<table>
<thead>
<tr>
<th>TIME</th>
<th>ACTIVITY</th>
</tr>
</thead>
</table>
| 1:00-2:00 PM EDT  
10:00-11:00 AM PDT | BioMADE Technical Mission Overview  
- Technical Focus Areas  
- Manufacturing Readiness Levels  
- Roles and Responsibilities of the Technical Committee  
- Types of BioMADE Projects  
- Q&A |
| 2:30-4:00 PM EDT  
11:30 AM-1:00 PM PDT | Proposers’ Day information on responding to Open Call RFP  
- Scope and Mission of Open Call RFP  
- Two-Stage Proposal Process  
- Membership Requirements and Teaming  
- Proposal Review Criteria  
- Q&A |
| 4:00-5:00 PM EDT  
1:00-2:00 PM PDT | Mapping the Domestic Pilot-Scale Infrastructure  
- BioMADE Mission on Mapping, Connecting, and Growing Infrastructure  
- Lightning Talks from Available Pilot Scale-Up Production and Downstream Processing  
- Q&A |
BioMADE Technology Day
April 29, 2021
Overview of the Technology Program of BioMADE

Three Sessions Today

Overview of the BioMADE Technical Mission & Operations

- Steve Evans, BioMADE Interim CTO
- Jimmy Gollihar, Government CTO
- Laura Vitko, Membership Manager

Current Open RFP Program - Let’s Get to Work!

- Clem Fortman, Director of Program Management

Mapping, Connecting, and Growing the Domestic Pilot-Scale Infrastructure

- Mike Smanski, Deputy CTO, plus Lightning Talks
BioMADE Technical Mission & Operations

What is the Mission?

- Manufacturing Readiness Levels and the Valley of Death
- National Bio-Manufacturing Technology Roadmap

How will we achieve the Mission together?

- Membership - the key to Committee and Project participation
- Technical Committee and Subcommittees
- Projects

How do we keep the Institute responsive to the Funder’s intent?

- Thrusts Areas and the M.A.D.E. Operational Modules
- Close working relationship between CTOs
Mission and Fit with other MIIs

BioMADE's mission is to enable domestic bioindustrial manufacturing at all scales, develop technologies to enhance U.S. bioindustrial competitiveness, derisk investment in relevant infrastructure, and expand the biomanufacturing workforce to realize the economic promise of industrial biotechnology.

The DoD Manufacturing USA innovation institutes are a key strategic investment for the DoD ManTech program. Each institute is designed to overcome challenges by advancing manufacturing innovation for specific, focused technology areas.
Bioindustrial Manufacturing Innovation for Specific Technology Areas

For BioMADE, these were framed in the Funding Opportunity Announcement (FOA) in 2020.

This is the origin of terms and concepts that are central to the Technology Program of BioMADE, such as:

- Manufacturing Readiness Levels (MRLs)
- Thrust Areas
- Roadmaps

BioMADE can’t do everything. Innovations must focus on bio-manufacturing needs.
The Institute’s Marching Orders from the FOA

Focus on maturing technologies from MRL 4-7

BioMADE’s synthesis of the requirements

- Corresponds to the Valley of Death
- Recognizes the positive impact of robust DBTL, and its limitations
- Emphasizes
  - Scale Up
  - Downstream Processing
  - Risk Mitigation
- M.A.D.E. creates to aid in conceptualizing a complex FOA
  - 5 Thrust Areas & 14 Sub Thrusts
Risk Mitigation: What besides Technical Risk?

Product and Technology Development face substantial commercialization risks:

- Product Demand and Pricing
- CapEx/OpEx
- Pilot scale availability
- Performance in systems
- Non-bio competition
- Regulatory / Legal
- Supply Chain
- IP theft
- Workforce
- And others

The BioMADE Technology Roadmap will develop strategies to deal with technical and business risks.
Looking Ahead to Projects

- How can we make a strain to synthesize $x$ (low priority)
- **How can we:**
  - overcome ____ in scaling or manufacturing...
  - boost accumulation from 5 gL$^{-1}$ to 80 gL$^{-1}$ and double the rate...
  - remove 2 unit operations from purification ... *to make kilograms*
Roadmapping: Integral to BioMADE’s Success

Must Haves:

● Stakeholder-Driven, Industry-Led, and DoD-Relevant
● Mature technology areas, manufacturing processes and capabilities
● Attend to both the defense applications and commercial applications

Why?

● Plan, Prioritize, Compete, Evaluate, and Execute Projects
● Integrate business plan with the Roadmap to partner with other Federal agencies

How?

● Roadmapping is a key responsibility of the BioMADE Technical Committee (TC)
● This TC is a key element guiding Member involvement in BioMADE
Membership: The Key to Committee and Project Participation

Members directly contribute to the success of BioMADE by working on committees and subcommittees focused on strategic, technical, and workforce development.

Members remain engaged and active in submitting proposals to the current and future project calls.
BioMADE Membership

- Provides a broad range of benefits
- Membership tiers are inclusive to organizations of all sizes
- Annual membership investment is on a rolling basis
- Nearly 100 organizations have already committed to join
BioMADE Membership Benefits

Leverage a network of the best resources in bioindustrial manufacturing

• Intellectual Property Ecosystem
• Technical Roadmaps
• Governance Through Councils and Committees
• Extend Research and Development Capabilities
• Apply for Project Funding
• Education and Workforce Development Programming
Join BioMADE Today

New to BioMADE?
Visit biomade.org/membership and fill out an application.

Letter of Commitment Member?
Your organization’s point of contact will receive the membership agreement and terms & conditions documents.
Questions about Membership?

Contact

Laura Vitko, Membership Manager
membership@biomade.org
The Technical Committee is the focal point for the technical objectives of BioMADE. It must drive innovation activities to bridge MRL 4-7.


Subcommittees created as necessary to achieve technical objectives. Will meet quarterly, chairs elected from within.

- Subcommittee participation is open across the entire BioMADE membership spectrum.
What do they do, and not do?

The Technical Committee

- **Steward the Roadmap**
- Set *priorities* within and between areas of interest based on Roadmap
- ID areas that fall outside MRL 4-7 which may have strategic impact
- Not charged with voting on or approving individual projects

Subcommittees

- **Own sections of the Roadmap**
- Draft *Project Calls* aligned to the Roadmap with input from Government SMEs
- Not charged with reviewing all the proposals
Projects - Appetizer for the Second Section Today

Projects are where BioMADE member institutions collaboratively drive innovation.

**Institute Projects:** Responsive to Calls initiated through the Technical subcommittees and aligned to Institute priorities from the Roadmap ~ a yearly cycle

**Open RFP:** Standing call for submission of proposals, not constrained by current Institute priorities

**Government Directed Projects:** Activity funded in whole or part by a government agency separate from the BioMADE core investment. Government need driven

**Industry Initiated Projects:** Member company initiated project performed through the BioMADE institute infrastructure
Remaining true to Funder’s intent?

- Stay in the MRL 4-7 lane - with strategic deviation to lower MRLs
- Retain focus on the FOA’s Thrust Areas, but integrate and expand them via M.A.D.E.
  - Make kilograms
  - Make systems that make kilograms
  - Make systems that enable designing new production systems that make kilograms robustly
- Create a collaborative, effective, and resilient ecosystem
- Increase understanding of industry and government needs through BioMADE’s two CTOs
The Asks

What can you do now?

● **Enable the Technology Committee**
  ○ **Network your Organization to** find your Tech Point of Contact person
● **Join a Subcommittee** - open to all Members
● **Read the Project Call** - *Let’s Get to Work!*

<table>
<thead>
<tr>
<th>TO: <a href="mailto:SEVANS@BIOMADE.ORG">SEVANS@BIOMADE.ORG</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>FROM: Your Name @ your org</td>
</tr>
<tr>
<td>CC: TPOC @ your org</td>
</tr>
<tr>
<td>Your technical expertise</td>
</tr>
<tr>
<td>Your interests</td>
</tr>
</tbody>
</table>
Handoff to Jimmy Gollihar
BioMADE Government CTO
Roles & Responsibilities

Industry
Companies provide leadership in developing roadmaps that impact bioindustrial funding and extend research and development capabilities through a network of regional and national resources.

Small Business & National Lab
Small businesses, start-ups, venture capital firms, laboratories, and Federally Funded Research and Development Centers can forge unique partnerships.

Academic & Non-Profit
Universities, technical schools, community colleges, and non-profit organizations all have a role in the BioMADE community.
Thrust Areas from the FOA
Thrust Areas reimagined in BioMADE

- **Manipulate**
  - Develop predictive models, new tools, and robust platforms that ease the transition from lab to production scale.

- **Accumulate**
  - Produce relevant scales as quickly and efficiently as possible. This is accomplished through a network of preferred sites capable of pilot-scale production, leveraging commercial partnerships not currently available.
Thrust Areas reimagined in BioMADE

● **De-risk**
  ○ Explore and evaluate new technologies, particularly around scale-up and downstream processing, and partner with stakeholders to clarify market potential. This incentivizes private investments that will sustain future growth of bioindustrial manufacturing.

● **Execute**
  ○ Focus its network on manufacturing at pilot and intermediate scale to readily transition to production partners. While this often involves traditional manufacturers, BioMADE may also create the ability to produce high quality materials by alternative means or scales. Critically, BioMADE co-develops the needed workforce and regulatory packages required to ensure the technical successes are able to reach their end-to-end potential.
Modules & MRLs

MANIPULATE
Extended DBTL
- 1A Digital Backbone
- 1B Datasets
- 1C Data Analytics
- 1D Strain Engineering & On-boarding

ACCUMULATE
Make Some
- 2A Sensors
- 2B Non Destructive Assay
- 2C Material T&E

DE-RISK
Make More
- 3A Automation
- 3B Recovery Roadmapping
- 3C DSP Infrastructure

EXECUTE
Graduate
- 4A Low Cost Culture
- 4B Process On-boarding
- 4C SUP Infrastructure

MRL 4
COMMERCIAL READINESS

MRL 5
6A TEA

MRL 6
6B SIMs

MRL 7
BioMADE Partner's Infrastructure Network

3RD PARTY ENTRY

FED FOUNDRIES
FED PRODUCTION
FED MEASUREMENT
SUPPLY CHAIN
Production scenarios

Key Manufacturing Criteria

Path to Market
- Regulatory Processes
- Public Acceptance

Cost Pressures
- Research & Development
- Capital Expenditures
- Operating Expense

Market Dynamics
- Global Competition
- Volume Demand

Customer Classes
- Military Products
- Civilian Products

Representative Production Scenarios (RPSs)

Dedicated Production Plant

Multi-product Production Plant

Modularized Production Plant

Redeployable Production Plant

Manufacturing Scale

Volume

Manipulate
Virtual Infrastructure and Strain Engineering
- Digital Backbone
- Database and Datasets
- Data Analysis
- Strain Engineering

Accumulate
Scale-Up Production for Test and Evaluation
- Sensors & Assays
- On-boarding
- SUP Infrastructure
- Low-Cost Culture
- Material T&E

De-Risk
Downstream Processing and Recovery
- Automation
- Recovery Roadmap
- DSF Infrastructure

Execute
End-to-end Resiliency
- Cyberphysical Security
- Domestic Supply Chains
- Product to Customer

Enabling Technology Modules
## Production scenarios

<table>
<thead>
<tr>
<th>RPS</th>
<th>Characteristics</th>
<th>Application Spaces</th>
</tr>
</thead>
</table>
| **Dedicated Production Plant** | This RPS is appropriate for bioproducts requiring large production volumes and with low profit margins. Production is continuous throughout the year, and markets are predictable for several years out to justify the CapEx. Infrastructure is purpose-built, and tailored solutions are OK. Utilities (e.g., steam/power/etc.) are available at required price-points. Locating the facility with proximity to feedstocks is feasible. | - Biofuels  
- Commodity chemicals  
- Bioplastics  
- Monomer/polymer  
- "traditional biomanufacturing" |
| **Multi-product Production Plant** | The RPS is appropriate for bioproducts requiring medium to large production volumes. The plant is designed to shift production between multiple end-products, depending on dynamic (e.g., seasonal) markets, fluctuating economics (e.g., feedstock prices, supply/demand saturation). This environment will have different requirements on workforce talent and new supply chain, scheduling, and regulatory complexity. Utilities and feedstocks needs are similar to above. | - Low demand bioproducts  
- Bioproducts with short shelf-lives and non-continuous demand  
- Specialty bio-chemicals  
- Bioproducts with unpredictable or volatile feedstock markets |
| **Modularized Production Plant** | This RPS will facilitate locating a production plant anywhere in the world. The modular nature will limit production volumes compared to purpose-built plants. These could feature dedicated or flexible production processes. They are particularly useful when proximity to feedstocks or to end-customers is of high priority (e.g., single-buyer markets, expensive shipping of feedstock or products, security needs in production). Modules can be reconfigured to fit process needs or recycled to a new location. These may need to be more flexible regarding utilities (on-site generation is more likely). Possibly complex regulatory and workforce needs. | - Bioproducts with high shipping costs or stability issues  
- Foreign markets requiring in-country production  
- Bioproducts with complex regulatory issues around shipment of product  
- Single-user markets where proximity to purchaser is high-priority |
| **Redeployable Production Plant** | This RPS is ideal for situations where on-site production is required, but the actual site location is transient. It is likely only feasible for small volume production needs. There is a need for flexibility on on-site utility provisions and possibility for self-sufficiency. Ruggedization is required. These would likely be purpose-built for a single set of unit operations for dedicated manufacturing of one bioproduct. It may use non-traditional operations (e.g., single-use components, continuous systems, cell-free or immobilized enzyme technology, etc.) that are not economically feasible in traditional plants. | - Disaster relief applications (e.g., oil spills, hurricane, etc.)  
- Armed services applications (e.g., on-site biofuel production)  
- Bioremediation operations |
Q&A Session 1

PLEASE ENTER ALL QUESTIONS INTO THE ZOOM CHAT
BioMADE Technology Day
April 29, 2021
Overview of the Technology Program of BioMADE

Three Sessions Today

Overview of the BioMADE Technical Mission & Operations
- Steve Evans, BioMADE Interim CTO
- Jimmy Gollihar, Government CTO
- Laura Vitko, Membership Manager

Current Open RFP Program - *Let’s Get to Work!*
- Clem Fortman, Director of Program Management

Mapping, Connecting, and Growing the Domestic Pilot-Scale Infrastructure
- Mike Smanski, Deputy CTO, plus Lightning Talks
Goals for this Session

● Provide an overview of the RFP
● Describe how you can make yourself known to other BioMADE members
● Answer your questions - please submit your questions in the chat as they arise.

MAIN GOAL - Everyone leaves this session understanding what we’re looking for in terms of proposals.
Open Request for Proposals (RFPs): The Basics

**What** - non-medical biotechnology products and processes to advance the field of bioindustrial manufacturing

**Who** - BioMADE members

**Funding availability** - $10,000,000 over 2 years

**Cost share requirement** - 1:1 minimum (see Appendix B of the RFP)
Manufacturing Readiness Levels 4-7

**BioMRL3**: Proof of concept (POC) - **OUT OF SCOPE**

**BioMRL4**: Independent validation and verification of POC, plans for at-scale production

**BioMRL5**: Capability to produce prototype unit operations in a production relevant environment

**BioMRL6**: Capability to produce a prototype system or subsystem in a production relevant environment

**BioMRL7**: Capability to produce systems or subsystems in a production representative environment
What constitutes bioindustrial manufacturing?

Examples:

● The scale-up production of a novel bio-based monomer to test DSP or polymerization chemistry at-scale,
● The invention of new DSP protocols or equipment for enhanced recovery of water soluble end-products from fermentation broth,
● The industrial production of new enzyme catalysts to test their integration to industrial chemical production at-scale, or
● The creation and curation of a new database storing information on biomolecules or medium components that is critical for predictive SUP and DSP workflow design.
Cross-Institute Collaboration

**BioMADE's mission** is to enable domestic bioindustrial manufacturing at all scales, develop technologies to enhance U.S. bioindustrial competitiveness, derisk investment in relevant infrastructure, and expand the biomanufacturing workforce to realize the economic promise of industrial biotechnology.

The DoD Manufacturing USA innovation institutes are a key strategic investment for the DoD ManTech program. Each institute is designed to overcome challenges by advancing manufacturing innovation for specific, focused technology areas.
Team Composition

**BioMADE** was established in response to a call for a bioindustrial manufacturing innovation institute. Find one or more industry partners!

**Foreign participation** - BioMADE, like all of the MIIs, was established to stimulate U.S. manufacturing capabilities. International partners are eligible to participate under some circumstances. Specifics will need to be discussed with a BioMADE program manager.
Lead organizations are required to be members of BioMADE at the time of full-proposal submission.

All members of a project team will be required to become BioMADE members in the event of funding.

Vendors and CMOs are exempt from this requirement if they are solely providing service or materials as part of their regular business.
Safety, Security, Sustainability, and Social Responsibility (4S)

The broader impacts of what we do and how we do it will be an integral part of BioMADE’s program assessment. You should consider them while generating your proposals.

This is not part of the white paper process, but will be an important aspect of full proposals.
The White Paper Template

Why did we go with a fillable template?
Why did we not lock the Form?
How should you add more Tasks, objectives, etc.?

If you’re targeting bioproduct, for small molecules use the IUPAC name, for proteins use an official protein name (something that would return a hit if searched in GenBank).

The initial template had a glitch, please download the updated version.
Submissions

- **This is a two-step submission process.** There will be a white paper phase followed by invitations to submit full proposals.
- **White papers are templated and submitted via email** (detailed instructions are in the RFP).
- **White papers are reviewed by BioMADE staff and USG personnel.** Other members will NOT see your proposal.
- **Teams invited to submit full proposals** will be afforded a **one hour meeting** with the BioMADE Project Management team to discuss expectations of the project.
- **Full proposals will be 12 pages or fewer.**
Key dates for this Open RFP are as follows:

- **April 22, 2021**: BioMADE Open RFP is released
- **April 29, 2021**: BioMADE launch event will coincide with an optional proposer’s day to discuss program requirements and answer questions about the proposal submission process.
- **May 28, 2021**: White papers are due by 11:59 pm EST.
- BioMADE will send invitations for Full Proposals to selected teams within a month of the White Paper deadline.
- Furthermore, Full Proposals will be due within a month of notice of selection.
Teaming

In order to help you get to know each other, we will be collecting a single slide per member (company or academic lab), collating them, and redistributing to the BioMADE ecosystem.

The teaming slide should contain:

- **Goals** (e.g., I have strain that produces a lot of compound x, but I can’t efficiently get it out of the media)
- **Needs** (e.g., we have a great DSP for some chemical class, we’d like to prove it on several strains)
- **Capabilities** (e.g., I have a high throughput strain construction and screening facility with a, b, and c analytical instruments)
- **Achievement** (e.g., I’ve engineered various microbes to produce >10g/L of 7 different small molecules)

Please submit these to membership@biomade.org by **May 7th 4pm CDT**. We will distribute a consolidated deck by Monday May 10.

Please use “Teaming” in the subject line.

Please do not include any proprietary information. The consolidated deck should be considered public.
Member Organization [your name here]

POC: Name & Email

Goals

• Describe the types of work you want to conduct
• ...
• ...

Capabilities

• Describe the experience and resources you bring to a proposal team
• ...

Needs

• Describe the capabilities you’re looking for to help move a project forward in the BioMADE mission space
• ...
• ...

Achievements

• List prior achievements relevant to your goals
• ...
• ...
Q&A Session 2
BioMADE Technology Day
April 29, 2021
Overview of the Technology Program of BioMADE

Three Sessions Today

Overview of the BioMADE Technical Mission & Operations
- Steve Evans, BioMADE Interim CTO
- Jimmy Gollihar, Government CTO
- Laura Vitko, Membership Manager

Current Open RFP Program - Let’s Get to Work!
- Clem Fortman, Director of Program Management

Mapping, Connecting, and Growing the Domestic Pilot-Scale Infrastructure
- Mike Smanski, Deputy CTO, plus Lightning Talks
SESSION 3
Mapping, Connecting, and Growing Domestic Infrastructure for Bioindustrial Manufacturing

Introduction to BioMADE Infrastructure Mission
○ Current status of pilot-scale infrastructure in US
○ Plans to Map, Connect, and Grow domestic infrastructure

Lightning Talks from pilot-scale SUP and DSP facilities
○ Unit operations and scales
○ Contact information to encourage teaming

Q & A
There is a gap in existing domestic infrastructure

- Lab-scale is abundant
- Commercial-scale is present for current bioproducts
- Pilot- and intermediate-scale is lacking
US companies are forced to look overseas for pilot-scale process development

- Extra costs
- National security implications
- Lost opportunities (supply chain businesses to support pilot scale work)
- Continuity of scaling operations
Pilot-scale CMOs, while needed for the community, have substantial hurdles for independent development

- “Niche” technology space
- Internal Rates of Return (IRR) not suitable for VC investment
- Feasibility of commitments
- Traditional supply/demand economics difficult
MISSION

BioMADE will **map** the existing infrastructure for bioindustrial manufacturing (first SUP and DSP unit operations, but eventually supply chains and formulation infrastructure). BioMADE will strengthen **connections** between disparate nodes on the infrastructure map by catalyzing teaming and providing virtual infrastructure to streamline collaboration. Long-term, BioMADE will work with the community to **grow** the availability of domestic pilot- and intermediate-scale infrastructure.
Mapping existing domestic infrastructure available to the BioMADE membership

- Where is it located?
- What are the available unit operations?
- What are the available scales?
- How to work with operators?
Mapping existing domestic infrastructure capabilities of entire community

- Protecting proprietary information
- Allow modeling of domestic risk and surge capabilities
- Provide summary-level information to US Government
- Leverage data to secure more funding for infrastructure
Connecting existing infrastructure for new workflows

- Matching scales
- Linking disparate unit operations for complete workflows
- Developing working relationships
Connecting domestic physical infrastructure via the BioMADE virtual infrastructure

- Seamless data-sharing
- Electronic record-keeping and material tracing
- Complex scheduling and project management
Growing bioindustrial manufacturing infrastructure at each scale where it makes sense to do so

- Public-private funding for “bridges and roads” to product commercialization
- Organize for the greatest impact
Diversify and Specialize infrastructure for a robust and resilient network of manufacturing capabilities

- Leverage regional feedstocks
- Couple with regional supply chains and manufacturing needs
- Proximity locations to customer markets for T&E
Innovate new Scale-Up Production (SUP) infrastructure

- Make diverse types of pilot-scale bioreactor designs accessible for testing
- Innovate in bioreactor design and materials to decrease CapEx and OpEx
- Couple SUP infrastructure innovations with strain optimization

Low-cost large-scale bioreactors
Innovate new Downstream Processing (DSP) infrastructure

- Make diverse types of pilot-scale DSP unit operations accessible for testing
- Innovate in IC, CCC, resin properties, and selective membrane separations
- Couple DSP capabilities to minimize the number of unit operations and maximize purity
BioMADE Headquarters: Microbial Cell Production Facility

- SUP to 5k L
- Diverse DSP suite for chemical purification
- Groundbreaking September 2021, opening 2023
How can member institutions help?

**Mapping:** Discuss with your organization the ideas about sharing information on *available* infrastructure and *proprietary* infrastructure, with appropriate restrictions in place.

**Connecting:** Participate in BioMADE projects, which will eventually include requirements to plug-in to the BioMADE digital backbone.

**Growing:** Talk to us if you are willing to help petition for more USG funding for infrastructure development. Matching funds from the private sector will always help.
Lightning Talks

Deepti Tanjore  
ABPDU

Tom Douville  
UMN-BRC

Brent Shanks  
Iowa State

Sankar Nair  
Georgia Tech

David Blum  
UGA

Vijay Singh  
Illinois

Chad Pastor  
MBI
Advanced Biofuels and Bioproducts Process Development Unit (ABPDU LBNL): Fermentation Scale-up infrastructure available

<table>
<thead>
<tr>
<th>Volume</th>
<th>100mL</th>
<th>2mL</th>
<th>250mL</th>
<th>2L</th>
<th>300 L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactors</td>
<td>12</td>
<td>48</td>
<td>12</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>
**Advanced Biofuels and Bioproducts Process Development Unit (ABPDU LBNL): Fermentation Scale-up infrastructure available**

<table>
<thead>
<tr>
<th>S/L Separation</th>
<th>Cell Disruption</th>
<th>Extraction/Purification</th>
<th>Evaporation &amp; Drying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disc stack centrifuge (max 150 L/min, continuous)</td>
<td>Mini DeBEE homogenizer (max 12 L/h, continuous)</td>
<td>Karr column (250 mL/min, continuous)</td>
<td>Rotary evaporator (4 L, batch)</td>
</tr>
<tr>
<td>Dead-end centrifuge (2L x 6, batch)</td>
<td>Bench-scale batch or continuous ultrasonicate (20 L/h)</td>
<td>Tangential flow filtration (0.01 to 3.5 m², continuous)</td>
<td>Wiped film evaporation/distillation (1-3 L/h, batch)</td>
</tr>
<tr>
<td>Basket centrifuge (7.4 L, semi-continuous)</td>
<td>High speed blender (4 L, batch)</td>
<td>AKTA Avant 150 Chromatography (150 mL/min, continuous)</td>
<td>Vacuum oven (4.2 cu.ft; batch)</td>
</tr>
<tr>
<td>Decanter centrifuge (max 6 m³/h, continuous)</td>
<td>Microfluidizer (27L/h, continuous)</td>
<td>TetraPak membrane unit (3.5-7.9 m², continuous)</td>
<td>Freeze dryer (12 L, batch)</td>
</tr>
<tr>
<td>Filter Press (12” plate, semi-continuous)</td>
<td>GEA homogenizer (120 L/h at 1000 bar; continuous)</td>
<td></td>
<td>Spray dryer (0.5-6 kg/h, rental continuous)</td>
</tr>
</tbody>
</table>

*Rental Units*
Advanced Biofuels and Bioproducts Process Development Unit (ABPDU LBNL): Contact Information

abpdu@lbl.gov

Director, Deepti Tanjore: dtanjore@lbl.gov

Program Manager, James Gardner: jgardner@lbl.gov
University of Georgia: Pilot-scale infrastructure available for use

**Upstream Equipment**
Fermentation for *E. coli*, *Pichia*, anaerobes & thermophiles (no spore formers)

- SIP systems - 2 x 20L, 100L, 200L, 400L, 500L, 800L (DCI)
- Benchtop systems: 4 x 4L, 2 x 2L, 8 x 1L (DG)
- High Cell Density up to 200L
University of Georgia: Pilot-scale infrastructure available for use

Downstream Equipment
mg – multigram protein purification experience
• 2 Sharples AS16 units
• GEA & Constant systems Homogenizers
• Smartflow TFF Skid, small-scale TFF
• Chromatography: AKTA Avant, Start, 2 AKTA Purifiers, 1.6 – 40 cm empty columns
University of Georgia: Contact Information

Main contact: David Blum - 706-542-1035
e-mail: bff@uga.edu
Web: https://bff.uga.edu
Web: https://biomanufacturing.uga.edu
YouTube: https://tinyurl.com/mbb-youtube
BFF LinkedIn: https://tinyurl.com/bff-linkedin
MBB LinkedIn: https://tinyurl.com/mbb-linkedin
Michigan State University Bioeconomy Institute (MSU BI): Lansing Facility (Fermentation & Analytical)

Fermentation
• Fermentation process development (≤10 liters)
• Scale-up of biobased technologies in our Pilot Plant (150L, 200L, 3800L, and bench satellites)
• Automated control/data acquisition
• In-line mass spectrometer off-gas analysis

Analytical Facilities
• HPLC, UPLC, GC, GC/MS
• UV-Vis Spectroscopy
• YSI analysis
• Protein analysis
• Full access to MSU analytical equipment, including NMR, LC/MS MS
Michigan State University Bioeconomy Institute (MSU BI): Lansing Facility (Downstream)

Purification and Recovery Capabilities

- High-speed disk stack centrifugation
- Filtration, ultrafiltration, microfiltration
- Chromatographic processes
- Ion Exchange
- Cell Disruption
- Vacuum Evaporation
- Solvent Extraction (Pilot scale at Holland Facility)
- Crystallization and Tray Drying
- Additional space and full utilities set-up for client or rental DSP equipment
Michigan State University Bioeconomy Institute: Contact Information

Please contact us to discuss project needs and requirements.

**Chad Pastor**
pastorc@msu.edu
517.336.4647

Website: Bioeconomy.msu.edu
University of Illinois at Urbana-Champaign: Pilot-scale infrastructure available for use

Integrated Bioprocessing Research Laboratory (IBRL) - Pilot scale unit operations related to feedstock pre-processing, deconstruction, conversion, product recovery

Vijay Singh

Director, IBRL
vsingh@illinois.edu
Integrated Bioprocess Research Laboratory

Equipment List Available at: ibrl.aces.illinois.edu

Dr. Beth Conerty  
Assistant Director of Business Development  
bconerty@illinois.edu

Brian Jacobson  
Assistant Director of Pilot Plant Operations  
bjacobs3@illinois.edu
Iowa State University – Fermentation Facility
Pilot-scale infrastructure available for use

- Pilot scale fermenters (500-L, 1000-L and 1,500-L)
- Continuous centrifuges (Horizontal decanter, disc clarifier, bowl type)
- Filtration system (Spiral wound MF, UF, NF and RO)
- Falling film evaporators (vacuum function, 20 to 50-L/hr capacity)
- Homogenizers (20-L/hr capacity)
- Pasteurizer (HTST & UHT, 60 to 180-L/hr capacity)
- Spray dryers (10-L/hr and 30L/hr capacities) & Freeze dryer
Iowa State University: Contact Information

Center for Crop Utilization Research (https://www.ccur.iastate.edu/):
Prof. Zhiyou Wen, Director
ccur@iastate.edu
phone: 515-294-0160
scheduling: depending on project

Alternative Contact:
Prof. Brent Shanks, Director – Center for Biorenewable Chemicals
bshanks@iastate.edu
phone: 515-294-1895
UMN Biotechnology Resource Center

Upstream / Downstream Capabilities:

• 6L – 550L Fermentors
• GEA CS8A Disc Stack Centrifuge
• CARR Powerfuge P12 Centrifuge
• Gaulin M15 Cell Homogenization
• BioProcess Chromatography skid with shells up to 40 cm dia
• MilliporeSigma UF/DF systems up to several square meters membrane area
• Bench-scale Lyophilization and Rotoevaporation

Lead time:

2–3 month average time from initial contact to run initiation

Coming Attraction:

• New pilot plant scheduled to come on-line November, 2023
• Fermentation up to 1,500L scale
UMN Biotechnology Resource Center
Contact Information

Website
https://bti.umn.edu/2020/09/13/brc-contacts/

Direct
Thomas Douville, Director
douvi010@umn.edu
+1-612-301-1612
Georgia Institute of Technology
Pilot-scale infrastructure available for collaborative use

Membrane Pilot Systems

- Two membrane pilot rigs custom-built by Membrane Specialists
- Nanofiltration/reverse osmosis
- Feed stream up to 3.5 gallons/minute
- Temperature up to 70C, Pressure up to 70-80 bar
- Can handle flat, spiral wound, tubular, or hollow fiber membranes
- Analytical: GC, HPLC, UV-Vis, ion chromatography, conductivity, TOC, coulometry, etc.
- Facility available for collaborations through research or testing agreements
 Adsorption Pilot Systems

- Three simulated moving bed (SMB) adsorption pilot systems available
- Can also be converted to fixed-bed operation
- GT-built SMB mini-plant (left)
  - Controllable temp. (30-220°C)
  - 16-column configuration
  - Individual column sampling
  - Total length of columns: 3.2 meters
- SEMBA SMB mini-plant
  - Ambient temperature operation
  - 8-column configuration
  - Resistant construction materials
- Knauer SMB mini-plant
  - Controllable temp. (25-60°C)
  - 16-column configuration
- Analytical: GC, HPLC, UV-Vis, ion chromatography, conductivity, TOC, coulometry, etc.
- Available for collaborations through research or testing agreements
Lead time: Facilities would be available via research or testing agreements, and timelines would be pre-determined based on the agreement objectives and projected user load of the facility.
Michigan State University Bioeconomy Institute (MSU BI): Holland Equipment Overview

Stills

Operating Parameters
- Temperature: -10 to 140° C
- Pressure: Full Vacuum to 75 psig
- Variable agitation

Vessel Sizes
- 2 x 4000L Glass-lined
- 2 x 2000L Glass-lined
- 2 x 800L Stainless Steel
- 800L Hastelloy C276
- 400L Glass-lined
- 200L Glass-lined
- 80L Glass-lined

Reactors

Operating Parameters
- Temperature: -10 to 140° C
- Pressure: Full Vacuum to 75 psig
- Variable agitation

Vessel Sizes
- 4000L Glass-lined
- 2 x 2000L Glass-lined
- 800L Glass-lined
- 400L Glass-lined
- 200L Glass-lined
- 120L Glass-lined
Michigan State University Bioeconomy Institute (MSU BI): Holland Equipment Overview

**Tanks**

*Operating Parameters*
- Pressure: Full Vacuum to 75 psig

*Vessel Sizes*
- 4000L GL, 2000L GL, 800L GL, 120L GL

**Centrifuges**

- 2 x 40in Basket, Hastelloy C276

**Dryers**

- Temperature Range: 30 to 95° C
- Pressure Range: Atmospheric to Full Vacuum
- Vacuum Tray Dryers (~250 kg capacity/each)
- 500L Glass-lined Rotary Vacuum Dryer (~150 kg capacity)
- 850L Geudu Pan Dryer, Hastelloy C22

**Filters**

- Niagara Filters, 316 SS
- 16 – Plate 18 in
- 4 – Plate 18 in
- Bag filter
- Cartridge Filters

**Specialized Equipment**

- 400L Low Temperature Hastelloy C276 Reactor
- Cooling capability with liquid nitrogen to -100° C at 5 psig; or
- Operating temperature range: 25 – 80° C at 75 psig
- 400L Hastelloy C276 reactor
- 120L GL high temperature still with 316 SS fractionation column or 316 SS Riser; heating capability to 230 C
- 150 sq/ft Cold Room
Michigan State University Bioeconomy Institute: Contact Information

Please contact us to discuss project needs and requirements.

Chad Pastor
pastorc@msu.edu
517.336.4647

Website: Bioeconomy.msu.edu
Q&A Session 3

PLEASE ENTER ALL QUESTIONS INTO THE ZOOM CHAT