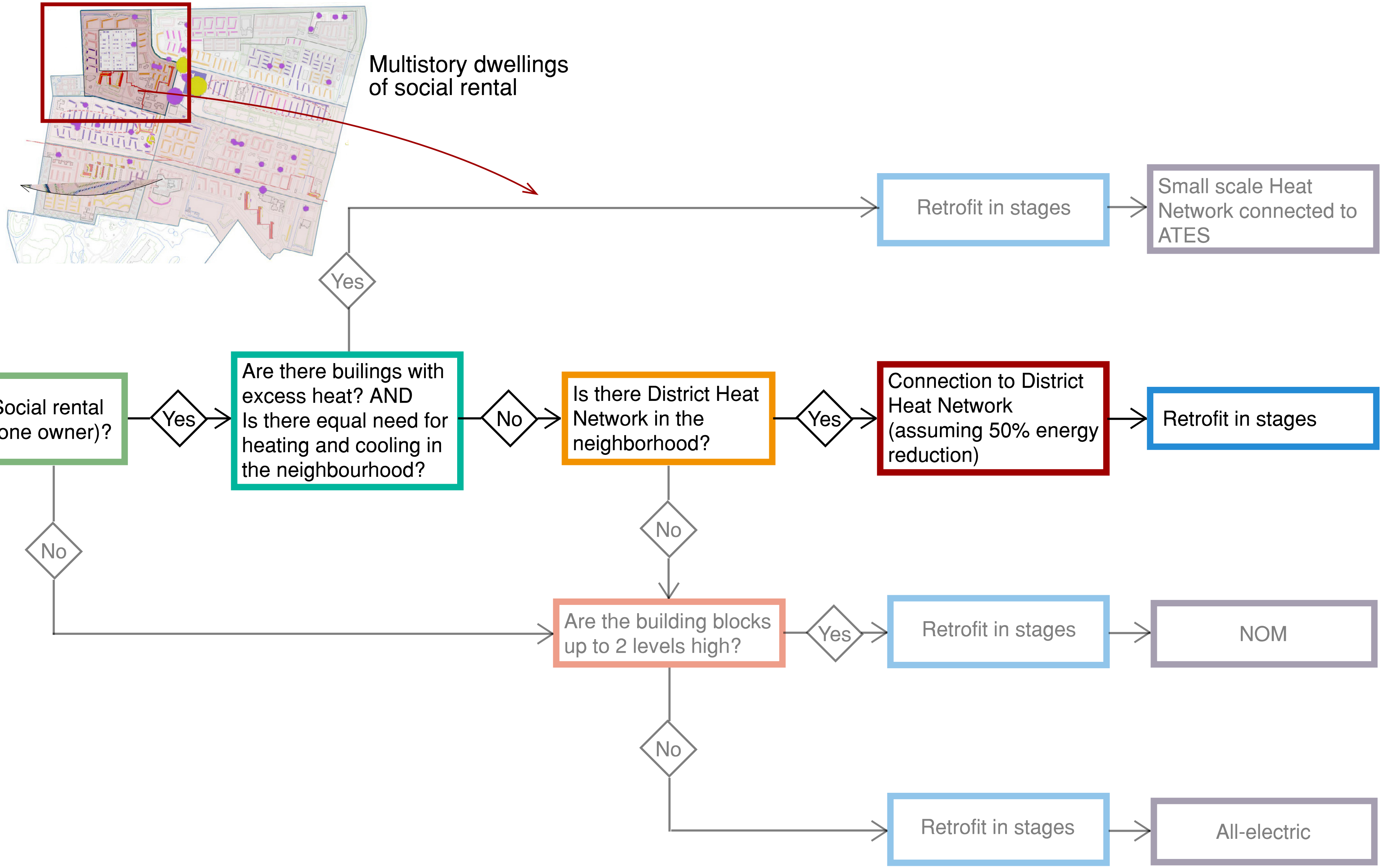
STEP 4 ROADMAP DESIGN

4a Define suitable energy systems in 2050 for each neighbourhood_Buurt 2



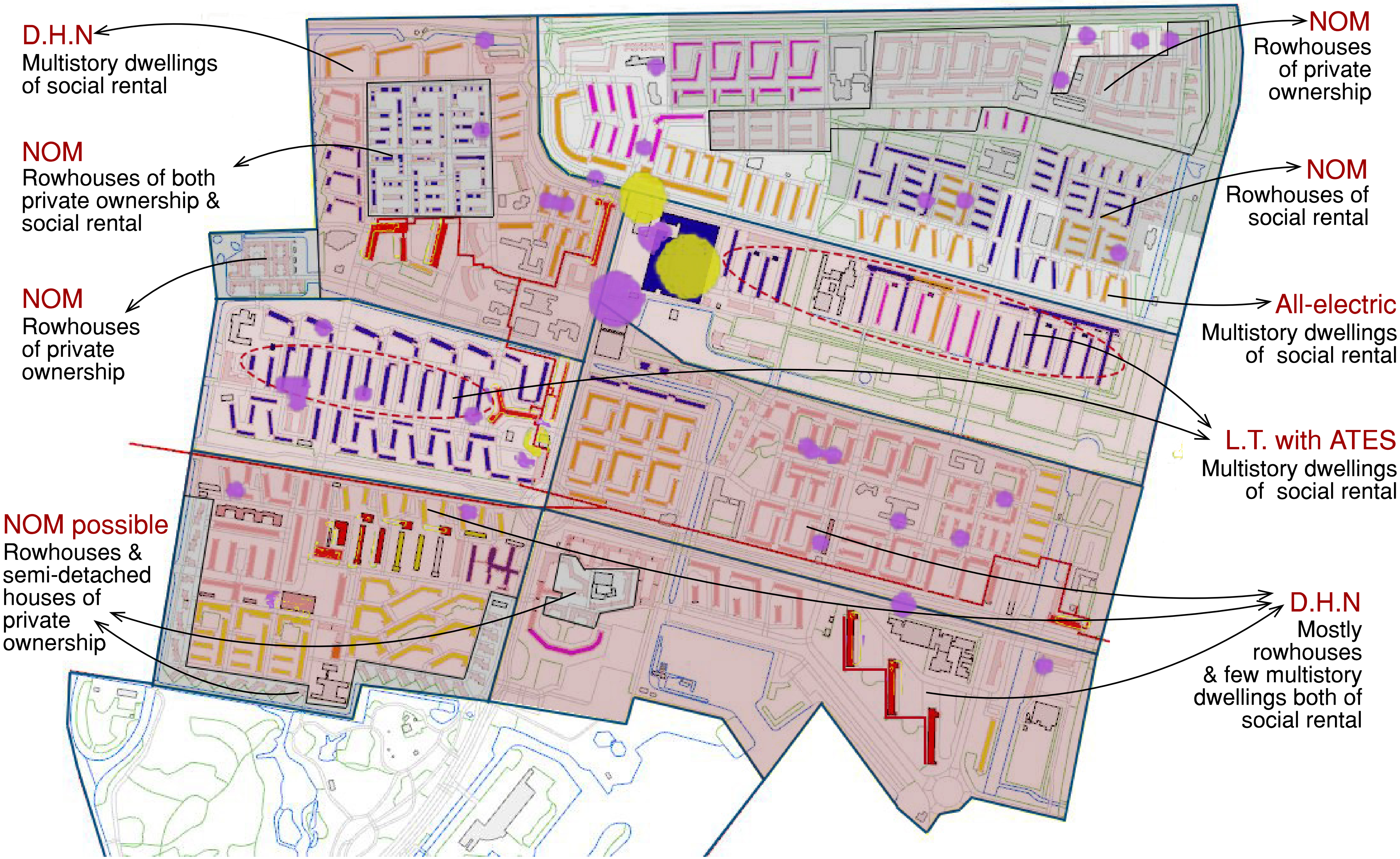
STEP 4 ROADMAP DESIGN

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



STEP 4 ROADMAP DESIGN

4a Define suitable energy systems in 2050 for each neighbourhood

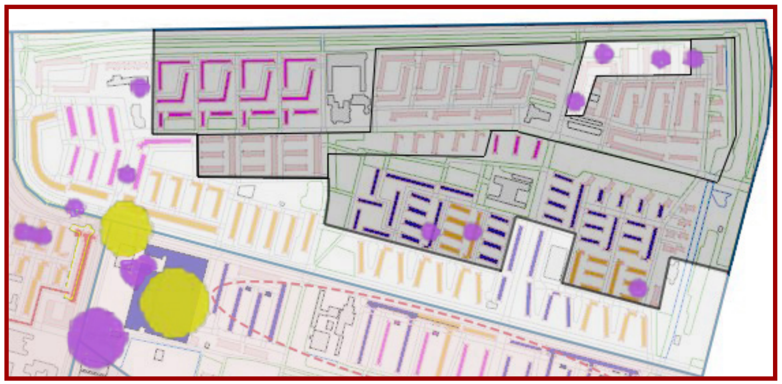


STEP 4 ROADMAP DESIGN

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

This template includes only the heat demand and the electricity need for heat pumps

Zero On the Meter (NOM)

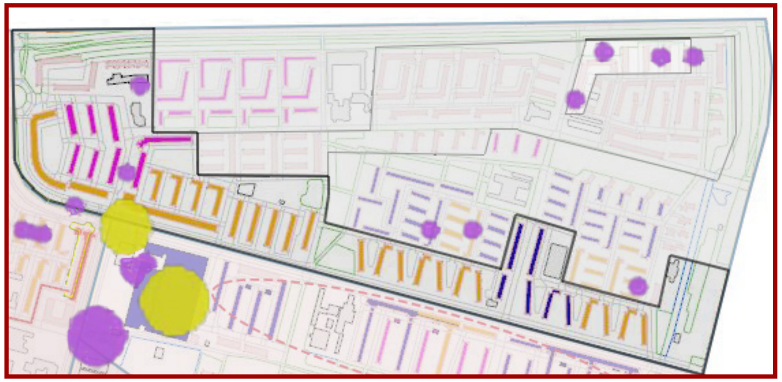


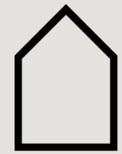
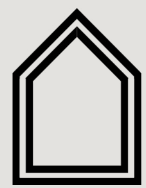
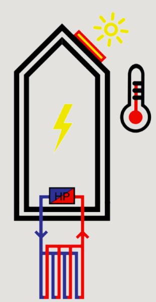
PRINCIPLES	STEPS AND FEATURES	RESULTS
0. EXISTING SITUATION	Features: • 124 multifamily and rowhouses, some for social rental and some of private ownership • poor energy performance	Heat demand H 14363 MWh/y CO_2 2908 tCO_2eq/y
1. DEMAND REDUCTION	Insulation: • roof, walls, roofs • high performance windows Installation efficiency: • Smart appliances • change heating system • efficient mechinical ventilation with heat recovery • shower heat exchangers	Remaining heat demand H 3591 MWh/y CO_2 727 tCO_2eq/y
2. HEAT PRODUCTION	• Transition to NOM energy system • Individual GSHP with horizontal heat exchanger • Heat pump is used with GSHP system_the electriciry used is produced by renewable sources	Remaining heat demand & Electricity demand for heat pump with COP = 6 H 0 MWh/y CO_2 0 tCO_2eq/y E 599 MWh/y
3. ELECTRICITY PRODUCTION	PV on roofs: • 9 m2 per roof	Remaining heat & Electricity demand H 0 MWh/y E -60 MWh/y

STEP 4 ROADMAP DESIGN

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

All-electric

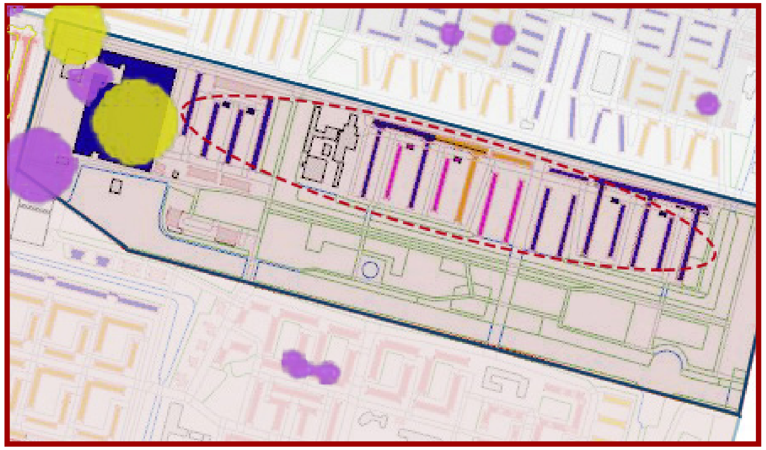


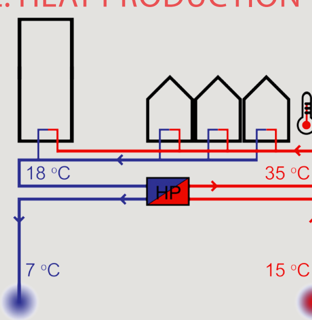
PRINCIPLES	STEPS AND FEATURES	RESULTS
0. EXISTING SITUATION 	Features: • 45 multistory dwellings of social rental • poor energy performance	Heat demand H 15430 MWh/y CO2 3124 tCO2eq/y
1. DEMAND REDUCTION 	Insulation: • roof, walls, roofs • high performance windows Installation efficiency: • Smart appliances • change heating system • efficient mechinical 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 electriciry 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

Small scale heating network connected to ATES system

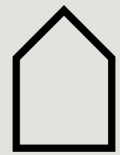
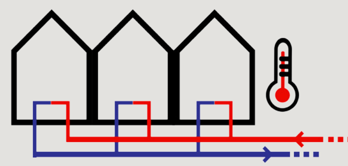
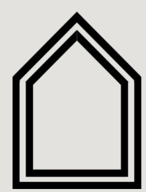


PRINCIPLES	STEPS AND FEATURES	RESULTS
0. EXISTING SITUATION	Features: • 22 multistory building blocks of social rental • poor energy performance	Heat demand H 12289 MWh/y CO2 2488 tCO2eq/y
1. DEMAND REDUCTION	Insulation: • roof, walls, roofs • high performance windows Installation efficiency: • Smart appliances • change heating system • efficient mechinical 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 electriciry 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

STEP 4 ROADMAP DESIGN

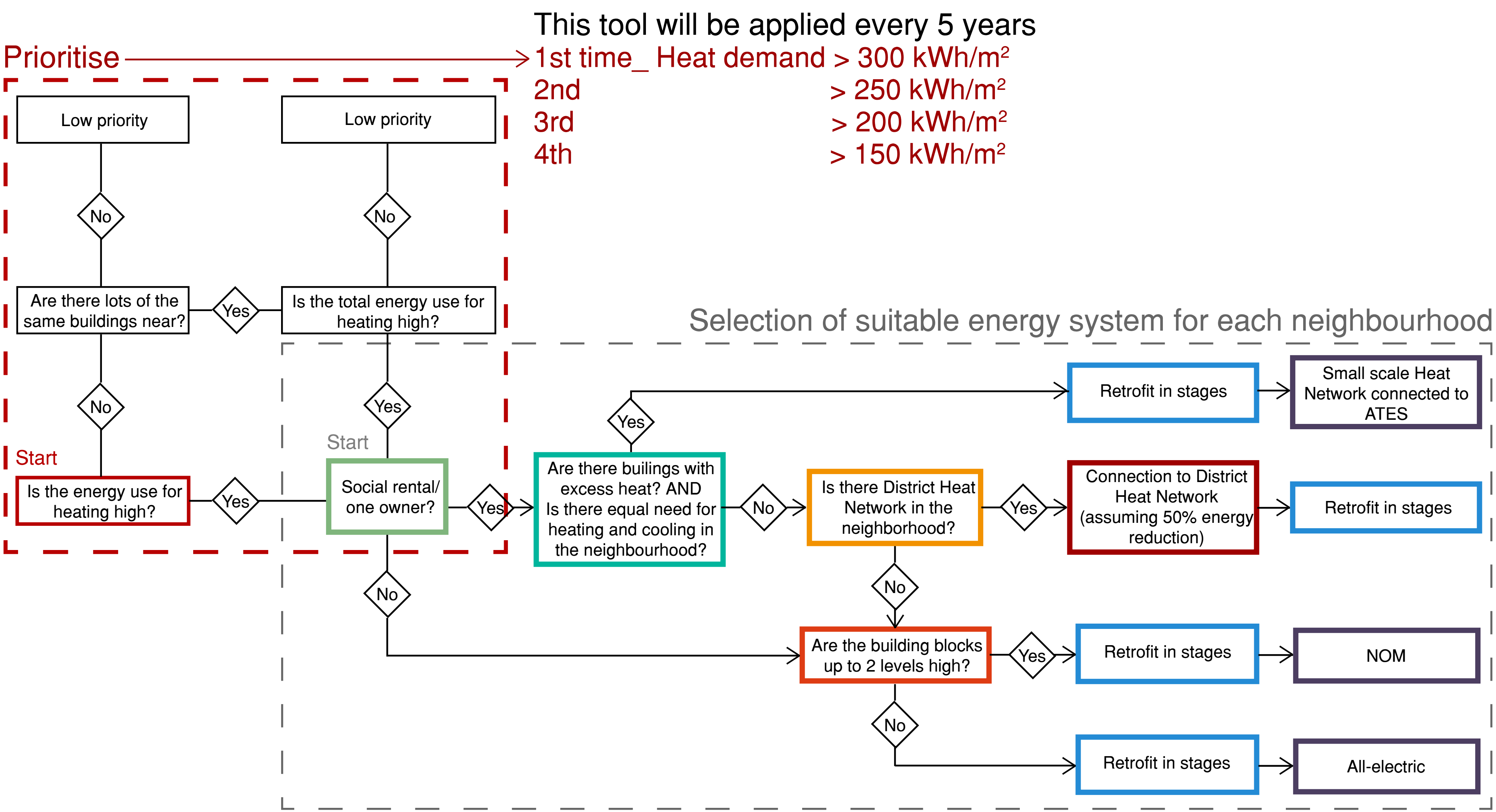
4b Describe energy systems and retrofit measures leading to 2050 vision_Buurt 4 Oost

District Heat Network (D.H.N.)

PRINCIPLES	STEPS AND FEATURES	RESULTS
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 win-dows Installation efficiency: • Smart appliances • change heating system • efficient mechinical venti-lation 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



STEP 4 ROADMAP DESIGN

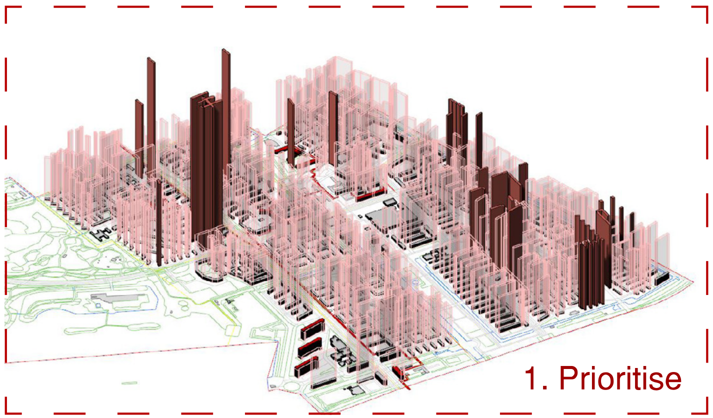
4c Define the interventions on timeline

Retrofit in stages		Representation in 3D map
Minor -> 30% energy savings	1-3 energy retrofit measures	Minor -> 15% energy savings
Moderate -> 30%-60%	3-5 energy retrofit measures	Moderate -> 45%
Deep -> 60%-90%	Holistic retrofit approach - Package of measures	Deep -> 75%
nZEB -> 90% +	Addition of renewable energy technologies	The represented heat demand stops at the point where it shows the consumption that needs to be fulfilled by renewable energy technologies

Source: Europe's buildings under the microscope . A country-by-country review of the energy performance of buildings. Buildings Performance Institute Europe (BPIE)

STEP 4 ROADMAP DESIGN

4c Define the interventions on timeline



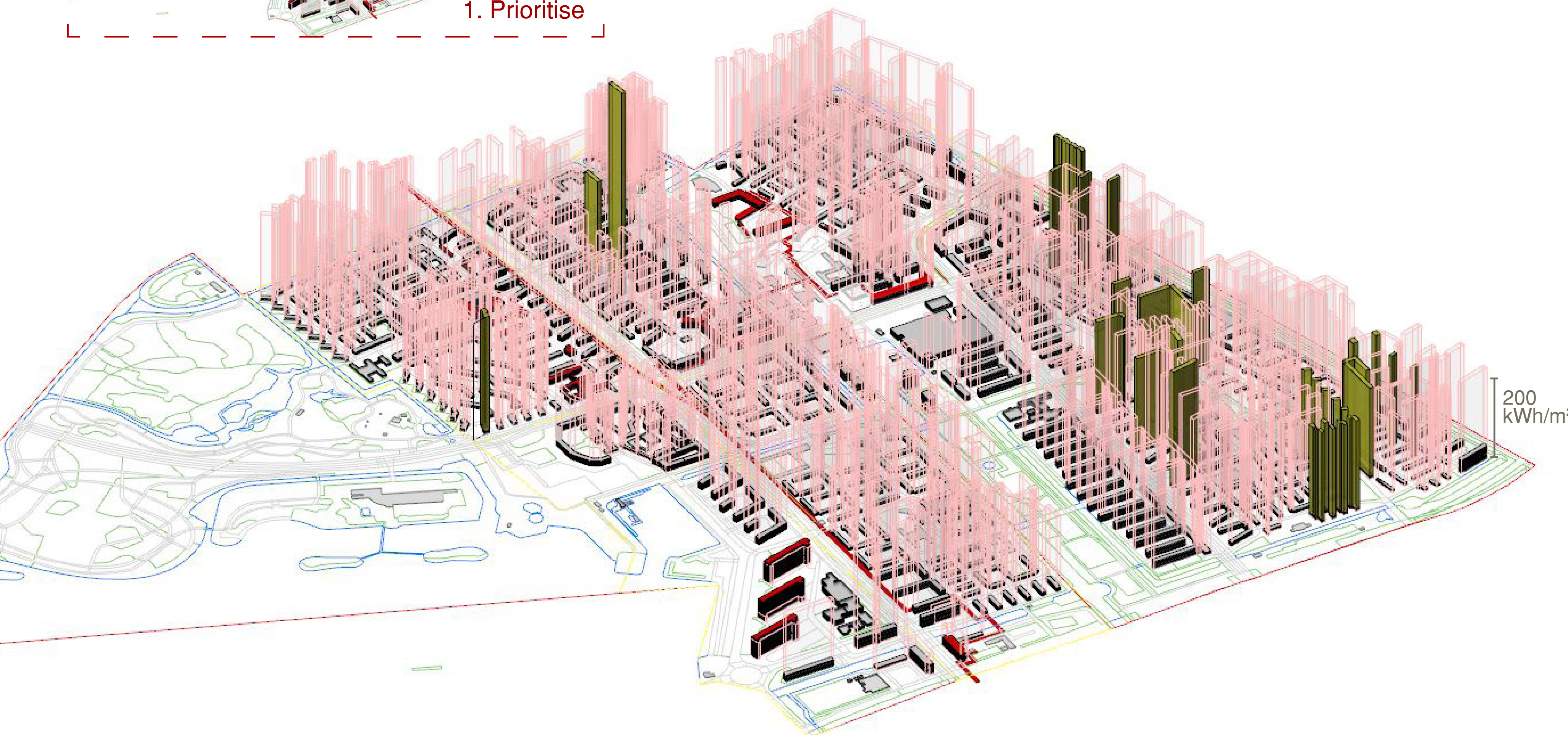
Heat demand > 300 kWh/m^2

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



STEP 4 ROADMAP DESIGN

4c Define the interventions on timeline

1. Prioritise

Heat demand > 250 kWh/m²

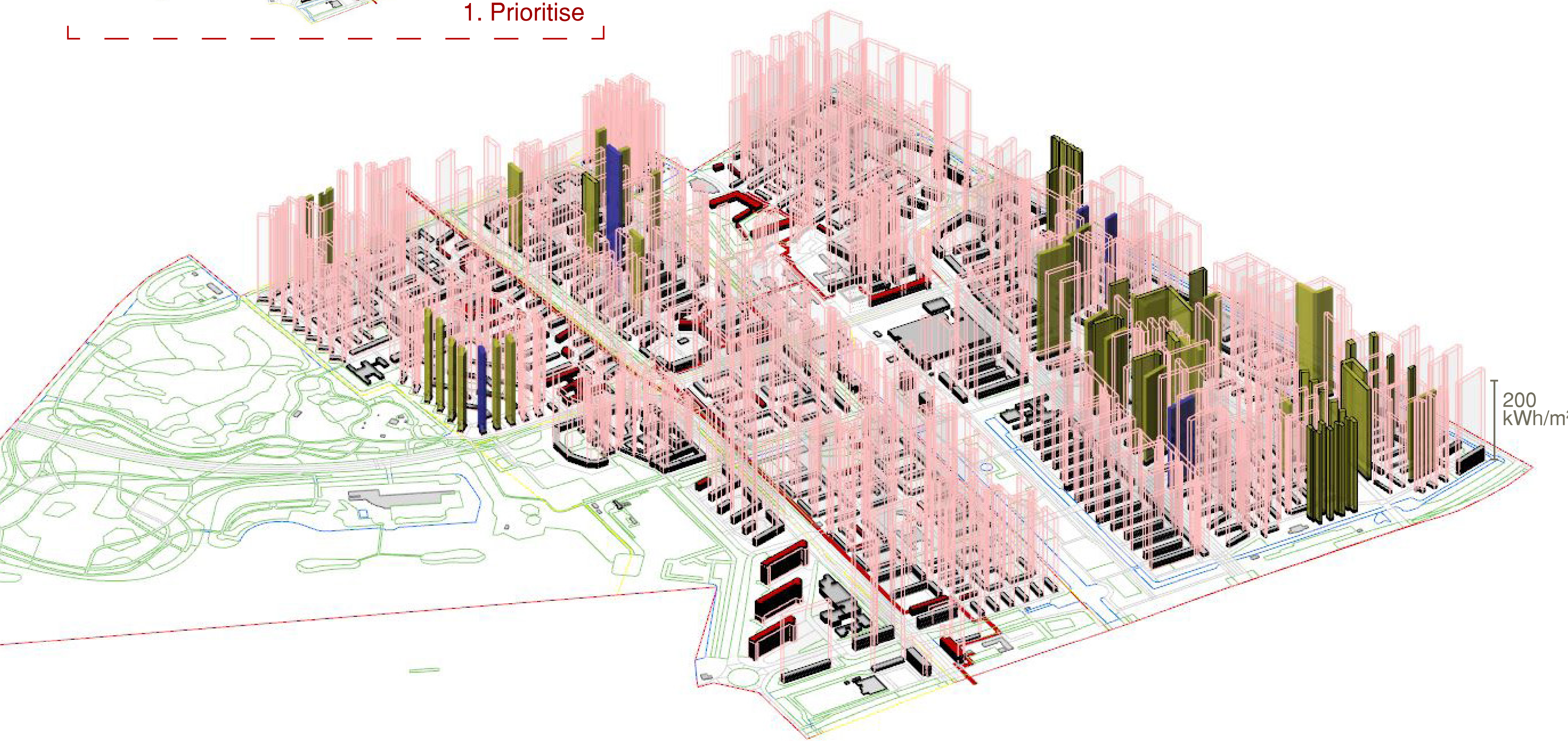
2017 — 2020 — 2025 — 2030 — 2035 — 2040 — 2045 → 2050

2.Decide which buildings need:

a. Connection to District Heat Network

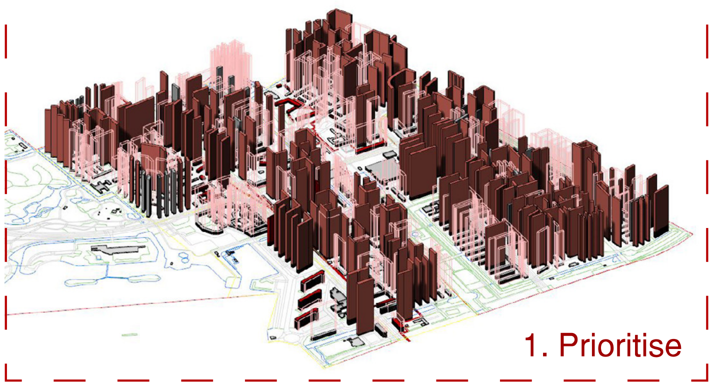
b. Minor Retrofit -> 15% energy reduction

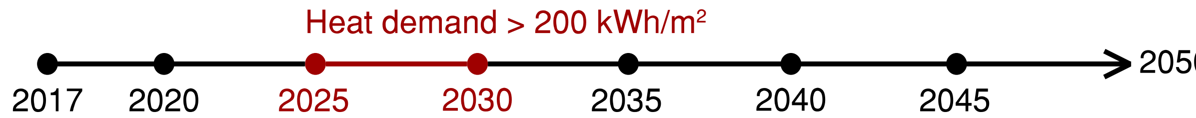
c. Moderate Retrofit -> 45% energy reduction in total



STEP 4 ROADMAP DESIGN

4c Define the interventions on timeline



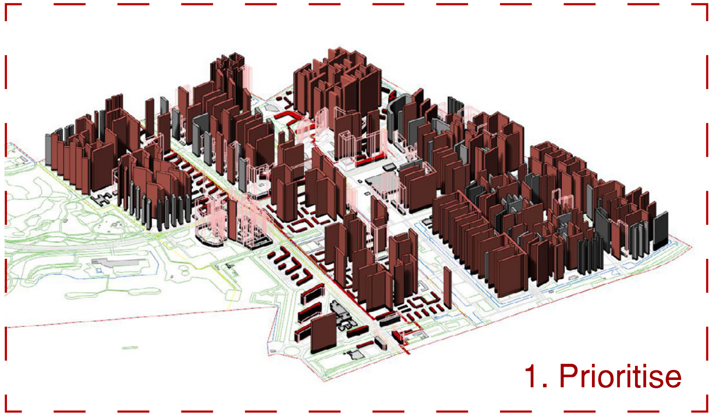


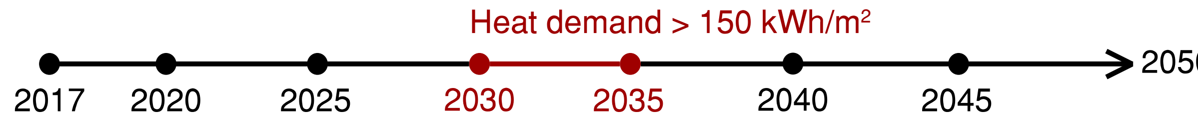
2.Decide which buildings need:

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

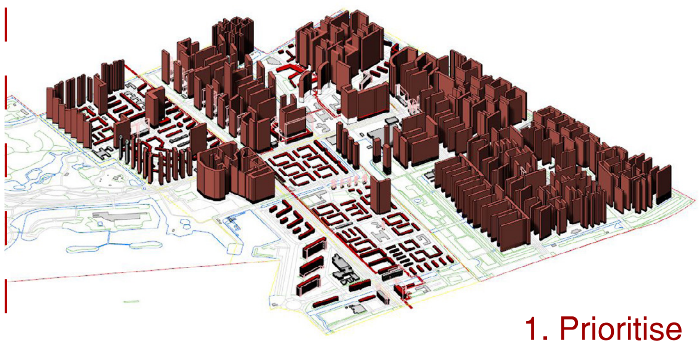
4c Define the interventions on timeline





STEP 4 ROADMAP DESIGN

4c Define the interventions on timeline



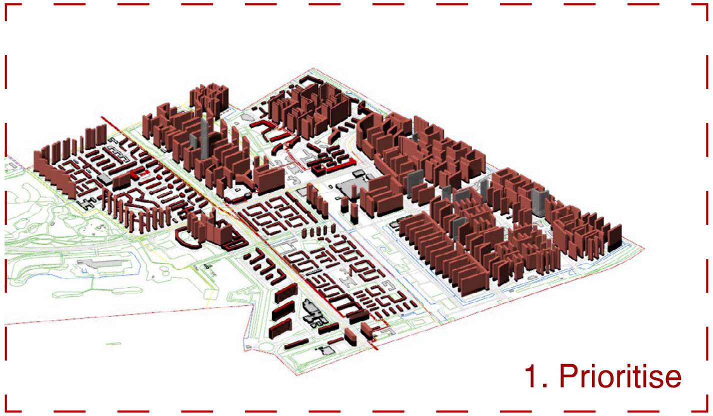
1. Prioritise

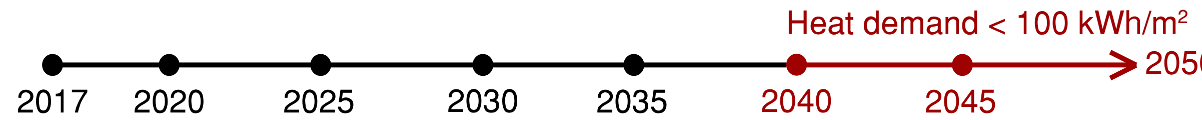
Heat demand > 100 kWh/m²

2017 — 2020 — 2025 — 2030 — 2035 — 2040 — 2045 → 2050

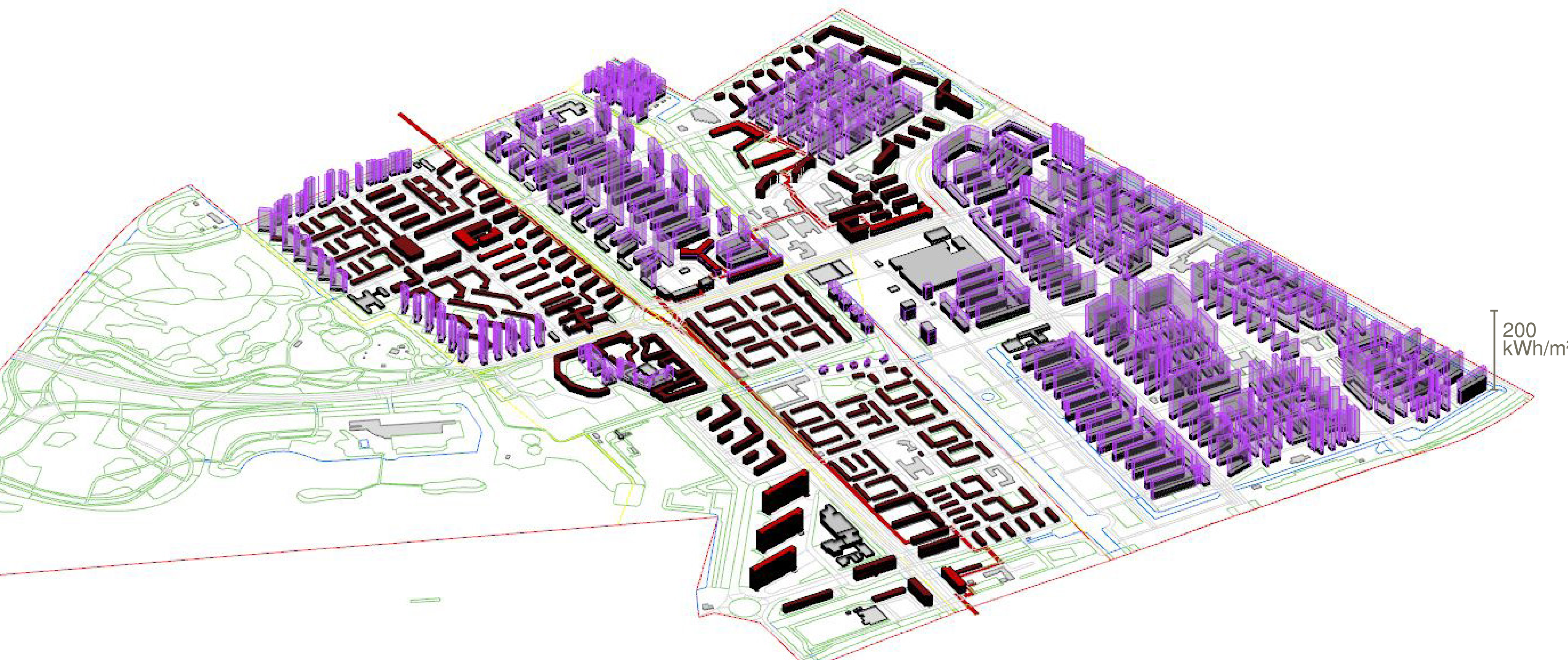
STEP 4 ROADMAP DESIGN

4c Define the interventions on timeline





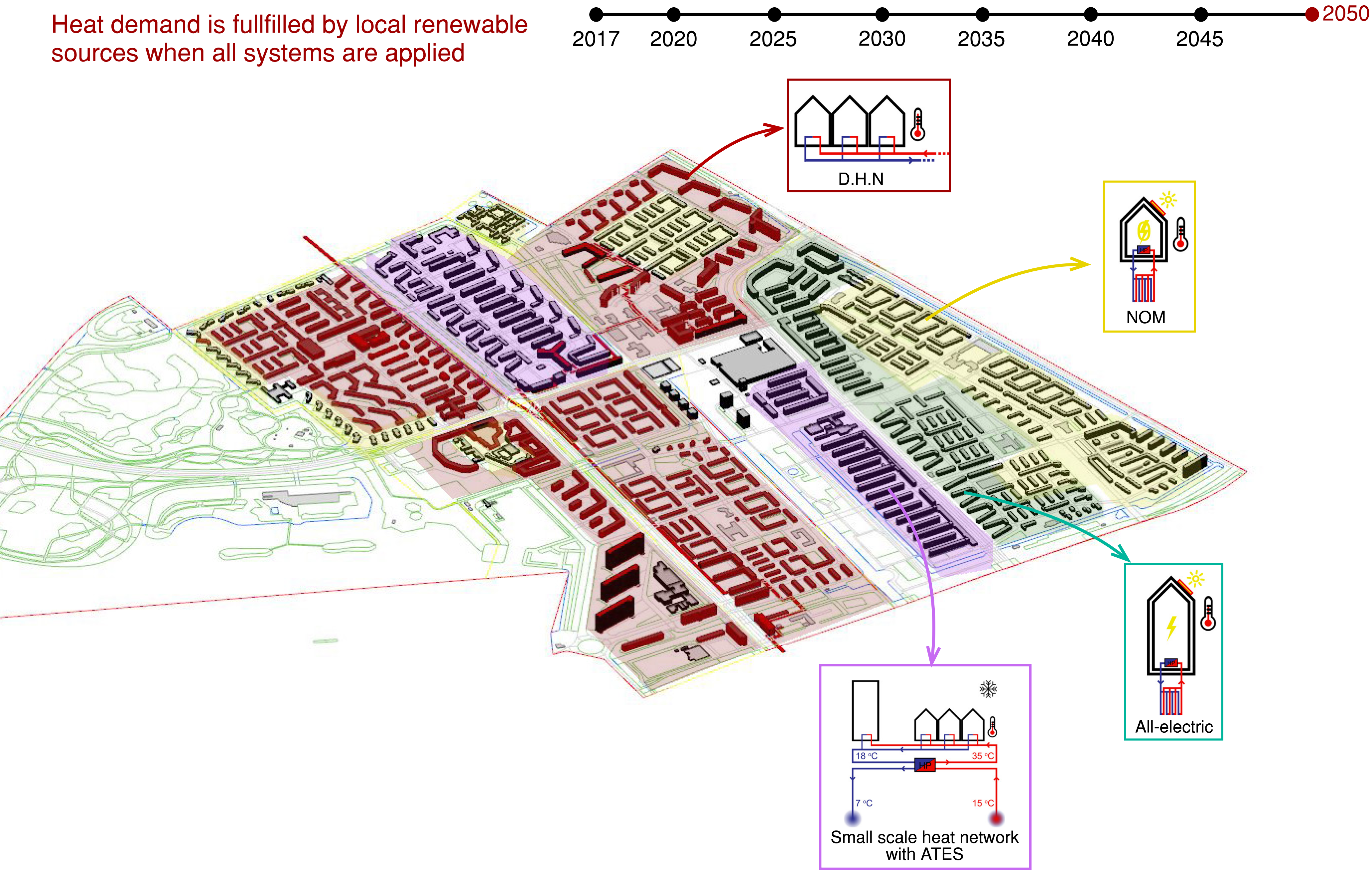
Remaining need to be covered by renewable sources



STEP 4 ROADMAP DESIGN

4c Define the interventions on timeline_Final vision

Heat demand is fullfilled 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.**