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Building Automation and Management Systems [BAMS] for Sports Facilities in the Gulf Region: A Focus on Impacts and Considerations

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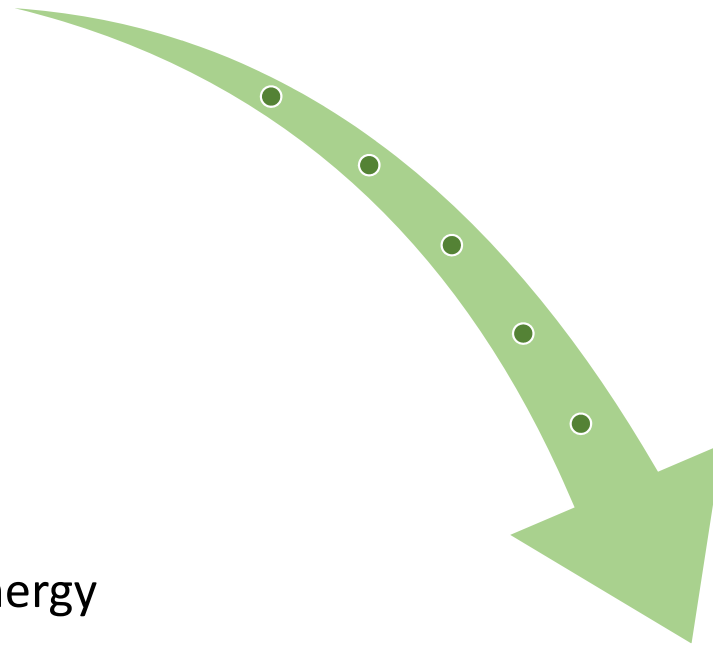
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Context

- The buildings sectors accounts for¹:
 - over one-third of global final energy consumption
 - nearly 40% of total direct and indirect CO₂ emissions
- Energy demand from buildings continues to rise, driven by:
 - improved access to energy in developing countries
 - greater ownership and use of energy-consuming devices
 - rapid growth in global buildings floor area

¹ <https://www.iea.org/topics/buildings>. Accessed on 10th of March 2021.

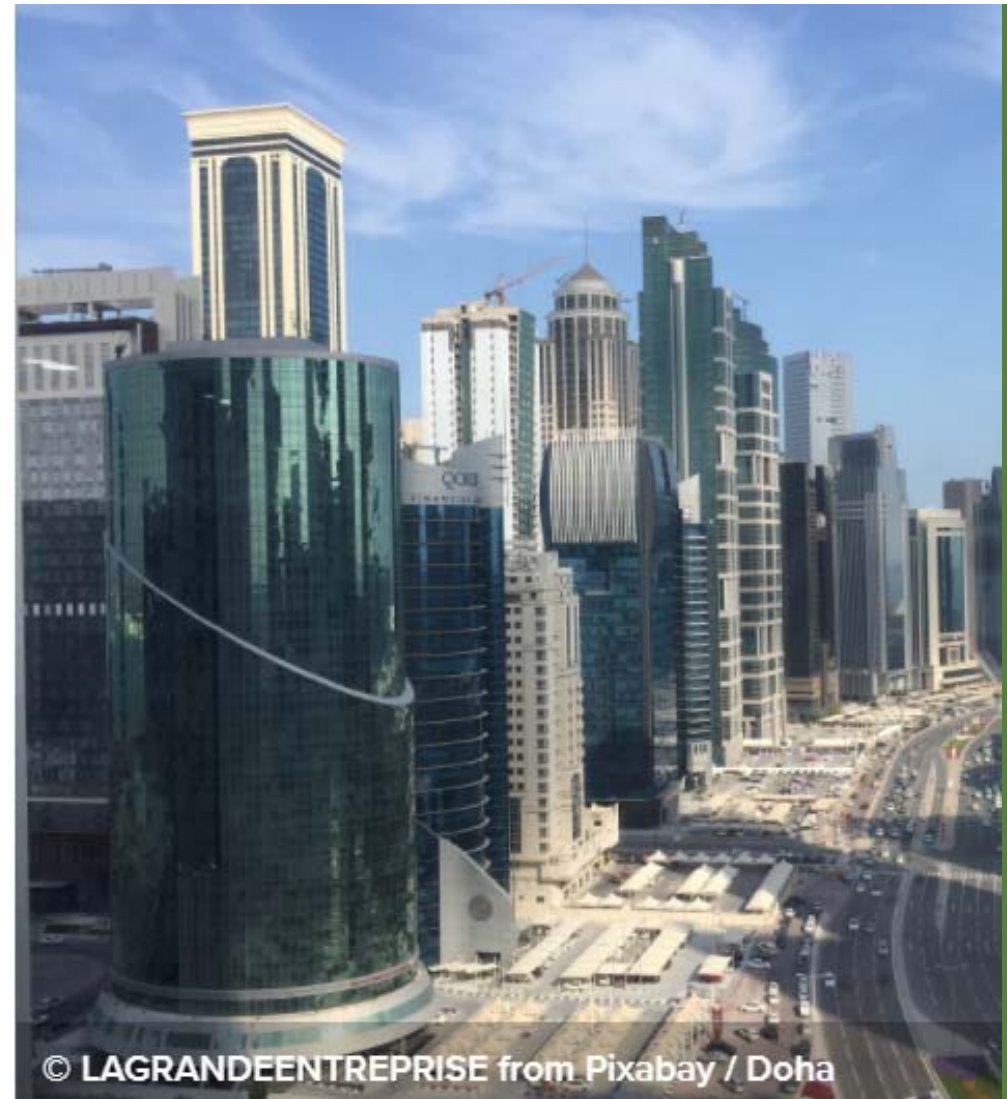


Image source: <https://www.skyscrapercenter.com/country/qatar>. Accessed on 7th of October 2021.

Context

- Mitigating to **climate change** is a key challenge of the 21st century²
- The question of energy and the great dependence on fossil fuels is a key factor
- The world urgently needs to use energy efficiently while embracing clean energy sources



² www.eea.europa.eu. Accessed on 10th of March 2021.

Image source: <https://rmi.org/financing-the-transition-from-coal-to-clean-energy/>
Accessed on 7th of October 2021

Objectives

- This work is focused on the Building Automation and Management System (BAMS) operation and the air-conditioning requirements for sports facilities
- This work aims at highlighting the significance of energy management and optimization systems in sports facilities
 - Especially for those located in hot arid climatic zones such as the Gulf region

Objectives

- The focal points of this work are:
 - The necessity of energy management and optimization in sports facilities due to:
 - The increased global energy demand
 - The global warming dilemma
 - The energy use considerations in sports facilities in hot arid regions
 - Towards developing smart solutions for energy saving and optimized management
 - The impacts and considerations related to the reliable operation and security of the BAMSs of sports facilities
 - In light of the advancements in their deployed technologies



Characteristics of sports facilities

- Sports facilities are known for their exceptional energy demand profile for the following reasons:
 - They encompass spaces involving different types of activities
 - They require extensive lighting and broadcasting requirements
 - They operate at high-occupancy seasonal rate

Image source: <https://www.mecreeled.com/much-stadium-lights-cost> Accessed on 10th of March 2021



Characteristics of sports facilities

- The capacity of football stadiums is at least 30,000 spectators on average during events
- It is estimated that the energy used in a 90-minute game is equivalent to a year worth of energy consumption of residential buildings [2]
- Inevitably, this results in increased levels of CO₂ emissions since the energy source in the Gulf region is crude oil [3]

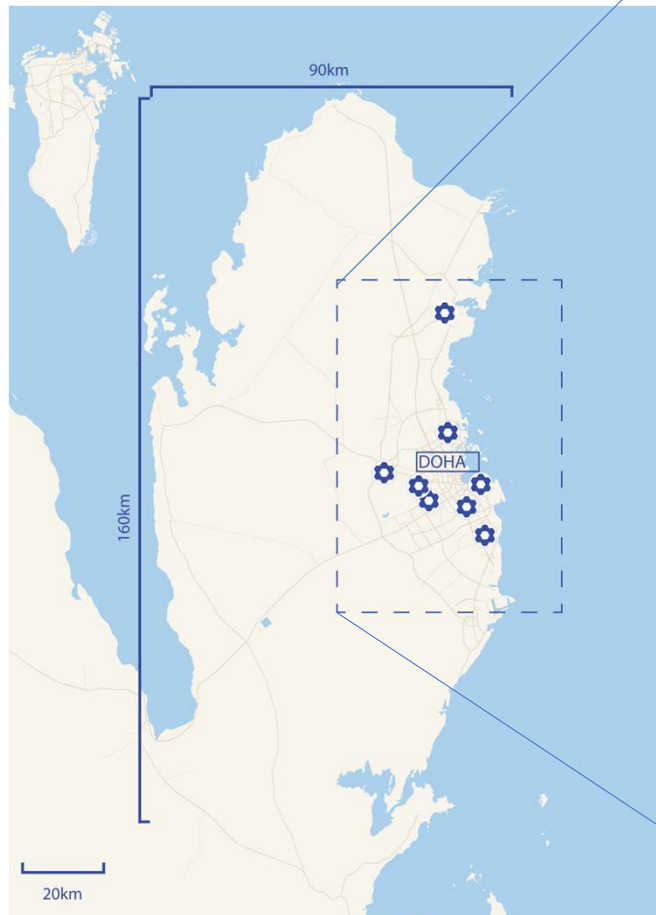
Image source: <https://www.mecreeled.com/much-stadium-lights-cost> Accessed on 10th of March 2021

Sports tourism in the Gulf region

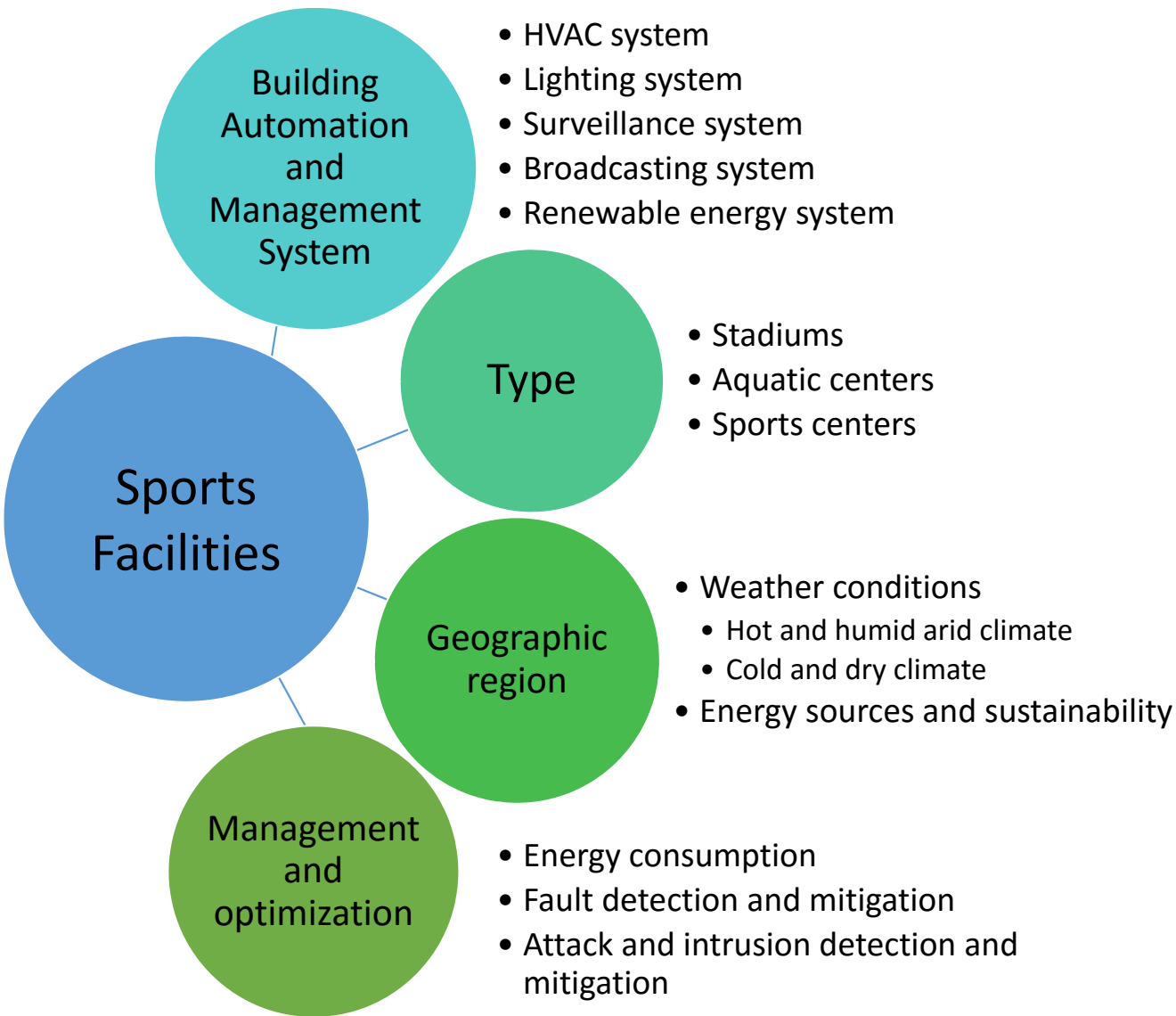
- The Gulf region has secured several mega international sport events such the FIFA World Cup 2022
- The number of sports facilities in Qatar has increased by 25% in the past decade [1]
- Many of them are equipped with outdoor air conditioning systems
- The incurred costs due to the indoor and outdoor air ventilation and conditioning is anticipated to increase given the climate of the Gulf region



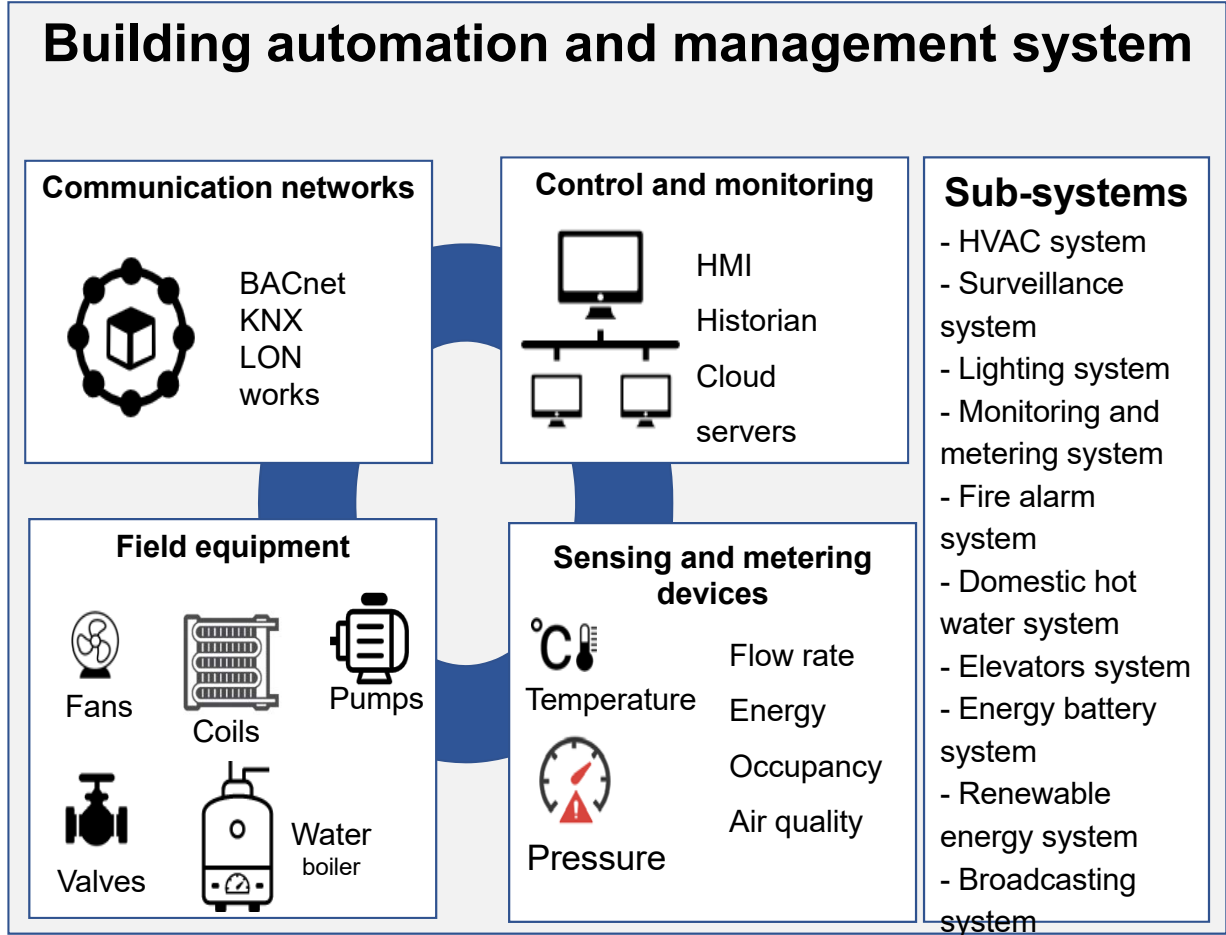
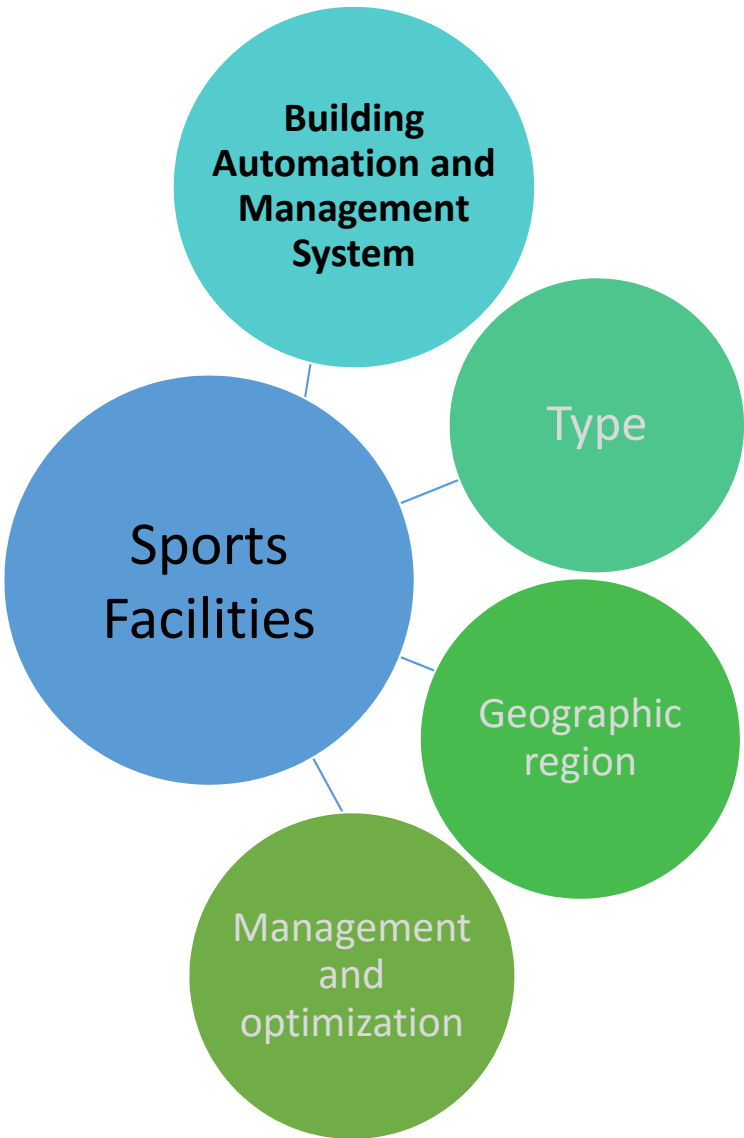
FIFA World Cup 2022 Stadiums

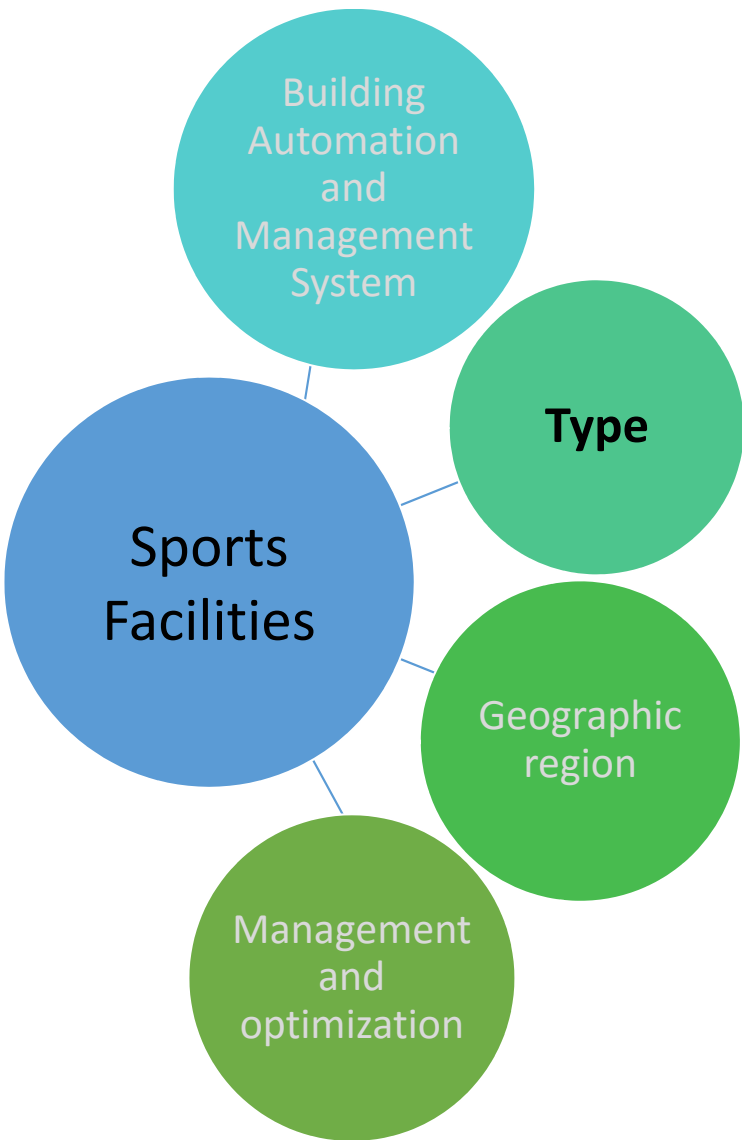


Photos are courtesies of the Supreme Committee for Delivery & Legacy



Optimization of building automation and energy management systems of sports facilities





Sports centers

Capacity: 15,000 spectators at most

Play field size: 1,000 m² at most

Types of sports: tennis, volleyball, basketball, squash, etc.

Involved activity: running, jumping, throwing, standing, hand swinging

Aquatic centers

Capacity: 15,000 spectators at most

Play field size: 1,250 m² at most

Types of sports: water polo, swimming, water volleyball, diving, etc.

Involved activity: swimming, throwing

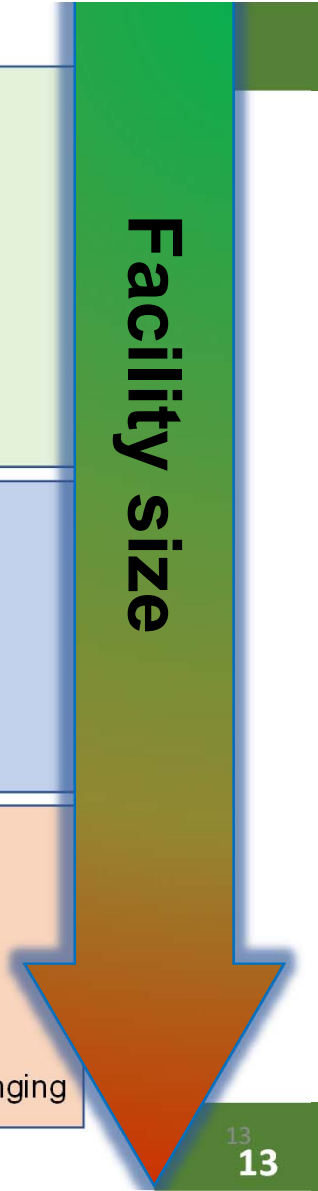
Stadiums

Capacity⁵: 120,000 spectators at most

Play field size: 6,000 m² at most

Types of sports: football, baseball, rugby, etc.

Involved activity: running, throwing, standing, hand swinging



⁵ <http://www.worldstadiums.com/> . Accessed 5th of July 2021.

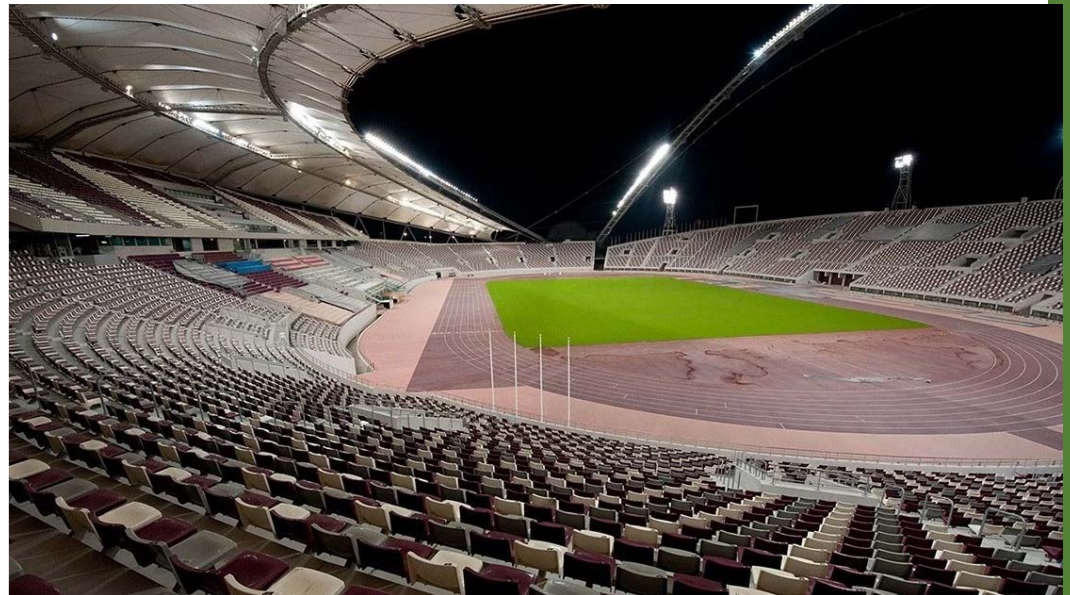
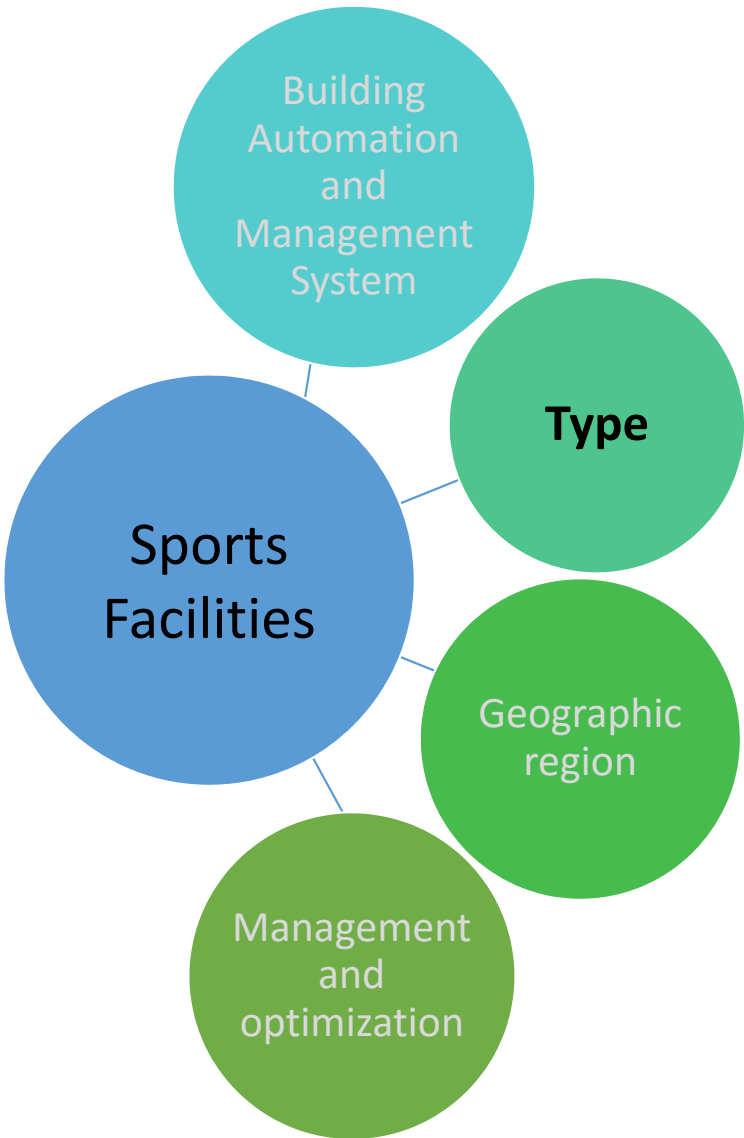
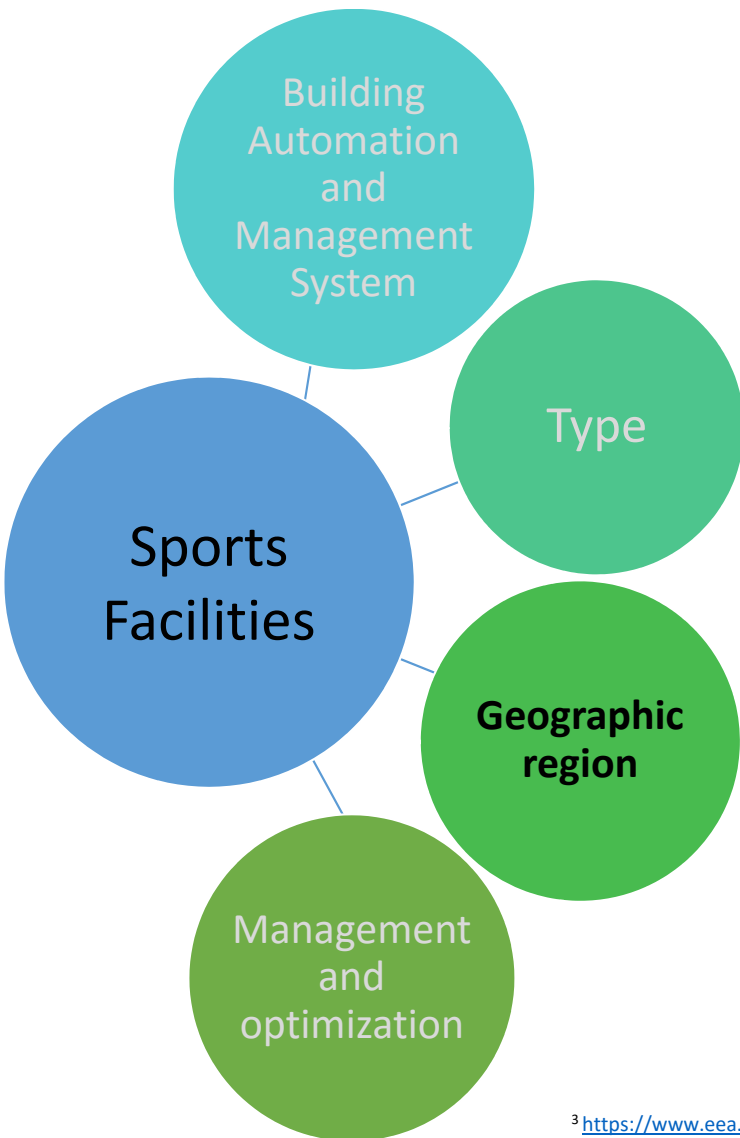


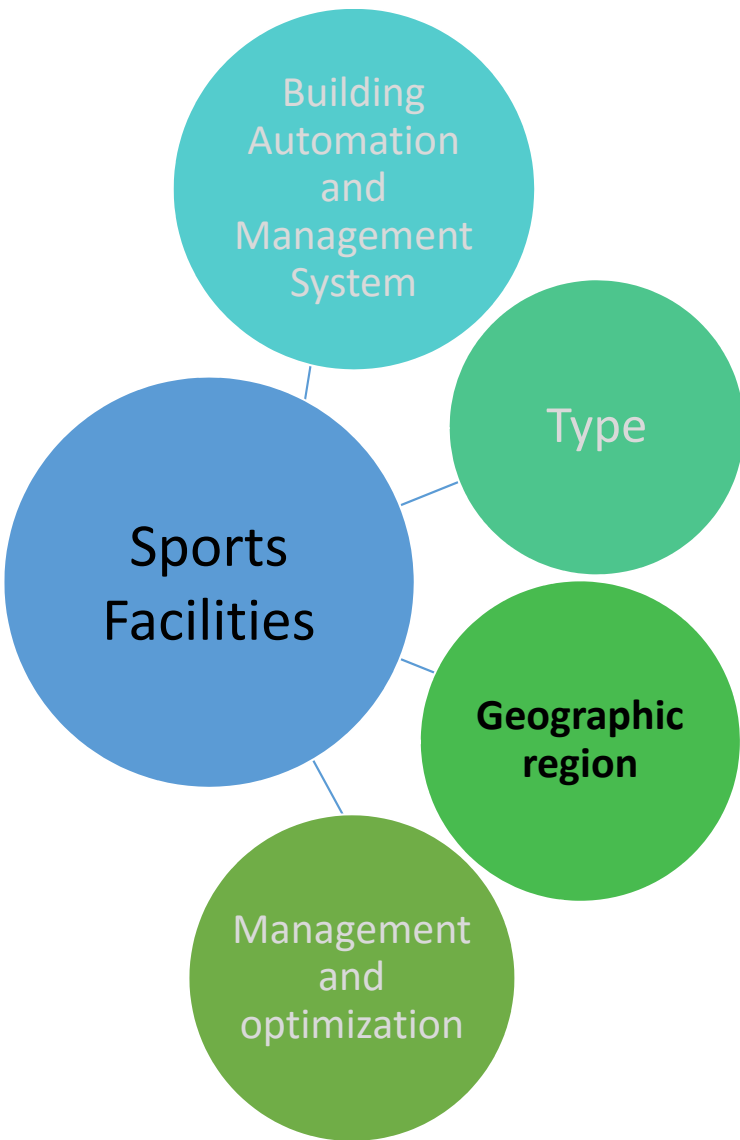
Image source: www.qatar2022.qa .Accessed on 7th of October 2021
Photos are courtesies of the Supreme Committee for Delivery & Legacy



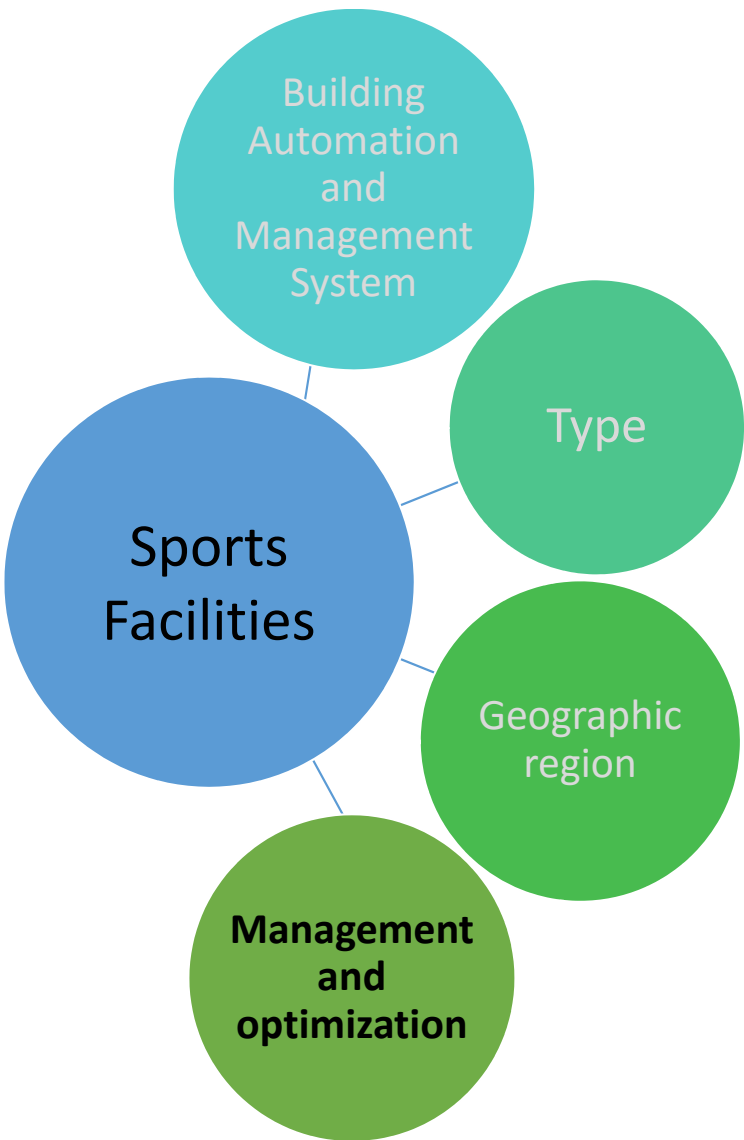
- The HVAC systems are the most extensively operated equipment and the greatest energy consumer in buildings
- For cold to average weather conditions³:
 - Heating is only required for less than 3 months of the year
 - Minimal and economical air conditioning is sufficient during the rest of it due to the fair and amiable weather conditions
- For hot arid weather conditions⁴ (e.g., the Gulf region) :
 - Extensive space cooling is required for about 9 months of the year due to the hot and humid arid climate
 - Standard air conditioning is applied for the rest of the year (i.e., winter season) to maintain air quality and ventilation requirements

³ <https://www.eea.europa.eu/data-and-maps/indicators/global-and-european-temperature/global-and-european-temperature-assessment-3>
Accessed on 29th of March 2021

⁴ <https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,doha,Qatar> . Accessed on 29th of March 2021

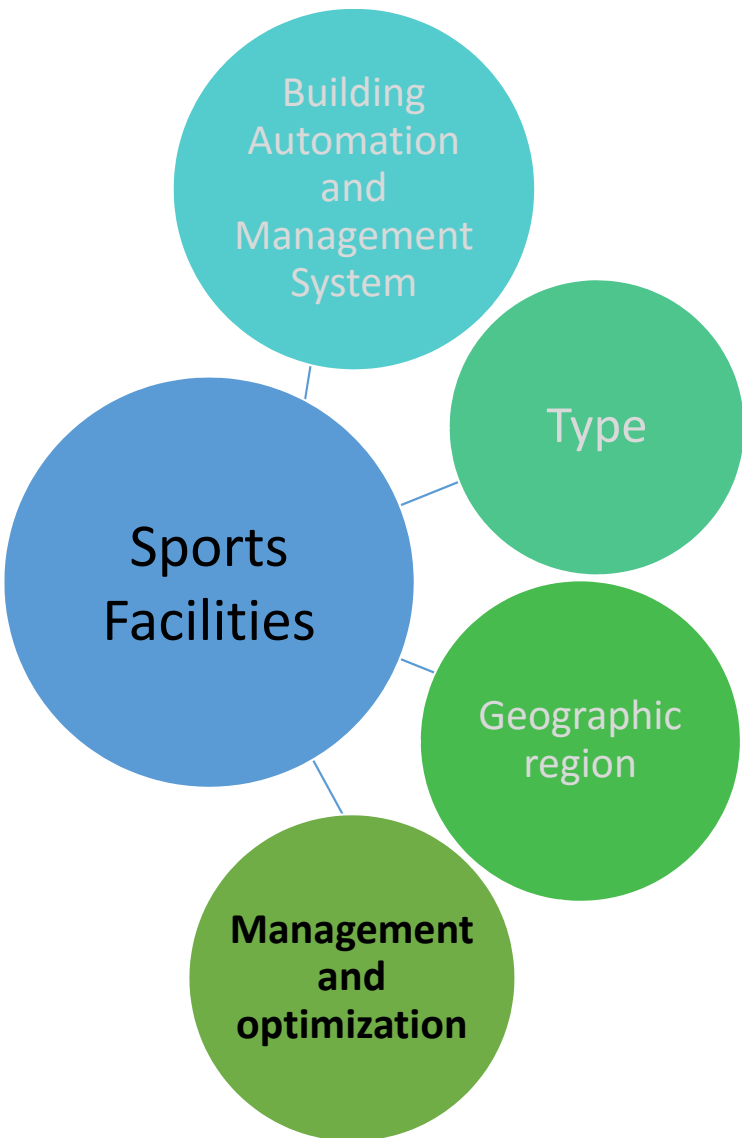


- The energy sources and their sustainability are influenced by the geographic location
- The electricity generation driving fuel is bound by the geographic region in terms:
 - the available resources
 - the technology advancement and popularity
- The Gulf region is rich in oil and gas which are mainly used for electricity generation.
 - The renewable energy plants harvesting solar power and wind power are still evolving and not yet fully harnessed



Given the increased energy demand, global warming, and the worldwide increased BAMS threats and attacks in the buildings sector, the following is crucial in sports facilities:

- Efficient energy consumption
- Reduction of CO2 emission
- Secured and successful hosting of sporting events in terms of:
 - The overall management and execution
 - Fans and athletes experience and satisfaction
 - Their safety, security, and health

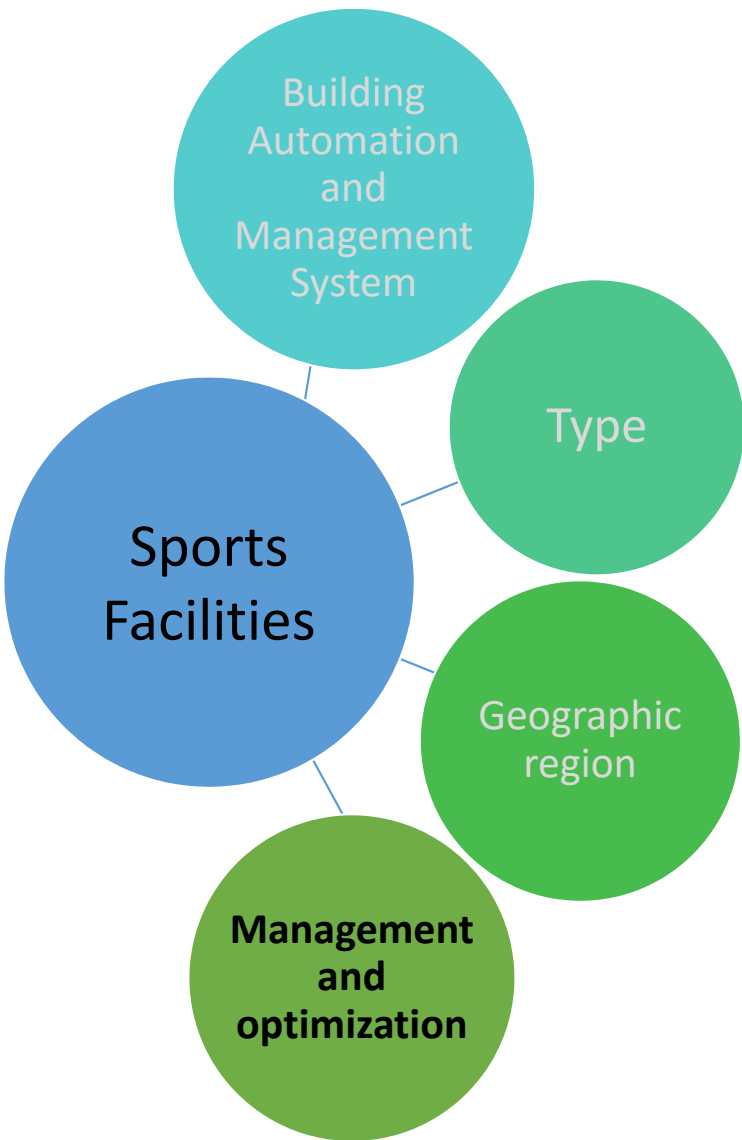


- **Energy management and optimization:**

- Sports buildings have their unique characteristics that distinguish them from other common types of buildings
- Careful attention and consideration of the characteristic features is essential, which are:
 - Energy usage profiles, occupancy levels and patterns, types of users' activity, types of systems and equipment present, and types of spaces encompassed in the building.



Image source: <https://www.gtechholdings.com/energy-optimization/>.
Accessed on 27th of September 2021

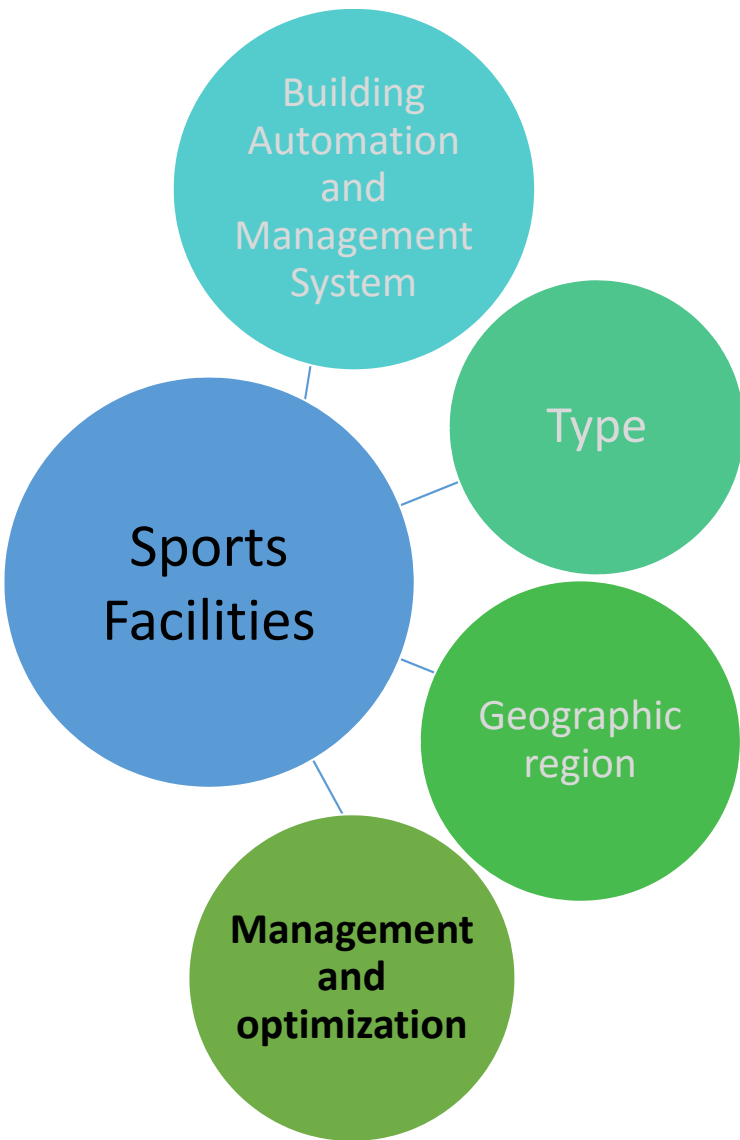


- **Energy management and optimization:**

- Several works were conducted for sports facilities using the following approaches:

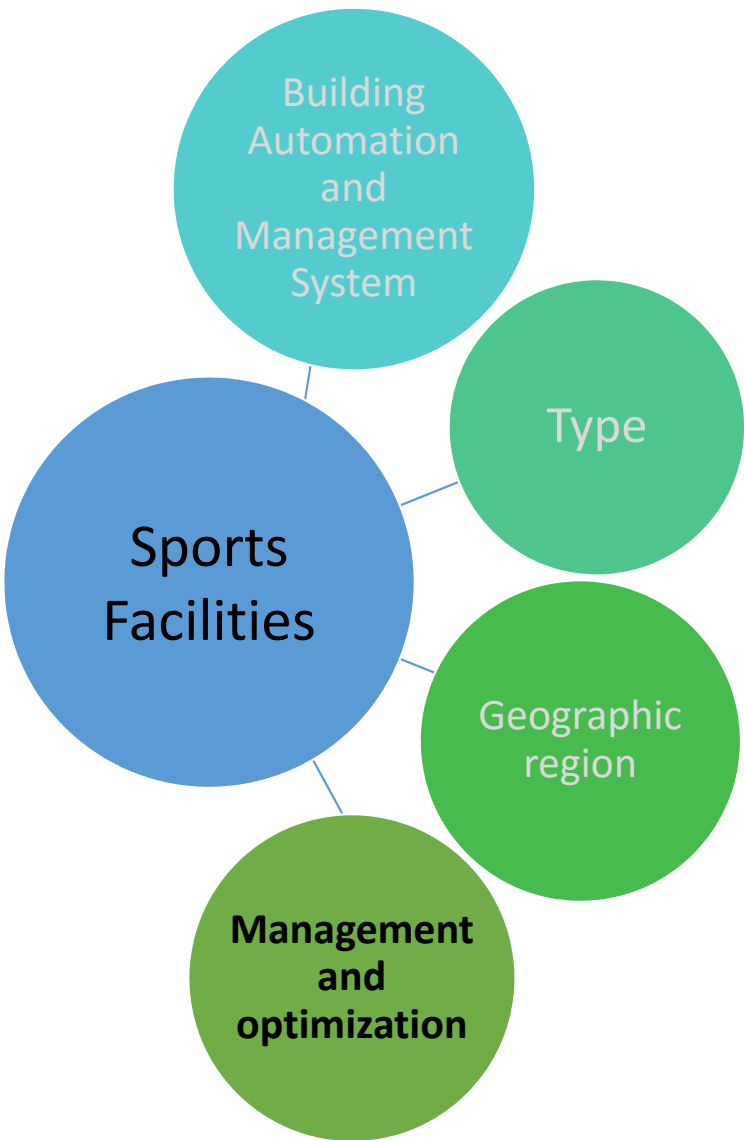
1. Computational simulation	TRNSYS, Energy Plus, Design Builder, EPS-r, IDA ICE
2. Optimization algorithms	Genetic algorithms, Particle Swarm
3. Artificial intelligence	Neural Networks, Support Vector Machine, Fuzzy logic, clustering

- Most of which were for facilities located in cold climatic regions.



- **Energy management and optimization:**

- The regional context relates to energy management and optimization of sports facilities in terms:
 - Sports recognition
 - Technologies used
 - Energy requirements
- In the Gulf region, football is the most popular and dominant sport
 - Several of football stadiums are equipped with outdoor air conditioning systems
- Additionally, investigating the use of renewable energy system in sports facilities to exploit solar and wind energy will be advantageous



- **Anomaly detection and mitigation concern:**
 - Fault detection and mitigation
 - Attack/intrusion detection and mitigation
- Anomalies can result in:
 - Reduction of the energy efficiency of the facility
 - Disruption of evacuation execution in emergency cases
 - Interruption of on-going activity due to false alarms
 - Perturbing the athletes/users' experience
 - Physical harm to users and/or athletes



Image source: <https://thedata scientist.com/anomaly-detection-why-you-need-it/>

Image source: <https://www.pandasecurity.com/en/mediacenter/security/the-goal-of-early-cyber-threat-detection/>. Accessed on 27th of September 2021

Conclusion

- An analytical review was presented for the state-of-the-art works regarding management and optimization of BAMSs in terms of:
 - Operation and energy optimization
 - Fault & attack diagnosis and mitigation
- Studies focused on the management and optimization of sports facilities are:
 - **Scarce** compared to other types of buildings
 - **Rare** for facilities located in hot arid regions compared to amiable and cold ones
- Further investigation is required for BAMSs of sports facilities in terms of **energy optimization, health monitoring system, and security systems** with emphasis on their importance for facilities located in hot arid climatic regions such as the gulf region

Recommendations

- Towards efficient and sustainable facility, the successful management and optimization of sports facilities require accounting for their special requirements and characteristics in terms of:
 - The type of BAMSs and technologies used
 - Activity and operation schedules
 - Occupancy and energy demand profiles
 - Geographic location
- The reliable and secured operation of BAMSs determines the success and prosperity of the sporting events in terms of the execution as well as fans and athletes experience and safety

Acknowledgement

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[2] Badia, J. S. (2020, November 26). How much energy does a World Cup Stadium use in 2018? Retrieved February 14, 2021, from <https://selectra.co.uk/energy/news/world/world-cup-2018-stadium-energy-use#:~:text=A%20stadium%20is%20a%20power,going%20for%20an%20entire%20year.>

[3] Triantafyllidis, S. (2018). Carbon dioxide emissions research and sustainable transportation in the sports industry. C—Journal of Carbon Research, 4(4), 57.



Thank you!

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More information about the SportE.3Q project can be found in <https://www.sporte3q.com/>