

Chapter 17

Building Organizational Capability for Life Cycle Management

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Abstract Corporations are being pressured to integrate life cycle thinking and practices across global supply chains. The UNEP/SETAC Life Cycle Initiative has been developing a life cycle management capability maturity model (LCM CMM) to help mainstream life cycle assessment (LCA) and life cycle management (LCM). Pilot projects in small-to-medium-sized enterprises (SMEs) to apply the model showed the companies were able to identify and implement projects that delivered both near-term business value and developed the organizational capability for LCM. A key benefit of the life cycle approach was enhanced cross-functional integration and collaboration with suppliers and customers. The projects did identify a need for more guidance on how to interpret the business impact of environmental

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concerns and to align LCM efforts with company business strategy. Collaborative networks where more advanced companies can share their knowledge are a key enabler, particularly in developing economies.

Keywords Business • LCM capability maturity model • Life cycle assessment • Life cycle management • Life cycle thinking • Sustainability • UNEP/SETAC life cycle initiative • Value chains

1 Introduction

Advances in information and communication technology have enabled companies to rationalize their production systems across the globe for peak efficiency, providing a continuous stream of innovative and low-cost consumer goods. The dramatic expansion of the market economy has been extremely successful in raising the material standards of living. However, there is growing awareness that the material and energy intensive modes of current production systems are unsustainable as the size of the global middle class consumer market is expected to grow from 1.8 billion in 2009 to 4.9 billion by 2030 (Pezzini 2012). Business has recognized the challenge and is moving from a narrow focus on short-term economic value to a broader concept of shared value, defined as policies and operating practices that enhance the competitiveness of a company while simultaneously improving the economic and social conditions in its host community (Porter and Kramer 2011). Leading companies, as well as some new firms, are working to develop value chain indices that measure and price all externalities, from raw materials to final product disposal enabling direct comparison of products at the point-of-sale (Chouinard et al. 2011; UNEP/SETAC 2014, 2015). Life cycle assessment (LCA) is an internationally standardized method for quantifying environmental impacts of product systems and has been recognized as the primary methodology for helping decision-makers select effective improvement strategies while avoiding burden shifting between impact categories or life stages (Guinée et al. 2011; Hellweg and Milà i Canals 2014). However, there is concern that small-to-medium-sized enterprises (SMEs) lack the capacity to provide quality data for the various supply chain metrics, let alone conduct comprehensive LCAs.

The UNEP/SETAC Life Cycle Initiative has been working to promote the implementation of life cycle management, or the effective integration of life cycle thinking into the day-to-day routines of business (UNEP/SETAC 2013a) for more than a decade. During Phase I (2002–2007), researchers identified a need for training materials and technical resources to build capacity for life cycle management (LCM), particularly in developing economies and small-to-medium-sized enterprises (SMEs) (Saur et al. 2003). During Phase II (2007–2012), one of the work areas was life cycle approaches for capability development (including institutional empowerment, training, curricular development, etc.), with a particular focus on

addressing challenges in implementing LCM in SME suppliers as part of sustainable value chain initiatives (Swarr et al. 2011). That effort was continued in Phase III (2012–2016) with the funding of a series of pilot projects to apply a LCM Capability Maturity Model (LCM CMM) to help guide the implementation of a life cycle based improvement project.

The LCM CMM builds on well-established methods from the process quality improvement discipline and provides a structured framework to help companies incrementally build the organizational capacity for more comprehensive and powerful life cycle (LC) methods (Swarr 2011). Previous research on organizational change has shown that ~70 % of failed change initiatives were attributed to inadequate attention to ‘softer’ issues of organizational health (Keller and Price 2011). Sustained high performance requires a balance between top-down initiatives for results-driven action and bottom-up organizational development efforts to instill a culture of learning and continuous improvement (Beer 2001). Thus, the LCM CMM complements top-down efforts to drive sustainability measures across global supply chains with bottom-up organizational development efforts to build the necessary skills in SMEs to enable them to provide high quality data and to adapt LCM objectives to meet their specific competitive and stakeholder pressures.

1.1 Chapter Outline

The capability maturity model (CMM) concept originates from a quality management maturity grid proposed by Phil Crosby (1979), subsequently developed for numerous functions, such as software engineering, integrated product development, systems engineering and more. The CMMI Institute (cmmiinstitute.com) integrated these models, but they are extremely complex and inappropriate for SME suppliers (Sukhoo et al. 2007). Development of a simpler and more practical LCM CMM is described under Methods. A series of company case studies are then presented to compare the theory of CMMs with the real world practice of LCM. In some cases, the company projects explicitly applied the LCM CMM developed by UNEP/SETAC. In other cases, the company projects made no direct application of CMM, but were simply efforts to apply LCM principles to address specific objectives. The focus of the case studies is on the change management issues that can promote or inhibit success of company improvement initiatives. These company experiences are then reviewed and reconciled with the LCM CMM concepts to develop a framework that companies can use to tailor LCM to their specific competitive context, environmental constraints and opportunities, and strategic priorities. The basic premise is that a structured approach to help address these softer management issues can be a useful strategy to mainstream LCM in business. Finally, the chapter concludes with recommendations for future research to expand business capacity for LCM and to promote its effective integration into routine business decision-making processes.

2 Methods

2.1 *Development of the Life Cycle Management Capability Maturity Model*

The life cycle management capability maturity model (LCM CMM) was based on a model developed at the Massachusetts Institute of Technology to guide enterprises implementing lean production practices (Nightingale and Mize 2002). Researchers, academics, consultants and business managers had developed a broad vision of the values, behaviors and practices that constituted a lean enterprise (Womak and Jones 2003). However, practitioners were faced with a confusing array of principles, tools and practices, but no help on the order or precedence to implementing various best practices in a cohesive management system. These same considerations describe the current challenge of deploying sustainability across global supply chains.

The LCM CMM was structured into three broad categories. Leadership processes set the direction for the organization and determine if there is sufficient motivation and organizational support to successfully achieve the stated goals. Life cycle processes provide operational excellence to design, build, deliver and support product offerings in a safe, clean, equitable and profitable manner. Enabling infrastructure assures resources are in place over the long-term to successfully implement the defined strategy. The intent is to accelerate learning by defining a logical sequence of skill-building improvement projects that gradually build robust decision-making processes necessary for effective implementation of LCM. The model is summarized in Table 17.1.

The LCM CMM framework simply expands the concept of customer to include other interested stakeholders and the ‘voice of the environment’ and looks beyond the immediate financial and efficiency goals to continually assess how the value chain is meeting the broader needs of civil society and preserving its resiliency to adapt to external disruptions (Hart and Milstein 2003). Building on lean concepts

Table 17.1 Life cycle management capability maturity model (LCM CMM)

Maturity level	Span of concern	Metrics	Appropriate projects
Qualified	Project or facility	Binary yes-no compliance; wastes	Basic work procedures/skills, unit process improvements, waste minimization
Efficient	Enterprise	Process inputs/outputs; eco-efficiency	Interconnected processes, pollution prevention, process redesign, collaboration with key supplier or customer
Effective	Value chain	LCA; cradle-to-grave	Eco-design, enterprise-wide initiative, value chain collaborations
Adaptive	Society	Sustainability, resiliency indices	Public-private partnerships, community development outreach, public policy reform

was also intended to leverage any previous investments in lean methods and to ally with the quality function within the company. A questionnaire¹ was developed that provided diagnostic questions for key processes, along with example practices that described the various maturity levels.

In May 2013, the initiative announced a call for proposals from companies “interested in implementing a project which adopts life cycle thinking in their business management and operation”. The proposal application required companies to conduct a maturity self-assessment and propose improvement projects to advance both life cycle and business objectives. Applicant companies identified a “LCM CMM coach” to help with the maturity assessment and the eventual implementation of identified projects. There was no requirement that coaches had previous training in the LCM CMM, and training materials that were developed in earlier phases of the LCI were made available to support their preparation of proposals (Swarr et al. 2011). In addition, UNEP/SETAC contracted a “mentor” to provide remote technical support to the coaches. Eight projects were selected from 22 applications and were awarded small grants to help implement the life cycle based improvement projects (UNEP/SETAC 2013b).

2.2 *Company Case Studies*

2.2.1 UNEP/SETAC LCM CMM Pilots

There were several constraints in the application process, which complicated evaluation of the efficacy of the LCM CMM. Coaches were required to conduct a maturity assessment and propose specific improvement projects as part of the application process. Few coaches had any prior exposure to the LCM CMM, and thus had to conduct the maturity assessment based on their review of the training materials, a PowerPoint presentation and a workbook. However, the maturity assessments submitted all appeared to be of reasonable quality and identified existing organizational strengths and weaknesses. In general, identified projects seemed to be reasonably aligned with the maturity assessments (i.e. existing LCM capability within the organization), with the possible exception being an over-emphasis of LCA in the projects. A second constraint was a short timeline, approx. 6–9 months, which meant that many proposed improvement projects would extend beyond the contract end date, precluding a final evaluation of outcomes. A list of the projects is provided in Table 17.2.

Several projects in companies led by executives with visions of strong LCM programs raised interesting questions of just how much life cycle knowledge is required and where should it reside in the organization. RUCID processes tropical fruits into juice and dried crisps. NEHSU Foods produces and sells soya-based milk

¹A copy of the questionnaire and an accompanying workbook are available at http://blog.pucp.edu.pe/media/2360/20130211-4__cmm_workbook_ilcm2012_s_valdivia.pdf (Accessed 24 Feb 2015).

Table 17.2 LCM CMM pilot projects

Pilot	Outcomes	
	Training	Environmental
Freudenberg, SA	Conducted procurement audit, supplier workshop, site visits to two suppliers	Sustainability criteria used to create supplier scorecard, built into contracts
RUCID, UG	Stakeholder workshop-23 individuals; staff trained	Established energy monitoring procedures; project plan for anaerobic digester and higher efficiency stove
NEHSU Foods, CM	Executive team trained in LCM; pilot results shared with three sister organizations	Began implementation of Food safety management system; identified KPIs for supply chain and defined requirements for management information system
SDA, Bogota, CO	Workshop 1–18 co Workshop 2–13 co Workshop 3–16 co Workshop 4–10 co	Eleven companies developed improvement plans; five projects completed within time frame of pilot study
Ediouro Grafica, BR	Completed baseline assessment of wastes	Book printing waste reduced 41 %, stapled magazine waste 36 % and glued magazine waste 32 %
Finca Mountain, PE	Baseline study and options assessment reports	Implementation plan in place, started on motor management system
Polygenta Technologies, IN	Training workshop for core team for LCA/ten individuals	Improved data systems to measure environmental parameters
India Glycols Ltd., IN	2 day workshop – 30 individuals	Baseline LCA completed, developed LCM manual and merged with Integrated Management System (IMS)

and yoghurt products; Finca Mountain cultivates, produces and exports specialty coffees. All rely on relatively low-skilled labor that may be seen as having little need for LCM expertise. RUCID's project was to develop proposals to obtain funding for energy upgrades. As part of the baseline assessment, employees were trained to monitor energy use on a regular basis to raise awareness and promote higher process efficiency. Finca Mountain's project was similarly focused on equipment upgrades to improve efficiency, but the company also started with a motor management system to build the foundation for improved operational controls and a more comprehensive energy management system. NEHSU Foods focused on defining key performance indicators to manage its supply chain and realized a need for more formal and robust systems to manage internal operations. The company started by focusing on a Food Safety Management system that directly supported the company strategic value proposition.

The companies did not seem to have any difficulty identifying relevant projects that provided business value and addressed life cycle environmental concerns. The companies in the Bogota, CO network assessed themselves as having limited understanding of LCM principles. However, several developed useful screening tools to prioritize their improvements. Somos K S.A., a bus transit company, used a

screening LCA to focus on improved maintenance procedures to reduce fuel consumption, providing operating savings and reduced greenhouse gas emissions. Azul K S.A., a manufacturer of cleaning products developed a qualitative screening tool that considered design, materials, manufacturing, marketing, waste generation, disposal and market trends. Based on this screening assessment, a liquid dishwashing detergent was selected for further analysis based on a high qualitative impact ranking and a growing market. Ediouro Grafica rated its LCM maturity at a relatively low level, and thus, decided to focus on a waste minimization project that could be used to develop basic data systems and lay the foundation for more complete LCAs. Freudenberg Nonwovens South Africa manufactures interlinings for the garment industry and develops and produces nonwovens for the energy, car interior, hygiene, medical, building interiors, as well as for special applications. Their LCM maturity was rated higher and the company had support from the corporate parent. Thus, it conducted a more sophisticated evaluation of its supply chain, defining specific sustainability criteria to be integrated into a supplier scorecard.

There was some tendency for companies to conflate LCA and LCM. Many viewed LCAs almost as a compliance requirement, and it was necessary to reassure companies that their projects did not necessarily require cradle-to-grave studies. For example, Cristacryl de Colombia S.A. is a manufacturer of high quality acrylic products using 100 % virgin materials. The company completed a streamlined study of its products that showed the production of basic chemicals dominated the impact assessment, but they saw little value, or ability, to gather more detailed data on upstream processes they had virtually no ability to affect. Instead, the company developed a communication campaign to educate customers on how to improve yields, improve recycling rates and avoid landfill disposal of the acrylic scrap. This directly supported their strategy of positioning themselves as a quality supplier of superior products. However, during the pilots, it was necessary to reassure the company that LCM did not require a complete LCA with site-specific data from their chemical suppliers.

In other cases, companies conducted LCAs, but struggled to identify improvements that provided a financial benefit. India Glycols conducted a study of polyethylene glycol made from sugar cane molasses, a byproduct from a sugar refinery. Although the study showed benefits relative to petroleum-based products, their customers have limited understanding and appreciation for the environmental benefits, and the product currently competes in a commodity market. It will require significant marketing to build awareness and identify niches that will attach a premium to bio-based chemicals. Similarly, Multidimensionales S.A., a packaging company, conducted a LCA of disposable polypropylene (PP) and polystyrene (PS) cups. Although there would be significant benefits from improved recycling rates, there is a lack of recycling infrastructure in Bogota and a need to change end user behaviors. The company has identified shopping mall operators as a high leverage point, with sufficient volume of material that can be practically collected and a good venue for end user outreach programs. Azul K identified landfill disposal of the empty bottle as a significant impact, but did not have the ability to influence end-of-life recycling rates. The company was able to redesign a light-weight version that had the same

look and feel necessary for customer acceptance, which would at least reduce the weight of material being landfilled. High concentration cleaning products were also identified as a potential improvement, but again would require a significant outreach effort to change consumer behaviors.

The Secretaria Distrital de Ambiente (SDA) project in Bogota, CO, offered a model for future efforts to disseminate LCM practice. SDA is the environmental agency for the city and had been working with a network of companies to advance their environmental programs. The companies had previously participated in programs on compliance, clean production and environmental management systems. Although not explicitly based on a CMM approach, these earlier programs were well aligned with the structure of the LCM CMM. In addition, the experience helped establish the technical credibility of SDA for this program and helped build trust among the member companies necessary for voluntary projects. A good example is a project Colcafé S.A.S. conducted in collaboration with Andria Logística, a waste hauler, and Santa Reyes, an egg producer, to find a better solution for managing a waste stream of coffee bean 'silver skins'. The waste silver skins were used as an additive to improve the anaerobic digestion of poultry manure, boosting efficiency, reducing odors and improving the logistics of waste hauling for both Colcafé and Santa Reyes. This type of project is only feasible for local companies that have a necessary level of trust to overcome transaction costs and to arrive at equitable sharing of the costs and benefits.

The Federation of Indian Chambers of Commerce and Industry (FICCI) coordinated the two pilots in India. A specific advantage of FICCI was that their quality group managed the pilots. Quality professionals are more familiar with CMM concepts, and this was important in helping to communicate the concepts to the company. The project was designed to facilitate adoption of LCM practices in business operations through three key activities including the LCM CMM maturity assessment by the senior management team, training of departmental heads and officers and joint review of results with the coach. The initial maturity self-assessment exercise lasted 10 days, as senior management needed several back and forth discussions with the project coach to understand the model and relate it to the company's day-to-day activities. It was clear that dedicated effort was needed to rearticulate the model for wider socialization. The model was therefore converted into a Yes/No questionnaire on LCM CMM and its extensions. Participants could choose 'Yes' or 'No' (with reasons) based on their own work/knowledge (categorized as 'Primary') as well as based on reliable information through other sources (categorized as 'Secondary'). For questions where participants were not dealing with that particular area nor had any reliable information from other sources, they could choose 'Don't Know' or leave a blank. The model was socialized through a specially designed training workshop on LCM CMM for officers from different departments of the organization. As part of the training, all generic terms in the questionnaire were mapped to company specific language and examples. The significant reduction in Blank/Don't Know responses shown in Fig. 17.1 demonstrates how the rearticulation and mapping exercises helped staff from different departments understand the practical application of LCM in the organization and in their own work areas after completion of the training workshop.

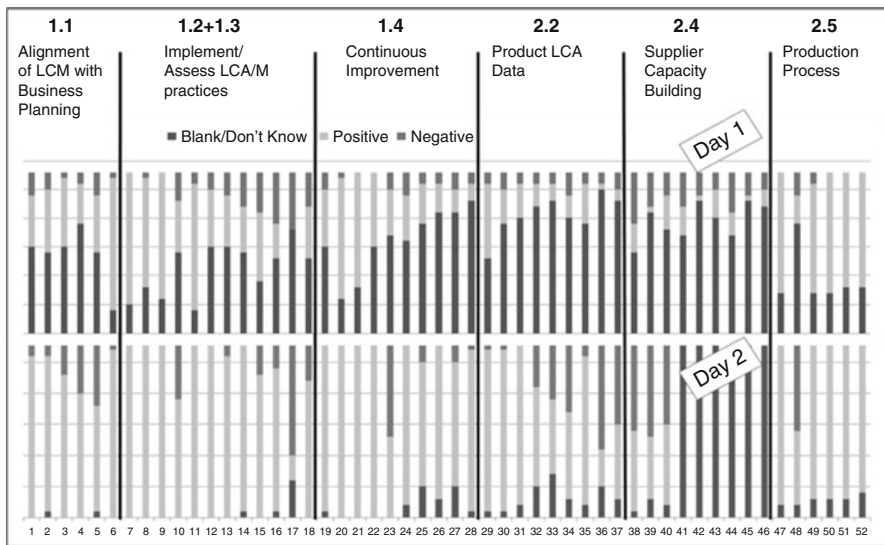


Fig. 17.1 Comparison of participant responses on day 1 and 2 of the training showing improvement in understanding of LCM concepts

2.2.2 Additional Case Studies of Mature Companies

Few companies have explicitly used a formal CMM to guide efforts to implement LCM practices. Thus, it is useful to survey experiences of companies with more mature programs to elicit lessons that might be applied to evaluating the efficacy of a capability approach. GE (General Electric) has been developing LCM and LCA since 2008. The GE Ecoassessment Center of Excellence (CoE) was founded to assess the environmental impact of products and technologies throughout the entire lifespan, from raw material extraction through reuse, recycling and disposal at end of life. The programs avoid a ‘one-size fits all’ approach by developing and applying a variety of tools and resources, from simple screening tools to detailed LCAs. The intent is to leverage the screening and streamlined approaches in early phases of product development, make strategic use of LCA and focus on value creation for customers, investors and society. The Ecoassessment CoE does not dictate the use of LCM, but rather works to build awareness, deliver tools and resources, provide guidance and support, and where necessary manage the detailed LCA studies. An environmental LCM portal is used to make tools and resources easily accessible to diverse business units. It is also necessary to tailor the tools to the diverse needs of different businesses. For example, a product LCM tool includes ten separate sets of customizable weightings that can be used to emphasize issues most relevant to a specific business context. When detailed LCA studies are warranted, the CoE provides trained professionals to perform the LCA or manage the work with external experts. It is necessary to demonstrate value to the business to promote adoption of LCM practices. An interactive tool was created to build awareness of how a LCM

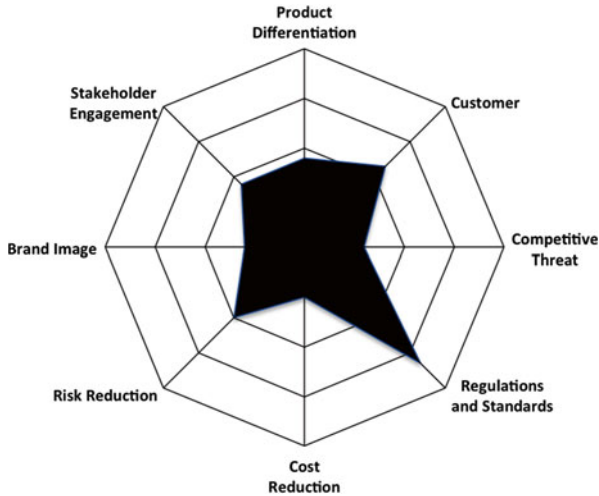


Fig. 17.2 Interactive tool showing perspectives on creating business value with LCM (example output: results shown are specific to a particular product)

perspective can create business value for a particular product or business activity, and the results are plotted in a spider chart easily interpreted by business managers (see Fig. 17.2.)

AQUA+TECH is a global leader in water purification systems and wastewater treatment technology for industrial and infrastructure markets. The company is collaborating with the University of Coimbra to explore the use of organic wastes to create coagulants for improved wastewater treatment. The majority of coagulants currently used are derived from iron and aluminum recovered from waste streams. In general, for each ton of carbon removed from the wastewater, one ton of sludge is generated. Even after thickening, the sludge is typically 70 % water. LCAs have shown us that the main environmental impact is, therefore, the transport of the sludge to its ultimate disposal (Rebitzer et al. 2004). If the coagulants were produced from organic sources, instead of the inorganic waste metals, wastewater clarification would be possible concomitant with biodegradability. If bacteria, already used in the wastewater plant, could metabolize the coagulant itself, then less sludge could be generated. AQUA+TECH is able to leverage an expanded technical base for a detailed LCA study through the collaboration, which is part of a SME-PhD program supported by EU FP7. An interesting caveat of making water treatment chemicals from waste streams is that the final product has high levels of water. Therefore, the extraction and transformation must take place near the waste stream and the final product can only be transported economically about 300 km. A key driver of the project is AQUA+TECH's vision of a zero-discharge facility. Therefore, any aqueous streams used in production have to be either re-used or recycled with minimum cost and effort, back into the process.

The Renault group conducted its first full vehicle LCA in 2005 (Cabal 2005). This first LCA project led to a standardized global assessment, and many later

studies provided accurate and quantified information to document the improved environmental profile of new vehicles. In 2012, the company organized a cross-functional team from design, innovation, manufacturing, IT systems, marketing and more to benchmark Renault's life cycle thinking activities and propose recommendations to advance their efforts. Renault developed a CMM tailored to their specific needs. The model addressed five management areas:

1. Plan – set strategy and define targets
2. Enablement tools and competencies
3. Evaluate – measure product performance
4. Eco-design – create products with improved environmental performance
5. Value-clarify benefits and capital creation

Five stages of maturity were defined – Compliant (license to produce), Fragmented (localized environmentally efficient approaches), Integrated (company aligned behind common key indicators), Extended (company has integrated the key stakeholders) and Global (pioneer in innovation and sustainable value creation, i.e. human, natural, financial capitals). The LCM CMM was used as a resource to develop semantic descriptions for the maturity matrix. For example, an 'Integrated' maturity level for the management area 'Enablement' was described as 'Partial integration with traditional company IT system. Personal development in place for all employees, including sustainability training & development.'

The eco-transition matrix was used to survey the top 20 suppliers and proved to be a valuable aid for enhancing collaboration, which is not an intuitive action and need to be organized (Segrestin 2003). The transition from 'Integrated' level to 'Extended' is particularly ambitious, as the company needs to open its boundaries to engage stakeholders and integrate them into its activities. Specific projects, such as an LCA of electric vehicles (Renault 2011) were used to engage value chain partners in co-designing tools, making key decision or product specific rules in a Collaborative LCA scheme (Morel 2014). The matrix clearly documents company progress and helps identify additional opportunities to enhance sustainable development management. It has also proved to be a very good team-building tool within supplier training programs. The matrix also helps disseminate knowledge of company activities and reveal differing perceptions of various functional groups or business units.

3 Discussion

The case studies presented cannot be considered a rigorous evaluation of the LCM CMM. Case studies are always subject to concerns about the degree to which the observations can be generalized. Thus, the results should be viewed in terms of an ongoing action research project to further refine the approach (Kaplan 1998). To validate the efficacy of the LCM CMM it would be necessary to demonstrate the model incorporates the capabilities needed to effectively conduct LCM programs

within a company; that the sequence of skill-building provided does speed learning from experiences of companies with more mature programs; and, that the balanced focus on both near-term performance objectives and long-term organizational development needs leads to sustained high performance in both financial and environmental dimensions.

There is a rich literature on capabilities required for sustainable business management (van Kleef and Roome 2007; Wiek et al. 2011; Silvius and Schipper 2014; Wesselink et al. 2014). While there is yet no broad consensus on a definitive list, there are common themes – system thinking, interpersonal skills, anticipatory or foresighted thinking, embracing diversity and strategic management. Additional insights can be gathered from research on organizational health and financial performance (De Smet et al. 2007). Concepts such as direction, leadership, accountability, innovation, coordination and external orientation were found to contribute to financial success. Although the UNEP/SETAC Life Cycle Initiative pilots were not intended to evaluate the structure of the LCM CMM, some useful insights can be elicited from the various projects. The basic structure of leadership, life cycle practices and enabling infrastructure appears adequate to capture the various elements identified in the literature. The process model is summarized in Table 17.3. Observations from the pilots, however, identified some gaps in the supporting training materials.

Leadership and vision are obvious success factors. The case studies presented, however, are a biased sample with all showing projects motivated by strong vision and leadership. Thus only one example will be presented to illustrate the significance of vision on results. The Colcafé project was viewed not as a waste minimization project, although it was selected to help meet a company zero waste goal. The ‘waste’ silver skins were re-imagined as a co-product valued at the price of the purchased coffee beans. Thus, the alternative of using the silver skins as an additive to improve the digestion of poultry manure was implemented. The silver skins, when initially viewed as a waste, were collected in bulky bags expensive to ship and difficult to handle by workers at the digester. The company evaluated options to compact the material for easier transport and redesigned the packaging for easier handling while feeding material into the digester. The redesign of the packaging leveraged their expertise in product logistics. Strong management support is a critical success factor for the implementation of these kinds of complex collaborations. The same can be said for AQUA + TECH where zero-discharge, as a policy, forced the firm to look at new products it could make from its “waste” streams.

One of the key training gaps identified in the pilot studies was a need for more guidance in tailoring the model to specific contexts, such as industry sector or geographic area. The model was developed primarily for an individual coach or change agent attempting to champion implementation of LCM at a manufacturing facility. Thus, application to service industries was particularly challenging. There was also a need for additional guidance on interpreting the business significance of environmental impacts. These gaps can be related to capabilities associated with strategic management. Companies achieve a competitive advantage by assembling a unique, valuable and difficult to imitate collection of resources and capabilities (Helfat and

Table 17.3 Summary of LCM CMM

Key business processes of LCM CMM
Leadership processes
Integrate LCM into business planning
Implement LCM practices
Assess performance and communicate to interested stakeholders
Focus on continual improvement
Life cycle processes
Business development and program management
Requirements definition
Design and develop products and processes
Manage the supply chain
Produce products
Distribute, support and retire products
Enabling infrastructure
Organizational enablers (structure and design)
Process enablers (systems, support groups and incentives)

Peteraf 2003; Sanchez 2004). The targeted capabilities need to be tailored to the specific competitive environment facing the company, linked directly to shareholder value and supported by organizational design (Hart and Milstein 2003; Heraty 2004; Sanchez 2004). The LCM CMM was designed to build the capability to measure and report a company’s environmental performance, with an emphasis on LCA. It is possible that too much emphasis was placed on LCA to the detriment of mainstreaming LCM or LC thinking.

The training resources did cover the evaluation of a company’s competitive context, but clearly were insufficient to meet the needs of the coaches. In part, this can be attributed to the dominance of environmental or LCA practitioners acting as coaches. However, it should be acknowledged that strong management leadership and cross-functional teams helped many companies identify appropriate projects that delivered business value as well as environmental benefits. The coach need not be the strategic expert, but does need sufficient understanding to tap the right people within the company. The guidance provided by the GE Ecoassessment CoE is a good model for supporting the LCM champions. In particular, the various weighting schemes available in the LCM tool and the interactive tool showing how LCM can add business value would help address this gap. These examples also demonstrate the importance of management vision – a clear expectation that LCM *will* add business value – that is supported with resources and enabling infrastructure (the environmental portal). The Renault initiative to deploy eco-design across its supply chain and the role played by SDA and FICCI in supporting the pilot studies are further evidence of the importance of strong leadership and focus on adding value.

Another common feedback from the coaches was that the maturity assessment tended to be somewhat abstract and difficult to translate into specific actions. The customized maturity assessments FICCI and Renault developed are noteworthy.

Renault adopted a model structured around management practices. The FICCI maturity assessment was tailored to the needs of its members, and the yes-no format was easier to connect to corrective actions. Another potential problem for the maturity assessment is that it can be viewed as just another environmental audit. This can drive a “check the box” strategy to achieve a “good” score across all elements. Research on organizational health has shown that the key to success is to focus on fixing broken processes and target a few key capabilities that were critical to the success of the company’s selected strategy. Attempting to exceed benchmarks on all practices was ineffective and wasted resources (Keller and Price 2011). It is important to first identify the core tasks a company must perform to successfully execute its strategy, and then link competencies to these tasks to prioritize improvement efforts (Wesselink et al. 2014). The maturity assessment questionnaire did provide examples of key tasks and the LCM CMM focuses on decision-making processes to help target actions, but it was clear that additional guidance on how to effectively align LCM improvement projects with a company’s business strategy would be helpful.

Another risk for any improvement project is that the softer organizational development objectives get lost due to a singular focus on performance outcomes. It is natural for any business to emphasize the immediate demands of customers, investors, regulators, etc. The LCM CMM is designed to promote a balanced approach that addresses both performance and organizational development goals in parallel. Change programs with well-defined goals for both were more than four times more likely to succeed (Keller and Price 2011). This can be challenging for the change agent. Typically, the organizational development efforts have a delayed impact. Support for the longer-term changes depends on delivering near-term performance gains. Sometimes resolving this apparent dilemma is easy, such as improved maintenance procedures at Somos K, which provided fuel savings, reduced emissions and better trained employees. Other cases can be more difficult and required a management commitment. The ability of Multidimensionales or India Glycols to benefit from improved data collection systems supporting their LCA studies will depend on the success of customer education programs. The ability to communicate the business value of the organizational systems and structures necessary to embed the new practices is vital to maintain ongoing management support.

The structure of the pilot studies, specifically requiring identification of a dual objective for each project to meet both performance and organizational development goals, was a strength that resulted in numerous positive outcomes, such as NEHSU developing a Food Safety Management System, Finca Mountain a motor management system, RUCID developing procedures for employees to monitor energy use and so on. Examples from the companies with more mature programs reinforce the importance of providing the enabling infrastructure to embed the improved procedures into normal routines. GE founded the Ecoassessment CoE to support the business units. AQUA+TECH tapped university support to obtain added capability for LCAs. Freudenberg Nonwoven also benefited from a corporate support function. For SME companies in particular, a local resource, such as FICCI or SDA, is a critical success factor for providing the enabling infrastructure to help

institutionalize changes. This can be in the form of training workshops or simply nurturing informal networking and exchange of ideas among member companies.

These observations are particularly relevant to developing countries, where over 85 % of companies are small and medium-sized. Accordingly, most of these companies focus their efforts on compliance with environmental standards, and they have limited understanding of the added value of advanced environmental practices, such as EMS, LCA, green procurement or LCM. Interventions to strengthen the ability of companies to implement voluntary projects to advance environmental performance require two components: technical and collaboration. The technical component is related to creating knowledge, starting with basic issues as Cleaner Production, Eco efficiency, data management, environmental management systems before tackling LCM, which has been the focus of many programs to build capacity for LCM. This is a necessary element to ensure companies with low maturity can address issues such as LCM and develop them in a proper and technically valid way. But the technical knowledge must also be supported and nurtured through collaborative networks. Companies that have achieved leadership in environmental performance and have progressed in the implementation of LCM can share their experiences with other companies that are just beginning to develop these practices. This is a key point for SME companies, because they prefer real world examples over theory; and, on the other hand, companies that are sharing their experiences also deepen their knowledge through these workshops. Several examples also highlighted the important role of government policy to help drive the need for LCM.

4 Conclusions and Research Needs

The case studies represent a snapshot in time, so it is not possible to draw significant conclusions regarding the sequence of skill-building suggested in the LCM CMM. However, the programs SDA had conducted with its network of companies to incrementally develop compliance, clean production and environmental management systems were seen to be significant factors in the success of their pilots and were consistent with the suggested sequence of LCM CMM. It seems there is a logical order for acquiring LCM skills that is path dependent, but also a need to embed the lower level capabilities in more developed patterns of action (Hart 1995). Thus, Ediouro Grafica focused on wastes, but used the data in an LCA study. Freudenberg and NEHSU developed KPIs for supply chain management, but again within a LCM frame. The premise is that developing the capabilities with an appreciation of higher-level maturities (i.e. beyond the company's current level) will result in faster and more effective learning. Only time will tell if LCM CMM achieves that objective.

The pilot projects also revealed some key gaps in the training resources provided to coaches attempting to apply the model. Key needs are interpreting the business

impact of environmental issues and aligning LCM initiatives with the company's business strategy. The pilots and observations from mature company programs highlighted the need to support efforts to develop the technical capacity for LCA and LCM with complementary resources to address softer management issues associated with individual and organizational development. The success of the pilots was correlated with strong management vision and direction and greater cross-functional representation on project teams. In fact, one of the greatest benefits of the LCA studies conducted might be the enhanced communication across functional groups, supply chain partners and customers. The Renault Collaborative LCA emphasized the importance of developing relationships that crossed organizational boundaries to improve value chain performance.

The collaboration among companies within a geographic region can be a powerful facilitator for disseminating LCM, particularly in developing economies. The networks facilitated by SDA and FICCI are models for future efforts to promote LCM. SMEs often lack the resources necessary to help champion and support change initiatives develop new procedures and systems due to the pressing competitive priorities, production schedules, etc. The external support of a credible organization can be a critical factor in overcoming the inertia to change. It is important that the human change management issues receive the same attention as concern for the technical methodological details of LCA and LCM. It is also important to recognize that companies face numerous market and regulatory barriers to implementing LCM. The social networks, and especially collaboration with government agencies, will be a necessary factor in negotiating policies that facilitate sustainable consumption and production.

A pressing need is more rigorous evaluation of the efficacy of LCM CMM in promoting faster learning in business and in producing outcomes that do move business toward more sustainable practices. The customized maturity assessments developed by FICCI and Renault raise an interesting dilemma. Is it better to tailor the maturity assessment to be more relevant to the local context and company priorities, or work towards a more standardized assessment that would facilitate correlating performance with maturity level? A fundamental challenge in evaluating the efficacy of LCM CMM is that there is no broad consensus on the desired end state. Views of sustainability are value-laden, and different groups will value the same outcome differently. It would be interesting to revisit these pilot studies in 6 months to a year for a retrospective evaluation of the benefits achieved.

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