

Multiphysics Analysis of a Photobioreactor

Eric Dunlop

Pan Pacific Technologies, Pty Ltd

*L.T. Gritter, J.S. Crompton, and K.C.
Koppenhoefer*

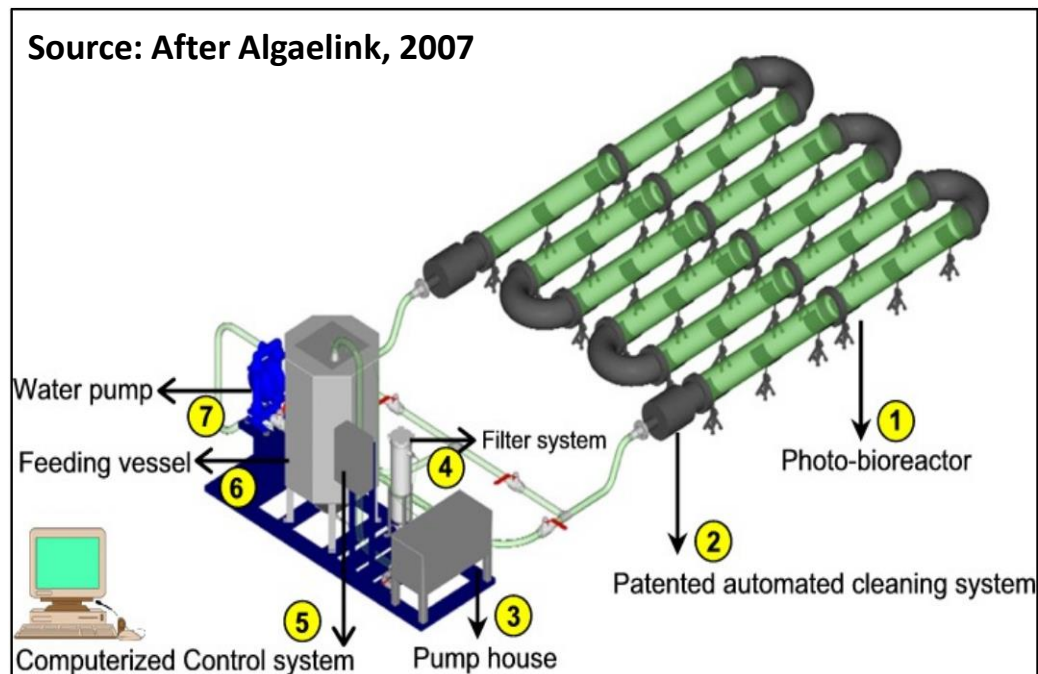
AltaSim Technologies, LLC



Overview

- **Algae growth in photo-bioreactors represents an important class of problems to solve**
- **COMSOL Multiphysics provides the capabilities and flexibility to solve this class of problems**
- **Current work represents a good start with room to extend modeling**

Motivation for Algae Photo-Bioreactors



- Source for biodiesel and bioethanol, animal feed additive and fertilizer
- Absorb carbon dioxide from power plants

Horizontal Photobioreactor

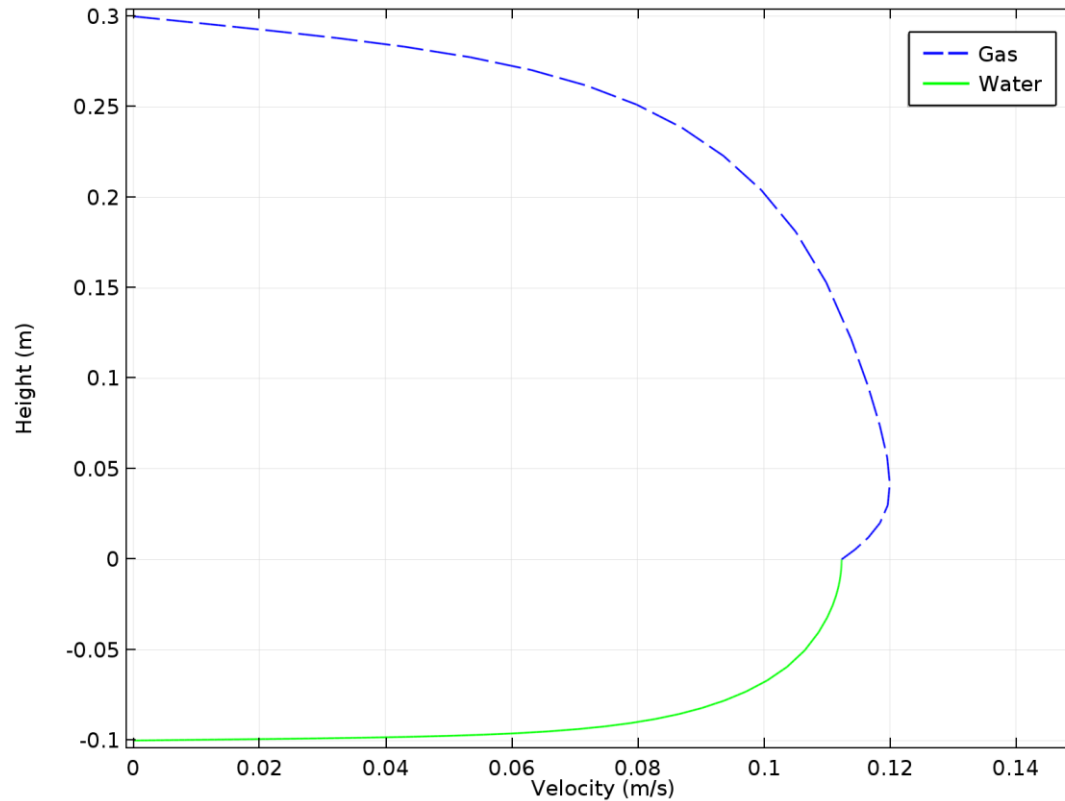


Use of COMSOL Multiphysics

- **Multiphysics problem**
 - **Fluid flow - Two phase**
 - Gas flow
 - Water flow
 - **Species transport**
 - Concentrated species in gas
 - Diluted species in water
 - **Light penetration**
 - Beer-Lambert Law
 - **Algae growth**
 - Chemical reaction as a function of species, pH and light

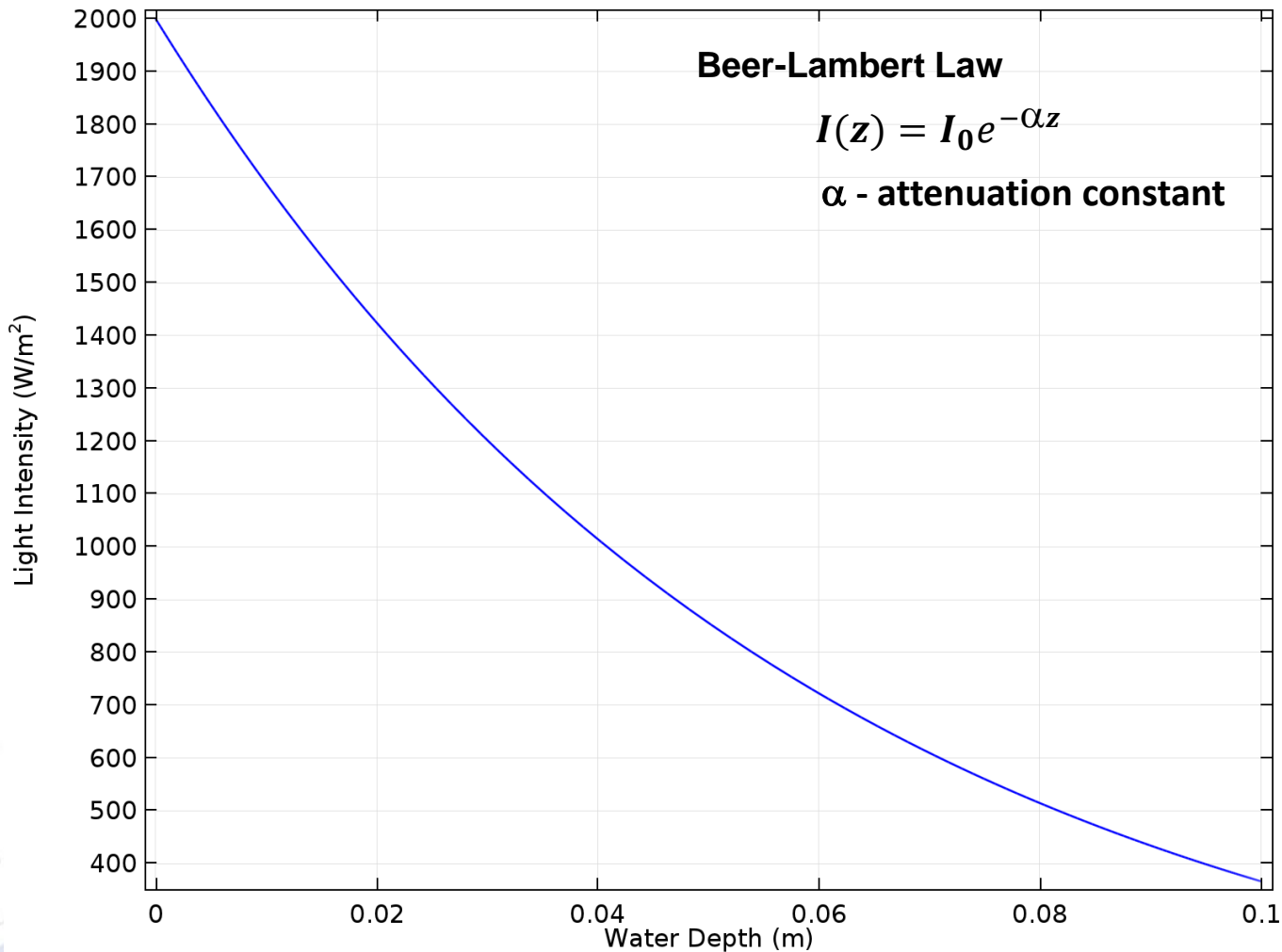
RESULTS

Results – Fluid Flow

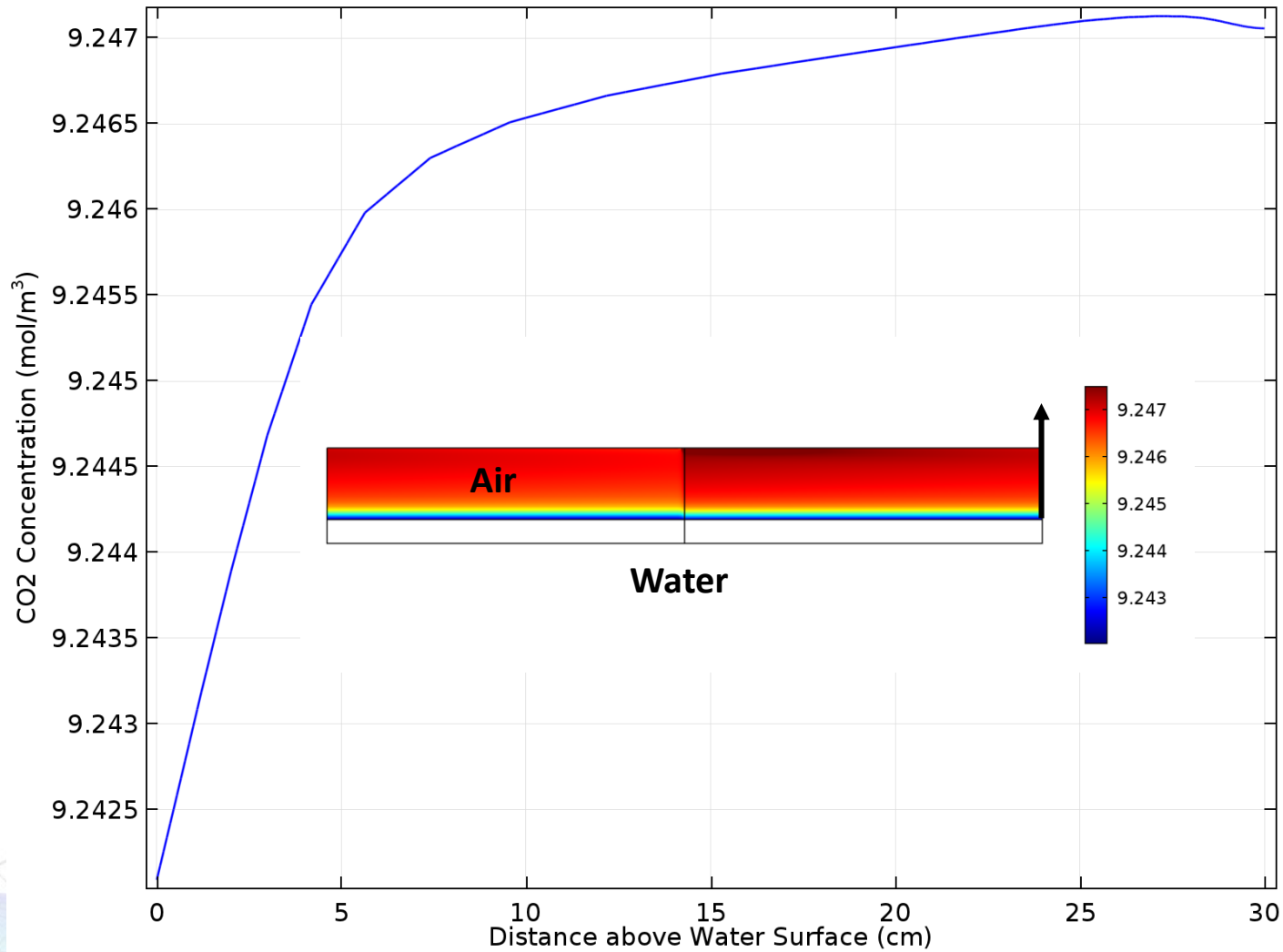


Fully developed velocity profile mapped to reactor

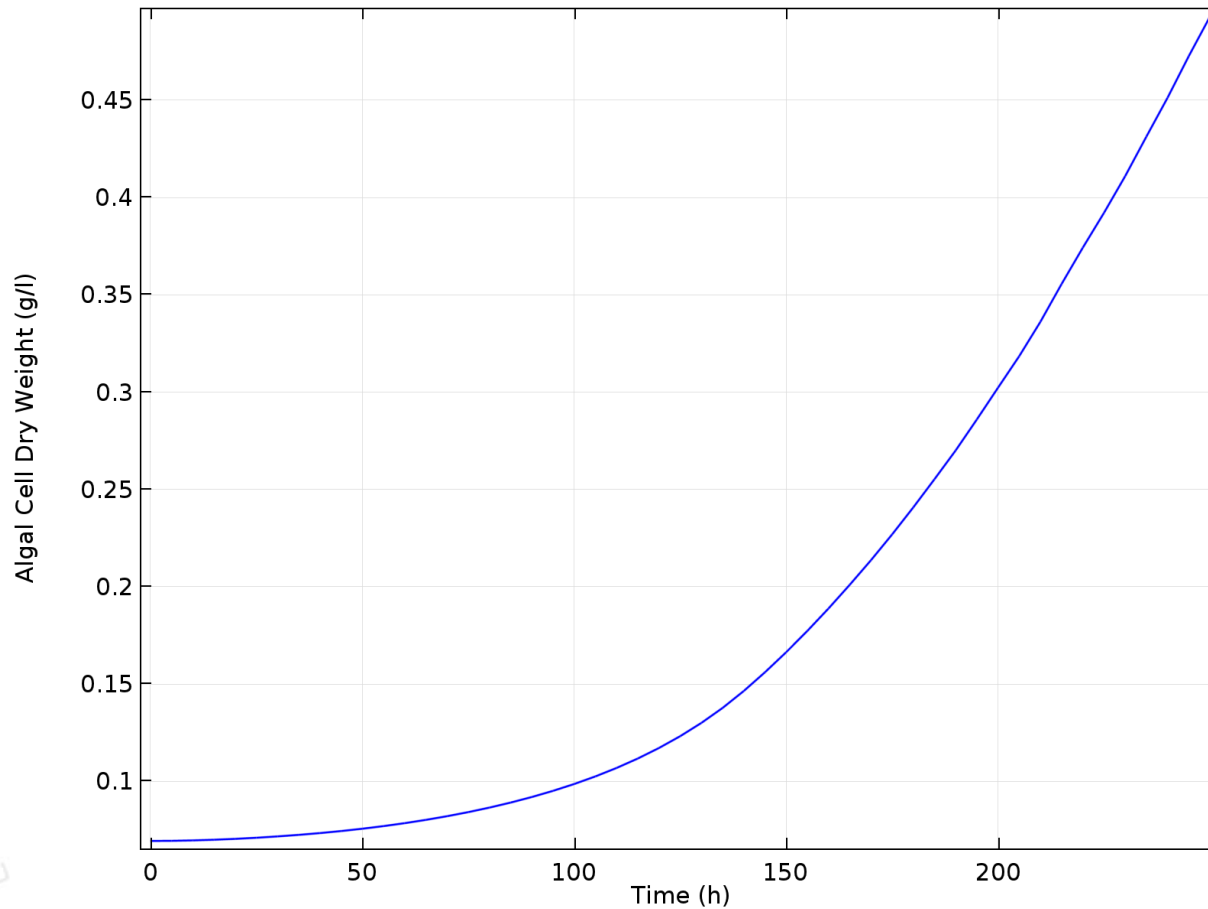
Results – Light Penetration



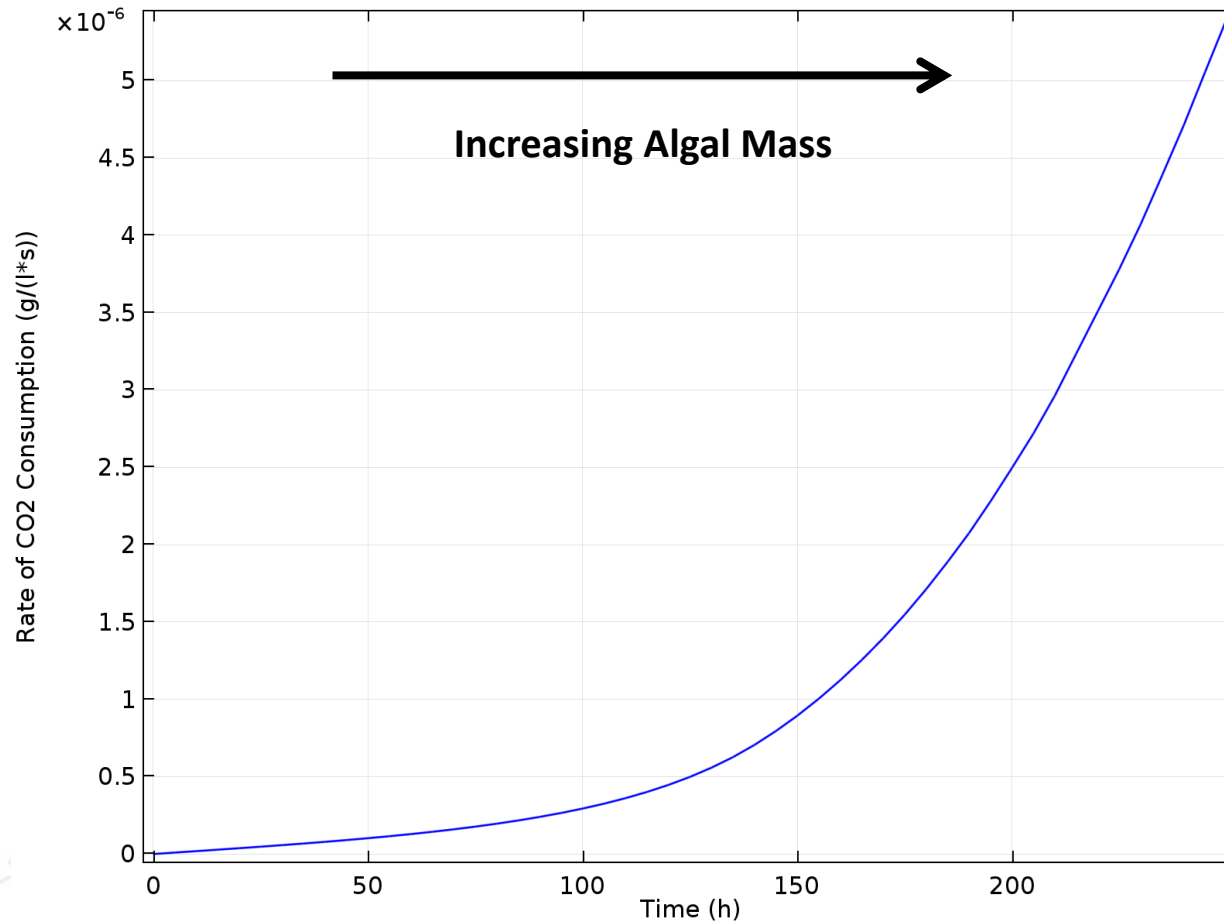
Results – CO₂ Concentration



Results – Algal Cell Dry Weight



Results - CO₂ Consumption



Summary

- **Computational framework developed for assessing PBR designs**
- **Primary features of system developed in COMSOL Multiphysics**
 - **Multiscale solution**
 - **Multiphysics solution**
 - **Flexibility to input systems of complex equations**
- **Experimental data under development for validation**

Future Work

- **Thermal modeling**
 - Heating due to sunlight
 - Conduction/convection
 - Effect of temperature on algae growth rate
- **Comparison with experimental data**
- **Parametric study of design space**
- **Extension to new designs**