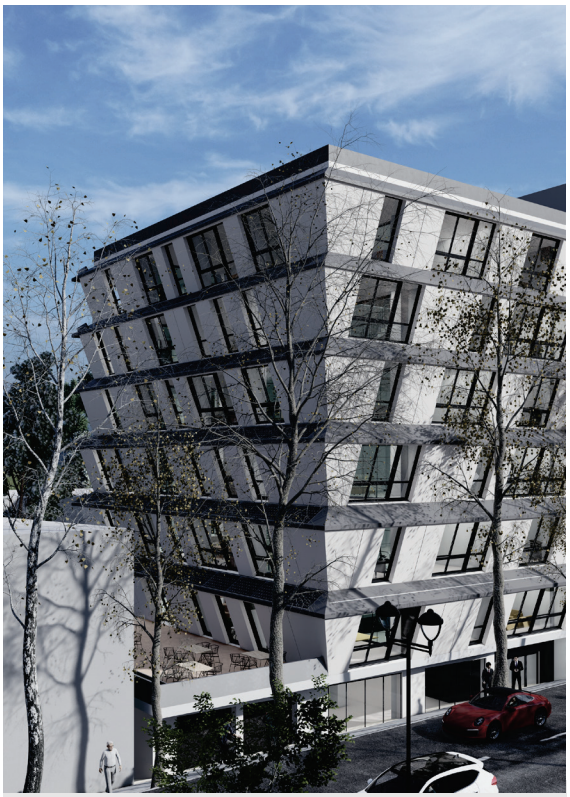
U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

University of Art
Tehran, Iran

Office Building (OB) | The Mehr team | November 30, 2021



DIPLOMAT BUILDING

Project Summary

A large amount of energy consumption in buildings in Iran is allocated to office and residential buildings in the country. Sustainable construction has recently been considered in the building sector regrading global commitments. It is obvious that retrofitting the existing buildings would be much more effective than constructing new ones. Retrofit of existing buildings will also help reduce carbon emissions. Therefore, our team selects an office building in Tehran not only to reduce its energy consumption but also to consider various aspects which affect its overall energy consumption.
This office building was constructed in 2009 on downtown Tehran in a busy district. It is 10 stories high. Although not much time has passed since the construction of this project, none of the Iranian and international standards on energy has been applied in this building, which has resulted in a high energy consumption. In order to enhance the energy performance of the building our team came together, each with a different expertise and decided to retrofit the building to the desired dimensions.

Design Strategy

In the first step, the retrofit process has been evaluated and measured by carefully examining the building's performance, including lighting conditions, cooling and heating energy consumption, and thermal comfort of the residents, with tools related to each area. Given the weaknesses assessed from the initial surveys, the COVID-19 Pandemic, and the importance of occupant health, it was decided to improve the building's performance by modifying some of the building's interior and exterior elements, including the façade and roof. Since one of the goals of this project is to redesign the sustainable and eco-friendly building, so from the linear approach of designing and renovating the current buildings, (which after construction and operation, is eventually abandoned or buried in landfills as C&D waste), this team will move towards a Circular Economy model. As a result, we will keep the building as a bank of materials so that it can be used in the chain many times and the extraction of virgin resources will be reduced. One of the proposed passive and active solutions to improve the visual and thermal comfort conditions of the occupants and reduce the consumption of fossil fuels is to add Photovoltaic panels and canopies. Due to the country's natural crises such as earthquakes and climatic conditions, it is recommended to strengthen the structural parts by using suitable materials and with the ability to dismantle after the end of life and also to optimize the insulation of external envelopes using biocompatible materials. Finally, in addition to improving the building using a regenerative approach, it will increase the friendship between the environment, humans and construction sites, and will also help reduce carbon emissions and environmental consequences, such as global warming.

Project Data

Location:	Iran, Tehran
Climate Zone:	3B, Bsk
Lot Size:	0.174 acres
Building Size:	63944.09 ft^2
	10 Stories
Occupancy:	140 People
	(456.75 ft^2/person)
Target Source EUI:	51 kBTU/ft^2/year
Average Utility Cost:	3352 $/month
TOTAL ENERGY CONSUMPTION (Source):	51 kBTU/fT^2/year

Technical Specifications

R-Values

EXISTING
- EXTERNAL WALL: 3.07 ft^2.f.h/BTU
- EXTERNAL ROOF: 10.16 ft^2.f.h/BTU

TARGET
- EXTERNAL WALL: 21.03 ft^2.f.h/BTU
- EXTERNAL ROOF: 24.68 ft^2.f.h/BTU

HVAC

EXISTING:
2 PIPE CEILING FAN COILS WITHOUT FRESH AIR POWERED BY:
-HEAT:
ON-SITE CENTRAL HOT WATER CAST-IRON BOILER
-DOMESTIC HOT WATER:
ON-SITE CENTRAL HOT WATER CAST-IRON BOILER
-COOLING:
ON-SITE CENTRAL ABSORPTION CHILLER

TARGET:
ADDING FRESH AIR TO THE HVAC SYSTEM BY CHANGING THE FAN COILS TO THE AIR HANDLING UNIT (AHU) WITH HEAT RECOVERY
IMPROVE THE SYSTEM EFFICIENCY
COMBINATION OF PVT AND BIPVT PANELS AND THE HVAC SYSTEM

On-Site BIPVT and PVT

42.24 kW BIPVT SOUTH FACADE
51.84 kW PVT ROOFTOP

Project Highlights

ARCHITECTURE

By converting the closed plans to open ones, and multiple spaces to flexible spaces, it can be accessed better lighting conditions during the day. Also due to the reusable and recyclable materials in the reconstruction process such as creating glass terraces with separate entrances to control critical conditions for clients like COVID 19 pandemic. Our goals in the architecture department are to increase daylight in plans and environmental quality, redesign the facade to improve the quality of daylight, also reduce energy consumption by paying attention to the interior design and in conclusion aim to increase occupants' thermal and visual comfort beside the improvement of their mental health.

ENGINEERING

The primary goal is to optimize the efficiency of the HVAC system and add fresh air to the rooms. To this end, first, the combustion efficiency of the cast-iron boiler is improved by adding fresh air to the installation room, and then, 2 pipe fan coils are replaced by air handling units (AHU) with heat recovery coils. Improving the boiler efficiency, result in improving absorption chiller COP as it works by boiler hot water. As the absorption chiller has low COP, then BIPVT south façade and PVT rooftop system are added to the HVAC system to improve the COP and supply part of DHW and Heating demands at the same time. Using the gray water recycling pipe system and collecting rainwater tanks and drain water tanks are engineering methods to improve building water usage efficiency and sustainability. To Improve the seismic performance of the building, four parts were added to the edge of the building to change the existing shape of the building to a convex form.

MARKET ANALYSIS

Paying attention to economic items and reducing costs in this retrofit project, with special attention to the topic of cyclical economics and ideas such as recycling waste and making new products from them will continue to eventually end up with minimized waste and maximized resource utilization to achieve significant amounts of energy storage and cost.

DURABILITY AND RESILIENCE

In this project, the goals of resilience and durability can be mentioned as follows: The use of appropriate materials harmonized with the relevant climate and suitable insulation in redesigning the facade and roof, the use of lighter materials in the retrofit process to lighten the structure and improve the performance of building structure during an earthquake, the use of gray water systems to increase the resilience of the building amid the water crisis, reuse of facade materials as interior furniture material, the use of passive strategies, such as daylight and natural ventilation as well as using solar panels to help increase the resilience of the building.

Embodied Environmental Impact:

In line with the principles of Circular Economy (CE) and Regenerative design, our team intends to use biocompatible materials and low carbon emissions to rebuild or add new parts. One of the biocompatible materials used in the retrofit of this office building is the algae-based vernacular coating, which was recently invented in our country and has been used to cover the outer wall of the building. We also calculated the environmental impact, recycling, reuse, and recovery of the materials by calculating the LCA and CE for the demolition materials to be used again in the reconstruction. Hence, in addition to reducing carbon emissions and global warming, this approach could help conserve natural resources and reduce the consumption of virgin materials

Integrated Performance:

A central renewable CCHP system integrated onto the south façade is designed to reduce energy demand and fossil fuel emission without wasting any free space, money, and useless material. The central system is made by integration of BIPVT façade panels, PVT rooftop panels, hot water cast-iron boiler, and indirect absorption chiller. BIPVT façade panels are used as finishing façade material to produce energy, save useless finishing façade material costs, and keep the free spaces of the building.

Occupant Experience:

The results from a survey that current office employees took, revealed that they do not have optimal visual and thermal comfort. Therefore redesign by using flexible co-working spaces, changeable furniture, and designing an open office plan to prevent infectious diseases was considered to achieve visual quality, improve air quality, and connect with the environment, a plant box was used in the interior design of the project.

Comfort and Environmental Quality:

Recognizing the necessity of increasing the daylight penetration depth and reducing direct sunlight exposure, we devised a new form based on the inclined windows combined with opaque panels. Daylighting simulations on the devised form reveal perfect compliance with the LEED v4 standard, receiving all three credits. Improving artificial lighting quality was the other way to increase occupant comfort.

Energy Performance:

Changing the existing building to the energy-efficient one and reducing energy consumption, the designer team first integrate each floor plan into an open office plan. The second effort is Changing the envelope heat transfer characteristics by using thermal insulation, replacing useless material with green, renewable, and generator ones, and replacing existing windows with high-quality ones. Other changes are to replace old lighting and equipment with efficient ones and use a thermostat control system.