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Technion - Israel Institute of Technology

מוסד שמואל נאמן
למחקר מתקדם במדע וטכנולוגיה

ENERGIE

Energy Conservation
In Buildings
at the
Technion Campus

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Acknowledgements:

When gathering information on existing buildings one is confronted with the well-known main trait of the building sector: fragmentation of duties and responsibilities. Although the two buildings described in this report are in the same campus, and have been design and constructed not more than seven years ago, and despite the fact that the information sought is merely technical, it was not an easy task to gather it. However, upon finalizing this report, due to the good will of all those who assisted us, there were only a few details we had to omit due to extreme uncertainty regarding their correctness. So, even at this stage, when the report is finished and ready for publication, we must confess that we cannot be entirely sure that all the details we gathered are exactly as in the "as made" situation, but we are sufficiently certain that those presented in the report reflect sufficiently well the two buildings, and can serve as a basis for the comparison of monitoring results that will become available during the next year.

At the end of this task we would like to thank all those who assisted us and supplied all the information they had. For the Taub Building: Yael & Yaron Granot, architectural designers; Doron Meidad, air-conditioning consultant. For the Rabin Building: Rafi Lerman & Dror Sdomi, architectural designers; Rafi Aharoni, air-conditioning consultant; Irit Inbar, project manager on behalf of the Technion. For the Technion Development and Maintenance Division: Izhak Romano, electricity; Adi Ben-Ari, air-conditioning. For OPETI: Ofira Ayalon.

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1. Introduction

The current research "Energy conservation in buildings at the Technion campus" is part of various activities undertaken lately by Technion with the aim of reducing the impacts on the environment and improving energy conservation within the campus. Technion has also recognized recently the need for providing improved internal conditions in the newly erected buildings, while putting more emphasis on reduction of the operating costs, with the knowledge that energy would be a prime factor.

This work focuses on two new buildings errected recently on the Technion campus - The faculty of Computer Science (Taub Building) and The Faculty of Civil and Environmental Engineering (Rabin Building).

Taub Building

Rabin Building

1.1 Research objectives, stages and methods

The objective of the long-term research project is to survey the energy-conservation aspects of these new Technion buildings, determine their effectiveness and to explore and compare their energy-related performances as experienced in practice.

The project is divided into four main stages:

- The 1st stage, which is reported in this document: description and survey of the buildings and energy conservation means implemented in the design and construction of the two recently erected buildings: Rabin Building, and Taub Building.

- The 2nd stage, which is still in progress, and is partially reported here: Instrumentation of the buildings with additional data acquisition points and software in order to enable a coherent set of measurements, which will be amenable to energy analysis per functional spaces. This stage includes also the establishment of the comparison indicators and methods for analysis of the gathered data.
- The 3rd stage, which has not been performed yet, and only demonstration samples are included in the present report: Pilot measurements during some weeks in order to verify the measurement system and methodology, the analysis scheme, and the completeness of data. At the time of writing this report we were able to receive only a one day sample measurement of the air conditioning units in the Rabin Building, and another sample of the electricity consumption measurements in the Taub Building.
- The 4th stage, that will hopefully be carried out during the coming year (depending on availability of adequate funds): Monitoring the energy and electricity consumption, systems functionality and climatic conditions in the two buildings along their continuous operation during the full winter and spring semesters, and analysis of the results by means of the tools developed in the previous stages.

1.2 Brief introduction of the buildings

The two buildings are in the campus of the Technion – Israel Institute of Technology (ITT), which is located on the northern slope of the Mount Carmel, facing the Haifa-Acre bay, at the eastern border of the city of Haifa. The longitude and latitude of Technion campus are 35.00 degrees east, and 32.80 degrees north, respectively, and the altitude is 200 m above sea level. The weather in this area is moderate Mediterranean: Winter temperatures ranging within 8°C at night to 17°C during the day, with a few colder spells that do not reach lower levels than 4°C on a monthly basis, and an absolute minimum of 1°C on a yearly basis. It seldom snows (only once in some ten years), and rain fall is typical to the winter season only (October to April), with a yearly average of 540 mm. Summer temperatures range within 20°C at night to 30°C during the day, with some very hot spells that may reach levels as high as 35°C on a monthly basis, and an absolute maximum of 39°C on a yearly basis. Daily relative humidity is 65% throughout the year, and it ranges within 70% in the morning to 50% at noon and to 75% in the evening.

The Taub Building was designed between December 1996 to April 1997, and constructed between May 1997 to January 2000. Most of the design concepts were concieved during the errection stages due to the evolutionary nature of the Faculty and students needs. It is occupied and operates continuously since March 2000. The total cost of the building was 21,000,000 USD.

The Rabin Building was designed from February 1997 to July 1999, and constructed from July 1999 to February 2003. It is occupied and operates continuously since 1.3.2003. Total cost of the building was 18,500,000 USD.

The design of the two buildings was developed under normal commercial working conditions, whereby the Technion was the client, and its Development and Maintenance Division (D&MD) supervised the project. However, in the Rabin Building the Project Manager was a Technion D&MD employee, whereas in the Taub Building this task was outsourced to a specific private company. Design and construction were outsourced for both buildings, involving services of various different firms and individual engineers for the following tasks: general planning and design, internal design, structural design, air conditioning and smoke control, design of the electrical and communications systems, design of sanitary systems and sprinklers, systems and cabling coordination, landscape architecture, etc. In case of the Rabin Building, a Steering Team, composed of Faculty seniour staff, has been consulted continuously during the various steps of inception, conceptual and detailed design. During the entire construction process a Faculty representative has supervised and controlled the works and expenses. User participation in the case of the Taub Building was quite intensive as well. The Faculty Dean himself fulfilled this task, communicated to the design team faculty and user-needs, and was very much involved in decision making and in the project's constant follow-up.

2. Background

2.1 Economic and environmental impact

It is already well-accepted that modern building design concepts enable the provision of low energy buildings, which are attractive, user friendly, well designed in other performance related areas, and cost efficient as well.

While there are market factors inhibiting the move to low energy design of buildings, Israel has the required skills and technology. This fact is important because a large percentage of Israel’s annual energy consumption is used to heat, illuminate and, most of all, cool our buildings. Accordingly, reducing energy consumption in commercial and institutional buildings will make us less dependent on foreign energy, improve our balance of payments, increase the lifespan of domestic energy suppliers, reduce pollution and lessen the investment required to increase energy production. Since commercial and institutional buildings account for almost half of that cooling, heating, and lighting energy consumption, they present significant conservation opportunities. One more significant factor is that the entrepreneurs and owners have or can aquire the skills required to evaluate the cost effectiveness of conservation measures more readily than private homeowners.

The need to save energy in the buildings of the future requires the know-how and ability to make it happen today. The Technion, as the most prestigious engineering and architecture school in Israel, should be a leader in this area, and set the benchmarks and examples for the rest of the country.

2.2 The commitment of the Technion

In the year 2000 Technion - ITT has joined OPET Israel (OPETI). OPETI, is part of OPET, the European network for Promotion of Energy Technologies, which deals with Energy Technology on a day to day basis. Its aim is to disseminate new energy solutions in regional markets within the EU and other regions.

The particular aim of OPETI is to promote efficient use of energy in Israel and to assist in sustainable growth of Israel by using advanced energy production technologies. It promotes the use of efficient and renewable energy systems by the energy community in Israel. The OPET Buildings consortium supports the implementation of EU regulation related to the efficient use of energy in the building sector and focuses on efficient energy use in buildings.

In effort to work with the OPETI principles and being the leading Technological academy in Israel, Technion - ITT has decided to apply the energy efficiency technologies in design of new buildings errected on the campus, in addition to other activities that are presented briefly in Section 2.2.1 below.

The design of the two buildings chosen for this project, the Taub building - Faculty of Computer Science and the Rabin building - Faculty of Civil & Environmental Engineering has been initiated before the Technion undertook this initiative and commitment. Construction of the Taub building has been in progress at that time, while the Rabin building was at the stage of bidding construction. Since the construction budget was strictly limmited to the available donations, it was Technion's policy to invest as much as possible in effective functional spaces such as classrooms and offices. Thus, any creative "green" ideas have been considered with major skepticism due to their initial cost. However, the design and construction of these two buildings seems to be the turnpoint in the attitude of IIT's management in whatever has to do with energy-saving or environment-friendly systems. Consequently, some of the Green initiatives were accepted by the Technion management after their economical payback was proven.

2.2.1 The Technion's Green Campus project

The Technion, Israel Institute of Technology, has accepted that as Israel's first and major technological university, it bears responsibility for educating engineers and scientists and for being in the forefront of research and development resolving environmental issues. The Technion today is the country's leading institute in this field and is a model for other academic institutions in Israel.

Science, technology and engineering are key means to reach environmental sustainability and to ensure development that is not environmentally damaging and destructive. The Technion, as an educational institute for engineers and scientists, is now committed to incorporate the environmental perspective in all its operations, and to mobilize the best of its knowledge and talent so as to lead in Israel's sustainable development, an environmentally-responsive development.

In order to achieve this goal, the Technion, at the beginning of May 2000, launched the Technion's Green Campus (GC) project at the initiative and support of the S. Neaman Institute.

At this point, the Technion, through its different departments and units, has set up numerous activities in the area of the environment.

The GC project's objective is to challenge the entire Technion community – faculties, students, and administration – in carrying out its activities. The steering committee of the project has representatives of the Students Union (full participants in the project's activities and initiative), faculty representatives (The President of the Technion has recently announced the Green Campus council that will guide the activities of the GC and improve the implementation of the projects' outcomes within the different faculties. A dozen of faculty members have volunteered to participate in this council and new ideas and directions will be implemented), and key Technion administrative personnel. Reports on the project's activities are published bi-weekly in Technion's Bulletin. In addition, a web site has been set up: http://tx.technion.ac.il/~greenweb.

The GC initiative and activities are widely spread, leading to changes in environmental awareness and behavior across the campus.

Technion employees, students and faculty are deeply involved, offering suggestions and comments and changing the project to a grass root initiative.

The GC activities and projects embrace a broad range of issues:

Energy conservation - in new buildings and in cases where a building's electrical systems are renovated, various measures for energy saving will be implemented, such as: systems for automatic turning off of lights and air conditioners in lecture halls; restricting usage to periods of activity and need; establishing procedures for turning off unnecessary lighting, and operation of air conditioners.

Aside from the benefit to the environment, it is anticipated that very significant savings in resources will be achieved (in the estimate made by Mosad Neeman, an amount of 3-4 million shekels of normal Technion budgetary expenditures could be saved).

Water conservation - The Technion campus lawns' sprinkler system operates only at night. The lawn situated in the heart of the Technion campus is watered with the air-conditioners' condensation water of the Taub Building – saving approximately 3,000 cubic meters of water per year. In the new Rabin Building a separate system for collecting effluents from sinks has been installed (as presented in more detail in section 3.2.2.4 below). The treated effluents will be used for watering gardens. Across campus all toilets have dual quantity flushing cisterns. Gardening using water efficient plants, trees and lawns are studied and demonstrated in the Ecological Garden at the Department of Agricultural Engineering. All new plantings on the campus are of Mediterranean vegetation suited to growing under arid conditions. The potential of water saving across the country by following this approach is about 5% of Israel water budget. The new watering systems are based on computer-controlled drip systems.

Recycling and resource conservation - include addition of extra bins for paper recycling. The procedure for collection of printer and fax machine toners and ink cartridges has been revived and intensified. In the first year of operation there has been a six-fold increase in collection and recycling of ink cartridges. Containers have been placed near restaurants and dormitories for collection of recyclable plastic bottles.

Pollution Prevention - includes promotion of the use of internal campus transportation and collection of used batteries for transfer to the Ramat Hovav Israel's national hazardous waste site, rather than disposing of them in regular waste bins.

2.3 Modern methods for energy saving and intelligent buildings

Modern, properly concieved buildings would result in minimum use of primary energy for cooling, heating and lighting. Among various technics usually applied in energy-efficient buildings the most common are:

- Passive solar heat gain in winter
- Envelope design that decreases heat loss and gain
- Thermal mass and thermal storage as a means for utilizing night low temperatures in summer, and preventing daytime overheating in winter.
- Ventilated facades, and hybrid ventilation systems.
- Wise building orientations and adequate shading devices in the various orientations to block summer sun, including winter-fall trees and special vegetation.
- Artificial lighting control depending on type of occupancy, natural lighting availability, and human presence.
- A computer controlled optimization and building management system, which analyzes and controls energy input, storage and output.
- Evaporative cooling
- Water fountains for passive cooling and humidification
- Natural ventilation when energy effective during working hours, and night ventilation in summer.

3. Description and review of the two buildings

3.1 The Taub Building

The Taub building was the largest project undertaken by Technion in the last years. It replaced the original Computer Science building built in the 1950's. During the last decade the Faculty of Computer Science proved to be the fastest growing department on campus. This raised the need to upgrade the laboratories and create new classroom and research space, which would help recruit students and faculty. It was thus decided to erect a new modern building in "the heart" of the campus to house the department.

The Department of Computer Science is the second largest academic unit in the Technion, with about 1,300 under-graduate students (about one-eighth of the total number of Technion students) and more than 200 graduate students. It comprises about 53 faculty members.

The department's main divisions are devoted to the following research areas:

- **Application & Scientific Computation**
    - Graphics and Geometric Computing
    - Image Processing and Computer Vision
    - Robotics and Complex Systems
- **Artificial Intelligence**
- **Interdisciplinary Research**
    - Bioinformatics
    - Computational Linguistics
    - Quantum Information Processing
- **Systems**
    - Communication
    - Databases
    - Hardware
    - Software Engineering and Verification
- **Computer Science**

- Coding
- Logic and Semantics
- Algorithms

The Taub building is comprised of a basement floor containing a parking lot (100 cars) and numerous electricity rooms, two 8 story rectangular wings perpendicular to each other, creating an L-shaped plan, and a 2 story block that contains the faculty administration offices, an auditorium and the department library. The L-shaped main structure and the 2-storey block are connected by a curved public space covered by a glazed roof, allowing natural light penetration.

The building is constructed of in-situ reinforced concrete columns and beams, pre-fabricated pre-stressed hollow-core concrete slabs, pre-cast concrete curtain-walls, and gypsum wall-board partitions.

The designers' aims for the Taub building were "both to project an image of technical progress (hi-tech building elements) and to create a convenient environment for academic pursuits that characterize the faculty”. By the use of different materials, the architects’ design target was to keep the uniformity with the other buildings on campus, and on the other hand to impart the building with the modern outlook that fits the activities which take place inside of it.

3.1.1 Climatic design and energy saving aspects in the programme (pre-design brief) of the Taub Building.

Since the Israeli standard no. 1045, part 3 (Thermal insulation of buildings: office buildings) was not yet mandatory and ITT was not a member of OPETI during the design of the Taub building the brief did not contain any special mandatory requirements for energy efficient features.

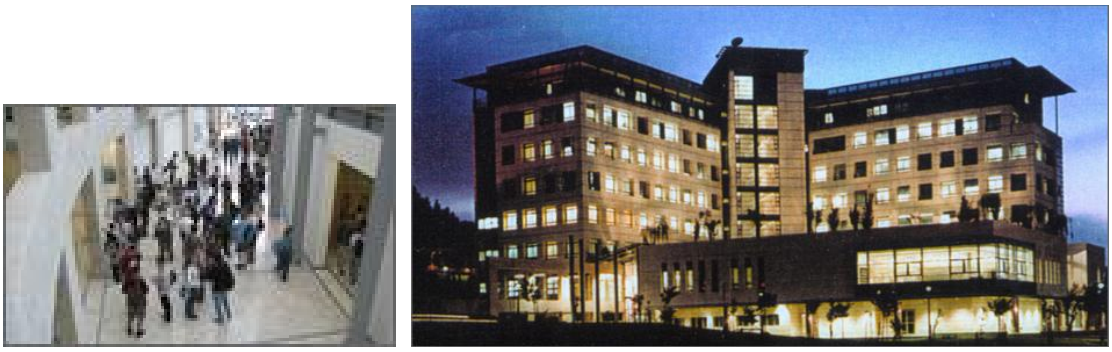
3.1.2 Detailed design of the building, envelope, and systems

3.1.2.1 General description

The Taub building houses the Computer Science Department. It has a floor area of 17000m^2 (originally meant to be 5000 m^2), on 8 floors with a curved atrium (floor area

~240m^2) which links between the main entrance on the northern façade and the secondary entrance on the eastern façade. The main computer and multimedia classrooms and laboratories (together ~800m^2) and two large auditoria of 152 and 252 seats (altogether ~520m^2) are located on the ground floor together with administration offices. On the first floor there are 6 classrooms (~500m^2), some laboratories and research facilities (~200m^2) and a 750m^2 Faculty library. The remaining upper 6 floors are similar in their design, containing mainly academic staff and visiting researchers' offices (~500m^2 on each floor). All offices are aligned along the corridors of the L-shaped wing, meeting and conference rooms, labs and some facility spaces. The faculty staff offices are located along the outside walls, so that as many people as possible will have natural light in their workspace.

A significant feature that characterizes the Faculty of Computer Science is its intensive occupation, including very late at night. The nature of studies demands that students spend long hours within the building, and some computer laboratories are active 24 hours a day on regular basis.



Intensive student and faculty activity

3.1.2.2 Building envelope and roof

The exterior walls of the building are composed of pre-cast curtain wall panels covered with dimensioned architectural limestone and incorporated with aluminum windows. There are 6 main types of pre-fabricated wall modules used in the entire building envelope. The units vary in their dimensions and window size.

Eastern Façades

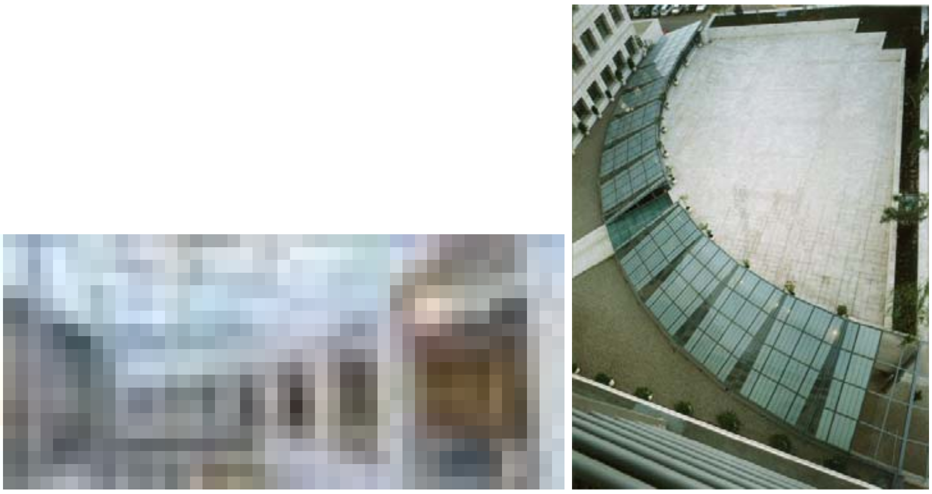
Western and southern facades

In general dimensions of windows on the facades facing the front side of the building (northern and eastern facades) are larger (200/216 cm), whereas those facing the back side (southern and western facades) are smaller (150/116 cm).

During the design of the Taub building the Israeli standard no. 1045, part 3 (Thermal insulation of buildings: office buildings) was not yet published. Consequently thermal insulation was not provided in the walls and roof, and solar heat gain calculations have not been performed.

Atrium roof

Laminated glass is used for the atrium roof. It consists of two sheets of glass with a plastic membrane of polyvinyl butyral (PVB) sandwiched between. The external sheet is of Low-e glass. It is transparent to short-wave solar energy and opaque to long-wave infrared energy, therefore allowing most of the solar spectrum to pass through, including visible light. The coating reflects most of the radiated energy back to the source side, keeping heat in during winter and preventing the ingress of radiated heat from the outside. The internal glazing layer has printed stripes, so that a certain degree of visibility can be achieved while more of the direct solar radiation is eliminated. When broken, the laminated glass will stick firmly to the membrane and prevent shards or splinters to fly off. The PVB film has ultraviolet-screening properties as well, reducing the direct solar radiation penetration even further.



Atrium roof – views from below and above

Natural lighting is supplied via this atrium cap into the large lobby and passage way that crosses the building.

Main through-building naturally lighted passage-way at entrance level

The envelope

The entire building windows are glazed by single sheet "Ford blue", reflective, tempered, Low-E glass.

Library north-east corner, with full height windows

In offices and classrooms there are three main window types: horizontally sliding windows, "dreh-kipp" windows and top-hung casement windows. The top-hung casement windows, which open outwards, are installed in classrooms and other academic facilities on the lower 2 floors. Southern and western facades feature "dreh-kipp" windows (150/116 cm), eastern and northern facades feature sliding windows (200/216 cm).

Sliding and Dreh-Kipp Windows with venetian blinds

All offices are equipped with internally hung venetian blinds which may be operated manually.

Internal venetian blinds

The classrooms and library are equipped with internal electrically controlled fabric roller blinds.

Fabric roller blinds in classrooms

Although fabric blinds are less adaptable in dealing with direct sunlight than venetian blinds they have the merit of simplicity in operation and are easy to maintain. The fabrics used in the Taub building are too dense to allow useful light through them when fully drown, but this satisfies the need for darkness in classrooms when using multimedia for presentations.

Maintenance fixtures, installed along the roof edge for glazing cleaning device were assumed to perform a shading function as well for the 8-th floor. However, this feature is actually effective for this function only for the southern façade.

South **West**

Peripheral upper maintenance & shading fixture

3.1.2.3 Climate control systems

The HVAC (Heating, Venting and Air Conditioning) system in the Taub building is comprised of four chillers (600 kW capacity, each), numerous AHUs (Air Handling Units) and FC (Fan & Coil) units (indicated by AW in the results table and floor maps).

The AHUs, whose task is to collect and mix outdoor air with that returning from the building space, are an integrated piece of equipment consisting of fans, heating and cooling coils, air-control dampers, filters and silencers. The air mixture is then cooled or heated, after which it is discharged into the building space through a duct system.

In the large computer farms, where extremely large heat loads from equipment and occupants exist continuously, a VAV (Variable Air Volume) duct system is used for air distribution. The ducts are installed above the false ceiling and the air is supplied via circular diffusers. These outlets have temperature sensing devices (VAV), which modulate the air volume passing through each outlet in response to the space temperature.

Monitoring and control

A unique feature of the building is the computerized Building Management System (BMS) that controls all the climatic service systems as well as other functions. The building is equipped with the Instabus network. The use of the bus-technique, which was installed inside the building during the construction in a way similar to that of a power network, is performed in combination with computer software. The system, which is based on digital technology, is comprised of a communications network through which all the electrical points on the network are connected. Its main scope is to control the air conditioning systems, lighting, safety, and security network.

Occupancy Sensors are installed in all Faculty member offices in order to switch off lights and air conditioners, when offices are not occupied (after a predetermined period of no-movement, in this case 5 minutes). The illumination is automatically switched on when the room is re-occupied and A/C may be turned on manually.

Software

The system which enables performance monitoring as well as measuring building's energy consumption is under the supervision of the building manager through friendly software. The software communicates with different controllers, and is responsible for information reception and its transference. Other features like: graphical display of all A/C units and other implementation systems as well as set points, energy measurements, fault documentation and control, etc., are included in the software.

The building manager has a constant control of the lighting in public areas of the building as well as in private offices, air-conditioning set points, building openings and other safety and security units such as fire alarms and video surveillance security camera system that records onto the internal hard drive using motion detection technology.

The network enables the overall system to be operated and fine tuned by the building manager using central or decentralized control.

3.2 The Rabin building

The faculty of Civil Engineering is the oldest faculty of the Technion, and with its growth during the 75 years of its existence has occupied more and more small separate buildings on the Campus. The increasing number of undergraduate and graduate students, as well as the recent academic reforms, which aimed at uniting the previously separate faculties of Civil Engineering, and Agricultural Engineering into one faculty, has evoked the need for one bigger and united teaching and office facility. The new building was to house several groups that have been eventually incorporated into a single Faculty of Civil and Environmental Engineering. The building had to be integrated with the main existing computer laboratories building in front of it, and provide all the classrooms, library and offices for the three major departments of the faculty. Each of these departments consists of several divisions specializing in different fields:

i. **Department of Structural Engineering and Construction Management**

- Structural Engineering
- Construction Management
- Building Materials, Performance and Technology
- Geotechnology

ii. **Department of Transportation and Geo-Information Engineering**

- Transportation and Highways Engineering
- Geodetic Engineering

iii. **Department of Environmental Engineering, Infrastructure, and Environmental Sciences**

- Environmental and Water Resources Engineering
- Agricultural Engineering

The Rabin building (total area of 9600 m^2) is located in the center of some research facilities of the faculty, and connected to the existing main computer laboratory building by means of a pedestrian bridge. It consists of seven floors with a central atrium throughout the height of the first four floors. Due to the particular site dimensions, three main facades are facing north, east to south-east, and west to south-west, and a the southern façade is the shortest of all. The northern facade has large glazed area in the form of curtain walls, whereas windows on the other facades vary in size according to the functional space behind.

3.2.1 Climatic design and energy saving aspects in the programme (pre-design brief) of the Rabin Building.

The Programme (known also as: pre-design brief) prepared usually by the Technion D&MD architects after some consultation with the Faculty's representative, has been strongly influenced in this case by an original draft prepared the Faculty's Steering Committee. In order to develop the detailed brief for the project (no easy task given the number and variety of users and their engineering expertise), a series of weekly meetings between the two teams made of the Faculty Steering Committee and the Technion Development and Maintenance Division, were held.

In addition to the common requirement for the exact mix of staff offices, secretarial spaces, classrooms, library, food services, lounges, auditorium and other designated spaces, the Programme included requirements for proximity relations between spaces, and many statements regarding the Faculty's expectations for proper performance in all the other relevant aspects. In addition, it included a statement regarding the message that should be conveyed by the building to the students of Civil Engineering, who would spend their entire studying period of four years in this building.

With a Technion's policy, that mandated a "hi-tech" building, and some of the Faculty Steering Committee members, who were "***very*** supportive of thermal comfort and green building issues", it was almost inevitable that the brief would call for: "***maximal use of natural resources for lighting, ventilation and solar energy***".

The Programme included, inter alia, the following as design objectives:

- Providing a feeling of serenity and functional amenity
- Energy conservation and thermal comfort
- Design of the building to express by it’s outlook and the materials the new millennium Faculty of Civil Engineering at the Technion
- Design of the facades, construction materials, building details, shading and systems to ensure high service quality from the architectural and engineering viewpoints without depending on excessive maintenance.

- Long life durability and “easy care” maintenance
- Achievement of lighting conditions, thermal comfort and acoustic comfort that suit the characteristic use of different spaces of the building all year round
- Design based on maximal use of the natural resources for lighting, ventilation (including the option for summer cooling by night ventilation) and solar energy (in winter). On the other hand prevention of glare and direct solar radiation on occupants (except lounges in winter).
- Option for energy-saving lighting fixtures, depending on economic optimization
- Temperature regulation and control in every room
- Computerized control systems for air-conditioning and temperature control
- Design in accordance with at least the levels required by existing building regulations and standards in any subject not mentioned specifically

The designers' basic response to the Programme was by conceiving a modern building with a non-standard plan, which caters for all the spatial requirements, is naturally lit all through, and is equipped with present-day technology in order to cope with providing the required performances. The design process involved by-weekly meetings with the Faculty Steering Committee, which served as a watch-dog of implementing the Programme and its goals in all the design details. Consequently, the Rabin Building includes many features that would not have been there if energy saving and sustainable construction had not been basic mottos of the Programme. Despite all of the above cited statements that were included in the brief, the Rabin building was neither defined nor designed as a “green” building at the beginning. However, during the advanced design stages and the erection of the building a series of relevant ideas was brought up in the discussions between the faculty steering committee and the project manager and design team. The energetic-environmental alternatives that have been chosen for application in the Rabin building are detailed in the following sections, and some additional alternatives are mentioned briefly in section 3.2.2.4.

3.2.2 Detailed design of the building, envelope, and systems

3.2.2.1 General description

The Rabin building is definitely aesthetically exciting, both inside and outside.

It includes seven floors, with the first four providing 16 classrooms for 780 students (~1300m^2), a 220 seats auditorium (~256m^2), a cafeteria, a 1270m^2 library, and the under-graduate and graduate students' secretariats. These four stories are penetrated by a full-hight atrium (floor area of ~56m^2) with a conical glass dome that extends into an internal court of the other three stories. The functional spaces of the building have been placed arround the atrium, which provides the visual and activity focus of the building. The atrium space of triangular form, is penetrated by an open shaft with two transparent elevators, and contains the main stairs that link the four floors.

Atrium extending on the four first floors

Atrium - view towards northern curtain wall

The entrance floor contains the main entrance plaza, the auditorium, cafeteria and some service facilities. The second floor is occupied mainly by the library, and contains two classrooms and auxilary teacher room as well. About half of the third floor is occupied by the upper level of the library. It also contains the secondary, south entrance plaza, four classrooms, secretariat, and the bridge connection to the old building of the Civil Engineering Faculty, which includes the computer laboratories. The fourth floor is dedicated to classrooms only (ten of them).

First floor and fourth floor main entrances

The upper three floors house the faculty members' offices, the Dean's unit, the faculty council meeting room, and the departmental administrative offices (altogether 2400m^2). They are arranged in two longitudinal wings around an internal open courtyard, which includes the glazed dome of the atrium, as well as the enclosed technical space above it (for elevator machinery and smoke control).

The following sections provide a detailed description of the building's energy-related features.

Internal courtyard on sixth floor

3.2.2.2 Building envelope and roof

Fenestration and curtain walls

To accommodate for natural lighting on one hand, but reduce as much as possible the direct solar heat gains, the size of the transparent parts (windows) in the curtain-walls in the various directions is not uniform. Northern windows are generally the largest. They do not include an upper opaque part, featuring a height of 185cm and extending along most of the room width. Windows in other directions are smaller, featuring a 100cm height, and extending along most of the room width in the external office, while on the eastern wall facing the internal court they are only 85cm wide.

The three main facades are fully double-glazed and orriented approximatly to north, south-east and south-west respectively. The double-glazed windows consist of a 6 mm external tinted glass sheet (65% visible light transmission), 5 mm internal clear glass sheet and 21 mm or 13 mm (depending on whether there is a blind embedded or not) air space between the glazing. Most windows and glazed courtain walls are fitted with motorized venetian blinds, which are embedded between the glazings to be operated upon demand. Fixing the venetian blinds in the cavity between the glazing of the window is an effective way of overcoming the possible difficulty of the swinging of sashes when the blinds are external to the windows. Enclosure also helps to keep the blinds clean.

Southern, eastern and western façade windows with embedded blinds

Eastern windows facing internal court, with embedded blinds

The windows which do not have the built-in blinds (lounge windows on southern and northern orientations) are compensated by a special low-emissivity (low-e) glass, which reduces significantly the solar radiation penetration. The main advantage of the chosen kind of glass is that it transmits visible light while selectively reflecting the longer wavelengths of radiant heat, produced by depositing the low-e coating on the external glass sheet.

All windows are of the “dreh-kipp” type. They can be tilted by the occupants to get a relatively small ventilation opening, or turned open fully when conditions are appropriate. The unique feature of this kind of window (“tilt and turn” in English) is that it may function as a bottom-hung casement or may be turned into a side-hung casement which opens fully into the room. The northern facade windows have different blinds’ solutions for each typical space, as following: large library and lounge glazed courtain walls have no blinds at all, the secretariats offices on floor 3 and two classrooms on floor 4 facing north have the venetian built-in blinds mentioned above, and the faculty staff offices on floors 5 to 7 have internal vertical venetian blinds. The decision to fit the northern facade windows (the facade is rounded and roughly considered northern, though part of it has north-east orientation) of the Faculty staff offices with the internal vertical venetian blinds has been a post occupancy addition, stemming from some inconvenience associated with solar radiation penetration in early morning of the summer days. Due to the specific direction, these vertical louvers can be set to exclude the direct low angle sun radiation while allowing almost non disturbed penetration of diffused daylight and a good view out when positioned normal to the plane of the window.

Northern office windows, with vertical internal venetian blinds

The Rabin building is a conventional concrete frame building, with internal light weight partitions (single skin gypsum wall board on steel studs), and light weight curtain walls on the main facades. The glazed curtain walls consist of vision glass and opaque spandrel panels supported by aluminum framing. The opaque parts include behind the external glass a 3" rock wool thermal insulation layer placed between aluminum sheathing and an internal gypsum wallboard covering.

The atrium dome glazing is made of 15 mm thick triplex glass. This kind of glass is made by sandwiching a transparent polyvinyl butyral (PVB) interlayer between sheets of glass and bonding the three layers together under heat and pressure. The triplex glass is useful for atrium overhang glazing mostly for its safety, due to the vinyl resin which holds the shards of glass in case it is broken.

Walls and roof

The heavyweight parts of the external vertical envelope are composed of 20 cm reinforced concrete columns and beams, with an internal thermal insulation layer of 2" mineral wool.

The roof is a conventional reinforced concrete slab that includes an external thermal insulation layer of 4 cm expanded polystyrene.

Natural lighting

In the lower section of the first four floors, the library, atrium, corridors, offices and classrooms have been provided with natural daylight through the combination of full story glazed curtain walls and large windows on the north and south facades. Additional daylight is provided by the glazed roof of the cone shaped atrium dome.

Atrium roof –view from below

Natural light flowing into corridors from northern curtain wall

Similarly, in the upper section of the other three floors, the corridors as well as all offices are provided with daylight through large windows in external walls, or full height glazed curtain walls facing the internal courtyard that extends throughout the three floors.

Natural light flowing into corridors via internal courtyard

Special shading features

In addition to the blinds that are incorporated within or on the inner side of the windows, some geometrical features to prevent excessive solar radiation in summer have been implemented in the architectural design.

On the two library floors the western façade wall has been provided an architecturally unique undulating outline, so that the windows could face north to eliminate the penetration of direct solar radiation into the library.

Undulating western façade with windows facing north

Solar heat gain to the fifth and sixth floors of the south-west facade is limmited by the use of a deep two story high colonnade balcony. The top of the colonnade provides a continuous horizontal shading overhang for the two stories. But as this is not sufficient to provide shading in the late afternoon, the external glazing of the curtain walls and windows is tinted here as well, with embedded venetian blinds in the operable windows.

Shading colonnade on western façade of upper floors

3.2.2.3 Climate control systems

The entire building is air-conditioned and controlled as detailed below.

Air-conditioning and thermal storage

The design team of the Rabin building came to a decision to use a system featuring air-cooled screw chillers and ice storage tanks as an optimum solution for building cooling. In conventional cooling systems, the chiller operates during peak-demand daytime hours. Regulated electricity providers' rates during these hours are considerably higher than off-peak rates, making conventional cooling systems extremely expensive to operate.

Air conditioning of buildings such as the Rabin Building during daytime hours is the largest single contributor to electrical peak demand. In the early afternoon, as more air conditioning is needed to maintain comfortable temperatures, the increased demand for electricity adds to the load already created by lighting, operating equipment, computers, intensive human occupancy in classrooms, and a few minor other sources.

An Ice Storage Tank technology or Thermal Energy Storage (TES) system is a technology which shifts electrical load to off-peak hours, which will not only significantly lower energy expenses during the air conditioning season, but may also lower total energy usage (kWh) as well.

The system uses a standard chiller to produce solid ice at night during off-peak periods when the building’s electrical loads are at a minimum. The electricity supplier's generating capacity is also typically under-utilized at night and, consequently, its rates are lowest then. The ice is built and stored in modular ice tanks to provide cooling to help meet the building’s air conditioning load requirement the following day allowing chillers to be downsized or turned off.

The technology

The essential element of the ice storage system is a modular, insulated, polyethylene tank containing a spiralwound plastic tube heat exchanger surrounded with water. The Rabin Building has ten such tanks. At night, water containing 25% ethylene glycol is cooled by a chiller (there are two chillers with a cooling load of 200 tons of refrigeration) and is circulated through the heat exchanger, extracting heat. The fluid is at about -4^{o}C and freezes the water surrounding the heat exchanger until eventually some 95% of the water in the tank is frozen solid. The ice is built uniformly throughout the tank by the temperature averaging effect of closely spaced counter-flow heat exchanger tubes.

The following day, during the discharge process, the stored ice cools the solution of ethylene glycol, which is circulated through the coils where it is cooled by the melting ice and to the air-conditioning units to provide cooling to the building. The ice storage component decouples the cooling demand of the building from the operation of the chiller. The chiller can operate at night (more efficient condensing temperatures) to meet a daytime cooling demand and is being turned off in the morning. This flexibility permits a smaller chiller to satisfy a larger peak cooling load. Further, as mentioned before, the system can shift the cooling demand to off-peak hours when electricity from the utility supplier is generated more efficiently and at lower cost.

Monitoring and control

The building is equipped with the computerized Building Management System (BMS) similar to one installed in the Taub building, though by a different company. As in Taub, the BMS is fed by the Instabus network. More developed software than in Taub allows easier and more comprehensive control of the facilities. With the "intelligent" devices (time-switches and presence detectors) the system supplies a solution for managing and operating a building with such complex and diverse facilities as Rabin. Instubus is an intelligent building management system for measuring, regulating, switching, control, signaling and monitoring. Its main scopes of application are: lighting control, blind and shutter control, heating, ventilation and air conditioning systems, safety and security devices, monitoring and alarm systems, load management.

Numerous sensors (for monitoring external and internal conditions of all kinds) feed the management system with information, while controllers (controlling air-conditioning, louver settings, artificial light switching and security network) enable accomplishment of the various tasks most efficiently.

As the Rabin building has only recently been occupied, the BMS is still under test runs. The following features are thus only partially operational at this stage, and would probably be in full operation only in the coming year.

For example, the system can operate automatic lowering of blinds according to pre-set timetable or reduce the luminance by switching off lighting units at programmed times (breaks, weekends, end of working day, holidays etc.). Using sensors (door and window contacts), monitors or displays indicate which building openings are open and which are closed. Locking is initiated electro-mechanically.

The Instabus timer allows for automatic ‘ON’ and ‘OFF’ while still allowing the possibility of manual overriding.

Occupancy Sensors in classrooms indicate to the system to turn the lights off after 20 minutes of no-movement.

The system reduces the luminance by switching off 2/3 of the lighting units in lounge areas during daytime (at programmed times). In the evenings additional luminance may be turned on according to need.

Current applications in the Rabin building include:

Most of the air-handling units (AHU) which provide air-conditioning for the Rabin building are active five days a week, only during the defined working hours (7am-19pm), but may be activated manually in specific spaces at any other time of the day. Once the system is turned on during the off-work hours, it will automatically turn off after two hours.

As in the Taub Building, the building manager has a constant control of the lighting in public areas of the building, air-conditioning set points, building openings and other safety and security units such as fire alarms and video surveillance security camera system that records onto the internal hard drive using motion detection technology.

The network enables the overall system to be operated and fine tuned by the building manager using central or decentralized control.

Air quality

In order to maintain the quality of the air in the building forced ventilation initiated by the A/C system is used. The air-conditioning system consists of 13 air-handling units (AHU) which provide airflow to different zones of the building (the units have different temperature set points according to zone orientation, occupants activity and heat load). Each unit operates independently taking some fresh outdoor air, mixing it with circulated inside air (return air), filtering, cooling and sending it through ducts to the desired spaces. The fresh air is mixed with the returning inside air in proportion predetermined by the air-conditioning designer. The number of air changes per hour was designed according to the ASHRAE-62 code requirements for the various functional spaces, and consists of: 10 l/s/p in offices, and 8 l/s/p in classrooms and the auditorium.

Smoke venting

The smoke venting system was placed at the top of the atrium dome. The system is based on an the simplest way of stopping smoke spread within a building by allowing it to escape outside. In case of fire the system will be activated using the mechanical extraction vents installed at the atrium top.

Theoretically the atrium venting system may be used in summer to exhaust the warm air concentrated at its top during the day, as well as for night ventilation. However, using the system for these functions can be efficient only when the external temperature is at least some 2^{o}C below the comfort set-point, and the humidity conditions outdoors are appropriate. In the meantime the system has not yet been activated for ventilation purpose.

3.2.2.4 Special additional features

Gray water

Gray water is all the non-toilet wastewater produced in the average household including the water from bathtubs, showers, sinks, washing machines, and dishwashers. In case of the Rabin building the drainage systems have been built in such a way as to provide a separate system for the toilet and washbasins, enabling water from washbasins to be recycled to irrigation. Although gray water does not need extensive chemical or biological treatment before it can be used in the garden as irrigation water, it still must be used carefully because it usually contains grease, hair, detergent, cosmetics, dead skin, food particles and small amounts of fecal matter. Consequently, the water undergoes short biological treatment and disinfection.

Additionally, the condensation water from the air-conditioning network is utilized for watering the lawns. Condensation from air conditioners is basically distilled water and is safe to apply to any plant. The water is stored for up to 24 hours and therefore there’s no need for it to be treated.

Options considered but not implemented

Several other energetic/environmental (“green”) options were considered during the design and erection stages. Among them:

- External shading fixtures, such as operable or fixed louvered screens, overhangs in southern orientations and vertical in the eastern and western orientations - these were rejected due to high initial and maintenance costs.
- Special louvers in the Venetian blinds, which are reflective on one side and absorbent on the other so that they can provide shading in summer and solar collection in winter.
- Solar collector panels to operate the boilers for winter heating.
- Adjustable dimming of artificial lighting with light sensors.
- Night ventilation of the entire building in summer.

These were abandoned at different stages of the design process as too difficult to achieve at this stage in Israel, or too expensive within the given limited budget.

Rain harvesting by collecting the rain from the roof was considered in two options: cistern collecting during winter for irrigation utilization later in the arid summer, which was abandoned due to the high costs of water treatment required by the health authorities; instillation through a pile into the underground aquifer, which was abandoned due to the geological features of the soil in the vicinity of the building.

4. Monitoring of energy performance in practice

The HVAC and electricity supply system in the two buildings are under instrumentation in order to enable monitoring of supplied heating venting and cooling power as well as the electrical power consumption of the various systems.

Electrical power consumption: In the Taub Building the data for electrical power consumption can be collected and analyzed from existing meters. In the Rabin Building "Satec" power meters have been installed for this purpose. Power meters integrate easily into the BMS and are compatible with Instabus, which allows convenient data presentation and analysis. In both buildings the data is transmitted through the Instabus and processed by software, specially designed for the purpose of the present project. The measurement results can be presented in tabular or graph form for analysis of trends in consumption.

Preliminary measurements have been performed at this stage only in the Taub Building, but as instrumentation for the monitoring of air-conditioning supply loads in this building is not yet complete, the actual efficiency of the system's components cannot yet be derived.

HVAC power supply: All the air-conditioning system components in both buildings will be monitored and instrumented with the adequate software to produce the power demand they provide on the supply side.

Rabin building: chillers, AHUs, Aws, VAVs, heat exchangers, ice tanks.

Taub building: chillers, AHUs, Aws, VAVs.

An example of the data set derived from the preliminary measurements, performed at this stage only in the Rabin Building, is given in the following table. The data has been gathered between 15:30, October 27, to 10:30, October 8, 2003 every five minutes, and integrated to give the delivered energy loads (in kWh) during every entire hour. The symbols for the various components are explained by means of the floor maps presented in the schematic drawings below the tables. However, as the instrumentation for the electrical power consumption monitoring in this building is not yet complete, the actual efficiency of the system's components cannot yet be derived.

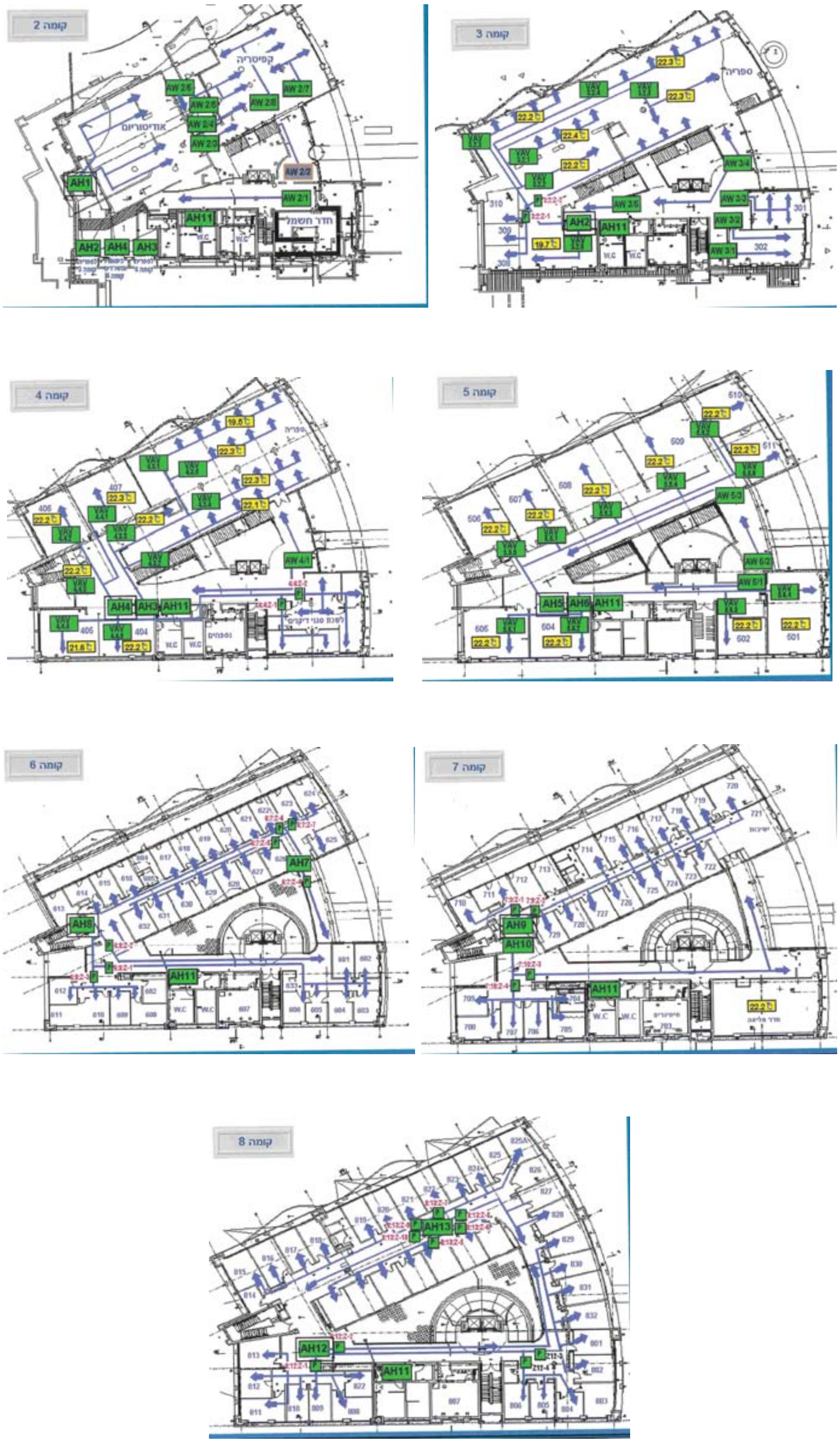
DATE	TIME	CH1	CH2	CH3	RES
27/10/2003	16	20.77	20.77	0.00	616.58
27/10/2003	17	0.00	0.00	0.00	585.29
27/10/2003	18	0.00	0.00	0.00	460.37
27/10/2003	19	0.00	0.00	0.00	246.69
27/10/2003	20	0.00	0.00	0.00	120.93
27/10/2003	21	0.00	0.00	0.00	93.33
27/10/2003	22	0.00	0.00	0.00	34.14
27/10/2003	23	326.36	326.36	0.00	466.35
27/10/2003	24	543.74	543.74	0.00	925.87
28/10/2003	1	17.64	17.64	0.00	945.79
28/10/2003	2	0.00	0.00	0.00	946.07
28/10/2003	3	0.00	0.00	0.00	938.68
28/10/2003	4	0.00	0.00	0.00	746.05
28/10/2003	5	0.00	0.00	0.00	0.85
28/10/2003	6	0.00	0.00	0.00	0.00
28/10/2003	7	0.00	0.00	0.00	228.48
28/10/2003	8	0.00	0.00	0.00	488.54
28/10/2003	9	0.00	0.00	0.00	537.77
28/10/2003	10	0.00	0.00	0.00	583.86

DATE	TIME	AH1	AH2	AH3	AH4	AH5	AH6	AH7	AH8	AH9	AH10	AH11	AH12	AH13
27/10	16	18.21	31.30	50.08	37.84	41.26	23.62	20.49	19.35	0.00	35.28	39.55	23.90	17.07
27/10	17	1.99	27.88	41.83	30.73	33.57	18.78	17.93	14.51	0.00	31.58	32.15	15.93	11.38
27/10	18	0.00	2.85	15.08	12.23	12.23	6.83	7.40	6.26	0.00	11.67	13.37	0.00	0.00
27/10	19	0.00	0.00	10.24	9.67	8.25	6.83	6.83	3.41	0.00	5.98	6.26	0.00	0.00
27/10	20	0.00	0.00	9.11	6.83	6.83	6.83	6.83	3.41	0.00	3.41	3.41	0.00	0.00
27/10	21	0.00	0.00	7.97	7.40	5.98	6.83	6.26	3.41	0.00	4.27	3.41	0.00	0.00
27/10	22	0.00	0.00	13.66	10.24	3.41	6.83	5.41	3.41	0.00	5.41	1.99	0.00	0.00
27/10	23	0.00	0.00	13.66	10.24	3.41	6.83	3.41	3.41	0.00	3.41	1.99	0.00	0.00
27/10	24	0.00	0.00	13.66	10.24	3.41	6.83	3.41	3.41	0.00	3.41	1.71	0.00	0.00
28/10	1	0.00	0.00	13.66	10.24	3.41	5.98	3.41	2.28	0.00	4.27	0.85	0.00	0.00
28/10	2	0.00	0.00	13.66	10.24	3.41	3.41	3.41	0.57	0.00	3.41	1.42	0.00	0.00
28/10	3	0.00	0.00	13.66	10.24	3.41	3.41	3.41	2.56	0.00	3.98	2.56	0.00	0.00
28/10	4	0.00	0.00	13.66	9.39	3.41	3.41	3.41	1.99	0.00	3.70	2.56	0.00	0.00
28/10	5	0.00	24.19	25.32	16.79	13.37	23.05	19.35	15.93	0.00	34.43	14.23	0.00	0.00
28/10	6	15.65	34.00	61.74	36.99	41.83	26.18	21.34	19.35	0.85	39.41	40.26	7.97	5.69
28/10	7	25.32	32.44	54.63	39.55	40.97	25.32	22.48	21.06	3.98	37.27	40.12	23.90	17.07
28/10	8	23.90	31.30	55.48	40.97	40.97	24.75	23.05	20.77	3.70	32.44	39.55	23.90	17.07
28/10	9	16.50	27.03	32.44	22.19	23.90	11.10	13.09	8.82	2.28	16.79	23.62	13.94	9.96
28/10	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DATE	TIME	AW2/1	AW2/2	AW2/3	AW2/4	AW3/1	AW3/2	AW3/3	AW3/4	AW3/5	AW4/1	AW5/1	AW5/2	AW5/3
27/10	16	0.00	9.11	11.38	4.55	11.38	9.11	11.38	9.11	0.00	86.78	0.00	0.00	0.00
27/10	17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.81	0.00	0.00	0.00
27/10	18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.27	0.00	0.00	0.00
27/10	19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.28	0.00	0.00	0.00
27/10	20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.86	0.00	0.00	0.00
27/10	21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.87	0.00	0.00	0.00
27/10	22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.87	0.00	0.00	0.00
27/10	23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.43	0.00	0.00	0.00
27/10	24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.56	0.00	0.00	0.00
28/10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.82	0.00	0.00	0.00
28/10	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46.66	0.00	0.00	0.00
28/10	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.82	0.00	0.00	0.00
28/10	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.43	0.00	0.00	0.00
28/10	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	72.84	0.00	0.00	0.00
28/10	6	4.55	4.55	5.69	2.28	5.69	4.55	5.69	4.55	0.00	76.54	0.00	0.00	0.00
28/10	7	13.66	13.66	17.07	6.83	17.07	13.66	17.07	13.66	0.00	61.17	0.00	0.00	0.00
28/10	8	13.66	13.66	17.07	6.83	17.07	13.66	17.07	13.66	0.00	88.21	0.00	0.00	0.00
28/10	9	7.97	7.97	9.96	3.98	9.96	7.97	9.96	7.97	0.00	33.86	0.00	0.00	0.00
28/10	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Floors are numbered between 2 to 8 (floor level no. 1 does not exist in this building, whose floors are numbered according to the levels in an older building connected to it by a bridge). RES is the symbol for the ice reservoir, while the various AC units supply the air conditioned air as follows:

Unit	**Spaces**
AH1	Auditorium, floor 2
AH2	Library, floor 3
AH3	Library, floor 4
AH4	Classes (and offices), floor 4
AH5 + AH6	Classes, floor 5
AH7 + AH8	Offices, floor 6
AH9 + AH10	Offices, floor 7
AH11	Lavatories, all floors
AH12 + AH13	Offices, floor 8
AW2/1 + AW2/2	Entrance lobby, floor 2
AW2/3 to AW2/8	Cafeteria, floor 2
AW3/1 to AW3/3	Classes, floor 3
AW3/4 + AW3/5	Corridors, floor 3
AW4/1	Corridors, floor 4
AW5/1 to AW5/3	Corridors, floor 5



Schematic of air-conditioning components in Rabin Building, floors 2 to 8

5. Conclusions

At the stage of presenting this report we could describe the change that has occurred in the attitude of Technion management towards energy conscious design of buildings on the Haifa Campus (probably with Technion joining OPET), and its consequences in the design of the two most recently constructed facilities, the Taub Building, which was designed and constructed before the change in attitude, and the Rabin Building, which was designed and built during the change. There are some obvious differences in the detailed design and construction of these two buildings, with many more energy conscious items provided in the Rabin Building (e.g., thermal insulation, shading, ice tank, provisions for night ventilation, etc.). However, it is not uncommon that with more intelligent control a building with poorer energetic details would perform better than one designed to a higher standard, but with poorer control. As the control systems in both buildings are similar, but not identical, it is valid to monitor and follow their energetic performance along the various seasons, in order to be able to compare the effects of the various differences.

Instrumentation of the two buildings, in order to enable monitoring of their actual energy performance, is in advanced progress. It is envisaged that starting this winter we will be able to gather continuous data of the following items: electrical consumption for the various functions and units, air-conditioning (heating and cooling) loads supplied to the various functional spaces, loads supplied by the chillers, and the cooling load supplied by the ice reservoir in the Rabin Building. Consequently, this data will be used for the comparative study of the actual energy performance of the two buildings, and the investigation of the main question: are there true and significant differences in the energy efficiency of the two buildings, and can they be attributed to the different energy conservation measures that have been implemented?