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Big Data Driven Asset Management: A Comparative Analysis and Case Study Approach for Smart Grid Energy Management in Sunderland, UK [1]

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Abstract

Nowadays there exist numerous possibilities of enhancement of energy efficiency, reliability and sustainability of energy consumption by using Big Data Analytics, IoT, Artificial Intelligence and Asset Management due to constantly rising digitization of urban infrastructures. In this article the usage of Big Data Analytics to develop Energy Management systems in collaboration with Asset Management and Engineering Management in Smart Cities including the analysis of Sunderland, UK city is proposed. A methodology of qualitative research including analysis of secondary documentary sources and case studies was conducted. The literature review of academic literature, international standards, governmental and organizational resources was performed using thematic and comparative analysis techniques. Sunderland was compared to Manchester, Barcelona, Amsterdam and Singapore. The conclusion has been made that effective Energy Management in a Smart City includes interconnected processes of data management, digital infrastructure, Life-cycle Asset Management, analytics and decision making.

Keywords: Big Data Analytics; Asset Management; Energy Management; Smart City/Grid; Sunderland; ISO 55000; Predictive Maintenance.

1. Introduction

Urban infrastructure relies heavily on interconnections within the digital-physical system. Generation of significant operational data by energy networks, buildings, transportation and municipal services creates potential for better infrastructure management efficiency. The

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evolution of the Smart City concept has seen increased utilisation of Internet of Things (IoT), Cloud Computing, Artificial Intelligence (AI), Digital Twins and advanced analytics tools (Caragliu, et al., 2011; Bibri and Krogstie, 2017). However, deployment of relevant technologies itself cannot bring improvements to Energy Management. Digital information value relies on the quality, governance of information and ability of organisation to make appropriate engineering decisions based on the available information (Dixon et al., 2017).

Special attention should be paid to Energy Management since it encompasses many processes related to energy systems: generation, transmission and distribution, consumption, condition of infrastructure and environmental aspects. An increase in number of renewable sources of energy, electric vehicles, and distributed energy sources raises the necessity to maintain permanent monitoring and decision making (Gellings, 2017; Zhou, et al., 2016). In some cases, maintenance according to fixed schedules might prove to be ineffective for those types of infrastructure that produce continuous operational data (Baglee et al., 2017).

Asset Management constitutes a useful complement. ISO 55000:2024 defines the principles and concepts for asset management throughout asset lifecycle, focusing on value, alignment, leadership, assurance, adaptability and sustainability (ISO, 2024a; Institute of Asset Management, 2015). Thus, data-driven Asset Management could provide a link between operational data and decisions regarding maintenance, replacement, investments, risks and value of asset lifecycle (Baglee et al., 2017).

Sunderland represents a reasonable choice for this research since Sunderland City Council pursues digital transformation in parallel with carbon-reduction goals (Thornbush et al., 2021). According to Sunderland City Council (2024; 2025), Sunderland City Council carried out several Smart City projects, including monitoring of energy consumption and development of a Digital Twin. Available information on city carbon shows approximately 1.034 million tonnes of CO_2 emissions in 2023 year. While emissions were reduced from 2015 baseline level, the city still struggles with meeting the carbon reduction pathway.

1.2 Research question

What could be done with the help of Big Data Analytics and Asset Management to improve implementation of Energy Management in Smart Cities, taking Sunderland as an example?

1.3 Objectives

Objectives of the project are to analyse Smart City Energy Management issues; research possibilities for use of Big Data Analytics to solve energy optimisation and infrastructure management decisions; assess ISO 55000 Asset Management; compare Sunderland to other cities and develop a practical framework for Sunderland.

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2. Literature Review

2.1 Smart Cities and Energy Management

Smart Cities integrate technology with infrastructure, services and governance (Caragliu, et al., 2011). The success of smart cities is dependent not only on the number of sensors used but on how well data is analyzed for better decisions. When talking about Energy Management, sensors and smart meters provide valuable insight into the patterns of energy consumption whereas analytics help identify the trends and anomalies in terms of energy demands (Daki et al., 2017). However, fragmentation, inconsistency of systems and incompatibility of data formats could reduce their effectiveness. Interoperability and governance become critical here (Dixon et al., 2017).

2.2 Big Data Analytics

Big Data Analytics encompasses large and heterogeneous data sets that emerge rapidly; they have volume, velocity, veracity, variety, and value (Hashem et al., 2016; Manyika et al., 2011). In terms of Energy Management, they could assist in energy demands prediction, anomalies detection, maximization of energy efficiency and maintenance prediction (Zhang et al., 2023; Ponnusamy et. al (2021). The IoT allows developing the infrastructure of the sensors while machine learning and AI would uncover the data in the operations (Elmouatamid et al., 2019; Lee, Bagheri and Kao, 2015). Still, there is a need for appropriate input and models for Big Data Analytics.

2.3 Asset Management and ISO 55000

The goal of asset management is to extract the value of the assets, combining performance, risks, expenses and opportunities during the entire life cycle (ISO, 2024a; Institute of Asset Management, 2015). There are multiple types of energy infrastructure assets such as substations, transformers, cables, energy metering devices, renewable-energy assets, energy system installations. The current condition of these assets influences their reliability, cost and energy efficiency. Thus, in terms of data-based asset management, it is possible to integrate their age, importance, failure history and performance.

2.4 Predictive Maintenance

Predictive maintenance helps to create a connection between Big Data Analytics and Asset Management (Al-Romaimi, 2024). With the help of sensors one can measure parameters, including temperature, vibrations, pressure, load and energy consumption and then with the help of analytics identify the abnormal situation and potential failures (Zhang, et al., 2018). However, one should

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use predictive maintenance in a careful way. One should always consider the quality of the data and reliability of models and engineering considerations (Baglee et al., 2017).

2.5 Research Gap

Three gaps emerge. First, the research on Smart Cities does not correlate the use of digital technologies with asset management. Second, there is a lot of attention paid to separate infrastructural sectors (such as power transformers) but not Energy Management as whole within a city in Asset Management literature (Al-Romaimi, 2024). Third, models created for big and/or centralized cities cannot be directly applied to middle-size UK cities. By bridging these gaps, one can combine Big Data Analytics, Asset Management and Engineering Management.

3. Methodology

3.1 Research Philosophy

A pragmatic research philosophy has been applied since the study tries to formulate a solution to an Engineering Management problem. As Saunders, Lewis and Thornhill (2023) state, a pragmatic research philosophy assumes that different discipline evidence can be employed according to its usefulness to answer research questions.

3.2 Research Approach and Design

Mainly a deductive research approach has been used. Concepts of several disciplines of Smart Cities, Big Data Analytics, Asset Management and Engineering Management were reviewed and applied to Sunderland case. This study follows a qualitative, secondary-data and comparative case study approach, which means comparison of Sunderland to other cities like Manchester, Barcelona, Amsterdam and Singapore (Thornbush et al., 2021).

3.3 Evidence and Data Selection

The evidence has been collected in peer-reviewed journals, international and national standards, governmental and institutional reports, industry literature. Preference was given to credible evidence sources. The selection of the sources was based on relevance to research objectives, authority, substantiveness and contemporaneity.

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3.4 Evidence and Data Analysis

Evidence analysis consisted of identification of recurrent themes in the literature using thematic analysis techniques. This entailed familiarisation, initial coding, theme generation, theme review, defining themes and theme interpretation (Braun and Clarke, 2006). Generated themes include Smart City Governance, Big Data Analytics, Internet of Things, AI, Digital Twins, Energy Management, ISO 55000 asset management, predictive maintenance and engineering, lifecycle management and systems supporting engineering management. After this, comparisons have been made on all five cases.

3.5 Research Quality and Limitations

Multi-perspective triangulation has been employed to enhance credibility of the findings. Credibility of the study has been ensured through research process documentation and transferability through comparisons among case studies on cities. Confirmability has been attained through systematic evidential coding and interpretation of the evidence presented (Lincoln and Guba, 1985; Yin, 2018). Limitations of this study include limitation of empirical validation due to use of secondary sources; thus, future research on Sunderland is important.

4. Results and Comparative Analysis

4.1 Energy and Digital Sunderland Context

Digital and environmental transformations are currently ongoing in Sunderland (Taylor, Green and Roberts, 2024). Existing initiatives as Smart City and Digital Twin developments make it possible to use collected data to manage Energy. The evidence on energy monitoring initiatives of the council suggests that the operational data has been collected already concerning public buildings, which consist of energy and environment data, building information, Building Management System information.

However, separate digital-related projects do not indicate comprehensive management of the city's assets regarding energy. The information could yet be distributed among different departments, infrastructures and property owners. In other words, the issue is governance and interoperability solutions which would help to coordinate various sets of data into decision-making (Dixon et al., 2017). The carbon position of Sunderland requires such efforts and investments.

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4.1.1 Carbon dioxide emissions of Sunderland city from sectors

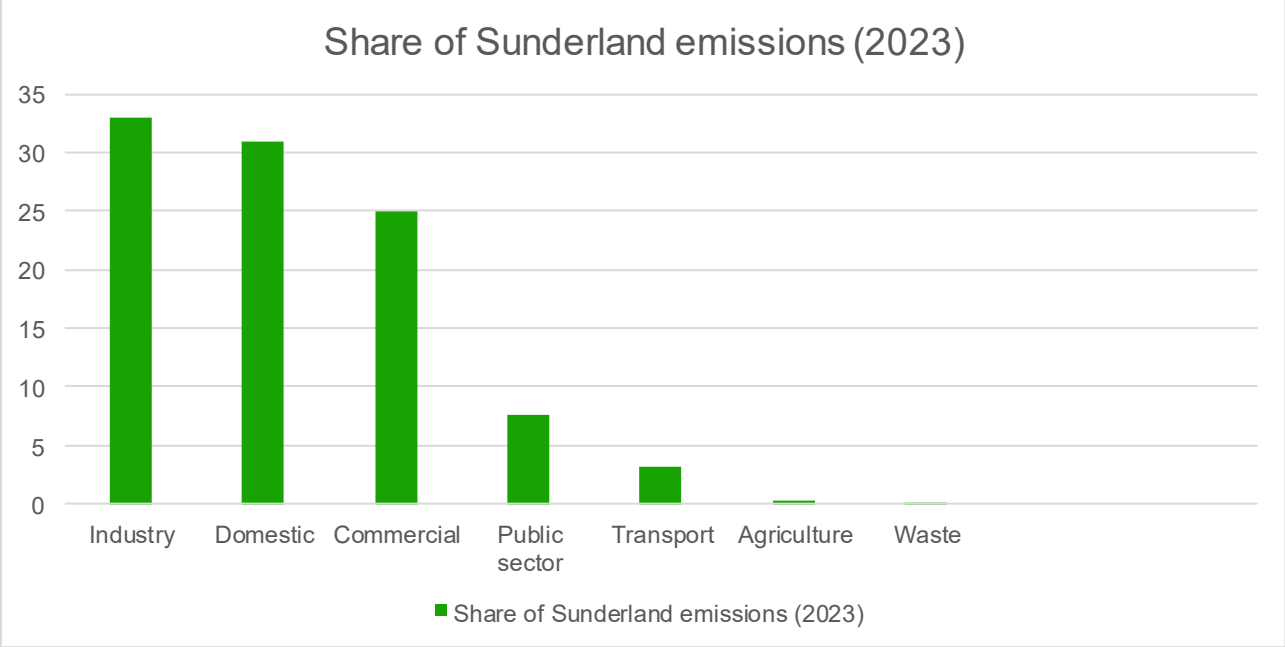
Sunderland emitted 1,034,400 tCO2 of net carbon emissions within the scope of control of the city authorities in 2023. It is an increase of 1.1% compared to 2022, owing mainly to increased industrial emissions that resulted from the usage of industrial gases. Sunderland City Council (2023/24).

Sector	**Share of Sunderland emissions, 2023**	**Approx. emissions (tCO_2)**
Industry	32.92%	340,548
Domestic	30.96%	320,258
Commercial	25.02%	258,810
Public sector	7.60%	78,614
Transport	3.17%	32,791
Agriculture	0.32%	3,310
Waste	0.01%	103
Total	**100.00%**	**1,034,400**

Table: Sunderland city-wide emissions by sector, 2023.

Source: Sunderland City Council, Low Carbon Annual Report 2024/25.

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Source: Sunderland City Council, Low Carbon Annual Report 2024/25.

These top three sectors account for nearly 88.9% of the total emission within the Sunderland city. As such, any energy management approach that will target solely the council-owned properties will not sort out the whole energy challenge in the city. Consequently, the recommended framework ought to ensure integration of the city-wide data, where the city council and other infrastructure owners can govern their assets effectively.

Industrial sector is key considering that according to the 2024/25 Sunderland report, there is a 22% increase in emissions from this sector in 2023, owing to the high usage of industrial gas. Council notes that the calculation is made using meter-level consumption and part of data is commercially confidential.

4.2 Comparative cases

Manchester provides valuable experience in UK with emphasis on cooperation between public sector and business/industry/research organizations. Transferrable knowledge in terms of Sunderland is related to partnership rather than scale of Manchester initiatives (Hashem et al., 2016).

In Ponnusamy et. al (2021) Barcelona provides good practice related to usage of sensors and open data, urban platform integration. In terms of this case one can say that the data is capable to act as urban resource. Anyway, Sunderland should modify its experience according to scale and institutional context of the city.

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Amsterdam provides an example of collaborative innovation in terms of involvement of various sectors in it (government, business, research and communities). What Sunderland can get from this experience due to the nature of Energy Management is collaborative governance (Bibri and Krogstie, 2017).

Singapore can be considered yet another case with high degree of coordination and highly developed urban digital infrastructure. Within the framework of the Smart Nation initiative, it becomes possible to utilize smart meters, Energy Management, sensors and Digital Twin. But the level of difference between two cases makes it impossible to treat Singapore case as blueprint (Manyika et al., 2011).

4.3 Cross-Case Comparison

Criterion	Sunderland	Manchester	Barcelona	Amsterdam	Singapore
Smart City governance	Developing	Collaborative	Integrated	Collaborative	Highly coordinated
Big Data capability	Developing	Advanced	Advanced	Advanced	Highly advanced
Digital infrastructure	Developing	Advanced	Advanced	Advanced	Highly advanced
Asset Management integration	Emerging	Moderate	Moderate	Moderate	Advanced
Energy-data integration	Emerging	Developing	Advanced	Advanced	Advanced
Transferable lesson	Integration	Partnership	Data platforms	Collaboration	Coordinated governance

Source: Author's own construction based on the comparative literature and documentary evidence reviewed in this study.

5. Proposed Big Data Asset Management Framework

The proposed framework combines digital data and Lifecycle Asset Management and Engineering Management decisions (Baglee et al., 2017). This framework consists of the following six levels of processes: (1) Data acquisition; (2) Data governance and integration; (3) Big data analytics; (4)

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Asset condition and risk assessment; (5) Engineering management decision support; and (6) Monitoring and continuous improvement.

Level one includes smart meters, IoT sensors, BMS systems, energy networks, asset register, maintenance information, and environmental sensors (Hashem et al., 2016; Daki et al., 2017). At level two information is standardized and validated, and issues concerning interoperability, cybersecurity, data ownership, and data access are addressed. At level three application of AI and machine learning algorithms, statistical analytics and digital twins technology is implemented for detection of anomalies and deteriorations (Zhang et al., 2018; Lee et al., 2015).

At level four analytics results are integrated with the information about criticality, age, condition, previous failures and risks associated with assets and their lifecycle (Al-Romaimi, 2024). In other words, at this level analytics should be aligned with the principles of ISO 55000 (ISO, 2024a; ISO, 2024b). Finally, at decision support level managers can make decisions with respect to asset maintenance, refurbishment, replacement, investment and energy management.

Implementation in Sunderland city will begin from selected critical public assets and without trying to implement this framework for city-wide scale from the beginning. Energy consumption and equipment condition in some public buildings will be monitored and analyzed for identification of abnormal energy consumption or equipment failure. Based on this information, engineering teams will investigate the causes of abnormalities and make decision according to the stated above criteria (Lincoln et al., 2015).

Logic of implementation: Data → Governance → Analytics → Assessment → Decision → Action → Feedback

6. Discussion

The results convincingly demonstrate that, on its own, Big Data is not of much relevance when isolated from the Asset Management and the decision-making process of any organisation (Hashem et al., 2016; Sassanelli et al., 2020). SCHEME is comprised of the following three elements: technology know-how, engineering and governance capabilities (Dixon et al., 2017).
In the first place, integration is essential because despite the value created by smart metering, IoT technologies, maintenance data and asset databases the latter is greatly diminished by the fragmentation of the former. In the second place, Asset Management process of decision-making where data provides value, in particular, the standard ISO 55000:2024 linked to the above asset management process and value creation (ISO, 2024a; Institute of Asset Management, 2015).

In the third place, engineering judgement must never be ignored; at times, AI may provide evidence about potential malfunctions while decision-making must account for safety, criticality

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and legislative aspects thereof. Lastly, it is important not to underestimate the importance of proper governance since Sunderland needs all the four above – data ownership, sharing, interoperability and cybersecurity (Elmouatamid et al., 2019). At the same time, no doubts should be left that every single case is unique, the large international cities having different financial and engineering resources and making different technology choices.

Answers to Research Questions:

The application of Big Data Analytics and Asset Management can help enhance Energy Management within the context of Smart Cities through analysing vast amounts of data related to energy consumption, assets and the environment to create effective decisions regarding energy consumption, maintenance, investments and decarbonisation. The example of Sunderland city can be helpful because the city is already using IoT sensors, smart buildings' solutions, digital platforms and data analysis to enhance energy efficiency. The data from smart meters, Building Management Systems and asset records can be used to uncover inefficiencies in energy consumption and equipment issues. Predictive analysis can be used for the timely detection of problems and preventive maintenance to reduce energy waste and breakdowns. Based on these data, Asset Management can prioritise maintenance, refurbishment and replacement of the assets taking into consideration their state, risks, costs, energy efficiency and carbon emissions.

6.1 SWOT Analysis

Strengths	Weaknesses
• Existing Smart City initiatives • Digital Twin capability • Energy-monitoring experience • Carbon-reduction objectives	• Fragmented datasets • Limited integration • Resource constraints • Multiple stakeholders
Opportunities	**Threats**
• AI-enabled Energy Management • Predictive Asset Management • Renewable-energy integration • University–industry collaboration	• Cybersecurity risks • Data privacy concerns • High implementation costs • Technology obsolescence

Source: Author's own construction based on the thematic and comparative analysis.

6.2 PESTLE considerations

Political – Decarbonization process, Smart City creation as well as energy policy changes may impact on their implementation

Economic – Cost of investment and necessary skills as constraints

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Social – Trust and acceptance of population to data-enabled infrastructure

Technological – Interoperability and cybersecurity – constraints, legal data protection regulations

Environmental – Energy Management plays role in achieving carbon reduction objectives.

7. Conclusion and recommendations

The purpose of the research was to examine the potential integration of Big Data Analytics and Asset Management to implement Energy Management within Smart Cities taking Sunderland as the main case study and comparison with such Smart Cities as Manchester, Barcelona, Amsterdam and Singapore. It has become apparent that Smart City Energy Management encompasses more than the technological deployment itself.

There are several preconditions for developing Smart City Energy Management system in Sunderland including Smart Cities initiatives, Digital Twin, energy-monitoring activities and decarbonization objectives, but not integrated into the framework of Asset Management.

The research suggests Sunderland to develop Energy and Asset Data Governance; prioritize critical energy assets and public buildings; increase interoperability between energy, maintenance and asset databases; introduce predictive maintenance where it is possible depending on the data availability; establish partnerships between local authorities, infrastructure operators, technology providers and universities; align Energy Management with ISO 55000:2024; apply incremental framework in accordance with the measurable indicators.

The limitations of the current research relate to the fact that only second-hand data are used, the lack of the data concerning the operations. The future research will analyze real-time energy, asset conditions and maintenance data with the help of interviews with energy managers, infrastructure owners, etc. It does not make sense for Sunderland to become a clone of biggest international Smart Cities but rather develop a proportional and appropriate combination of international experience and ISO-conformant Asset and Energy management.

References

Al-Romaimi, K.S.H. (2024) *Asset Management Power Transformer Health Index Development and Analysis for Driving Asset Maintenance Strategy for Electrical Utilities*. PhD thesis. University of Sunderland. University of Sunderland Repository

Baglee, D., Campos, J., Sharma, P., Gabiria, U.G. and Jantunen, E. (2017) 'A Big Data Analytical Architecture for Asset Management', *Procedia CIRP*, 64, pp. 369–374.
DOI: 10.1016/j.procir.2017.03.019. DOI / ScienceDirect

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Bibri, S.E. and Krogstie, J. (2017) 'Smart sustainable cities of the future: An extensive interdisciplinary literature review', *Sustainable Cities and Society*, 31, pp. 183–212. DOI: 10.1016/j.scs.2017.02.016. DOI / ScienceDirect

Braun, V. and Clarke, V. (2006) 'Using thematic analysis in psychology', *Qualitative Research in Psychology*, 3(2), pp. 77–101. DOI: 10.1191/1478088706qp063oa. DOI / Taylor & Francis

Bryman, A. (2016) *Social Research Methods*. 5th edn. Oxford: Oxford University Press. Oxford University Press / book record

Caragliu, A., Del Bo, C. and Nijkamp, P. (2011) 'Smart Cities in Europe', *Journal of Urban Technology*, 18(2), pp. 65–82. DOI: 10.1080/10630732.2011.601117. DOI / Taylor & Francis

Creswell, J.W. and Creswell, J.D. (2018) *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 5th edn. Thousand Oaks, CA: SAGE. SAGE

Daki, H., El Hannani, A., Aqqal, A., Haidine, A. and Dahbi, A. (2017) 'Big Data Management in Smart Grid: Concepts, Requirements and Implementation', *Journal of Big Data*, 4, 13. DOI: 10.1186/s40537-017-0070-y. DOI / Springer Nature

Dixon, T., van de Wetering, J., Sexton, M., Lu, S.L., Williams, D., Duman, D.U. and Chen, X. (2017) *Smart Cities, Big Data and the Built Environment: What's Required?* London: Royal Institution of Chartered Surveyors (RICS). RICS publication

Elmouatamid, A., NaitMalek, Y., Bakhouya, M., Ouladsine, R., Elkamoun, N., Zine-Dine, K. and Khaidar, M. (2019) 'An energy management platform for micro-grid systems using Internet of Things and Big-data technologies', *Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering*, 233(7), pp. 904–917. DOI: 10.1177/0959651819856251. (Sage Journals) DOI / SAGE

Gellings, C.W. (2020) *The Smart Grid: Enabling Energy Efficiency and Demand Response*. Boca Raton, FL: CRC Press. CRC Press / Routledge

Hashem, I.A.T., Chang, V., Anuar, N.B., Adewole, K., Yaqoob, I., Gani, A., Ahmed, E. and Chiroma, H. (2016) 'The role of Big Data in Smart City', *International Journal of Information Management*, 36(5), pp. 748–758. DOI: 10.1016/j.ijinfomgt.2016.05.002. DOI / ScienceDirect

Institute of Asset Management (2015) *Asset Management – An Anatomy*. Version 3.0. Bristol: Institute of Asset Management. Institute of Asset Management

International Organization for Standardization (ISO) (2024a) *ISO 55000:2024 Asset management — Vocabulary, overview and principles*. Geneva: ISO. ISO 55000:2024

International Organization for Standardization (ISO) (2024b) *ISO 55001:2024 Asset management — Asset management system — Requirements*. Geneva: ISO. ISO 55001:2024

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Lee, J., Bagheri, B. and Kao, H.A. (2015) 'A Cyber-Physical Systems Architecture for Industry 4.0-Based Manufacturing Systems', *Manufacturing Letters*, 3, pp. 18–23. DOI: 10.1016/j.mfglet.2014.12.001. DOI / ScienceDirect

Lincoln, Y.S. and Guba, E.G. (1985) *Naturalistic Inquiry*. Beverly Hills, CA: Sage. SAGE

Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C. and Byers, A.H. (2011) *Big Data: The Next Frontier for Innovation, Competition and Productivity*. San Francisco, CA: McKinsey Global Institute. McKinsey Global Institute

Saunders, M.N.K., Lewis, P. and Thornhill, A. (2023) *Research Methods for Business Students*. 9th edn. Harlow: Pearson. Pearson

Sunderland City Council (2024) *Annual Carbon Data Report 2023/24*. Sunderland: Sunderland City Council. The official 2024 Cabinet documentation contains "Annual Carbon Data Report 2023-24" as an appendix to the Low Carbon Annual Report 2023/24. Official Sunderland City Council report — 2023/24

Sunderland City Council (2025) *Annual Carbon Data Report 2024/25*. Sunderland: Sunderland City Council. The official November 2025 Cabinet papers explicitly list "Annual Carbon Data Report 24-25" and the accompanying Low Carbon Annual Report 2024-25. Official Sunderland City Council report — 2024/25

Thornbush, M. and Golubchikov, O. (2021) 'Smart energy cities: The evolution of the city-energy-sustainability nexus', *Environmental Development*, 39, 100626. DOI: 10.1016/j.envdev.2021.100626. DOI / ScienceDirect

Yin, R.K. (2018) *Case Study Research and Applications: Design and Methods*. 6th edn. Thousand Oaks, CA: Sage. (EBSE) SAGE

Zhang, Y., Huang, T. and Bompard, E.F. (2018) 'Big data analytics in smart grids: a review', *Energy Informatics*, 1, 8. DOI: 10.1186/s42162-018-0007-5. DOI / Springer Nature

Zhou, K., Fu, C. and Yang, S. (2016) 'Big data driven smart energy management: From big data to big insights', *Renewable and Sustainable Energy Reviews*, 56, pp. 215–225. DOI: 10.1016/j.rser.2015.11.050. DOI / ScienceDirect

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