UKP NESK: TNT Green Office in Hoofddorp, Holland

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Strong fluctuating and rising energy prices, depletion of fossil fuel and growing awareness of global warming led to planned actions to reduce carbon dioxide emissions. As the built environment is responsible for nearly 40% of CO_2 emissions new approaches are necessary. In July 2009 the G8, the 8 most important industrial countries, agreed on 80% CO_2 reduction by 2050. In the Netherlands stakeholders agreed with the government to increase gradually to 0-energy new houses over 25% CO_2 reduction in 2012, and 50% CO_2 reduction in 2016.

Recent literature review indicates that there is wide diversity among ZEB definitions [Torcellini et al 2006, Marszal and Heiselberg 2009, Kilkis 2010, Kang et al 2010, Ritter 2010]. In current practice ZEB use the electricity grid both as a source and a sink of electricity to avoid expensive on-site electric storage systems [Hernandez & Kenny 2010].

In 2009 the Dutch government started the so called UKP NESK program to stimulate innovation for energy neutral buildings. UKP means unique chances projects and NESK means 'Towards energy neutral schools and offices' (Naar Energieneutrale Scholen en Kantoren). This program of the Dutch government gave in 2010 funding to projects which show exceptional innovation in the area of energy conservation, sustainability or organization within the building industry, see **Table 1**. Innovation is needed in the construction sector in order to make the transition to energy neutral building. The Ministry of Housing, Spatial Planning and the Environment is therefore giving support to fifteen innovative projects in the commercial and industrial sector. The aim of the NESK scheme is to learn by experience with building for extreme energy efficiency in order to build energy neutral buildings in 2020 and to stimulate innovation. Agentschap NL will take care of supervising the projects, monitoring and evaluation, setting up a Community of Practice, master classes for leading figures and communication.

The Ministry presented NESK certificates to the initiators of offices and schools that are acquiring experience in energy neutral commercial and industrial buildings. These projects are very innovative projects that already meet the energy requirements for 2020. These projects

Table 1. UKP NESK office projects.

	Project	Type	Location	Year	Special features of project
	TNT Green Office	New office	Hoofddorp	2010	Cooperation between principle and project developer, bio heat power combination, heat pump, aquifer
	Villa Flora	New office	Venlo	2011	Technology from green houses applied
	CBW-Mitex	New office	Zeist	2011	Performance contracting by Kropman and Octalix for a guaranteed energy neutral office building.
	Zeswegen	New office	Heerlen	2012	Heatpump uses mijnwater as heat and cold source.

and organizations play as inspiring examples an important part in stimulating other leading figures and the mainstream in commercial and industrial building in The Netherlands.

This article presents one of the current nZEB (Net Zero Energy Building) offices planned and built in the last year. It shows that already an important step can be made from Low energy offices towards nZEB.

TNT Green Office

The TNT Group, a global express delivery service headquartered in the Netherlands, recently announced to move its operations to newly to be developed green office buildings [Eichholtz et al 2009]. TNT Green Office project shows how important it is that a client has a strong and clear vision about the sustainability goals he wants to achieve in their housing. Despite the driving trends sustainable office development is still far from being main stream. One of the causes is the circle of blame; a vicious circle in which the stakeholders blame each other for not initiating the demand or supply of sustainable buildings [Vink 2009]. Breaking this circle of blame was one of the intentions of TNT. The office building of TNT in Hoofddorp (NL) is their first Green Office. Green Offices is part of the ambitious Planet-Me program, by which TNT wants to prove its ambition to become the first emission-free mail and express delivery company in the world. The most important key success factors for sustainable office buildings are [Vink 2009]: 'commitment to sustainability from the involved persons', 'willingness of the end-user to invest in sustainability', 'focus on long term value creation', 'early involvement of all stakeholders in the project' and 'clear definition of sustainability goals'. All these requirements were met within the new Green Office in Hoofddorp, as it should meet the highest standards regarding sustainability: CO_2 emission free, the design should also achieve more than 1000 points under the Dutch green building certification GreenCalc+ and LEED Platinum certified.

The development of GreenCalc started in 1997. The Greencalc+ assessment method is a questionnaire which allows you to estimate how much land it takes to run and maintain your office. It that can be used to calculate what the developers call the environment index of a building. This is done by calculating the environmental impact of the buildings by Life Cycle Analysis (LCA). The GreenCalc+ software consists of four modules, each representing a different aspect of the building characteristics; mobility, materials, water and energy. The input values for this program are divided in the following four groups: Materials: Energy: Water: Travel to and from work.

LEED (Leadership in Energy & Environmental Design) is an American methodology for assessing the sustainability qualities of a building and was developed by the US Green Building Council (USGBC) for the US Department of Energy. The pilot version (LEED 1.0) for new construction was first launched at the USGBC Membership Summit in August 1998 [Lee and Burnett 2007]. The current LEED reference Guide presents detailed information on how to achieve the credits which are divided in the following six groups [Fowler and Rauch 2006]: Sustainable site: Water efficiency: Energy & Atmosphere: Materials & resources: Indoor Environmental Quality: Innovation & Design process.

To guarantee this, TNT entered into cooperation with an experienced consortium in the field of sustainability: Triodos Bank and OVG Development. The sustainability ambition is an essential part of the contract between TNT and the consortium which had not only to develop the building but also had to own the office for 10 years. TNT Real Estate has made an innovative form of contract similar to a DBFMO (Design-Build-Finance-Maintain-Operate) contract with the consortium [OVG 2010]. TNT Real Estate has a contract for 10 years, with a fixed price for water, electricity, heating and cooling. This gives TNT as the consortium's principal hard guarantees in the areas of energy and other sustainability performances. The consortium and end-user TNT are both encouraged to reduce energy consumption throughout the lease period of the building. The consortium acts as an Energy Service Company (Esco) for the tenant and all investments in additional sustainability measures are taken within a ten-year payback period [OVG 2010].

Architect Paul de Ruiter is responsible for the design of the Green Office. He has a clear vision about sustainability and architecture [de Ruiter 2010];

> *"After the release of Al Gore's An Inconvenient Truth, Dutch politicians are prepared to put the environment on the political agenda. However, the Dutch government primarily views sustainable construction in terms of energy-efficient construction, and to this end has decided to implement a more stringent Energy Performance Norm, without giving much thought to the architectural quality, let alone the quality of the building's interior. The results of this approach are smaller windows, more isolation and a balanced ventilation – resulting in, for example, airtight homes and schools that are actually very unhealthy for their users. Not enough oxygen; ex-*

cessive CO_2 levels; insufficient daylight and restricted views; buildings that are too ugly: this can hardly be what was intended. The quality norms relating to comfortable homes, a healthy life and a properly functioning professional and residential environment are far more important than mere energy efficiency. It makes far more sense to base the theme of sustainability on the viewpoint of the end user. Architecture needs to develop a radical service attitude. In other words, it should not only satisfy the demands of the client, but actually exceed them, delivering added value as a result. We can only achieve real improvements by radically addressing the actual needs of the end users, clients and their environment. Only this way, we can create an obligation to really get to grips with innovative solutions that work and as a result have a tangible impact on the world of tomorrow." [de Ruiter 2010]

The design of the TNT Green Office is characterized by sustainability, transparency and connectivity. First a volume study was done to test different volumes regarding criteria like compactness, flexibility, daylight factor, view, building costs and the highest LEED results. The design consists of two rectangular parallel volumes, each six stories high. On the Westside (the Geniedijk) the lower three stories of these two volumes are connected by terrace-like volumes and the upper three stories by connective bridges [OVG 2010]. These connections offer great meeting places for the employees as well. On the Eastside both volumes are connected by a third 'floating' volume. For the TNT headquarters, 16-meterlong concrete floor slabs were used that were made out of recycled rubble and granulate. Due to the long span, fewer supports were needed, which saves material and generates spaces that can be divided up freely [OVG 2010].

Sustainability

The atrium has been designed in such a way that as many daylight as possible can enter and it offers the employees a beautiful view. The atrium and the entrance are clearly connected, and the terrace-like volumes encourage employees to take the stairs instead of the elevator, thereby serving both a health and social purpose [de Ruiter 2011, OVG 2010].

The presence of daylight in living and working areas is of crucial importance to the wellbeing of the working and living environment and also for the health of the user. Daylight gives energy, generates happiness and stimulates productivity [de Ruiter 2010]. Smart window awnings keep out the heat of the sun while letting more than enough daylight enter the building. This way, less cooling and less artificial light is needed. Smart awnings help reduce energy use and increase wellbeing at the workplace. Daylight was the leitmotif in the design of the building, which has a completely glazed north façade. In addition to an optimum interior climate, daylight incidence was at the center of Paul de Ruiter's sustainability philosophy, which goes beyond purely technical aspects: "It has to be about the people who work in the building. You can erect a building that saves energy, yet is still bad for employees. That's not sustainable" [Schueco 2010]. The Schüco mullion-transom FW 50+ was used as a façade system, offering a very narrow profile face widths and large module widths, as well as excellent sound and thermal insulation. Due to their narrow face widths, the window systems AWS 102 and AWS 65 (Aluminum window system) allow for a large amount of glazing. U-value of the glazing units is 1.4 W/(m² K) and the solar heat gain coefficient g is 0.27 or 0.33, depending on facade, corresponding to visible transmittance of 0.5 and

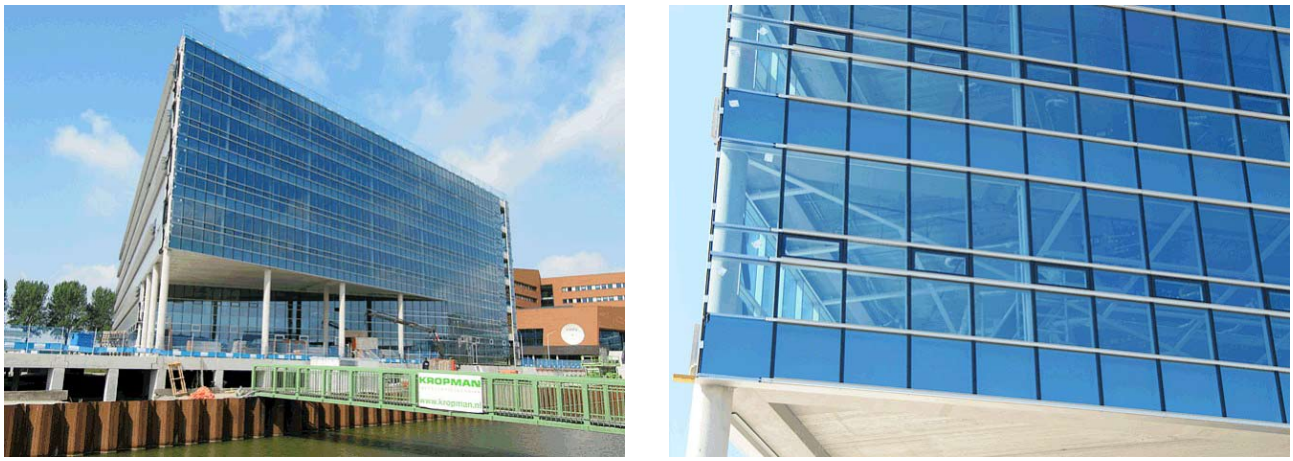

Figure 1. Facade of the TNT Green office building Hoofddorp.


Figure 2. Roof and area of the atrium.

0.6 respectively. Intelligent solar shading louvers were installed on the façade.

Heat load

Goal was to minimize the heating load as much as economical possible made sense, high levels of insulation were applied, see **Table 2**. Also the internal heat gains were reduced as much as possible to reduce the cooling load in summer.

The different equipment types included in the calculation of miscellaneous equipment are: PC's, mLCD monitors, printers/copiers/scanners, communication and A/V, and kitchen en restaurant equipment. The Datacenter equipment comprises the computer server equipment located in the Main Equipment Room and Satellite Equipment rooms, spread throughout the building. This led to the following results: Office rooms 28 W/m², from which persons and equipment 20 W/m² and lighting 8 W/m², total energy use office appliances 19.2 kWh/(m² a) and total energy use of data center equipment 24.0 kWh/(m² a). The breakdown of energy use is shown **Table 3**.

Space heating and cooling energy use

All the measures to reduce the heat and cooling load resulted in a low energy consumption; the proposed design space heating energy use is 9.8 kWh/(m² a) and that for cooling 3.3 kWh/(m² a), which both are electric energy use of heat pumps.

Ventilation

The overall ventilation for the building is done by 4 central air handling units, all equipped with heat recovery systems, see **Figure 3**. HVAC total supply air volume is 111.091 m³/h, static fan pressure 944 Pa for supply air fan and 688 Pa for extract fan, with total fan energy use of 16.8 kWh/(m² a).

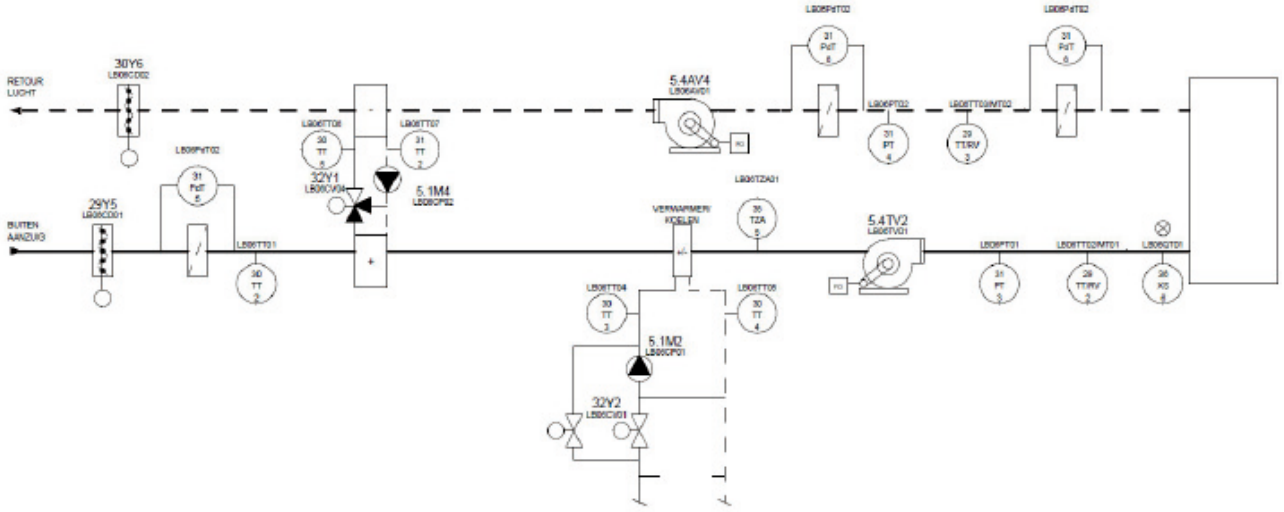

Figure 3. Process and information diagram of central air handling units.

Table 2. Applied levels of insulation.

Construction	Description	U-Factor (W/m²-°C)	HC (kJ/m²-K)
Roof	Roof TNT Green office	0,240	39,8
Ceiling	Gyp. bd. ceiling, radiant barrier	4,229	10,6
Floor	Floor on ground	0,240	190,8
Int. Floor	Floor above garage	0,320	300,5
Interior Wall	CMU Partition	3,282	381,6

Table 3. Simulated energy performance of the building. All specific values are per net floor area. The data center electricity use and heat rejection of bioCHP coolers are not included in the building energy balance.

	Net delivered energy use kWh/(m² a)	**Primary energy factor** -	**Primary energy use** kWh/(m² a)
Heating, electricity to heat pumps	9,8	2	19,6
Hot water, electric boiler	3,5	2	7,1
Cooling, electricity to heat pumps	3,3	2	6,6
Fans	16,8	2	33,7
Pumps	0,7	2	1,5
Elevators	0,8	2	1,5
Lighting (interior)	21,1	2	42,2
Lighting (exterior)	0,8	2	1,6
Appliances (plug loads)	19,2	2	38,3
BioCHP electricity generation	-73,8	2	-148
BioCHP fuel consumption	184	0,5	92,2
Heating energy exported to other buildings (estimated value)	-50	0,5	-25
Total	**137**		**72**
Not included in the building energy balance			
Data center electricity	24,0	2	48,0
Heat rejection of BioCHP coolers (electricity)	10,0	2	20,0

Maximum heating need
Air handling .....28.6 W/m²
Transmission .....14.2 W/m²
Infiltration ..... 8.5 W/m²
Total .....51 W/m²

Maximum cooling need
Air handling .....13.1 W/m²
Cooling load.....41.8 W/m²

Total .....55 W/m²

Divers sustainable measures

Several sustainable techniques are applied: intelligent awning, hybrid ventilation (natural if possible, mechanical if necessary), heat recovery from the extract air, energy-saving equipment and lighting, long term cold/heat storage in the aquifer, on site generation of electricity through the use of bio-CHP (Green Machine) and an advanced building management system. Kropman and Schneider Electric worked together in full transparency, not only on specific components but on the total solution for the energy distribution, building management solution as well as energy management and maintenance. The whole process control management system is based on process control LON FT10IP, bit rate 10Mbs.

Long Term Energy Storage

The surplus heat of heat pumps in the summer and the surplus of cold in the winter are stored below ground level in the aquifer. The stored heat is used through heat pumps to warm the building in the winter, and the stored cold to cool it down in the summer. The electricity for

the two heat pumps of 332 kW is delivered by the bioCHP.

BioCHP

All electricity for the Green Office (on yearly basis) is generated on site in a sustainable way using a bioCHP. For the remainder of the peak demand, green electricity is purchased. This way, the TNT Green Office operates completely CO_2 emission free. The produced heat of bioCHP is supplied to nearby (yet to be realised) office buildings. During the periods when bioCPH heat production cannot be fully utilized, the excess heat is rejected with roof placed coolers.

Figure 4. Ceiling of concrete core activation for heating and cooling, with integrated air diffusers in the ceiling panels..

The bio-CHP installed is a Cummins KTA 19 bioCHP unit of electric power 300 kW with a Stamford HCI 534C generator, which should generate 1.200 MWh/a (73.8 kWh/(m² a)). The bioCHP unit that generates electricity for the building uses biolone as fuel, which is oil produced from slaughter house waste. The electrical efficiency of bioCHP plant is 40% and the total fuel efficiency with heat production 86%.

Solar hot water heater

A solar hot water heating system has been added to the building. The system includes two solar collectors with size of 2.4 m² each. The system contributes heat toward the DHW system. 0.25 kWh/(m² a) of heat is collected on average each year. Since the DHW system comprises electric boilers, the energy contribution of the solar collectors displaces electric energy.

Results GreenCalc+ and LEED

Based on the design and the actual relalisation the Milieu Index Gebouw has been calculated for the TNT Green office [DGMR 2008], the building will have an Environmental Index of at least 1,000 points in accordance with the GreenCalc methodology. This is more than 1.5 times better than the current building with the highest Building Environmental Index [Volker Wessels 2011]. This index is determined on the basis of the materials and the quantities used. During the design and preparation for the construction of the building continuous attention is devoted to assessing whether the choice of materials is the most environmentally friendly and whether the quantities remain within estimates so as to guarantee that the building achieves an ultimate index of at least 1,000 [Volker Wessels 2011]. Not only materials count towards this goal, also how water and energy are treated contribute to a higher index. The TNT Green Office has a bioCHP (combined heat and power production from biofuel) for the purpose of generating power. The high score for energy is due to the compensation effect of applying the bioCHP, without that the score for energy would have been around 220. This would lead to a GreenCalc+ score of 481, still among the best, par example one of the most environmental friendly office buildings in the Netherlands, the 2004 Rijkswaterstaat building in Terneuzen, has a score of 323 [Greencalc 2011].

	Material cost a year		
	design	reference	MIG
Materials	€ 28.473	€ 38.352	135
Energy	€ 0	€ 264.958	∞ / 200
Water	€ 1.138	€ 1.663	146
Total	€ 29.610	€ 304.973	1030 / 481

The LEED assessment takes place in the area of design, implementation, the ultimate use and management. This is tracked in five categories: materials, energy consumption, efficient water use, interior environment and the environment. By way of example: the location is important, therefore including the proximity of the building to the public

transportation network [Volker Wessels 2011]. The methodology even extends to the need for documenting the specific properties of the paints used. These may not contain more harmful substances than prescribed by LEED. In addition, a prescribed minimum quantity of recycled materials must be used and a large percentage of the materials used must be 'regional' [Volker Wessels 2011]. The highest certificate that can be issued under this methodology is the LEED Platinum Certificate and this will indeed be the certificate awarded to the building [olker Wessels 2011].

List of basic information:

Clients	Triodos Bank and OVG Development, Green Office B.1
User	TNT
Address	Taurusavenue 111, 2132 LS Hoofddorp, The Netherlands
Net floor area of the building	**16.136 m²**
Gross floor area building	17.956 m²
Floor area parking garage	7.207 m²
Number of floors	6
Building Occupants	873
Program	Emission free office building with parking garage
Start design	June 2007
Start construction	2009
Delivery	2011
Design	Architectenbureau Paul de Ruiter b.v.
Building physics consultant	DGMR
Structoral consultant	Van Rossum Raadgevende Adviseurs
Building Services consultant	Deerns, Rijswijk
Consultant LEED	B en R Adviseurs voor duurzaamheid
Building company	Boele & van Eesteren
Facade	De Groot & Visser
Building Services contractor	Kropman
Process control	Schneider Electric
EPC value	0,67
GPR result	8,7
LEED	Platinum certificate

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