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Dutch Hybrid Neighbourhoods of the Late 19th Century in Heat Transition

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Abstract

This paper explores the typo-morphologic characteristics of late 19th century hybrid neighbourhoods in urban region of The Netherlands and possibilities of a feasible climate neutral energy system in the future. Sustainable Development Goals are involved such as ensure access to affordable and clean energy (SDG 7) and make cities inclusive, safe, resilient and sustainable (SDG 11). With the Dutch-Climate-Agreement 2019 The Netherlands decided on a neighbourhood approach to the transition from natural gas to a climate neutral energy supply in buildings. Implicit homogeneity in most buildings of neighbourhoods is presupposed, in contrast to older neighbourhoods that were laid out before WWI. These are nowadays heterogenic, attractive, mixed and often protected neighbourhoods because of the quality of the architecture. Establishing a generic energy plan here is a challenge. The foremost important conclusion is the recognition of the architectural and urban quality and features of these kinds of neighbourhoods and to develop specific legislation and rules about insulation, service and energy systems. Conclusion about the strategy is that one should not rely on a single generic solution but apply multiple forms of heat supply over a longer period of time. There is lack of heat and construction capacity. And in inhabited state and combine it with a box-in-box-renovating, for example when people are moving. Organise the tenants of neighbourhood, not buildings owners, and implement legislation and framework for rental apartments; insulate to mandatory EPC label (B/C), sound and energy production of heat pumps and district heating.

Keywords

Hybrid neighbourhood, energy transition, heritage.

1 INTRODUCTION, RELEVANCE AND AIM OF THIS PAPER

With the Dutch-Climate-Agreement 2019, The Netherlands chose for a neighbourhood approach for the transition from natural gas to a climate neutral energy supply of buildings (https://www.klimaatakkoord.nl/). Dutch municipalities should have a vision on the heat transition and an energy plan for every neighbourhood by 2021. Implicit homogeneity of neighbourhoods is presupposed. However, the older neighbourhoods are different, especially the ones which were laid out before WWI. These are nowadays heterogenic, attractive and often protected because of the quality of the architecture. Neighbourhoods with a mix of users, building ages, property owners and habitation forms. Developing a generic energy plan for neighbourhoods laid out and constructed between 1860 and 1910, is a challenge. There is a missing link in the knowledge. The link between the bigger scale of region and municipality on one side and the smaller scale of different types of buildings on the other side is missing. From the perspective of heat strategy it is necessary to map the typo-morphologist characteristics of these neighbourhoods and researching the use and inhabitation form of the buildings.

The aim and the main question of this study is to research a framework or strategy for a feasible climate neutral energy supply of the housing stock of late 19th century hybrid neighbourhoods in urban region of The Netherlands based on the typo-morphologic characteristics. Sub-questions are:

What are the typo-morphologic characteristics of urban spaces and building stock? What is the use and ownership of these buildings? Which climate neutral heating or energy systems are possible in hybrid neighbourhoods?

FIG. 1 Zeeheldenkwartier 1970, photographer: Jaap Rijkenberg.
Source: Mediabank: Haags Gemeente Archief HGA identification number 0.87668

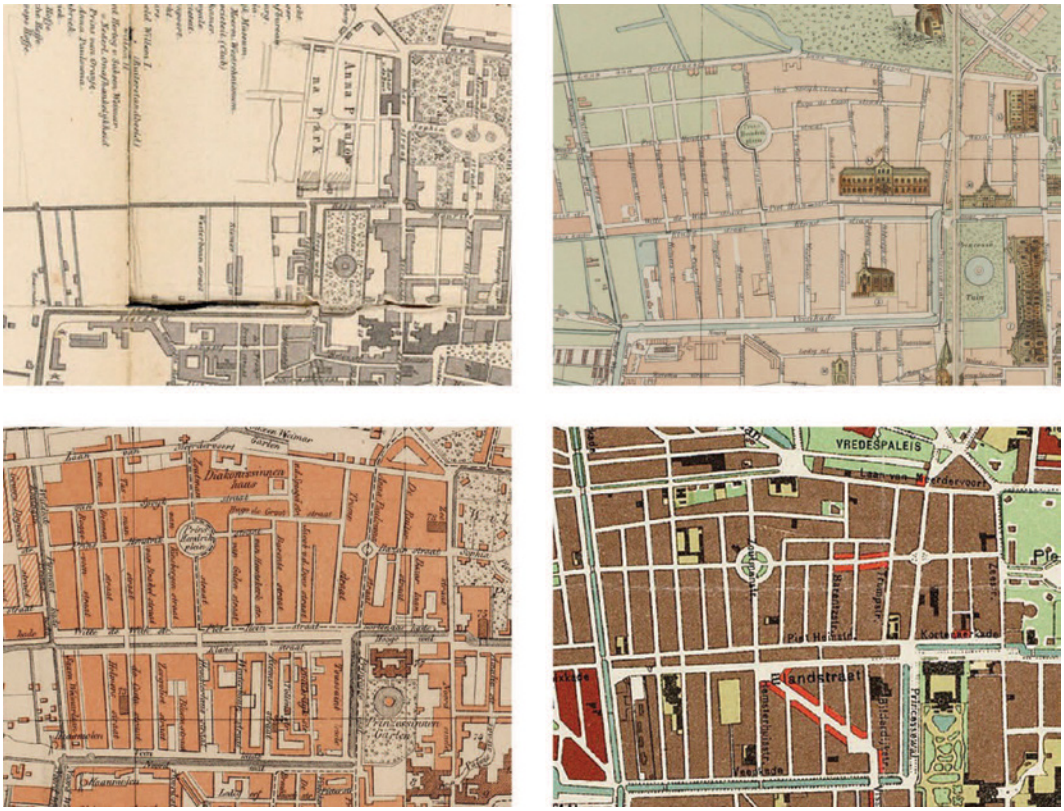

FIG. 2 Zeeheldenkwartier. Top left: a map with the situation in 1867. Top right: the map from 1884. Bottom left: the map from 1891. Bottom right: the map of 1908. Source: Mediabank: Haags Gemeente Archief HGA identification numbers z.gr.0024, z.gr.0031, z.gr.0048, gr.0535

The method applied was al living lab in the neighbourhood initiated and subsidized by the municipality and minor with students of The Hague University of Applied Sciences in autumn 2018. Mapping the typo-morphologic characteristics of the neighbourhood and buildings in 2019 of one case: Zeeheldenkwartier in Den Haag. Reviewing literature and reports on this subject from the Municipality of Den Haag, the province Zuid-Holland, the Dutch government and institutes such as CBS (Statistics of The Netherlands CBS; statistics of Municipality of Den Haag; Warmte Transitie Atlas of Zuid-Holland; Nationale Energie Atlas; Warmte Atlas of RVO; and references renovation of the existing housing stock RVO). Finally debate and reflection with expert meetings in the neighbourhood in 2018 and LDE Conference Heritage and the Sustainable Development Goals at TU Delft in 2019.

2 FRAMEWORK OF A TYPO-MORPHOLOGIC ASSESSMENT

Changes in society and precipitation in typo-morphologic characteristics of neighbourhoods from a specific period is postulated. The hypothesis is that cities and neighbourhoods have an ontology that refer to their own built structure in each period. Additionally, the pattern of inhibition is usually related to the specific characteristics of a neighbourhood. Changes in the built environment happen in a broader perspective in relation to changing legislation, subsidy, central policy or lack of governance. This is why each generation neighbourhoods in modern Dutch cities since 1850 has its own specific characteristics. In the last part of the 20th century the ontology of cities developed as a valuable tool and method to provide knowledge about existing cities, neighbourhoods and their buildings (Rowe, 1960; Vidler, 1976; Moudon, 1994). Typo-morphology gives attention to how the physical form of a city changes over time and to how different cities or neighbourhoods compare to each other. According to Rowe (1960), people form mental maps of their surroundings consisting of five elements: 'paths', 'edges', 'districts', 'nodes', and 'landmarks'. These elements are also useful to characterise neighbourhoods. At Delft University of Technology, the method of typo-morphology was introduced in the eighties of the last millennium. The research was based on reducing maps and drawings on aspects or layers. Urbanists of Delft University of Technology distinguishes five layers: territory, street pattern, public space, use and buildings (Meyer et al., 2008). But which typo-morphologic characteristics of a neighbourhood are relevant in relation to the energy question? As mentioned, a premise is that every neighbourhood in a certain period has a recognisable and regular structure. The structure is determined by the urban morphology, the characteristics of the buildings, urban spaces, and the types of households that inhabit the dwellings (Oorschot, 2014). The energy question is, among others, related to the typo-morphology of the neighbourhood. Because of the space that is needed by the heat network the seize of the urban spaces of the neighbourhoods is relevant. Because the of the use of solar panels the shape of the roof is relevant. Because of the energy demand the quality of the built structures is relevant. Some characteristics are determined by the original lay out of neighbourhoods and buildings such as street pattern, size and orientation of urban spaces, size and orientation of the plot, division private property and public domain, position of building types and functions in the neighbourhood, as well as the quality and status of buildings (ownership, architecture, bearing structure, energy performance, shape of the roof). Other characteristics depend on the structure and morphology of the landscape, inhabitation or the architectural value. Furthermore, characteristic for neighbourhoods is the position of certain functions and types of buildings in the neighbourhood. According to the energy question the position of types and functions of buildings are mapped and researched in this assessment. The layers related to the energy question in late 19the century neighbourhoods are mapped: Morphology; Buildings types; Use of the building; Ownership of the buildings.

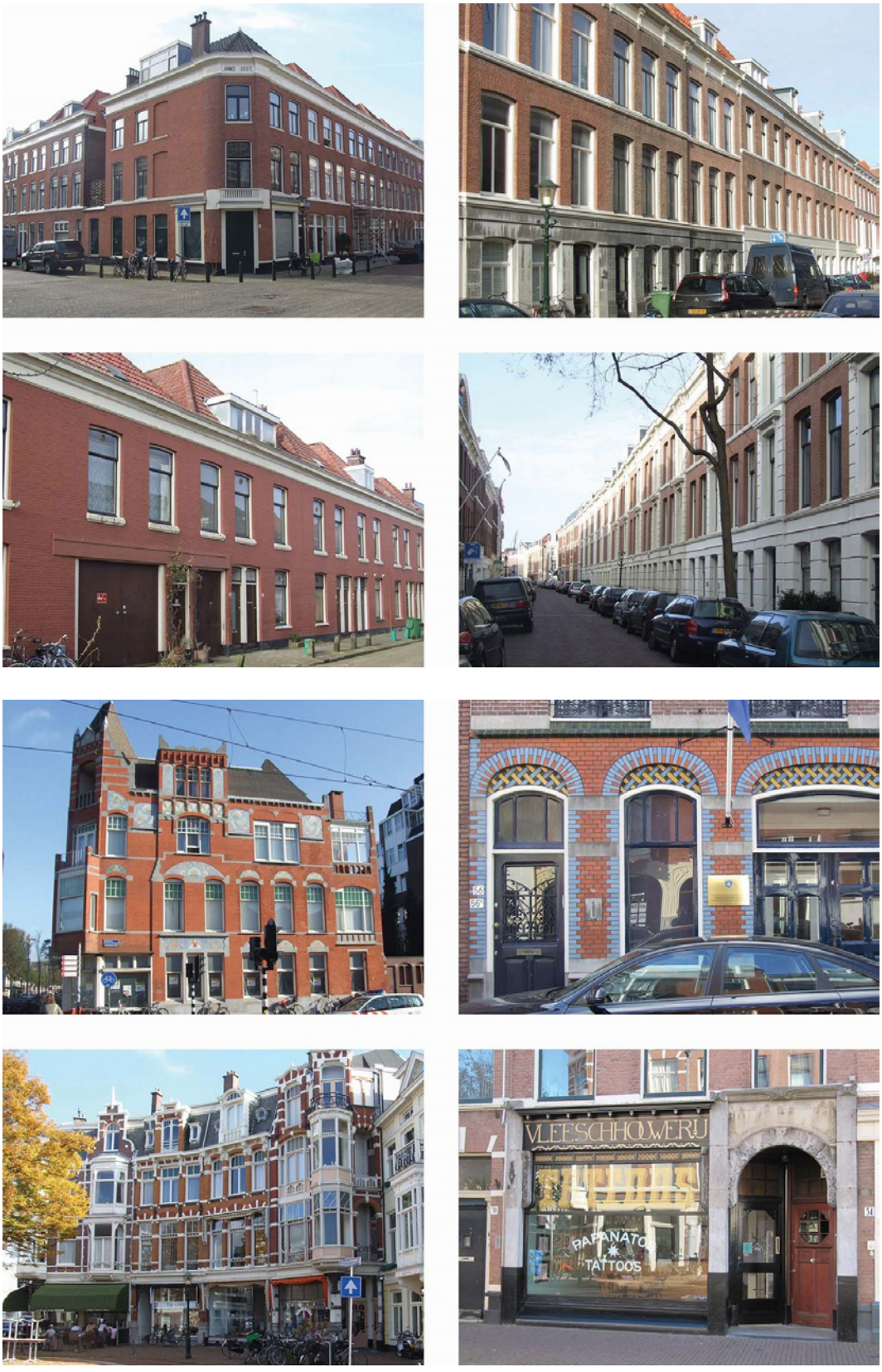

FIG. 3 Hybrid neighbourhoods have a great variety of brickwork residential architecture. Residential buildings are usually in eclecticism style, public buildings in Dutch neo renaissance, and the shops in beautifully designed fin de siècle architecture. Photographer: Leo Oorschot.

3 ENERGY SUPPLY IN LATE 19TH CENTURY NEIGHBOURHOODS

This section describes the possibilities of a climate neutral energy supply in general and more specific in 19th century neighbourhoods in Dutch city regions. What is the Regional Energy Strategy (RES) of the biggest region of The Netherlands: Energiestrategie Regio Rotterdam-Den Haag? In the Green Deal Warmte Zuid-Holland in 2011 is decided by the government and province Zuid-Holland to lay out an open district heating with industrial waste (WfE) from Rotterdam and geothermal heat as source. Also housing association in Den Haag have a deal with the municipality about the district heating of 70-degrees Celsius. With the Aedes Woonagenda 2017-2021 housing associations promised to have climate neutral housing stock by 2050 and have an average of EPC label B of their housing stock by 2021. According to the Dutch climate agreement of 2019, in areas laid out before 1995 with a high density of buildings, a heat network is favoured in densely built areas, while all-electric for new homes in new spacious districts is better.

The Expertise Centrum Warmte (ECW) was organised by several Dutch institutes and organisations to support municipalities on producing a vision and implementing the heat transition (https://www.expertisecentrumwarmte.nl/). Offering a guideline, tools and helpdesk they advise municipalities. They describe five strategies how to provide heat in the future: All electric with a heat pump (EPC label B, LT-heating is assumed); Heat network MT (70-degrees Celsius, EPC label C is assumed); Heat network LT (50-degrees Celsius, EPC label B, LT-heating is assumed); Renewable gas (bio, synthetic, hydrogen) with a hybrid heat pump; Renewable gas with a boiler.

According to the Dutch province of South Holland in the *Energiestrategie Regio Rotterdam-Den Haag* in 2018 there will be a shortage of electricity and surplus of industrial waste and geothermal heat in the future. Data centres, electric cars, and greenhouses of the Westland will demand exponentially more energy in the future.

In July 2019 the province of South Holland published the *Energieperspectief 2050 - Energiestrategie regio Rotterdam-Den Haag*. This document defines the preferences of reduction of fossil heat of the region Rotterdam-Den Haag. Firstly, insulation of dwellings (EPC label C or B), secondly use of industrial waste heat (WfE) from Rotterdam, thirdly use of geothermal energy (GSHP), fourthly individual heat pumps, fifthly bio gas and bio mass. The regional and open heat network of 70-degrees Celsius is considered the best solution to provide heat in Rotterdam-Den Haag, even though the question of ownership and the cost for the consumer are still problematic. The minister Eric Wiebes of economic affairs and climate recently announced that the Gasunie is going to develop, lay out and manage a public and open district heating transport network in the region of Rotterdam-Den Haag in the future.

The Municipality of Den Haag already developed several strategies and agreements with stakeholders for a 70-degree Celsius heat network in 2017 and 2018 (https://denhaag.raadsinformatie.nl/dossiers/27532). A report by the municipality in March 2019 on a conference explained that the heat network will have three main heat sources: industrial waste energy (WfE) from Rotterdam, local geothermal energy (GSHP) and local aquathermal energy (WSHP).
The municipality also appointed a number of pilot neighbourhoods to work with stakeholders on a heat plan. Two of these are hybrid neighbourhoods. The municipality categorised these hybrid neighbourhoods as 'innovation' instead of 'heat network' or 'all electric'. However, the municipality categorised them also as 70 degrees Celsius neighbourhoods because of the poor thermal quality of their old buildings. The municipality presupposes in their publications more and different solutions to provide heat in the future because of a capacity problem. There is not enough capacity to heat all the dwellings. Hybrid neighbourhoods are still an anomaly.

Some assessments are already made in late 19th century neighbourhoods. All cost is taken into account with a Total Cost of Ownership TCO assessment. In a more or less similar neighbourhood Statenkwartier from the period 1890-1910 in Den Haag the consultancy DWA did a TCO assessment about the possibilities of climate neutral heat supply in relation to existing building stock, they did energy and renovation calculations on three reference houses which were similar as the houses in the Zeeheldenkwartier (DWA, 2020). The method that is applied is based on the Vesta-MAIS-spatial-energy-model by the Planbureau voor de Leefomgeving PBL. To levels of renovation/energy are assumed: measures A with EPC label C and the more expensive measures B with EPC label B. The current situation is a central heating of 90-degrees Celsius and no energy measures at all. They conclude that there are just five possibilities: (a) Heat network MT (70-degrees Celsius) (EPC label C is assumed); (b) Heat network LT (50-degrees Celsius) (EPC label B and LT-heating is assumed); (c) Renewable gas (hydrogen) with a boiler; (d) Mix option a and c; (e) All electric with a heat pump and air as source (EPC label B and LT-heating is assumed). Their conclusion was that option a is the most affordable and option b, c and e the most expensive. But option a (like option b and d) needs collectively and urban space to lay out the heat network.

Another assessment is about the neighbourhood Theresia in Tilburg from the period 1850 to 1930 by consultancy CE-Delft. They applied another method to calculate the TCO: the CEGOIA-model (CE Delft, 2019). They conclude that there just four option: (a) All electric with a heat pump and air as source (EPC label B and LT-heating is assumed); (b) Renewable gas with a hybrid heat pump; (c) Heat network MT (70-degrees Celsius) (EPC label C is assumed); (d) Heat network LT (50-degrees Celsius) (EPC label B and LT-heating is assumed). More or less the same options as ECW and DWA. The best business case is option b and c. The problem with renewable gas is the availability. The problem with the heat network is the lack of collectively and the cost and complexity of a secondary network in a dense built neighbourhood with narrow streets.

On a conference about the energy transition on 2019 June 29 the municipality Den Haag mentioned some poor options for all neighbourhoods like energy from the sewer system, biogas, synthetic gas or hydrogen. These are not very likely options according the municipality. For example, 5,000 connections to the sewer system would be needed to heat 100 houses in wintertime. For biogas, synthetic gas or hydrogen there will be capacity and logistic problems if the existing natural gas pipes are used. Two other ineffective options in the hybrid neighbourhoods of Den Haag are either the heat pump with soil or water as energy sources. The problem is the lack of open terrain and water because of the dense proximity of the buildings, facades on the building line, and all of the courtyards being private property.

The two most likely options for providing climate neutral energy to a hybrid neighbourhood is a mix of a collective open secondary heat network MT (EPC label C is assumed) and the more expensive individual all electric with a heat pump and air as source (EPC label B and LT-heating is assumed). The perspective for all neighbourhoods in the future as described for the province Zuid-Holland in: *Energieperspectief 2050 - Energiestrategie regio Rotterdam-Den Haag*. The energy question is now narrowed to what could be the framework within the two energy supply systems could be implemented in late 19th century neighbourhoods. For that reason the typo-morphologic characteristics of these neighbourhoods are relevant.

4 MAPPING THE TYPO-MORPHOLOGY: CASE STUDY ZEEHELDENKWARTIER

This section describes the general typo-morphologic characteristics of hybrid neighbourhood from the late 19th century. These neighbourhoods are found everywhere in the urban regions and are nowadays densely populated areas with primarily small units and households. Originally built as middle class neighbourhoods such as in Amsterdam with: De Pijp; Dapperbuurt; Oud-West (Helmersbuurt, Da Costabuurt); Staatsliedenbuurt-Noordoost and Oosterpark. Rotterdam: Delfshaven; Nieuwe Westen; Middelland; Oude Westen and Agniesebuurt or in Den Haag Archipelbuurt, Stationsbuurt, Bezuidenhout, Regentessekwartier and Valkenboskwartier. As point out, related to the energy question in late 19the century neighbourhoods are the next layers mapped: Morphology; Buildings types; Use of the building; Ownership of the buildings. As case study the Zeeheldenkwartier Den Haag is assessed on these four layers.

4.1 MORPHOLOGY OF A LATE 19TH CENTURY NEIGHBOURHOOD

As Figs. 1 and 2 shows traditionally the public domain and private property are clearly separated by the building line. Facades are built on this building line. The buildings and court yards are private property and the streets belongs to the municipality. The first roads in these neighbourhoods generally followed ownership of strip fields and waterways and morphology of the landscape. The width of building plots is the traditional size of 6 to 8 meters and the depth of the plot is related to the distance between the ditches, depth of the building is usually between 11 and 12 meter with often an extension at the back side. Entrepreneurs (Bouwgrondmaatschappij) usually owns one or more fields, lay out the street in the middle of a strip field and parceling the ground. Small contractors bought two up to ten plots to construct townhouses and sold them to the middle class. Inside the perimeter urban blocks were often small units for poor people who could not afford a townhouse with a front door to the street. The orientation of the streets is the direction of the old strip fields and pattern of canals and ditches.

There was some legislation on the size of the streets in relation to the height of the facade in the local Politieverordening but entrepreneurs had the possibility to change this by negotiating with the municipality. Usually townhouses are three storeys with a pitched roof and the street are about 10 meters. Sometimes streets are wider because of a streetcar, 14 or even 20 meters. Municipalities tightened legislation after 1887 on street plans and after the fin de siècle they began designing their own street patterns. Around 1890 roofs in Den Haag and Rotterdam changed to flat roofs. Later main roads were laid out along these neighbourhoods.

Occasionally an ideal street pattern was designed following examples of neighbourhoods in great European metropoles of the 19th century, street grids with a ronde-point in its centre and a monument. However, this was an exception in The Netherlands. The most abstract street pattern in these neighbourhoods is the deformed grid with perimeter blocks and neighbourhood enclosure streets between the main roads. Neighbourhood enclosure street are sometimes linear with a streetcar or a forming a cross and has a ronde-point in the center with monumental building, statue, fountain or small park. Public buildings are often found along main roads and shops are traditionally located along the crossing neighbourhood enclosure streets. Public buildings are often found along main roads on the edge of the neighbourhood and shops are traditionally located along the neighbourhood enclosure streets. Often these two types of streets were connected to the older streets and roads that connect the neighbourhood to the city. Later, streets patterns became enhanced with the introduction of automobiles and urban renewal projects.

In the case of the Zeeheldenkwartier the edges of the neighbourhood along the canals and main roads were already constructed before the grid was laid out. Furthermore, streets patterns became enhanced with the introduction of automobiles. In the interbellum there was a monumental reconstruction of the Vondelstraat by the architect Berlage. Fig. 2 shows the irregularities of this abstract scheme.

There is a strong cohesion between the brickwork townhouses with pitched roofs and narrow streets, this is an important characteristic of late 19th century neighbourhoods. They give expression to the image of a neighbourhood (Oorschot, 2014).

Problems with a heat network are: Lack of urban space in the narrow streets for the secondary network, plants and storage capacity such as ecovat. It is possible but not easy and expansive; Risk of damage of the brickwork structure of townhouses when the network is laid out the narrow streets. A heat network is possible but not easy and expensive. Problems with all electric and heat pump are noise and vibrations in these dense neighbourhoods and the cost of the expensive renovation to EPC label B.

FIG. 4 Urban space. Source Leo Oorschot.

4.2 HOUSING TYPES OF A LATE 19TH CENTURY NEIGHBOURHOOD

By determining age and type of the housing stock (in relation to energy efficiency) the Agentschap NL & Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (2011) developed a classification system of reference houses which is based on major changes in legislation. This periodisation is used by architectural historians and municipalities for various publications and is linked to important changes in society, which lead to change of legislation on buildings and urban planning. Important milestones in legislation on buildings are the local *Politieverordening* of the 19th century, local *Bouwverordening* 1905-45, *Bouwverordening* 1946-1991, *Bouwbesluit* 1992-2020 and *Besluit Bouwerken Leefomgeving* 2021.

Types of houses are related to de kind of neighbourhood, size of the plot, construction period and legislation at that time, the used materials, shape of the roof and way of inhabit the house. Original construction period of different buildings. Periodisation is often linked to great changes in society such as world wars and change in the electoral system. These events lead usually to a change of legislation and building culture. The hybrid neighbourhoods of the late 19th century usually comprise buildings from the period 1870 to 1910, the period that the process of suburbanisation and city forming started in The Netherlands, although there was some urban renewal in the period 1965 to 1984. The townhouses have brickwork load bearing masonry construction and facades, and a pitched roof. The urban renewals have concrete load bearing construction, wooden floors and flat roofs. Morphology of the neighbourhood and its buildings is important to determine whether there is room for a heat network or flat roofs for PV(T) panels or whether the inner areas are public or private with space for a heat pump. Buildings from the period 1860-90 usually have pitched roofs and buildings after 1890 also have flat roofs. The urban renewals and new public buildings also usually have flat roofs. Older public buildings such as churches and schools commonly have impressive roofs. There are possibilities for PV(T) panels on the flat roofs.

Energy performance of the buildings in original state is EPC label F or G. After the discovery of a natural gas field in Slochteren in 1959, it was decided to lay out a national gas network. Between 1960 and 1965 central heating with natural gas boilers was introduced in residential buildings and became a standard for all houses by 1967. For the first time in 1975 heat resistance (Rc) for facades and roofs of =>1,29 m^2K/W was demanded. Most old townhouses in hybrid neighbourhoods were constructed in the period of the local *Politieverordening.* The most townhouses and urban renewals in the Zeeheldenkwartier are heated with natural gas boilers and an hydronic heat distribution system of 90-degrees Celsius to all parts of the dwelling with radiators in each room, some still have gas heaters.

Architectural value of buildings and urban ensemble is usually well protected by the municipality. The neighbourhood zoning plan of most hybrid neighbourhoods is based on maintaining existing buildings. Furthermore, these neighbourhoods are often designated areas by the municipality because of their architectural and urban value. This means that only a box-in-box-renovation is allowed to have a more energy efficient building, and no heat pumps on the facade on the street side. Furthermore, residents are proud of their neighbourhood with its architectural quality. Next to the zoning plan and the periodisation is the architectural valuation of the buildings in the area. Townhouses are usually not listed by the municipality because of their architectural quality. Only public buildings in the neighbourhood are municipality-listed and some are nationally-listed as a building with an architectural value (Oorschot, 2014).

Because the quality and variation of facade architecture and ownership a box-in-box-renovation of the individual houses is recommended. As point out, with heat supply are two options the collective heat network MT (renovation to label C) and the individual all electric with heat pump (renovation to label B). On the flats roofs PV(T)-panels could be applied. In the gardens and on the flat roofs heat pumps are possible (Oorschot et al., 2018; Oorschot et al., 2019).

FIG. 5 Periodisation of the buildings. Source Leo Oorschot.

4.3 THE USE OF THE BUILDINGS

There is a relation between the building type and use or function of it and the kind of street. The function of a building is defined in the building act as either for living; meeting; detention; health; industry; office; guest accommodation; educational; sport; shop or another functionality. All of these functions are recorded in neighbourhood zoning plans. Usually shops, small businesses, restaurants, bars, and guest accommodations are found along the neighbourhood's cross of enclosure streets. Along the main streets and edge of the neighbourhood are supermarkets and public amenities such as schools and healthcare facilities (Oorschot, 2014).

FIG. 6 Map Use of the Building. Source Leo Oorschot.

4.4 THE OWNERSHIP OF THE HOUSES

The old townhouses are usually privately owned and urban renewals are usually rentals from housing associations. The traditional Dutch down-up-townhouse with a ground and an upper floor apartment (beneden-boven-woning) and a front door directly on the street was designed in the 19th century as a divided townhouse and it is usually private owned. However, data provided by CBS shows that many private owned townhouses were divided into three or four small apartments for rentals (so called 'buy-to-let') (https://cbs.nl/; https://allecijfers.nl/). According to the CBS about 80% of the landlords own just one house. A hybrid neighbourhood such as the Zeeheldenkwartier is 62% private rental and 90% of the dwellings are apartments. Just 10% are real townhouses and 16% is uninhabited. Usually young inhabitants and small households are living in small apartments of the divided townhouses.

FIG. 7 Map Ownership of the Buildings. Source Leo Oorschot.

5 DEBATE AND REFLECTIONS

A Living Lab Zeehelden was organised five expert meetings for the Zeeheldenkwartier in the autumn of 2018 and LDE Conference Heritage and the Sustainable Developments Goals at TU Delft was attended in 2019. The expert meetings comprised a number of lectures and debates about providing climate neutral heat in the Zeeheldenkwartier. Scientists from the TU Delft, civil servants from the municipality, specialists from consultancies, corporations, energy companies, housing associations, frontrunners of other neighbourhood organisations dealing with the energy transition, and residents of the Zeeheldenkwartier were all present. The first lecture was given by emeritus professor Kees Duivesteijn and the last one by alderman Liesbeth van Tongeren. Several issues were addressed at the living lab and conference, results of the debates are:

- Narrow the problem and insulate the dwelling with a box-in-box-renovation, EPC label B (heat pump) or C (heat network);
- Narrow the problem to the base load heat/cool of demand and not the peak load, provide the peak heat load by a centrally regulated electricity network or reneweble gas;
- Narrow the problem and leave usage of household energy outside the neighbourhood energy plan. Behaviour of people and size of households are of great importance for the heat demand. However, this has no relation to the type of neighbourhood;
- Due to a lack of heat capacity mix different climate-neutral heat systems; do not choose one heat supply for the entire neighbourhood. Make use neighbourhood characteristics such as building types and positions. Combine central, local heat networks and all-electric solutions;
- Due to a lack of construction capacity (of service systems), spread the energy transition over a longer period of time and apply an integrated box-in-box-renovation. Quality improvement, energy reduction, and a new heat supply for the dwelling could be combined. When a house changes ownership, it could first be renovated in uninhabited state. In addition, continual technical and material innovations make the energy transition of buildings even more efficient in the future;
- Because of the impact on the living environment and quality of the buildings in the different neighbourhoods the municipality should coordinate and facilitate the energy transition in each neighbourhood and develop a clear framework and legislation on heat networks, heat pumps, PV(T)-panels in relation to the typo-morphology of the neighbourhoods.

6 CONCLUSION

The aim of this study is to research a framework for a feasible climate neutral energy plan for hybrid neighbourhoods of the late 19th century in the urban regions of The Netherlands. The two best options of heat supply in are a heat network MT (with industrial waste energy from Rotterdam, local geothermal energy as energy source in the province Zuid-Holland) and all electric with heat pumps (with air as heat source). The typo-morphologic characteristics of these neighbourhoods are a deformed grid based on old strip fields between main roads. Along the mains streets the public buildings. The neighbourhood had enclosure streets (often with streetcars) with shops and narrow residential streets with townhouses with the façade on the building line. Public spaces are rond-points in the centre or squares with public buildings. The perimeter urban blocks are closed and have private courtyards. The townhouses are varied from 120 to 240 m^2. There are three variations: a townhouse as one dwelling, a townhouses with a unit on the ground floor and a unit the first and second floor. A townhouse that is split in three or four units. The urban renewals are usually apartments. The households are small and the most residents of the neighbourhood live in rental units in split townhouses. The best strategy is that individual townhouses need an integral box-in-

box renovation aiming at EPC label B (heat pump) or C (heat network) in uninhabited state and over a longer period. The urban renewals of housing association could apply he heat network. Also public buildings such as schools and institutes, and buildings dealing with healthcare along the main roads. Air-water-heat pumps could be applied in the better insulated houses that already have a central heating system. Air-air-heat pumps could be applied to small apartments in the split houses. Some general recommendations to municipalities are therefore:

- Develop rules for the aesthetic fitting of all elements such as PV(T)-panels, energy roofs, heat pumps, heat stations, and on insulation that could damage the architecture of the neighbourhood.
- Take initiative in organising energy cooperatives of users and not building owners. Unburden tenants and residents who do not know what to do.
- Plan and implement legislation and a framework for:
- Insulate to mandatory EPC label B or C of rental unit;
- Sound and vibration of 40dB (A) of heat pumps;
- Heat production in summertime by heat networks and heat pumps because of heat stress.
- Damage to the old brickwork buildings with the layout of heat networks.
- Due to a lack of heat capacity, mix different climate-neutral heat systems.
- Due to a lack of construction capacity (renovation and service systems), spread the energy transition over a longer period of time and apply an integrated box-in-box-renovation.

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