ZEROBUILD JOURNAL

Derleme

Aslan ve ark. 02:02 (2024) 115-128

Binalar Arası Enerji Etkileşimi İçin 'Sinerji Alanı' Kavramının İncelenmesi

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Öne Çıkanlar:

- Bina doluluk oranlarına göre enerji tüketimi ve verimli kullanım stratejileri araştırıldı.
- Fakülteler, yemekhaneler ve kütüphaneler için enerji kullanımında sinerik yöntemler tartışıldı.

Geliş Tarihi: 20.06.2024   Kabul Tarihi: 25.07.2024   Doi: 10.5281/zenodo.13117627

Amaç:
Bu çalışma, üniversite kampüs binalarındaki sinerji alanlarının rolünü ve bu alanların nasıl optimize edilebileceğini araştırmayı amaçlamaktadır.

Metot:
Sinerji alanları, farklı disiplinlerden bireyler arasında etkileşimi ve iş birliğini teşvik ederek yeniliği destekleyen ortak alanlardır. Bu alanlarda esneklik, erişilebilirlik ve teknolojik ekipman entegrasyonu gibi tasarım ilkeleri incelenmiştir. Ayrıca, sinerji alanlarının enerji verimliliği üzerindeki etkileri değerlendirilmiş ve stratejik kullanımlarıyla enerji tüketiminin nasıl minimize edilebileceği araştırılmıştır. Çalışma, su ve enerji kaynaklarının verimli kullanımı, bina tipleri ve bunların enerji kullanım alışkanlıkları gibi konuları da kapsamaktadır.

Sonuç:
Bulgular, iyi tasarlanmış sinerji alanlarının kampüs yaşamının kalitesini artırarak, öğrenciler ve akademisyenler arasında etkileşim ve memnuniyeti artırdığını göstermektedir. Bu alanlar, binaların enerji verimliliğini artırmakta ve sürdürülebilirliği desteklemektedir. Çalışma ayrıca, Atatürk'ün köy-şehir projesi gibi yenilikçi girişimlerin, kırsal alanların sürdürülebilir ve kendine yeterli topluluklar haline getirilmesine yönelik çabalarını vurgulamaktadır. Bunun yanı sıra, piezoelektrik jeneratörler gibi ileri enerji çözümlerinin, genel enerji verimliliğini artırma potansiyeline sahip olduğu gösterilmiştir.

Anahtar Kelimeler: Sinerji Alanları, Üniversite Kampüsleri, İşbirlikçi Çalışma Alanları, Sosyal Etkileşim, Kampüs Tasarımı, Akademik İşbirliği, Esnek Alanlar

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Review

Aslan et al. 02:02 (2024) 115-128

Investigation of the 'Synergy Area' Concept for Energy Interaction of Buildings

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Highlights:

- Energy consumption and efficient use strategies were investigated according to building occupancy rates.
- Synergistic methods in energy use for faculties, dining halls and libraries were discussed.

Received: 20.06.2024 Accepted: 25.07.2024 Doi: 10.5281/zenodo.13117627

Abstract

In This paper, the importance of synergy zones in university campus buildings is examined. Synergy zones are shared spaces that encourage interaction and collaboration among individuals from different disciplines, fostering innovation. These zones, created with attention to design principles such as flexibility, accessibility, and technological equipment, provide ideal environments for group work, socialization, and cultural activities for students and academics. The results demonstrate that well-designed synergy areas enhance the quality of campus life by increasing interaction and satisfaction. Energy efficiency in buildings, which entails minimizing energy consumption without compromising service quality, is also a focal point. Effective use of synergy zones can significantly impact a building's energy use, thereby improving efficiency. The article covers topics such as the design and use of synergy zones, efficient use of water and energy resources, types of buildings and their energy consumption, and innovative energy solutions like piezoelectric generators. It also touches on Ataturk's village-city project, aiming to create sustainable and self-sufficient rural communities through efficient resource management and community cooperation.

Keywords: Synergy Zones, University Campuses, Collaborative Workspaces, Social Interaction, Campus Design, Academic Collaboration, Flexible Spaces.

1. Introduction

In Türkiye, the second highest energy consumption, following industrial applications, occurs in buildings, and the potential for energy savings in buildings is around 15% of total consumption [1]

Consequently, energy efficiency in buildings has become a focal point and a primary concern of the modern era. Energy efficiency entails minimizing energy consumption without compromising the quality and quantity of production in industrial facilities or the quality of service in buildings [2]. This approach offers several benefits, including sustainability, cost savings, and reduced environmental impact. However, one of the challenges in improving energy efficiency in buildings is understanding the significant disparities between the building's intended purpose and its actual energy usage, often stemming from the activities and behaviors of the building occupants [3].

Energy efficiency in buildings can be enhanced employing Synergy Zones (SZ). SZs are an important factor that has a direct impact on a building's energy consumption. SZ, such as workspaces, meeting rooms, and recreational areas, influence the activities and energy consumption by means of occupant's actions. To improve energy efficiency in buildings, the design and use of these SZs may be employed in a strategic way.

The term synergy is defined as the state in which the sub-parts that make up a whole come together to create a greater effect than the sum of individual parts [4]. Synergy is the emergence of creativity through bringing individuals together. According to another definition, synergy is seen as "the positive energy and added value created by the combination of different talents" [5].

SZs in buildings are areas where spaces with different functions come together and provide advantages based on the interaction of users. For example, by installing gray water recovery systems in buildings, used water (sink, shower, etc.) can be purified and reused. This water can be used in garden irrigation systems or toilet flushes. Thus, clean water can be used not only as drinking water but also for other purposes, ensuring more effective and efficient use of water.

SZs enhance the user experience through the combination of various utilization; while at the same time increasing productivity, using resources more efficiently, enhancing environmental sustainability, and strengthening community ties.

SZ approach offers benefits, such as improving our creative design and planning skills, adopting user-centered approaches, encouraging social interaction, and increasing the diversity of spaces.

2. Building Typologies and Definitions

2.1. Most common buildings typologies

• **Residential Buildings**: These buildings are used for human habitation. Includes structures such as houses, apartments, villas, and residential complexes.

• **Commercial Buildings:** These are buildings are shops, offices, shopping centers, restaurants, hotels etc. These buildings are for commercial activities.

• **Industrial Buildings:** These are the buildings where production facilities, warehouses and storage areas, factories, and workshops perform their activities.

• **Education Buildings:** These building types serve schools, universities, colleges, and similar educational institutions.

• **Health and Care Buildings:** Buildings where health services such as hospitals, clinics, health centers, and nursing services are provided.

• **Social and Sports Buildings:** Buildings used for entertainment purposes such as stadiums, sports halls, theaters, cinemas, and entertainment centers.

- **Public Buildings:** Buildings where government institutions, municipalities, courts, libraries, places of worship, and similar public services are provided.
- **Infrastructure Buildings:** Airports, train stations, water treatment plants, power plants, and communication centers are buildings used for transportation and communication infrastructure.

Each type of building is built to meet specific needs. Therefore, each type has different characteristics and requirements. In this study, the types of buildings according to their intended use are summarized and discussed under these headings in general.

2.2. Types of buildings in Yalova University campus:

I. **Classrooms and Academic Buildings:** These buildings have classrooms, laboratories, faculty offices, and academic departments.

II. **Libraries** With a variety of resources, library buildings are important place for academic activities.

III. **Dormitories and Student Accommodation Buildings:** Dormitories or student apartments meet the accommodation needs of students.

IV. **Administration Building:** Rectorate building serves as management and administrative purposes.

V. **Sports and Recreation Facilities:** Facilities such as gymnasiums, swimming pools, sports fields, and fitness centers meet the sports and recreation needs of inhabitants.

VI. **Cafeteria and Dining Halls:** Where students can eat and socialize.

VII. **Art and Cultural Centers:** Where cultural activities and artistic works are carried out, such as theater halls, art galleries, music rooms, game and recreation halls.

VIII. **Health Centers:** Facilities to provide health services.

IX. **Worship Areas:** Masjids or prayer areas where students can meet their worship needs.

X. **Scientific Research Laboratories:** Laboratory buildings and greenhouses specifically designed for engineering faculty.

XI. **Storage Facilities:** Parking lots, depositories, and storage places.

XII. **Social Facilities:** Green areas, gardens, banks, career centers, community centers.

XIII. **Commercial Buildings:** Barber, tailor, stationery, and dry-cleaning buildings to meet the needs of students.

2.3. Types of buildings for Yalova University Central Campus:

The types of buildings on the main campus of Yalova University are shown in Figure 1, as seen from the satellite image. Where a, n, f, h, k, j, r, o, t, classrooms and academic buildings, r library, c administration building, y, x are sports and recreation facilities, g, v, i cafeterias and dining halls, m, and p are health center and scientific research center, ö art and culture center, e, s, w parking lots, i, z green spaces and gardens, l stationery, b represents dormitories and student accommodation buildings.

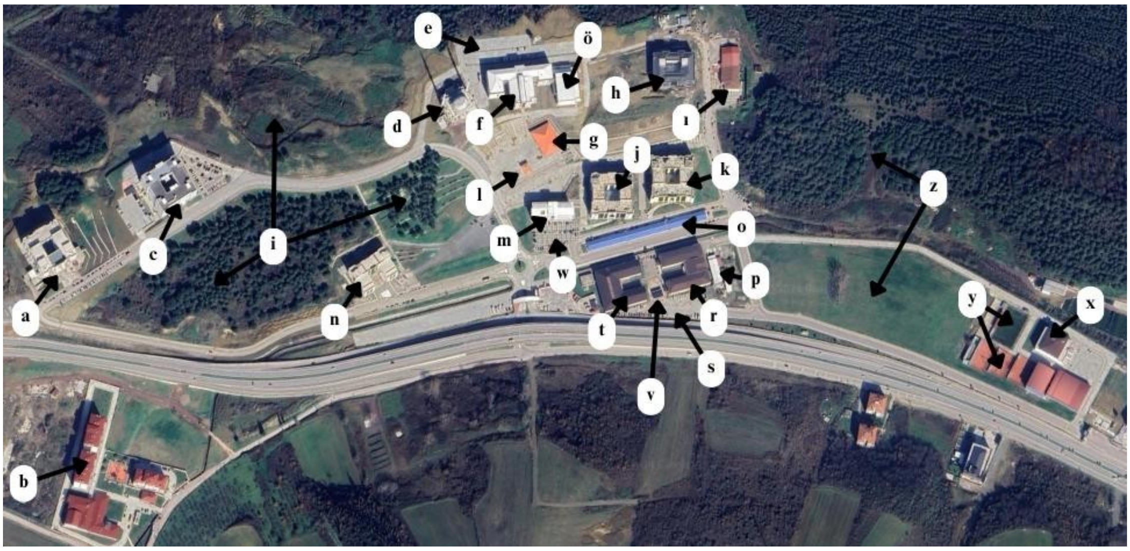

Figure 1. Yalova University Campus satellite image Buildings shown with letters in the figure letters a, n, f, h, k, j, r, o, t, classrooms and academic buildings

Table 1. Energy Related Inputs and Outputs for Different Building Types.

Building Types	Inputs in terms of Energy	Outputs in terms of Energy
Classrooms, Academic Buildings, Libraries,	Electricity, natural gas, solar energy, water, people, educational materials, internet access and food supplies	Wastewater, CO_2, used air, light, information, research, labor, plug loads, electronic waste, stationery waste, bio-waste, organic waste, glass waste and general waste
Cafeteria, Dining Halls, Dormitories and Student Accommodation Buildings	Food, kitchen equipment, cleaning items, internet access, electricity, natural gas, solar energy, water, lighting systems, heating, ventilation and air conditioning systems, furniture and equipment	Wastewater, CO_2, used air, lighting, food waste, electronic waste, paper and cardboard waste, plastic waste, glass waste, organic waste, general waste and medical waste
Art and Culture Centers	Musical instruments, art materials, electrical energy, natural gas, solar energy, water, lighting systems, heating, ventilation and air conditioning systems, stage equipment, furniture and equipment, cleaning materials	Wastewater, CO_2, used air, lighting, electronic waste, paper and cardboard waste, plastic waste, glass waste, organic waste
Sports and Recreation Facilities	Sports equipment, cleaning supplies, security systems, electrical energy, natural gas, solar energy, water, lighting systems, heating, ventilation and air conditioning systems, health and first aid supplies	Wastewater, CO_2, used air, lighting, electronic waste, paper and cardboard waste, plastic waste, glass waste, organic waste, general waste, medical waste and biological waste
Health Centers	Medical devices and equipment, medicines and medical supplies, electrical energy, natural gas, solar energy, water, lighting systems, heating, ventilation and air conditioning systems, cleaning materials, furniture and equipment	Wastewater, CO_2, used air, lighting, medical waste (infected waste, needles, pharmaceutical waste), electronic waste, paper and cardboard waste, plastic waste, glass waste, organic waste, general waste and biological waste

Building Types	Inputs in terms of Energy	Outputs in terms of Energy
Scientific Research Laboratories	Laboratory equipment (e.g. microscopes, instruments, reactors), chemicals and materials, computers and data processing systems, electrical energy, natural gas, water, solar energy, lighting systems, heating, ventilation and air conditioning systems, agricultural equipment, cleaning materials	Wastewater, CO_2, used air, lighting, chemical waste, electronic waste, glass waste, paper and cardboard waste, plastic waste, organic waste, general waste, agricultural products, organic food
Social Facilities	Landscaping and maintenance materials, electrical energy, lighting systems, heating and cooling systems, seating, computers and technological equipment, cleaning materials, playground equipment	Used air, waste from maintenance and landscaping of green spaces, community services, recycling waste and garbage

3. Synergetic Applications

3.1. Staff and Student Synergy on University Campuses:

University campuses are essential for developing academic knowledge, social and professional skills, and strengthening personal and social ties. Synergistic management can enhance these aspects by encouraging teamwork, interdisciplinary cooperation, and strategic alliances, leading to efficient resource use and stronger results in both academic and social fields [6, 7]. Creating synergy areas and strategic plans helps campuses address their strengths and weaknesses and achieve their long-term raison d'être [8]. Tools like co-working spaces, mentoring programs, interactive seminars, social events, digital platforms, joint projects, and community services can strengthen campus synergy, contributing to a more connected and supportive community. University administrations should promote these initiatives to maximize the potential of students and staff.

3.2. Implementation of the Village-City Project on University Campuses:

Increasing industrialization in Türkiye in the 1950s led to rural-urban migration, weakening village production [9]. Because of this village-oriented projects aim to transform villages into centers of education, culture, and industry, making villagers educated, social, cultured, and productive, using modern agricultural methods were proposed [10]. Another goal of the project was to reduce the rural-urban divide by increasing income, welfare, and livability in rural areas [11].

The Village-Cities model combines urbanization and industrialization concepts to meet the social, cultural, economic, and public needs of rural populations. It aims to raise living standards and ensure sustainable development in rural regions [11]. The project was first proposed by Ataturk as Village-City project. Atatürk's village-city project also focused on creating synergies in water and energy fields, promoting efficient and shared use of resources and fostering cooperation among villagers.

Examples of water and energy synergies include:

I. Common Water Resources and Irrigation Systems:

- Coordinated irrigation using shared water resources for equitable distribution and efficient irrigation.
- Rainwater collection systems to diversify and efficiently use water resources.

II. Collective Energy Production and Consumption Systems:

- Solar panels for communal energy production used by homes, schools, and other village buildings.
- Biogas plants utilizing agricultural and livestock waste for energy, integrating waste management and energy production.
- Wind turbines to meet some energy needs from renewable sources.

III. Joint Infrastructure Projects:

- Communal water treatment plants providing clean, safe water and improving sanitation.
- Modern electricity grids ensuring efficient energy distribution and reducing energy costs through communal use.

IV. Education and Awareness Raising:

- Sustainability training to increase awareness of efficient water and energy use, enhancing resource sustainability.

V. Cooperatives and Community Participation:

- Establishing water and energy cooperatives for active village management, fostering cooperation and responsibility.

These synergies applications aim to make villages self-sufficient and sustainable, improving economic development and quality of life by encouraging efficient and sustainable resource use in line with Atatürk's village-city project. This model exemplifies the CSZs approach by integrating shared infrastructure projects, renewable energy, and community participation to improve resource use and quality of life.

3.3. Implementation of Village City Projects on Campuses and Potential to Create Synergy Zones:

Creating SZs on campuses can create positive impacts in many areas such as education, sustainability, social participation, and economic benefit. These projects allow universities to integrate with society and contribute to regional development in line with their mission.

I. Education and Research Opportunities: A well designed project may provide application opportunities in agriculture, ecology, sustainable development, and rural sociology.

II. Sustainability and Environmental Awareness: Waste management and energy efficiency projects may implemented.

III. Community Engagement and Social Responsibility: These projects enable universities to collaborate with local communities.

IV. Economic Benefit: Compact campus project can contribute to the local economy.

Recycling food scraps as food for animals not only reduces the amount of waste but also ensures that animals are fed in a healthy way. Converting leftover food waste into biomass is an important step for the environment. Biomass energy production reduces the amount of waste by using organic waste as an energy source and provides a renewable source of energy production. These methods can be an effective strategy to increase the sustainability of campuses.

3.4. Utilizing Human Resources for Energy Conversion

Piezoelectric generators are based on the ability of piezoelectric materials to convert mechanical energy into electrical energy. This feature offers opportunities for renewable and sustainable energy applications through power harvesting and self-sufficient smart sensors in buildings [12]. Aqsa states that piezoelectric materials placed under pavement can generate large amounts of electricity during the movement of vehicles, influenced by vehicle suspension [13]. This can also applied University campuses to several places to convert students movements into electrical energy.

3.5. Building occupancy and energy consumption:

Occupancy detection in buildings is commonly achieved by monitoring indoor CO2 levels or using passive infrared (PIR) sensors. Occupancy can also be detected using CO2, lighting, temperature, humidity, and presence sensors [14]. In Ref. [14], occupancy counting was done using both occupancy sensors and Wi-Fi access points in an office building. The maximum occupancy detected by camera-based sensors was higher because not everyone connects to Wi-Fi throughout the day. At lunchtime, Wi-Fi data showed a greater decrease in the number of people compared to camera-based sensors, as devices remain connected even when individuals leave the area.

Another study compared hourly electricity and Wi-Fi data for various facilities such as offices, laboratories, health centers, and libraries [3]. These comparisons showed changes in energy consumption and internet usage at different times of the day, providing insights into usage patterns and activity levels. Variations in Wi-Fi data for offices, laboratories, and health centers typically matched expected occupancy patterns, with increases in the morning, slight decreases at lunchtime, stabilization during working hours, decreases towards the evening, and flatter profiles on weekends.

This does not show a synergy between Wi-Fi and energy consumption but there is a correlation between them.

3.6. The Impact of Occupancy Rates on Electricity Consumption in Campus Buildings:

The rising use of electric energy and the increasing demand for energy have made energy conservation imperative. Decreasing energy intensity, escalating efforts in energy efficiency, and fostering public awareness all fall within the scope of energy strategy, encompassing the initiation and sustainability of energy efficiency endeavors [15]. Studies have indicated that there is a stronger correlation between building occupancy rates and electricity usage than occupancy rates and thermal loads [15].

In the morning, when the building occupancy rate increases, socket loads increase, and at noon, when the occupants leave the building, socket loads decrease. After working hours, the occupancy rate drops to zero and socket loads return to the building occupancy rate.

The electricity consumption and occupancy profiles of two different campus buildings are studied in Ref. 15. This study presents that there is a difference in electricity consumption because of occupancy levels between the two buildings.

3.7. System Design for an Efficient Lighting System Installation:

I. **Architectural Design:** Designs where the building can make maximum use of daylight, where living spaces can benefit the most from daylight, and even lighting channels that transfer the light falling on the exterior of the building to the interior environment are used.

II. **Basic Lighting Project:** Lighting products that are suitable for the intended use of the space and provide the required minimum light intensity in the desired area should be selected.

III. **Lighting Automation:** From the simplest control logic to the most detailed one:

IV. **Control with Motion - Presence Detector:** Determining whether the space is in use or not and turning off the lighting after a certain period of time if it is empty. Especially when presence detectors are used, even very small hand movements on the table can be detected and an accurate occupied-unoccupied analysis can be made. Self-detector luminaires are the simplest and most common application area.

V. **Time Program Control:** Automatic control of luminaires without the need for human intervention according to the usage times of the space, holidays, working hours, and shifts.

VI. **Control by Light Intensity:** Depending on the light coming from the windows at different points of the space, some luminaires are dimmed and turned on to ensure equal illumination at every point of the space and maximum use of daylight. Operating the perimeter lighting according to the day-night situation.

VII. **Combined Control:** The use of different control types together for maximum efficiency. For example, turn-off the system if there is no movement in a place with dimmer control based on light intensity or if it is a holiday [16].

3.8. Methods of Effective Use of Water:

When the sectoral distribution of water is analyzed, it is seen that urban consumption accounts for 16% of water use. When the water used in residences is analyzed, it is seen that the water used in showers and bathrooms and reservoirs are proportionally high. In public areas, it is known that water is mostly consumed in reservoirs and sinks [17].

Various strategies and practices are used to use water effectively, reduce water consumption, and protect water resources. Examples of these can be given as follows:

- Rainwater collection.
- Natural landscape applications.
- Recycling and reuse.
- Consumption reduction and resource conservation.

3.8.1. Use of gray water:

Graywater refers to the reuse of water discharged from baths, showers, washing machines, and sinks (domestic wastewater excluding septic tank effluents) for irrigation and other water conservation applications. It accounts for 75% of domestic wastewater by volume and is the least polluting in terms of pollution. Since graywater is rich in organic matter, it is envisaged to be used for irrigation water and groundwater recharge [18].

Graywater should not be stored for more than 24 hours. This is due to the risk that the water is not biologically safe and needs to be treated carefully to minimize possible contamination risks due to its constantly changing content [18].

A gray water recovery system is a system that collects and stores gray water and provides a continuous supply of high-quality domestic water by reducing the amount of organic matter and making it healthy.

The size of the gray water recovery system should be considered separately in the calculations depending on variables such as the characteristics of the place where the system will be installed, water demand, and the amount of gray water. In this way, the size of each system is determined [19].

3.8.2. Stormwater:

Rainwater is the water that accumulates on natural or artificial surfaces after rainfall and usually flows into the sewer system or natural waterways. In cities and other urban areas, rainwater is usually collected from impervious surfaces such as the roofs of buildings, roads, and sidewalks and transported through drainage systems. The basic method of rainwater harvesting is to collect the water during rainfall from less permeable surfaces in the desired area with a slope. Stormwater management includes various infrastructure and practices to prevent flooding, protect water quality, and manage water resources sustainably [20].

In Figure 2, the wastewater storage system is depicted with two main components: "sanitary sewer" and "storm drain." The sanitary sewer system is responsible for collecting and managing domestic and industrial wastewater for biological treatment and purification processes. This system ensures that wastewater is treated and discharged without harming the environment. On the other hand, the storm drain system collects and directs surface runoff and excess water resulting from rainfall. This drainage system helps reduce the risk of flooding by directing the natural flow of water and protecting infrastructure. Figure 2 illustrates how these two systems are structured.

3.9. The Green Shield:

A green shield is a system that increases energy efficiency, improves air quality, and adds aesthetic value by growing plants on the exterior walls of buildings. This system contributes to energy efficiency by providing shading by preventing heat fluctuations on the wall surface in summer, thus reducing energy consumption for air conditioning; and by increasing thermal insulation in winter, reducing energy consumption for heating [22]. Efe found a significant energy saving of 48 MWh and CO_2, emission reduction in his green facade simulation study for a university building [23]. The differences between a traditional wall facade and a green facade are illustrated in Figure 3. Green facades provide natural insulation through plants. These plants help cool the building during the summer and provide insulation during the winter, contributing to energy savings. Unlike traditional wall facades, green facades are effective in regulating the indoor temperature, thus enhancing comfort and reducing energy costs.

4. Results

The analysis of elevation and water channels obtained from satellite images of Yalova University's main campus reveals significant impacts on the design and functionality of SZs. The distribution of elevation on the campus affects water flow accumulation and direction, thereby shaping the use of SZs, particularly in regions with steep inclines where water accumulation plays a crucial role in water management and functionality. The distribution of water channels within the campus, in relation to existing water management systems, also influences the effective use and design of SZs. Consequently, it is essential to optimize these areas in accordance with the physical characteristics of the campus. The findings provide valuable insights into how physical features can be leveraged to enhance the performance of SZs in campus design.

Figure 2. Wastewater storage system [21].

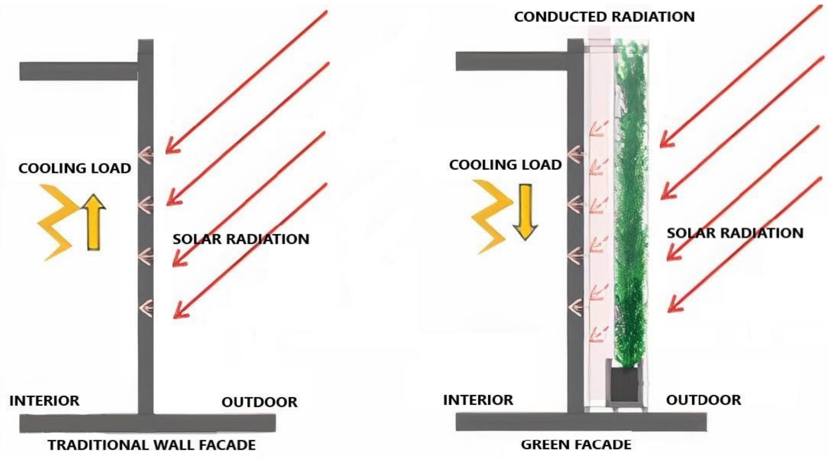

Figure 3. The difference between a traditional wall facade and a green facade. [24]

- Generating electrical energy from gym vibrations is possible using piezoelectric generators, which produce an electrical charge under mechanical stress. These generators can convert vibrations from gym equipment and exercisers' steps into electrical energy. The harvested energy can be fed directly into the building's electrical system, supplementing the existing energy supply for indoor consumption.

- Bicycle stations installed across the campus can also generate electrical energy. Pedaling bicycles collects and stores energy for use in campus facilities. To motivate students, a reward system, such as offering meal vouchers for a certain amount of cycling time, can be implemented. This energy can then be utilized in faculties or other campus areas.

- Works of Landscape department of the University may provide a green shield covering the exterior surfaces of buildings with the green shield application create a natural insulation layer, protecting the interior from external weather conditions. This reduces energy consumption by reducing heat exchange inside the building. Especially in summer, the shade of the plants protects the building walls from the effects of the sun's rays and keeps the internal temperature of the building low. In winter, the plants minimize heat loss by reducing the wind effect. In this way, green walls act as a natural shield for the building and provide significant savings on energy bills.
- Water management strategies, together with the integration of innovative practices such as gray water recycling, offer an important opportunity for sustainable building management. By storing gray water from faculties and dormitories, recycling and using gray water can minimize environmental impacts by reducing water consumption as well as saving energy. The water obtained contributes to the efficient use of water for green facade application; garden, greenhouse, landscape irrigation.
- In a university campus, the buildings that are used 24 hours a day are identified and these buildings are positioned close to each other at the entrance of the campus. Thus, the paths to these buildings are primarily illuminated with appropriate lighting methods. These designs can be an approach that will save energy and increase security.
- As it gets dark early in the winter, the shared use of dining halls and dormitory cafeterias on a university campus can be an important step, especially in terms of energy efficiency. The need for lighting can be reduced and energy costs can be lowered. The lighting systems used in both the dining hall and dormitories can be planned and managed more effectively by managing them from a single center.
- Effective use of the building by creating a mobile appointment system in the library, study areas, and social activity areas can enable students to use campus resources more efficiently. For example, in a 2-storey library building, rather than randomly distributing students and using separate lighting in each area, filling one floor completely and opening the other floor for use with an appointment system can save energy and allow for a more balanced and efficient use of library resources.
- Ice storage systems can be used to meet the need for air conditioning at low energy costs. Many university campuses use large amounts of energy to cool faculties, laboratories or gymnasiums.

5. Conclusion:

The energy efficiency and resource management initiatives carried out at Yalova University Campus have offered various solutions that promote sustainability and reduce environmental impact. Methods such as rainwater harvesting and gray water recovery have been implemented to conserve water, allowing its reuse for purposes such as garden irrigation and toilet flushing. In terms of energy efficiency, energy consumption has been managed based on building occupancy rates, and efficient use strategies have been developed. Notably, energy savings have been achieved in lighting systems through the use of motion and light sensors. Strategically applied SZs in campus design have combined different functions to encourage user interaction and collaboration, thereby improving both user experience and energy efficiency. SZs have been designed with principles of flexibility, accessibility, and technological equipment integration in mind, resulting in minimized energy consumption. Additionally, by considering the types of buildings on campus and their energy consumption patterns, more efficient resource use has been achieved and environmental impacts reduced. Overall, these efforts have successfully created a sustainable and environmentally friendly campus environment at Yalova University.

6. References

[1] M. Yılmazoğlu, A. Timoçin, A. Şenlik, K. Al, and Ü. Ünver, "Examination of Fuel Cell Cogeneration Systems for Energy-Efficient Buildings," *El-Cezerî Journal of Science and Engineering*, vol. 8, no. 2, pp. 766-781, 2021.

[2] H. Demir, G. Çıracı, R. Kaya, and Ü. Ünver, "Energy efficiency in lighting: a case study of Yalova University engineering faculty," *Uludag University Faculty of Engineering Journal*, vol. 25, no. 3, pp: 1637 – 1652, 2020.

[3] S. Zhan and A. Chong, "Building occupancy and energy consumption: Case studies across building types," *Energy and Built Environment*, vol. 2, no. 2, pp. 167-174, 2021.

[4] S. Koçak and A. Bostancı, "The role of school DNA profiles on organizational synergy," *Journal of National Education*, vol. 51, no. 233, pp. 55-75, 2022.

[5] C. Aker and A. Bostancı, "Investigation of the relationship between teachers' perceptions of organizational synergy towards their schools and their leadership levels," *Turkish Journal of Educational Studies*, vol. 10, no. 1, pp. 85-109, 2023.

[6] H. Pınar and M. Turan, "Research on the effect of synergical management practices on strategy components," *Journal of Çukurova University Institute of Social Sciences*, vol. 19, no. 2, pp. 427-449, 2010.

[7] C. C. Aktan, "Synergistic management: the effect of synergy in organizations," *Journal of Organization and Management Sciences*, vol. 4, no. 1, pp. 1-12, 2012. ISSN: 1309-8039.

[8] Z. E. Sati and O. Işik, "The synergy of innovation and strategic management: Strategic innovation," *Journal of Social Sciences*, vol. 9, no. 2, pp. 538-559, 2011.

[9] E. Güreşçi, "The phenomenon of urban-to-village migration in Turkey," *Journal of Doğuş University*, vol. 11, no. 1, pp. 77-86, 2010.

[10] C. Sarı, F. Tunç, and İ. Bulut, "Research at Uzunlar Village/Manavgat on the degree of support and participation for rural development by local people for a project to produce pistachio from turpentine trees through grafting," *Mediterranean Journal of Humanities*, vol. I, no. 2, pp. 417-425, 2016.

[11] E. Çolakoğlu, "Village-city project as a solution search for rural development problem," *ZKÜ Journal of Social Sciences*, vol. 3, no. 6, pp. 187-202, 2007.

[12] B. C. Sekhar, B. Dhanalakshmi, B. S. Rao, S. Ramesh, V. Prasad, P. S. V. Subba Rao, and B. Parvatheeswara Rao, "Piezoelectricity and its applications," in *Multifunctional Ferroelectric Materials*, Chapter 5.

[13] A. Abbasi, "Application of piezoelectric materials and piezoelectric network for smart roads," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 3, no. 6, pp. 857-862, 2013.

[14] Z. Wang, H. Tianzhen, M. A. Piette, and M. Pritoni, "Inferring occupant counts from Wi-Fi data in buildings through machine learning," *Building and Environment*, vol. 158, pp. 281-294, 2019.

[15] Y.-S. Kim, M. Heidarinejad, M. Dahlhausen, and J. Srebric, "Building energy model calibration with programs derived from electricity usage data," *Applied Energy*, vol. 190, pp. 997-1007, 2017.

[16] C. Alsat, "EEC integrated building control technologies: lighting automation and energy saving systems (In Turkish)" 2011. https://www.emo.org.tr/ekler/2a546c6b4e346c4_ek.pdf last access: 22.07.2024

[17] N. Delibaş, "Comparative examination of water efficient use strategies within the scope of sustainable architecture through the examples of Turkey and America," M.S. thesis, Trakya University Institute of Science and Technology, 2017.

[18] B. B. Beler and A. D. Allar, "ECOSAN: Ecological domestic wastewater management," *Journal of Istanbul Technical University*, vol. 17, no. 3, pp. 3-12, Nov. 2007.

[19] Y. Öcal, "Permaculture design potential in urban settlements: Burdur Karamanlı case," M.S. thesis, Gazi University Graduate School of Natural and Applied Sciences, Jan. 2020.

[20] A. E. Barbosa, J. N. Fernandes, and L. M. David, "Key issues for sustainable urban stormwater management," *Water Research*, vol. 46, no. 20, pp. 6787-6798, 2012.

[21] M. Öztürk, "Bioswales and rain gardens against flood disaster (In Turkish)" *Independent Turkish*, Oct. 1, 2022. White Paper: https://www.indyturk.com/node/558636/türkiyeden-sesler/sel-felaketine-karşı-bioswale-ve-yağmur-bahçeleri-1 Last access: 22.07.2024

[22] M. Esgil and R. Yamaçlı, "Research on green facade applications as a biophilic design approach," *Istanbul Commerce University Journal of Technology and Applied Sciences*, vol. 6, no. 2, pp. 97-113.

[23] O. Efe, "Shading of Yalova University Faculty of Engineering Building with green shield and evaluation of savings on cooling load," *ZeroBuild Journal*, vol. 1, no. 02, pp. 1-12, 2023.

[24] M. S. Abdullahi and H. Z. Alibaba, "Facade greening: A way to attain sustainable built environment," *International Journal of Environmental Monitoring and Analysis*, vol. 4, no. 1, pp. 12-20, Feb. 2016.