How does eco-innovation affect sustainable business model change? Case studies on green energy projects[1]

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Abstract

Purpose of the paper: *The study analyzes how eco-innovations implemented by companies may change sustainable business models by affecting their economic performance.*

Methodology*: The paper is based on a case study of Enel, a multinational utility sector company, and refers to three innovative green energy projects.*

Results*: The analysis shows that the adoption of eco-innovative projects in sustainable energy affects sustainable business models. The main changes are related to customer sensing, value proposition, and the business model's value chain and linkages components. The new value proposition usually consists of the green and sustainable value offered through the eco-innovation projects that determine novelties in the sustainable value proposed by the company. Innovations that affect the business model's value chain and linkages components are mainly related to new relationships with partners and new competencies developed within Enel.*

Research limits: *The cases refer to just one company.*

Practical implications: *The study provides useful insights for companies and practitioners to understand whether and how the adoption of eco-innovation by companies changes their sustainable business models and how such aspects may affect the economic performance of companies.*

The originality of the paper: *This paper clarifies the relationships between innovative green projects and sustainable business model innovation by considering the different business models' dimensions, which allows for a detailed analysis of their components. At the same time, the paper explores the effects of sustainable business model innovation on the company's performance.*

Key words: sustainable business model; business model change; eco-innovation; green energy projects

1. Introduction

Eco-innovations are defined as the '*introduction of any new or significantly improved product (good or service), process, organizational*

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change or marketing solution that reduces the use of natural resources and decreases the release of harmful substances across the whole-life cycle' (Eco-Innovation Observatory, 2011).

Extensive empirical evidence shows that eco-innovation improves a firm's environmental performance (Costantini *et al.*, 2017; Singh *et al.*, 2020). One of the most critical issues is the limited diffusion or adoption of eco-innovation by companies. Companies are unsure as to exactly how eco-innovation adoption may also increase their economic performance (Ch'ng *et al.*, 2021).

This paper explores the effects of adopting eco-innovations on business model innovation (hereafter BMI). The aim is to understand whether and how eco-innovation implementation positively impacts business performance. Although the literature on traditional innovation has identified multiple constraints to BMI, yet studies on BMI affected by the adoption of eco-innovation are quite limited.

We investigated the phases in which eco-innovation projects are adopted by firms; particularly how and why changing the BM can help firms to accommodate the challenges of eco-innovation adoption and, in turn, to improve their economic performance. We investigated three business cases regarding a more sustainable use of energy related to Enel Group, a company in the energy utility sector.

2. Theoretical background

2.1 Business model and business model change

BM comprises customer sensing, customer engagement, value delivery, and monetization. These components reveal the causal links between value creation and value capture at a company level (Baden-Fuller and Mangematin, 2013; Zott *et al.*, 2011). The BM is a tool that analyses and describes how firms operate and suggests how they could innovate and increase their performance at a business level (Teece, 2010).

The concept of BMI is very popular in the literature. BMI is a process that changes the central elements of an organization and its business logic (Bucherer *et al.*, 2012). BMI, also defined as BM change, entails modifying the firm's activity systems (Shakeel *et al.*, 2020). Given that companies, are continuously adapting, changing, redefining their strategies and actions that affect their traditional BMs (Geissdoerfer *et al.*, 2018), BMI may lead to radical or incremental modifications of existing BMs to adapt to change and innovation. When adopting new technologies or ideas, it is not easy for companies to change their BMs (Chesbrough, 2007), and uncertainty linked to multiple aspects plays a key role. Studies on BMI linked to traditional innovation (i.e., not eco-innovation) identified some constraints or barriers linked to the changes in existing BMs; for example, managerial cognitive bias plays a key role in preventing BMI in new technologies or adopting new ideas (Chesbrough, 2010; Tripsas and Gavetti, 2000).

This study contributes to the literature on BMI related to a specific typology of technologies or ideas known as eco-innovation. Eco-innovation

could address some environmental and social needs for all society. This study aims to understand, as in the case of traditional innovations, the effects on BMI that may arise due to the adoption of eco-innovation and any limits or constraints to changing BM components. Specifically, we explore how different BM components have been redesigned or how novel BMs take form when companies implement new eco-innovation.

Moreover, as in sustainable business, uncertainty linked to the return of investments in green innovations is more significant than in traditional innovation (Gauthier and Wooldridge, 2012; Ozaki, 2011). This paper aims to adopt a BM perspective to understand whether and how BM change affected by the adoption of eco-innovation can positively influence the economic performance at the business level.

2.2 Business model for sustainability

There is a recent and growing literature on BMs for sustainability (De Giacomo and Bleischwitz, 2020), some of which have focused on BMI in terms of environmental sustainability (e.g., Sun *et al.*, 2021; Ferlito and Faraci, 2022). Others have explored the effects of BMI on organizational sustainability (Carayannis *et al.*, 2015; Pedersen *et al.*, 2018), for example focusing on ways firms introduce BM change (Brennan and Tennant, 2018; Rajala *et al.*, 2016). Other scholars dealt with BMI for sustainability shift (e.g., Long *et al.*, 2018; Schaltegger *et al.*, 2016); with the attention of factors determining the changes (Ritala *et al.*, 2018).

Multiple dimensions of BM (Baden-Fuller and Mangematin, 2013) can be changed due to eco-innovation, such as customer sensing, customer engagement, value delivery, and monetization. Our paper aims to advance knowledge on BM for sustainability by exploring how introducing a new eco-innovation affects all the key multiple BM dimensions recognized by the mainstream literature. In this sense, this study offers a comprehensive analysis of all the relevant BM components that may be changed after adopting green energy projects.

The *customer sensing* component of a BM is related to identifying targeted users and customer groups (Baden-Fuller and Mangematim, 2013). This component identifies whether users pay for the eco-services and goods offered by the companies or whether other customers pay. Customer sensing also refers to sustainable needs, and requests from the customers/market.

Customer engagement, also known as the customer value, identifies the value proposition from a customer perspective. Value proposition refers to the embedded value in sustainable products and services. This component comprises eco-innovative offers.

The *chain and linkages* concern value delivery and include all the company's means to deliver and offer its sustainable products and services to customers (Amit and Zott, 2001; Casadesus-Masanell and Ricart, 2010). This component aims to clarify how interrelationships with suppliers and other partners are managed.

Monetization identifies how organizations exploit the value they create. This dimension is a key part of the value capture. It refers to aspects related

to timings and methods of payments and collecting revenues. It includes how revenues are gathered and costs are produced.

3. Methods and data

To understand how adopting eco-innovation positively impacts a firm's economic performance we explored the effects of various eco-innovation projects adoption on the BM's components of Enel, a multinational company in the energy utility sector. Enel is very active in environmental sustainability and renewable energy.

Specifically, we carried out a case study on different business units that adopted three different eco-innovation projects. The three cases focused on innovative projects in sustainable energy to reveal how changing the BM affects the economic returns of eco-innovation for the company.

The empirical part of the study was based on an inductive case-study method. This form of empirical inquiry is particularly suited for investigating processual issues and revealing new theoretical relationships (Yin, 2009). We executed a case study research design of multiple eco-innovation adoption processes. We adopted a purposive sampling strategy (Patton, 1990), consisting of selecting cases based on observable features that affect the relationship/problem/outcome under investigation.

Specifically, eco-innovation episodes were chosen to get variance regarding BM dynamics by following a multi-stage screening procedure (Su *et al.*, 2014). First, we approached several business units of Enel to see if they would participate in the study. Second, we selected different kinds of eco-innovation projects for three cases. In fact the projects had already finished and qualitative data were already available.

Interviews were carried out with managers at different levels of the organization that had been involved under different capacities in implementing the eco-innovations. This helped us to get the most accurate and rich representation of the process under investigation. Specifically, semi-structured interviews, made through phone and web calls and face-to-face, were carried out between July to December 2019. The authors designed an interview protocol to investigate whether and how each eco-innovative project had changed the company's BM. Questions were included with reference to each of the investigated four BM dimensions.

Before the interviews, the protocol was tested through some pilot interviews (Bowles *et al.*, 2019) with respondents who were not part of the organization. These pilot interviews verified the level of comprehension of the questions and helped us to methodologically define the protocol (Bruning and Campion, 2018).

Each interview lasted between 30 and 60 minutes. The interviews were recorded and transcribed to analyze in depth their content. In addition, the interviews were triangulated by collecting and analyzing data from multiple sources in order to increase the quality of empirical inference and triangulate/cross-check primary and secondary source data.

Archival data were collected (Yin, 2009) for the three cases, including minutes of meetings, emails dealing with decision-making processes

affecting BMs and their components, annual reports, financial reports, other internal documents and reports, and press releases. These kinds of data concerned multiple aspects linked to the eco-innovative projects of the company and revealed the main aspects related to the BM changes.

The data analysis, based on transcriptions of the interviews and the other collected information from multiple documents, highlighted the main dimensions of the BMs affected by the adoption of eco-innovative projects. Specifically, the four components identified by extant literature as being the principal dimensions of a BM were considered: customer sensing, customer engagement, value delivery, and monetization (Baden-Fuller and Mangematin, 2013; Aversa *et al.*, 2015).

4. Results

The effects and changes on the BM's components are described for each eco-innovative case. The impacts of the BM change are then discussed with reference to Enel's economic performance.

4.1 Eco-innovation Project 1 - Geothermal Gas Abatement System

4.1.1 Customer sensing

Geothermal resources generate clean and renewable energy. The electricity produced based on geothermal resources is more environmentally favorable than traditional energy based on the combustion of fossil fuels. However, geothermal energy production involves gas emissions (Padilla, 2007).

The relationship between geothermal plants and the conservation of some key resources of the local areas where plants are located, for example, tourism or agriculture, is a central aspect of the level of sustainability of geothermal energy. Good geothermal development is thus strictly based on the acceptability of local communities (Baldacci *et al.*, 2005). To maintain the environmental quality of the areas where communities live, power plants need to be integrated into the landscape, gas emissions and cooling tower drift need to be reduced and noise minimized.

Geothermal plants in Italy are mainly in small areas, with a strong historical and cultural heritage, a beautiful natural environment, and tourism. The main issue of geothermal plants is air emissions of hydrogen sulfide and mercury. There was a need to address the environmental impacts generated from the plants, especially in the local areas. These needs led to the eco-innovation implementation by the company.

With regard to our case studies, given that power plants in Italy have specific characteristics, as they are usually small and unattended with a high content of non-condensable gases, the abatement technologies available on the market were not applicable and implied high costs. Enel thus developed an eco-innovative process to reduce emissions of geothermal plants. Specifically, the firm patented a new eco-innovative technology for the reduction of atmospheric pollutants from geothermal plants.

4.1.2 Customer engagement

Enel developed and patented an eco-innovative technology to reduce hydrogen sulfide and mercury emissions, which was based on the characteristics of geothermal power plants in Italy (Sabatelli *et al.*, 2009). Hydrogen sulfide causes bad smells in the areas where geothermal plants are located. The newly developed eco-innovation enabled a more sustainable and green process as it does not use chemicals and does not generate sulfur-based by-products to be disposed of or recycled (Baldacci *et al.*, 2005).

The other main issues of geothermal plants are the drift from wet cooling towers (salts, boric acid), noise from the machinery and cooling towers, and the visual impact of the plants on the landscape. Before the implementation of the eco-innovation, Enel did some preliminary technical studies. Laboratory tests on mercury sorbents and catalysts for hydrogen sulfide oxidation were then carried out, and a pilot plant using a side stream of a geothermal power plant was then used to demonstrate the feasibility of the process.

The patented eco-innovative technology is based on three main phases:

1. Removal of mercury through chemical absorption
2. Selective catalytic oxidation of hydrogen sulfide to sulfur dioxide
3. Sulfur dioxide scrubbing by a side stream of cooling water

4.1.3 Chain and linkages

To develop the eco-innovative technology, the interviewee said "E*nel has developed new contacts with different kinds of partners. For example, Enel worked with suppliers of products or with maintenance or cleaning services companies*".

Enel, that patented the eco-innovative technology also adopted new internal competencies that did not have before. *"Many training activities have been carried out within Enel*" to support the development of new knowledge required by the project among employees.

The adoption of the new eco-innovation led changes in the Enel company's BM that established "*new relationships with partners, new knowledge, and skills*", according to the interviewee.

4.1.4 Monetization component

Enel sustained the cost of the investment of the patented eco-technology. Enel had several contracts with multiple partners/suppliers involved in the value offer coming from the eco-technology adoption. Contracts were usually based on periodical payments for ordinary services and specific payments for tailored services offered by partners. Contracts usually had a duration of two years.

The return of investment required a long payback time. Since the first pilot version of the eco-innovation project is dated, and then other plants have been improved with the new technology, *"it has not been easy to quantify the entire direct economic returns of the eco-investment*", said

Enel. However, there are also some indirect economic effects from the eco-innovation resulting from the company's positive image and reputation gained, and the better environmental performance perceived by the community where plants were located.

4.1.5 The effect of the eco-innovation project on Enel's performance

The implementation of the eco-innovation led to some changes in Enel's BM that positively affected the company's performance. There was an improvement of the plant efficiencies in terms of mercury removal and H2S abatement in the NCG (Non-condensable gas) steam, which are over 90% and 99+%, respectively. Multiple benefits generated for satellite activities and for the local communities, thanks to the new sustainable and green value proposition, as eco-innovation has proven to be an effective and reliable abatement technology (Sabatelli *et al.*, 2009). The eco-technology affected the BM by adding new knowledge and competencies likely leading to more efficiency in the company.

Enel's performance has achieved positive effects from the development of the technology; however, they are difficult quantify.

Firstly, many positive effects were indirect. Moreover, the eco-innovative project was first in just one plant and then in other new plants over a time period that makes it difficult to quantify exactly all the effects generated on the company's performance.

Secondly, other benefits derived from the positive image and reputation that the company gained from the local community. The innovative eco-technology meant that the geothermal plants performed better environmentally (fewer gas emissions and less smell from hydrogen sulfide), thus raising the environmental quality of the areas where the plants were located (Baldacci *et al.*, 2005).

These aspects may also have had an indirect impact on the business performance. Thanks to the innovative technology that they patented, Enel's competitive edge heightened their financial performance

4.2 Eco-innovation Project 2 - New technologies for the treatment of cooling towers.

4.2.1 Customer sensing

The cooling waters of thermal energy plants need to be controlled to avoid scaling or fouling the system and the condenser. The cooling circuit of the power plant of the case study is composed of a natural-draft cooling tower. Enel set up an eco-innovative pilot project to address some operation and maintenance main issues inside a thermal energy power plant and specifically to improve heat exchange efficiency and reduce the environmental impact of the process, through the:

- Minimization of water consumption
- Minimization of chemical products
- Use of innovative products with low environmental impact
- Protection from scaling and corrosion

- Microbiological protection of the circuit
- Automation of the treatment and performance monitoring

Various sustainable needs were behind the eco-innovative project. "*The first is linked to the request to reduce water consumption*", said Enel. Moreover, "*another aspect is related to some critical issues due to the fouling of the cooling circuit*". The latter aspect lowered the plant's performance and efficiency. In addition, another need was the request to reduce the efforts of plant operators.

The eco-innovation consists of a plant installation owned by Enel. For this reason, consumers cannot be directly identified. Citizens have a sustainable benefit, as the eco-innovation allowed minimization of water consumption in the plant and, therefore, the local community have more water availability.

4.2.2 Customer engagement

The pilot phase of eco-innovative project consisted of:

a. Chemical treatment for pH monitoring.

This activity is based on using specific products to control the pH and the microbiological fouling, make a scaling minimization and reduce corrosion, and reduce the addition of chemicals.

b. Management and control system.

This activity enables the management and automation of the treatment and the performance monitoring linked to the applied treatment.

There was the minimization of water consumption since the treatment adopted in the pilot project allowed the system to work at higher concentration cycles in the cooling towers. Specific data on the amount of water consumption were estimated. In terms of minimization of chemical products, "*the eco-innovative project adopted by the company reduces chemical consumption through the automation of the dosage of chemical products and the reduction in make-up water to be treated*", commented an interviewee.

The eco-innovation project related to the plant represented a significant change in the management of the cooling towers - from a model of a product purchase contract to a service contract.

4.2.3 Chain and linkages

Chain and linkages refers to Enel's mechanisms to deliver and offer a sustainable and green value proposition. It also enables us to understand whether a network of partners contributes to creating and offering sustainable value. In this case study, for example, suppliers other than Enel may be identified. This component aims to clarify how interrelationships with suppliers and other partners are managed. Specifically, in the case of this eco-innovation, Enel worked alongside an external partner that is a worldwide global leader in water treatment and improvement of the related processes. This partner is a leader in technologies and water and energy services.

Regarding the change in the BM, the eco-innovation allowed some processes to be automized thereby reducing the workload of those

managing of the thermal energy plant. Some employees thus moved to be dedicated to other operations and maintenance activities within Enel.

4.2.4 Monetization component

Enel paid a periodical fee for the service and the support offered by the supplier involved in the eco-innovation project (see the previous paragraph for details on the supplier). Moreover, in addition to the periodical fee, another item cost was linked to the purchase of chemical products. There were some fixed and variable costs paid to the supplier involved in the eco-innovation project. The allocation of the costs to be paid by Enel was the following: products (71% of the total costs), costs of the equipment (16%), and the technical assistance provided by the supplier company (13%).

The supply of all services and products was provided within one month from the signature of the contract, based on a monthly invoice that had to be paid within 60 days. The delivery of chemicals and other tools was provided after 15 and 30 days from the order date.

Regarding users of this project, consumers and private citizens did not directly pay for this eco-innovative project and offer, but it was Enel that sustained the investment costs. However, the company gained some benefits thanks to a reduction in the costs of the produced energy.

4.2.5 The effect of the eco-innovation project on Enel's performance

Several changes in the BM have been adopted due to the implementation of eco-innovation. As the project was in a pilot phase at the moment of the realization of the case study, we could not assess the exact effects of eco-innovation adoption on Enel's economic performance. However, the case study results highlighted positive estimates of the eco-innovation project on Enel's performance. Indeed, the water and chemicals savings may lead to reductions in costs and may guarantee, at the same time, an improvement in resources management in the plant. For example, Enel has carried out some estimates on the reduction of water consumption equals 510.000 mc/year. Moreover, in terms of environmental benefits, the project expects to minimize thermal pollution on river water. There is likely to be a 40%-45% reduction in chemical products consumption due to the automation and the management of the dosage of the products due to innovative technology. There are thus economic and environmental benefits for the company that implemented the eco-innovation project of the plant and environmental benefits for the citizens and the private community.

A positive impact on the economic performance may also derive from improving the plants' operation and maintenance processes with enhanced condenser cleanness and heat exchange efficiency. Moreover, the automation of some processes allowed the company to dedicate the operators (previously working to the management of the cooling towers) to other high priorities O&M activities in the company. The consequence for Enel is a more efficient use of human and natural resources and cost savings.

4.3 Eco-innovation project 3 - Hybrid solution coupling diesel engines with storage devices to improve power generation efficiency and grid stability.

4.3.1 Customer sensing

The third eco-innovation was designed to reduce the cost of electric energy linked to a plant located on an island in Italy that is not connected to the national electric distribution network. The plant is essential for the security of the electric system.

The island's local community benefited from a more sustainable plant, with noise emissions reduction.

"*The primary client of the project can be identified in the national administrative, regulatory authority for the energy networks and the environment*", said the interviewee, who has a primary role, at a national level, in guaranteeing the efficiency of public services, as energy, to users and consumers.

4.3.2 Customer engagement

This new eco-innovation aims to develop a storage system through batteries to optimize the production of a power generation plant located on an island.

The growing use of renewable energy and the traditional use of diesel adopted in the plant has determined a partial load of the plant operation. This aspect has led to an increase in costs due to the higher use of fuels and a non-efficient use of the plant. The eco-innovative project managed to overcome some limits of the system described above, through a storage system that increases the efficiency of the plant and the use of renewable energy, by also reducing noise emissions. Volume of renewable energy available cannot be planned due to its natural characteristics. Therefore, the storage system compensates for the fluctuation linked to the production of renewable energy.

In addition, eco-innovation aims to minimize the environmental impact of the generation from fossil fuels and increase the electrification of network services. The main objective of the project, consisting of installing the storage system on the island, is linked to the optimization of the generation system, the minimization of emissions and consumptions, and the guarantee of the continuity of the production service. The outcome is also to expect to increase a more incisive generation from renewable energy (e.g., photovoltaic system) and to optimize the performance of diesel motors and the energy distribution networks, both from the perspective of the environmental impact and of the cost of the produced energy, by generating benefits for the society.

The project involved a shared value creation approach (Porter and Kramer, 2019) by engaging with local companies to work on the plant.

4.3.3 Chain and linkages

Chain and linkages dimension of the BM enables us to appreciate the company's mechanisms to deliver and offer eco-innovation.

Thanks to the project, "*Enel had developed specific and new competencies in terms of the storage area which employees had to learn specifically for the project*". Before the project, indeed, the storage topic was seen as being interesting and with some potential for Enel, but not as a business line with economic opportunities. "*After the implementation of the eco-innovation project, Enel had developed strong know-how on these novel eco-technologies*", said the company. Thanks to the project, the company has started to think that the storage area could be a business for the entire company and for multiple energy sites. New working groups in Enel have been set up to explore new business opportunities in this new area. "*A new awareness has been created within the company about the business potential of storage activities*".

Enel's top management level has been involved in strategic decisional processes aiming to define new areas to apply the storage. Business and functional units have been re-organized to include new competencies, and activities related to storage. The innovation has thus allowed Enel to deeply change the company's BM, as, until that moment, there was not a unit within the company dedicated to storage. Enel has collaborated with several partners for the realization and offer of the eco-innovative project.

4.3.4 Monetization component

Enel has sustained the investment costs of the eco-innovation, but has required to the national administrative, regulatory authority for the energy networks and the environment a reintegration of the expenses on a multiyear basis (n. 15 years). Indeed, a national norm provides that it is possible for organizations having essential plants for the security of the electrical system to ask for a reintegration of the costs sustained for investments carried out in those plants.

4.3.5 The effect of the eco-innovation project on Enel performance

Before the realization of the eco-innovative project, some estimations on the potential benefits were made. For example, the main estimated benefit consisted in more efficient use of diesel generators and thus minimization of the use of fuels, as well as reduced maintenance and an extension of the life cycle of motors, due to an improvement in the performance of diesel motors. After the implementation of the eco-innovation, the company recognized some additional benefits with respect to those originally estimated.

Some results include the minimization of generation costs. The outcome has been an improved efficiency of the electric system of the island. The analysis of the estimated benefits of the project has resulted in a specific amount of fuel savings with consequent costs. These aspects enable us to conclude that the eco-innovation project has been determined some changes in the BM and a positive impact on the company's performance.

Solutions developed and adopted through the eco-innovative project are valuable for small islands and isolated/disconnected small grids that may use batteries to improve service quality with unstable load curves

and high renewable presence. All these aspects, potentially, may generate positive impacts on the economic performance at a company level.

5. Discussion and conclusions

This paper has explored whether and how the implementation of eco-innovation by companies affects their BMI. The study sheds light on the relationships between green projects and sustainable BMI by also considering the company's performance.

Theoretical contribution

The paper contributes to the emerging literature on sustainable BMI (Yang *et al.*, 2017; Sinkovics *et al.*, 2021) and on sustainable BM and performance (Evans *et al.*, 2017) by showing that the adoption of eco-innovation affects various BM components. Eco-innovation aims to respond to specific societal needs in addition to corporate objectives. For example, having a higher quality of the natural environment in local areas is a need that an eco-innovative project may address. Based on our findings, we argue that the top management team will be more prone to change their BM due to the adoption of eco-innovation. This can be explained as when companies adopt technologies or innovations to reply to specific societal needs (as eco-innovations do), the cognitive bias of the top management team identified by a part of the literature on BMI and mainly linked to traditional innovation may be limited and less extended. In other words, the business modeling activity (Baden-Fuller and Morgan 2010) that may determine a BMI can be easier in the case of eco-innovation, which is a kind of innovation aimed to satisfy specific needs. Eco-innovation thus represents a distinctive kind of innovation, technology, or idea as its social purpose is more evident with respect to traditional innovation. This paper shows that when technologies or ideas are clearly connected to social or environmental needs, the changes on BM are easier to implement for the organization with respect to BMI due to traditional innovations.

Managerial implications

The study also provides useful insights for companies and practitioners to understand whether and how the adoption of eco-innovation may change BMs or some of their components and how such aspects may affect the economic performance of companies.

The main BM changes are related to customer sensing, value proposition, and the BM's value chain and linkages components. In our case study, the innovations that affect the BM's value chain and linkage components are mainly related to new relationships and collaborations between Enel and other partners. They are also related to the new knowledge and competencies required by the eco-innovation developed within the company. Companies may take the opportunities offered by the adoption of eco-innovation to improve their competencies and acquire new skills.

The results also suggest that the adoption of eco-innovation and the BMI positively impacts the company's economic performance. Moreover, indirect aspects seem to benefit the company's performance, such as the reputation gained, the positive image that the local community has of the company, and some environmental and competitive advantages that derive from eco-innovation projects.

The cases also showed that it is not always straightforward to establish to what extent the adoption of eco-innovation (and the related BM change) increases the economic performance at a company level. This aspect is particularly evident in more recent eco-innovation projects, where the impacts on the performance only become clear in subsequent years, or older projects where it is not possible to quantify exactly all the economic impacts generated directly from the project.

Understanding how firms may create and offer sustainable and green value by exploiting it may stimulate the adoption of sustainable innovations at a firm level by meeting the main objectives of the green policies at national and European levels. Moreover, through a deeper comprehension of BM's aspects and components, firms may learn to recognize the opportunities they can achieve by adopting green strategies and innovations (De Giacomo and Bleischwitz, 2020).

Some limitations of the study refer to the fact that cases refer to a single company. Future studies could investigate eco-innovative projects of different companies by comparing the effects of their eco-innovation adoption on the BM change and the company's economic performance.

References

AMIT R., ZOTT C. (2001) "Value Creation in E-Business", *Strategic Management Journal*, vol. 22, n. 6-7, pp. 493-520.

AAMIT R., ZOTT C. (2010), *Business model innovation: Creating value in times of change,* IESE Business School of Navarra, Barcelona (2010), IESE Working Paper, No. WP-870

AVERSA P., HAEFLIGER S., ROSSI A., BADEN-FULLER C. (2015), "From business model to business modelling: Modularity and manipulation", In *Business models and modelling*, Emerald Group Publishing Limited.

BADEN-FULLER C., MANGEMATIN V. (2013), "Business models: A challenging agenda", *Strategic Organization,* vol. 11, n. 4, pp. 418-427.

BADEN-FULLER C., MORGAN M.S. (2010), "Business models as models", *Long Range Planning*, vol. 43, n. 2-3, pp. 156-171.

BALDACCI A., MANNARI M., SANSONE F. (2005, April), "Greening of geothermal power: an innovative technology for abatement of hydrogen sulphide and mercury emission", *Proceedings of the World Geothermal Congress,* Antalya, Turkey, vol. 2429

BIRKIN F., CASHMAN A., KOH S.C.L., LIU Z. (2009), "New sustainable business models in China", *Business Strategy and the Environment*, vol. 18, n. 1, pp. 64-77.

BOWLES H.R., THOMASON B., BEAR J.B. (2019), "Reconceptualizing what and how women negotiate for career advancement", *Academy of Management Journal*, vol. 62, n. 6, pp. 1645-1671.

BRENNAN G., TENNANT M. (2018), "Sustainable value and trade-offs: Exploring situational logics and power relations in a UK brewery's malt supply network business model", *Business Strategy and the Environment*, vol. 27, n. 5, pp. 621-630.

BRUNING P.F., CAMPION M.A. (2018), "A role-resource approach-avoidance model of job crafting: A multimethod integration and extension of job crafting theory", *Academy of Management Journal,* vol. 61, n. 2, pp. 499-522.

BUCHERER E., EISERT U., GASSMANN O. (2012), "Towards systematic business model innovation: lessons from product innovation management", *Creativity and Innovation Management,* vol. 21, n. 2, pp. 183-198.

CARAYANNIS E.G., SINDAKIS S., WALTER C. (2015), "Business model innovation as lever of organizational sustainability", *Journal of Technology Transfer,* vol. 40, n. 1, pp. 85-104

CASADESUS-MASANELL R., RICART E.J. (2010) "From Strategy to Business Models and onto Tactics", *Long Range Planning*, vol. 43, n. 2-3, pp. 195-215.

CH'NG P.C., CHEAH J., AMRAN A. (2021), "Eco-innovation practices and sustainable business performance: The moderating effect of market turbulence in the Malaysian technology industry", *Journal of Cleaner Production,* n. 283, pp. 124556.

CHESBROUGH H. (2007), "Business model innovation: it's not just about technology anymore", *Strategy and Leadership,* vol. 35, n. 6, pp. 12-17.

CHESBROUGH H. (2010), "Business model innovation: opportunities and barriers", *Long Range Planning,* vol. 43, n. 2-3, pp. 354-363.

COSTANTINI V., CRESPI F., MARIN G., PAGLIALUNGA E. (2017), "Eco-innovation, sustainable supply chains and environmental performance in European industries", *Journal of Cleaner Production*, n. 155, pp. 141-154.

DE GIACOMO M.R., BLEISCHWITZ R. (2020), "Business models for environmental sustainability: Contemporary shortcomings and some perspectives", *Business Strategy and the Environment,* vol. 29, n. 8, pp. 3352-3369.

ECCLES R.G., SERAFEIM G. (2013), "The performance frontier: Innovating for a sustainable strategy", *Harvard Business Review,* vol. 91, n. 7, pp. 17-18.

ECO-INNOVATION OBSERVATORY (2011), The eco-innovation challenge: pathways to a resource-efficient Europe. The way to a green economy through eco-innovation.

EUROPEAN COMMISSION (2017), Supporting the Evaluation of the Implementation of EMAS. Final report. Written by Daniel Weiss, Alexandra Skinner; Maeve Smyth, Monika Slupska; Walter Kahlenborn; Fabio Iraldo, Tiberio Daddi, Maria Rosa De Giacomo, Francesco Testa, Michela Melis. ISBN 978-92-79-69740-1; doi:10.2779/430892; KH-01-17-629-EN-N. Luxembourg: Publications Office of the European Union, 2017

EVANS S., VLADIMIROVA D., HOLGADO M., VAN FOSSEN K., YANG M.Y., SILVA E.A., BARLOW C.Y. (2017), "Business model innovation for sustainability: Towards a unified perspective for creation of sustainable business models", *Business Strategy and the Environment*, vol. 26, n. 5, pp. 597-608.

FERLITO R., FARACI R. (2022), "Business model innovation for sustainability: a new framework", *Innovation and Management Review,* vol. 19, n. 3, pp. 222-236.

GAUTHIER J., WOOLDRIDGE B. (2012), "Influences on sustainable innovation adoption: evidence from leadership in energy and environmental design", *Business Strategy and the Environment,* vol. 21, n. 2, pp. 98-110.

GEISSDOERFER M., VLADIMIROVA D., EVANS S. (2018), "Sustainable business model innovation: A review", *Journal of Cleaner Production,* vol. 198, pp. 401-416.

KIRON D., KRUSCHWITZ N., REEVES M., GOH E. (2013), "The benefits of sustainability-driven innovation", *Mit Sloan Management Review*, vol. 54, n. 2, pp. 69-73.

KIRON D., KRUSCHWITZ N., REEVES M., GOH E. (2013), "The benefits of sustainability-driven innovation", *Mit Sloan Management Review,* vol. 54, n. 2, pp. 69-73.

LONG T.B., LOOIJEN A., BLOK V. (2018), "Critical success factors for the transition to business models for sustainability in the food and beverage industry in the Netherlands", *Journal of Cleaner Production,* n. 175, pp. 82-95.

OSTERWALDER A., PIGNEUR Y., TUCCI C. L. (2005), "Clarifying business models: Origins, present and future of the concept", *Communications of the Association for Information Science (CAIS)*, vol. 16, pp. 1-25.

OZAKI R. (2011), "Adopting sustainable innovation: what makes consumers sign up to green electricity?", *Business Strategy and the Environment*, vol. 20, n. 1, pp. 1-17.

PADILLA E.K. (2007), "Preliminary Study on Emission Abatement and use of gas from Geothermal Power Plants in El Salvador", *Report*, n. 18, pp. 417-446.

PATTON M. (1990), *Qualitative data analysis* (2nd ed.), Sage Publications, Thousand Oaks, CA.

PEDERSEN E.R.G., GWOZDZ W., HVASS K.K. (2018), "Exploring the relationship between business model innovation, corporate sustainability, and organisational values within the fashion industry", *Journal of Business Ethics,* vol. 149, n. 2, pp. 267-284.

PORTER M.E., KRAMER M.R. (2019), "Creating shared value", In *Managing sustainable busines"s* (pp. 323-346), Springer, Dordrecht.

RAJALA R., WESTERLUND M., LAMPIKOSKI T. (2016), "Environmental sustain- ability in industrial manufacturing: Re-examining the greening of Interface's business model", *Journal of Cleaner Production,* n. 115, pp. 52-61.

RITALA P., HUOTARI P., BOCKEN N., ALBAREDA L., PUUMALAINEN K. (2018), "Sustainable business model adoption among S&P 500 firms: A longitudinal content analysis study", *Journal of Cleaner Production,* n. 170, pp. 216-226.

SABATELLI F., MANNARI M., PARRI R. (2009), "Hydrogen sulfide and mercury abatement: development and successful operation of AMIS technology", *GRC Trans.,* n. 33, pp. 343-347.

SCHALTEGGER S., LUDEKE-FREUND F., HANSEN E.G. (2016), "Business models for sustainability: A co-evolutionary analysis of sustainable entrepreneurship, innovation, and transformation", *Organization and Environment*, vol. 29, n. 3, pp. 264-289.

SHAKEEL J., MARDANI A., CHOFREH A.G., GONI F.A., KLEMEŠ J.J. (2020), "Anatomy of sustainable business model innovation", *Journal of Cleaner Production,* n. 261, pp. 121201.

SINGH S.K., DEL GIUDICE M., CHIERICI R., GRAZIANO D. (2020), "Green innovation and environmental performance: The role of green transformational leadership and green human resource management", *Technological Forecasting and Social Change,* n. 150, pp. 119762.

SINKOVICS N., GUNARATNE D., SINKOVICS R.R., MOLINA-CASTILLO F.J. (2021), "Sustainable Business Model Innovation: An Umbrella Review", *Sustainability*, vol. 13, n. 13, pp. 7266.

SU H.C., LINDERMAN K., SCHROEDER R.G., VAN DE VEN A.H. (2014), "A comparative case study of sustaining quality as a competitive advantage", *Journal of Operations Management*, vol. 32, n. 7-8, pp. 429-445.

SUN Y., GONG Y., ZHANG Y., JIA F., SHI Y. (2021), "User-driven supply chain business model innovation: The role of dynamic capabilities", *Corporate Social Responsibility and Environmental Management,* vol. 28, n. 4, pp. 1157-1170.

TEECE D.J. (2010), "Business models, business strategy and innovation", *Long Range Planning*, vol. 43, n. 2-3, pp.172-194.

TRIPSAS M., GAVETTI G. (2000), "Capabilities, cognition, and inertia: Evidence from digital imaging", *Strategic Management Journal,* vol. 21, n. 10-11, pp. 1147-1161.

VAN BOMMEL K. (2018), "Managing tensions in sustainable business models: Exploring instrumental and integrative strategies", *Journal of Cleaner Production,* n. 196, pp. 829-841.

YANG M., EVANS S., VLADIMIROVA D., RANA P. (2017), "Value uncaptured perspective for sustainable business model innovation", *Journal of Cleaner Production*, vol. 140, pp. 1794-1804.

YIN R.K. (2009), *Case study research: Design and methods* (4th ed.), Sage Publications, Thousand Oaks, CA.

ZOTT C., AMIT R., MASSA L. (2011), "The business model: Recent developments and future research", *Journal of Management,* vol. 37, n. 4, pp. 1019-1042.

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