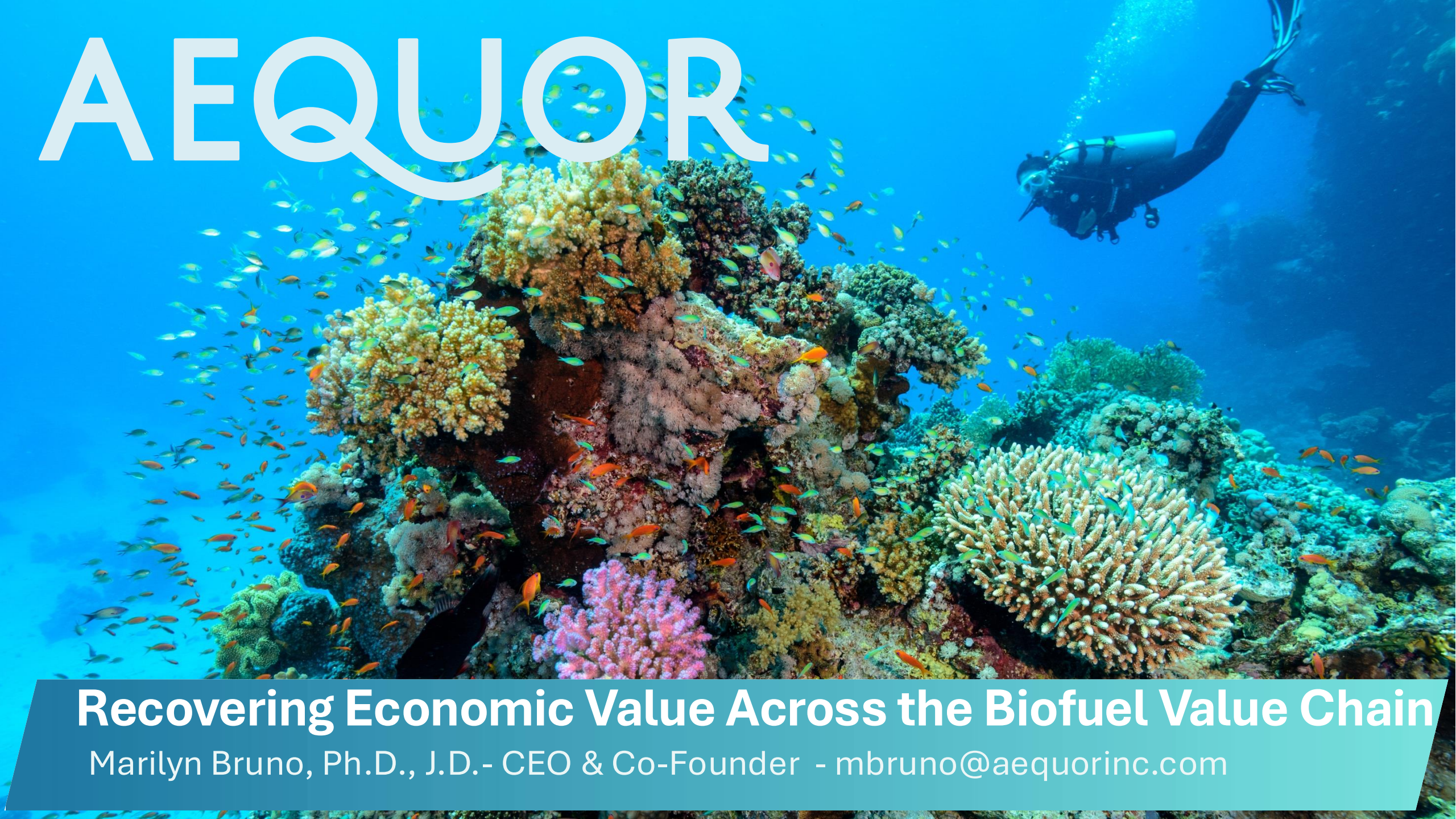


Recovering Economic Value Across the Biofuel Value Chain

Marilyn Bruno, Ph.D., J.D.- CEO & Co-Founder - mbruno@aequorinc.com

The Bioeconomy Nemesis - Biofilm

Feedstocks - 2–10% loss

Fermentation - 1–30% loss

Conversion – 2-10% loss

SAF /Fuels – 1-3% loss

Storage, Distribution – 1-3% loss



Biocontamination in Actual Groundwater Sample

Biofilm - a constant financial—and carbon—drain on ROI



ENERGY ↑ ~50%

LABOR ↑ DOWNTIME ↑

WATER + CHEMICALS ↑

PRODUCTION ↓ ROI ↓

The cost of remediation is only one line item
The larger opportunity is avoiding the cascade of operating losses

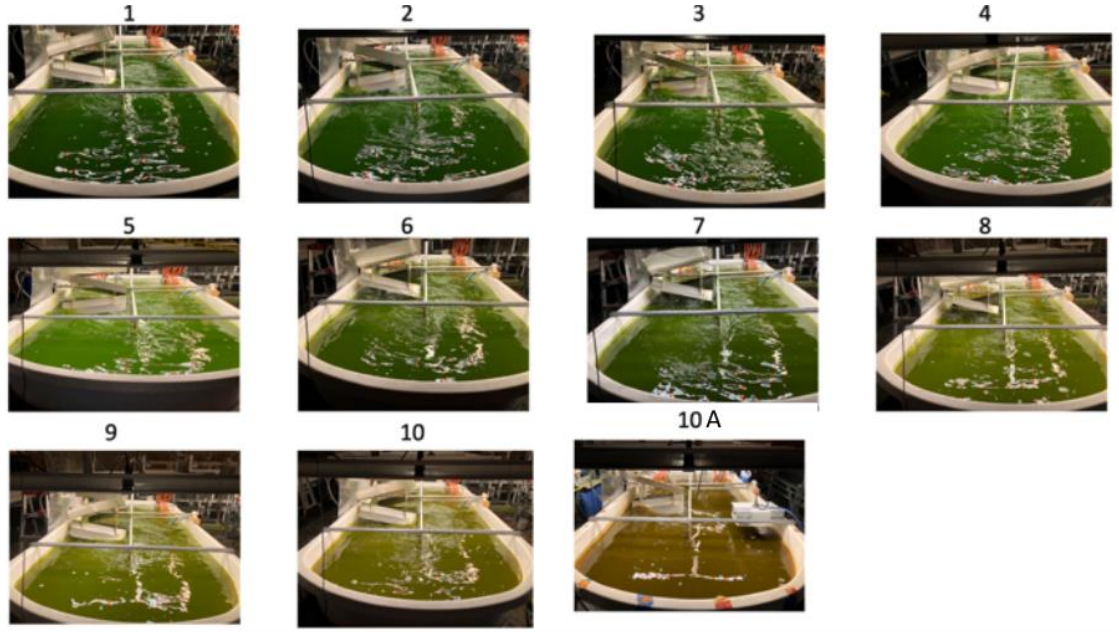
Biofilm choke points across the biofuel industry supply chain

Operation	Primary biofilm mechanism	Screening loss range*	Example of annual value at risk**
Feedstock integrity	Microbial/ fungal degradation during storage; loss of dry matter & usable energy	**2–10%**	**$3–16M**
Fermentation	Biofilm + metabolites; sugar diversion; yeast inhibition; stuck batches	**1–5% typical; 20–30% severe**	**$2–10M; severe $40–60M**
Heat exchangers	Biofilm/fouling layer lowers heat transfer; ΔP and cleaning frequency rise	**~2–10% energy penalty*** **	**$0.2–1.0M/yr energy + downtime**
SAF production	Biofouling in water/process circuits and surfaces; contamination-driven fouling/rework	**1–3% planning case**** **	**$5–15M**
Fuel stability/storage	Biofilm at water/fuel interfaces → degradation, sludge, filter plugging, MIC	**1–3% planning case***** **	**$3.5–10.5M**

Sources / basis: Citations on following slides: *Wood-chip storage studies report 7–9% dry-matter loss over ~5 months; other storage systems can be higher. | **Fuel-ethanol literature reports 1–5% yield effects at high bacterial loads and up to 20–30% in severe contamination. |*** Heat-exchanger estimate is a planning envelope; a 50-MGY ethanol study reported $3.53M/yr total fouling cost and 0.38 kWh/L extra energy. | ****SAF and storage planning cases are illustrative.

Risk #1: 2-10% Feedstock storage loss; 100% production loss





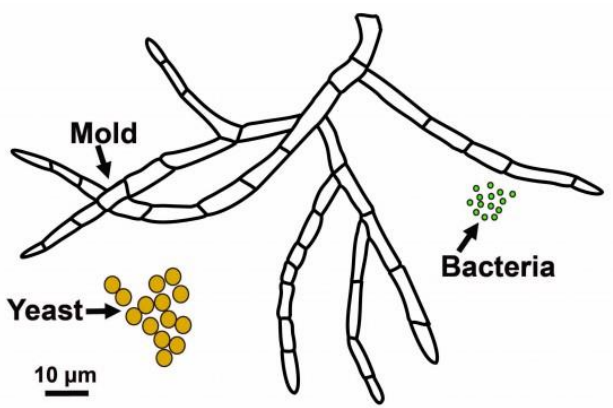
Example: Stored crop residues/corn stover with visible degradation – contributes to aggregation, blockage, and processing inefficiency

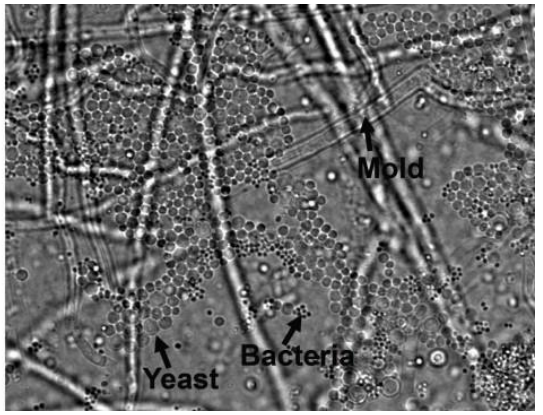
https://www.frontiersin.org/journals/energy-research/articles/10.3389/fenrg.2022.868019/full

Example: Algae cultivated in open ponds crash when attacked by bacterial and fungal predators

Risk #2: 1-30% loss in fermentation process – bioethanol

U.S. produced 52% (16.494 bg) of 32 bg total world bioethanol production in 2025



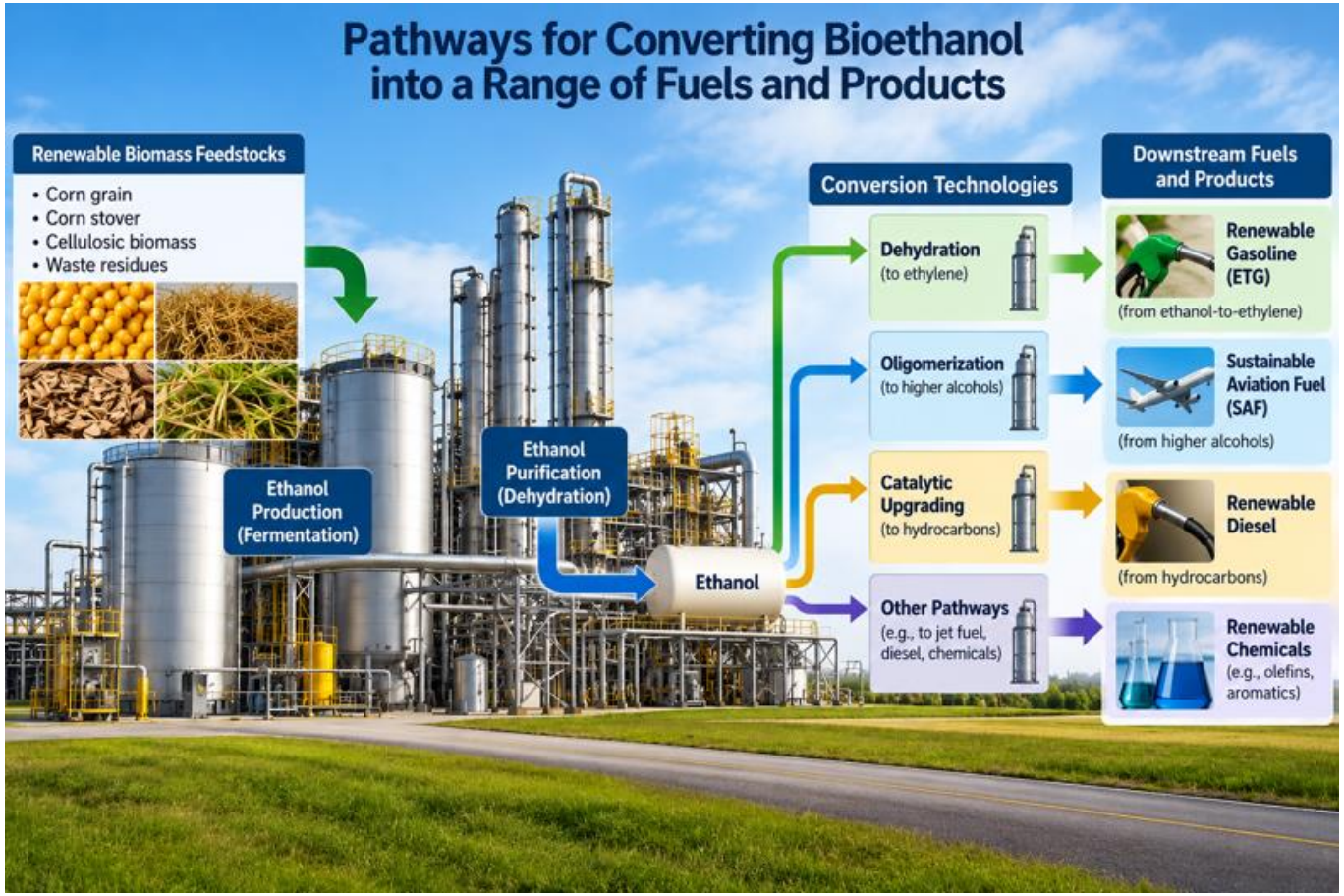


Impact per every 1% loss in U.S. = ~ $32B revenue + $230M feedstock input cost

	Production Volume Loss	Direct Revenue Loss
Typical Plant (100mg/year)	**1 million gallons**	**~ $1.6M**
Total U.S. industry (16.494 bg/yr)	164.9 million gallons	~ $264M

https://ethanolrfa.org/media-and-news/category/news-releases/article/2026/03/u-s-ethanol-production-set-a-record-in-2025-new-data-show
https://www.ars.usda.gov/research/publications/publication/?seqNo115=430601&utm_source=chatgpt.com
https://pubmed.ncbi.nlm.nih.gov/15338420/
https://microbialfoods.org/using-microscopy-to-monitor-artisan-fermentations/

Risk #3: 2-10% Conversion Loss -- a tax on energy + uptime





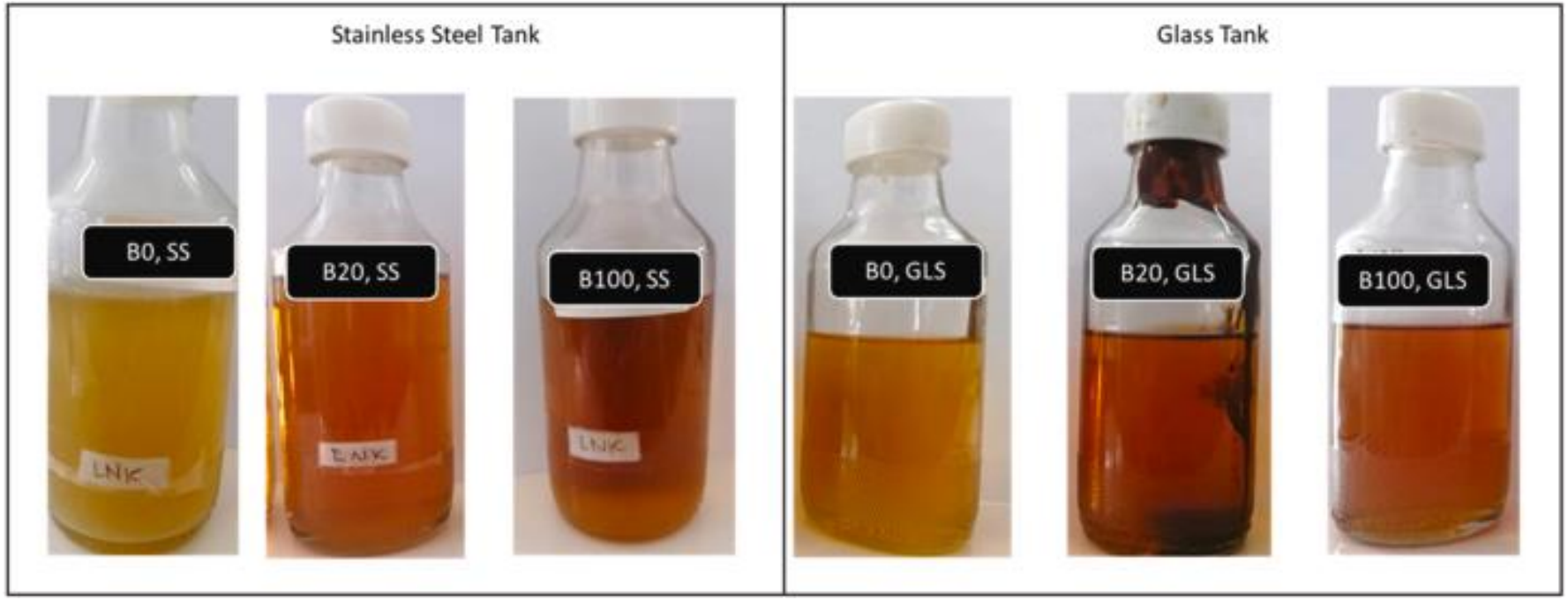


Appl Microbiol Biotechnol. 2015 Jun 20;99(16):6945–6957. doi: 10.1007/s00253-015-6729-4

AI-generated illustration prepared for Aequor, Inc.; pathway concept informed by U.S. Department of Energy Bioenergy Technologies Office materials on ethanol-to-jet conversion.
https://www.nlr.gov/bioenergy/ibrf
https://www.sciencedirect.com/science/article/pii/S0196890426009684
https://pmc.ncbi.nlm.nih.gov/articles/PMC4513208/?utm_source=chatgpt.com
https://biomassmagazine.com/articles/pnnl-technology-clears-way-for-ethanol-derived-jet-fuel-15369

Risk #4: 1-3% Finished Biofuel Stability Loss

Visible fuel degradation/sludge/deposits associated with biocontamination



Source: Heliyon. 2022 Apr 9;8(4):e09264. doi: 10.1016/j.heliyon.2022.e09264

ASTM D1655 and DEFSTAN 91-91 fuel specifications do not specify limits for microbial contamination - IATA, JIG, ASTM, EI, A4A guidance emphasizes monitoring/preventing it

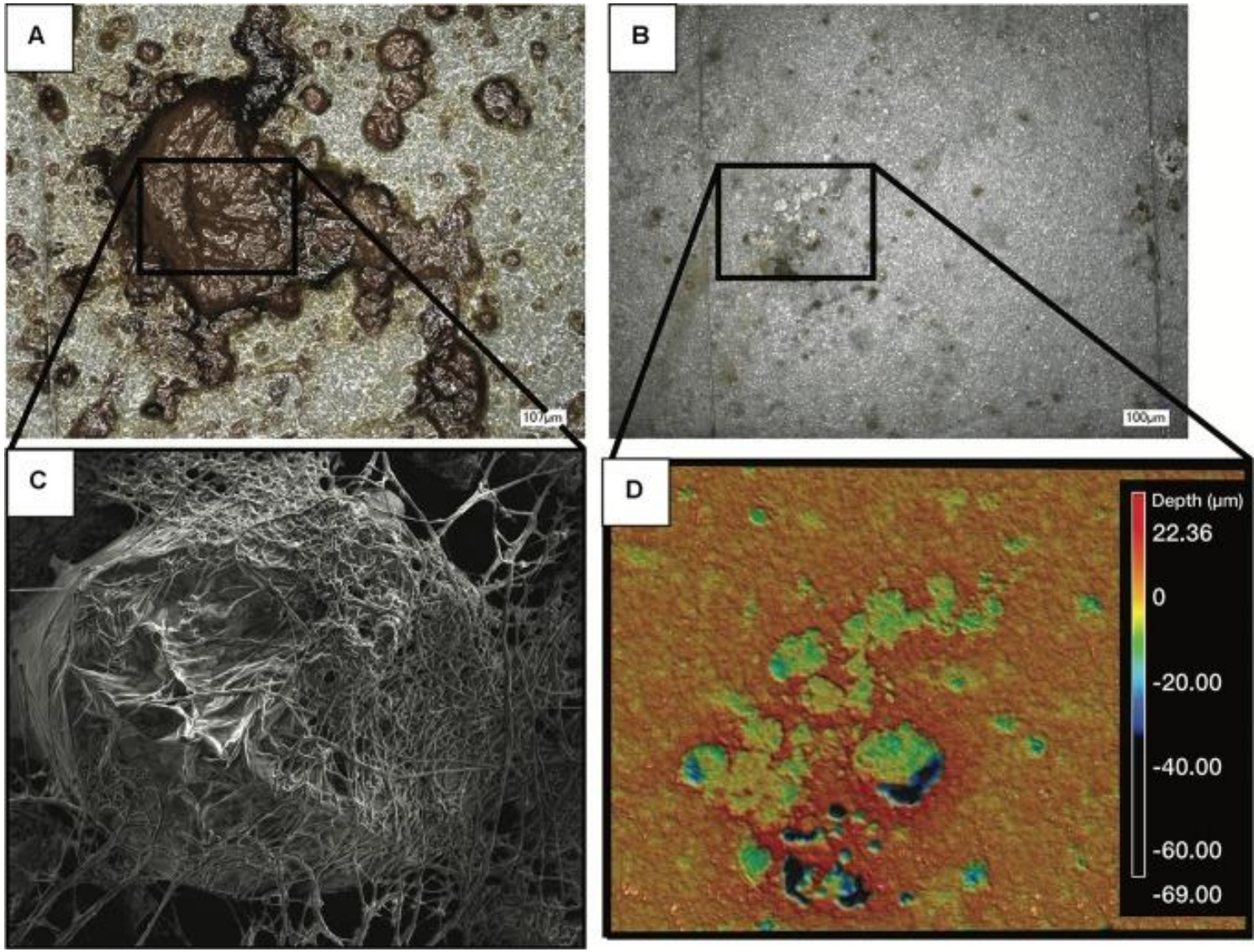
Risk #5: 1-3% Fuel Storage Loss to Bacteria and Fungi

(A) biofilm on a witness coupon

(B) after cleaning, pitting corrosion underneath the biofilm

(C) fungal hyphae on coupon before cleaning (SEM imaging)

(D) after cleaning, pitting corrosion (profilometry)



Impact: MIC Corrosion is a $450B problem in the U.S.

Source: https://tcdfillinois.org/the-high-cost-of-corrosion/

Source: Front Microbiol. 2020 Feb 25;11:167. doi: 10.3389/fmicb.2020.00167

Impacts of biofuel storage risk

Example: 10-million-gallon fuel inventory @ $3/gallon

INVENTORY VALUE
$30M

1% LOSS EXPOSURE
$300K

Cascading impact on ROI

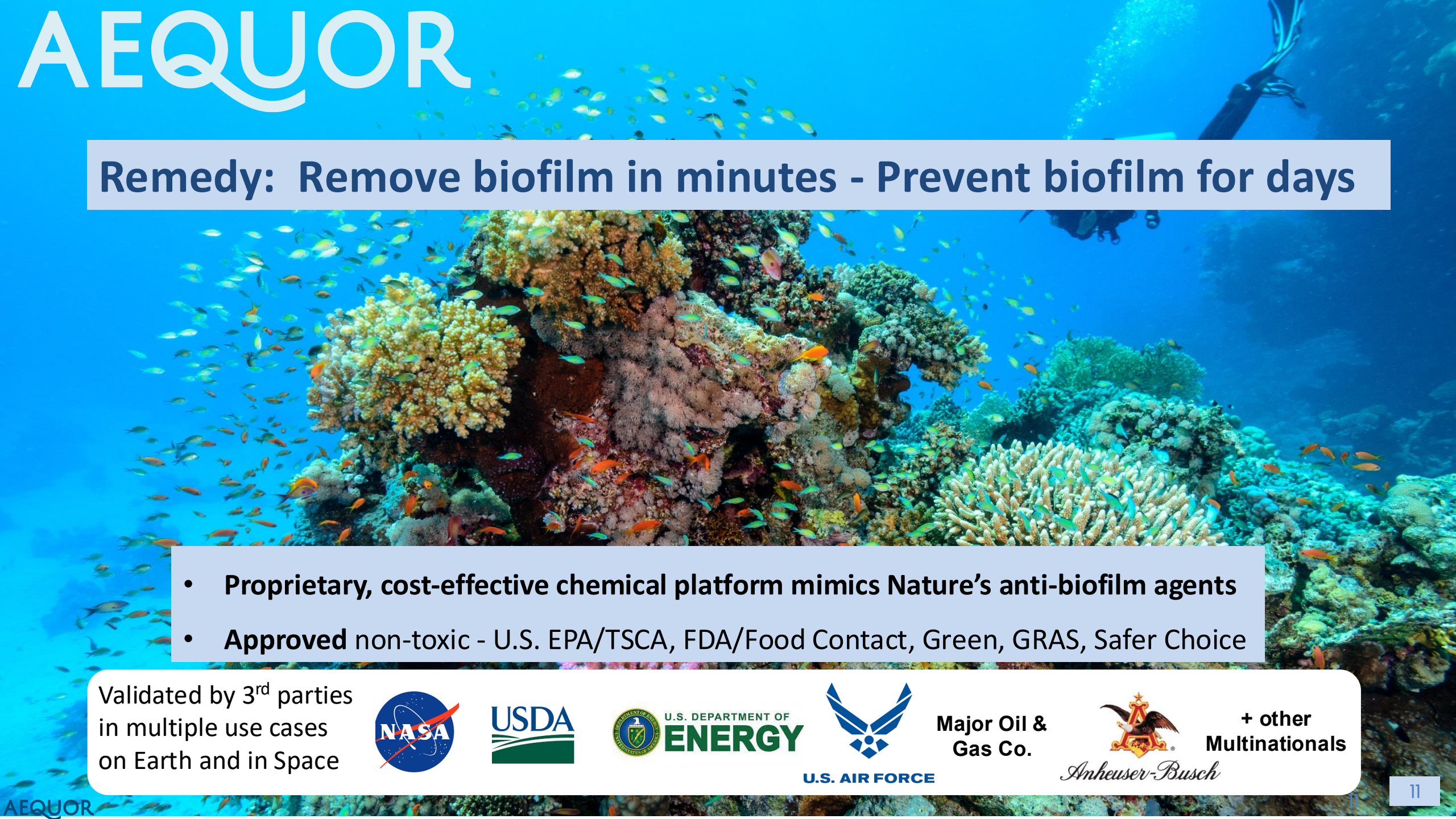
- CapEx – carbon-intensive replacement tanks, components
- OpEx – labor, downtime, maintenance frequency, cleaning treatments

Cascading impact on demand

- Zero tolerance for performance risk
- Zero tolerance for risk to infrastructure

AEQUOR

Remedy: Remove biofilm in minutes - Prevent biofilm for days



- **Proprietary, cost-effective chemical platform mimics Nature's anti-biofilm agents**
- **Approved** non-toxic - U.S. EPA/TSCA, FDA/Food Contact, Green, GRAS, Safer Choice

Validated by 3rd parties in multiple use cases on Earth and in Space

NASA

USDA

U.S. DEPARTMENT OF ENERGY

U.S. AIR FORCE

Major Oil & Gas Co.

Anheuser-Busch

+ other Multinationals

Compare remedies for feedstock losses

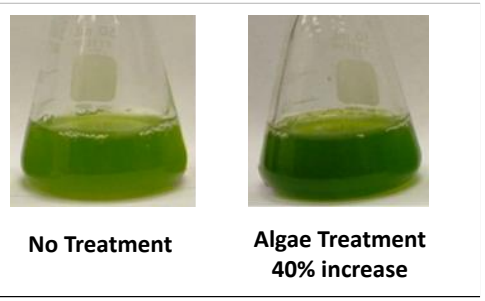
Current practice	Limitation	Aequor opportunity	Key Performance Indicators - KPIs
Covering / drying / controlled storage	Capital + energy; does not directly address surface biofilm	Surface treatment + biofilm prevention strategy	Dry-matter loss %; usable MJ/ton
Moisture, temperature control, pile design	Reduces microbial growth but may not remove established films	Removes biofilm in minutes Prevents biofilm for days	CFU/ATP; retard degradation; storage stability
Chemical preservatives / biocides	May require repeated dosing; HAZMAT use, disposal/ regulatory burden	Non-toxic, EPA/TSCA and FDA/Food Additive-approved; GRAS, Green, Saver Choice	Dose, persistence, residue profile

Example: $160.7M/yr feedstock value @ 2–10% loss = ~$3.2–$16.1M/yr at risk

Each ton of degraded dry matter requires more feedstock harvesting, S/H to make same output

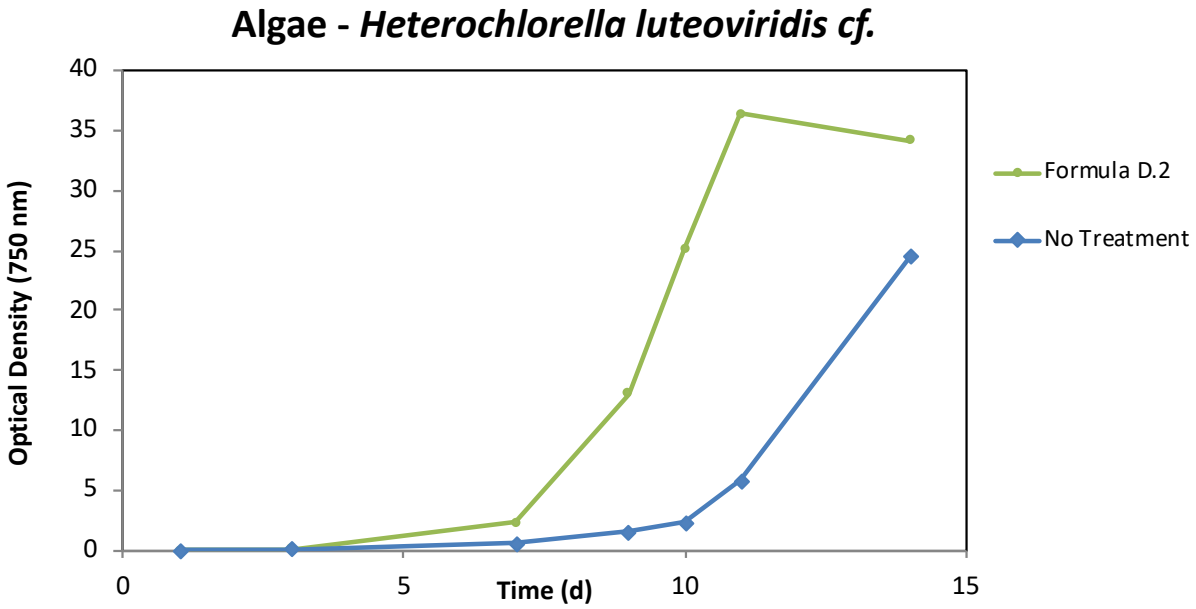
Sources / basis: Kuptz et al., Biomass & Bioenergy (2020): Wood chip storage - 7–9% dry-matter loss in ~153-days | Anerud et al., Biomass & Bioenergy (2021): uncovered wood chips ~1.1% loss/month; covered ~0.4%/month in one study.

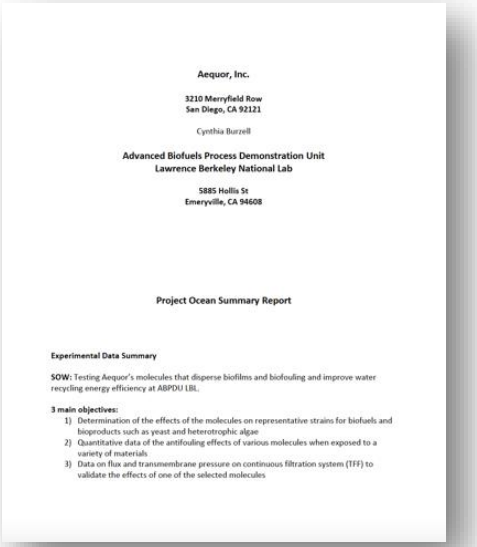
Unique remedy for algae cultivation in bioreactors + boost biomass 40% in half the time



No Treatment

Algae Treatment
40% increase





Aequor, Inc.

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San Diego, CA 92121

Cynthia Burzell

Advanced Biofuels Process Demonstration Unit
Lawrence Berkeley National Lab

5885 Hollis St
Emeryville, CA 94608

Project Ocean Summary Report

Experimental Data Summary

SOW: Testing Aequor's molecules that disperse biofilms and biofouling and improve water recycling energy efficiency at ABPDU LBL.

3 main objectives:

1) Determination of the effects of the molecules on representative strains for biofuels and bioproducts such as yeast and heterotrophic algae
2) Quantitative data of the antifouling effects of various molecules when exposed to a variety of materials
3) Data on flux and transmembrane pressure on continuous filtration system (TFF) to validate the effects of one of the selected molecules

Impact

Save CAPEX
Save OPEX
Extend harvest cycles; increase profits

Unique remedy for algae cultivation in open ponds



Photo courtesy of Aeuqor – Cynthia Burzell

Impact

Aequor is the only remedy that protects algae from fungal attack
Crop protection
No pond crashes
Extend harvest cycle by >100%

DOE/NREL technoeconomic analysis shows 20% overall energy savings

Compare remedies for fermentation losses

Example: 100 MMGY basis: $2.00/gal product value → $200M annual revenue

Current method	What it does	Aequor comparison	Economic KPI
Antibiotics	Suppress LAB; resistance/recurrence concerns	Potential antibiotic-alternative / biofilm strategy; validate in process stream	Yield %, acid load, antibiotic use
Acid treatment / CIP	Reduces contamination after the event	Target biofilm + contamination before recurrence; custom formulation	Cleaning frequency; downtime h/yr
Sanitation + monitoring	Detects contamination; often reactive	Add biofilm-specific prevention layer	Stuck batches; $/batch

Commercial fuel-ethanol plants experience chronic bacterial contamination; Lactobacillus is commonly reported. /Published literature reports ethanol-yield reductions of ~1–5% at high bacterial loads and severe cases reaching 20–30%. /One published estimate for a 100-MMGY facility put moderate chronic contamination at ~$4.5M/yr revenue loss; a single stuck fermentor could cost ~$190,000.

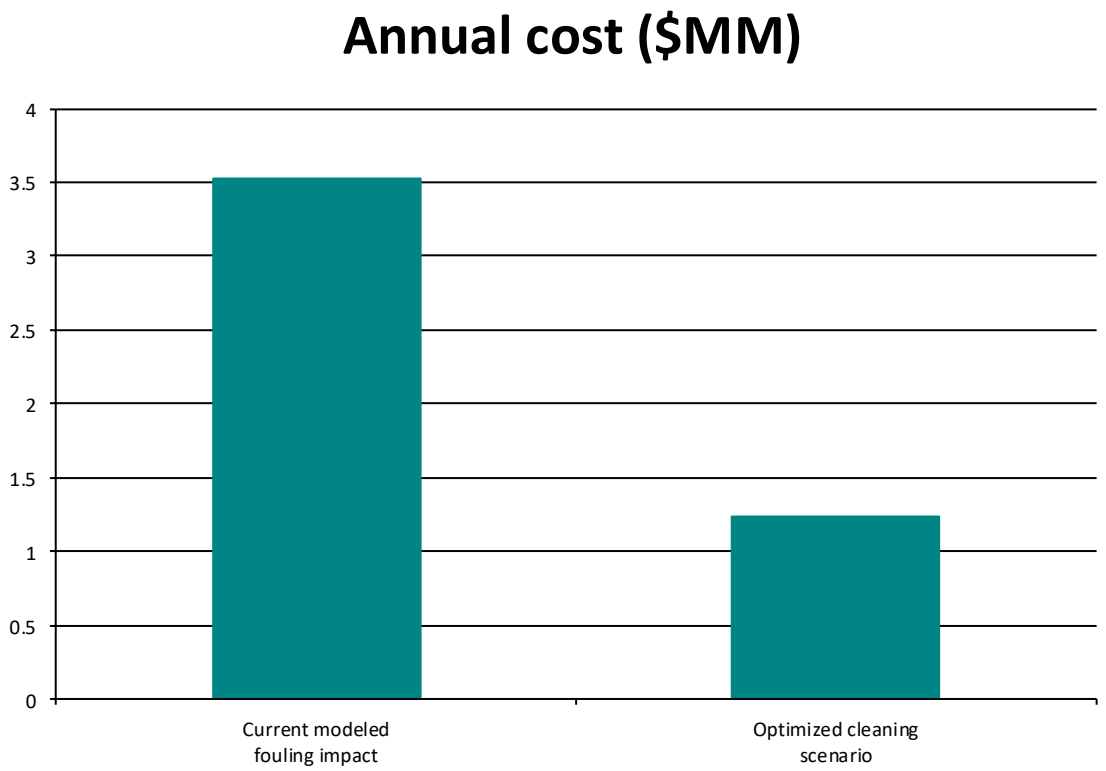
Sources / basis: Rich et al., Bioresource Technology Reports (2020): 1–5% yield loss literature; $4.5M/yr at 100 MMGY; stuck fermentor up to $190k. | Rich et al., Bioresource Technology (2015): persistent biofilms; 92% of isolates were Lactobacillus in the studied facility. | Aequor: productivity enhancement and antibiotic-alternative positioning; validate site-specific claims in pilot.

De-risking 3-30% fermentation loss – reduce energy + carbon penalty

Example - 50 MMgal/year dry-grind ethanol plant

$3.53M/year additional cost under fouling conditions

Optimized cleaning – 5-70% reductions in energy, water and emissions



15,435 t CO_2/year modeled impact

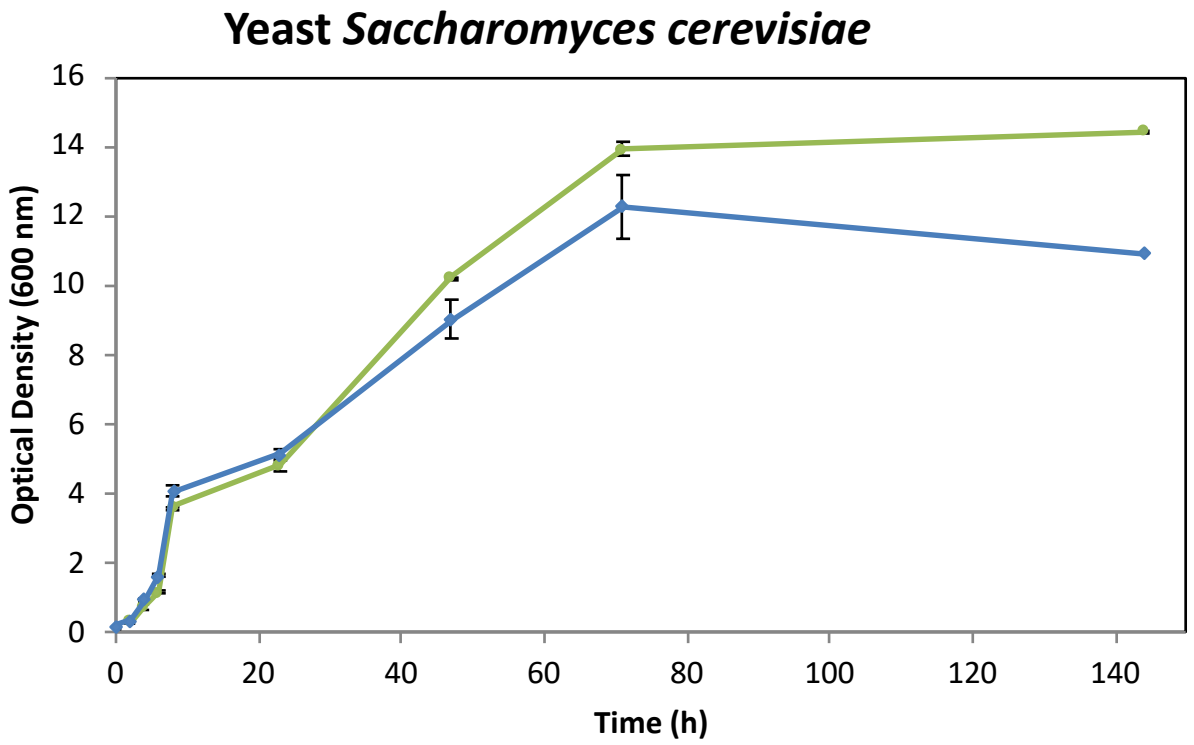
70,809 MWh additional energy

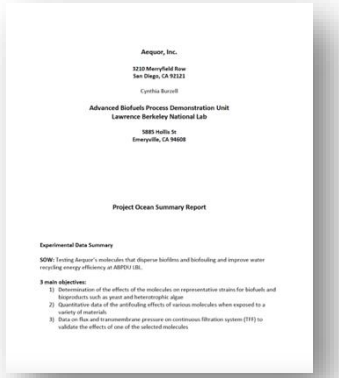
106,738 m^3 additional water

65–70% cost reduction

Source: Impact of heat exchanger fouling in bioethanol plants (2024)
https://www.sciencedirect.com/science/article/abs/pii/S0263876224006610

Example: Aequor de-risked **fermentation**




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3) Data on flux and transmembrane pressure on continuous filtration system (TFF) to validate the effects of one of the selected molecules

Impact

Save CAPEX
Save OPEX
Boost biomass 30%
Eliminate use of antibiotics that remain in fermentation residues sold as animal feed

Compare remedies for downstream heat exchange losses

Current method	Trade-off	Aequor opportunity	KPIs
CIP / chemical cleaning	Downtime + water + chemical load	Biofilm removal/prevention to extend clean intervals	ΔP; U-value; clean interval
Higher steam / utility input	Maintains duty but raises energy and CO_2	Reduce fouling layer before utility escalation	kWh/gal; steam/gal
Mechanical cleaning	Labor + outage; reactive	Target persistent films between cleanings	Hours offline; labor $

Impact

- Reduced heat transfer, higher pressure drop
- Increased cleaning, energy, water, emissions
- In a 50-MMGY case = $3.53M/yr - 0.38 kWh/L extra energy - 81.67 g CO_2/L

Source: "Impact of heat exchanger fouling in bioethanol plants," authored by C. Prieto, M. Martín, and F. Coletti, published in the journal Chemical Engineering Research and Design (Volume 213, January 2025, with early versions available in late 2024).
Note: ΔP = differential pressure; U-value = rate of heat transfer through one square meter of a structure for every degree of temperature difference between inside and outside.

Example: Hydrogen

Example: 10 MW electrolyzer

AUXILIARY LOAD
5% of electrical input

OPTIMIZATION
10% auxiliary reduction

ENERGY AVOIDED
438 MWh / year

ANNUAL VALUE

~ $30K

at $70/MWh

CARBON REDUCTION

~ 153 tCO_2 / yr

at 0.35 kg CO_2/kWh grid intensity

Scale example to 100 MMGY	
~ $7.1M/yr	**~ 30,900 tCO_2/yr**
total fouling cost	

Compare remedies for SAF losses

Example: 100-MMgal SAF value base at $5/gal = $5-15M/year value at risk

Current method	Typical purpose	Aequor opportunity	KPIs
Water control + filtration	Limit microbial habitat/solids	Biofilm-focused water and surface treatment	ATP/CFU microbial load; filter life
Biocide / preservative programs	Suppress microbial growth	Lower-toxicity antibiofilm option	Biofilm reduction; dose
CIP / exchanger cleaning	Restore heat transfer	Prevent recurrence and extend intervals	Throughput loss; ΔP; clean interval
Rework / off-spec management	Contain product quality risk	Reduce contamination-driven excursions	Off-spec material %, $ rework

Sources / basis: DOE/Argonne GREET models the full corn-to-jet pathway and identifies ethanol production and farming as major emissions sources.
SAF biofilm loss range used is a screening assumption, not a published industry average – Applied regardless of pathway: fermentation, alcohol-to-jet or other upgrading, hydroprocessing, separations and water/process utility loops. .

Summary - Convert technical performance into financial outcomes

4 measurable economic levers

PROTECT
Feedstock integrity and usable yield

CONTROL
Biofilm + contamination persistence

CLEAN
Remove fouling + maintenance efficiency

STABILIZE
Process continuity + fuel quality

↑ Yield
Increased margins

↓ OpEx
cleaning / water labor/ energy

↑ Uptime
fewer interruptions

↓ CI
lower process emissions

Plus the Aequor carbon-abatement stack

Carbon benefit accumulate across multiple operating levers

ENERGY
avoided kWh

MATERIALS
preserved feedstock

WATER
less cleaning

CHEMICALS
lower consumption

UPTIME
less restart waste

OUTPUT
more renewable product

Measured operating deltas → lifecycle carbon factors → tonnes CO_2e avoided

Supports customer-specific carbon accounting, including lifecycle frameworks

Sources / basis: DOE GREET: lifecycle energy and GHG accounting across fuel supply chains. Biomass storage study: dry-matter losses can increase net GHG emissions 3–53% depending on storage pathway. Heat-exchanger fouling study: 15,435 t CO_2/yr at 50 MMGY; 81.67 g CO_2/L additional emissions.

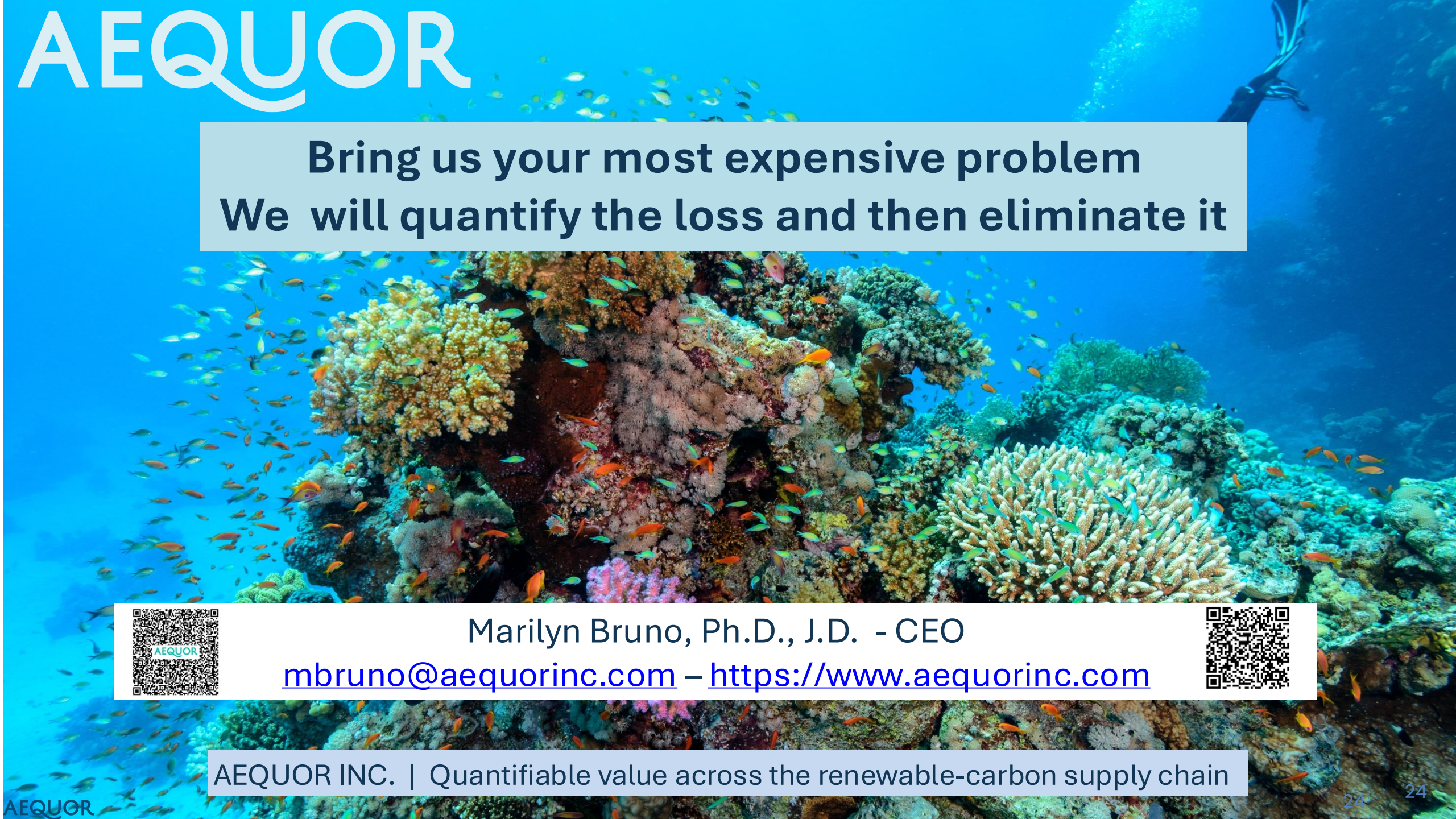
Conclusion - Avoid losses, CO2e, costs

Sector	Carbon mechanism	Illustrative carbon effect	Why Aequor matters
Feedstock integrity	Less biomass loss → less replacement farming/harvesting/transport	Storage losses can increase net GHG emissions 3–53% depending on system	Protect embedded biogenic carbon and energy
Fermentation	Higher yield → same gallons from less feedstock + fewer shutdown utilities	1% yield recovery on 100 MMGY ≈ 1 MMgal avoided production burden	More product per unit feedstock
Heat exchangers	Less fouling → less steam/electricity + less water	50-MMGY case: 15,435 t CO_2/yr fouling impact	Reduce utility carbon intensity
SAF	Less rework/throughput loss → lower energy/feedstock per delivered gallon	Use GREET/40BSAF-GREET with site data	Protect SAF carbon-intensity score
Fuel stability	Less off-spec, sludge and replacement fuel/infrastructure	Avoided disposal, reprocessing and replacement energy	Extend useful fuel life

See for yourself: kg CO_2e avoided per $1 of Aequor spend

AEQUOR

Bring us your most expensive problem
We will quantify the loss and then eliminate it



Marilyn Bruno, Ph.D., J.D. - CEO

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OPTIONAL SLIDES

NEXT STEPS – SEE FOR YOURSELF

26 Bring us 1 expensive problem
27 Identify hotspots
28 Baseline – Deploy – Verify – Scale
29 Screening economics
30 Assess performance – You do the math
31 Bottom line – Quantified value
32 Example – Feedstock preservation
33. Example – Fermentation improvement
34. Example – Fuel stability
35. Example – Fuel storage
36. Compare outcomes



Bring us one expensive biofilm problem

Partner → Pilot → Prove → Scale

- Industrial fermenters & bioprocessors
- Biomass / renewable-feedstock operators
- Fuel producers & storage operators
- Water / process-treatment partners
- Strategic investors, licensors & manufacturing partners

Identify the Hotspots – Baseline KPIs - Deploy Aequor

Baseline loss at risk vs savings in strategic uptime, ATP/CFU, water, labor + CO2e benefits

Value pool	Illustrative annual loss at risk	Aequor value lever	KPIs /metric
Feedstock integrity	$3–16M	Reduce microbial degradation / preserve usable biomass	% dry-matter loss; $/ton preserved
Fermentation	$2–10M typical; severe cases much higher	Reduce contamination, yield loss and stuck batches	% yield; $/batch; downtime
Heat exchangers	$7.1M total fouling benchmark at 100 MMGY	Reduce biofilm contribution to fouling and extend clean intervals	kWh/gal; ΔP; clean interval
SAF production	$5–15M planning case	Reduce contamination-driven throughput/rework risk	% throughput; off-spec %
Fuel stability	$3.5–10.5M planning case	Prevent biofilm, sludge, corrosion and filter plugging	filter life; off-spec %; MIC

Sources / basis: All dollar values are screening calculations, not audited customer losses. | Aequor claims and product status are based on Aequor public materials; application-specific efficacy should be independently validated. SAF-specific economics should be validated with customer process data.

Checklist: From chemistry to measurable customer ROI

1	**BASELINE**	Energy • labor • cleaning • water • chemicals • downtime • yield
2	**DEPLOY**	Apply Aequor technology under defined operating conditions
3	**VERIFY**	Compare performance, economics and carbon intensity
4	**SCALE**	Customer purchase • strategic partnership • licensing

THE BOTTOM LINE

$ annual value created

tCO_2e annual reduction

Screening economics → customer ops. → measured $/yr and kg CO_2e avoided

Buyer group	Aequor use	Time / downtime	CapEx effect	OpEx effect	Carbon effect
Feedstock producers & storage	Feedstock protection	Potential fewer emergency interventions, losses and cleanouts	Potential deferral/reduction of added capacity needed to replace degraded feedstock	Recovered feedstock; lower handling/cleaning/waste	100,000 dry-ton/yr woody biomass illustrative case: 5% storage loss × 50% recovery = 2,500 tons preserved; ~4,580 tCO2e biogenic carbon retained
Fermenters	Feedstock/fermentation formulation	Potential reduction in contamination events, cleaning and downtime	Potential reduction/deferral of redundant tanks/CIP capacity	Illustrative 100-MMGY case: ~$450K/yr potential value associated with a 10% productivity scenario	Illustrative potential ~33,000 tCO2e/yr; not demonstrated
Process-water/cooling	Process-water/cooling formulation	Potential reduction in fouling maintenance and cleaning downtime	Potentially less redundant heat-exchanger/water-treatment capacity	Potential lower energy, chemicals, labor and maintenance	Site-specific energy/chemical savings to be measured
Fuel storage/distribution	Fuel-storage/distribution formulation	Potential fewer tank/pipeline cleanouts and contamination events	Potential deferral of replacement/expansion capacity	Lower product loss, cleaning, labor and maintenance	Reduced product loss and associated emissions; site-specific
Hydrogen / adjacent clean fuels	Process-water/contamination control where applicable	Potential maintenance interruptions avoided	Potential water-treatment/equipment capacity deferral	Potential water, chemical, energy and maintenance savings	No independent hydrogen-sector savings demonstrated yet

Assess performance

✓ PREVENT	✓ REMOVE	✓ OPTIMIZE
Stop biofilm/contamination before downstream costs compound	Restore performance where biofilm and deposits already exist	Produce more with the same infrastructure—or the same with less

You do the math

Energy + labor + water + chemicals + avoided downtime + preserved product + incremental output

+ carbon value using the same measured operating deltas → tonnes CO_2e avoided

minus Aequor cost

= improved ROI

Bottom line – Quantified value

E.g. $20–60M+ of Annual Value at Risk Across a 100-MMgal/yr Biofuel System

Buyer / application	Quantified value opportunity
Feedstock integrity	$3–16M/yr
Fermentation	$2–10M+/yr
Heat exchangers / fouling	$7.1M benchmark
SAF production	$5–15M/yr
Fuel stability / storage	$3.5–10.5M/yr

Aequor creates measurable economic value through five levers:

Lower OPEX → Less downtime → Lower carbon → Lower labor /downtime

Deferred CAPEX → combat corrosion, stability, need for new infrastructure

Example: Ligno-cellulosic feedstocks KPIs

Example: $10M annual feedstock inventory

Annual feedstock managed	**$10.0M**
3% degradation / loss exposure	**$300K**
50% loss reduction	**$150K**
Recovered annual value	**$150K**

- ✓ Dry-matter preservation
- ✓ Lower spoilage / heating
- ✓ Protect downstream yield
- ✓ Avoid replacement carbon

Preservation is a margin strategy—not just a storage strategy

Example: Fermentation KPIs: protect yield, uptime, turnaround

BATCH LOSS

Product + feedstock + reactor time

CIP

Water + chemicals + labor + utilities

DOWNTIME

Lost production hours + delayed campaigns

VARIABILITY

Yield, quality and scheduling risk

- Pilot KPIs: microbial load / biofilm, yield, batch duration, CIP frequency, water and chemical use, downtime and $/batch.

Example: Fouling and fuel stability KPIs

Biofilm can create operating costs after fermentation is complete.

ΔP

pressure drop / flow impact

CLEAN

cleaning interval / labor

QUALITY

off-spec / rework risk

- Heat exchangers: biological fouling can reduce heat-transfer performance and increase cleaning requirements.
- Fuel storage: microbial growth at water/fuel interfaces can contribute to sludge, filter plugging, corrosion and fuel degradation.
- Pilot endpoints: filter life, flow, ΔP, clean interval, microbial load, water bottoms, corrosion indicators and product quality.

Example: Biofuel storage and infrastructure risk

Current method	Strength	Weakness	Aequor opportunity
Water draw-off / tank housekeeping	Removes microbial habitat	Does not remove established biofilm	Treat tank/line surfaces + water loop
Biocides	Can suppress microbes	Resistance, repeat dosing, disposal	Antibiofilm approach; optimize dose
Antioxidants / stabilizers	Controls chemical oxidation	Does not directly address biofilm	Combine stability + biofilm control
Filter replacement	Restores flow	Reactive labor + waste	Extend filter life by preventing biofilm

Microbes grow at fuel/water interfaces; biofilms can generate sludge, acids and other metabolites, accelerate corrosion and plug filters and lines.

NREL recommends keeping tanks dry, removing water bottoms and routinely sampling/testing for microbial contamination.

A 100-MMgal inventory at $3.50/gal represents $350M of product value; a 1–3% contamination/rework/off-spec planning case is $3.5–10.5M.

Sources / basis: DOE/NREL Biodiesel Fuel Management Best Practices: biofilm can plug filters/lines and contribute to MIC. | NREL Biodiesel Handling (2024): microbial contamination can plug dispensers and filters; water control is a primary defense. | 2026 review: biodiesel storage risks include biofilm, fuel degradation, corrosion and filter clogging.

Compare outcomes: your methods vs. Aequor's economics

Sector	Current-control spend / loss	Aequor role	Target measurable outcome
Feedstock	2–10% dry-matter loss	Surface/water biofilm control during storage & handling	≥25–50% reduction in avoidable storage loss*
Fermentation	1–5% yield loss; severe 20–30%	Antibiofilm + productivity/antibiotic-alternative strategy	+1–3 % yield; fewer stuck batches*
Heat exchangers	$3.53M/50 MMGY benchmark	Biofilm removal/prevention in water-contact systems	5–10% energy or clean-interval improvement*
SAF	1–3% planning case	Process-water/surface fouling control	1–2% throughput/rework improvement*
Fuel stability	1–3% planning case	Tank/line biofilm control + stability program	1–2% product-value recovery*

Sources / basis: Aequor product positioning: green water treatments, cleaners, industrial antibiofilm/antifouling treatments
Projects ~10% energy/water/labor savings as a general opportunity and up to 40% productivity enhancement for certain lgae/yeast applications