Tilburg: A Road Map for becoming a Zero-Carbon City in 2045

Erik Alsema, Jappe Goud, Geurt Donze, W/E Consultants Sustainable Building, Utrecht, The Netherlands
Martin Roders, Tilburgse Woonstichting, Tilburg, The Netherlands

Abstract
The City of Tilburg wants to become a zero-carbon city by the year 2045. For this purpose the various policy options have been investigated and a route map for reaching this situation has been developed. In this paper we first discuss how a clear definition of the policy target of net zero-carbon can be established. This definition concerns among others the choice which options for CO_2 mitigation will or will not be allowed. Secondly scenarios have been developed for achieving a net zero-carbon building stock for the three housing associations in Tilburg. Starting from a full assessment of the present CO_2-emissions of the building stock these scenarios investigate the possibilities for improvement of the existing housing stock, taking into account autonomous portfolio developments as well as intensified improvement programmes. Furthermore the contributions from new-built low-energy houses are considered as well as potential for generation of renewable energy on or for the total housing stock. With this approach we show that it is possible to realize a net zero carbon situation for the housing stock. We finish with a list of key action points for cities that want to develop an action plan for reaching a zero-carbon situation.

Introduction

The City of Tilburg and the Social Housing Organizations (SHO) take climate change seriosly. It is for that reason that the municipality has drawn up a declaration which was signed by the four SHO's of Tilburg among more than 40 other local enterprises in the beginning of 2009.
The goal of the declaration is to become a zero-carbon or climate neutral city by the year 2045. Although this target is still several decades away, action already needs to be taken now in order to achieve this goal. The assignment of the declaration ties in closely with the energy saving policies of the SHO's that have been joined forces on this issue since 2002, in 3 consecutive 'energy covenants'. During the recent covenant (2006-2010) the SHO's have mapped the energy performance of the existing building stock. All dwellings were provided with an energy label.
A logical phase after the inventory is the creation of a long term perspective for adapting the building stock. The climate declaration came in time to provide the overall goal for such a long term plan. Main question however for the SHO's was: Is it possible to reach a zero carbon situation for their buildings by 2045. For this reason the Tilburg SHO's together with the municipality of Tilburg commissioned W/E Consultants to investigate this question and to develop a Roadmap towards the goal of a zero carbon building Stock. The Roadmap developed byW/E showed that the target can indeed be achieved.
The year 2010, which is the last year of the 3rd energy treaty, will be used to explore the possibilities of establishing a 4th covenant, where SHO's and municipality agree on what concrete measures will be taken to make their building stock climate zero carbon. The guidelines provided by the zero carbon roadmap will serve as a base for the agreement.

Project definition

In this paper we consider two questions concerning the zero carbon planning. We focus here on the carbon emission from housing stock owned by the three housing associations in Tilburg.
The first question concerns the precise definition of the zero carbon target: what are the system boundaries and what means exactly will be allowed in order to realize the zero-carbon target. For example, should all emission reductions be realized within the city borders or can reductions also be

* P*resented at the SB10 Sustainable Building Conference Western Europe, 11-13 October 2010, Maastricht, Aachen, Liège.*

"imported" from outside the city. This discussion should result in an unambiguous and transparent definition of the local policy target for 2045.
The second question we will address is how the housing stock in Tilburg can make the transition towards a zero carbon situation. How much can or should be achieved by reducing energy demand from existing houses, what targets should be set for the energy performance of new dwellings and what can be the role of renewable energy in this development? Together with W/E Consultants the three housing associations in Tilburg have developed a common road map to set out the priorities with regard to their own housing stock. We will discuss the research that was conducted for the development of this road map.

Definition of the zero carbon policy target

In a recent report a definition framework for zero energy and zero carbon building projects has been described [1]. This framework discerns three aspects of the definition, namely: 1) the goal, 2) the scope and 3) the means. Furthermore we discern the project boundary which encloses the buildings themselves and the "system boundary" which encloses not only the project but also all energy conversion processes that are necessary for operating the buildings (i.e. electric power plants). As is usual the "net zero carbon" situation is defined as: "zero emission when summed over a full year". It is important to realize that these emissions are to be measured on the system boundary and not on the project boundary. For a further explanation of these concepts see [1].
Although for the Tilburg case the overall goal was already established by the municipal climate plan the specific target for the housing corporations was further detailed in line with above-mentioned framework. It was decided that the *goal* for 2045 would a zero carbon situation for the operational phase of the buildings only, that is without consideration of carbon emission embodied in the building materials. Energy consumption by households is to be included in the carbon accounting with the restriction that the housing associations could not take any final responsibility for this part of the emissions.
Not surprisingly, the *scope* was defined as all the housing complexes owned by the associations[1]. Some discussion was needed to establish precisely the means that are allowed for reaching the zero carbon target (see Table 1). It was decided that "external energy saving" that is energy saving occurring outside the project boundary (i.e. heat supply from CHP to a district heating system) can be accounted for the zero carbon goal. Also external renewable generation, e.g. certified green electricity that is purchased by the associations or households, can also be accepted for the zero carbon accounting. Carbon compensation schemes, nuclear power and carbon capture, on the other hand were not marked as allowable measures.

Of course a net zero carbon situation does not yet imply that we will also have a zero-impact situation. There are several other negative effects from buildings, with regard the environment the environment and otherwise. However, from Life Cycle Assessment it is also known that many environmental impacts are ultimately related to fossil energy winning and combustion (reference, date). Therefore the quest towards zero carbon emissions will have positive effects also on other environmental themes than just climate change.

[1] The office buildings of the associations were not included in the roadmap study

Table 1: Overview of the target definition for Net Zero Carbon for the Tilburg social housing study

Target: **Year:**	Net Zero Carbon (during operation phase) 2045
Scope:	Houses of 3 corporations in Tilburg
Means:	
Energy saving – Project	Yes
Energy saving– External	Yes
Renewable generation – Project	Yes
Renewable generation– External	Yes
CO2-compensation – Project	No
CO2-compensation – External	No
Nuclear – Project	No
Nuclear – External	No
CO2-capture and storage – Project	No
CO2-capture and storage – External	No

Roadmap for a zero carbon building stock

In order to develop a Roadmap for a zero carbon building stock for the Tilburg housing associations [2] we developed a new stock model which focuses on CO_2 emissions and CO_2 reductions. The model starts from the present composition of the buildings stock in terms of building age and energy performance. The latter data are based on the energy performance audits for the EPBD obligation (see Figure 1). Our model then considers developments in the building stock taking into account yearly rates of building sales, demolition, and new construction. In line with existing practice the new construction rate is taken to be equal to the selling rate. Building improvement is also an important parameter in the model, especially where it regards improvements in the building's energy performance. Both an annual improvement rate and an improvement factor, specified as the achieved reduction in primary energy demand of the building, may be specified for each building type (i.e. construction year and label class) and for each 10 year period until 2050.
For new buildings (90 m^2 gfa) the energy performance requirements from the Building Code have been considered, with the foreseen reduction towards a net zero energy standard by 2030 and further improvements beyond that time (see Table 2).

Table 2: Requirements for new houses in terms of primary energy consumption (building-related only), with indicative values for the Energy Performance Coefficient and CO2 emission.

Construction period	**E-consumption primary (GJ/house/yr)**	**EPC***	**CO2 emission (kg/house/yr)**
2010-2020	18	0,50	1040
2020-2030	11	0,30	630
2030-2040	9	0,25	510
2040-2050	9	0,25	510
** EPC is the Dutch Energy Performance Coefficient; EPC values are indicative only and excl. PV; because PV is not accounted here, it seems as if no "net zero energy" situation is reached for houses after 2030.*			

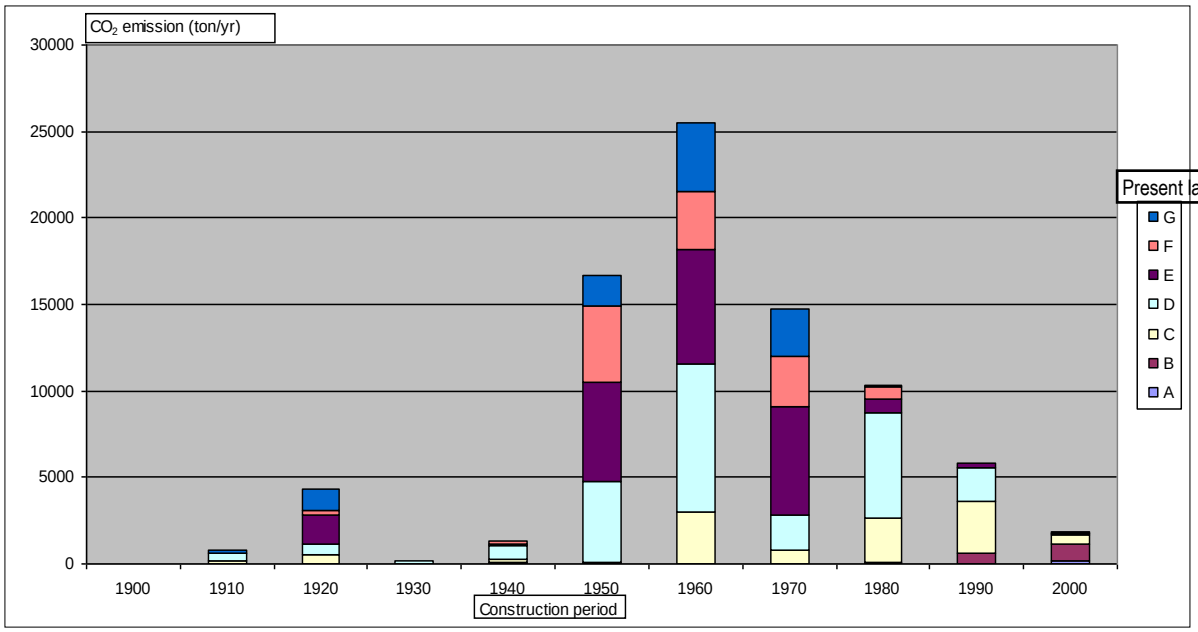

Figure 1: Yearly greenhouse gas emission from the building stock for the year 2009, broken down by construction period and by energy label class. Total stock comprises some 28,000 houses.

Also the introduction of renewable energy sources for use by the buildings and the building inhabitants has been described by the model. We discern two types of renewable options which are treated differently by the model. Firstly there is a number of renewable options, like solar hot water boilers and heat pumps which cannot be easily evaluated in terms of generated energy but which are considered in our model as heat demand reduction measures, i.e. their contribution is already incorporated in the demand data of table 2.
Secondly we have options like PV, wind turbines, sustainable heat supply (e.g. from biomass) and the purchase of green electricity which we have accounted separately from the buildings' energy demand (even though some installations, like PV, will probably be placed on those buildings). The latter renewable options are expressed as a *CO_2 emission reductions* which are finally accounted on the level of the building stock where they should compensate the remaining CO_2 emissions from the buildings.

With this model a number of scenarios have been assessed for the development of emissions from the existing and new housing stock and for renewable energy generation until 2050. Figure 2 shows the development of the emissions from the buildings in the so-called Reference scenario which is based on an extrapolation of existing policy targets for the Dutch social housing sector until 2020 ("Aedes-covenant").. One can observe that the emissions from the existing housing stock, and especially those constructed before 1970, will continue to dominate in the emissions for several decades. New buildings on the other hand have only a relatively small contribution.
In the Reference scenario we also assume a modest growth of renewable sources. Figure 3 subsequently shows both the CO_2 emissions from buildings and the emission reductions by the renewable options. As we can observe, the top-most line of the buildings' emissions (in red) and second solid line from the top (in green) of the emission reductions do not cross before 2050, implying that no zero carbon situation is reached within this scenario.

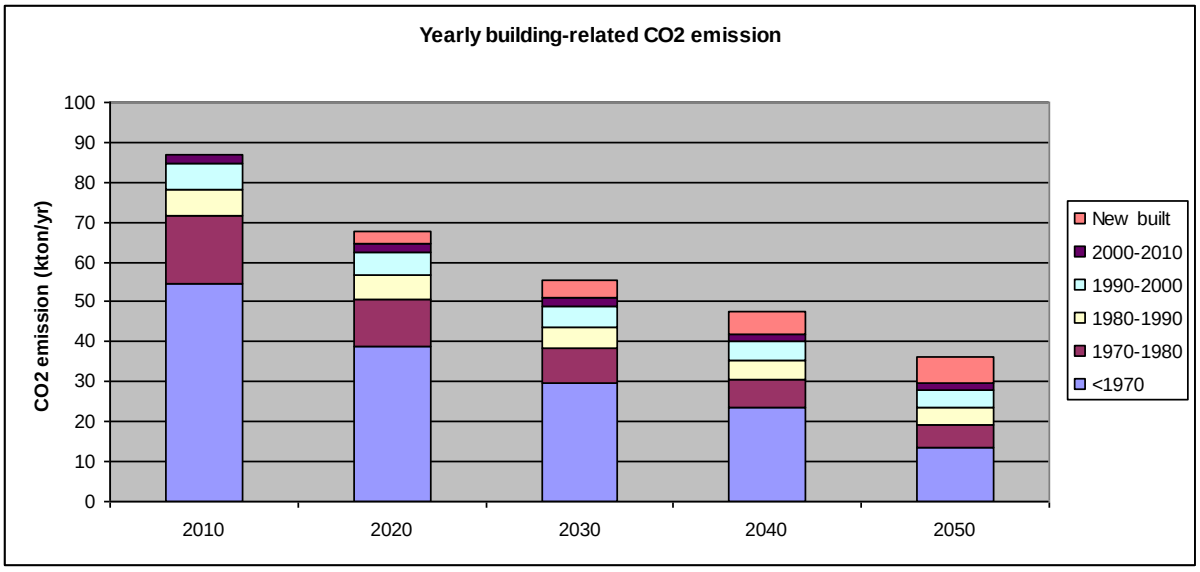

Figure 2: Development of the GHG emission (in kton/yr) from the building stock in the Reference Scenario, with a break down by construction period ("New built" = construction after 2010). Emissions from domestic energy consumption (i.e. household appliances) are not included here.

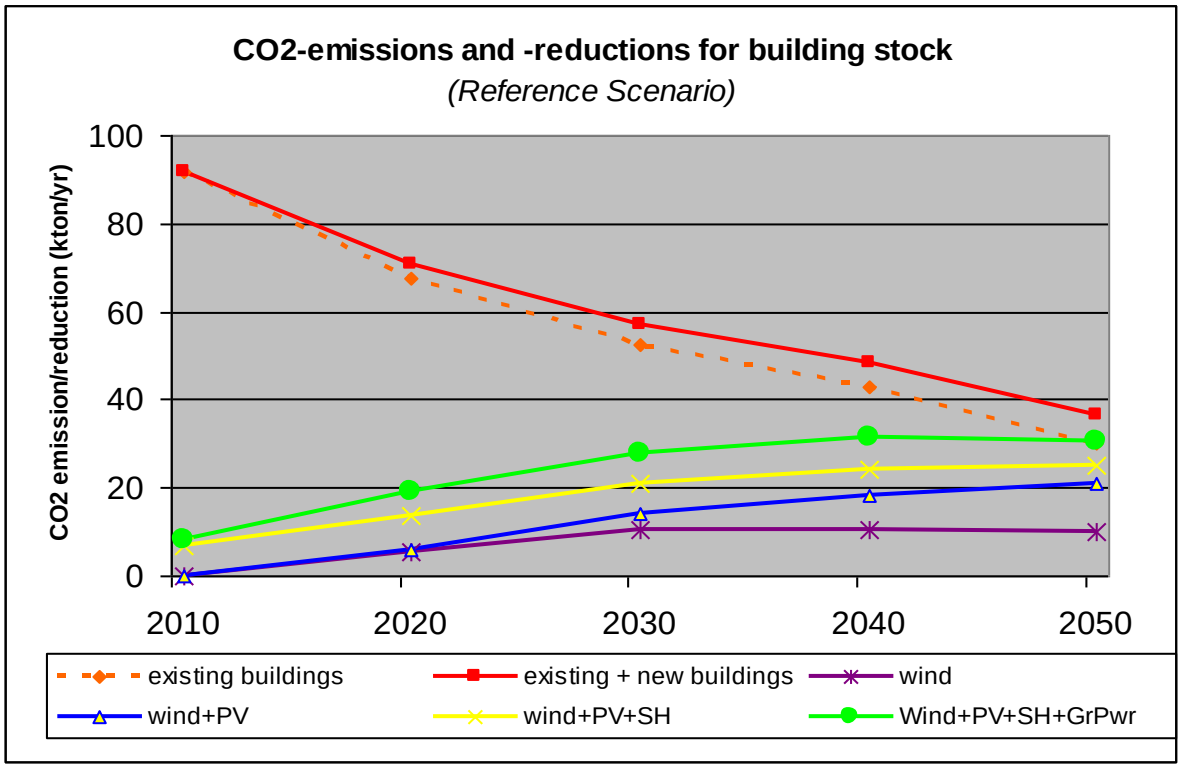

Figure 3: Development of CO_2-emissions by buildings and emission reductions by renewable energy generation in the Reference Scenario (SH= Sustainable Heat supply, GrPwr = Green Power supply).

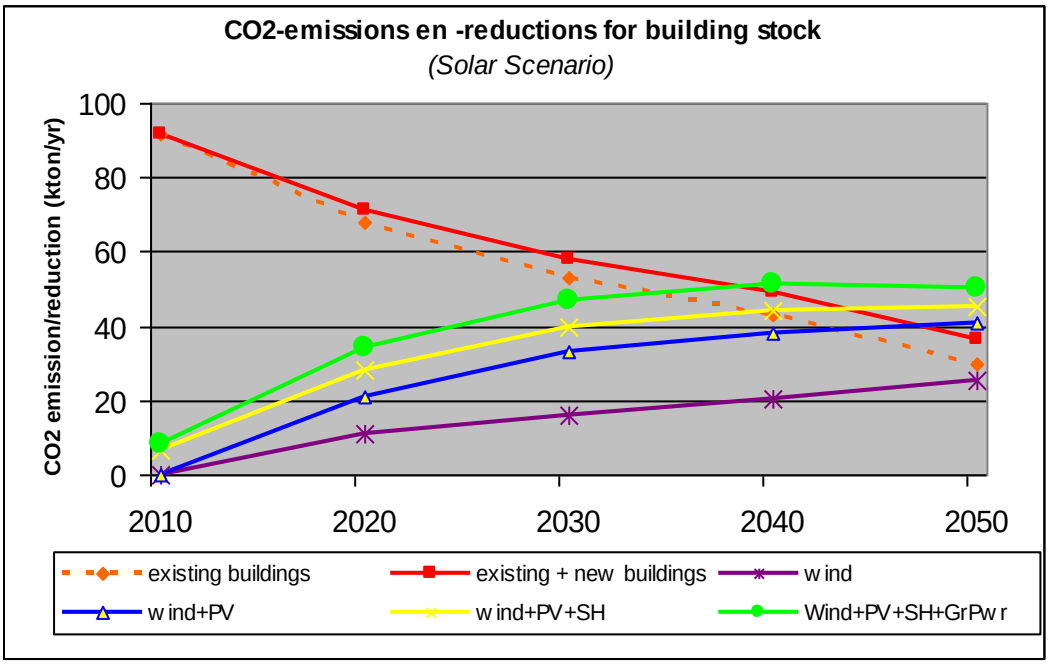

Figure 4: Development of CO2-emissions by buildings and emission reductions in the Solar Scenario (SH= Sustainable Heat supply, GrPwr = Green Power supply).

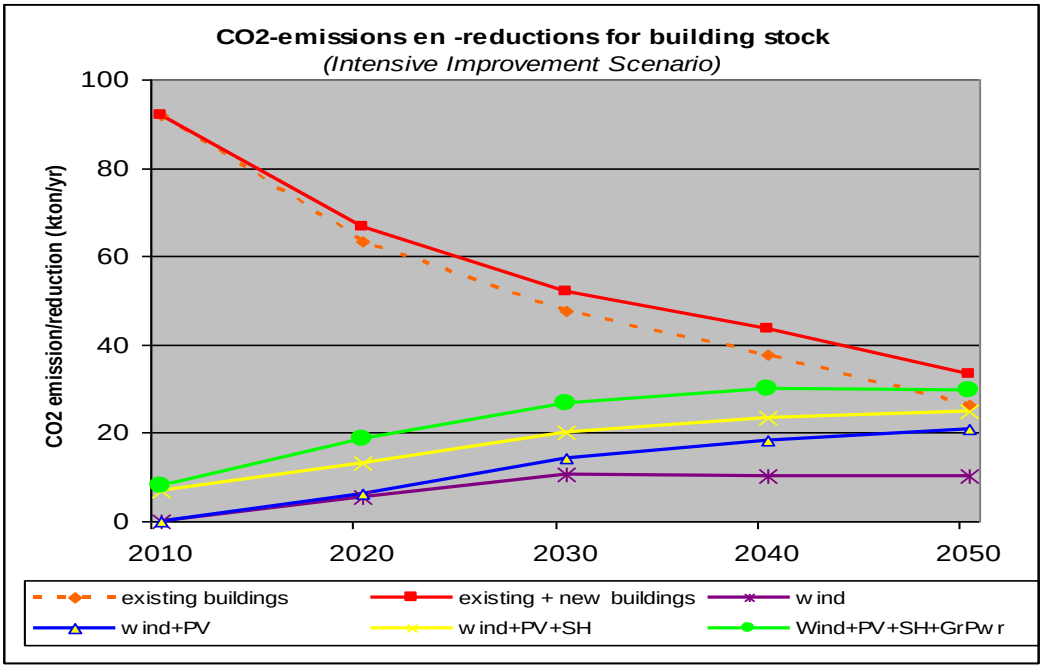

Figure 5: Development of CO2-emissions by buildings and emission in the Intensive Improvement Scenario (SH= Sustainable Heat supply, GrPwr = Green Power supply).

In the Solar scenario of Figure 4, however, which assumes a strong growth of renewable installations and of green power purchases a zero carbon situation is reached around 2040, showing that the zero carbon policy target can indeed be reached. Our financial analyses show a drawback of this approach, namely that it may require 3 times more investments in the coming decade as the Reference scenario. A third scenario (Figure 5) which assumes a more intensive programme of building improvement combines a number of attractive features such as lower investments than the Solar Scenario, a faster emission reduction from the buildings and prospects for a zero carbon situation around 2050. We want to remark here that a faster pathway of emission reduction has advantages from a climate policy perspective (i.e. lower cumulative emissions to the atmosphere) which are overlooked when one focuses only on zero carbon achievement for a certain year.

Based on our analyses we have recommended a roadmap for the Tilburg housing associations which focuses on buildings improvements first and starts with the development of renewable options somewhat later. The total investment costs in the first ten years for this scenario are estimated to be less than 130 M€, with a gross return on investments of at least 4%. We have concluded that this last approach has advantages from three perspectives, namely from the viewpoint of the investor, for the climate policy and for building inhabitants.

Conclusions

We have shown a new approach for cities or housing associations that want to make a transition to a net zero carbon or net zero energy situation. The approach follows a number of steps to get the target clearly defined and to develop a roadmap towards this target:

- Define the scope, target year and allowed means for your climate policy ambition
- Assess your starting situation in terms of building types, energy performance data, CO_2 emissions and renewable generation
- Asses the potential for exploitation of renewable energy resources within your community;
- Investigate the prospects for reaching a net zero carbon (or energy) situation by means scenario studies for building stock development, building improvement and renewable energy exploitation;
- Based on the scenario results select the approach that best fits with your ambitions, investment budgets and other building portfolio objectives;
- Elaborate this approach into a 5 year action plan which identifies key action points, budgets and targets;
- Evaluate the progress after 5 years and update your action plan for a new period.

For the Tilburg case we have used this approach to demonstrate that it is realistically possible to make the transition towards a zero carbon housing situation, and to describe which concrete steps should be taken on the short term to work towards this goal. The approach and tools that have been shown allows housing associations and other real estate owners to integrate energy performance and CO_2 emissions into their portfolio management strategy for the housing stock. In this way climate policy goals can become an integral part of the overall strategic planning of the organisation. With their proactive approach the municipality of Tilburg and the three Tilburg housing associations belong to the front runners in the Netherlands where it concerns climate policy.

References

[1] E.A. Alsema, H. Hoiting, E. Roth (2009). Firm Ambitions, Clear Language, A framework for establishing targets and means for climate, energy and CO_2 neutral building projects (in Dutch). Utrecht: W/E Consultants in commission by PEGO/SenterNovem. http://www.senternovem.nl/energieneutraalbouwen/publicaties/stevige_ambities_klare_taal_definitiestudie_.asp

[2] E.A. Alsema, J. Goud, G.J. Donze, E. Roth (2010). Roadmap for a net zero carbon social housing stock in Tilburg (in Dutch). Utrecht: W/E Consultants in commission by Tiwos, TBV, WonenBreburg, and Municipality of Tilburg.