Zero Build Forum’20

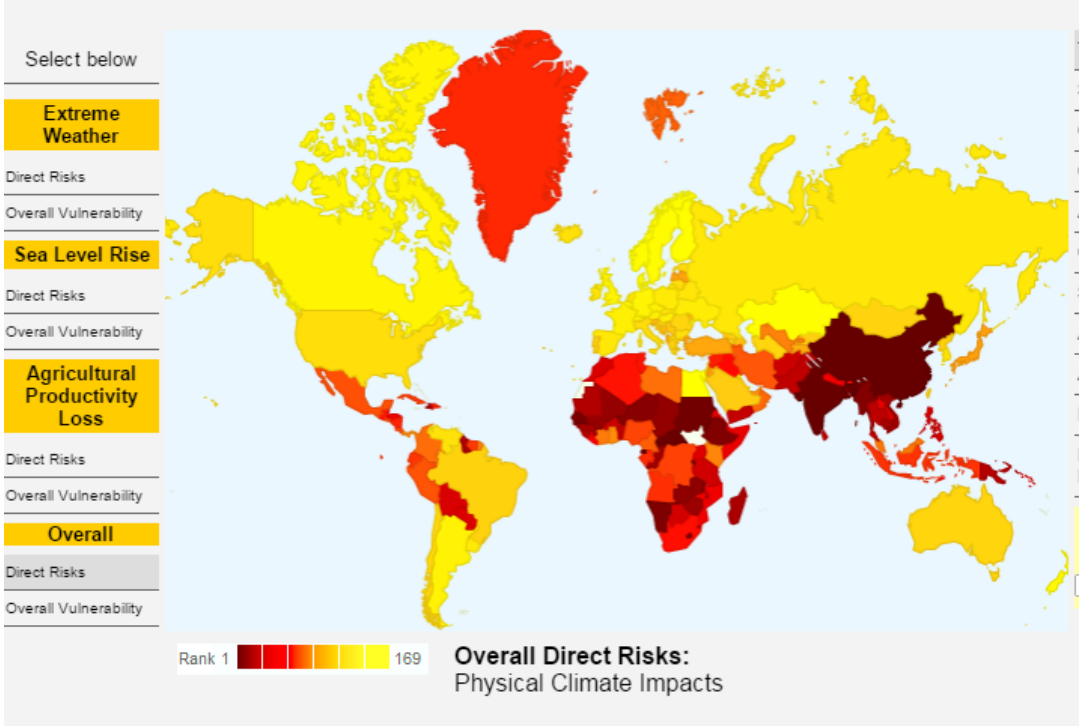
International Virtual Forum on Zero Energy Buildings

BIM-Enabled Performative Design Education for Achieving Sustainable and High-Performance Buildings

Speaker’s Name: Prof. Salih Ofluoglu

Speaker’s Position & Institution: Head, Department of Informatics, Mimar Sinan Fine Arts University

Climate Change



Effects of Climate Change
(Source: Center for Global Development)

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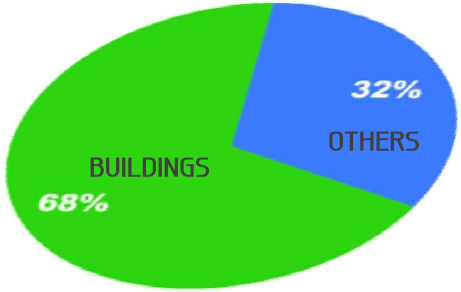
Effects of Buildings on Climate Change

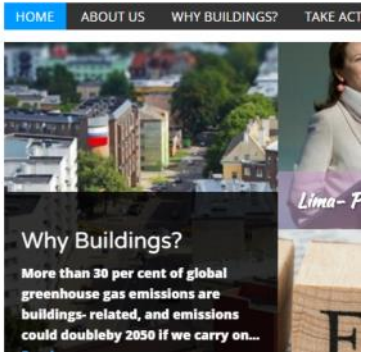
- High (**fossil-based**) **energy** consumption
- High **carbon emission**
- **There is an increasing need for sustainable building solutions**

Country	Buildings	Industry	Transportation	Others
USA 2004	39	33	28	---
EU 2006	39	28	30	3
Turkey 2008	36	32	20	12

Energy Consumption by sectors
(Source: İzoder ısı yalıtım report, 2010)



Global CO^2 emission
(Source: International Energy Agency, EIA)



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Energy Efficient/Sustainable Buildings Initiatives

- **EU: 2050 Energy Strategy** %80-95 reduction in carbon emission
- **USA: Architecture 2030 Initiative**: carbon neutral building
- **Green Building Certitification programs**
- **Turkey:**
  - **Energy Performance Legislation,**
  - **Mandatory Energy ID Document** and the **BEP-TR** software

Architecture 2030 initiative

Green Bulding Certification Programs

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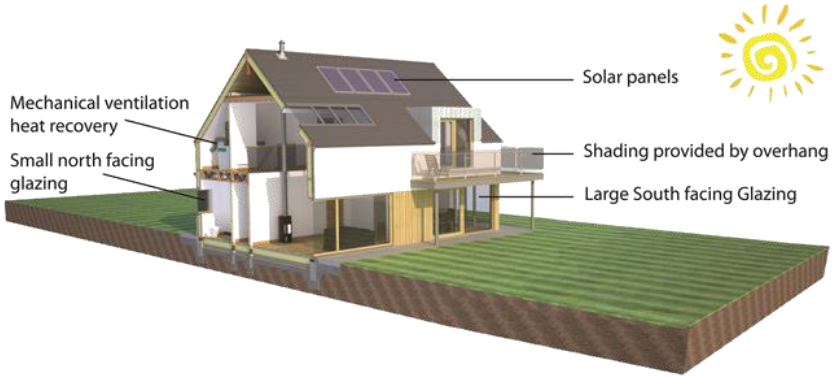
Where to start?

- **Design** (especially early design) is the critical project phase when most **sustainability** related decisions are made
- **Good Design** achieves:
  - Good building performance
  - High occupants' comfort
  - Low operational cost
- **Sustainability strategies** applied by architects are **intuitional and based on general knowledge and precedents** and the effects of site/project type specific situations are often ignored.



1. **Occupants' comfort**
   - Thermal comfort
   - Visual comfort
   - Air quality

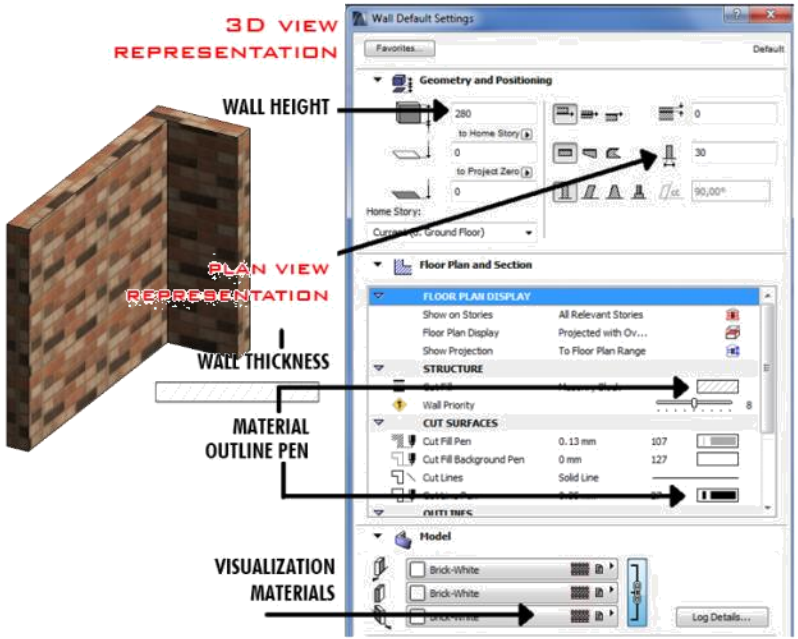
2. **Resource uses**
   - Material use
   - Energy systems
   - Water use

← personal happiness and productivity →

← natural, supported by mechanical →

Building Information Modeling (BIM)

BIM is a project production method that relies on a **3D model** by **integrating** both **graphic** (geometry/form etc.) and **alpha-numerical** (material, cost, building physics, etc.) data



graphical data

Data	
DangerousSubstances	NPD
DryBrickWeight	2.3 kg
InitialRateOfWaterAbsorption	0.90 kg/m²/min
ManufacturingPlantName	Throckley, Tyne & Wear
PackQuantity	500
Appearance	Red multi, sandfaced perforated
BondStrength	0.15
GrossDryDensity	1610 kg/m³
MeanCompressiveStrength	>=60 N/mm²
NetDryDensity	2190
RecycledContent	n/a
ThermalConductivity	1.12 W/mK
ThermalResistance	0.09
WaterAbsorption	<=10
WaterVapourPermeability	50/100
Other	
NominalHeight	65.0
NominalLength	215.0
NominalWidth	102.0
Size	215 x 102 x 65 mm
SustainabilityPerformance	ISO 14001, BES 6001
ExpectedLife	60 years minimum

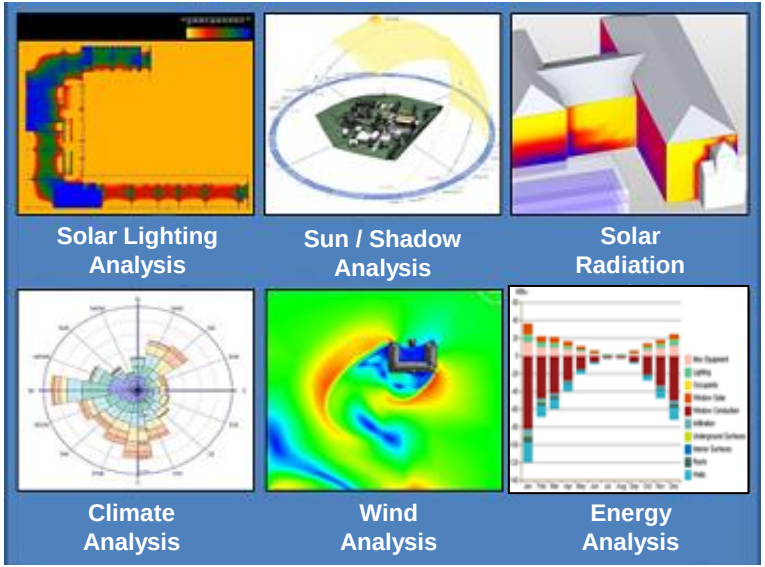
non-graphical data

building physics related alphanumerical data such as
thermal conductivity, fire resistance acoustical properties, cost, etc.

Building Information Modeling (BIM) → BPA

BIM Model = Virtual Physical Building

- **Building Performance Analysis (BPA) models** can be produced from a BIM model.
- They predict how a building responds to **environmental factors.**
- **Design decisions** can be tested and improved **in a real time.**



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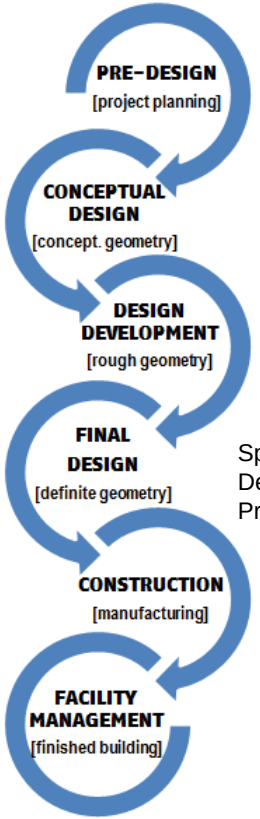
Performative Building Design

The design approach that takes building performance from early to late phases of design can be called **Performative Design.**

Basic principles:

1. Relies on **sustainability criteria** comsumption of energy and raw materials, selection of materials, waste reduction, passive climatization
2. Works with **measurable alphanumerical data**
3. Allows **real time / spiral design iterations** for design revisions



Spiral Design Process

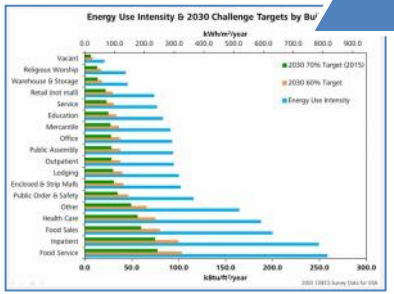
Sustainable/Performative Architectural Design Course Workflow

- **A postgraduate elective course**

  A high performance building design with performance analysis

  - Selecting a Building type/project site
  - Designing a form/ building shell
- **Weekly sustainability analysis exercises**
- **Final project submission**
- **Digital Tools:**

  Modeling: Revit/Formit
  Analysis: Green Building Studio, Trimble Sefairai,Insight 360, Flow Design



Energy Use by Building Type and Architecture 2030 Initiative

EPA United States Environmental Protection Agency

AUTODESK BUILDING PERFORMANCE ANALYSIS CERTIFICATE
AUTODESK

Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (kBtu/ft²)	Site EUI (kBtu/ft²)	Reference Data Source - Peer Group Comparison
Banking/Financial Services	Bank Branch *		252.8	87.0	CBECS - Bank/Financial
	Financial Office*		148.1	67.3	CBECS - Office & Bank/Financial
Education	Adult Education		141.4	59.6	CBECS - Education
	College/University		262.6	130.7	CBECS - College/University
	K-12 School*		141.4	58.2	CBECS - Elementary/Middle & High School
	Pre-school/Daycare		145.7	70.9	CBECS - Preschool
	Vocational School		141.4	59.6	CBECS - Education
	Other - Education				
Entertainment/Public Assembly	Convention Center		69.8	45.3	CBECS - Social/Meeting
	Movie Theater		85.1	45.3	CBECS - Public Assembly
	Museum				
	Performing Arts				
	Recreation	Bowling Alley	96.8	41.2	CBECS - Recreation
		Fitness Center/Health Club/Gym			
		Ice/Curling Rink			
		Roller Rink			
		Swimming Pool			
		Other - Recreation			
	Social/Meeting Hall		69.8	45.3	CBECS - Social/Meeting

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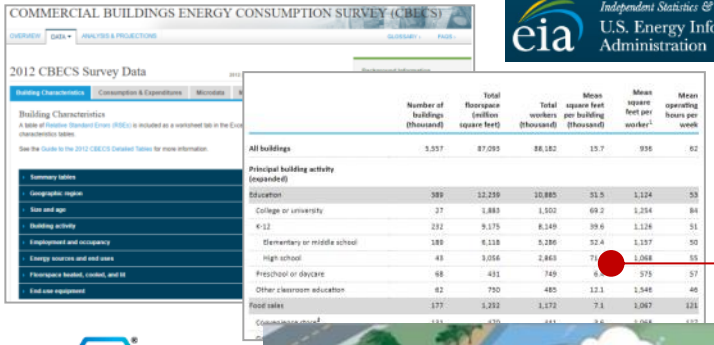
BPA data for Conceptual Designs

Conceptual Design Phase:

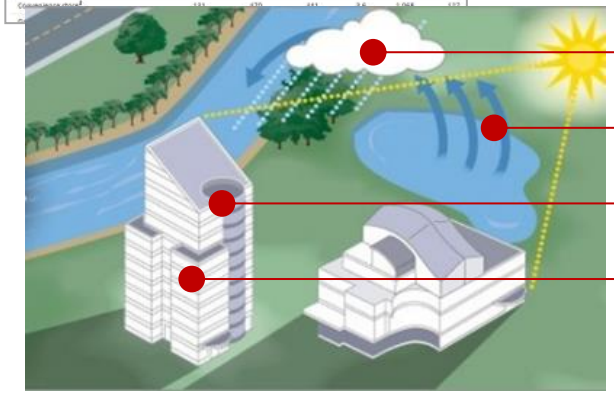
The earliest design phase when the **basic building mass and its location** is defined. **All higher level design decisions** that shapes the following design phases are made at this phase.



eia Independent Statistics & Analysis U.S. Energy Information Administration

ASHRAE

American Society of Heating, refrigerating and Air Conditioning Engineers



BPA DATA FOR CONCEPTUAL DESIGN

Building type related operational, comfort data and standards

Local **climate data**

Site topography surrounding buildings

Building **geometry**

Facade elements: **Wall-window ratio**

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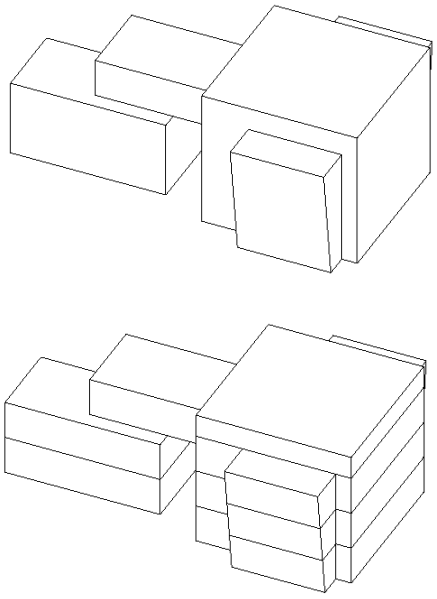
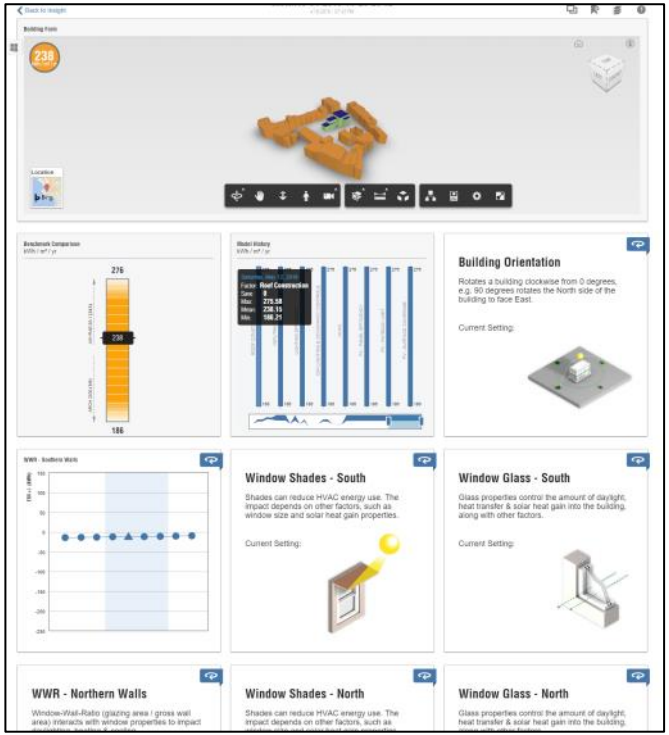
Mass Modeling

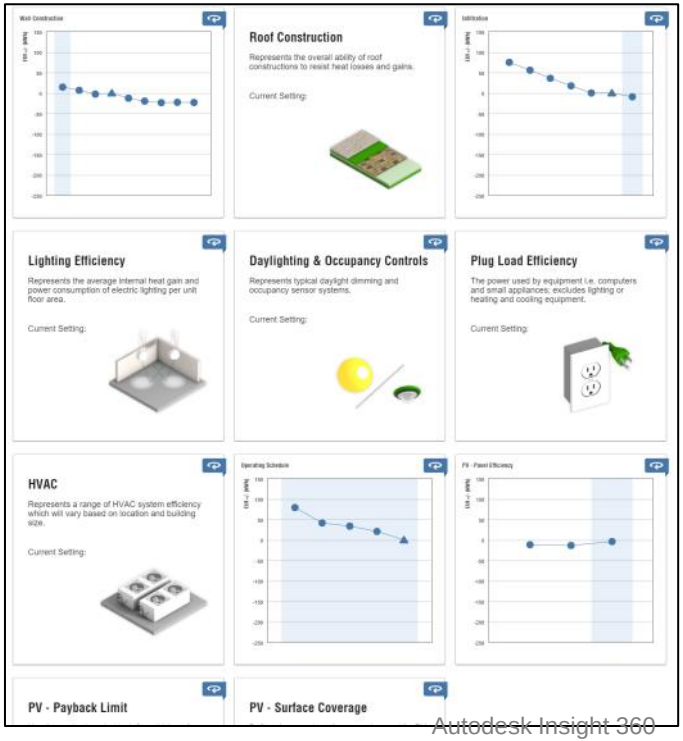


The **least detailed** (LOD100) modeling type for creating **conceptual volumes** with surfaces (**surface modeling**)

Typical BPA Scenarios

1. BIM Model Output
2. Passive Systems
3. Passive + Active Systems
4. Passive + Active Systems + PV Panel



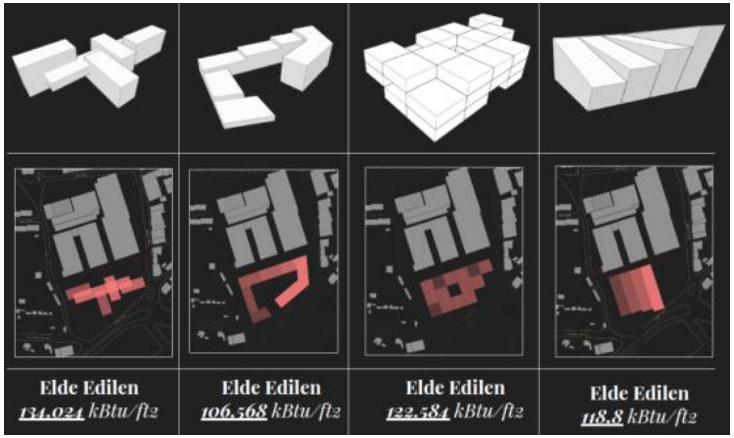


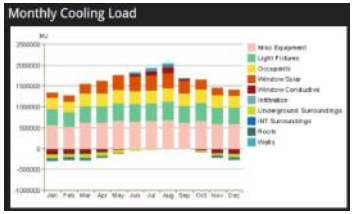
Autodesk Insight 360

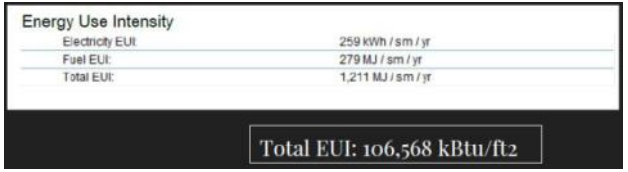
BPA → Building Energy Analysis

- **The flow of heat** in a building, basic information about **heat transfer**, **thermal qualities** (U and R values) in materials

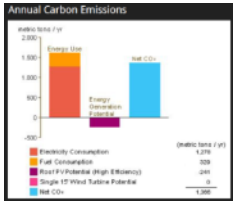
- Factors that affect building **heating/cooling** needs: **External loads** (sun, airflow, humidity) **Internal loads** (occupants, equipments, lighting)







Energy Analysis Work
by S. Cengiz



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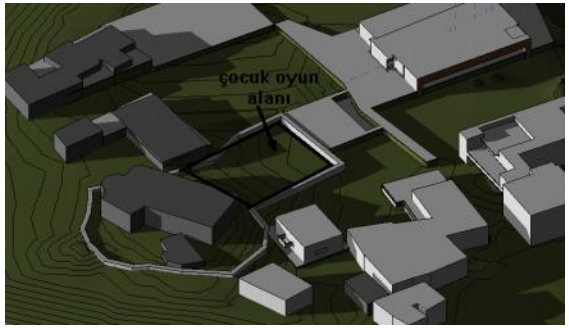
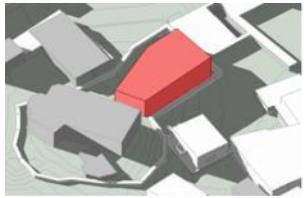
BPA → Sun and Shadow studies

- Relation of **building mass** and its **site position** to solar access
- **The Sun's position at extreme times of the year:**
  - Sun altitude and azimuth
  - Equinox (21 March, 23 Sept.)
  - Solstice (21 June, 21 Dec.)
- **Shadow** casted by **Building itself** and Shadow casted by **sorrounding buildings**,



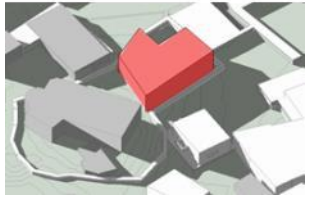
Allocating outside spaces and making landscape decisions acording to sun/shadow movements

Examining sun/shadow effects on different design alternatives on the model



21 March – 21 Sept. (15:00) Equinox

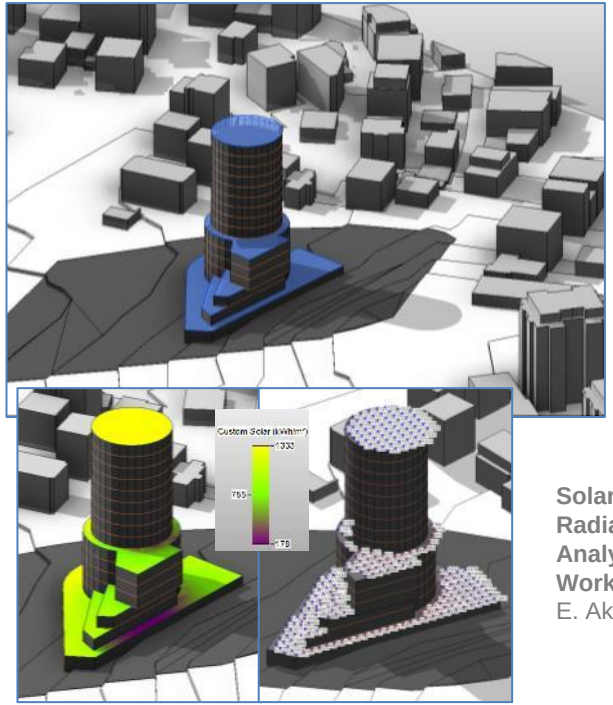
21 June(15:00) Summer Solstice



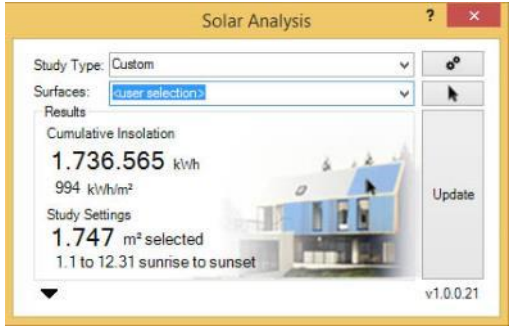
21 December (15:00) Winter Solstice

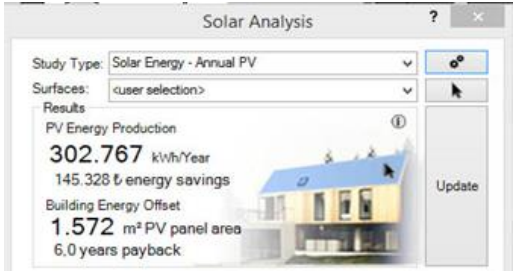
BPA → Sun Radiation Analysis

- Using solar radiation as a **source of energy** and utilisation of **PhotoVoltaics** (PVs)
- The effects of **solar radiation on energy loads** (heating/cooling) and **sunshade design** (placing and sizing sunshades and sunshelves and their types)
- **Strategies allowing and preventing solar radiation** (massing, color, material selection, positioning)



Colored/Numeric representation of solar radiation

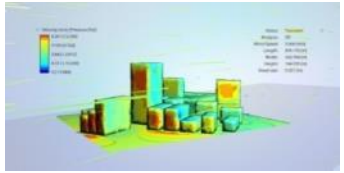




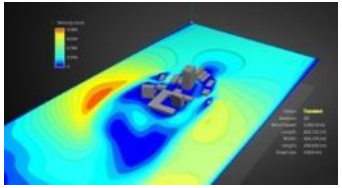
Solar Radiation Analysis Work
E. Akdeniz

BPA → Wind Analysis

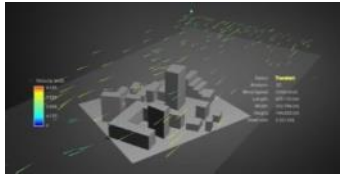
- **Simulating existing air currents** around the building and understanding **natural ventilation** solutions
- **Preventing** the **unwanted air currents** for surrounding buildings and pedestrians



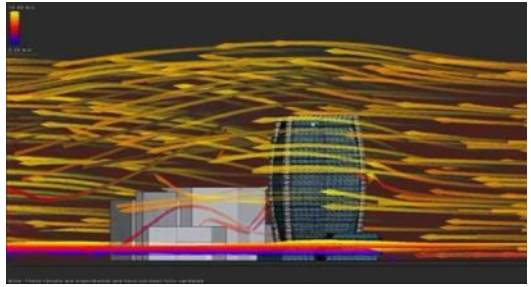
Wind Tunnel 3D Pressure Factor simulation



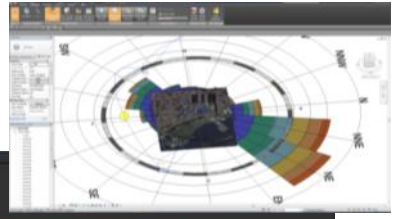
Wind Tunnel 2D Plan Shade simulation

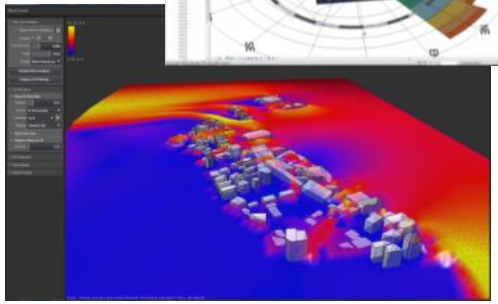


Wind Tunnel 2d Flow lines simulation



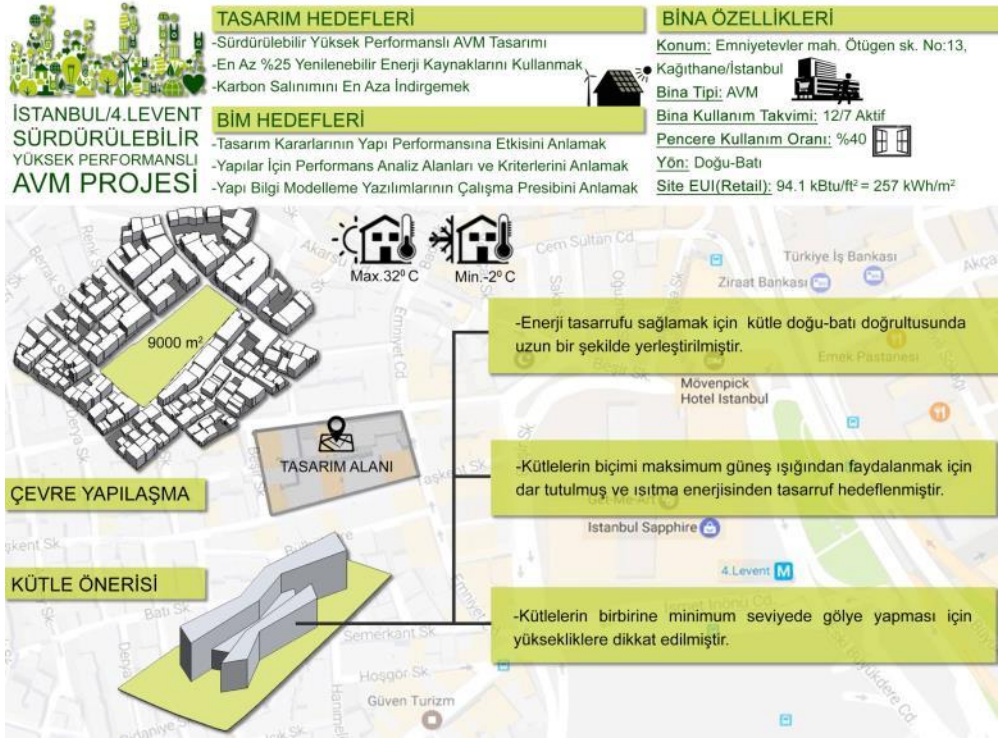
Wind Analysis Work, by F. D. Çapkın





Wind Analysis Work by S. Tarakcı, H. Bilgin, B. Cantürk

Selected Student Works



Site Analysis and Design Objectives

EUI Benchmark: 94,1 kBtu/ft2 - 257 kwh/m2

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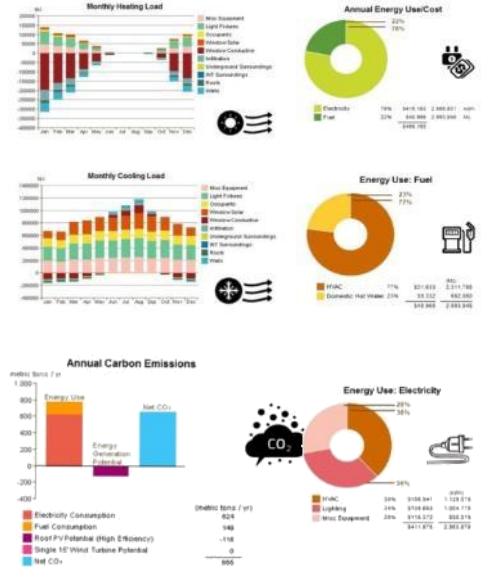
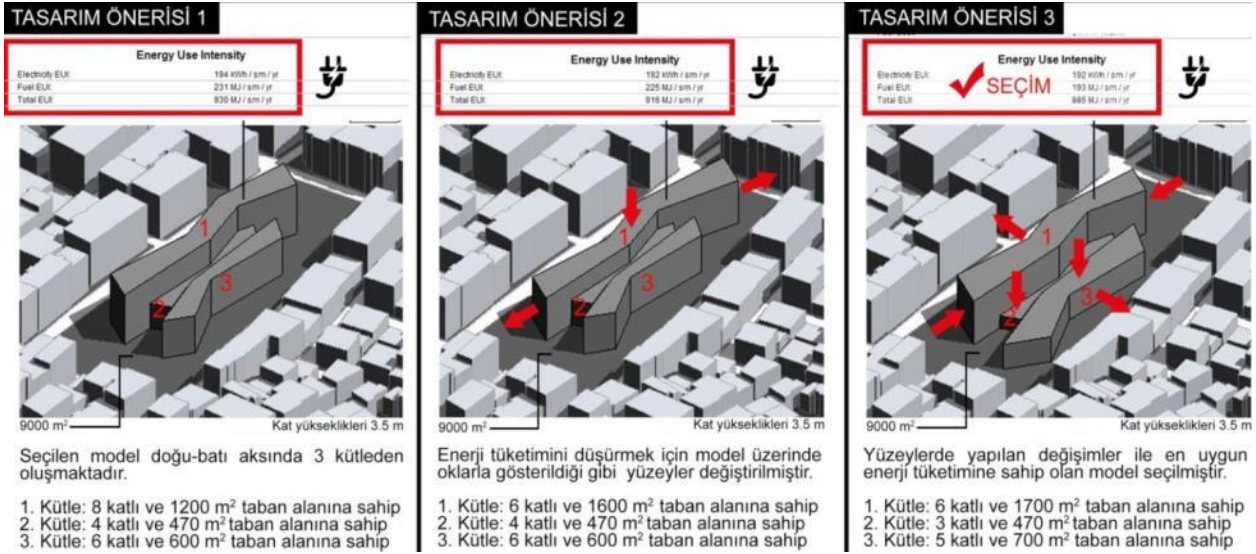
Selected Student Works



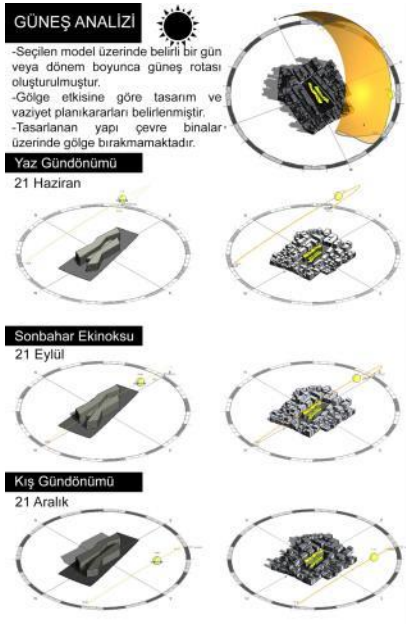


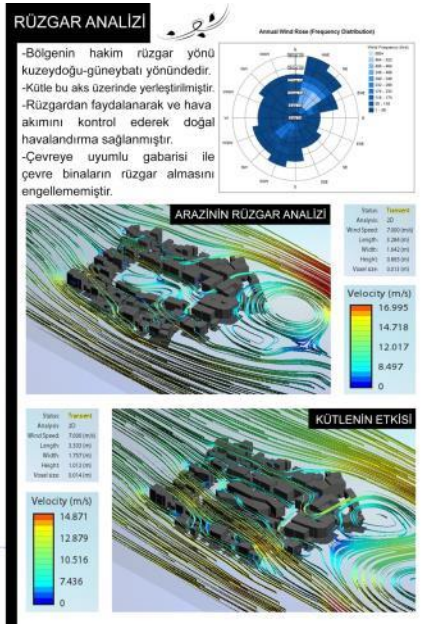
Energy Analysis for Design Alternatives

Selected Student Works

HIGH PERFORMANCE
SHOPPING CENTER DESIGN
by T. Bacaksız

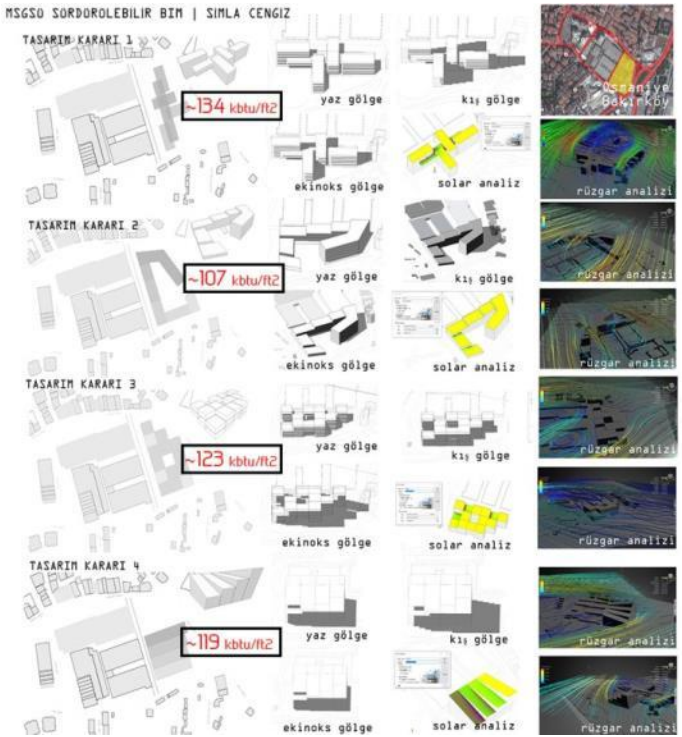
ZERO BUILD FORUM '20

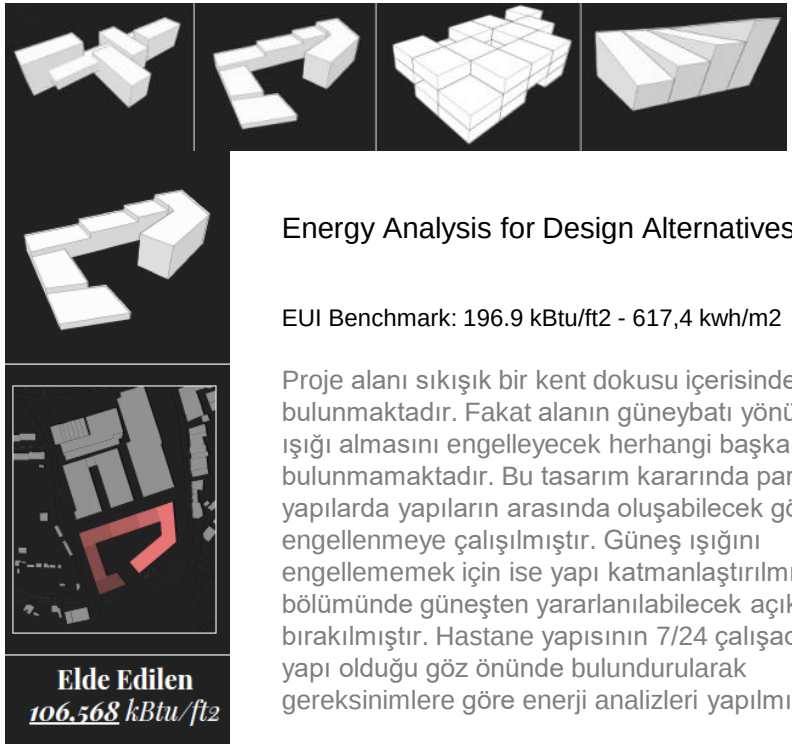




Solar radiation and Wind Analyses for the Selected Design

Selected Student Works



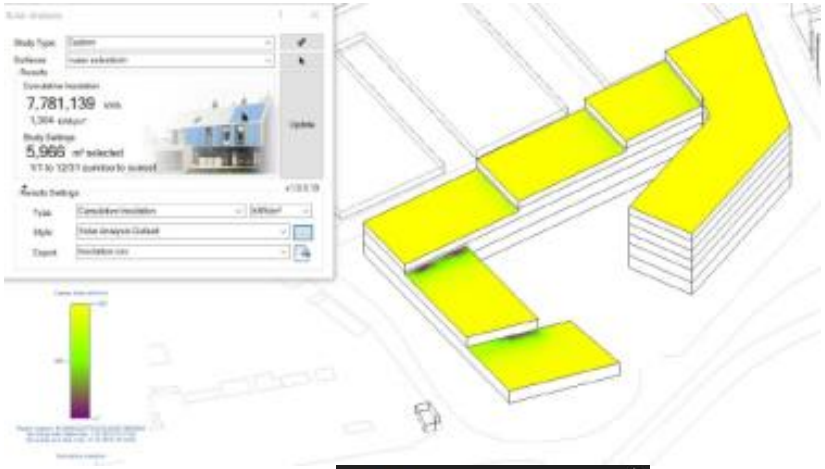


Energy Analysis for Design Alternatives

EUI Benchmark: 196.9 kBtu/ft2 - 617,4 kwh/m2

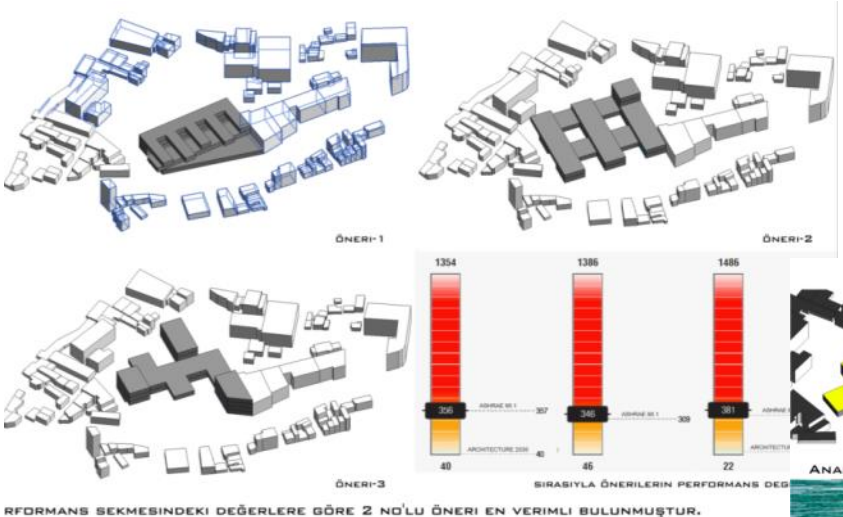
Proje alanı sıkışık bir kent dokusu içerisinde bulunmaktadır. Fakat alanın güneybatı yönünde gün ışığı almasını engelleyecek herhangi başka bir yapı bulunmamaktadır. Bu tasarım kararında parçalı yapılarda yapıların arasında oluşabilecek gölgeler engellenmeye çalışılmıştır. Güneş ışığını engellememek için ise yapı katmanlaştırılmıştır. Giriş bölümünde güneşten yararlanılabilecek açık alan bırakılmıştır. Hastane yapısının 7/24 çalışacak bir yapı olduğu göz önünde bulundurularak gereksinimlere göre enerji analizleri yapılmıştır .

Selected Student Works



Solar Radiation Analysis for
the Selected Design

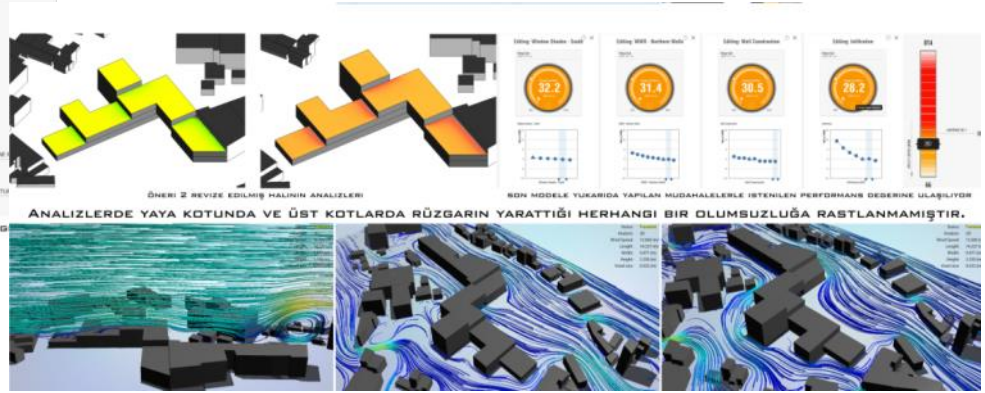
Selected Student Works



Energy Analyses for Design Alternativesc

EUI Benchmark: 85.1 kBtu/ft2 - 268 kwh/m2

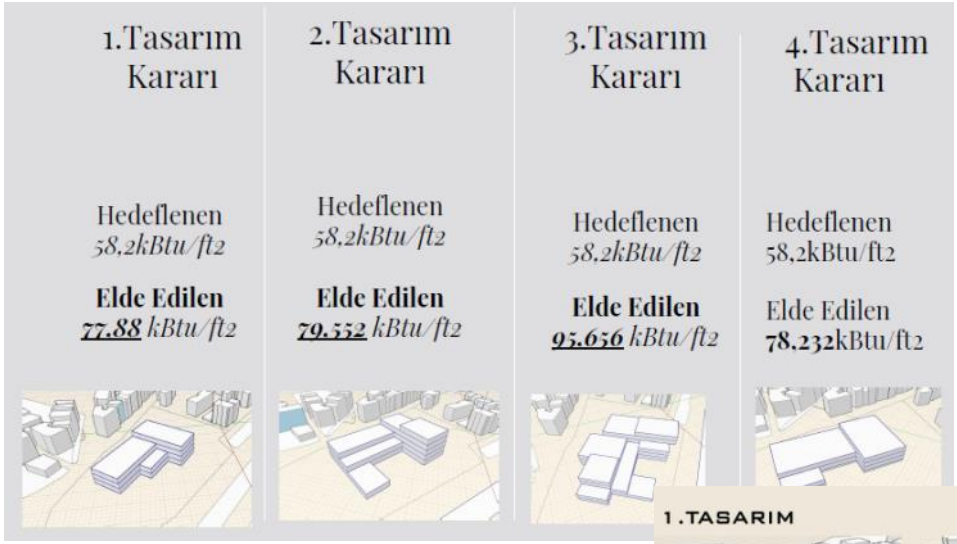
Üç öneride de yapı kütleleri mimari kaygılarla parçalanarak hafifletilmeye çalışılmış, zemin kat kuzey cepheleri kuzey güney aksını, sergi alanlarının ışık alması kaygısıyla üst kattaki kütleler de kuzeydoğu aksını karşılayacak şekilde yerleştirilmiştir.



Wind and Solar Analyses for the selected Design

Presentation Title: Prof. Salih Ofluoglu
Speaker's Name & Institution: Head, Department of Informatics, Mimar Sinan Fine Arts University

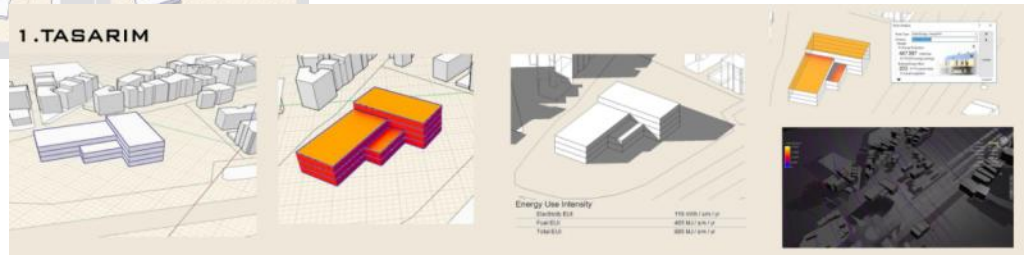
Selected Student Works



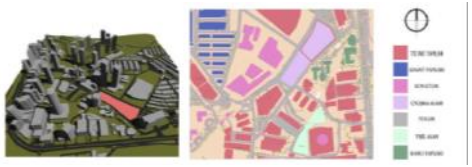
EUI Benchmark: 58.2 kBtu/ft2 - 183,33 kwh/m2

Güneş enerjisinden maksimum derecede yararlanabilmek için yapı güney-batı ve kuzey-doğu yönünde konumlandırılmıştır. Parçalı oluşan yapıda, yapının her alanında maksimum güneş enerjisinden yararlanabilmek için kat sayıları farklı tutulmuştur. Böylece yapı içerisinde oluşabilecek gölgeler en aza indirgenmeye çalışılmıştır.

Energy Analyses for Design Alternatives

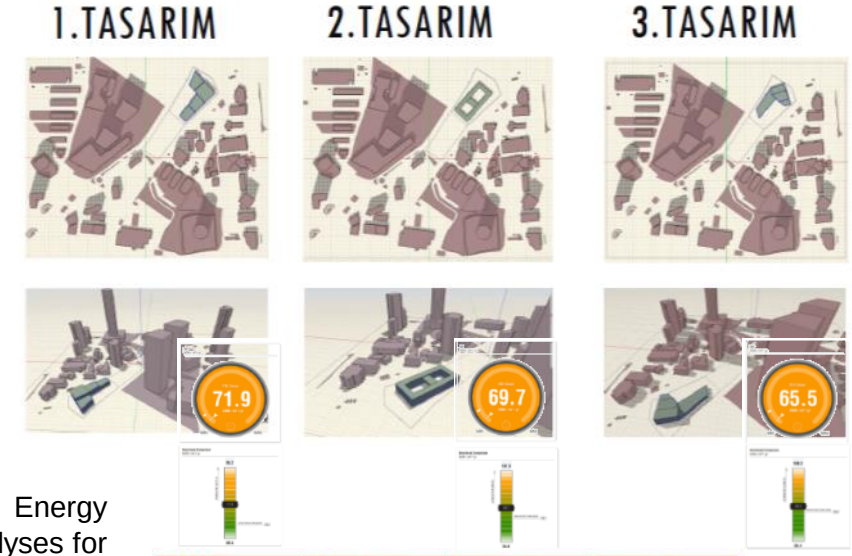


Selected Student Works



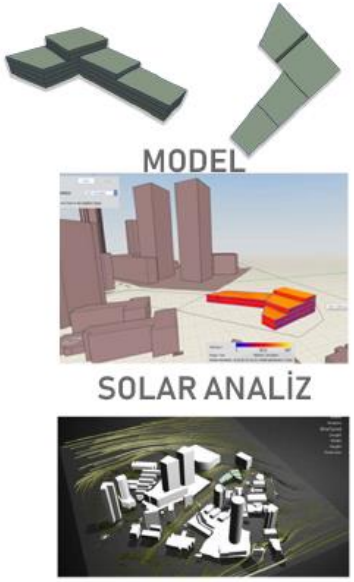
EUI Benchmark:
26,9 kBtu/ft2 - 85 kwh/m2

Çevre yapılar göz önünde bulunduğunda, yakın çevrede cephelerde çok sayıda yüksek katlı olması nedeniyle kat sayısının az tutulup yayılan bir plan örgüsü izlenmesi tercih edilmiştir. Çevredeki yoğun sanayi bölgesinden dolayı ise yapılan 3 alternatiftede de avlular yaratılmıştır. Bir iş merkezi olacak olan yapını Kütlelerin güneşten maksimum enerji tasarrufu yapabilmesi adına konumlandırılmıştır.



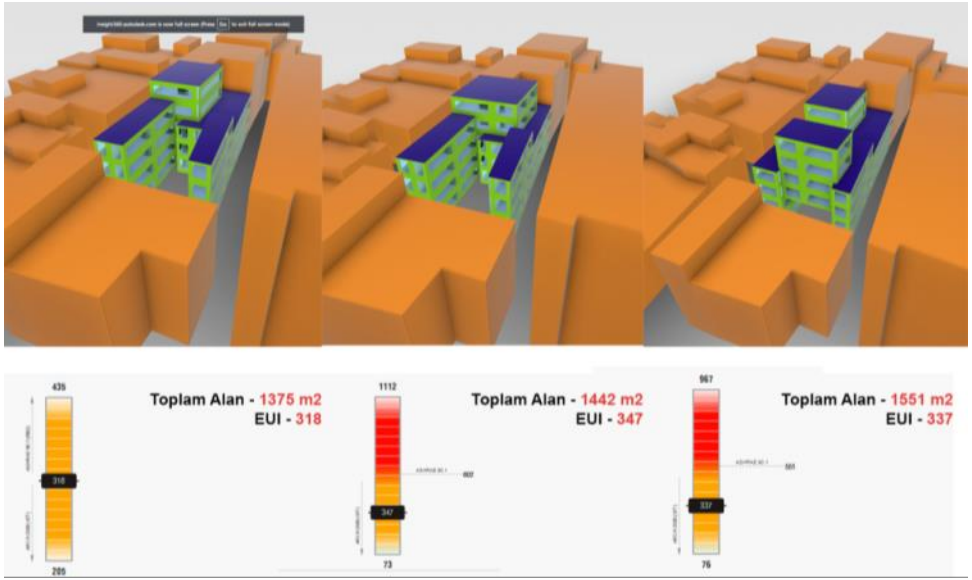
Energy Analyses for Design Alternatives

TASARIM	İLK EUI DEĞERİ	İLK DEĞER	SON DEĞER
1.TASARIM	632 MJ / sm / yr	170 kWh/m²/yr	71,9 kWh/m²/yr
2.TASARIM	719 MJ / sm / yr	186 kWh/m²/yr	69,7 kWh/m²/yr
3.TASARIM	677 MJ / sm / yr	182 kWh/m²/yr	65,5 kWh/m²/yr

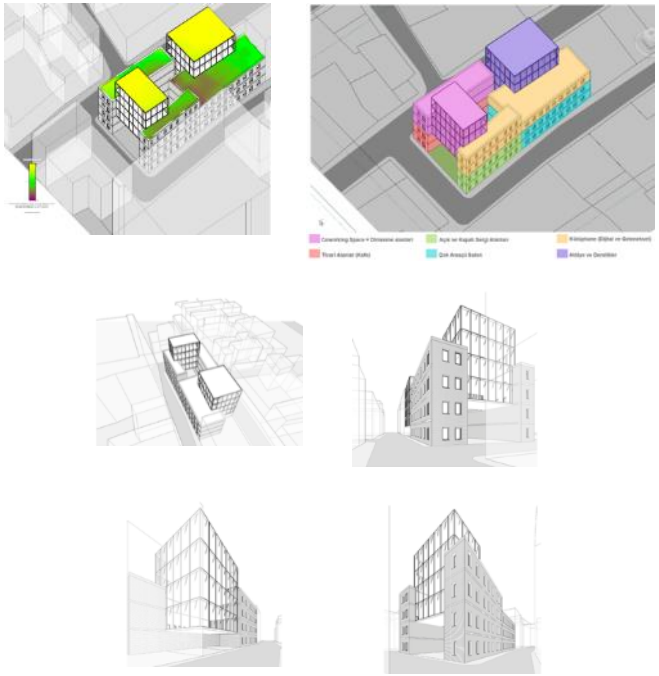


Solar and Wind Analyses for the Selected Design

Selected Student Works



Energy Analyses for Design Alternatives
and Space Allocations



Final Words

By simulating **real world conditions** in the Performative Design framework, students made

“informed design decisions”

with **measurable data** and **instant feedback** and gained valuable insights regarding sustainable architectural design.

Thank you

Questions and Comments

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