

'SUSTAINABILITY AS A DESIGN TOOL'

A sustainable biology and chemistry teaching laboratory for Georgetown University In Washington D.C.

'INFORM[ATION]AL BACKBONE'

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Submitted to the Faculty of the Virginia Polytechnic Institute and State University

In partial fulfillment of the requirements for the 'Master of Architecture' Degree

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June 2004

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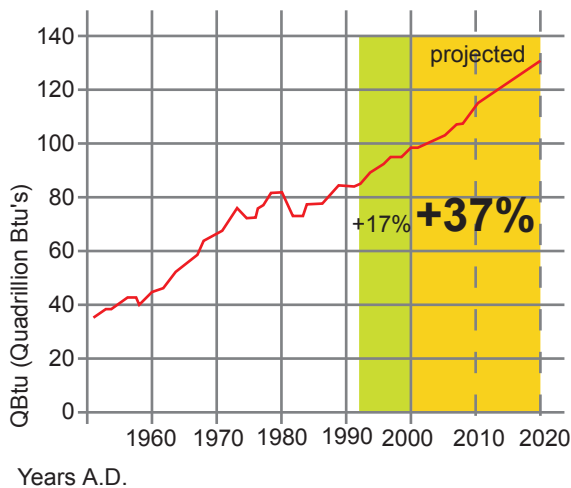
ABSTRACT

Like much of the world, the United States is currently experiencing intense growth, especially in and around its cities. Unfortunately, this growth is often at odds with the natural environment. In order to reduce the demand of foreign energy resources designing with "green" or ecologically responsive design objectives in mind is vital. We may think of cars and factories as the most obvious enemies of the environment, but buildings consume half of the energy used world wide. The idea of this thesis project was to explore the possibilities of sustainable strategies. That is to develop an energy intensive building based on ecological principles as design tools that demonstrate the economic value of sustainability, and to highlight an energy intensive building type as an example of energy-responsive-living that actually 'looks good'.



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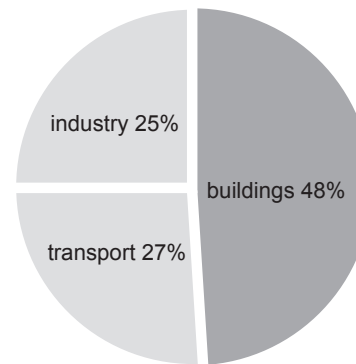


Total U.S. Energy Consumption

Despite the United Nations Framework Convention on Climate Change which promised to restore greenhouse gas concentrations in the atmosphere to 1990 levels, US energy consumption increase by 17% through the 90s. Experts predict an additional 37% rise in energy consumption by 2020.

[source:metropolis 10/03]

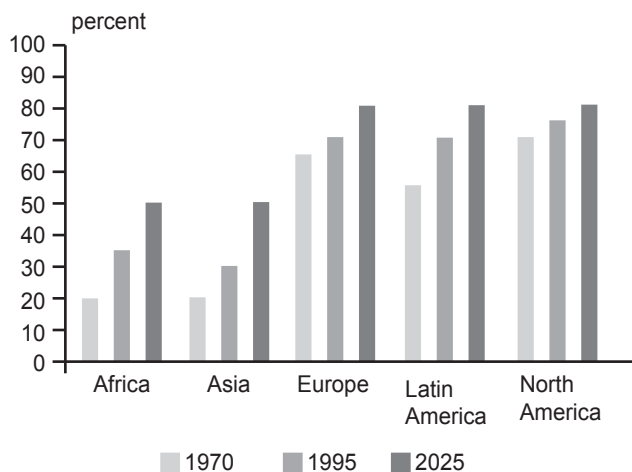
ILLUSTRATIONS OF ENERGY USE IN THE U.S.



U.S. Energy Consumption by Sector

A reorganization of existing data —combining the energy required to run residential, commercial, and industrial buildings along with the embodied energy of industry-produced materials like carpet, tile, and hardware—exposes architecture as the hidden polluter.

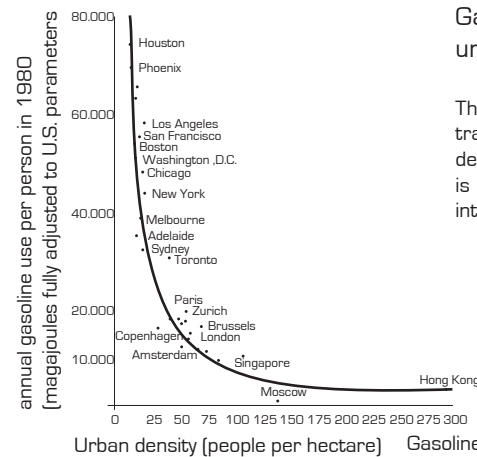
[source:metropolis 10/03]



Increase in human population

in 1970 the world population was approximately 3 billion people. Expectations for 2025 right now are an increase to 8 billions. The cities around the globe will most certainly continue to expand and to develop with increasing intensity. Despite the changes and the benefits of the digital revolution, the rural-to-urban migration of the population in the developing world will continue to increase.

[source:UN,New York 1995]



Gasoline consumption and urban density

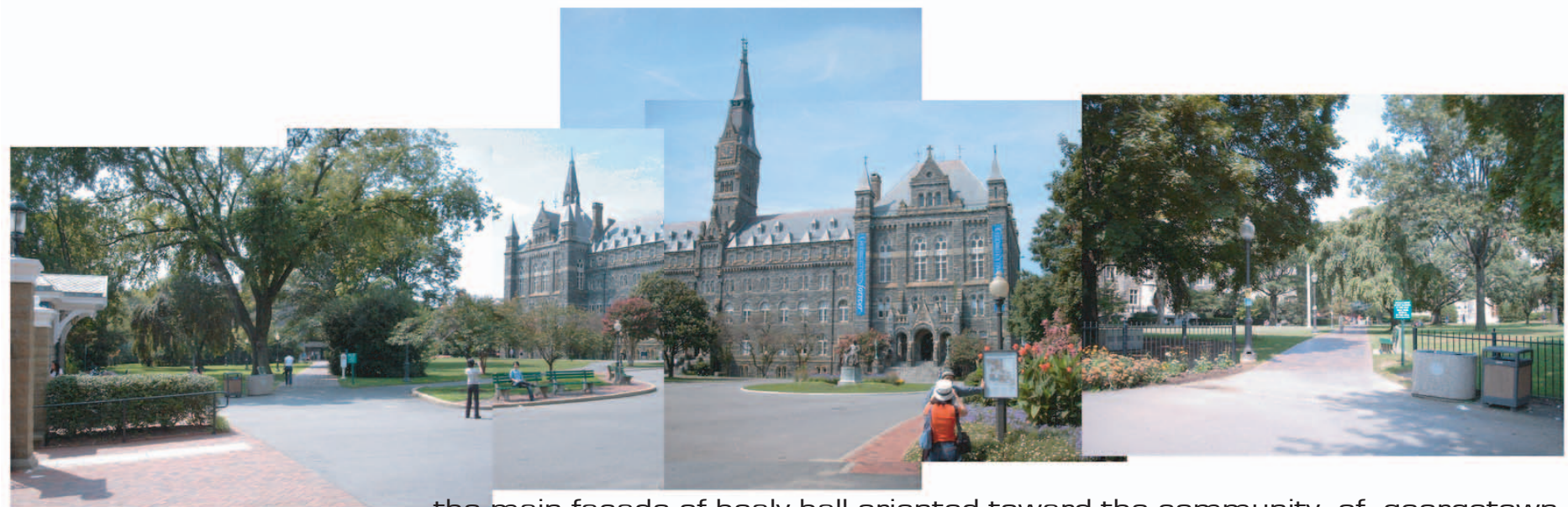
The chart shows that a city's transportation energy consumption decreases as the city intensifies. This is one of the main justifications of intensification.

Gasoline consumption and urban densities (1980)
[source:Robert Paehke, 1989]

SITE AND URBAN RELATIONSHIPS

Located one block east of the main entrance to Georgetown University, the building site is the most important interface between the residential neighborhood of Georgetown and the University. Founded in 1789, the same year as the U.S. Constitution took effect, Georgetown is the nation's oldest catholic university. Between its founding in 1789 and the end of the Second World War, Georgetown University's growth was gradual and incremental, integrating the simple but clear gridiron plan of the neighboring community with a traditional pattern of academic quadrangles. The principal facade of Healy Hall, the entrance building, was oriented toward the city and not the river, signaling the University's desire to present itself as an institution of national importance and with a relation to the community. With its boldly scaled greystone facade, influenced by the late medieval architecture of France and Flanders, Healy has since been the visual embodiment of the soul of Georgetown. It was built as a residential college building similar to English models wherein student living quarters and academic facilities are contained under one roof. In the post-war period, Georgetown expanded rapidly and the formal quadrangle organization was abandoned. The development of the campus is guided by the desire to maintain a quality of intimacy within the larger urban fabric while providing the intellectual and physical environment necessary to support the university mission. Georgetown University stands at a critical juncture in its history. To maintain and improve its leadership position in higher education, Georgetown must expand its Catholic, Jesuit tradition of scholarship, service and faith and its 200-year record of achievement to meet the rapidly developing demands of the twenty-first century.

PICTURES OF THE IMMEDIATE SURROUNDING



the main facade of healy hall oriented toward the community of georgetown



residential neighborhood surrounding georgetown university

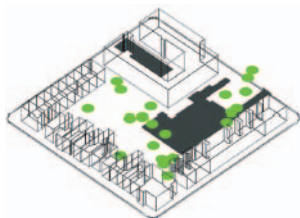
PICTURES OF THE IMMEDIATE SURROUNDING



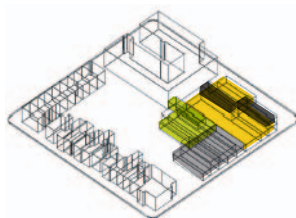
residential neighborhood



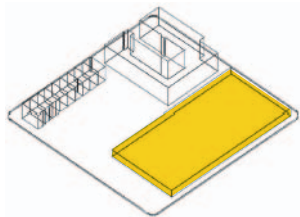
residential neighborhood



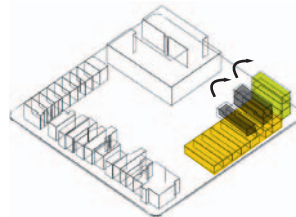
existing situation



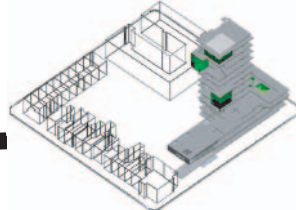
keeping the listed buildings on o street, more compact distribution of the program



in the outline, suggested site with distribution of the program on 1 floor



stacking and layering the program to get a maximum of unsealed courtyard space



closing the existing block structure with a maximum of green space



georgetown university

new laboratory

potomac river

DISTANT VIEW OF THE BUILDING



potomac river

key bridge

siteplan georgetown

THE WELL TEMPERED BUILDING _ ORIENTATION AND THE SUN

The position of the building and the layout of the floor plans was driven by three major facts:

- existing urban grid pattern
- relation to Healy Hall
- the sun.

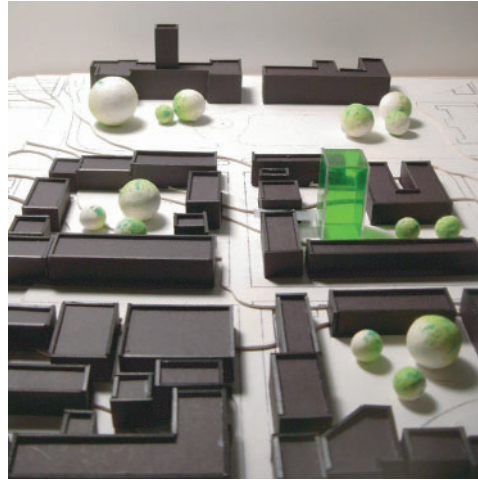
The new laboratory closes the existing block structure with its horizontal I-shaped part. The vertical is set back to cast as little shadow on the adjacent residential buildings as possible. The internal layout of the laboratory tower is organized according to the following principles :

- In summer, much more radiation falls on the horizontal surface than on the north face. This is because the sun is much higher in the sky, so that the angle of incidence favors the horizontal surface.
- The incident radiation on the east face in the morning and the west face in the evening is much greater than that on the north face during the middle of the day.
- The south face peaks in the morning and in the evening. This is because the sun rises and sets slightly south of east and west, providing a small direct component at these times. Outside these times the south face is generally a good indicator of the overall diffuse component.

During the day, solar energy falls on the surfaces of a building as both direct and indirect radiation. Direct radiation refers to the energy arriving through the atmosphere straight from the sun. Indirect radiation, however, refers to the ambient energy that is deflected in the atmosphere or reflected off other surfaces around the building. As such, the amount of indirect radiation falling on a surface is almost independent of surface orientation whereas direct radiation is highly dependent on orientation.

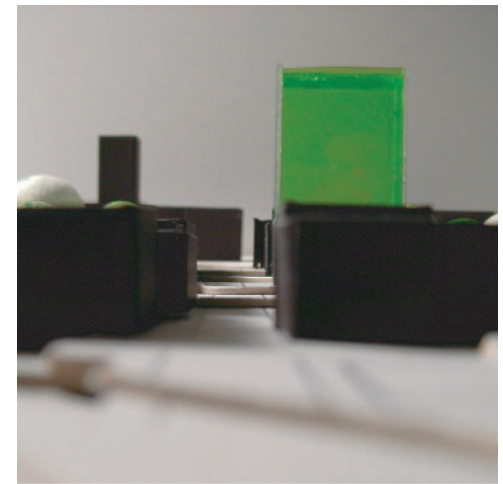


integrated in the existing
block structure, free form
located in the court

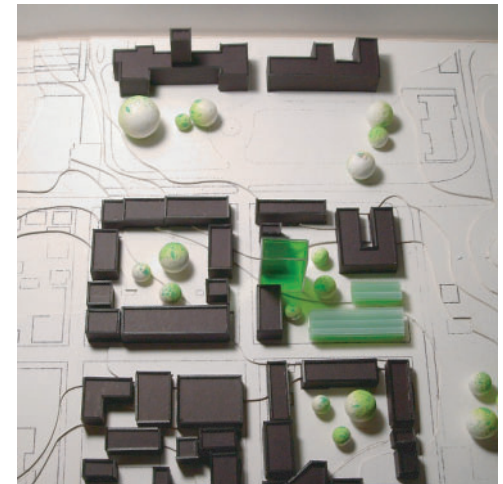
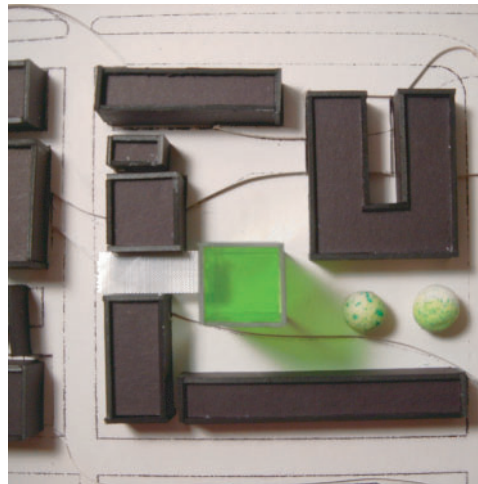


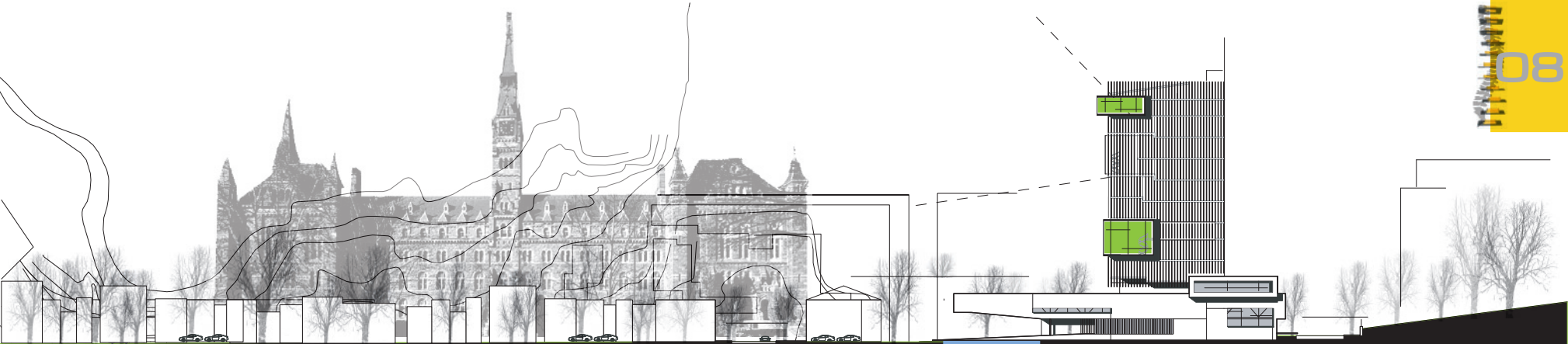
integrated in the existing
block structure, entrance from
o- street

SITE STUDY MODELS



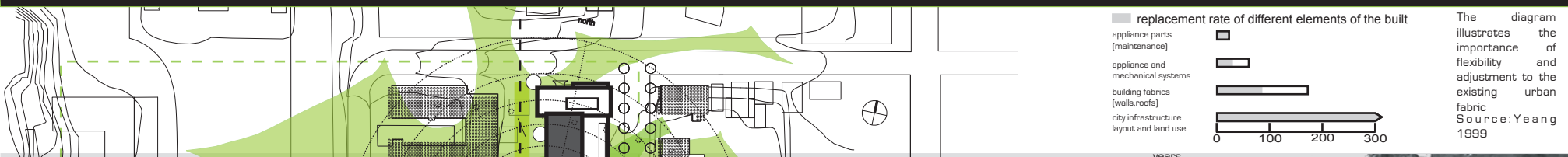
dialog between the main
building and the new
laboratory, a "new edge" for
the existing block





TRANSCENDENCE

SCIENCE



The diagram illustrates the importance of flexibility and adjustment to the existing urban fabric
 Source: Yeang 1999



COPLEY LAWN

HEALY LAWN

HEALY HALL

36 TH STREET

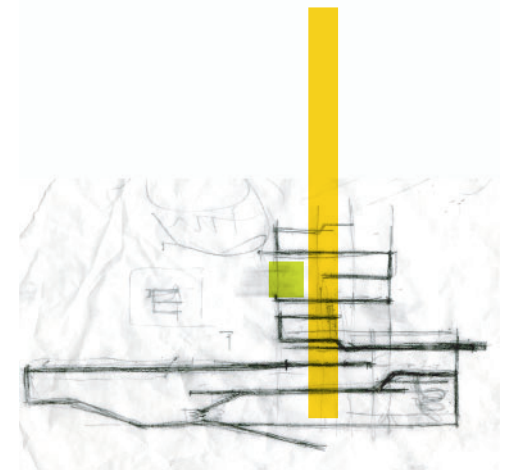
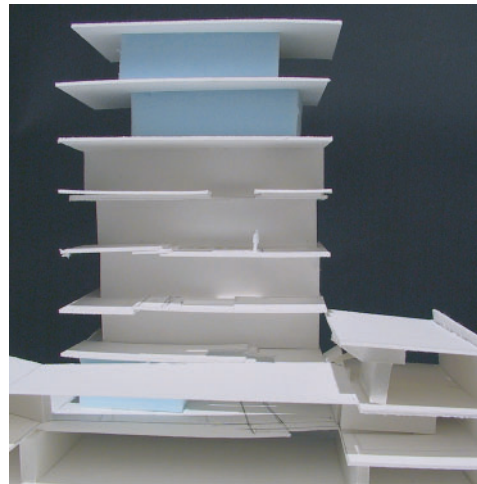
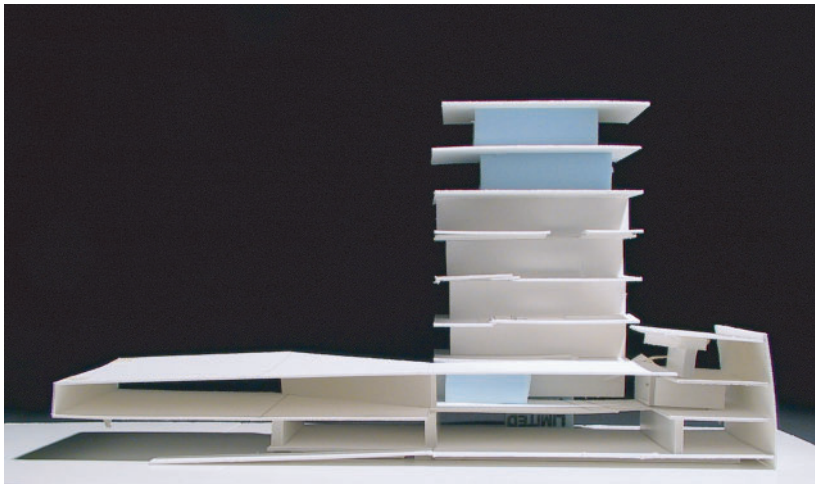
O STREET

"PASSIVE COOLING" AND NATURAL VENTILATION

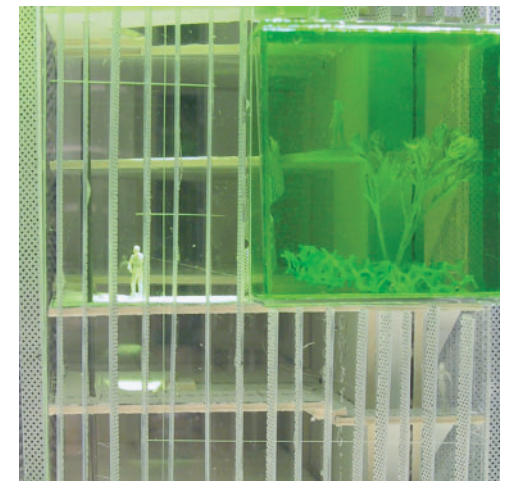
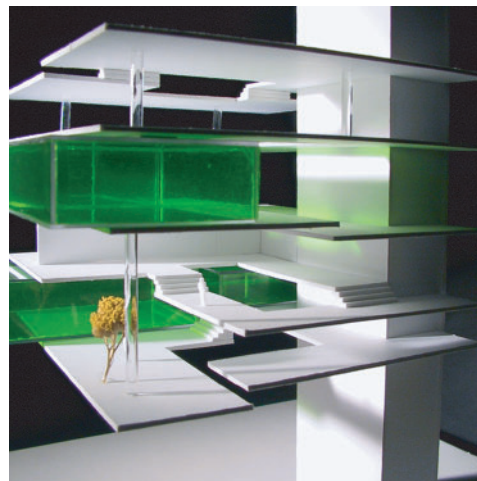
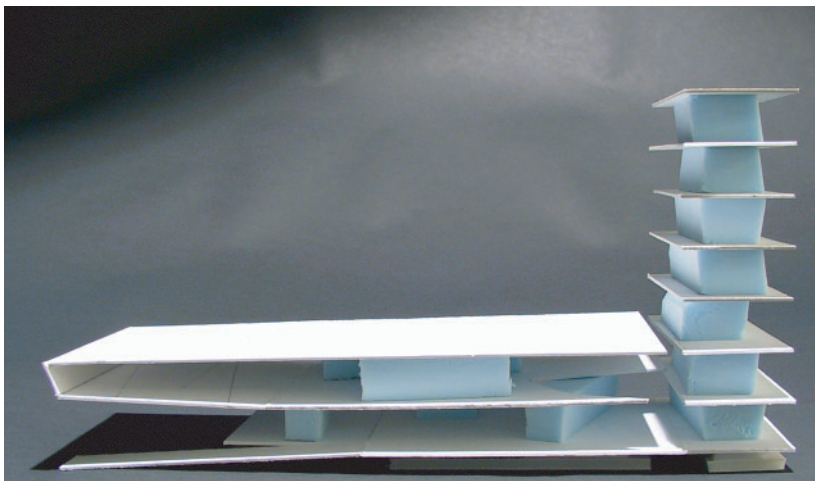
Natural methods were developed over thousands of years as integral parts of building design to keep it cool. Today they are called "passive cooling." Ironically, passive cooling is considered an "alternative" to mechanical cooling that requires complicated refrigeration systems. By employing passive cooling techniques in modern buildings, advantages are to eliminate mechanical cooling or at least reduce the size and cost of the equipment. There are four passive cooling strategies : natural ventilation, evaporative cooling, high thermal mass and high thermal mass with night ventilation.

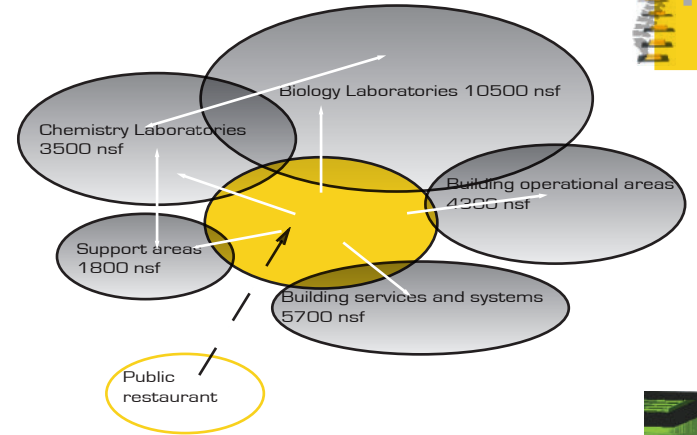
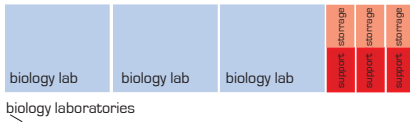
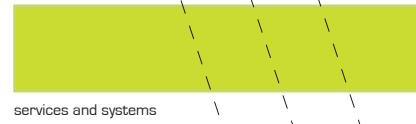
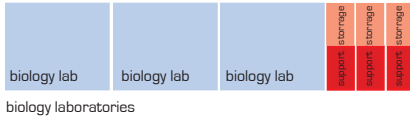
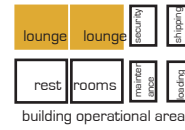
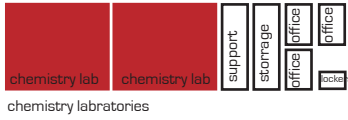
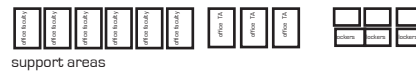
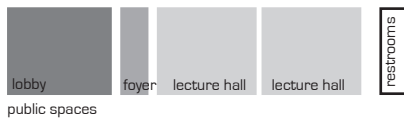
- Natural ventilation depends solely on air movement to cool occupants. Window openings on opposite sides of the building enhance cross ventilation driven by breezes. Since natural breezes can't be scheduled. To enhance natural ventilation the laboratory building uses the tall void within the atrium as a "stack". With openings near the top of the atrium, warm air can escape, while cooler air enters the building from openings with pre-cooled air from the ground channels. Ventilation requires the building to be open during the day to allow air flow.
- High thermal mass depends on the ability of materials in the building to absorb heat during the day. Each night the mass releases heat, making it ready to absorb heat again the next day. To use walls and slab floors is an easy way to accomplish this. The new laboratory is constructed completely of concrete which has a high thermal mass.
- Night ventilation relies on the daily heat storage of thermal mass combined with night ventilation that cools the mass. The building must be closed during the day and opened at night to flush the heat away.
- Evaporative cooling, in this case the plants in the "sky gardens", are often supplemented with mechanical means, such as fans. Even so, they use substantially less energy to maintain comfort compared to refrigeration systems. It is also possible to use these strategies in completely passive systems that require no additional machinery or energy to operate.

STUDY MODELS AND SKETCHES OF THE ATRIUM



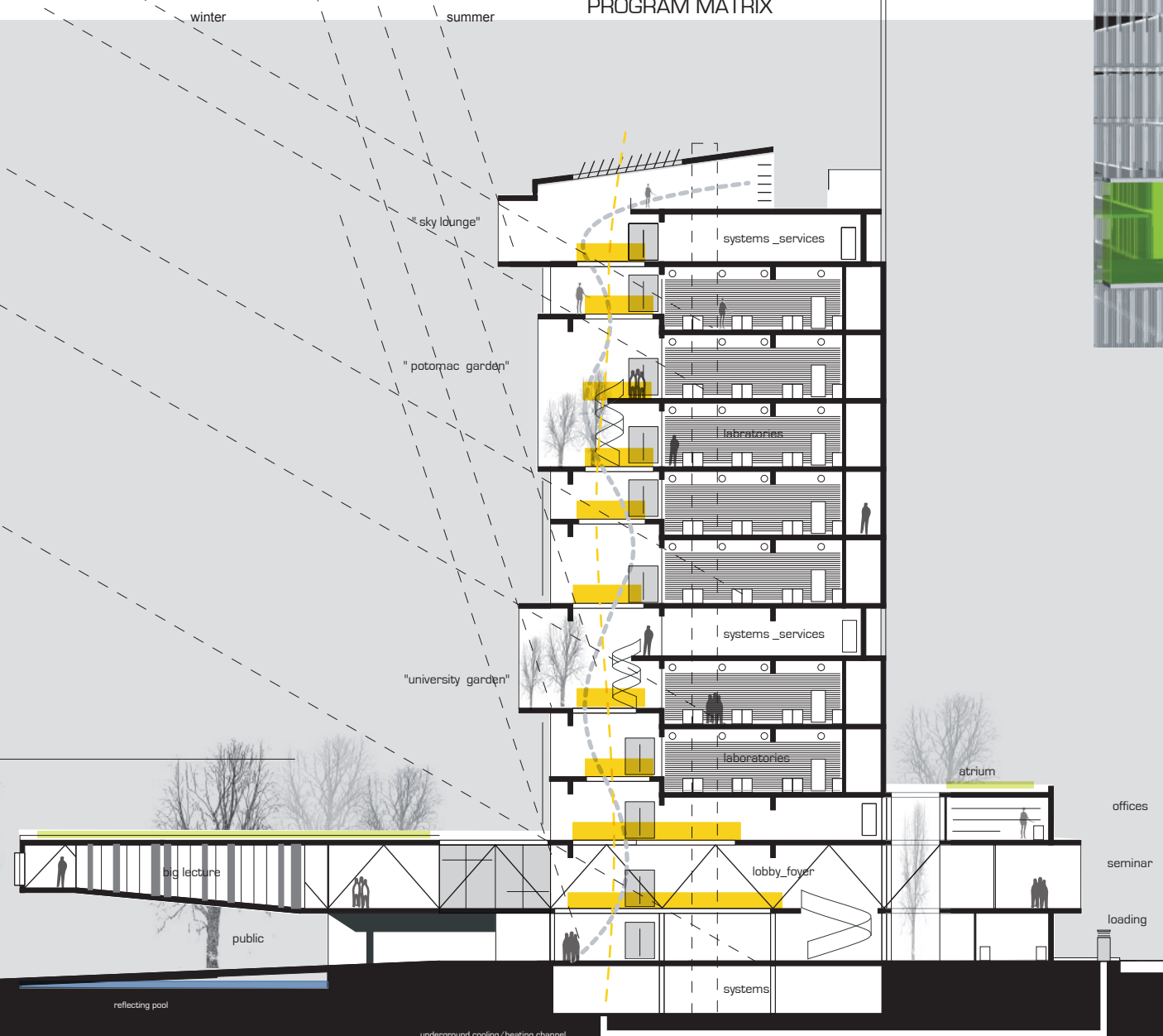
different study models showing the development of the atrium void, also visible the location change of the tower, main emphasis was given the integration of the tower according to the existing urban condition and shadow casting on the adjacent residential houses.





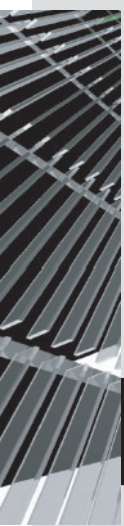
PROGRAM

PROGRAM MATRIX



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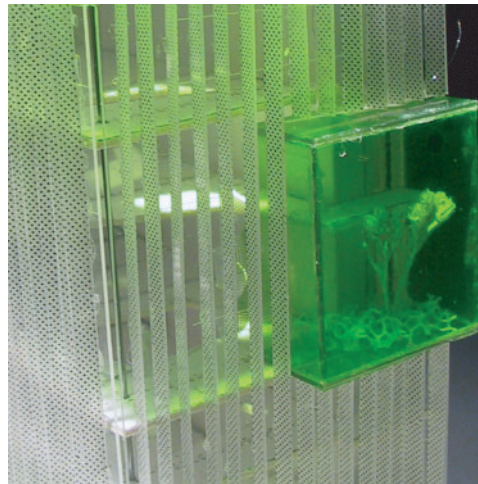
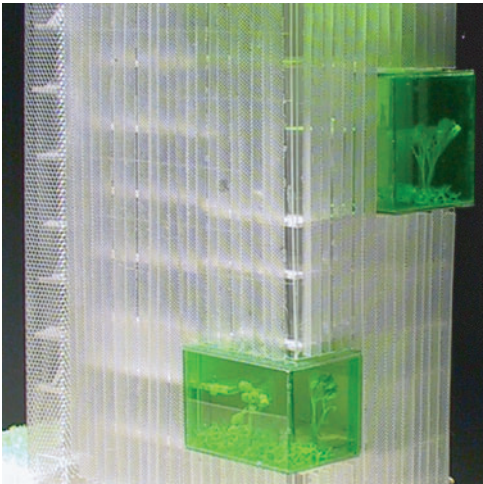
SECTION



COOLING BY TRANSPIRATION AND NATURAL VENTILATION

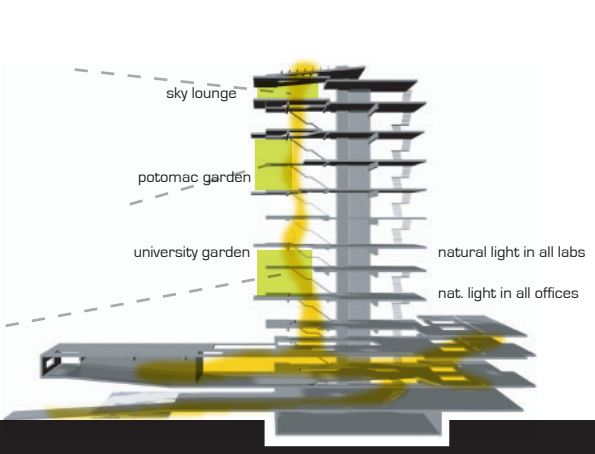
Everyone knows how pleasant it is to sit in the shade of a tree in summer but few of us think of the situation as being 'energy efficient'. Yet one mature tree potentially provides nearly as much cooling as five 3 kilowatt air conditioners (a domestic air conditioner uses generally about 2 kW). A survey conducted in an American city showed that public street trees saved approximately \$US 800 per day in costs compared to their equivalent in machine air conditioning. In a hot space, plants provide cooling by transpiration, evaporating moisture on the surface of leaves, and by reducing the overall mean radiant temperature. Interestingly, the surface of plant leaves has a very low emissivity, meaning that they do not emit infrared radiation (heat) very well. In contrast, most building materials have a very high emissivity. The effectiveness of transpiration in energy transfer can be judged by the fact that a transpiration rate of only five ten thousandths of a gram of water per square centimetre gives rise to an energy loss of approximately three tenths of a calorie. This is enough to lower the temperature of a transpiring leaf by as much as 15° C [Gates, 1969]. Temperature is a major factor in human comfort, distributing large areas of broad-leaved foliage within a space can improve perceived comfort levels. Also the psychological effects: Living plants refresh the spirit and generate "joie de vivre..". The absence of green causes depression, and results in stress and mental illness. The atrium is the main emphasis regarding energy conscious design principles. It becomes essential for the understanding of the design. It serves spatially as a multi-functional space and acts as a "thermal buffer" and "cooler" with its sky gardens and open void. It can be occupied by students seeking contemplation, as an informal seminar environment or as an extended laboratory for work. It is an undefined, free space for all staff and students to dwell in. Additionally, it enhances the users' comfort, providing visual and physical contact between all floors and functions and with its extensive "green" interior gardens. It is precisely that undefined space that makes this building so intriguing.

STUDY MODELS OF THE SKY GARDENS

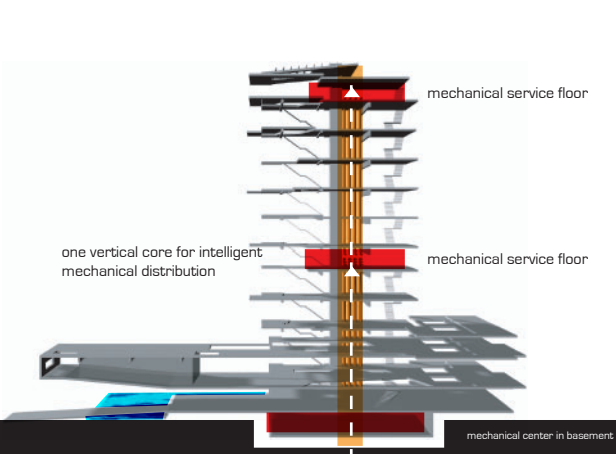


different study models showing the "sky gardens", temperature is a major factor in human comfort, distributing large areas of broad-leaved foliage within a space can improve perceived comfort levels, the "sky gardens" act as "coolers" and informal extension of the laboratories.

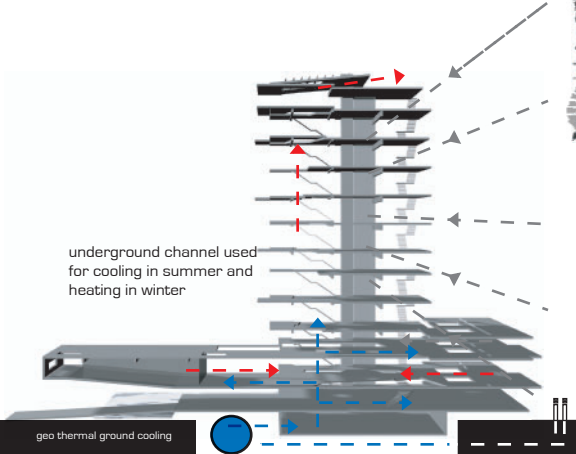




SKY GARDENS & ATRIUM ACT AS THERMAL BUFFERS



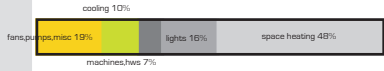
DISTRIBUTION OF SERVICES



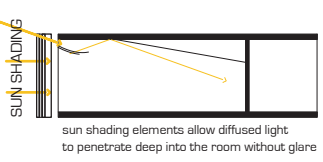
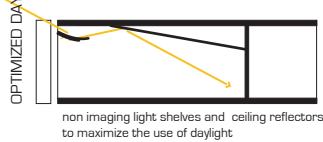
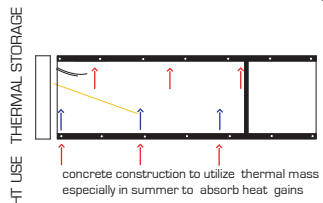
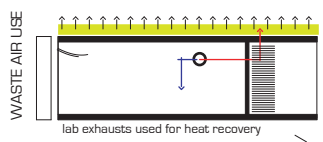
BUILDING COOLING AND HEATING

By comparison of the two diagrams, a significant need to emphasize thermal buffers and geothermal devices to heat and cool the building without hvac. Additionally, activate thermal mass storage. Due to the huge amount of conditioned air in the lab the use of heat recovery systems is a chance to decrease energy consumption dramatically.

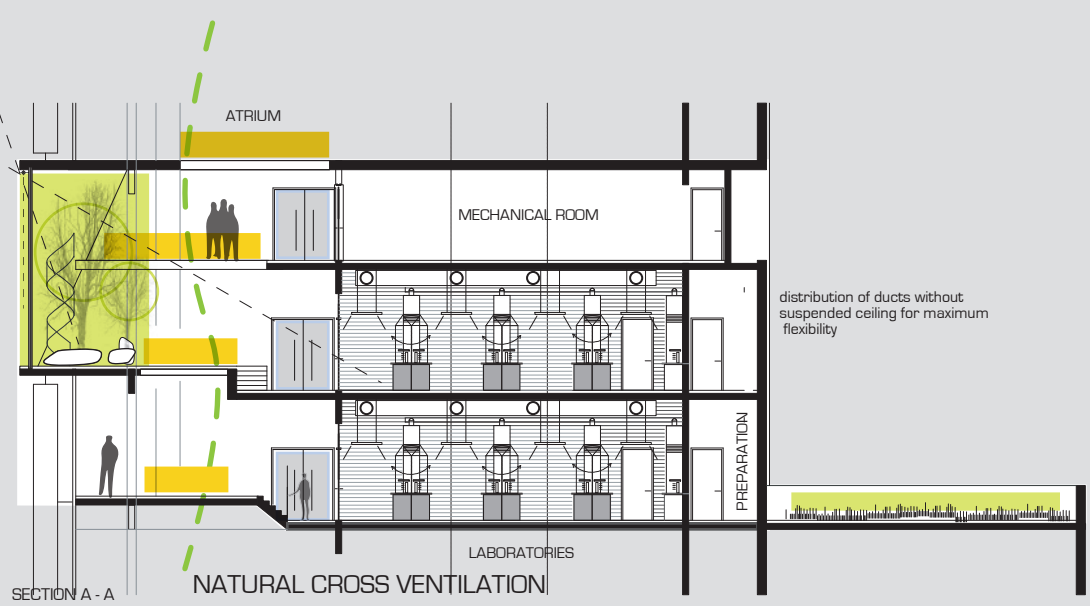
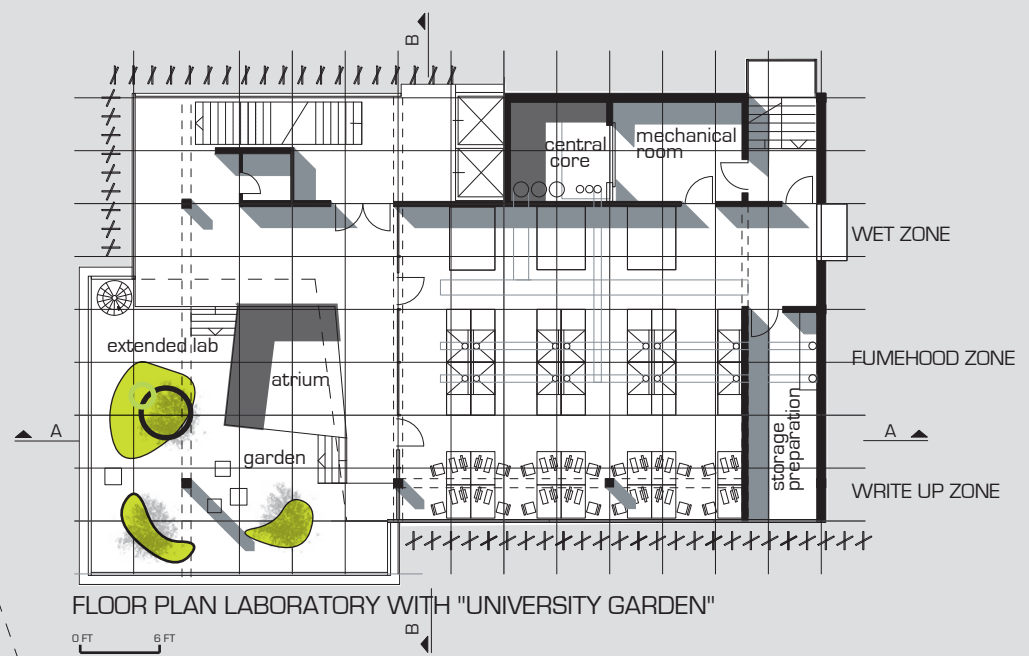
Energy use typical air conditioned building in the U.S.



Energy use typical laboratory



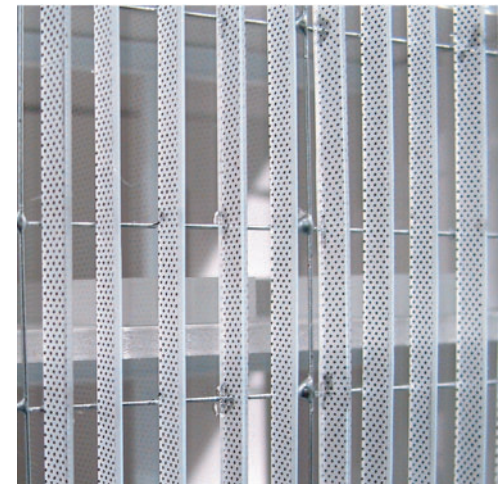
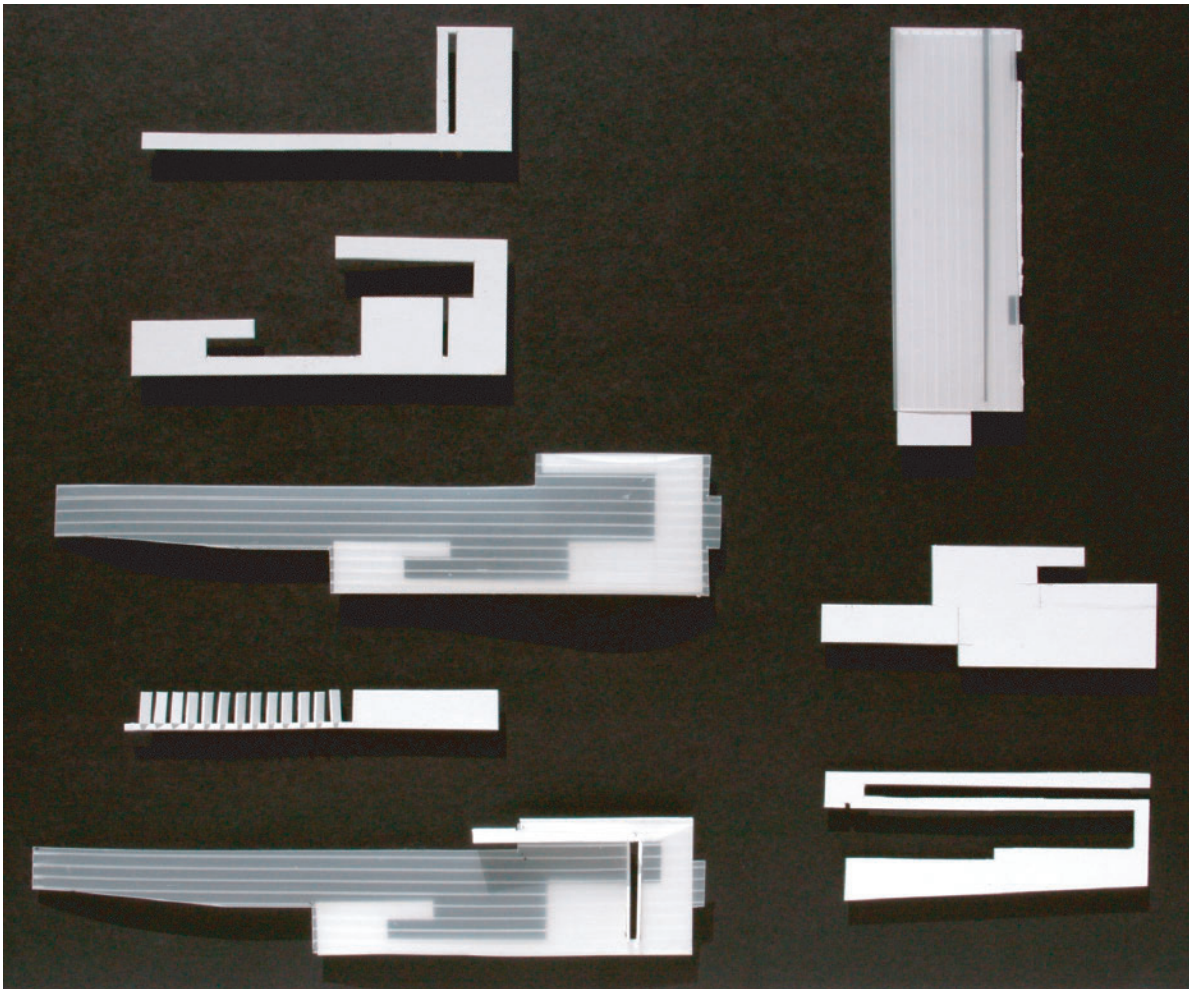
LOW ENERGY CONCEPT



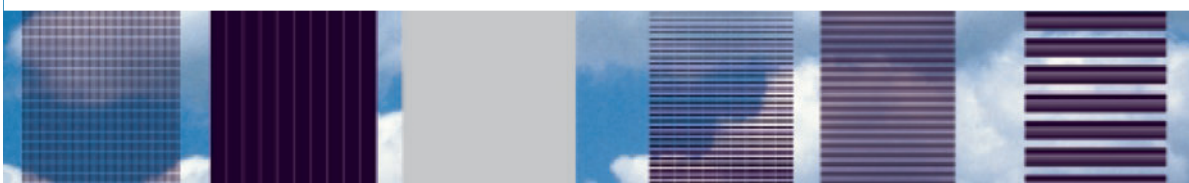
THE BUILDING SKIN_A SURROUNDING FILTER

The skin of a building is the connection between the natural environment and the built environment. Climate adaptive building skins use materials and design elements to improve interior comfort, provide visual and thermal access to the natural environment, and reduce energy use. The building's skin is separated from the load-bearing structure and presents itself as a derivation of a curtain wall system. In the laboratory tower a double-wall envelope is applied. Double envelope skins can reduce heat loss in the winter while still capturing solar gains. In the summer, the double skin reduces heat gain and lowers air conditioning loads while allowing in daylighting and natural ventilation. One special feature of the building skin is the use of a layered combination of opaque "pv" panels and a transparent double glazed envelope. The outer layer of the facade consists of glass panels with printed on "pv" modules. They are applied to shade the interior in summer and to gain energy at the same time. To accomplish the most effectivity the whole facade system is sun tracked. The inner layer is made up of a double glazed curtain wall system to gain a maximum of daylight. In winter the outer layer can be closed and be used as a third layer to reduce heat loss. The interior is equipped with light shelves that reflect light deep in the space to maximize the use of daylight. The shelves are supported by reflecting ceiling panels between the duct work. The facade of the horizontal part is a multi layer steel or concrete construction highly insulated and cladded with a rear ventilated cedar wood panel system. The aim is to provide comfort in the building's interior in the most energy efficient manner. The use of local wood with little transportation and energy costs to the construction site was the key to achieve this. Additionally, the wooden surface mediates between the old residential buildings and the new science edifice.

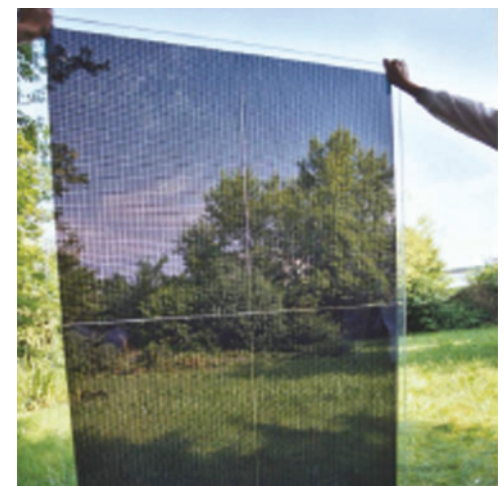
STUDY MODELS AND MATERIAL EXAMPLES OF THE PV PANEL AND WOOD FACADE



facade pattern of the laboratory tower



different patterns can be printed on the panels



grade of translucency of the pv panels

SUN TRACKED PV-PANEL FACADE

open facade



facade moving with the sun



blocking direct light and gaining energy by means of PV panels at the same time

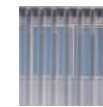


in winter the panels are used as a thermal buffer

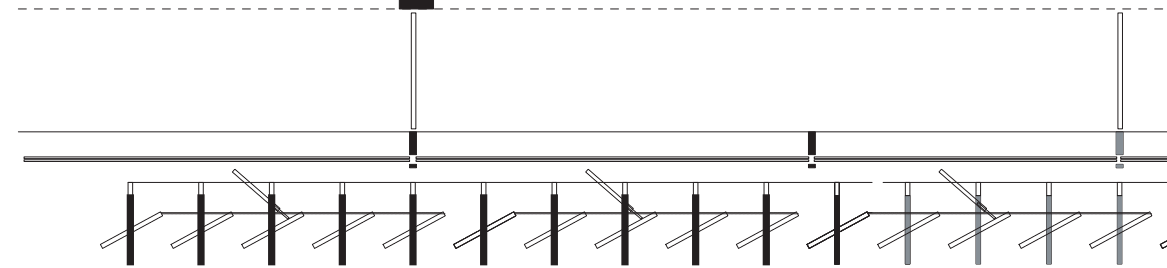
PV FACADE EXAMPLES



crystalline glass modules
semi transparent

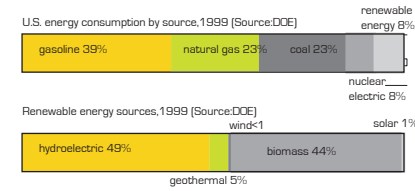


facade pattern



HORIZONTAL FACADE

0 FT 2.5 FT



Solar Energy

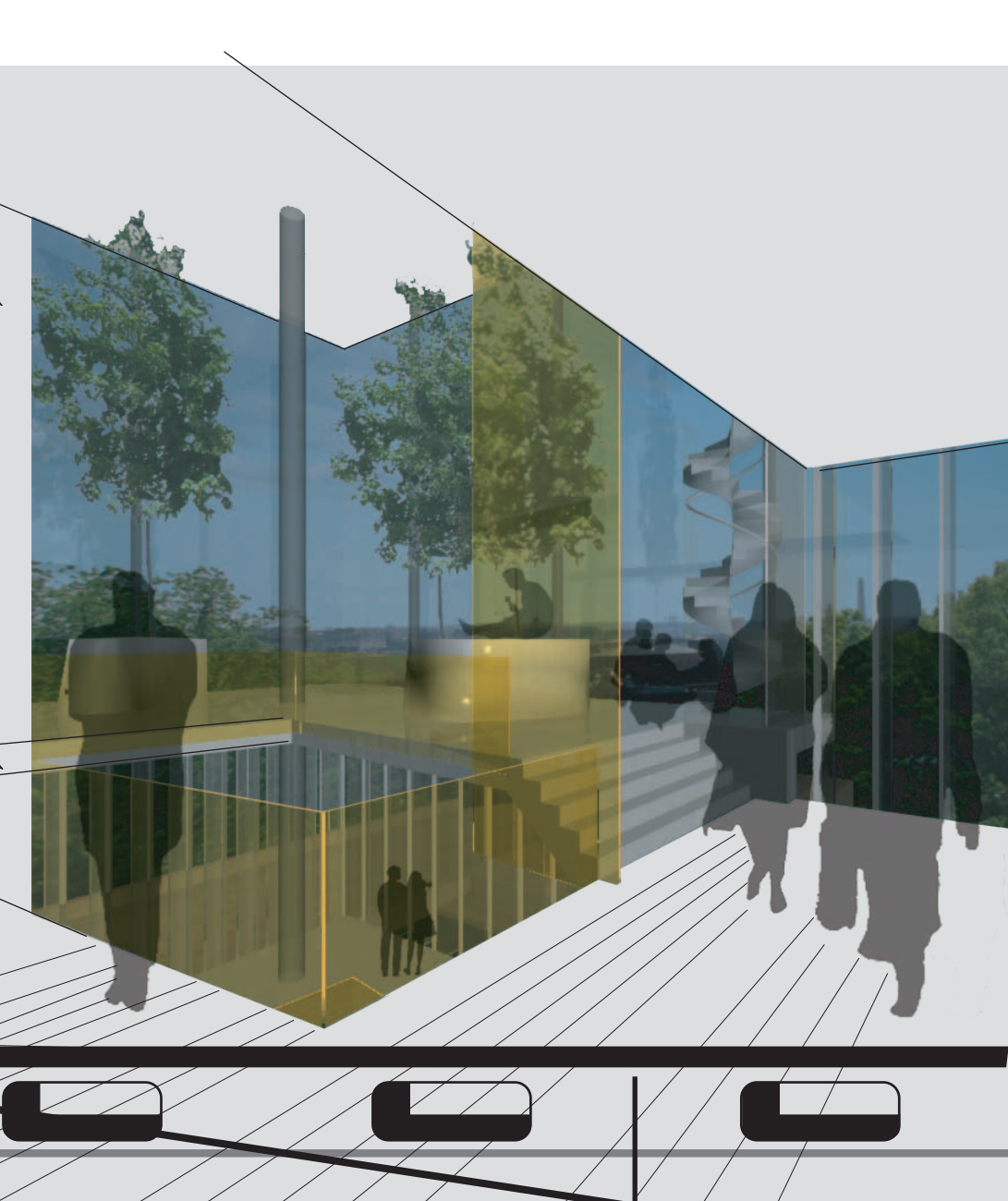
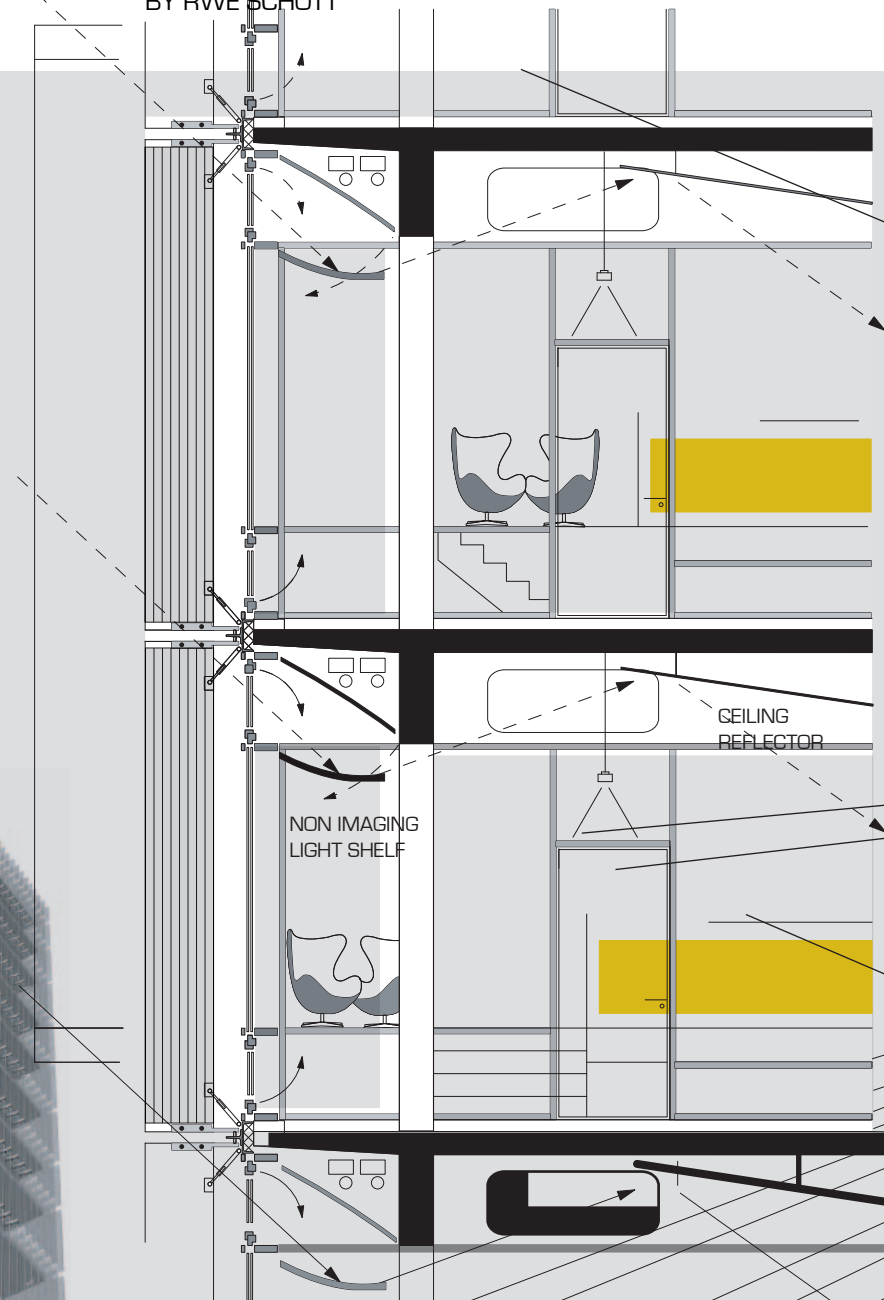
The applied aesthetic principle is the sun flower following the sun. Facts for a wider use of solar energy:

The progress in efficiency of pv panels and the decrease in price.

The length of sunshine especially in summer in the D.C. area.

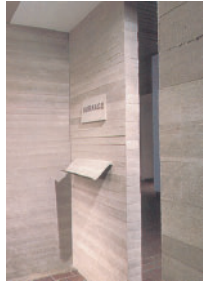
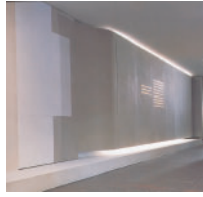
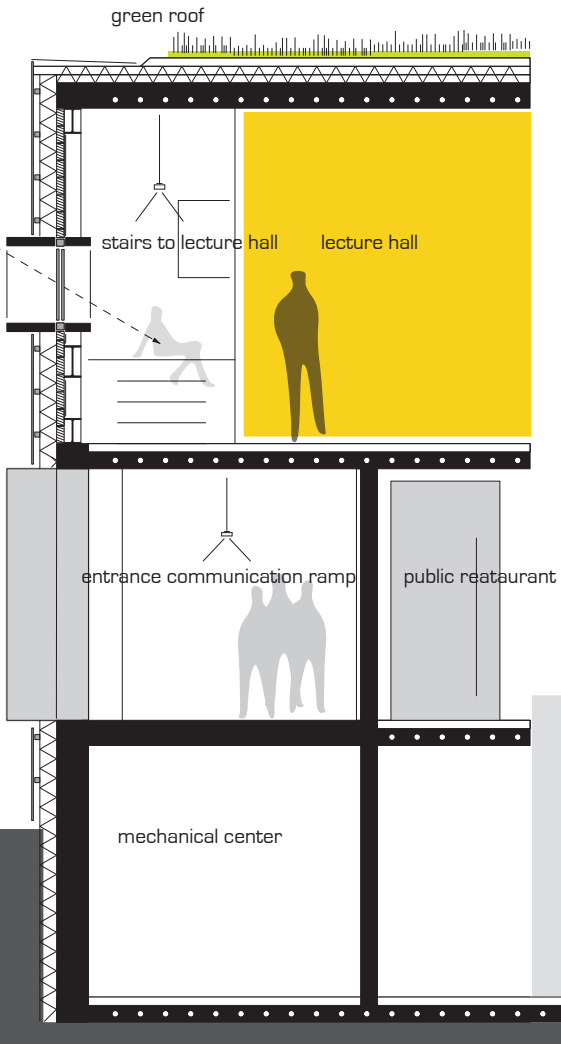
The height of the facades in south and west direction.

TRACKED CRYSTALLINE SOLAR PANEL MODULES BY RWE SCHOTT



VERTICAL FACADE SECTION PV GLASS FACADE

0 FT 2.5 FT



recycled paper walls

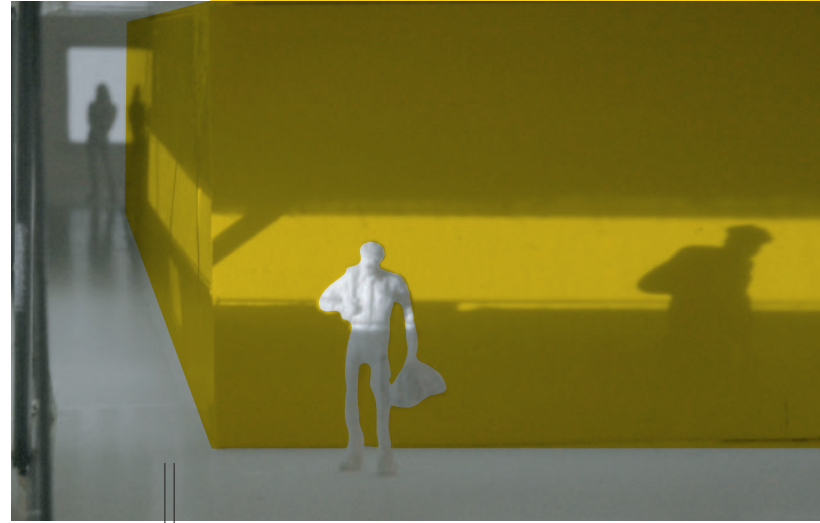
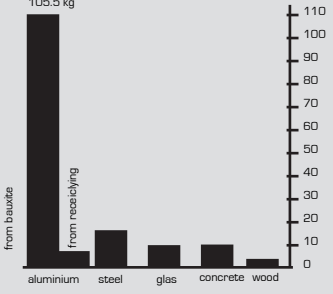


PHOTO IN FRONT OF BIG LECTURE HALL

MATERIAL EXAMPLES INTERIOR WALLS

VERTICAL FACADE SECTION WOOD FACADE

Energy cost of material (source Von Weizaecker et al., 1997) 105.5 kg



Strategies for material selection

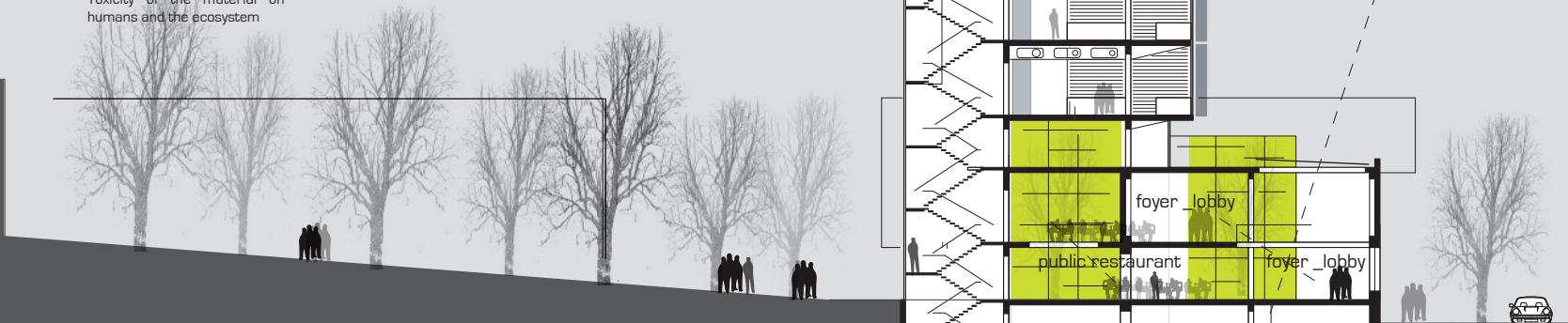
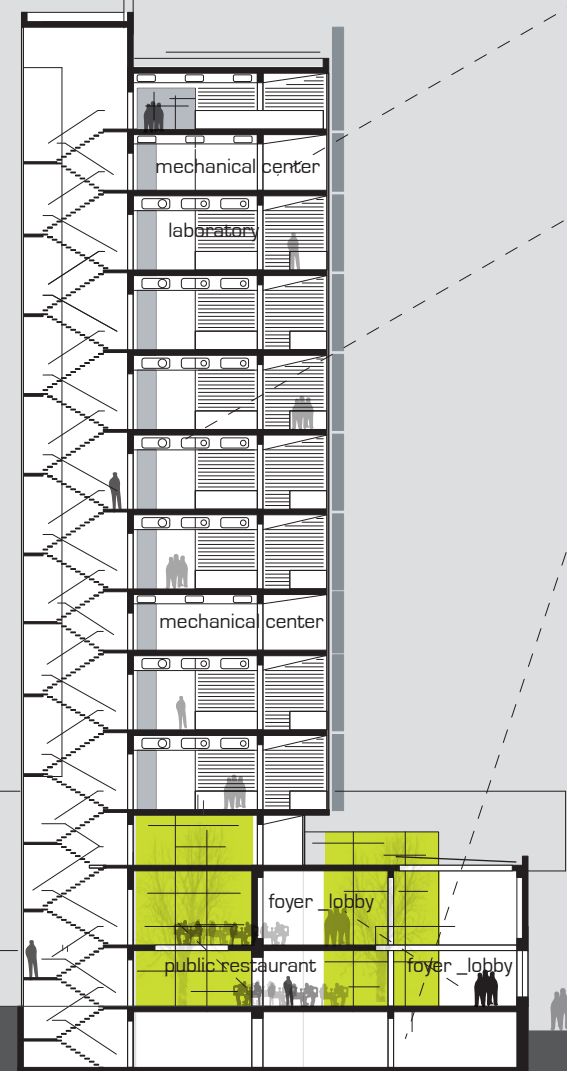
Besides the usual architectural criteria [aesthetic, cost, etc.] the ecological criteria should be:

Potential of reuse and recycling

Embodied ecological impact as a consequence of production and delivery to the construction site

Embodied energy cost of production and delivery to the construction site

Toxicity of the material on humans and the ecosystem



CROSS SECTION BUILDING

FLOORPLANS, ELEVATIONS AND MODELL PICTURES

The building program was determined by the "Lab's 21 Student Design Competition". The competition challenged architecture students and faculty from the United States and Canada to design a laboratory building that exemplified high performance, low-energy design principles, in addition to meeting core architectural design considerations.

In developing a design proposal, competitors were asked to address several critical issues:

- Architectural expression that embraces the ethic of sustainability
- Minimal ecological impact
- Design for human performance
- Design for flexibility and adaptability
- Exceptional innovation



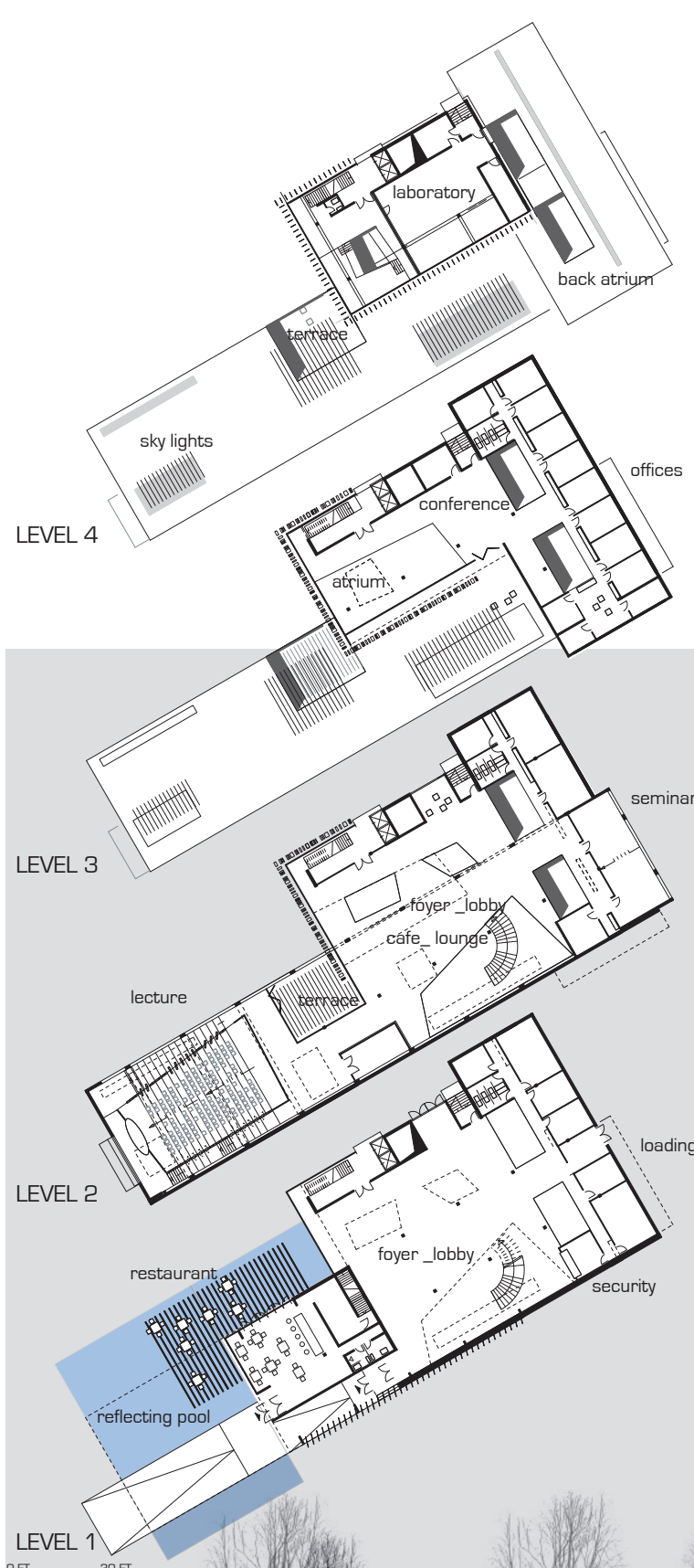
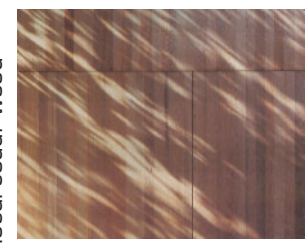
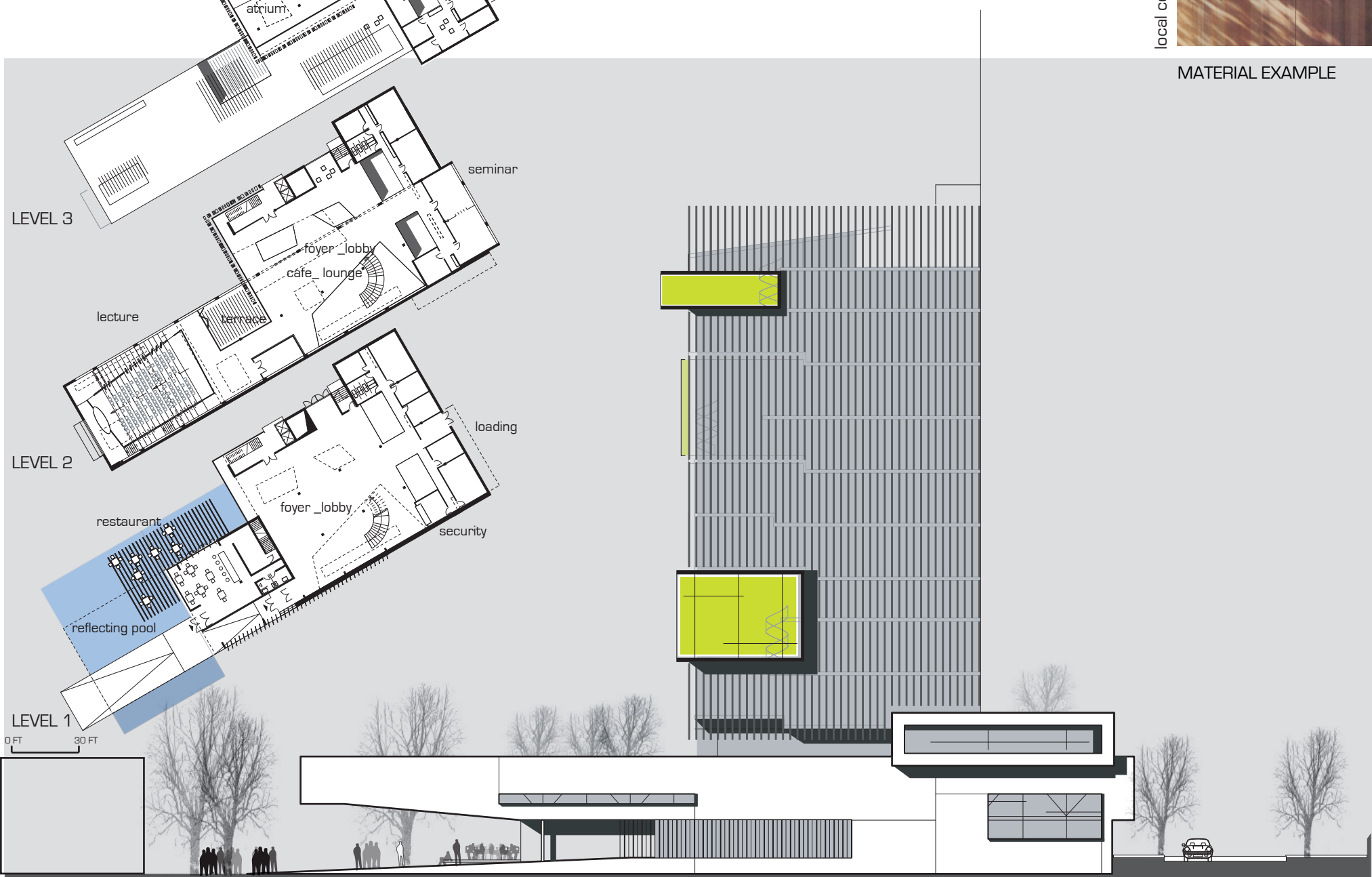


PHOTO CEDAR WOOD FACADE

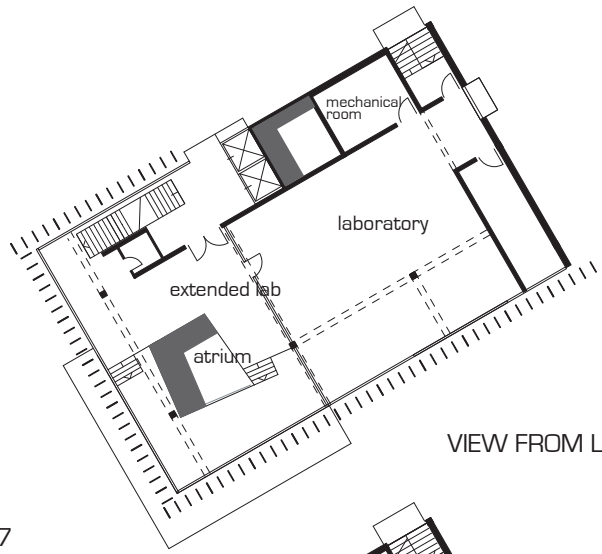


local cedar wood

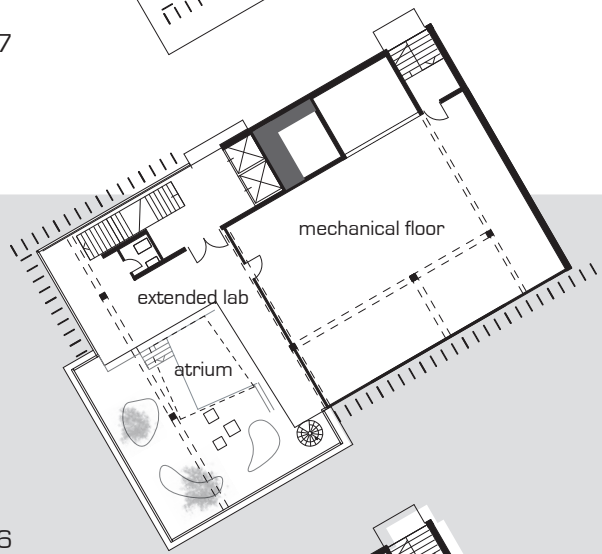
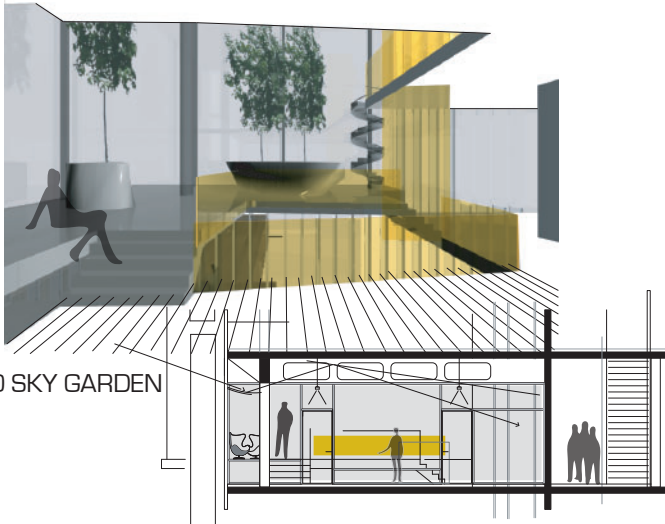
MATERIAL EXAMPLE



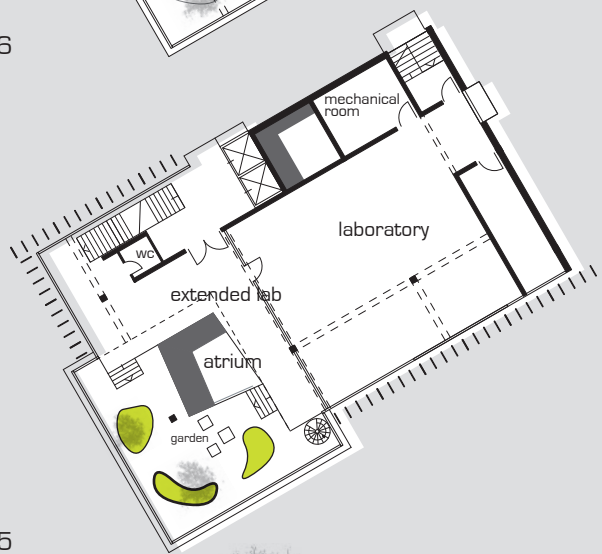
ELEVATION EAST



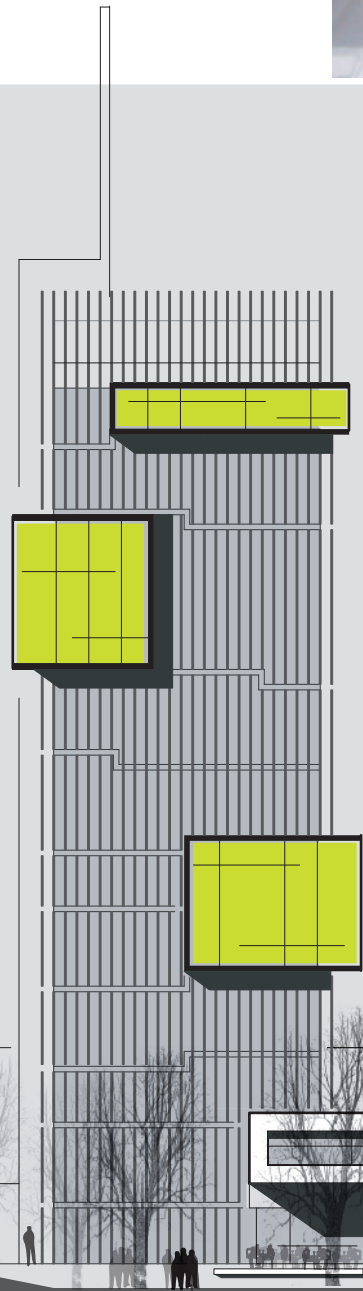
LEVEL 7



LEVEL 6

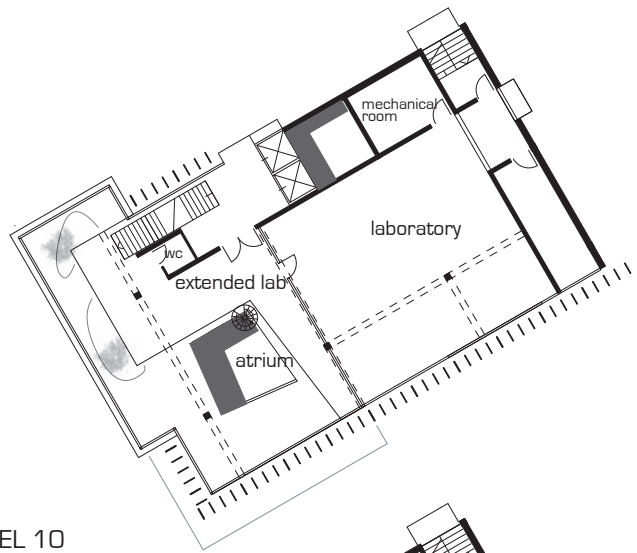


LEVEL 5



0 FT 15 FT

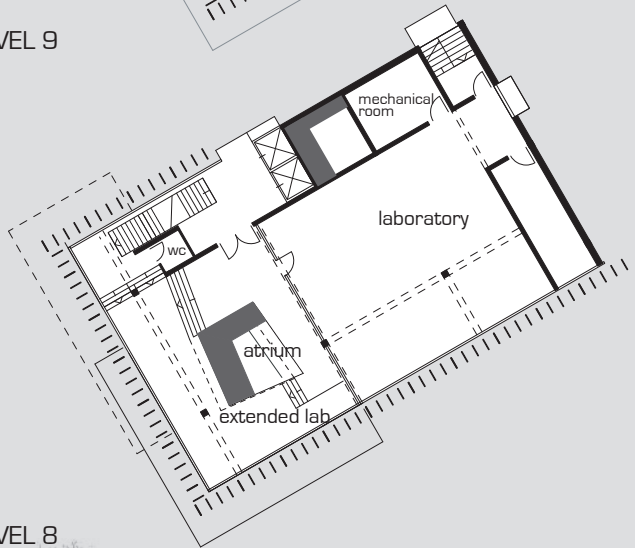
ELEVATION SOUTH



LEVEL 10

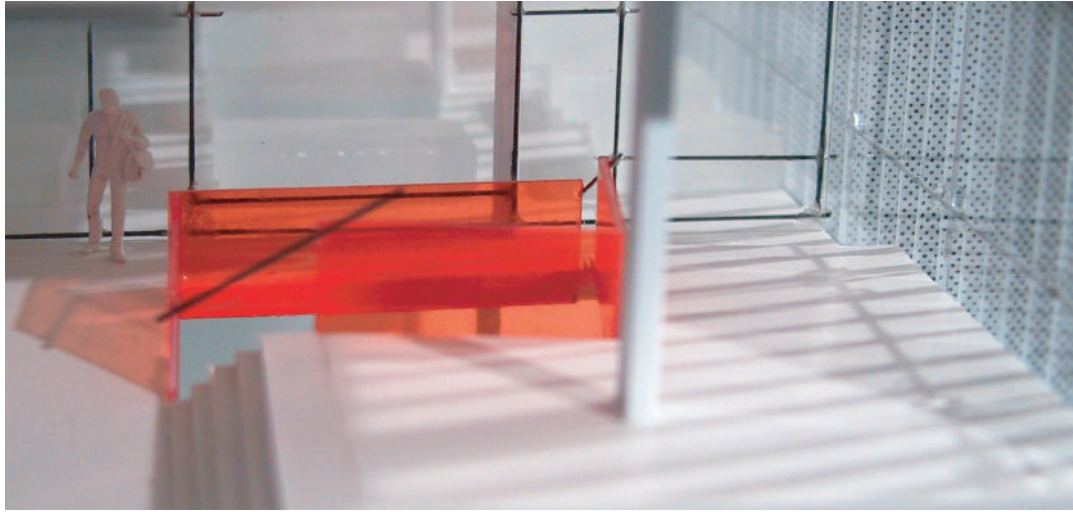


LEVEL 9

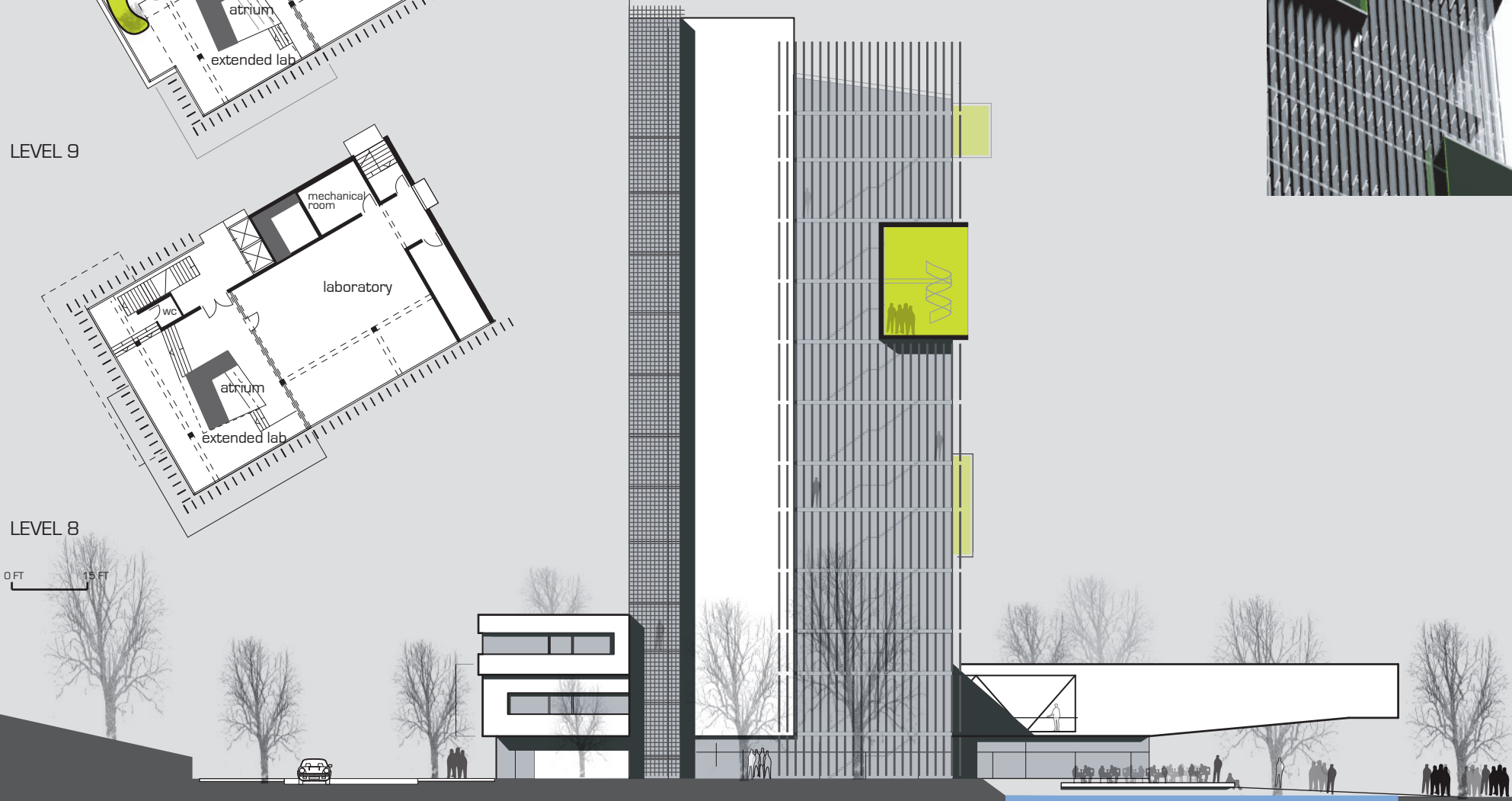
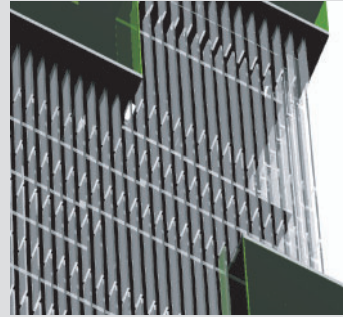


LEVEL 8

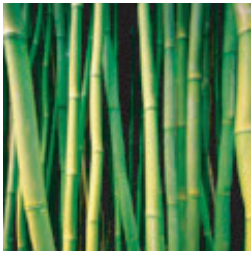
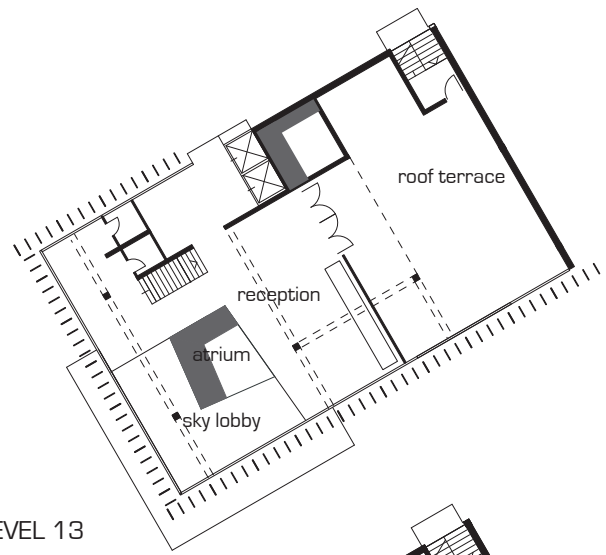
0 FT 15 FT



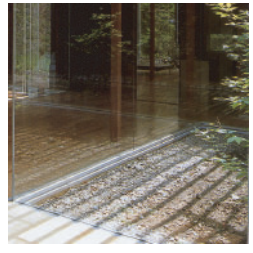
LOOKING INTO EXTENDED LABORATORY



ELEVATION SOUTH

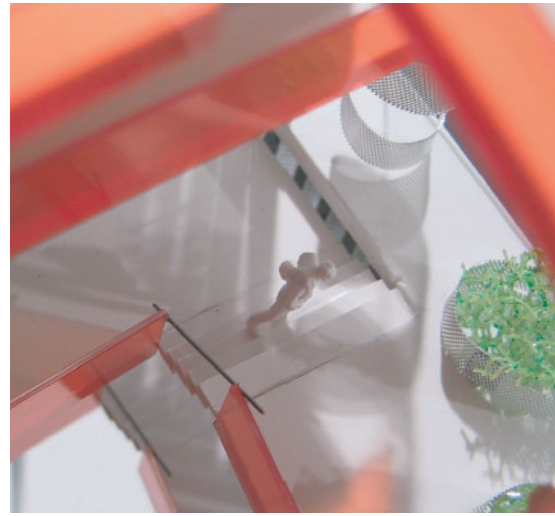


bamboo garden

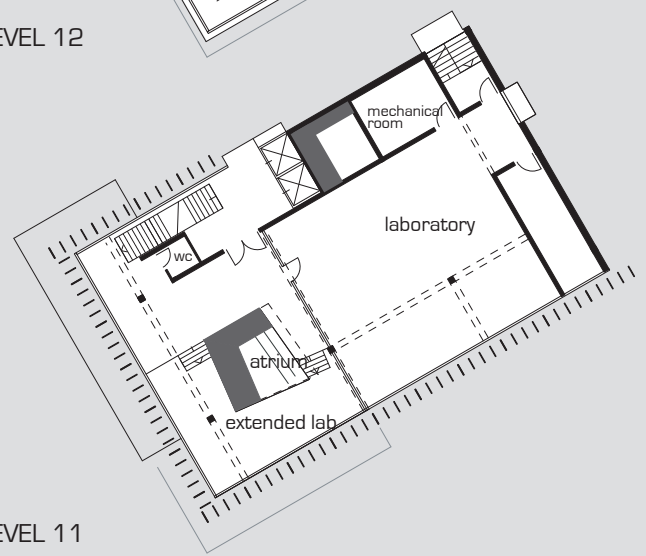
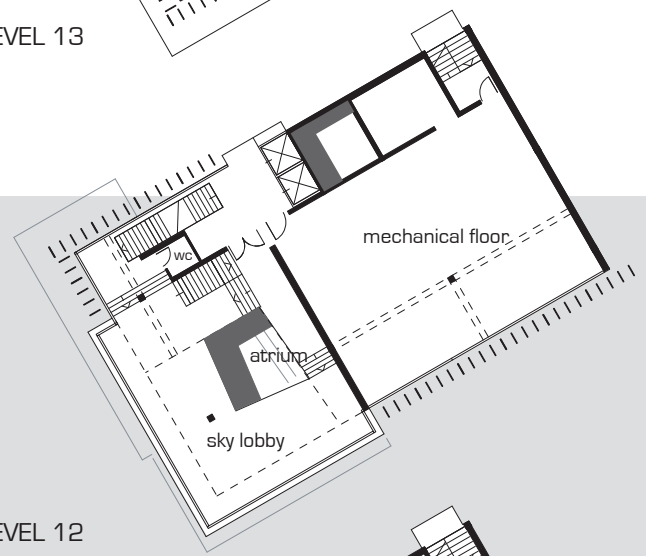


gravel garden

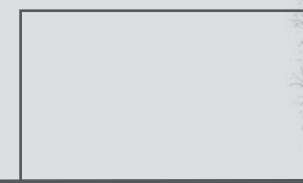
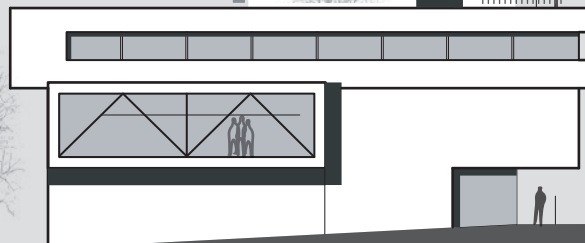
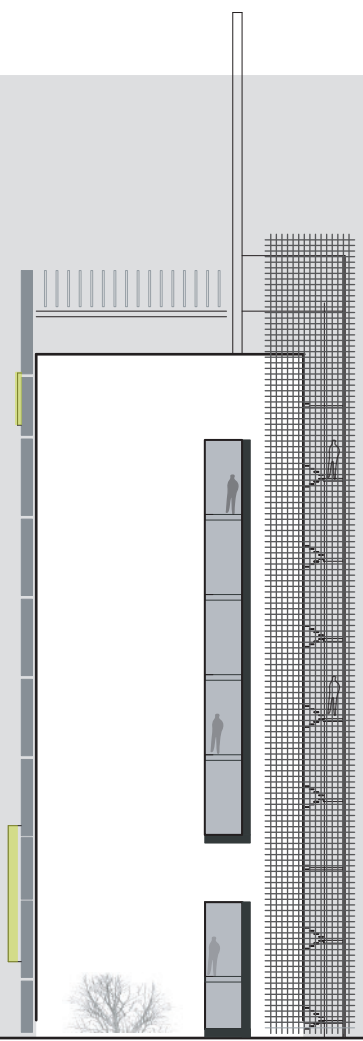
MATERIAL EXAMPLES GARDEN



LOOKING DOWN INTO ATRIUM



LOOKING INTO EXTENDED LAB



ELEVATION SOUTH

CONCLUSION

The main goal of this design proposal is to achieve an atmosphere able to improve and enhance communication. To overcome the reservations between the public and science, the building blurs the boundaries, providing an excellent space for learning, exchanging ideas, and informal conversations between students and faculty. But it also allows the public to experience and interact with this academic institution. It combines its role as an open public space by means of environmental friendly design strategies.

Urban principles:

The building presents itself as a dense three-dimensional urban fabric. The urban design is guided by two principles: presence and integration. From a distance, the new laboratory is a vertical statement for Georgetown University and marks the east end of the campus. Looking closer, the vertical is set back from the street front, allowing the wooden horizontal gesture to mediate between the residential neighborhood and the new science building. The height of the horizontal is adjusted to the scale of the adjacent residential houses. Additionally, to increase spatial transparency of the residential neighborhood, the backyard is converted into an herbal garden. To stimulate the courtyard and enliven it, a public restaurant with café is located at the interface between laboratory entrance and courtyard. The aim is to provide a space for interaction between the public life and the science building.

Function:

The entire program is stacked and layered. The ground level addresses the street with its restaurant and the two story entrance lobby to the south east. The loading dock and services are located in the north. All other functions are stacked on top to enhance flexibility. The laboratories are consequently oriented to the north east to provide stable climatic conditions. There are service floors to provide space for mechanical rooms and systems between the laboratories. The vertical distribution is concentrated in one single vertical core. The horizontal distribution in the laboratories works without a suspended ceiling plane to maximize flexibility.

CONCLUSION CONTINUED

Structure and building materials:

The general structure of the laboratory is based on a regular 21 foot grid. This method of construction provides efficiency, a high grade of prefabrication, thereby reducing construction cost. It is executed in prefabricated concrete to utilize thermal mass advantages. The cantilever is supported by two trusses running the complete length of the building.

The main materials are cedar wood, glass and PV crystalline module panels. The tower's façade is double glazed for maximum insulation. The additional layer consists of PV glazing. These panels move with the sun to gain a maximum of solar energy but at the same time shading the inside. For this reason they cover the main energy needs of the building. In winter the outer façade layer is utilized, protecting against heat loss. In general materials of low embodied energy are used as well as semi finished products that are considered to have economic and ecological advantages.

To summarize the sustainable principles:

The building volume displays compactness. The floor plan layout and the organization of functions is driven by the sun to minimize solar gains in summer and maximize them in winter.

Passive and active solar energy is utilized. The glazed atrium and gardens serve as climate buffers. The controlled façade is the main energy source. Additionally, natural cross ventilation in the atrium improves human comfort and reduces the need for HVAC systems. A highly efficient and thermally insulated envelope lowers energy loss. The heating and cooling is accomplished by a ground channel that tempers air in winter and summer. Moreover, a low temperature heating system is applied. A benefit is to use the conditioned laboratory exhaust air for heat recovery to bring the air temperature in winter to a certain level without heating costs.

In conclusion, the new laboratory for Georgetown University is accommodated in a progressive building. The design embodies the efficient use of energy as a planning principle which is expressed in its appearance. Possibilities are offered for new forms of learning and the interaction between scientists and public. It enhances the university campus as a vibrant forum for integral communication.

" Always in motion is the future."
Yoda



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christian schittich "in detail. building skins. concepts,layers,materials"
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<http://www.squ1.com/>
cardiff university,welsh school of architecture

education

2002_2004	virginia polytechnic institute and state university blacksburg & alexandria, va	master of architecture'
1997_2002	university of applied sciences stuttgart,germany	german professional degree in architecture

professional experience

fall 2004 _	xten architecture los angeles,ca	architect
2002_2004	virginia polytechnic institute and state university blacksburg & alexandria, va	teaching assistant
2001_2002	kopf interior design stuttgart,germany	intern designer
summer 2001	nixdorf architekten stuttgart,germany	intern architect
spring 2001	arc - hitekten stuttgart,germany	intern architect
1999_2000	schlude & stroehle architekten stuttgart,germany	intern architect
1994_1997	schreinerei pfefferle tamm,germany	cabinet maker apprentice

awards

2002_ present	fulbright scholarship _ graduate studies in the usa
2005	exhibited on the aia 2005 convention in las vegas and the acsa annual meeting in chicago
fall 2004	project presentation at the 2004 labs 21 conference inst.louis,mo
fall 2004	exhibited on the 40th anniversary exhibition of virginia tech's school of architecture
summer 2004	1 st prize_ acsa,doe' sustainable laboratories for the 21 st century student design competition'
winter 2003	publication_ v ² , arrivare/luce a venezia, projekte des si, universitaet stuttgart
spring 2003	honorable mention _aia virginia society competition