Technology Transition Case Study
The Joint BioEnergy Institute (JBEI)

The Joint BioEnergy Institute (JBEI) is one of three DOE Bioenergy Research Centers (BRCs) funded by Department of Energy (DOE) for five years starting in September 2007, with a second 5-year phase beginning in 2012. The ultimate goal for the BRCs is to "provide the fundamental science to underpin a cost-effective, advanced cellulosic biofuels industry." (http://genomicscience.energy.gov/centers/) JBEI often refers to its research as "mission driven science." The original JBEI member institutions were Lawrence Berkeley National Laboratory (Berkeley Lab), Sandia and Livermore National Laboratories, the Universities of California at Berkeley and Davis, and the Carnegie Institution. Pacific Northwest National Laboratory joined JBEI during the 2012 funding renewal period.

JBEI's mission is unique among the BRCs in that it does not work on technologies to produce ethanol. Its purpose is to advance the development of cellulosic, next-generation biofuels to replace petroleum-based gasoline, diesel, and jet fuels. From inception, it was designed to effectively partner with industry. To date, JBEI has brought in funding under nearly two-dozen Cooperative Research and Development (CRADAs) and Work for Others (WFO) agreements (now known as Strategic Partnership Projects (SPP)) with industry, including several multi-year strategic partnerships, to conduct research that both aligns with JBEI's mission and supports industry's market objectives. Based on metrics reported to the Association of University Technology Managers (AUTM) and JBEI DOE reports, the number of invention disclosures, licenses, and startup companies generated by JBEI's commercialization program is consistently as high or higher than the top three US universities, per funding dollar.

The BRC Funding Opportunity Announcement (FOA) that led to JBEI was based on outcomes from the December 2005 Biomass to Biofuels Workshop convened by the Office of Biological and Environmental Research (BER), under the DOE Office of Science, and the former Office of the Biomass Program (currently the Bioenergy Technologies Office (BETO)), under the DOE Office of Energy Efficiency and Renewable Energy (EERE). The purpose was to "define barriers and challenges to a rapid expansion of cellulosic-ethanol production and determine ways to speed solutions through concerted application of modern biology tools as part of a joint research agenda." (http://genomicsgtl.energy.gov/biofuels/b2bworkshop.shtml)

In the wake of the workshop, a few senior leaders at Berkeley Lab began to explore the opportunity to respond to the anticipated FOA and convened discussions with academics and other DOE Labs. In June 2006 Dr. Jay Keasling, ultimately JBEI's Principle Investigator (PI) and Chief Executive Officer (CEO), launched planning discussions with the Universities of California at Berkeley and Davis, Sandia and Livermore National Laboratories, the Carnegie Institution at Stanford University and the local USDA Agricultural Research Service, which was ultimately not included as a member of the consortium. Sandia had already emerged as the Berkeley Lab's principal partner.

Prepared in response to formal guidance and a request by Sam Baldwin, Ellen Williams and Charles Russomanno of the U.S. Department of Energy (DOE) for input into the DOE Industrial Consortia Initiative and the 2015 DOE Quadrennial Technology Review.

The JBEI founders explored industry partnerships during the proposal preparation period. Initially, the group talked with a large U.S. company that was interested in receiving a portion of the FOA funding, but the founders determined that post-award engagement would open a larger range of possibilities and maintain flexibility as the nascent advanced biofuels industry took shape. Seven years later, JBEI believes it made the right decision. The JBEI founding team discussed at length how industry would be engaged post-award. They generated a consortium plan with a comprehensive set of privileges corresponding to fee-based membership levels. This approach was adopted during JBEI's first two years but discussions with companies ultimately boiled down to defining collaborations of mutual interest, so the membership concept was ultimately dropped. Instead, industry engagement was based on exploring the needs of potential partners on a case-by-case basis. JBEI also established an Industry Advisory Committee to ensure that JBEI researchers remained aware of challenges faced by the biofuels industry.

In July 2007, the Berkeley Lab–led consortium was selected for an award of $25 million/year for 5 years. This funding was renewed in 2012 for an additional 5 years after an extensive peer review. JBEI is comprised of four scientific divisions, each lead by a vice president. These vice presidents, along with the CEO, Chief Science and Technology Officer (CSTO), and Chief Operations Officer (COO), serve on the JBEI Research Committee (RC), which is the executive body of the center. The responsibilities of the RC include:

- Recommending the annual JBEI research and management plan to the CEO, who then presents it to the Board of Directors for approval.
- Recommending the redirection or termination of funding of specific research programs within JBEI to the CEO and CSTO for approval by the Board of Directors.
- Reviewing and approving IP management decisions as set forth in the JBEI Intellectual Property (IP) Management Plan, including whether or not JBEI will financially support patent applications on JBEI-funded IP.
- Meeting on a quarterly basis to assess overall research progress and ensure that specific milestones are accomplished.
- Recommending members of the Science Advisory Committee and the Industry Advisory Committee for appointment by the CEO.

Each division also has 3-5 division directors who lead specific scientific programs. Except for a feedstock research group located at UC Davis, JBEI researchers are co-located on a single floor of a building in Emeryville, California, which was designed specifically for and by JBEI. From the beginning of the JBEI effort, Dr. Keasling had insisted on co-location of the majority of JBEI researchers. He felt this would provide a heightened sense of teamwork and closer integration of the four JBEI research divisions. JBEI divisional research spans the biofuels pipeline from cellulosic feedstock development, to feedstock deconstruction, to synthesis of fuels from the resulting cellulosic sugars. It also includes a technology division that supports this research pipeline. Industry faces challenges in integrating these steps and therefore it has been important for JBEI to target those intersections through cross-divisional research. Co-location has enhanced integration through frequent and fluid communication among all JBEI researchers, regardless of home institution.

The JBEI Board of Directors (BOD) is comprised of one executive-level representative from each of the partner institutions, and meets annually (the JBEI CEO is an ex-officio member). The chair rotates and is elected by the members. Final authority for the following areas rest with the BOD: budget and resource allocation and oversight; program review; researcher affiliation; resolution of major scientific, operational, and/or policy disputes; and appointment of the CEO. The BOD also reviews and approves the overall budget and research plan annually.

JBEI's BER funding is allocated by the JBEI RC (with BOD oversight) to the scientific divisions, and driven by research goals established by the initial JBEI proposal. Research directions are adjusted in response to scientific results, with an eye to industry and market needs and opportunities. While JBEI establishes yearly (and even monthly) research goals, major goal setting occurs every five year, in response to the funding cycle. JBEI chose from the beginning to take risky, rather than incremental, approaches to addressing industry challenges. As a result the basic scientific approaches have not shifted significantly in response to immediate industry challenges. However, due to results from the JBEI Techno-Economic Model the deconstruction division has allocated a greater portion of its funding to developing creative strategies to reduce the cost of its potentially game changing approach to feedstock conversion. (The feedstock division has shifted focus based on early successes in the integration of novel synthetic biology techniques.)

JBEI researchers are encouraged to seek additional research funding and have been successful in garnering awards from sources such as Advanced Research Projects Agency – Energy (ARPA-E), BETO, and Defense Advanced Research Projects Agency (DARPA). The core DOE funding is also supported by complementary projects funded by industry through WFOs and CRADAs

JBEI is reviewed by BER at an annual 1.5-day site visit. The reviewers are selected by BER from universities and other national laboratories. The scientific and industry advisory committees provide feedback to the JBEI CEO and RC, the JBEI BOD, and DOE, but these reports are not considered in the DOE annual reviews.

JBEI has an entrepreneurial culture in its DNA. CEO Jay Keasling had founded two companies before JBEI existed. Other members of the JBEI RC had been heavily engaged in industry collaborations and were familiar with the biofuels industry. Robust engagement and partnering with industry, diligent protection of IP, and accelerated transfer of JBEI inventions and expertise to the private sector were established as critical institutional goals. Implementation of these goals took the form of:

1. Execution of a thorough JBEI IP management plan that created a one-stop shop for industry engagement.
2. RC involvement in IP decisions and industry-facing activities.
3. Funding for a 50% time business development staff member with an office in a central location at JBEI. This position evolved into the Director of Commercialization (DOC) position, which is currently funded 100% by JBEI.

4. Establishment of an Industry Advisory Committee.
5. Development of a commercialization and industry engagement program, including an emphasis on industry visits to JBEI.
6. Creation of a special "startup" track for IP that could form the basis of a spinoff company.
7. Development of a techno-economic model of a cellulosic biofuel refinery.
8. Internal entrepreneur-in-residence office hours and seminars.

Dedicated and embedded Tech Transfer staff

During JBEI's formation, JBEI took the unusual step of dedicating funding to hiring a 50% FTE for business development. This hire augmented the core IP and licensing team provided by the Technology Transfer Department (TTD) at Berkeley Lab. The business development staff member, now the DOC, is located at JBEI and the JBEI tech transfer staff members hold office hours on site. This sends a signal to the JBEI team that industry engagement is a core JBEI mission and invites routine interaction with JBEI researchers This has been crucial in transforming a common view of technology transfer within DOE Lab's from one of compliance to an opportunity for growth and impact.

The JBEI staffing and responsibilities for IP and industry-related activities included:

2007-2012

- Manager of business development (50% Full Time Equivalent (FTE), funded by JBEI): industry outreach and engagement (open houses, visits, etc.), manage collaborations and Industry Advisory Committee
- IP and licensing associate (50-75% FTE, funded by TTD:IP management, licensing transactions
- In-house patent attorney, (50% JBEI): file and prosecute JBEI patent applications
- Non-Disclosure Agreement (NDA)/Material Transfer Agreement (MTA) specialist (one FTE for all of Berkeley Lab)

2012-current:

- Director of Commercialization (DOC) (2012-2014, 100% FTE - 50% funded by JBEI, 50% TTD; as of 2015, 100% funded by JBEI): combined business development and IP/licensing duties so that one person was responsible for overseeing industry projects or licensing agreements from start to finish. Moving to a single position eliminated inefficient overlap between business development and licensing responsibilities. The DOC is accountable for resolving bottlenecks in the entire partnership process, which helps prevent agreements and paperwork from falling through the cracks.
- In-house patent attorney (50% JBEI)
- NDA/MTA specialist (one FTE for all of Berkeley Lab)
- Entrepreneurial advisor (one FTE for all of Berkeley Lab)

JBEI IP management plan

Berkeley Lab's licensing manager led negotiations among the JBEI partners and DOE IP counsel to develop IP management principles. The principles were codified in an IP Management Plan and appended as part of a side letter to the contractor's agreement to operate JBEI. This plan became the basis for a more detailed inter-institutional agreement (IIA) among the JBEI partner institutions.

The IP Management Plan and the JBEI IIA establish Berkeley Lab as the manager of all IP arising from JBEI funding and the single signatory authority for JBEI non-disclosure agreements, Material Transfer Agreements (MTAs), licensing transactions, and CRADAs and WFOs. (Exceptions are made for mutual NDAs and NDAs-in, which require a Sandia signature). This allows Berkeley Lab to serve as the single point of contact creating a "one-stop shop" for all industry engagement and agreements, greatly streamlining the process. This structure has resulted in 23 CRADAs and WFOs between JBEI and industry collaborators.

The JBEI IIA includes the following additional principles:

- Each party takes title to the inventions of its employees; joint inventions are jointly owned;
- Each party discloses its inventions to Berkeley Lab and Berkeley Lab reports those to the owning institutions;
- Berkeley Lab is responsible for filing, prosecuting, and maintaining all patent applications covering JBEI inventions, providing owning parties with all necessary records and copies of patenting activities.
- JBEI has the option to pay for up to fifty percent of JBEI patent applications/patents. This includes fifty percent of all filing and maintenance fees, as well as a $6500 patent application preparation fee that covers in-house patent attorney time for filing provisional, utility and Patent Cooperation Treaty patent applications and a second $6500 fee that covers patent attorney time from the first office action through issuance. If outside attorneys are used, JBEI covers fifty percent of their fees. JBEI receives royalties from JBEI-funded inventions in pre-defined "core" areas of research. Sixty percent of royalties accrue to JBEI once they exceed $200,000 net per license.
- The JBEI institutional members have the right to finance patent applications from their inventors, and receive corresponding royalties. Participation rights are based on inventor share and whether or not JBEI is participating.
- Berkeley Lab can negotiate for equity as partial consideration in a licensing agreement and will have any equity shares issued in the name of the JBEI institutional owner;
- Berkeley Lab retains 15% of licensing income, including royalties, up-front fees, maintenance fees, milestone payments, etc. to help offset the cost of administration;
- All JBEI inventors receive thirty-five percent of net royalty income for their licensed inventions, regardless of their institution's royalty policy. This includes thirty-five percent of any equity stake taken in a licensee.

RC involvement in IP protection and industry engagement

The DOC and JBEI patent attorney bring patent filing recommendations and industry partnership issues to the RC at bi-monthly meetings. Inventors are invited to present their technologies and the RC decides whether or not JBEI will fund 50% of any given patent application. In this approach, the patenting decisions benefit from the experience of JBEI senior management, patenting and licensing issues are surfaced to ensure broad alignment on tactics and strategies, and inventors are showcased to management, all of which contribute to improving the quality of JBEI IP and commercialization activities.

JBEI management diligently reviews all planned public disclosures to identify IP that has not been disclosed to the Berkeley Lab TTD. In addition, the DOC and technology transfer staff periodically brief JBEI personnel on IP disclosure and management procedures and on progress towards JBEI's commercialization goals.

The JBEI Industry Advisory Committee

The JBEI IAC meets annually and is comprised of leading companies representing all facets in the production of transportation fuels from biomass. Members are recommended by the RC and appointed for a twelve-month term, renewable by mutual agreement, upon advisement to the DOE. Companies that undertake significant collaborative research projects with JBEI are also invited to join the IAC.

At the annual IAC meeting, JBEI researchers and senior management provide an overview of JBEI research directions and progress, and IAC members hold panel discussions on topics of particular interest to their industry and attend a poster session. During feedback sessions and Q& A periods, the IAC provides JBEI with valuable insights from an industry perspective and identifies industry challenges that are not yet being fully addressed. The IAC is also charged with preparing a formal report with feedback and recommendations. The report is delivered to the JBEI CEO, Research Committee, the JBEI Board, and DOE.

JBEI IAC meetings take place on a non-confidential basis. In 2014 the IAC and SAC meetings were combined and integrated into the annual JBEI retreat. JBEI did require IAC members to sign NDAs if they wanted to attend the non-IAC portions of the retreat. About half the members of the IAC chose to do so. IAC and SAC members did sign NDAs if they wanted to attend non-IAC meeting events at the retreat.

The benefits of having an IAC are that it:

- provides researchers with an industry perspective on technical pain points and opportunities that may benefit their research.
- provides a great opportunity to develop relationships that may lead to collaborative research and cost share partners for proposals for federal funding.
- exposes grad students and post docs to opportunities to continue research careers beyond academia.

Lessons learned:

- Hold the IAC portion of any meetings without asking companies to sign NDAs. Ensure that any relevant patent applications are filed before presenting research to the IAC.
- Ensure that the companies understand that their charge is not to review the research but to add a commercial perspective.
- Create opportunities for IAC members to participate in the meeting on panels, give talks, etc.
- Invite companies for a one-year term, renewable by mutual consent.

Current IAC members and titles:

Arborgen – CSO (early member, no longer a member)
Amyris – Senior VP of Research
Boeing - Tech Leader, Energy & Emission (early member)
BP - VP, Technology (early member)
Burrill & Company – Partner
Ceres - VP, Trait Development
DuPont Genencor - Head of BioChemistry
DuPont - Director, DuPont Central R & D (early member)
General Motors - GM Technical Fellow, R & D (early member)
Genomatica - Executive Vice President and Chief Technology Officer
LS9 - VP, Research and Development (no longer a member)
Monsanto – Technology prospecting lead
Novozymes - Sr. Dir. Bioenergy R&D (early member)
Pacific Ethanol – VP (early member)
PerkinElmer (Caliper) – R&D Expert (no longer a member)
POET - Senior Director of Research (early member)
StatOil - Biofuels Project Manager (early member)
Total Energies Nouvelles Activites USA SAS - VP Research & Development (early member)
Total Energies Nouvelles Activites USA SAS – Head, Biotechnology R&D (early member)
Weyerhaeuser - Director, Technology Partnerships (early member)

Industry partnership program (IPP):
JBEI industry outreach was originally based on a tiered membership program with three levels of benefits. The program was modeled after a number of similar industry partnership programs run out of universities. Below are the descriptions of the three membership tiers:

- ***JBEI Strategic Partners*** leverage JBEI capabilities on research projects of significant scope and scale, with the goal of achieving a significant return on investment. Strategic research is conducted under a standard CRADA agreement. There is no specific dollar limit, but strategic partners are engaged in more than one significant project.
- ***JBEI Topical Partners*** collaborate with JBEI by sponsoring research on a focused research agenda. Topical research is typically conducted under a CRADA agreement. There is no specific dollar limit.

- ***JBEI Supporting Partners*** have the opportunity to be a part of the JBEI community by sponsoring a modest project- $20,000 and above, or $10,000 and above for small businesses and non-profits.

JBEI Strategic and Topical Partners received IAC membership, opportunities to network with graduate students and post docs, and advanced notice of new JBEI inventions. Supporting partners have mostly received recognition for their support.

The early JBEI leadership team did not seek out feedback from industry when developing the IPP but it garnered interest after they rolled it out. The IPP was a good structure to use to attract industry partners in the early years when there was little JBEI IP and few JBEI publications. However, once JBEI became more established, the IPP was de-emphasized and outreach was centered on a understanding a potential partner's needs and goals and matching those with JBEI expertise and research. In other words, the real value proposition for industry was actually conducting research with JBEI. The ancillary benefits offered by the membership program were icing on the cake but not compelling on their own.

JBEI still provides advance notice of new inventions to partners that have a significant collaboration with JBEI. The advanced notice is followed by robust public promotion of the inventions to ensure Fairness of Opportunity and identify the most qualified licensee (inventions are never licensed before Fairness of Opportunity standards have been met). Industry partners engaged in significant collaborations are also offered a seat on the IAC.

JBEI Startup Track

The JBEI "startup track" approach leverages the industry perspective provided by the RC, DOC, internal Berkeley Lab entrepreneur advisor, Cleantech to Market (C2M) program, and internal reports with a strategic view of JBEI IP to create potential JBEI startup companies. Every year JBEI works with at least one interdisciplinary team of graduate students in business, engineering, and science from the UC Berkeley Haas Business School's Cleantech to Market program that prepares a go-to-market plan for the most promising JBEI IP. Inventors are exposed to relevant business concepts and educated about the variety of roles they can play in a startup, many of which do not involve leaving his or her current career. The benefit of this approach is that IP is not undervalued via fragmented licensing or undiscovered applications and inventions that might otherwise languish are more quickly developed and commercialized. Start-ups are often the best avenue for commercialization of IP because they often license inventions that are either too risky for existing companies or that need more focused and dedicated development than existing companies are often prepared to provide.

JBEI Technoeconomic Model (TEM)

In 2008/2009 JBEI began to develop a TEM of a cellulosic biorefinery, based on existing SuperPro software. The approach comprises building models that describe the material and energy flows in a virtual biorefinery (material and energy balances), which become the basis for capital and operating cost calculations. The TEM allows investigation into the impacts of various technologies, research strategies, and business decisions, on the

economics of biofuel production. The TEM has been used to evaluate and make adjustments to JBEI research goals and technologies.

Strategic Plan for the Commercialization Program

Partnerships Results

13 CRADAs	**Background IP (BIP)/ CRADA IP** **(Companies pay for BIP)**
Abengoa – successfully completed, in discussions to renew	No Optioned BIP/no CRADA IP
Afingen – ongoing (SBIR)	Optioned BIP/no CRADA IP yet
Afingen – ongoing (SBIR)	Optioned BIP/no CRADA IP yet
Bridgestone – ongoing	Optioned BIP/ no CRADA IP yet
Compact Membrane – successfully completed (SBIR)	Optioned BIP/ no CRADA IP yet
Statoil – successfully completed	No BIP/no CRADA IP
Total – Lignin research: successfully completed, extended Could lead to new applications for lignin, which is typically a waste stream	Optioned BIP/ 2 CRADA inventions
Total – Efflux Pump research: successfully completed. Discovered new pumps to eliminate toxic products from cells	Optioned BIP/ 2 CRADA inventions
Total – Hexene research: completed but unsuccessful, pivoting to 2 new projects	Formerly optioned BIP/no CRADA IP
Total – Biological Hydrogenation research, ongoing	No BIP/no CRADA IP yet
Virdia: successfully completed, results indicate current method may not be economically viable, in discussions to renew. Research on HMF production	3 CRADA inventions
POET – biomass deconstruction, ongoing	Optioned BIP/ no CRADA IP yet
Technology Holding – ongoing (SBIR)	Optioned BIP/ no CRADA IP yet
6 ongoing, 6 successfully completed (3 of those are in discussions to renew), 1 unsuccessfully completed	8 new CRADA inventions

WFOS

10 WFOs	**Background IP (BIP)/ WFO IP**
Boeing – Technoeconomic model: successfully completed	Licensed BIP/WFO software
BP: successfully completed	No BIP/No WFO IP
Braskem: successfully completed	No BIP/No WFO IP
COFCO: ongoing	
GM - Technoeconomic model: successfully completed	Licensed BIP/WFO software
TeselaGen: successfully completed	No BIP/No WFO IP
Statoil - Technoeconomic model: successfully completed	Licensed BIP/WFO software
Statoil – microalgae: successfully completed	No BIP/No WFO IP
University of Queensland (with Boeing, GE, Sugar Research Australia): successfully completed	BIP not licensed/No WFO IP
Virdia: successfully completed	No BIP/No WFO IP
1 ongoing, 9 successfully completed, one was extended under a CRADA.	

Total funding from all CRADAs and WFOs: $4,848,000 (see details of each agreement in separate excel sheet for DOE data call)

Afingen, Total, Virdia, COFCO, and Braskem have embedded their employees at JBEI to work side-by-side with JBEI researchers under CRADA and WFO agreements. The strategic Total partnership is unique in that a series of CRADAs were implemented under a master NDA, personnel management plan, steering committee charter, and CRADA Option agreements. It took many months to execute the first CRADA, but implementing new projects has been extremely efficient.

JBEI also negotiated a significant loan agreement with an equipment supplier, resulting in hundreds of thousands of dollars in equipment and software being located at JBEI at no cost. JBEI has informal collaborations with many other companies, where materials, information, and data are exchanged on a regular or one-time basis.

Example: Strategic Partnership with Total Energies Nouvelles

JBEI has had several strategic partnerships with industry. One of the most successful of these is with Total Energies Nouvelles Activites, USA, SAS. The following is a summary of the relationship as described by the Total scientist managing the JBEI relationship and projects:

“Total Energies Nouvelles Activites, USA, SAS has been and is involved in several partnership projects with JBEI. The goal is to discover novel and economic technologies that could lead to the production of molecules of interest for Total, either by valorizing

plant residues (collaboration with the JBEI Deconstruction division), or by developing new pathways in microbes (collaboration with the JBEI Fuels Synthesis division).

To perform this research, Total, under CRADA agreements, has provided funds and employees (Total postdocs and scientists) who work side by side with JBEI researchers. The projects have a precise scope of work and follow defined milestones that are reviewed every three to four months during joint steering committee meetings.

The steering committee is comprised of two voting members from each partner. The members are senior research scientists who are also senior managers. The IP advisors and the JBEI director of commercialization also attend most of the meetings. The purpose of the committee is to present research results, evaluate progress towards milestones, advise the scientists, and adjust the project, if necessary, to make sure the goals of both partners are aligned. These meetings offer the opportunity to discuss potential scientific bottlenecks and new ideas and approaches, and for the senior industrial and academic managers who are not directly involved in the collaborative projects on a daily basis to develop relationships. Most importantly, the steering committee makes crucial decisions such as whether or not to file patent applications or pursue new research projects.

Total employees, seconded at JBEI and working under a broad mutual NDA, have been perfectly accepted and integrated into teams of the various JBEI divisions and benefit from the advanced technologies and platforms available in the institute. JBEI directors involved in Total collaborative projects have developed their research with respect for Total industrial objectives. The collaborations between Total and JBEI have resulted in a patent application that has been drafted by both parties to ensure that it will cover Total needs. Two additional invention disclosures are being evaluated for patent applications. Total anticipates using the discoveries and commercializing the products in a relatively short time period and is highly supportive of its collaborative projects with JBEI."

IP Metrics since JBEI's inception in late 2007

- Invention disclosures: **192** (average of ~30/yr for past 6 years)
- Patent applications filed: **99**
- Currently active JBEI IP licensed or optioned (whether or not license/option has expired): **59** (includes US and foreign patents and patent applications, and copyrights licensed exclusively, during the life of JBEI,)
- Total License/Option agreements: **23**
- Startups: **4** (all incorporated in the past 3 years.)
- Industry visits: approximately **275**

New invention disclosures and patent applications are reported to DOE on a monthly basis. The goals of the DOC (and all JBEI staff) are clearly defined and related to milestones in a performance management system, which is updated/revised quarterly by the DOC, and reviewed by management annually. The IP/industry engagement data is presented

periodically at JBEI retreats, seminars, and IAC/SAC meetings, and frequently at JBEI and Berkeley Lab industry meetings, tech transfer-related conferences, and in talks around the world by JBEI senior management. The data is also compared to the AUTM technology transfer data for top US universities. Based on this data, JBEI is a clear leader in the rate of invention disclosure, licensing, and startup creation.

JBEI's synthetic biology, mass spectrometry and omics tools and methods are currently making an impact in industry and academia. These tools and methods have been transferred through over four hundred JBEI publications as well as through collaborations and licenses. JBEI is starting to gather data to quantify these impacts.

The cellulosic advanced biofuels industry is still nascent. Most industry players are still building or perfecting first generation cellulosic ethanol plants. It is anticipated that JBEI biomass deconstruction technology will be incorporated into second generation cellulosic ethanol plants. Third generation plants may adopt JBEI fuel synthesis technology to tackle the production of biofuels that are direct replacements for diesel and jet fuels. Due to long development times for new feedstocks, JBEI's plant technologies are not likely to be adopted for 10-15 years. Once the industry starts to mature, JBEI's impact should be measured based on metrics such as products on the market, jobs created, dollars saved, and contribution to carbon savings.

Strategic plan developed in 2012

In 2012 the DOC worked with the JBEI team to develop a strategic plan for commercialization. The strategic plan reenergized technology transition and industry partnership efforts.

The plan identified innovation, teamwork, and excellence as core values. These core values apply as much to the industry/IP program as they do to the scientific program.

Under the plan, JBEI as a whole developed the following vision statement: *JBEI will be the place that made possible a sustainable, sugar-based fungible fuels industry by creating the most innovative model of mission driven research and commercialization of recent decades*

The strategic objectives are:

1. Demonstrate significant Return on Investment to DOE, Congress and U.S. taxpayers

- Track the following metrics: inventions, patents, patents licensed, startup companies, CRADA/WFO outcomes, industry visits. Ultimately report on downstream results, e.g. products on the market, jobs created, dollars saved, contribution to carbon savings
- Communicate impact by telling the stories behind the IP data, communicate impacts of Open Source tools and resources
  GOALS:
    - Streamline tech transfer process, accelerate execution of agreements
    - Develop JBEI templates and new template language that resolves common issues (license, option, CRADA option, bailment)

- Increase IP relevance by deepening JBEI employee understanding of industry challenges and increasing market awareness
- Discover unrealized and possibly valuable applications of JBEI research/IP

2. Expand research funding through industry interactions to:

- Deepen and broaden the research base
- Enable more seamless transition of inventions to the next readiness level and/or to the marketplace

  GOALS:
  - Industry-funded collaborations
    - Market our expertise/capabilities, not just our IP
  - Partner w/industry for federal grants
    - Hold grant writing seminars at JBEI covering mechanics, agency dynamics, how to secure industry partners
  - Targeted business development
    - Develop list of priority companies for each division
    - Contact 3 potential private sector partners per month that JBEI has not interacted with in a significant way, 5 total
    - Continue to emphasize outreach to potential US partners
  - Startup Track: Cultivate startups
    - Grow single inventions into IP portfolios that have the potential to support a startup
    - Write Lab navigation guide/checklist for researchers interested in starting a company (will cover conflict of interest practices, information on licensing your own IP from Berkeley Lab, etc.)
    - Provide more intensive entrepreneurial guidance, business and legal resources
    - Identify near term/long term applications and low cost value inflection points for de-risking tech and increasing fundability
  - After Startup track:
    - Introduce startups to investors
    - Refer potential industry partners to startups when JBEI can't meet the need
    - Enable fast turn-around Work for Others agreements so startups and other small companies can more easily access unique JBEI expertise and equipment

Summary

The demonstrated benefits of JBEI to the taxpayer are significant. JBEI has spun out 4 US companies, which have already begun to create jobs. (3 potential startups are in the queue.) It has also established seven platform technologies, supported by substantial patent portfolios. Several of these portfolios have been licensed and companies are embarking on commercialization steps such as greenhouse trials, fermentation scale up, and integration of software into customer technology platforms. While it has yet to be seen how the JBEI technologies will be employed at scale in the cellulosic biofuels industry, many of them have applications beyond biofuels and will inevitably be commercialized in one or more fields of use. Non-fuel applications may play a critical role in "paving the way" for ultimate production of

biofuels, especially if “experience curve” effects in manufacturing are obtained, such that continued experience making chemicals by fermentation leads to continually reduced costs.

JBEI has also published over 430 publications with an average h-index of 37 and 16.6 average citations per publication, some of which have depended on formal or informal industry engagement. Sixty alumni have moved on to industry jobs, taking with them cutting edge research techniques, a deep knowledge base in their fields, and typically a more sophisticated understanding of IP, partnership management, team science, and industry drivers than one would be exposed to in most academic or national laboratory settings.

JBEI has used standard DOE CRADA and WFO and licensing mechanisms to achieve impacts that far exceed what one would expect out of a national lab or typical academic environment. This is attributable to both the JBEI model itself and the personnel executing the model. JBEI practices and approaches, and the management philosophy described in this overview, could be beneficially applied at other institutions.

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