Eco-business Planning: Idea Generation Method

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Abstract

From the point of view of sustainability as well as an economic perspective, business planning, monitoring, evaluation, and communication with customers and a wide variety of other stakeholders are becoming more and more important. In this context, a growing number of methods and tools for sustainable product and business design are proposed. Examples include design for environment (DfE), product service system (PSS), industrial product service system (IPSS), servicizing, function selling, service engineering, life cycle assessment (LCA), and life cycle simulation (LCS) methods.

However, it is often difficult to determine business activities that actually contribute to or harm the sustainability of the earth due to complexity of the cause-effect chains observed in business activities among stakeholders. Rebound effects typically show such indirect causality; for instance, the development of fuel-efficient vehicles may contribute to the reduction of energy consumption from a systemic perspective. However, the development sometimes increases energy consumption, because users of these vehicles may be less aware of the environmental loads of driving activities and drive more in consequence. Furthermore, governmental subsidies that stimulate the market introduction of these vehicles may result in the purchasing power of the potential owners in a long term.

In such a case, it is crucial to configure the business economically and environmentally feasible in a long term by introducing new activities (e.g., introduction of a user incentive scheme regarding the reduction of energy consumption) accompanied with energy-efficient technologies. Consideration of such direct and indirect influences of the development of energy-efficient

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technology on business activities in multiple time scales, and vice versa, is indispensable for idea generation of eco-business.

Although LCS and LCA can analyze both direct and indirect influences of business activities in a long term if they are appropriately represented in the numerical models, they are not sufficient for idea generation of eco-business. To support the idea generation of eco-business, study on modeling methods dealing with indirect causalities in a systematic and comprehensive manner is inevitable. Collection of a variety of cause-effect patterns observed in the existing eco-business cases and utilization of these patterns at the idea generation process is a basis of such study.

The objective of this chapter is to propose an idea generation method for eco-business planning that handles complex relations among business activities among stakeholders from multiple time scales. Firstly, cause-effect patterns in a successful eco-business models and cases, including IPSS and function selling, are identified and formulated into cause-effect pattern library focusing on the gaps between the condition of each successful case and those of conventional businesses. Causal-loop diagram (CLD), which is a kind of system dynamics tool, is utilized to describe the gaps. Then, using information contained in the library, an idea generation procedure of eco-business is illustrated with a simplified "EcoFleet" business. Finally, future development needs of the proposed method are also discussed.

This chapter is prepared for all business planners and product designers who wish to make their product and service more environmentally friendly. Any specific knowledge in engineering design are not necessary to read through this chapter.

1 Introduction

Sustainable development (SD) has become a critical issue due to growing concern about environmental problems in recent years, and firms are obliged to justify their presence in society more than ever before (Karl-Henrik 2000). In this context, a number of methods and tools for sustainable product and business design (Umeda et al. 2009; Meier et al. 2010; Kobayashi and Kumazawa 2005; UNEP 1997; Umeda et al. 2000; Wimmer et al. 2004; Hauschild et al. 1999; Lindahl and Olundh 2001) are being proposed.

However, it is often difficult to determine business activities that actually contribute to (or harm) the sustainability of the earth due to the highly complex nature of the environmental and economic systems of society. As shown in the abstract, rebound effects are typical examples showing such complexity. In order to handle such complexity in a systematic and comprehensive manner in designing eco-businesses, business planners (and product designers) need to explicitly deal with cause-effect chains in the businesses and consider indirect influences as well as direct ones in their decision-making and communication processes. To support such upstream thinking, collecting a wide variety of cause-effect chains based on existing eco-business cases holds considerable promise.

This chapter proposes an idea generation method for eco-business planning by using a cause-effect pattern library. Firstly, cause-effect patterns in various successful eco-businesses, including Industrial Product Service Systems (Meier et al. 2010), are identified and formulated into a cause-effect pattern library. Then, the library is used by business planners (and product designers) to generate practical eco-business ideas in the planning procedure. For the illustration of the procedure, the chapter provides readers with a simplified example of "EcoFleet" business.

This chapter first gives a brief summary of eco-business and discusses its prerequisites and characterizes its ideal state using a causal-loop diagram (CLD) (Sterman 2000). Then, the chapter classifies the gaps between ideal eco-business (IEB) and conventional ones into five categories and explains the construction of a cause-effect pattern library focusing on the gaps. Finally, the chapter proposes an idea generation method for eco-businesses using the library and discusses future necessary developments.

2 Eco-Business in Industry

Eco-business is regarded as the business that directly or indirectly reduces environmental loads of society while maintaining the benefits of companies and users. Examples include product (e.g., car and loading space) sharing, reuse and recycling of components and materials (e.g., closed loop manufacturing of photocopiers and single-use cameras) and remarketing of secondhand products (e.g., home electric appliances).

In car-sharing business, a car club provides its members (generally, on a local basis) with access to vehicles. In this business the driving costs of each member become less than the car ownership costs especially in congested urban areas with very high driving and parking costs. From the viewpoint of society, this business potentially reduces the number of consumer cars and their resulting environmental load. In addition, some car clubs use electric vehicles of which mileage is better than that of conventional vehicles. Thus, car sharing can reduce the environmental load of society while maintaining the benefit of a car club and its users.

Sharing of underutilized loading space of trucks in return trips is also a promising eco-business, because it decreases both environmental loads and transportation costs. Ecologicom (2012), which is a loading space exchange service via the internet, is a typical example of the business. By joining the service, users (both businesses and consumers) can significantly reduce their transportation costs and environmental loads.

Reuse and recycling of post-use products, components, and materials sometimes play an important role in reduction of environmental impacts. The closed loop manufacturing of products such as photocopiers and single-use cameras which effectively utilizes the post-use components and materials to make new products is a promising eco-business because it can significantly reduce the costs and environmental loads at the production stage without deteriorating the quality of new products.

Remarketing of waste home appliances can be regarded as an eco-business to some extent. In Japan, it is necessary for consumers to pay recycling fees when discarding TVs, air conditioners, refrigerators, washing machines, and personal computers. Therefore, the secondhand use of waste home appliances is beneficial for their first and second users (sometimes in developing countries); the former can reduce discarding costs, and the latter can obtain home appliances at low cost. The secondhand use of waste home appliances has some potential to reduce environmental loads by extending their life span. However, the business sometimes hinders the diffusion of more energy-efficient and environmentally conscious products. In addition, when they are exported to developing countries, their improper treatment causes significant environmental pollution in destination countries (Puckett et al. 2002). Thus, consideration of indirect influences of secondhand use is crucial for the assessment of the business from environmental and economic perspectives.

3 Idea Generation Method for Eco-Business

3.1 Causal-Loop Diagram (CLD)

In order to represent complex cause-effect chains among the activities in a business, this chapter introduces a causal-loop diagram (CLD). A CLD is a kind of system dynamics (SD) (Sterman 2000) tool. The idea behind SD is that every action triggers a reaction. This reaction is called feedback, and the behavior of a system is expressed by a set of circles of causality. This set of circles is called a causal-loop diagram (CLD). CLDs contain two types of feedback, namely, (1) reinforcing feedback (R) and (2) balancing feedback (B). Reinforcing feedback accelerates the existing trend of a process. In contrast, balancing feedback counteracts and opposes the change.

Figure 34.1 shows examples of CLDs. The arrows indicate causal relationships. The + or − sign at the arrowhead indicates whether the effect relates positively or negatively to the cause, i.e., whether an increase in the cause leads an increase or decrease in the result. Dotted arrows represent delays in the processes. As shown on the left in Fig. 34.1, if a firm lowers its price to gain market share, its competitors also lower their prices and force the firm to lower its price again. Thus, the price becomes much lower. This is an example of the reinforcing feedback. As shown on the right in Fig. 34.1, the higher the price of a commodity becomes, the lower the demand becomes and the more the stock increases. This leads to pressure to lower the price of the commodity and the price will fall. This is an example of balancing feedback. In some cases, a feedback or reaction does not occur immediately, so delays in processes should also be identified. Note that the loop with even number of negative links (as shown in the left of Fig. 34.1) and the one with odd number of negative links (as shown in the right of Fig. 34.1) are a reinforcing loop and a balancing loop, respectively.

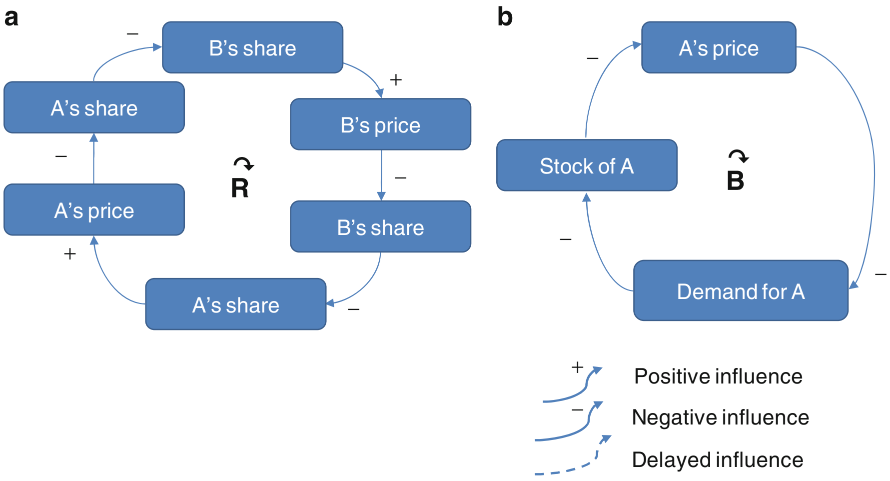


Fig. 34.1 Examples of CLD (**a**) Reinforcing feedback (**b**) Balancing feedback (Modified from Kondoh and Mishima (2011))

3.2 Representation of and Prerequisites for Eco-Business

3.2.1 CLD of Eco-Businesses

Since all businesses are driven by profit, causality among business activity, user value (UV), and profit should first be considered. In addition, the analysis of 130 Japanese eco-businesses (Kondoh et al. 2006) has identified four kinds of UV: (1) improvement of service quality, (2) reduction of user's cost, (3) avoidance of user's risks, and (4) improvement in user's eco-image from society and market. Therefore, causality among business activity, UV, profit, life cycle environmental load (LCE), and life cycle cost (LCC) should be taken into account in the process of planning eco-businesses.

There exist 20 possible causal links (i.e., a complete graph with five nodes) among these nodes. This chapter especially focuses on the following seven causal links: C_{AE}, between business activity and LCE; C_{EP}, between LCE and profit; C_{AC}, between business activity and LCC; C_{CP}, between LCC and profit; C_{AV}, between business activity and user value; C_{VP}, between user value and profit; and C_{PA}, between profit and business activity, as shown in the middle part of Fig. 34.2, because an eco-business can be driven by the reduction in LCC and LCE, as well as the improvement in UV. These links can form three feedback loops of business activity: L_{AEP}, consisting of C_{AE}, C_{EP}, and C_{PA}; and L_{ACP}, consisting of C_{AC}, C_{CP}, and C_{PA}; L_{AVP}, consisting of C_{AV}, C_{VP}, and C_{PA}. Each can be either a reinforcing or a balancing (immediate or delayed) feedback loop.

3.2.2 Requirements and Ideal Causality Configuration of Eco-Businesses

Theoretically, there exist 3^7 causality configuration patterns because there are three possibilities, no influence, positive influence, and negative influence, for each causal link. In practice, however, the numbers of configuration patterns describing conventional businesses and eco-businesses are much smaller.

The requirement for the success of a conventional business is to form a reinforcing feedback loop including business activity, UV, and profit (i.e., L_{AVP}) as shown in the upper part of Fig. 34.2, because a conventional business does not care about LCE and LCC of society. As UV, it provides increases through its business activity, profit and investment in business activity generally increase; thus, C_{AV}, C_{VP}, and C_{PA} are positive influences.

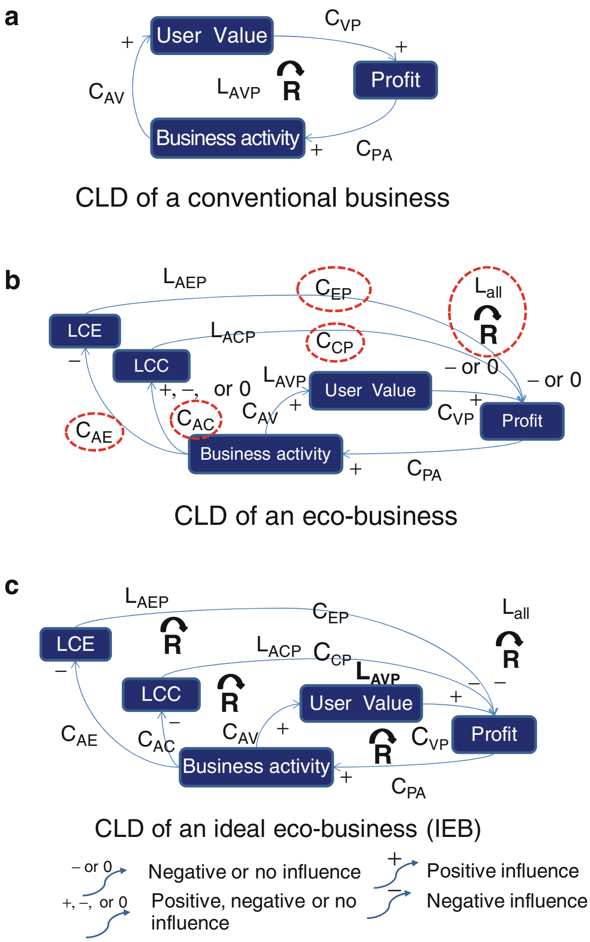


Fig. 34.2 CLD for an eco-business (**a**) CLD of a conventional business (**b**) CLD of an eco-business (**c**) CLD of an ideal eco-business (IEB) (Modified from Kondoh and Mishima (2011))

Since eco-businesses are defined as businesses that, directly or indirectly, lead to a reduction in environmental load through their business activities, their causality configuration patterns are identified as follows: First, the overall causality trend L_{all}, which is the resultant of L_{AEP}, L_{ACP}, and L_{AVP}, should form a reinforcing feedback loop to accelerate the business activity, even though L_{ACP} is balancing feedback loop. Second, C_{AE} (i.e., the causal link between business activity and LCE) should be negative influence.

Some eco-businesses such as product sharing can reduce both of environmental load and cost to society (i.e., both L_{AEP} and L_{ACP} are reinforcing feedback loops) and others such as provision of cleaner treatment service of hazardous materials than legally required might incur additional cost (i.e., L_{ACP} is balancing feedback loop). Eco-businesses can take multiple configuration patterns.

Among them, the ideal eco-business (IEB) is identified as the one for which the L_{AEP}, L_{ACP}, and L_{AVP} loops are reinforcing loops while C_{AE} and C_{AC} have negative influence as shown in the lower part of Fig. 34.2. This model shows that an IEB increases user value and decreases both societal environmental load and cost simultaneously, and all of these effects increase profit, which may promote investment in the business' activities.

Note that an eco-business designer does not always have to design IEB. IEB is introduced as a reference model that screens out all possible gaps between ideal state of eco-business and those of conventional businesses.

Causality configuration patterns for conventional businesses, eco-businesses, and IEB are summarized as shown in Table 34.1. Characters $+$, $-$, 0, R, and B in each cell of the table denote positive influence, negative influence, no influence (or no feedback loop), reinforcing feedback loop, and balancing feedback loop, respectively. Shaded cells in the first, second, and third rows in the table give the requirement for the success of conventional businesses, eco-businesses, and ideal eco-business, respectively.

3.3 Structuring Cause-Effect Pattern Library

As mentioned in the introduction section, a cause-effect pattern library should be structured focusing on how each successful case overcomes the gaps between the conditions for IEB and conventional businesses. The gaps are classified into five types as shown in Fig. 34.2:

(a) Insufficient or no C_{AE}

Since every business pursues profit, its activity does not necessarily reduce society's LCE. Therefore, the first gap to overcome is C_{AE}, which should be negative influence.

(b) Insufficient or no C_{AC}

Every business activity does not necessarily reduce LCC of products or services. For example, businesses have no incentive to reduce EOL treatment cost of their products unless they are responsible for that. Thus, C_{AC} can be the gap to overcome, which should be negative influence.

Table 34.1 Causality configuration pattern of sustainable and conventional businesses

<table>
<tr><th rowspan="2">Row No.</th><th rowspan="2">Business case</th><th rowspan="2">User</th><th rowspan="2">UV</th><th colspan="7">Causal links</th><th colspan="4">Feedback loops</th></tr>
<tr><th>C_{AE}</th><th>C_{EP}</th><th>C_{AC}</th><th>C_{CP}</th><th>C_{AV}</th><th>C_{VP}</th><th>C_{PA}</th><th>L_{AEP}</th><th>L_{ACP}</th><th>L_{AVP}</th><th>L_{all}</th></tr>
<tr><td>1</td><td>Requirements for conventional business</td><td></td><td></td><td></td><td></td><td></td><td></td><td>+</td><td>+</td><td>+</td><td></td><td></td><td>R</td><td></td></tr>
<tr><td>2</td><td>Requirements for eco-business</td><td></td><td></td><td>–</td><td>– or 0</td><td>+,–, or 0</td><td>– or 0</td><td>+</td><td>+</td><td>+</td><td>R, B, or 0</td><td>R, B, or 0</td><td>R</td><td>R</td></tr>
<tr><td>3</td><td>Conditions of Ideal Eco-Business (IEB)</td><td></td><td></td><td>–</td><td>–</td><td>–</td><td>–</td><td>+</td><td>+</td><td>+</td><td>R</td><td>R</td><td>R</td><td>R</td></tr>
<tr><td>4</td><td>ESCO business</td><td>Factory, office building</td><td>Reduction in energy cost without initial investment</td><td>–</td><td>0</td><td>–</td><td>–</td><td>+</td><td>+</td><td>+</td><td>0</td><td>R</td><td>R</td><td>R</td></tr>
<tr><td>5</td><td rowspan="2">Green electricity certificate business</td><td>Direct green electricity user</td><td>Improvement of user's eco-image from society with reasonable electricity price</td><td>–</td><td rowspan="2">–</td><td rowspan="2">+</td><td rowspan="2">–</td><td rowspan="2">+</td><td rowspan="2">+</td><td rowspan="2">+</td><td>R</td><td>B</td><td>R</td><td rowspan="2">R</td></tr>
<tr><td>6</td><td>People who buy green electricity certificate</td><td>Improvement of eco-image from society by environmental impact reduction certificate</td><td>–</td><td>R</td><td>B</td><td>R</td></tr>
</table>

(c) Insufficient or no C_{EP}

Even if a business reduces the LCE of its products, the reduction does not necessarily increase the firm's profit. Green consumers might accept environmentally conscious products, but their market segment is not generally large enough to insure success. Therefore, how to relate societal LCE reduction to profit is an important issue for eco-business planning.

(d) Insufficient or no C_{CP}

Even if a business reduces the LCC of its products, the reduction does not necessarily increase the firm's profit unless it is properly shared by the firm, users, and society. Therefore, how to relate societal LCC reduction to profit is also an important issue for eco-business planning.

(e) Insufficient drivers

As in conventional businesses, in order to drive eco-businesses, the overall causality trend L_{all} should form a reinforcing loop even if the businesses incur additional costs to reduce their societal LCE through actions such as providing cleaner end-of-life treatment for their products.

A cause-effect pattern library is constructed based on an analysis of 130 eco-business cases in Japan (Kondoh et al. 2006). Table 34.2 summarizes typical examples. Taken from these examples, Fig. 34.3 depicts a CLD of ESCO business (Association for ESCO Business Introduction in Japan 1998), which solves a common problem pattern where adoption of energy-efficient but expensive technology causes a delay in C_{AC}. This problem can be categorized as a gap of the second type, insufficient C_{AC}.

Introduction of more energy-efficient technology like photovoltaic electricity and hybrid vehicles promises to reduce both users' and society's LCE and LCC. However, energy-efficient products are sometimes more expensive than conventional ones which hinders their diffusion. This problem is represented in the CLD as shown in Fig. 34.3; adoption of energy-efficient technology may increase the initial cost (price) for users (causal link (iii) in Fig. 34.3) although it may reduce the LCE and LCC for society (two pairs of causal links: (x) and (xii) and (i) and (ii) in Fig. 34.3). Thus, UV in the case is cost reduction, and the delay in C_{AC} (causal links (i) and (ii)), which causes the delay in C_{AV}(causal links (i), (ii), and (vi)), is the gap to overcome. In ESCO business, the business provides energy-saving service based on a long-term performance contract so that the user need not invest in necessary equipment at the beginning, thus overcoming the delay in C_{AC} (and C_{AV}) as summarized in the fourth row in Table 34.1. This means that ESCO satisfies the requirements for eco-business but not for IEB in terms of C_{EP} and L_{AEP}.

Figure 34.4 depicts the green electricity certification business (Green Power Certification Council 2001). As shown in this figure and the fifth and the sixth rows of Table 34.1, this business solves the problem: insufficient C_{EP}.

Green electricity generated by hydro and wind turbine has a potential to reduce LCE of society. UV of the business is improvement of environmental image of users from society, by using environmentally conscious electricity. However, its power generation cost is more expensive than those of conventional ones, and this hinders the diffusion of green electricity (L_{ACP}, which includes business activity,

Table 34.2 Examples from a cause-effect pattern library

	Sustainable business case	Explanation of solution pattern	The gaps overcome
Gaps between ISB conditions and conventional business	Car sharing, household rental for students, etc.	Product sharing (lease, rental, product pooling) can reduce the production volume over the whole society by improving the utilization rate of under-utilized products	C_{AE} and C_{AC}
	Proper treatment of EOL products that contain hazardous materials (e.g., fluorescent lamps)	Proper management and control of product life cycle can reduce societal LCE and LCC	C_{AE}
	ESCO, air conditioner with heat pump, etc.	Improvement of environmental performance of products and services can reduce societal LCE and LCC	C_{AE} and C_{AC}
	Reuse of toner cartridges, etc.	Reutilization of waste materials and energy can reduce societal LCE and LCC	C_{AE}
	Eco-drive training service for automobiles, etc.	Consultation and receipt of advice on proper product usage can reduce societal LCE and LCC	C_{AE} and C_{AC}
	Zero emission factory, etc.	Cooperation among different business sectors can sometimes contribute to societal reduction of LCE and LCC	C_{AE}, C_{AC}, and C_{CP}
	Carbon tax, etc.	Proper legislation, taxation, and subsidy can increase the profit from the reduction in societal LCE and LCC	C_{EP}
	Green power certification business, etc.	Enlargement of the green market size is effective for strengthening C_{EP}	C_{EP}
	Carbon offset products, selling automobiles with maintenance contracts, etc.	Proper combination of various user value (improvement of service quality, cost reduction, improvement of image, and avoidance of risks) can make the overall causalities of the business into a reinforcing loop	L_{all}

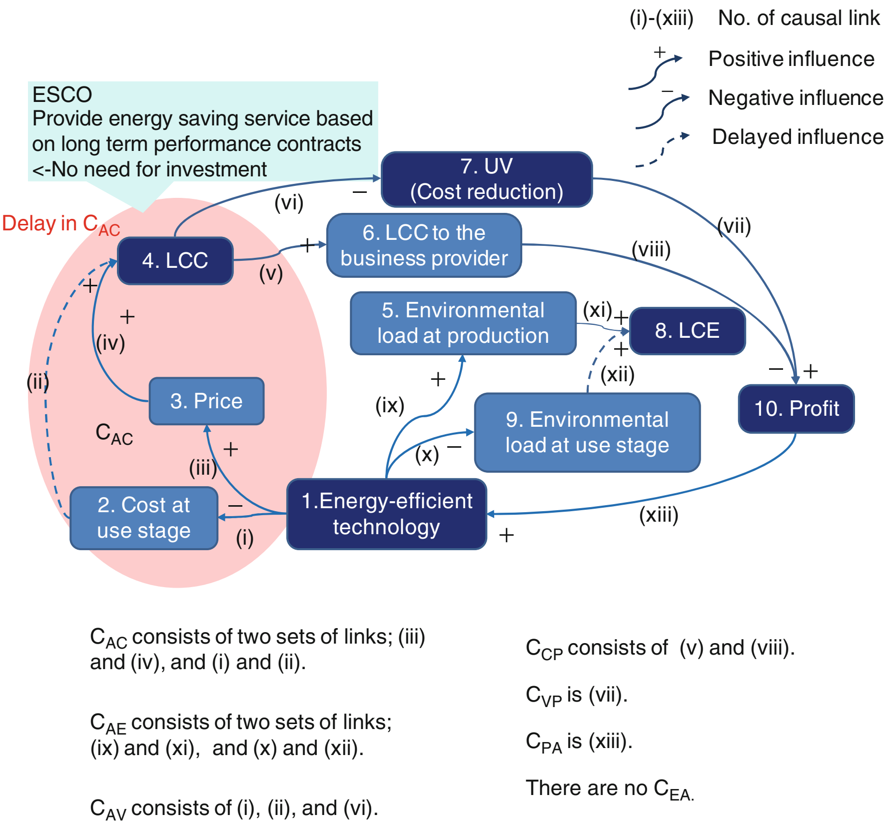
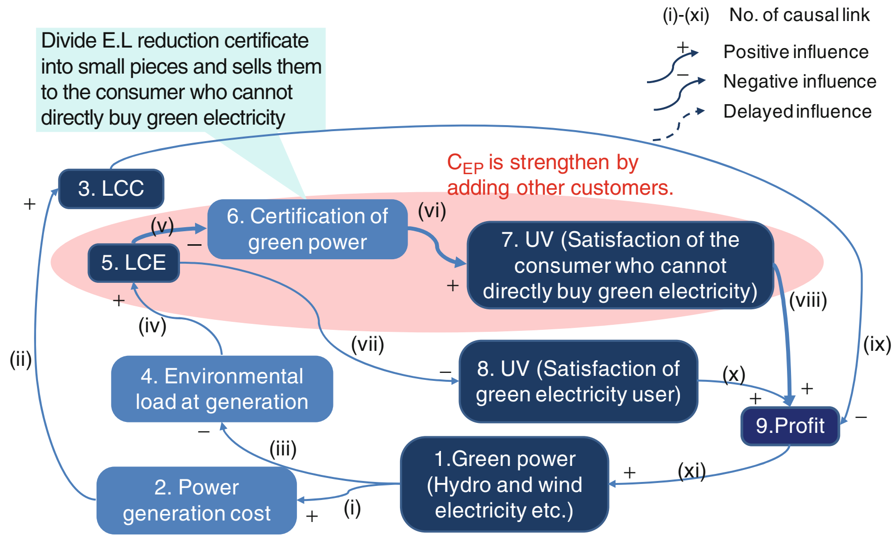


Fig. 34.3 CLD of ESCO business (Modified from Kondoh and Mishima (2011))

LCC, and profit, is balancing loop). Although some users prefer green electricity and are willing to pay more money for it, the volume of the users is insufficient to compensate the increase in the power generation cost because only limited users who live near from the plant can buy the green electricity. The C_{EP} (causal links; (vii) and (x)) is not strong enough to introduce green electricity. To solve this problem, green electricity certificates organization, which is a different organization from the power company, calculates the LCE reduction potential, divides LCE reduction certificate into small pieces, and sells them to the other people and companies who are willing to do something good for environment (causal links: (v), (vi), and (viii)). The revenue is used to compensate the cost for green electricity. By that way, C_{EP} is strengthened in this example. This means that green electricity certification business satisfies the requirements for eco-business but not for IEB in terms of C_{AC} and L_{ACP}.



C_{AC} consists of (i) and (ii).

C_{AE} consists of (iii) and (iv).

C_{AV} consists of two sets of causal links; (iii), (iv), and (vii), and (iii), (iv), (v), and (vi).

C_{EP} consists of two sets of causal links; (vii) and (x), and (v), (vi), and (viii).

C_{CP} is (ix)

C_{VP} are (viii) and (x)

C_{PA} is (xi)

Fig. 34.4 CLD of green power certification business (Modified from Kondoh and Mishima (2011))

3.4 Eco-Business Design and Communication Procedure

The procedure by which the cause-effect pattern library is used to design eco-businesses and to communicate the design with pertinent stakeholders is summarized as follows:

- Step 1: Identification of current business environment
  First, the business designer identifies a set of key parameters that describe the given business environment in terms of UV, LCE, LCC, and profit, with causality among these parameters and describes the situation using a CLD, so that he/she can decide the types of causality among the seven causal links and identify the gaps between the conditions necessary for an IEB and his/her business environment.

- Step 2: Idea generation for an eco-business
  The next step is to generate the ideas that overcome the gaps identified in step 1. By referring to the cause-effect pattern library, which is structured based on the gaps, as discussed in Sect. 3.3, a designer can easily find adequate solution patterns for his/her problems. Note that the similarity of the case is evaluated focusing on the gaps rather than those of target products themselves. By this way, the library can provide a wide variety of the cases over multiple business sectors.
- Step 3: Validation of CLD through communication with stakeholders
  Since the business model developed in step 2 may contain a variety of technological, economical, and social causalities, its validity and feasibility should be evaluated through discussion with multiple experts in various fields. In addition, in order to implement the business model, negotiation among all the business' stakeholders is indispensable. Thus, the model should be simplified for this purpose after evaluating its validity and feasibility.
- Step 4: Assessment of business ideas
  After evaluating the CLD of the business model, the performance of the business should finally be assessed. In order to calculate the LCE, LCC, and profit of the business, the CLD of the business model should be interpreted as a life cycle model (LCM) for its products, defining all material and energy flows related to them. Based on the LCM, the LCE and LCC of the products are calculated by using conventional life cycle assessment (LCA) and life cycle costing (LCC) methods. Chapter ▶Product LCA and PCF describes how to calculate LCE based on LCA methods.

4 Case Study: *EcoFleet*

In order to illustrate how to use the library to come up with eco-business ideas (steps 1 and 2 in Sect. 3.4), this section presents a case study of an energy-efficient vehicles business (*EcoFleet*). First, the designer identifies his/her customers, their user value, and causal links among business activities, UV, LCE, LCC, and profit as shown in the upper part of Fig. 34.5. Although energy-efficient vehicles such as electric vehicles and hybrids have the possibility to reduce LCE and LCC in many cases, they are more expensive than conventional vehicles. In addition, there are no negative causal link between LCE and profit; environmental load reduction itself makes no profit at all. Thus, the gaps to overcome in this case are insufficient C_{AC} and insufficient C_{EP}. Referring to the cause-effect pattern library, the designer finds two cases (ESCO businesses and a green power certification business) that overcome these respective gaps. The business idea they arrive at by applying the solution patterns from the successful businesses to this case is summarized as shown in the lower part of Fig. 34.5.

The "EcoFleet" business provides a fleet management service to carriers based on a long-term performance contract similar to those used by ESCO businesses. First, EcoFleet determines the best mix of multiple types of vehicles based on the

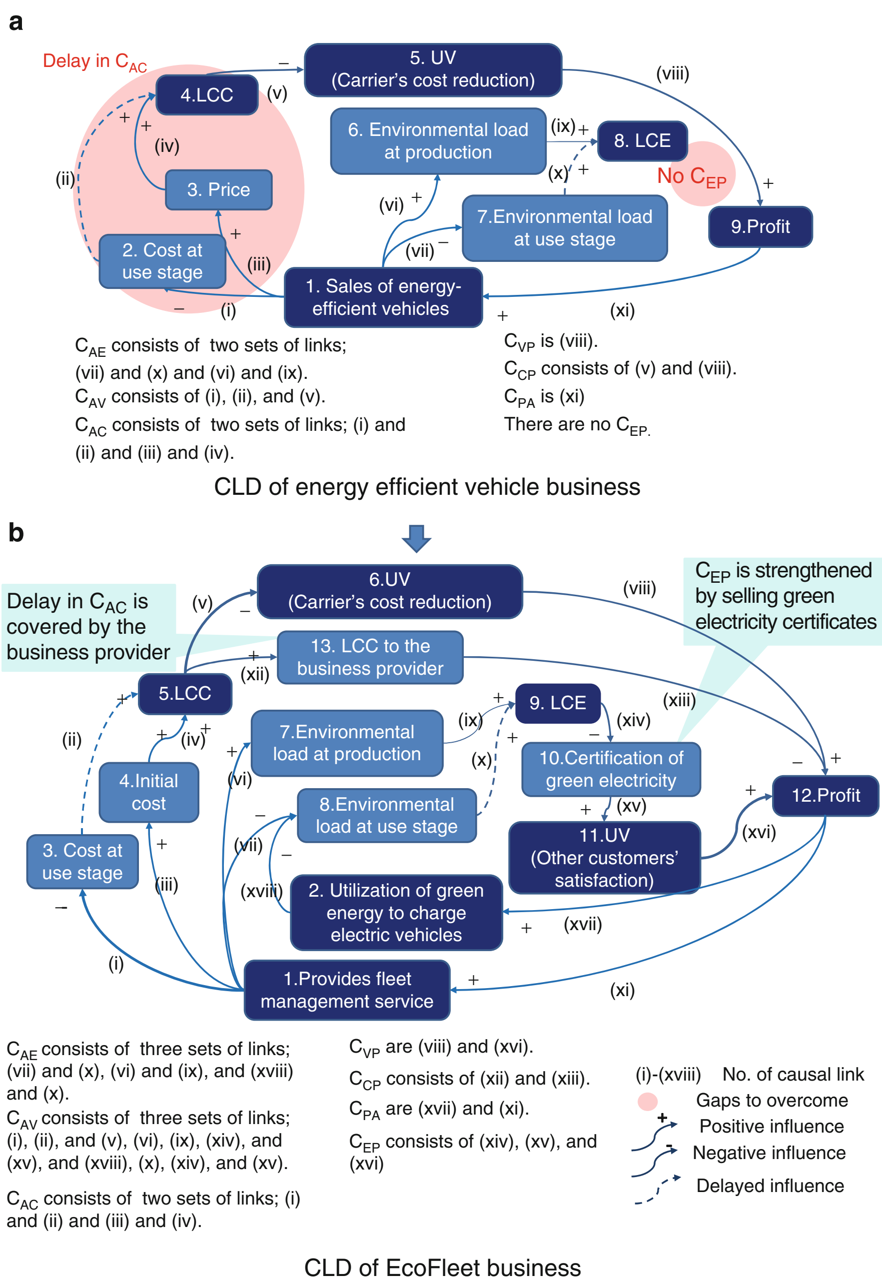


Fig. 34.5 CLD of EcoFleet business (**a**) CLD of energy efficient vehicle business (**b**) CLD of EcoFleet business (Modified from Kondoh and Mishima (2011))

customer's fleet usage pattern and replaces some of them with electric vehicles and plug-in hybrid vehicles to reduce the fleet's gasoline consumption. The investment required for replacement is covered by reduced gasoline consumption, and there is no need for initial investment by the customer. In addition, to enhance the profit from the reduction of environmental load, green electricity such as solar or wind power is used to charge the batteries of electric and plug-in hybrid vehicles. Selling green electricity certificates to the people or companies who are willing to do something good for environment increases the profit that can be earned from the environmental impact reduction.

5 Architecuture of the Eco-business Design Support System

To support a case-based design of eco-businesses, it is considered effective to implement the design method as a software system. Figure 34.6 shows the architecture of the system. The system consists of three sub modules, namely, CLD editor (CLDE), life cycle modeler (LCM), and eco-business evaluator (EBE). CLDE is the module that directly supports the design flow described in Sect. 3.4.

CLDE provides a designer with a CLD template of eco-business, which includes seven causal links among business activity, LCE, LCC, and profit, and the designer

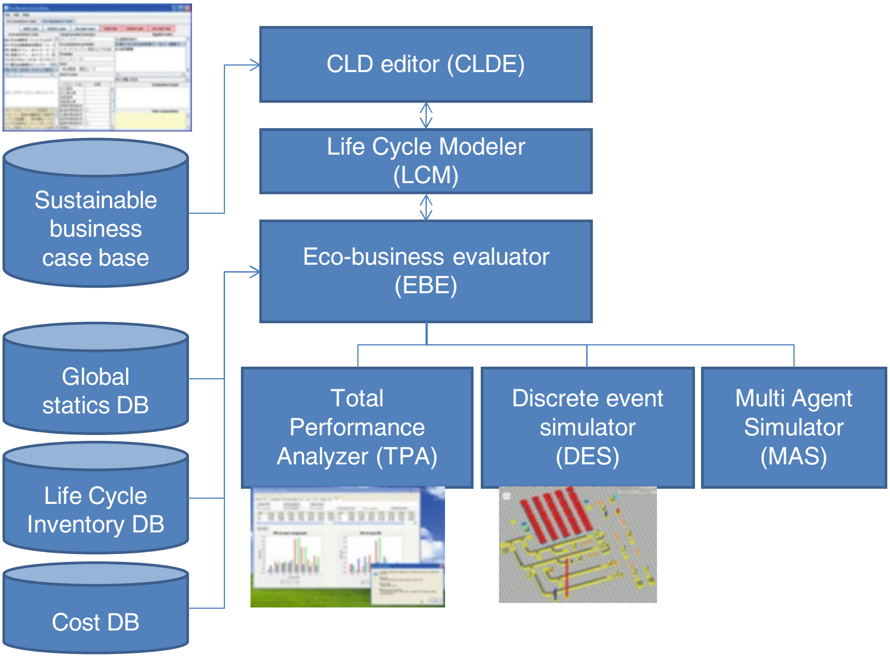


Fig. 34.6 Architecture of the case-based design support system for eco-businesses (Modified from Kondoh and Mishima (2011))

can modify the template so that the modified template can represent the environment of the eco-business designed by the designer. The designer uses the modified template in order to identify the gaps between IEB and the business environment. The gaps are then used to identify a set of eco-business cases that can potentially overcome them. The designer generates an idea of eco-business referring to the identified eco-business cases and describes it in the form of a CLD. On LCM, the designer models the eco-business in terms of activities defined in the life cycle of products, which are used in the business. The model on LCM also includes material, energy, and monetary flows caused by these activities. The model on LCM helps the designer interpret the corresponding CLD from the perspective of life cycles of products included in the business. EBE helps the designer evaluate the environmental and economic performance of the eco-business modeled on LCM. To provide such an evaluation feature, EBE includes three different tools, the total performance analyzer (TPA) (Kondoh et al. 2008), a discrete event simulator (DES), and a multi agent simulator (MAS). TPA, which has been developed by authors group, is used for the evaluation of environmental and economic performance of the business modeled on LCM. TPA provides the quantitative evaluation methods of UV based on the multi-attribute utility theory (MAUT) as well as the LCE and LCC based on the static life cycle of products. DES imports the activities defined on LCM and simulates the dynamics of the business in terms of energy, material, and monetary flows among the stakeholders. Chapter ▶Life Cycle Simulation for Sustainable Product Service Systems illustrates how to use DES for this purpose. MAS is used to detail the interactions of stakeholders during the life cycle of products. For example, the literature (Kondoh et al. 2009) represented the variations in the preference for and purchasing behavior of personal computers and investigated the environmentally and economically feasible reuse strategy for each individual user considering the interaction among them, by using MAS. EBE is also connected to a set of database including global statistics (e.g., gloss domestic product and population), life cycle inventory of energy and materials, and cost.

6 Summary

This chapter proposed an idea generation method for eco-business planning by using a cause-effect pattern library of existing eco-businesses. The chapter first explained a method to describe various eco-businesses with CLD and structured the eco-business library focusing on the gaps between the conditions of IEB and conventional businesses. Then, the chapter explained a procedure to generate eco-business with the library and discussed the architecture of a software system, on which the procedure is implemented. Future development includes the following topics:

- Collection and analysis of existing cases:

  Collection and analysis of various exiting cases are required to build a useful library. Environmental (or sustainability) reports of the businesses in various industrial sectors can become also sources for the library. In addition to the business cases, macro level causality patterns (e.g., market reaction to the environmental legislation or taxation and causal description of rebound effect) are also indispensable for the method.

- Structuring the library in more detail:

  As the number of the cases increases in the library, screening out the adequate cases from the library becomes more crucial. To this end, more detailed structuring is indispensable. It will be quite promising to identify the key elements of problem-solution patterns such that most of the successful cases are explained as their combination.
- Implementation of the system:

  Implementation of the system is also included in the future work of this study. In addition to TPA, eco-business case base, and MAS, which have already been partially implemented, CLDE and LCM should be implemented and integrated into the overall framework of the proposed system.

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