Exploring circular activities and business models in the energy sector to answer the grand challenge

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Résumé :

It can be argued that thriving towards circular economy cannot be done without considering the inputs of energy. Energy is one of the important flows as it powers the activities of many sectors and industries. However, it is often overlooked with regard to the CE. Furthermore, reconciling the reduction in the consumption of natural resources with the economic activity of companies in the energy sector raises questions such as solving simultaneously the ecological issues while preserving their economic results, promoting the decrease in energy consumption and identifying new sources of income. The literature on BM highlights that it is a tool to analyze the mechanisms for an organizations to create value, it is also a narrative and calculative device that helps investigate a new market, and a venue for innovation. In order to contribute to the burgeoning literature about Circular BM, this research aims to build on an existing framework of circular BMs and to discuss it based on the circular activities developed by a large company in the energy sector. For this purpose, we studied the case a large multinational company. More specifically, we explore how the company adapts its activities, develops novel ones, promotes circularity outside its boundaries and assist its partners in that evolution towards circularity. Furthermore we aim to delineate the business models adopted for these various activities.

Mots-clés : circular economy, business models, energy

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INTRODUCTION

The linear economy and its consumption and production models that inflicts pressure on global resource is challenged by the requirements of Sustainable Development (SD) (Bocken, Schuit, and Kraaijenhagen 2018). In this context, the circular economy (CE) principles and practices, tackling the issue of non-infinite resources availability, appears as a judicious and relevant approach. It should enable to reach the goals of SD (Saidani et al. 2019; M. Linder and Williander 2015) and address major trends of global concerns. Scholars' and practitioners interest in this CE approach have been translated in a rapid growth of peer-reviewed articles (Geissdoerfer et al. 2017; Homrich 2018; Ruiz-Real et al. 2018) and reports from consulting company such as Accenture, Deloitte, McKinsey. Nevertheless, there is still no clear consensus that sets a comprehensive definition and systemic framework on current CE understandings (Kirchherr, Reike, and Hekkert 2017). The embryonic concept of circular economy is believed to be initially brought up by K. Boulding in 1966. He stated that, "The closed economy of the future might similarly be called the "spaceman" economy, in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for extraction or for pollution, and in which, therefore, man must find his place in a 8 cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy."

Thus, it can be argued that thriving towards a fully circular system cannot be done without considering the inputs of energy. Energy is one of the important flows of the economy, it powers the activities of many sectors and industries (Safa, 2017). It is required to operate a circular economy (Allwood, 2014) and should be renewable (Haas et al. 2015). However, it is often overlooked with regard to the circular economy. Furthermore, forgetting to include energy issues in implementing a CE approach can lead to limited results as regards to of naturel resource consumption. Scholars argues a company or a sector can achieve tremendous progress in terms of circularity (for example by making its products more recyclable per unit of input and / or output) without the economy in its whole becoming more circular (Mentink 2014). In other words, "increasing circularity performance on the micro level, can go hand in hand with a performance deterioration on the macro level, in terms of energy, if the sector circularization requires greater consumption of energy to provide technologies or certain components thereof". Hence, we claim to include energy in CE elaboration, an aspect which is rather absent in the literature and in the operational practices targeting a transition towards circular economy.

Finding adequate tools and powerful dynamics is a stepping stone to achieve this shift successfully. Many have praised the action of governments and public authorities (Ranta et al. 2018; Kirchherr et al. 2018; de Jesus and Mendonça 2018) to promote laws (such as European Commission 2015a) and standards (ISO) related to CE, the awareness and willingness of citizens to be part of the solution (Kirchherr et al. 2018) and disruptive technologies of the fourth revolution to enhance the practical implementation of circular principles (Pagoropoulos 2017; Despeisse et al. 2017; Bressanelli et al. 2018). However, other evolutions concerning the organization of the sectors and the economic models are also needed (de Jesus and Mendonça 2018; Lopes de Sousa Jabbour et al. 2019). The operating methods of economic activities related to the exploitation of renewable and / or non-renewable natural resources, should also evolve in order to contribute to a transition towards the circular economy. Reconciling the reduction in the consumption of natural resources with the economic activity of companies that commercialize the use of this resources raises many questions. These companies should simultaneously take into account the ecological issues and thus promote a decrease of energy consumption, while preserving their economic results and identifying new sources of income. These matters refer to that of business models.

In order to contribute to this literature, the present research aims to analyze how circular principles can be implemented in companies of the energy sector. For this purpose, we studied the case of a large multinational company. More specifically, we explore how the company adapts its activities, develops novel ones, promotes circularity outside its boundaries and assist its partners in that evolution towards circularity. Furthermore, we aim to delineate the business models adopted for these various activities.

The contribution of this paper is threefold. First, it provides insights into the activities that a large company in the energy sector can undertake to implement circular principles in businesses. Furthermore, various types of activities are differentiated. Second, we highlight BM supporting these activities. Third, we discuss and expand the framework developed by Bocken et al. (2016).

The paper is structured as follows. Section 1 presents the literature mobilized and emphasize that BMs are an adequate mean to analyze Circular Economy implementation in a large company and introduce the notion of Circular Business Models. Section 2 describes the methodology, including how data were collected in the organization and the method adopted to identify the various circular activities developed. Section 3 presents the findings on the circular activities in an Energy company differentiating various circular strategies. A typology of BMs is also proposed based on the data analysis. Section 4 contains a discussion on the particularities of circular economy in the energy sector. Future research directions are highlighted, as well as the main research contributions and limitations.

1. THEORETICAL BACKGROUND

This section introduces the key concepts underlying this research, which are the business models (BM), circular economy (CE) and circular business models (CBM). It develops the reasons why the BM appears as an adequate prism to analyze the implementation of Circular Economy principles at the level of companies and elaborates on the notion of Circular Business Models.

1.1. CIRCULAR ECONOMY

Voices have raised to underline the negative impacts on environmental, economic and social dimensions of the linear economy (Steffen et al. 2015). Nowadays companies are bound to operate in a complex environment with volatile and scarce resources, rising costs, higher supply chain risks, and more regulatory laws. Despite the controversial roots, definition and conceptualization of circular economy(Kirchherr, Reike, and Hekkert 2017), its principles inspire the development of promising solution to tackle our resources constraints(Saidani et al. 2019; M. Linder and Williander 2015; Geissdoerfer et al. 2017). It is likely to guide deep transformations in production and consumption methods (Preston 2012). Not only has it been gaining momentum among practitioners (D'Amato et al. 2017) but also among scholars since 2010. There is a rapid growth of peer-reviewed articles and consulting reports on circular economy. In fact, the number of reviews and articles per year with the topic circular economy on Web-of-Science increased from less than 5 in 2006, to 11 in 2010 and more than 100 in 2016 (Geissdoerfer et al. 2017; Homrich 2018), and 371 in 2017 (Ruiz-Real et al. 2018).

The circular economy goes beyond the sole considerations of preserving natural resources and strives to optimize their use. Such an approach and model of circular economy aims to reverse the trends leading to the crossing of planetary limits and to return to an ecological footprint on the scale of a planet (Bourg 2018) by defining new economic, organizational and technical trajectories. It is "*an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at various levels (micro: product, firms and consumers, meso: regional and Eco industrial park and macro: global, national and global structure of industry) with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers*" (Kirchherr, Reike, and Hekkert 2017). Bocken et al. (2016) state that it consists of "*design and business model strategies [that are] slowing, closing, and narrowing resource loops*". Other circular economy definitions focus on the downstream aspects of energy. For instance, Geissdoerfer et al. (2017) state that "*Circular Economy is a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops*". Thus, we argue that the issue about implementing circular principles to energy does restrict to the leakage problem. In fact, the energy by itself ,once consumed, is either dissipated or revalorized in other industrial processes. Either way, it does not generate tangible waste and leakages that pollute the environment. Therefore the main specificity about applying circular economy principles in the energy sector occurs in the upstream part which is to produce and consume less. Also, regenerative design "*is a principle that calls for products or services to contribute to systems that renew or replenish themselves. It means the materials and energy that go into a product or process can be reintroduced into the same process or system, requiring little to no inputs to maintain it*". In the actual context and technological advances, it is physically impossible for an energy system to be regenerative and to renew and replenish itself by only reintroducing excess energy and valorizing side steams of energy, due to thermodynamic and practical reasons.

Consequently, by definition, circular economy in the energy system consists of designs of processes and solutions that strives for the most efficient and sustainable production, distribution and consumption of energy, as well as revalorization of excess energy and side streams following business model strategies that slow, close and narrow the extraction of resources and energy inputs.

The need for new BMs in order to implement CE has been widely expressed and is regarded as one of the important pillar for successful CE implementation. In fact, innovative technical solutions do not always factor the transition towards a circular economy. An effective circular economy implementation involves both technological and nontechnological innovations (Mendoza et al. 2017). For instance, technical solutions should be coupled with other managerial evolutions regarding business models. Research on the links between CE and innovative business models has rapidly grown over the last five years (Diaz Lopez, Bastein, and Tukker 2019). Some studies have already questioned the importance of the subject, with real cases investigation(M. Linder and Williander 2015), whereas other work on farming the concept (Nußholz 2017; Lewandowski 2016).

1.2. BUSINESS MODELS

Even though the term Business Model is considered to be relatively new, it still manage to create a tumult of discussion around its definition. In fact, discussions on business model definitions are one of the most frequently tackled subject in the literature (Pateli and Giaglis 2004). Many scholars discuss the polysemic character of this notion by reviewing different definitions (Massa, Tucci, and Afuah 2017; Zott, Amit, and Massa 2011). It is simultaneously referred as an architecture, design, pattern, plan, method, assumption or statement etc. This lack of consensus on the concept, not only creates challenges to determine the nature and components of a business model, but also generates a confusion in the terminology. Indeed, business model, strategy business concept, revenue model and economic model are used equivalently by some authors (Morris, Schindehutte, and Allen 2005). While all the definitions of business model have a similar aim they somehow differ. Case in point, some emphasize the monetary valuation of an activity, other focus on the value proposition (Lecocq, Demil, and Ventura 2010), on the activity system nature of the BM (Zott and Amit 2010) or its nature as a cognitive tool to understand the functioning of an activity (Baden-Fuller and Mangematin 2013).

Amongst these various definitions we could find in the literature, we decided to emphasize three aspects of a Business Model that we consider key to analyze the circular economy implementation.

1.2.1. Business model is a tool to analyze the mechanisms of an organizations and create value

Beyond the generic definitions, the business model has the capability to analyze the mechanisms by which companies can create and capture value. Several models have been proposed in the literature for this purpose. They present several "components". The combination between these components lead to a proposal that can generate value for consumers and for the organization (Tikkanen et al. 2005). For example, Stähler (2001) states that a business model consists of four components. The first component: the value proposition aims to answer the question of what is intended to be created by the business for the stakeholder. It is a description of what value a customer or partner receives from the business. The second component introduces a link between the firm and the customer by providing a description of the product or the service proposed by the company for the market. It answers the question of what the firm sells. The third component is the description of the architecture of value creation aiming to answer how the value is created. For example, it describes how the value chain functions and who is involved in the value creation and what are the roles of the various contributors. The last component delineates the revenue model for the firm, explaining how a company earns money. Chesbrough (2002) list six main elements of a business model. These are the articulation of the value proposition, the identification of the market segment, the definition of the structure of the value chain within the firm, the definition of the cost structure and profit potential, the description of the position of the firm within the value network, including identification of complementors and competitors and finally the formulation of the competitive strategy (Chesbrough 2002).

Other scholars, extend the components' listing in introducing a visual tool: the business model canvas (Osterwalder and Pigneur 2002). By doing so they contribute to the literature aiming at offering a representation of a BM and at pointing out its fundamental components in a simplified way.

Even though there are different approaches and visualization of the components, the business model appears as a tool aiming to help managers understand and describe the business logic of their firm in order to create a value. Thus analyzing how circular economy principles are implemented with this prism appears relevant.

1.2.2. Business model is a narrative and calculative device that help investigate a new market

Business models are very distinctive because they present a mix of storytelling and calculation. They should pass both the narrative test and the number test to succeed (Doganova and Eyquem-Renault 2009). Other argue that the importance of a business model does not reside in the simple description of a firm, but in its explicative and predictive power with regards to the value created in the entrepreneurial environment (Amit and Zott 2001). Moreover, business model tells a good story, they are "at heart, stories-stories that can explain how enterprises work" (Magretta 2002). She argues that "a good story", that are easy to understand and easy to recall, can get people in the organization to agree on the kind of value they want to create and deliver to the market. Furthermore, when analyzing the performances of a business model, M.Eyquem–Renault (2011) discusses its circulation in different spaces between different actors (investors, partners, entrepreneurs, customers, journalists…) and its plasticity (dosage between narration and calculation) allowing an enterprise to explore the market (Eyquem-Renault 2011). By exploring the market, it allows entrepreneurs to bring their innovation – a new product, a new venture and the network that supports it – into existence.

We therefore advance that aside from the essentialist view, business models allow entrepreneurs to investigate the market, by embracing this narrative and its calculative character.

1.2.3. Business model is a venue for innovation

Some researchers focus in particular on the role of business models as a tool and catalyst for innovation. Some unequivocally recognize the business model as a locus for innovation (Amit and Zott 2001). Furthermore, A.Osterwalder (2004) believes that a conceptual and modular business model approach can foster innovation. For him, "it is like giving a business model designer a box of Lego stones. He can play around with these stones and create completely new business models, limited only by his imagination and the pieces supplied." This converges with L. Doganova et al. (2009), for whom business models provide proof of the feasibility of an innovative project. J.Magretta (2002) joins this stream of literature too. She states that a new business model's plot could trigger an innovation process, for example a better way of making or selling or distributing an already proven product or service.

Even though business models are a snapshot of a current situation in time, they are under constant pressure to change due to the numerous challenges the firm are faced to in their internal and external environment (J. Linder and Cantrell 2000). Many acknowledge the fact that consistent business model innovation is fundamental to keep the business thriving (Demil and Lecocq 2010).

1.3. BUSINESS MODELS AND THE CIRCULAR ECONOMY

Implementing circular economy principles through business models innovation appears to be promising. However, approaches for circular economy oriented towards business model innovation are very diverse, and no systemization or methodological guidance has so far been proposed. The literature on the topic is nascent. Below we present the research works linking business model innovation and the circular economy.

Some authors propose guidelines for business model design (Bocken et al. 2016). They present a framework describing CBM types and associate them with product design strategies for CE:

- Slowing loops: the period of utilization of a product is extended and intensified. This long lasting of a product is achieved through services, repair loop, maintenance and remanufacturing. It results in the slowdown of the resources flow. The product design strategies corresponding to this type are the following: "access and performance models"; "extending product value"; "classic long-life model"; "encourage sufficiency".
- Closing loops: recycling is put forward to create a circular flow of resources. The product design strategies are : "extend resource value", "industrial symbiosis".
- Narrowing resource flows: It aims at using fewer resources per product.

Despite the increasing interest for the topic of circular business models, few scholars provide a clear definition. For some a circular business model is "a business model in which the conceptual logic for value creation is based on utilizing the economic value the products still have after use as they may be used in the production of new offerings"(M. Linder and Williander 2015). For other, "a circular business model is the rationale of how an organization creates, delivers and captures value with and within closed material loops"(Mentink 2014). Thus, a circular business model can be part of a system of BMs which altogether closes a material loop and does not require to close material loops by itself (within its internal system limits). In other words, a circular business model should be identified as a subcategory of BMs which fit in an economic system of restorative or closed material loops.

To date, many essential questions in this rapidly evolving field remain unanswered, such as their definition or their relation to sustainability (Hofmann 2019; Manninen et al. 2018; Bocken, Miller, and Evans 2016). Also, there are several propositions of how to categorize circular business models.

One of this study's objective is to present the specificities of the implementation of the CE principles to BM in the energy sector based on a real case study. To do so, the framework developed by N. Bocken et al. (2016) is used and expanded to include the energy dimension.

2. METHOD AND DATA COLLECTION

The methodology used in this study focuses on a unique case to develop theory inductively by highlighting how a large company manage to implement circular economy principles in the energy sector.

The case of a French industrial energy group was identified. It has 172 703 employees in different business units across the world. In 2020 it generated 56 billion euros in revenues and its total capacities of electricity generation was 101 GW of which 31 GW were renewables.

Table 1. Share of electricity generation capacity per inputs

TYPES OF INPUTS	ELECTRICITY GENERATION CAPACITY IN GW
Natural gas	52.5
Coal	4.3
Nuclear	6.2
Other non renewables	3.3
Wind (offshore and onshore)	10.1
Solar	3.1
Hydropower	21.2
Other renewables	0.4

With its position on different types of inputs for electricity generation, it is well suited to reveal various emergent circular business models in the field. Furthermore, it is one of the few companies in the energy sector that advocates for a sustainable development and formulates clear commitments and strategic action plan on the issue : "Acting to accelerate the transition towards a carbon-neutral economy, through reduced energy consumption and more environmentally-friendly solutions.".

Table 2. Share of electricity generation capacity per inputs

ACTIVITIES	DESCRIPTION OF MAIN OBJECTIVE	REVENUES IN BN EUROS IN 2020
Renewables	Production of wind (offshore and onshore), solar	2.5

Energy solutions	Development of cooling and heating networks and energy efficiency services	20.1
Networks	Distribution, transmission and storage of natural gas	6.7
Thermal	Production of thermal energy	3.2
Energy supply	Development of decarbonized energy supply and consumption management offers for private customers	20.9

The data collection lasted 6-month from May 2020 to October 2020.

The decentralized organization of the company made it hard to systematically identify circular activities. Thus, in a first step, data was collected by examining documents dedicated to internal communication. The intranet of the group named appeared as an efficient mean to gather data on circular activities developed in the company. This platform is used to publish news, press releases about projects and achievements done in the company and all over the world. Thanks to this database, it was possible to access to a very significant sample of circular activities. Indeed projects related to circular economy are positively perceived by the company and thus, it is very likely that the actors involved in this kind of projects communicate about them on this internal platform. A query was launched using the key words "Circular Economy", "Circular Business Models", "Circular Business", in English and French, in order to find articles describing circular activities. The query in English resulted in 55 documents whereas in French it resulted in 67. In addition to that, an analysis done by a business unit of Engie on its circular activities was added to the data base. After reading all the documents and cross-checking redundancy in the two queries and the business unit report, a list of 50 circular activities was compiled (see appendix 1).

The documents about the various different 50 activities were read thoroughly several times. This allowed to group them by similarities and inductively propose a list of 9 categories of circular activities (Appendix 1). The categories, listed below, are presented in more details in the result section: Eco-design, Circular Supplies, Product Recovery and Recycling, Energy Recovery, Product Life Extension, Sharing Platform, Renewable Energy Production, Circular Energy Distribution and Use, Access and Performance. (see Table 2)

The second was done to reflect on the strategy of the circular activities, following an adaptation of the three environmental strategies defined by N. Bocken et al. (Table 3). Thus, we propose a framework describing activities, which builds on N. Bocken et al. (2016) and expands it to include the energy dimension.

With this circular activities repertoire, it was intended to gather detailed information about an activity in each of the 9 categories. Due to time constraints on our side and on the managers side, 6 person among those contacted agreed for a meeting. The semi-constructed interviews lasted 1-hour and were conducted through videoconference with managers in various positions (Table 3) They were conducted according to an interview framework, divided in three main areas of discussions: (i) Understanding the activity's circular features and the business model built around it, (ii), principles of Circular Economy and its implementation in the activity, (iii) Identification of challenges and barriers of the activity. The order and content of the interview questions were adapted depending on the role of the interviewees and following the flow of conversation. The interviews provided a different perspective on Engie's circular BM deployment.

Table 3. List of interviewees, position and circular activities involved in.

UNIT NAME	INTERVIEWEE'S ROLE	CIRCULAR ATIVITIES CATEGORY	DESCRIPTION OF THE ACTIVITIES
Engie Bioz	Deputy General Director	Energy Recovery	Development of Biomethane project inspired by a model associated with wind and solar energy
Engie Solution	Project Manager	Access and Performance	Engie buys the boilers maintains them and operates them for the customers
Engie Laborelec	Sustainability Officer	Circular Supplies	Developing a project to implement sustainable procurement within the Group.
Engie Netherlands	Business Developer	Product Recovery & Recycling and Product Life Extension	Develop a successful business model incubator for Engie's assets
Engie Lab Crigen	Research Engineer	Sharing platform	BeCircle : tool for eco-design of industrial parks and resource loops creation

Engie Rassembleurs d'énergies	Investment Director	Energy Recovery	Computing heaters and boilers of Data center will heat 11 000 Social Housing for free

Based on this analysis of CE principles implementation in ENGIE and these interviews we propose in the result section four types of business models.

3. RESULTS

3.1. TYPES OF CIRCULAR ACTIVITIES IN THE ENERGY SECTOR

Announced in the method section we propose below nine types of circular activity that can be developed in a large energy company. The table below presents each type and the corresponding activities among the 50 listed.

Table 4. Types of circular activities

CIRCULAR ACTIVITY	CASES OF ACTIVITIES LISTED IN ENGIE COMPANY (AS ANALYZED IN APPENDIX 1)	EXPLANATION
Eco-design	• Substituting virgin materials inputs • Reducing material use • Built to last, be repaired and reused Planning the recyclability of materials from energy production plants and grids	Substituting virgin raw materials with secondary used recovered or recycled materials would enhance closing the loop. Also, if standards related to repairability, durability and recyclability are followed, the activity would slow the loop because assets life are extended and would narrow the loop because less resources are used.
Circular supplies	• Sustainable Procurement	Activity with sustainable procurement of energy assets implying responsible purchases that would intrinsically lead to using less resources and more secondary resources in the assets.
Access & Performance	• Heating as a service • Electricity as a service • Lighting as a service O&M contracts B2B and B2C (extended lifetime approach)	Activity would potentially lead to a reduction in resources and materials usage because the company sells a service but own the products and assets, and keep them longer in the system, if well maintained. It would have more control on the end of life management. Heating, electricity, or lighting as a service and new types of contracts with an extended life time approach are examples of this model.

Product recovery & recycling	• Recycling materials from energy production plants Dismantling of energy assets	Activity helps keep materials and products in use in the system, instead of being discarded, by recycling and dismantling energy assets from energy production plants coming from the collection point
Product life extension	• Remanufacture • Upcycle • Resell Repair & Maintain	Activity that can help put in place a slowed material loop for assets, By repairing and maintaining the products in use, because it helps keep materials longer in the system
Sharing platform	• Industrial symbiosis Digital Platform	Activity implementing physical or virtual symbiosis would have the potential to use by products of one industry as an input for energy production or use and put in place a closed loop.
Renewable energy production	• Solar • Wind • Geothermal Hydropower	Activity that runs on free resources that are by themselves infinitely regenerative and run on cyclic models.
Energy Recovery	• Utilization or Storage of excess heat • Utilization or Storage of excess energy • Utilization of ashes • Energy from waste – Biomass - Biomethane • Valorization of Co2	Activity could enhance the return and the extension of residual and excess energy that would be otherwise wasted in the system. Activities like using or storing excess heat and ashes, producing energy from waste, are examples that close the energy loop.
Circular energy distribution and use	• Demand Response • Smart grid Management and control	Activity that encourages sufficiency and efficiency from the end-user's side and control energy consumption. Controlling the demand and response would be sound solution to monitor, raise awareness and change consumer's behaviors. Likewise, smart grid including smart meters and smart appliance could help in reducing energy inputs in the system.

3.2. TYPES OF CIRCULAR ACTIVITIES AND CIRCULAR STRATEGIES

The framework of N. Bocken et al. (2016) differentiates the three following strategies:

- Closing the loop, where recycling is put forward to create a circular flow of resources
- Slowing the loop, where period utilization is extended and intensified and long lasting product design through service loop or repair, maintenance and remanufacturing result in the slowdown of the resources flow, sufficiency and efficiency in resources use
- Narrowing the loop, where less resources are used.

It is clear that there is a strong focus on tangible products. As argued in section 1.1, there is a need to distinguish energy from resources regarding circular economy principles. In fact, when consumed, the resources remains in the system as "tangible waste" that can pollute. Whereas energy is either dissipated or revalorized in an industrial process and is not considered as "waste" that pollute.

This is why we split in two each strategy of N. Bocken et al. (2016) and propose to differentiate these strategies to material resources and energy. The following table associates the six strategies presented above with the 9 types of circular activities exhibited.

Table 5. Types of circular activities and associated circular strategies

CIRCULAR ACTIVITY	CLOSING THE RESOURCES LOOP	SLOWING THE RESOURCES LOOP	NARROWING THE RESOURCES LOOP	CLOSING THE ENERGY LOOP	SLOWING THE ENERGY LOOP	NARROWING THE ENERGY LOOP
Eco-design	x	x	x			
Circular supplies	x	x	x			
Access & Performance	x	x				
Product recovery & recycling	x					
Product life extension		x				
Sharing platform	x			x		
Renewable energy production				x		
Energy Recovery				x		
Circular energy distribution and use					x	x

Two main blocks appear from table 5. In the upper left side of the table circular activities are limited to strategies related to the material resources loop. Whereas in the lower right side of the table, circular activities are associated with strategies regarding the energy loop.

Even though some activities share the same combination of strategies, it appeared necessary to keep them distinct. For instance, eco-design and circular supplies or renewable energy production and energy recovery. For the former case, the difference relies in the product's stage lifetime: Eco-design concerns an early stage of the product's life, the design phase. While circular supply relates to the purchasing phase of the product. For the latter case, the difference relies in how energy is made available. Renewable energy production relies on regenerative and readily available energy, whereas energy recovery depends on the availability of residual and excess energy that would be otherwise wasted in a system.

Only the "sharing platform" activity is associating strategies from both resources and energy loops. Indeed it has the potential to be used for products, material and tangible resources or energy that is recovered, of one industry as an input for another product or energy production or use.

3.3. BUSINESS MODELS FOR THE CIRCULAR ACTIVITIES IN THE ENERGY SECTOR

From these 9 activities, we abstracted four generic business models. As for the circular strategies, BMs were also differentiated according to resources and energy loops to highlight specificities from the energy sector. Building on table 5, the upper left part of the table combining the 3 strategies to close, slow and narrow the resources loop was associated to *BM1* which highlights businesses around the assets and equipment. The lower right part relying on strategies to close slow and narrow the energy loop was associated to diverse BMs: *BM2* relying on circular activities to supply, produce and deliver energy. *BM 3* puts forward the consulting offer proposed to boost circular energy supply, production and delivery activities. Finally, *BM 4* is the entrepreneurial support to financially support, from a technical and organizational perspective, other circular businesses.

In the following paragraphs are depicted the value proposition, the offer, the circular features as well as the targeted clients on cases of circular activity we analyze in more details and which illustrate each kind of BM.

3.3.1. BM 1: Activities related to energy assets – The case of Access & Performance

Engie Solution developed the Assets based Solution offer. This model is based on integrated offers often with performance obligations. This model bills for charges as a service or performance fees instead of selling the product itself. The contracts can go from 10 to 50 years. For example, Engie buys the boilers maintains them and operates them for the customers. It can also be applied to district heating and cooling network, public transportation, public lighting, on site generation and off grid energy supply. In these long-term contracts Engie takes higher risk and management responsibility. The cost structure consists of material and energy depreciation, internal staff, and subcontractors. This Assed Based Solution offered to Engie's clients fit within the scope of the Access and Performance model. It aims at slowing the loop of materials and reducing the amount of virgin materials injected in the system. Effectively the model keeps assets and products in the system longer which results in a slowdown of the material loop. Also, it reduces the quantity of new raw materials, because the company owning the equipment will follow the life cycle of the product and implement a proper end of life management.

3.3.2. BM 2: Activities related to supply, produce and deliver energy – The case of Energy Recovery

Engie Bioz brings recognized expertise at each stage of anaerobic digestion projects, from feasibility studies to their operation. Thanks to its location and its knowledge of the territories, it operates across the entire value chain, bringing together all local players around suitable solutions. The unit specializes in initiating, developing, financing, building and operating biomethane production units.

It integrates the principles of circular economy through three loops:

- Agricultural loop: where farmers bring their effluents, and recover a digestate from the plant which is spread on their land as a fertilizer for their plants to grow.
- Waste loop: where citizens' waste is collected by trucks to be sorted in the plant. Once sorted, the waste is fed to the anaerobic digestor to produce biogas, a part is purified and injected into the gas network and sold to a subsidiary of Engie in charge of the distribution of gaseous alternative fuel, mainly biomethane fuel: BioGNV. The trucks is fueled by gas generated at the plant.
- Energy Loop: Once the sorted waste is fed to the anaerobic digestor to produce biogas, another part goes through a cogeneration processes to be valorized in energy and heat and another can be purified into biomethane to be injected in the natural gas network

Thus, it enhances the return and the extension of residual and excess energy that would be otherwise wasted in the system.

3.3.3. BM 3: Consulting for energy supply – the case of Sharing Platform

Be circle is a consulting offer to support territories (industrial parks, campuses, airport hubs, cities, eco-districts, etc.) and / or industrial players in transition to a more circular model.

Anchored in the circular economy principles, it aims to close resource loops at local scale with economic benefits thanks to a geodata-based web platform that allows to represent territorial clusters in terms of resources flows (water, materials, energy) without using confidential data. BeCircle is integrated into the upstream strategic phases of industrial and / or territorial projects (choice of technologies and sectors, planning decisions, resource management master plans, territorial marketing and attractiveness strategies territorial…). The offers proposed are Mapping of territories, visualization of data and analysis and deployment of scenarios. It also undertakes project management assistance, advice (B2B), door-opener and / or integrator (for ENGIE offers integrated or complex). With an objective to enhance industrial and territorial ecology, It thus deploys an innovative service to foster the development of circular models, particularly The Sharing Platform to contribute to a unified strategy development and an industrial symbiosis.

3.3.4. BM 4: Entrepreneurial support for energy supply – The case of Energy Recovery

Engie had an important global presence alongside major clients, that were widely distributed geographically. However, it lacked a presence alongside individual clients. Engie Rassembleurs d'énergies appeared to be a solution to address this shortage and broadens the grasp of Engie to reach out to small populations. Therefore, it is a financing approach. Engie Rassembleurs d'énergies performs a BM analysis, validates its financial viability. It evaluates the business model innovation. It also ensures that it imperatively meets the three criteria of sustainable development: economic, social and environmental. It therefore, targets companies or startups pertaining to one of the 5 sectors of activities the unit defined : clean decentralized collective energy, Clean individual energy solutions, Energy efficiency and frugality , Clean cooking and Circular Economy. The offer they propose, is a support for the growth of the company they are investing in, from a technical (engineering) and organizational (governance and skills) point of view. In this case, they are investing in Computing heaters and boilers of Data center that will heat 11 000 Social Housing for free.

Table 6. Business models for the circular economy

CIRCULAR BUSINESS MODEL	VALUE PROPOSITION	VALUE CREATION	VALUE CAPTURE

BM1 for circular activities related to energy assets and equipment	Eco designing, remanufacturing upcycling, reselling, repairing, Maintaining or recycling energy assets – As a service	Collaborating, R&D	Additional value generated
BM 2 for circular activities to supply, produce and deliver energy	Renewable and recovered energy production and distribution	In house expertise and technique for Initiating, developing, financing, building and operating energy systems	Selling the energy
BM3 consulting offers	Designing circular and sustainable solutions and processes to supply energy	Project management assistance, advice, In-house GIS tool Continuous design and product development Training and hiring - IT	Invoicing of a service offer
BM4 entrepreneurial support	Financial investment and managerial support to circular and sustainable startups	Feasibility studies through In house tool to evaluate the viability and circularity of the businesses	Return on Investment

4. DISCUSSION AND CONCLUSION

Several insights can be inferred from the results. First and foremost, our results show that a large company in the energy sector, taking on the challenge of the energy transition, can actively promote circular economy through its businesses by developing new types of activities.

There is little work done on the circular economy in the energy sector. Therefore, by analyzing the large energy company, we were able to highlight a list of 9 circular activities specific to the energy sector. We expanded the circular strategies of N Bocken et al. by differentiating the material resources loop and the energy loop. This leads us to associate these strategies with the 9 circular activities established. Building on this, a typology of four generic BMs emerged: BM1 for products (strategies related to resources loop that can be applied inside the company and for its clients) and BM2, 3 and 4 for energy (strategies related to energy loop and addressed to its clients) more diverse.

Therefore the first contribution of this paper lies in the typology of circular activities associated with an existing framework for circular strategies. It contributes to build a better understanding of implementation of circular economy in the energy sector and the business models associated. Business model archetypes can be used by organizations to shape their transformations. They can provide assistance and guidance in investigating new ways to create and deliver sustainable value (Bocken, Schuit, and Kraaijenhagen 2018). Furthermore, by focalizing on the energy sector, we were able to highlight its specificity regarding the circular economy. In fact, the main difference lies in the fact that the consumption of the energy does not become "waste" in the same way the consumption of another resource becomes "waste" after it is consumed. In that sense, energy dissipates or is revalorized not leaving "waste" after its use. Therefore the main focus should be on the upstream part where producing less and consuming less energy is put forward. BM 2, 3 and 4 can propose new services and new ways of producing and consuming energy for the clients. Nonetheless these 4 business models can be transposable to other industries.

The second contribution of this paper is to investigate the notion of CE. The paper builds on existing authors who intend to qualify and specify circular economy and characterize business models for the circular economy. The last contribution is linking the literature on business models which is mature to authors who are mainly interested in the literature on circular economy.

Our work has some limitation in the methodology to assess the circular activities undertaken by Engie. In fact it is important to note that the list found is not exhaustive and does not include all circular activities that Engie may have implemented. It only reflects activities and information communicated on the intranet. Further investigation should be done to enlarge our scope. Despite the high significance of big companies in the transition toward circular economy, other types of firms can play a role too. Other empirical studies could be undertaken to investigate the circular economy implementation within smaller firms as other dynamics and organizations may emerge.

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Appendix 1: Circular subcategories of the list of the 50 activities found on the intranet

List of the 50 activities	**Subcategories of the circular activities**

Project andrade: Construction Biomass plant that uses sugar cane	Industrial Symbiosis
Hydrogen for industry and mobility territory - Nouryon excess sodium chlorate generate a signifciant amount of Hydrogen	Industrial Symbiosis
PEPS: electricity mini-storage concept that involves pumped storage installed in mines and quarries, linked up to a renewable energy production facility, connected up to users on site and to the power grid.	Utilization or Storage of excess energy - Demand and Response
Jupiter 1000: Power to Gas demonstrator , storing the excess of electricity generated by wind and solar farms and transform it to methane (with Co2 from near industries) and hydrogen to injected back in the system to be used by PIICTO platform	Utilization or Storage of excess energy
Yoplait - Network (Claude Bernard School and 791 Social Housing) - Recovering untapped energy source at Yoplait by installing Heat pump and injecting in the network	Utilization or Storage of excess energy
Electrolyser for the Production of Green methanol from hydrogen and locally generated Co2	Valorization of Co2 - Energy from waste
Power to Methanol: methanol produced from hydrogen and locally generated Co2	Valorization of Co2 - Utilization of energy
Generation of H2 as an input for methane synthethis - help a lime producer to capture Co2 emission	Valorization of Co2
Construction of a new dump condenser and a long term O&M contract	Energy from waste
District Heating powered by the heat of the thermoelectric plant and the energy produced by Solis biomass power plant	Utilization of excess heat and energy
Pilot Project : Heat waste recovered from Steel factory and injected into District heating system built by engie	Utilization or Storage of excess heat
Computing heaters and boilers of Data center will heat 11 000 Social Housing for free (by 2023)- Engie invest and carry out the transition	Utilization or Storage of excess heat
development of Biomethane project inspired by a model associated with wind and solar energy	Energy from waste
Gaya: Pyrogasification of renewable resources to produce biomethane	Energy from waste
Investing in Gecco : recycling waste from restaurant into renewable energies and new raw materials, converting used food oils into biofuels and biolubricants	Energy from waste
Recovering heat from steelmaking activities	Utilization or storage of excess heat
Production of formic acid from Recovering Co2 present in the blast furnace fases produced by ArcelorMittal using green hydrogen produced locally from renewable electricity - C2Fuel	Utilization of ashes - Valorisation of Co2

Investing in HomeBiogas System : turns household waste and animal manure into energy through methanation creating two hours of free clean cooking gas daily	Energy from waste
Organic residues of 10 farmers are processed in the AgribioMethane plant to supply them with green gas for the natural distribution network and fuel for their vehicles	Energy from waste
Using ashes from the biomass boiling rooms in a filter to clean biogas (substitution of active carbon, polluting)	Utilization of ashes
Cogeneration using solid biomass to produce electricity and heat	Energy from waste
Giving 48 used Li-Ion batteries from electric cars a second life to form one large storage battery in the Umicore Industrial site	Extending Product Value : Upcycle
Energy Bay platform : markt for buying and selling spare parts (surplus, obscolescence) within a global community of energy professionals	Extending Product Value: Resell
Relocation of Large gas Turbines	Extending Product Value : Upcycle
Extending Life Time of large scale PV plants	Extending Product Value : Repair and Maintain
Reuse of domestic hot water heat pump as tanks (under development)	Extending product value: upcycle
90% renewable energy and recovery	Renewable energy
Solar energy plants on waste recycling and treatment facilities that already produces biogas	Renewable energy
Energy Efficiency audit, Energy Managmenet System optimization	Management and control
BeCircle : tool for ecodesign of industrial parks and resource loops creation	Industrial symbiosis - digital platform
Greenway : to advise energy efficiency, recovery and conversion	Management and control
Boxx: touchscreen and mobile app together make a powerful tool for tracking electricity, natural gas and water consumption in real time.	Demand response
Transform the waste from the minihydroplants into biopellets	Circular Supplies: Substituting virgin material inputs
Assessment of local resources for biomass - biogas CHP projects	Circular Supplies: Substituting virgin materials inputs
Initial use of LCA in product and service procurement and design	Circular Supplies- Resource efficiency- Efficient Design
Eco design of boilers (under development)	Efficient Design
Design and development of ecodistricts (main focus on energy)	Efficient Design

Simulation based strategy for sizing dispatching of local energy assets	Efficient Design
Self consumption system design and operation	Efficient Design
Invest in this company that produces improved cookstoves and charcoal briquettes reconstituted from waste materials	Circular Supplies: Substituting virgin material inputs
sustainable Procurement, Safety As a Service, Lighting As a Service	Circular Supplies, Lighting As a Service
Biomethane Recharge station for trucks, also allows the local recycling of part of the organic waste collected in stores.	Electricity as a service - energy from waste
Recharging Station for renewable hydrogen buses (produced by green electrcity from hydraulic dams, wind turbines, solar pannel in France)	Electricity as a service - Renewable energy
Green PPA	Renewable energy
Public compressed natural Gas Station	Electricity as a service
Support, give strategic advice and market intel, make part of Engie's solution portfolio : Manufacturer and Installer of bioenergy power plants (natural gas, propane, fuel oil)	O&M contracts B2B and B2C (extended lifetime approach
Financing, building, owning, maintaining operation Heat cold and power generation - energy Contract 15 years	O&M contracts with extended lifetime approach
10 year O&M of the Covestro steam assetm option to optimize energy assests with profit sharing of outcome	O&M contracts with extended lifetime approach
Hystart: Charging Station As a Service	Electricity as a service
Beewe : digital platform for used and spare parts of energy assets	Product life extension : Resell - upcycle/ Digital platform