

# Evaluation Dutch preliminary nZEB requirements for hospital and university buildings

Wim Maassen<sup>1,2\*</sup>

<sup>1</sup>Royal HaskoningDHV

<sup>2</sup>Eindhoven University of Technology

**Abstract.** The need for (nearly) Zero Energy Buildings (nZEBs) in the Netherlands becomes increasingly important due to climate change, increasing energy prices, scarcity of fossil fuels and increasing geopolitical conflicts. In line with the EU EPBD, from 2020 new buildings, including hospital and university buildings, have to fulfil more strict energy requirements. Besides that, also the energy requirements for existing buildings will become stricter to realize an energy neutral built environment in 2050. On request of the Dutch Universities (WO) and the Dutch Academic Medical Centre's (UMC), the Netherlands Enterprise Agency (RVO) assigned Royal HaskoningDHV to study the effect of the preliminary nZEB requirements on the real estate of the sector [1]. The feasibility of the nZEB requirements has been assessed for several representative, recently designed or realized buildings. For the selected hospital and university buildings, the results show that the preliminary nZEB requirements are not yet fulfilled. The requirement that 50% of building related energy should be of a local renewable energy source seems not to be feasible for both hospital and university buildings. Based on the results and recommendations of the study, a letter to the Dutch minister of the Ministry of the Interior and Kingdom Relations was sent and included a strong request to incorporate these in the definitive nZEB requirements, which will be set at the end of 2018.

## 1 Introduction

One year earlier than planned, the nZEB regulation will be put into practice on the first of January 2020. Dutch Minister of the Ministry of the Interior and Kingdom Relations, Mrs. Ollongren, has written in the letter that not only new requirements are being introduced, but also the calculation method is about to be altered. The provisional nZEB requirements were already proposed in 2015 and led to many questions regarding their feasibility, in particular regarding the demand for more than 50% renewable energy generation on site. These provisional requirements from 2015 are presented in Table 1.

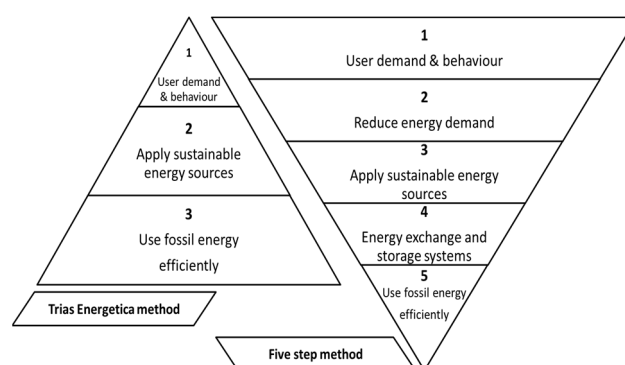
**Table 1** Provisional nZEB definitions (2015).

Building function	Energy demand [kWh/(m <sup>2</sup> .y)]	Energy use [kWh/(m <sup>2</sup> .y)]	Sustainable energy [%]
Dwellings	25	25	50
Offices	50	25	50
Schools	50	80	50
Health Care facilities	65	120	50

The current Dutch energy performance requirements for new buildings, which have to be met until 2020, are expressed in a dimensionless number E/E<sub>set</sub>, which is the quotient of the calculated and the set admissible amount of Energy use.

Among most concerned parties are university buildings and hospitals, consisting of several (often high rise) buildings. The consequences of new regulations need to

be known before renovations and new constructions can be planned. Therefore the aim of this study was to discover whether current actions and practices are in line with upcoming changes in regulations in order to assure a future-proof design of healthcare facilities [1]. For this reason a number of representative buildings were selected for investigation, all being recently designed and realised projects. The methodology used in this study originates from an extended version of "Trias Energetica". This approach, used for an energy-efficient building design, has been upgraded to a 'Five-Step Method', as can be seen in Figure 1. The additional steps to the original approach are: user demand and behaviour (step 1) and energy exchange and storage systems (step 4).



**Figure 1** Building design approaches: 'Trias Energetica' versus the upgraded 'Five Step Method'.

\* Wim Maassen: [wim.maassen@rhdhv.com](mailto:wim.maassen@rhdhv.com)

## 2 Case study analysis

The hospital building Bernhoven was selected for a more in-depth analysis. It's a 43,100 m<sup>2</sup> facility, with around 21,600 m<sup>2</sup> of healthcare with bed area, 16,600 m<sup>2</sup> of area classified as "other healthcare", 3,900 m<sup>2</sup> of office space and 1,100 m<sup>2</sup> of gathering functions. Four different cases have been prepared, trying to comply with the required energy use [120 kWh/(m<sup>2</sup>.y)], as stated in nZEB definitions for healthcare facilities see Table 1. Table 2 presents selected parameters of the reference scenario and changes that have been implemented in the four following cases.

**Table 2.** Changes introduced in Cases ZH10, ZH11, ZH13 and ZH20 compared to the reference case (REF).

REF	
1	Lighting control: room, sweep and daylight
2	Rc = 4 W/m <sup>2</sup> .K; HR++; Shades; Infil 0,6 l/(s.m <sup>2</sup> ); Heat recovery 70%; lighting 9 W/m <sup>2</sup>
3	
4	
5	Cogeneration of Heat and Power; Boiler; Absorption Chiller; Chiller

Changes in ZH10 ↔ REF	
1	Lighting control: detection in area no beds Ventilation: CO2 control
2	Rc = 9 W/m <sup>2</sup> .K; Tripe gl; Infil 0,2 l/(s.m <sup>2</sup> ); Heat recovery 90%; lighting 9 W/m <sup>2</sup> ; HTC & LTH
3	PV-50% Roof: 4750 m <sup>2</sup>
4	Acquifer Thermal Energy Storage
5	Electrical Heat Pump

Changes in ZH11 ↔ ZH10	
1	
2	lighting 8 W/m <sup>2</sup> ; Shower Heat Recovery
3	
4	
5	

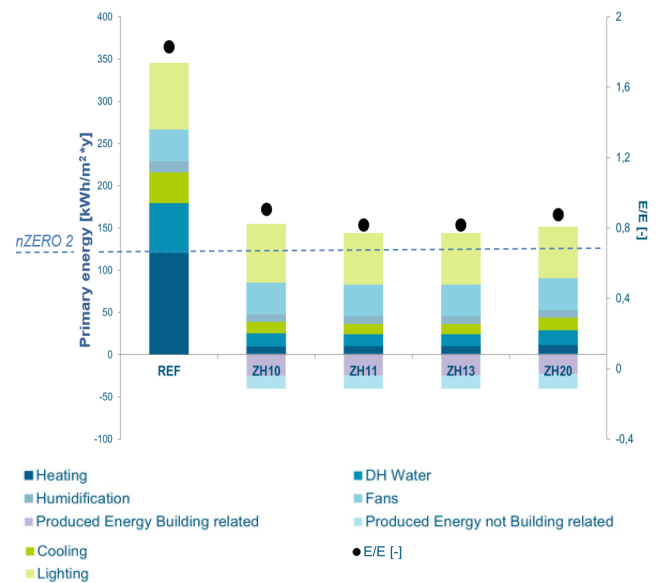
Changes in ZH13 ↔ ZH11	
1	
2	Roof-Rc = 12 W/m <sup>2</sup> .K
3	
4	
5	

Changes in ZH20 ↔ ZH13	
1	
2	Roof-Rc = 10 W/m <sup>2</sup> .K
3	
4	
5	District Heating (efficiency 1.5); Chiller

Various changes have been introduced to reduce the energy consumption. These four cases (ZH10, ZH11,

ZH13 and ZH20) are presented on Figure 2, together with a reference case of a current situation (REF).



**Figure 2** Results of the analysis of four cases, aiming to reduce the energy usage and comply with nZEB regulations.

The results are summarised in Table 3.

**Table 3** Summarized results of the case study for a hospital in Bernhoven.

Variant	Energy demand [kWh/(m <sup>2</sup> .y)]	Energy use [kWh/(m <sup>2</sup> .y)]	Sustainable energy [%]	E/E [-]
Requirement	< 65	< 120	> 50	< 1.00
Ref	95	210	0	1.83
ZH10	60	115	19	0.91
ZH11	55	105	21	0.82
ZH13	55	105	21	0.82
ZH20	55	110	12	0.88
ZH20 => BIO Heat	55	83	39	0.66

The requirement for the energy demand and energy use has been reached when the aquifer thermal energy storage system (ATES) is used instead of a combined heat and power (CHP) plant. However, the third part concerning the percentage of sustainable energy hasn't been achieved for any of the cases, even if energy generation from BIO-mass was included. Hospitals have a relatively high energy consumption per square meter and often consist of several floors. In many cases, even if the roof and facade are fully covered with PV panels, the share of sustainable energy generation cannot be achieved. What makes it even harder is the fact that the cold stored in ATES, under the current EU definition, does not count as renewable energy. In the Netherlands, this system is frequently used and considered as a renewable energy source, see for example BREEAM credit ENE 5.

To reach the nZEB requirements more renewable energy has to be generated on site using additional PV, windmills, bio-mass and/or geothermal energy. However this will depend on the possibilities at the buildings

location. Therefore the generation of renewable energy at larger distances, for example above 10 km, should be taking into account as a solution.

Next the analysis has been conducted for 5 more hospital buildings and 4 more university buildings, see Figure 3.



**Figure 3** The hospital and university buildings which have been considered in this study.

The results are shown in Table 4 and 5.

**Table 4** Summarized results of the case study for selected hospital buildings.

Variant	Energy demand [kWh/(m <sup>2</sup> .y)]	Energy use [kWh/(m <sup>2</sup> .y)]	Sustainable energy [%]
Requirement	65	120	50
Ref Gebouw XL 18.2	63	75	31
Bernhoven	95	210	0
Admiraal de Ruijter	80	150	19
Prinses Maxima Center	50	127	16
Radboud S-Building	67	89	24

Again, no building apart from the reference one managed to comply to all the nZEB requirements. Mostly, none of the three requirements were met. The requirement for energy use was the highest when healthcare with bed is a dominating function.

**Table 5** Summarized results of the case study for selected university buildings.

Variant	Energy demand [kWh/(m <sup>2</sup> .y)]	Energy use [kWh/(m <sup>2</sup> .y)]	Sustainable energy [%]
Requirement	50	60	50
EUT - Flux Building	65	104	18
UU - Education Centre	74	127	27
UU - Geo sciences	41	91	10
RUG - Energy Academy Europe	29	-11	132

The results for 4 university buildings were similar as the results of the hospital buildings although less measures are required to meet the energy demand and energy use requirements. However again the third requirement, regarding sustainable energy, was hard to meet.

### 3 Discussion

The points of attention are, among others, the limited number of building definitions. The assessment can improve by creating better definitions for more building functions and sizes. Especially hospitals should get more attention on the layout of building functions based on ventilation demands seen in practice.

The requirements regarding the amount of ventilation for each room in a hospital differ strongly. Another point of attention is considering the cold of the ATES as renewable energy. Also, more realistic assumptions internal heat gains and the use of hot water in the calculation method should be adapted to give more realistic values.

The value for sustainable energy share should be lowered and made more flexible, depending on the location of the building and the availability of renewable energy sources. If there is no possibility to apply a thermal storage system, other techniques should be considered, such as geothermal energy, all-electric smart grids, biomass/gas in combination with other smart solutions that could help reach the energy requirements.

### 4 Conclusions

The main conclusion of the study is that the provisional nZEB requirements are not met by any of the considered case studies and the requirement on sustainable energy is so strict that it really is very hard to comply with. Therefore the nZEB requirements should be reconsidered.

### 5 Recommendations

The study resulted in the following list of recommendations:

- 1) Increase the number of building types for which separate nZEB definitions are set and provide clarity on the typology of the building for evaluating compliance with the nZEB requirements.
- 2) Consider the cold stored in Aquifer Thermal Storage System as renewable energy.
- 3) Research/optimize starting points for different building functions, particularly for health care facilities such as hospitals. Certain fixed numbers are very high or unrealistic compared to practice.
- 4) Create a new subdivision in building functions to be considered in hospitals, based on ventilation requirements.
- 5) Check whether the nZEB requirements, depending on the location and possibilities, can be implemented in steps. (Example: new construction which is coupled to the existing energy infrastructure on campus)
- 6) Reduce nZEB-3 requirement (Sustainable Energy) for higher education and hospitals. The current 50% is not feasible on site. Proposal: 20% of hospitals and 30% for

higher education. Or: Allow the possibility to generate energy beyond the 10 km limit.

7) The nZEB-1 requirement concerning the energy demand is the most important requirement. Buildings have a lifespan of around 40-60 years, meaning that a good design can provide significant energy savings and reduction in CO<sub>2</sub> emissions during all that time. Research ways to reduce the energy demand and substitute the other two parameters of the regulation with only this one (example: nZEB Hospital Building research project that Royal HaskoningDHV carried out in cooperation with the TU/e [2] and [3]).

8) Collect more practical information, which the standard can be based on. Also provide reliable and proven solutions.

9) Determine financial feasibility based on the EU cost optimality.

10) The Dutch Government should keep the building owners and other stakeholders updated on the development of the final nZEB requirements. At the moment the Dutch government is developing simultaneously a new Energy calculation method, based on CEN standards, and setting the definitive nZEB requirements. On November 20<sup>th</sup> 2018 a new version of nZEB regulations was published and the requirements which have to be calculated with the new calculation method are shown in Table 6 below.

**Table 6** Updated nZEB requirements from November 2018.

Building function	Energy demand* [kWh/(m <sup>2</sup> .y)]	Energy use [kWh/(m <sup>2</sup> .y)]	Sustainable energy [%]
Offices	90 + curve	50	30
Schools	180	80	40
Health Care facilities - no bed	100 + curve	60	40
Health Care facilities - with bed	350	150	30

The Netherlands Enterprise Agency (RVO) assigned Royal HaskoningDHV to study the effect of these new nZEB requirements on the real hospital and university buildings considered in this study. The results will be available in February 2019.

## References

- [1] Maassen, W.H., Peeters, B., *RAPPORT - BENG eisen en Utiliteitsgebouwen voor Hoger Onderwijs en Universitair Medische Centra/Ziekenhuizen, Studie naar haalbaarheid BENG eisen*, Reference: I&BBF1511R001D1.2, Date: October 27<sup>th</sup> 2017
- [2] Maassen, W.H., *REPORT (nearly) Zero Energy Hospital Buildings*, Reference: I&BBE3112R001F0.1, Revision: 0.1/Final, Date: 25 January 2017, [Online]. Available: <https://tc0906.ashraetcs.org/I&BBE3112R001D01%20nZEB%20Hospital%20Buildings%201701125.pdf>

- [3] REHVA Journal 2017/05, *HVAC in Health Sector, NZEB Hospitals case studies*, October 2017, [Online]. Available: [https://www.rehva.eu/fileadmin/REHVA\\_Journal/REHVA\\_Journal\\_2017/RJ5/RJ1705\\_WEB.pdf](https://www.rehva.eu/fileadmin/REHVA_Journal/REHVA_Journal_2017/RJ5/RJ1705_WEB.pdf)

## Appendix

More detailed information about cases is given in the Table below.

Naam	Ag	BENG - indicatoren*			Aandeel Hernieuw- bare Energie [%]	Ag-verdeling			Bijeenkomst [%]	Gemeensch [%]	cel functie [%]	winkel [%]	onderwijs [%]
		BENG 1	BENG 2	BENG 3		Gez klin [%]	Gez n-klin [%]	Kantoor [%]					
		[kWh/(m <sup>2</sup> .jr)]	[kWh/(m <sup>2</sup> .jr)]	[kWh/(m <sup>2</sup> .jr)]									
<b>Ziekenhuis</b>		65	120	50%									
Ref. gebouw 18.2 Gezondheid met bed XL	34.178	63	75	31.1%	50%	44%	15%	3%	7%	31%	0%	1%	0%
Bernhoven	43.106	95	210	14.0%		50%	39%	9%	3%	0%	0%	0%	0%
Admiraal de Ruijter	18.410	80	151	19.0%		35%	40%	14%	2%	8%	0%	0%	0%
Prinses Maxima Centrum	23.483	50	127	16.0%		17%	30%	24%	7%	21%	0%	0%	0%
Radboud nieuwbouw S Gebouw	46.621	67	89	23.6%		21%	25%	13%	0%	40%	0%	0%	0%
<b>HO Gebouw</b>		50	60	50%									
Ref. gebouw 23.2 Onderwijs XL	15.729	45	38	51%		0%	0%	7%	20%	27%	0%	0%	46%
TU/e - Flux Gebouw	21.561	65	104	18%		0%	0%	46%	12%	14%	0%	1%	28%
UU - OWC - Onderwijscentrum	10.437	74	127	27%		0%	0%	0%	6%	21%	0%	0%	74%
UU - GEO - Geowetenschappen	14.094	41	91	10%		0%	0%	71%	22%	6%	0%	0%	0%
RUG - Energy Academy Europe	9.363	29	-11	132%		0%	0%	70%	22%	0%	0%	0%	7%

\*onderstreepte waarden met ENORM v3.40 berekend

\*niet onderstreept met handreiking bepaald