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Sustainable Supply Chain Management in LED Manufacturing: A Qualitative Case Study of Orenda Energies Private Limited, Pakistan

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ABSTRACT:
This thesis explores sustainable supply chain management practices of Orenda Energies Private Limited, a manufacturer of LED and SMD lighting that operates within the Allah Hoo Industrial Estate in Lahore, Pakistan. The research is inspired by three overlapping gaps in the current body of SSCM research: that the electrical manufacturing industry in Pakistan has not been dedicatedly studied, that systematic underrepresentation of domestically-oriented SME manufacturers in developing country SSCM research, and the methodological hegemony of survey-based quantitative designs that cannot generate the operational specificity that firm-level SSCM analysis demands.

The research will follow a qualitative single case study research design based on an interpretivist philosophical stance and an inductive research methodology. It was collected as primary data using the reflexive thematic analysis process of Braun and Clarke (2019) with five semi-structured interviews with respondents representing the executive, technical, operational, and client-side functions of the firm. The theoretical framework is a combination of three complementary lenses: the Natural Resource Based View of Hart (1995), which explains the motivational logic behind the sustainability practice in a resource-constrained environment; the Nine R Hierarchy of Potting et al. (2017), which evaluates how deep the practices surrounding the circular economy are placed in a spectrum of resource value retention; and the Institutional Voids framework of Khanna and Palepu (2010), which explains the conditions in which structures are placed to shape SSCM decision-making in the Pakistani manufacturing environment.

The thematic analysis resulted in four themes. The first established: Orenda has a hybrid energy infrastructure consisting of a 100KW grid supply, a 50KW solar generation, a 100KW diesel backup, and that recycles polymer at a blended rate of 30 percent across their product range, and engages in an informal inter-firm steel-for-cardboard exchange of materials placed across R2, R3, and R8 of the Nine R Hierarchy. The second determined that the stakeholders view these practices as creating the value of continuation in operations, cost competitiveness, and creation of ESG value to the B2B clients. The third found that barriers limiting the effectiveness of SSCM are structural and institutional, based on the financial, regulatory, information, and infrastructure gaps in Pakistan. The fourth one determined that the most consequential strategic pathway that could be adopted by the firm is that of formalisation of the existing informal practices.

This discussion synthesises these findings into the Emergent Sustainability Formalisation Model, a three-stage theoretical framework that proposes that the development of SSCM in manufacturing SMEs in institutional void conditions follows a trajectory of cost-driven emergence through formalisation to strategic deepening. The seven strategic recommendations are made within the immediate, medium-term and long-term periods all based on the empirical evidence and the theoretical framework.

KEYWORDS: Sustainable Supply Chain Management, Natural Resource Based View, Circular Economy, Nine R Hierarchy, Institutional Voids, LED Manufacturing, Pakistan, SME, Qualitative Case Study, Industrial Symbiosis

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List of Abbreviations

9R	—	Nine R Hierarchy
AEDB	—	Alternative Energy Development Board
APA	—	American Psychological Association
B2B	—	Business to Business
BESS	—	Battery Energy Storage System
CE	—	Circular Economy
CEO	—	Chief Executive Officer
ESG	—	Environmental Social and Governance
GSCM	—	Green Supply Chain Management
ISO	—	International Organisation for Standardisation
KW	—	Kilowatt
LCCI	—	Lahore Chamber of Commerce and Industry
LED	—	Light Emitting Diode
NEPRA	—	National Electric Power Regulatory Authority
NRBV	—	Natural Resource Based View
PBT	—	Polybutylene Terephthalate
PC	—	Polycarbonate
SMD	—	Surface Mounted Device
SME	—	Small and Medium Enterprise
SSCM	—	Sustainable Supply Chain Management
TBL	—	Triple Bottom Line
WAPDA	—	Water and Power Development Authority

1 Introduction

1.1 Background of the Study

Structural energy stress, unmatched among similarly sized industrial economies, afflicts the industrial economy of Pakistan. From 2021 to 2024 industrial electricity tariffs increased by more than 155%, the shortfall in energy supply regularly exceeded 5,000 megawatts during the peak demand season, and the circular debt in the electricity sector exceeded PKR 2.5 trillion, a structural deficit that has resulted in energy cost becoming the most important variable in the cost of production for Pakistani manufacturers (NEPRA, 2021; World Bank, 2023). In this context, energy efficiency in industrial activity has become critical in the survival and competitive strategies of manufacturers, rather than a marginal consideration in the optimisation of operational practices.

Manufacturing firms in this context are simultaneously unusual in two respects. They are users of energy in crisis circumstances and in the case of the LED/electrical hardware industry, suppliers of technologies explicitly designed to facilitate less energy use. This makes them a very interesting focus for the study of Sustainable Supply Chain Management (SSCM) which applies the logic of the supply chain to the co-management of environmental, social and economic concerns while delivering value to stakeholders (Carter and Rogers, 2008; Seuring and Gold, 2020). A company producing energy-efficient lighting in the midst of a national energy crisis, sourcing recycled polymers for its manufacturing process, and entering into materials exchange agreements with adjacent industrial players is not a supply chain player. It is a practitioner case for embedded sustainability whose operations reflect the actual conditions of implementation of SSCM in a developing country and can reveal insights that both theoretical models developed for multinational corporations, as well as survey instruments applied to samples of large organisations are unlikely to reveal.

SSCM has received considerable attention in the literature over the last two decades, growing from being a niche field of corporate social responsibility, to being integrated with supply chain design, procurement policy and performance measurement (Koberg and Longoni, 2019; Govindan et al., 2020). The central tenet of the field, that supply chains must be considered along economic, environmental, and social metrics intertwined as per the Triple Bottom Line framework (Elkington, 1997), has been put into

practice by multinational corporations in the developed world through green procurement, eco-design, reverse logistics, and supplier sustainability assessment. But the empirical evidence is institutionally and geographically biased. In a systematic literature review, Jia et al. (2018) identified less than 20% of firm-level SSCM studies in developing economies, and these were typically focused on large export-driven manufacturing where international buyer pressure and adoption of sustainable practices is driven by foreign buyers. The circumstances that exist in the local market-oriented SME manufacturing sector, where no external pressure is present, where enforcement of regulatory requirements is weak, and where the emergence of sustainability behaviours is driven by the pragmatic realities of competing on cost rather than strategic consideration, remains relatively understudied.

This thesis does so by means of an in-depth qualitative case study of Orenda Energies Private Limited, a Lahore-based LED and SMD lighting manufacturer located in the Allah Hoo Industrial Estate. The organisation provides an empirically accessible and conceptually rich case study. Its power supply system has a 100KW grid supply, 100KW diesel backup generator and a 50KW solar PV system. Its production system has a 100% use of plastic with a 30% blended recycled content across its product portfolio. Its procurement processes feature a materials exchange with its local competitors that is an ad hoc example of industrial symbiosis. Overall, these attributes represent a set of publicly observable SSCM practices whose study promises to deliver context-specific insights that contribute to the empirical and theoretical understanding of the SSCM field in the context of manufacturing in developing countries.

1.2 The Pakistani Manufacturing Context and the Energy Efficiency Imperative

Pakistani manufacturing accounts for roughly 13-14% of GDP and over 16% of the workforce, but is confronted with a set of constraints that distinguish the nature of manufacturing from that assumed in the dominant body of SSCM theories (Pakistan Bureau of Statistics, 2023). The cost of energy, coupled with devaluation of the Pakistani rupee, the gradual phase-out of industrial fuel subsidies, and the sustained underinvestment in generation capacity, has emerged as the most pressing operational

challenge for manufacturers in Pakistan's provinces of Punjab and Sindh, with the share of energy cost in the total cost of production increasing from an estimated 18% in 2018 to more than 28% in 2023 for energy-intensive SMEs (World Bank, 2023; IRENA, 2022). This cost trend has demanded a paradigm shift in supply chain thinking among manufacturers operating in Pakistan, with energy procurement shifting from the traditional status of a support function to being a strategic consideration in production scheduling, product design, capital investment and supplier selection.

As a consequence, the growth in industrial adoption of solar photovoltaic systems in Pakistan has surged significantly, with the Alternative Energy Development Board (AEDB) recording a close-to-tripling in registered commercial solar projects between 2020 and 2023 (AEDB, 2022). This trend is most evident in the industrial estates of Lahore, where manufacturers have installed solar generation on-site, to guard against both rising tariffs and load-shedding outages. NEPRA's State of Industry Report (2021) reveals that, in general, industrial firms who have invested in on-site solar capacity in addition to diesel back-up and grid supply have reduced their grid-connected energy consumption by 20% to 40%, and their production disruption during load-shedding events which in turn translates into reduced rework and scrap costs. Accordingly, the hybrid energy source methodology deployed by Orenda (100KW grid supply, 100KW diesel and 50KW solar) is therefore not an isolated firm-specific response to Pakistan's energy infrastructure but rather increasingly commonplace adaptation to Pakistan's energy infrastructure.

On the other hand, Pakistan is grappling with material resource challenges. Annually, Pakistan produces some 49.6 million tonnes of solid waste, with a growing and poorly managed component of industrial plastic waste (Shafique and Clark, 2022). Current official recycling activities in Pakistan are unable to absorb more than 5% of plastic waste, resulting in firm-level integration of recycled material that occurs at the informal level rather than through institutionalised reverse logistics (Iqbal et al., 2023). The integration of recycled polymer material into manufacturing processes is therefore a cost reduction strategy for manufacturers in the plastics-intensive electrical hardware sector, for whom the price of recycled polymer material is 15-25% cheaper than "virgin" materials in Pakistani wholesale markets and a de facto circular economy practice with implications for sustainability beyond procurement.

In this context it is noteworthy that the LED and SMD lighting manufacturing sector is strategically located. The LED lighting segment in Pakistan was a USD 320 million annual market in 2022 and is estimated to be growing at an annual rate of 12 to 15% due to increased electricity prices, government promotions of energy efficiency, and the gradual phasing out of incandescent and fluorescent bulbs (World Bank, 2023). Domestic manufacturers capable of delivering hardy, widely compatible and compliant lighting hardware and incorporating sustainable practices in their supply chain are well positioned to meet the burgeoning industrial demand within the nation, as well as export opportunities in the region to markets with similar climatic conditions and challenges for energy security.

1.3 Overview of Orenda Energies Private Limited

Orenda Energies Private Limited is an active private limited liability company registered under the Pakistani Companies Ordinance and registered with the Lahore Chamber of Commerce and Industry (LCCI) as Member ID 1,014 with National Tax Number 8263398-3. The firm is based at Plot 32, Street 1, Allah Hoo Industrial Estate, near Gajju Mata, Lahore, an industrial specialised manufacturing area of Lahore that accommodates a variety of manufacturing tenants, including garment manufacturers, steel processors, and others, that offers the spatial conditions for the various forms of resource exchange between firms that are the focus of this research. The company is co-owned by Chief Executive Officer Mr. Hassan Ali whose professional background includes overseeing domestic manufacturing operations and operating an international affiliate at one time in the UK, now defunct (Orenda Energies Pvt. Ltd., 2022).

The company's key products include LED and SMD lighting fittings, light bulb housings and related electrical components with about 50 to 60 staff engaged in the production of products catering to residential and commercial business-to-business consumption markets. Its proximity to the Ferozepur Road, one of Lahore's major thoroughfares, within the Allah Hoo estate, ensures access to upstream suppliers and downstream distributors in the Punjab industrial belt. Co-location of large-scale packaging factories and steel manufacturing plants within the same estate provides a natural business-to-business customer base for high resilience energy efficient light fixtures, and also offers

the proximity needed to make the exchange of waste materials between firms sustainable.

Orenda is a substantively-informative case study for SSCM research in three ways. Its energy supply is a hybrid of three energy sources that speaks to both operational resilience and an incremental approach to the integration of renewable energy sources, namely 100KW national grid supply, 100KW diesel generator for peak load generation, and 50KW solar PV panel array. Its supply procurement includes 30% recycled plastic (blended) across its product range, with the PBT (a plastic) material comprising its bulb housing containing 15% recycled matter and the polycarbonate housing containing 30% recycled matter, with the balance made up of commercially available virgin-grade polymer material. Its inter-firm procurement is centred around an exchange of material resources with other estate tenants which involves trading steel offcuts for cardboard packaging material at a negotiated 10% discount, which is in the language of the circular economy literature an example of informal industrial symbiosis (Katz-Gerro and Sintas, 2018). The latter three characteristics constitute the empirical basis of this study.

1.4 Problem Statement and Research Gap

While the body of knowledge on SSCM is growing, there is a significant gap in empirical studies at firm level in Pakistani manufacturing SMEs. A literature review by Koberg and Longoni (2019) of 1,243 SSCM studies reveals that less than 3% were carried out in the South Asian region of developing economies, of which the vast majority were in large export-oriented manufacturing industries where international buyer pressure and export certificates create the main incentive for SSCM adoption. The way small, domestic manufacturers implement sustainability initiatives in their supply chains in the absence of such contexts remain empirically understudied and theoretically underdeveloped.

Three gaps are combined to define the thesis' problem statement. The first is a sectoral gap, as Pakistan's electrical and LED sector has not previously received any dedicated research attention from the SSCM literature despite its prominence in addressing energy efficiency in Pakistan and its growing incorporation of circular practices. The second is a firm-size gap, as the SSCM literature's focus on multinational corporations and large firms means that much of its research is only partially applicable to the SME sector where formalised sustainability governance such as dedicated ESG units, supplier auditing

procedures and formal "green" procurement policies is absent (Durrani et al., 2024; Manzoor et al., 2024). The third is a research-gap, as the dominance of quantitative cross-sectional survey research in South Asian SSCM studies constrains the information provided about the processes of sustainability decisioning, contest and implementation within firms. Reporting more than 70% of Pakistan-specific SCM research from 2015-2022 used survey instruments, Khan et al. (2022) note, this over-concentration of methodology represents a systematic oversight of the operational level detail and context-specific insights that can be gleaned from qualitative case studies (Adewole, 2021).

Orenda Energies is precisely the sort of firm that is missing from this body of research: a locally-focused SME manufacturer in a key industry operating in a resource-scarce setting with visible and recordable sustainability practices in energy procurement, material procurement and exchange with other firms. A deep qualitative case study of this firm has the potential to yield context-specific insights inaccessible to survey-based SSCM research designs and to SSCM studies of multinational supply chains, whose theoretical insights are applicable to the significant size of the population of SME manufacturers operating in similar circumstances in South Asia and in developing economies broadly.

1.5 Research Question

The overarching research question of the thesis is: What is the nature of sustainable supply chain management (SSCM) practices implemented by Orenda Energies Private Limited, and how do these practices impact, challenge and inform the strategic decision-making in a Pakistani manufacturing context?

This core question is subdivided into two questions that guide the empirical and theoretical analysis in the thesis. The first sub-question is: what are the current SSCM practices that are being deployed in Orenda's energy procurement, material sourcing and inter-firm exchange activities, and how do key stakeholders inside and around the firm perceive the impact of these practices on the operational efficiency and environmental sustainability? The second sub-question asks what structural, institutional and managerial factors limit the effectiveness of the implementation of SSCM practices at Orenda, and what strategies based both empirically and theoretically

would most plausibly overcome such constraints to support the firm's sustainable development.

1.6 Research Objectives

The research objectives provide a road map to address the main research question. The first is to assess the existing sustainable supply chain management (SSCM) practices of Orenda Energies Private Limited, with a focus on its hybrid energy system, use of recycled materials and inter-firm procurement. The second objective is to investigate the perceptions of management and stakeholders surrounding the impact of SSCM practices on the company's efficiency and sustainability performance from the perspectives of those who are directly involved and immediately surrounding the company's supply chain. The third objective is to assess the structural, institutional, financial, and managerial factors that limit the success and expansion opportunities for SSCM in the company's business environment. The fourth objective is to recommend evidence-based, context-specific recommendations that would allow Orenda to build on its SSCM strategy and improve its sustainability performance in a way that is commensurate with its scale, industry, and the country in which it operates.

1.7 Scope and Delimitations

The study is an embedded single case study of Orenda Energies Private Limited and, therefore, its findings are limited by the analytical framework of case study research as opposed to statistical generalisation (Yin, 2018). The boundaries of study are limited to the supply chain processes of Orenda's Allah Hoo Industrial Estate (Lahore) branch, including energy and material sourcing, the integration of recycled content and inter-firm exchanges during the current period of the firm's operational structure. The research does not address the downstream use of Orenda's LED products, the environmental sustainability of its upstream supply chain or a comparative study of other LED manufacturers in the Pakistani industrial ecosystem.

The five interview respondents were drawn from the set of individuals who are directly involved in the supply chain operations of the firm and who have the authority to speak to the research questions, as outlined in Chapter Three. As a qualitative investigation

that is premised upon an interpretivist epistemological stance, this research prioritises depth of analysis over statistical representativeness, and the findings are meant to be relevant in an analytic sense - that is, in the sense of producing theoretical propositions that would hold true in similar SME manufacturing settings - rather than in a statistical sense - that is, that they would be representative of a population. Such limitations are in line with study's epistemological position and are expanded upon in the methodological critique in Chapter Three.

2 Literature Review and Theoretical Framework

The framework of this thesis is built upon three streams of literature, chosen because they speak to an aspect of the problem that the others do not. The first is the Natural Resource Based View which explains the incentive for a firm facing resource scarcity and unregulated by the state to adopt sustainable supply chain practices at all. The second is the Circular Economy framework, in particular as operationalised in the Nine R Hierarchy (Potting et al. 2017), which provides the evaluative criteria for how to determine the extent and ambition with which Orenda engages with the Circular Economy rather than just the fact that it engages with them. The third is the Institutional Voids framework by Khanna and Palepu (2010) that provides the structural explanation for the context in which all of Orenda's supply chain practices take place, that is, the absent and underdeveloped regulatory, financial and infrastructural institutions that constrain their operational possibilities as a Pakistani manufacturing SME. Together, the three frameworks provide a diagnostic framework in which the NRBV accounts for motivation, the 9R Hierarchy accounts for practice and Institutional Voids accounts for context. This chapter examines each framework in detail, together with its limitations and how it applies to the situation at Orenda, and concludes with an integration of the three frameworks into the conceptual framework that informs the empirical analysis in Chapter Five.

2.1 The Natural Resource Based View

2.1.1 Origins and Core Propositions

The Natural Resource Based View (NRBV) was developed by Hart (1995) as an extension of the Resource Based View (RBV) of the firm that defined competitive advantage in terms of firm-specific resources and capabilities that are valuable, rare, inimitable and non-substitutable (Barney, 1991). Hart's argument against the Resource Based View was that it excluded the natural environment from its analysis of firm strategy and that this excluded it from understanding a rapidly growing set of competitive interactions in which management of constraints imposed by the environment created long-term firm-specific advantages. The NRBV identified three interlinked strategic capabilities that firms could

use to generating competitive advantage from environmental resource management. The first is pollution prevention, which involves the mitigation of emissions, effluents and waste through incremental improvement in operational processes, resulting in cost savings which accumulate as competitive advantage. The second is product stewardship, which involves designing products to take environmental considerations into account and managing products across the product lifecycle including at the point of product recovery. The third is sustainable technology, which involves the creation or introduction of technologies that decouple economic value creation and natural resource consumption, to position the firm for strategic advantage in a future environment of increasingly scarce natural resources and regulatory inflexibility.

The particular contribution of the NRBV to the current study is its conception of resource constraint not as a threat to sustainability but as its driving force. According to Hart's original treatment of the theory, firms in markets where resources are expensive, constrained or otherwise unpredictable, are the firms where we would expect to find pollution prevention and resource efficiency capabilities. This dynamically applies to Pakistani manufacturing SMEs. A firm in which 28% of the production cost is attributable to energy, that operates in a market where recycled polymer costs 15 to 25% less than its virgin counterparts, and that is based in an industrial estate in which other firms generate waste streams suitable for reuse, confronts economic imperatives for resource efficiency that are more structurally preeminent than any top-down or bottom-up pressure for regulatory or reputational compliance that a developing state government or domestic purchaser might bring to bear. The NRBV recasts these economic imperatives as the basis for a new competitive advantage rather that cost control, which is an important distinction for the theory of Orenda's sustainability practices, and for the recommendations that should be made for its improvement.

2.1.2 Limitations and Application to the Orenda Case

The NRBV has faced criticism on a number of fronts that are pertinent to its application here. Aragón-Correa and Sharma (2003) noted that the original framework was formulated with large-scale companies in mind and that the link between environmental strategy and competitive advantage in the context of SMEs is more complex, being influenced by industry sector, regulatory regime and managerial perceptions than Hart's (1995) original model proposed. In SMEs situated in developing country markets, the

lack of formalised sustainability governance systems means that pollution prevention and product stewardship capabilities, while they may be implemented in practice, may not be spelled out, quantified or communicated in a manner that creates market-based competitive advantages. Govindan et al. (2020) build on this critique, observing that in manufacturing in developing countries, NRBV capabilities often remain informal, rooted in operational practices (rather than strategic decisions) and are therefore difficult to generalise and communicate to potential customers or partners who might value them. These limitations can be applied to the Orenda case and are integrated into rather than excluded from the analysis. The anticipation, shaped by the NRBV and its critiques, is that Orenda will display pollution prevention and resource efficiency practices whose competitive value proposition is economically attractive but whose strategic value proposition and market communication is weak. This underpins the recommendations in Chapter Six, which are not directed at implanting sustainability practices into existing operations but formalising, strengthening and articulating the practices that economic need has already created.

2.2 The Circular Economy and the Nine R Hierarchy

2.2.1 Origins and Core Principles

Over the last decade the idea of the circular economy has gained one of the most prominent positions in the field of sustainability management, providing a systemic alternative to the linear extract-produce-dispose model of industrial production that has dominated since the first Industrial Revolution (Geissdoerfer et al., 2017). This concept traces its roots from the closed-loop system thinking of Boulding (1966) through the industrial ecology of Frosch and Gallopoulos (1989) to the performance economy of Stahel (2016), and culminates in the operationalised version of the Ellen MacArthur Foundation (2013), which proposed three practical CE principles of designing out waste and pollution, keeping products and materials in use at the highest possible value, and regenerating natural systems. In a comparative review of 114 CE definitions, Kirchherr et al. (2017) found a persistent conflict between narrow ones which reduce the circular economy to recycling and resource efficiency and broader ones that stress systemic change in the relationship between production and consumption. This is important for

the current study because it defines the interpretation of Orenda's practices. A company that uses 30% recycled plastic in their product is practising a circular economy behaviour, but whether it is a successful implementation of CE or a small improvement to a linear production system depends on its position within a spectrum of CE ambition, which is what the Nine R Hierarchy measures.

2.2.2 The Nine R Hierarchy and Its Application

The Nine R Hierarchy, developed by Potting et al. (2017) for the PBL Netherlands Environmental Assessment Agency, is the most finely grained hierarchy for measuring circular economy strategies in terms of resource value retention. The hierarchy ranks a series of nine circular economy strategies in descending order based on ambition, starting with R0 Refuse, which avoids product creation altogether, through R1 Rethink, R2 Reduce, R3 Reuse, R4 Repair, R5 Refurbish and R6 Remanufacture, concluding with R7 Repurpose, R8 Recycle for material recovery and R9 Recover for energy recovery. The essential point of analysis here is not that recycling and reuse are distinguished but that the hierarchy highlights the loss of resource value. For example, while material recycling at R8 requires considerable energy, and commonly produces a product with different material properties to the original, reuse at R3 preserves the value of the product's original manufacturing process. A company that recycles but fails to declare its practices in terms of the hierarchy is not asserting as much.

This hierarchy provides a granular rather than a fuzzy picture for Orenda. The use of recycled PBT (15%) and recycled polycarbonate (30%) puts these material practices at R8, the material recovery stage, and the second-lowest level of CE ambition. The steel-for-cardboard swap with other nearby factories is more complicated. It is not "recycling" in the traditional sense since the materials are not being "reprocessed". It is better conceptualised as an informal type of industrial symbiosis underpinned by one firm's waste material being used as another's raw material (without being reprocessed) which more closely fits the R3 Reuse or R7 Repurpose elements of the 9R Hierarchy depending on whether the steel is used as is or modified for another purpose. The investment in solar energy does not fall under the Nine R hierarchy, which is a material strategy hierarchy, but is included under the Sustainable Technology Capability of the NRBV model. Our deployment of the 9R Hierarchy enables a theoretically rigorous assessment

of Orenda's circular economy practices that is well beyond a "yes or no" analysis of whether Orenda engages or does not engage in circular economy activities.

2.2.3 Industrial Symbiosis and Informal CE in Pakistan's manufacturing

The inter-firm material exchange described in the Orenda case is an example of what the CE literature calls industrial symbiosis, where one firm's waste becomes inputs for another firm and vice versa, so that the overall demand for material inputs and waste generated is reduced for both firms (Katz-Gerro and Sintas, 2018). Industrial symbiosis is well documented in formal eco-industrial parks such as Denmark's Kalundborg Symbiosis, but the literature also consistently reports industrial symbiosis in geographically compact clusters of firms for whom knowledge sharing and waste-material exchange is made easier by the relative proximity between firms (Anderson, 2020). The Allah Hoo Industrial Estate, in which Orenda operates alongside garment manufacturers and steel processors in a spatially concentrated industrial cluster, is the sort of context in which one would most likely find informal industrial symbiosis in the absence of specific policy design or formal institutional arrangements.

Iqbal et al. (2023) and Amanullah (2024) confirm that in Pakistani manufacturing, micro-scale (firm-level) circular economy practices are largely informal, ad hoc and cost-oriented rather than strategic for sustainability. This fact is analytically significant because it means that the lack of formal CE policy and sustainability governance at Orenda should not be taken as a lack of CE practice. It means instead that CE has emerged through the economic process that the NRBV forecasts, that the formalisation and deepening of CE is a starting point for rather than starting from scratch sustainability strategy.

2.3 The Institutional Voids Framework

2.3.1 Origins and Core Propositions

The Institutional Voids framework was proposed by Khanna and Palepu (1997, 2010) to account for why the usual business strategies developed for high-income economies are often ineffective in emerging markets; and why firms operating under their conditions also behave in a way that, by the standards of the high-income economies, seems

inefficient. The core idea of the framework is that in high-income economies, markets operate efficiently because they are complemented by a rich tapestry of intermediary institutions: regulatory agencies that enforce contractual obligations and environmental regulations, financial institutions that give firms access to capital for investment, information intermediaries that increase transparency between consumers and producers, and educational institutions that produce skilled managerial talent. The underdevelopment or absence of these intermediaries are what Khanna and Palepu call institutional voids, and are not merely superficial imperfections but structural elements of the emerging market environment that determine the feasible business strategies available to firms in these markets.

In the world of supply chain management, Institutional Voids have been most widely applied by Samarth in the context of last-mile logistics, where the lack of formal address systems, credit card payment systems, and minimum service guarantees is a set of voids that render Western-style optimisation strategies of little use (Khanna and Palepu, 2010). The same argument holds in the context of sustainability in Pakistan's manufacturing sector. The regulatory void in the form of poor enforcement of environmental regulations means that SSCM cannot be mandated. The funding void, in the absence of green financing options for SMEs, means that sustainability investment needs to compete against short-term operational needs without long-term finance that can tolerate longer payback periods. The information void, manifested in the lack of certified standards for recycled material and sustainability auditing of suppliers, means that recycled material integration is done via informal channels with dealers. The infrastructure void, reflected in the lack of a formalised waste collection and processing infrastructure in Pakistan, means that circular economy behaviour happens through informal trade and networks. Each such void informs a decision that Orenda makes in its supply chain that is then directly informative to a theme within the findings analysis of Chapter Five.

2.3.2 Limitations and Critical Application

The Institutional Voids approach has been criticised for its potential to view the operating environments of developing countries as deficient in relation to a westernised ideal, which would pathologise the informal institutional structures that firms create to overcome voids as shrivelled fig-leaves rather than as well-adapted innovations (Mair

and Marti, 2009). This is particularly pertinent in this study. Orenda's informal industrial symbiosis, its informal recycled material sourcing through dealer networks and its informal energy management based on its hybrid electric infrastructure are not substandard substitutes for the formalised sustainability governance prevalent in developed economies. They are context-specific, institutionalised responses to a particular institutional environment, and they may achieve sustainability effects that are more robust and flexible than their formal cousins. The analytical challenge is not to construct a formal institutional framework and then note the gap between Orenda's practices and an idealised model based on developed-economy practice, but to understand how the firm negotiates its particular institutional environment and what that negotiation suggests about how and by what means SSCM might emerge and grow in the absence of the institutional framework that is assumed in the mainstream literature.

2.4 Synthesis and Conceptual Framework

The three theoretical perspectives reviewed in this chapter are mutually complementary in a specific way. They tell different parts of the story that can't be told by the others, and they give a comprehensive diagnostic structure to the empirical work. The Natural Resource Based View explains the motivational logic of Orenda's SSCM practices, revealing resource constraint and cost considerations as the primary drivers of Orenda's pollution prevention and resource efficiency capabilities in the absence of regulatory or market drivers. The Nine R Hierarchy offers the evaluative language for describing the practices' depth and ambit with precision: by placing the inclusion of recycled materials, industrial symbiosis and solar investment in a spectrum of circular economy strategy, this allows us to ask Orenda questions about what it does and what it should do. The Institutional Voids framework explains the institutional context in which all of these practices take place, and highlights the regulatory, financial, information and infrastructure voids that limit the ambition of Orenda's SSCM and render informal sustainability practices the only way to practically engage in CE for a firm of Orenda's circumstances and size.

This integration is captured in the framework in Figure 1. This framework explains Orenda's SSCM practices as an interaction between the firm's internal resource

management practices, captured by the NRBV, and the institutional environment within which it operates, captured by the Institutional Voids framework, and the 9R Hierarchy as the evaluative lens through which the practices that emerge from this interaction are judged. This framework is the framework to which the four research objectives of this study are directly mapped. The first objective, describing current SSCM practices, is answered through the 9R Hierarchy, which offers the categories and assessment criteria to evaluate these practices. The second objective, exploring perceptions of SSCM's impact on performance, is addressed through the NRBV which predicts the types of benefits that resource efficiency capabilities should bring in terms of competitive advantage and operational efficiency and serves as a normative benchmark for perceptions. The third objective, examining implementation challenges, is addressed through the Institutional Voids framework, which offers a theoretically suggested classification of the institutional constraints on SSCM in Pakistan. The fourth objective, making recommendations, involves the simultaneous application of the three frameworks, to prioritise areas where NRBV capabilities can be enhanced, 9R positioning can be enhanced and institutional voids can be attuned through firm-level strategy and practice.

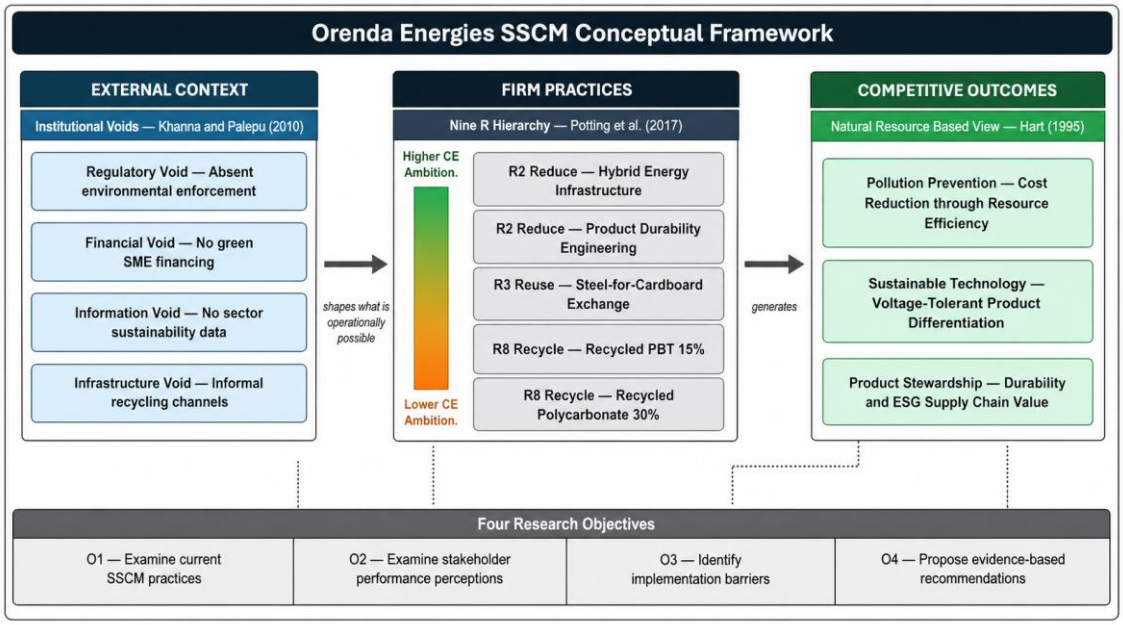

Figure 1: Conceptual Framework of the Study: NRBV, Nine R Hierarchy and Institutional Voids (Author: Hassan Ali)

2.5 Summary of Key Literature

Table 1 lists the key theoretical and empirical contributions to the analytical framework, grouped by theoretical category and the research objective(s) they address.

Table 1: Summary of Key Literature — Theoretical Domains and Relevance to Study (Author: Hassan Ali)

No.	Author(s)	Year	Key Contribution	Relevance to Study
1	Hart	1995	NRBV — competitive advantage from environmental resource management	Core motivational framework for Orenda's SSCM practices
2	Barney	1991	Resource Based View — firm-specific capabilities as competitive advantage	Theoretical foundation of NRBV
3	Aragón-Correa and Sharma	2003	NRBV contingency — SME applicability limits	Qualifies NRBV application to Orenda's SME context
4	Govindan et al.	2020	NRBV in developing country supply chains	Tacit capability limitation in SME SSCM
5	Potting et al.	2017	Nine R Hierarchy — CE strategy value retention spectrum	Evaluates depth and ambition of Orenda's CE practices
6	Geissdoerfer et al.	2017	CE as sustainability paradigm	CE theoretical foundation
7	Kirchherr et al.	2017	114 CE definitions — CE as spectrum not binary	Prevents conflation of recycling with comprehensive CE
8	Ellen MacArthur Foundation	2013	Three CE operational principles	CE framework foundation
9	Katz-Gerro and Sintas	2018	Industrial symbiosis in SME clusters	Theoretical frame for steel-cardboard exchange
10	Anderson	2020	Informal CE emergence in industrial clusters	Contextualises informal symbiosis at Allah Hoo
11	Iqbal et al.	2023	CE business models in Pakistani industry	Pakistan-specific CE evidence
12	Amanullah	2024	Informal CE behaviours in Pakistani manufacturing	Confirms informality pattern in Pakistan
13	Khanna and Palepu	1997, 2010	Institutional Voids framework	Core structural context framework
14	Mair and Marti	2009	Institutional Voids deficiency critique	Qualifies voids application, prevents deficit framing
15	Jia et al.	2018	SSCM in developing countries systematic review	Establishes contextual gap this thesis addresses
16	Koberg and Longoni	2019	SSCM systematic review — geographic concentration	Identifies 3% developing economy study share
17	Moktadir et al.	2018	SSCM barriers in Pakistani manufacturing	Validated barrier taxonomy for Chapter Five

18	Rashid et al.	2022	Emergent sustainability in Pakistani manufacturing	Frames cost-driven SSCM as theoretically legible
19	Mahar et al.	2024	GSCM and sustainability in Pakistani industry	Pakistan-specific GSCM evidence base
20	Durrani et al.	2024	Sustainability barriers in Pakistani SMEs	Contextualises underinvestment in SSCM
21	Khan et al.	2022	GSCM practices and performance in Pakistan	Empirical benchmark, 70% survey dominance statistic
22	Shafique and Clark	2022	Waste management in Pakistan	Contextualises recycled material sourcing conditions
23	AEDB	2022	Solar energy adoption in Pakistan	Energy infrastructure context
24	NEPRA	2021	State of Industry Report	Energy efficiency benchmarks
25	Yin	2018	Case study research methodology	Justifies single-case qualitative design

3 Research Design, methodology, and Case context

3.1 Research Philosophy

All research studies are grounded on a philosophical stance about the nature of reality, the nature of knowledge and the relationship between the research and the subject of study. It's not a procedural nicety but an epistemological imperative because the philosophical stance taken determines which research designs make sense, which research instruments are appropriate, and which forms of analysis are valid (Saunders et al., 2019). This chapter explicates the philosophical basis of the present study, and justifies the coherence of all the methodological choices it makes on that basis.

This study builds on an interpretivist philosophy. Interpretivism asserts that social phenomena, including those of organisations, cannot be studied through natural scientific methods because human organisations are saturated in meanings - the intentions, values, understandings and categories which people use to interpret their actions and situations (Lincoln and Guba, 1985). The sustainable supply chain practices of Orenda Energies Private Limited (Orenda) are not the "reality" that exists out there, separate from the perceptions and understandings of individuals who see it, understand it and frame it. They are social practices whose meaning, significance and strategic purpose is informed by the interpretations of the Chief Executive who justifies energy investments in terms of operational continuity, the Production Manager who explains the use of recycled material in terms of thermal performance, the Supply Chain Manager who evaluates the economics of the steel-for-cardboard swap, the B2B client who assesses Orenda's sustainability practices in terms of ESG compliance for their own exports, and the Technical Consultant who locates the firm's practices within the national energy transition. To understand how Orenda incorporates SSCM, we need access to these first-person perspectives, which quantitative measurement is incapable of offering.

In the interpretivist research paradigm, this study takes a constructivist realist ontological stance. This position allows recognition that some aspects of Orenda's reality are objectively ascertainable - the 50KW capacity of its solar system, the 30% recycled content of its polycarbonate roof, the coordinates of Plot 32 in the Allah Hoo Industrial Estate. At the same time, it acknowledges the strategic significance of these features -

whether the solar installation is a sustainability commitment or a grid reliability hedge, whether the use of recycled material is a circular economy intention or pragmatic cost-avoidance strategy - is an interpretation based on the accounts of people involved in decision making. The constructivist realist stance allows the study to work with both objective contextual and interpretive qualitative data without privileging one over the other.

3.2 Research Approach

The approach to empirical research can be placed at a point along the spectrum of deductive approaches, which derive theoretical hypotheses from empirical data to be tested against theoretical propositions, and inductive approaches which derive theoretical propositions from patterns in empirical data (Saunders et al., 2019). This study adopts an inductive approach, based on the understanding that the existing body of literature on SSCM has been developed largely in high-income economy settings and multinational large corporate contexts whose patterns do not apply to that of a Pakistani manufacturing SME in conditions of energy crisis, institutional voids and the affordability challenges associated with pursuing sustainability.

To deductively apply existing SSCM frameworks to Orenda - using theory as a constant standard against which the firm's SSCM practice is assessed for fit or misfit - would be to commit the same sin that Samarth (2025) finds in the application of the western logistics literature to India's last-mile logistics sector, by reading the structure of the theory into a context for which it was not designed, and misreading contextually rational behaviours as anomalies of the theory. The inductive approach taken in this study reverses this process so that interpretation is allowed to arise out of and remain rooted in the empirical accounts of the research participants; and so that the three theoretical frameworks in Chapter Two are regarded as lenses through which theoretical interpretation is made of the research findings rather than as hypotheses to test.

3.3 Research Design: Single Qualitative Case Study

This study adopts a single embedded, qualitative case study design of Orenda Energies Private Limited. The case study is preferred when the research question is "how" or "why" a particular phenomenon works in its context; when the boundaries between the phenomenon and its context are not clearly evident; and when the dynamics of the investigated phenomenon are beyond the control of the researcher (Yin, 2018). These three criteria apply to this study. The research question - how Orenda embeds SSCM practices and what outcomes, challenges, and implications are generated - is a contextual question that can only be answered in the specific institutional, industry and geographical context of the firm. The SSCM practices being studied are not independent variables but depend on their organisational context for their meaning. Nor does the researcher control Orenda's operations and supply chain, or the institutional context in which decisions are made.

A single case study is especially interesting, according to Siggelkow (2007), when it is revelatory, that is, when it offers access to an empirical phenomenon that has not been investigated systematically before and whose investigation generates theoretical insights that are transferable to a broader class of phenomena. This is the case with Orenda. It is an LED and SMD manufacturer in a Pakistani industrial estate, using recycled polymer interconnects, relying on a hybrid solar energy system, and from informal industrial symbiosis - a bundle of characteristics that has not yet been directly studied in the SSCM literature and whose study produces findings that are analytically replicable for the large number of domestic-facing manufacturing SMEs operating under a similar institutional void in Pakistan and the wider South Asian industrial landscape.

A single case design is preferred to multiple case designs in this study because of the focus on embeddedness within a specific context. Several cases would necessarily compromise the operational and interpretive detail that make the findings of this study analytically unique, swapping thick description for thin representation in a manner detrimental to achieving the study's research purpose. The findings are intended to facilitate analytical generalisation (development of a theoretical proposition that goes beyond the single case) rather than statistical generalisation (population generalisation), which accords with the interpretivist epistemological stance and the inductive approach taken in this study (Yin, 2018).

3.4 Case Selection and Justification

The choice of Orenda Energies Private Limited for study is based on a set of three criteria which serve to provide a theoretical, empirical and practical rationale for the case study. First, theoretical fit. Orenda is the point of intersection between the three theoretical frameworks outlined in Chapter Two. Its resource scarcity operating environment and its cost-based sustainability practices provide an empirical context within which to test NRBV propositions about the use of environmental resources in creating competitive advantage in a developing economy. Its practices of material recycling and inter-firm exchanges offer meaningful examples of circular economy operations whose placement within the 9R Hierarchy is both empirically and theoretically insightful. And its operating context within the regulatory, financial and infrastructural environment of Pakistan offers a tangible context for the direct application of the Institutional Voids framework in a developing economy context.

The second criterion is empirical content. Orenda's supply chain practices provide multiple observable and documentable sustainability-relevant elements (hybrid energy systems, heterogeneously integrated recycled polymer, informal steel-cardboard trading) that yield distinct empirical and explicit content for thematic analysis in Chapter Five. The availability of five interview subjects covering the organisation's executive, technical, operational and customer segments provides the multi-perspectival data needed to address the second research question about the impact of SSCM on performance, as viewed by the firm's management and stakeholder groups. The firm's operating status, registered status and LCCI membership, and the willingness of its leadership to participate in structured interview processes facilitate robust primary data gathering.

The third criterion is representativeness. The insights of a single case-study are not statistically generalisable to a wider population, but the conditions under which Orenda operates - SME-scale manufacturing in a Pakistani industrial estate, operating under energy crisis conditions, engaging in informal circular economy practices in the absence of institutional support infrastructure - are typical of a large and largely overlooked population of South Asian manufacturing firms. The propositions developed from the Orenda case are, therefore, transferable in the way that Yin (2018) describes: not as

propositions that all firms in the population would display the same behaviour as Orenda, but as theoretically deduced propositions regarding the conditions under which SSCM behaviours take place, the obstacles that hinder them and the challenges that are most likely to promote them.

3.5 Data Collection: Semi-Structured Interviews

The primary data source for this study was five semi-structured interviews with key informants identified based on their functional involvement in Orenda's supply chain and their ability to address the research objectives. Semi-structured interviews were selected as the main data-collecting tool because they retain the standardization of a topic guide in advance of the interview - ensuring that all four of the study's research objectives are addressed in the set of interviews - while allowing the interviewer to follow up unexpected lines of enquiry that may be spontaneously introduced by respondents (Bryman, 2016). In a project intended to understand the enactment, perceptions, and constraints of SSCM practices within a particular organisational setting, the lack of flexibility inherent in a standardised interview with a full questionnaire would preclude the kind of context-specific information required to address the research objectives, while the lack of consistency that would result from an entirely unstructured interview would undermine the cross-respondent comparability needed for the thematic analysis.

The five respondents were purposively sampled - specifically, by criterion-based sampling - which means that individuals are selected not for their representativeness of a statistical population but for their perceived ability to provide rich data relevant to the research objectives (Patton, 1990). The criteria for selection was that each respondent should have functional responsibility for at least one aspect of Orenda's supply chain operations: energy management, material procurement, manufacturing process, logistics and/or client-side supply chain integration, and that the collective set of the five respondents should address the four research objectives from multi-functional perspectives within a typical firm.

Table 2 details the role, position and key research objective relevance of each respondent.

Table 2: Respondent Profiles and Interview Relevance to Research Objectives (Author:

Hassan Ali)

Respondent	Designation	Organisation	Primary Relevance to Research
R1	Chief Executive	Orenda Energies Pvt. Ltd.	Strategic SSCM intent, energy investment rationale, overall sustainability positioning
R2	Head of Manufacturing	Orenda Energies Pvt. Ltd.	Production process, recycled material integration, thermal management, operational constraints
R3	Operations Lead	Fine Garments Industries, Allah Hoo Estate	B2B client perspective, ESG compliance requirements, supply chain integration
R4	Technical Consultant	Pakistan Energy Sector	Sectoral energy context, demand-side efficiency, national SSCM landscape
R5	Supply Chain Manager	Orenda Energies Pvt. Ltd.	Procurement operations, inter-firm exchange, logistics, material sourcing channels

The interview topic guide was organised around the four research objectives, with initial questions aimed at providing a general description of each respondent's involvement with Orenda's supply chain before proceeding to more targeted questions concerning energy management, material sustainability, inter-firm exchange, challenges and opportunities to improve. Interviews were semi-structured and of a duration of 45-60 minutes. The purpose of the research, the academic nature of the study, and the option of withdrawing from the study at any time were explained to the respondents, in line with ethical considerations outlined in Section 3.8. Interviews were recorded and transcribed for analysis, with the consent of the respondents.

3.6 Data Analysis: Reflexive Thematic Analysis

The method used to analyse the interview data is the reflexive thematic analysis (RTA) method outlined by Braun and Clarke (2019), which offers an epistemologically coherent, systematic approach to discovering, generating, and analysing patterns of meaning in qualitative data. The reflexive method proposed by Braun and Clarke (2019) was preferred over other forms of qualitative analysis - grounded theory, framework analysis and content analysis - because it is explicitly identified as suitable to studies in which the researcher approaches the data with a theoretical framework, rather than inductively generating theory from the data, and to studies in which meaning is to be explored interpretively, rather than simply counted as in content analysis.

The analysis followed six phases outlined by Braun and Clarke (2019). In phase one, the researcher immersed in the data by reading through the five interview transcripts several times to gain an initial familiarity with the phenomena for analysis prior to any coding. In the second phase, initial coding, the researcher developed descriptive codes reflecting semantically meaningful units of analysis across the entire data set, with attention to both explicitly stated and implied conditions, constraints and logic informing SSCM practice at Orenda. In the third phase, theme development, the initial codes were organised, grouped and sorted to form candidate themes, which reflected important patterns of experience and meaning across respondents. In the fourth phase, theme review, the candidate themes were reviewed against the full data set to determine whether they were fully grounded in the data and whether they "worked" together to capture the most interesting patterns of perception and experience. In the fifth phase, theme definition and naming, the themes were precisely defined and given memorable names that reflected their analytical content, rather than their topic. In the sixth phase, writing up, the themes were written into the narrative analytical account of Chapter Five, using direct quotations from the interview data as sources of evidential support for claims made.

The theme structure produced by this process aligns with the three theoretical frameworks of Chapter Two, and the four research objectives of the study. The NRBV framework provides the interpretative framework for themes focusing on the motivation and competitive advantages of Orenda's sustainability behaviours. The 9R Hierarchy provides the normative vocabulary to interpret themes related to the ambition and practice of its circular economy behaviours. The Institutional Voids explanation provides the framework for issues regarding the constraints to effective SSCM. This isn't an imposed fit but an actual congruence between the theoretical frameworks (chosen for their salience in analysing the research problem) and the patterns of experience and perceptions articulated by the respondents.

3.7 Research Quality and Trustworthiness

The criteria of validity and reliability that apply to quantitative research are replaced in qualitative studies with the criteria of trustworthiness as described by Lincoln and Guba (1985): credibility, transferability, dependability and confirmability. These criteria have

been taken into account through particular procedural considerations in the design and conduct of this study.

Credibility, corresponding to the criterion of internal validity in quantitative research, is the extent to which the researcher's interpretations resonate with the interpretations of research participants. This study has improved it through member checking, in which the researcher presents his key conclusions arising from each respondent's account for review and confirmation before finalising the thematic analysis. Credibility was also enhanced through the use of multiple respondents from a range of organisational roles and points of view, which constitutes a form of investigator triangulation minimising the likelihood of bias from individual respondents having a distorting effect on the interpretation.

Transferability, the qualitative equivalent of external validity, does not refer to the statistical generalisability of the findings, but to the need to provide sufficient detail of the research context to allow readers to determine whether the findings are relevant to a given context. This has been achieved by the provision of the thick description of the organisational context of Orenda in Chapter Four, as well as by the clear specification of the applicability of the analytical propositions advanced in this study.

Dependability, the qualitative analogue of reliability, refers to the auditability of the research process. It was achieved through the maintenance of a detailed methodological audit trail of the coding, theme generation and interpretive process involved in the thematic analysis, so that the process of interpretation could be audited by another researcher.

Confirmability, the qualitative equivalent of objectivity, refers to the extent to which the findings are a reflection of the data, not the researcher's preconceived ideas. It was ensured through reflexivity (the researcher's reflective acknowledgement of the ways in which their ideological beliefs, institutional affiliations and interpretive biases may have influenced the way they analysed the data) and by the researcher's adherence to the discipline of providing evidential examples in the form of direct quotations from the interview data for all of the interpretive claims made.

3.8 Ethical Considerations

The research adhered to the ethical guidelines for academic research involving human subjects. Before data collection, each of the five respondents received an information sheet that explained the purpose for the research, the way in which the data collected would be used, how their confidentiality would be maintained, and their ability to withdraw from the study at any time without penalty. Each respondent was required to give informed consent prior to their interview. Given the private status of Orenda Energies, and the fact that the five respondents are either employees of or otherwise closely involved with the company, extra care was taken to ensure that respondents were aware that their individual stories would be anonymised when reporting the findings, and that no sensitive commercial information would be reported in a way that could be traced to a particular individual.

The company's informed consent to take part in this research was granted by the CEO before data collection commenced, with a clear understanding that the research would be used for academic purposes and the firm would be named in the thesis (due to the nature of the case study). There was no remuneration offered for participation and no data was collected about or from individuals who had not consented to participation.

3.9 Methodological Limitations

This study has three methodological limitations. First, the case study design, inherently, restricts the extent to which statistical generalisation can be made and leaves open the argument that Orenda's practices and challenges are unique to its specific organisational, cultural, historical and geographical context rather than typical. This is an inherent weakness of the case study design, and is addressed as outlined in Section 3.3 by the theoretical rather than statistical nature of generalisation. The second limitation is the use of self-reported data from interviews, which is influenced by social desirability bias - the inclination of respondents to overstate the practices of their firm more favourably than an objective assessment would reflect. This was partly overcome by including the external respondent, the Fine Garments Operations Lead, who provides a client perspective that cannot be as prone to social desirability bias as Orenda's managers' accounts are. Finally, the cross-sectional nature of this study, which provides

a snapshot of Orenda's SSCM practices at one point in time, means that it cannot describe the evolution of these practices over time, or how they will adapt to changing market conditions, energy costs or regulatory requirements. Longitudinal studies would make an important analytical contribution to this study's context-specific findings

4 Findings and Analysis

The research findings of this study are based on a thematic analysis of five semi-structured interviews with key informants from Orenda Energies Private Limited and its immediate supply chain partners. The analysis adhered to the six-stage reflexive process of Braun and Clarke (2019) outlined in Chapter Three above, arriving at four themes which resonate with the three theoretical ideas developed in Chapter Two and the four research questions of the study. The Natural Resource Based View provides the interpretive framework for explaining why Orenda's SSCM practices are, and what competitive advantage they afford. The Nine R Hierarchy offers the critical language to describe how comprehensively and ambitiously the practices interact with the principles of circular economy. The Institutional Voids framework offers the structural explanation for the institutional conditions under which all supply chain decisions are made and the factors that constrained ambition in SSCM. Table 3 outlines the respondent detail, job title, primary contribution to the themes and research objectives addressed by their accounts that underpins the confidence in the thematic analysis.

Table 3: Respondent Profiles and Primary Contribution to Research Objectives (Author: Hassan Ali)

Respondent	Designation	Organisation	Primary Themes Raised	Objectives Addressed
R1	Chief Executive	Orenda Energies Pvt. Ltd.	Strategic intent, energy positioning, demand-side efficiency, competitive logic	O1, O2, O4
R2	Head of Manufacturing	Orenda Energies Pvt. Ltd.	Production process, recycled material integration, thermal management, operational constraints	O1, O2, O3
R3	Operations Lead	Fine Garments Industries, Allah Hoo Estate	B2B client perspective, ESG compliance, inter-firm collaboration, supply chain integration	O2, O3
R4	Technical Consultant	Pakistan Energy Sector	Sectoral energy context, demand-side efficiency, national SSCM landscape, talent development	O1, O2, O4
R5	Supply Chain Manager	Orenda Energies Pvt. Ltd.	Procurement operations, inter-firm exchange, logistics, competitive positioning	O1, O3, O4

The four themes are offered in a serial manner. Theme One explores Orenda's existing SSCM practices in terms of energy, material and inter-firm procurement, addressing Research Objective One. Theme Two explores stakeholders' perceptions of the effect of these practices on operational and environmental performance (addressing Research Objective Two). Theme Three maps the structural, institutional and managerial issues limiting the effectiveness of SSCM, addressing Research Objective Three. Theme Four articulates the strategic thinking of respondents to outline believable avenues for progress in SSCM, which provides the basis for the recommendations in Chapter Six, and addresses Research Objective Four. The chapter ends with a synthesis that addresses the main research question and the two sub-questions.

4.1 Theme One - SSCM Practices in Action: Energy, Materials, Inter-Firm Exchange

4.1.1 Energy Infrastructure as a Hybrid Sustainability Practice

The single most frequently and detailed element of Orenda's SSCM practice in the interview data is its hybrid energy system, comprising a 100KW national grid connection, a 100KW diesel generator to provide back-up generation, and a 50KW solar photovoltaic system. The importance of this system is framed by respondents not in terms of environmental responsibility but in terms of business survival - to wit, an analysis that accords with the NRBV view that resource-constricted firms build sustainability capacity primarily through a calculus of resource efficiency rather than through environmental strategy.

The Chief Executive powered through the strategic core of the hybrid energy system in a way that is revelatory. R1 explained that the main purpose is tolocalise the manufacturing of high-efficiency electrical items to help Pakistani industries fight against the rising cost of energy, and that the company is the "demand-side revolution" and is playing its part in energy-saving (and therefore energy creation) for the national economy. The framing is illustrative: sustainability is framed as a systemic contribution to national energy efficiency but the means to achieve it (localised LED and SMD manufacturing) is also a competitive positioning strategy, informed by the NRBV logic of developing advantage from the resource-based constraints of Pakistani manufacturing.

The Technical Consultant framed the energy positioning in a sectoral sense that enhances its theoretical framing. R4 said firms like Orenda are critical for Pakistan's energy security plans because they address load reduction at the end-consumer level, and while there's considerable investment in large-scale wind and solar infrastructure, the industrial sector needs to adopt efficient hardware to make these investments effective. This narrative casts Orenda's hybrid energy system not as an efficiency measure for firm success but as a demand-side sustainability strategy complementary to Pakistan's supply-side renewable energy investments - in line with Hart's (1995) sustainable technology capability, where investment in resource decoupling technology leads to competitive advantage in a resource transition environment.

Table 4 shows Orenda's energy profile and implications in the three axis of the analytical framework, mapping sources to their 9R position, NRBV capability profile and institutional void partially filled.

Table 4: Energy Infrastructure Configuration — 9R, NRBV and Institutional Voids Mapping (Author: Hassan Ali)

Energy Source	Capacity	Primary Function	9R Position	NRBV Capability	Institutional Void Addressed
National Grid (WAPDA)	100KW	Baseline production power	R2 Reduce	Pollution Prevention	Energy infrastructure void — partial
Solar PV Installation	50KW	Renewable generation and cost reduction	R2 Reduce	Sustainable Technology	Financial void — self-financed hedge
Diesel Generator	100KW	Backup during load-shedding	Operational continuity	Pollution Prevention	Infrastructure void — fully self-addressed

The Plant Manager provided operational detail that hints at a sustainability dimension that can be found in the production process, rather than in formal environmental management. R2 explained the plant was "focused on precision assembly of SMD fixtures which must be thermally managed to function under high temperature ambient conditions in Pakistan", and that, unlike cheaper imports, locally assembled units are tested for heat dissipation and luminous efficacy to ensure durability in harsh industrial settings. The focus on product longevity via thermal management engineering is, in the Nine R Hierarchy, a practice of product stewardship at R2 Reduce: through engineering product lifetime via heat dissipation, the firm reduces the rate of consumption of the product and hence the total material and energy consumption over the product lifetime.

This is a circular economy supply chain impact resulting from process rather than formalised corporate sustainability planning and governance, in line with the informal NRBV capability of the manufacturing firms in the developing world identified by Govindan et al. (2020).

4.1.2 Recycled Material Integration and its Limits

The second key aspect of Orenda's SSCM practice is the integration of recycled plastic content in its product manufacturing at a blended ratio of 30% for its product portfolio (15% recycled content for PBT housings and 30% for polycarbonate housings). The application of the Nine R Hierarchy with the clarity and precision demanded by the model results in a clear verdict: integration of recycled material places Orenda's material practices at R8 Recycle - the second lowest grade of CE ambition. This does not mean that this practice is not important: R8 is categorically better than R9 energy recovery and landfill, but it does place this practice in its proper position on the CE continuum which differentiates between systemic circularity and incremental improvement to a linear production system, as Kirchherr et al. (2017) stress in their review of 114 CE definitions. The Production Manager operationally justifies the difference in recycled content percentages between PBT and polycarbonate in terms of specific technical restrictions on the use of recycled content in precision micro-manufacturing. R2's explanation of thermal management and luminous efficacy standards suggests that the lower percentage used in PBT is related to the more stringent performance demands for this component in heat-exposed areas of bulb assembly, where material variability and changes in mechanical properties across recycling iterations is more important than in the polycarbonate housings. This firm-specific detail explains why a qualitative case study approach is analytically suited to investigating recycled material use in manufacturing supply chains: it describes the firm-specific technical detail unavailable in survey approaches.

The Supply Chain Manager's account of procurement logic for integrated use of recycled material confirms the cost-driven rationale predicted by the NRBV. R5 described the overall objective as "to prove Pakistan's electrical goods are equal to the international brands in terms of durability and specification", with the use of recycled material as part of a cost structure strategy that allows for competitive pricing at an equal or higher quality level, rather than as an independently motivated sustainability strategy. This is

the same cost competitiveness mechanism that the NRBV predicts pollution prevention capabilities create competitive advantage, not through higher prices for a sustainability premium, but through cost competitiveness that allows lower prices for desired quality levels.

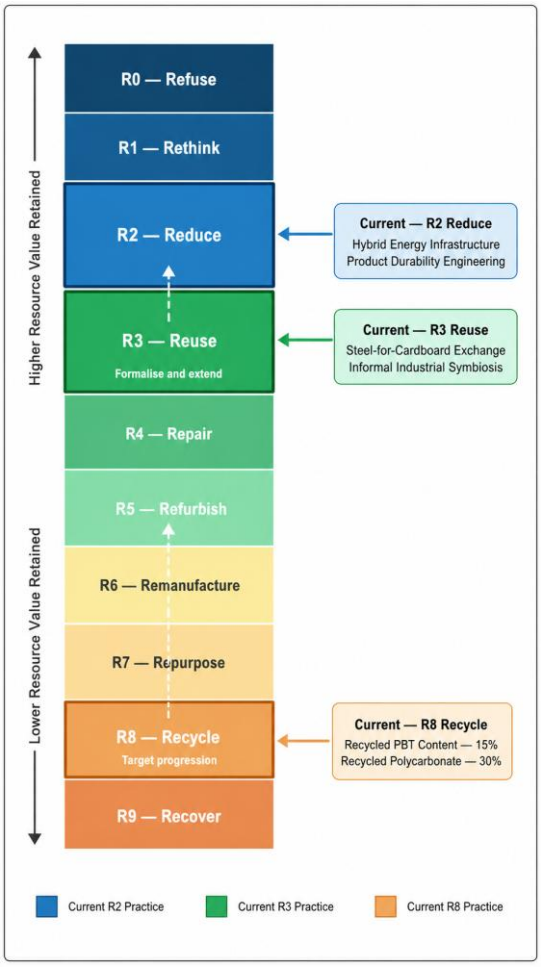

Figure 2: Orenda's Current CE Practices Mapped on the Nine R Hierarchy with Progression Pathways (Author: Hassan Ali)

4.1.3 Industrial Symbiosis: Steel-for-Cardboard Exchange

The third facet of Orenda's SSCM practice is the material exchange with their fellow tenants at the Allah Hoo Industrial Estate, where steel offcuts from Orenda's manufacturing are exchanged for cardboard packaging materials at a 10% discounts agreed between the firms. The location of this practice in the Nine R Hierarchy is more positive than that of recycled polymer integration: the material exchange without reprocessing corresponds to R3 Reuse or R7 Repurpose (and is therefore higher than R8 Recycle) because no energy costs are involved and no properties are lost in the switching

of uses. As a result, the industrial symbiosis practice is Orenda's highest order circular economy practice in analytical terms, even if it is informal and unrecorded.

The Supply Chain Manager's account of Orenda's procurement practice confirmed the logistics underpinning this arrangement, noting the proximity to Gajju Mata is a logistical advantage in that it brings them close to the main industrial corridors of Punjab. The proximity of different sorts of manufacturing firms in the Allah Hoo estate (garment manufacturers, steel processors, electrical hardware manufacturers) within a compact industrial cluster creates the inter-firm proximity highlighted in the industrial symbiosis literature as the key contextual feature enabling informal resource exchange arrangements (Katz-Gerro and Sintas, 2018; Anderson, 2020).

The description from R3, the Lead of the division of Fine Garments, confirmed the operational reality of active inter-firm cooperation within the estate, detailing how the decision to convert to Orenda's LED technology was strategic given it reduced costs and earned the company's compliance with international ESG performance standards, while noting the proximity of a specialist manufacturer means that technical support and supply chain problems can be solved immediately. This outsider view is of analytic interest for two reasons. It confirms that Orenda's sustainability practices have a real operational benefit for one local stakeholder, offering initial empirical evidence to support the NRBV claim that these practices create competitive advantage in the B2B market. And it highlights a supply chain sustainability mechanism at the level of Orenda's governance and beyond: the B2B clients for whom Orenda provides energy-efficient products are subject to global ESG pressures, and Orenda's products would be a sustainability input for the B2B clients - providing an indirect value proposition through which formalised SSCM practices would create market value if formalised and communicated.

Table 5 provides a summary of all five dimensions of SSCM practices, their 9R hierarchy placement, NRBV capabilities classification and institutional voids shaping their practice.

Table 5: SSCM Practice Summary - 9R Hierarchy, NRBV and Institutional Voids (Author: Hassan Ali)

SSCM Practice	**Description**	**9R Position**	**NRBV Capability**	**Institutional Context**
Hybrid energy infrastructure	100KW grid, 50KW solar, 100KW diesel	R2 Reduce	Sustainable Technology and Pollution Prevention	Self-addressed infrastructure and financial voids

Recycled PBT integration	15% recycled content in bulb PBT housing	R8 Recycle	Pollution Prevention	Informal material sourcing via dealer networks
Recycled polycarbonate	30% recycled content in PC housing	R8 Recycle	Pollution Prevention	Informal material sourcing via dealer networks
Steel-for-cardboard exchange	Inter-firm exchange at 10% negotiated discount	R3 Reuse and R7 Repurpose	Pollution Prevention	Spatial proximity bypasses infrastructure void
Product durability engineering	Heat dissipation design for extended product life	R2 Reduce	Product Stewardship	Internally developed technical capability

4.2 Theme Two — Stakeholder Perceptions of SSCM Influence on Performance

4.2.1 Operational and Competitive Performance

Across the five interviews, a recurrent theme is the belief in beneficial operational performance outcomes of Orenda's SSCM practices, including respondents who only interact with the firm externally. This outcome is consistent with the NRBV proposition that resource efficiency benefits translate into competitive advantage, although in Orenda's case the form that this advantage takes is operational continuity and cost advantage, rather than market premium - an outcome more reflective of the institutional context of manufacturing in Pakistan.

This effect is most explicitly explained by the Chief Executive. R1 explained that the company's emphasis on SMD (Surface Mounted Devices) and LED (Light Emitting Diodes) technologies is offering products that are tailored for the local grid's voltage issues, which positions the engineering of voltage-tolerance as a resource efficiency capability that is valuable, context specific and rare for imported products. This is the precisely the situation in which Hart (1995) predicts sustainable competitive advantage will be gained from sustainable technology capability. The Production Manager added to this from the shop floor, observing ongoing tweaking of assembly lines to incorporate the latest semiconductors and low carbon emissions (the only specific reference to a carbon metric in all the interviews, and the fact that it is mentioned in an operational rather than

strategic interview confirms the tacit, functionally embedded character of the NRBV capabilities at Orenda).

The Technical Consultant pushed the operational efficiency to a national level. R4 noted that localising the manufacture of LED and SMDs avoids the need to exchange the country's foreign exchange earnings to meet the national demand for these goods, and in so doing, develops a technical workforce in Lahore, with Orenda's manufacturing site as a social sustainability achievement simultaneously forming part of the economic case for localising manufacture. This system-wide understanding of value creation from firm-level SSCM that extends to the industry and national level is consistent with the NRBV perspective on sustainable technology as a source of competitive advantage that reaches beyond the firm, to the value network.

4.2.2 Environmental and Social Performance Perceptions

Conceptualisations of the value of environmental performance in the data were expressed largely through the metrics of cost reduction and operational efficiency rather than environmental performance criteria (consistent with Rashid et al.'s (2022) assessment of emergent sustainability in Pakistan manufacturing where sustainability outcomes are perceived, not as strategic goals, but as by-products of economic efficiency). The very explicit account of the B2B client's environmental performance value was most visible to the outside world. R3 indicated that adopting Orenda's LED lighting helped achieve international ESG compliance standards, demonstrating a type of environmental performance value creation that takes place through the supply chain. This supply chain sustainability is important for commercial ends because it is an existing market mechanism that would be made more valuable for commercial ends through formalisation of SSCM documentation - a point made by the strategic considerations in Section 4.4.

Table 6 captures perceptions of the impact of SSCM on performance across the three TBL dimensions, and the specific interview respondent which expressed each perception and the theoretical lens through which it is viewed.

Table 6: Stakeholder Perceptions of SSCM Performance Across TBL Dimensions (Author: Hassan Ali)

Performance Dimension	Perception	Respondent	Theoretical Frame

Economic — cost efficiency	Recycled material and solar reduce production costs	R1, R5	NRBV Pollution Prevention capability
Economic — competitive positioning	Voltage-tolerant durable products compete with imports	R1, R2	NRBV Sustainable Technology capability
Economic — B2B value	LED solutions reduce client operational overhead	R3	NRBV Product Stewardship capability
Environmental — carbon footprint	Assembly process maintains low carbon footprint	R2	Tacit NRBV capability — unarticulated formally
Environmental — ESG supply chain	Products enable client ESG compliance	R3	Institutional Voids — indirect sustainability market
Social — employment and talent	Technical workforce development in Lahore	R4	TBL Social dimension
Social — national efficiency	Demand-side contribution to energy security	R1, R4	NRBV Sustainable Technology — systemic level

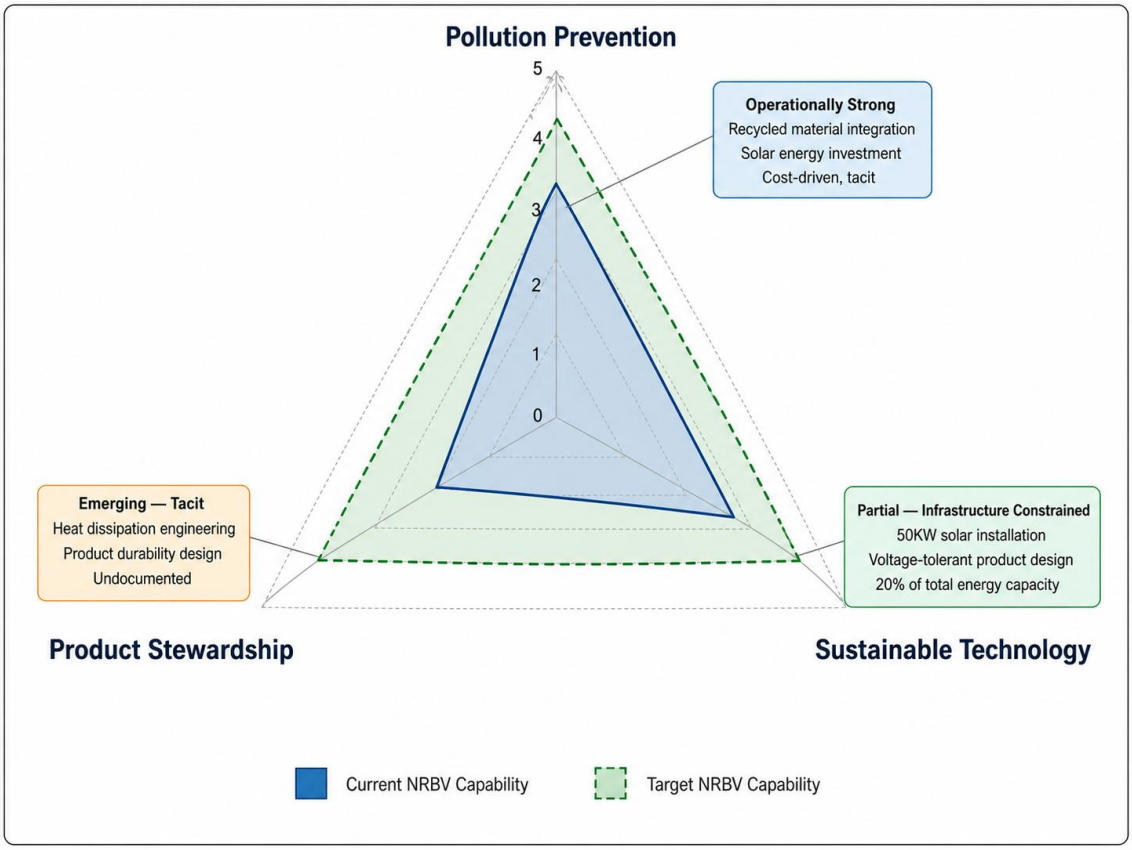

Figure 3: NRBV Capability Profile of Orenda Energies — Current State and Target Assessment (Author: Hassan Ali)

4.3 Theme Three — Barriers and Constraints on SSCM Effectiveness

4.3.1 Financial and Investment Constraints

The most frequently implied constraint on the dataset is financial constraint imposed by the combination of high energy costs with the tight gap between cost and price and the institutional absence of green finance instruments that would allow SME-scale manufacturers in Pakistan to make initial investments with medium- to long-term payback horizons - that is, the financial void from the Institutional Voids framework. This constraint was most clearly articulated in the Supply Chain Manager's description of a procurement process that is squarely focused on demonstrating the ability of products made in Pakistan to compete with global brands, and a margin environment that makes longer-term investments (beyond cost reducing) into sustainability practices unsustainable. The 50KW solar project, use of recycled material, and the steel-for-cardboard swap are practices whose implementation was made financially feasible by their cost-reducing effects, rather than their immediate up-front costs with medium- or long-term pay-back windows. Sustainability activities which would require patient capital - formal reverse supply chain, third-party sustainability certification, waste heat recovery - are simply outside the range of investment that the Orenda financial environment allows.

4.3.2 Regulatory and Institutional Voids

The fact that no mention of regulatory compliance is made as a driver of Orenda's sustainability practices in the five interviews is significant in and of itself. In a regulatory environment where environmental regulation is being fully applied, interviewees could be expected to refer to regulatory compliance as one of the drivers of implementing SSCM (alongside economic drivers). This supports the Institutional Voids framework's characterisation of the regulatory void in Pakistan's manufacturing environment, and confirms that Orenda's SSCM adoption is entirely endogenous as predicted by the NRBV, not exogenous and driven by regulatory incentives. The information void is also apparent: the Technical Consultant's articulation of Orenda's contribution to Pakistan's demand-side energy security provides a policy-relevant argument for the absence of

sector-wide data collection and communication infrastructure to support, measure, and communicate at the industrial and government level.

4.3.3 Formalisation and Governance Gaps

The third gap revealed by the dataset is the lack of formal structures of sustainability governance to measure, communicate, and develop existing SSCM practices - in the form of specialised environmental management functions, written green procurement policies or supplier sustainability evaluation procedures or sustainability reporting frameworks. The Chief Executive's strategic narrative of the firm's purpose expressed in terms of localisation and demand side efficiency, but not sustainability measures, environmental goals, or formalised CE strategies is the quintessential expression of this formalisation and governance gap. The capabilities are there; but there is no governance and measurement framework to build, measure and report on them. This is not a case of strategic blindness, but an outcome of the institutional voids conditions under which the firm is operating in the Khanna and Palepu (2010) framework and it can be addressed at the firm level with the recommendations of Chapter Six.

Table 7 provides a mapping of the barriers identified in the data set against the Institutional Voids framework's four categories of "voids", the interview evidence that led to the identification of each barrier, and the NRBV capability development opportunity that would come with addressing each of the institutional voids.

Table 7: Barriers to SSCM Effectiveness — Institutional Voids Framework and NRBV Opportunities (Author: Hassan Ali)

Barrier	Void Category	Interview Evidence	NRBV Opportunity Unlocked
Absence of green financing for SMEs	Financial void	Sustainability limited to cost-reducing practices only	Sustainable Technology — deeper solar and CE investment
No environmental regulatory enforcement	Regulatory void	Zero compliance references across five interviews	Pollution Prevention — currently only cost-driven
No sector-level sustainability data	Information void	R4's energy security argument unsupported by sector statistics	Product Stewardship — certification and ESG labelling
Underdeveloped recycled material infrastructure	Infrastructure void	Recycled material sourced through informal dealer networks	R8 to R5 progression — formalised reverse logistics
No formal sustainability governance	Institutional capacity void	No metrics, targets, or reporting across any respondent account	All three NRBV capabilities — formalisation pathway

4.4 Theme Four — Strategic Pathways: Respondent Perspectives on SSCM Advancement

4.4.1 Deepening Energy Sustainability

Respondents who proactively engaged with the future-oriented aspects of the interview and interview analysis identified energy infrastructure as the most tangible and feasible means of improving Orenda's SSCM performance. The Chief Executive's profiling of the firm as a major player in the demand side revolution implicitly sets a strategic target that the current 50KW solar power installation only partially achieves: 50KW is 20% of the total 250KW energy capacity. The distance between this strategic self-positioning and the current energy mix represents the most operationally accessible opportunity for Orenda to progress on its sustainability aspirations in the data set, an opportunity that builds on an existing NRBV capability rather than the need to develop new firm capacities.

This pathway offered a sectoral rationalisation by the Technical Consultant. R4's commentary that the industrial sector must embrace efficient hardware to enable the gains of utility-scale renewable energy suggests that increased solar capacity at Orenda is not only an efficiency gain for the firm, but also a step toward the national energy transition that the firm's Chief Executive pinpoints as its strategic vision. Expanding solar capacity from 50KW to 100KW to 150KW would successively transform its energy profile from a hybrid towards a mainly renewable profile, further developing its NRBV sustainable technology viability from adoption to differentiation.

4.4.2 Elevating Circular Economy Ambition

The second avenue supported by the interview evidence is the advancement of Orenda's CE practices from R8 Recycle to higher order CE strategies in the Nine R Hierarchy. Two avenues are validated by the interview data as plausible and feasible. Firstly, the institutionalisation of the steel-for-cardboard symbiosis scheme and possibly its expansion. The Supply Chain Manager' description of Orenda's procurement processes and the confirmation from the B2B client of collaboration within the estate also support

the possibility that Orenda can increase inter-firm resource exchange to include other material streams within the Allah Hoo cluster. The second is the gradual increase of recycled polymer content in components where the thermal and mechanical performance requirements do not exceed the thermal performance requirements imposed by the PBT components, providing a material-specific avenue for gradually increasing recycled content (currently 15% and 30%) in components while not affecting product quality or product lifetimes.

4.4.3 Formalisation as a Commercial Opportunity

The third, and strategically most important pathway, as revealed in the interview data, is the formalisation of Orenda's existing SSCM practices that can create commercial visibility. The explicit mention of ESG compliance by the B2B client as a motivating factor in its choice of Orenda's products signals a market process whereby documented sustainability practices have direct commercial value. R3 confirmed that the conversion to Orenda LED solutions aided compliance with international ESG standards - but as yet unmeasured and uncertified, this contribution is not yet commercially visible. The first step in the transition from "practice" to "document" to "commercial advantage" is to measure existing practices, documenting them in verifiable form for communication to current and potential B2B clients in terms of ESG compliance that the R3 account confirms as being valuable to their businesses, and then progressively formalising procurement and material management practices in a fashion that facilitates third-party verification without costly international certification at this stage in the firm's growth.

Table 7 juxtaposes Orenda's current SSCM position with the recommended progression of strategic pathways along all three dimensions of practice to inform the specific strategic recommendations in Chapter Six.

Table 7: Strategic Pathways Summary - Current 9R Position and Progression (Author: Hassan Ali)

SSCM Practice	Current 9R Level	Target 9R Level	Progression Mechanism	Commercial Benefit
Solar energy capacity	R2 Reduce — 20% of total energy	R2 Reduce — 40 to 60% of total energy	Expand solar from 50KW to 100 to 150KW	Reduced grid dependency, lower energy cost, stronger sustainability narrative
Recycled PBT content	R8 Recycle — 15%	R8 Recycle — 25 to 30%	Material trial with non-heat-exposed PBT components	Reduced material cost, stronger CE positioning

Recycled polycarbonate	R8 Recycle — 30%	R8 Recycle — 40 to 50%	Formal supplier quality protocol for higher-grade recycled PC	Reduced material cost, ESG documentation value
Steel-cardboard exchange	R3 Reuse — informal	R3 Reuse — documented and extended	Formalise exchange to additional material streams in estate	Documented CE practice, B2B ESG communication asset
Product durability	R2 Reduce — tacit	R2 Reduce — documented	Life cycle data collection, product longevity documentation	Premium positioning, ESG supply chain input for clients
Sustainability governance	None	Basic documented system	Internal sustainability reporting framework	Platform for certification, client communication, investment case

4.5 Synthesis of Findings

The four themes briefly outlined in this chapter answer the overarching research question and both sub-questions. The documentary and interview evidence establishes the fact that Orenda Energies Private Limited has developed a series of SSCM practices whose existence, coherence and logic are empirically sufficient, but whose magnitude, formalisation and messages are limited to the particular institutional void conditions of Pakistan's manufacturing sector. The hybrid energy generation, integration of recycled materials, and inter-firm exchange of materials are real circular behaviours, analytically speaking at the levels of R2 and R8 of the Nine R Hierarchy, while the industrial symbiosis is at the more resource-value-retaining levels of R3 to R7. The adoption logic of each of the three is consistent with the NRBV's pollution prevention and sustainable technology capabilities: each have been adopted because the Pakistan energy and material shortage and cost context makes it economically sensible, not because it is legally or socially necessary.

In response to Sub-question One, all five interviews support stakeholders' beliefs in the operational and competitive benefits of Orenda's SSCM. The Chief Executive and Technical Consultant articulate these in systematic terms, identifying the company's energy demand-efficiency contribution as an input to national energy security. The Production Manager explains them in product quality terms as an input into the heat dissipation engineering that product stewardship achieves, thereby delivering product

durability competitive advantage. The B2B customer articulates them in supply chain terms, with Orenda's products as ESG compliance inputs that lower the costs of compliance and meet international standards. These need not be conflicting views; they confirm the NRBV prediction that resource efficient capabilities create competitive advantage at multiple locations along the value chain.

To Sub-question Two, the evidence confirms the constraining factors limiting the effectiveness of Orenda's SSCM practices are structural and institutional rather than managerial. The finance, regulation, information and infrastructure voids of Pakistan's manufacturing sector limit the depth, formalisation and scalability of practices that the firm's internal economics and managerial practices would otherwise encourage. The most significant of these voids is the formalisation void - without metrics, documents, and systems to communicate and convert potential sustainability assets into visible and commercialised form. The strategic recommendations in Chapter Six prioritise this gap as the main response to advance Orenda's SSCM practices within its current resource and institutional limitations.

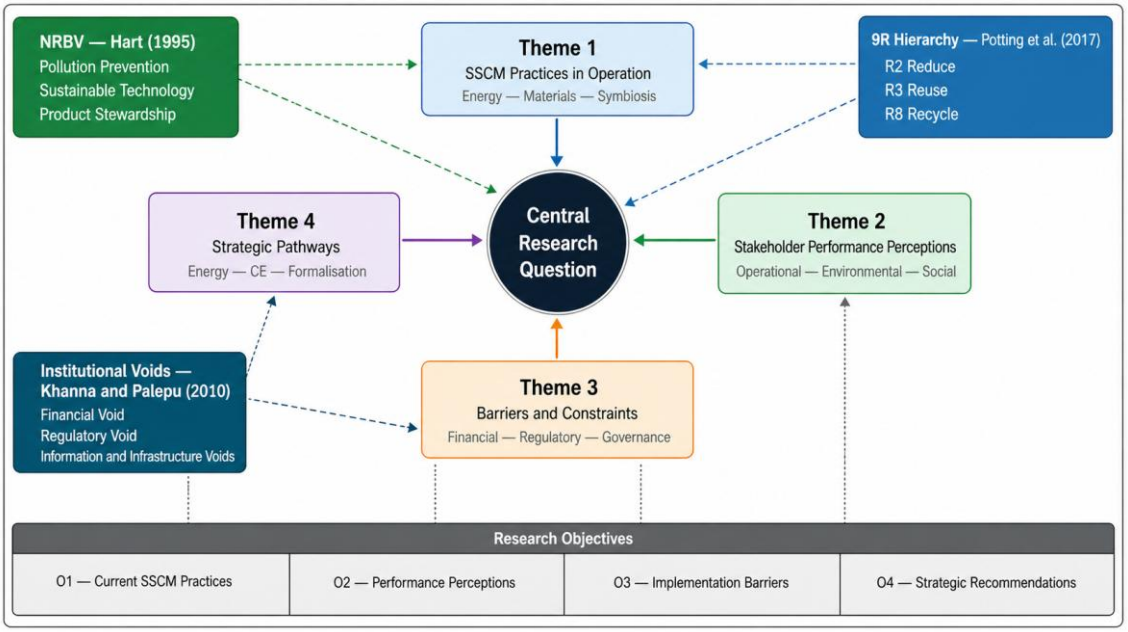

Figure 4: Thematic Map Connecting Four Interview Themes to Theoretical Frameworks and Research Objectives (Author: Hassan Ali)

5 Discussion

In this chapter, the empirical findings laid out in Chapter Four are discussed by reference to the three theoretical frameworks described in Chapter Two. This chapter is not the place for the reiteration of what was discovered but to interpret it - to construct the propositions that are generated by what was discovered, interpreted in the light of the Natural Resource Based View, the Nine R Hierarchy and the Institutional Voids. The chapter is organised in four analytical sections which parallel the four themes from Chapter Four before providing a synthesis which represents this study's theoretical contribution. Table 9 offers a pre-emptive mapping of the theoretical framework validation across the four themes; setting the content for the discussion which follows.

Table 9: Theoretical Framework Validation Against Empirical Findings (Author: Hassan Ali)

Theoretical Framework	Core Proposition Applied	Empirical Finding	Validation Status
NRBV — Pollution Prevention	Resource constraint drives cost-reducing sustainability capability	Recycled material and solar adopted for cost reduction without regulatory pressure	Validated — cost logic confirmed across all five interviews
NRBV — Sustainable Technology	Contextually appropriate technology generates durable competitive advantage	Voltage-tolerant LED products outcompete generic imports in Pakistan grid conditions	Validated — R1 and R2 accounts confirm contextual differentiation
NRBV — Product Stewardship	Durability engineering reduces lifecycle material and energy consumption	Heat dissipation design extends product life in high-ambient-temperature conditions	Partially validated — practice exists but is tacit, not formally governed
9R Hierarchy	CE practices can be precisely positioned on a spectrum of resource value retention	Recycled polymer at R8, industrial symbiosis at R3, durability engineering at R2	Validated — hierarchy provides precise differentiation between practice types
Institutional Voids	Absent regulatory, financial, information, and infrastructure intermediaries constrain SSCM	Zero compliance references, informal material sourcing, no green financing accessible	Validated — all four void categories confirmed across interview dataset
Institutional Voids — Informal adaptation	Firms develop contextually rational responses to institutional voids	Steel-cardboard exchange, informal dealer networks, self-financed hybrid energy	Validated — informal adaptations confirmed as operationally effective

5.1 The NRBV in Practice: When Resource Constraint Drives Sustainability

The analytical importance of this study is that SSCM at Orenda did not emerge from strategy but from the economic realities of operating a resource-constrained economy and that this does not negate its strategic significance but rather establishes the particular type of competitive advantage arising from its practices. This outcome is the prediction that Hart (1995) made in the original Natural Resource Based View (NRBV) formulation, and the Orenda experience is one of the few case studies confirming this prediction in an SME manufacturing firm in an emerging economy.

The Chief Executive's description of the company's business model - localising production of high-efficiency electrical items - to help Pakistani industries fight rising electricity costs - exemplifies the NRBV dynamic brilliantly. The strategic purpose is economic and environmental: local manufacturing of LED and SMD products is cheaper than importing from China (where products are typically produced), creates a contextually-differentiated product that provides superior performance to generic imports in Pakistan's environment of grid voltage instability, and supports the national energy efficiency demand-side agenda described by the Technical Consultant as critical for making large-scale renewable investment viable. Hart (1995) noted that sustainable technology capability creates competitive advantage when it is tailored to particular resource and infrastructure circumstances that generic technology is not. Orenda's engineering of voltage tolerance capabilities is this capability in its most practical form: it is valuable because the Pakistani grid is unstable, rare because few local manufacturers have such capabilities, and hard to copy because it depends on both technical and manufacturing capabilities embodied in the Allah Hoo manufacturing facility.

The pollution prevention capability - embodied in the blending of recyclables at 30% polymer rate and the steel-for-cardboard swap - works differently. Aragón-Correa and Sharma (2003) qualified Hart's original NRBV formulation by claiming that, in the context of SMEs, the relationship between environmental strategy and competitive advantage is more complex than the framework implies because it depends on managerial cognition, industry environment and to what extent sustainability capabilities are articulated and communicated rather than embedded. This qualification is confirmed in the Orenda

case. Orenda has the NRBV substance without the NRBV strategic infrastructure - the pollution prevention capabilities at the operational level - using recycled content to reduce material costs, having an exchange to avoid a disposal cost and reduce a procurement cost - but without the NRBV strategic assets - not articulated as sustainability assets, not measured according to environmental performance standards and not communicated to the market in ways that would establish the ESG-based competitive advantages that the account of the B2B client reveals to be marketable.

This capability-communication gap is the key to this analysis. Orenda has the NRBV material but lacks the NRBV strategic apparatus - the practices, not the governance, measurement and communication that would translate the informal operational capabilities into formally recognised strategic assets. This is precisely what Govindan et al. (2020) observe in their study of NRBV competencies in developing country supply chains - that informal, functionally-based sustainability practices are ubiquitous in SME manufacturing but undercapitalised due to the lack of institutional architecture (formal, organisational practices) to communicate them. This is exactly the pattern observed with Orenda, and the theoretical takeout is that the strategic focus is not on developing sustainability practices but formalising, measuring, and communicating them.

5.2 The Nine R Hierarchy as a Diagnostic Lens: Honest Positioning and Progression Pathways

The use of the Nine R Hierarchy to assess Orenda's circular economy practices yields a more nuanced, and more diagnostic, assessment than a binary judgement of whether the company is or is not engaging in CE practices. The hierarchy shows that there are three stages of ambition demonstrated by Orenda's CE practices in the supply chain, whose relative positioning in the hierarchy has clear ramifications for recommendations for CE advancement.

Steel-for-cardboard industrial symbiosis is the most resource-value-retaining CE practice at Orenda, and is positioned at R3 Reuse in the Nine R Hierarchy. This is a better R position than the integration of recycled polymers because it doesn't have the energy, property, and processing costs required for material recycling (R8). The industrial symbiosis literature finds that inter-firm material exchanges within and between

geographically co-located clusters is the most operationally accessible high-order CE practice for SMEs without formal institutional supports (Katz-Gerro and Sintas, 2018; Anderson, 2020), and the Allah Hoo Industrial Estate's spatial co-location of garment manufacturers, steel processors, and electrical hardware manufacturers furnishes the locality conditions under which this practice is most likely to emerge spontaneously, as it has. The implication for the analysis is that Orenda's highest-order CE practice is also its most informal and least easy to account for in its CE strategy - a point that informs the formalisation recommendations in Section 5.4.

The recycled polymer integration at R8 is less sophisticated but potentially more scalable in the short term as it is an internal rather than inter-firm practice. The difference between PBT at 15% recycled content and polycarbonate at 30% is a technically rational material-specific approach to CE integration that is what Potting et al. (2017) advocate: setting specific targets for recycled content that are dictated by the requirements of precision manufacturing (mechanical and thermal properties) rather than the same percentage for all materials, regardless of application-specific constraints. This technical rationality is a form of internally developed but not publicly visible product stewardship capability - again consistent with the NRBV recipe of internally sophisticated but ungoverned tacit capability.

Karen's analysis of WestEnergy suggests a similar pattern in a very different institutional environment: the 9R Hierarchy at WestEnergy reveals that the main activity of R9 Recovery is not a barrier to parallel R2 Reduce improvements, nor to aspirational positioning towards carbon-negative via ECCU (Energy from Carbon-containing gases, liquids and solids removed from the atmosphere). The analytical parallel serves as an insight. Just as WestEnergy's CE positioning represents a dynamic trajectory in the hierarchy rather than a singular point, Orenda's CE positioning should not be read as a static R8 classification but as an R8 starting point with specific trajectories toward R3 and R2 being operationally credible and already partially realised. The hierarchy is best used as a trajectory model rather than a classification model, a fact that is reinforced by the Orenda case and which is one of the theoretical insights of this research.

The product durability engineering practice, situated at R2 Reduce in the hierarchy through its life-extending logic, is the least visible of Orenda's CE practices to the outside world, but the most important in terms of overall material and energy impact. The

product that lasts twice as long as a generic import doubles the resource efficiency of the material and energy inputs from its production - a CE practice whose magnitude is greater than that of recycled content integration at comparable levels of production, but which currently produces no commercial returns due to its lack of documentation and communication as a sustainability attribute.

5.3 Institutional Voids as the Structural Explanation for SSCM Informality

The Institutional Voids model offers the structural account for the most recurrent and analytically relevant finding in Chapter Four that real and practically effective SSCM practices coexist with an absence of formal sustainability governance, measurement and communication. This situation is not a conundrum but a normal consequence of the distinctive institutional void conditions that exists in the Orenda case and internalising this through the Khanna and Palepu (2010) framework avoids the analytical mistake of viewing the governance gap as a managerial failure rather than a structural impediment. The regulatory void is most directly confirmed by the absence of references to compliance in the five interviews. Where environmental regulation is enforced, one would expect the respondents to identify regulatory compliance as one of a number of incentives for adopting sustainability alongside economic motives. The failure to cite any such references across the entire sample of five interviews with respondents from executive, technical, operational and client functions confirms that there is no direct regulatory push on SSCM practices towards Orenda either through governments' environmental agencies, or through industry associations' standards, or through formal procurement procedures in Orenda's domestic B2B market. This regulatory void isn't unique to Orenda: both Moktadir et al. (2018) and Durrani et al. (2024) show it as a systemic attribute of the institutional context of Pakistani manufacturing. The Orenda case confirms their survey findings at the firm level with the clarity that surveys cannot provide.

The financial void is also confirmed by the pattern of adoption of SSCM practices: all sustainable behaviours at Orenda were adopted for cost reduction rather than for investment with a medium to long return on investment (RoI). The 50KW photovoltaic system reduces energy cost. The use of the recycled polymer reduces material cost. The cardboard-for-steel substitution reduces cost of disposal and cost of procurement. This

configuration is not accidental, but is the expected behaviour of a company without access to the green financial instruments, patient capital structures and incentives for investment in sustainability that the ECCU project at WestEnergy enjoyed as a result of the Finnish government subsidy and municipal consortium governance. The funding gap does not deter SSCM adoption; it directs it towards low-impact, low-cost investment and away from capital-intensive sustainability investment whose benefits are realised in the longer term.

The information void is more hidden, but is corroborated in the Technical Consultant's narrative. R4's framing of Orenda's sustainability contribution as a policy-focused argument - we need to grow companies like Orenda for Pakistan's energy security - is unsupported by empirical information in the form of statistics on the contribution to energy efficiency made by the LED industry. This information is absent because no industry, regulatory or government energy body in Pakistan collects and publishes the data. The lack of this quantitative information means that Orenda's sustainability contribution is policy invisible even though it is commercially real, and that Orenda lacks the market credibility that would result from information documenting sustainability performance.

Mair and Marti's (2009) critique of the Institutional Voids framework - that it can lead to a view of developing country environments as deficient relative to a developed economy ideal - is pertinent and must be recognised in this context. Orenda's informal SSCM practices are not deficient substitutes for formalised policies and practices; they are contextually rational responses to a particular set of institutional circumstances; they deliver sustainability outcomes that are in some ways more robust and more resilient to changing circumstances than formally governed outcomes because they are constrained by the operational economics of firm-level practices rather than external regulatory or financial interventions that may be withdrawn. The challenge here is not to compare Orenda against the developed-economy ideal but to draw on its practices to comprehend what kind of SSCM can arise and flourish in the absence of institutional infrastructure - and what firm-level measures are likely to be trusted within the given institutional environment.

5.4 The Formalisation Opportunity: Converting Informal Capability into Commercial Advantage

The interaction of the three analytical lenses in this research generates a single key analytical proposition, which is the main theoretical contribution of the study: in manufacturing SMEs operating under institutional voids conditions, the next most significant SSCM gap is not the lack of sustainability practices but the lack of governance, measurement and communication infrastructure that would formally declare informal sustainability practices as competitive advantages. This proposition - the formalisation opportunity as the major strategic advantage - is generated by the dynamic interaction of the three frameworks and cannot be derived from any one of them individually.

The NRBV forecasts that pollution prevention, product stewardship and sustainable technology capabilities create competitive advantage. The Nine R Hierarchy shows that Orenda practices R2, R3 and R8 - a portfolio of CE that is multi-level and, thus, worth more than just R8. The Institutional Voids framework reveals why these capabilities and this portfolio are invisible to the market: the regulatory, financial, information and infrastructure voids that are pervasive in Orenda's marketplace have led to a firm with sustainability substance and no sustainability visibility. The interplay of these three perspectives generates the formalisation proposition, and its implications for Orenda's future are actioned in the Chapter Six recommendations.

The B2B client's case study grounds this proposition. R3's affirmation that transitioning to Orenda's LED offered assistance towards compliance with international ESG standards - spoken in the present, as an established business fact, rather than as an anticipated benefit - indicates that there is already demand for Orenda's sustainability contribution in its local market. It's not known by Orenda because it's not measured and documented and spoken in the ESG language that the B2B client understands. The difference between the sustainability contribution that exists and the sustainability contribution that is commercially recognised and-valued is the formalisation gap.

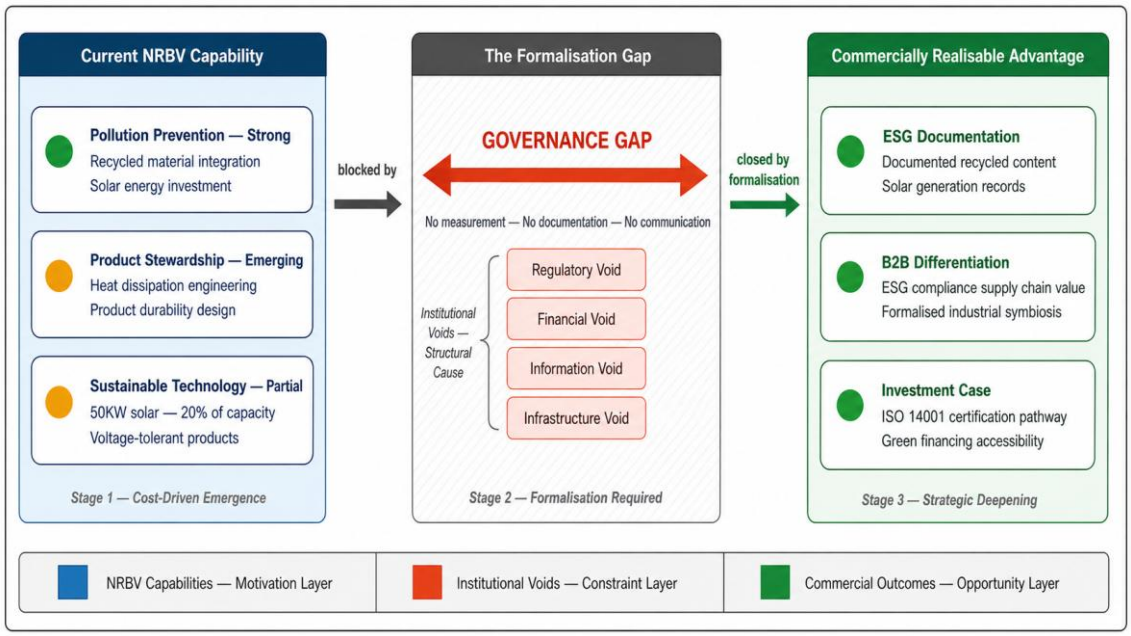

Figure 5: The Formalisation Gap Between Current NRBV Capability and Commercially Realisable Advantage (Author: Hassan Ali)

5.5 Towards a Pakistan SME SSCM Model: A Theoretical Contribution

The analytical propositions derived from the Orenda case study can be distilled into a theoretical model that builds on the existing literature on SSCM in a way relevant to the research gap outlined in Chapter One. This model, which this study calls the Emergent Sustainability Formalisation Model, suggests that the evolution of SSCM in manufacturing SMEs in institutional void environments passes through three distinct stages.

The first stage, which this study calls cost-driven emergence, is a stage in which sustainability practice emerges directly from the economics of scarcity, rather than from proactively formulated sustainability strategy or from regulatory need. Sustainability practices emerging in this stage are operationally justified, cost-effective and implicit to operational practices. They are true sustainability practices in their environmental and circular economy outcomes, but are not measured, documented, or publicly communicated as such by the firm in which they are practised. Orenda's current SSCM stage is in this phase.

In the second stage, formalisation, the firm develops the measurement, documentation, and governance capacity that formalises sustainable practices as organizational

capabilities. This stage does not require new sustainability investment or technology - it requires management effort to document and report. The leap from stage one to stage two is the most important strategic move for firms in Orenda's situation because it turns existing operational sustainability investments from a cost management tool into a marketing tool that can be used to distinguish the firm from its competitors, and as a catalyst for further sustainability investment.

In the third stage, strategic deepening, the new formalisation capacity built in stage two allows the firm to access sustainability-focused capital, certification, and market signals that allow the firm to make deeper sustainability investments, such as increased solar generation capacity, formalised reverse logistics and supplier sustainability assessment, which are currently off the table due to the financial void. The shift from stage one to stage two is the way in which institutional voids are in part circumvented through the development of firm capabilities.

The three-stage model is the key theoretical contribution of this research. It offers a theoretical model of SSCM development trajectories for SME manufacturing firms that is empirically grounded in the Orenda case study, analytically derived from the intersection of three existing theoretical models, and transposable - in the sense of providing testable hypotheses - to the large number of manufacturing SMEs in the developing world whose sustainability efforts are responsible for the cost-driven emergence pattern predicted by the NRBV and Institutional Voids models.

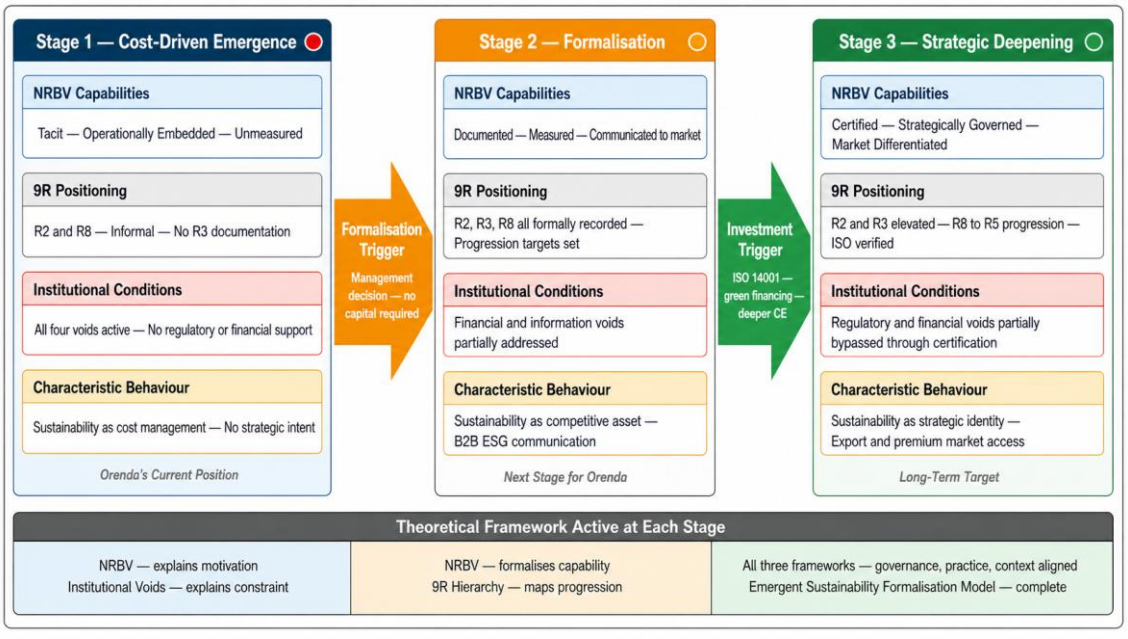

Figure 6: The Emergent Sustainability Formalisation Model — Three Stage SSCM Development Trajectory (Author: Hassan Ali)

6 Conclusions and Recommendations

6.1 Research Summary

This thesis explored sustainable supply chain management of Orenda Energies Private Limited, LED and SMD lighting manufacturer, which operates in the Allah Hoo Industrial Estate in Lahore, Pakistan. The three overlapping gaps that led the researchers to conduct the study were as follows: 1) the lack of specific and dedicated study on the electrical manufacturing industry of Pakistan, 2) the systematic underrepresentation of domestically-oriented SME manufacturers of the electrical manufacturing industry in Pakistan, and 3) the methodological dominance of the quantitative design, using a survey, that cannot generate the operation specificity that the firm level SSCM analysis requires.

The research question posed was how Orenda incorporates the practices of SSCM into its operations and what the consequences, difficulties and strategic implications of such practices in the context of Pakistani manufacturing are. Five semi-structured interviews with respondents of the executive, technical, operational, and client-side functions of the firm were analysed using reflexive thematic analysis and interpreted using the Natural Resource Based View, the Nine R Hierarchy and the Institutional Voids framework.

Four themes emerged. The former established that Orenda has a hybrid energy infrastructure of 100KW grid supply, 50KW solar generation and 100KW diesel backup and has a recycled polymer content of a blended rate at 30 percent across its product range, and an informal inter-firm steel-for-cardboard barter exchange with its neighbouring estate tenants. The second one determined that these practices are perceived by the stakeholders as creating operational continuity, cost competitiveness, product differentiation in the Pakistan voltage-unstable grid setting, and ESG compliance value to B2B customers. The third recommended that obstacles to SSCM performance fall more into structural and institutional than managerial categories, based on the financial, regulatory, information, and infrastructure gaps prevalent in Pakistan. The fourth determined that the most consequential and directly actionable strategic pathway that the firm could pursue. The discussion has synthesised these findings into the Emergent Sustainability Formalisation Model, a three-stage theoretical framework

that suggests that SSCM development of manufacturing SMEs within the circumstances of institutional void follows a trajectory of cost-driven emergence through formalisation to strategic deepening.

6.2 Responses to the Research questions.

Central Research Question: How does Orenda Energies Private Limited incorporate sustainable supply chain management into its operations and what are the results, challenges and strategy implications of these practices in the Pakistani manufacturing environment?

Orenda incorporates SSCM using the three operational channels, namely, hybrid energy sourcing, integration of recycled materials at differentiation rates across polymer type, and the informal inter-firm resource exchange within the industrial estate cluster. And these are not necessarily designed as a sustainability programme, and are not regulated by formal environmental management infrastructure. They were found as a result of this economics of resource scarcity, under the conditions of the energy crisis situation in Pakistan, which confirmed the NRBV prediction that resource-constrained firms develop sustainability capabilities through the logic of resource efficiency as opposed to an intentional environmental policy. Their strategic implication is evident: the practices are durable since they are entrenched in the operations of economics, but not durable because they are systematically underrealised because they are not visible in the market unless it is supported by documentation and communication infrastructure.

Sub-question One: Which special SSCM practices are in place and how do the stakeholders feel their contribution towards performance?

The hybrid energy infrastructure is one which provides operational continuity and which gradually lessens the fossil energy dependency, which is placed at R2 Reduce on the Nine R Hierarchy. The 30% blended recycled polymer integration lowers the cost of materials with a differentiated rate across PBT and polycarbonate reflecting technically rational material specific CE integration. The steel-for-cardboard trade gets R3 Reuse positioning, the highest-order CE practice of the firm, through informal industrial symbiosis through spatial proximity within the Allah Hoo estate. Stakeholders in all the five accounts view the practices as the ability of resource efficiency to create competitive advantage at a variety of different positions in the value chain at the same time.

Sub-question Two: What structural obstacles limit the effectiveness of SSCM, and what interventions would be most plausible to deal with such obstacles?

The four categories of institutional voids are the basis of the constraining challenges. The financial vacuum restricts sustainability investment to cost-cutting measures that are cost-cutting in the short run. The compliance pressure can be removed as an SSCM driver due to the regulatory vacuum. The information gap makes the contribution of sustainability by Orenda invisible at the policy and industry level. The infrastructure gap routes the recycled material acquisition by informal networks of dealers, restricting the quality assurance and scalability. The most plausible interventions to these constraints in the current resource constraints of Orenda are found in the recommendations below.

6.3 Strategic Recommendations

The recommendations are organized into three periods and they are directly based on the empirical results and the theoretical discussion. Both fill a particular institutional gap, each grows a particular NRBV capability, and each enables a particular Nine R Hierarchy progression.

6.3.1 Immediate Recommendations: Formalise What Exists

The most consequential and least costly intervention that could be offered to Orenda is documentation and internal governance of the current SSCM practices, which should not be capitalized but, instead, the management should be addressed.

The first short-term step is the development of a basic sustainability data record that encompasses four measures, which include: monthly solar generation as a percentage of the total energy consumption, monthly recycled polymer volume as a percentage of the polymer inputs by material type, quarterly steel-for-cardboard exchange volumes and estimated cost savings, and annual product return and failure rates as a proxy of product longevity performance. The four metrics are the minimal evidential base upon which the subsequent SSCM performance can be measured.

The second short-term measure is the creation of a one-page sustainability summary document written in ESG-compliant language, describing the energy set-up at Orenda, the percentage of recycled material in its products, and its practice of industrial symbiosis. The company confirmed that compliance with the ESG is a commercially significant criterion in Orenda proximate market, through the confirmation by the B2B

client in his account. In this document, third-party certification is not required - it must simply be accurately described as existing practices that do generate commercial value that is currently invisible because it is undocumented.

6.3.2 Medium-Term Recommendations: Deepen and Extend

The medium-term suggestions are based on the formalisation foundation of the immediate phase and the modest capital investment would be in the current fiscal strength of Orenda.

The first medium-term suggestion is the growth of solar photovoltaic capacity currently at 50KW to 100KW or even 150KW to increase solar contribution to total energy to 20 percent and then 40 percent and finally 60 percent. Additional capacity is readily available financially using retained earnings within a 12 to 24 month time frame at the prevailing Pakistan commercial solar installation costs which decreased by an approximate 60 percent between the years 2018 and 2023 according to AEDB (2022). This investment advances the NRBV sustainable technology capability, initially adopted, to competitive differentiation and produces the documented renewable energy data, enhancing the sustainability communications developed during the initial phase.

The second of the medium-term recommendations is the formalisation and extension of the inter-firm arrangement of materials exchange. The creation of documented volumes, values, and estimated environmental benefit which were documented through the creation of a written exchange agreement transforms an informal working arrangement into a documented industrial symbiosis practice communicable as a CE credential. The spatial concentration of various manufacturers in the Allah Hoo estate sets up a condition of the extension of the exchange to other streams of materials other than the current pairing of steel and cardboard, which will further reduce procurement and disposal costs as well as elevate the CE positioning of the firm.

The third medium-term suggestion is the gradual introduction of recycled polymer content in product components, where thermal and mechanical performance requirements are not as stringent as those in thermally exposed PBT components. An organised material trial programme that tests recycled material in small steps above the existing rates in individual components would establish the empirical performance data required to guide progressive content elevation without having to compromise the

quality of the product, and would generate the documented material experimentation record that will support further assessment of supplier sustainability in the future.

Long-Term Recommendations In Strategic Deepening: 6.3.3 Recommendations.

The long-term recommendations are concerned with the transition between the Stage Two formalisation to the Stage Three strategic deepening in the Emergent Sustainability Formalisation Model, at which the formalised governance opens the door to capital, certification, and market recognition that opens the door to more ambitious sustainability investment.

The first long-term recommendation is the one that could be pursued by Orenda concerning the profile of a manufacturing SME is the pursuit of the ISO 14001 Environmental Management System certification, the most credible and internationally recognised certification pathway towards manufacturing SME profile. The ISO 14001 does not strive at creating environmental perfection but documented environmental management, which is exactly what the immediate and medium-term recommendations will have already firmly established. Its commercial benefit lies in the fact that informal SSCM capability can now be converted into a certified third party verified credential that can be adopted by international procurement standards and export market requirements.

The second long-term suggestion involves the creation of an official supplier sustainability assessment protocol to the recycled polymer suppliers of Orenda, including documented source of recycled material, basic processing quality certification, and material property consistency test. This protocol is a direct response to the infrastructure gap, by partially substituting the firm-level governance with the missing institutional certification infrastructure, and generates the verified supply chain information that supports the lack of the institutional certification infrastructure as well as the ESG communications that are more and more sought by the B2B clients.

The entire recommendation implementation matrix is given in Table 10.

Table 10: Recommendation Implementation Matrix (Author: Hassan Ali)

Priority	Recommendation	Void Addressed	NRBV Capability	9R Progression	Timeframe	Primary Benefit
1	Establish sustainability data record — 4 core metrics	Institutional capacity void	All three capabilities — measurement foundation	Baseline for all progression	0 to 3 months	Internal governance, performance tracking

2	Develop B2B sustainability summary document	Information void	Product Stewardship — market communication	R8 and R3 documentation	0 to 3 months	B2B differentiation, ESG compliance value
3	Expand solar capacity from 50KW to 100 to 150KW	Financial void	Sustainable Technology — deepening	R2 Reduce — elevated share	12 to 24 months	Energy cost reduction, renewable narrative
4	Formalise and extend inter-firm material exchange	Infrastructure void	Pollution Prevention — formalised	R3 Reuse — documented and extended	6 to 18 months	CE credential, procurement cost reduction
5	Incremental recycled content elevation by component	Infrastructure void	Pollution Prevention — deepened	R8 toward R5 Refurbish	12 to 24 months	Material cost reduction, CE depth
6	Pursue ISO 14001 Environmental Management certification	Regulatory void	All three capabilities — governance formalised	Full portfolio formally certified	24 to 36 months	Export readiness, ESG market access
7	Develop supplier sustainability assessment protocol	Infrastructure void	Product Stewardship — supply chain extension	R8 quality verification	18 to 30 months	Supply chain ESG credibility, ISO support

6.4 Theoretical Contributions

In this study, three theoretical contributions are made that go hand in hand. The first one is the empirical confirmation and contextual specification of the NRBV in a Pakistani manufacturing SME context, which provides firm-level qualitative evidence that pollution prevention and sustainable technology capabilities are all revealed by pressure on resource costs in the absence of formalisation infrastructure, and confirming and validating Aragón-Correa and Sharma (2003) contingency qualification that SME sustainability capabilities tend to stay tacit and commercially underrealised without formalisation infrastructure. The second is that the Nine R Hierarchy is used as dynamic trajectory map rather than fixed classification tool and that the Orenda case demonstrates that simultaneous positions in the hierarchy and the pathways of progression are both dynamic and simultaneous. The third and most significant

contribution is the Emergent Sustainability Formalisation Model, which suggests a three-stage development trajectory of a SSCM under institutional void conditions including, but not limited to, manufacturing SMEs, would make a significant contribution to the literature in the academic field.

6.5 Limitations and Future Research.

It is admitted that three limitations exist. The restricted statistical generalisability of single case design is solved by the analytical logic of transferability to Chapter Three. This presents a risk of social desirability, alleviated to some extent by the external B2B client respondent. Cross-sectional data collection only captures a snapshot of Orenda practices at one point in time and does not trace how the practices were developed or evolved over a period of history.

These limitations, as well as the theoretical contributions of the study, lead to four directions of future research. A comparative case study of using the Emergent Sustainability Formalisation Model across a sample population of manufacturing SMEs within the ecosystem of the industrial estate of Pakistan would test whether the three-stage trajectory can be generalised across the population of firms that the NRBV and Institutional Voids frameworks jointly predict followed the cost-driven emergence pattern. Causal evidence of the commercial and sustainability impacts of the formalisation transition would be generated by a longitudinal study that would track SSCM development at Orenda during three to five years following the formalisation recommendations. A cross-national comparative study that uses the same theoretical framework to examine the cost-driven nature of the emergence pattern and the formalisation gap would test whether they are universal attributes of SME SSCM under institutional void conditions or specific to the Pakistani context. A policy research study investigating the governance frameworks within industrial estates that have a systematic way of facilitating inter-firm industrial symbiosis would rely on the Allah Hoo estate as a prime case study as well as comparative developments in eco-industrial parks in South Korea, the Netherlands, and China.

6.6 Final Reflections

The LED bulb produced at Plot 32, Street 1, Allah Hoo Industrial Estate has more material of the circular economy than the market price of the product or the public image of its manufacturer, Allah Hoo. Its polycarbonate housing, uses 30 percent of the non-virgin material that is sourced by an informal dealer network within a city where formal recycling services capture less than 5 percent of all recoverable plastic waste. That energy required to assemble it is partially powered by a 50KW solar unit installed not as a sustainability message but as a buffer to an unstable national grid whose inadequacy has made the cost of energy the defining parameter in the survival of industries in Pakistan. The steel offcuts produced in its manufacture are exchanged with the cardboard that packages it - a circular loop so operationally embedded, economically natural that none at the firm have yet named it as a circular economy practice.

This work has given it its name. It has placed it on the Nine R Hierarchy, explained its motivational rationale in the Natural Resource Based View, and placed its constraints within the framework of Institutional Voids. The situation in which what Orenda does and what the market knows Orenda does is not a gap in capabilities but a gap in governance and communication, and that bridging between what Orenda does and what the market knows Orenda does is the most consequential strategic step available to the firm within its prevailing resource and institutional constraints. The Emergent Sustainability Formalisation Model provided here is not, but a transferable framework on the substantial population of manufacturing SMEs throughout the developing world whose sustainability practices are real, whose competitive potential is underrealised, and whose formalisation pathway is more accessible than the mainstream SSCM literature has yet fully adequately theorised.

6.7 AI Tool Disclosure

This section will list all AI tools that were used in the process of writing this thesis, their version where applicable, and the purposes this tool was to be used according to the University guidelines regarding the use of AI tools in academic writing. It is completely up to the researcher to select the research design and the theoretical framework within which the research will be conducted, the conduct of the interviews, the coding of the

thematic analysis, and the interpretation of the analytical results. In the drafting, editing, data analysis, coding, or interpretation of any section of this thesis no other AI tools were used. The complete quantitative analysis was done using Microsoft Excel and Flourish.studio. The researcher used draw.io and Datawrapper to draw all process flow diagrams and conceptual framework figures. Each of the citations points to the sources which are independently determined and verified by the researcher. The independent intellectual work of the researcher can be found in the analytical propositions, theoretical contributions, and recommendations made in the current thesis.

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APPENDIX A: INTERview topic guide.

Title of the study: Sustainable Supply Chain Management Practices in LED/SMD Manufacturing: a Qualitative Case Study of Orenda Energies Private Limited, Lahore.

Purpose: The semi-structured interviews with five key informants were conducted using this interview guide. Questions are organised around the four research objectives of the study. The guide is not prescriptive but indicative that is, the interviewers were allowed to probe, extend, and adapt questions based on the accounts of the respondents.

Estimated Time: 30-45 minutes per interview.

Ethical Note: the purpose of the research was explained to the participants before the interview, they were told of their right to withdraw at any time, and the anonymisation policy applied to their accounts in the written thesis.

Part A - Background and Role.

1. Would you just tell me a little about your present position and what your primary responsibilities are with or in reference to Orenda Energies?
2. How many years have you been in this position and how deeply do your work activities involve you in the operations of the supply chain of the company?

Part B - Current SSCM Practices (Research Objective One)

3. Please explain how Orenda is currently governing its energy supply? What is the contribution of solar generation in the businesses of the company?
4. What does the company do when it has to source the plastic materials used in its manufacturing process? Can you tell me about the use of recycled versus virgin material?
5. I know there is a materials exchange system with other companies in the industrial estate. How does this practically work?

6. Do you have other answers to the question of what other features of the Orenda supply chain would you describe as either environmentally oriented or sustainably oriented?

Section C - Performance Perceptions (Research Objective Two)

7. How, in your opinion, have the energy and material practices of the company affected the operational efficiency and cost structure of the company?
8. Do the practices you have described have any environmental benefits? What role do these play in your everyday decision making?
9. Have you ever heard clients/partners mention sustainability practices by Orenda? Has this had any commercial impact?
10. What does the sustainability strategy of Orenda have in common with other companies that work in the same field or industrial park?

Section D — Challenges and Barriers (Research Objective Three)

11. What are the key challenges that Orenda has encountered in its sustainability in managing its supply chain? Does the company have certain constraints in terms of finances, regulation, infrastructure etc that limit what the company can do?
12. Does it have any external support, i.e. government agencies, industry associations, or financial institutions are willing to help companies like Orenda in making investments in sustainability? If yes, have you made use of it?
13. Do environmental laws or compliance issues play any role in any of the supply chain decisions at Orenda? If so, how?

Section E Strategic Pathways (Research Objective Four).

14. Should Orenda enhance its sustainable supply chain management strategy within the next two to three years, what would you implement first? Which step would have the greatest influence?

15. Do other companies locally, regionally or internationally practice things that you feel Orenda could adopt or adapt?
16. Is there anything about the sustainability of the supply chain of Orenda that you feel is especially unique or worth emphasizing that we have not yet discussed?

APPENDIX B: RESPONDENT PROFILES

Respondent Code	Designation	Organisation	Interview Context
R1	Chief Executive	Orenda Energies Private Limited	Strategic and executive perspective on SSCM intent, energy investment, and competitive positioning
R2	Head of Manufacturing	Orenda Energies Private Limited	Operational perspective on production process, recycled material integration, and thermal management
R3	Operations Lead	Fine Garments Industries, Allah Hoo Industrial Estate	B2B client perspective on ESG compliance, inter-firm collaboration, and supply chain integration
R4	Technical Consultant	Pakistan Energy Sector	Sectoral perspective on energy transition, demand-side efficiency, and national SSCM landscape
R5	Supply Chain Manager	Orenda Energies Private Limited	Procurement perspective on inter-firm exchange, logistics, material sourcing, and competitive positioning

All respondents participated voluntarily and provided informed consent prior to interview. Individual accounts are anonymised using respondent codes throughout the thesis. Company-level identification is retained in accordance with the case study design and with the consent of the Chief Executive obtained prior to data collection.

APPENDIX C: THEMATIC ANALYSIS CODING FRAMEWORK

The table below presents the primary codes generated during the initial coding phase of the thematic analysis, the researcher themes into which codes were grouped during theme development, and the final themes as defined in Chapter Four.

Initial Code	Candidate Theme	Final Theme
Solar installation rationale	Energy as operational resilience	Theme 1 — SSCM Practices in Operation
Grid unreliability as driver	Energy as operational resilience	Theme 1 — SSCM Practices in Operation
Diesel backup logic	Energy as operational resilience	Theme 1 — SSCM Practices in Operation
Recycled PBT percentage	Material CE integration	Theme 1 — SSCM Practices in Operation
Recycled polycarbonate percentage	Material CE integration	Theme 1 — SSCM Practices in Operation
Virgin material remainder	Material CE integration	Theme 1 — SSCM Practices in Operation
Steel-cardboard exchange mechanics	Inter-firm resource exchange	Theme 1 — SSCM Practices in Operation
Estate proximity as enabler	Inter-firm resource exchange	Theme 1 — SSCM Practices in Operation
Heat dissipation engineering	Product durability as CE	Theme 1 — SSCM Practices in Operation
Cost reduction as sustainability driver	Cost-performance link	Theme 2 — Stakeholder Perceptions
Voltage tolerance as differentiation	Competitive performance	Theme 2 — Stakeholder Perceptions
ESG compliance for B2B client	Supply chain sustainability value	Theme 2 — Stakeholder Perceptions
Carbon footprint reference	Environmental performance	Theme 2 — Stakeholder Perceptions
National energy security framing	Systemic sustainability value	Theme 2 — Stakeholder Perceptions
Talent pool development	Social performance	Theme 2 — Stakeholder Perceptions
No green financing accessible	Financial void	Theme 3 — Barriers and Constraints
No compliance references	Regulatory void	Theme 3 — Barriers and Constraints
Informal material sourcing	Infrastructure void	Theme 3 — Barriers and Constraints
No sustainability metrics	Formalisation gap	Theme 3 — Barriers and Constraints

No sustainability targets	Formalisation gap	Theme 3 — Barriers and Constraints
Solar expansion as priority	Energy deepening pathway	Theme 4 — Strategic Pathways
Recycled content elevation	CE progression pathway	Theme 4 — Strategic Pathways
Exchange formalisation	Symbiosis formalisation pathway	Theme 4 — Strategic Pathways
ESG documentation opportunity	Formalisation as commercial opportunity	Theme 4 — Strategic Pathways