1. INTRODUCTION

PROJECT SUMMARY
- Year of construction: 1990
- Past energy renovations: None

SPECIAL FEATURES
- Glazing facades and shading systems
- 600 kWp photovoltaic system
- Solar cooling, absorption chiller 15 kWf
- 10 m² solar collectors for DHW

ARCHITECT
B+B Associati (Renato Bredariol e Marco Bonariol)

OWNER
Schüco International Italia s.r.l.

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Schüco Italia Headquarter, Padova, ITA

IEA – SHC Task 47
Renovation of Non-Residential Buildings towards Sustainable Standards
2. CONTEXT AND BACKGROUND

BACKGROUND

- The building is located in the industrial district of Padova.
- 20,900 m² net heated floor area (1,300 m² boat office area, 2,500 m² butterfly office area).
- Occupational profile: the offices are occupied from 08:00 to 20:00.

OBJECTIVES OF THE RENOVATION

- Increased office area.
- Creation of a restaurant area.
- Creation of a showroom area.
- Reduction of heating and cooling energy consumption to obtain Energy Label A certification for both the new and renovated building.

Critical points

- No measured data available.
- Problematic split of consumptions between renovated and new building.
- No information on the energy consumption of the original building.

SUMMARY OF THE RENOVATION

- Considerable energy reduction for heating and cooling.
- 600 kWp photovoltaic system.
- Costs: approximately 7,2 M€ (renovation and new construction).
3. DECISION MAKING PROCESSES

- The project was initiated by the General Manager, Technical Director and German parent company.
- A need for more space and the decision to restore a building on an industrial estate at Padua: a challenge.
- Good level of energy efficiency together with high indoor comfort, without exceeding a reasonable economic budget.
- Serve as an exemplary case.
- Up-to-date technologies and products [building envelopes and renewable energy] to build a construction where the mission to save and produce energy is clear and visible.
- To create a large structure for the training and for showroom.
- To use the same building components both in the refurbished and new building.
- No public funding programs involved.
- No changes in the ambition level during the process. No reduced operational costs were used for payback.
- No information available about the selection of contractor and subcontractors.

Timeline for the decision making process

**Idea was born**
2008

**First brief project description completed**
Mar 2008

**Detailed project description completed**
Jun 2008

**Tendering process started**
No tendering process

**Signing of contract with main contractor**
xx

**Start renovation**
Nov 2008

**Renovation completed**
Oct 2009

**Evaluation among occupants**
dd.mm.year
4. BUILDING ENVELOPE BOAT

Roof construction: $U$-value: 0.296 W/m²K
Materials: (Exterior to interior): example:
- Gravel tiles: 30 mm
- Waterproofing
- Concrete: 40 mm
- Polystyrene insulation: 120 mm
- Concrete slab: 400 mm
- Air space: 70 mm
- Plasterboard: 20 mm
Total: 680 mm

Wall construction: $U$-value: 0.56 – 0.25 W/m²K
Materials: (Interior to exterior): example:
- Polystyrene insulation: 60 mm
- Concrete: 200 mm
- Rockwool insulation: 80 mm

Windows: $U$-value: 1.25 - 1.6 W/m²K
Materials: Low-emissivity glass
- Aluminum frame

Summary of $U$-values [W/m²K]

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOAT</td>
<td></td>
<td></td>
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<tr>
<td>Roof/attic</td>
<td>1.48</td>
<td>0.296</td>
</tr>
<tr>
<td>Walls</td>
<td>1.25</td>
<td>0.378</td>
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<tr>
<td>Windows</td>
<td>4.0</td>
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<table>
<thead>
<tr>
<th></th>
<th>Before</th>
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<tbody>
<tr>
<td>BUTTERFLY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roof/attic</td>
<td>-</td>
<td>0.296</td>
</tr>
<tr>
<td>Walls</td>
<td>-</td>
<td>0.250</td>
</tr>
<tr>
<td>Windows</td>
<td>-</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Window: AWS65 [$U_w$: 1.25 W/m²K]
Shielding: external louvers, internal roller blind
Window: E2 [$U_w$: 1.6 W/m²K]
Shielding: automated sun blind control system (external roller micro-louver) [$g_{glaz+shad} = 0.06$]
4. BUILDING ENVELOPE

**BOAT**

**Roof construction:** $U$-value: 0.296 W/m²K

Materials: (Exterior to interior): **example:**
- Gravel tiles: 30 mm
- Waterproofing
- Concrete: 40 mm
- Polystyrene insulation: 120 mm
- Concrete slab: 400 mm
- Air space: 70 mm
- Plasterboard: 20 mm
- Total: 680 mm

**Walls:** $U$-value: 0.250 – 0.296 W/m²K

Materials: (Interior to exterior): **example:**
- Polystyrene insulation: 60 mm
- Concrete: 200 mm
- Rockwool insulation: 80 mm

**Windows:** $U$-value: 1.25 – 1.6 W/m²K

Materials: Low-emissivity glass
- Aluminum frame with thermal break

**Summary of U-values [W/m²K]**

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<th></th>
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</tr>
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<td>0.378</td>
</tr>
<tr>
<td>Windows</td>
<td>4.0</td>
<td>1.6</td>
</tr>
</tbody>
</table>

**BUTTERFLY**

**Roof construction:** $U$-value: 0.296 W/m²K

Materials: (Exterior to interior): **example:**
- Gravel tiles
- Waterproofing
- Concrete
- Polystyrene insulation
- Concrete slab
- Air space
- Plasterboard
- Total

**Wall construction:** $U$-value: 0.56 – 0.25 W/m²K

Materials: (Interior to exterior): **example:**
- Polystyrene insulation
- Concrete
- Rockwool insulation

**Windows:** $U$-value: 1.25 - 1.6 W/m²K

Materials:
- Low-emissivity glass
- Aluminum frame with thermal break

---

**Shadings:**
- Automated sun blind control system (external roller blinds) [$g_{glaz+shad} = 0.06$]
- Automatic internal roller blinds

**Window:**
- E2 [$U_w$: 1.6 W/m²K]
- FW 60 [$U_w$: 1.5 – 1.8 W/m²K]
- Bow-window: double skin facade
  - Internal window: AWS 70HI [$U_w$: 1.55 W/m²K]
  - External window: FW 60 [$U_w$: 1.5 W/m²K] with integrated thin film glass-glass photovoltaic modules (amorphous thin-film)
  - Shadings: automatic internal roller blinds
  - $g_{total}$ (double skin facade) = 0.1

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Cross section [X-X]
5. BUILDING SERVICES SYSTEM
OVERALL DESIGN STRATEGY
Real-life demonstration of Schuco components and technology (example for other projects).

LIGHTING SYSTEM
- Lighting power: 28.5 kW (boat), 33.5 kW (butterfly), 4.5 kW (external).
- Internal heat gains: 24 W/m² (overall).

HEATING SYSTEM
- Existing: n°2 condensing boiler (615 kW).
- New: ground-coupled heat pumps (17 kW), 7 DN32 vertical pipe probes (depth 80 m) (10 m² solar panels integration).

HOT WATER PRODUCTION
- Existing: electric boiler.
- New: 10 m² solar thermal collectors [4 Schüco CTE 520 OF2 glazed flat collectors].
- (geothermal heat pumps integration in winter; (regeneration of heat probes in summer).

COOLING SYSTEM
- Existing: n°2 chiller (536 kWf).
- New: solar cooling, absorption chiller (15 kWf), 18 solar collectors (45 m²) [Argon filled double glazed top unit].

VENTILATION
- UTA system (offices and canteen).

RENEWABLE ENERGY SYSTEMS
- 600 kWp PV plant on the warehouse’s roof (4 550 m², 3 570 monocrystalline modules).
- PV clad double skin bow-windows façade (amorphous thin-film, 3 kWp).
- 9 + 1.8 kWp for test.

- Opening mechanism of the windows: horizontal pantograph movement opening outwards.
- Automated shielding for exploitation of natural light and reduction of thermal load through the windows façade.

Existing:
- Heating and cooling power plant
- Fancoil system (even for butterfly office)
- UTA system (boat office)

New (SHOWROOM):
- Radiant panels (heating + cooling)
- Ground coupled heat pump + tank-in tank storage
- Solar cooling plant
- Solar thermal collectors (DHW + heating support)

New (Floor1 and Floor2):
- Fancoil system
- UTA system (showroom, office and conference room)
6. ENERGY PERFORMANCES

- Purchased energy consumption:
  40 000 m³ gas (± 30%); 1.0 GWh electric
- Conditioned $S_U = 5,956 m²$
  (1 334 exist, 2 461 new, 2 161 warehouse)

### THERMAL

- Energy performance (kWh/m²)
  $EP = 102.7 \text{kWh/m}^2/\text{y}$ (declared)
- Primary energy consumption (*):
  $EP = 21.6 \text{kWh/m}^2/\text{y}$ (calc.) $[-47\%]$
  ... + (warehouse, 2 conditioned floors of the new building, kitchen)

### ELECTRICAL

- Photovoltaic production: 650 000 kWh/y
- Electrical primary energy could be considered as ZERO

(*) lighting is not included in EP

Naturally ventilated, NO cooling

Primary energy factor:
1.0 (gas), 2.18 (electricity)

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**Dynamic simulation [TRNSYS].** Heating, cooling, ventilation and hot water. Lighting is not included.

$S_U = 1'334 m²$

<table>
<thead>
<tr>
<th>HOT WATER</th>
<th>DELIVERED EN. kWh/m²/y</th>
<th>PRIMARY EN. kWh/EPy/m²/y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fancoils-offices</td>
<td>10.22</td>
<td>10.22</td>
</tr>
<tr>
<td>Fancoils-canteen</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>AHU-offices,heating</td>
<td>15.71</td>
<td>15.71</td>
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<tr>
<td>AHU-offices,post-heating</td>
<td>7.90</td>
<td>7.90</td>
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<tr>
<td>AHU-canteen,heating</td>
<td>9.58</td>
<td>9.58</td>
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<tr>
<td>AHU-canteen,post-heating</td>
<td>2.69</td>
<td>2.69</td>
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<tr>
<td>Radiators</td>
<td>0.58</td>
<td>0.58</td>
</tr>
<tr>
<td>Kitchen</td>
<td>11.93</td>
<td>11.93</td>
</tr>
<tr>
<td>Dressing room</td>
<td>1.98</td>
<td>1.98</td>
</tr>
</tbody>
</table>

**COLD WATER**

<table>
<thead>
<tr>
<th>ELECTRICAL CONSUMPTIONS</th>
<th>DELIVERED EN. kWh/m²/y</th>
<th>PRIMARY EN. kWh/EPy/m²/y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fancoils-office</td>
<td>3.34</td>
<td>7.26</td>
</tr>
<tr>
<td>Fancoils-canteen</td>
<td>0.20</td>
<td>0.44</td>
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<tr>
<td>AHU-offices,cooling&amp;dehum</td>
<td>4.02</td>
<td>8.73</td>
</tr>
<tr>
<td>AHU-canteen,cooling&amp;dehum</td>
<td>1.36</td>
<td>2.96</td>
</tr>
<tr>
<td>Domestic Hot Water</td>
<td>3.59</td>
<td>7.80</td>
</tr>
<tr>
<td>Fans AHU-offices</td>
<td>12.98</td>
<td>28.22</td>
</tr>
<tr>
<td>Fans-AHU-canteen</td>
<td>3.15</td>
<td>6.85</td>
</tr>
<tr>
<td>Fans, Fancoils-office</td>
<td>0.60</td>
<td>1.30</td>
</tr>
<tr>
<td>Fans, Fancoils-canteen</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td>Fans, Kitchen</td>
<td>3.10</td>
<td>6.73</td>
</tr>
<tr>
<td>Fans, Dressing room</td>
<td>0.40</td>
<td>0.88</td>
</tr>
<tr>
<td>Pumps, fancoils</td>
<td>1.52</td>
<td>3.31</td>
</tr>
<tr>
<td>Pumps, AHU</td>
<td>6.02</td>
<td>13.10</td>
</tr>
<tr>
<td>Pumps, AHU post-heating</td>
<td>0.75</td>
<td>1.63</td>
</tr>
</tbody>
</table>

**DHW**

<table>
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<tr>
<th>ELECTRICAL CONSUMPTIONS</th>
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<th>PRIMARY EN. kWh/EPy/m²/y</th>
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**DELIVERED EN. kWh/m²/y**

- 61.46
- 97.01
- 41.06
- 89.27
- 8.28
- 18.00

**PRIMARY EN. kWh/EPy/m²/y**

- 93.60
- 93.60
- 93.60
- 93.60
- 93.60
- 93.60

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**Clarification:** the energy calculations and given energy numbers will be according to the national standards which might vary between countries, i.e. numbers are not always comparable.
7 ENVIRONMENTAL PERFORMANCE

Indoor climate

As the figures on the right show, the thermal conditions during the summer season have improved significantly.

AFTER – BEFORE: -30% (-14% winter, -39% summer)
AFTER – AFTER without blinds: -40% (-35% winter, -45% summer)
8. MORE INFORMATIONS

RENOVATION COSTS
- 7.2 M€ renovation and new constr. (+ 0.81 M€ automated warehouse)

<table>
<thead>
<tr>
<th></th>
<th>M€</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building (Existing)</td>
<td>0.92</td>
</tr>
<tr>
<td>Building (New)</td>
<td>4.28</td>
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<tr>
<td>HVAC system</td>
<td>0.78</td>
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<tr>
<td>Electrical system</td>
<td>0.64</td>
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<tr>
<td>Design &amp; project management</td>
<td>0.50</td>
</tr>
<tr>
<td>Others</td>
<td>0.10</td>
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</tbody>
</table>

Gross conditioned area:
1 515 m² exist. building, 2 796 m² new building
- Cost of renovation: 1 120 €/m²
- Cost for the new build: ≈ 2 000 €/m²
- Overall cost: 1 680 €/m²

FINANCING MODEL
• No information (no subsidized loans, no grants, no ESCO contracts).

OTHER INTERESTING ASPECTS
• Solar gains and solar shading systems.

Irradiation threshold on external surfaces (120 W/m² in summer, 200 W/m² in winter).

In winter the shading system does not fully close

Users can control the shadings.