

XI. ULUSAL AYDINLATMA SEMPOZYUMU
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2023



DİNAMİK CAM UYGULAMASININ GÜNIŞİĞİ VERİMİNE ETKİSİ:

İZMİR YÜKSEK TEKNOLOJİ ENSTİTÜSÜ'NDEKİ BİR DERSLİK ÜZERİNDE SİMÜLASYON ÇALIŞMASI

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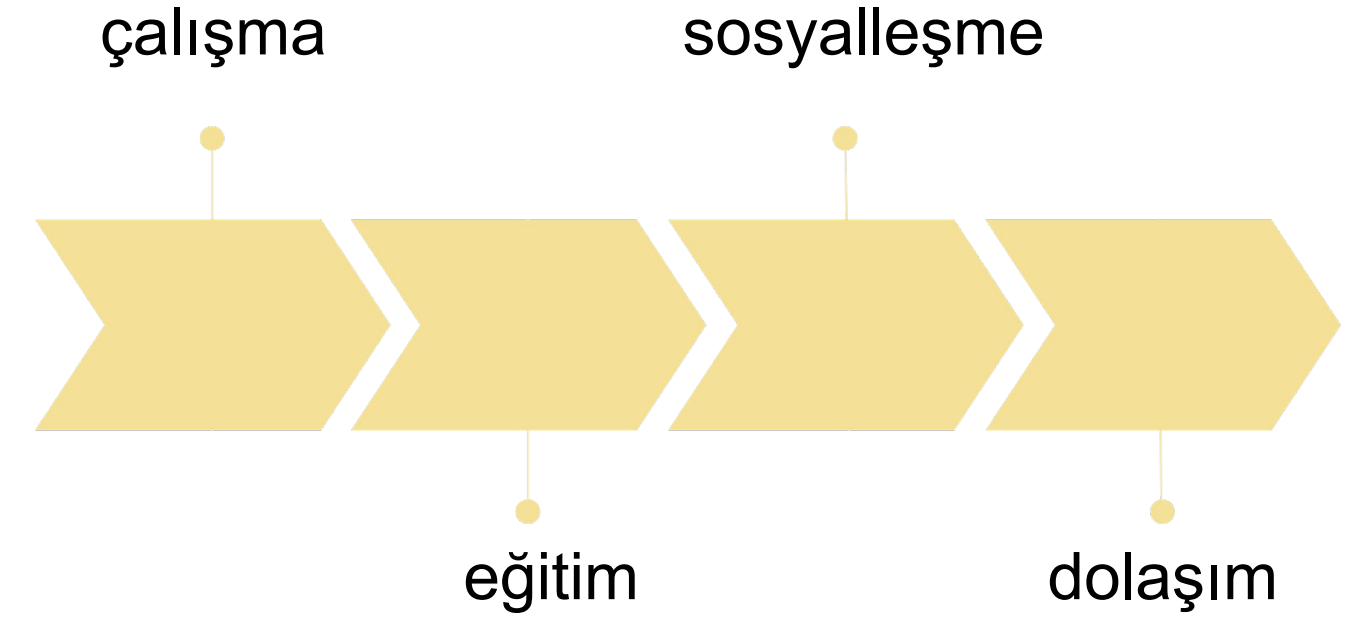
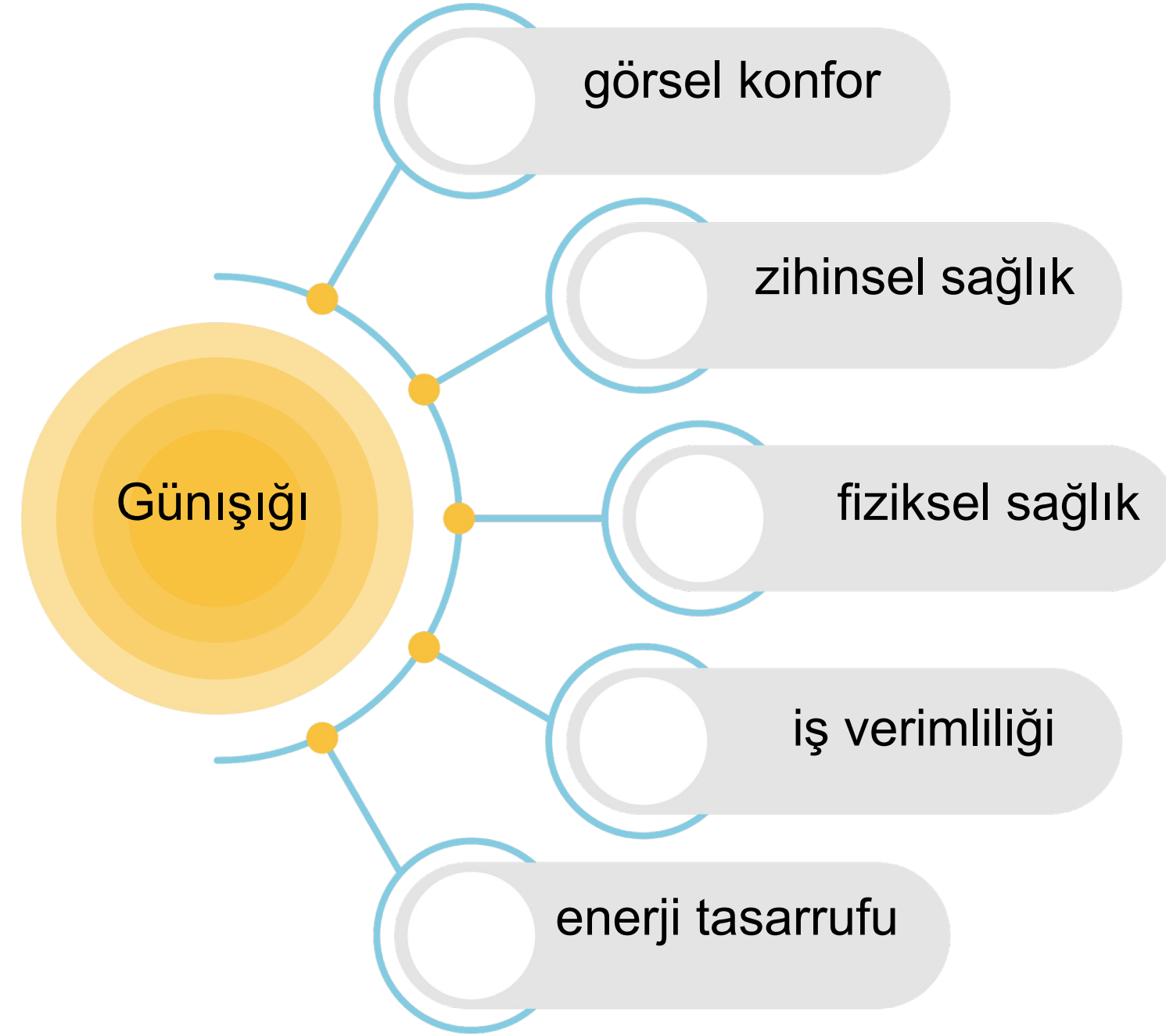
Kaynakça



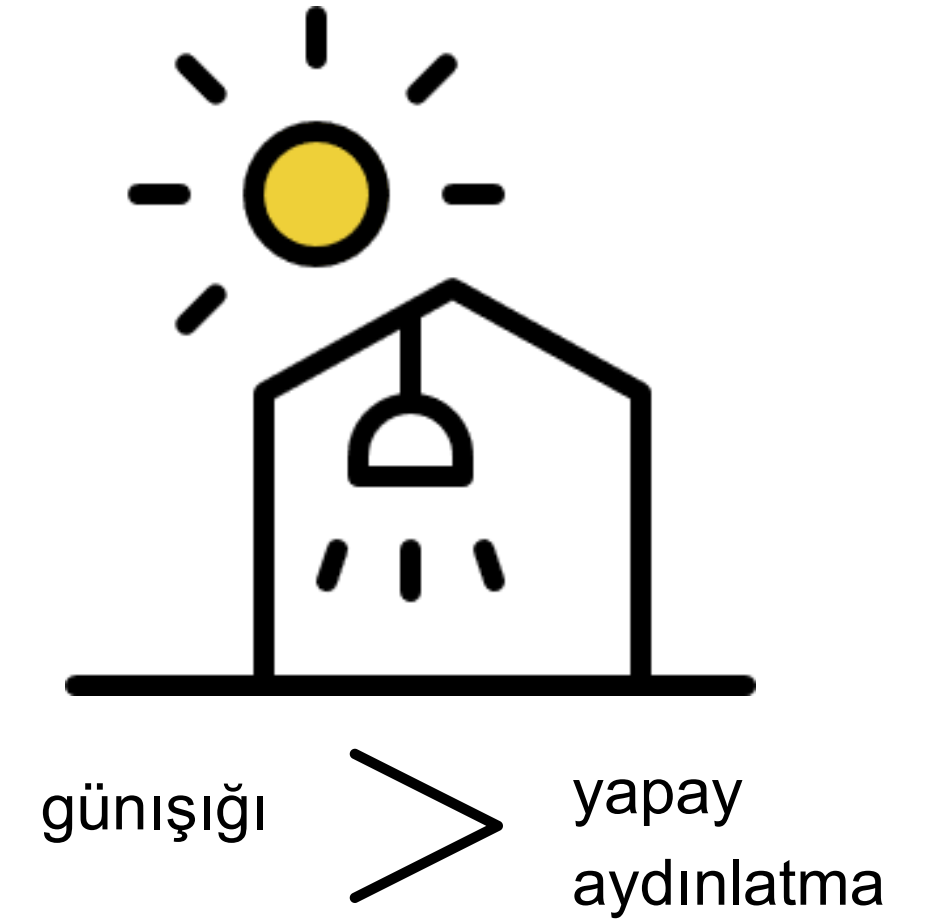
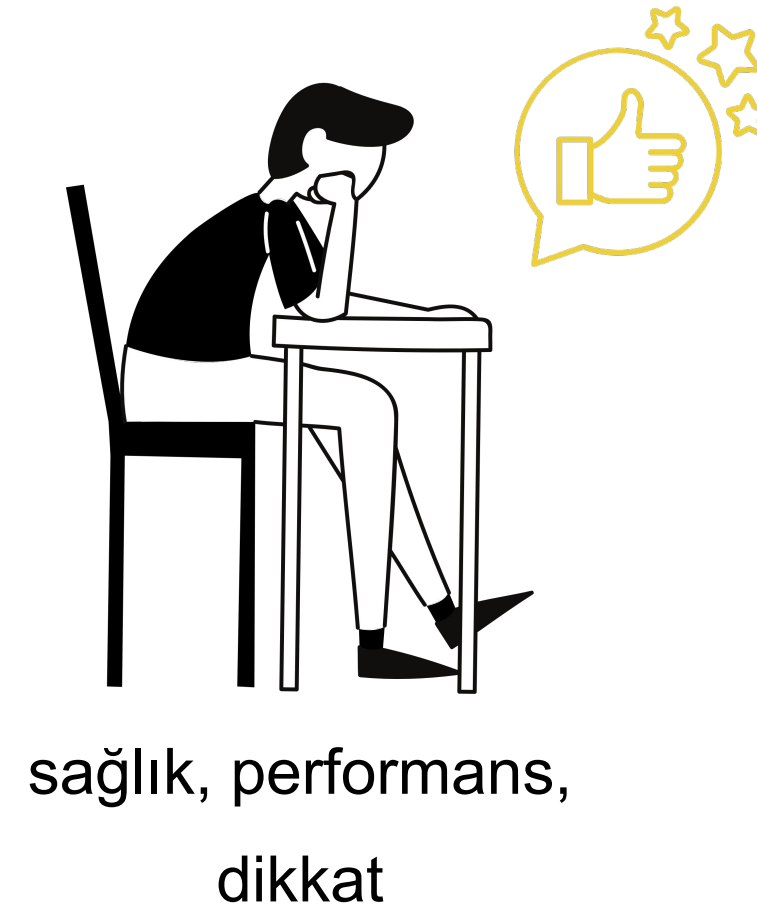
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GİRİŞ

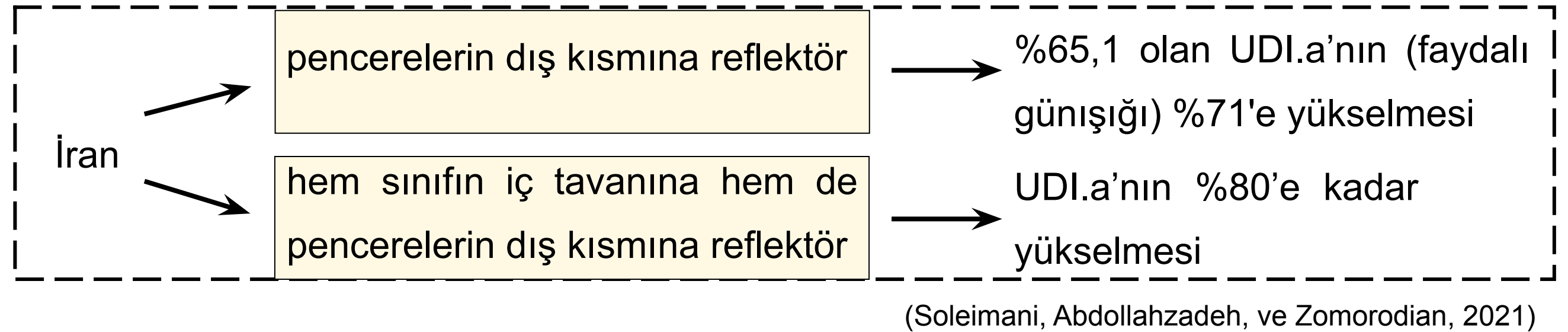
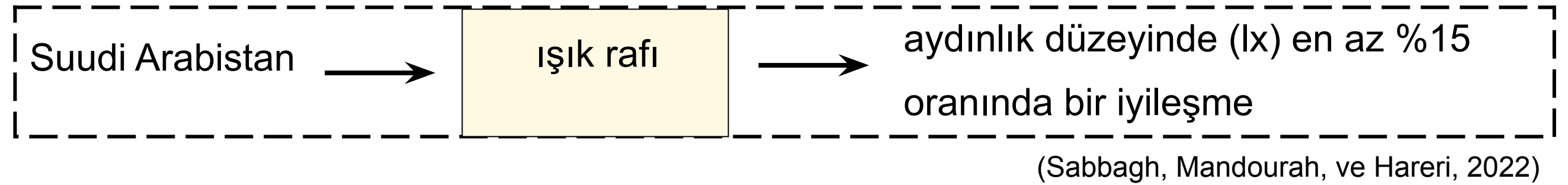


EĞİTİM YAPILARINDA GÜNIŞIĞI



EĞİTİM YAPILARINDA GÜNIŞIĞI

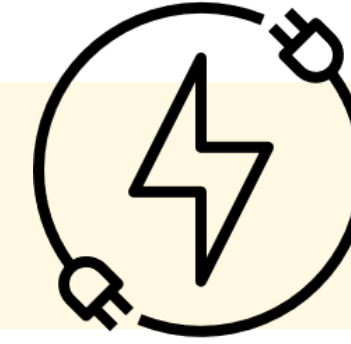
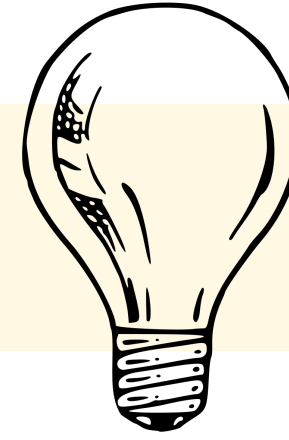
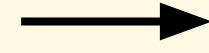
Literatür Bulguları



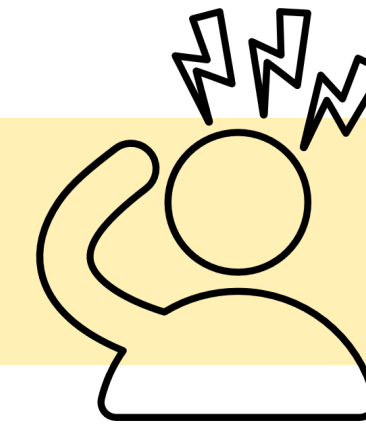
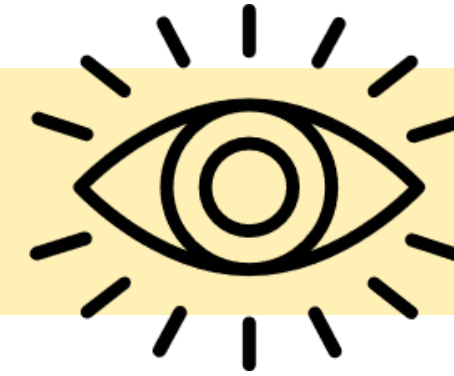
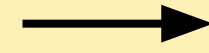
EĞİTİM YAPILARINDA GÜNIŞIĞI

Günişığı

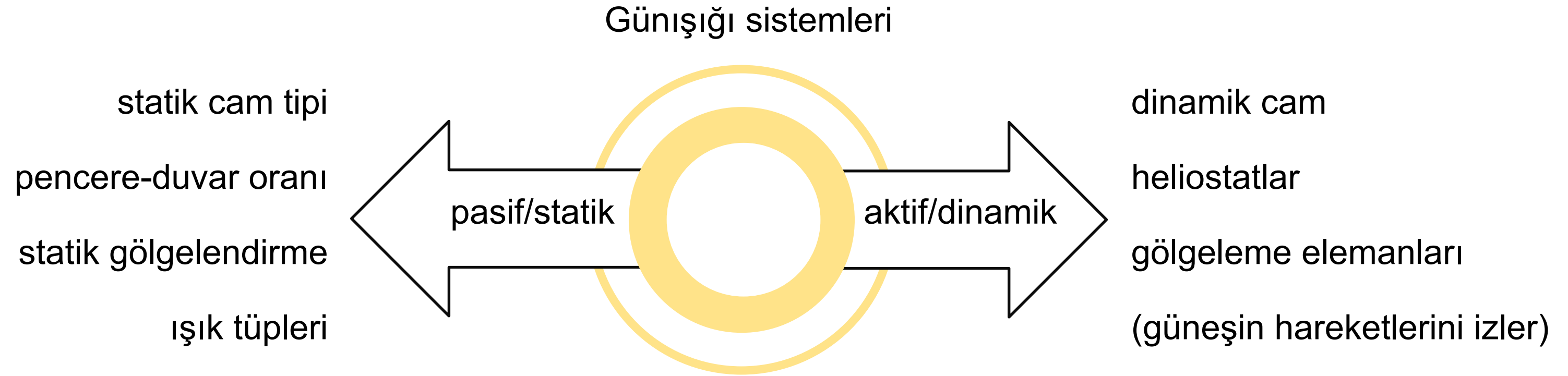
Yetersiz düzeyde



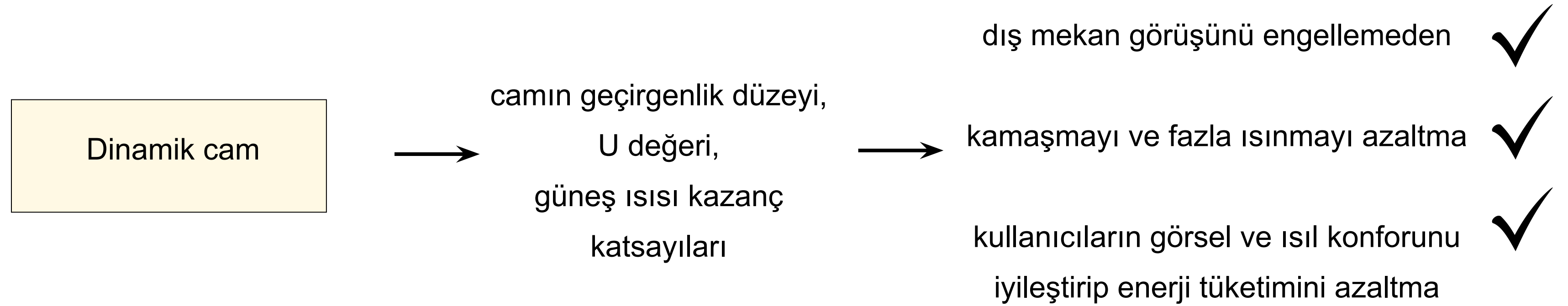
Fazla veya kontrolsüz düzeyde



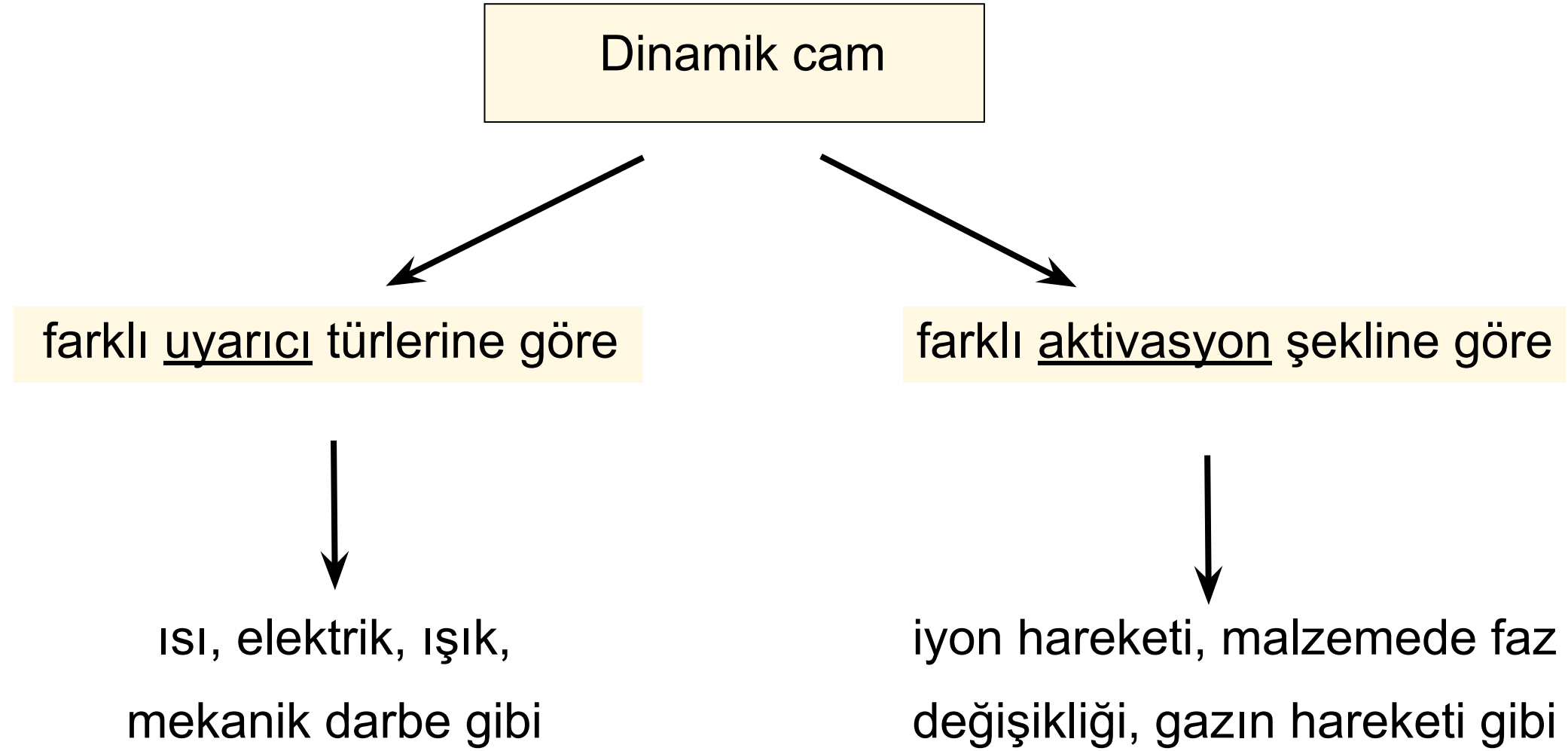
STATİK VE DİNAMİK SİSTEMLER



DİNAMİK CAM SİSTEMLERİ



DİNAMİK CAM SİSTEMLERİ



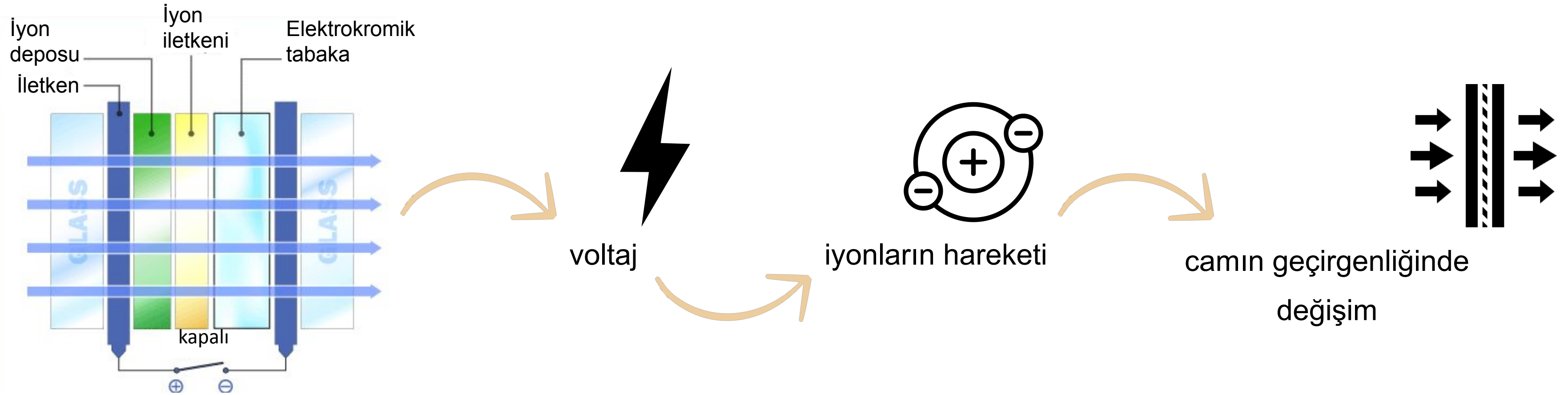
DİNAMİK CAM SİSTEMLERİ

| Dinamik Cam Tipi | <u>Uyarıcı</u> Türü | <u>Aktivasyon</u> Şekli |
|-------------------|---------------------|--------------------------|
| Fotokromik Cam | UV ışık | fotoresponsif katı madde |
| Gazokromik Cam | ISI | seyreltilmiş hidrojen |
| Termokromik Cam | ISI | gaz |
| Mekanokromik Cam | mekanik darbe | optik malzeme |
| Elektrokromik Cam | elektrik | iyon hareketi |

(Ghosh ve Norton, 2018; Marchwinski, 2014; Matin vd, 2022)

DİNAMİK CAM SİSTEMLERİ

Elektrokromik Cam (EC)



<https://home.howstuffworks.com/home-improvement/construction/green/smart-window4.htm>

DİNAMİK CAM SİSTEMLERİ

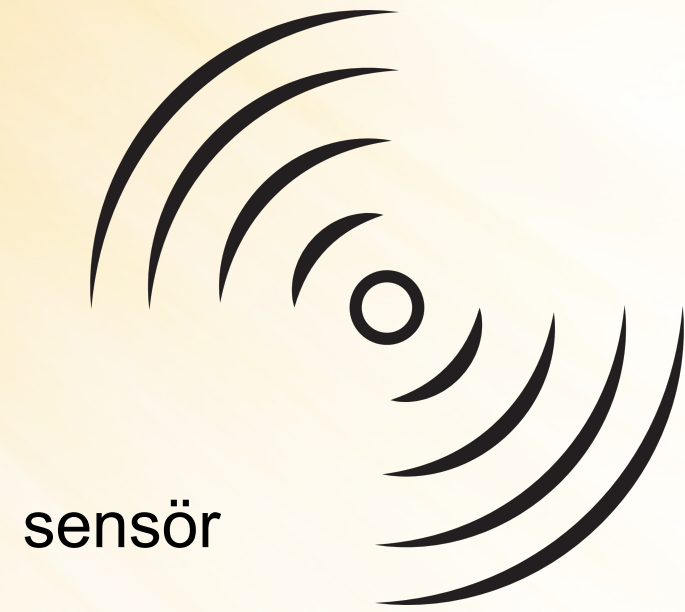
Elektrokromik
tabakadan iyon çıkışı
camı koyulaştırır



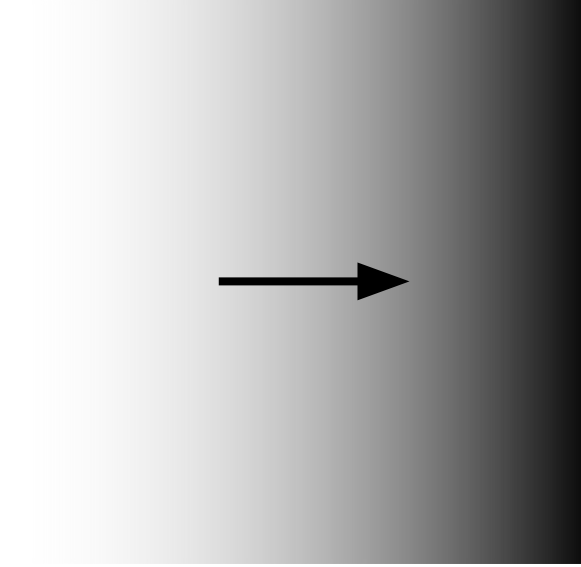
İyonların elektrokromik tabakaya
geri dönmesiyle de cam
şeffaf/daha geçirgen hale gelir



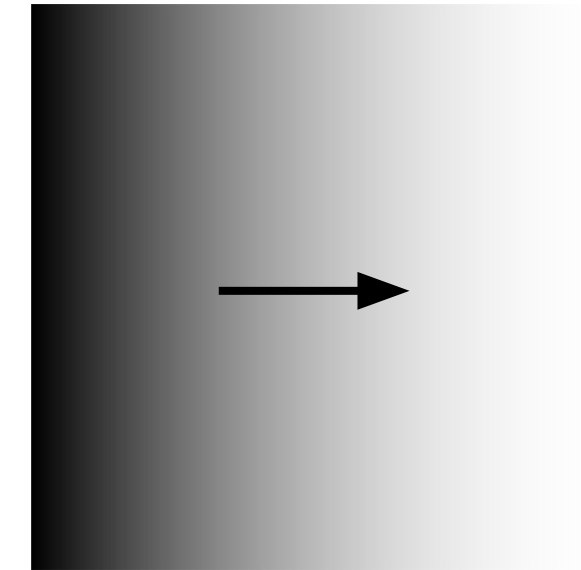
DİNAMİK CAM SİSTEMLERİ



→
kamaşmayı ve aşırı ısı
kazancını önlemek için



→
camdan içeriye daha
fazla ışık girmesi için

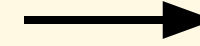


DİNAMİK CAM SİSTEMLERİ



<https://www.cepheyedair.com/akilli-malzeme-cam/>

Elektrokromik tabakadan iyon çıkışı



<https://www.cepheyedair.com/akilli-malzeme-cam/>

İyonların elektrokromik tabakaya geri dönmesi

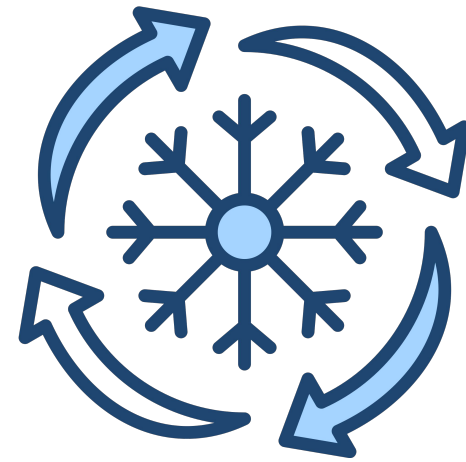


DİNAMİK CAM SİSTEMLERİ

Literatür Bulguları

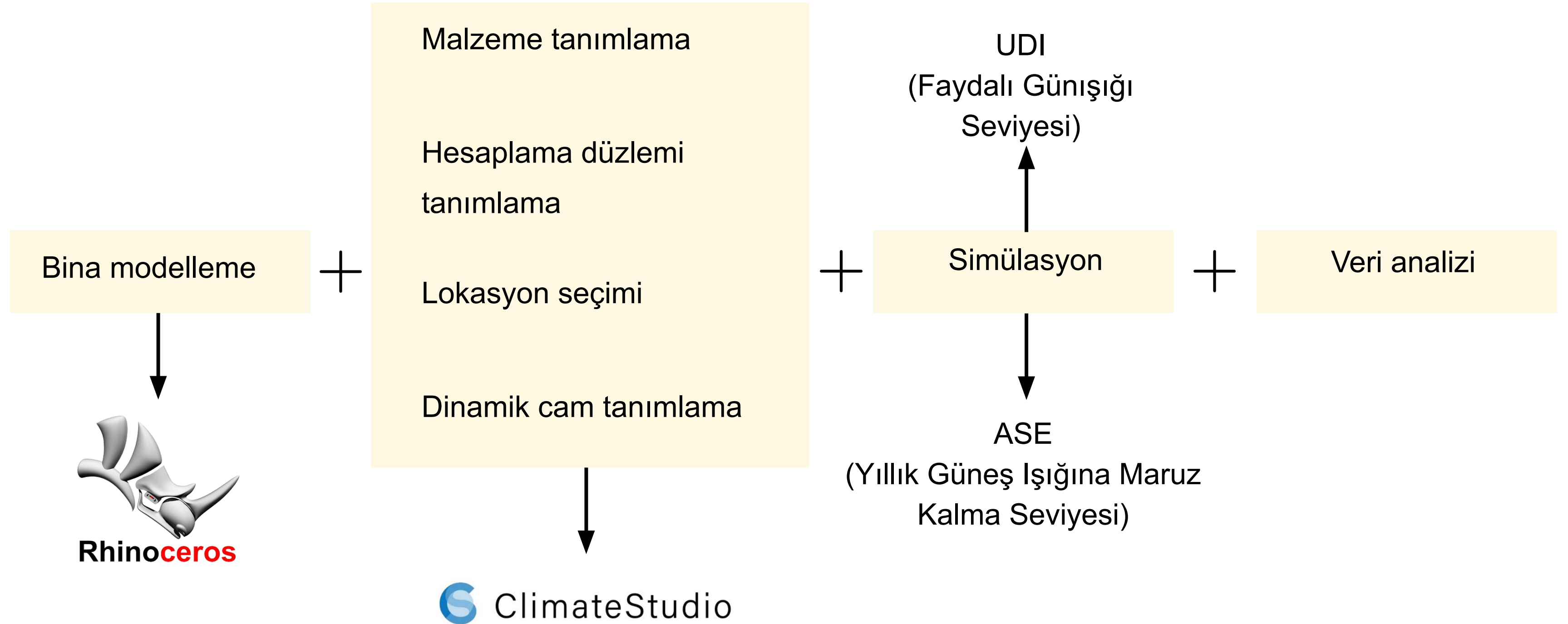


- UDI'de %35,33'e kadar artış ve yaklaşık %15,79 enerji tasarrufu (Zhang, 2023)
- UDI'de %111,76 artış (Hosseinzadeh Zarrabi, Azarbayjani, Amirazar, ve Asharafi, 2018)

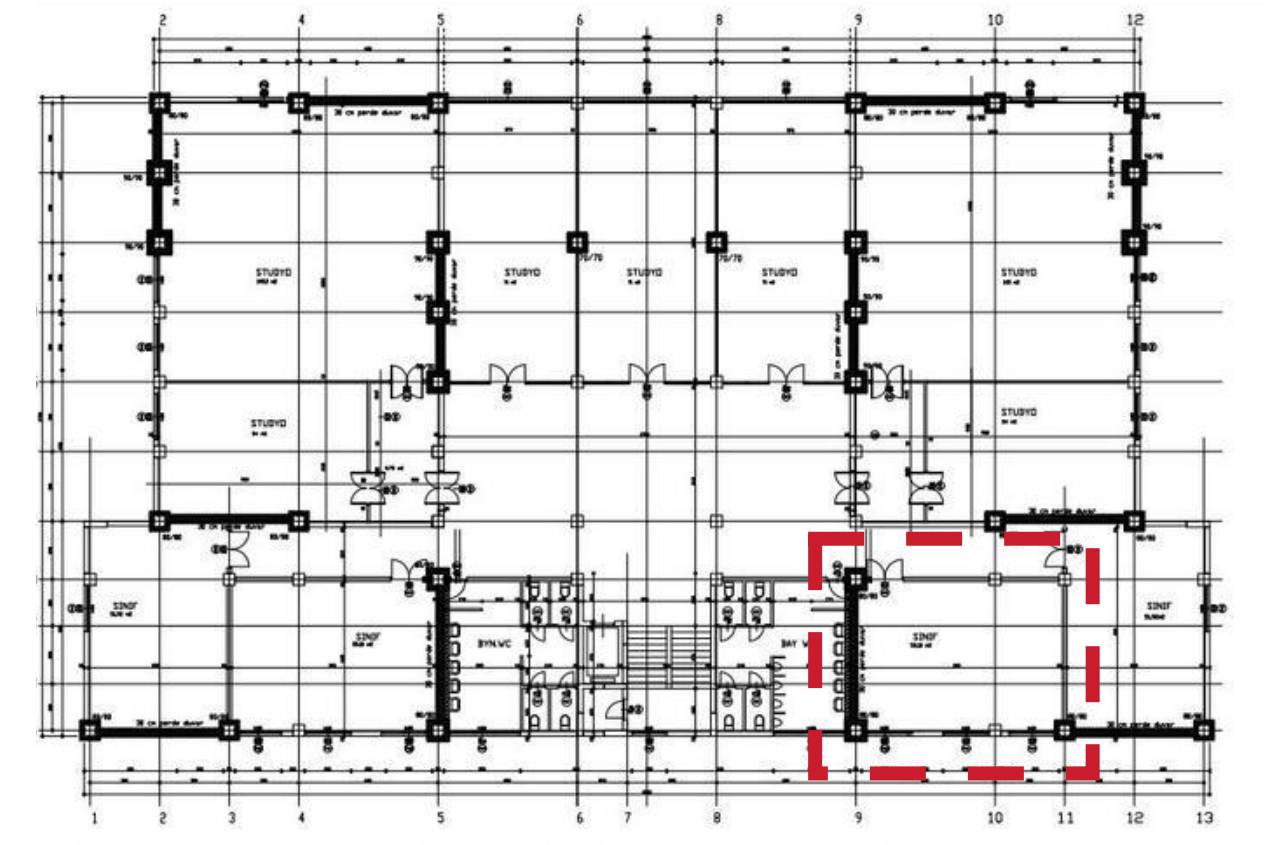


- Soğutma yükünde %60'a kadar azalma (Piccolo, 2010)

ÇALIŞMANIN METODU

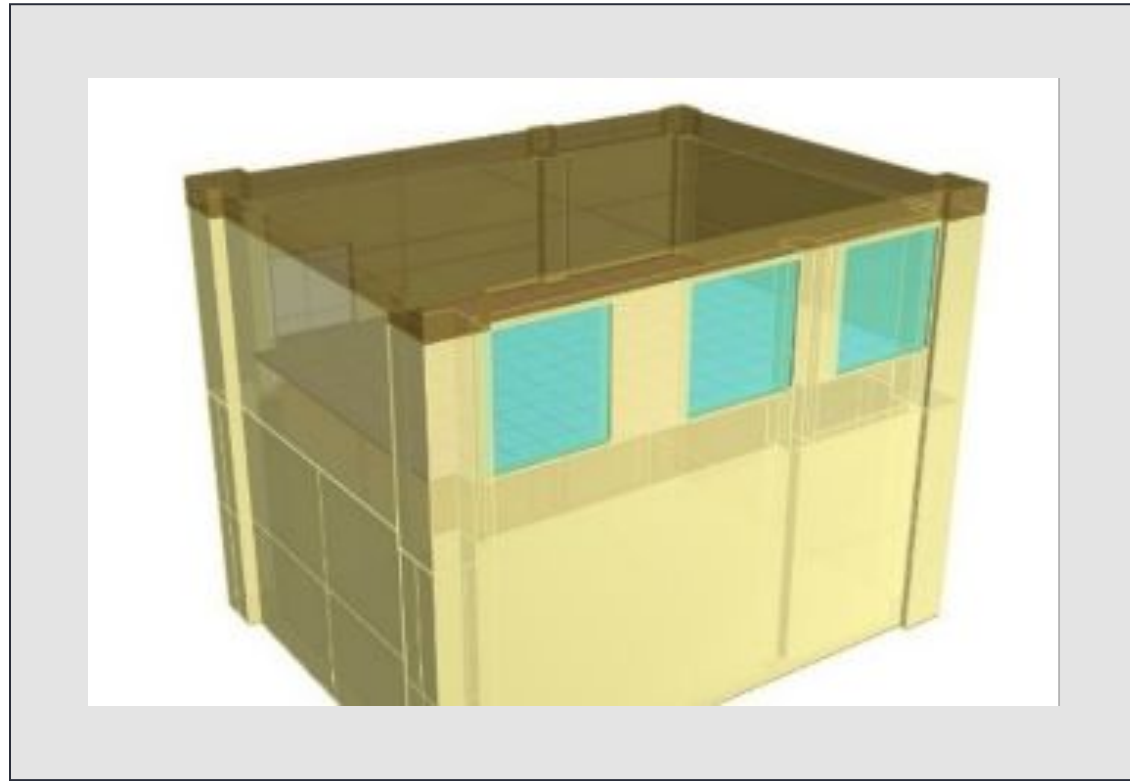


SİMÜLE EDİLEN DERSLİK



Şekil 1. Derslik binasının görselleri ve planı

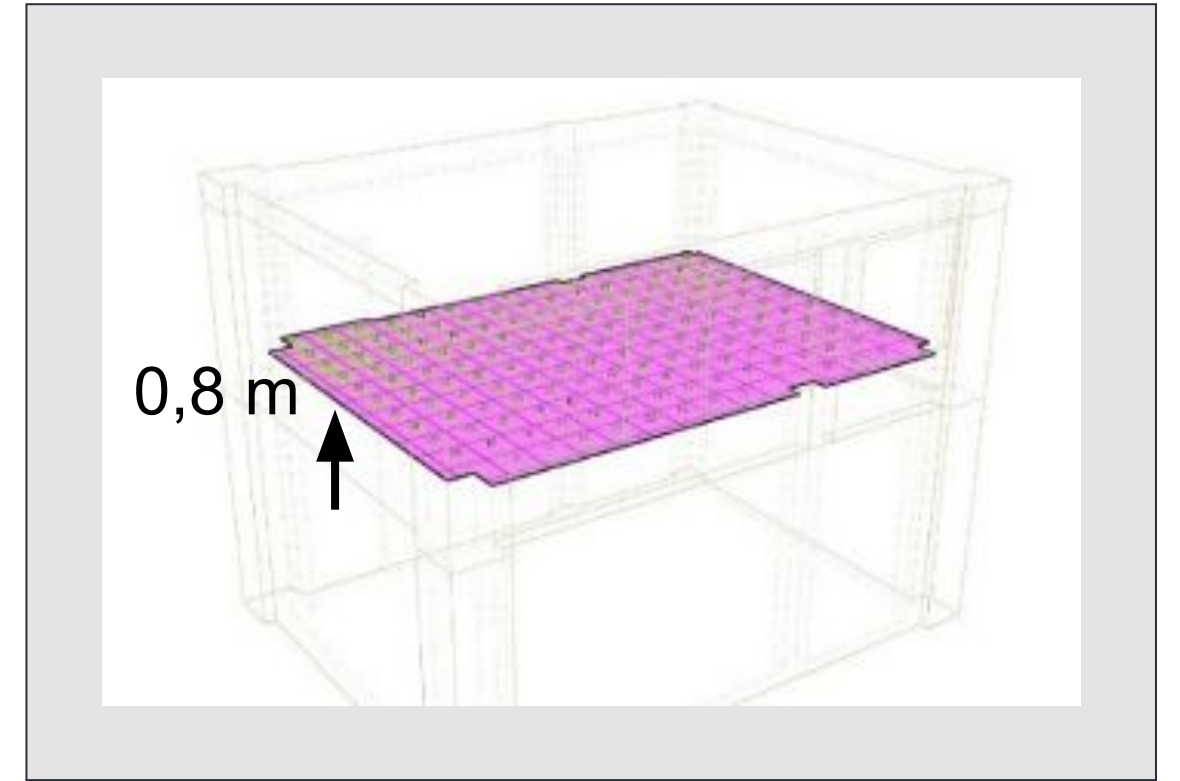
SİMÜLE EDİLEN DERSLİK



Pencere ölçüsü: 2 m x 2 m (3 adet),
yerden yüksekliği: 0,9 m

Derslik derinliği: 6,4 m
genişliği: 8,8 m
yüksekliği: 3,1 m,

Toplam derslik alanı: 53,1 m²



Şekil 2. Simüle edilen dersliğin cephesi ve hesaplama düzlemi

SİMÜLE EDİLEN DERSLİK

Tablo 1. Modeldeki yüzey malzemelerinin geçirgenlik / yansıtıcılık değerleri

| | |
|-------|--|
| Cam | %80,5 (Starphire - Sungate 400 (3) on Starphire (Argon)) |
| Duvar | %79,80 (Beyaz Boyalı Koridor Duvarları) |
| Zemin | %70,32 (Seramik Karo Zemin) |
| Tavan | %89,40 (Beyaz Boyalı Tavan) |

UYGULANAN DİNAMİK CAM ALTERNATİFLERİ

Tablo 2. Dinamik cam alternatiflerinin renk tonu geçirgenlik seviyeleri (Climate Studio, 2020)

| Dinamik Cam Adı | Tvis0 | Tvis1 | Tvis2 | Tvis3 | Tvis4 | Tvis5 | Tvis6 | Tvis7 | Tvis8 |
|-----------------|--------|--------|--------|--------|--------|-------|-------|-------|-------|
| Halio | % 62,5 | % 43,2 | % 30,0 | % 22,1 | % 13,9 | % 8,9 | % 7,0 | % 4,4 | % 1,5 |
| Halio Black | % 51,3 | % 21,6 | % 11,3 | % 2,3 | % 0,8 | % 0,5 | % 0,1 | - | - |
| Sage | % 59,7 | % 17,3 | % 5,5 | % 0,9 | - | - | - | - | - |
| View | % 62,1 | % 41,2 | % 5,4 | % 1,1 | - | - | - | - | - |

Yılın her saati için, kullanılan alanın % 2'sinden fazlası 1000 lüks'ten fazla doğrudan güneşi aldığı durumlarda, dinamik cam sistemine odanın sensörlerinin %2'den azı güneşi alana kadar kapanmaları talimatı verilmektedir (LEEDv4 2% Kuralı). (Climate Studio, 2020)

DEĞERLENDİRİLEN GÜNIŞIĞI METRİKLERİ

UDI
(Useful Daylight Illuminance/Faydalı Günişığı Seviyesi)

Gerçekçi gökyüzü, iklim tabanlı koşullar



günişığı kullanılabilirliği,
güneşe maruz kalma seviyeleri

(Nabil ve Mardaljevic, 2006)

$$UDI.a \geq \%8$$

0

(Al-Sallal, 2018)

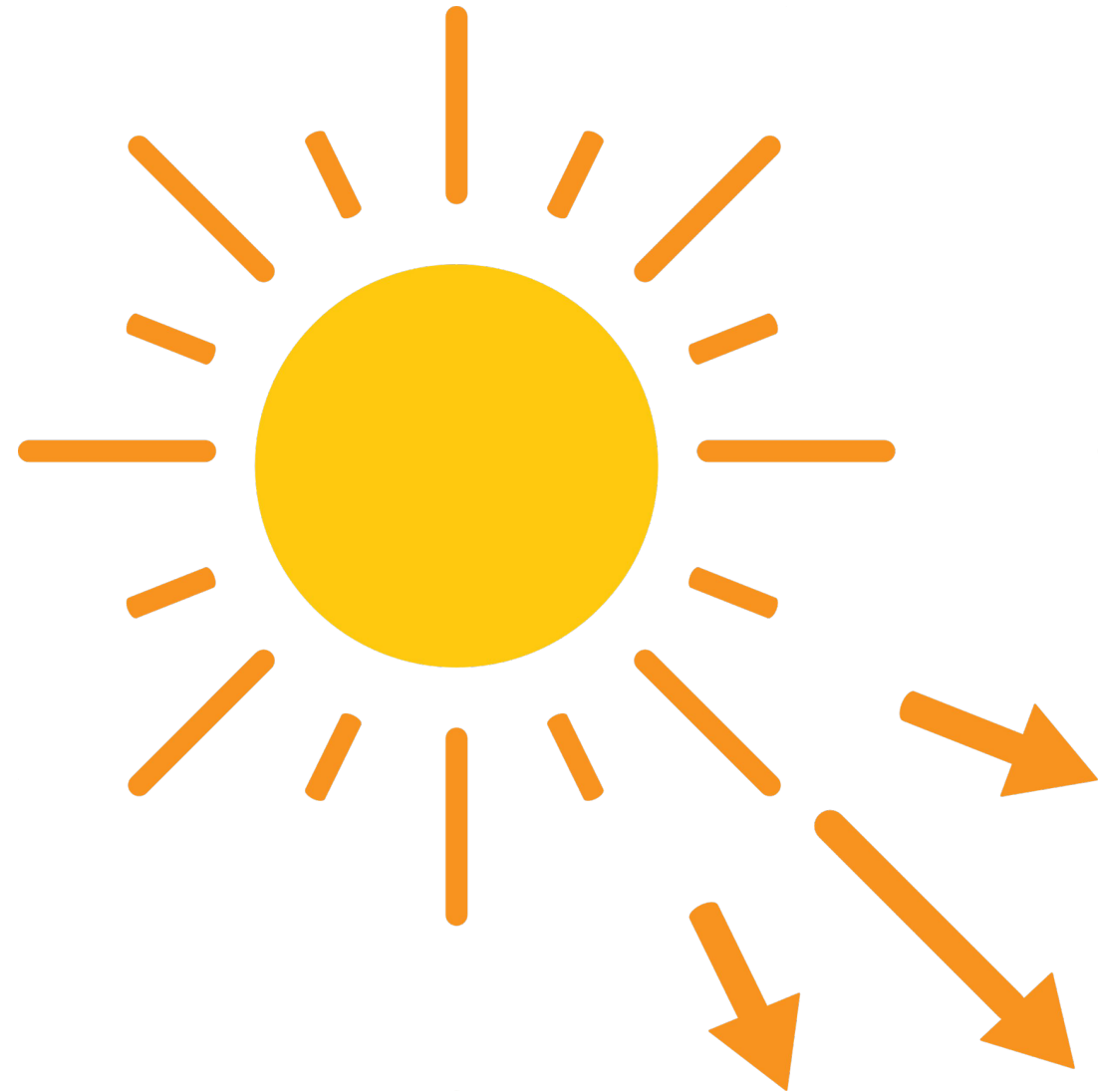
Tablo 3. UDI tipleri ve kapsamaları (Climate Studio, 2020)

| UDI Tipi | Lüks Aralığı |
|--------------------------------------|-------------------------------------|
| UDI.f (Failing)= Yetersiz | UDI.f <100 lüks |
| UDI.s (Supplemental)= Tamamlayıcı | 100 lüks < UDI.s, UDI.s < 300 lüks |
| UDI.a (Autonomous)= Faydalı | 300 lüks < UDI.a, UDI.a < 3000 lüks |
| UDI.e (Excessive)= Aşırı | UDI.e >3000 lüks |

DEĞERLENDİRİLEN GÜNIŞIĞI METRİKLERİ

ASE

(Annual Sunlight Exposure/Yıllık Güneş Işığına Maruz Kalma Seviyesi)



Aydınlatma sınırını rahatsızlık verecek boyutta

aşmış



1000 lüks'ten fazla aydınlatmaya 250 saatten fazla maruz kalmış alanların yüzdesi

(Climate Studio, 2020)

$$ASE \leq \begin{matrix} \%1 \\ 0 \end{matrix}$$

(Reinhart, 2015)

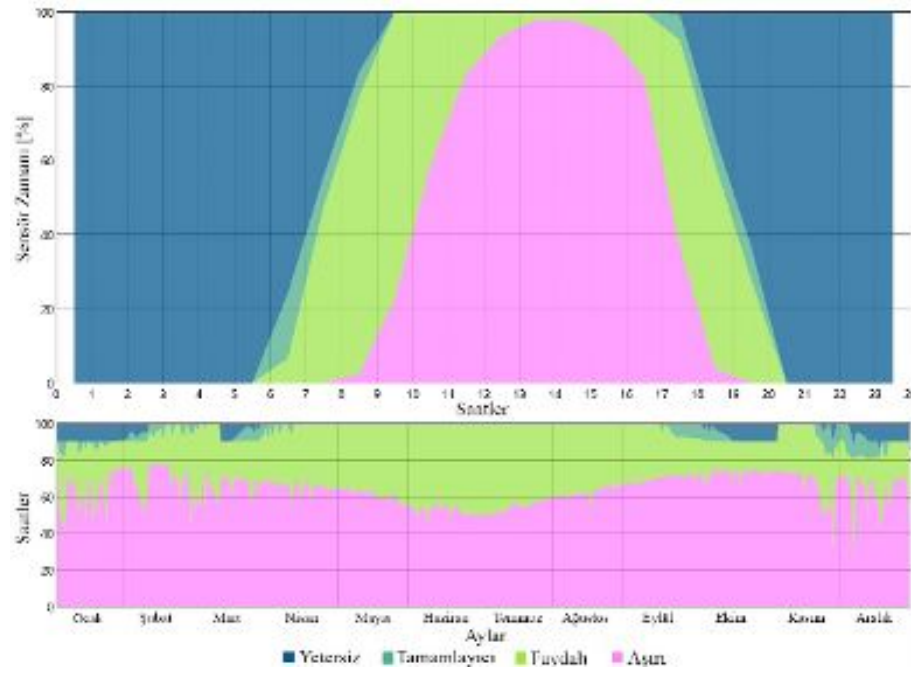
BULGULAR

Tablo 4. UDI Sonuçları

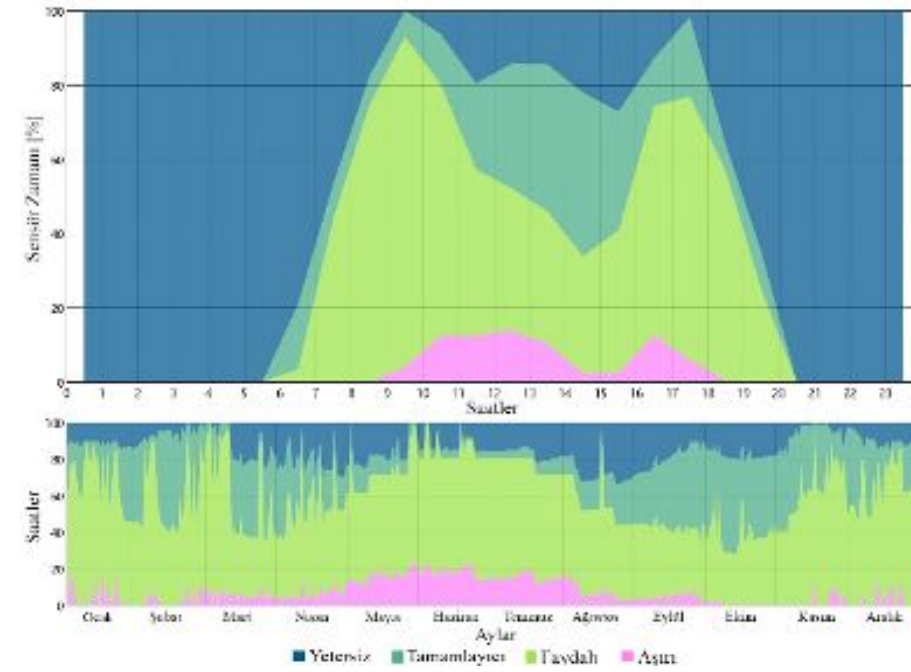
| Alternatifler | UDI.f | UDI.s | UDI.a | UDI.e |
|-------------------------------|--------|--------|-----------------------|-----------------------|
| Temel Model (dinamik cam yok) | %2,64 | %2,18 | %31,31 | %63,88 |
| Halio | %14,75 | %23,11 | %55,12 (%76,04 artış) | %7,02 (%89,01 azalış) |
| Halio Black | %21,50 | %21,30 | %52,99 (%69,24 artış) | %4,20 (%93,42 azalış) |
| Sage | %29,17 | %12,28 | %52,59 (%67,96 artış) | %5,95 (%90,68 azalış) |
| View | %24,94 | %18,83 | %49,38 (%57,71 artış) | %6,84 (%89,29 azalış) |

UDI.f: Yetersiz, UDI.s:Tamamlayıcı, UDI.a: Faydalı, UDI.e: Excessive

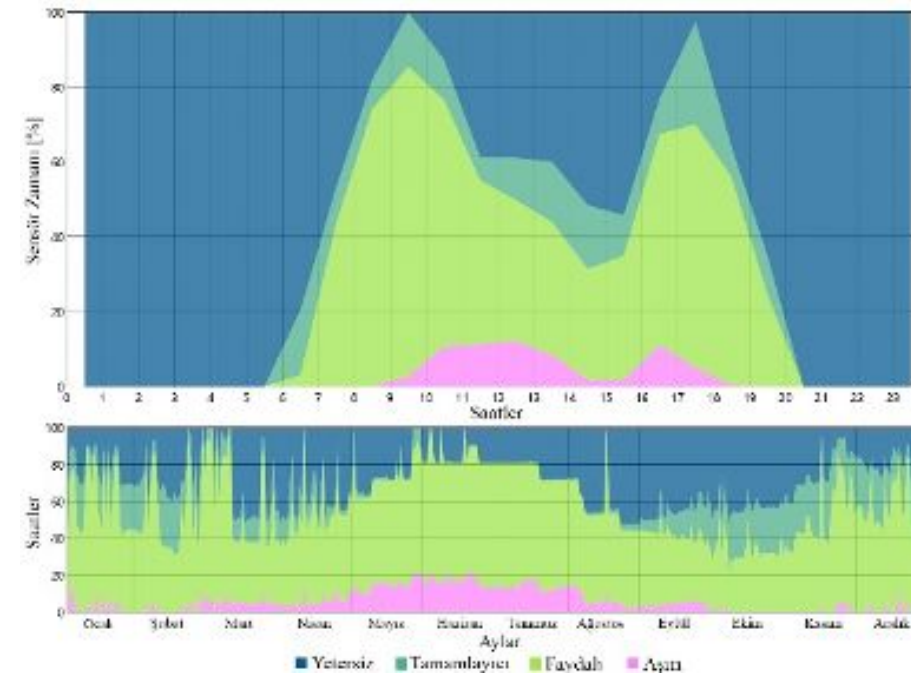
BULGULAR



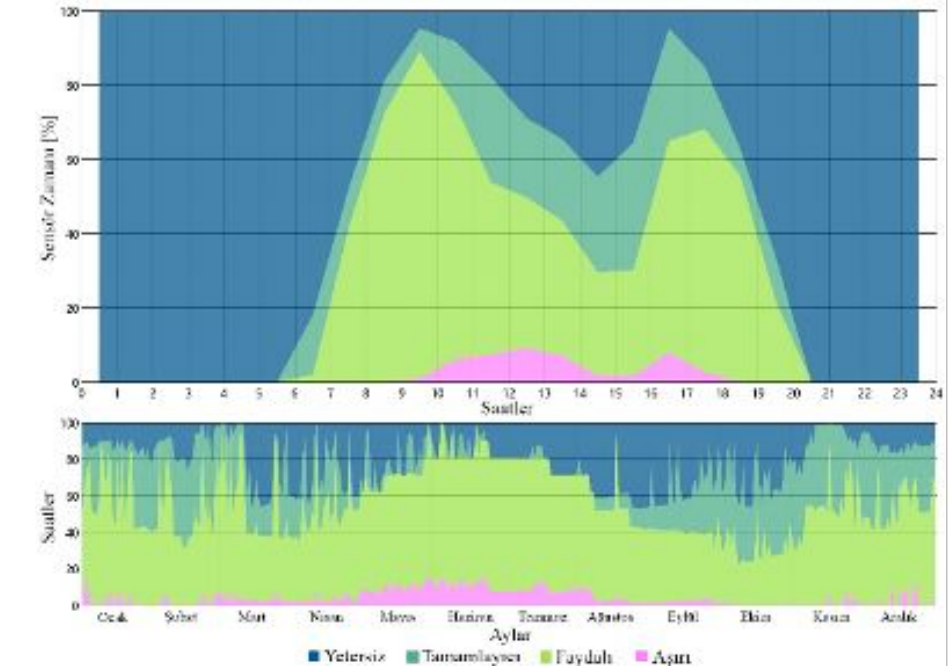
Şekil 3. Temel model
(dinamik cam yok)



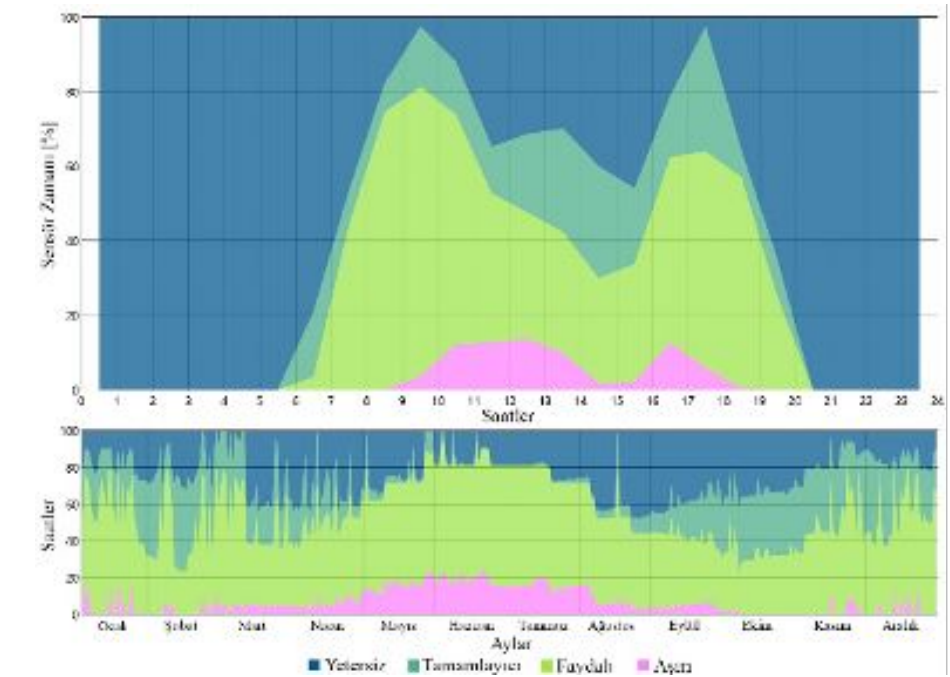
Şekil 4. Haliyo dinamik cam



Şekil 6. Sage dinamik cam

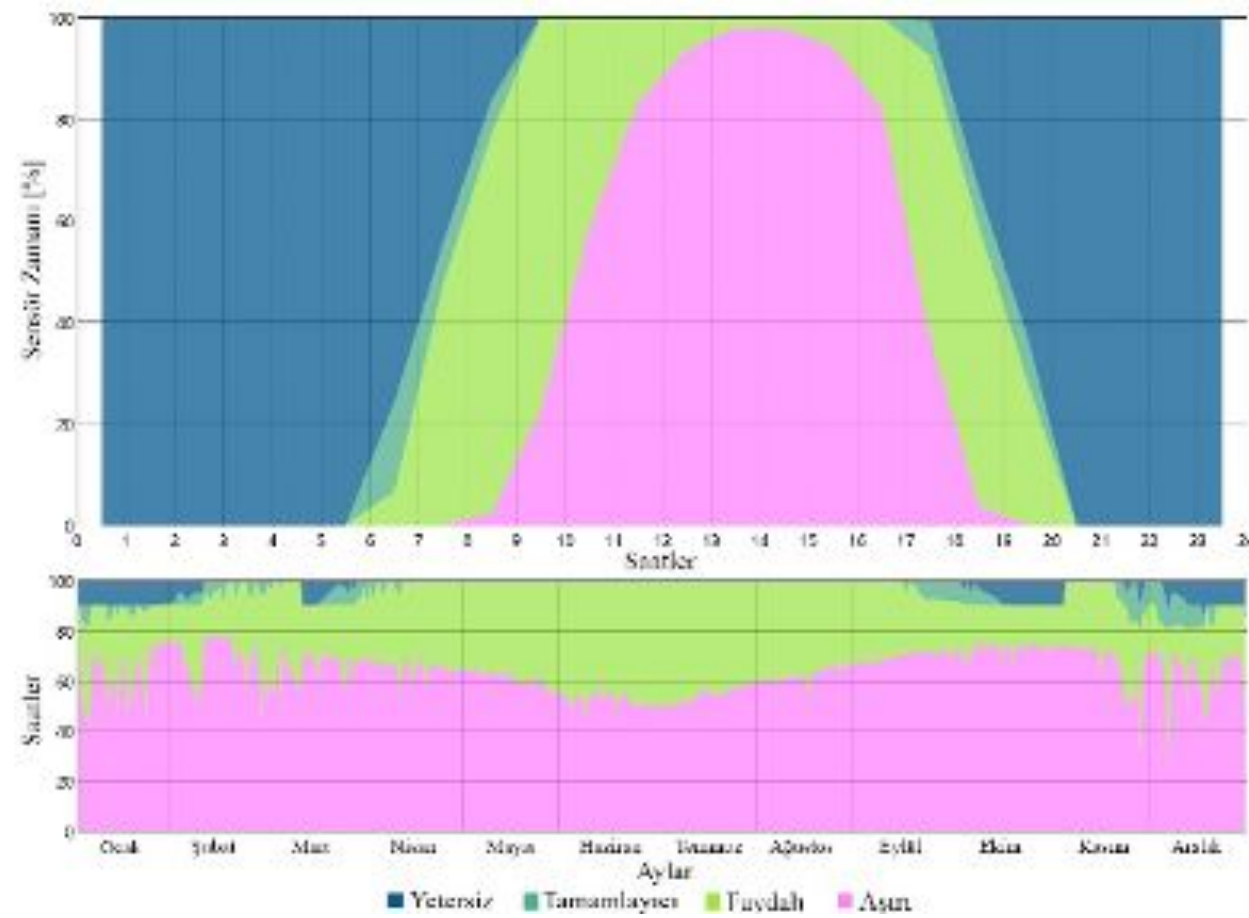


Şekil 5. Haliyo Black dinamik cam



Şekil 7. View dinamik cam

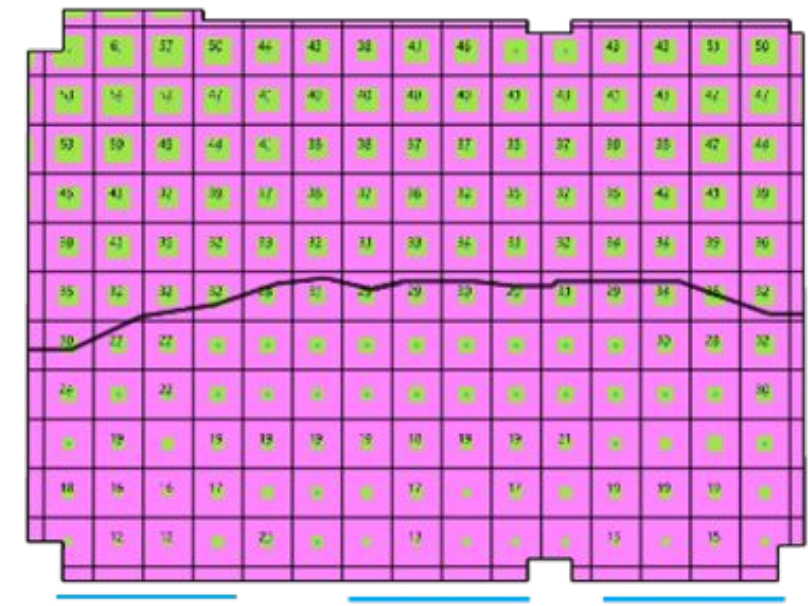
BULGULAR



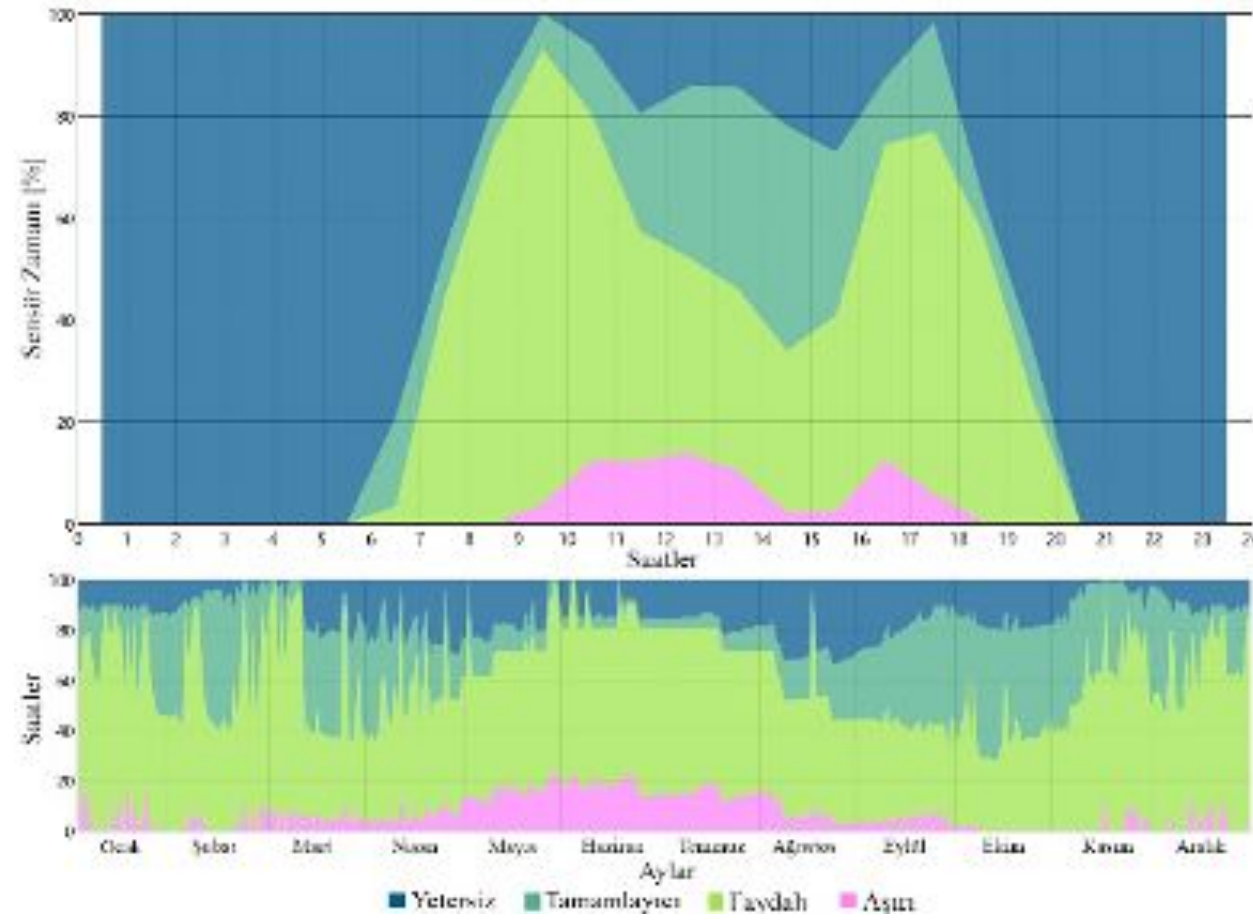
Şekil 4. Temel model (dinamik cam yok)
UDI sonuç grafiği

| | UDI.f | UDI.s | UDI.a | UDI.e |
|-------|-------|-------|--------|--------|
| Temel | %2,64 | %2,18 | %31,31 | %63,88 |

Tablo 5. UDI ve ASE sonuçları

| Alternatif | UDI - ASE |
|----------------------------------|---|
| Temel model (dinamik cam yok) |  <p style="text-align: center;">%31,31 - %50,63</p> |
| | <p>■ Yetersiz ■ Tamamlayıcı ■ Faydalı ■ Aşırı</p> |

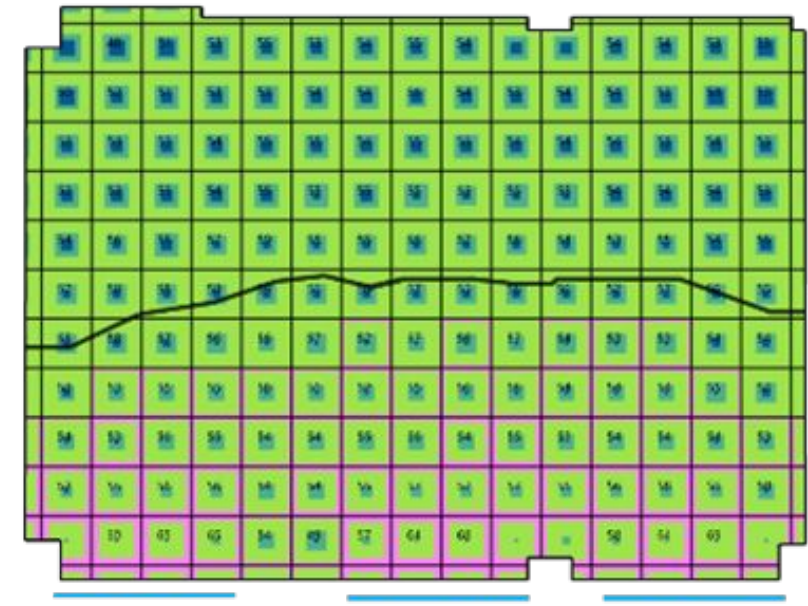
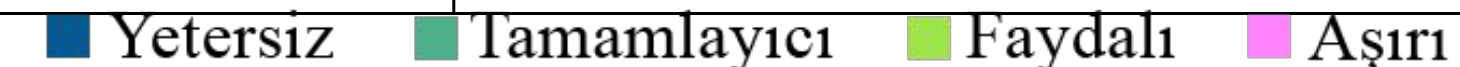
BULGULAR



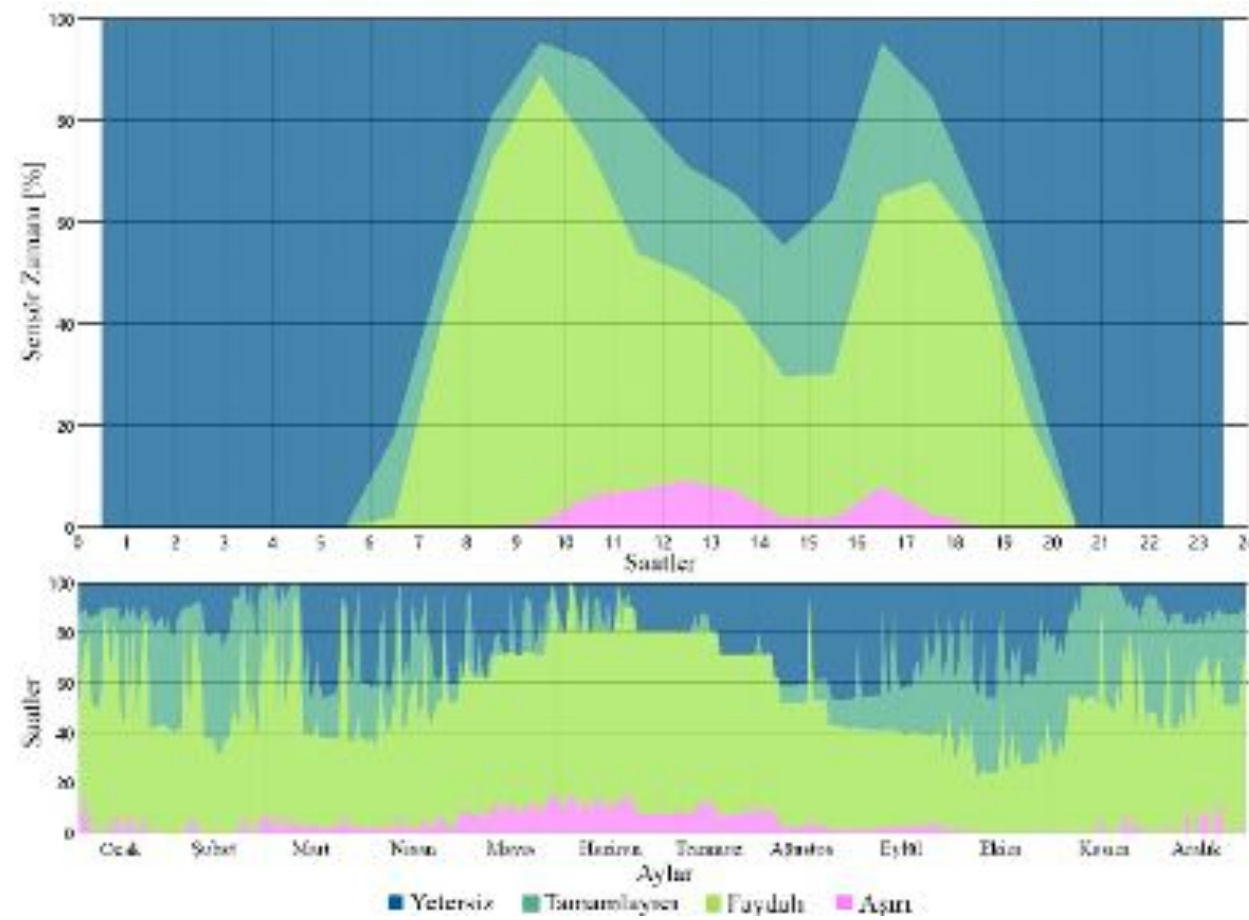
Şekil 4. Halio dinamik cam kullanılan modelin UDI sonuç grafiği

| | UDI.f | UDI.s | UDI.a | UDI.e |
|-------|--------|--------|--------|-------|
| Halio | %14,75 | %23,11 | %55,12 | %7,02 |

Tablo 5. UDI ve ASE sonuçları (devamı)

| Alternatif | UDI - ASE |
|----------------------|---|
| Halio dinamik cam |  <p>%55,12 - %50,63</p> |
| |  |

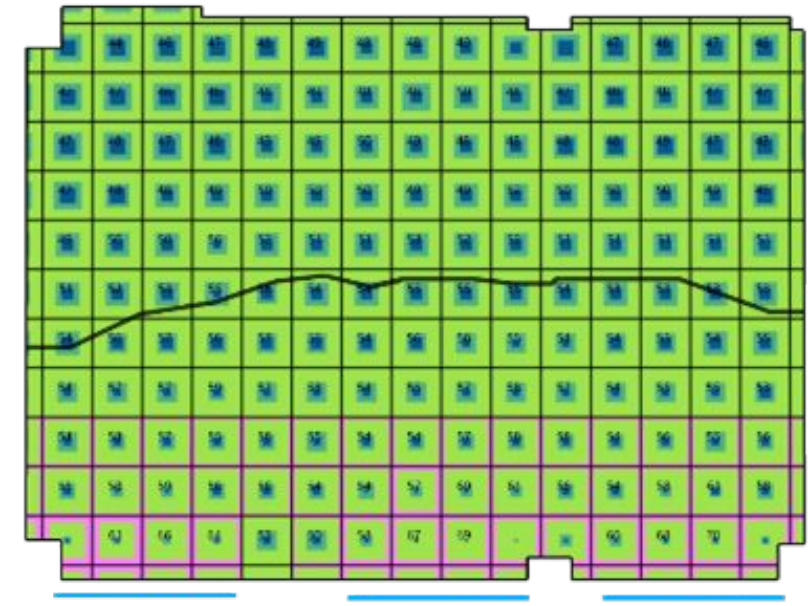
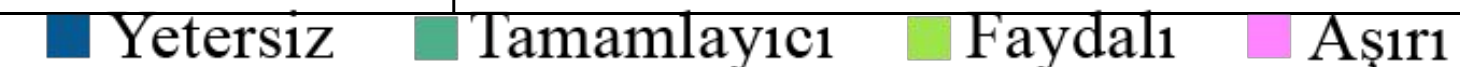
BULGULAR



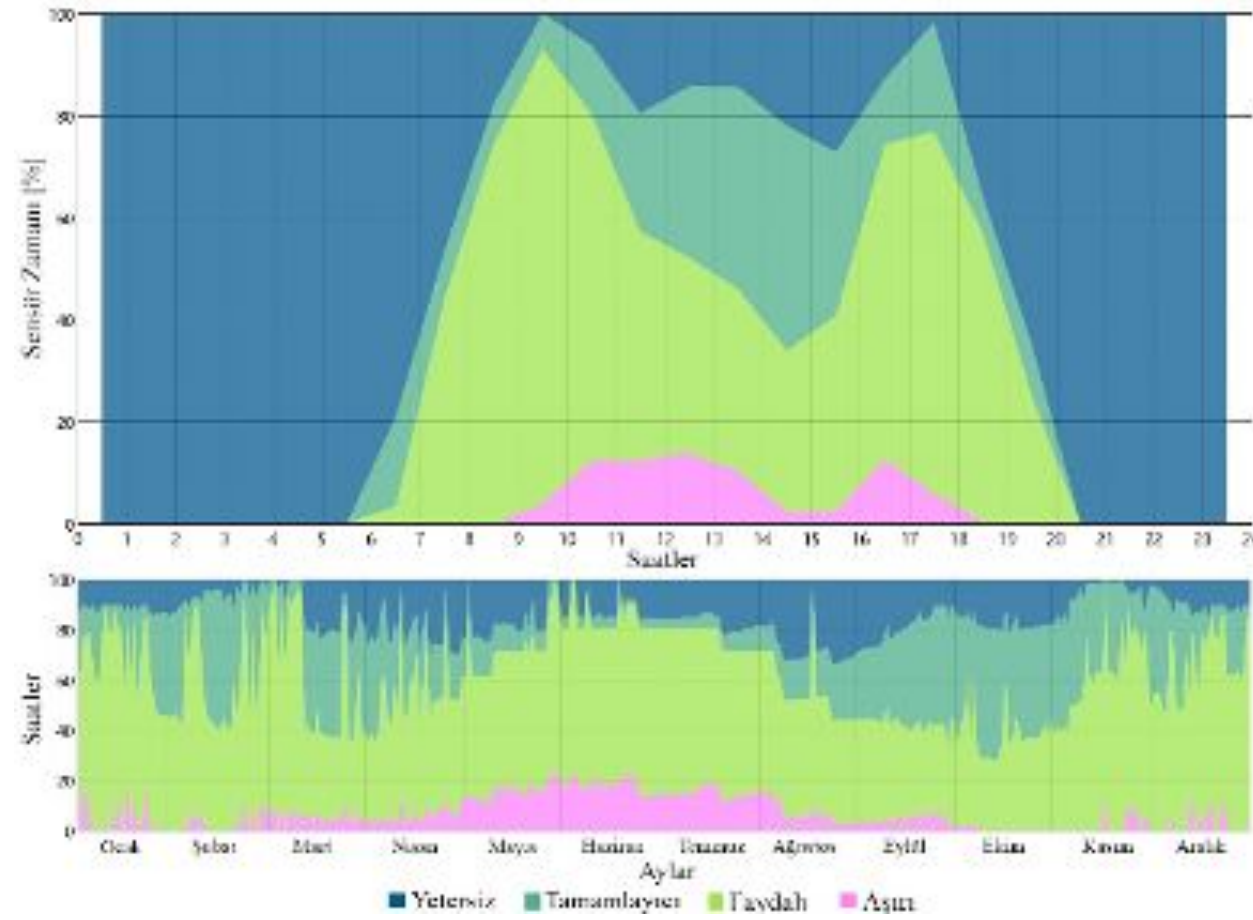
Şekil 4. Halio Black dinamik cam kullanılan modelin UDI sonuç grafiği

| | UDI.f | UDI.s | UDI.a | UDI.e |
|---------|--------|--------|--------|-------|
| Halio B | %21,50 | %21,30 | %52,99 | %4,20 |

Tablo 5. UDI ve ASE sonuçları (devamı)

| Alternatif | UDI - ASE |
|-------------------------|--|
| Halio Black dinamik cam |  <p>%52,99 - %50,0</p> |
| |  |

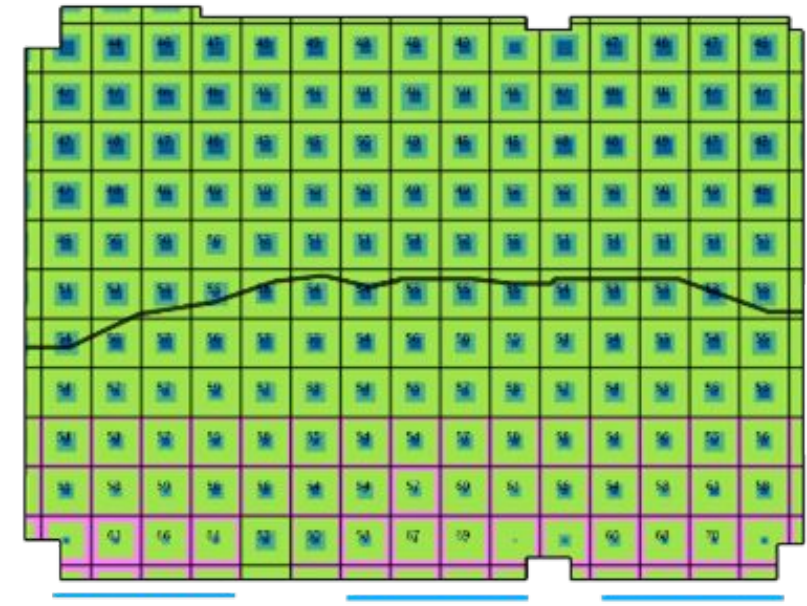
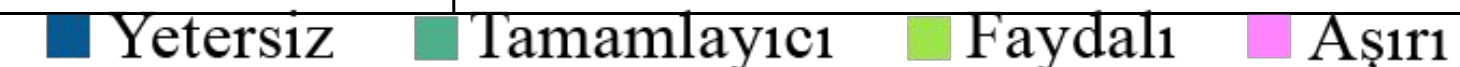
BULGULAR



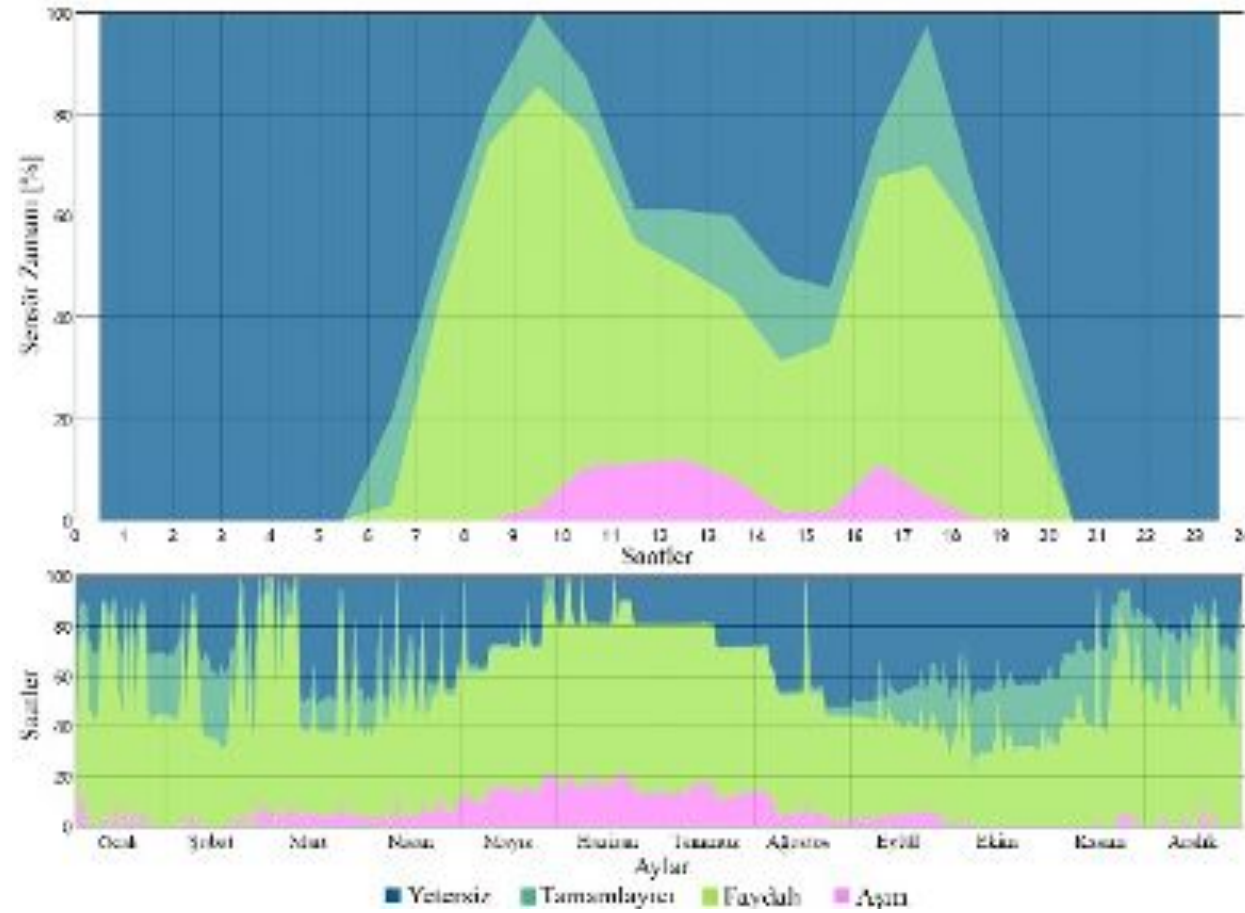
Şekil 4. Sage dinamik cam kullanılan modelin UDI sonuç grafiği

| | UDI.f | UDI.s | UDI.a | UDI.e |
|------|--------|--------|--------|-------|
| Sage | %29,17 | %12,28 | %52,59 | %5,95 |

Tablo 5. UDI ve ASE sonuçları (devamı)

| Alternatif | UDI - ASE |
|------------------|---|
| Sage dinamik cam |  <p>%52,59 - %50,63</p> |
| |  |

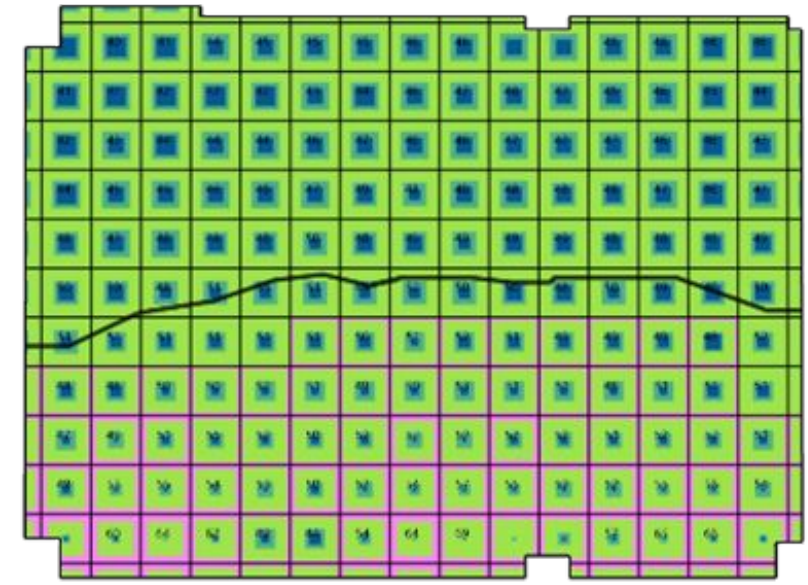
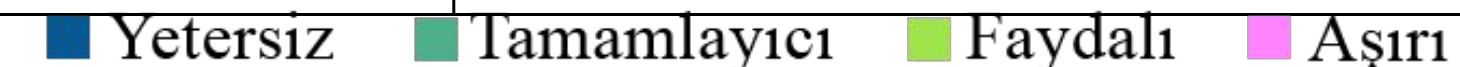
BULGULAR



Şekil 4. View dinamik cam kullanılan modelin UDI sonuç grafiği

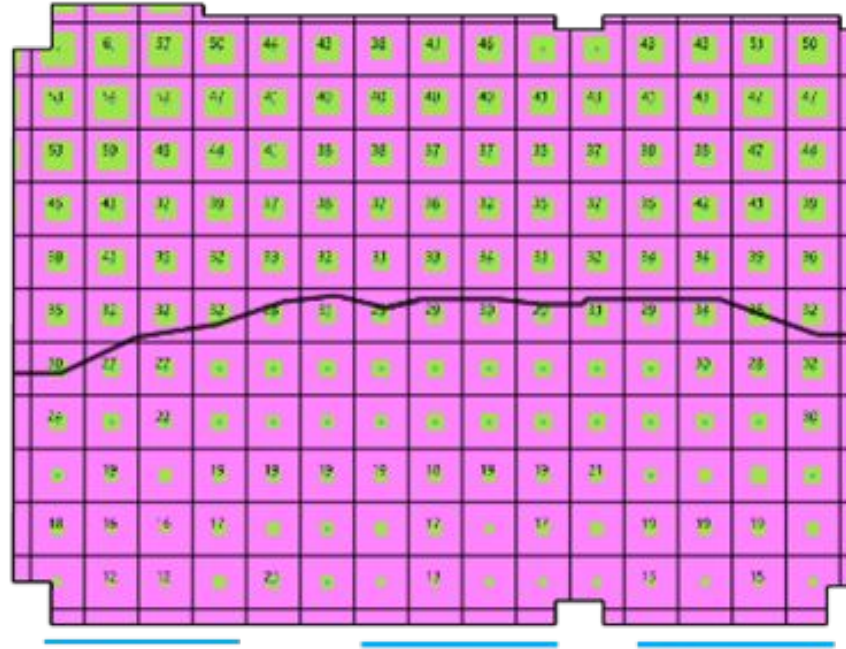
| | UDI.f | UDI.s | UDI.a | UDI.e |
|------|--------|--------|--------|-------|
| View | %24,94 | %18,83 | %49,38 | %6,84 |

Tablo 5. UDI ve ASE sonuçları (devamı)

| Alternatif | UDI - ASE |
|------------------|---|
| View dinamik cam |  <p>%49,38 - %50,63</p> |
| |  |

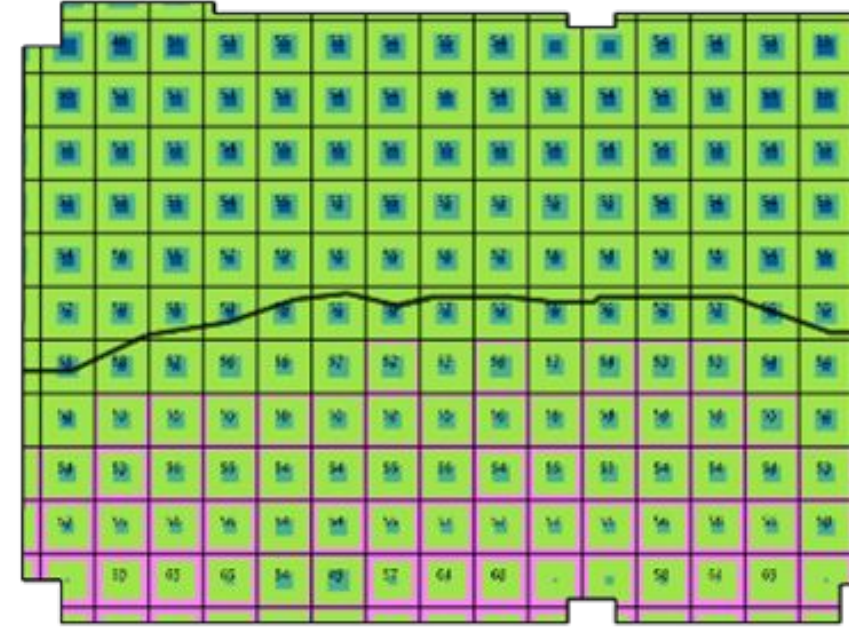
BULGULAR

UDI - ASE
%31,31 - %50,63



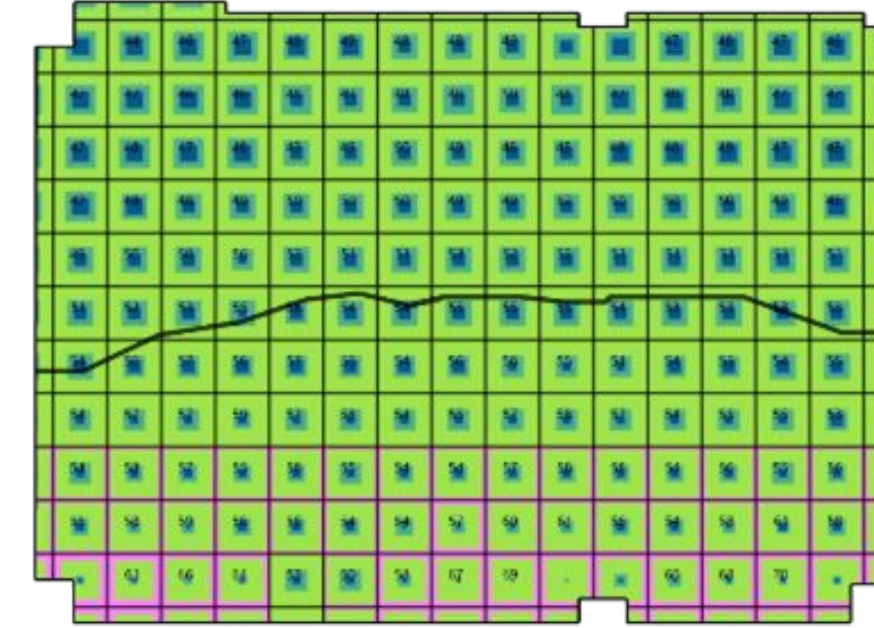
Şekil 3. Temel model
(dinamik cam yok)

UDI - ASE
%55,12 - %50,63



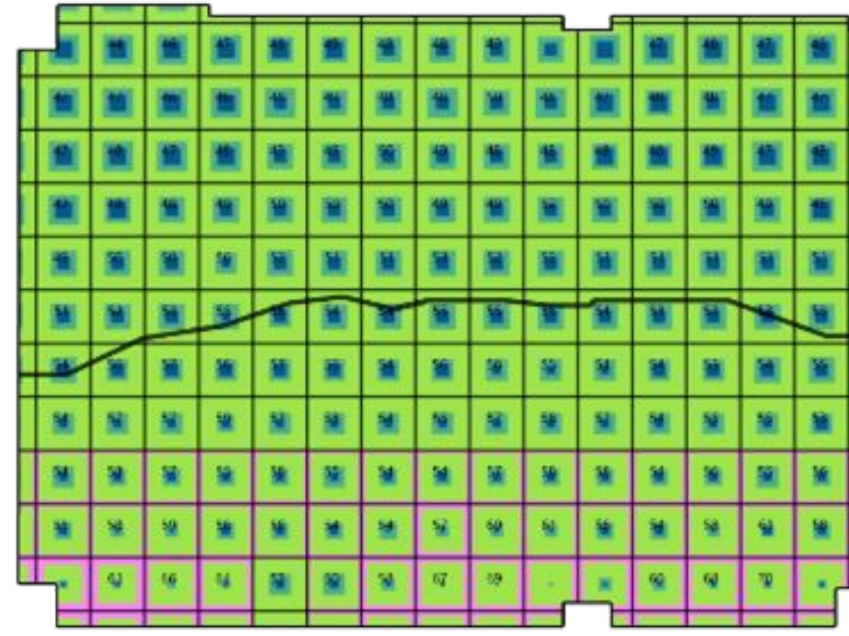
Şekil 4. Halio dinamik cam

UDI - ASE
%52,99 - %50,0



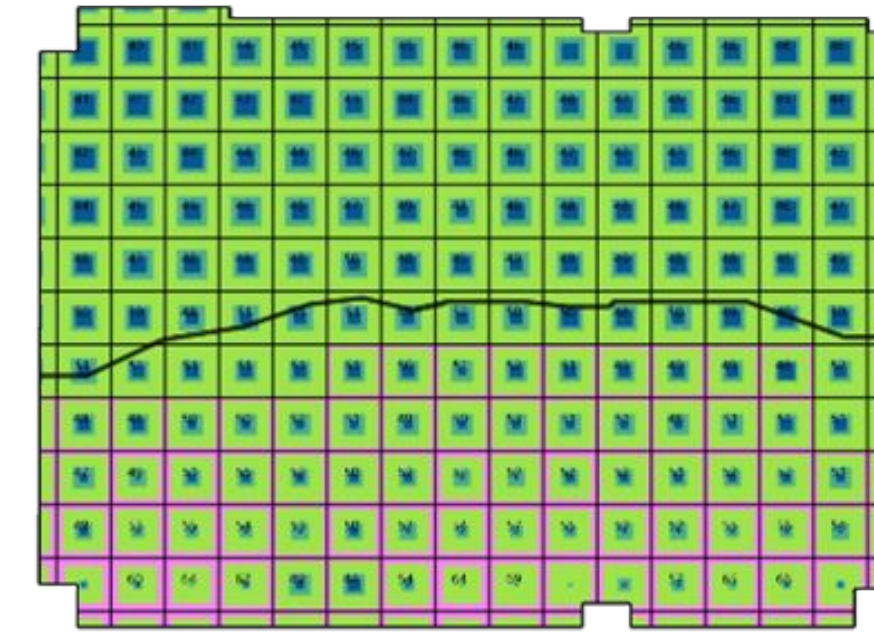
Şekil 5. Halio Black dinamik cam

UDI - ASE
%52,59 - %50,63



Şekil 6. Sage dinamik cam

UDI - ASE
%49,38 - %50,63



Şekil 7. View dinamik cam

TARTIŞMA

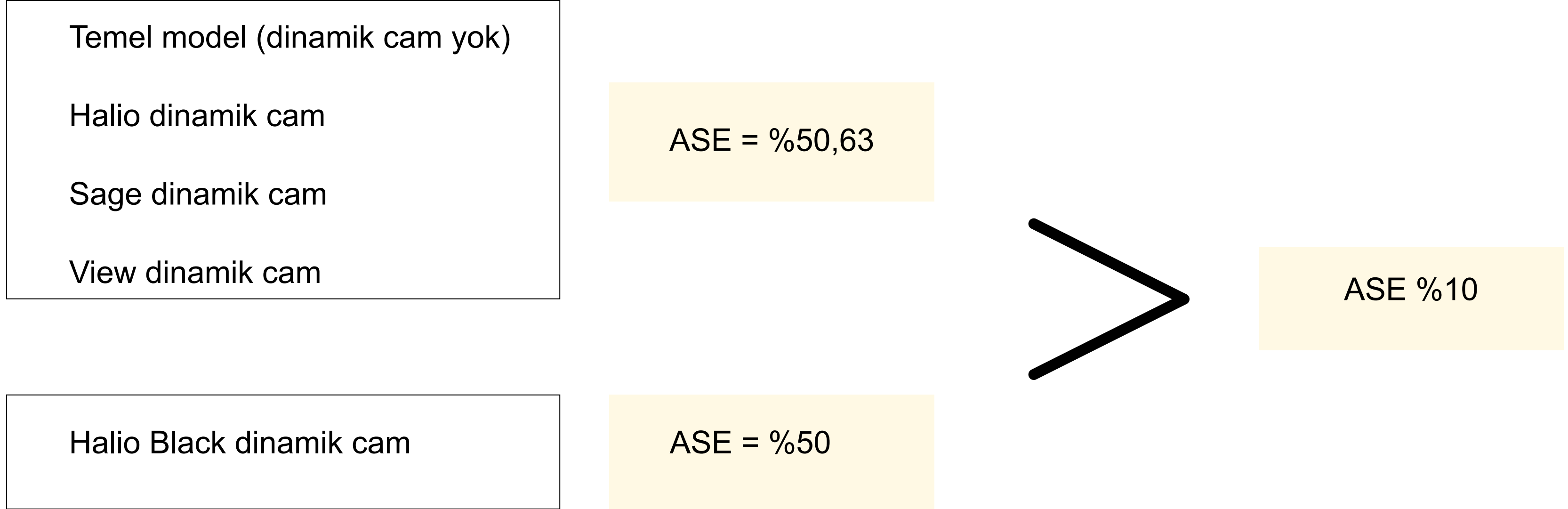
UDI.a'da en çok artış (%76,04) → Halio dinamik cam

%62,5 ile %1,5 arasında değişen
9 farklı geçirgenlik seviyesi

UDI.e'de en çok azalış (%93,42) → Halio Black dinamik cam

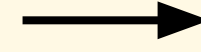
%51,3 ile %0,1 arasında değişen
7 farklı geçirgenlik seviyesi

TARTIŞMA



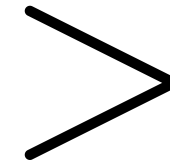
SONUÇ

En iyi UDI.a sonuçları



En çok sayıda farklı geçirgenlik seviyelerine sahip dinamik camlar

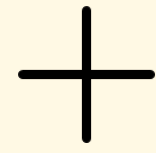
Çok sayıda farklı geçirgenlik seviyesine sahip dinamik camlar



Az sayıda farklı geçirgenlik seviyesine sahip dinamik camlar

SONUÇ

En düşük geçirgenlik seviyesine sahip cam

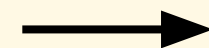


geçirgenlik seviyesinin diğerlerine göre daha uzun kullanımı

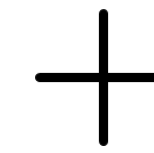


ASE sonucunda iyileşme

UDI.a'da iyileşme olmasına rağmen ASE'nin üst eşiği aştığı durumlarda



dinamik cam



 gölgeleme elemanı

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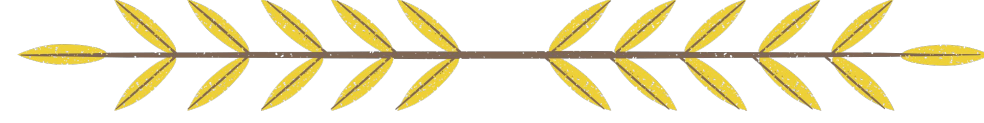
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ETUK
2023

XI. ULUSAL AYDINLATMA SEMPOZYUMU, 2 KASIM 2023, İZMİR

İLGİNİZ İÇİN TEŞEKKÜR EDERİZ



DİNAMİK CAM UYGULAMASININ GÜNIŞİĞİ VERİMİNE ETKİSİ:

İZMİR YÜKSEK TEKNOLOJİ ENSTİTÜSÜ'NDEKİ BİR DERSLİK ÜZERİNDE SİMÜLASYON ÇALIŞMASI

Doktora Öğrencisi Nurefşan SÖNMEZ

Dr. Öğr. Üyesi Arzu CILASUN KUNDURACI

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