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BARRIERS AND DRIVERS FOR ENERGY EFFICIENCY: AN EXPLORATORY STUDY IN SOUTH AFRICA'S PULP AND PAPER INDUSTRY

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ABSTRACT

South Africa is a major player in key pulp and paper segments in regional and global markets. The country is one of the world's largest producers of dissolving wood pulp and is the largest producer of pulp, paper, and paper products on the African continent. South Africa is ranked the 15th largest producer of pulp in the world and 24th in paper production. Much of this is invested in local resources, innovation, and people power. In 2013, the forestry-to-paper value-add to South Africa's economy was R18.2 billion – this equates to 0.6% of the country's gross domestic product (GDP). The pulp and paper industry is facing major challenges and will need to find more versatile products to remain competitive. Large amounts of both solid and liquid residues are formed in the production line from tree to paper. Pulp and Paper Industries consume a huge number of resources like wood and water every year and create large amounts of solid wastes and wastewater that must be treated. Despite the highly challenging operating environment, demand for most pulp and paper grades is strong and business appears to be booming. The shift away from single-use plastic packaging and the growth of online retailing and food delivery is driving demand for recyclable/renewable paper bags, corrugated boxes, and lightweight and thermal paper-based packaging. This paper looks at barriers and drivers to energy efficiency in Pulp and Paper Industry. The paper aids the understanding of barriers and drivers for the Pulp and Paper Industry and provides scope for appropriate policy interventions. This focus will help policymakers evaluate to what extent future interventions may be warranted and how one can judge the success of interventions.

Keywords: *Energy Efficiency Barriers; Energy Efficiency Drivers; Energy Efficiency; Pulp and Paper Industry; Energy Management*

1. Introduction

South Africa is a major player in key pulp and paper segments in regional and global markets. The country is one of the world's largest producers of dissolving wood pulp and is the largest producer of pulp, paper, and paper products on the African continent. South Africa is ranked the 15th largest producer of pulp in the world and 24th in paper production. Much of this is invested in local resources, innovation, and people power. In 2013, the forestry-to-paper value-add to South Africa's economy was R18.2 billion – this equates to 0.6% of the country's gross domestic product (GDP) The Paper Story (2014). The pulp and paper industry are facing major challenges and will need to find more versatile products to remain competitive. Large amounts of both solid and liquid residues are formed in the production line from tree to paper. Pulp and Paper Industries consume a huge number of resources like wood and water every year and create large amounts of solid wastes and wastewater that must be treated. Despite the highly challenging operating environment, demand for most pulp and paper grades is strong and business appears to be booming. The shift away from single-use plastic packaging and the growth of online retailing and food delivery is driving demand for recyclable/renewable paper bags, corrugated boxes and lightweight and thermal paper-based packaging.

Research and Markets provides industry/market reports with respect to "The Manufacture of Paper and Paper Products in South Africa 2018". The report investigates the manufacture of pulp, paper, and related products, including tissue and packaging grades.

Shifting Demand: In South Africa, demand for writing paper and newsprint has declined due to the migration from print to paperless digital formats, leading some industry players to diversify their product lines or convert their operations to focus on higher-margin products with more sustainable revenue streams, such as packaging, pulp, tissue, packaging specialty papers and wrapping papers. Anti-plastic sentiment has created a growing market for sustainable packaging, and role players expect paper and paper-based products to progressively replace less sustainable materials.

Trends: The market has undergone several significant changes since the onset of the pandemic. Panic-buying and stockpiling of toilet paper and other products have moderated, while online shopping, online learning and working from home have been widely embraced. Online shopping continues to fuel demand for packaging. Demand for writing and printing paper declined but has since rallied. Role players say that tight market conditions and supply and demand imbalances continue to drive up prices.

Report Coverage: This report focuses on the manufacture of paper, pulp and paper products, and includes comprehensive information on the size and state of the industry, production and consumption, recycling, trends, the performance and development of major players and corporate actions. There are profiles of 35 companies including Mondi and Sappi, both recognised players internationally.

While the report focuses on the South African market, recent developments in the industry, as well as factors influencing the success of the sector, it also examines the state of the African and global pulp and paper markets. This report profiles 37 players in the industry, including Sappi, the largest manufacturer of dissolving wool pulp in the world with a 20% market share, Mondi, the global market leader in the industrial bags segment and Mpact, a market leader in the Southern African packaging segment.

The Manufacture of Paper and Related Products: Disruption in the South African pulp and paper market continues to take a heavy toll on producers of paper and related products. Total production and consumption of paper and paper-based products declined in 2017. The local pulp and paper market is dominated by Sappi Limited and the Mondi Group, which are both vertically integrated with significant forest plantations and manufacturing facilities. South Africa is ranked as one of the world's top 20 pulp producers, and manufacturing sales of paper and paper products totalled R75.51bn in 2017.

Opportunities and Challenges: Digitisation has prompted numerous manufacturers to restructure. Rationalization and streamlining initiatives in recent years, which include the closure or conversion of several pulp and paper production facilities, have generally yielded positive results. The industry continues to be affected by ongoing calls for a paperless society, declining consumption of printing and writing paper driven by digitization and an increase in the off-shoring of printing. The industry is also affected by land restitution claims and possible land expropriation without compensation, as well as wildfires and droughts.

There are, however, many opportunities presented by new technologies and innovation including in recyclable paper and lightweight, eco-friendly consumer packaging.

Greycon (2023) stated that:

''As we remarked last year, paper's importance remains undeniable even in this digital age. It features in almost all aspects of our daily lives. One might assume that the geopolitical instability and lingering supply issues from the COVID-19 pandemic would put a damper on demand. However, forecasts suggest that the international pulp and paper market will expand from $354.39 billion in 2022 to $372.7 billion in 2029.

While the global pandemic profoundly influenced every industry, most pulp and paper companies are successfully shaking off the effects. The gains made in e-commerce packaging have remained, and some firms have expanded them further. Nevertheless, public health restrictions persisted in some countries through part of 2022, and supply lines have not recovered fully. Moreover, inflation and labor shortages are affecting the whole world's economy. But the pulp and paper industry remains robust, and some familiar faces have posted record profits. Considering these dynamics, let's delve into the top ten pulp and paper manufacturers of 2022".

In the report Top 10 Pulp & Paper Manufacturers in 2022, Greycon (2022) provided the following re-report about Sappi, one of the country's top manufacturers, and exporters of pulp and wood products:

Sappi Limited is a leading global manufacturer of diversified wood fiber products, with a special focus on dissolving pulp, paper, packaging, and biomaterials. Headquartered in Johannesburg, South Africa, Sappi's strong presence in Europe, North America, and Southern Africa earned $7.3 billion in revenue in 2022.

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With a deep commitment to sustainable practices, Sappi utilises renewable resources to create innovative solutions that meet evolving global demand. Beyond paper, the company is recognised for its high-quality dissolving pulp used in textiles and consumer products. Sappi's wide range of paper products includes graphic papers, casting release papers, and packaging and specialty papers, serving numerous industries worldwide. Despite challenging market conditions, Sappi remains committed to its growth strategy, focusing on product innovation, operational efficiency, and sustainability.

Barriers prevent investments in energy-efficient technologies. It is also certain that there are drivers that help increase investments. The barriers hinder the penetration of energy-efficient technologies, even though these technologies have been shown to be economically cost-effective. If policies to encourage investments in improved energy efficiency are to be successful, understanding the nature of these barriers and drivers is essential. These policies must succeed both in highly regulated energy markets as well as in the context of liberalizing energy markets in increasing the development of a broad-based energy service industry Sudhakara (2013).

The aim of the present paper is thus to examine the nature of barriers and drivers for energy efficiency in the Pulp and Paper Industry. The paper aids the understanding of barriers and drivers for the Pulp and Paper Industry and provides scope for appropriate policy interventions. This focus will help policymakers evaluate to what extent future interventions may be warranted and how one can judge the success of interventions.

2. Background to Barriers and Drivers for Energy Efficiency Adoption

Sorrell (2004) defines a barrier to energy efficiency as "a postulated mechanism that inhibits a decision or behavior that appears to be both energy and economically efficient". To expand on this definition in the context of this research, a barrier is hereby referred to as a factor that negatively impacts an organization's intention to implement energy efficiency opportunities. Several studies have identified energy efficiency measures across a diversity of industries (Hasanbeigi et al., 2010, Worrell et al., 2001). These measures include low-cost or no-cost options for reducing organic fuel energy usage. Research has shown that the P & P industry does not adopt energy efficiency measures in despite of them being practical and able to reduce energy use significantly (Brown, 2001). The difference that arises between energy efficiency levels achieved and theoretical energy efficiency levels is hereby defined as the energy efficiency gap (Brown, 2001); (Jaffe and Stavins, 1994a).

Many debates have been undertaken about why energy efficiency measures are not adopted by industry and as of today many researchers have concluded that the industry is not willing to uptake technologies that can result in substantial energy savings (DeCanio, 1998); (Sanstad and Howarth, 1994). Two conflicting observations have been noted on the existence of energy efficiency gaps in industry. One observation takes cognizance of the fact that most energy managers take cost minimization decisions. This is because many managers prefer improvements that are cost-effective and therefore all projects not implemented are therefore regarded as being not cost effective. More consideration is hereby taken to view energy saving measures as being unnecessarily expensive hence are not important as the P & P industry is economically efficient already. However, the contrary observation exists which is that the P & P industry is not economically efficient since it does not adopt energy efficiency measures. These analysts base their observation on the expected level of energy efficiency that can be achieved by this sector. It is hereby concluded that many opportunities are not adopted because many barriers are still in place and inhibit improvement and these are discussed in detail in the following sections.

3. Barriers to Energy Efficiency in Pulp and Paper Industry

Barriers to energy efficiency in the P & P industry have been identified and summarized in several studies (De Groot et al., 2001); (DeCanio and Watkins, 1998); (Sardianou, 2008). These barriers have been categorized into different groups. In this research, barriers to energy efficiency adoption by P & P industry can be grouped into i) financial, economic and market barriers, ii) institutional, organizational and behavioral barriers, iii) technological barriers, and v) uncertainty barriers.

3.1 Financial, Economic and Market Barriers

Financial, economic and market barriers described in this dissertation are discussed below.

Availability of Capital – Competition between energy and maintenance projects for available capital is a huge barrier to energy efficiency measures adoption in the P & P industry. Availability of capital has a large impact on capital energy projects. Many energy projects require training of staff hence it is vital that enough capital is made available for energy projects. For energy efficiency projects to gain attention for allocation they must be well justified and the return on investment must be clearly defined (Reddy and Assenza, 2007).

High Hurdle Rates – Corporations often require high internal hurdle rates for investment to be undertaken, which are set at greater levels than the cost of capital (DeCanio, 1993). Investment decisions are subject to budget constraints. It is a complex decision to invest in new pulping processing capacity as the decision is highly dependent on present asset performance and expectations about the future (Reddy and Assenza, 2007). On the other hand, Hassett and Metcalf (1993) argue that “what appears to be myopic behavior, i.e. a high discount rate, may simply reflect an optimal investment strategy in the face of uncertainty”, and therefore the high hurdle rate is simply a manifestation of future uncertainty. The payback period is a financial tool that can be used to inform investment decisions and it is generally termed as the time required to recoup the investment cost through energy savings. Energy consumers generally insist on relatively short payback periods of approximately two years (Reddy, 1991). Some energy efficiency improvements have a relatively short payback period, however “deep retrofits” which save the most energy, require a longer time to pay back (Schwab, 2009). According to (Simon,1979), short paybacks required for energy efficiency investments may represent a rational response to risk.

Competing Investment Priorities – It is common for every organization will encounter competing investment priorities. Prioritizing energy projects as opposed to maintenance or process upgrade projects can cause a diversion from the pulp mill core business of producing pulp. Giving more attention to energy efficiency projects causes production process unreliability and low-capacity growth (Szklo and Schaeffer, 2007). Most companies tend to focus more on increasing market share of their products and increasing profit margin than on opting for energy efficiency projects which are viewed as having a small return on investment (Hassett and Metcalf, 1993). Preference is given to projects that produce new products or those that increase plant capacity and not to energy saving measures (Ren, 2009).

Economic Trend or Market Situation – An important obstacle for energy efficiency investments to take place is the external risk of the economic climate or market situation, such as an economic downturn. If a firm has difficulty raising additional funds through borrowing or share issues, energy-efficient investments may be prevented from going ahead due to a lack of available capital. In a stagnating market situation, investment in new technologies may be overshadowed by maintenance and minor improvements to extend the lifetime of existing technologies (Simon, 1979).

Delayed Investment Decision – Many organizations delay their investment decisions based on availability of information regarding return on their expenditure. A firm may also ‘hold’ an option to invest by waiting for new information that could affect the timing or attractiveness of the expenditure. This “ability to delay irreversible investment expenditure can profoundly affect the decision to invest”. The investor holds an option not to invest, prior to making an investment decision. This option of not investing is valuable because once the investment is made, the option is lost, as the investment cannot be undone (irreversibility of the investment).This option then becomes more valuable with increasing uncertainty in future energy costs (Hassett and Metcalf, 1993).

Perceived Cost of Energy Saving Measures – Generally, a higher initial cost is incurred for higher energy efficiency equipment (Reddy, 1991). There is a perception that these first costs are too high for energy efficiency measures. Despite the possibility of long-term savings, these high upfront costs can deter investment (Simon, 1979). The decision maker must decide whether to minimize upfront costs or minimize energy costs in the future (Reddy, 1991). In addition, energy-saving projects rarely rank equal with projects to capture new markets or increase production in fast growing economies. The main financial benefits of energy efficiency investments are focused on energy cost savings, as opposed to visible new production assets. The slow rate of return of investments and uncertainty about future energy prices, especially in the short term, can result in higher perceived risk and this risk leads to more stringent investment criteria associated with projects (Sardianou, 2008).

Transaction Costs – Small incremental opportunities in energy efficiency can lead to big savings, although as opposed to one large investment, these actions have transaction costs (Ren, 2009). Collecting relevant information and researching new technology uses valuable time and resources, therefore many industries may prefer to focus financial and human capital on other investment priorities (Simon, 1979). These transaction costs are often omitted in cost evaluations without justification. They mostly comprise information costs such as search costs, data collection costs, negotiating and monitoring costs. These costs depend on the organizational set-up and the routines for making and implementing decisions. Transaction costs are sometimes confused with hidden costs although in the true sense, transaction costs are a subset of hidden costs (Ostertag, 1999). Hidden costs are generally referred to in energy economics literature as any costs which are not conventionally included within engineering economic models (Sorrell, 2004). The various types of neglected or ‘hidden’ costs can include ‘production’ type costs such as the cost of possible production disruption or the embedded cost of specialist personnel for installation or maintenance due to energy efficiency measures (Ostertag, 1999).

Lack of Specialized Knowledge – According to Tonn and Martin (2000) and De Groot et al. (2001) the lack of knowledge by decision makers is one of the main causes of market failure to implement energy efficiency opportunities. The inability to account for the economic benefits of energy efficiency improvements is an additional information challenge and adequate management techniques, tools and procedures are often lacking within companies (Worrell and Price, 2001).

Lack of Credibility and Trust – Many energies usually users adopt the most credible information available to them (Reddy, 1991); (Rohdin et al., 2007). Information providers for energy efficiency should be well-informed and honest (Sorrell, 2004). It is common that some information providers such as energy services companies may be distrusted by many firms due to the lack of industrial sector-specific knowledge required to offer such services to give accurate energy consumption estimates (Brown et al., 1998).

Split Incentives – According to Brown et al. (1998), if actors cannot appropriate the benefits of an investment, energy efficiency opportunities are likely to be forgone. An example which is given is the lack of incentive to improve energy efficiency by individual departments within an organization if they are not accountable for their energy use. In addition, within businesses, operating and capital budgeting are often handled separately in the accounting and budgeting process. There may be split incentives or disconnect between the party who makes the initial investment or procurement decisions and the party who pays the ongoing operating costs. Therefore, projects may be rejected in the capital budget even though they provide investment-grade returns to the operating budget (Brown et al., 1998). This fundamental contradiction in incentives can lead to the inheritance of inefficient equipment (Reddy, 1991).

Furthermore, according to DeCanio (1993), the interests of managers and shareholders may not always coincide. Managers are induced to act in a manner as consistent as possible with the interest of the shareholders of the corporation, through the organizational design. Due to this principal problem many profitable investments might not be undertaken (Statman and Sepe, 1984).

Short-Term Thinking and Planning of Owners – Underinvestment in energy saving technologies has been frequently claimed to stem from short-sightedness of management. This short-termism is considered to manifest in very short payback periods required of investments (DeCanio, 1993). Often short-run earnings, earnings per share or sales growth are rewarded, and may encourage management to forego investment in the maximization of long-run value of the firm (Pinches, 1982). In addition, investment in human capital for energy conservation expertise i.e. retraining, will be low if the compensation and prestige of the managers responsible for energy use (facilities personnel) are less than the rewards for other positions (DeCanio, 1993).

Energy Management Not Core Business Activity – The behavior of individuals within the industrial firm affects the decision-making process for investment decisions. Investment in energy efficiency improvement is thus linked to managerial attitudes towards energy conservation. With this in mind, there is a common view that energy efficiency is often overlooked by management because it is not a core business activity, thus it is not worth much attention (Sardianou, 2008).

Bureaucratic Procedures Aimed at Garnering Government Incentives – Most organizations in the P & P industry do not undertake energy efficiency investments if they are not government-funded (Brown et al., 1998). It is common that some organizational policies in the P&P industry may prevent government from offering financial support for energy efficiency measures (Sardianou, 2008)

3.2 Technological Barriers

Technical Risks – Common technologies are generally preferred rather than new energy efficiency practices due to reliability and operational risks (Reddy and Assenza, 2007). Business decision makers are more likely to initiate energy efficiency adoption rather than engineering decision makers who should be involved due to the technical risks involved (Brown et al., 1998). Lengthy field testing of new technologies, slower diffusion of technology and more stringent investment criteria all impact negatively on energy efficiency adoption (Reddy and Assenza, 2007).

Technology Fitting into Process – It has been difficult to incorporate new technology into existing pulp mills (Zilahy, 2004). Process designs of existing processes makes it difficult to retrofit new technologies due to space limitations. Hence engineering decision makers tend to prefer installation of 'already known' process equipment as opposed to new technology with high savings returns.

Resistance to Replacing Existing Machinery – The resistance to replace existing machinery is an important obstacle to energy efficiency improvement (De Groot et al., 2001). The long lifetime of energy intensive industrial equipment can hamper replacements for new technology (Worrell et al., 2001). In many cases, equipment is used if its functioning can be preserved by regular maintenance (Zilahy, 2004). When a company invests in a new technology, it considers the depreciation costs of the existing machine that is not fully depreciated. This influences the payback period of the new technology as these costs for early depreciation need to be added to the operating costs of the new technology.

Loss of Flexibility in Process – Small technology modifications in pulp mills can result in major process upgrades and performance. Despite that, the uncertainty that goes with integrating new technologies with old ones due to fear of losing flexibility in processing is a huge barrier to energy efficiency adoption (Reddy and Assenza, 2007). The integration process may manifest in the process becoming more complex and very inflexible.

Uncertainty in Energy Price – Energy efficiency decisions involve the analysis of future energy prices and potential energy savings. Understanding the potential for future savings can be difficult as the variation and unpredictability of future prices are significant areas of uncertainty. Energy prices, and therefore the returns from an investment (avoided energy costs), are subject to fluctuations. This uncertainty seems to be a particularly important barrier in the short term (Velthuijsen, 1995). More stringent investment criteria are often the result of higher perceived risk from these uncertainties (Worrell et al., 2001). Investors tend to avoid investments by playing it safe, leading them to postpone the decision during times of economic instability when uncertainties are aggravated. (Hassett and Metcalf, 1993) suggest that the slow diffusion of new energy technologies may be the result of rational cost minimizing behavior in the light of uncertain future conservation savings, rather than the result of consumer/investor ignorance.

Uncertainty Related to Environmental Regulations – Uncertainty regarding environmental regulation poses a huge barrier to energy efficiency adoption in P & P industry (De Groot et al., 2001).

Uncertainty about Future Technologies – Fears that future technologies will be significantly better or cheaper can be a rational reason for decision makers to delay an investment in energy efficient technology. Delaying an investment means short term energy savings may be foregone. But due to the irreversibility of an investment, a firm waiting to install better technology options in the future may benefit in the long run (Van Soest and Bulte, 2001).

3.3 Drivers for Energy Efficiency ImprovementDrivers for Energy Efficiency Improvement

In addition to the development of a wide-scale support infrastructure, deploying energy efficiency also requires the investment of capital (Dutta and Mia, 2010). Drivers for energy efficiency improvement include:

Decrease in Technology Price Levels – The price of a technology is an important factor in the penetration of energy efficient technologies into the market. Competition can lead to a decrease in the cost of a technology (Reddy and Assenza, 2007).

Increase in Energy Prices – According to Reddy and Assenza (2007) a continuous and predictable increase in energy prices affects purchasing and investment decisions for energy efficient equipment, where the direct cost savings in energy bills through reduced energy consumption is a motivation to adopt energy efficient equipment (Reddy and Assenza, 2007).

Awareness – This is regarded as a key driver to energy efficiency since the flow of information created by awareness activities like campaigns and advertisements is rapid (Reddy and Assenza, 2007).

Technology Appeal – Non-economic motivators, such as the impression that energy efficient equipment gives, is a factor worth considering. Technologies 'smartness', such as that it looks 'appealing', 'fashionable', and 'modern', can be a dominating factor in high-income groups, where technology appeal is a major driving factor (Reddy and Assenza, 2007).

Non-Energy Benefits – From an end-user perspective, non-energy benefits can also motivate energy efficiency. These can be direct or indirect economic benefits such as from i) downsizing or elimination of equipment, ii) labor and time savings, or iii) increased reliability, convenience and productivity (Reddy and Assenza, 2007).

Environmental Regulations – The impact of environmental regulation is a key driver for energy efficiency since it allows companies to formulate a clear framework to monitor energy consumption due to charges involved in violating them. These regulations are a key driver of internal environmental costs which make energy saving investments very attractive (Reddy and Assenza, 2007).

Values and Culture – The values and culture shown by an organization is a combination of different individual values and culture. Top management values and culture have the greatest impact on the overall picture portrayed by an organization (Simon, 1979).

Credibility and Trust – This is key on the part of consultants in communicating energy saving suggestions to organization since the more credible you are the more your information is adopted and implemented.

4. Conclusions

This paper attempts to study the barriers and drivers that influence investments in energy efficiency. An investigation into factors influencing energy efficiency adoption found that there are many barriers to energy efficiency adoption by the P & P industry. Major barriers identified by the research were "energy costs are sufficiently important" and slow rate of return of investment in energy efficiency projects. Other noted barriers were capital availability, staff shortage for energy projects and uncertainty regarding the future of pulp mills. Key drivers to energy efficiency that were unveiled are government policy and corporate support. The understanding of barriers to energy efficiency adoption allows a better understanding of factors affecting industry and this initiates more detailed analysis which will enhance efforts to reduce energy consumption and greenhouse gas emissions.

After studying barriers and drivers to energy efficiency adoption, the overall recommendations for industry and government suggested by this research are for the Government to put aside funding for energy efficiency initiatives and energy auditing, more senior management involvement in energy efficiency initiatives, and more energy efficiency awareness for organizations so that all employees become aware.

REFERENCES

Brown, M. A. 2001. Market failures and barriers as a basis for clean energy policies. *Energy Policy*, 29(14): 1197-1207.

Brown, M. A., Levine, M. D., Romm, J. P., Rosenfeld, A. H. & Koomey, J. G. 1998. Engineering-economic studies of energy technologies to reduce greenhouse gas emissions: opportunities and challenges. Annual Review of Energy and the Environment, 23: 287-385.

De Groot, H. L., Verhoef, E. T. & Nijkamp, P. 2001. Energy saving by firms: decision- making, barriers and policies. Energy Economics, 23(6): 717-740.

Decanio, S. J. 1993. Barriers within firms to energy-efficient investments. Energy Policy, 21(9): 906-914.

Decanio, S. J. 1998. The efficiency paradox: bureaucratic and organizational barriers to profitable energy-saving investments. Energy policy, 26(5): 441-454.

Decanio, S. J. & Watkins, W. E. 1998. Investment in energy efficiency: do the characteristics of firms matter? Review of Economics and Statistics, 80(1): 95-107.

Dutta, S. & Mia, I. 2010. The global information technology report 2009–2010. World Economic Forum and INSEAD, SRO-Kundig, Geneva, Switzerland.

Greycon Top 10 Pulp & Paper Producing Manufacturers in 2021

Hasanbeigi, A., Price, L., Lu, H. & Lan, W. 2010. Analysis of energy-efficiency opportunities for the cement industry in Shandong Province, China: A case study of 16 cement plants. Energy, 35(8): 3461-3473.

Hassett, K. A. & Metcalf, G. E. 1993. Energy conservation investment: Do consumers discount the future correctly? Energy Policy, 21(6): 710-716.

Jaffe, A. B. & Stavins, R. N. 1994a. The energy-efficiency gap. What does it mean? Energy Policy, 22(10): 804-810.

Ostertag, K. Transaction costs of raising energy efficiency. IEA International Workshop on Technologies to Reduce Greenhouse Gas Emissions: Engineering-Economic Analyses of Conserved Energy and Carbon. Washington, DC, 1999.

Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden P.J. and C.E. Hanson, P.J., Eds. (2007) Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge, UK, 976 pp.

Pinches, G. E. 1982. Myopia, capital budgeting and decision making. Financial Management, 1(3): 6-19.

Reddy, A. K. 1991. Barriers to improvements in energy efficiency. Energy Policy, 19(1): 953-961.

Reddy, B. S. & Assenza, G. 2007. Barriers and drivers to energy efficiency. WP2007-003. IGIDR Working Paper Series.

Ren, T. 2009. Barriers and drivers for process innovation in the petrochemical industry: a case study.

Journal of Engineering and Technology Management, 26: 285-304.

ResearchAndMarkets -The Manufacture of Paper & Paper Products in South Africa 2018 - Opportunities in New Technologies and Innovation - ResearchAndMarkets.com | Business Wire The Manufacture of Paper and Paper Products in South Africa 2022 (researchandmarkets.com)

Rohdin, P., Thollander, P. & Solding, P. 2007. Barriers to and drivers for energy efficiency in the Swedish foundry industry. Energy Policy, 35(1), 672-677.

Sanstad, A. H. & Howarth, R. B. 1994. ‘Normal’ markets, market imperfections and energy efficiency. Energy policy, 22(1): 811-818.

Sardianou, E. 2008. Barriers to industrial energy efficiency investments in Greece. Journal of Cleaner Production, 16(13): 1416-1423.

Schwab, K. The global competitiveness report 2009-2010. 2009. Geneva: World Economic Forum.

Simon, H. A. 1979. Rational decision making in business organizations. The American Economic Review, 69(4): 493-513.

South African pulp and paper industry Summary of 2018 production, import and export statistics: https://thepaperstory.co.za/wp-content/uploads/2021/01/PAMSA-2018-Industry-Statistics-Summary-edited.pd

Sorrell, S. 2004. The economics of energy efficiency. Cheltenham: Edward Elgar Publishing.

Statman, M. & Sepe, J. F. 1984. Managerial incentive plans and the use of the payback method. Journal of Business Finance & Accounting, 11: 61-65.

Sudhakara Reddy, B. (2013). Barriers and drivers to energy efficiency – A new taxonomical approach. Energy Conversion and Management, 74, 403-416. https://doi.org/10.1016/j.enconman.2013.06.040

Szklo, A. & Schaeffer, R. 2007. Fuel specification, energy consumption and CO 2 emission in oil refineries. Energy, 32(7): 1075-1092.

Van Soest, D. P. & Bulte, E. H. 2001. Does the energy-efficiency paradox exist? Technological progress and uncertainty. Environmental and Resource Economics, 18(1): 101-112.

Velthuijsen, J. W. 1995. Determinants of investment in energy conservation. Doctoral thesis, Amsterdam School of Economics Research Institute, Amsterdam, Netherlands.

Wising, U., Berntsson, T. & Stuart, P. 2005. The potential for energy savings when reducing the water consumption in a Kraft Pulp Mill. Applied Thermal Engineering, 25: 1057-1066.

Worrell, E. & Price, L. 2001. Policy scenarios for energy efficiency improvement in industry. Energy Policy, 29(14): 1223-1241.

Worrell, E., Price, L. & Martin, N. 2001. Energy efficiency and carbon dioxide emissions reduction opportunities in the US iron and steel sector. Energy, 26(5): 513-536.

Zilahy, G. 2004. Organisational factors determining the implementation of cleaner production measures in the corporate sector. Journal of Cleaner Production, 12(4): 311-319.