Decreased drying energy demand using starch-kaolin clay additives

A joint study between Primient, Artemyn, and Western Michigan University

Presented By: Heather Starkey
Applications Development Scientist
Performance Starches, Primient



Thermoformed Molded Fiber Symposium
October 5-7,2026 - Orono, Maine

Primient at-a-Glance

Enriching Lives Through Plant-Based Solutions



Acidulants



Agrifunctionals



Natural Diols



Performance Starches



Sweeteners

Nearly

120

years as a leader in
Sustainable Innovation

Performance Starches offer a broad product portfolio with technical expertise to support customers across **paper**, **packaging**, **building products**, **adhesives**, and **specialty ingredients**.

Artemyn minerals at-a-Glance

Mission

Leverage our historical expertise in minerals to serve our clients with the right solutions



48 sites total:

- 22 industrial facilities (sites & mine)
- 07 terminals
- 05 warehouses
- 10 offices
- 02 mines
- 01 lab
- 01 port

Visit www.artemyn.com for more information on each location

Project Team Introduction

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Tyler Froman

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Gregg Reed

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Molded Fiber Market Overview

In 2025 the global molded-fiber market was valued at **$10.2B**

It is expected to reach **$17.1B** by 2034[1]

#1 Fiber is the largest raw-material cost[2]

- Virgin-fiber prices rising with demand and supply constraints
- Recycled-fiber availability is increasingly competitive

>60% of process energy is consumed by thermal drying[2]

- Thermal drying dominates operating cost per ton

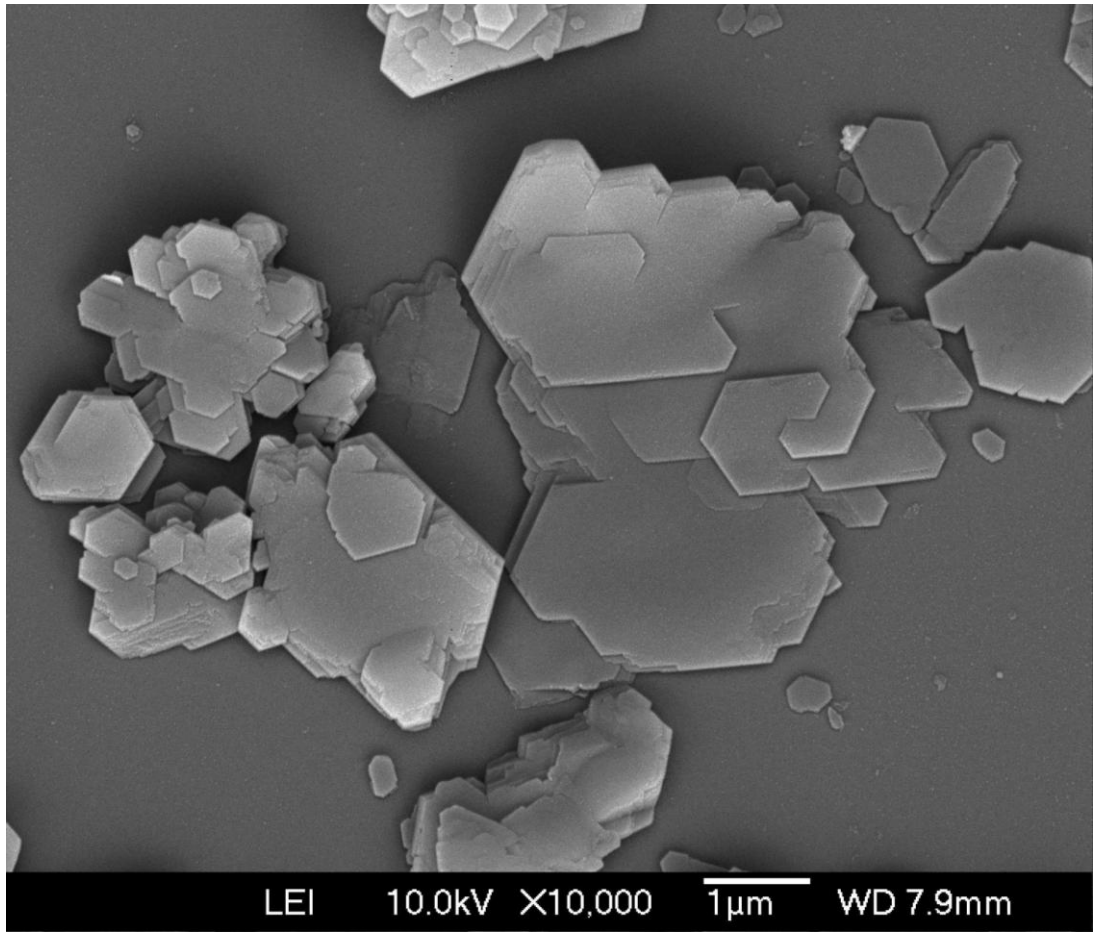
Fiber substitution with filler offers a single lever to reduce material and operating costs

Objective: Determine how filler and starch can be used to offset fiber in wet thermoformed trays.

[1]*Prismane Consulting (2026) Global Molded Fiber Packaging Market Report*
[2]*AFRY Presentation, TAPPI Fiber Molding Committee Meeting (2026)*

Benefits of Kaolin Clay

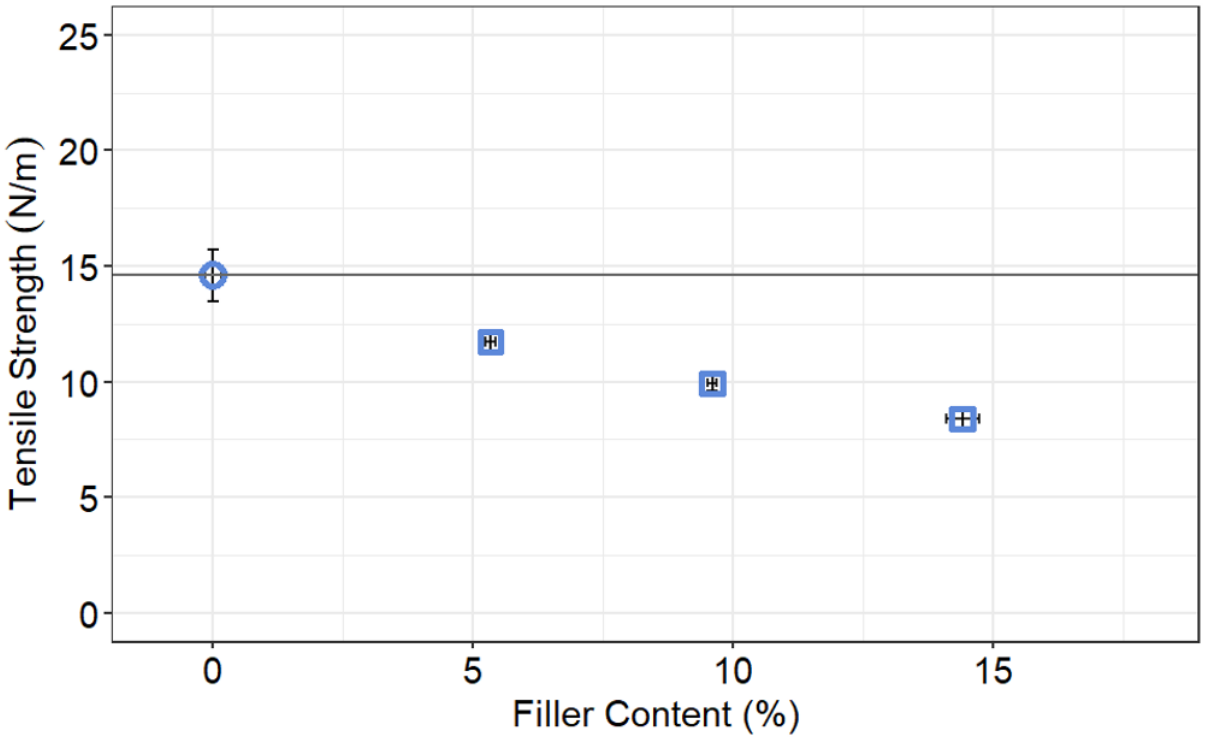
- Lower raw-material cost per ton than fiber
- Faster drainage at the forming stage
- Higher solids before thermal drying
- Reduced drying energy per ton
- Improved surface smoothness



SEM image of Capim™ NP
Provided by Artemyn

Hubbe & Gill (2016) Bioresources

Drawbacks of Kaolin Clay



- Disrupts fiber hydrogen bonds – reduces strength
- Requires retention chemistry to stay in the article
- Requires a bonding agent to offset the strength loss

Error bars represent the 95% confidence interval

Hubbe & Gill (2016) Bioresources

Known Benefits of Cationic Starch for Filler-Containing Pulps

- Increases strength
- Reduces filler loss to white water*
- Improves first-pass retention of fines*
- Supports drainage efficiency*

**n.b., in the absence of competing colloidal charge contributors such as microparticle retention aid systems*

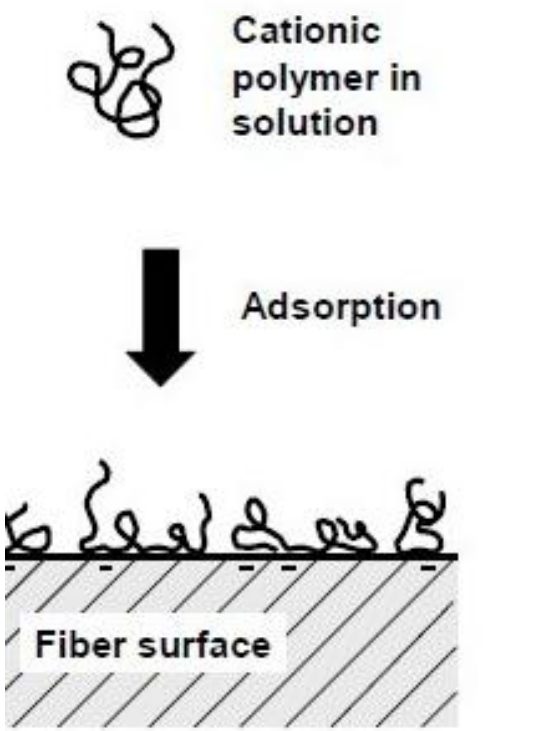
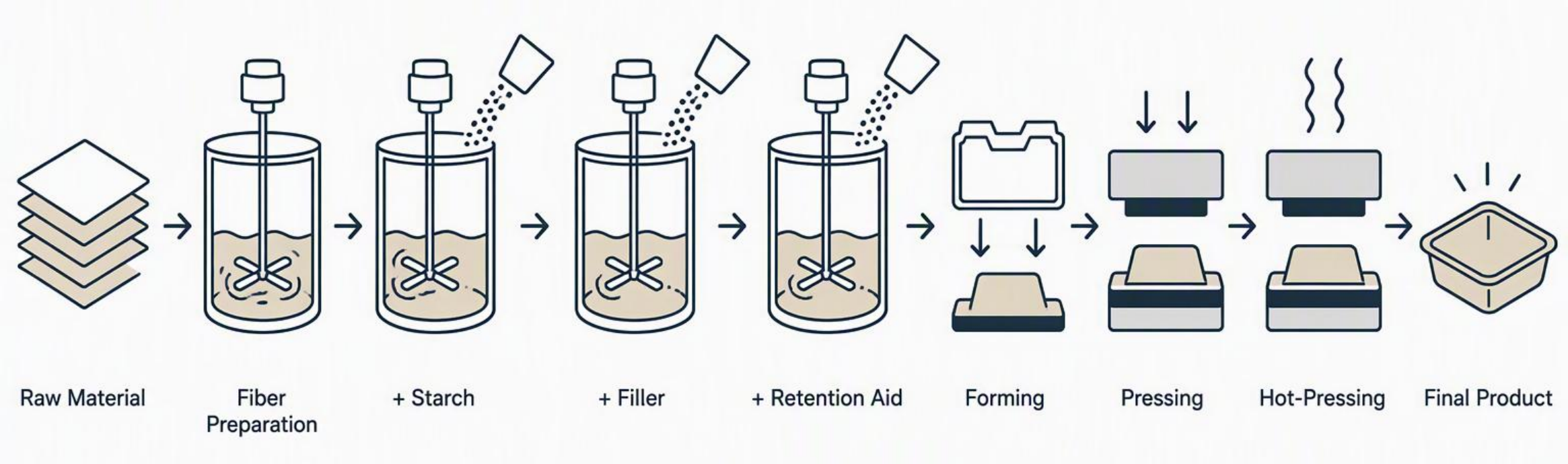


Image from Lofton et al. (2005) TAPPI Journal 4(9)

Hubbe & Gill (2016) Bioresources

Experimental Approach

- Trays were made using the NATUREFORMER by Kiefel
- Basis weight target: 450 g/m^2



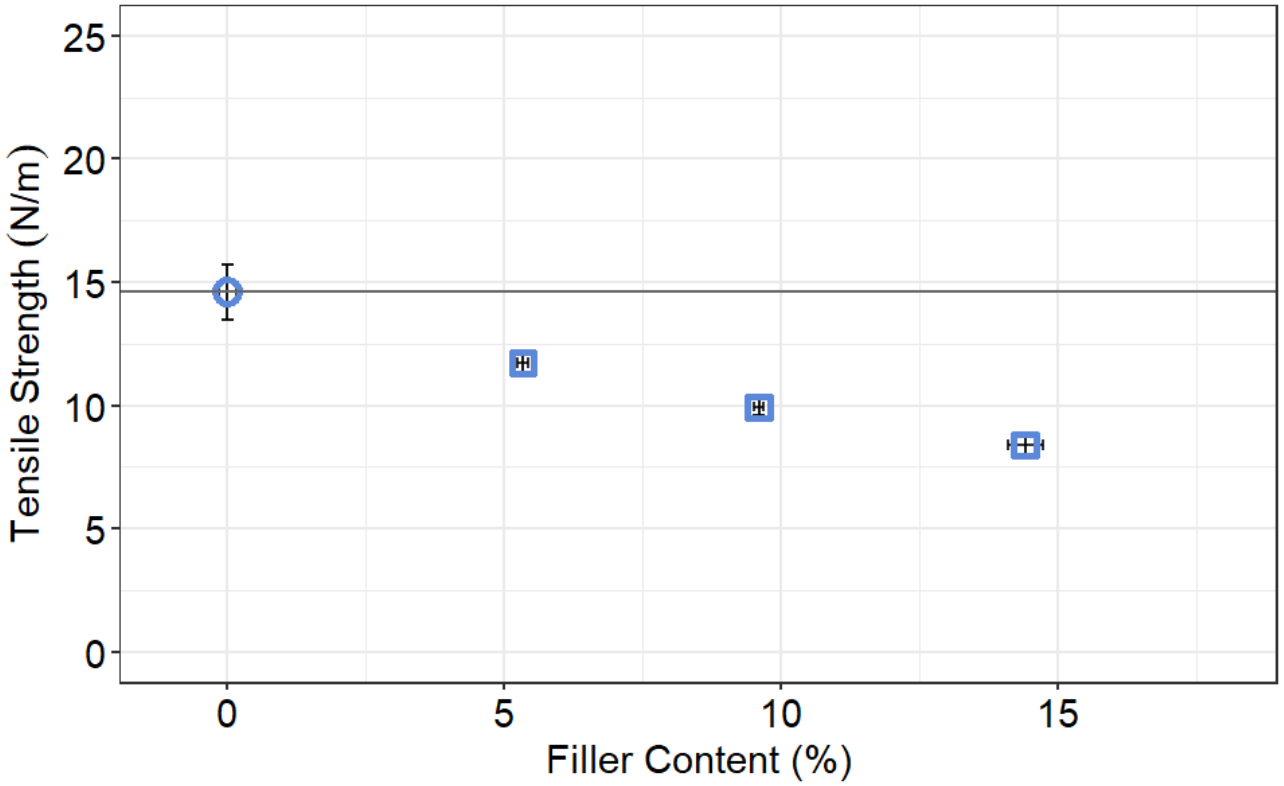
Experimental Approach

- **4 additive scenarios** were evaluated
  - Unmodified Filler
  - Cationic Starch + Unmodified Filler
  - Modified Filler
  - Cationic Starch + Modified Filler
- **4 levels of filler addition** were evaluated
  - 0%, 6%, 12%, 18%
- **2 levels of cationic starch** addition were evaluated
  - 0%, 1.5%
- Retention aid was added at 0.1% for all conditions
  - A low molecular weight, medium charge cationic polyacrylamide was used

- Trays were tested using the following TAPPI Standard Methods:
  - T-211 Ash content
  - T-494 Tensile strength
  - T-826 Short-span compression aka STFI

Strength results were normalized by basis weight

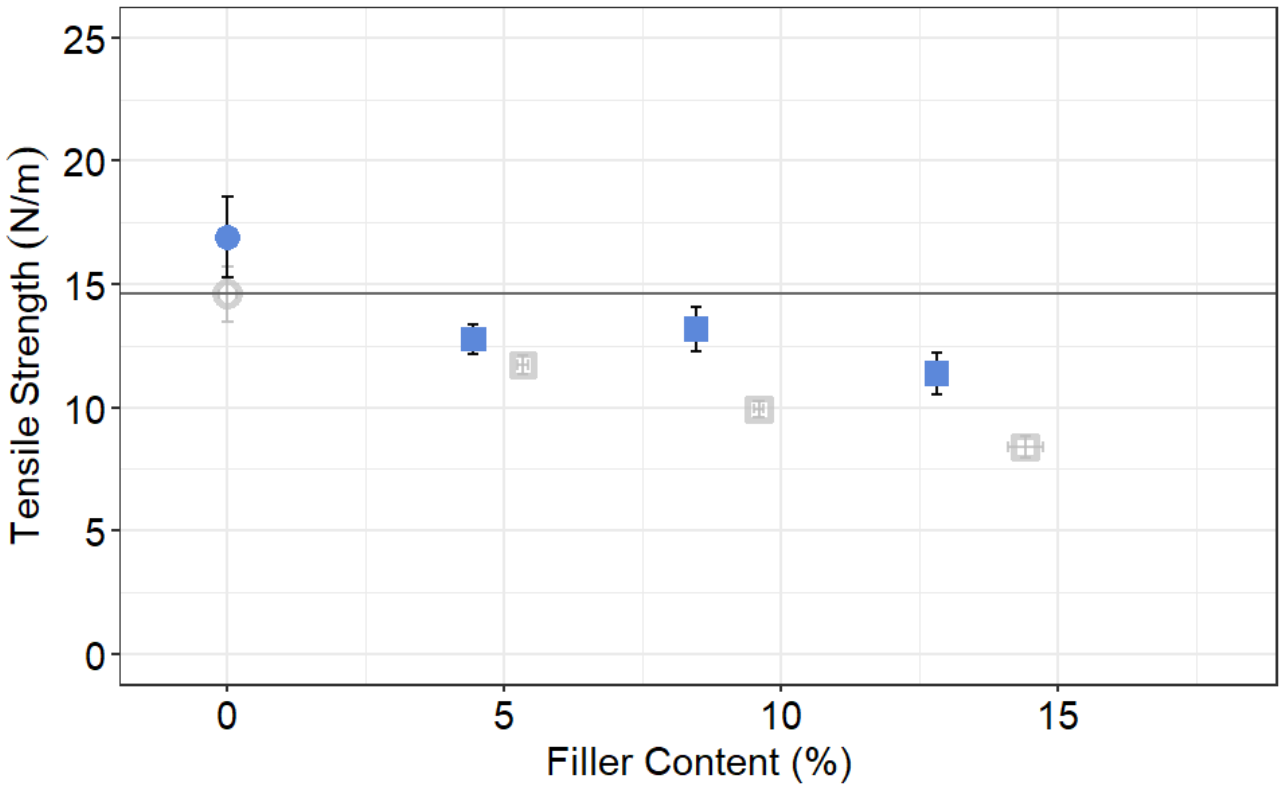
Scenario 1: Unmodified Filler (Control)



- Tensile strength **decreased 20-43%** with increased filler content

Error bars represent the 95% confidence interval

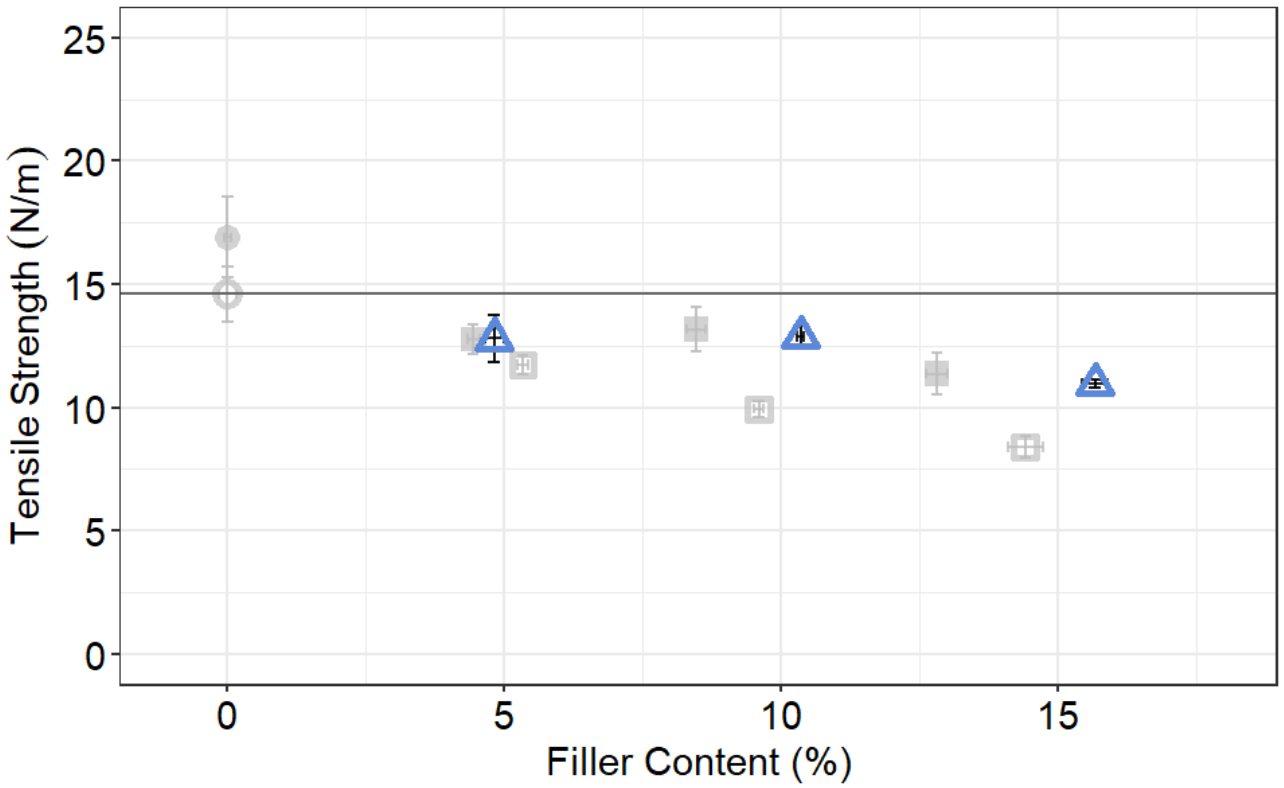
Scenario 2: Cationic Starch + Unmodified Filler



- The addition of cationic starch **increased tensile strength by 9-35%**
  - Tensile strength in trays with 4.4% and 8.5% filler is not statistically different than the control (without starch)
- The addition of cationic starch significantly **reduced filler retention by 11-17%**
  - Can be attributed to competing charge interactions with the retention aid

Error bars represent the 95% confidence interval

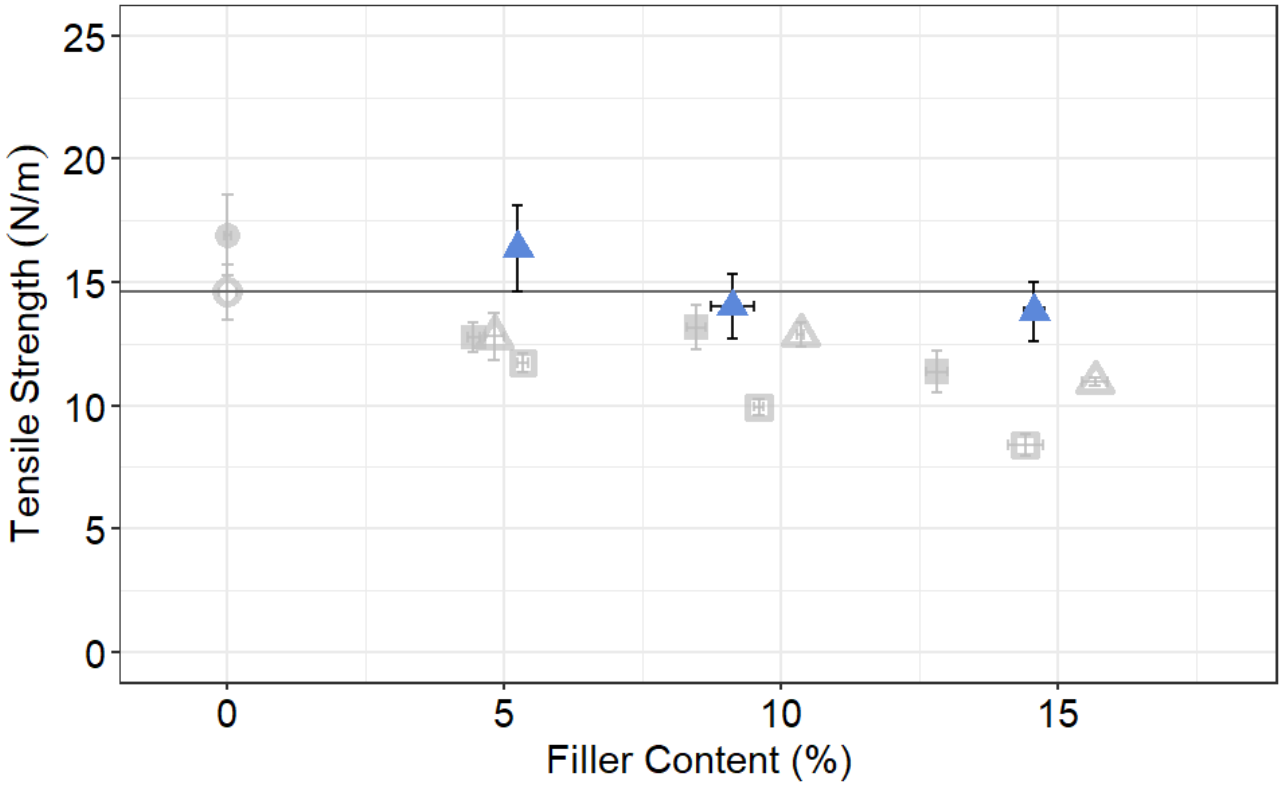
Scenario 3: Modified Filler



- Using a **modified filler increased tensile strength** relative to the unmodified filler
- The resulting strength was not statistically different than Scenario 2 (Cationic Starch + Unmodified Filler)
- **Modified filler showed efficient retention**

Error bars represent the 95% confidence interval

Scenario 4: Cationic Starch + Modified Filler

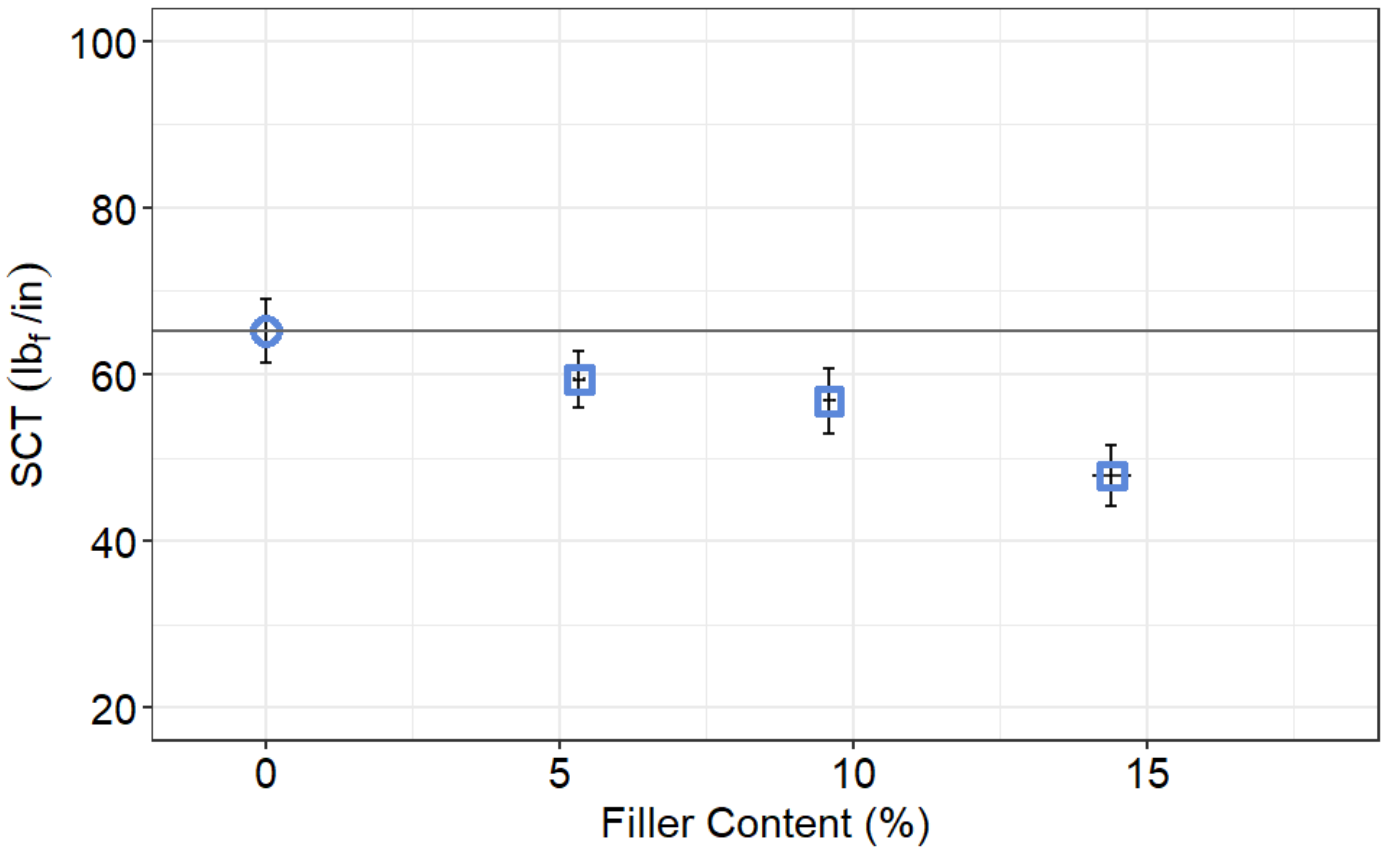


- **Tensile strength increased by 40-65%** compared to the unmodified filler

- This scenario produced a tray with 14.6% filler with no statistically detectable difference in tensile strength relative to the baseline.

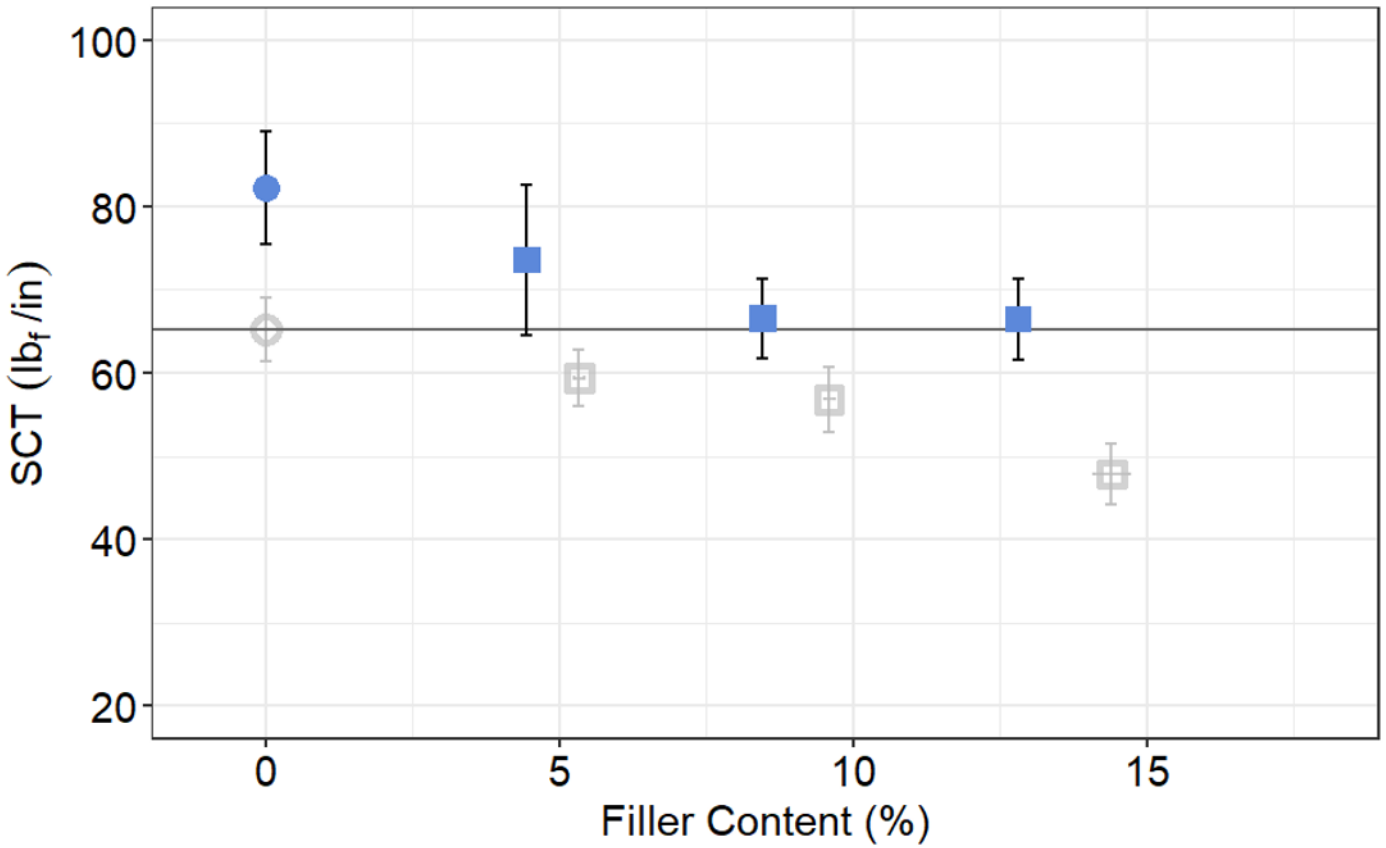
Error bars represent the 95% confidence interval

Short Span Compression Strength (SCT)



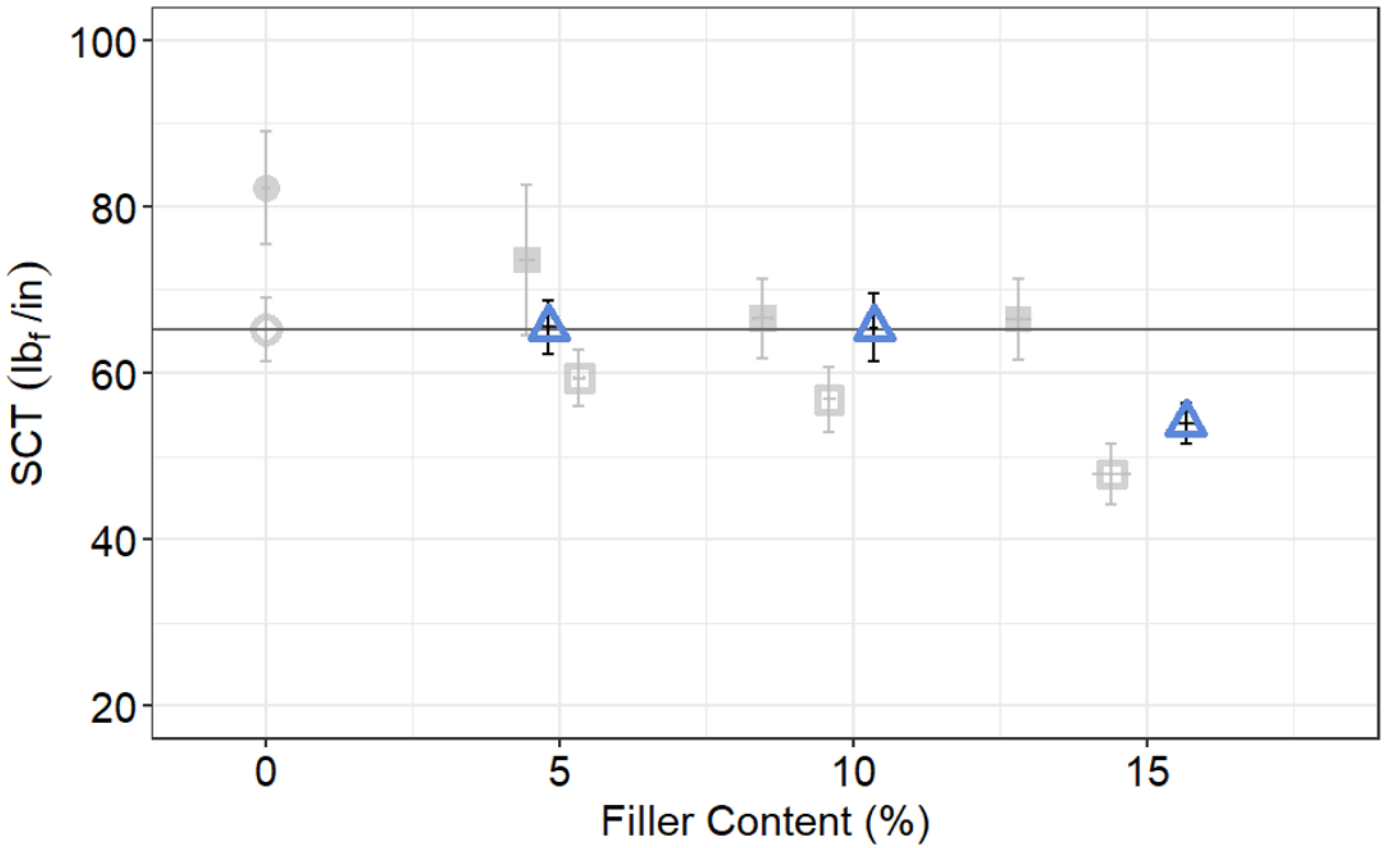
- SCT followed a similar trend to tensile strength
- Unmodified filler (Scenario 1) **decreased compression strength**

Short Span Compression Strength (SCT)



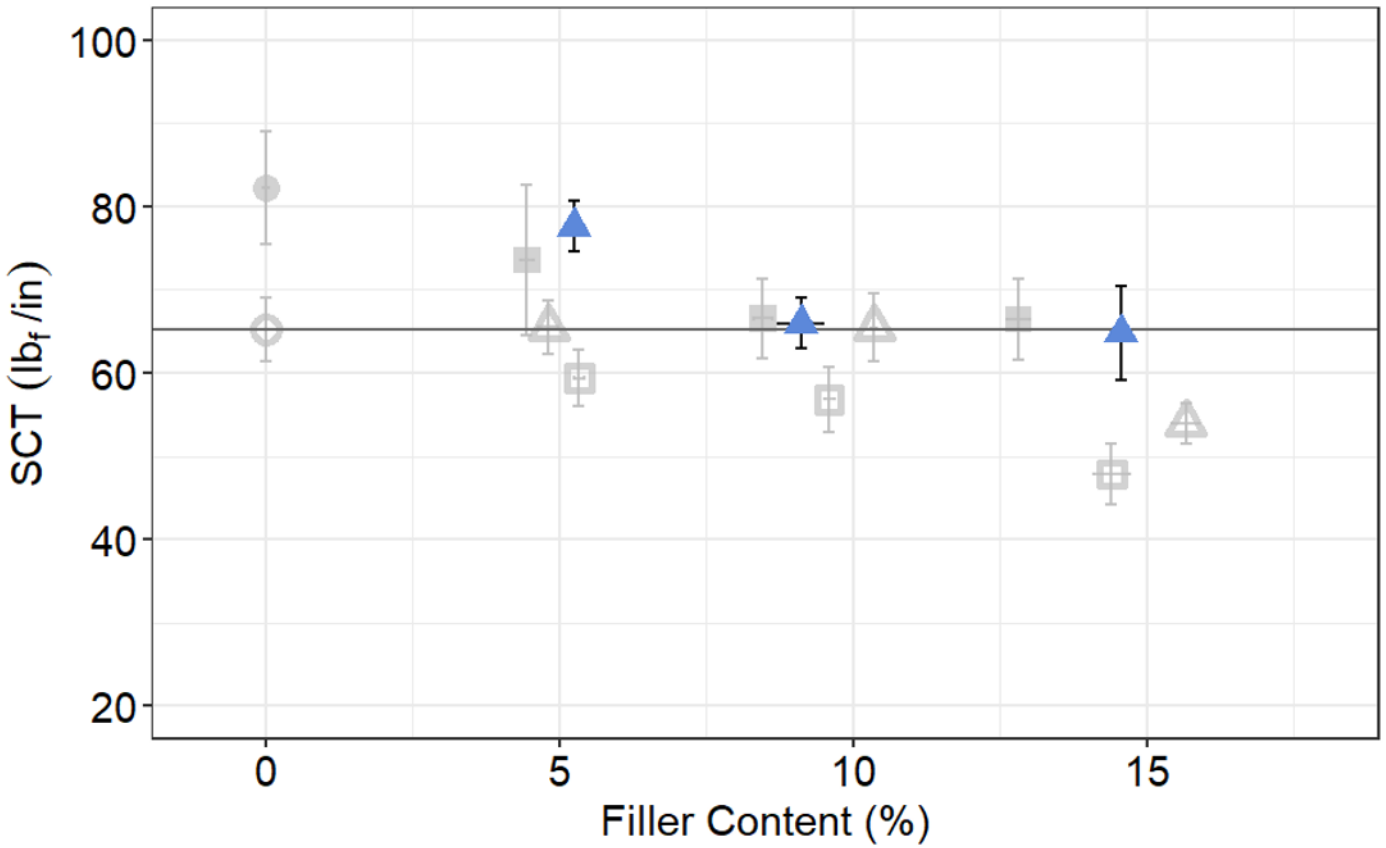
- Starch addition to the unmodified filler (Scenario 2) **increased compression strength**

Short Span Compression Strength (SCT)



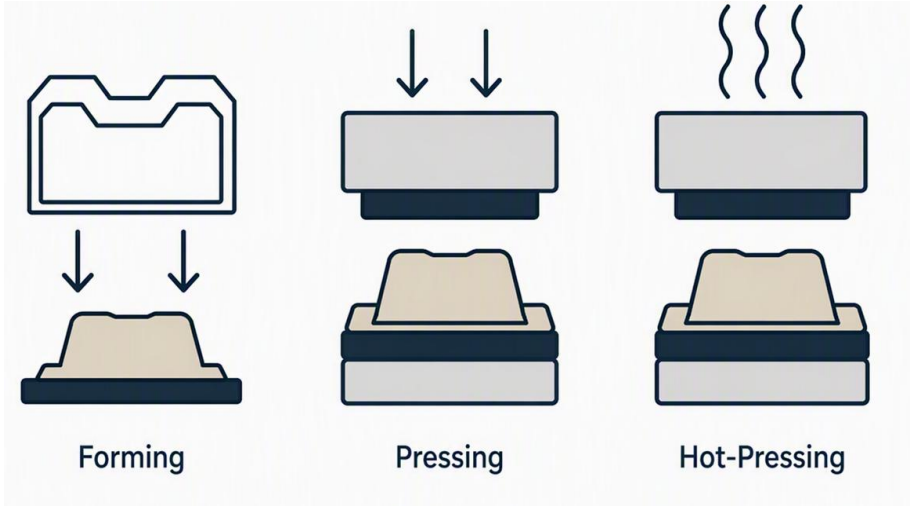
- Modified filler (Scenario 3) **increased compression strength**

Short Span Compression Strength (SCT)



- Starch addition to the modified filler (Scenario 4) resulted in the best trade off **– high filler content (14.6%) without sacrificing strength**

Fiber Reduction Impact on Drying



Filler Content	Solids Content			Modeled Energy Demand (kWh/t)	Energy Savings
0%	17%	28%	95%	6,200	--
12.8%	21%	29%	95%	4,700	24%
14.6%	22%	31%	95%	4,200	32%

- The solids content of the tray was measured after each key production stage for the best two conditions and the control
- Reducing fiber content through filler addition reduced **energy requirements by 24-32%**
  - Translates to a **Scope-2 CO_2 reduction of 1200-1600 lb CO_2/t**

U.S. EIA 2024

Study Applicability and Limitations

Furnish Type

- Single furnish tested
- Additive addition should be optimized for each production line

Filler Morphology

- One mineral type evaluated
- Other fillers may behave differently

Quality Parameters

- Limited testing scope
- Application specific performance validation is needed

Scale

- Pilot-scale trials
- Single forming technology evaluated
- Production-line validation is required

Emissions

- CO_2 factor varies by region
- U.S. average used here

Regulatory

- FDA §176.170 & §176.180 compliance screening done
- Local confirmation needed

Take-Aways

Technical Findings

- The combination of a modified filler and cationic starch addition preserves molded fiber article strength
- Dewatering improves at every process stage when using modified filler with cationic starch.
- Drying energy requirements drops by **32%** with the incorporation of **14.6%** filler

Commercial Impacts

- 14.6% reduction in fiber raw material due to substitution with filler
- Lower operating costs due to a 32% reduction in energy usage from filler reducing the thermal drying load
- Costs savings per ton are greater than the cost of introducing the modified filler and starch
  - Payback period <2 years

Next steps: Contact Primient or Artemyn to collaborate on using this technology to reduce your raw material and operating costs.

Thank You!



Primient

minerals
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