A Life Cycle Assessment of Energy and Greenhouse Gas Emissions for Almond Processing and Distribution in California

UC DAVIS
AGRICULTURAL SUSTAINABILITY INSTITUTE

December 2014

Lead Investigator: Alissa Kendall, PhD (amkendall@ucdavis.edu); **Co-Investigator**: Sonja Brodt, PhD (sbbrodt@ucdavis.edu); **Graduate Student Researcher**: Katherine Hoeberling

Research Objectives

- **Quantify** net life cycle greenhouse gas (GHG) **emissions** and **energy** use in California almond processing and distribution
  - Stage 1: Hulling and Shelling
  - Stage 2: Processing
    - Steam or PPO Pasteurization
    - Oil/Dry Roasting, Blanching
    - Slivering, Salting, Salting
  - Stage 3: Distribution
    - Domestic Distribution
    - International Shipping
- **Why do these calculations matter?**
  - Consumer and retailer demand, particularly in Europe for "carbon footprints" (another phrase for life cycle GHG assessment)
  - Potential AB32 Carbon Offsets
  - Understand energy use over the production life cycle to improve efficiency and mitigate energy-related costs
- This study will build on a previous life cycle assessment of almond production from nursery to farm gate, as well as preliminarily findings for hulling and shelling processes

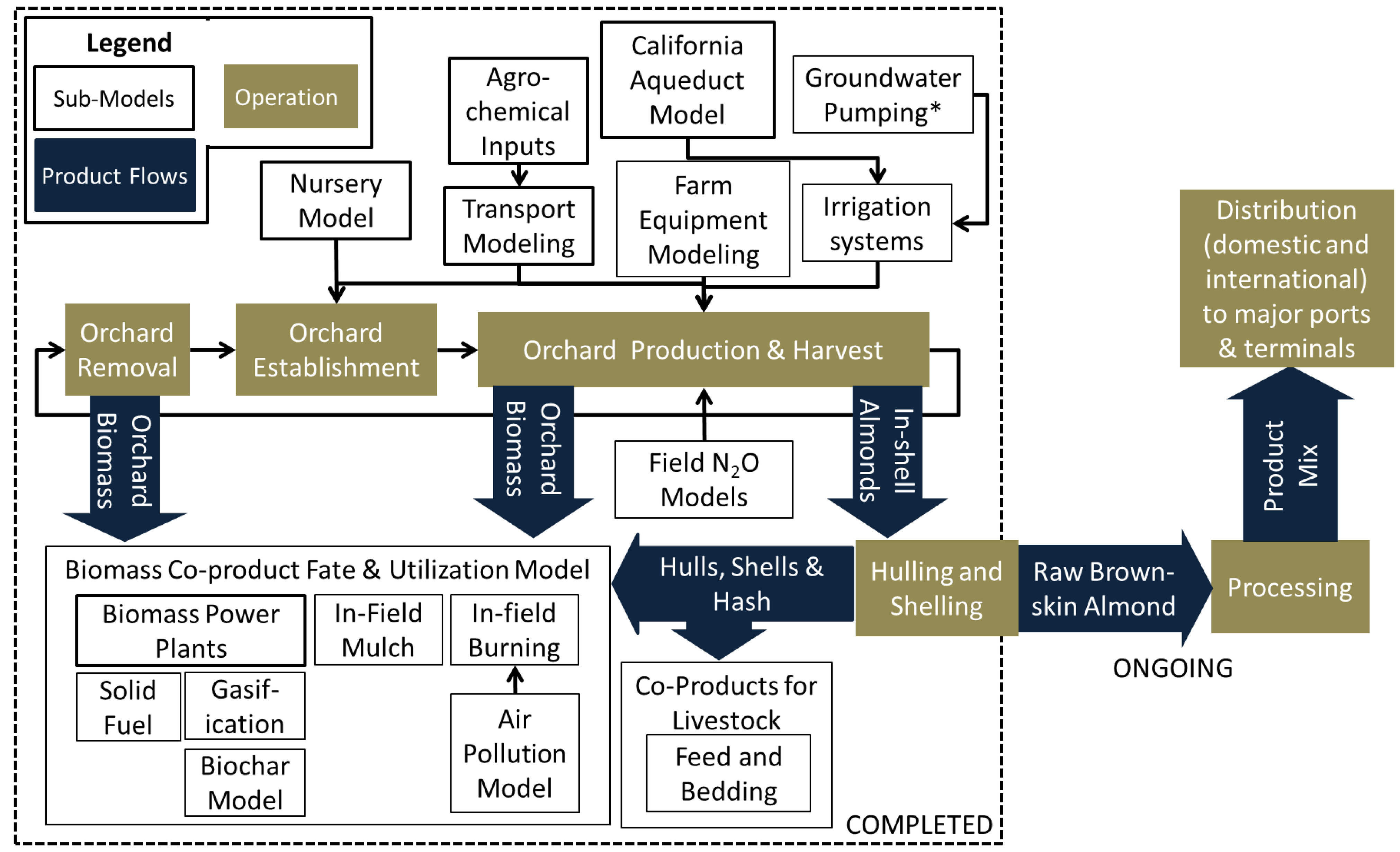

Figure 1. Life cycle flow diagram illustrating completed and ongoing research

Methods: Life Cycle Assessment (LCA)

LCA evaluates the environmental flows (energy and material **inputs** and pollution and product **outputs)** over a system's life cycle. In this study, environmental flows associated with the almond processing and distribution life cycle will be measured from **farm gate** to **domestic wholesaler destinations** and **international ports of entry**. This research will thus include the following life cycle stages: **hulling and shelling**, **pasteurization**, **finishing processing**, and **handling**.

- **Emissions** and **energy** use data for industrial processes will be collected through **surveys** distributed to interested processors and supplemented by **guided tours** of processing facilities.
- **Cogeneration potential** will be calculated using the mass of twigs and shells recovered from hulling and shelling operations.
- **Hauling and shipping** routes and distances will be mapped using survey responses and Geographic Information System software.
- **Upstream impacts** of producing fuels, chemicals, and other inputs will be modeled using life cycle inventory data from the commercial databases *GaBi Professional DB* and *Ecoinvent*.

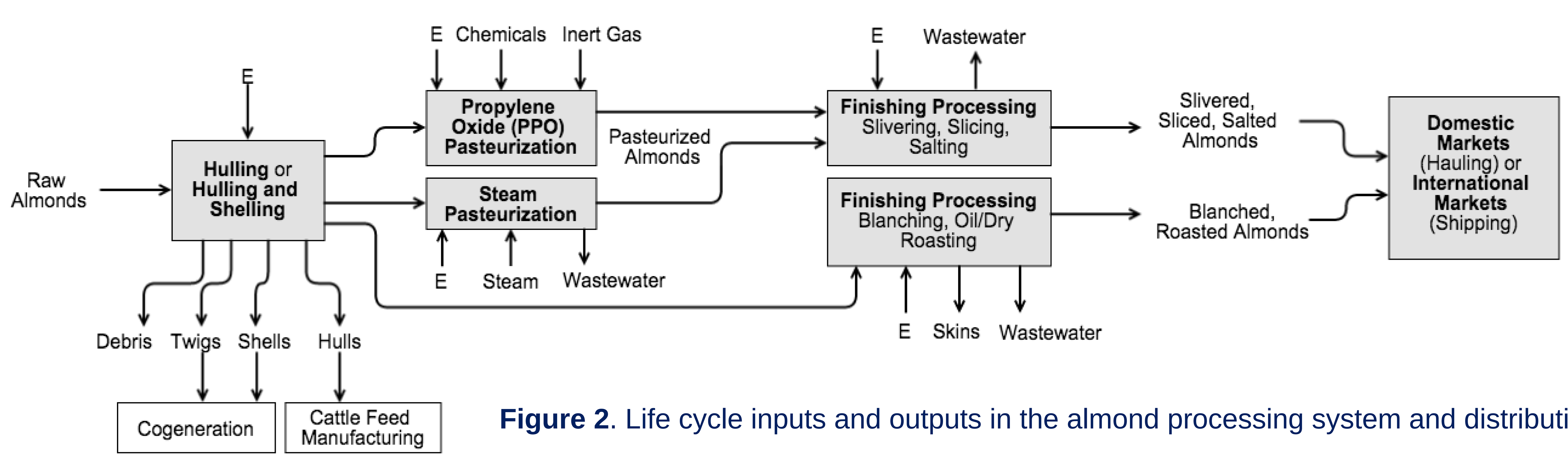

Figure 2. Life cycle inputs and outputs in the almond processing system and distribution channels

Results from Previous Research: From field through hulling and shelling

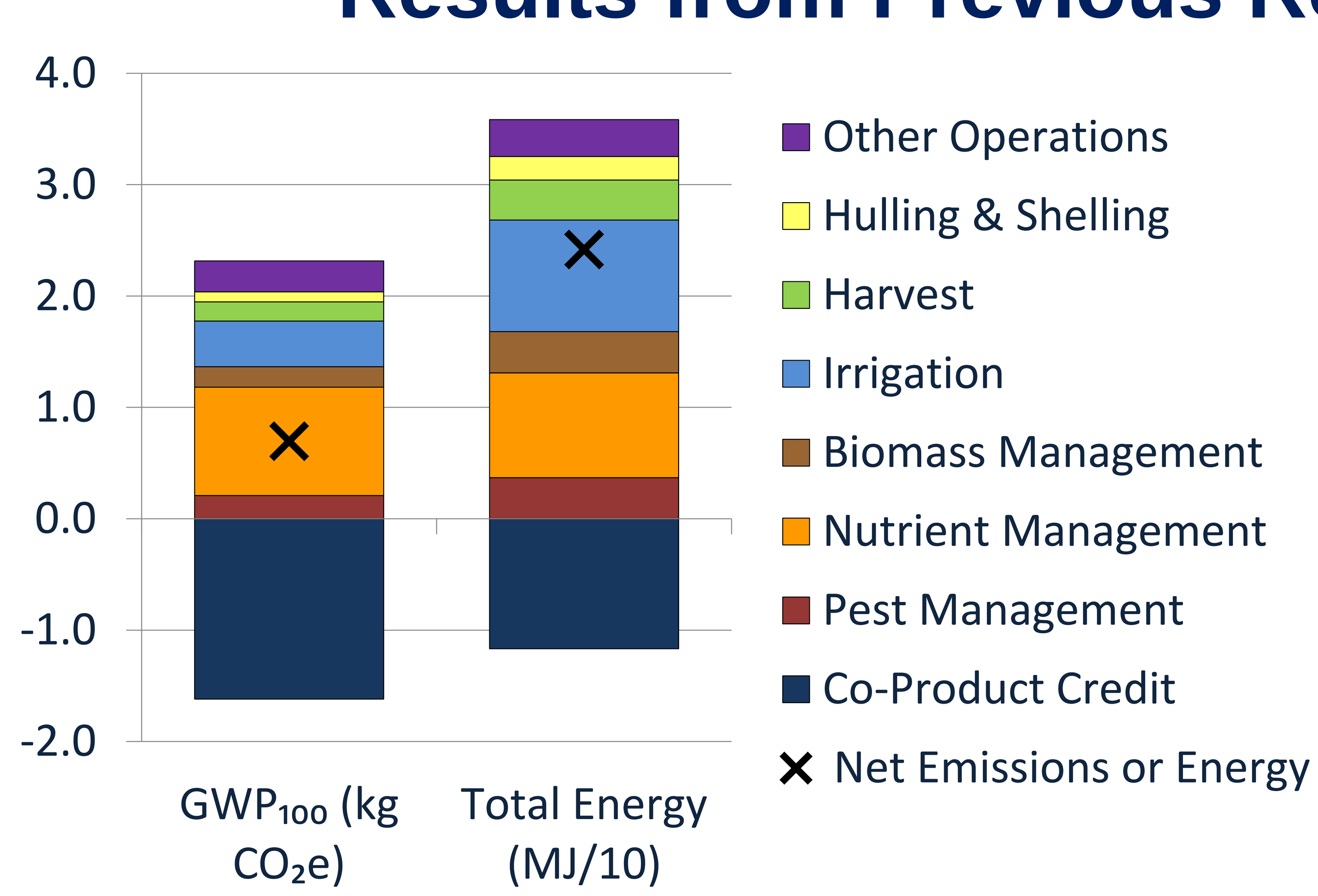

Figure 3. Life cycle GHG emissions by process, **Greenhouse gas emissions** are expressed as 100-year Global Warming Potential (GWP), calculated according to Intergovernmental Panel on Climate Change (IPCC) guidelines.

•Co-Products include electricity generated from waste orchard biomass and shells, and from hulls used as dairy cattle feed. Co-product credits are estimated by modeling the GWP and energy use of the substitutable products that would be used in the absence of almond production.

•These credits are important for determining the net environmental and energy impacts of almonds.

• The bulk of energy use and emissions are derived from nutrient management – particularly from production of nitrogen fertilizers, and from irrigation. These are hotspots and can be targeted for improvements in energy efficiency, and resource efficiency actions.

•Almonds compare favorably to many other nutrient rich and energy dense foods.