

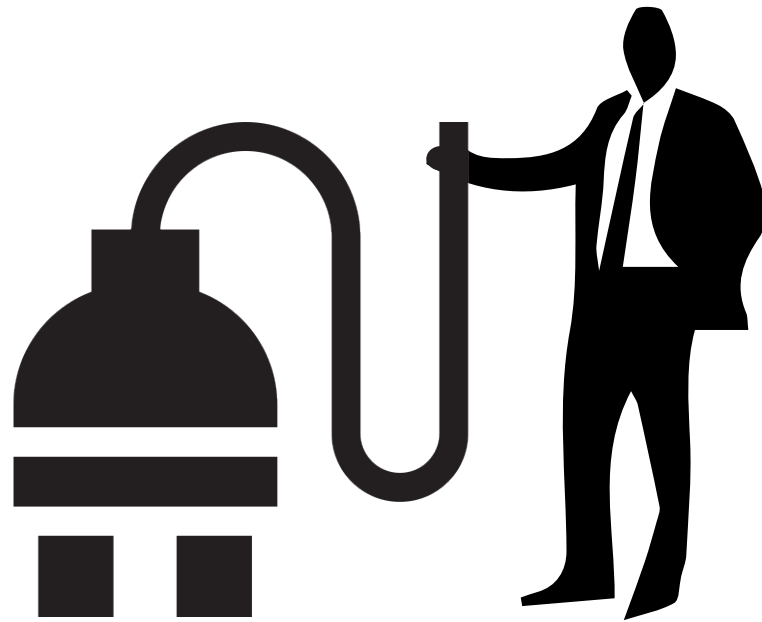
Beyond label C

The proposed policy evaluation of office building adaptation towards nearly zero-energy buildings

Saskia Geerts
28th June 2019

Dr. H.T. Remøy
Prof. dr.ir. H.J. Visscher

Dr. ir. H. Sohn



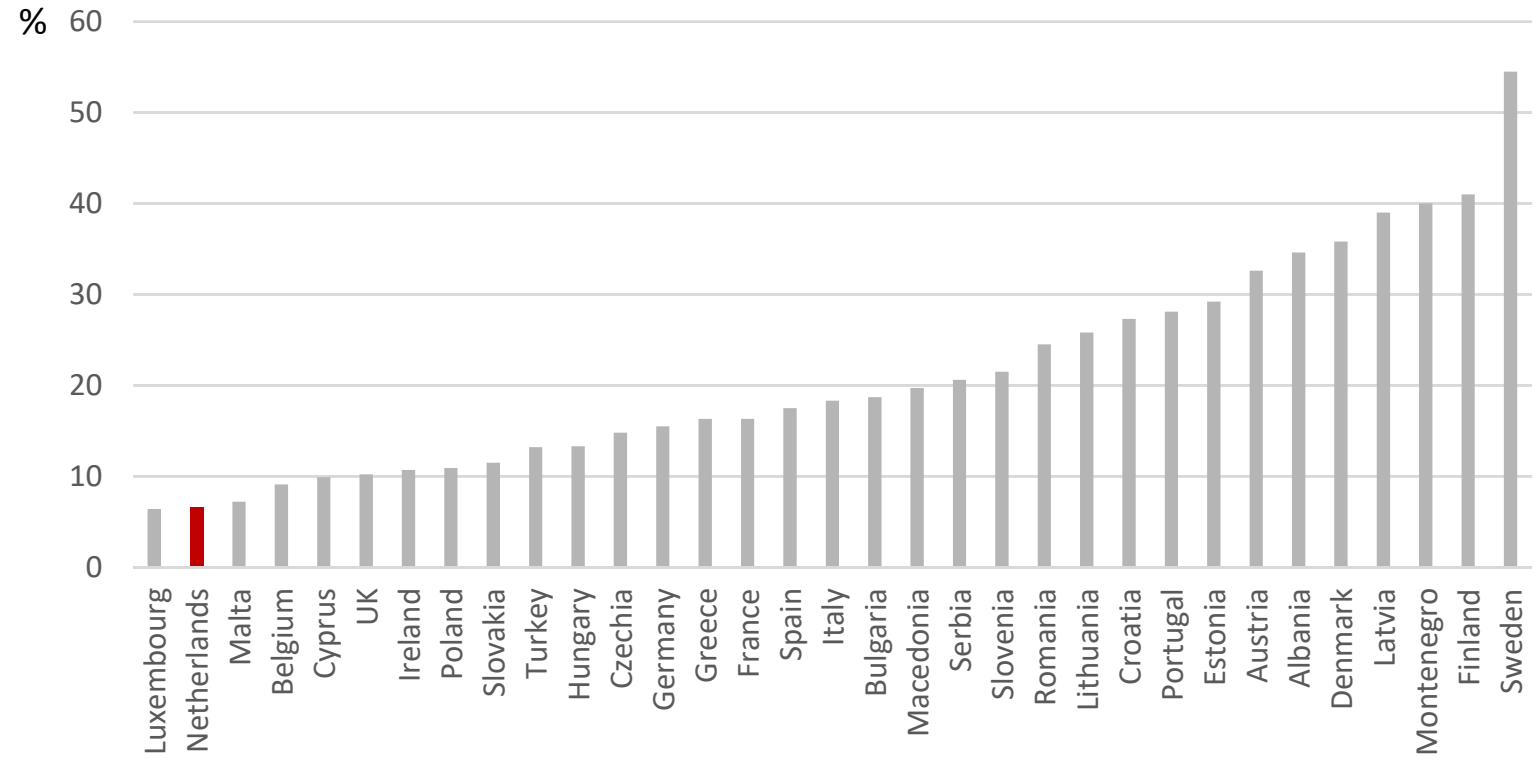


FOSSIL FUELS



GLOBAL WARMING

% RENEWABLES EU MEMBER STATES



THE NETHERLANDS

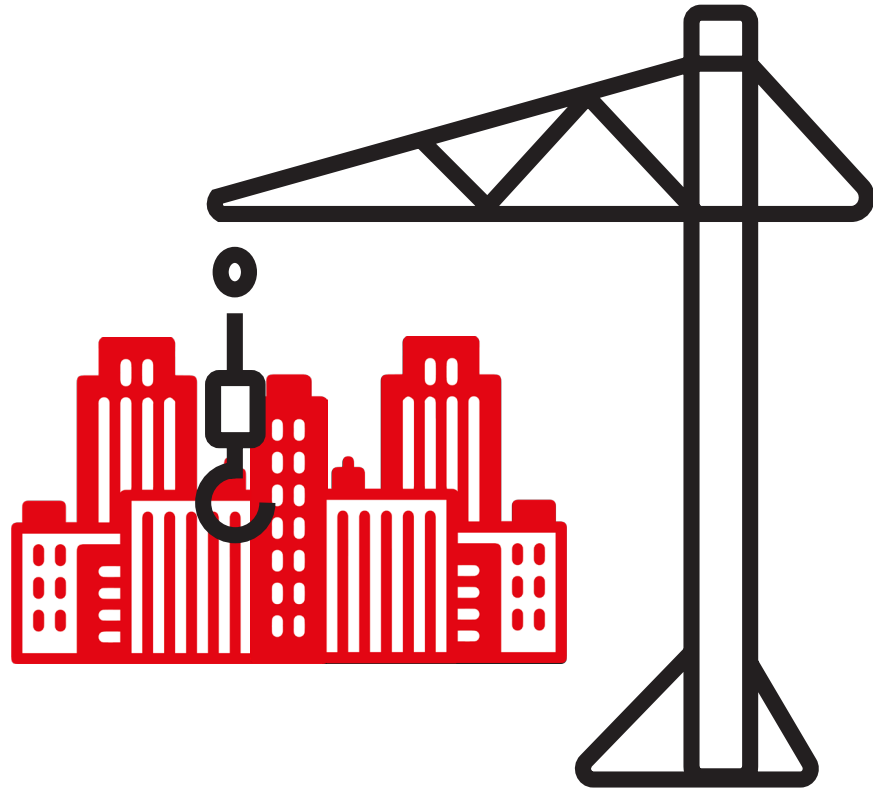


BUILDINGS:

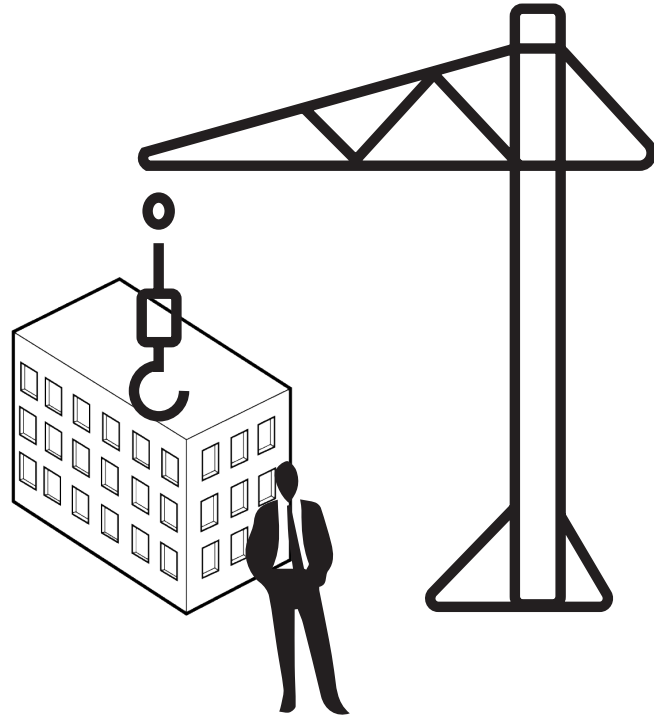
**CONSUME 40% OF OVERALL
ENERGY CONSUMPTION**



87% OF THE BUILDING
STOCK NEEDED IN 2050 IS
ALREADY BUILT

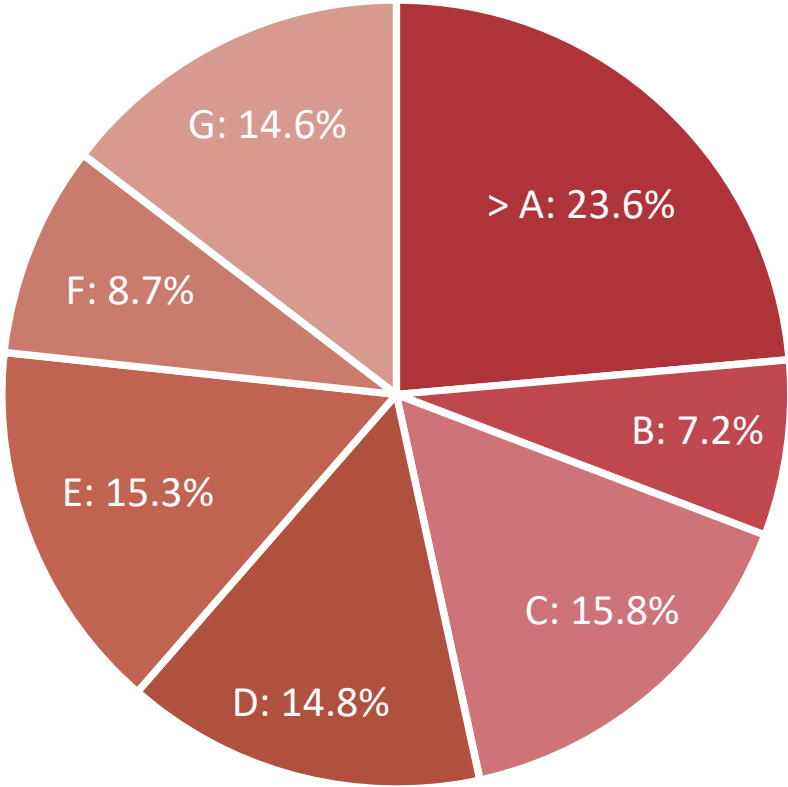


**ADAPTATION OF
EXISTING BUILDINGS**

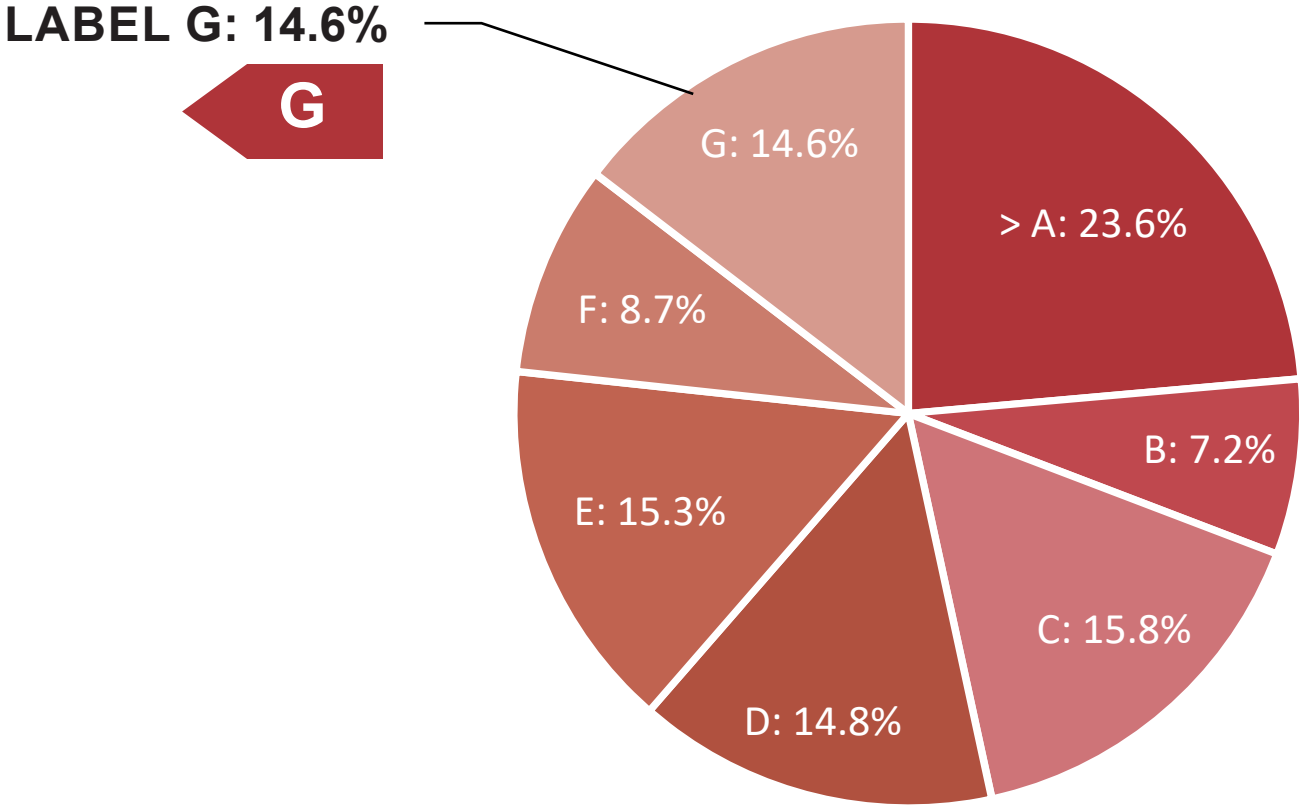


OFFICE ADAPTATION

ENERGY LABELS OFFICES



ENERGY LABELS OFFICES





1950 - 1975

Single glass

No heat exchange

Natural ventilation

No or little insulation



DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 19 May 2010

on the energy performance of buildings

(recast)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty on the Functioning of the European Union, and in particular Article 194(2) thereof,

Having regard to the proposal from the European Commission,

Having regard to the opinion of the European Economic and Social Committee ⁽¹⁾,Having regard to the opinion of the Committee of the Regions ⁽²⁾,Acting in accordance with the ordinary legislative procedure ⁽³⁾,

Whereas:

- (1) Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings ⁽⁴⁾ has been amended ⁽⁵⁾. Since further substantive amendments are to be made, it should be recast in the interests of clarity.
- (2) An efficient, prudent, rational and sustainable utilisation of energy applies, inter alia, to oil products, natural gas and solid fuels, which are essential sources of energy, but also the leading sources of carbon dioxide emissions.
- (3) Buildings account for 40 % of total energy consumption in the Union. The sector is expanding, which is bound to increase its energy consumption. Therefore, reduction of energy consumption and the use of energy from renewable sources in the buildings sector constitute important measures needed to reduce the Union's energy dependency and greenhouse gas emissions. Together with an increased use of energy from renewable sources, measures taken to reduce energy consumption in the Union would

ENERGY PERFORMANCE OF BUILDING DIRECTIVE

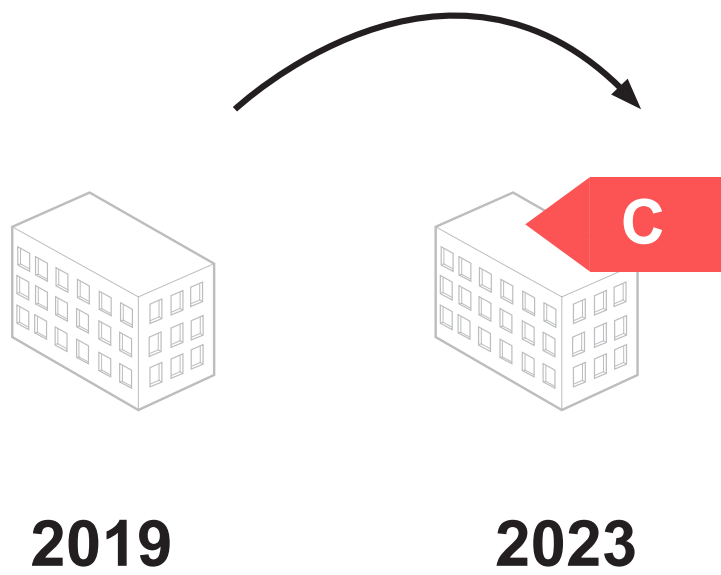
Adaptation of existing buildings towards:

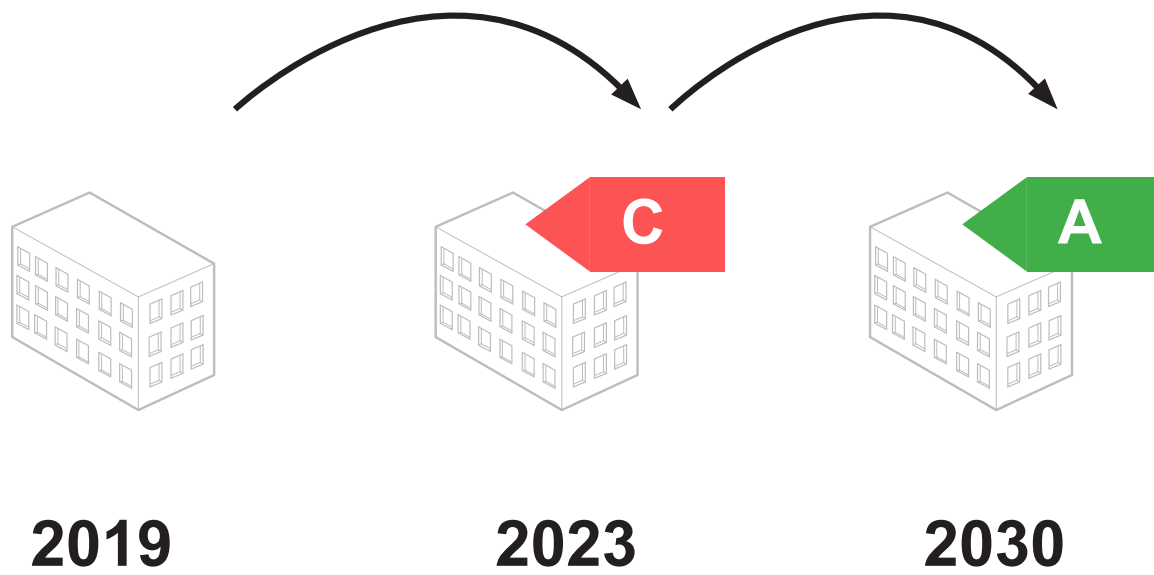
nearly zero-energy buildings by 2050

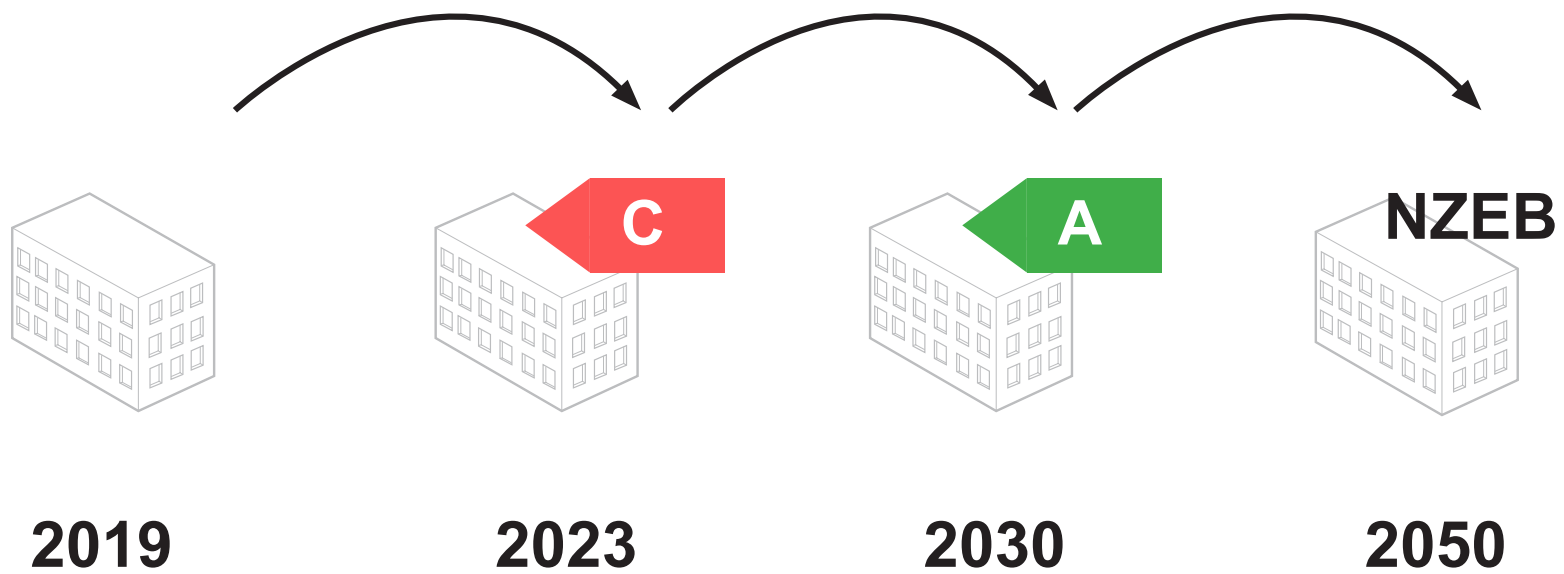
NEARLY ZERO-ENERGY BUILDINGS

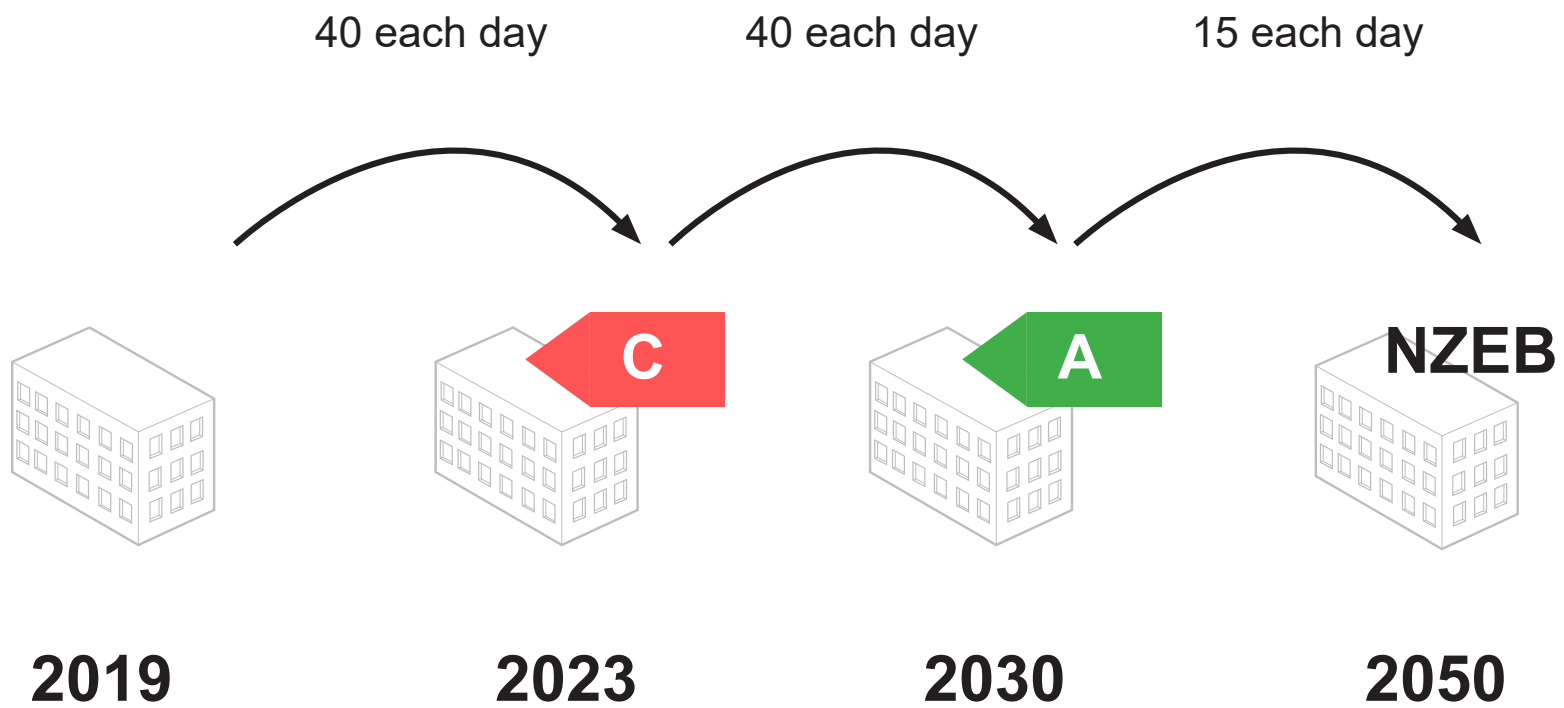


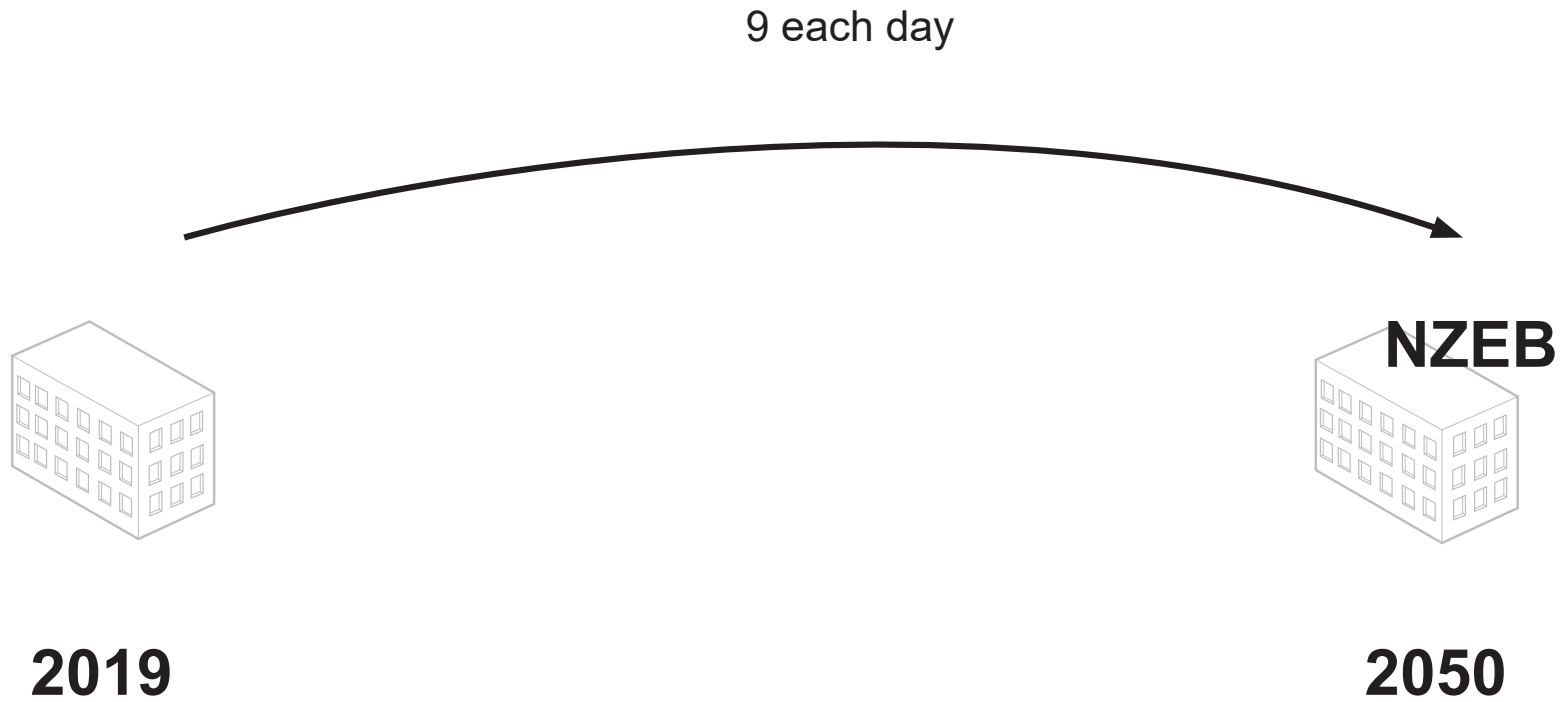
very high energy performance and the nearly zero amount of energy used, is generated to a significant extent by renewable sources

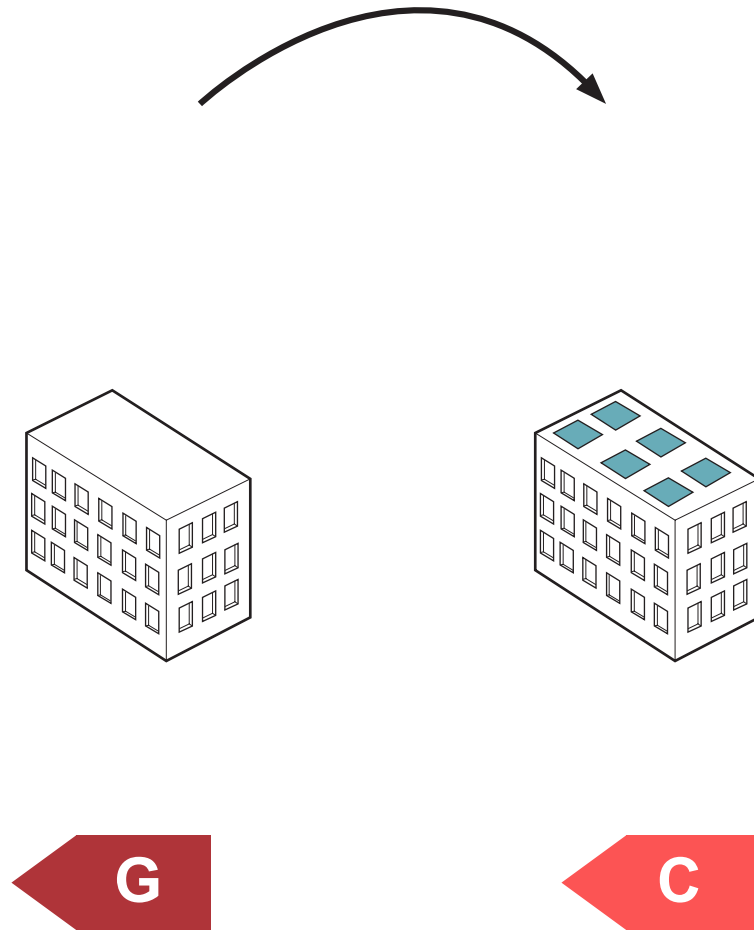


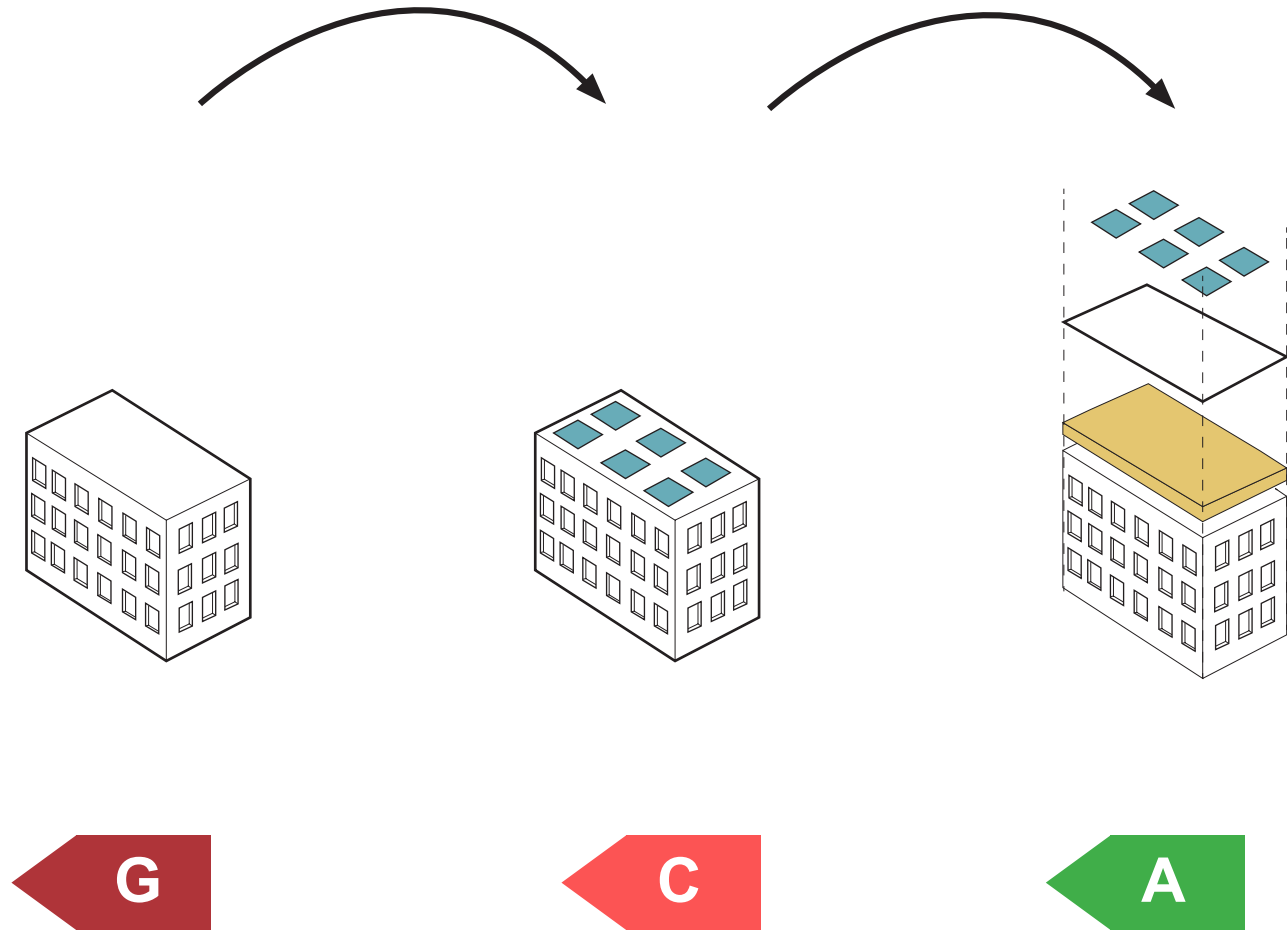


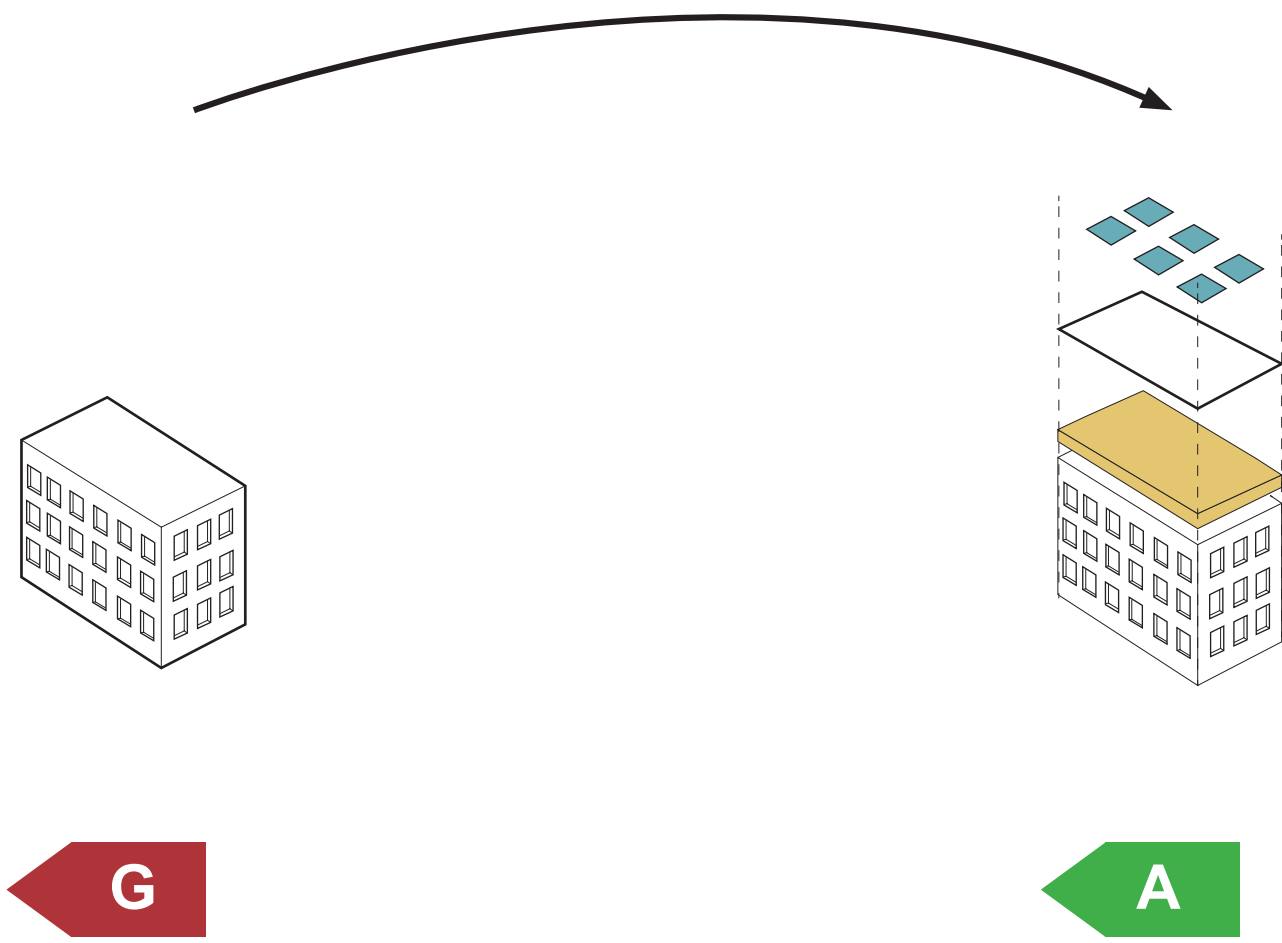








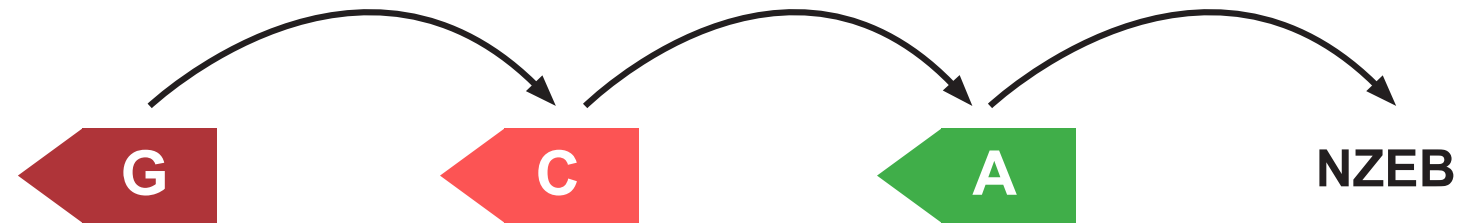




G

A

STEP BY STEP APPROACH



INEFFICIENT

**PRESSURE ON ADAPTATION
INDUSTRY**

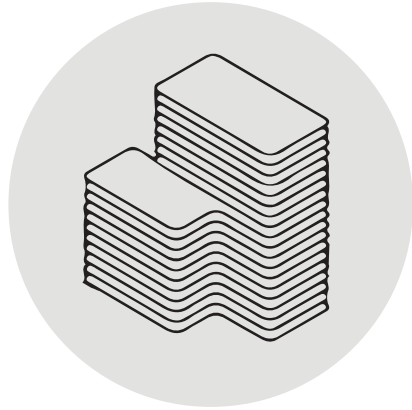
DIRECT APPROACH



RESEARCH QUESTION

What are the technical, financial, environmental and social implications of the proposed policy requirement of direct NZEB adaptation of office buildings with a current energy label G?

Technical:	needed techniques
Financial:	investments and resulting payback period
Environmental:	energy and CO2 savings
Social:	nuisance for the owners



OFFICE STOCK



ENERGY POLICY



ADAPTATION



OFFICE OWNERS



OFFICE STOCK



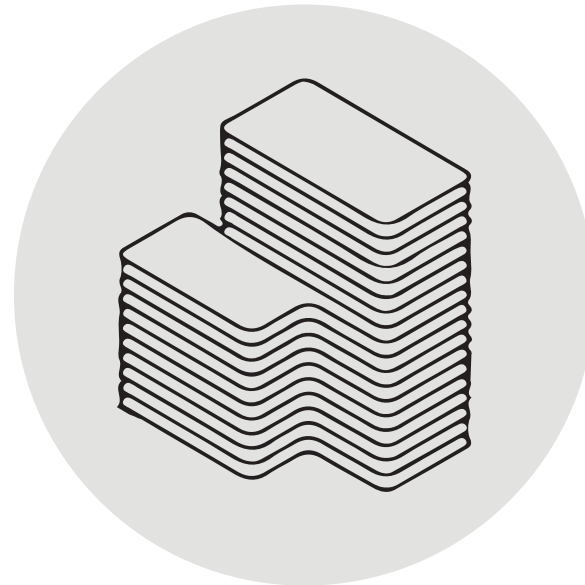
ENERGY POLICY



ADAPTATION



STAKEHOLDERS



THE OFFICE STOCK



OFFICE STOCK



ENERGY POLICY

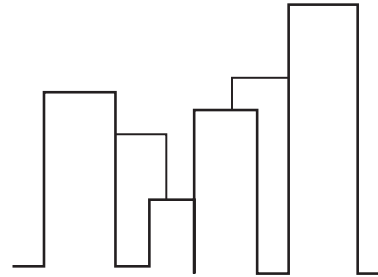


ADAPTATION



OFFICE OWNERS

THE OFFICE STOCK





OFFICE STOCK



ENERGY POLICY

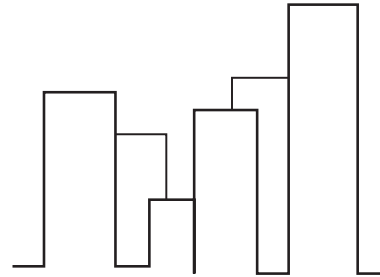


ADAPTATION

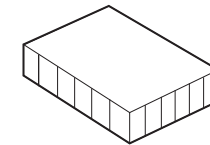
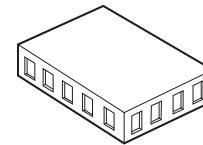
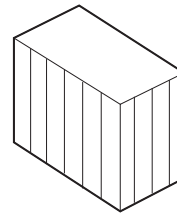
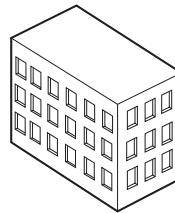


OFFICE OWNERS

THE OFFICE STOCK



OFFICE TYPOLOGIES





OFFICE STOCK



ENERGY POLICY

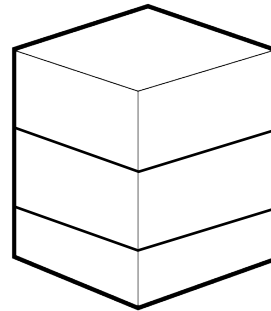


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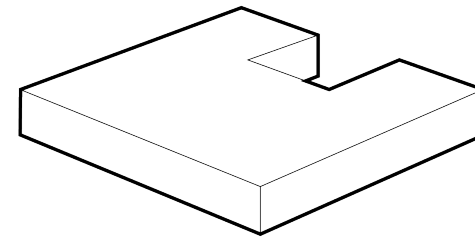


STAKEHOLDERS

COMPACTNESS



COMPACT



NON- COMPACT



OFFICE STOCK



ENERGY POLICY

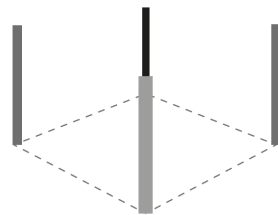


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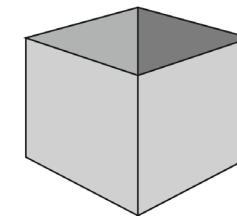


OFFICE OWNERS

STRUCTURE



NON LOAD BEARING FACADE



LOAD BEARING FACADE



OFFICE STOCK



ENERGY POLICY

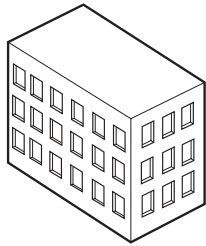


ADAPTATION



OFFICE OWNERS

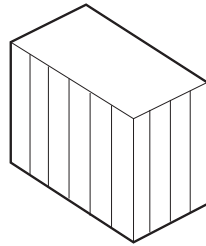
TYPE 1



COMPACT

LOAD BEARING

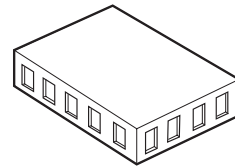
TYPE 2



COMPACT

NON-LOAD BEARING

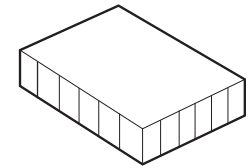
TYPE 3



NON- COMPACT

LOAD BEARING

TYPE 4



NON- COMPACT

NON-LOAD BEARING



OFFICE STOCK



ENERGY POLICY

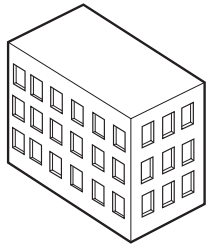


ADAPTATION



OFFICE OWNERS

TYPE 1

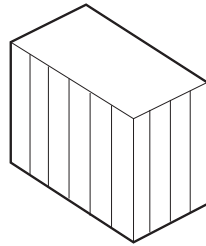


COMPACT

LOAD BEARING

27%

TYPE 2

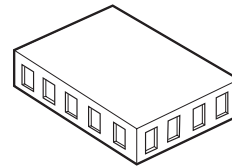


COMPACT

NON-LOAD BEARING

50%

TYPE 3

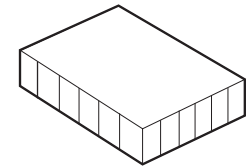


NON- COMPACT

LOAD BEARING

17%

TYPE 4



NON- COMPACT

NON-LOAD BEARING

7%



OFFICE STOCK



ENERGY POLICY



ADAPTATION



STAKEHOLDERS



ENERGY POLICIES



OFFICE STOCK



ENERGY POLICY



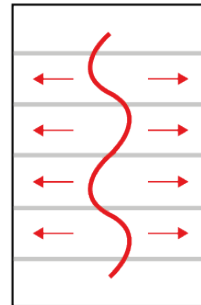
ADAPTATION



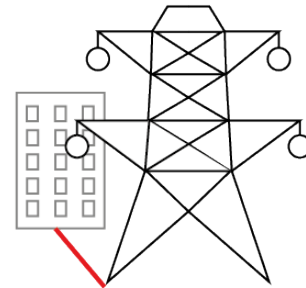
OFFICE OWNERS

NEARLY ZERO-ENERGY BUILDINGS

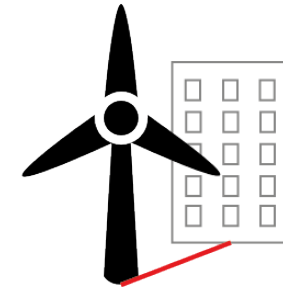
MAX ENERGY DEMAND



MAX PRIMARY FOSSIL ENERGY USE



MIN PERCENTAGE OF RENEWABLES





OFFICE STOCK



ENERGY POLICY



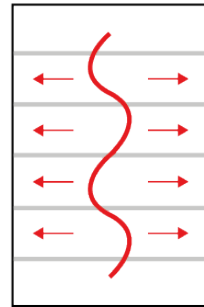
ADAPTATION



OFFICE OWNERS

NEARLY ZERO-ENERGY BUILDINGS

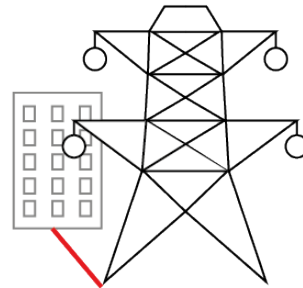
MAX ENERGY DEMAND



90

kWh/m².year

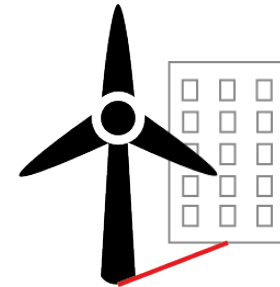
MAX PRIMARY FOSSIL
ENERGY USE



50

kWh/m².year

MIN PERCENTAGE OF
RENEWABLES



30

%



OFFICE STOCK



ENERGY POLICY



ADAPTATION



OFFICE OWNERS

DUTCH NATIONAL CLIMATE AGREEMENT





OFFICE STOCK



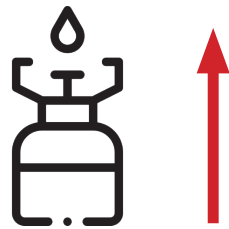
ENERGY POLICY



ADAPTATION



OFFICE OWNERS



**TAX FOR GAS WILL
INCREASE**



**PRICE FOR
ELEKTRICITY WILL
DECREASE**



OFFICE STOCK



ENERGY POLICY



ADAPTATION

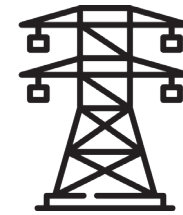


OFFICE OWNERS

SCENARIO 1



+10 CENTS

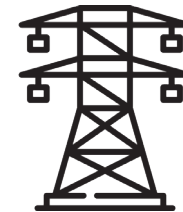


-5 CENTS

SCENARIO 2



+22 CENTS



-5 CENTS



OFFICE STOCK



ENERGY POLICY



ADAPTATION

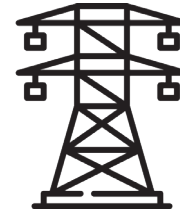


OFFICE OWNERS

SCENARIO 1



+10 CENTS

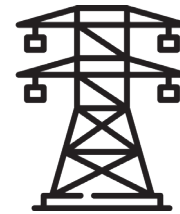


-5 CENTS

SCENARIO 2



+22 CENTS



-5 CENTS



OFFICE STOCK



ENERGY POLICY



ADAPTATION



STAKEHOLDERS



BUILDING ADAPTATION



OFFICE STOCK



ENERGY POLICY

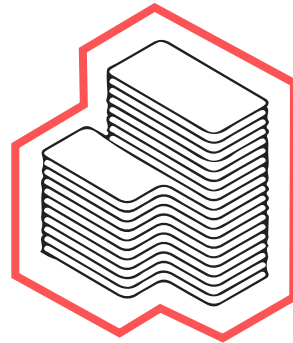


ADAPTATION



STAKEHOLDERS

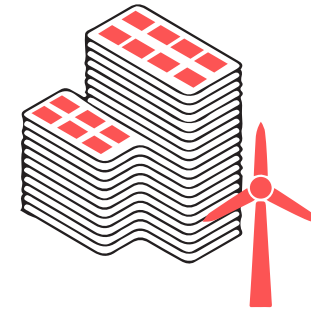
TRIAS ENERGETICA



REDUCE THE
DEMAND



USE FOSSIL ENERGY
AS EFFICIENT AS
POSSIBLE



USE SUSTAINABLE
ENERGY SOURCES



OFFICE STOCK



ENERGY POLICY

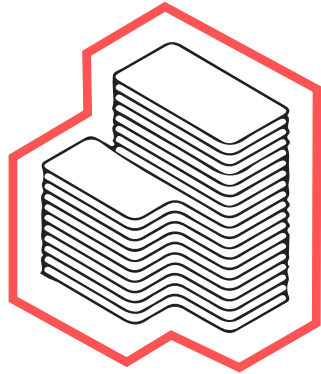


ADAPTATION



OFFICE OWNERS

ADAPT FACADE



REDUCE THE DEMAND



REPLACE FACADE



RENOVATE FACADE



OFFICE STOCK



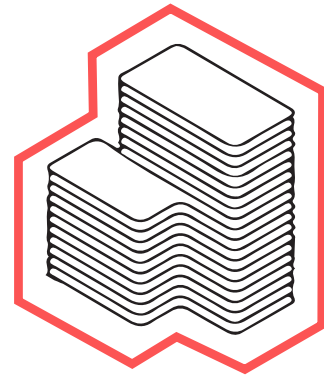
ENERGY POLICY



ADAPTATION



OFFICE OWNERS



REDUCE THE DEMAND

ADAPT FACADE

Roof and wall insulation	lambda-value of 0,035 W/m.K
HR+++ glass	U: 0,4 W/m ² K ZTA: 0,45
Window frames	U-value of 0,72 W/m ² K
Automatic outside shading	ZTA of 0.15
Seal off gaps and cracks	Airtightness: 0,15 dm ³ /s per m ²



OFFICE STOCK



ENERGY POLICY

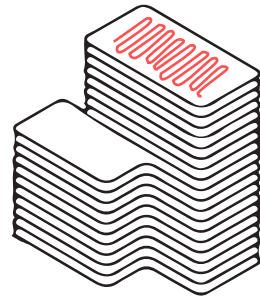


ADAPTATION



OFFICE OWNERS

REPLACE INSTALLATIONS



USE FOSSIL ENERGY
AS EFFICIENT AS
POSSIBLE

Daylight depending light

pulse or lighting sweep

led lights

wko and heat pump



OFFICE STOCK



ENERGY POLICY

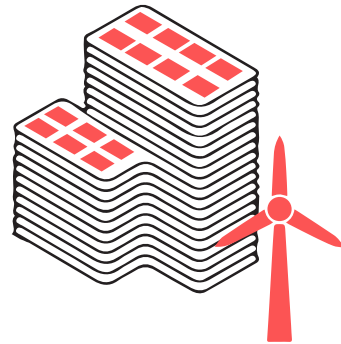


ADAPTATION



OFFICE OWNERS

GENERATE RENEWABLES



USE SUSTAINABLE
ENERGY SOURCES

Solar panels



OFFICE STOCK



ENERGY POLICY

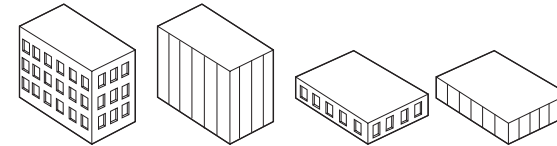


ADAPTATION



OFFICE OWNERS

INVESTMENT COSTS



Measure	Surface	Investment €/m2	Types			
			1	2	3	4
Roof insulation Rc 6	NRS	71	€ 25.560,00	€ 25.560,00	€ 110.050,00	€ 110.050,00
Floor insulation Rc 3,5	NBS	20	€ 7.200,00	€ 7.200,00	€ 31.000,00	€ 31.000,00
Outside wall insulation Rc 4,5 + plaster	NFS	130	€ 59.020,00		€ 74.880,00	
Cavity insulation 200mm Rc 5,7	NFS	14	€ 6.356,00		€ 8.064,00	
Replace facade panels RC 4,5	NFS	202		€ 91.708,00		€ 116.352,00
Windows U=0,8 + window frames 0,72	OF	389	€ 117.478,00	€ 117.478,00	€ 149.376,00	€ 149.376,00
Automatic sun shading ZTA 0,15	OF	108	€ 32.616,00	€ 32.616,00	€ 41.472,00	€ 41.472,00
80% wtw Luka D	AG	19	€ 20.520,00	€ 20.520,00	€ 29.450,00	€ 29.450,00
Heat pump 100 KW	AG	98	€ 105.840,00	€ 105.840,00	€ 151.900,00	€ 151.900,00
Insulation of pipes	AG	1	€ 1.080,00	€ 1.080,00	€ 1.550,00	€ 1.550,00
LED	AG	25	€ 27.000,00	€ 27.000,00	€ 38.750,00	€ 38.750,00
Daylight depending light	AG	4				
Pulse- or (timed) lighting sweep	AG	1	€ 1.080,00	€ 1.080,00	€ 1.550,00	€ 1.550,00
Solar panels 300wp Roof	m2	237	€ 21.330,00	€ 21.330,00	€ 24.885,00	€ 24.885,00

Total [€]	€ 425.080,00	€ 451.412,00	€ 662.927,00	€ 696.335,00
Incl btw [€]	€ 463.337,20	€ 492.039,08	€ 722.590,43	€ 759.005,15
Total [€/m2]	429,0159259	455,5917407	466,1873742	489,6807419
Maintenance [€/m2]	€ 75,70	€ 75,70	€ 75,70	€ 75,70
Additional costs [€/m2]	€ 353,32	€ 379,89	€ 390,49	€ 413,98



OFFICE STOCK



ENERGY POLICY

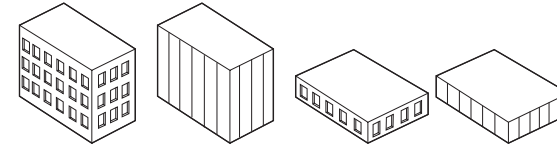


ADAPTATION



OFFICE OWNERS

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Total [€]	€ 425.080,00	€ 451.412,00	€ 662.927,00	€ 696.335,00
Additional costs	€ 353,32	€ 379,89	€ 390,49	€ 413,98
Total [€]	€ 425.433,32	€ 451.791,89	€ 663.317,49	€ 696.748,98



OFFICE STOCK



ENERGY POLICY



ADAPTATION



OFFICE OWNERS

ENERGY SAVINGS

	NZEB
Energy savings [PJ]	3.1
Reduction CO₂ emissions [Mton]	0.6 - 0.7



OFFICE STOCK



ENERGY POLICY



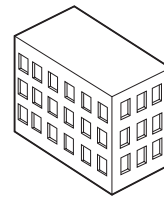
ADAPTATION



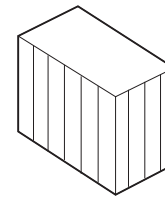
OFFICE OWNERS

PAYBACK PERIOD

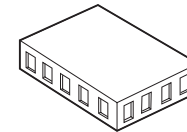
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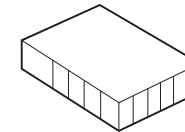
TYPE 2



TYPE 3



TYPE 4



Scenario 1	26	28	30	32
Scenario 2	22	23	24	26



OFFICE STOCK



ENERGY POLICY



ADAPTATION



OFFICE OWNERS

COMPARING TO LABEL C

	NZEB	C
Techniques	Major renovation	Mainly replacement of installations
Investment costs [€/m²]	353 - 413	39 - 57
Energy savings [PJ]	3,1	2,4
[MJ/€]	8	42



OFFICE STOCK



ENERGY POLICY



ADAPTATION



OFFICE OWNERS



OFFICE OWNERS



OFFICE STOCK



ENERGY POLICY

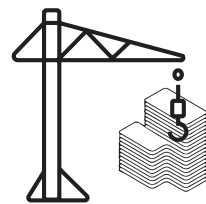


ADAPTATION



OFFICE OWNERS

DECISION MAKING OFFICE OWNERS



ADAPT



OFFICE STOCK



ENERGY POLICY

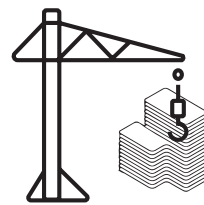


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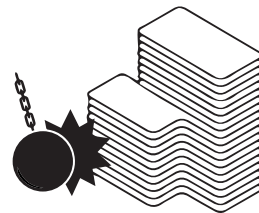


OFFICE OWNERS

DECISION MAKING OFFICE OWNERS



ADAPT



DEMOLISH



OFFICE STOCK



ENERGY POLICY

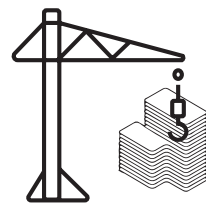


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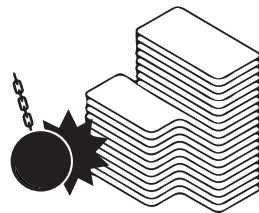


OFFICE OWNERS

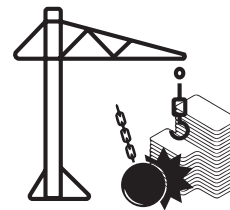
DECISION MAKING OFFICE OWNERS



ADAPT



DEMOLISH



DEMOLISH AND
BUILT NEW



OFFICE STOCK



ENERGY POLICY

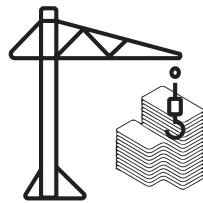


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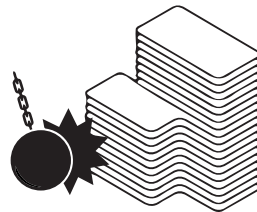


OFFICE OWNERS

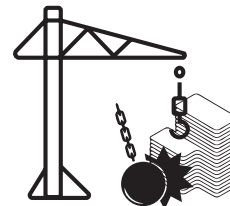
DECISION MAKING OFFICE OWNERS



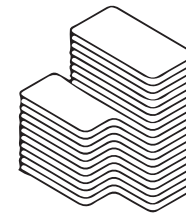
ADAPT



DEMOLISH



DEMOLISH AND
BUILT NEW



LEAVE VACANT



OFFICE STOCK



ENERGY POLICY

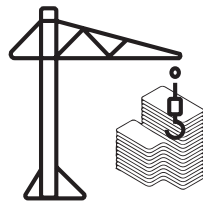


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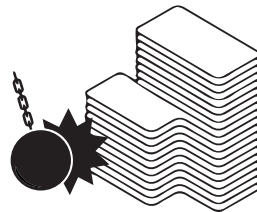


OFFICE OWNERS

DECISION MAKING OFFICE OWNERS



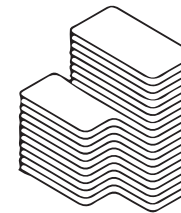
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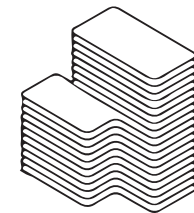
DEMOLISH



DEMOLISH AND
BUILT NEW



LEAVE VACANT



SELL



OFFICE STOCK



ENERGY POLICY



ADAPTATION



OFFICE OWNERS



Dordrecht (1982)



Molenaarsgraaf (1962)



Amersfoort (1977)



Emmen (1971)



Rotterdam (1991)



Huis ter Heide (1987)



OFFICE STOCK



ENERGY POLICY



ADAPTATION



OFFICE OWNERS

FACTORS THAT INFLUENCES THE DECISION MAKING

Location

Technical opportunities

Personal situation of the owner

Vision of the owner regarding sustainability

Possibilities to change the land use plan



OFFICE STOCK



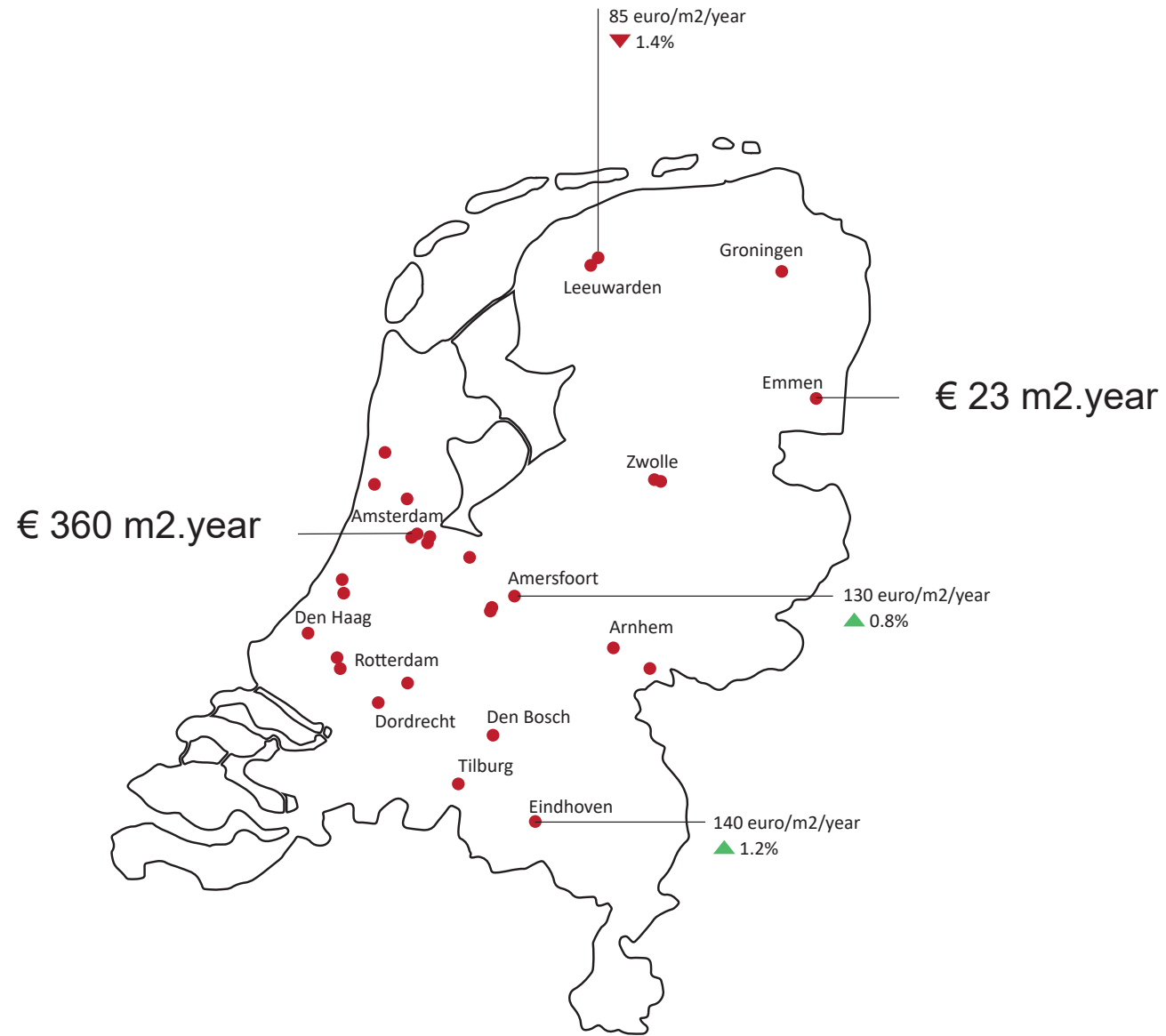
ENERGY POLICY



ADAPTATION



OFFICE OWNERS





OFFICE STOCK



ENERGY POLICY



ADAPTATION



OFFICE OWNERS

FACTORS THAT INFLUENCES THE DECISION MAKING

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OFFICE STOCK



ENERGY POLICY

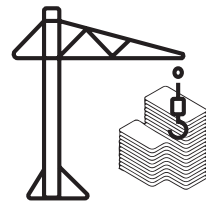


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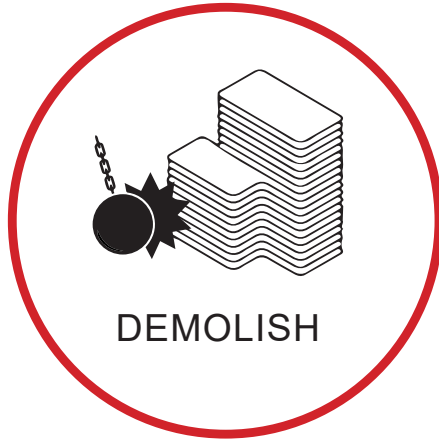


OFFICE OWNERS

DECISION MAKING OFFICE OWNERS



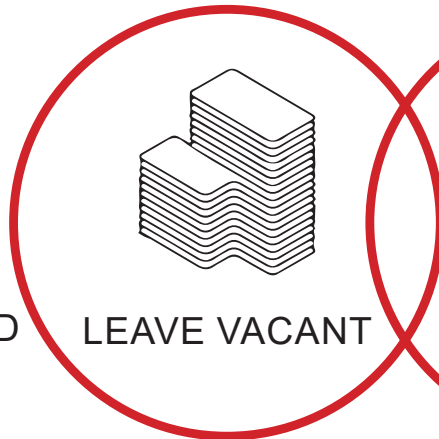
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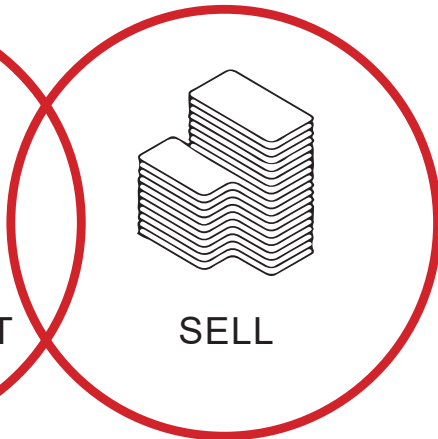
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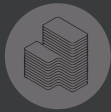
DEMOLISH AND
BUILT NEW



LEAVE VACANT



SELL



OFFICE STOCK



ENERGY POLICY



ADAPTATION



OFFICE OWNERS

EMMEN

€ 45 M2/YEAR





OFFICE STOCK



ENERGY POLICY



ADAPTATION



OFFICE OWNERS

HUIS TER HEIDE € 85 M2/YEAR

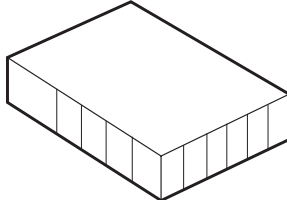
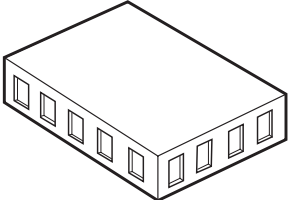
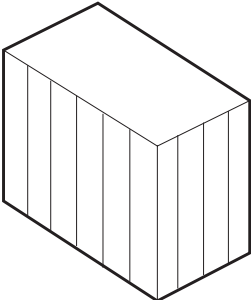
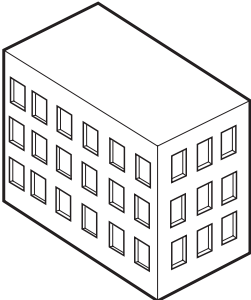


AMSTERDAM € 450 M2/YEAR

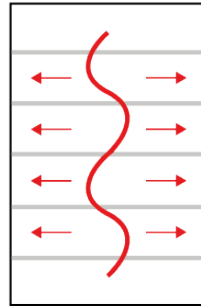


RESULTS

4 TYPOLOGIES



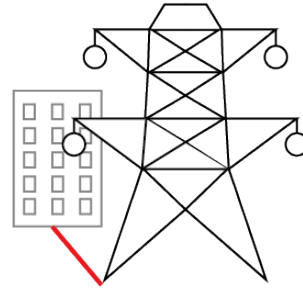
1. MAX ENERGY DEMAND



90

kWh/m².year

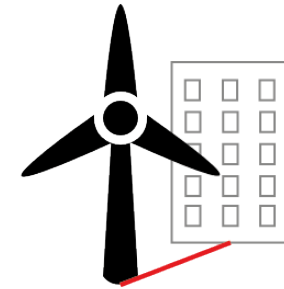
2. MAX PRIMARY FOSSIL ENERGY USE



50

kWh/m².year

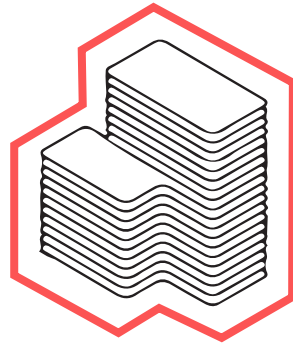
3. MIN PERCENTAGE OF RENEWABLES



30

%

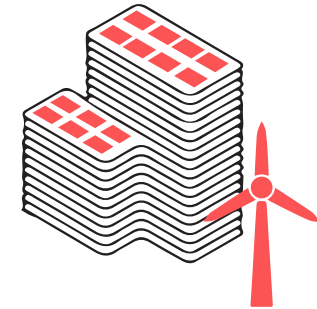
ADAPTATION TECHNIQUES



ADAPT FACADE



**REPLACE
INEFFICIENT
INSTALLATIONS**

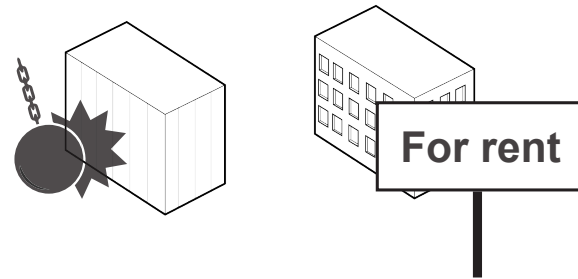


**GENERATE
RENEWABLES**

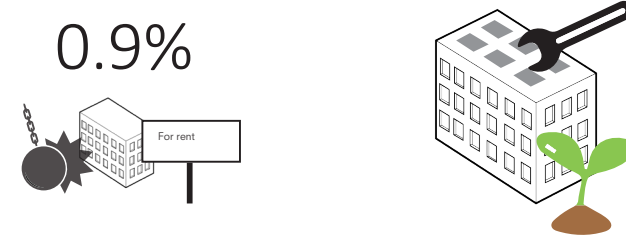
INVESTMENT COSTS/ ENERGY SAVINGS

	NZEB	C
Costs	353 – 414 €/m ²	39 -57 €/m ²
Energy savings	3,1 PJ	2,4 PJ
CO₂ savings	0,6 – 0,7 Mton CO ₂	0,4 Mton CO ₂
Payback period	22 – 32 years	3 – 4,5 years
Cost effectiveness	8 MJ/€	42 MJ/€

NZEB



LABEL C



CONCLUSIONS

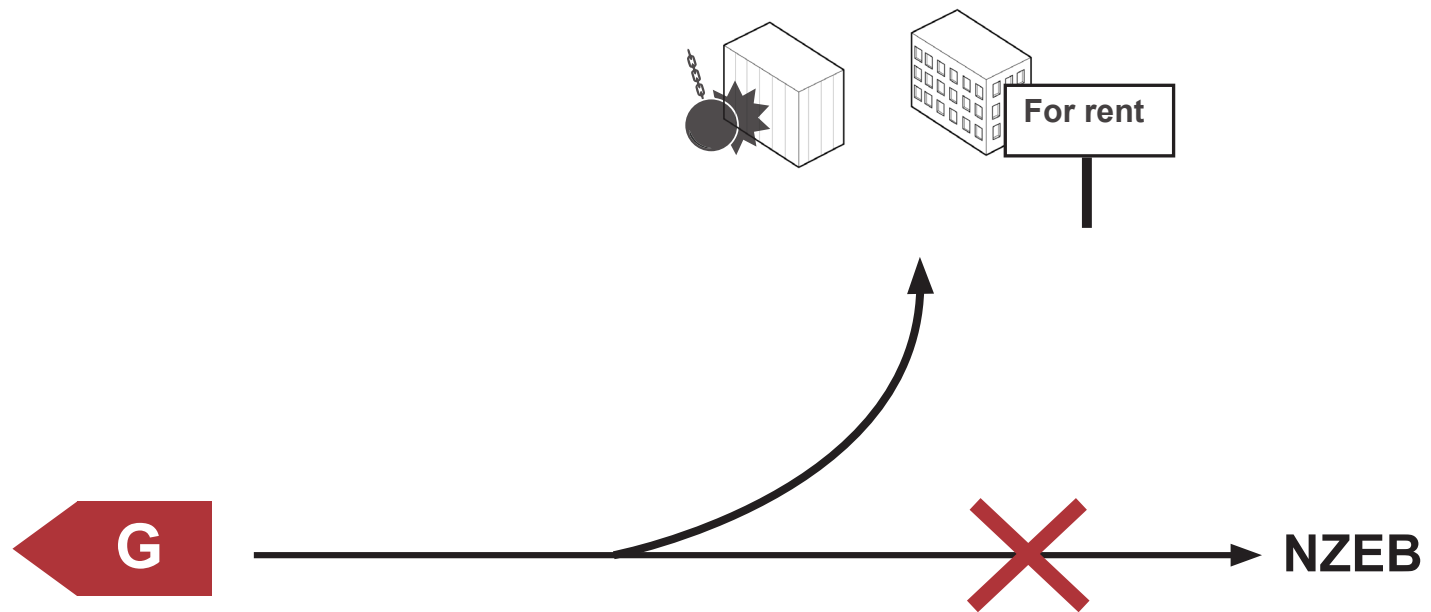
What are the technical, financial, environmental and social implications of the proposed policy requirement of direct NZEB adaptation of office buildings with a current energy label G?

Technically: the adaptation from label G to NZEB is possible

Financially: the adaptation results in the need for big investments and a payback period of over 32 years.

Environmentally: the adaptation leads to large energy savings

Socially: the adaptation leads to major nuisance for the office owners. They have to sell, demolish or leave the building vacant.



RECOMMENDATIONS

1. **Involve stakeholders, when evaluating policies**

RECOMMENDATIONS

- 1. Involve stakeholders, when evaluating policies**
- 2. Focus on the continuation of rent income**

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- 3. Creating visions for the future of office locations**

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- 1. Involve stakeholders, when evaluating policies**
- 2. Focus on the continuation of rent income**
- 3. Creating visions for the future of office locations**
- 4. Make use of other policy tools at a differentiated approach to achieve NZEB**

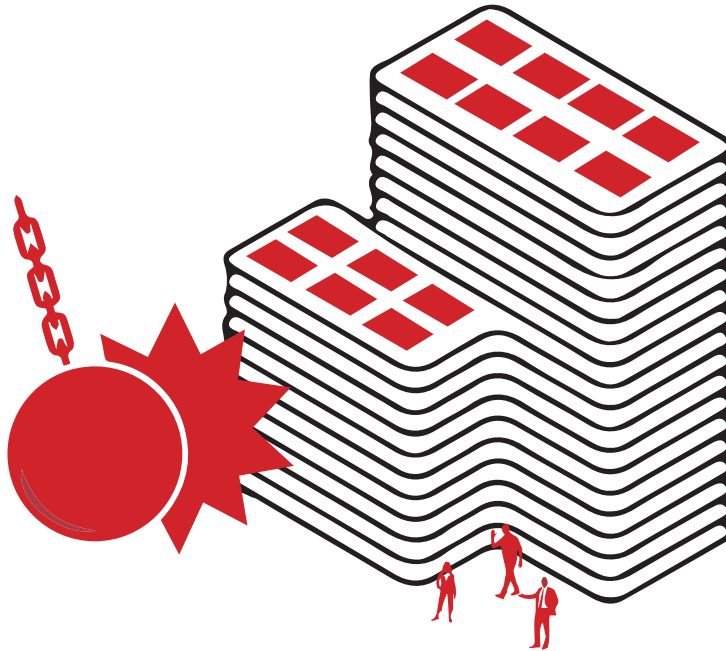
DISCUSSION

Depending on district heating

Possibilities to accelerate adaptation capacity

Heat pumps become cheaper

CO₂ costs during whole life cycle



Beyond label C

The proposed policy evaluation of office building adaptation towards nearly zero-energy buildings