



Introduction Tim de Jonge:

Construction economist with own consultancy.

Clients are: architects, housing associations, municipalities, school boards

Member of NVBK.

President of Bouwprojecteconomie-corporation

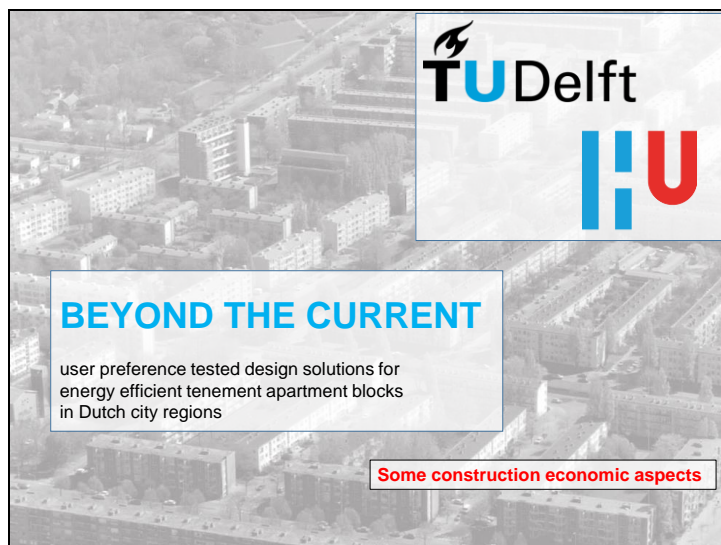
12 consultancies that work together on EcoQuaestor

calculation model and database

for construction costs and environmental impact of buildings.

Next month training 90 consultants of the Central Government Real Estate Agency.

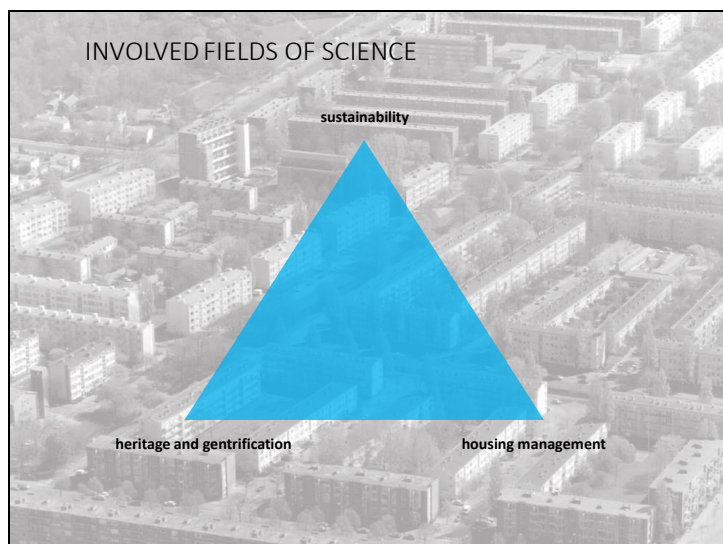
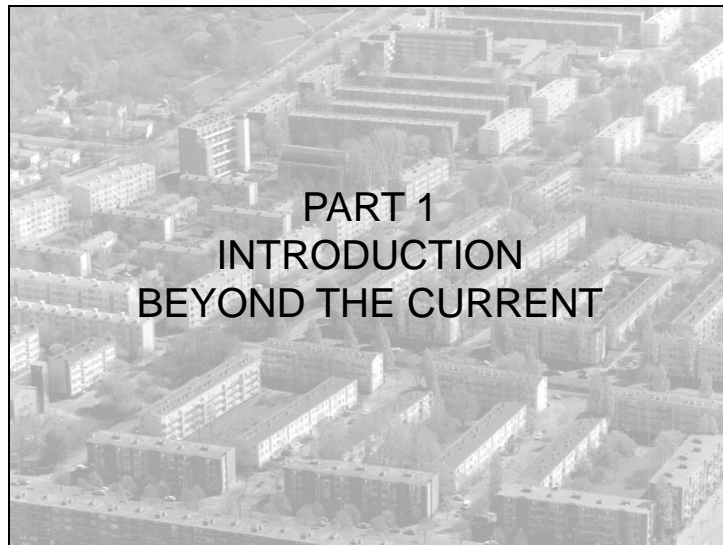
None of this will feature in my presentation.



A year ago I was asked to join a research team of
Delft University of Technology and
Utrecht University of applied sciences,

Dealing with a research on energy efficient renovation of tenement apartment blocks.
The main focus in this research is to test tenants preferences to various design solutions.

But I will present to you some construction economic aspects.





The research finds its place of course within the context of the climate change issue.

THE PROBLEM: EXISTING DUTCH HOUSING STOCK

Problems of existing Dutch houses

- to big energy demand
- to much CO2 emission
- not much use renewable energy
- the Dutch are addicted to cheap fossil gas



MULTI DISCIPLINARY RESEARCH TEAM

TUD

Management in the Built Environment
Ir. Sabira El Messlaki

Architectural Engineering + Technology
Dr.ir. Thaleia Konstantinou

Architectural Engineering + Technology
Dr.ir. Leo Oorschot

UJ

Dr.ir. Tim de Jonge

Delft University of Technology: Architecture and Built Environment

Chair: Housing Management
Prof. dr.ir. Vincent Gruis

Chair: Architectural Engineering
Prof. ir. Thijs Asselbergs

Chair: Heritage & Design
Prof. Ir. Wessel de Jonge

Utrecht University of applied Sciences
Prof. Jan Willem Kroon

dr. Clarine van Oel

ir. Tjalling Homans

ir. Lidwine Spoom

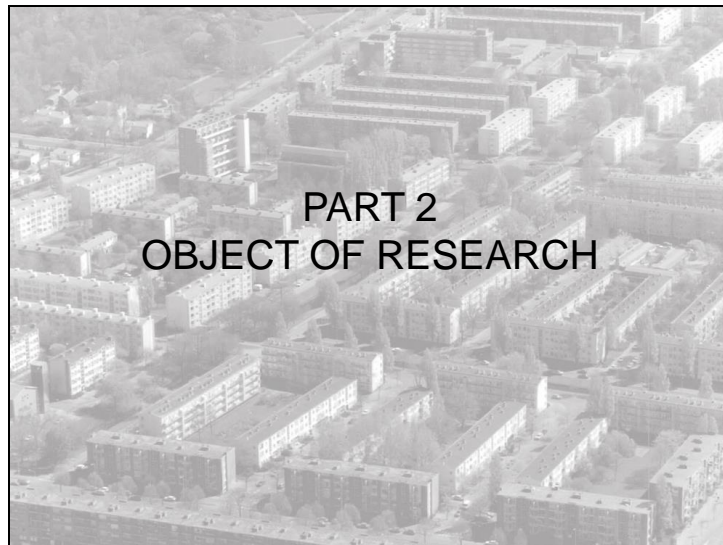


Sabira El Messlaki – housing management, tenants preferences

Thaleia Konstantinou – construction physics, energy


Leo Oorschot – architecture, heritage

Tim de Jonge – construction costs, life cycle



OUR OBJECT OF RESEARCH

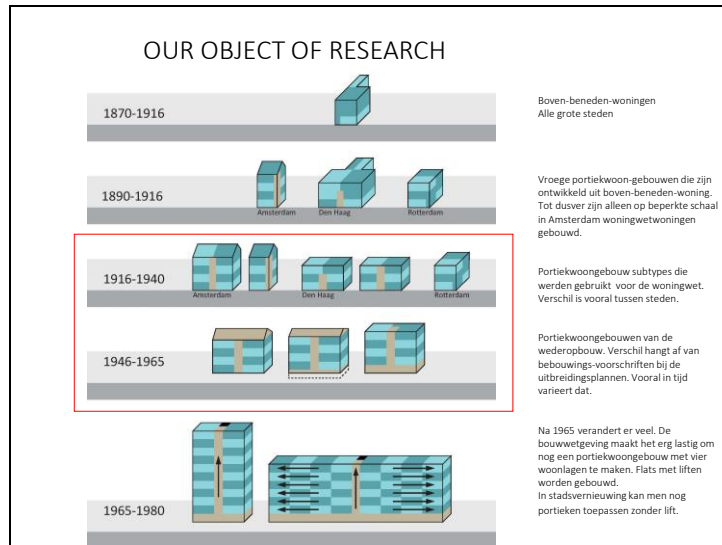
- Type: Three to five storey tenement apartment blocks
- Period: Inter war period 1916-1925
Post war period 1946-1965
- Ownership: Housing Association subsidized houses
- Place: In cities regions Amsterdam 150.000 Rotterdam 100.000
The Hague 100.000 Utrecht 30.000
- Characteristics: A building block has 4 to 8 units with access stairs
One unit has 4 – 8 apartments, a shared staircase and no lift
Blocks are always a part of a coherent urban ensemble



The research is aimed at 3 – 5 storey tenement apartment blocks;
Constructed between WI and WII, and in the first 20 years after WII;
Owned by housing associations, so social housing (for income-groups up to 32.000 / year)

About half a million of these apartments, located in the larger cities in NL.

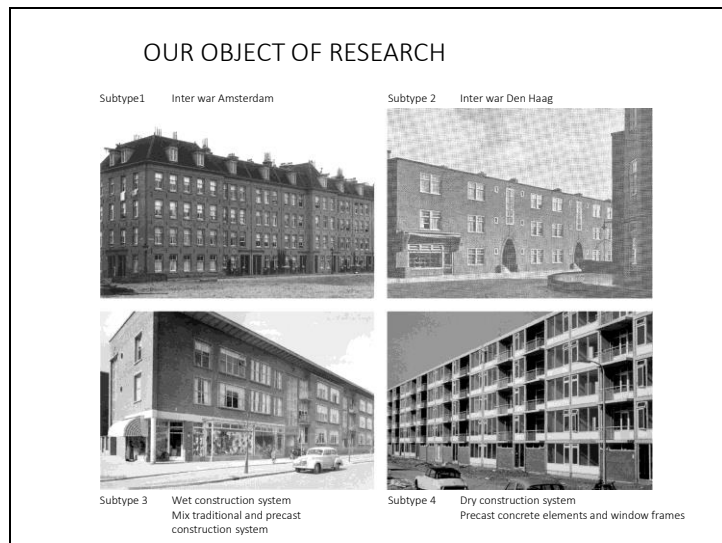
A characteristic building block consists of 4 to 8 units;
Each unit contains 4 to 8 apartments around a share staircase;
There are usually no lifts.
The building blocks are always part of a coherent urban ensemble.



At the start of the research
a classification of apartment buildings
categorized by:

- period of construction,
- main organization principles of their lay-out.

The research is aimed at these construction periods.



In this housing stock, we have distinguished 4 sub-types:

- 2 sub-types in the inter bellum era
- 2 sub-types in the post second world-war reconstruction-era.

DESIGN CASE 1

CAMERA OBSCURA UTRECHT - SUBTYPE DRY CONSTRUCTION SYSTEM

Plaats	Utrecht, Overvecht
Adres	Camera Obscuradreef
Stedenbouw	wijkgedachte, bouwstempel, oorspronkelijk Wissing
Architect	Gemeente Utrecht & VAM
Gebouwobject	314 appartementen in 6 bouwstroken
Bouwjaar	1964-1965
Bouwwijze	droog prefab bouwsysteem VAM
Eigenaar	Mitros



According to these apartment-types, we have selected 4 projects, mainly based on what was available at the housing associations in our stakeholders group.

Utrecht – reconstruction era.

DESIGN CASE 2

SURINAMEPLEIN DE BAARSJES AMSTERDAM - SUBTYPE INTER WAR

Plaats	Amsterdam, De Baarsjes
Adres	Surinameplein 26-38, Curaçaostraat 4-40, Hoofdweg 1–9
Stedenbouw	De Gordel '20 - '40 / AUP, Van Eesteren & Van Lohuizen
Architect	Posthumus Meyjes & Van der Linden
Gebouw object	80 appartementen in een bouwblok
Bouwjaar	1936
Bouwwijze	traditioneel (Haagse architectonische karakteristieken zoals open portiek)
Eigenaar	Eigen Haard



(According to these apartment-types, we have selected 4 projects, mainly based on what was available at the housing associations in our stakeholders group.)

Amsterdam – inter bellum

DESIGN CASE 3
VECHTSTRAAT AMSTELZUID AMSTERDAM - SUBTYPE INTER WAR

Plaats	Amsterdam, Zuid
Adres	Vechtstraat 62-84, Lekstraat 48-52
Stedenbouw	De Gordel '20 - '40, Berlage
Architect	Zietsma
Gebouwobject	59 appartementen in een bouwblok
Bouwjaar	1924
Bouwwijze	traditioneel (Haagse architectonische karakteristieken zoals plat dak)
Eigenaar	De Alliantie



(According to these apartment-types, we have selected 4 projects, mainly based on what was available at the housing associations in our stakeholders group.)

Amsterdam - interbellum

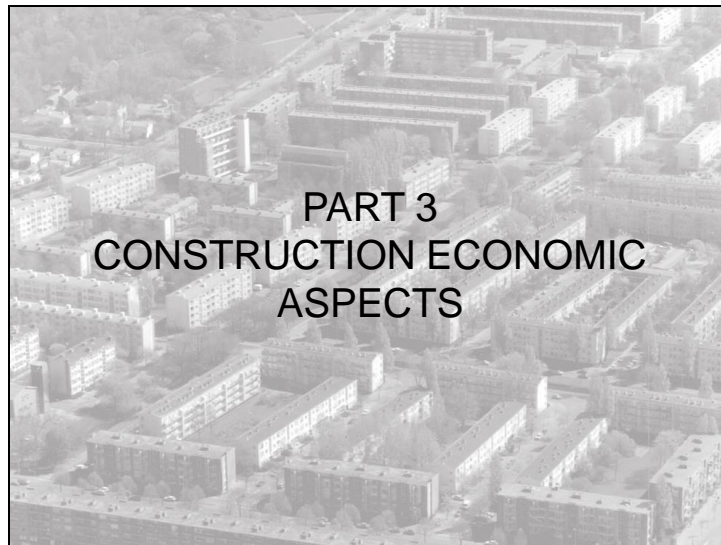
DESIGN CASE 4
MARIAHOEVE DEN HAAG - SUBTYPE WET CONSTRUCTION SYSTEM

Plaats	Den Haag Mariahoeve
Stedenbouw	Wederopbouw ensemble, midden periode, Van der Sluijs
Architecten	Fels & Kroon
Gebouwobject	264 appartementen in verschillende bouwstroken
Adres	Robijnhorst 4-276 / 3-127 & Diamanthorst 1-179
Bouwjaar	1959-1960
Bouwwijze	mix traditioneel - bouwsysteem (Korrelbeton)
Eigenaar	Haag Wonen



(According to these apartment-types, we have selected 4 projects, mainly based on what was available at the housing associations in our stakeholders group.)

The Hague – reconstruction era.

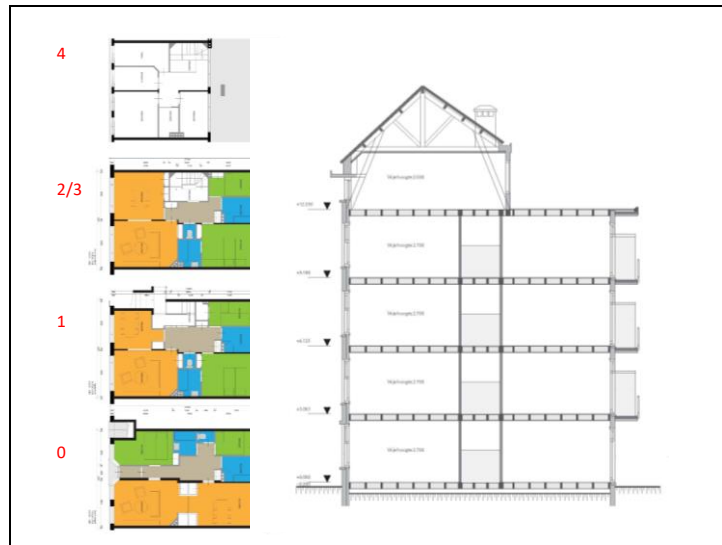


The main object of the research is to find design solutions that are preferred by tenants.

For our profession however, the focus of this presentation is on: construction economic aspects.



The example for my explication is this Amsterdam building complex.



It is a 5 storey building

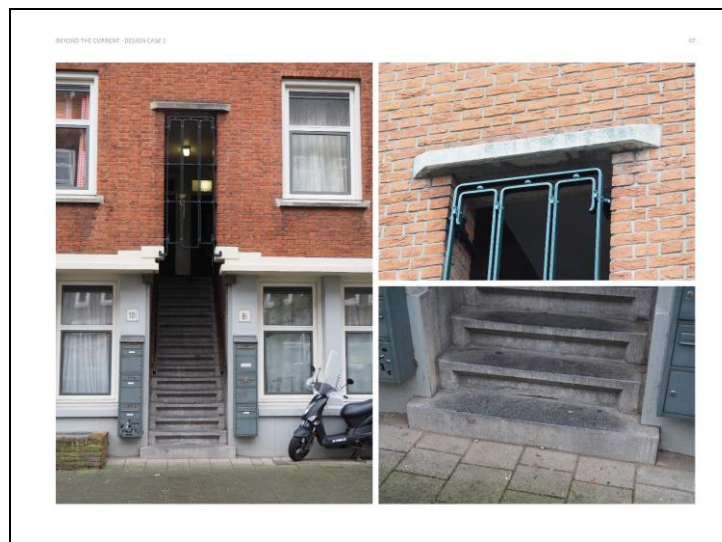
4 apartments on top of each other

And a shared attic, where every apartment has a kind of storage-room.

Ground floor apartment is accessible directly from the street.

Upstairs' apartments can be reached by an outside, stone made staircase (see next sheet)

Apartments on the 2nd and 3rd floor are further accessed by internal staircases.

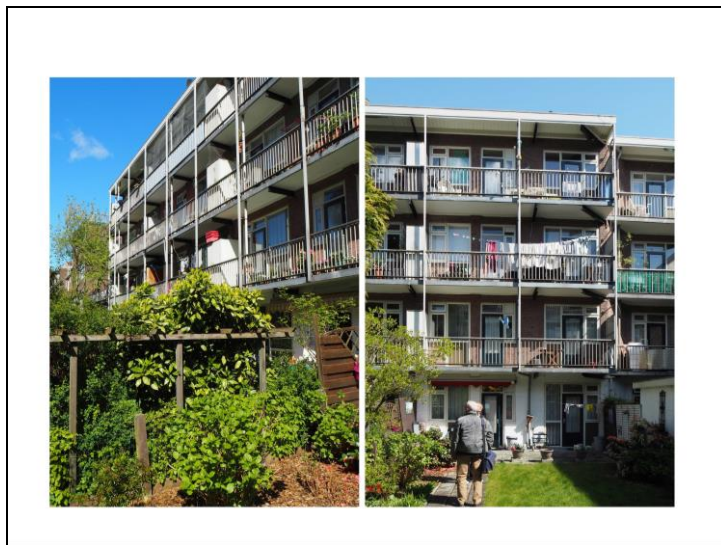


... can be reached by an outside, stone made staircase (back to previous sheet).

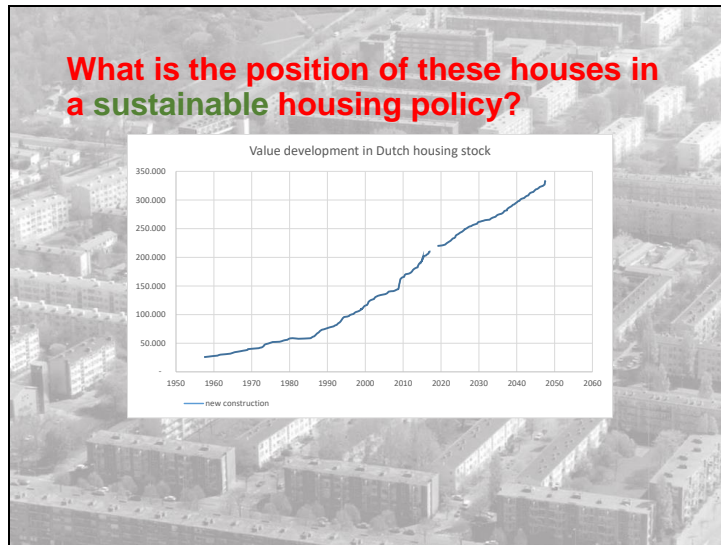
Apartments on the 2nd and 3rd floor are further accessed by internal staircases.



Here again the building block, with the stone made, open staircases.



And the back side of the building, renovated apparently in the 1980s.
In good weather it looks quite friendly!



So: What is the position of these apartments in a SUSTAINABLE housing policy?

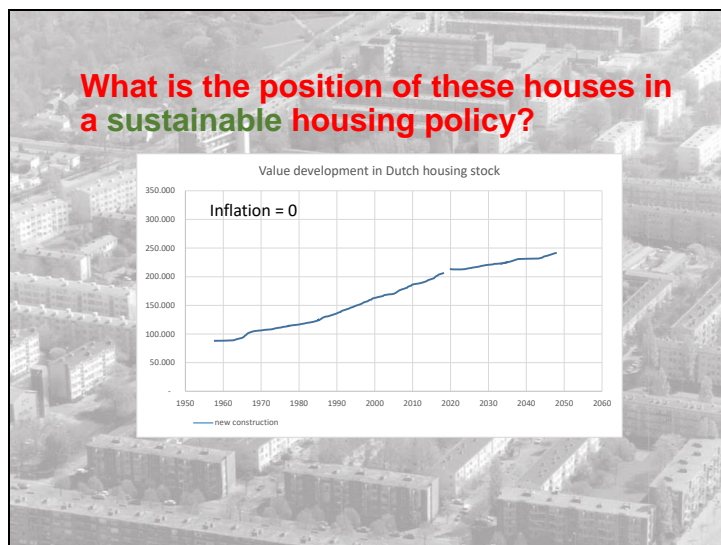
Here you see the value development of new-construction in Dutch housing. So the value of a typical new constructed apartment in the subsequent years in the second half of the 20th century up until now, and the expected development of that value in years to come.

I want to point out that value is not the same as costs.

The value is what one would be prepared to pay for the ready product, in this case the newly-built apartment.

The costs that should be covered by this value would apparently be:

- capital construction costs
- associated capital construction costs
- ground costs.



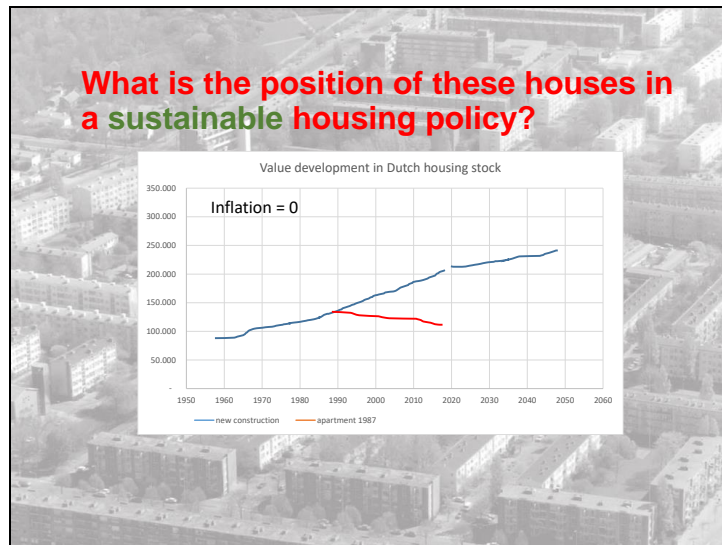
If we correct this graph for inflation, it looks like this.

The real growth of value is of course related to better performances of new buildings compared to older ones.

For instance, new apartments will have better equipment like bathrooms, kitchens, electricity systems.

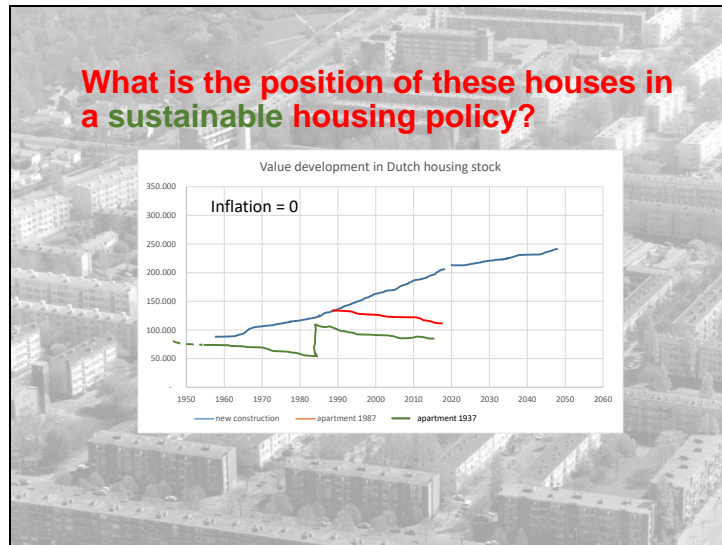
Better functioning windows and doors as to locks and fasteners, double or triple glazing. Better thermal and sound insulation.

Better water systems, ventilation services, heating.



If we look at the value of a 30 years old apartment, and the development of that value in time, it would look like this.

As you see, the value rather diminishes; that is partly due to wear and tear, but mainly because the appreciation for an older building, will decrease when the performance of the newer buildings set the standard a little higher.



In the research, however, we are looking into an apartment from the inter bellum era. The value of such an apartment could be expected to develop like this.

In the middle you see the effect of a 1980s' renovation.

In 2017 you see a rather big gap between the value of the inter bellum apartment and a newly-built apartment.

However, in practice all inter bellum apartments in the larger cities in NL are very much in demand.

Partly because of a moderate rent, but also because they are still nice dwellings in interesting neighbourhoods.

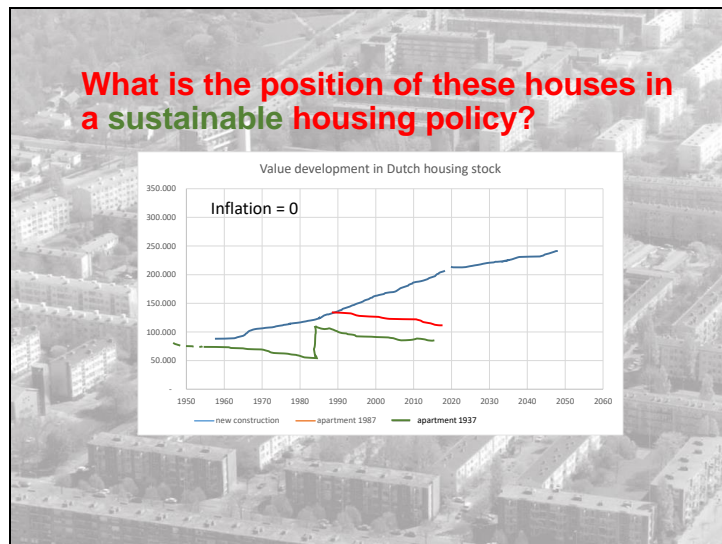
THE PROBLEM: EXISTING DUTCH HOUSING STOCK

Problems of existing Dutch houses

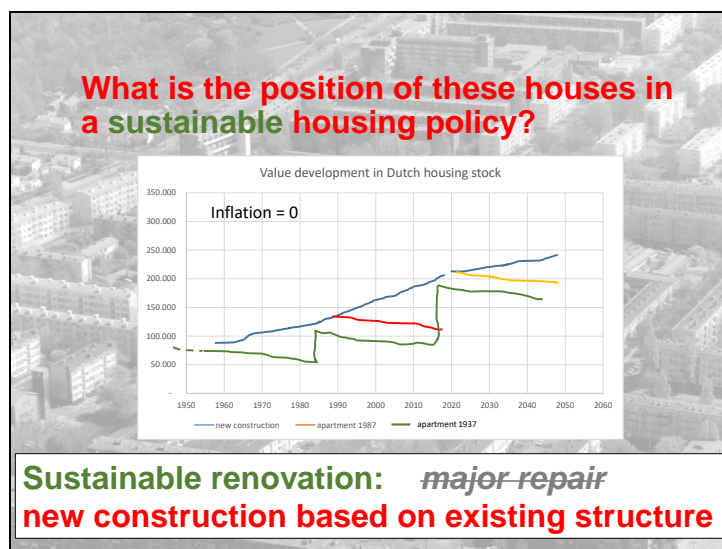
- too big energy demand
- too much CO2 emission
- not much use renewable energy
- the Dutch are addicted to cheap fossil gas



Let's remember for a moment the problems that are at the basis of our research.



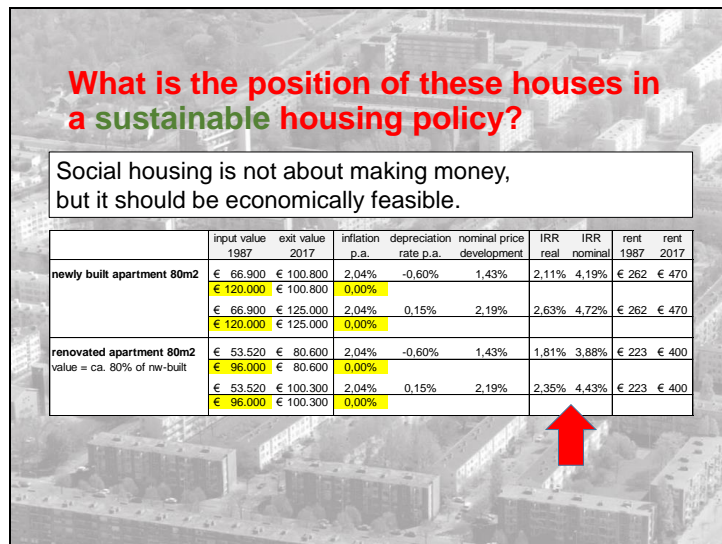
In the housing stock, at least until the 1990's, the quality of houses add to this problem. So improvements should be made to all these buildings in order to achieve the goals of the Paris treaty on climate change..



That implicates rather big investments, while the required improvements can only be realised, if the apartments undergo major renovations.

In fact - in order to get the right mind set for this operation - we should state: sustainable renovation should not be seen as “major repair”, but rather as “new construction based on existing structure”.

(Of course in the future the diminishing of the value will inevitably continue.)



Social housing is not about making money,
but it should be economically feasible for housing associations.

So a certain return has to be made.

Here you see, what the return would have been on investments on apartment,
if rents would have been on the 2017 level (with rents following inflation).

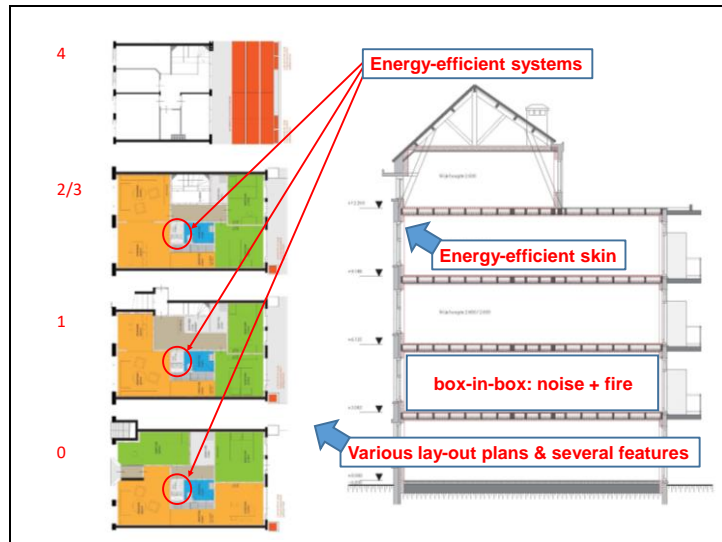
In reality, rents have been lower,

that is starting with lower rents and increasing more than inflation, have led to the
2017 level.

Associations did not go bankrupt, so the appearing IRR should be enough for social
investments in housing.



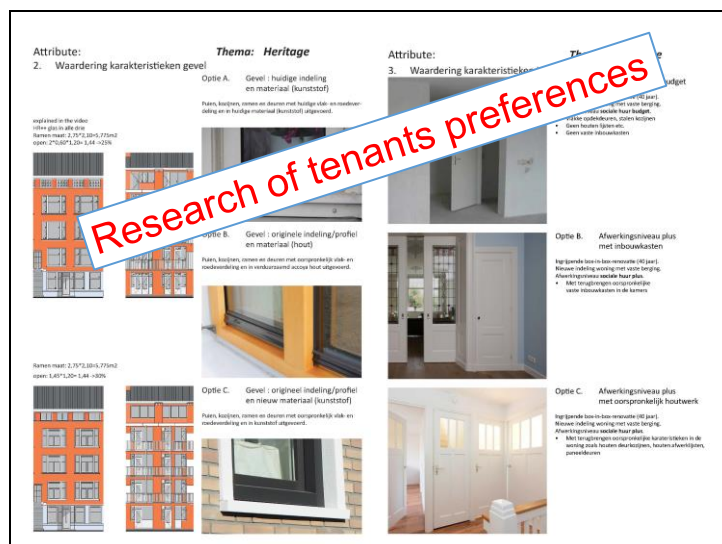
Back to the apartments block and the design in our research.



In order to deal with noise and fire protection a so-called box-in-box renovation plan has been designed.

With various lay-out plans and several features, to be researched for tenants preferences.

Measures to create an energy-efficient skin (external walls and roof) were selected. And energy-efficient systems were selected, and since these systems ask for extra room, the extra room was incorporated in the design.



The features have been researched for preferences, but I cannot go into that right now.

Thema: Energiehuishouding

Attribute: 4. Hoofverwarming

Optie A: Pelletkachel als blootverwarming

Pelletkachel als centrale blootverwarming in de woonkamer, hoofdelingen naar de woonkamer, in de woonkamer een verwarmingsysteem met vloerverwarming.

Optie B: Warmtepomp op balkon

Lucht/water warmtepomp met warmtepomp (CV en tapwater) split unit, unit op balkon in een gesloten, on-uitgeschakelde omringing in de woning met warmtepomp (CV en tapwater) split unit, unit op balkon in een gesloten, on-uitgeschakelde omringing in de woning.

Optie C: Warmtepomp op dak

Lucht/water warmtepomp met warmtepomp (CV en tapwater) split unit, unit op dak van de woonkamer, hoofdelingen naar de woonkamer, in de woning een verwarmingsysteem met vloerverwarming.

Attribute: 5. Ventilatie

Optie A: Balansventilatie + WTW

Centraal systeem, geen ventilatievoorzieningen in de panden, met daarvoor een warmtepomp (CV en tapwater) split unit, unit op balkon in een gesloten, on-uitgeschakelde omringing in de woning.

Optie B: Climadax aan de straatzijde

Mechanische ventilatie tussentijdse

In de woonkamer aan de straatzijde wordt een Climadax 2.0 radiator met WTW geïnstalleerd, met daarvoor een warmtepomp (CV en tapwater) split unit, unit op balkon in een gesloten, on-uitgeschakelde omringing in de woning.

Optie C: Climadax aan de straatzijde

Mechanische ventilatie tussentijdse

In de woonkamer aan de straatzijde wordt een Climadax 2.0 radiator met WTW geïnstalleerd, met daarvoor een warmtepomp (CV en tapwater) split unit, unit op balkon in een gesloten, on-uitgeschakelde omringing in de woning.

(The features have been researched for preferences, but I cannot go into that right now.)

Thema: Energiehuishouding

Attribute: 6. Hernieuwbare energie

Optie A: Geen

Optie B: PV-panelen

PV-panelen op het platte dak van het dak.

- 10 PV-panelen op het dak van 3 woningen
- Per PV-paneel 250 Wp
- Per woning 10 PV-panelen
- Geschatte productie 10 kWh per jaar
- Geschatte productie 10 kWh per jaar

Optie C: PV-panelen + batterij

Zakelijke batterij met batterij

Attribute: 7. Trombe glas

Optie A: Trombe glas gordijn

Individuele leunende gordijn

Deel van de glas in de raamkozijnen op de voor- en achterzijde is afgevoerd als leunende gordijn.

Optie B: Trombe glas gordijn

Individuele leunende gordijn

Deel van de glas in de raamkozijnen op de voor- en achterzijde is afgevoerd als leunende gordijn.

Optie C: Scattered glass in window frames

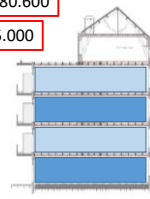
In alle raamkozijnen op de voor- en achterzijde.

Deel van de glas in de raamkozijnen op de voor- en achterzijde is afgevoerd als verspreid glas.

(The features have been researched for preferences, but I cannot go into that right now.)

Life cycle approach (NEN-standard 2699)			Renovation ~ nw.const.-level
Investment			
Acquisition value of existing premises (per dwelling)	€ 80.600	Benefits	
Number of dwellings (per staircase) before renovation	8		$80.600 \times 8 = 80.600$
Number of dwellings (per staircase) after renovation	8		
Acquisition value of existing dwelling	€ 80.600		$758.915 / 8 = 95.000$
Construction costs (VAT excluded)	€ 95.000		
VAT on construction costs 21%	€ 19.950		
Construction costs (VAT included)	€ 114.950		
Additional costs 20%	€ 22.990		
Contingencies ca. 3%	€ 8.960		
	€ 144.800		
Yield / transfer to operation	€ -	€ 225.400	
Balance (profit / loss)	€ -	€ 225.400	
Operation			
Intended operation period (years)	30		
Inflation	2,04%		
Real (internal) rate of return	1,82% which is nominal	3,89%	
Real depreciation rate / year	-0,60% which is nominal	1,42%	
Vacancies	1,00%		
Annual reservation for management	€ 900 VAT included		
Annual reservation for maintenance and repair	€ 1.200 VAT included		
Annual reservation for business expenses	€ 600 VAT included		
	€ 225.400		
Costs			
Acquisition value of renovated dwelling	€ 21.040		
Management (discounted value)	€ 28.050		
Maintenance (discounted value)	€ 14.020		
Property expenses (discounted value)	€ 63.110		
Total discounted value of periodic expenses	€ 178.130		
Gross revenues from rent (discounted value)	€ -1.780		
Less: cash value due to vacancies	€ 176.350		
Net revenues from rent (discounted value)	€ 339.540		
Nominal exit-value (non-recurring yield)	€ 112.160		
Discounted exit-value (non-recurring yield)	€ -		
Balance (profit / loss)	€ 288.510	€ 288.510	
Housing expenses			
Rent per month	€ 635,05	Benefits	$(635 \times 8 + 592 \times 0) / 8 = 635$
Energy per month	€ 128,45		$(128 \times 8 + 113 \times 0) / 8 = 128$
Service costs per month	€ -		$(763 \times 8 + 705 \times 0) / 8 = 763$
Total housing expenses	€ 763,50		

IRR = 1,82%



So: Is this approach indeed economically feasible?

We researched that on the basis of the life cycle scheme of NEN-standard 2699.

This scheme is divided in 3 sections:

Section 1 Investment – from the viewpoint of the project developer.

Section 2 Operation – from the viewpoint of the landlord, i.e. the housing association.

Section 3 Housing expenses – from the viewpoint of the end user, the tenant.

When we start with assessing the values of the investment and the housing expenses.

We can next see under which conditions a balanced operation is possible.

The IRR should be around 2%, as we have seen previously.

We will start with a renovation that brings the apartments on a new-construction level.

No lifts, however. And moreover no energy-efficiency measures.

We start with 4 apartments on top of each other, that is 8 apartments in a staircase-unit.

After renovation we have again 8 apartments (with approximately new-built qualities).

The investment exists of:

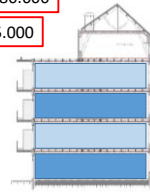
acquisition value $\times 8/8$

construction costs of renovation

associated costs.

The investment is transferred to the operation; we will come to that later on.

Life cycle approach (NEN-standard 2699)			Renovation ~ nw.const.-level
Investment			
Acquisition value of existing premises (per dwelling)	€ 80.600		$80.600 \times 8 / 8 = 80.600$
Number of dwellings (per staircase) before renovation	8		
Number of dwellings (per staircase) after renovation	8	€ 80.600	
Acquisition value of existing dwelling	€ 95.000		$758.915 / 8 = 95.000$
Construction costs (VAT included)	€ 19.950		
VAT on construction costs 21%	€ 4.189,50		
Construction costs (VAT included)	€ 24.139,50		
Additional costs 20%	€ 4.827,90		
Contingencies ca. 5%	€ 1.206,98		
	€ 144.800		
Yield / transfer to operation		€ 225.400	
Balance (profit / loss)	€ -	€ 225.400	
	€ 225.400	€ 225.400	
Operation			
Intended operation period (years)	30		
Inflation	2,04%		
Real (internal) rate of return	1,82%	which is nominal	3,89%
Real depreciation rate / year	-0,050%	which is nominal	1,42%
Vacancies	1,00%		
Annual reservation for management	€ 900	VAT included	
Annual reservation for maintenance and repair	€ 1.200	VAT included	
Annual reservation for business expenses	€ 600	VAT included	
	€ 2.700		
Costs			
Acquisition value of renovated dwelling	€ 225.400		
Management (discounted value)	€ 21.040		
Maintenance (discounted value)	€ 28.050		
Property expenses (discounted value)	€ 14.509		
Total discounted value of periodic expenses	€ 63.110		
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Less: cash value due to vacancies		€ -1.780	
Net revenues from rent (discounted value)		€ 176.350	
Nominal exit-value (non-recurring yield)		€ 339.540	
Discounted exit-value (non-recurring yield)		€ 112.160	
Balance (profit / loss)	0%	€ -	
	€ 288.510	€ 288.510	
Housing expenses			
Rent per month	€ 635,05		$(635 \times 8 + 592 \times 0) / 8 = 635$
Energy per month	€ 128,45		$(128 \times 8 + 113 \times 0) / 8 = 128$
Service costs per month	€ -		
Total housing expenses	€ 763,50		$(763 \times 8 + 705 \times 0) / 8 = 763$



IRR = 1,82%

Now for the housing expenses.

In NL the rent for social housing is assessed to be socially acceptable if it does not exceed € 635 for a two-and-more persons household, or € 592 for a single person household. Households with income less than € 32.000, will be subsidised according to their actual income.

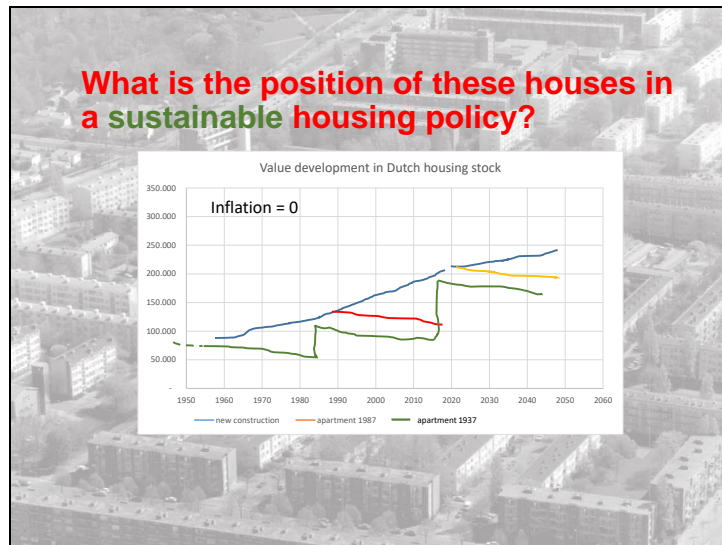
Based on statistics by Energie Centraal (Energy Centre) we assessed the average energy-bill of the same households.

Rent and energy-costs together are the housing expenses.

So, on the one hand we have the investment costs for the renovated apartment, and on the other we have the rent, which can serve as a benefit for the landlord.

We bring the values of both items (cash-flows, if you want) to the operation-section of the life cycle scheme. We have to translate them into present values (I won't bore you with the technicalities.)

We put also some other operating costs. And finally, we have the exit-value of the property after 30 years ...



... Remember this!

Life cycle approach (NEN-standard 2699) Renovation ~ nw.const.-level

Investment		Benefits	
Acquisition value of existing premises (per dwelling)	€ 80.600		
Number of dwellings (per staircase) before renovation	8		
Acquisition value of existing dwelling	€ 80.600		
Construction costs (VAT excluded)	€ 95.000		
VAT on construction costs 21%	€ 19.950		
Construction costs (VAT included)	€ 114.950		
Additional costs 20%	€ 22.990		
Contingencies ca. 5%	€ 5.860		
	€ 144.800		
Yield / transfer to operation	€ -	€ 225.400	
Balance (profit / loss)	€ 225.400	€ 225.400	

Operation		Benefits	
Intended operation period (years)	30		
Inflation	0,00%		
Real (internal) rate of return	1,82% which is nominal	1,82%	
Real depreciation rate / year	-0,60% which is nominal	-0,60%	
Vacancies	1,00%		
Annual reservation for management	€ 900 VAT included		
Annual reservation for maintenance and repair	€ 1.200 VAT included		
Annual reservation for business expenses	€ 600 VAT included		
	€ 225.400		
Acquisition value of renovated dwelling	€ 225.400		
Management (discounted value)	€ 21.040		
Maintenance (discounted value)	€ 28.050		
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Net revenues from rent (discounted value)	€ 176.350		
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Discounted exit-value (non-recurring yield)	€ 112.160		
Balance (profit / loss)	€ 288.510	€ 288.510	

Housing expenses		Benefits	
Rent per month	€ 635,05		
Energy per month	€ 128,45		
Service costs per month	€ -		
Total housing expenses	€ 763,50		

IRR = 1,82%

(635x8 + 592x0) / 8 = 635

(128x8 + 113x0) / 8 = 128

(763x8 + 705x0) / 8 = 763

Now, if we correct the whole thing for inflation, you can see that the exit-value is less than the input-value.

The IRR is 1,82%; that is on the bottom side of the feasibility.

Life cycle approach (NEN-standard 2699)			Renovation ~ nw.const.-level
Investment			
Acquisition value of existing premises (per dwelling)	€ 80.600	Benefits	
Number of dwellings (per staircase) before renovation	8		
Number of dwellings (per staircase) after renovation	10		
Acquisition value of existing dwelling	€ 64.480		
Construction costs (VAT excluded)	€ 79.000		
VAT on construction costs 21%	€ 16.590		
Construction costs (VAT included)	€ 95.590		
Additional costs 20%	€ 19.120		
Contingencies ca. 5%	€ 4.780		
Yield / transfer to operation	€ 120.400		
Balance (profit / loss)	€ -	€ 184.880	
Operation			
Intended operation period (years)	30		
Inflation	0,00%	which is nominal	1,82%
Real (internal) rate of return	1,82%	which is nominal	-0,00%
Real depreciation rate / year	-0,00%	which is nominal	-0,00%
Vacancies	1,00%		
Annual reservation for management	€ 900	VAT included	
Annual reservation for maintenance and repair	€ 1.200	VAT included	
Annual reservation for business expenses	€ 600	VAT included	
Costs			
Acquisition value of renovated dwelling	€ 184.880	Benefits	
Management (discounted value)	€ 21.040		
Maintenance (discounted value)	€ 28.050		
Property expenses (discounted value)	€ 14.020		
Total discounted value of periodic expenses	€ 63.110		
Gross revenues from rent (discounted value)		€ 173.360	
Less: cash value due to vacancies		€ -1.730	
Net revenues from rent (discounted value)		€ 171.630	
Nominal exit-value (non-recurring yield)		€ 155.270	
Discounted exit-value (non-recurring yield)	6% € 15.640	€ 92.000	
Balance (profit / loss)	€ 263.630	€ 263.630	
Housing expenses			
Rent per month	€ 618,25	Benefits	
Energy per month	€ 122,27		
Service costs per month	€ -		
Total housing expenses	€ 740,52		

$$80.600 \times 8 / 10 = 64.480$$

$$786.469 / 10 = 79.000$$

IRR = 2,23%

$$(635 \times 6 + 592 \times 4) / 10 = 618$$

$$(128 \times 6 + 113 \times 4) / 10 = 122$$

$$(763 \times 6 + 705 \times 4) / 10 = 740$$

What we can do, is make more apartments in the building block.
Investment costs and housing expenses will change.
But the effect is, that the IRR moves to the safer end of the spread.

Life cycle approach (NEN-standard 2699)			Renovation ~ sustainable
Investment			
Acquisition value of existing premises (per dwelling)	€ 80.600	Benefits	
Number of dwellings (per staircase) before renovation	8		
Number of dwellings (per staircase) after renovation	10		
Acquisition value of existing dwelling	€ 64.480		
Construction costs (VAT excluded)	€ 87.000		
VAT on construction costs 21%	€ 18.270		
Construction costs (VAT included)	€ 105.270		
Additional costs 20%	€ 21.050		
Contingencies ca. 5%	€ 5.280		
Yield / transfer to operation	€ 132.600		
Balance (profit / loss)	€ -	€ 197.080	
Operation			
Intended operation period (years)	30		
Inflation	0,00%	which is nominal	1,82%
Real (internal) rate of return	1,82%	which is nominal	-0,00%
Real depreciation rate / year	-0,00%	which is nominal	-0,00%
Vacancies	1,00%		
Annual reservation for management	€ 900	VAT included	
Annual reservation for maintenance and repair	€ 1.200	VAT included	
Annual reservation for business expenses	€ 600	VAT included	
Costs			
Acquisition value of renovated dwelling	€ 197.080	Benefits	
Management (discounted value)	€ 21.040		
Maintenance (discounted value)	€ 28.050		
Property expenses (discounted value)	€ 14.020		
Total discounted value of periodic expenses	€ 63.110		
Gross revenues from rent (discounted value)		€ 180.240	
Less: cash value due to vacancies		€ -1.980	
Net revenues from rent (discounted value)		€ 178.260	
Nominal exit-value (non-recurring yield)		€ 165.520	
Discounted exit-value (non-recurring yield)	6% € 16.320	€ 98.070	
Balance (profit / loss)	€ 278.510	€ 278.510	
Housing expenses			
Rent per month	€ 642,56	Benefits	
Energy per month	€ 73,25		
Service costs per month	€ -		
Total housing expenses	€ 715,81		

$$80.00 \times 8 / 10 = 64.480$$

$$867.445 / 10 = 87.000$$

IRR = 2,22%
actually IRR could be higher,
but some is given to tenants

$$(661 \times 6 + 615 \times 4) / 10 = 643$$

$$(77 \times 6 + 68 \times 4) / 10 = 73$$

$$(738 \times 6 + 683 \times 4) / 10 = 716$$

Finally, we add the extra measures, to make it a sustainable renovation in terms of energy efficiency and CO2-reduction.

This can yield the same IRR, if the profit of the reduction of energy-costs is split 50/50 between the tenant and the housing association.

Of course an extra investment has to be made.

