The effect of the Estimated Service Life on the sustainability of vacancy strategies

6 Juli 2012

Sascha Jansz, 1302949
The problem

14% ± 7.000.000 M²
Actieprogramma leegstaande kantoren

‘Kantorenleegstand in tien jaar naar 5 procent’

Suggested strategies:
• Redevelopment, transformation and demolition

How??
Decision making process

Idea

Financial analysis

Design variants

Choice of design

Sustainability analysis

Construction

breeam

GreenCalc+
Environmental load per year

- Materials
- Energy
- Water

Once-off load caused by construction

Annual loads

Will all strategies have the same lifespan? → ESL

Construction load

Load has been paid off

Lifespan accounting model (Van Den Dobbelsteen, 2004)
Research question

What effect does the *Estimated Service Life* (ESL) have on the measurement of the *sustainability* of possible real estate *strategies* for *vacant office buildings*?

Framework:

- No financial considerations
- No social considerations
- All strategies as equal as possible: same location, constructor, project manager, etc.
- All strategies as equal as possible to the reference building
Decision making process

- **Idea**
  - Financial analysis
  - Design variants
    - Sustainability analysis
  - Choice of design
    - Construction

- **Strategies**
  - Transformation
  - Redevelopment
  - Demolition
  - ... & New-build

- **Ambition levels**
Decision making process

Ambition levels

Sustainability analysis
Financial analysis

Choice of ambition

Design variants

Choice of design

Construction
Ambition levels

Traditional:
- Complying to all building decree requirements

Sustainable:
- Better than building decree requirements
- State-of-the-art building, also on non-sustainability issues.
## Strategies

<table>
<thead>
<tr>
<th>Redevelopment</th>
<th>Transformation</th>
<th>Demolition &amp; new-build</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>Dwellings</td>
<td>Office</td>
</tr>
<tr>
<td>Tradition</td>
<td>Sustainable</td>
<td>Dwellings</td>
</tr>
<tr>
<td>Renovation</td>
<td>Traditional</td>
<td>Traditional</td>
</tr>
<tr>
<td>Extensive</td>
<td>Transformation</td>
<td>Office</td>
</tr>
<tr>
<td>renovation</td>
<td>Sustainable</td>
<td>Sustainable</td>
</tr>
<tr>
<td>Intervention</td>
<td>Transformation</td>
<td>Sustainable</td>
</tr>
<tr>
<td>level</td>
<td>Sustainable</td>
<td>Sustainable</td>
</tr>
<tr>
<td>comparable</td>
<td>office</td>
<td>dwellings</td>
</tr>
<tr>
<td>to</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Consolidation**
Not one of the existing sustainability models includes the ESL →

- A new model had to be developed →

**S³ Model**

*Sustainable Strategy Selection model*

Environmental load per year
Important questions:

• What strategies are possible for this building?
• What is the environmental load caused by:
  • Construction
  • The strategies
• What is the ESL of each strategy?

Input

Step 1: Vacancy risk meter

Step 2: Transformation potential meter

Strategy pre-selection

S³ model

Step 4: Calculating the Remaining Environmental Load

Results per pre-selected strategy

Step 5: Determining the ESL
Remaining environmental load

- **Linear**
- **Positive**
- **Negative**

Real vs. Fictive

Sascha Jansz | p13
Determining the ESL Factor method

\[ ESL = RSL \times A \times B \times C \times D \times E \times F \times G \times T \times R \]

- A = Quality of components
- B = Design level
- C = Work execution level
- D = Indoor environment
- E = Outdoor environment
- F = Usage conditions
- G = Maintenance level
- T = Trends
- R = Related components

\[ \text{RSL: 50 years} \]
\[ \text{ESL: 75 years} \]
\[ \text{ESL: 25 years} \]
Determining the ESL

Factor method

\[
\text{ESL} = \text{RSL} \times A \times D \times T
\]

- A = Quality of components
- B = Design level
- C = Work execution level
- D = Indoor environment
- E = Outdoor environment
- F = Usage conditions
- G = Maintenance level
- T = Trends
- R = Related components

Framework:

- All strategies as equal as possible: same location, constructor, project manager, etc.
- All strategies as equal as possible to the reference building
- Replacing the design with ambition levels
Estimated service life

The improved factor method:

\[
ESL = RSL \times A_W \times D_W \times T_W
\]

\[
A_W = \left( \left( 1 - A \right) \times a \right) + 1
\]

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
<th>Weight</th>
<th>Factor</th>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Quality of components</td>
<td>1.89</td>
<td>A</td>
<td>Quality of components</td>
<td>1.89</td>
</tr>
<tr>
<td>B</td>
<td>Design level</td>
<td>1.62</td>
<td>B</td>
<td>In-use conditions</td>
<td>0.95</td>
</tr>
<tr>
<td>C</td>
<td>Work execution level</td>
<td>1.14</td>
<td>C</td>
<td>Maintenance level</td>
<td>1.06</td>
</tr>
<tr>
<td>D</td>
<td>Indoor environment</td>
<td>0.51</td>
<td>D</td>
<td>Indoor environment</td>
<td>0.95</td>
</tr>
<tr>
<td>E</td>
<td>Outdoor environment</td>
<td>0.79</td>
<td>E</td>
<td>Related components</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Improved factor method (Van Nunen, 2010)
The improved factor method:

\[ ESL = RSL \times A \times B \times C \times D \times E \times F \times G \]

where

\[ A_{W} = \left( \left( \left( \left( a_1 - a_0 \right) \times a_0 \right) + 1 \right) \right) \]

Requirements:

- If \( A = 0 \), than \( A_{W} \) should also be 0
- If \( A = 1 \) than \( A_{W} = 1 \) (building is the same as the reference building)
- For values above 1 the model is correct
Estimated service life

The improved improved factor method:

Requirements:

- If $A = 0$, than $A_W$ should also be 0
- If $A = 1$ than $A_W = 1$ (building is the same as the reference building)
- For values above 1 the model is correct

Improved improved factor method (Olthof & Jansz, 2012)
No literature available
• New system had to be developed

A: Quality of components
  - Structural quality
  - Facade quality

D: Indoor environment
  - Enquiry
  - Measurements

T: Trends
  - Vacancy percentage
  - Market position
Determining the ESL

No literature available
• New system had to be developed

Objective standard / reference building:
Building decree 2012
## Determining the ESL

### A: Quality of Components

<table>
<thead>
<tr>
<th>Structure (Incl. foundation)</th>
<th>Current building decree</th>
<th>Building decree of the year</th>
<th>0</th>
<th>1 - 2</th>
<th>3</th>
<th>4 - 5</th>
<th>6: Reference building</th>
<th>7 - 8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Adaptable</td>
<td>Yes</td>
<td>Significantly</td>
<td>There are distinguishing features (e.g. listed as a monument) that assure a longer lifetime</td>
<td>This score can only be assigned in retrospect</td>
</tr>
</tbody>
</table>

### Table

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0,17</td>
<td>0,33</td>
<td>0,50</td>
<td>0,67</td>
<td>0,83</td>
<td>1</td>
<td>1,17</td>
<td>1,33</td>
<td>1,5</td>
<td>1,67</td>
</tr>
</tbody>
</table>
**S^3 model**

- **Energy** \( \frac{p}{y} \)
- **Water** \( \frac{p}{y} \)

\[
\text{Materials } \frac{p}{y} \times 50 = \text{once-off load}
\]

\[
\text{Energy } \frac{p}{y}
\]

\[
\text{Water } \frac{p}{y}
\]

\[
+ \\
= \\
\]

**Total load caused by materials**

**Remained by materials**

**ESL**

**RSL = 50 Years**

GreenCalc+
### Score tables

#### Quality of components

<table>
<thead>
<tr>
<th>Structure</th>
<th>Yes/No</th>
<th>Sub-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the structure comply to the building decree 2012?</td>
<td>Yes/No</td>
<td>4-5</td>
</tr>
<tr>
<td>Does the structure comply to the building decree of its origin?</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Can the structure be adapted to comply to the building decree?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facade</th>
<th>ESL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the facade comply to the building decree 2012?</td>
<td>5</td>
</tr>
<tr>
<td>Does the facade comply to the building decree of its origin?</td>
<td></td>
</tr>
<tr>
<td>Can the facade be adapted to comply to the building decree?</td>
<td></td>
</tr>
</tbody>
</table>

#### Strategy pre-selection

- Do nothing
- Transformation TR dwellings: 60
- Transformation SUS dwellings: 125
- Demolition & new build TR dwellings: 75
- Demolition & new build SUS dwellings: 201

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Sascha Jansz | p23
Case A: Consolidation

Building age: 30 years \(\rightarrow\) 60% paid off \(\rightarrow\) 40% remaining \(\rightarrow\) 170.660

Greencalc reference: 50 years

ESL: 5 years (5.44...)

\[
\text{Env. L.}^p/\text{y strategy}_x = \frac{\text{Remaining Env. L.} + \text{Once off load}}{\text{ESL}} + \text{Env. L. Energy}^p/\text{y} + \text{Env. L. Water}^p/\text{y}
\]

\[
\frac{\text{Remaining Env. L.} + 40.100}{\text{ESL}} + 30.883 + 683 = 170.660 + 40.100 + 30.883 + 683 = 62.944
\]
### Results case A

| Redevelopment | Consolidation | 42,944 | 40,100 |
| Renovation    |             | 46,222 | 29,860 |
| Extensive renovation |             | 41,064 | 29,013 |
| Transformation | Traditional transformation | 32,332 | 28,367 |
|                | Sustainable transformation | 24,521 | 26,227 |
| Demolition & new-build | Traditional office | 39,081 | 28,977 |
|                | Traditional dwellings | 32,741 | 29,400 |
|                | Sustainable office | 26,909 | 28,860 |
|                | Sustainable dwellings | 24,066 | 26,287 |

**Vacancy risk:** Substantial

**Transformation potential:** high
Effect of the ESL

\[ Env.L.^{p/y}_{strategy\ x} = \]

\[ \frac{\text{Remaining Env.L.} + \text{Once off load}}{\text{ESL}} + Env.L.Energy^{p/y} + Env.L.Water^{p/y} \]

- SUS Transf.: 125 years
- D&N SUS DW: 201 years

Advantage for strategies with a longer ESL
Effect of the ESL

\[
\text{Env. L.}^P/\text{y} \text{ strategy } x = \frac{\text{Remaining Env. L.} + \text{Once off load}}{\text{ESL}} + \text{Env. L. Energy}^P/\text{y} + \text{Env. L. Water}^P/\text{y}
\]

<table>
<thead>
<tr>
<th>Transformation</th>
<th>Demolition &amp; new-build</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transf.</td>
<td>170.660 / 125 = 1.365</td>
</tr>
<tr>
<td>D&amp;N</td>
<td>170.660 / 201 = 850</td>
</tr>
<tr>
<td></td>
<td>28.818 / 125 = 231</td>
</tr>
</tbody>
</table>
Quality of components

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
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<td>1.89</td>
</tr>
<tr>
<td>D</td>
<td>Indoor environment</td>
<td>0.51</td>
</tr>
<tr>
<td>T</td>
<td>Trends</td>
<td>1.19</td>
</tr>
</tbody>
</table>

→ Equal to the reference building (5 → 6)
→ ESL increases

Transformation: 125 → 150
Demolition & new-build: 201 → 201
<table>
<thead>
<tr>
<th>Case</th>
<th>Structural quality</th>
<th>Linear</th>
<th>Pos. annuity</th>
<th>Neg. annuity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>5</td>
<td>8/9</td>
<td>9/10</td>
<td>9/10</td>
</tr>
<tr>
<td>Case 2</td>
<td>4</td>
<td>8/9</td>
<td>8/9</td>
<td>8/9</td>
</tr>
<tr>
<td>Case 3</td>
<td>8</td>
<td>7/8</td>
<td>7/8</td>
<td>6/7</td>
</tr>
<tr>
<td>Case A</td>
<td>5</td>
<td>6/7</td>
<td>5/6</td>
<td>5/6</td>
</tr>
</tbody>
</table>
Conclusions

What did I do?

- Replacing design with ambition levels
- Adapted Van Nunen (2010)
- Developed a model that corrects het Greencalc+ scores with the ESL

What did I learn?

- ESL influences the sustainability measurement
- Including the ESL advantages strategies with a higher ESL
- Remaining environmental load and deduction method do influence the sustainability measurement
Recommendations

1. More research on the calculation method of environmental load.
   • Including the remaining environmental load or not.
   • What deduction method is to be used to calculate the remaining env load?

2. Standardize the calculation method.

3. More research on assigning ESL factors (score tables).

4. Standardisation of assigning ESL factors to existing buildings and ambition levels of strategies.
Questions?
Cases
Case Analysis

Effect of the ESL

Greencalc\(^{+}\)

Case A

- Transformation
- Sustainable dwellings

Case 1

- Demolition & new-build
- Sustainable dwellings

Case 2

- Demolition & new-build
- Sustainable dwellings

Case 3

- Transformation
- Sustainable dwellings

ESL included

- Demolition & new-build
- Sustainable dwellings

- Demolition & new-build
- Sustainable dwellings

- Demolition & new-build
- Sustainable dwellings

- Transformation
- Sustainable dwellings
Data:

Vacancy risk : Class 1
Transformation potential : Class 2

Quality of components
- Structural quality : 6
- Facade quality : 4

Trends
- Market position : 3
- Vacancy : 4

Indoor climate
- Enquiry : 4
- Measurements : 4

Result:
### Data:

<table>
<thead>
<tr>
<th>Category</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacancy risk</td>
<td>Class 2</td>
</tr>
<tr>
<td>Transformation potential</td>
<td>Class 1</td>
</tr>
<tr>
<td>Quality of components</td>
<td></td>
</tr>
<tr>
<td>- Structural quality</td>
<td>5</td>
</tr>
<tr>
<td>- Facade quality</td>
<td>3</td>
</tr>
<tr>
<td>Trends</td>
<td></td>
</tr>
<tr>
<td>- Market position</td>
<td>3</td>
</tr>
<tr>
<td>- Vacancy</td>
<td>4</td>
</tr>
<tr>
<td>Indoor climate</td>
<td></td>
</tr>
<tr>
<td>- Enquiry</td>
<td>3</td>
</tr>
<tr>
<td>- Measurements</td>
<td>4</td>
</tr>
</tbody>
</table>

### Result:
Data:

Vacancy risk : Class 1
Transformation potential : Class 2

Quality of components

• Structural quality : 4
• Facade quality : 2

Trends

• Market position : 3
• Vacancy : 4

Indoor climate

• Enquiry : 2
• Measurements : 3

Result:

DEMOlITION & NEW-BUILD
SUSTAINABLE DWELLINGS
The cases

Case 3

Data:

- Vacancy risk: Class 2
- Transformation potential: Class 1

Quality of components
- Structural quality: 8
- Facade quality: 7

Trends
- Market position: 4
- Vacancy: 4

Indoor climate
- Enquiry: 2
- Measurements: 3

Result:
ESL formula
Estimated Service Life

Van Nunen, 2010

Formula including the weighting

\[ ESL = RSL \times A_w \times B_w \times C_w \times D_w \times E_w \times F_w \times G_w \times T_w \times R_w \]

\[ A_w = \left( (A - 1) \times a \right) + 1 \]

\[ B_w = \left( (B - 1) \times b \right) + 1 \]
Assessing vacant buildings, low factor values

Estimated Service Life

Negative values

Weight > 1

Reference
Estimated Service Life

Assessing vacant buildings, low factor values

Possible solution, all weights smaller than 1
(Weighting stays intact if the ratio stays the same)
Estimated Service Life

Assessing vacant buildings, low factor values

Possible solution, all weights smaller than 1

New problem: weighted factor never 0
Estimated Service Life

Van Nunen (2010)  
Adapted weighting factors

Negative values
Estimated Service Life

Negative values

Wanted mathematical relationship
Estimated Service Life

Olthof & Jansz, 2012

Wanted mathematical relationship

\[
ESL = RSL \cdot A_w \cdot B_w \cdot C_w \cdot D_w \cdot E_w \cdot F_w \cdot G_w \cdot T_w \cdot R_w
\]

\[
A_w = \begin{cases} 
1 + (A - 1)a_0 & \text{for } A > 1 \\
\alpha_1 A^2 + \alpha_2 A & \text{for } A \in [0..1] \end{cases}
\]

\[
\begin{align*}
\alpha_1 &= \alpha_0 - 1 \\
\alpha_2 &= 2 - \alpha_0
\end{align*}
\]
S$^3$ Model
S³ Model

Strategies

Smart estimates

Ambition levels

Building specifications
General information

Independent factors

Design

Vacancy risk & transformation potential
Lifespan accounting model

Adapted from literature

ESL

Materials
Energy
Water

S³ model

Environmental load per year

GreenCalc+
Vacancy risk & transformation potential

Checklist with Veto criteria and gradual criteria

• Location level
• Building level
• (Small) market analysis

Vacancy risk / transformation potential class

• 1 – 5
• 1: Very suitable as office function / very suitable for transformation
• 5: Not suitable at all as office function / not suitable at all for transformation
Estimated Service Life

Olthof & Jansz, 2012

Used formula:

\[ ESL = RSL \times A_w \times B_w \times C_w \times D_w \times E_w \times F_w \times G_w \times T_w \times R_w \]

\[ A_w = \begin{cases} 1 + (A - 1)a_0 & \text{for } A > 1 \\ \alpha_1A^2 + \alpha_2A & \text{for } A \in [0..1] \end{cases} \]

\[ \alpha_1 = a_0 - 1 \]
\[ \alpha_2 = 2 - a_0 \]

\[ A_0 = A_w \]
Inside of the model

\[ Env.L. \frac{p}{y} \text{strategy}_x = \]

Building year

Deduction method

Linear

Positive

Annuity

Negative

\[ \frac{\text{Remaining Env.L.}}{\text{Total once off load}} + Env.L.\text{Energy}\frac{p}{y} + Env.L.\text{Water}\frac{p}{y} \]

Ambition level

Traditional

Sustainable

TR DW: 54

D&N DW: 75

TR DW: 95

D&N DW: 162
Inside of the model

\[ \text{Env. L.}^{P/y} \text{ strategy} \ x = \]

\[ \frac{\text{Remaining Env. L.} + \text{Total once off load}}{\text{ESL}} + \text{Env. L. Energy}^{P/y} + \text{Env. L. Water}^{P/y} \]

Example:

\[ \frac{10,000}{95} = 105 \]
\[ \frac{10,000}{162} = 62 \]
Inside of the model

\[ \text{Env. L.}^p_y \text{ strategy } x = \]

\[ \frac{\text{Remaining Env. L.} + \text{Total once off load}}{\text{ESL}} + \text{Env. L. Energy}^p_y + \text{Env. L. Water}^p_y \]

Ambition level

Traditional
- Transf.: 60
- D&N DW: 75

Sustainable
- Transf.: 125
- D&N DW: 201
Score tables
## Score table quality of components

<table>
<thead>
<tr>
<th>Component</th>
<th>Up-to-date with:</th>
<th>0</th>
<th>1-2</th>
<th>3</th>
<th>4-5</th>
<th>6: Reference building</th>
<th>7-8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structure (Incl. foundation)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current building decree</td>
<td>N</td>
<td>No</td>
<td>N</td>
<td>Adaptable</td>
<td>Yes</td>
<td>Significantly better</td>
<td>There are distinguishing features (e.g. listed as a monument) that assure a longer lifetime</td>
<td>This score can only be assigned in retrospect</td>
<td></td>
</tr>
<tr>
<td>Building decree of the building year</td>
<td>N</td>
<td>Adaptable</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Facade</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Score table trends

<table>
<thead>
<tr>
<th>Trends</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6: Reference to ‘normal’ market</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacancy percentage</td>
<td>20% or higher</td>
<td>20 – 15 %</td>
<td>15 – 11 %</td>
<td>8 -5 %</td>
<td>5% or lower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market position</td>
<td>95% of offices is better</td>
<td>70% of offices is better</td>
<td>45% of offices is better</td>
<td>20% of offices is better</td>
<td>10% of offices is better</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are distinguishing features that assure a continuous unchallenged position in the office market with a very low vacancy percentage.

This score can only be assigned in retrospect.
# Score table indoor quality

<table>
<thead>
<tr>
<th>Enquiry (old) user</th>
<th>% of users that complain about indoor quality</th>
<th>0</th>
<th>1 - 2</th>
<th>3</th>
<th>4 - 5</th>
<th>6: Reference building</th>
<th>7 - 8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indoor quality</strong></td>
<td><strong>Up-to-date with:</strong></td>
<td>90%</td>
<td>73%</td>
<td>55%</td>
<td>37%</td>
<td>20%</td>
<td>10% or less</td>
<td>20%</td>
<td>10% or less</td>
</tr>
<tr>
<td>Enquiry (old) user</td>
<td>% of users that complain about indoor quality</td>
<td>90%</td>
<td>73%</td>
<td>55%</td>
<td>37%</td>
<td>20%</td>
<td>10% or less</td>
<td>20%</td>
<td>10% or less</td>
</tr>
<tr>
<td><strong>Measurements</strong></td>
<td><strong>Current building decree</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Adaptable</td>
<td>Yes</td>
<td>Significantly better</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Measurements</strong></td>
<td><strong>Building decree of the building year</strong></td>
<td>No</td>
<td>Adaptable</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- There are distinguishing features (e.g. use of energy producing installations) that assure a longer lifetime.
- This score can only be assigned in retrospect.
From score to factor

\[ A = \text{Structure} \times 0.65 + \text{Facade} \times 0.35 \]

\[ T = \text{Market position} \times 0.5 + \text{Vacancy rate} \times 0.5 \]

\[ D = \text{Enquiry} \times 0.5 + \text{Measurements} \times 0.5 \]
What is sustainability?

- No financial considerations
- No social considerations

Comparison:

- Monetized output
- Same model for all strategies

When sustainability is mentioned this concerns the ecological **sustainability** of a building. This means it concerns the **materials, energy and water use of a building**.
Greencalc+ output

Case A

Original building:

<table>
<thead>
<tr>
<th>Original building</th>
<th>Environmental load per year by Greencalc+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>8.533</td>
</tr>
<tr>
<td>Energy</td>
<td>30.883</td>
</tr>
<tr>
<td>Water</td>
<td>683</td>
</tr>
</tbody>
</table>

All possible strategies

<table>
<thead>
<tr>
<th>Variant</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renovation Office</td>
<td>29.860</td>
</tr>
<tr>
<td>Extensive renovation Office</td>
<td>29.013</td>
</tr>
<tr>
<td>Transformation Traditional Residential</td>
<td>28.367</td>
</tr>
<tr>
<td>Transformation Sustainable Residential</td>
<td>26.227</td>
</tr>
<tr>
<td>Demolition &amp; New-build Traditional Office</td>
<td>32.897</td>
</tr>
<tr>
<td>Demolition &amp; New-build Sustainable Residential</td>
<td>29.400</td>
</tr>
<tr>
<td>Demolition &amp; New-build Traditional Office</td>
<td>28.860</td>
</tr>
<tr>
<td>Demolition &amp; New-build Sustainable Residential</td>
<td>26.287</td>
</tr>
</tbody>
</table>
### Greencalc screenshot

**Sureac - GreenCalc+ V4.2 - DEMOVERSIE**

**Ontwerp**

<table>
<thead>
<tr>
<th>Code</th>
<th>Bouwproduct</th>
<th>Aantal</th>
<th>Eenh.</th>
<th>Maat</th>
<th>Begrenzing</th>
<th>Milieukosten</th>
</tr>
</thead>
<tbody>
<tr>
<td>S00594</td>
<td>PIB aluminium verstevigd</td>
<td>355,03</td>
<td>m</td>
<td></td>
<td>n.v.t.</td>
<td>10,40</td>
</tr>
<tr>
<td>S10010</td>
<td>Deur (zachthout maaie)</td>
<td>1,44</td>
<td>m²</td>
<td></td>
<td>noordwest</td>
<td>0,11</td>
</tr>
<tr>
<td>S10088</td>
<td>Raam (trop.hardh. K)</td>
<td>123,76</td>
<td>m²</td>
<td></td>
<td>noordwest</td>
<td>15,75</td>
</tr>
<tr>
<td>S10010</td>
<td>Deur (zachthout maaie)</td>
<td>6,84</td>
<td>m²</td>
<td></td>
<td>zuidwest</td>
<td>0,51</td>
</tr>
<tr>
<td>S10088</td>
<td>Raam (trop.hardh. K)</td>
<td>589,16</td>
<td>m²</td>
<td></td>
<td>zuidwest</td>
<td>74,99</td>
</tr>
</tbody>
</table>

**Slabben**

S00594 PIB aluminium verstevigd (€ 0,03/m)

**Opmerkingen**

Gebouwdeel 1
Other
Place in the decision making process

Idea → Financial analysis → Design variants → Choice of design → Construction

Idea → Financial analysis → Sustainability analysis → Design variants → Choice of design → Construction
Lifespan

Functional

Technical

Vacancy

Economic

Vacancy

Environmental

Vijverberg, 2004
Van Den Dobbelsteen, 2004
Analysis DHV research

Transformation

Water use
Lifetime
Design
Energy use

Re-use of materials

Construction

Estimated service life?

Utilization

Design?

Energy use

Construction materials

Water use

New building

Equal building volume

Building statistics

Sustainability model

Conclusion:
Demolition & new built is more sustainable due to a much lower energy use and better use of space.

250 dwellings in transformation

Environmental load per M2 usable living space

370 dwellings in new building