5th International Conference on Smart Energy Systems
Copenhagen, 10-11 September 2019
#SESAAU2019

Session 17: 4GDH concepts, future DH production and systems

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Designing smart low temperature heat grids based on spatial allocation of demands and sources

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Innovation Fund Denmark
4DH

- Dutch Funded Research Project 'KoWaNet': Koele WarmteNetten'.
- Partners:

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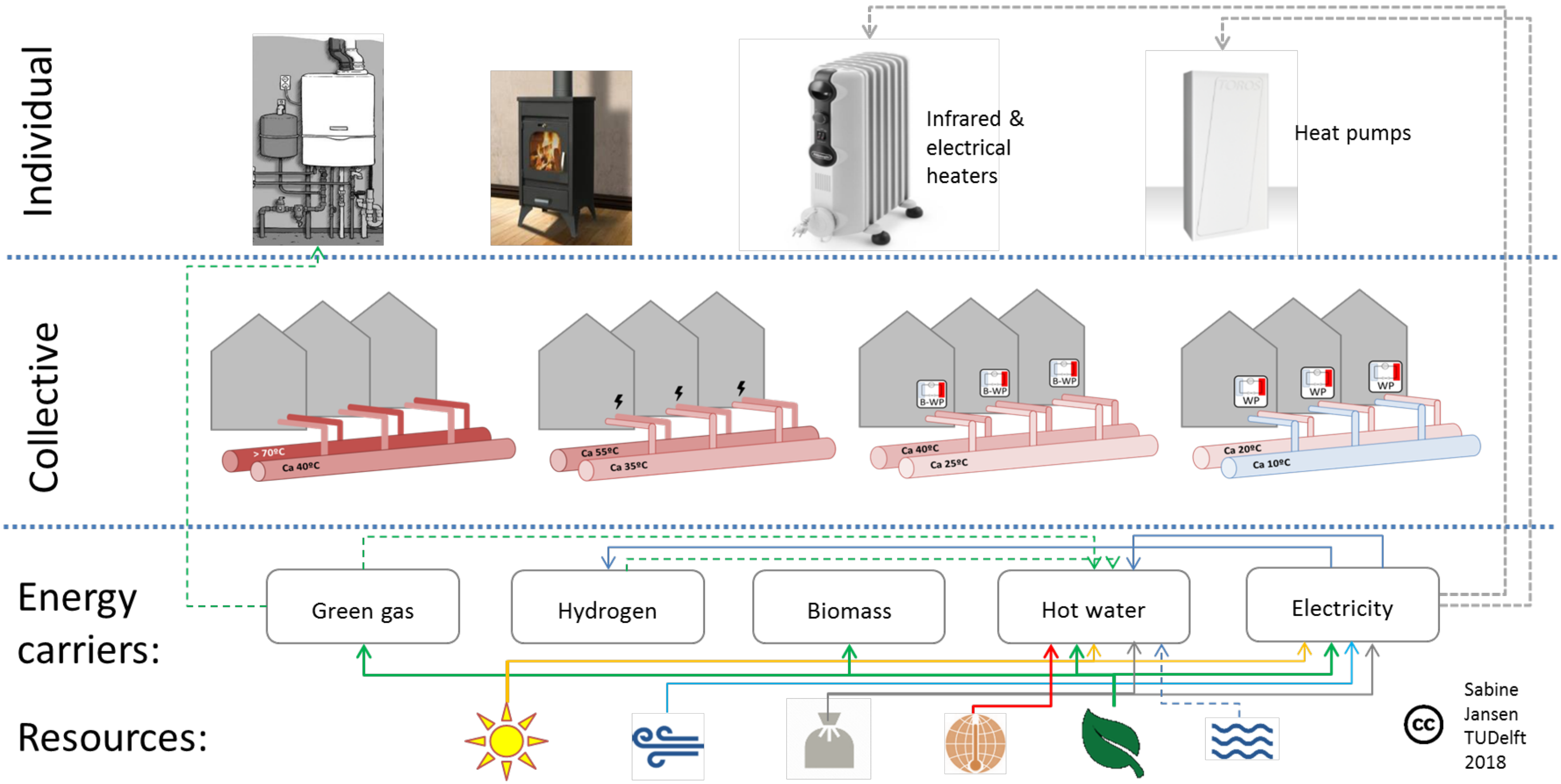
Alternative heating solutions for the built environment



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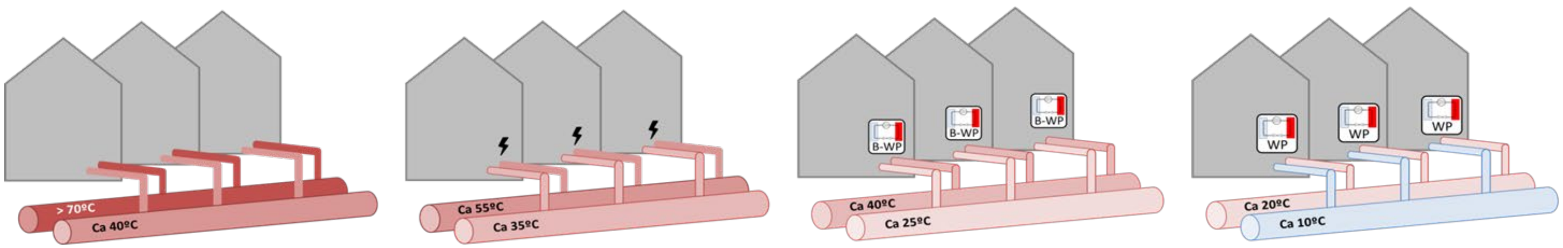
Temperature levels

Table 1

	1st Generation	2nd Generation	3rd Generation	4th Generation
Label	Steam	In situ	Prefabricated	4GDH
Period of best available technology	1880–1930	1930–1980	1980–2020	2020–2050
Heat carrier	Steam	Pressurised hot water mostly over 100 °C	Pressurised hot water often below 100 °C	Low-temperature water 30–70 °C
Pipes	In situ insulated steel pipes	In situ insulated steel pipes	Pre-insulated steel pipes	Pre-insulated flexible (possible twin) pipes

[Lund et al, 2014, 4th Generation District Heating (4GDH) Integrating smart thermal grids into future sustainable energy systems]



Hot > 90º Cold ~ 70º Traditional district heating	Hot > 70º Cold ~ 40º High Temperature (direct supply of hot water)	Hot = 45-70º Cold ~ 30- 40º Medium Temperature (additional solution for hot water)	Warm = 30-45º Cold = 18-30º Low Temperature (direct space heating Booster HP for DHW)	Warm = 10-30º Cold = 5-18º Ultra low Temperature (heat pump for space heating and DHW)

Approach for matching sources and demands

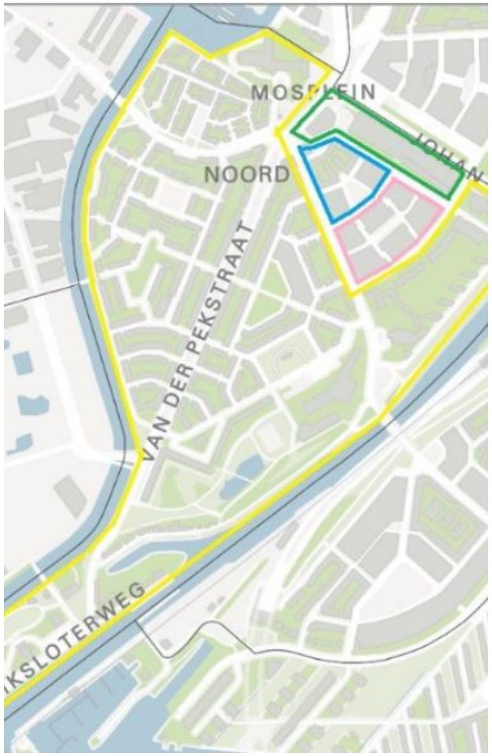
Aim:

to develop a conceptual configuration for a local, low temperature district heating system for a given neighbourhood, based on local sources and demands

Steps

1. Quantify sources and supply
   a) Energy (GJ)
   b) Power (MW)
   c) Temperature (°C)
2. Map these on a spatial scheme (building > city)
3. Develop potential configurations
4. Estimate rough performance

   Energy, costs, governance



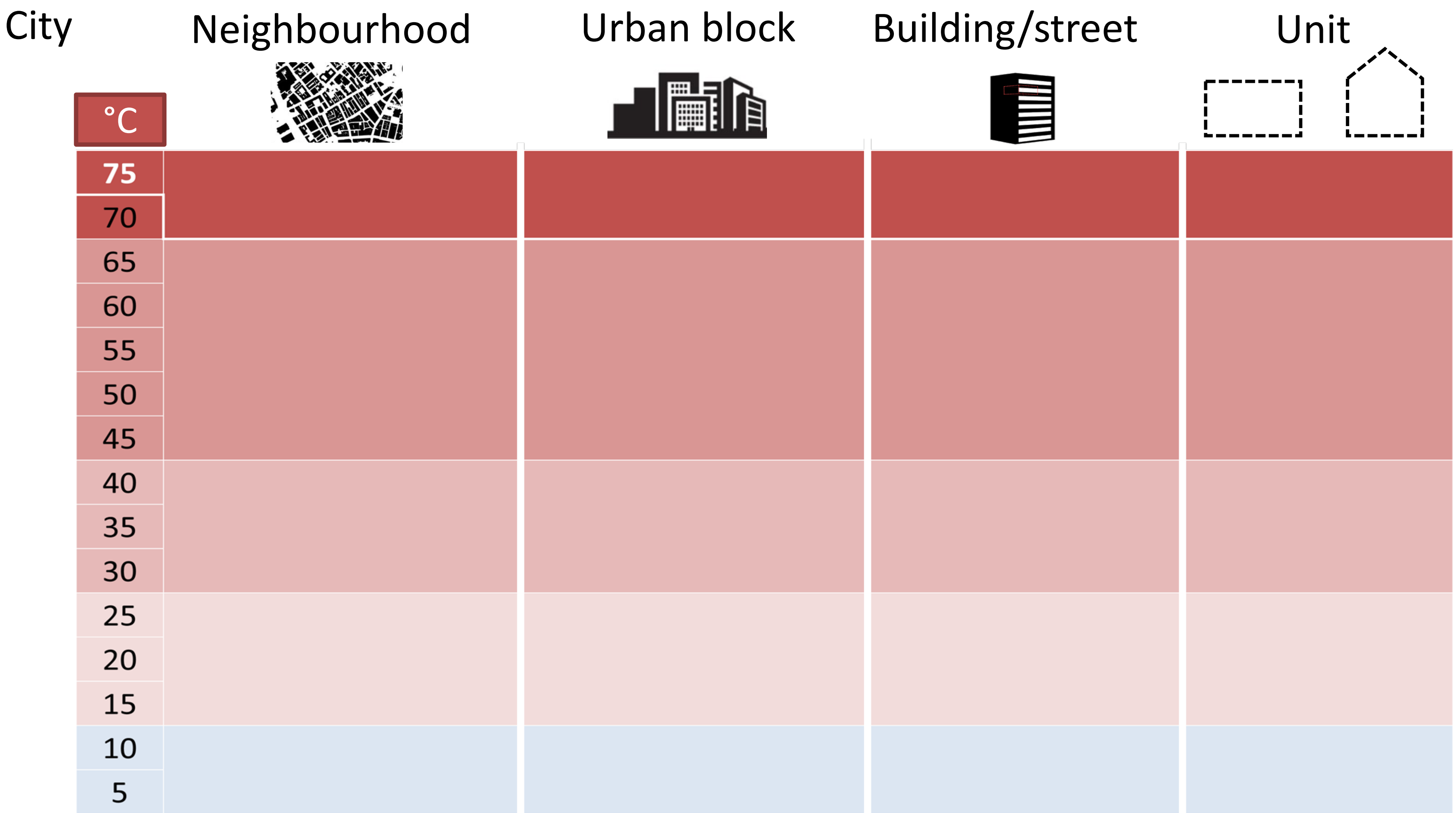
Step 1a: Quantify thermal demands

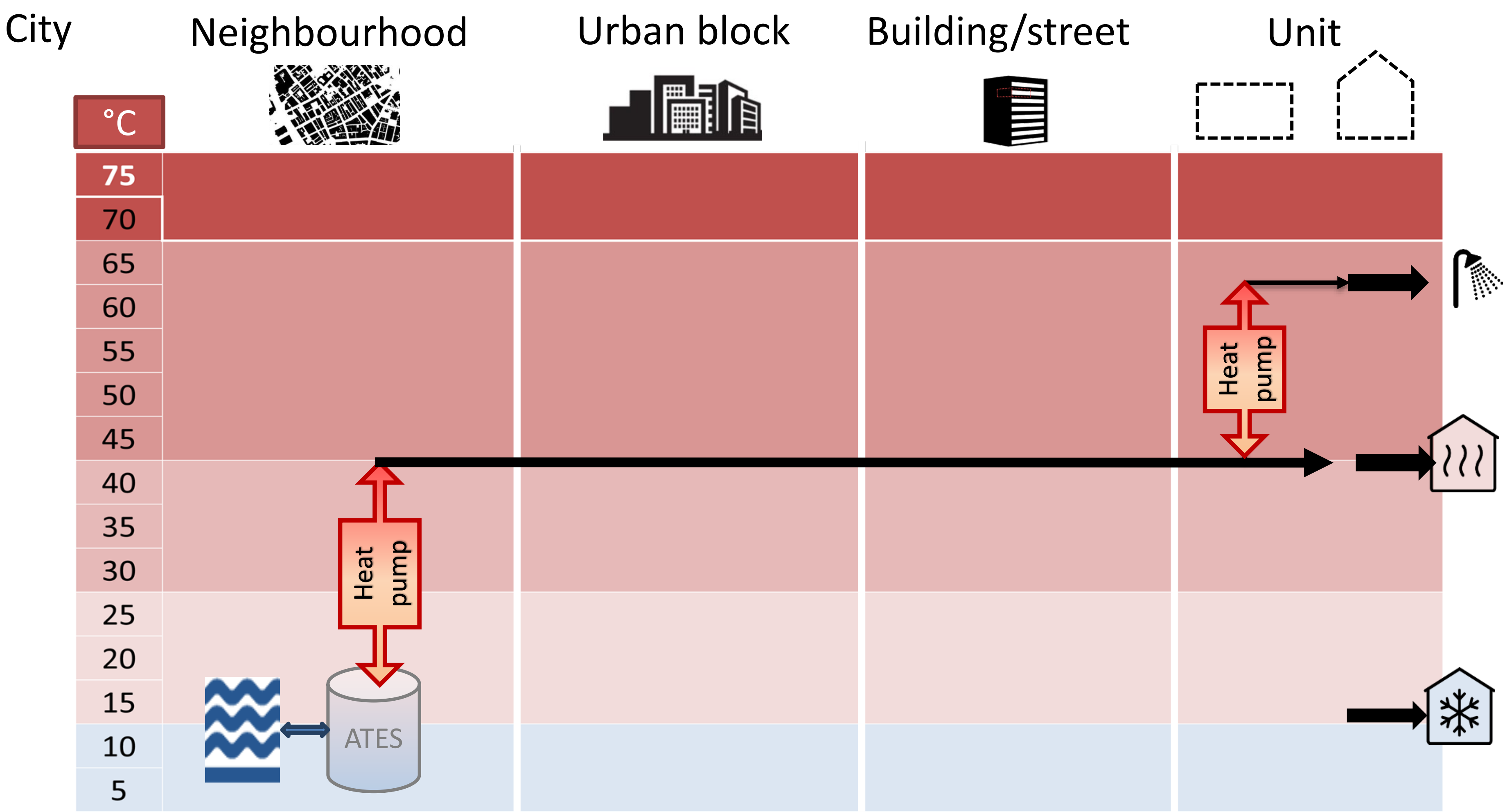
Step 1b: Quantify thermal potentials

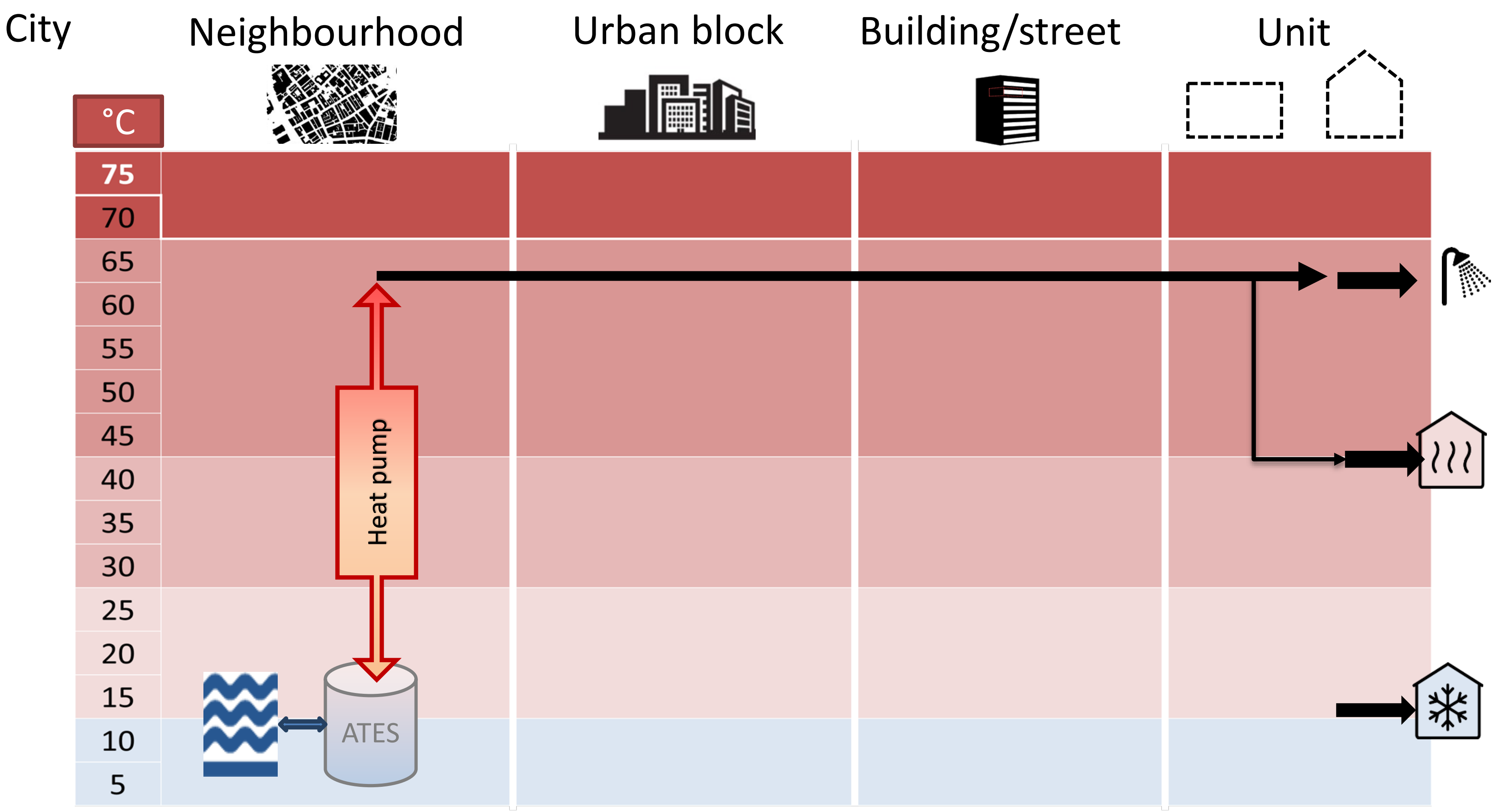
1. **Solar thermal energy:**
   Solar Collectors & PVT (PV + thermal)
   - with low temperature output
   - with high temperature

2. **Thermal potential of water**
   - Waste water
   - Surface water

3. **Energy from waste & biomass**
4. **Other (waste heat, etc)**
5. **Storage potentials**


City
Neighbourhood
Urban block
Building/street
Unit
°C
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5

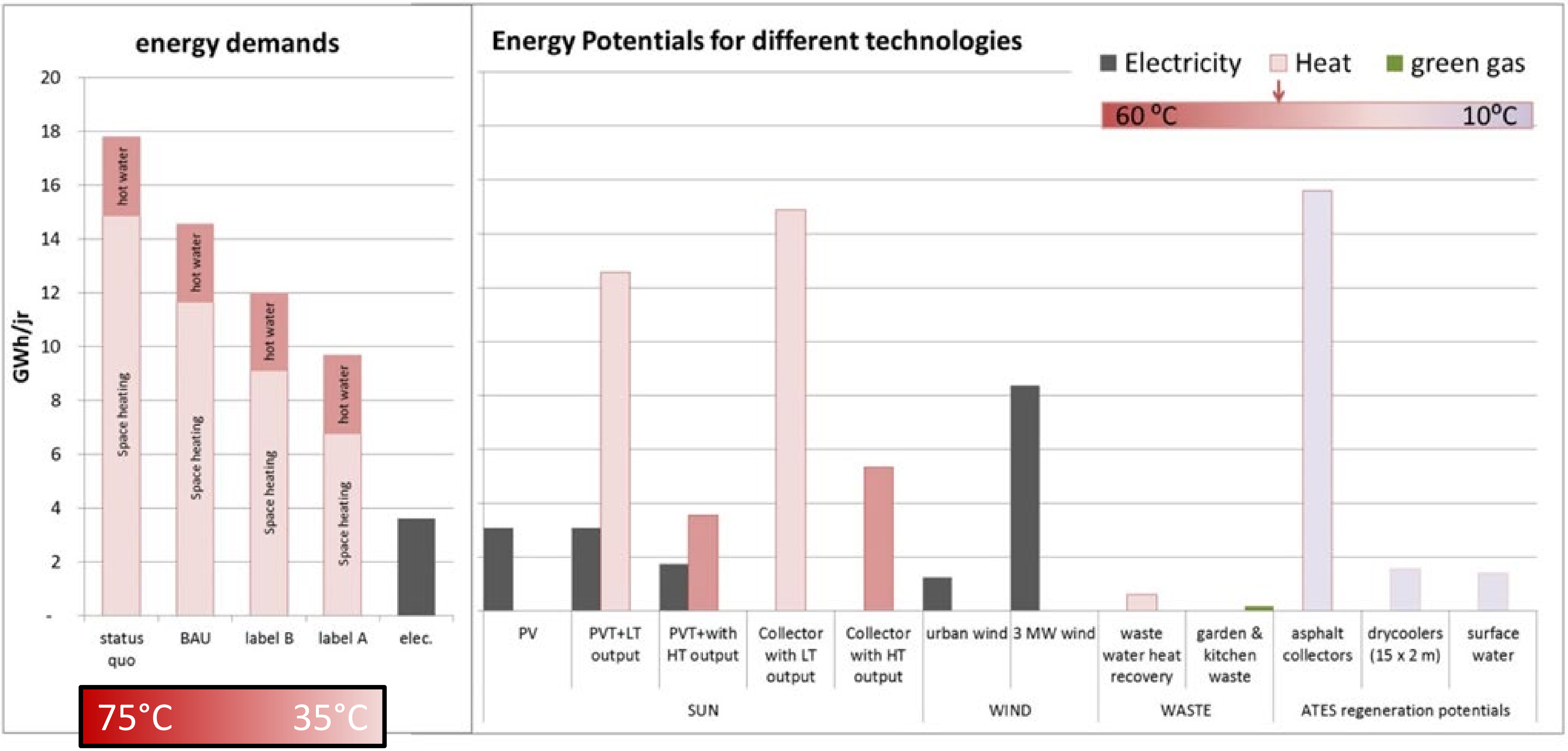

City
Neighbourhood
Urban block
Building/street
Unit
°C
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Heat pump
Heat pump
ATES

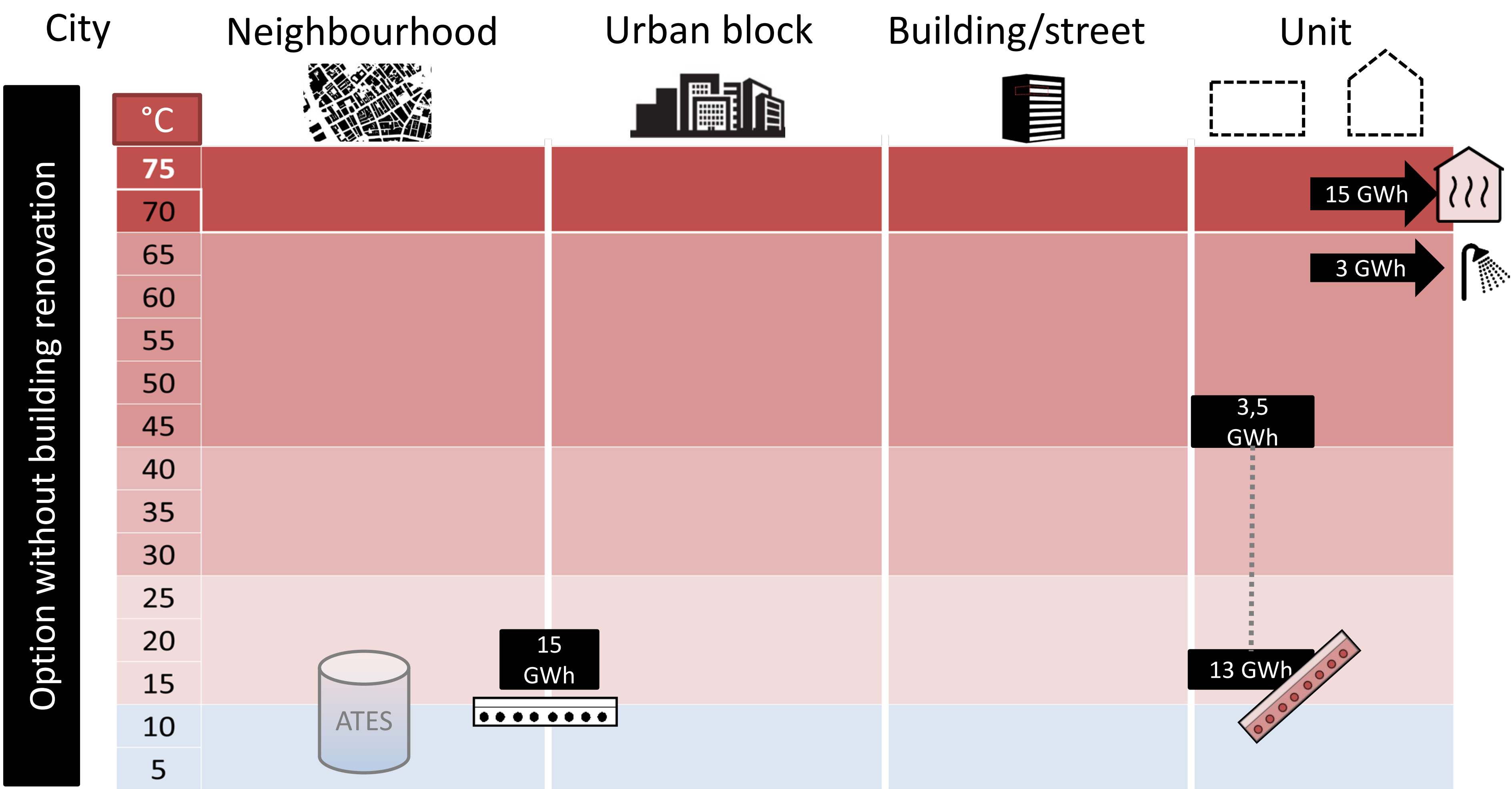

City
Neighbourhood
Urban block
Building/street
Unit
°C
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Heat pump
ATES

Case 1: Ramplaankwartier

- Haarlem, NL
- 1127 single family houses
- 47 small enterprises
- Poor energy labels (built in ’30s and ’50s)

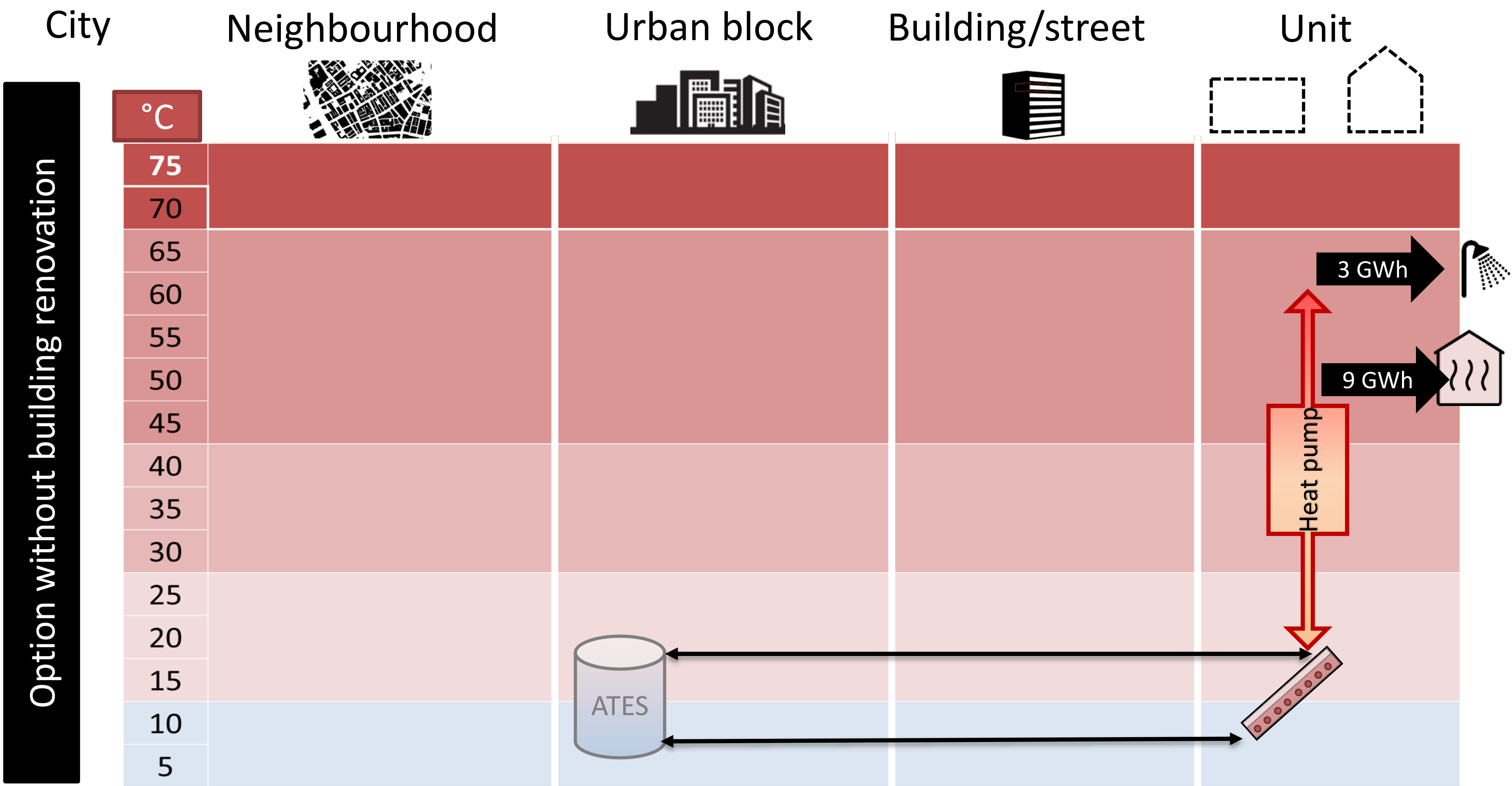
Case 1: demands and potential supply




City
Neighbourhood
Urban block
Building/street
Unit
Option without building renovation
°C
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
15 GWh
3 GWh
3,5 GWh
13 GWh
15 GWh
ATES

	ULT heat grid with individual HP		LT/MT heat grid with booster HP)		HT heat grid
renovation scenario	**label C/D**	**label B**	**label C/D**	**label B**	**label C/D**
Net heat demand of buildings (GWh/yr)	14,6	11,9	14,6	11,9	14,6
Building level boiler losses (GWh/yr)	0,6	0,6	0,6	0,6	
Distribution losses (GWh/yr)			0,6	0,6	2,8
Total electricity needed for heating (GWh/yr)	4,1	3,2	3,5	2,8	5,5

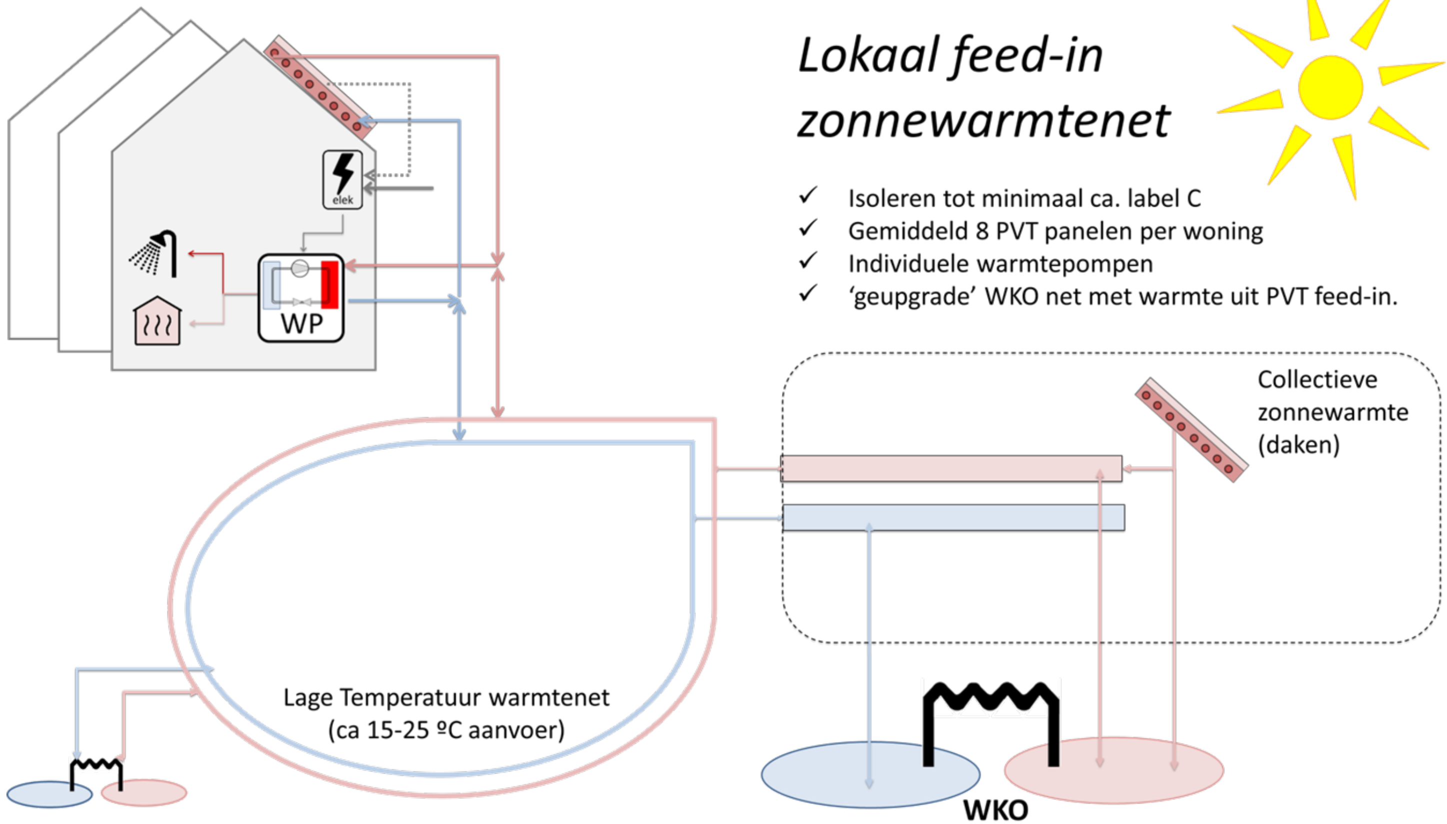
- LT/MT grid seems the most energy efficient, but:
  - » Not certain how many hours time the grid temperature (ca 40 degrees) is sufficiently high for space heating
  - » We have difficulty supplying enough heat at this temperature > too much solar (PVT) collectors needed.
- Also, booster HP performance is not sufficiently better than normal HT
- → ULT grid was selected for further development


City
Neighbourhood
Urban block
Building/street
Unit
Option without building renovation
°C
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
3 GWh
9 GWh
Heat pump
ATES

Following case study 1: New system now under development Low Temperature Solar feed-in heat grid (deZONNET)
See session 25, Wednesday morning

Lokaal feed-in zonnewarmtenet

- ✓ Isoleren tot minimaal ca. label C
- ✓ Gemiddeld 8 PVT panelen per woning
- ✓ Individuele warmtepompen
- ✓ 'geupgrade' WKO net met warmte uit PVT feed-in.

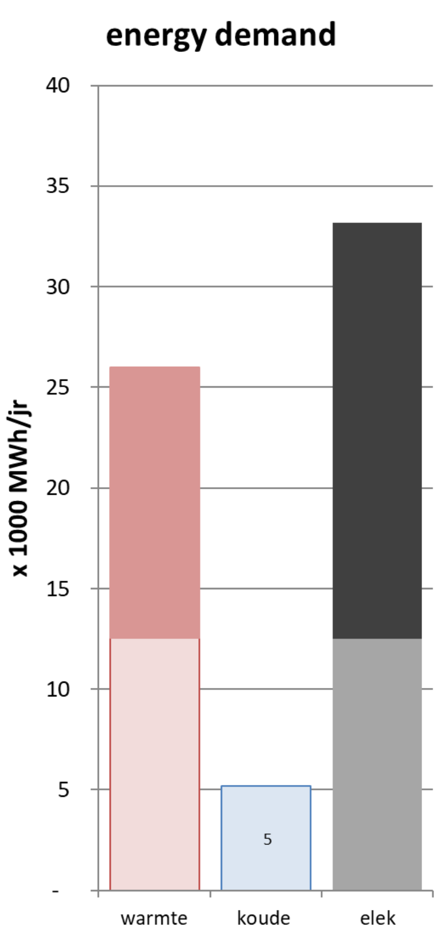


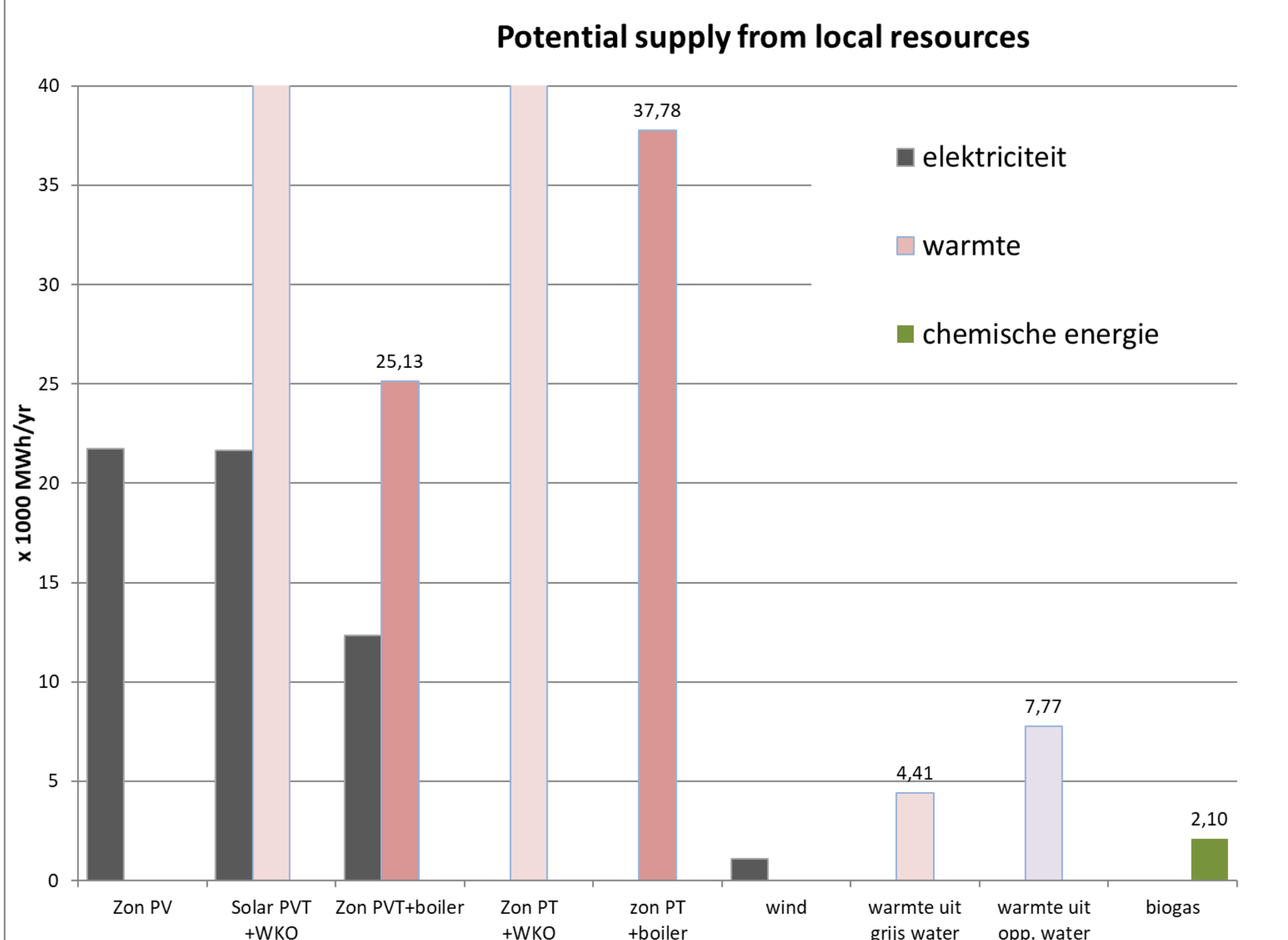
maximaal lokaal duurzame wijk-warmtevoorziening, TU Delft, Smart Urban Isle Project, 2017

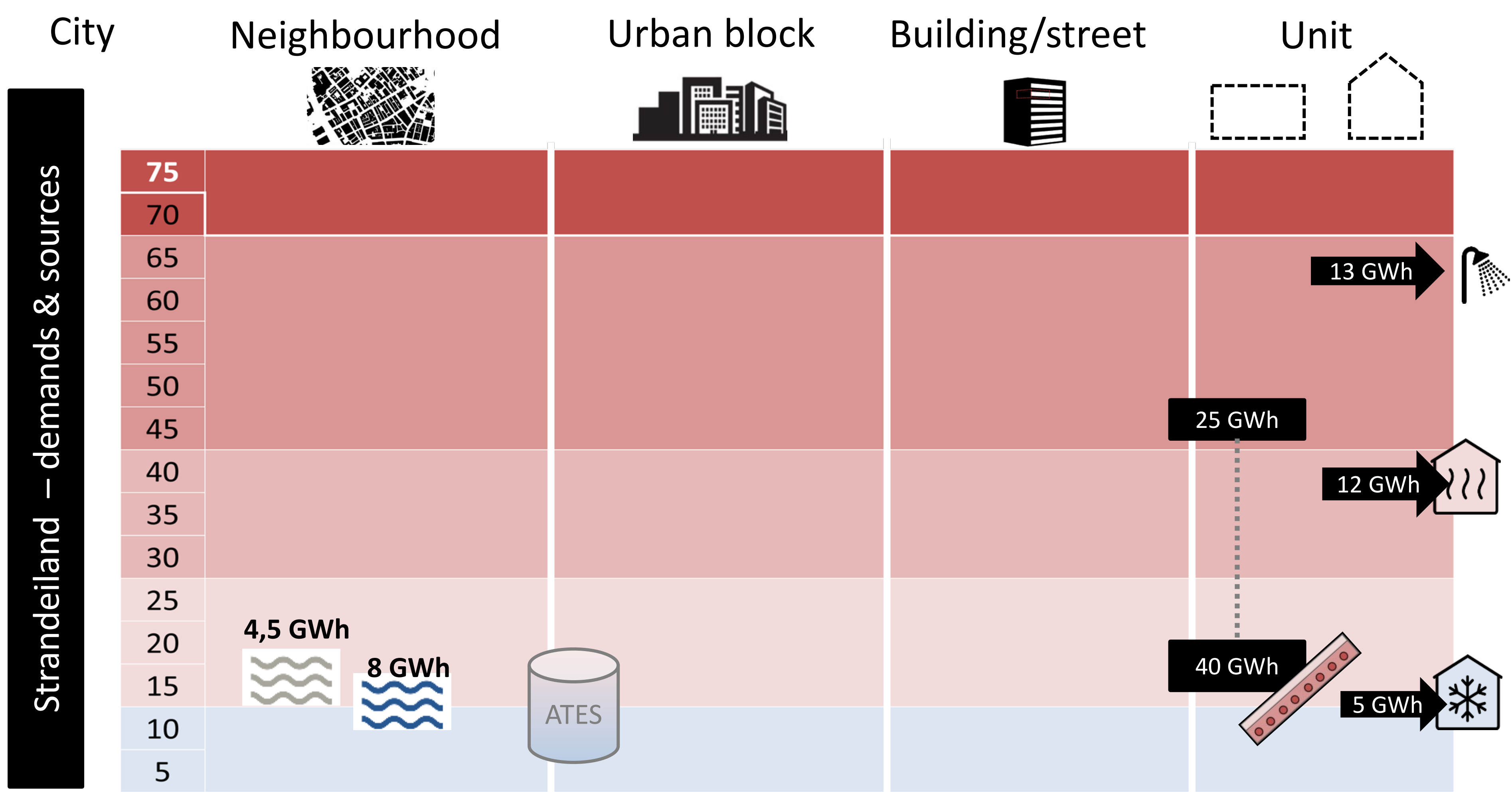
Case 2: Strandeiland

- Amsterdam, NL
- New development area
- 8000 new dwellings
- 150.000 m² non-residential

Strandeiland -8000 dwellings






City
Neighbourhood
Urban block
Building/street
Unit
Strandeiland – demands & sources
75
70
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55
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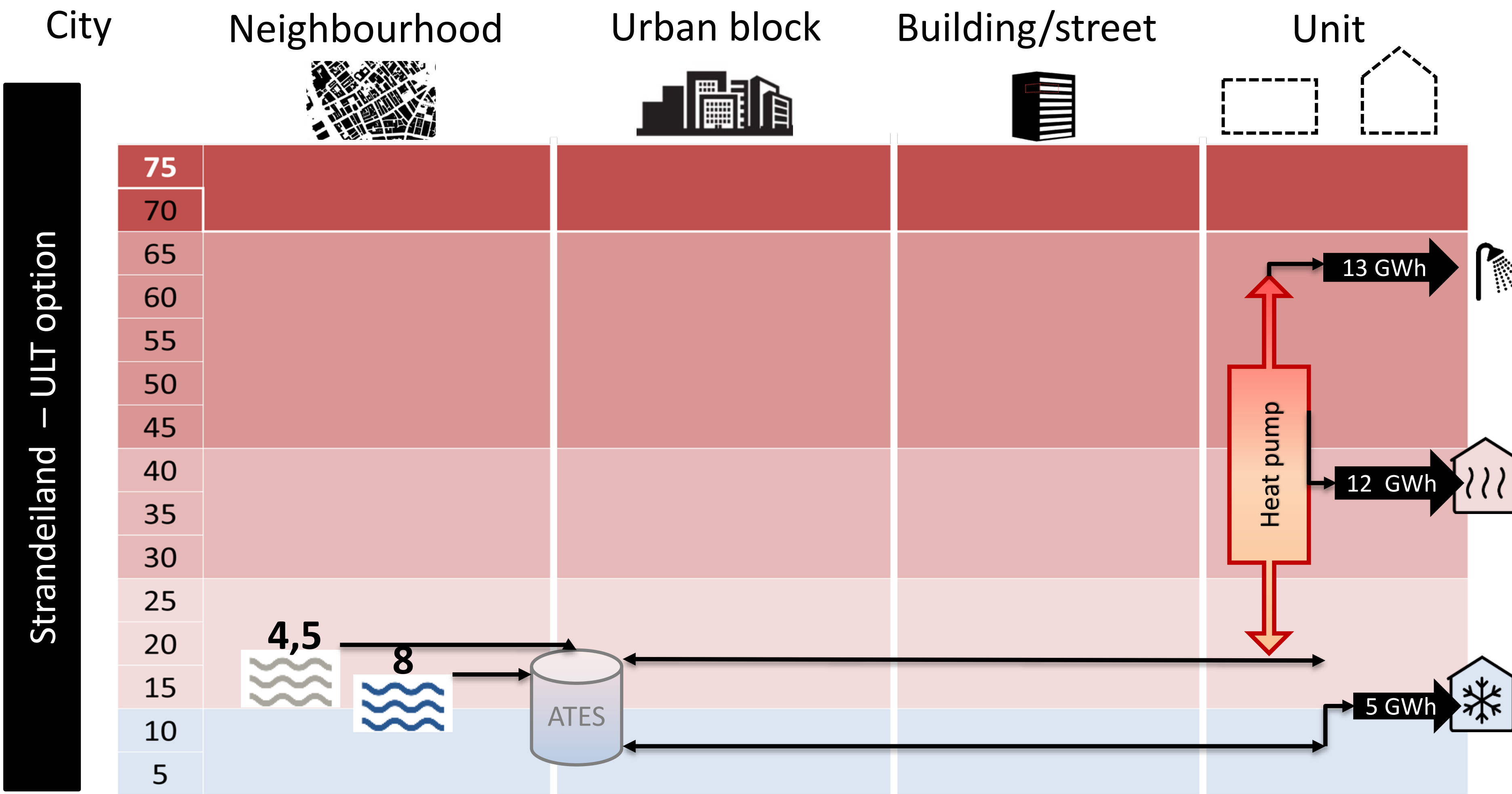
13 GWh
25 GWh
12 GWh
4,5 GWh
8 GWh
ATES
40 GWh
5 GWh


City
Neighbourhood
Urban block
Building/street
Unit
Strandeiland – ULT option
75
70
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35
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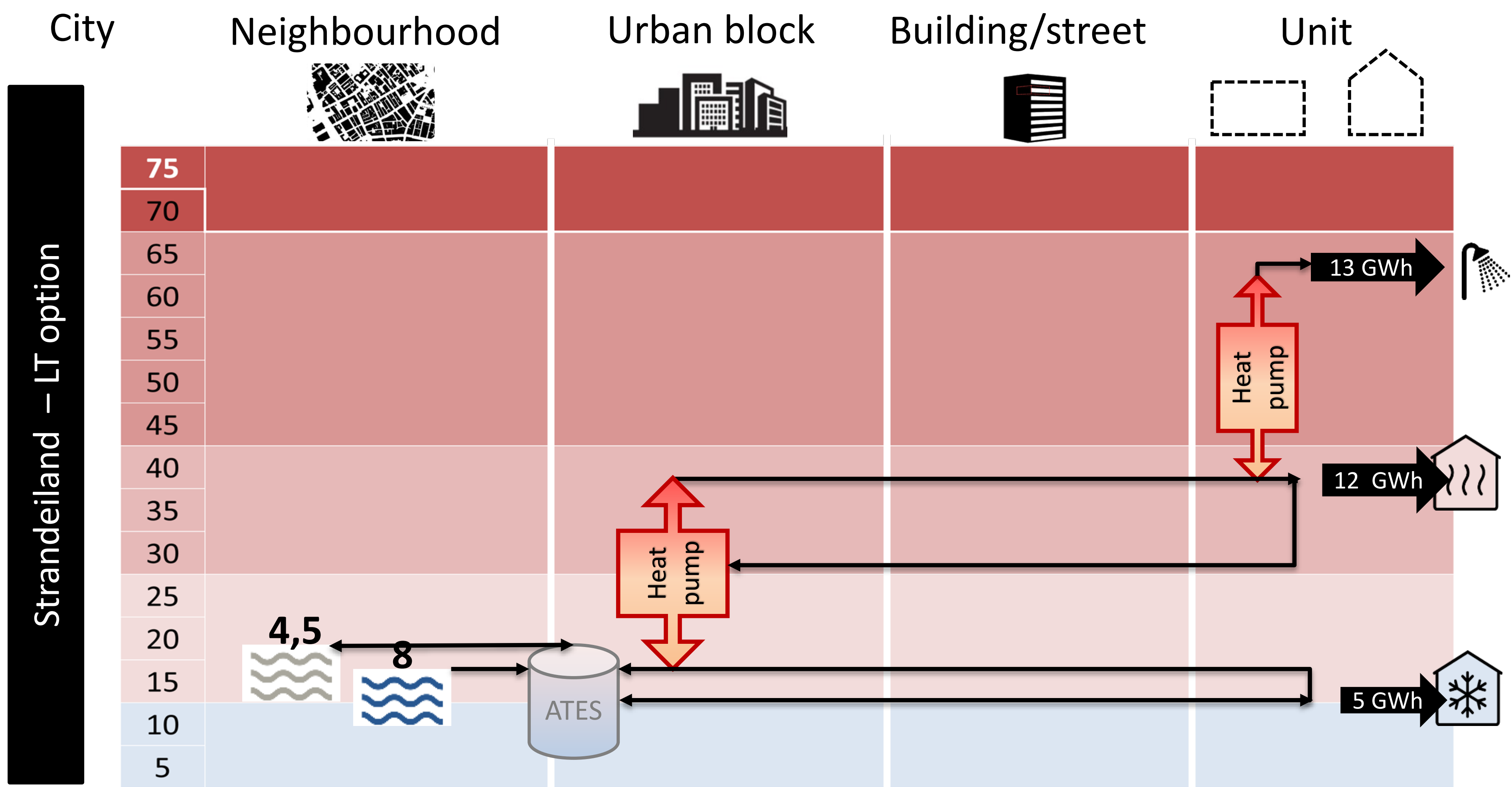
15
10
5
4,5
8
ATES
Heat pump
13 GWh
12 GWh
5 GWh


City
Neighbourhood
Urban block
Building/street
Unit
Strandeiland – LT option
75
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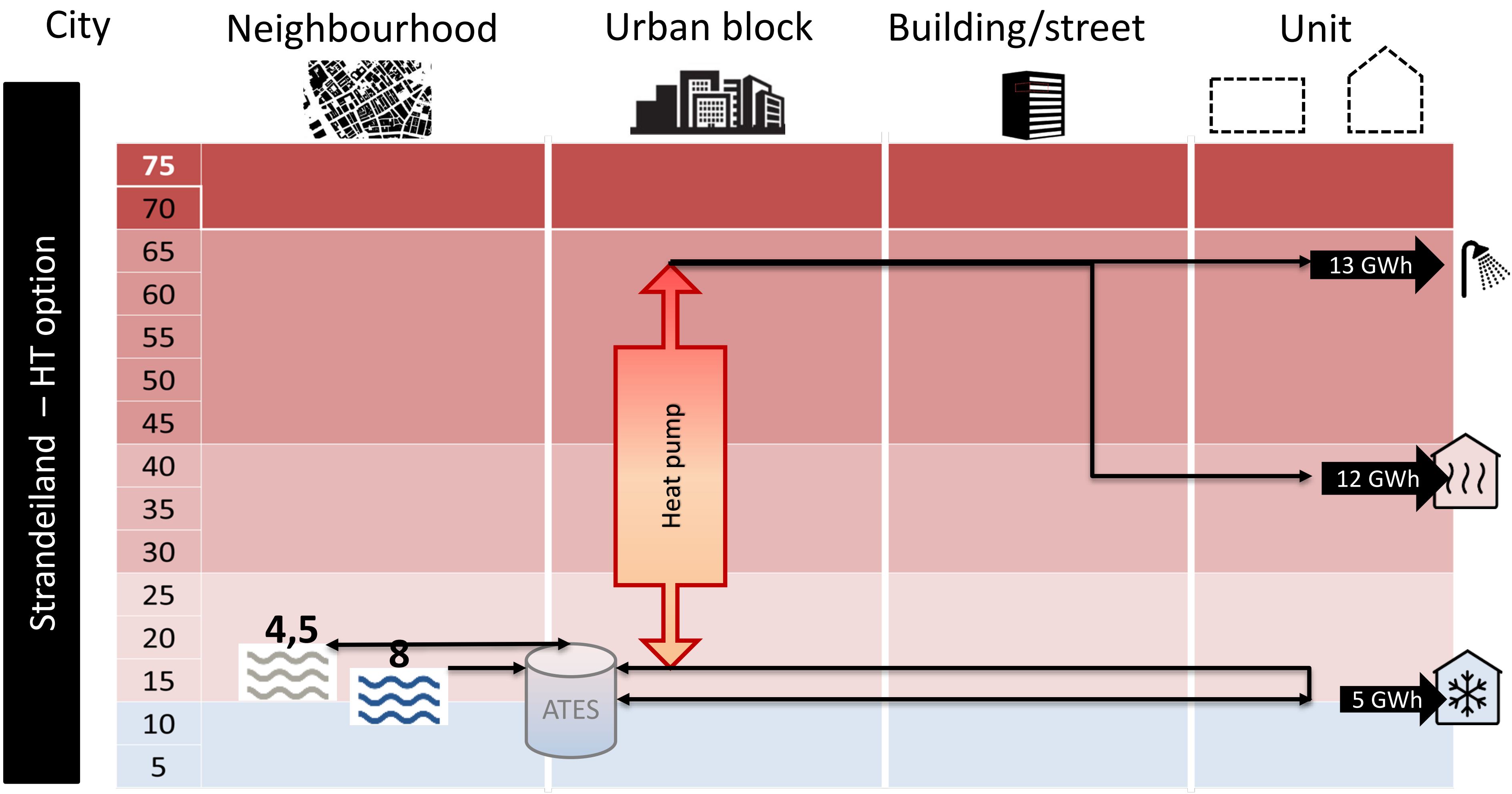
13 GWh
Heat pump
12 GWh
Heat pump
4,5
8
ATES
5 GWh


City
Neighbourhood
Urban block
Building/street
Unit
Strandeiland – HT option
75
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15
10
5
Heat pump
13 GWh
12 GWh
5 GWh
4,5
8
ATES

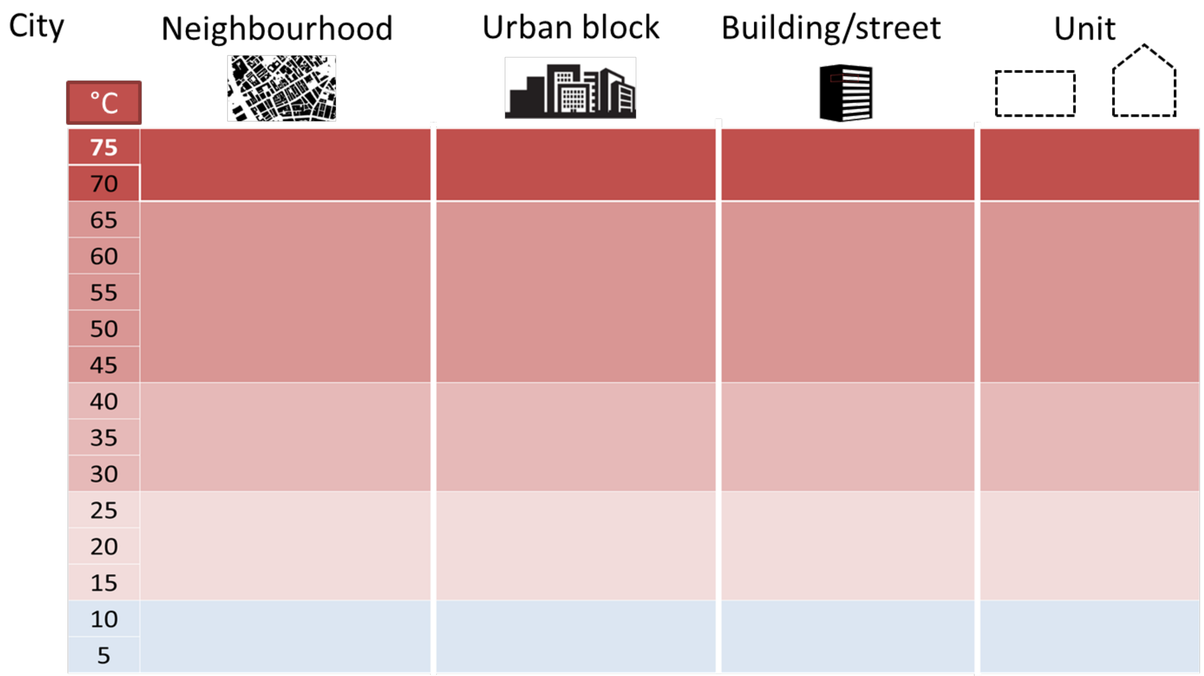
STRANDEILAND with 8000 dwellings (NZEB) + 150.000 m² other	ULT heat grid with individual HP	LT/MT heat grid with booster HP)	HT heat grid	
			coll. HP	external heat
renovation scenario	**NZEB**	**20**	**label C/D**	**label C/D**
Net heat demand of buildings (GWh/yr)	25	25	25	25
Building level boiler losses (GWh)	incl	incl		
Distribution losses (GWh/yr)		2	10	10
Total electricity needed for heating (GWh/yr)	9	8,9	11,5	
District heating supply (GWh/yr)				35

- ULT & LT grids result in similar electricity needs:
  - Higher efficiency of collective heat pump versus more distribution losses
  - For this case, collective HP was selected since results in lower installed power > lower costs. Also
  - Different concepts on building level can be
- Also, booster HP performance is not sufficiently better than normal HT
- → ULT grid was selected for further development

Conclusions:

- Choice of temperature level depends on:
  - Required temperature of the space heating demand & available sources
  - Distribution losses versus storage losses
  - Actual heat pump performance for a given situation
    - » Often a large collective heat pump is more efficient
    - » Ramplaan case: Booster heat pumps do no perform sufficiently better than 'onvensional' heat pumps > too little gain in case high temp space heating is needed
- Energy performance of ULT (~20°C) and LT (~40°) seems similar; preferred option depends on available sources and where these are located, plus costs and spatial needs for energy systems.
- The spatial representation of the sources helps to identify options and simplify the comparison based on rough energy performance indicators
- Tool is still under development within the KoWaNet project.

Thank you


City
Neighbourhood
Urban block
Building/street
Unit
°C
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15
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