

**Programme: BSC Applied
Computing Module:
Changemakers: Creativity and
Value Creation**

Module code: ACCA5033

Lecturer: Dr Fahad Ahmed

Internal Verifier: Dr Sana Jokhio

Assignment 2: Project Management & Innovation.

Pier Paolo Penne (2336786)

Contents

Introduction.....	2
Comprehensive Project Report: Smart Campus Energy Management System	2
Task 1: Project Management	2
Q1. Project Management & Planning.....	2
Q2. Project Design	5
Element 1: System Architecture Diagram	5
Design Element 2:	7
Database Entity Relationship Diagram (ERD)	7
Task 2: Enterprise & Innovation (T2-Enterprise)	8
Q1. PEST & SWOT Analysis.....	8
PEST Analysis for Tesla, Inc.	9
Q2. Start-up Business Plan	10
Company Name: EcoSense Solutions	10
Task 3: Project Reflection	15
Conclusion	18
References	19

Introduction

This report presents a comprehensive project plan for developing a Smart Campus Energy Management System, an IoT-based solution designed to reduce energy consumption in university buildings by 25%. The project addresses the growing need for sustainable technology solutions in educational institutions while demonstrating practical applications of Internet of Things devices, cloud computing, and data analytics. Through careful planning and structured development methodologies, this system will provide real-time monitoring of energy usage, automated control of building systems, and actionable insights for facilities management.

The report is organized into three main sections. Task 1 examines project management and planning, including scope definition, timeline development, and design documentation. Task 2 explores enterprise considerations through PEST and SWOT analysis of Tesla Inc., followed by a start-up business plan for commercializing the technology. Task 3 provides a reflective analysis of skills development opportunities, societal impact, and risk management strategies. Together, these sections demonstrate both the technical feasibility and commercial viability of smart energy management solutions in modern building infrastructure.

Comprehensive Project Report: Smart Campus Energy Management System

Task 1: Project Management

Q1. Project Management & Planning

Project Scope and Proposed Solution

This project aims to develop a Smart Campus Energy Management System to reduce energy consumption in university buildings by 25% within one academic year. The solution involves creating an IoT-based monitoring system with a web dashboard that tracks real-time energy usage, identifies wasteful patterns, and provides automated controls for lighting and heating systems. IoT-based energy management systems can significantly reduce operational costs while improving sustainability in educational institutions.

Required Technologies and Resources

The project requires several key technologies:

- **Hardware:** Raspberry Pi 4 microcontrollers, DHT22 temperature sensors, current sensors, and smart relays
- **Software:** Python for backend development, React.js for frontend dashboard, MySQL database, and MQTT protocol for device communication
- **Cloud Services:** AWS IoT Core for data processing and storage
- **Development Tools:** Visual Studio Code, Git for version control, and Postman for API testing

Project Timeline and Constraints

The project spans 16 weeks with the following major phases:

1. Planning and Requirements (Weeks 1-2)
2. Hardware Setup and Testing (Weeks 3-5)
3. Backend Development (Weeks 6-9)
4. Frontend Dashboard Creation (Weeks 10-12)
5. Integration and Testing (Weeks 13-14)
6. Deployment and Documentation (Weeks 15-16)

Key Constraints:

- Limited budget of £2,000 for hardware components
- Access to university buildings restricted to specific hours
- Single developer working on the project
- Must comply with university data protection policies

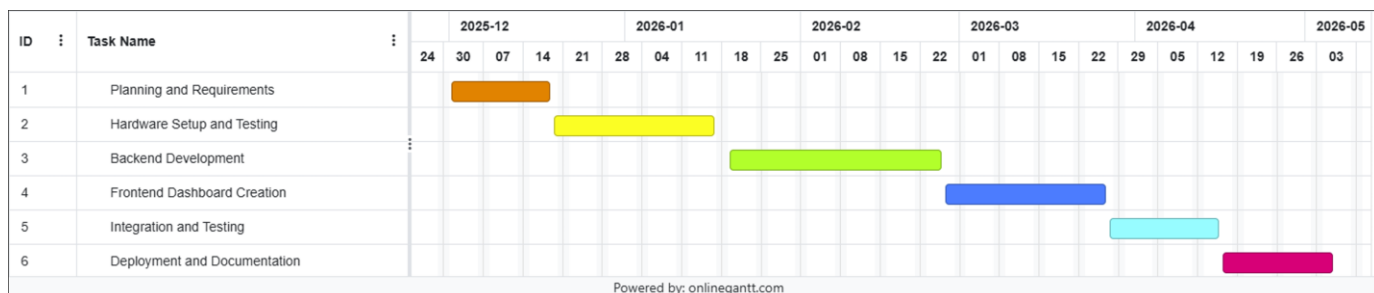


Image 1 (Gantt Chart)

	A ^B C Name	A ^B C Start	A ^B C Finish	A ^B C Duration
1	Planning and Requirements	01/12/2025	18/12/2025	14 day
2	Hardware Setup and Testing	19/12/2025	16/01/2026	21 day
3	Backend Development	19/01/2026	25/02/2026	28 day
4	Frontend Dashboard Creation	26/02/2026	26/03/2026	21 day
5	Integration and Testing	27/03/2026	15/04/2026	14 day
6	Deployment and Documentation	16/04/2026	05/05/2026	14 day

Image 2 (Gantt Chart. Days)

Development Methodology

This project will follow the **Agile Scrum methodology** [1] with two-week sprints. Agile is particularly suitable for IoT projects because it allows for iterative development and quick adaptation to hardware challenges. Each sprint will include:

- Sprint planning meetings to define goals

- Daily stand-ups (self-reflection for solo developer)
- Sprint reviews to demonstrate working features
- Sprint retrospectives to improve processes

The Agile approach allows for continuous testing of hardware components and software integration, which is essential when working with physical devices that may require adjustments.

Q2. Project Design

Element 1: System Architecture Diagram

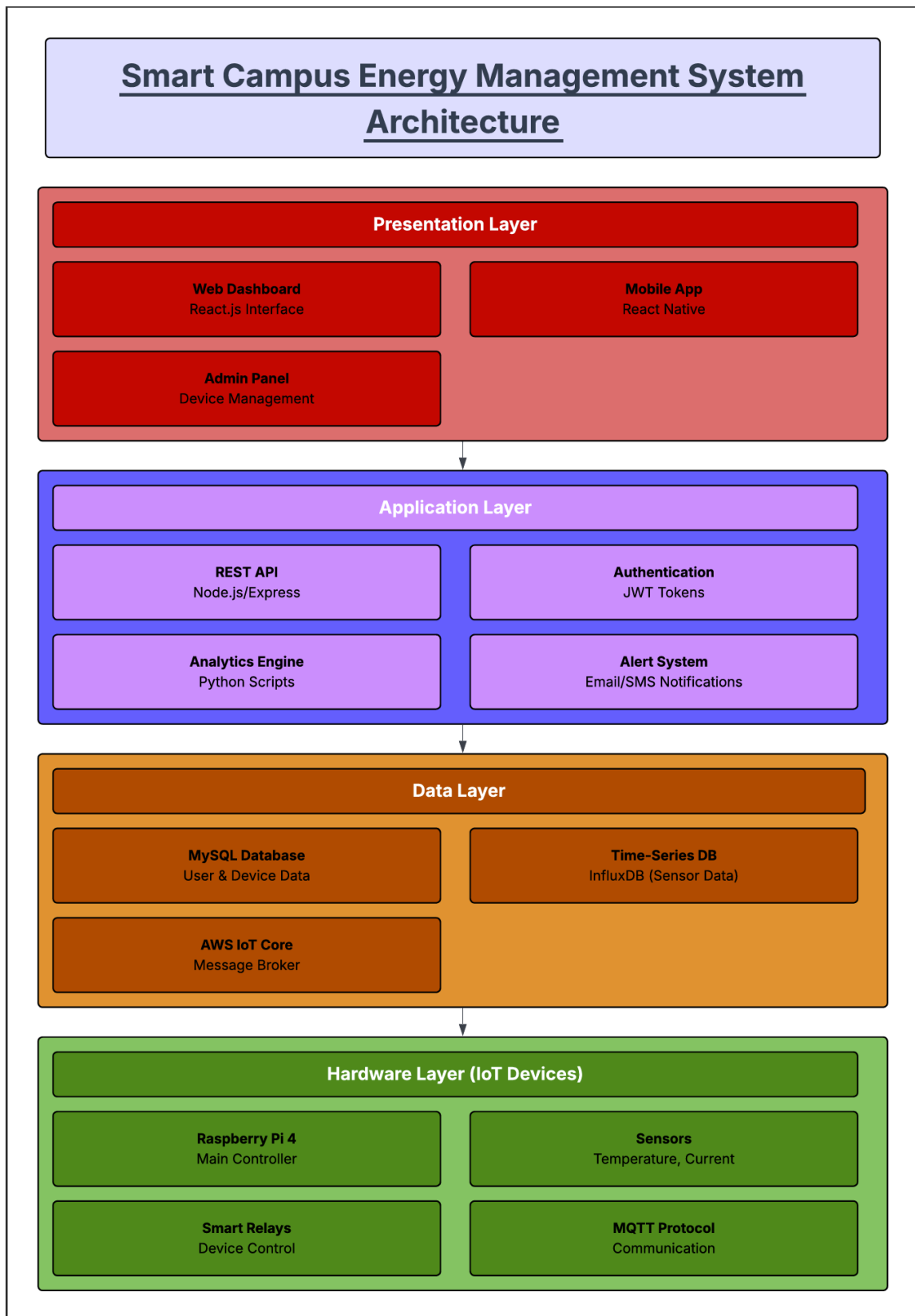


Image 3 (System Architecture Diagram)

The system architecture follows a four-layer design pattern. The hardware layer collects energy consumption data through sensors connected to Raspberry Pi controllers. This data flows through AWS IoT Core to the data layer, where it's stored in databases. The application layer processes this data and provides APIs, while the presentation layer displays information to users through web and mobile interfaces.

Design Element 2:

Database Entity Relationship Diagram (ERD)

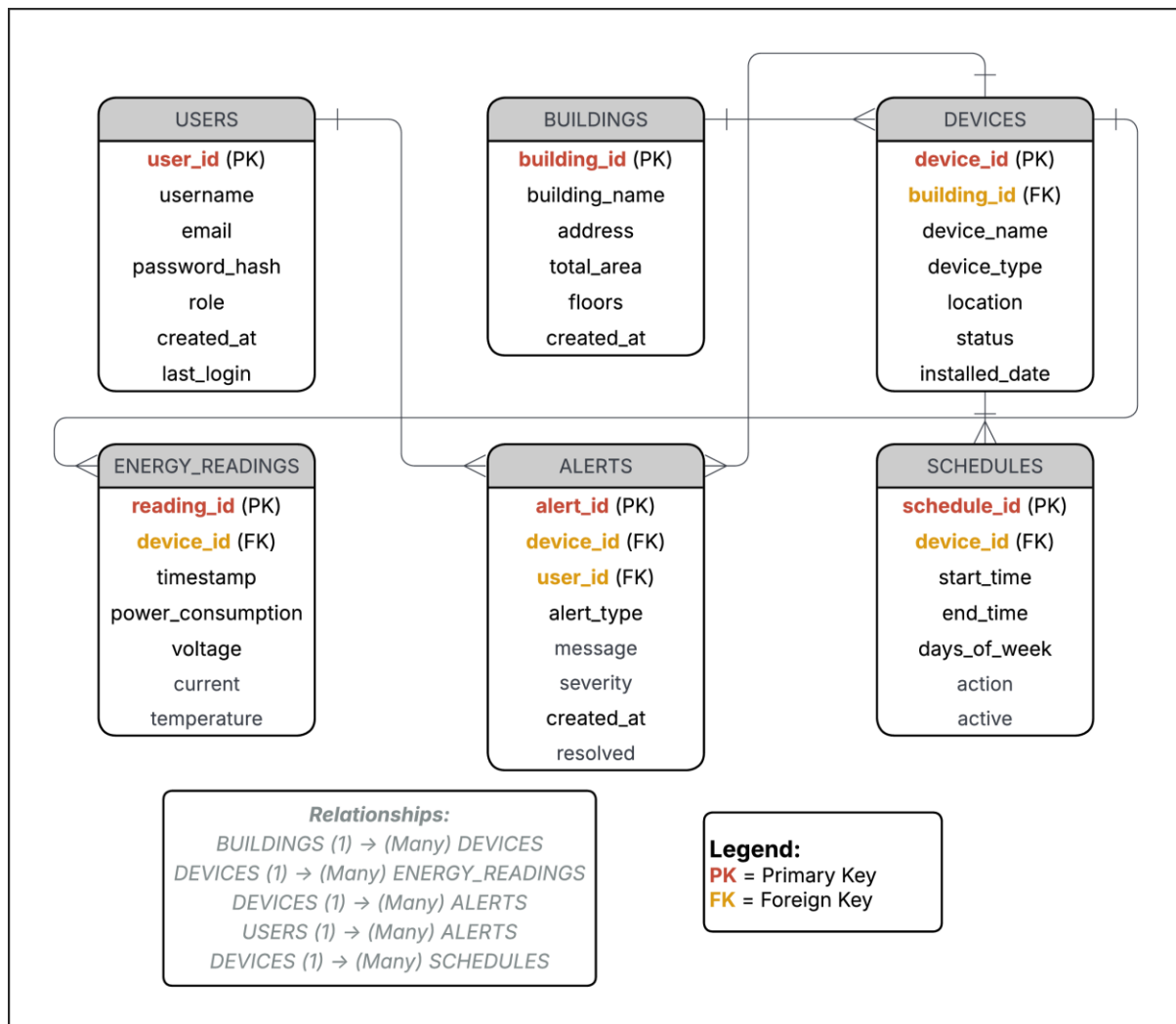


Image 4 (Crow foot ERD Diagram)

The database design includes six main tables. The **BUILDINGS** table stores information about campus buildings, while **DEVICES** stores details about sensors and controllers installed in each building. **ENERGY_READINGS** captures time-stamped consumption data, allowing for historical analysis. The **ALERTS** table manages notifications sent to administrators when unusual patterns are detected. **USERS** stores authentication information, and **SCHEDULES** manages automated control of devices based on building usage patterns.

Task 2: Enterprise & Innovation (T2-Enterprise)

Q1. PEST & SWOT Analysis

Company Selection: Tesla, Inc.

Tesla is an appropriate example for this analysis because it operates in the renewable energy and technology sector, which closely relates to the energy management focus of this project.

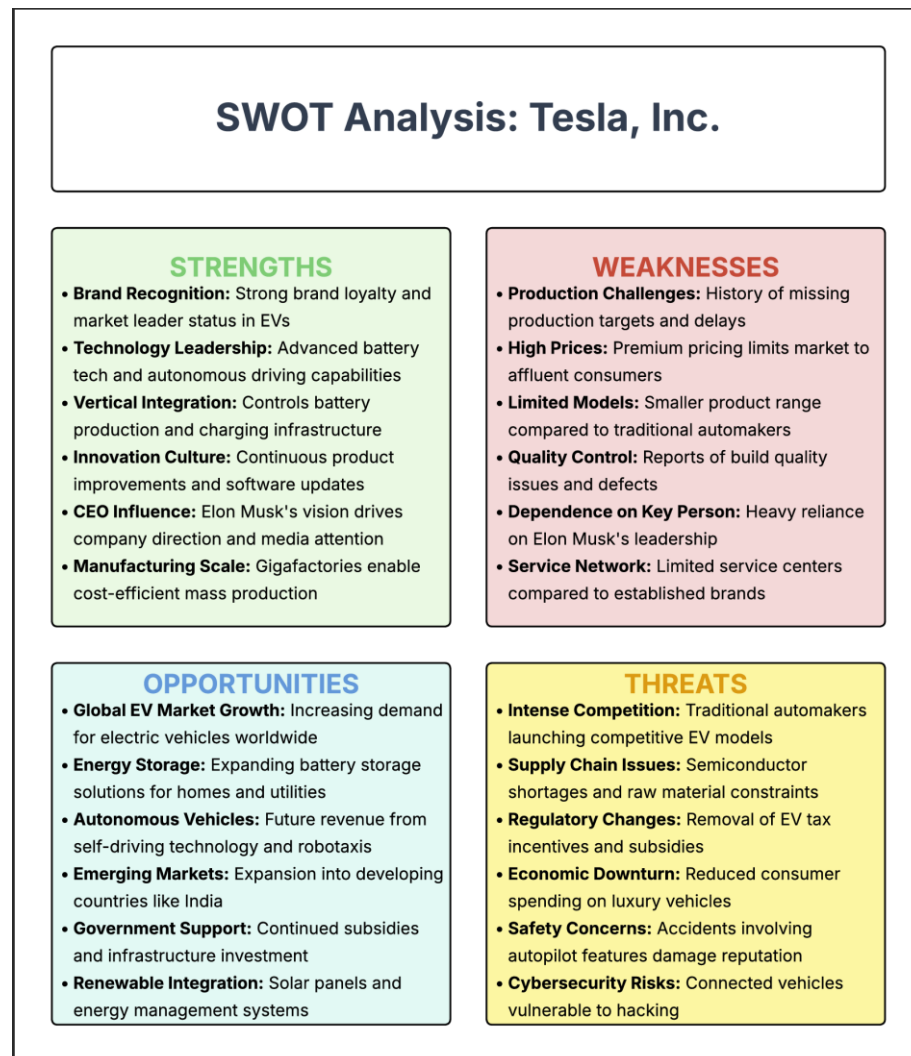


Image 5 (SWOT Analysis)

PEST Analysis for Tesla, Inc.

Political Factors

Government policies significantly influence Tesla's operations and market opportunities. Electric vehicle subsidies and tax incentives in various countries directly impact consumer purchasing decisions [6]. The US federal tax credit of up to \$7,500 for electric vehicles has been crucial for market adoption. Additionally, government mandates for carbon emissions reduction create favorable conditions for Tesla's growth. However, political instability and trade tensions, particularly between the US and China, affect supply chain operations and market access. Trade tariffs on imported components increase production costs, while differing regulatory standards across countries complicate international expansion.

Economic Factors

The global economy's transition toward sustainable energy creates substantial opportunities for Tesla. Rising fuel prices make electric vehicles more economically attractive compared to traditional combustion engines. However, Tesla faces challenges from economic downturns that reduce consumer spending on high-cost items like vehicles. Interest rate fluctuations affect financing costs for both manufacturing operations and consumer vehicle loans. The availability and cost of raw materials, particularly lithium, cobalt, and nickel for battery production, directly impact profitability. Economic conditions in key markets like China and Europe determine sales performance and overall company growth.

Social Factors

Growing environmental consciousness among consumers drives demand for sustainable transportation solutions. Younger generations increasingly prioritize environmentally friendly products, creating a favorable demographic shift for Tesla. Social media and online communities amplify brand perception, with Tesla benefiting from strong customer advocacy. However, concerns about autonomous vehicle safety and the ethics of self-driving technology create social challenges. Public perception of electric vehicle range limitations and charging infrastructure availability affects adoption rates. The status symbol associated with Tesla vehicles attracts affluent consumers but may limit mass market penetration.

Technological Factors

Rapid advancement in battery technology determines Tesla's competitive advantage. Improvements in energy density, charging speed, and battery lifespan are critical for market leadership. The development of autonomous driving technology represents both opportunity and risk, requiring massive investment in artificial intelligence and machine learning. Competition in charging infrastructure and battery technology from established automakers and new entrants intensifies. Software updates and over-the-air improvements differentiate

Tesla from traditional manufacturers. However, cybersecurity threats to connected vehicles pose significant risks, requiring continuous investment in security measures.

Q2. Start-up Business Plan

Company Name: EcoSense Solutions

Logo Design

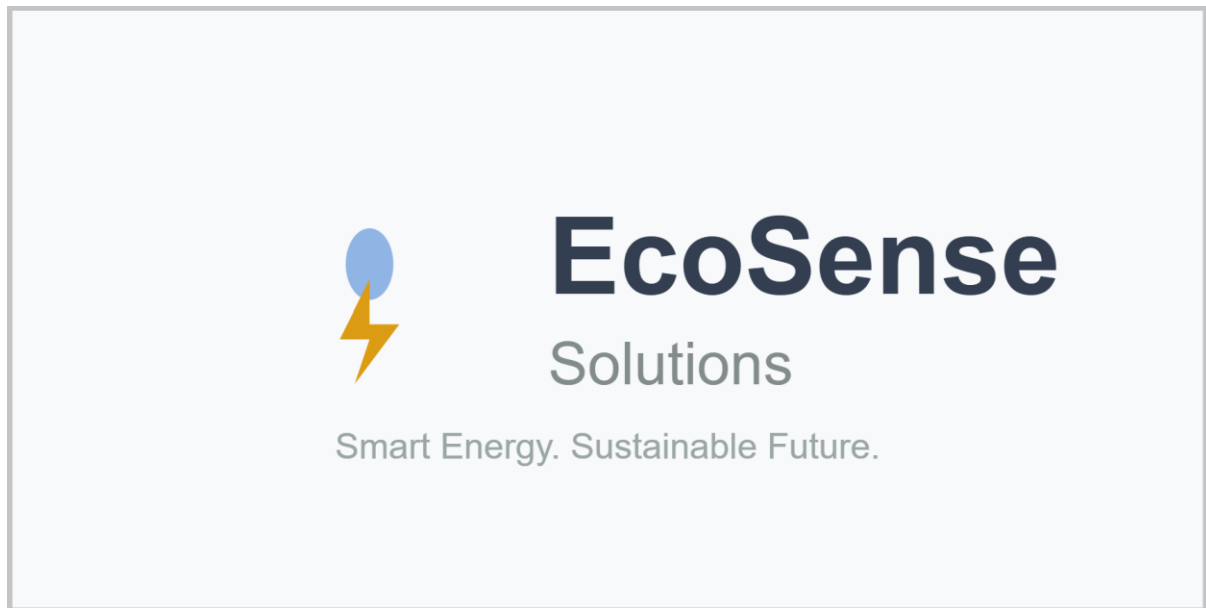


Image 6 (Logo Design)

The logo combines technology symbols (blue sensor circle and orange energy bolt) to represent the company's mission of using smart technology for environmental benefit.

Business Type: Private Limited Company (Ltd)

A Private Limited Company structure offers several advantages for a technology start-up. It provides limited liability protection, meaning personal assets are separated from business debts. This structure also makes it easier to attract investors and secure funding compared to sole proprietorship. The company can issue shares to investors while maintaining control through shareholder agreements.

Business Strategy

EcoSense Solutions will follow a B2B (Business-to-Business) strategy, targeting educational institutions as the primary market. The strategy includes three phases:

Phase 1 (Year 1): Focus on local universities and colleges. Offer pilot programs at discounted rates to build case studies and demonstrate energy savings. This creates proof of concept and generates testimonials.

Phase 2 (Year 2-3): Expand to corporate offices and retail chains using success stories from educational clients. Develop partnerships with building management companies who can recommend the system to their clients.

Phase 3 (Year 4-5): Scale nationally and introduce subscription-based monitoring services. Develop a platform where building managers across multiple locations can access their data.

The revenue model combines hardware sales, installation services, and recurring subscription fees for cloud-based analytics and support. This creates both immediate income and long-term recurring revenue.

Funding Initiatives

Several funding sources could support EcoSense Solutions:

Government Grants: The UK offers Innovate UK Smart Grants for innovative technology projects addressing environmental challenges. These grants can provide up to £500,000 without requiring equity in return. The company could also apply for the Sustainable Innovation Fund focused on green technology.

University Partnerships: Many universities operate technology incubators and accelerator programs. These provide initial funding, workspace, mentorship, and access to research facilities. Programs like SETsquared Partnership support technology ventures from universities.

Angel Investors: Individual investors interested in green technology could provide seed funding between £50,000-£250,000. In exchange, they typically receive 10-20% equity and may offer business guidance based on their experience.

Venture Capital: Once the business demonstrates traction with paying customers, VC firms specializing in clean technology might invest larger amounts (£500,000-£2 million) for scaling operations. However, this requires giving up more significant equity stakes.

Crowdfunding: Platforms like Crowdcube or Seedrs allow raising capital from many small investors. This approach also builds a community of supporters who become brand ambassadors. Environmental projects often generate strong public interest on these platforms.

Task 3: Project Reflection

Skills Development

This Smart Campus Energy Management project offers excellent opportunities to develop both technical and professional skills that are increasingly valuable in today's job market. The combination of hardware and software development will build comprehensive engineering capabilities that employers actively seek.

Technical Skills Development

Working with IoT devices requires understanding hardware-software integration. Setting up Raspberry Pi controllers and connecting various sensors teaches practical electronics and embedded systems programming. These skills are fundamental for any career in IoT, smart cities, or industrial automation. According to research on IoT skill requirements, professionals who understand both hardware and software earn significantly higher salaries than those with only one specialization.

Learning cloud infrastructure through AWS IoT Core provides experience with scalable systems architecture. Modern applications increasingly rely on cloud services, so

understanding how to design systems that handle thousands of devices sending data simultaneously is very valuable. This knowledge transfers to many other technology projects beyond energy management.

Database design for time-series data presents unique challenges. Energy readings generate massive amounts of data that must be stored efficiently and queried quickly. Optimizing database performance for this use case develops skills applicable to any data-intensive application, from financial trading systems to social media platforms.

Professional Skills Development

Project management experience gained through Agile methodology prepares for real workplace environments. Most technology companies now use Agile or similar approaches, so understanding sprint planning, daily stand-ups, and iterative development creates immediate workplace readiness. Even managing oneself through an Agile process builds discipline and organizational skills.

Documentation skills improve throughout the project. Creating clear technical documentation for hardware setup, API endpoints, and user guides is essential but often overlooked by new developers. Good documentation makes projects maintainable and shareable with others. Employers value team members who communicate technical concepts clearly.

Problem-solving abilities grow when facing real hardware challenges. Unlike purely software projects, IoT work involves debugging physical issues like sensor calibration, wireless interference, and power supply problems. This develops practical troubleshooting skills and patience when solutions aren't immediately obvious.

Positive Impact on Society

Energy management technology directly addresses climate change, one of society's most pressing challenges. Buildings account for approximately 40% of global energy consumption, so even small efficiency improvements create significant environmental benefits. A 25% reduction in energy use across campus buildings could save hundreds of tons of carbon emissions annually.

Environmental Benefits

Reducing unnecessary energy consumption helps slow climate change while preserving natural resources. Every kilowatt-hour saved means less fossil fuel burned at power plants (in regions still using non-renewable energy). The project demonstrates how technology can support sustainability goals without requiring people to significantly change their behavior - the system automates energy savings.

Smart monitoring also extends equipment lifespan. When heating and cooling systems run only when needed rather than continuously, they experience less wear and require fewer repairs. This reduces waste from manufacturing replacement equipment and the environmental impact of disposal.

Educational Impact

Installing this system in university buildings creates learning opportunities for students across multiple disciplines. Engineering students see practical applications of concepts learned in class. Business students could analyze the financial benefits and return on investment.

Environmental science students might study the carbon footprint reduction. This real-world example makes abstract concepts tangible.

The dashboard showing live energy data raises awareness among building occupants. When people see how their actions affect energy consumption, they often modify behavior voluntarily. Simple changes like turning off unused equipment or adjusting thermostat settings create additional savings beyond automated controls.

Economic Benefits

Reducing energy costs frees institutional budgets for other purposes. Universities could redirect savings toward student services, research funding, or facility improvements. For businesses, lower operating costs improve competitiveness and profitability. These economic benefits make sustainability financially attractive rather than just morally right.

The project also contributes to the growing green technology sector, creating jobs and economic growth. As demand for energy management solutions increases, skilled professionals will be needed to design, install, and maintain these systems. Early experience in this field positions someone well for future career opportunities.

Risk Management

Every project faces potential challenges that could prevent success. Identifying risks early and planning responses increases the likelihood of completing the project successfully.

Technical Risks

Hardware failures present significant risks for IoT projects. Sensors might malfunction, wireless connections could become unreliable, or power supplies might fail. To reduce these risks, the project should include redundancy where critical. For example, deploying backup sensors in key locations ensures data collection continues if one device fails. Choosing well-tested, industrial-grade components rather than hobby-level equipment improves reliability.

Software bugs and security vulnerabilities could compromise the system. Following secure coding practices from the start prevents many issues. Regular code reviews, even self-reviews, catch errors before they reach production. Using established frameworks and libraries rather than writing everything from scratch reduces bugs because others have already tested that code extensively.

Integration challenges between different technologies might cause delays. The project uses multiple programming languages, databases, and protocols that must work together smoothly. Creating small proof-of-concept tests early verifies that components can communicate properly before building the complete system. This incremental approach identifies incompatibilities when they're easier to fix.

Project Management Risks

Scope creep threatens many projects. The temptation to add "just one more feature" can delay completion indefinitely. Maintaining clear project boundaries and a prioritized feature list prevents this. Using the Agile approach with time-boxed sprints naturally limits scope because only features that fit within available time get implemented.

Time management becomes difficult when working alone. Without external deadlines, procrastination can occur. Setting up accountability mechanisms helps maintain progress. This might include regular progress reports to a supervisor or mentor, or publicizing project milestones to create social pressure to deliver.

Budget overruns could halt the project if hardware costs exceed expectations. Careful price research before starting and maintaining a contingency fund of 20% above estimated costs provides a buffer. If budget becomes tight, the project could be scaled back to fewer buildings initially while maintaining all core functionality.

External Risks

Access to university buildings might be restricted or delayed due to administrative processes or security concerns. Building relationships with facilities management early and obtaining necessary permissions before starting prevents last-minute access problems. Having a backup location or building identified provides alternatives if primary sites become unavailable.

Data privacy regulations could complicate deployment. The system monitors building usage patterns which could indirectly reveal when people are present. Ensuring the system collects only necessary aggregate data rather than tracking individuals addresses privacy concerns. Consulting with the university's data protection officer early ensures compliance with GDPR and institutional policies.

Technology changes during the project timeline might make chosen tools obsolete. While unlikely over 16 weeks, staying informed about major changes in IoT platforms prevents investing heavily in deprecated technology. Choosing widely-adopted, established technologies rather than brand-new options reduces this risk.

Mitigation Strategies

Creating a detailed risk register at project start lists potential problems with their likelihood and impact. This forces consideration of what could go wrong before it happens. For high-probability or high-impact risks, specific mitigation plans should be documented and reviewed regularly.

Building flexibility into the project plan accommodates unexpected challenges. The Agile methodology supports this naturally through its iterative approach. If hardware issues delay one sprint, work can continue on software components that don't depend on physical devices.

Maintaining good documentation throughout the project helps recover from setbacks. If something breaks and needs rebuilding, detailed setup instructions and code comments make this much faster than trying to remember everything later.

Task 3: Project Reflection

Undertaking the Smart Campus Energy Management System presents a transformative opportunity to develop technical competencies that align with the rapidly evolving demands of the technology sector. This reflection examines how this project will facilitate skills development, contribute to societal benefit, and addresses potential challenges through strategic risk management.

Q1. Technical and Professional Skills Acquisition

The project offers comprehensive skills development across multiple technology domains. Working with IoT devices requires mastery of hardware-software integration, including programming Raspberry Pi microcontrollers and configuring various sensors for data collection. Research indicates that professionals with combined hardware and software expertise command premium salaries in the technology sector, as these hybrid skills remain relatively scarce [2]. The practical experience of troubleshooting physical devices, managing wireless communications, and optimizing sensor networks develops problem-solving abilities that transcend this specific project.

Cloud computing skills acquired through AWS IoT Core implementation provide experience with scalable architecture design. As organizations increasingly migrate toward cloud-based solutions, understanding how to architect systems that process data from thousands of connected devices becomes invaluable [3]. This knowledge extends beyond energy management to applications in healthcare monitoring, industrial automation, and smart city infrastructure. Additionally, designing databases optimized for time-series data addresses unique challenges in storing and querying high-velocity sensor readings, developing expertise applicable to financial systems, social media analytics, and scientific research platforms.

Professional competencies gained through Agile project management prepare for contemporary workplace environments. Most technology organizations employ iterative development methodologies, making familiarity with sprint planning, retrospectives, and incremental delivery immediately applicable [1]. Even managing oneself through structured Agile processes cultivates discipline, time management, and self-reflection capabilities essential for professional success. Furthermore, creating comprehensive technical documentation for hardware setup, API specifications, and user guides develops communication skills that employers highly value, as the ability to articulate complex technical concepts clearly distinguishes exceptional engineers from average practitioners.

Q2. Societal Impact and Sustainability Contributions

This project directly addresses climate change by reducing energy consumption in buildings, which account for approximately 40% of global energy usage [4]. Achieving a 25% reduction

in campus energy consumption could eliminate hundreds of tons of annual carbon emissions, contributing meaningfully to environmental sustainability goals. Smart monitoring systems automate efficiency improvements without requiring significant behavioral changes from building occupants, making sustainability achievable through technology rather than relying solely on voluntary actions.

The educational impact extends beyond energy savings. Installing this system creates interdisciplinary learning opportunities where engineering students observe practical applications of theoretical concepts, business students analyze return on investment, and environmental science students study carbon footprint reduction [3]. Real-time energy dashboards raise awareness among building occupants, often motivating voluntary behavioral modifications that compound automated savings. This combination of technological intervention and awareness generation creates lasting cultural change toward sustainability.

Economic benefits amplify societal impact by demonstrating that environmental responsibility aligns with financial prudence. Reduced operating costs free institutional budgets for educational programs, research initiatives, or facility improvements. This financial attractiveness makes sustainability initiatives more appealing to decision-makers who might otherwise prioritize cost reduction over environmental concerns. Moreover, contributing to the expanding green technology sector creates employment opportunities and economic growth, positioning early adopters advantageously in emerging career fields.

Q3. Risk Management and Mitigation Strategies

Technical risks pose significant challenges for IoT implementations. Hardware failures, including sensor malfunctions or wireless connectivity issues, could compromise data collection [5]. Mitigation strategies include deploying redundant sensors in critical locations and selecting industrial-grade components with proven reliability rather than consumer-level equipment. Software vulnerabilities and security concerns require adherence to secure coding practices, regular code reviews, and utilizing established frameworks that have undergone extensive community testing. Creating incremental proof-of-concept tests verifies component integration before full system implementation, identifying incompatibilities when corrections remain straightforward.

Project management risks include scope creep and timeline delays. The Agile methodology with time-boxed sprints naturally limits scope expansion by enforcing prioritization decisions [1]. Establishing accountability mechanisms through regular progress reporting to supervisors or mentors maintains momentum when working independently. Budget overruns could halt development, necessitating careful cost estimation with 20% contingency reserves and willingness to scale initial deployment to fewer buildings while maintaining core functionality.

External risks involve access restrictions to university buildings and data privacy compliance. Building relationships with facilities management early and obtaining necessary permissions prevents administrative delays. Consulting with data protection officers ensures compliance with GDPR and institutional policies by collecting aggregate data rather than personally identifiable information. Maintaining detailed documentation throughout the project facilitates recovery from setbacks, as comprehensive setup instructions and code comments enable efficient rebuilding if components fail.

Conclusion

This project represents more than technical implementation; it embodies professional development, environmental stewardship, and practical problem-solving. The combination of IoT, cloud computing, and data analytics skills positions one advantageously in technology careers while contributing meaningfully to climate change mitigation. Through proactive risk management and flexible methodology, potential challenges become learning opportunities rather than insurmountable obstacles. Ultimately, this project demonstrates how technical expertise can serve societal needs, creating value that extends far beyond individual career advancement.

References

- [1] A. Srivastava, S. Bhardwaj and S. Saraswat, "SCRUM model for agile methodology," *2017 International Conference on Computing, Communication and Automation (ICCCA)*, Greater Noida, India, 2017, pp. 864-869, doi: 10.1109/CCAA.2017.8229928.
- [2] M. H. Rehman, I. Yaqoob, K. Salah, M. Imran, P. P. Jayaraman, and C. Perera, "The role of big data analytics in industrial Internet of Things," *Future Generation Computer Systems*, vol. 99, pp. 247-259, 2019.
- [3] A. Zanella, N. Bui, A. Castellani, L. Vangelista, and M. Zorzi, "Internet of Things for smart cities," *IEEE Internet of Things Journal*, vol. 1, no. 1, pp. 22-32, 2014.
- [4] D. Minoli, K. Sohraby, and B. Occhiogrosso, "IoT considerations, requirements, and architectures for smart buildings—Energy optimization and next-generation building management systems," *IEEE Internet of Things Journal*, vol. 4, no. 1, pp. 269-283, 2017.
- [5] R. K. Barik, H. Dubey, C. Samaddar, R. D. Gupta, and P. K. Ray, "FogGIS: Fog computing for geospatial big data analytics," in *2016 IEEE Uttar Pradesh Section International Conference on Electrical, Computer and Electronics Engineering (UPCON)*, 2016, pp. 613-618.
- [6] J. Porter, "How Tesla's battery mastermind is tackling EV's biggest problem," *The Verge*, 2021.