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ECOLOGICAL ARCHITECTURE IN THE NETHERLANDS A CASE STUDY ON THE "DCBA-DESIGN METHOD" APPLIED IN AMERSFOORT NIEUWLAND

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Summary

This study focuses on the application of the DCBA-design method as a decision-support tool for ecological architecture in the Netherlands. The method provides a framework for a building design team to formulate their own working definitions when considering ecological aspects in a given project. The D variant stands for the normal situation and the A variant for the highest attainable environmental quality. These two variants are often relatively easier to define. Having established these two reference points, the B and C levels can be set as logical points somewhere between the two pre-defined A and D points. The DCBA approach is not meant to limit the design freedom for the architect, but to inform, inspire and stimulate ecological architecture. The DCBA was used in Nieuwland from master plan to housing design. Most of the DCBA variants were selected between C and B. The resulting flexibility allowed many kinds of designs to be made for the houses in Nieuwland.

Introduction

The purpose of this study is to make it clear how the low-energy houses in Amersfoort Nieuwland were designed. Nieuwland is an ecological town constructed between 1995 and 2002. It comprises 4,500 houses and is located in the central part of the Netherlands. Especially, the town is known for the 1MW PV-Project (using photovoltaic generation on a large scale). This paper focuses on the DCBA-design method (DCBA). DCBA was used to define environmental criteria in the project from the master plan to the architectural design. This study analyses how the houses in Nieuwland were designed, with a focus on the energy aspect. The Analysis is based on bibliography, interviews with architects and other stakeholders, and on analysis of the architectural drawings of three selected buildings.

The first section outlines the characteristics of the DCBA-design Method. The second section presents an outline of Nieuwland and the master plan. It also outlines how a few DCBA variants were integrated in the urban design. The third section presents three building examples and analyzes them in the terms of energy as a DCBA theme. The fourth section discusses the results and the fifth section presents the conclusions.

1.DCBA-design method

1.1 What is the DCBA-design method?

The DCBA-design method (DCBA) was developed by the BOOM office in Delft the Netherlands. The method provides a framework for a building design team to formulate their own working definitions when considering ecological aspects in a given project. The DCBA presents reference information for environmental design in a concise and structured manner, thereby facilitating the process of discussing, prioritizing and selecting environmental design strategies. The method works with themes -such as energy, building materials, water, food and waste, traffic- and sub themes -such as heating, solar energy, roofing material, and drinking water-. Each theme and sub theme are described in variants in ascending order of environmental friendliness.

DCBA variants

D variant: (normal situation) current standards without specific consideration for the environment.
C variant: corrections to this normal use, so that environmental aspects are considered.
B variant: minimizing damage to the environment.
A variant: the strictest design requirements concerning the environment

Table 1. Example of the DCBA-method

DCBA Chart: Urban design for Nieuwland Amersfoort (12/10/1998)				
Theme *sub-theme*	D **The normal situation**	C **Correction of normal use**	B **Minimised Damage**	A **Autonomous**
1 Energy	4000m^3 natural gas equiv./househ./yr	3000m^3 natural gas equiv./household/yr	2000m^3 nat.gas equiv./household/yr	only sustainable energy
1.1 generation	power station & gas-pipes	combined heat & electricity generation	sun and wind	seasonal storage
1.2 building energy	10000m^3 natural gas equiv.	7000m^3 natural gas equiv.	4000m^3 natural gas equivalents	local material
: :	:	:	:	:

The four DCBA variants apply to each theme and subtheme. The method has been used both on the building level and on the urban design level, in many projects such as: Amersfoort Nieuwland; the "Energy Balance House" and Vathorst in Amersfoort; HAL Environmental Quality Plan and; GWL site in Amersterdam.

1.2 Characteristics of the DCBA-design method

One important feature of the DCBA-design method (DCBA) is flexibility. The requirements for each variant are benchmarks, which are defined relative to current regulations. D stands for the normal situation and A for the highest attainable point. Having established these two reference points, logical points B and C can be set somewhere between the two. C was the minimum requirement set by Amersfoort local authority. Suppliers that reached point B received a reward for improving the environment. DCBA was one way of generating discussion about abstract issues. For example, with regard to sun orientation it was possible to stipulate precisely what percentage of each house had to be situated between southeast and southwest.

DCBA approach is not meant to limit the design freedom for the architect, but to inform, inspire and stimulate ecological architecture. It is a sort of communication tool for use among different, stakeholders, such as architect, landscape designer, developer, and municipality. DCBA makes it easier for non-specialists to understand environmental criteria and ecological design. When the Nieuwland project started in 1995, by clearly stating environmental requirements and targets, DCBA also helped to stimulate dialogue and enhance trust between various parties, such as architect, builders, developers and so on. The table on the last page is the DCBA-method which was used in Amersfoort Nieuwland. It is composed of 9 themes and 37 sub-themes.

2. Amersfoort Nieuwland

Location: Nieuwland Amersfoort, The Netherlands
Population: 12,000
Houses: 4,500
FIELD: 170 ha
Construction: 1995-2002

This section outlines three examples of urban features which were designed using DCBA: Sound Barriers, Waterways, and Roads. Tables in each example show a selection of themes / subthemes, the corresponding DCBA requirements, and examples of possible design results. The DCBA requirements are subdivided into variants D,C,B and A. For each urban feature, the corresponding table highlights the variants that were targeted in Nieuwland. For example, feature 3.1 stands for land improvement, 3.3 for recreational greenery, etc.

2.1 Sound Barriers

The problem of noise from nearby motorways was solved by building sound barriers surrounding the town. These sound barriers are built on earth banks. The outdoor spaces on top of these banks are used by residents as green leisure areas. Table 2 shows DCBA examples.

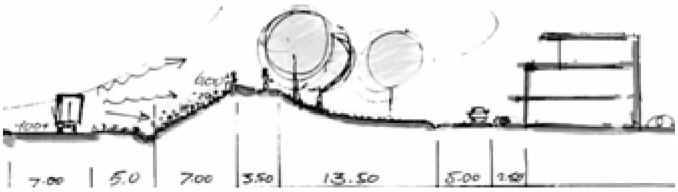


Figure 1. Section of sound barriers

Table 2. Variants and Final Design Results for Sound Barriers

Subthemes	REQUIREMENTS				FINAL DESIGN RESULTS
	VARIANTS				
	D	C	B	A	
3.1 land improvement	if needed, raise by fill (overall)	partial fill, save precious plants	fill under houses and streets only	no fill	Fill under the bank
3.3 recreational greenery	according to standards	greenery within walking or cycling distance	recreation within the neighbourhood	completely integrated	Walking path on the bank
5.3 noise	Noise Abatement Act with	Noise Abatement Act without	quiet facade (front) for every dwelling	natural background	Sound barrier

2.2 Waterways

Half of the site in Nieuwland had many canals. This part of the site is known as the"wet area". The waterways had to be planned from the first stages. The waterways in Nieuwland do not communicate with other waterways outside the town. Instead, water is circulated within Nieuwland, making use of height differences and allowing the water to purify naturally at the rate of 50 %. The waterways were mainly constructed in the wet area and provide recreation to the residents. Table 3 shows DCBA examples.

Table 3. Variants and Final Design Results for Waterways

Subthemes	REQUIREMENTS				FINAL DESIGN RESULTS
	VARIANTS				
	D	C	B	A	
2.1 surface water	intake and distrib. to/from rivers	wetland treatment, storage and level	seasonal storage, intake for extremes	no intake, complete purification	Circulation for 50% purification
3.1 land improvement	if needed, raise by fill (overall)	partial fill, save precious plants	fill under houses and streets only	no fill	No fill of water lands Fill under houses and streets only
3.2 ecology/ nature	small greenery; limited ecology	differentiated dynamic usage	make use of potential soil gradients	ecological infrastructure	Water circulation in the town
3.3 recreational greenery	according to standards	greenery within walking or cycling	recreation within the neighborhood	completely integrated	Waterfront connected to some houses

Figure 2. Map of waterways in Nieuwland

2.3 Roads

Nieuwland consists of four residential areas and a center with commercial and public facilities. It is easy to access the center from each house on foot and by bicycle. On the other hand, it is more difficult for cars to go to a destination, because they have to make detours. Table 4 shows DCBA examples.

Table 4. Variants and Final Design Results for Roads

Subthemes	REQUIREMENTS				FINAL DESIGN RESULTS
	VARIANTS				
	D	C	B	A	
7.1 slow traffic	inferior, detours	defined structure	right-of-way	only method of transportation	Direct, comfortable and safe slow traffic routes
7.3 car traffic	the car is sacred	narrower traffic lanes	subordinate; no right-of-way	car-free neighb., shared car ownership	No through-traffic

Figure 3. Map of roads in Nieuwland

3. Three cases of houses in Nieuwland

This section outlines three housing design examples in Nieuwland. There are several types of houses aiming at energy conservation there. There are also buildings with integrated photovoltaics (PV). Three examples of PV integration are discussed in this item. First, the Zero energy houses, aimed at demonstrating A-level design. Second, the Panta Rhei houses, standard types of integrated photovoltaic. Third, the 56 Houses with Solar Overhangs, located along the sound barriers. The houses are designed to suit the local topography.

The tables referring to each case show the DCBA variants and design results. Each table also highlights the variants which were targeted in the corresponding housing design (e.g. A; B+A; C+B+A; etc). The themes in each table are selected from the general DCBA table: "1.ENERGY" stands for limited use of energy resources; "1.3 Usage" indicates the influence of building layout; "5.1 Solar Orientation" and "PSE/ASE/PV" indicate building orientation and its influence on solar energy (passive, active, photovoltaic).

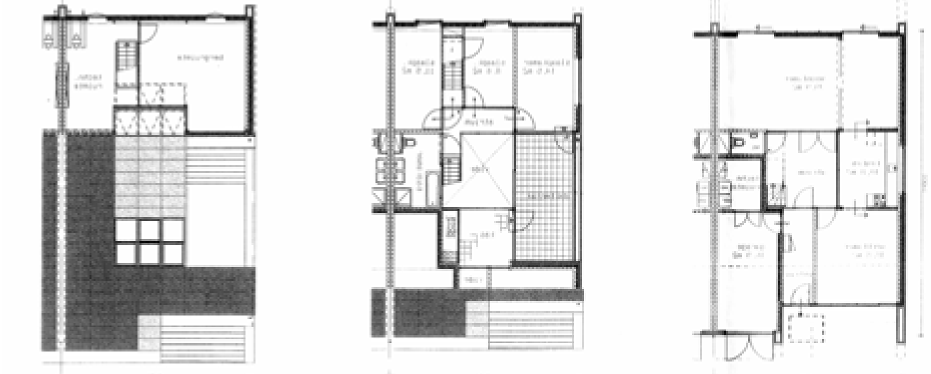
3.1 Case 1- Zero Energy Houses

Total houses: 2
Architects: M.Drok, H.van Zwieten, Boom
Consultants: Ecofys, DWA, Boom
Solar PV panel surface : 78 m^2 and 30m^2 (Transparent)
Peak Capacity (total): 18kW
Average annual production: 15,000kW (per house 7,500kW)

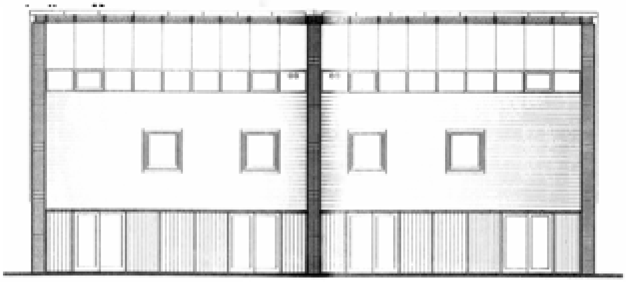
The Zero energy houses are semi-detached houses with a solar roof. The houses are experimentally designed to cover annual energy by using solar PV panels. To maximize the efficiency of the solar panels, the entire roof is sloped towards the south side (inclination 21 degrees). The houses achieve energy conservation very well and have an excellent design quality. The DCBA variants targeted in the project are shown in table 5.

Table 5. Variants and Final Design Results for Zero Energy Houses

THEMES	REQUIREMENTS				FINAL DESIGN RESULTS
	VARIANTS				
sub theme	D	C	B	A	
1 Energy	4000m^3 natural gas equiv./ househ./yr	3000m^3 natural gas equiv./ household/yr	2000m^3 nat.gas equiv./household/yr	only sustainable energy	Use sustainable energy
1.3 usage	spreading of buildings	addition of sun lounge and storage	unbroken row of buildings in length, width and height	compact construction/ building	Shared walls (two houses) to save energy
5.1 solar orientation	arbitrary orientation	optional use of PSE	use of Active Solar Energy (ASE)	dwelling type determined by orientation	Plan determined by orientation Active solar Energy
PSE/ASE/PV		80% between SE & SW; panel angle ASE/PV 20°-50°	90% between SSE & SSW; panel angle ASE/PV 20°-	100% South; ASE / PV 20°-50°	South; Active solar energy / PV 23°

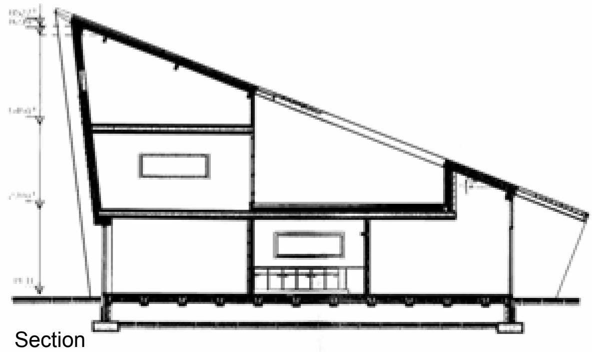


Second level Plan First level Plan Ground level Plan



North Elevation

Figure 4. Drawings of Zero Energy Houses



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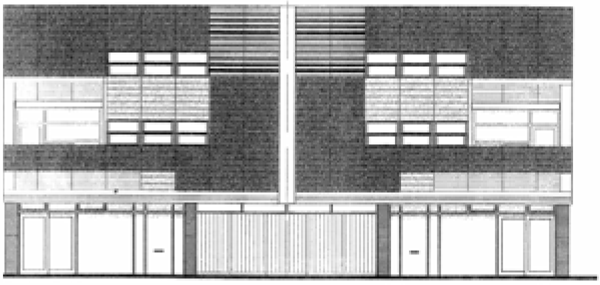


South Elevation

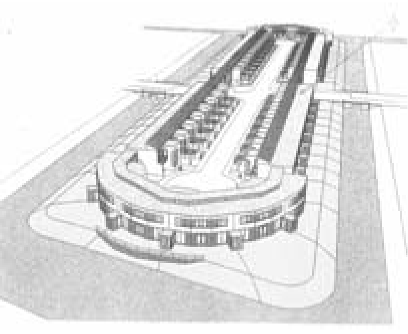
3.2 Case 2- Panta Rhei

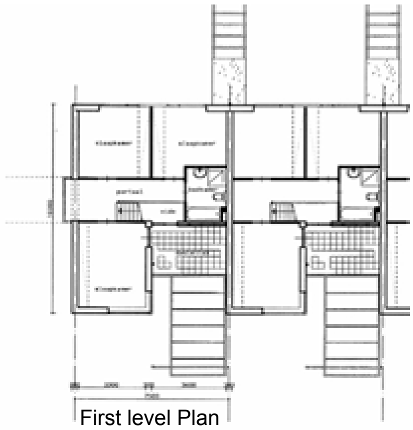
Total houses: 50, only 38 of which have solar panels
Architect: Architectenbureau Van Straalen,
Solar PV panel surface area: 766 m^2solid panels in
"street roof" and 94 m^2 transparent panels in portals
Estimated annual yield: 65,000 kWh (Per house 1,300kWh)

The floor plans of the houses are not mirrored, but are repeated side by side. The houses on the north side and on the south are symmetric in relation to the street. Each house has its own porch and a balcony. The entrance and the kitchen are on the street side, and the living room at the back has sliding doors onto the garden and the nearby canal. The roofs of 38 houses are mostly flat, apart from the middle section, which has solar panels.

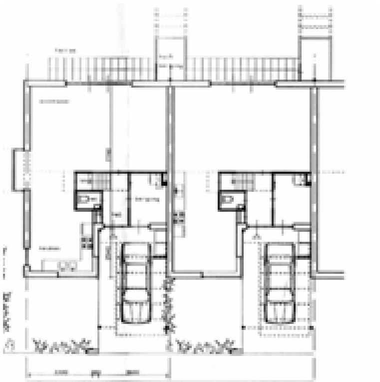
Table 6. Variants and Final Design Results for Panta Rhei

THEMES	REQUIREMENTS				FINAL DESIGN RESULTS
	VARIANTS				
subthemes	D	C	B	A	
1 Energy	4000m^3 natural gas equiv./ house h./yr	3000m^3 natural gas equiv./ household/yr	2000m^3 nat.gas equiv./household/yr	only sustainable energy	Partly use sustainable energy
1.3 usage	spreading of buildings	addition of sun lounge and storage	unbroken row of buildings in length, width and height	compact construction building	Shared walls (7or 10 houses) to save energy
5.1 solar orientation	arbitrary orientation	optional use of PSE	use of Active Solar Energy (ASE)	dwelling type determined by orientation	Active Solar energy, Open to the garden and waterway
PSE/ASE/PV		80% between SE & SW; panel angle ASE/PV 20°-50°	90% between SSE & SSW; panel angle ASE/PV 20°-50°	100% South; ASE / PV 20°-50°	38 south-oriented houses ; Active solar energy PV, 17°

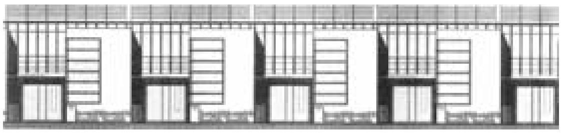




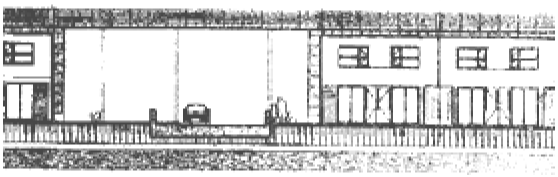
First level Plan



Ground level Plan



Street side Elevation



Garden side Elevation

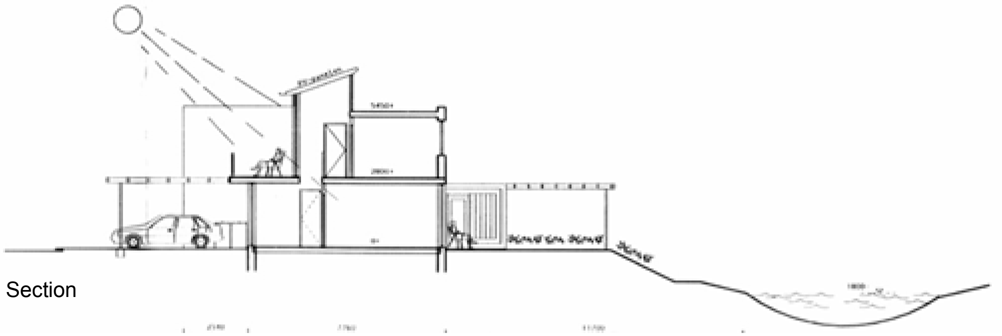


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Figure 4. Drawings of Pata Rhei

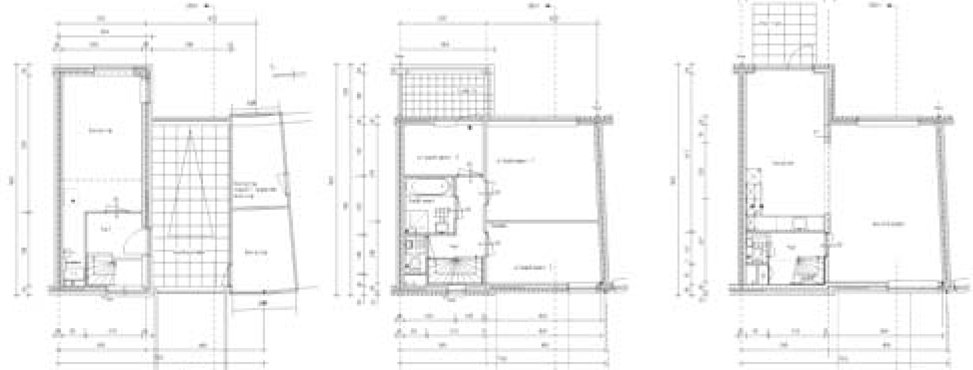
3.3 Case 3-56 Houses with Solar Overhangs

Architect: Bear Architects,
Consultant and installer: Sunecro
Solar PV panel surface area: 224 m^2
Estimated annual yield 14,000kWh (per house 250kWh)

The site has a 5 meter high slope which makes up the sound barrier. The living-room is situated on the first floor. A loggia is attached to the living room. Sleeping and study rooms are on the ground floor. These rooms are all on the south side, because there are a garden and a canal there. The entrance, a big room and the parking lot are situated on the second floor, which is reached by a small bridge from the road on top of the sound barrier. In this design a 'PV-spoiler' was made at the edge of the roof. Approximately 224 m^2 of transparent panels with photovoltaic cells have been included in the eaves of these houses.

Table 7. Variants and Final Design Results for 56 Houses with Solar Overhangs

THEMES	**REQUIREMENTS**				**FINAL DESIGN RESULTS**
	VARIANTS				
subthemes	**D**	**C**	**B**	**A**	
1 Energy	4000m^3 natural gas equiv./ househ./year	3000m^3 natural gas equiv./ household/yr	2000m^3 nat.gas equiv./ household/yr	only sustainable energy	Partly use sustainable energy
1.3 usage	spreading of buildings	addition of sun lounge and storage	unbroken row of buildings in length, width and height	compact construction/ building	Shared walls (56 houses) to save energy
5.1 solar orientation	arbitrary orientation	optional use of PSE	use of Active Solar Energy (ASE)	dwelling type determined by orientation	Active Solar energy open to the south garden
PSE/ASE/PV		80% between SE & SW; panel angle ASE/PV 20°-50°	90% between SSE & SSW; panel angle ASE/PV 20°-50°	100% South; ASE / PV 20°-50°	All houses south oriented PV (4m²/house)



Second level Plan First level Plan Ground level Plan

South Elevation

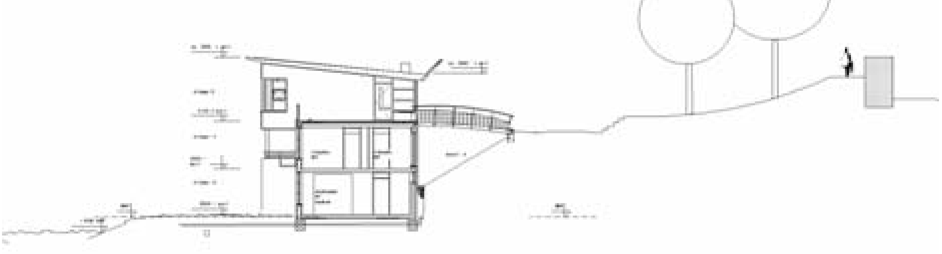


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Figure 4. Drawings of 56 Houses with Solar Overhangs

4. Discussion

As stated above, the Zero Energy Houses (Case 1) were designed mainly as A-variants. On the other hand, the Subproject Panta RHEI (Case 2) and the 56 Houses With Solar Overhangs (Case 3) were designed between B and C, except for some requirements that were set at A level. The interviews with architects made it clear that mostly B-C variants were used in Nieuwland.

As for the design of A variants, the requirements are high and severe. Therefore, the room for freedom in the design may be constrained. For example, there may be very specific requirements regarding the form of buildings and the possibility to create design variations may be limited.

It is challenging to design A variants. On the other hand, B-C variants allow more flexibility in meeting different requirements. B-C variants of housing design may be somewhat less energy-efficient than A-variants. The increased design flexibility allowed by B-C variants also has advantages. For example, it allows more variation in building design, and makes it easier to incorporate other environment-friendly themes as well. In Nieuwland, the above-mentioned Case 2 and Case 3 are instances in which the site conditions influenced the building design.

The flexibility allowed by B-C variants resulted in many kinds of designs to be made for the houses in Nieuwland. In fact, the urban features and housing designs analyzed in this study indicate that the final design results archived often do not have a one-to-one correspondence with the individual (sub)themes and variants targeted in the DCBA process.

5. Conclusion

This paper presents the results of a study carried out by Y.Konishi at Delft University of Technology in the context of a graduate exchange program. The main features of the DCBA-design method were studied from literature, interviews were done with architects and developers, and design examples of integrated photovoltaic (PV) were analyzed. The analysis and interviews gave insight into the aims and working of the DCBA design method. The DCBA design method is seen mainly as an awareness–raising and discussion tool. Because it is not prescriptive, it allows designers and planners sufficient freedom to integrate different aspects of environmental quality into a variety of well balanced design solutions. With regard to the levels of environmental requirements, the main features of the DCBA variants can be summarized as follows:

A variant:
- Stimulates the achievement of a very high or ideal level of ecological design
- Model buildings can help raise awareness of ecological design
- A major challenge is to raise one or more design aspects to the A-level

B-C variants:
- Are close to current practice (allow incremental improvements)
- Have less ambitious goals, which may result in some added flexibility to integrate different features of a specific site in the ecological design of a building (e.g. orientation may consider the sun, but also nearby canals)
- This flexibility can also be inspiring for ecological design, although in a different way

D variant:
- Represents the baseline of current regulations/practice
- Is dynamic, in that it evolves together with regulations/practice

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Appendix

DCBA Chart: Urban design for Nieuwland Amersfoort (12/10/1998) [4]

Theme *sub-theme*	D **The normal situation**	C **Correction of normal use**	B **Minimisd Damage**	A **Autonomous**
1 Energy	4000m^3 natural gas equiv./househ./year	3000m^3 natural gas equiv./household/year	2000m^3 nat.gas equiv./household/year	only sustainable energy
1.1 generation	power station & gas-pipes	combined heat & electricity generation	sun and wind (heating and electricity)	seasonal storage
1.2 building	10000m^3 natural gas equiv.	7000m^3 natural gas equiv.	4000m^3 natural gas equivalents	local material
1.3 usage	spreading of buildings	addition of sun lounge and storage	unbroken row of buildings in length,	compact construction/building
heating	1300 natural gas equiv. (n.g.e.)	750 nat. gas equiv. (Overbos level)	450m^3 nat.gas equiv., minimum	zero natural gas equivalents
electricity	elec.pow.station;1000 n.g.e.=3000kWh	economical equipment, daylight 1500 kWh	no electric heating/cooking, 1000 kWh	limited usage; 500 kWh
2 Water	flush system			closed system
2.1 surface water	intake and distrib. to/from rivers	wetland treatment, storage and level fluctuations	seasonal storage, intake for extremes	no intake, complete purification
banks	concrete wall, trop. hard wood timbering	shallow banks, timbering of natural materials	slope 1:8, 'timbering' reed/vegetation	natural banks
2.2 waste water	7 x per year flooding of sewer	separated sewer system	restrict need, vegetation roof/rain barrels	disconnection of clean areas
2.3 drinking water	supply according to demand (120L/p)	rain barrel in yards, water conservation (70 L/p)	use rain and surface water	supply from neighbourhood as well
3 Green	tabula rasa			building in existing landscape
3.1 land	if need be, raise by fill overall	partial fill, save precious plants	fill under houses and streets only	no fill
3.2 ecology/natur	small greenery; limited ecology	differentiated dynamic usage	make use of potential soil gradients	ecological infrastructure
management	mow 8 times; spray insecticides	phased mowing, max. 2 x year & removal	ecological management; sheep, cows, horses	natural balance
3.3 recreational greenery	according to standards	greenery within walking or cycling distance	recreation within the neighbourhood	completely integrated
3.4 food production	kitchen gardens as afterthought	educative value 20m^2/househ. in neighbourhood	100m^2/hh. crops and small livestock	>> 1000 m^2 / household
4 Living/Work				
4.1 work opportunity	residential housing v. office parks	several dwellings with office space	clean industry and offices within the neighbourhood	teleworking local centre
4.2 services	concentrated at neighbourhood level	services within walking or cycling distance	several small scale services within the neighbourhood	small scale services
4.3 occupant behaviour	slow changes in behaviour	changes through education/information	residents have a say	residents directly involved
5 Residential				
5.1 solar orientation	arbitrary orientation	optional use of PSE	use of Active Solar Energy (ASE)	dwelling type determined by orientation
PSE/ASE/PV		80% between SE & SW; panel angle ASE/PV 20°-50°	90% between SSE & SSW; panel angle ASE/PV 20°- 50°	100% South; ASE / PV 20°-50°
	obstruction angle 30° (1:1.7)	obstruction angle 24° (1 : 2.2)	obstruction angle, 17° (1: 3.2)	obstruction angle, 14° (1 : 4)
5.2 wind	no attention; obstruction coeff. 1.1	prevent draughty corners, coeff. 1.0	model in wind tunnel; coeff. 0.8	wind nuisance coeff. 0.6
5.3 noise	Noise Abatement Act with exemption(s)	Noise Abatement Act without exemption	quiet facade (front) for every dwelling	natural background
6 Waste				
6.1 from construction	to waste disposal or land-fill	sorted/separated removal	use for landscaping public areas	everything returns to recycle process
6.2 organic	to waste disposal or land-fill	sorted/separated collection	choice of compost for own use or collection	compost within the neighbourhood
6.3 glass	in glass recycle bin	glass recycle bin 60 metres from dwelling	collect in crates at home	deposit system
6.4 paper	sporadic collection	paper recycle bin in neighbourhood	collected from home at predetermined times	recycling 100%
6.5 chemical	chemical collection truck	collected separately	depot in neighbourhood; open 60 hours /week	does not exist
6.6 large waste	incinerated or to land-fill	special days for recycling (tempor. local covered storage)	second hand use; service area in neighbourhood	repair in the neighbourhood
6.7 dog poop	not permitted on footpath	dog walking route, dog toilet	cleaned-up by dog owner	no dogs in the city
7 Traffic	The further the better.	The car can do without you for a		No place like home.
7.1 slow traffic	inferior, detours	defined structure	right-of-way	only method of transportation
7.2 public transport	bus in the neighbourhood	bus stop max. 500 metres, 2 per hour	fast public transp. at max. dist. of 300 m, 4 per hour	optimally organised
7.3 car traffic	the car is sacred	narrower traffic lanes	subordinate; no right-of-way	car-free neighb., shared car
7.4 parking	at front door: parking standard 1.5	park at end of street, parking standard 1.0, teleworking	differentiated parking plan, parking standard 0.5	parking at entrance to neighb. /standard 0.25
8 Pipes/cables				
8.1 route	spread throughout the street	concentrated in narrow strips	connected to foundations	prevent necessity of pipes/cables
8.2 material	PVC/copper	ceramics/concrete/PE/steel	limited diameter	
9 Building material	choice based on investment			
9.1 pavement	asphalt	concrete/brick paving or tiles	half-paved, limited paved surfaces	rubble, wood chips, etc.
9.2 benches/lights/etc.	galvan. metal, alumin, tropical hardw.	European hard wood, recycled plastics, steel	brick, spar	loam, vegetation, etc.
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