



Advancing Research and Development of Sustainable Energy from Algae

Additional comments to the California Energy Commission Re: the AB 118 Investment Plan for FY 2011-2012, under the Alternative and Renewable Fuel and Vehicle Technology Program (Docket #10-ALT-1)

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On behalf of UC San Diego and the San Diego Center for Algae Biotechnology, I am pleased to have an opportunity to provide comment and observations on the CEC's draft AB 118 investment plan for FY 2011-2012. I am very appreciative of the thoughtful consideration of the potential for algae as a feedstock that the staff have placed in this draft. I am also excited by recent related interactions and discussions with CEC and its staff on the topic of advanced sustainable biofuels, and the role algae could play in California's renewable fuels portfolio. In these comments, I'd like to make some observations on the "big picture" with regard to the current state of algae RD&D, provide an update on related workforce development efforts, and offer a specific recommendation to the Commission for consideration under the FY 11-12 plan.

1. Algae – "the big picture" - I am always surprised at how flexible and adaptable single-celled organisms can be, and algae is certainly no exception to this rule. Many of the biological "hurdles" to algal biofuel production that we imagined just three years ago have already been solved. This is what is possible when your subject is capable of more than 700 generations per year! For example, a number of algae companies have already achieved growth rates of 40 grams/m²/day; these are results which only two years ago were projected to be ten years away. The separation of fuel precursors from biomass was also thought to be a significant obstacle, because of the cost of drying algae prior to extraction. Now, several companies – although not many academic labs – have identified very efficient protocols for "wet extraction", rendering this previously costly aspect of production very reasonable. I no longer view either of these "hurdles" as rate or cost limiting.

Dewatering, or harvesting, remains a costly part of the process, but here again there have been a number of significant advances made which suggest that this aspect of production will have been solved well before any commercial facility is up and running, which is projected to be 2014. Crop protection is another area where more work is needed, but then this is always going to be the case; as with traditional agriculture, this will be a never-ending battle between the farmers and the pests. This is just the nature of biology.

This is by no means to imply that all the challenges to algal biofuel production have been addressed – at least not yet. It does mean that the biological elements of this process are well in hand, and what we've learned in the last four years is that with a meaningful research effort we absolutely can solve the remaining biological barriers to production of fuels from algae, particularly with the application of state-of-the-art high through-put screening and selection protocols. The biology will hold up the commercial deployment of this technology. What we have also learned over the last few years is that the engineering involved in scaling up to

commercial levels remain significant hurdles to economic viability, and so meshing the biological successes with the related engineering needs continue to be a challenge. It is in this area specifically where serious research endeavors must continue.

The draft report notes four specific research areas that have been identified by the CEC's PIER Program, and which will be aggressively undertaken by the recently established California Initiative for Large Molecule Sustainable Fuels. SD-CAB is honored to serve as the anchor for this visionary CEC endeavor, and looks forward to working closely with the Commission and other collaborators to advance the development and viability of large molecule sustainable drop-in fuels.

2. Workforce Development - The SD-CAB also stands ready as a resource to the Commission with regard to its plans for Workforce Training and Development in the FY 2011-2012. As the Commission is aware, SD-CAB is currently engaged in one of California's more ambitious and comprehensive efforts to train workers for the growing biofuels industry. SD-CAB is proud to be part of the EDGE (Educating and Developing workers for the Green Economy) Initiative, funded by a \$4 million grant from the California Labor & Workforce Development Agency (LWDA). The EDGE Initiative will provide education, training and placement services in the growing biofuels and industrial biotechnology industry to unemployed and incumbent workers within San Diego and the Imperial Valley. Program curriculum has been carefully constructed with input from industry partners to ensure that the needs of this sector are met with highly skilled workers, and the program was successfully launched in March 2011, with certificate courses offered at UCSD Extension and MiraCosta College (69 students in 7 courses, with one hands-on lab course). The Industrial Biotech Immersion Program will launch in June 2011, with the Masters program anticipated to be launched in 2012. The EDGE program offers the following funded training opportunities:

* **Industrial Biotech Immersion Program:** This online certificate program will use industry driven curriculum to give individuals the business acumen and soft skills needed to successfully transition into industrial biotech careers.

* **Biomass Production Training Certificate:** This certificate, initially run through MiraCosta College, will provide a foundation in the technologies employed by biotechnology companies engaged in the production of microalgal biomass for biofuels and other applications for biomass production careers.

* **Biofuels Science Technician Certificate: Tracks - Biological/Biofuels Lab Technician, Microbiological/Crop Management, Biofuels Analytical Chemist:** This certificate, initially run through UCSD Extension, will provide the hands-on technical knowledge and experience in biofuels production, analysis and processing required to excel in a management-level biofuels career, in one of three areas: analytical chemistry, microbiological/crop management, or biological/biofuels lab techniques.

* **Advanced Training in Biofuels Production Certificate (Masters of Advanced Studies):** Fulfilling the need to continue to understand and improve the science of biofuels, the UCSD-based M.A.S. will prepare advanced degree holders to assume responsibility for important research in the growing biofuels industry by providing technical knowledge and hands-on experience in biofuels production, analysis and processing, as well as basic biotechnology business and entrepreneurial skills.

Who May Apply: 1) Job seekers and unemployed individuals looking to work in a high growth

industry; 2) Individuals transitioning from declining industries; 3) Students making a career choice; 4) Veterans transitioning into civilian work environments; 5) Incumbent workers looking to move into higher level positions.

SD-CAB and the EDGE Initiative would be happy to collaborate as appropriate with the Commission, and the California Community College Office of the Chancellor (CCCCO) in its related efforts as outlined in the staff draft report, related to curriculum development, trainer instruction, equipment needs, and other related elements of a robust statewide job training sector. If we can add value to CEC's efforts and enhance efficiency by sharing best practices and lessons learned in the course of the EDGE program, we would be pleased to do so. I would welcome the opportunity to discuss this further with the Commissioners and their staffs, and also extend a standing invitation to attend one of the courses currently being offered as part of the EDGE initiative.

3. Recommendation for Pilot Project - Following up on preliminary discussions with CEC staff, I wish to also offer a specific near term recommendation for this FY 2011-2012 investment plan. CEC should consider a competitive solicitation, in the range of \$10-12 million, for "A Demonstration and Teaching Facility for Next Generation Liquid Biofuels". This would be an academic-based pilot facility that would enable "soup to nuts" algae biofuels production, harvesting, and fuel processing. Such a facility would provide both a training and research platform, as well as a demonstration-scale pilot plant. This full production chain for fuels from algae facility would serve as an invaluable hands-on learning tool for students, researchers and engineers, as well as provide a test bed facility that small commercial partners could utilize to allow a translation from invention to commercial-scale production. This pilot project would entail the following:

Currently there is no consensus on the optimal system for production of large molecule "drop-in" biofuels. A number of candidate feedstocks are being examined, and several different biomass crops are likely to emerge as viable biofuel production systems. In addition, although ongoing projects at several small companies have begun, no large-scale production and processing facilities yet exist to validate the technology. Given these limitations, it is critical for the state of California to support a demonstration and teaching facility that has the flexibility to both train the future energy workforce and also provide a dynamic platform from which to communicate and advertise the future of sustainable energy to the people of California and beyond. This facility should be created from a partnership between academic researchers and leading bioenergy companies in our state and contain a full life cycle component of the biofuel process, including biomass production and harvesting; biofuel processing and analysis; electricity generation and emissions analysis; and waste stream processing and recycling.

Economically viable production of sustainable biofuel feedstocks will require continuous improvement of production and processing technologies, both biological and engineering, and a facility that enables these diverse scientific disciplines to work collaboratively at a single site is essential to the rapid deployment of these technologies. Training in the basic techniques of aquaculture, biofuel processing, and energy fuel analysis are essential to this end. In addition, complementarity with other next generation energy sources, such as solar panels and smart grid technology, should be emphasized.

This facility would also enable critical involvement on the part of analytical chemists, who would be able to focus on the refining of bio-oils produced at this facility into actual fuels, and the subsequent testing of these fuels to demonstrate that they really are "drop in" fuels. This would

be a logical collaborative partnership with the related research efforts that will be underway at the Commission's California Initiative for Large Molecule Sustainable Fuels.

Such a facility would be important for a host of reasons, not the least of which is incentivizing collaborative interactions between research biologists and engineers to start addressing the practical challenges of producing algae fuels. This would enable an expedited understanding of how to actually produce drop-in sustainable fuels from algae, albeit at a pilot scale, and in so doing address in a practical, hands-on manner the related challenges associated with crop protection, dewatering, harvesting and extraction. All these issues are currently being carefully examined in a lab research environment, but taking related discoveries and applying them to actual production of fuel will be critical in terms of helping to establish the viability of these processes, and better understanding how to bring this sort of production to commercial scale here in California, in ideal algae-growing locations such as Imperial County, or the Central Valley.

In terms of workforce needs, the biofuels industry will require a variety of occupational skills, from agricultural-style biomass production, to biological and microbiological technicians, and finally to highly trained molecular biologists and biochemists. There is already an acute shortage of staff with adequate training to meet these needs, and this shortage will be further exacerbated in the future due to the lack of biofuels training programs available in the nation. There is also a major need for a workforce trained beyond the Bachelor of Science level to perform the high-paying research-oriented and management-focused jobs in this sector. As mentioned above, multiple efforts are underway to address these shortcomings, and this type of facility would be an excellent "force multiplier" in terms of accelerating the related learning curves.

From a communications and publicity standpoint, the national and global media have already reported that California is at the forefront of renewable energy technologies, but criticism has in turn emerged that there is little to show for it. While such accusations may not be fair, with this type of facility California would have the capability to disprove such negative perceptions, by creating a world-class facility for the demonstration and evaluation of next-generation sustainable biofuels.

Commercial-scale production plants are now under construction in New Mexico, Texas, and Hawaii, all based on research expertise developed and perfected in California. For California to continue to lead the nation in energy solutions and production, it is critical that we take the state's already demonstrated expertise and capability on the research side and apply it to actually producing sustainable alternative transportation fuels here in California. There is increasing interest at both the state and federal level in examining how such production could be enabled and expedited, from a siting and permitting standpoint, and so it is important that efforts aimed at perfecting the production side also proceed in a parallel fashion.

A strong argument could be made for two such pilot facilities, one in northern California and one in the southern end of the state; this would maximize the ability of California-based academic expertise to help bring such facilities to bear, and in so doing take into account the issues of regional geographic diversity that must be addressed, such as strain selection, temperature and climate variables, potential pests, and so forth. However, assuming that two facilities may not be feasible in terms of overall budget capacity, I would urge that CEC in the near term - i.e. in the context of the FY 2011-2012 AB 118 investment plan - plan to issue an RFP for an academic pilot facility as described above, in the \$10-12 million funding range. That said, I would also suggest that CEC look ahead, possibly to the FY 2012-2013 investment plan cycle, and consider how it might encourage and fund construction of a functioning commercial scale production facility for algae-based fuels, here in California. There are a variety of ways this might be done

that would make it attractive to the industry leaders in this field, including competitive grant funds, tax incentives, and low-interest loans, but the important thing is to begin thinking about how, not whether, California plans to remain at the forefront of the development of this critical source of sustainable energy.

Thank you again for this opportunity to comment on and participate in the FY 2011-2012 AB 118 Investment Plan process, and I look forward to continued productive collaborations with the Commission on behalf of our mutually shared goals. Please don't hesitate to contact me directly should there be any questions, or if the San Diego Center for Algae Biotechnology can be a resource to the Commission in any way.

Sincerely,

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Stephen Mayfield