Available online at www.sciencedirect.com
ScienceDirect
Energy Procedia 61 (2014) 1191 – 1195
Energy Procedia

The 6th International Conference on Applied Energy – ICAE2014

Is Innovation an enabler of Energy Efficiency? An exploratory study of the foundry sector

Andres Ramirez-Portilla [a,b,]*, Enrico Cagno [a], Andrea Trianni [a]

[a]Politecnico di Milano, Piazza Leonardo da Vinci 32, 20133, Milan, Italy
[b]KTH Royal Institute of Technology, Lindstedsvägen 30, SE-10044, Stockholm, Sweden

Abstract

Using innovation such as new technologies, R&D, or new processes can support Energy Efficiency (EE). Building on this idea, this paper seeks to explore whether a novel approach to foster EE in Small- and Medium-sized Enterprises (SMEs) includes improving the overall innovation degree through the adoption of (OI) practices. To do this, a multiple case study with ten firms in Northern Italy operating in energy-intensive industries was conducted. The paper analyses the firm's specific energy consumption, the adoption of energy-efficient technologies, the perception of barriers to EE, and their relation with the firms' internal innovation and OI activities. Main results show that more innovative firms, in terms of internal and inbound innovation, have better EE indicators albeit a lower adoption of energy-efficient technologies or the challenge of economic and technology barriers. Equally, medium-large firms are more innovative and have better EE performance. This study offers preliminary evidence of a relation between certain innovation practices and the rise of EE in SMEs.

Peer-review under responsibility of the Organizing Committee of ICAE2014
Keywords: Innovation ; Open Innovation ; Energy Efficiency; Small- and Medium-sized Enterprises; Foundry Sector

1. Introduction

In last years, society has shown an increased interest in challenges related to innovation and energy. An example is the Europe 2020 strategy, a central guideline for European Union growth, in which two of its key targets translate into flagship initiatives such as promoting Energy Efficiency (EE) and innovation. Although these two concepts have been addressed in practice, there has been little discussion about connecting their research streams, which in turn may complement each other. Currently, innovation needs to be environmental sustainable, and this idea has stimulated studies to broaden the research views [1]. Nevertheless, there has been little discussion about a direct link between innovation and EE, which may support firms in addressing challenges like the reduction of energy consumption. To explore further this link and its effects, this paper takes the idea of Open Innovation (OI) [2], a model for managing innovation based on the purposive inflows and outflows of knowledge to accelerate internal innovation (inbound), and to expand the markets for external use of innovation (outbound) [3]. As OI has shown supporting Small- and Medium-sized Enterprises (SMEs) to innovate albeit their limited resources [5][6],

* Corresponding author. Tel.: +39-02-2399-3933; fax: +39-02-2399-4067 .
E-mail address: andres.ramirez-portilla@indek.kth.se .

Peer-review under responsibility of the Organizing Committee of ICAE2014
doi:10.1016/j.egypro.2014.11.1051

it could be the same case with EE challenges. Thus, this paper seeks to explore whether a novel approach to foster industrial EE in SMEs might include adopting OI practices. To do this, a multiple case study was conducted with ten SMEs within the foundry sector in Northern Italy. The analysis considered the measures of the firms' specific energy consumption, the adoption of energy-efficient technologies, the perception of barriers to EE, and proxies of the firm internal innovation and its adoption of OI practices.

2. Linking Energy Efficiency, Innovation and Open Innovation

EE means using less energy to produce the same amount of services or output. Firms must rely on a series of indicators to quantify variations in EE. One of these indicators might be the assessment of the most efficient technology or best process-specific technologies in a firm [6]. The practice of comparing these innovations, including the Best Available Technologies (BATs) in an industry, can improve a firm's overall EE performance [7]. Similarly, the adoption of BATs relates directly to the existing barriers that may inhibit investments in these technologies and thus limiting industrial EE [8]. Thus, the perception of the barriers to EE can be used as a suitable indicator [9]. Although recent research has examined some innovation characteristics of firms affecting the perception of barriers by SMEs to the diffusion of technologies [10], to our knowledge OI has not been linked to EE.

The idea to connect these two concepts is not obvious but its logic is direct. Organizations have historically invested in Research and Development (R&D) to drive innovation; however, current global competition has influenced different collaborations for innovation. OI embraces this idea and assumes that not all good ideas will come from inside the firm, and not all can be marketed internally [11]. OI suggests that a firm should balance, complement and leverage their R&D investments with other sources of knowledge [12]. As OI uses traditional management ideas and represents modern innovation practices, it can be operationalized with two main types of activities: inbound and outbound. OI lacks an accepted indicator; still, the degree of openness can be measured by gauging the type and number of activities [13].

Considering the above, the framework of this study was shaped (see Figure 1). It assumes that since OI activities can support the introduction of new technologies to a firm, it can also support the addition of BATs supporting the increase of EE in processes. Including the barriers to EE could also help to explain the EE performance as well as the specific energy consumption (SEC) for the firm main processes. Firm characteristics as size and type of alloy are included as a contingency approach for this study.

3. Research Methodology

To explore a positive relation between OI and EE, a multiple case study was conducted with ten firms from the foundry sector. This energy-intensive sector was chosen because EE can be measured straightforward in terms of energy used, which also provides information about the operative performance. The sample is composed by SMEs from Northern Italy producing different types of alloy: aluminum, steel, grey or ductile cast iron. Northern Italy was chosen as it presents a high propensity for innovation and have been suitable to conduct OI studies before [14]. In addition, the firms are tier-2 suppliers to the car industry, allowing the sample to be controlled for manufacturing industry pressures such as cost-optimization, R&D efficiency, and competition [15].

The data were collected through interviews and a questionnaire, and the 65 investigated items were divided into five sections measured either by single or multiple direct questions. The questions were asked to top management as in Italian SMEs these employees are deeply involved with strategic decisions inside firms such as the ones related with innovation, technology and efficiency topics [14]. To gauge the variables of the framework different sources were used (see figure 2). Questions to measure internal innovation and OI activities were taken from the Community Innovation Survey, the IMP3rove assessment [16], and the Open2-Innova8ion Tool [17], which were asked with a 1-4 Likert scale measuring the degree of importance (1-very low to 4-very high). An innovation index was created with only internal and inbound innovation, as outbound activities were not highly present in the sample. To gauge the EE three indicators were used: 1) specific energy consumption (SEC) was measured through a scale with values depending on the type of alloy; 2) the adoption of BATs was quantified with a binomial scale (0-not used, 1-used) with a list of technologies taken from literature, reports and industry benchmarks; 3) the perceived importance of barriers to EE was measured on a seven-item four-point Likert scale previously used in literature [8].

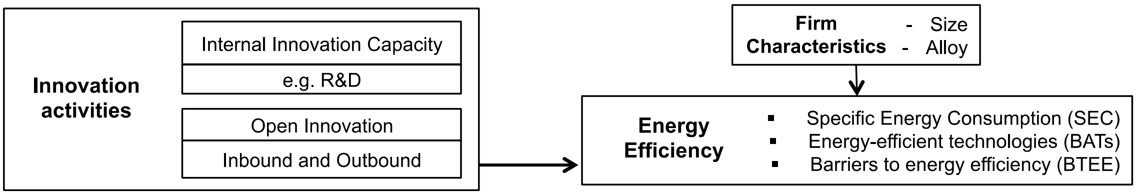

Fig. 1. Framework for this study depicting the innovation activities that may affect energy efficiency performance

Alloy	No. of Firms	Ener. Consumption [kWh/t]				Examples of Best Available Technologies (BATS)	Sources of BATs and Ener. Consumption values
		Poor	Accept.	Good	Excel.		
Aluminum	3	>830	>705	>490	>390	Drying of raw materials, Space heating and hot water supply, Hood and sealed furnace door, Oxygen enriched air or oxygen in the burners	U.S. Energy Reqs for Aluminum Production, Global Industrial EE Benchmarking
Steel	1	>2,530	>2,205	>1,075	>730	BOF Waste Heat and Gas Recovery, Scrap Pre-heating, Optimized sinter pellet ratio, Oxy-fuel Burners, Top Gas Recovery Turbine	EE in the EU27 iron and steel industry, BAT for Iron and Steel Production, IETD 2013
Ductile Cast Iron	3	>1,200	>1,000	>800	<800	Recovery heat solution, Sinter Plant Waste Gas Heat Recovery, Pulverized Coal Injection , Top Gas Recovery Turbine, Space heating and hot water supply, Indicators on fans, Oxygen enriched air or oxygen in the furnaces/burners.	Smitheries and Foundries BREF, Foundry bench D19, BAT Document for Iron and Steel Production, IETD 2013
Grey Cast Iron	3	>1,100	>900	>700	<700		
	Barriers to Energy Efficiency (Cagno et al, 2013)						
	1. Related to economical issues 2. Organizational 3. Lack of awareness or ignorance 4. Related to technology 54. Behavioral 6. Related to competences 7. Lack of information on costs, benefits, technology						

Fig. 2. Summary of firms studied, the energy efficiency measures used and their sources

4. Results and conclusions

The analysis of the whole sample shows that, as expected, all SMEs rated being energy-efficient as 'very important.' However, when comparing their SEC, only three out of ten firms have a 'good' level, whilst the other six firms present an average low level of energy efficiency. Firms answered to have adopted 0 to 5 energy-efficient technologies in the last 3 years, which aligns with the less than four BATs adopted on average by all firms. All SMEs besides presenting a small adoption rate of BATs (cf. [18-19]), they also show in general low barriers to EE. This suggests that firms are not energy efficient perhaps due to the poor adoption of BATs, yet lower barriers should counterbalance this effect. However, when analyzing the single barriers, economic and technology-related barriers are high for the whole sample, suggesting that these obstacles have more weight to impact a lower EE. As BATs differ within sectors, there is no generic convergence to the most used group of BATs by all firms. Most of the firms have an energy manager with the exception of three SMEs, which unsurprisingly had lower levels of SEC and rate of energy-efficient technologies in comparison to the average value of other SMEs. The innovation index shows that eight out of ten firms are profusely innovative and reasonably using inbound activities. Interestingly, only one firm has an innovation manager, which seems to influences directly the either important or very important perception of sixteen out of seventeen internal and inbound innovation practices. Moreover, if the full sample is analyzed by innovative and less innovative firms, results shows that six out of ten firms which are more innovative are also more efficient confirmed by a better level of SEC. In turn, while the six innovative firms adopt fewer BATs, they also show that five firms perceive as high economic barriers, and four consider also high technology-related barriers.

When analyzing the data by sub-sectors, aluminum firms have a lower SEC than the other sectors. Differences between sub-sectors are also visible in the average values of BATs and barriers to EE, specifically higher economic barriers for the aluminum sector and higher technology-related barriers for the others. Similarly, interesting differences in barriers between sub-sectors are related to lack of information and lack of awareness, which could be explained by the communication and support from associations of each foundry sub-sector. Aluminum enterprises show a homogenous high level of internal and inbound innovation across firms. The innovation practices considered as very important for them include getting access to external funding, purchasing technical services, acquiring advanced machinery, and a large range of collaborations with suppliers, universities, government, and industrial associations.

Further analysis showed that when grouping firms by size, slightly superior efficiency in the SEC is visible between five medium-large (i.e. 100-249 employees [20]) and five medium-small (i.e. 50-99 employees) firms. A similar case occurs with the adoption of BATs, which albeit both levels are very low, medium-large firms rate is better than medium-small firms. Barriers to EE are higher in medium-large firms than in medium-small ones; however, in both groups economic issues and technology-related barriers have a considerable weight. While internal innovation is higher in medium-large firms reinforced by practices such as investing resources in internal R&D and engaging in organizational innovation to improve operations, inbound innovation is higher in medium-small firms sustained by practices like getting access to external funding and taking innovation from atypical sources.

Concluding, energy policies to reduce energy consumption and fostering innovation are part of the key targets of the Europe 2020 strategy. Thus, in this preliminary study, we explored the relationship between OI practices and EE performance in energy-intensive sectors, such as foundries, by suggesting a framework to interpret better the reality of the industrial sector. Although the study considers a limited sample, it is useful as a starting point for future research. Results show that in general firms that are more innovative i.e. having a higher internal and inbound innovation levels, are also more efficient in terms of their SEC level. Likewise, these firms might embrace fewer BATs but in a better way, suggesting that a lower adoption of BATs could be a signal that the firm can achieve EE with its current structure, processes and systems. In general, therefore, it seems that even though not all innovation practices have a relationship with EE, some of them have a direct effect as enablers of EE in SMEs. The derived from this study can be used as a first reference to recommend SMEs and policy makers to support innovation initiatives, including OI practices, as a mean to increase its EE results and thus the performance of the industrial EE.

Acknowledgements

The authors thank Andrea Consonni and managers from ASSOFOND for their support in contacting the firms and collecting data. This paper is produced as part of the EMJD Programme *European Doctorate in Industrial Management (EDIM)* funded by the European Commission, Erasmus Mundus Action 1.

References

[1] Smith A, Voß J-P, Grin J. Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. Res Policy 2010;39:435–48.

[2] Chesbrough H. Open innovation: The new imperative for creating and profiting from technology. Boston: Harvard Business Press; 2003.

[3] Chesbrough H, Vanhaverbeke W, West J. Open Innovation: Researching a New Paradigm. Oxford: Oxford University Press; 2006.

[4] Van de Vrande V, de Jong JPJ, Vanhaverbeke W, de Rochemont M. Open innovation in SMEs: Trends, motives and management challenges. Technovation 2009;29:423–37.

[5] Xiaobao P, Wei S, Yuzhen D. Framework of open innovation in SMEs in an emerging economy : firm characteristics , network openness , and network information. Int J Technol Manag 2013;62:223–50.

[6] Trianni A, Cagno E, Thollander P, Backlund S. Barriers to industrial energy efficiency in foundries: a European comparison. J Clean Prod 2012;40:161–76.

[7] Norup J, Taylor G. Best Practice Benchmarking in Energy Efficiency: Canadian Automotive Parts Industry. Summer Study Energy Effic. Ind., Niagara Falls, NY: 2005, p. 96–106.

[8] Trianni A, Cagno E, Worrell E, Pugliese G. Empirical investigation of energy efficiency barriers in Italian manufacturing SMEs. Energy 2013;49:444–58.

[9] Cagno E, Worrell E, Trianni A, Pugliese G. A novel approach for barriers to industrial energy efficiency. Renew Sustain Energy Rev 2013;19:290–308.

[10] Trianni A, Cagno E, Worrell E. Innovation and adoption of energy efficient technologies: An exploratory analysis of Italian primary metal manufacturing SMEs. Energy Policy 2013;61:430–40.

[11] Chesbrough H, Crowther A. Beyond high tech: early adopters of open innovation in other industries. R&D Manag 2006;36:229–36.

[12] Huizingh E. Open innovation: State of the art and future perspectives. Technovation 2011;31:2–9.

[13] Laursen K, Salter A. Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. Strateg Manag J 2006;27:131–50.

[14] Lazzarotti V, Manzini R, Pellegrini L. Open innovation models adopted in practice: an extensive study in Italy. Meas Bus Excell 2010;14:11–23.

[15] Wyman O. 2015 Car Innovation. 2007.

[16] Brunswicker S, Vanhaverbeke W. Beyond open innovation in large enterprises: How do small and medium-sized enterprises (SMEs) open up to external innovation sources? 2011:38.

[17] Caird S, Hallett S, Potter S. The Open2-Innova8ion Tool—A software tool for rating organisational innovation performance. Technovation 2013;33:381–5.

[18] Cagno E., Trucco P. Cleaner Technology Transfer in the Italian Galvanic Industry: Economic and Know-How Issues. Journal of Cleaner Production. 2008; 16:32-36.

[19] Cagno E., Trucco P., Trianni A., Sala G. Quick E-Scan: A Methodology for the Energy Scan of SMEs. Energy. 2010; 35:1916–1926.

[20] Micheli G.J.L., Cagno E. Dealing with SMEs as a Whole in OHS Issues: Warnings from Empirical Evidence. Safety Science. 2010; 48:729–733.

Prof. Enrico Cagno, PhD
Professor of Design & Management of Production Systems at the School of Industrial and Information Engineering of Politecnico di Milano. His primary research interests are Industrial Energy Efficiency, Sustainable Operations and Risk Analysis & Management. Published more than 280 papers in books, journals, and proceedings.