

**РОЗВИТОК ПРОДУКТИВНИХ СИЛ ТА ГАЛУЗЕЙ.
ЕКОНОМІКА ТА УПРАВЛІННЯ ПІДПРИЄМСТВАМИ**

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Kayal Bassam, PhD, Professor

Department of Production Engineering, School of Industrial Engineering and Management, KTH Royal Institute of Technology, Stockholm, Sweden

Lina Abu-Ghunmi, PhD, Assistant Researcher,

Water Energy and Environment Centre, University of Jordan, Amman, Jordan, Islamic Development Bank visiting Scholar at Department of Production Engineering, School of Industrial Engineering and Management, KTH Royal Institute of Technology, Stockholm, Sweden

Diana Abu-Ghunmi, PhD, Associate Professor

Department of Finance, School of Business, University of Jordan, Amman, Jordan, Fulbright visiting scholar at Virginia Tech University, VA, USA

Mihai Nicolescu, PhD, Professor

Department of Production Engineering, School of Industrial Engineering and Management, KTH Royal Institute of Technology, Stockholm, Sweden,

Amir Rashid, PhD, Associate professor

Department of Production Engineering, School of Industrial Engineering and Management, KTH Royal Institute of Technology, Stockholm, Sweden

Iyad Al Khatib, PhD, Professor

Department of Computer Science, Faculty of Literature & Science, The American University of Culture & Education, Beirut, Lebanon, ITC, R&D, Stockholm, Sweden

Pulp Industry Performance and Circular Economy

The importance of pulp industry coupled with its intensive use of earth resources and its environmental pollution consequences raise concerns about the industry sustainability. This paper aims to review pulp industry performance in the context of circular economy, which achieves sustainability by tools of reduction, reuse and recycle. The study showed pulp industry is moving toward circularity through enhancing productivity by reducing materials consumption; fiber resource, water, chemical, and energy

pulp industry, circular economy, reduces, reuse, recycle

Каял Бассам, PhD, професор

Департамент виробничої інженерії, Школа індустріальної інженерії та менеджменту, КТН Королівський технологічний інститут, Стокгольм, Швеція

Ліна Абу Гунмі Ліна, PhD, науковий співробітник

Центр водної енергетики та довкілля, Амманський університет, Йорданія; дослідник Ісламського банку розвитку за запрошенням Департаменту виробничої інженерії, Школа індустріальної інженерії та менеджменту, КТН Королівський технологічний інститут, Стокгольм, Швеція

Діана Абу Гунмі, PhD, професор

Департамент фінансів, Школа бізнесу, Амманський університет, Йорданія; дослідник фонду Фулбрайта за запрошенням Технологічного університету Вірджинії, США

Міхай Ніколеску, PhD, професор

Департамент виробничої інженерії, Школа індустріальної інженерії та менеджменту, КТН Королівський технологічний інститут, Стокгольм, Швеція

Амір Рашід, PhD, професор

Департамент виробничої інженерії, Школа індустріальної інженерії та менеджменту, КТН Королівський технологічний інститут, Стокгольм, Швеція

Іяд Аль Хатіб, PhD, професор

Департамент комп'ютерних наук, Факультет літератури та наукових досліджень, Американський університет культури та освіти, Бейрут, Ліван та ITC, R&D, Стокгольм, Швеція

Целюлозно-паперова промисловість: продуктивність діяльності та економіка відтворення ресурсів

Інтенсивне використання природних ресурсів виробництва, що поєднується з забруднення навколишнього середовища, ставлять під загрозу стійке функціонування паперово-целюлозної промисловості. Метою даної статті є огляд роботи галузі з точки зору забезпечення продуктивної діяльності у ході створення економічних передумов стійкого розвитку за рахунок використання інструментів скорочення, повторного використання і відновлення виробничих ресурсів. У ході дослідження доводиться теза, що розвиток целюлозно-паперової промисловості відбувається у напрямі підвищення продуктивності за рахунок скорочення споживання матеріалів; волоконних ресурсів, води, хімічних речовин та енергії. У підсумку спостерігається скорочення обсягів продукування відходів виробництва та рівня забруднення ними навколишнього середовища, підвищується тривалість використання окремих матеріалів за рахунок їх повторного використання, переробки, відновлення енергетичних ресурсів, організації безвідходного виробництва

целюлозно-паперова промисловість, економічний цикл відновлення виробничого процесу, скорочення витрат, повторне використання, відновлення

Statement of the problem and analysis of recent researches and publications. The pulp and paper consumptions are used as indicators of the socioeconomic development of a nation [19]. The USA-EPA [22] classified pulp and paper industry as one of the major industry on the nation level. The pulp industry was traced back to the Chinese civilization in AD 105; however, it is still one of the very important industries in the world [2]. Kesalkar *et al* [9] reported that the annual increase in paper demand is 5 to 6%. Currently, the pulp industry annual supply of paper meets the demand of 5 billion people all over the world [2]. Moreover, paper production by 2020 is estimated to be 500 million tons [7]. The pulp industry is one of the most consuming industries of earthly resources, including forests (wood), water and energy. Furthermore, the pulp industry is classified as one of the major industries that causes pollution in the globe [22; 18; 20], which releases 0.1 million tons of toxic pollutants annually [3]. Wastes that are generated by this process are in three forms; liquid, solid and gas that need careful handling, treatment and disposal [7].

Forests are playing a crucial role in handling carbon dioxide problems (e.g. climate change), and they also contribute to ground and surface water resources. In the USA, Sappi [16] reported that forests contribute to about 67% of the fresh water, while 54% comes from timberland. Furthermore, the authors in [16] emphasize that forest industry consumes just 0.4% of the forest contribution to fresh water resources. Pulp and paper industry demand for water is expected to increase from 8.3 million in 200 to 4 million in 2020 [9]. Raw materials used by India's paper industry, which is classified as the world's 20th largest paper producer, comes from recycled paper, about 30%, and the rest comes from wood and non-wood sources [9]. The pulp industry, which is a highly water and energy intensive process [20], consumes 4% of the world energy and thus is classified as the fifth largest energy-consuming industry [7]. All in all pulp and paper industry is one of the largest water consuming industries [9; 20]. The importance of the pulp making industry coupled with its intensive use of earth resources and being one of the major polluted industries raises the concerns about the sustainability of this industry. In line with this need for sustainability, and the global demand for sustaining life on earth, the circular economy concept has been initiated and is currently being developed to handle sustainability issues using practical tools.

Circular economy is an ecology economy-based concept [8; 13; 25] that is based on the efficient management of earth resources within the frame of the earth ecosystem components and its working principles. On one hand, the components of the ecosystem are biotic and abiotic; i.e. living and non-living elements, respectively, that form the natural and synthetic working atmosphere of the earth resources. On the other hand, the principles of ecosystem management are based on efficient use of the resources and zero-waste generation and the tools to apply these principles are the concepts of reduce, reuse and recycle.

Statement of the objective. The aim of this paper is to review the performance of the pulping industry in light of the circular economy principles, with the focus on forest, water

and energy resources. The industry performance is reviewed according to the circular economy approach: reduce, reuse and recycle.

The main material. *Methodology.* The production factors of pulp industry are: material, energy, labors and capital. The concerns of this study, is the flow of material and energy flows throughout pulp industry and their compatibility with circular economy concept. The main materials are the fiber sources, water and chemicals, while energy forms are heat and electricity.

The approach that was applied in reviewing the performance of the pulp industry was based on reviewing the industry performance under two different scenarios. The first scenario applied the linear economic model principles, which are based on take, make and waste [14]. The second scenario applied the circular economy principles of reducing, reusing and recycling [8; 13; 25]. The reduction concept is based on reducing resources' consumption, by improving the efficiency of the production processes, and reducing waste generation. (1) Reducing resources' consumption and waste generation can be achieved also via the (2) reuse concept that aims to extend the product life through frequent use of the product without major changes in its original form; namely with simple repairing or modification and through (3) recycling the product into new product; which is achieved by applying large modification or bringing it back to its original components and/or material to be used for new applications. It is clear that the three principles; reduce, reuse and recycle are very interrelated.

Linear Economic Model. Pulp Production. The aim of this model is to produce a final profitable product that meets market demand and requirements, where profitability is a major issue for any industry. In line with this business model framework, what serves pulp production is pulp quality requirements, which in turn determine the type and the source of pulp raw material and the production processes [19]. Many fiber sources have been from wood sources, such as hardwood (e.g. oak, maple and walnut) and softwoods (e.g. pine or spruce) that are distinguished respectively by short and soft, and long and strong fibers. Each of these fibers has its specific applications. Furthermore, many of the production processes have been developed to produce the required quality; these processes are mainly mechanical pulping, chemical pulping and hybrid pulping that combines both mechanical and chemical pulping [7; 9; 19]. Most of the pulp and paper industry was established close to water course to meet its high water demand [20].

On one hand, mechanical pulping makes about one third of virgin pulp production worldwide [5; 6; 21]. These processes include Ground Mill Pulping (GMP) and Refiner Ground Mill (RGM), which produce pulp without removing lignin and the produced pulp is of short and weak fiber [15]. The mechanical pulping is distinguished by its high yield (90-95%) [19], very energy intensive and the pulp quality is limited for specific uses [7]. On the other hand, chemical pulping removes lignin and hemicelluloses to produce pulp of high purity of cellulose fiber [21]. The chemical pulping, in comparison with mechanical pulping is less energy consumption, but has low yield (40-50%), and high chemical consumption that has an impact on the profitability and the amount of waste produced [19; 21]. Chemical pulping is the dominant pulping processes with Kraft pulping (alkaline process) is ranked first in terms of use, others chemical processes include sulfite (Acidic process), soda and Neutral Sulfite Semi Chemical (NSSC). Chemical pulping, especially Kraft process, produces the strongest pulp, brown in color that can easily be bleached and is very bright [21]. Furthermore, its quality is high and can be used for high quality applications [21]. The advantage of the Kraft pulping is the potential of producing all sources of fibers using different types of wood that includes hard and softwood as well as non-wood sources that include bamboo, some kinds of grasses, kenaf and others [9; 20]. The hybrid processes include Thermal Mechanical Pulping (TMP) that pre-steam the fiber sources before mechanical treatment. Other process is the Chemical Thermal Mechanical Pulping (CTMP) that treats the fiber sources by chemical means in addition to the

thermal and mechanical treatment [19]. These hybrid processes are developed with the aim to overcome some of the negativities of chemical and mechanical pulping processes [1] such as energy consumption and chemical consumption while maintain the required quality. Hybrid processes have higher yield than the chemical processes but have less energy consumption than the mechanical.

Outputs of the production processes. The outputs of the pulp production processes are not only pulp, which is the main product, but also wastes that include; wastewater, solid waste and air pollutants (Figure 1). These by-products are discharged to the environment; namely, to water bodies, soil and air. Increasing demand and industry expansion has increased the burden on the environment to the extent that these wastes become unmanageable anymore by the natural processes of the environment and hence require human action. Therefore, environmental regulations have been developed and become guide to control the discharge to the environment; such as the standards of reclaimed wastewater discharge that have been developed on the country bases. In response to the emerged situation, the linear economic model has focused on the end of pipe management of these wastes.

Many stages and different technologies have been developed for treating pulp wastewater that include mainly two stages primary and secondary treatments, and in some situations tertiary stage is applied. In each of these stages different types of treatment technologies have been applied that includes basically; physical, chemical, biological and/or physio-chemical processes [10; 11]. While solid waste is mainly handled by combustion, incineration and/or land fill as final disposal stage or option [12; 24]. Air pollutants treatment focus on filtration, air scupper and other physio-chemical techniques [4]. This end of pipe approach in handling pulp industry waste require extra investment and thus significant impact on industry profitability and it is sustainability on the long run.

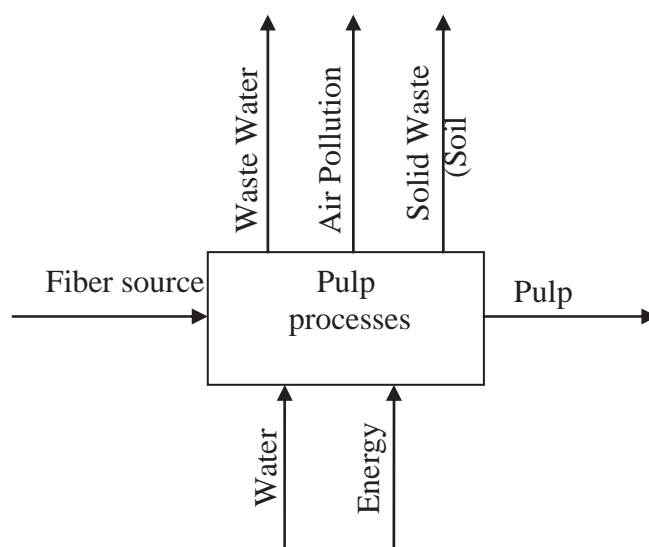


Figure 1 – Schematic Diagram of the Inputs and Outputs of the pulp industry

Source: compiled by the authors.

Circular economic model. The aim of this model is to sustain the final product that meets market demand and requirements, and make certain profitability. This objective highlights the pillars of product sustainability, which includes environmental, social and economic aspects that should be kept in harmony. The core of sustaining the production process is to view the waste as a valuable resource that should be handled carefully. The circular economy concept stresses that the core of the industrial process sustainability is the efficient management of the resources, which means increasing productivity with zero waste. The tools of this concept are: reduce, reuse and recycle.

Reduction. The reduction concept is based on reducing raw material consumption, namely increasing production efficiency and reducing waste generation, if not eliminating waste altogether. Waste elimination, along with increasing production efficiency, reduces negative impact on the environment and boosts industry profitability. Production efficiency is enhanced initially by reducing raw material consumption, for the same amount of production and through modifying production processes. Approaches that are applied to achieve this are many including:

Reducing material consumption. Reducing material consumption in pulp industry entails (a) using fiber sources of higher yield, such as hardwood that has higher pulp yield than the softwood; however for specific pulp quality using softwood is a must. (b) Using fiber sources that are more environment friendly such as: raw material with short cultivation period such as grass, bamboo and kenaf [9; 20] reported that agro-waste such as vegetables, bagasses, rice husk; fibers and also waste-paper is environment friendly. (c) Using the byproducts of other industries such as wood sawing residual to replace logs and/ or (d) utilizing logs from only certified forests that comply with specific environment regulations [17].

Furthermore, reducing water and energy consumption in pulp industry involves (a) using water discharge from one process to other processes, based on the quality of effluent and the required quality of the influent. This reduction in water consumption is directly linked to energy consumption in the pulp industry. The reason as reported by Sappi [16] is that water should be heated or steamed in order to be used in pulp production, such as in the digestion and washing processes.

Reduction of material consumption can also be achieved through production processes by; (a) Developing new techniques for pulp production, whenever possible, that reduce resources consumptions such as Kraft and sulfite processes, which use less energy than mechanical processes [19]. Furthermore, modifying the mechanical processes to TMP in order to reduce energy consumption and to CTMP to reduce chemical consumptions as well [1]. (b) Modifying and replacing the common bleaching process by elementary chlorine free (ECF) and total chlorine free (TCF) to reduce hazardous discharge to the environment [17; 18; 23]. (c) Replaying the hydraulic debarking process by a mechanical process to significantly reduce water consumption [9]. (d) Developing recovery process to reduce chemical consumption, such as recovery boiler and suing lime kiln in the Kraft pulping [21], and / or (e) Introducing biofuel and wood residue that include bark and others, to operate the power boiler in order to produce steam and thus reduce fossil fuel consumption [19].

Reducing waste production. Waste reduction is achieved by reducing waste generation and reducing waste discharge. Reduction of waste generation is achieved in parallel with reducing material and energy consumption; such as (a) reducing solid waste generation by using biofuel power boiler. (b) Reducing wastewater generation by moving from hydraulic to mechanical debarking and using a recovery boiler and / or (c) Reducing air pollutants by developing technologies to recover some of off-gasses; e.g. Sulphur, to prevent its discharge to the environment [4; 23].

Reducing waste discharge can be achieved by handling waste that could not be avoided in the production processes. For example, applying different techniques for treating wastewater to prevent discharge of pollutant to the environment. Pulp wastewater sources are two; process wastewater and cooling wastewater [16]. Treating process wastewater is a must as it consists of organics and inorganic materials in addition to the microorganism that have negative impact on the environment [16; 23]. Cooling water needs at least treatment to reduce its temperature to environment temperature [16]. The solid waste in term of sludge that is result from of lime kiln and from wastewater water treatment plant, is handled different by techniques such as dewatering followed by incineration and/ or as last step is landfill disposal

[16]. Furthermore, in some situation the fiber in wastewater could be recovered for reuse or recycle in pulp mill and last step is landfill disposal [16].

Reuse. The reuse concept aims to extend the life of the products/ by-product, but with no or simple modification in its original form. In this framework the reuse concept views things that have no values, and have been classified as waste, as valuable resources that can be used for other purposes. Therefore, many of the by-products of pulping industry are treated as resources for other applications. Among these reuses are; (a) using by-products such as barks, dissolved lignin and hemicelluloses as energy sources to reduce energy consumption (b) using spent paper in production of pulp to reduce raw material consumption. (c) Using the handled sludge and ash as fertilizers, and (d) using high pressure steam to generate electricity, low pressure steam for heating, and then using the condensate in steam production, all of which reduces energy consumption. Furthermore, treated wastewaters can be used for many internal purposes.

Applying the reuse concept required developing production technology and guidelines for the proper reuse. At the technological level, for example, a rotary kiln and recovery boiler have been developed to burn barks, and lignin & hemicelluloses, respectively. Another example of technological advances to apply the reuse concept is; dewatering the sludge produced by wastewater treatment plant before combusting or composting it. At the management level, for example, keeping different types of wastes, even of similar forms, separated based on their characteristics and potential applications. It should be noted that wastewater discharged from the industrial process is different in its characteristics from those of water discharged from the cooling process [1]. Even more while pulping process produces heavy loaded wastewaters, bleaching process produces wastewater that is less in organic loads but carries more hazardous materials [7].

Recycle and Recover. The recycle in pulping industry entail (a) recycling the digestion solution after combustion in recovery boiler and (b) recycling of lime (CaO) after treatment in the lime kiln. In the meantime the recovery involves recovery of energy in the form of heat in rotary kiln and recovery boiler, which is converted to electricity in some situation.

Conclusions and prospects for further researches. Pulp industry is consumes energy and water intensively. It basically relies on forest wood material that is one of the most earthly valuable and endangered resources. The importance of this industry to human beings attracts the attention to sustain both: this industry and the environment.

The methodology that we propose in this paper focuses on evaluating the performance of this industry, and it is based on analyzing two scenarios: (1) the base line scenario that applies the traditional linear economic model and (2) the circular economic model scenario, which was based on sustainability.

The review and analysis process revealed that the pulp making industry is moving forward towards circular economy. This was indicated by its performance in: (1) reducing resources consumption and waste production, (2) reusing some of the materials in different applications, and (3) minimizing waste production through recycling and recovering material and energy from what was previously treated as waste.

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Каял Басам, PhD, професор

Департамент производственной инженерии, Школа индустриальной инженерии и менеджмента, КТН Королевский технологический институт, Стокгольм, Швеция

Лина Абу Гунми, PhD, научный сотрудник

Центр водной энергетики и окружающей среды, Амманский университет, Иордания; исследователь Исламского банка развития по приглашению Департамента производственной инженерии, Школа индустриальной инженерии и менеджмента, КТН Королевский технологический институт, Стокгольм, Швеция

Диана Абу Гунми, PhD, профессор

Департамент финансов, Школа бизнеса, Амманский университет, Иордания; Исследователь фонда Фулбрайта по приглашению Технологического университета Виргинии, США

Михай Николеску, PhD, профессор

Департамент производственной инженерии, Школа индустриальной инженерии и менеджмента, КТН Королевский технологический институт, Стокгольм, Швеция

Амир Рашид, PhD, профессор

Департамент производственной инженерии, Школа индустриальной инженерии и менеджмента, КТН Королевский технологический институт, Стокгольм, Швеция,

Ияд Аль Хатиб, PhD, профессор

Департамент компьютерных наук, Факультет литературы и научных исследований, Американский университет культуры и образования, Бейрут, Ливан и ИТС, R&D, Стокгольм, Швеция

Целлюлозно-бумажная промышленность: производительность деятельности и экономики возобновления ресурсов

Интенсивное использование природных ресурсов производства, которое сочетается с загрязнением окружающей среды, ставит под угрозу устойчивое функционирование целлюлозно-бумажной промышленности. Цель данной статьи – обзор отрасли с точки зрения обеспечения производительной деятельности в ходе создания экономических условий стойкого развития за счет использования инструментов сокращения, повторного использования и возобновления производственных ресурсов.

В ходе исследований обосновывается точка зрения, согласно которой развитие целлюлозно-бумажной промышленности происходит в направлении повышения производительности за счет сокращения потребления материалов, волоконных ресурсов, воды, химических веществ и энергии. В результате наблюдается сокращение объемов отходов производства и уровня загрязнения ими окружающей среды, повышается длительность использования материалов за счет их повторного использования, переработки, возобновления энергетических ресурсов, организации безотходного производства.

Методология, которую предлагается в данной статье, позволяет уделить основное внимание оценке эффективности функционирования отрасли, которая базируется на использовании двух сценариев: базового, в основе которого лежит традиционная линейная модель экономики, и сценарий круговой экономической модели, который обеспечивает устойчивое развитие.

целлюлозно-бумажная промышленность, экономический цикл возобновления производственного процесса, сокращение расходов, повторное использование, возобновление

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О.О. Селезньова, доц., канд. екон. наук

Одеська державна академія будівництва та архітектури, м. Одеса, Україна

Методологічні аспекти дослідження управління маркетинговою діяльністю будівельних підприємств

У статті розкрито методологічні аспекти дослідження управління маркетинговою діяльністю будівельних підприємств. Обґрунтовано вибір предмету, об'єкту, мети дослідження. Обґрунтовано логіку та сутність змісту дослідження, що містить теоретичні основи управління маркетинговою діяльністю будівельних підприємств, методологічні засади дослідження обраної проблематики, стан та тенденції розвитку управління маркетинговою діяльністю будівельних підприємств, концептуальні основи та основні напрямки удосконалення управління маркетинговою діяльністю будівельних підприємств.

управління маркетинговою діяльністю, будівельне підприємство, методологія, менеджмент, маркетинг

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