Integrated Design: Lifecycle Eco-Consistency

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Abstract: - The XXI century engineer's activity is deemed facing the eco-targets required by the sustainable growth mandatory requirements. The technical challenge is impressive, not less than the socio-cultural efforts. The paper presents a survey of the state of the arts, especially discussing:
the development requirements at the product-service design phases, purposely dealing with the lifecycle and end-of-life key prerequisites;
the integration conditions at the supply chain management phases, wittingly discussing the networking aids and related business changes.
The presentation is limited to important hints. The usefulness of the discussion concerns the consideration of the lifecycle eco-consistency as total entrepreneurial challenge: it is not enough to separately tackle the design prerequisites out of the enterprise integration, with all needed functions and facilities; and vice-versa.

Key-Words: - Integrated Design, Lifecycle Eco-compliance, Extended Enterprise, Product-Service, Reverse Logistics

1 Introduction

The second millennium opens with the intriguing concept of the manufacturer's lifecycle liability of its supply chain. The accountability covers, [1,2,3,4]:

- the corporate social responsibility, with engagements of investors, employees and stakeholders;
- the eco-footprint of the product functioning, with compulsory recovery and reclamation targets.

For lawful action, the corporation shall contribute to a better society and a cleaner environment. The voluntary contribution and the betterment effort are crucial accountability elements; the aim is ‹keeping one step ahead of regulations›, chiefly in the field of environment protection. The question may arise: why do enterprises engage in an activity at first view economically illogical. The answer considers life-long loyalty and trust, before short-term profit. Here, the current benefit does not stop to the *instant* consumers (*manufacturers* and *purchasers*), but ought to cover third people, damaged by the *selfish* supply chain. The producers draw earth resources and take return at the point-of-sale, leaving the end-of-life wastes to the community: the transformation value-added is *private* income, the litter and contamination are *public* shortcoming. The new concept balances corporate liability, with compulsory recovery and reclamation targets, each time new products are brought out.

The deliberate role in long-term issues modifies the enterprise governance, because the lifecycle visibility makes incorporating duties outside the conventional manufacturing phases. The business requires comprehensive plans of action, to be taken globally, nationally and locally by organisations empowered at worldwide level. The protection of humanity survival is *global village* requirement, entailing the yet-to-be generations. The *selfish* utility is not matter of democratic consent, involving the today citizens only: if earth becomes a barren and poisoned land, the temporary wellbeing has meagre utility, just, for *instant* self-seeking consumers (*manufacturers* and *purchasers*). From now on, the definition of ‹consumer› includes the whole supply chain, with the further change in term of responsibility: the planning and engineering of the business has corporate explicit role, whereas the end-user is only implicit doer [5,6,7,8].

The eco-awareness is being the challenge of the millennium. The United Nations sponsor the XXI Century Agenda: worldwide sustainability actions, fostering people consensus and authority initiatives. The idea is joining ‹globalisation› with ‹regionalism›. The eco-threat consciousness is bottom up process that needs to involve one and all:

the citizens identify themselves with their country. The welfare of a district includes working conditions, environment protection, political steadiness, etc.; its planning assures regional competitiveness, that is, attractiveness compared to others. The appeal draws more investors, so that the eco-protection turns into crucial feature [9,10,11,12].

The political dimension of the XXI Century Agenda is beyond the scope of the paper. From the technical viewpoint, we need to focus on the engineering analysis models, permitting the ‹product lifecycle management›, PLM. The innovation is essential step towards service-engineering, SE, and reverse-logistics, RL, options, consenting the product-service delivery. The SE-PLM and RL-PLM tools are based on the twofold opportunity [13,14,15,16]:

- the lifecycle visibility, endowed with quantitative appraisals, grounded on virtual prototyping;
- the information sharing, provided through networking and co-operative knowledge processing.

The appropriate engineering analysis aims at concurrent *product-process* design, and at united *environment-enterprise* running. With product-service delivery, the corporation carries out life-long servicing, including conception, production, overhaul and recovery. The manufacture value-added is just part of the business, compulsorily joined to eco-target accomplishments. The engineering job needs entangled multiple-task efforts, demanding computer models and information management systems [17,18,19,20].

The paper discusses the state of the art of the engineering changes. The present situation shows that the industrialism paradigms go through a crisis: it is not tolerable to transform increasing amounts of raw materials into waste and pollution, at rate exceeding natural reclamation course. The climate is just warning sign that the sustainable growth cannot move this way in the near future. We cannot delay the turn, because the damages are cumulative, and lead to ‹no way ahead› lane, stopping the mankind survival conditions. The discussion refers to the already existing literature; the quotation is limited to books, and the choice is, certainly, somehow random, as the purpose is offering the cross-section of actual problems, with no intent to be exhaustive.

2 Lifecycle Eco-Compliance

The eco-design moves from ‹product lifecycle assessment›, PLA. The duty entails pooled tools, with changeful knowledge frames, depending on the on-the-go tasks [21,22,23,24]:

- choice between competing product-service offers, by streamlined lifecycle assessment, SLA;
- product-service delivery, fitted out with apt computer aided lifecycle inventory, CALI, files;
- life-long monitoring and diagnostics, by appropriate PLM (or SE-PLM and RL-PLM) tools;
- interaction with the independent certification bodies and the (local/global) control authorities.

The preliminary duty moves with SLA, simplified programme, capable of interfacing the PLA eco-requirements, with the complete PLM database. One major goal is to detail the CALI file, to be made available, as integral part of the product-service delivery, linking scope definition with impact appraisal. The inventory allows specifying life-long servicing and product-service amalgamation. In fact, the SE is qualifying provision of innovative producers, and RL is required duty in some cases (e.g., ELV, WEEE), chiefly, to expand to all other mass-produced goods (in the EU policy). At this time, the eco-design is far from being efficient, and the three SLA-CALI-PLM steps progress mostly as academic proposals. The independent certification bodies, still now, interact with the users, and the manufacturers only provide product databases, rather than full PLM tools.

The transition to lifecycle liability requires developing innovative CAD tools, chiefly, covering sophisticated multi-scale databases for virtual prototyping [25,26,27,28]:

- the resort to unifying ontology taxonomies, with people-to-document and people-to-people codes;
- the definition of product sustainability profiles, with broad-spectrum ‹technical› failure figures;
- the aggregated explanations to manage complexity, with diagnosis and recuperation purposes;
- the special purpose portrayal, to take full care of the in-progress enacted EU eco-regulations.

The example CAD aids are chosen to cover fundamental themes in the design engineering (the first two), and applied topics (the other two), directly related with advanced data management and sharing questions. The basically theoretical investigations focus on supplying self-comprehensive product characterisations, to make the lifecycle design achievable. The practical implementations aim at showing pioneering suggestions, for currently emerging engineering duties.

2.1 Database validation through ontology

In the area of knowledge management, the ‹ontology› is an explicit specification of a concept

group. The ‹concept group›, here, is a simplified view of the world we wish to represent for selected purposes. It consists of the identified concepts (objects, events, relationships, beliefs, etc.), and their (supposed to exist) links. Therefore, an ontology is a precise account of a shared understanding that improves the communication among people, organisations and computers. The knowledge portrayal consistency is relevant to avoid ambiguities and, moreover, to simplify encoders and editors. At this time, the database operation improves, [29,30,31,32], due to:

- the interoperability for PLM applications, without (timely tailored) translators and editors;
- the automatic construction of the involved group descriptions and of the population instances;
- the data consultation, manipulation and transfer, resorting to unified grammars and semantics;
- the knowledge evaluation, based on shared (and agreed) metrics and on incorporated standards.

The ontology taxonomies are useful for software interfacing: in the PLM case, with the many cross-linked tools, the option permits concurrent construction and deployment with reliable issues. The standard construal and reading helps in the people-to-document and people-to-people activity, with straight association of specification/validation, acquisition/validation, cataloguing/validation, restitution/validation, etc., each time using the chosen ontology to transfer the structured knowledge in a computer readable code.

2.2 Sustainability profiles and failure maps

The lifecycle eco-compliance is dynamic figure, selected at the design stage, and required life-long during the functioning and at the call-back stages. Early identification and planning of the eco-profile is becoming necessary accomplishment, according to the enacted and envisaged EU rules. It is important, however, to dispose of correlation figures, in view to extrapolate trends and to set up more conservative solutions. The item ‹failure›, in actual fact, matches up the *non* eco-conformity; and preserving viable profile is important feature of integrated design. To such purpose, the analysis aims at specifying the failing/refurbishing processes, [33,34,35,36], having resort to:

- the (law enacted) eco-conformity, defining degradation tendency and early warning features;
- the (predicted) eco-conformity, devising future bylaws with accuracy and wholeness guesses;
- the pre-planned revival and mending measures, to restore/up-grade the sustainability profiles;
- the re-design strategies, towards improved products and/or enhanced service engineering aids.

The technical failure occurs when the gap between the required operation and the actual running exceeds given thresholds. The malfunction is the situation, when the service performed by a device no longer meets requirements. The inability of a product-service to meet or continue to maintain the performance affects the producer/client relationship, and suited bylaws need to regulate fair market conditions. The eco-conformity affects the consumer/environment relation, and compulsory targets ought to be enacted, in view to balance manufacturer/user benefit, against third people damage. The corporate responsibility shall amalgamate the eco-sustainability within the product-service technical failure features, because it is directly in charge of selecting the value-added transformations and of planning the life-long/end-of-life operations.

2.3 Computer integrated service engineering

The traditional separation of the manufacturing, from the functioning phases of the products has the effect to ‹forget› the recovery/reclamation duties, with value-added entirely expropriated by the consumers (manufactures and users). The corporate responsibility makes indispensable to manage ‹complexity›, that is, to deal with systems, which parts interact, modifying the behaviour of the all and conditioning the demeanour of the combined entities. The effect superposition cannot apply, so the reductionism to elemental causes gives misleading depictions. The ‹complexity› is permanent character of service engineering, mixing the design and on-process knowledge. The diagnosis and recuperation purposes, [37,38,39,40], assemble:

- the aggregate description, to produce intra-domain links for the current domain of reference;
- the connecting knowledge explanation, to work out rehabilitation schemata, from prognoses;
- the automatic reasoning, to provide models having synergic utility in the remedial planning;
- the conception of product-service systems, exploiting engineering change management tools.

The aggregate description does not ‹reduce› complexity, but provides replacing instances, at the specified engagement conditions. The combining strategies move from the patterns (path searching, etc.), or from the collective types (attribution, etc.). The causal knowledge is rare in product design practices, because too time consuming. The heuristics frames are common substitutes, linking the data (declarative knowledge) and the operation setting (procedural knowledge) through the on-the-

go trustworthiness (contextual knowledge). The knowledge-based systems, however, are too much confident on computer learning and decision-making abilities. In engineering fields, the automatic reasoning is preferred as backing option, providing human-readable knowledge, but leaving the end interpretation (and remedial planning) to on-field operators. Finally, service engineering profits by meeting the demands of the customer, through the synergy of off-line support and on-line overhaul. The adaptive engineering change management defers the design of most recovery/reclamation tasks to life-long accomplishments. The goals of the business project are not defined explicitly, then the corporate lifecycle liability cannot be delegated, and the original producer is required to meet all the emerging incidents and clashes.

2.4 Computer integrated reverse logistics

The eco-regulation, today, devised by the EU Commission (and partners) aims at requiring the corporate liability for the recovery/reclamation tasks of given types of mass-products (i.e., the end-of-life vehicles, ELV, the waste electrical-electronic equipment WEEE). So, the appendage of the recovery (reuse/recycle) tasks to the manufacturing ones, is dealt with, by the concerned producers, expanding the ‹design-for-x› routines, to include the ‹design-for-recovery (reuse/recycle)› ones. The innovation is consistent with the current productive break-up and out-sourcing practices; the end-of-life requirements are given out by contract, as several other operations not thoroughly pertaining to the core business. In the setting of the product performance, the ‹design-for-reuse› and ‹design-for-recycle› allow the on-purpose predictable up-grading, to incorporate the reverse logistics cost in the forward processes. The devised options involve [41,42,43,44]:

- the establishment of unified databases, for uniform treatment of dismantling/upturn functions;
- the training of staffs/partners, especially effective in the recovery (reuse/recycle) work-cycles;
- the creation of appropriate RL-PLM tools, to be shared with the backward process operators;
- the promotion of applied R&D and co-operative feat, aiming at pollution/consumption lowering.

The reverse logistics is, as just recalled, especial target of the EU countries, by now, limited to series of widespread durables. The EU Directives properly address the waste management. The area is densely inhabited, and the landfills are impending threat for the life-quality continuance, unless to drastically bring down litter and rubbish. Until recently, the waste raising and treatment is thought public obligation, included in the standard tax system. The approach is generally harmful, because the community pays the bad habits of single individuals. Thus, the EU requires transforming the tax into a rate, in proportion of the litter produced. Some countries interpret the requirement, in view of applying fees, modulated by the personal income (according to the *proportional* tax spirit). Yet, the producer's liability in the reverse logistics case slightly modifies the general principle, because: the duty is required to the original consumer (the manufacturer); the charge applies to given subsets of durables. All over Europe, the situation is far from uniform. Moreover, the waste management does not exhaust the reverse logistics problem: targets on the reuse/recycle ratios, are constraints on the materials, but the pollution depends also on the consumed energy.

3 Net-Concerns and Extended Enterprises

The carrying out of eco-consistent supply chains moves from the full life-long transparency of the delivery footprint. Now, the information system management needs real-time interconnection of multiple partners, again, with changeful knowledge frames, to economically allocate the tasks, and verify corporate performance. The innovation trends show two choices [45,46,47,48]:

- the product-service delivery, supported by a cluster of partners, providing purposely aimed jobs;
- the reverse logistics duties (of given durables), (indirectly) performed by the original producers.

Today, networking is efficient reality, making possible collaborating many partners on a given business project. The actual achievements entail several steps up [49,50,51,52]:

- the choice between efficient co-operative partners, timely taken from a suited ‹facility market›;
- the net-concern amalgamation, after broking, negotiation, agreement and facility integration;
- the product-service management execution, fulfilled by the partnership with specific contract;
- the certification and accreditation completing, by third party, notified to the control authority.

The preliminary step knocks together specialists, relevant for the product-service delivery, so that each one operates in his core business. The second step deals with the negotiation and assembly of the apt extended/virtual enterprise, in order that the enabled partnership acts efficiently, so (third step) warranting the (compulsory or approved)

producer's liability. The subsequent step closes the data exchange, with the certifying bodies and the overseeing authorities.

The creation of efficient corporate assemblies requires networking interfaces. The internet and world-wide-web are today current opportunities, making low-cost and reliable the communication demands. The ‹concurrent entrepreneurship› develops, using multiple site facilities, to bring out the products close to the customers or to reach a partner distribution with included crucial competences. The facility cluster does not necessarily belong to a unique corporation; the effectiveness looks after optimising the particular business project, or after complying the enacted bylaws on the lifecycle corporate liability.

3.1 Facility/function market operation ruling

The fostering and management of the facility/function market, with transparent competition lay-out to facilitate effectual information systems, connecting the potential partnership. The knowledge sharing in product-service delivery is fundamental prerequisite, with the twofold constraint to keep the transparency of the product data up-grading, and to warranty co-operative problem-solving skill. The facility/function selection and assembly in view of the business project ought to be planned out, tackling technology facets (infrastructures, protocols, standards, etc.), organisation aspects (systems of collaboration, government, reporting, etc.), management issues (relationship rules, performance appraisal, etc.). The current accomplishments avail of robot age equipment and methodologies, and offer widespread potentials [53,54,55,56]:

- to deal with the yet-to-be manufacturing, embedding technology/organisation/management aids;
- to exploit efficient learning upbringing, to cancel out the borders among enterprises and people;
- to acknowledge the robotic equipment divide, fully addressing the cognitive revolution options;
- to turn towards transformations, having value added in intangibles, to minimise the eco-footprint.

The entrepreneurial changeover is impressive. From now on, the static ‹factory› does not exist any more. It is replaced by the cluster of facilities and functions, each time, best suited to solve the instant deeds of the current business project. The idea is to create the corporation, which assembles only the manufacture/overhaul functions, needed by the in-progress product-service delivery. In lieu of a ‹productive flow› along the floor-shop, we have an ‹entrepreneurial assembly› along the supply chain. Quite clearly, advanced design methodologies are necessary (e.g., ontology-based lifecycle management -with uncertainty-, etc.), to train people and to amalgamate the technologies. The turn is the only way to address the cognitive revolution, starting by transforming the traditional material processes, enhancing the intangible value-added. The basic technical analyses show that this change is only the beginning: the cognitive revolution, should it develop, requires mingling the robotic aids, combining artificial intelligence and artificial life, towards totally innovative processes.

3.2 Virtual/extended corporation establishment

The cognitive revolution horizons are conjecture for a future (hopefully) to come. Presently, it is better to consider the networking technology and the facility/function market. The first is technical opening; the second is industry outcome, to assure agility to the production corporations. However, the effectiveness presupposes suited work-organisation and business-management. Many solutions are examined, from the *virtual* enterprise top agility, to the *extended* enterprise utmost assembly. In a technology-driven view, agents search for partners to integrate the supply chain: no stable lay-out exists out of the business project and its deviser. For an integration standpoint, the ceaseless change conflicts with the firm theory, with optimal job allocation. Today, the separation of the ‹brand› from the ‹factory› is prospect, fostered with the productive break-up and out-sourcing. The all approaches an *extended* or *virtual* corporation, depending on the inner organisation and on the offer steadiness. In the technical literature, the opinions vary, and, perhaps, the disparity can privilege the knowledge allocation: shared by most of the partners, in *virtual* lay-outs; centralised by the leader, in extended organisations. Noteworthy investigations cover [57,58,59,60]:

- the knowledge entrepreneurship, purposely implemented to look at eco-sustainable end results;
- the concurrent corporate opportunities, best exploiting technology-driven networking benefits;
- the corporation benefit of co-operative altruism, fostered by knowledge sharing mechanisms;
- the facility amalgamation criteria, extending concurrent engineering to the corporate functions.

The networking and the virtual/extended corporations opportunities are areas widely

discussed in general, and, markedly, with focus on the corporate lifecycle liability. The knowledge sharing in the product-service systems profits by net-technologies, especially, if the suited premises are posed since the design stages (with PLM, RL-PLM and SE-PLM tools). The knowledge entrepreneurship is, thus, outcome of the net-concern age: the capability of managing information concurrently with processing materials expands the transformation value added. The opportunity has not to be left out, notably, when it allows increasing the business earnings. In the same time, the traditional ‹to make or to buy› firm choice will evolve towards virtual/extended corporation modes, with the advantage of dynamic and integrated knowledge allocation.

3.3 Corporate liability of product-service delivery

The corporate social responsibility is engineering change, with utmost relevance. Up today, the responsibility is, above all, linked to the deliberate infringement of an enacted law. Whatever is not forbidden, is allowed. The ownership of goods permits to use, misuse or destroy them, keeping little attention on their lifecycle. Once raw materials bought, a firm has full rights on them, and transfers the same privileges to the product purchaser. Those facts bring to the aberration of the lawfulness of processing boundless earth resources, and, in-progress, transforming them into waste and pollution. The alternative modifies the *ownership*, into *technical tenure*, or right to temporarily enjoy the item, provided *refunding* the third people, for the private appropriation. The *technical* side of the tenure is in the *refunding* process. Here, again, the opinions vary. Basically, we need a metrics, to assess the ‹tangibles yield per unit service›, so that leanness is weighed among equivalent services. Positively, the complexity of such system requires equally sophisticated lead roles. This brings to redefine the ‹consumer›, assembling the manufacturer-and-client. Then, the refunding process is assigned to the manufacturer, which, of course, moves the cost on the supply chain. From engineering viewpoints, the all is extensively investigated [61,62,63,64]:

- the product-service effectiveness seriously depends on the reliability engineering achievements;
- the virtual/extended corporation operation is heavily affected by the communication helpfulness;
- the overall networked organisation needs high-level information government and management;
- the public policy ought to develop proper social accountability, to grant transparent refunding.

These topics show the weigh of merely technical advances, in the management of the corporate social responsibility. Their technology-driven content confirms that the know-how and knowledge advances are feasible. Their actual deployment is fact entailing civic consent and political decision at the global and local levels. Our survey, just, illustrates example questions.

3.4 Certification of the consumers' eco-footprint

The citizens' awareness of the ecology impending threats is not enough, if confined into mostly cultural and ethical sentences. When by themselves, individuals and nation-states aim at their *utility* as contingent achievement. The effects and damages of third parties emerge, when these express the willingness of reactions. Within a country, the welfare policies and solidarity *vs*. less fortunate ones come out in parliamentary democracies. Within the *global village*, the ecology policies and altruism *vs*. yet-to-be generations are much more entangled questions, because these third people act the part of the mankind survival. We have quoted the UN XXI Century Agenda fostering ‹globalisation› by ‹regionalism›. The technical implementation requires worldwide eco-targets and common appraisal metrics. The international consent confers power to a central authority. The local governments take in charge controlling target and tax systems. The eco-footprint certification is done by third bodies (by respect to manufacturers and buyers), having regional accreditation, qualified by notification to the central authority. Limiting the discussion to the engineers' developments, the questions to tackle are diversified, with wide spectra of subjects [65,66,67,68]:

- the efficient administration of cross-linking relationships and of external constraint allocations;
- the eco-safeguard specification and monitoring, with reliable ‹technical› failure management;
- the promotion and qualification of the eco-quality standards and recovery/reclamation metrics;
- the effectual handling and coding of eco-footprint databases, with apt communication reliability.

The image of the whole supply chains for the totality of the citizens monitored and weighed *vs*. the *global village* future eco-consistency is rather oppressive and deplorable. At first view, the icon of the personal freedom and civil rights clashes against the full pre-planning of stocks consumption and earth contamination. Perhaps, it is not really so.

Today, we accept to fasten the seat belt, when starting the car, and this concerns our protection, more than the wellbeing of other people. With the third-body certification our privacy can be safeguarded: the communication to the controllers and authorities relates to aggregated date, and the information tracking can omit the one-to-one maps. In fact, we accept to not conceal our economic transactions (and to pay the income taxes); we ought to agree to not hide our ecologic transactions (and to pay the related fees).

4 Conclusion

The survey on the engineer's innovation during the second millennium beginning is the excuse to provide a fresco of why technologies evolve. Actually, the human progress is knowledge-driven build-up, selecting and performing *artificial* transformations, which modify the *spontaneous* trends, to establish the *civilisation* (compared to wild lands). The progress is regular outcome of the man *intelligence*, the faculty of choosing between facts and demeanours, and of designing solutions and improvements. The civilisation is man construct, with multifarious facets [69,70,71,72].

The engineering-change management is ability, more or less, critical. Trivial simplifying views define the *agricultural* revolution, when the men discovered farming and breeding for their benefit at weather and season pace, and the *industrial* revolution, when the spendable riches generation was speeded up at man will, with resort to artificial energy. Now, the earth eco-system is almost closed, and subject to the entropy law. The use of non-renewable sources cannot last for long. The progress through ‹innovation› is ticklish bet. The general policies provide hints, [73,74,75,76], based on acknowledged paradigms. Today, these paradigms are not like yielding growth sustainability; the over-pollution and over-consumption are impending dangers, not mitigated by the earth self-healing potentials. However, the all frames are sometimes questioned: we might devise leopard spot trends, hoping to be able to castle within affluent regions, so that the man eco-consistency is just confined to our safeguard.

The *selfishness* hypothesis is, mostly, cherished at nation-state or nation-state cluster level. The guess believes distinguishing ‹developed› and ‹developing› countries, trusting in sufficient advance, so that the bloodhounds never reach the hares. Alternatively, the *altruism* proposition considers the *global village*, and confides in the coming *cognitive* revolution, to make the progress continue. The yet-to-be innovation is only technology-driven optimism; the today diagnoses are truly threatening. The saying ‹forewarned, forearmed› fosters awareness. The engineering habit of impact assessing is the same as ‹well begun is half done›. The capability of understanding the actual seriousness of the earth living beings is available, and it does not leave open *selfishness* hypotheses. The queries can be dealt with along different views, [77,78,79,80]; all devised procedures and quality systems converge to similar conclusions.

The analysis of ecology data requires rather optimistic trust in the man wisdom to turn doing the second half. The innovatory know-how to go ahead is forced to deal with the over-pollution/over-consumption at the *global village* range. It is unsafe to devise sectional successes; the competition is blunted virtue; the stigma inexorably gets to affect the world over. The mentioned *agricultural* and *industrial* revolutions discovered:

- the 'culture': artificial rising of living supplies; or: trained and refined state, induced in people;
- the 'industry': business institution by ordered work-organisation; or: diligence, i.e., personal zeal.

The two link up tangible processes and human characters. Yet, only projections on the external world bring to helpful effects; the internal qualities belong to *knowledge* domains. The transition in view of the ‹forewarned, forearmed› warning needs to combine science and empathy, to recognise the ecology constructs [81,82,83,84]. The 'culture' and 'industry' ambivalence is notable fact.

The *cognitive* revolution follows from akin trends, with the *artificial* exploitation of the genetic codes for *regenerative* processes. The talent *intelligence* belongs to the tangible world; it generates in the ‹knowledge›, through self-sufficient processing. The cognitive faculty aims at self-sufficient processes, to enable transparent restoration and reclamation outcomes, based on mostly renewable resources, by ‹bio-mimicry›. The *intelligence* ability is required for process diagnosis and control. The pooled artificial life/intelligence aids merge bio-science/technology and computer engineering, moving the changeover towards knowledge domains: the ‹information› of the genetic codes to use ‹bio-mimicry› self-sufficiency. The current technical advances provide, perchance, hints; the whole innovation is expectation to come [85,86,87,88].

The conclusion is reluctantly vague. The survey insists looking at knowledge-driven innovation, because the ‹revolutions› occur if needed. The corporate social responsibility follows the lifecycle

liability; the two bring forth the many topics outlined, from sustainability profile, to net-concerns, from product-service delivery, to aggregated account of complexity. The ‹forewarned, forearmed› warning, thereafter, might suffice, once the ecology threats are understood.

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