Retrofitting Diplomat Building
Office Building Division (OB)
University Of Art | Tehran, Iran
**Design Goals**

1. Introducing The Team
2. Design Goals
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   5.5 Embodied Environmental Impact
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   5.7 Occupant Experience
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   5.9 Energy Performance
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- Water management
- Community engagement
- Minimizing energy consumption
- Active Facade
- Optimal occupant comfort + Retaining covid restrictions
- Enhanced occupant experience
- Locally sourced materials + using innovative materials
- Electricity management
- Multifunctional and flexible space
- Minimizing embodied carbon + global warming potential
- Increasing Building Circularty + biocompatible material usage
- Retaining Capital
### Software:

<table>
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<tr>
<th>Software</th>
<th>ETABS</th>
<th>Therm</th>
<th>DIALux</th>
<th>MS Project</th>
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<td>Energy Plus</td>
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### Project Highlights:

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Environmental condition

**S**

Ground slope: Maximum use of sunlight in the underground levels of the building

**O**

Sunlight: Optimum use of the sun for solar panels on the roof and facade

Nearby landscape: Providing a pleasing view for users and reducing glare

River: Operation in mechanical facilities of the building, attention to the existing capabilities of the river in designing staff rest areas

**W**

Ground slope: Inability to use the ramp to access the lower floors due to the slope

**T**

- Air pollution: Proper ventilation can reduce the need for users to open windows
- Noise pollution: The use of new materials and the design of the building envelope to maximize sound transmission to space
- The building is located in a densely populated area and construction-related transportation is limited
5. Architecture
• **Existing occupant:**

  **Building owner:**

  In each of the office floors, there are 4 separate units with different uses that have not helped to strengthen and complete each other. Also, there is no direct interaction between the people of the neighborhood and the building staff. Ground floor business units do not create an invitation and participation space for people in the neighborhood.

  **Employee:**

  Spaces such as the library, lounge, coffee shop, etc; do not exist and this causes the residents to feel exhausted after working for a short period of time, therefore the quality of their work reduces tremendously. Although there is a river adjacent to the building, it is not possible to exploit its potential.

  **Employee:**

  Not having an optimal air conditioning system or a mechanical system with fresh air and ignoring the importance of indoor health and covid-19 protective measures have limited the possibility of face-to-face communication.

  **Employee:**

  Light discomfort is felt, Such as glare in some places like on the monitor or working plane and lack of daylight.
• Design process:

1. Basic Building
Diplomat Building, the building on which the design is based.

2. Add
The base building became a complete cube with the addition of sections to the 4 corners of the form.

3. Divide
The building was then divided into sections to form a design concept.

4. Reduce
Parts were reduced to diminish the rigidity of the space and increase the flexibility of the volume (Glass Cabin).

5. Facade
A glass facade with a PV was added to the southern part. The same pattern was repeated for Eastern and Western to further match the views.

6. Final Building
Due to the function of the interior spaces and the amount of daylight required, parts of glass wall were turned into walls.
• Façade Design:
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Existing Building

Redesign Building
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- Floor Plans Design:
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- Structural analysis:

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- Force distribution in the south view

- Force distribution in the east view

- Etabs model
5.2 Engineering

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Solar System:

The annual radiation of existing building

The annual radiation on PVT and BIPVT

The TRNSYS model of the proposed trigeneration system

Trigeneration solar system diagram

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• Mechanical System and Plumbing:
• HVAC System:

Air handling unit supply and exhaust ducts: (a) Perspective view, (b) Section view, (c) Perspective section
5. Market Analysis
Demolition: $5,115.91
New Construction & renovated parts: $260,411.94
Total Renovation costs: $304,589.65

Total savings: $53,983.03 per year
Payback Period: after 6.1 years
5. Durability and Resilience
5.4 Durability and Resilience

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• Gray water system
5. Embodied Environmental Impact
**Carbon Reduction and Net Carbon Design**

Life-cycle assessment, EN-15978 in Energy use (B6 Level)

This diagram shows that in almost all six categories of environmental impacts, such as GWP, AP, EP, and ODP, the rate of damage has reached **half of the previous** environmental impacts.

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**Net Carbon kg CO2e (B6 level)**

the kg CO2e in phase B6, which is related to annual energy consumption, is approximately **31%** lower in the regenerative state, excluding the solar energy produced by the building. Also, considering the Exported Energy sector, this reconstruction has been able to show **47%** in the Net Carbon sector of optimal behavior compared to the base building.

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Sankey diagram, Global Warming Potential in construction materials

Using biocompatible material: Algae-based coating

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• **Life Cycle Assessment (Building Construction)**

![Life Cycle Assessment Diagram](image)

**Mass kg - Classifications**
- Floor slabs, ceilings, roofing decks, beams and roof - 46.1%
- External walls and facade - 24.2%
- Internal walls and non-bearing structures - 17.8%
- Columns and load-bearing vertical structures - 9.9%
- Building systems and installations - 1.3%
- Windows and doors - 0.6%

**Global warming kg CO2e - Resource types**
- Metal - 32.5%
- Cement - 8.7%
- Insulation - 5.2%
- Ready-mix - 4.3%
- Gypsum and plaster - 2.7%
- Other resource types - 2.2%

**Global warming kg CO2e - Life-cycle stages**
- A1-A3 Materials - 88.1%
- A4 Transportation - 9.8%
- B1-B5 Maintenance and replacement - 9.3%
- C1-C4 End of life - 1.8%

**Global warming kg CO2e - Classifications**
- External walls and facade - 28.6%
- Floor slabs, ceilings, roofing decks, beams and roof - 23.7%
- Internal walls and non-bearing structures - 20.6%
- Building systems and installations - 14.0%
- Columns and load-bearing vertical structures - 13.0%
- Windows and doors - 0.2%

Life-cycle overview of Global warming
Toward Circularity

5.5 Embodied Environmental Impact

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Analyzing the building circularity index of the optimized office building during the retrofit phase

We can use some solutions like the design for disassembly, reusable materials, and biocompatible materials to increase the circularity index.

This project identifies four design models that use practical tools to rethink and redesign products and services for the circular economy:
1. Design for longevity
2. Design for leasing or service
3. Design for re-use in manufacture
4. Design for material recovery
5. Integrated Performance
Diagram of the integrity of all parts of the building
• Integration of the solar system with mechanical installations
5. Occupant Experience
Building’s function:

The function of each space

The Function of each floor

Exploded plans
• **Flexible furniture**

• **Flexible Glass cabins**
• Occupant’s Views:

Leed standards

Avg. Distance: 4.5 m

EN 17037 standards (horizontal sight angle)

View analysis of Ground floor

View analysis of Floorplans (uppermost level)
• Integration of electrical appliances:

• Appliances for Occupant comfort:
  o Light sensor:
  o Temperature thermostat:
  o Windows:
5. Comfort and Environmental Quality
42  52

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• Daylight:

ASE analysis
sDA analysis
Avrg lux analysis
• Artificial light:

<table>
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<tr>
<th>( \Phi_{\text{total}} )</th>
<th>( P_{\text{total}} )</th>
<th>Luminous efficacy</th>
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<tr>
<td>171515 lm</td>
<td>2297.0 W</td>
<td>74.7 lm/W</td>
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• Acoustic:

**Sketchup model**

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<th>Band (Hz)</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
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<td>EDT (s)</td>
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<td>0.60</td>
<td>0.60</td>
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<td>T(15) (s)</td>
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<td>0.88</td>
<td>0.97</td>
<td>0.70</td>
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<td>SPL (dB)</td>
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**Room reverberation time function**

**Attenuation and reverberation time function of sound**

**Room reverberation time function**

**Sound simulation in glass cabin**
• Ventilation:

Icare filter

CFD analysis of air velocity

CFD analysis of air streamline

CFD analysis of air temperature
- Using indoor green wall and plants

Indoor plants detail
5. Energy Performance
5.9 — Energy Performance

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**Conclusion**

**BIPVT and PVT energy generation**

<table>
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<tr>
<th>Solar System</th>
<th>Tilt (°)</th>
<th>Nu</th>
<th>EEG (kWh)</th>
<th>TEG (kWh)</th>
<th>Total (kWh)</th>
<th>BIPVT Generation Respect to Total Site Energy Use (%)</th>
<th>BIPVT Generation Respect to Total Source Energy Use (%)</th>
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<td>Rooftop PVT</td>
<td>35</td>
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<td>Total</td>
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<td>93376</td>
<td>1365</td>
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• **Risk economic calculation**

**Risk economic calculation assumptions**

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<tr>
<th>Initial Cost ($)</th>
<th>Maintenance Cost ($/year)</th>
<th>Concrete Foam Price ($)</th>
<th>Absolute Price ($)</th>
<th>Gas Saving (m³)</th>
<th>Electricity Saving (kWh)</th>
<th>Gas Price ($/m³)</th>
<th>Electricity Price ($/kWh)</th>
<th>Total Saving ($/year)</th>
<th>Discount Rate (%)</th>
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**Risk economic calculation results**

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<tr>
<th>BIPVT and PVT Risk Analysis Results</th>
<th>Probability that the NPV will be Positive During the Life Span (%)</th>
<th>Probability that the IRR will be Greater than Discount Rate (%)</th>
<th>Probability that the DPBT will be less than 5 Years (%)</th>
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<td>95.84</td>
<td>56.62</td>
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Conclusion
Industry Partnership:
THANK YOU

U.S. Department of Energy
Solar Decathlon Organizers
Solar Decathlon Jurors