

Chapter 4

Artificial Intelligence and Machine Learning in Digital and Analog VLSI: Sustainability and Energy Management in Smart Cities

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ABSTRACT

Artificial Intelligence (AI) and Machine Learning (ML) are reshaping the frontiers of Very-Large-Scale Integration (VLSI) by revolutionizing energy management, vital for sustainable smart cities. VLSI, in which millions of transistors are combined onto a single chip, contributes significantly to the development of low-power electronic systems. These systems are further optimized by AI & ML techniques in terms of design, manufacturing to operations and help energy consumption from becoming bare minimal and their performance optimization. This chapter comprehensively explores the diverse aspects of artificial intelligence and machine learning in VLSI for energy management towards sustainability in smart cities.

1. INTRODUCTION

AI Facilitated VLSI Designs for Smarter Power Management: In the case of smart cities, which have a huge load on energy and exploitation can result in massive wastage reducing sustainability opportunity taking as it is diagram has been introduced that Sensed by AI driven intelligent power management. AI and ML are involved in developing smart grids which helps to predict energy needs, dynamically allocate power distribution as also integrate renewable sources of energy that make the urban ecosystems sustainable (Arya et al., 2024)., AI-enabled VLSI systems can help in evolving the smart IoT devices

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associated with all these sectors for efficient energy administration across different city departments. The integration of AI, ML and VLSI not only bolsters technology advancement but also gives birth to earth-friendly smart cities while complying international sustainability agendas (Gatti et al., 2024). This sort of dynamic power management is crucial for minimising the energy footprint in electronic devices deployed throughout smart cities (Kumar et al., 2024). These artificial intelligence (AI) -based predictive maintenance algorithms are designed to use data obtained from VLSI components and predict when failures will occur so that they can be prevented (Sharma & Singh, 2022). Taking this proactive and data-driven approach means systems run at the highest possible efficiency, preventing wastage through good quality energy monitoring (Rosiello& Maleki, 2024). It can also significantly extend the lifespan of electronic devices, which in turn makes it more likely for a malfunction to occur and thus reduces e-waste (Fischer & Preonas, 2010). ML applications like digital-analogue converters and other VLSI based things are also synthesized in smart grids to enhance energy distribution, make it more efficient. These models allow energy demand patterns to be forecast - helping balance supply and demand in real-time for more efficient management of renewable generation (Grubb et al., 2021).

Figure 1. Illuminates the landscapes of introduction section (Source- Original)



1.1 VLSI for Inhabitants of Smart Cities

VLSI technology is a driving force in the formation of smart cities, as it allows the realization of extremely complex integrated circuits (ICs) that are essential to modern urban infrastructure. One of the key elements making this smart city eco-system work is communication, driven by advanced technologies like Automation and Data processing- which in turn has been made possible due to VLSI (Very Large Scale Integration) which allows millions of transistors integrated on a single chip (Raihan et al., 2022). These ICs power a range of smart devices and systems; including sensors, controllers, and communication modules through which energy water transportation assets can be monitored in real-time. VLSI technology plays a key role in reducing devices size, lowering power consumption and improving the reliability of smart city systems. Its role in smart cities is intrinsic and extends across various verticals including traffic management, smart grids, environmental monitoring to public safety. VLSI Technology is that underlying hardware infrastructure to power these transformations, thus ensuring the long term scalability and sustainability of smart city applications at a city level as cities aim towards getting smarter and more connected.

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