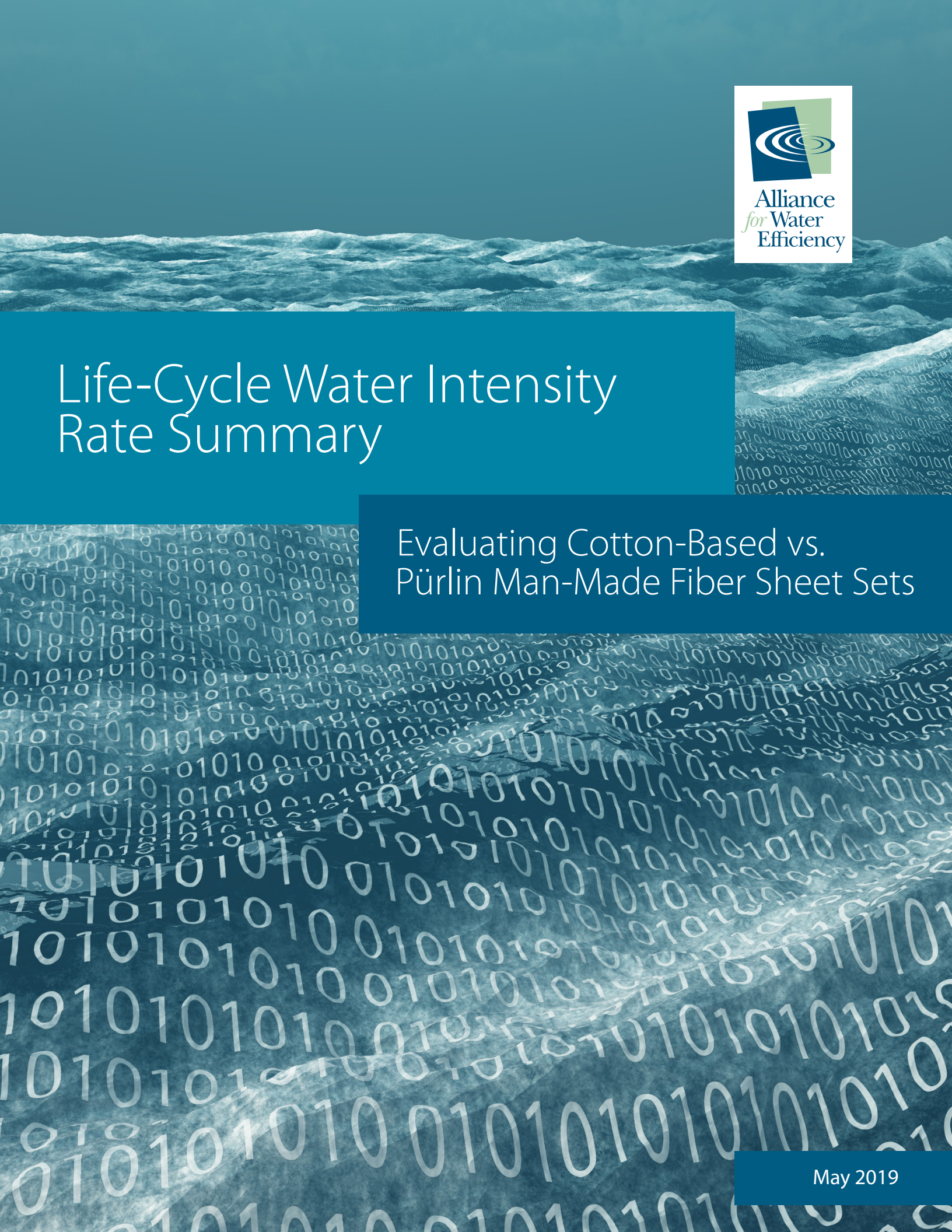

Alliance for Water Efficiency

Life-Cycle Water Intensity Rate Summary

Evaluating Cotton-Based vs. Pürlin Man-Made Fiber Sheet Sets

May 2019

Life-Cycle Water Intensity Rate Summary

Cotton-Based vs. Pürlin Man-Made Fiber Sheet Sets

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FOREWORD AND DISCLAIMER

There is great interest in evaluating products and processes for their contribution to a more sustainable future and particularly as they might contribute to overall water efficiency. To assist this evaluation process, the Alliance for Water Efficiency (AWE) has decided to retain third-party evaluators to assess the life-cycle water intensity rates associated with various products, practices, and processes and to prepare summary reports outlining their findings that can be posted on the AWE website and serve as important information for our members. This report is the first of what we hope will be a series.

The sole purpose of these Life-Cycle Water Intensity Rate Summary reports is to assess life-cycle water intensity rates. Therefore there are issues that are specifically not addressed, such as evaluating or assessing energy intensity rates, greenhouse gas production, customer satisfaction, cost effectiveness, labor conditions or practices, pollution production, or any other feature.

We are providing these reports as a service to our members, but water providers, agencies and customers are encouraged to make their own judgments regarding the suitability and value of the products, practices, and processes identified in these Life-Cycle Water Intensity Rate Summary reports. While every effort has been taken to ensure the accuracy and reliability of the information provided by these documents, please note that AWE does not accept any liability for the accuracy, content, completeness, legality, or reliability of the information presented, and does not specifically endorse any product, practice, or process identified.

We welcome your comments and suggestions.

Mary Ann Dickinson
President and CEO
Alliance for Water Efficiency

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1.0 INTRODUCTION

A significant volume of water is used to produce cotton sheet sets and to launder them after they have been used. Hospitality and healthcare facilities, e.g., hotels, motels, hospitals, nursing homes, etc., must maintain significant sheet set inventories in order to meet the demand of their patients and guests. A report by the Textile Rental Service Associated (TRSA)[1] estimates that many hotels have 4 full sheet sets per available room (PAR) and that 15% to 20% of this linen is replaced each year as a result of loss, theft, and premature discard due to tears, stains, discoloration, etc.

Hotel and motel rooms typically contain either two queen-size beds or one king-size bed. While the total volume and weight of bedding used by two queen-sized beds is greater than that used by a single king-size bed, to be conservative, the water volumes identified in this paper are based on rooms containing one king-size bed.

This paper attempts to compare the life-cycle water intensity rates associated with using cotton-based sheet sets vs. using 100% man-made fiber sheet sets – specifically Pürlin sheet sets – in the hospitality industry.[2]

2.0 COTTON SHEET SETS

2.1 Water Used to Produce Cotton Fabric

Table 4.4 in the September 2005 report, *The Water Footprint of Cotton Consumption*[3], states that it takes a total of 9,750 litres of water to produce a single 900-gram bed sheet, equating to a virtual water demand of 1,300 gallons per pound of cotton fabric[4]. This volume is based on global average demand values and includes the rainwater and supplemental irrigation required to grow the cotton, as well as water used to sufficiently dilute the polluted process water. When the water naturally provided by rainfall during the cotton growth stage is removed, the volume of supplemental irrigation and process water used to produce 1.0 pound of 100% cotton sheets is estimated to be about 767 gallons. It should be noted that the volume of water used to grow cotton varies from place to place depending on climate, soil conditions, agricultural practices, etc. While a water intensity rate of 767 gallons per pound of cotton fabric is used in this paper, the reader must understand that this is an approximate value and may not reflect the actual water intensity rate for cotton grown in your area.

The 2015 EDRO *Laundry Planning Guide*[5] identifies the weights of clean king-size sheets and pillow cases as 2.25 pounds and 0.32 pounds respectively. Based on these values, one full king-size sheet set (i.e., flat sheet, fitted sheet, 4 pillow cases) weighs approximately 5.78 lb. Based on a water intensity rate (excluding rainfall) for cotton fabric of 767 gallons per pound and a weight of 5.78 pounds per sheet set, it takes approximately 4,434 gallons of water to produce one full 100% cotton king-size sheet set.

Many bed sheets, however, are made from a blend of materials, the most common being a blend of cotton and polyester. While the percentage of cotton in a blended material can vary, the volume of water required to produce a 50/50 cotton/polyester (i.e., 50% cotton and 50% polyester) sheet set would be

[1] http://www.laundrycompliance.com/wp-content/uploads/2016/02/trsa-hospitality-hotel-linen-loss.pdf
[2] In this document a sheet set consists of one flat sheet, one fitted sheet, and four pillow cases.
[3] Published by UNESCO-IHE Institute for Water Education, authors: A.K. Chapagain, A. Y. Hoekstra, H.H.G. Savenije, R. Gautam. https://waterfootprint.org/media/downloads/Report18.pdf
[4] Virtual water is the volume of water used to produce consumer products.
[5] www.uschemical.com/wp-content/uploads/2016/04/L000228_Understanding_Institutional_Laundry.pdf

approximately half that used to produce a 100% cotton sheet set. **Table 1** presents the volumes of water (excluding rainfall) used to produce king-size sheet sets.

Table 1: Water Used to Produce King-size Cotton-based Sheet Sets

Type of Fabric	Gallons per Sheet Set
100% Cotton	4,434
50/50 Cotton/Polyester	2,217

Unlike residential sheets, which can last for years, a report by the Textile Rental Service Associated (TRSA)[6] estimates that sheets used in the hospitality sector are replaced on average about every 58.8 uses, or about 5 replacements per year based on an 80% room occupancy rate. The volume of water used to produce 5 king-size sheet sets per room per year is presented in **Table 2**.

Table 2: Annual Water Demand to Produce Cotton-based King-size Sheet Sets

Type of Fabric	Gallons per Room per Year
100% Cotton	22,170
50/50 Cotton/Polyester	11,085

2.2 Water Used to Launder Cotton-based Sheet Sets

The volume of water used to launder a sheet set depends on the type and efficiency of the washer used and how badly the sheets are soiled. For example, the Alliance for Water Efficiency website states that washer-extractors, the type of washers commonly found in on-premise laundry (OPL) facilities, use between 2.5 and 4.0 gallons of water per pound of laundry[7], whereas tunnel washers, the type of washers commonly found in off-premise or outsourced laundry facilities – use only between 0.5 to 1.0 gallons per pound of laundry[8].

As stated above, it is estimated that one full king-size sheet set (i.e., flat sheet, fitted sheet, 4 pillow cases) weighs about 5.78 pounds. As such, the volume of water required to wash one king-size sheet set ranges from 2.9 to 5.8 gallons for outsourced laundry and from 14 to 23 gallons for on-premise laundry (OPL).

The annual laundry water demand is dependent on the number of times sheet sets are washed per year. For calculation purposes, it is assumed that each set is washed 182 times per year (reflecting an 80% occupancy rate and an average duration of stay 1.6 days). Based on this assumption, annual water demands range from 528 to 1,056 gallons per room per year for outsourced laundry and from 2,548 to 4,186 gallons per room per year for OPL – see **Table 3**.

[6] www.laundrycompliance.com/wp-content/uploads/2016/02/trsa-hospitality-hotel-linen-loss.pdf
[7] http://www.allianceforwaterefficiency.org/commercial_laundry.aspx
[8] https://www.gabraun.com/assets/Uploads/Product-PDFs/150-220-Tunnel.pdf

Table 3: Annual Water Demand to Launder King-size Sheet Sets

Type of Laundry	Gallons per Wash	Washes per Year	Gallons per Room per Year
Outsourced	2.9	182	528
Outsourced	5.8	182	1,056
On-Premise (OPL)	14	182	2,548
On-Premise (OPL)	23	182	4,186

The costs associated with laundering sheet sets will vary from customer to customer depending on such factors as: the type and efficiency of their laundry system, the number of washes per year, the cost of washing chemicals, equipment costs, water and wastewater rates in their water agency, etc.

3.0 PÜRLIN 100% MAN-MADE FIBER SHEET SETS

3.1 Water Used to Produce Polyester Fabric

Polyethylene terephthalate (PET) - chemical formula $C_{10}H_8O_4$ - is the most commonly used type of thermoplastic polymer resin in the world. About 60% of the world's PET production (estimated at 56 million tons in 2016) is used to made synthetic fibers and about 30% is used to make plastic bottles.[9] This material is typically called polyester when it is used as a fabric and PET or PET resin when it is used for bottles and other containers. PET is commonly recycled and has the number 1 as its resin identification code.

PET is made from oil. Water is used by the oil industry to lubricate and cool well drills, to remove drilling mud and rock debris during drilling, and to hydraulically fracture ("frack") wells. Large volumes of water may also be injected into older wells to push out additional oil, a process called water flooding.

The 2012 report *Life Cycle Analysis of Water Use and Intensity of Oil and Gas Recovery in Wattenberg Field, Colo.*[10] calculated water intensities for drilled wells ranging from about 2.9 to 14 gallons per million British Thermal Units (MMbtu). Since 55 pounds of oil equals 1.0 MMbtu, the maximum water intensity rate of 14 gallons per MMbtu equates to 53 pounds of water per 55 pounds of oil. Since 1.0 gallon of water weighs 8.34 pounds, the maximum water intensity rate equals about 0.25 gallons of water for every pound of oil produced.

The Pacific Institute estimates that it takes about 17 million barrels (2.34 million tons[11]) of oil to make 0.9 million tons of PET[12], equating to an oil to PET ratio of 2.6 to 1.0. Combined with a maximum water intensity rate of 0.25 gallons of water for every 1.0 pound of oil produced, it is estimated that it takes about 0.65 gallons of water to produce 1.0 pound of PET.

A full king-size Pürlin sheet set weighs about 2.9 pounds.[13] Therefore, it takes about 2 gallons of water to produce enough oil to make one king-size Pürlin sheet set.[14]

[9] https://en.wikipedia.org/wiki/Polyethylene_terephthalate
[10] https://www.ogj.com/articles/print/vol-110/issue-5/exploration-development/life-cycle-analysis-of-water.html
[11] One barrel of crude oil weighs approximately 275 pounds.
[12] https://pacinst.org/publication/bottled-water-and-energy-a-fact-sheet/
[13] Two King-size sheets at 521 grams each plus four pillow cases at 66 grams each = 1,306 grams = 2.9 pounds.
[14] 2.9 pounds/sheet set x 0.65 gallons/pound = 1.9 gallons/sheet set, rounded to 2 gallons/sheet set

Very little water is used during the production of polyester fabric from polymer resin. The polymer resin pellets are heated and extruded through dies to produce thin fibers. The fibers are aligned (carded) and passed over a perforated roll (or screen) where high-pressure water jets mechanically intertwine individual fibers (hydro-entangling) to produce a thin, strong fabric. Almost all of the water used in the hydro-entangling process is captured, filtered, and re-used. **Table 4** presents the volume of water used to make one king-size Pürlin sheet set.

Table 4: Water Used to Produce King-size Pürlin Sheet Sets

Type of Fabric	Gallons per Sheet Set
100% Polyester	2

Pürlin sheet sets are not laundered. New, hypoallergenic sheets are used every time the bedding is changed. If each sheet set is replaced an average of 182 times per year (reflecting an 80% occupancy rate and an average duration of stay 1.6 days), the water used to produce king-size Pürlin sheets is approximately 364 gallons per room per year – **Table 5**.

Table 5: Annual Water Used to Produce King-size Pürlin Sheet Sets

Type of Fabric	Gallons per Room per Year
100% Polyester	364

3.2 Water Used to Recycle Polyester Fabric

Used sheets are collected by Pürlin's distribution agents and sent to a polyester recycling facility where the material is shredded, melted, and re-made into resin pellets used in the production of new Pürlin sheet sets or other polyester products. Virtually no water is used in the recycling process – **Table 6**.

Table 6: Annual Water Used to Recycle King-size Pürlin Sheet Sets

Type of Fabric	Gallons per Room per Year
100% Polyester	Nil

4.0 SUMMARY

Virtual Water – Production of One King-Size Sheet Set

100% cotton	4,434 gallons
50/50 cotton-polyester blend	2,217 gallons
100% Polyester	2 gallons

Virtual Water - Annual Use per Room

100% cotton (5 sheet sets/year)	22,170 gallons/room/year
50/50 cotton-polyester blend (5 sheet sets/year)	11,085 gallons/room/year
100% Polyester (182 sheet sets/year)	364 gallons/room/year

Facility Water - Laundering King-Size Bedsheets *(based on 182 washes/year)*[15]

Outsourced, high-efficiency laundry	528 gallons/room/year
Outsourced, low-efficiency laundry	1,056 gallons/room/year
On Premise Laundry (OPL), high-efficiency laundry	2,548 gallons/room/year
On Premise Laundry (OPL), low-efficiency laundry	4,186 gallons/room/year

Facility Water - Recycling 100% Man-made Fiber (Polyester) Bedsheets

100% Polyester	nil

While water intensity is not the only consideration when choosing between using cotton-based vs. 100% man-made fiber sheets, the difference between the water intensity associated with using cotton-based vs. 100% man-made fiber sheet sets may be an important consideration in water-scarce areas or areas trying to reduce wastewater volumes.

The potential for customer cost savings associated with reducing laundry costs will be greatest in areas with high water and/or wastewater rates.

[15] Because some water is evaporated during the drying process, the volume of wastewater generated through laundering cotton-based linens will be slightly lower than the volume of water used.

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