

Green Virtual Enterprise Breeding Environments Enabling the RESOLVE Framework

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Abstract. Shifting towards Circular Economy will have significant implications on how value offerings are created, delivered and their residual value recovered as well as how shared value is created and captured by various actors in a collaborative (business) network where information, materials, water, energy and cash will flow in different cycles and based on various dynamic interactions within a closed-loop value system. In this context, Green Virtual Enterprise Breeding Environments (GVBEs) will act as long-term strategic networks of green enterprises and their related support institutions established with the aim of providing the necessary conditions, including common (circular) operating principles and infrastructure, for increasing their members' preparedness towards rapid configuration of Forward- and Reverse-Green Virtual Enterprises (GVEs) in order to provide a dynamic model for operations management of closed-loop supply networks. This paper focuses on how GVEs and their breeding environments can contribute to enable McKinsey's RESOLVE framework of six core-principles, and corresponding actions, for circularity: REstore/REgenerate, Share, Optimise, Loop, Virtualise and Exchange.

Keywords: Collaborative networked organisations · Green virtual enterprises · Breeding environments · Sharing economy · Circular Economy · Collaborative consumption · Industrial ecology · Sustainability · Shared value

1 Introduction

A strategic transition towards the *Circular Economy (CE)* [1] requires: (a) the use of renewable energy sources and materials that can be recycled, as well as circular product designs, which support these two conditions, (b) the adoption of new circular business models, (c) global closed-loop networks that support circular material flows, and (d) various enabling conditions of the above [2].

Shifting towards the CE will have significant implications on how value offerings are created, delivered and their residual value recovered as well as how shared value is created and captured by the members of a collaborative (business) network where information, materials, water, energy and cash will flow in different cycles based on various dynamic interactions within a closed-loop value system.

In this context, this paper explores how the *Collaborative Networks discipline* can enable, by creating ‘Green Virtual Enterprises and their Breeding Environments’ [3–7], the circular business practices of McKinsey’s RESOLVE framework of six core-principles, and corresponding actions, to achieve ‘circularity’ in business operations: REstore/REgenerate, Share, Optimise, Loop, Virtualise and Exchange [8].

2 Green Virtual Enterprises and Their Breeding Environments







A *Green Virtual Enterprise Breeding Environment (GVBE)* has been defined as a “long-term strategic alliance of green enterprises and their related support institutions aimed at offering the necessary conditions (viz. human, financial, social, infrastructural and organisational) to support the rapid configuration of GVEs”... towards the creation of dynamic closed (circular) supply networks [3–5], and inter-organisational Circular [1, 8] and Sharing Economies [9]. *Green Virtual Enterprises (GVEs)* are “short-term alliances of green enterprises, known as GVE partners, which have come together to share their green skills or core-competences and resources in order to better respond and exploit green (circular) business opportunities, and that have been dynamically created within a GVBE”. Such GVEs, according to [6] and [7] respectively, must be created as “(a) *dynamic forward supply networks (F-GVEs)* for delivering green and circular products and/or services to the market, as well as (b) *dynamic reverse supply networks (R-GVEs)* for recovering such products sold under the GVBE brand (product stewardship) for service provisioning, product recovering or for safe disposal”. Both GVE types are created in order to support the collaborative management of sustainable closed (circular) supply networks [4]. Further details on concepts related to GVEs and their breeding environments can be found in the following references: [3–7].

3 Enabling the RESOLVE Framework

The RESOLVE framework has been developed by McKinsey’s Centre for Business and the Environment [8] with the aim of emphasizing six strategies to incorporate Circular Economy concepts into a business, as follows: Restore/REgenerate, Share, Optimise, Loop, Virtualise and Exchange strategies (see Table 1).

‘RE’ for Restore and Regenerate According to McKinsey [8], *REstorative/REgenerative (RE) systems* aim to “reclaim, retain and restore the health of natural and industrial ecosystems, and return recovered resources to the bio-sphere and techno-sphere to renew feedstocks”. GVBEs aim to develop *RE capabilities* in the techno-sphere (i.e. the industrial ecosystem) in order to reduce virgin materials extraction and materials waste flows, and to increase materials productivity and recovery in the Circular Economy. *RE industrial systems* [1, 8] focus on maximising the usage and value of either products themselves or of their components, and eventually their incorporated materials, by the ‘power of circling materials longer’ through their reuse, remanufacturing or recycling, and by the ‘power of their cascaded use’ by using materials discarded as by-products

Table 1. McKinsey’s RESOLVE Framework [8]

Circularity Actions	Examples
Restore/Regenerate 	<ul style="list-style-type: none"> Shift to renewable energy and materials Reclaim, retain, and restore health of ecosystem. Return recovered biological resources to the biosphere.
Share 	<ul style="list-style-type: none"> Share assets (e.g. cars, rooms, appliances). Reuse/Second-hand Prolong life through maintenance, design for durability, upgradability, etc.
Optimise 	<ul style="list-style-type: none"> Increase performance/efficiency of product. Remove waste in production and supply chain. Leverage big data, automation, remote sensing and steering.
Loop 	<ul style="list-style-type: none"> Remanufacture products or components. Recycle materials Digest anaerobic Extract biochemical form organic waste.
Virtualise 	<ul style="list-style-type: none"> Dematerialising directly (e.g. books, music, travel, etc.). Dematerialising indirectly (e.g. online shopping).
Exchange 	<ul style="list-style-type: none"> Replace old with advanced non-renewable materials. Apply new technologies (e.g. 3D printing). Choose new products/services (e.g. multimodal transport).

from one value chain to replace virgin materials inflow in another (e.g. Industrial Symbiosis [10]). Hence, GVBEs can act in different industrial sectors as *REstorative systems* (e.g. of land) by becoming ‘urban miners’ (cf. urban mining [11, 12], see Fig. 1), which extend their responsibility beyond their own ecological/environmental footprint, and transform landfills into ‘mines’ to reclaim the scraps of different materials (e.g. plastics, metals, wood, rubber, etc.) from discarded (landfilled) products. Such action allows recovering lost land and reintroduces various materials as reusable ones in their respective cyclic material flows, allowing the GVBEs to also act as *REgenerative systems* for such materials stocks in the techno-sphere of the Circular Economy.

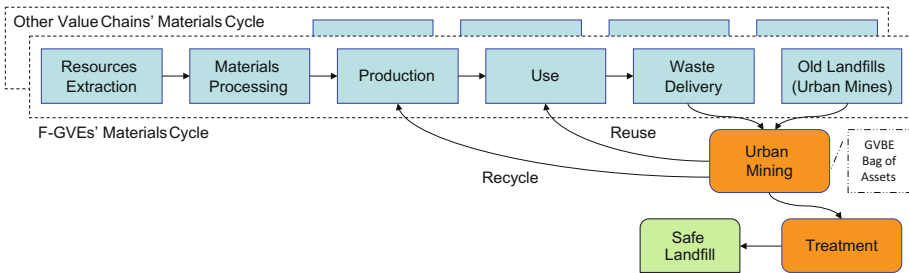


Fig. 1. GVBE Urban Mining based on GVEs Materials Lifecycle (Based on [12])

Other *regenerative or conservation actions* performed by GVBEs are the use of renewable sources of energy and sustainable (recyclable and renewable) materials. These actions are enabled by GVBE green practices such as:

- (a) Recruiting *GVBE members*/selecting *GVE partners* based on various quantitative and qualitative sustainability metrics [13] (viz. economic, social and environmental (e.g. recyclable materials, eco-design, clean technologies, emissions, waste) performance indicators) to select the most suitable *green enterprises* for *GVBE* membership and collaboration in F- and R-GVEs, and
- (b) The adoption of *green Information Systems (IS)* (software) focus on improving the flow and management of information (e.g. environmental management systems, lifecycle analysis tools), while *green Information Technologies (IT)* focus on the ecological footprints of hardware and other Information and Communication Technology (ICT)-infrastructure, designed and managed under an environmental-care perspective [14].

A good example of such greening effort in IT is the ‘GVBE advanced Collaborative Business ICT-Infrastructure’ [15], which adopts the *Cloud Computing paradigm* [16], to share hardware and ICT-infrastructures in order to reduce dispersed IT usage, maximise energy efficiency, adopt hardware recycling practices, lower emissions, and minimise water usage in cooling data centres [17].

‘S’ for Sharing. According to [18], “the *Sharing Economy* is founded on the principle of maximising the utility of assets and other shareable resources by means of renting, lending, swapping, bartering and giving them away in order to avoid their ‘idle existence’”. The *Sharing Economy* requires the adoption of wider business practices that, while economically sustainable, are able to reduce the environmental footprint of businesses, and also enable socially responsible business behaviours [9]. The concept of a ‘*GVBE bag of assets*’ was introduced in [9] as a virtual repository and/or physical warehouse, including collaborative procurement and shareable assets¹ management strategies and services, with the purpose of facilitating the sharing of tangible and intangible assets and resources among *GVBE members*, so that economies of scale and scope can be achieved and an ‘inter-organisational’ sharing economy enabled within a *GVBE* [9] (see Fig. 2). Hence, the *GVBE bag of assets* aims to develop a sharing economy business model that enables *GVBE members* to share their assets and resources in the sense of the RESOLVE framework, *shareable assets and resources* that would otherwise not be used cost-efficiently. This *GVBE inter-organisational sharing economy* can then be the basis of new revenue streams for *GVBE members* as well as to improve their efficiency in resources use (which ensures a positive environmental impact), and also creates stronger connections and trust among *GVBE members* (with expected positive social impact).

According to [9, 19], some example of *shareable assets* can be: “(a) tangible assets such as transportation vehicles (e.g. collaborative logistics), physical spaces (e.g. shared warehouses, excess space), infrequent-use items (e.g. event equipment), durable goods (e.g. productive assets), etc., and (b) intangible shareable assets like individuals’ knowledge, skills and services (both business and software services), data, time and experiences”.

¹ A *shareable (tangible) asset* “is characterised by its high acquisition price, low availability and low frequency of use” [9].

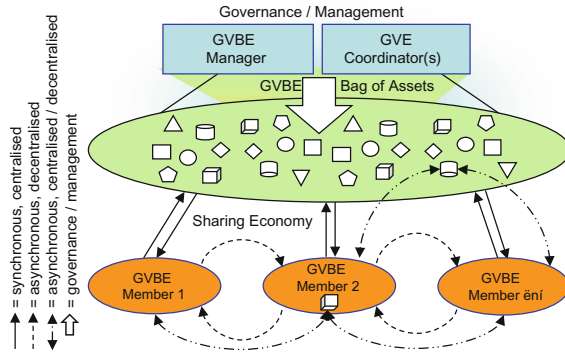


Fig. 2. GVBE Sharing Economy Scenario [9]

Other (quasi) *sharing actions* that GVBEs support are different strategies/services for prolonging life of products or components through their re-use, re-sale, repair, upgrade/refurbishment and/or re-manufacturing, as well as through the recovery of their residual value at their end-of-life via cannibalisation, recycling and/or smart incineration (viz. waste-to-energy) [20], based on the creation of *R-GVEs* [7].

As detailed in [7], *R-GVEs* must be able to sustainably manage ‘reverse logistics’, despite the sometimes uncertain nature of the reverse material flows in closed-loop (circular) supply networks, and be able to take advantage of new green (circular) business opportunities based on second-hand markets, repair champions, sharing societies, service-life extension programs and resources security initiatives (viz. materials, energy and water), also known as ‘Circular Economies’. Moreover, *GVBEs* and *GVEs brokers* [6, 21] will play a fundamental role in marketing, selling and branding *GVEs* circular products² and services (e.g. products as a service, products based on recycled, biodegradable and/or compostable resources, or products/assets in sharing platforms [22]) towards promoting their acceptance in a growing environmental conscious (green) marketplace.

‘O’ for Optimise. *GVEs* and their breeding environments aim to integrate and *optimise* complementary, and when needed, redundant green skills or core-competencies and resources (e.g. technologies and practices) of their *GVBE* members/*GVE* partners, and through this improve their competitiveness and environmental performance. According to [3], the advantage is to be able to offer green products and/or services that are circular, conserve natural resources, and importantly, are economically viable and socially rewarding for all stakeholders involved. Such *optimisation* is conducted at different scales within the breeding environment and involving different *GVBE* actors. Some examples of *GVBE optimisation actions* at the *breeding environment level* include:

² A *circular product* is “a product designed for servitization, lifecycle extension and easy-disassemble for composting and recycling, so their materials can circulate in closed-loops without generating waste” [22].

- (a) The GVBE membership and structure management (system) [23] focused on the strategic recruiting of *green enterprises* to become *GVBE members*, and later *GVE partners*, in order to avoid ‘competency gaps’ between the GVBE available competencies and the competencies required for responding to designed and emerging green (circular) business opportunities,
- (b) The GVBE profiling and competency management (system) [23] focused on building an inventory and proactively managing the green competencies (capabilities) and of the underlying resources (capacities) available in the breeding environment to guarantee their availability for the successful creation of F- and R-GVEs capable of offering, delivering and recovering green products and services to/from the market under a circular thinking, and
- (c) The GVBE lifecycle management itself (viz. creation, operation, evolution, metamorphosis and dissolution). This includes the GVBE ‘evolution lifecycle stage’, which refers to a set of feedback (*cf.* optimisation) processes through the GVBE performance management (system) [23], responsible for managing the continuous improvement of the breeding environment’s operations, and the GVBE ‘metamorphosis lifecycle stage’, which refers to various strategic imperatives such as changes in the GVBE mission, strategic adaptation of its business processes, ICT-infrastructure, governance principles and rules, etc. This may be necessary because of new market challenges or observed/predicted trends in the marketplace to remain competitive.

Furthermore, examples of *optimisation actions* at *GVE level* comprise:

- (a) The GVE partners’ search and selection process (tool) [24] focused on assisting in the selection of the most suitable (optimal) *GVBE members* to become *GVE partners* based on ‘multi-criteria’ approach (e.g. quality, cost, delivery time, geographical distance, flexibility, green practices, health and safety practices, trust, etc.) to meet customer requirements and sustainability standards and regulations, and
- (b) The GVE lifecycle management itself (viz. creation, operation, evolution and dissolution), where the GVE ‘evolution lifecycle stage’ is supported by simulation and decision support tools [25] for (re-)scheduling activities, optimising the production/service delivery plans, and finding solutions during operation when the original plan cannot be kept. Lastly, *optimisation actions* at *green enterprises level* focus on incentivising GVBE members’ sustainability continuum [26, 27] in order to increase their chances for involvement in GVEs as partners.

Generally, GVBEs’ goals are to increase and *optimise* the preparedness of their members based on mechanisms for enhancing their readiness for collaboration [28] (e.g. development of common working and sharing principles, governance rules and bylaws, a common ontology (terminology), shared (green) principles of operation, and an ICT-infrastructure that supports interoperability, etc.). This is necessary in order to

support the rapid configuration of F- and R-GVEs [4] as closed (circular) supply networks, and to *optimise* GVE partners' collaborative performance³ [29] based on systems and tools for GVEs creation and management [25].

'L' for Loop As developed in [5], GVBES aim to *loop* their information, materials, water, energy and infrastructure (services) flows in their closed (circular) supply networks to achieve zero-waste in a three-level holistic sustainable industrial development model for achieving a Circular Economy (see Fig. 3). At a micro-level (small-cycle), *Green Enterprises* (GVEBE members) focus on developing an 'industrial ecology' at factory level by linking "material, energy, water and waste (including by-products) flows between their manufacturing operations, supporting facilities and the surroundings buildings in order to increase resources productivity and pursue zero-waste" [30].

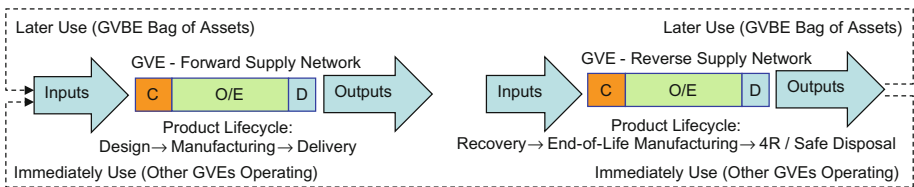


Fig. 3. GVEs Loops based on Industrial Symbiosis Strategies [5]

At meso-level (mid-cycle), *GVEs creation* aims to facilitate the development of dynamic closed-loop (circular) supply networks through the agile operation of F- and R-GVEs within a breeding environment in order to develop synergies between GVE partners. According to [5], this is performed "so the waste and/or surplus of downstream operations within a GVE lifecycle, through a certain degree of technical processing, return to the upstream operations of other GVEs in order to close various resources loops". Lastly, at macro-level (big-cycle), GVBES will act as 'intelligent collaborative networks' *optimising* the different core-competencies and resources (viz. capabilities and capacities) of their members. These resources include human and technology as well as financial ones, but also information and knowledge resources whether available in the breeding environment itself or through its GVEBE members to become as 'lean' as possible in all its operations. For example, this may involve the removal of some members, activities and/or resources, or continuously improving those [5].

The most natural *loop* for GVBES is the creation of R-GVEs (dynamic reverse supply networks) [7] for the purpose of recovering the products sold under the GVEBE brand (product stewardship), through F-GVEs [6], for service provision (e.g. repair), product recovery (e.g. re-manufacturing), or safe disposal [22], and therefore close-the-loop for closed (circular) supply networks based on GVEs creation [3–5].

³ Collaborative Performance is "the effectiveness and efficiency in creating an environment in which enterprises can merge their processes for performing joint activities in a non-hierarchic way" [29].

‘V’ for Virtualise As discussed in [3, 21], GVBEs as *virtual* eco-industrial clusters possess certain advantages over traditional eco-industrial clusters (located in one site) based on their nature of being geographically distributed (virtual) and supported by collaborative business ICT infrastructures [15] that allow to the breeding environment to act as a ‘*glocal networked enterprise*’ [21] with low environmental impact (e.g. on land).

Moreover, GVBEs as ‘glocal networks’ can have a *global* presence with *locally* available GVBE members/GVE partners to serve customers worldwide, creating in this way sustainable economic, environmental and social benefits for all stakeholders.

Other examples of GVBEs’ actions towards *virtualisation* are the shifting of physical products, services and/or processes by displacing or replacing those with the delivery of utilities through virtual channels. Such could be the case of a GVBE ‘Cloud-based’ Collaborative Business ICT-Infrastructures [15, 16] delivering (e-)service offerings based on cloud models like Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS) to their members, and GVEs adopting Product-Service Systems (PSS) [6, 31] in their business models (e.g. product-oriented, use-oriented or result-oriented [32, 33]) to improve resources productivity [34] in their value offerings.

‘E’ for Exchange. The final category of the RESOLVE framework [8] is *exchange*, and this action refers to adopting new green (circular) technologies and systems as well as to upgrading or replacing older ways of working (e.g. green (circular) practices and principles) at the GVBE as it evolves based on a sustainable development maturity model [35].

Such *exchanges* can take place at different scales within the breeding environment and involving different GVBE actors. Some examples of ‘greening’ (circular) efforts at GVBE members (green enterprises) and GVEs levels may include the adoption of:

- (a) Technologies, in the broad sense of the term, focused on sustainable materials (e.g. green chemistry [36]), circular product and service designs (e.g. designed for ease of maintenance and repair, upgradability and adaptability, and dis- and re-assembly [22]), green business processes (e.g. green marketing [37]), circular manufacturing [30, 38], reverse [39] and collaborative logistics [40], green packaging [41], to mention a few,
- (b) Systems, information technology based and non-information technology based, supporting Design for the Environment (DFE), Closed-loop Product Lifecycle Management (CPLM), Life Cycle Analysis (LCA), Lean Manufacturing, Total Quality Environmental Management (TQEM), Environmental Management Systems (EMS), Closed-loop Supply Chain Management (CSCM), ISO14000 series’ requirements, etc., and
- (c) Practices and principles, in addition to the Circular Economy ones, (viz. waste is food, diversity is strength, renewable energy, prices must tell the truth, and systems thinking [1]) like biomimicry (innovation inspired by nature) [42], industrial ecology (closed-loop processes) [43], cradle-to-cradle (regenerative industrial systems) [44] and blue economy (cascading systems) [45].

Furthermore, at GVBES level ‘greening’ (circular) efforts will focus on advanced eco-industrial networking strategies [35, 46] in domains such as materials, energy, transportation, marketing, human resources, information and communication systems, environmental, health and safety, production processes, quality of life and community, and waste management.

4 Conclusions

This paper has presented the manner GVEs and their breeding environment/s can act as enablers of McKinsey’s RESOLVE framework of six core-principles, and corresponding actions, for circularity, namely REstore/REgenerate, Share, Optimise, Loop, Virtualise and Exchange. Thus, a brief explanation of the RESOLVE framework was followed by a mapping of each of the principles against GVEs and breeding environments’ features and capabilities, emphasizing all relevant aspects. This has shown that a) the way McKinsey’s framework can be employed to structure complex Circular Economy artefacts such as Virtual Enterprises and their breeding environments, and b) the GVE and breeding environments are soundly grounded concepts that can be effectively used to model multifaceted Circular Economy scenarios at various levels. This work also contributes towards the further development of a GVE toolkit for supporting a Circular Economy on the basis of Collaborative Networks discipline.

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