Energy Efficiency and Industrial Competitiveness: The Case of Midwest Pulp and Paper Mills

Nate Aden, James Bradbury, and Forbes Tompkins, World Resources Institute[1]

ABSTRACT

Pulp and paper mills are the third largest energy-using manufacturing sub-sector in the U.S. In 2010 the pulp and paper sector accounted for 7 percent of total U.S. industrial energy use. As the U.S. region with the largest industry share of overall economic activity, the Midwest is of central importance for industrial energy efficiency and forging a new low-carbon economy. How do pulp and paper mills located in the Midwest compare with the rest of the country? This paper uses mill-level energy-use and production data and the ENERGY STAR© Energy Performance Indicator (EPI) tool to assess the energy efficiency performance of Midwest pulp and paper mills. The results of this EPI assessment indicate that Midwest mills are less efficient than the national average and have numerous energy efficiency improvement opportunities.

Energy cost reduction, improved competitiveness, and reduced environmental compliance costs provide a compelling business case for Midwest pulp and paper mills to invest in facility-appropriate energy efficiency improvements and energy management programs. On a national scale, the pulp and paper sector has recently experienced contraction and consolidation. While production remains below year 2000 levels and employment has dropped steeply, the sector has recorded increasing levels of economic activity. Between 2002 and 2011 U.S. paper manufacturing value-added grew by 8 percent while the number of employees declined by 30 percent. In this environment of consolidation, attrition, and increasing competition, energy efficiency serves as a determinant of pulp and paper mill survival. The role of energy efficiency performance in pulp and paper manufacturing competitiveness is demonstrated in case studies of successful mills. The information and case studies in this paper demonstrate that investment in energy efficiency improvements can help facilities successfully compete while creating a robust, lower-emissions pathway for U.S. manufacturing.

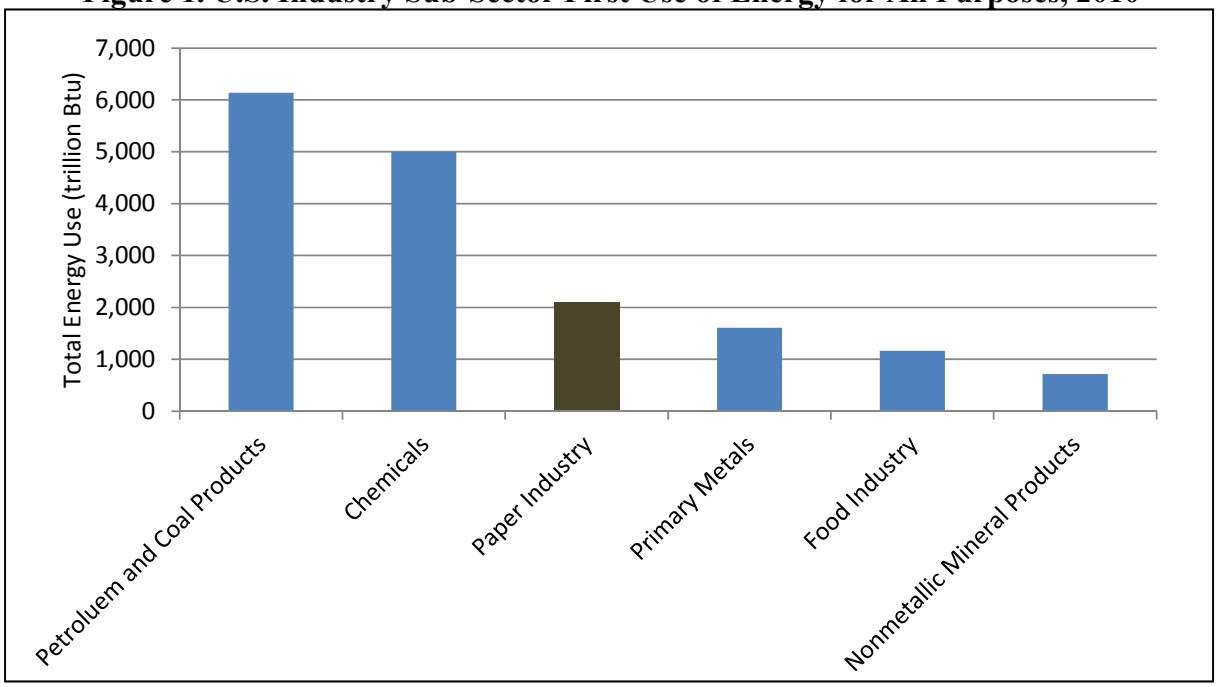
Introduction

Rising international energy and labor costs are combining with historically-low natural gas prices and improving productivity in the U.S. to create an intermittent resurgence of American manufacturing. In a 2012 survey of company decision makers, the Boston Consulting Group found that 37 percent of manufacturers with sales greater than $1 billion are planning to bring back production to the United States from China or are actively considering it. At the same time that companies are looking to grow their American manufacturing capacity, the long-anticipated finalization of the EPA's Boiler Maximum Achievable Control Technology (MACT) standards in December 2012 has created a foundation of regulatory certainty that will generate new investments for compliance actions. These developments bring new opportunities for low- and negative-cost efficiency investments that improve economic competitiveness.

[1] This paper is based on a WRI report entitled "From Pulp to Paper: Energy Efficiency in U.S. Midwest Pulp and Paper Mills".

In 2010, the U.S. produced 78 million metric tons of paper and paperboard, accounting for 19 percent of global production. That level of production required approximately 2 Quads of final energy use, as illustrated in Figure 1 below. Between 2009 and 2012 the value of U.S. paper exports grew by an average annual rate of 5 percent.[2] The paper sector is among many U.S. manufacturing sectors that contributed to the post-2008 U.S. economic recovery. However, at the same time, many mills have closed and struggled to compete in the face of changing markets.

Figure 1. U.S. Industry Sub-Sector First Use of Energy for All Purposes, 2010



Source: DOE 2013.

This analysis focuses on pulp and paper mills in the U.S. Midwest. The Midwest is an important region for understanding U.S. manufacturing energy use, greenhouse gas emissions, state programs, and policies. Manufacturing represents a greater share of total GDP and total workforce in the Midwest than in any other U.S. region. The industrial sector, which is predominantly made up of manufacturing, consumes more energy than any other sector in the Midwest region.[3] In 2010 the pulp and paper sector accounted for roughly 7 percent of total energy use by Midwest manufacturers, which was nearly twice as much as total regional energy consumption by vehicle manufacturers.[4]

Pulp and paper mills in the Midwest are more fossil fuel-intensive—and therefore more carbon emissions-intensive—than other mills in the U.S. In energy terms, fossil fuels accounted for 53 percent of Midwest mills' total final energy use in 2010 compared to 33 percent of total U.S. paper industry final energy use.[5] At the regional and national level, the pulp and paper

[2] The scope of paper trade is here defined by international Harmonized System code 48 (Paper, Paperboard).
[3] Bradbury and Aden 2012.
[4] DOE 2013.
[5] Fisher 2013; DOE 2012a.

sector is less fossil fuel-intensive than total U.S. industry, where 76 percent of total delivered energy use is from fossil fuels.[6]

The pulp and paper sector plays an important role in Midwest manufacturing. In Wisconsin, the largest paper manufacturing state in the Midwest, pulp and paper mills used an estimated 24 percent of total statewide energy for manufacturing—36 percent more than the next largest manufacturing sector.[7] The extent of Midwest pulp and paper manufacturing combines with its fuel mix and energy intensiveness to create substantial environmental impacts.

Published studies suggest that by applying current practices used by the most modern mills, the pulp and paper sector's purchased energy consumption could be reduced by 25 percent with current technologies, and up to 41 percent pending continued technology development.[8] According to DOE, the sector's cost effective energy efficiency (EE) potential in 2020 could reduce its energy consumption between 6 and 37 percent.[9] Within that range, McKinsey and Company estimate that an acceleration of adopting proven technologies and process equipment could reduce the sector's energy usage by 26 percent by 2020.[10] From those savings, the majority are predicted to come from fiber substitution, multi-process improvements, paper making, and steam efficiencies.

1. Sector Assessment with Efficiency Benchmarking and Emissions Inventory

This section evaluates the relative energy performance of the Midwest pulp and paper sector and estimates potential energy cost savings associated with energy efficiency improvements by regional mills. Greenhouse gas emissions reductions are also assessed under energy efficiency and fuel-switching scenarios. This bottom-up analysis is based on facility-level energy-use and production data from the private Fisher database.[11] Benchmarking is conducted to assess the relative energy-intensity of pulp-only mills and integrated pulp and paper mills in the region using an ENERGY STAR Energy Performance Indicator (EPI) Tool published in 2012. Greenhouse gas emissions are estimated by using a GHG calculator developed by the National Council for Air and Stream Improvement (NCASI) for the U.S. pulp and paper sector.

Benchmarking is a well-established method for quantifying facility, sector, or national-level energy and emissions performance. The methods involved in benchmarking industry energy use and emissions involve several considerations that influence final results. Five key issues include definition of product or sector (e.g., total pulp and paper versus market pulp), calculation methods and boundaries (e.g., whether to include indirect emissions associated with purchased energy), units for normalizing the benchmark (e.g., tons of output or value added), benchmark ambition (e.g., average versus best practice), and data sources (e.g., government surveys versus industry associations).[12] This study resolves these issues by using an established, publicly-available benchmarking framework established by the U.S. Environmental Protection Agency.[13]

[6] DOE 2012a.
[7] Bradbury and Aden 2012.
[8] NAS 2010.
[9] Brown et al. 2011.
[10] NAS 2010.
[11] Fisher 2013.
[12] SEI 2010.
[13] Boyd and Guo 2012.

Benchmarking provides a quantitative basis for comparative assessment and identification of energy efficiency gaps. Numerous publications have assessed the energy efficiency gap across multiple sectors of the U.S. economy as a whole[14] —largely from an economic perspective. Within industry, a number of engineering-accounting studies have quantified the energy efficiency gap for particular sectors.[15] As an economic and geographical center for U.S. manufacturing, the Midwest region—and individual Midwest states—has also been the subject of energy efficiency gap assessments.[16] Compared to prior publications, this paper provides a uniquely detailed assessment of paper sector energy efficiency opportunities throughout the Midwest.

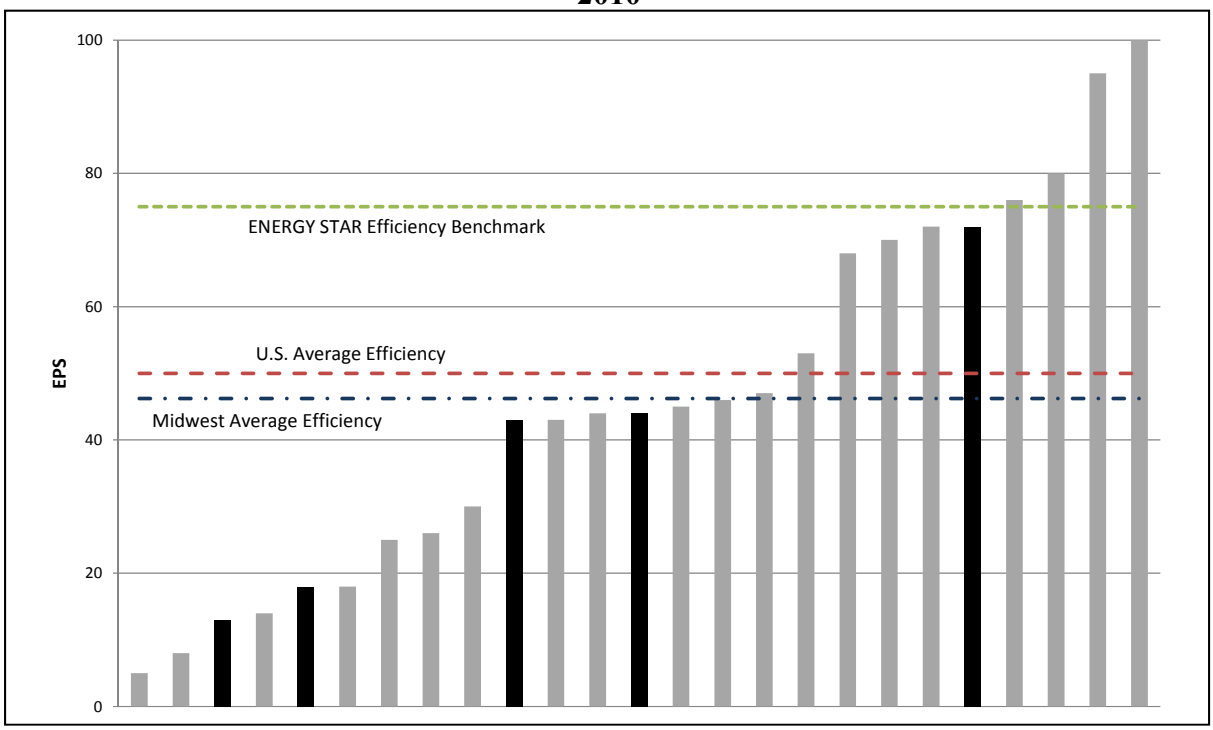
1.1. Pulp and Paper Mill Energy Efficiency Benchmarking

In order to assess paper mill energy performance on a comparable basis, the U.S. Environmental Protection Agency's ENERGY STAR program collaborated with industry representatives to develop an energy performance benchmarking tool for pulp mills and integrated pulp and paper mills. The core of the program is a piece of software called the Energy Performance Indicator (EPI) tool that compares an individual mill's energy performance with comparable mills with similar product mixes throughout the U.S. The ENERGY STAR Industrial program has developed EPI tools for various manufacturing sub-sectors based on confidential facility-level Census data.[17] In order to move beyond the one-size-fits-all benchmarking approach described above, the following analysis plugs facility-level energy use and production data into the EPI tool that was developed for pulp only mills and integrated pulp and paper mills (but not for paper-only mills). This EPI assessment covers more than 40 percent of total regional paper production by weight and 59 percent of total energy used by the Midwest pulp and paper industry in 2010.

The results of the EPI analysis for the 25 pulp and integrated pulp and paper mills located in the Midwest are shown in the figure on the next page.

[14] Jaffe and Stavins 1994; McKinsey and Company 2009; NAS 2010; Allcott and Greenstone 2012.
[15] Worrell, Price, and Martin 1999; DOE 2007; Oda et al. 2012.
[16] Livingston, Mason, and Rowe 2009; DOE 2009b; Energy Center of Wisconsin 2009; DeWahl et al 2010.
[17] EPI tools are publicly distributed online. A copy of the integrated pulp and paper mill EPI tool can be downloaded at http://www.energystar.gov/ia/business/industry/downloads/Integrated_Paper_Mill_EPI_v1.xls?a763-30d2.

Figure 2. Midwest Integrated and Pulp Mill Energy Performance Indicator Assessment, 2010



Note: integrated mills are displayed as grey bars and pulp-only mills are displayed as black bars.

This paper's EPI analysis finds that Midwest pulp only mills and integrated pulp and paper mills are slightly less efficient than the average U.S. mill. The dotted blue line in the figure above illustrates the un-weighted average Midwest benchmarked facility Energy Performance Score (EPS) of 46—slightly below the normalized U.S. average EPS of 50. The dotted green line shows the minimum EPS score required for ENERGY STAR certification. As illustrated by the black bars in the figure above, Midwest pulp-only mills are overall less efficient than other U.S. pulp mills and have an un-weighted average EPS of 38. If all 21 of the Midwest mills below the ENERGY STAR Efficiency Benchmark line invested in energy efficiency to achieve this level of performance they would realize gross energy savings of 36 trillion Btu per year according to results of the EPI analysis.[18] Among these mills, improvement to the ENERGY STAR benchmark efficiency performance level would reduce total purchased energy use by 30 percent. At the average Midwest 2010 paper sector purchased energy cost of $6.69/million Btu, these energy savings would have saved Midwest pulp-only mills and integrated pulp and paper mills approximately $240 million annually.

1.2. Emissions Scenarios: Savings from Fuel Switching and Efficiency Improvements

To quantify the extent and distribution of greenhouse gas emissions from Midwest pulp and paper sector, this study presents an inventory of energy-related non-biogenic CO_2 emissions

[18] The lack of facility-specific information regarding currently installed-technologies prevents us from estimating the upfront investment costs that would be necessary for underperforming mills to achieve U.S. average or EnergyStar levels of performance. As a result, we are not able to estimate the net cost savings associated with achieving these benchmarks.

from each of the 93 pulp and paper mills operating in the Midwest in 2010.[19] As with energy efficiency benchmarking, calculation of emissions inventories involves a range of assumptions and intermediate variables that influence final results. This study uses a GHG emissions calculation tool developed for the U.S. pulp and paper sector by the National Council for Air and Stream Improvement (NCASI)—an independent, non-profit research institute that focuses on environmental topics of interest to the forest products industry. Energy-related CO_2 emissions are calculated using version 1.3 of the NCASI pulp and paper manufacturing GHG tool, which is publically available.[20] The NCASI GHG tool was developed in 2005 to conform to the WRI/WBCSD GHG Protocol, and updated in 2008 to incorporate revised data from the 2006 IPCC guidelines for National GHG Inventories.

This analysis finds that Midwest pulp and paper mills generated 18 million metric tons of direct and indirect carbon dioxide emissions in 2010.[21] The EIA 2012 Annual Energy Outlook separately estimates total U.S. pulp and paper sector emissions of 77 million metric tons carbon dioxide equivalent in 2010.[22] Whereas Midwest pulp and paper mills produced 18 percent of total U.S. output, by weight, in 2010,[23] regional mills accounted for 24 percent of the sector's total national aggregate CO_2 emissions in the same year.[24]

Scenario analysis shows that investments that brought Midwest pulp and paper mills to the ENERGY STAR benchmark level for top performance would also result in greater carbon dioxide emissions reductions than would be achieved through fuel switching from end use of coal or oil to natural gas alone. Efficiency improvements would reduce facilities' carbon dioxide emissions by a total of 34 percent—15 percent more than fuel switching from end use of coal or oil to natural gas (though these options are not exclusive and could beneficially be done in combination). The specific impact of increased biomass use depends on life-cycle emissions assumptions; however, it is clear that biomass use can reduce mill costs and displace fossil fuel use. Likewise, the longer-term transition of electricity systems away from fossil fuels can largely reduce pulp and paper sector greenhouse gas emissions—to the extent that mills increase their use of renewably generated electricity. This scenario analysis demonstrates that efficiency improvements to the ENERGY STAR benchmark level of proven best-practice technologies would mitigate near-term emissions more than maximizing sector natural gas usage.

2. Energy Efficiency Options in Pulp and Paper Manufacturing

Whereas the above text presents a bottom-up assessment of mill energy efficiency performance and carbon emissions, this section uses aggregate, national-level data to describe the range of available energy efficiency options. Energy efficiency cost curves illustrate the relative cost and energy savings potential of existing EE technologies. The cost curve display has

[19] According to emissions data reported to the EPA registry (EPA 2012b) (http://www.epa.gov/ghgreporting/ghgdata/datasets.html) energy-related CO_2 emissions accounted for roughly 99 percent of U.S. pulp and paper sector greenhouse gas emissions (measured in terms of CO_2 equivalent over a 100 year time horizon). The remaining GHG emissions source categories are nitrous oxide and methane.
[20] See http://www.ncasi.org/support/downloads/Detail.aspx?id=3..
[21] For more information on this paper's emissions inventory (e.g., emissions factors assigned to each fuel type) see the related WRI report.
[22] DOE 2012a.
[23] Fisher 2013.
[24] DOE 2012a.

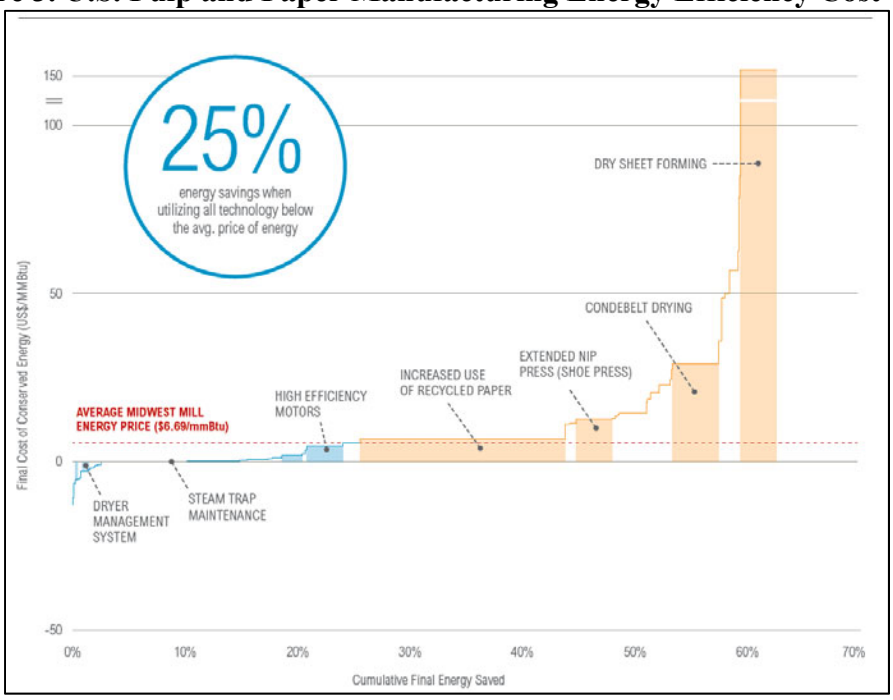
been popularized through studies of industrial energy efficiency potential in California[25] and on a national scale by McKinsey & Company, who previously estimated negative costs associated with the net present value of energy efficiency improvements for the residential, commercial, and industrial sectors by the year 2020.[26] This study presents an updated, regionalized version of the U.S. pulp and paper sector cost curve developed by the Lawrence Berkeley National Laboratory.[27] The cost curve data show that the U.S. pulp and paper sector could cost-effectively reduce its energy intensity by 25 percent.

Data limitations prevent a facility-level assessment of how widely particular EE measures have already been adopted by mills in the Midwest or elsewhere in the U.S. However, results of the EPI analysis above show that Midwest pulp and paper mills are less efficient that the U.S. average, which suggests that they have not yet fully implemented the energy efficiency options described in this section. This section offers a menu of EE options for Midwest mills to consider for significant energy savings; available data do not support mill-specific recommendations.

The figure below presents a U.S.-scale EE cost curve with each measure's cost of conserved energy (2010$/mmBtu) and saved final energy (percent of total average energy intensity). Within the curve, the width of each horizontal segment indicates the energy savings potential for each measure while the vertical height corresponds to the cost per unit energy saved for each measure. Individual energy efficiency options for the paper sector were ordered from least expensive to most expensive. The curve is based on aggregated data for the pulp and paper sector across the entire U.S., illustrating range of proven technology options available for cost-effective EE investments.

[25] Coito et al. 2005.
[26] McKinsey and Company 2009.
[27] Xu, Sathaye, and Kramer 2012 presents cost curves for saved energy and carbon reduction for the U.S. pulp and paper industry in 1994 and 2006. This report adapts the 2006 saved energy cost curve that assumes a 30 percent discount rate.

Figure 3. U.S. Pulp and Paper Manufacturing Energy Efficiency Cost Curve, 2010



Sources: Xu, Sathaye, and Kramer 2012; Bureau of Labor Statistics 2012.

This U.S. pulp and paper sector cost curve displays information for 101 established energy-saving technologies with the lowest cost of conserved energy. These technologies have a cumulative final energy savings potential of 62 percent of total average energy intensity. [28] The Y-axis values of Figure 3 range from negative $13/MMBtu to positive $157/MMBtu; options with a negative cost below $50/MMBtu and positive cost above $200/MMBtu account for less than 1 percent of the identified final energy savings potential. For comparison, the horizontal dotted line in the figure shows the average 2010 energy price for Midwest pulp and paper mills.[29]

By comparing the cost curve with the average energy price[30] we learn that cumulative savings of 25 percent are available for less than the average cost in 2010 for a typical Midwest mill to purchase energy. The figure also shows that the typical cost of increased use of recycled paper is within $0.15/MMBtu of the 2010 average Midwest energy price and would yield a significant additional 18 percent of savings. Increased recycling can require high capital expenditures for equipment retrofits and have varying emissions impacts depending on the fuel mix of consumed electricity. The overall finding that Midwest paper mills could cost-effectively reduce their energy use by 5-8 mmBtu/metric ton is consistent with the IEA's assessment that the U.S. pulp and paper sector could reduce energy intensity by 5.3 mmBtu/metric ton with implementation of best available technologies.[31] With higher energy prices, cost-effective energy savings would increase. Between 2010 and 2012 average industrial natural gas prices dropped

[28] These percentage savings estimates are based on national-level data reported in Xu, et al. 2012.
[29] In 2010 the average Midwest price of energy for pulp and paper mills was $6.69/mmBtu; for more information see the related WRI report.
[30] This is a simplified method to estimate cost-effective energy savings as some measures will only be operated with a single type of energy (e.g., electricity).
[31] IEA 2010.

by 57 percent; further energy price drops could undermine the cost-effectiveness of energy efficiency improvements, though they could also facilitate fuel switching away from coal and oil, perhaps in combination with installation of CHP equipment.

2.1. Mill and Company Case Studies

Several pulp and paper companies throughout the U.S. have used energy efficiency investment to successfully reduce energy use and emissions while improving economic competitiveness. The table below illustrates the range of recent energy efficiency projects conducted by U.S. pulp and paper companies.

Table 1. Overview of Recent U.S. Pulp and Paper Company Efficiency Improvement Projects

Company	Facility	Project Impact	Context
Flambeau River Papers	Flambeau River Papers (Park Falls, WI)	Aggregate energy savings through 2010 exceeded $10 million, reducing electricity requirements to produce each ton of paper by 15 percent.[32]	After high energy costs and dated equipment forced the mill to close in 2006, energy efficiency investments subsequently allowed the mill to resume operations and increase paper production while decreasing energy consumption
Weyerhaeuser/ Nippon Paper Industries	NORPAC (Longview, WA)	$60 million energy efficiency investment projected to save 100 million kWh/year. [33]	Largest industrial energy efficiency investment in Bonneville Power Administration history
International Paper	Company-wide	2011 energy efficiency projects estimated to reduce annual fossil fuel usage by 5.9 GJ.[34]	Only forest products company to receive inaugural Climate Leadership Award from EPA
Rock-Tenn	St. Paul, MN	Insulation of steam and condensate lines that resulted in annual savings of $171,000 from reduced energy consumption.[35]	Example of state technical assistance programs such as MnTAP
West Linn Paper	West Linn, OR	$176,000 energy efficiency investment that saved $379,000 in annual costs (< 6 month simple payback period) and 58,200 MMBtu in natural gas consumption.[36]	Example of government technical assistance programs such as DOE Save Energy Now

[32] http://www1.eere.energy.gov/manufacturing/tech_deployment/pdfs/case_study_flambeau.pdf.
[33] http://www.weyerhaeuser.com/Company/Media/NewsReleases/NewsRelease?dcrId=2012-08-09_WYNORPACBPACowlitzPUDEnergyProject.
[34] http://www.internationalpaper.com/documents/EN/Sustainability/IP_Sustainability_Re.pd
[35] http://www.mntap.umn.edu/paper/resources/rocktenn.pdf.
[36] http://www1.eere.energy.gov/manufacturing/tech_deployment/pdfs/42352.pdf

Company	Facility	Project Impact	Context
Liberty Paper	Becker, MN	$15 million investment in a water pretreatment plant with a bio-gas generator. The facility will pretreat the 550,000 gallons/day of water used by the mill. [37]	One of the first anaerobic digesters to be implemented at a paper mill in the state of Minnesota.

Sources: Flambeau River Papers; Weyerhaeuser; International Paper 2012 Sustainability Report; Minnesota Technical Assistance Programs; U.S. Department of Energy Industrial Technologies Program (now known as the Advanced Manufacturing Office); St. Paul Port Authority.

In combination with the cost curve of established EE technologies, these case studies demonstrate the economic and competitiveness benefits of pulp and paper mill energy efficiency investments. Other published studies have also highlighted the job-creation, energy security, and social benefits of energy efficiency investments.[38]

Conclusions

Energy-intensive industry is undergoing a transition in the United States that's driven by aging equipment, competitive pressure, and the need to reduce greenhouse gas and toxic air emissions. In 2010 industry accounted for 31 percent of total U.S. energy use (30 out of 98 Quadrillion Btu of final energy use) and 30 percent of total direct and indirect U.S. greenhouse gas emissions (2.0 out of 6.8 billion metric tons CO_2e).[39] Although transportation, residential, and commercial-sector energy use and greenhouse gas emissions have grown since 1980, industry remains the largest sector in end-use terms for both energy use and emissions. As the third largest energy-using industry subsector, U.S. pulp and paper manufacturing has opportunities for significant energy and emissions savings through efficiency improvements.

Given that Midwest pulp and paper mills are less efficient than the U.S. average, the business case for energy efficiency investment in this region is particularly strong. Cost of conserved energy analysis shows that Midwest mills could reduce their energy intensity by 25 percent through cost-effective investments in energy efficiency improvements (that have a cost per Btu below 2010 average regional energy market rates). A review of existing and emerging technologies shows that Midwest pulp and paper mills have a range of low-cost technology options for improving their energy efficiency. At the facility level, the case studies demonstrate the opportunity for mills to reduce energy costs while increasing production and competitiveness through energy efficiency investments. In a climate of increasing competition, the case study experiences suggest that energy efficiency investments are an important factor in determining which mills will survive the transition.

The policy landscape for the Midwest pulp and paper sector is varied and largely composed of voluntary programs. On a federal level, relevant mandatory policies such as the finalized Boiler MACT rule have been developed under the existing authorities of the Clean Air Act. At the state level, Illinois, Wisconsin, Minnesota, Michigan, and Ohio have implemented ratepayer funded energy efficiency policies; however, more could be done to achieve energy cost savings, competitiveness improvements, and emissions reductions among the most energy-

[37] http://www.sppa.com/wp-content/uploads/2012/05/AprilRePort.pdf.
[38] IEA 2012b.
[39] DOE 2012b; EPA 2012c.

intensive industries. To improve competitiveness while reducing environmental impacts, this paper makes four recommendations: measure pulp and paper mill energy efficiency performance; introduce a mix of Federal minimum standards with facility-auditing requirements and "reach" incentives for high-performing facilities; support CHP through revised state and federal policies, such as inclusion of CHP in state energy resource standards; and fourth, develop new regulatory frameworks to promote electric utility-manufacturer collaboration—for example, Congress could revisit PURPA to more fully align the interests of utilities with customer goals of self-generation and energy efficiency.[40]

Implementation of the efficiency improvements and innovations described in this report could help the pulp and paper sector reduce costs and improve competitiveness. The turnaround of leading mills and companies, including the case studies in this report, suggests that a combination of investments and policies could lead Midwest pulp and paper mills to achieve significant cost savings and emissions reductions. Beyond the Midwest, these pulp and paper sector efficiency opportunities can also inform longer-term strategies to improve manufacturing competitiveness throughout the country.

References

American Forest and Paper Association (AF&PA). 2012. "2012 Sustainability Report." Available online at: http://www.afandpa.org/sustainability/.

Boston Consulting Group (BCG). 2012. "More Than a Third of Large Manufacturers Are Considering Reshoring from China to the U.S.", Available online at: http://www.bcg.com/media/PressReleaseDetails.aspx?id=tcm:12-104216.

Boyd GA, Guo YF. 2012. "Development of ENERGY STAR® Energy Performance Indicators for Pulp, Paper, and Paperboard Mills" EPA ENERGY STAR Technical Document; available online at: http://www.energystar.gov/index.cfm?c=in_focus.bus_pulppaper_focus.

Bradbury, J., and N. Aden. 2012. "Midwest Manufacturing Snapshot: Energy Use and Efficiency Policies." WRI Working Paper. Available online at: http://pdf.wri.org/working_papers/midwest_manufacturing_snapshot/midwest_manufacturing_snapshot.pdf.

Brown, M.A., R. Jackson, M. Cox, R. Cortes, B. Deitchman, and M.V. Lapsa. 2011. "Making Industry Part of the Climate Solution: Policy Options to Promote Energy Efficiency." Oak Ridge National Laboratory (ORNL) Report 2010/78. Available online at: http://info.ornl.gov/sites/publications/Files/Pub23821.pdf.

Coito F., E. Worrell, F. Rafael, and M. Rufo. 2005. "California Industrial Energy Efficiency Potential." Lawrence Berkley National Laboratory (LBNL). Proceedings of the American Council on Energy Efficient Economy 2005 Summer Study on Energy Efficiency in Industry. Available online at: http://ies.lbl.gov/iespubs/59956.pdf

[40] For more information see related WRI report.

Department of Energy (DOE), U.S., Energy Information Administration (EIA), U.S. 2000 – 2011. “Annual Energy Outlook.”

Department of Energy (DOE), U.S. Energy Efficiency and Renewable Energy (EERE). Industrial Technologies Program (ITP). 2005a. “Energy and Environmental Profile of the U.S. Pulp and Paper Industry.” Available online at: http://www1.eere.energy.gov/manufacturing/resources/forest/pdfs/pulppaper_profile.pdf.

Department of Energy (DOE), U.S. Energy Efficiency and Renewable Energy (EERE). Industrial Technologies Program (ITP). 2009a. “Flambeau River Papers Makes a Comeback with a Revised Energy Strategy.” Available online at: http://www1.eere.energy.gov/manufacturing/tech_deployment/pdfs/case_study_flambeau.pdf

Department of Energy (DOE) , U.S., Energy Information Administration (EIA). 2012a. “Annual Energy Outlook 2012: with Projections to 2035.” Available online at: http://www.eia.gov/forecasts/archive/aeo12/sector_industrial.cfm

Department of Energy (DOE), U.S., Energy Information Administration (EIA). 2012b. “Annual Energy Review 2011.” Available online at: http://www.eia.gov/totalenergy/data/annual/pdf/aer.pdf.

Department of Energy (DOE), U.S., Energy Information Administration (EIA). 2012c. State Energy Data System. Available online at: http://www.eia.gov/state/seds/seds-datacomplete.cfm#data.

Department of Energy (DOE), U.S., Energy Information Administration (EIA). 2013. Manufacturing Energy Consumption Survey (MECS) 2010. Available online at: http://www.eia.gov/consumption/manufacturing/data/2010/.

Energy Center of Wisconsin. 2009. “A Review and Analysis of Existing Studies of the Energy Efficiency Resource Potential in the Midwest.” Available online at: http://www.midwesterngovernors.org/Energy/EEResourcePotential.pdf.

Environmental Paper Network (EPN). 2007. “The State of the Paper Industry: Monitoring the Indicators of Environmental Performance.” Available online at: http://www.greenpressinitiative.org/documents/StateOfPaperInd.pdf.

Environmental Protection Agency (EPA), U.S. 2010. “Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Pulp and Paper Manufacturing Industry.” Available online at: http://www.epa.gov/nsr/ghgdocs/pulpandpaper.pdf.

Ericsson, K., L.I. Nilsson, and M. Nilsson. 2011. “New energy strategies in the Swedish pulp and paper industry—the role of national and EU climate and energy policies,” *Energy Policy* 39: 1439 -- 1449.

Fisher International, Inc. 2013. FisherSolve™ Platform. <http://www.fisheri.com/>.

Focus on Energy (FoE). 2005. “Pulp and Paper Energy Best Practice Guidebook.” http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/pulpandpaper_guidebook.pdf.

Institute of Paper Science and Technology at Georgia Institute of Technology & Jacobs. 2006. “The Pulp & Paper Industry Energy Bandwidth Study.” Report prepared for American Institute for Chemical Engineers.

International Energy Agency (IEA). 2007. “Tracking Industrial Energy Efficiency and CO2 Emissions.” Available online at: http://www.iea.org/publications/freepublications/publication/tracking_emissions.pdf.

International Energy Agency (IEA). 2010. “Energy Technologies Perspectives 2010: Scenarios and Strategies to 2050.” Paris: IEA.

International Energy Agency (IEA). 2012. “World Energy Outlook 2012.” Paris: IEA.

International Energy Agency (IEA). 2012b. “Spreading the Net: The multiple benefits of energy efficiency improvements” Paris: IEA.

Kowalczyk I. 2013. “Barriers to the Expansion of Electrical Cogeneration by the Wood Products Industry in the United States”, Journal of Sustainable Forestry, 32:1-2, 159-174

Kramer, K.J., E. Masanet, T. Xu, and E. Worrell. 2009. “Energy Efficiency Improvement and Cost Saving Opportunities for the Pulp and Paper Industry: An ENERGY STAR Guide for Energy and Plant Managers.” Lawrence Berkley National Laboratory (LBNL).

National Academy of Sciences (NAS). 2010. “Real Prospects for Energy Efficiency in the United States.” Available online at: http://www.nap.edu/catalog.php?record_id=12621.

National Council for Air and Stream Improvement, Inc. (NCASI). 2008. “Calculation Tools for Estimating Greenhouse Gas Emissions from Pulp and Paper Mills, Version 1.1.” Revisions to version 1.1 to generate version 1.3. Research Triangle Park, NC: National Council for Air and Stream Improvement, Inc.

National Renewable Energy Lab (NREL). 2009. “2008 Industrial Technologies Market Report.” Available online at: http://www.nrel.gov/docs/fy09osti/46024.pdf.

Nowak, S., M. Kushler, M. Sciortino, D. York, and P. Witte. 2011. “Energy Efficiency Resource Standards: State and Utility Strategies for Higher Energy Savings.” American Council for an Energy Efficient Economy Research Report U113.

McKinsey & Company. 2009. “Unlocking Energy Efficiency in the U.S. Economy.”

Stockholm Environment Institute (SEI). 2010. “Issues and Options for Benchmarking Industrial GHG Emissions”. SEI White Paper available online at: http://sei-us.org/publications/id/320.

U.S. Census Bureau. 2012. American Survey of Manufacturers (ASM). Available online at: http://www.census.gov/manufacturing/asm/

Xu TF, Sathaye J, and Kramer KJ. 2012. “Bottom-up Representation of Industrial Energy Efficiency Technologies in Integrated Assessment Models for the U.S. Pulp and Paper Sector,” Lawrence Berkley National Laboratory (LBNL) Report 5801E.