Terra-Fresh

# The use of mini-containers in fresh food supply chains: the small grower perspective

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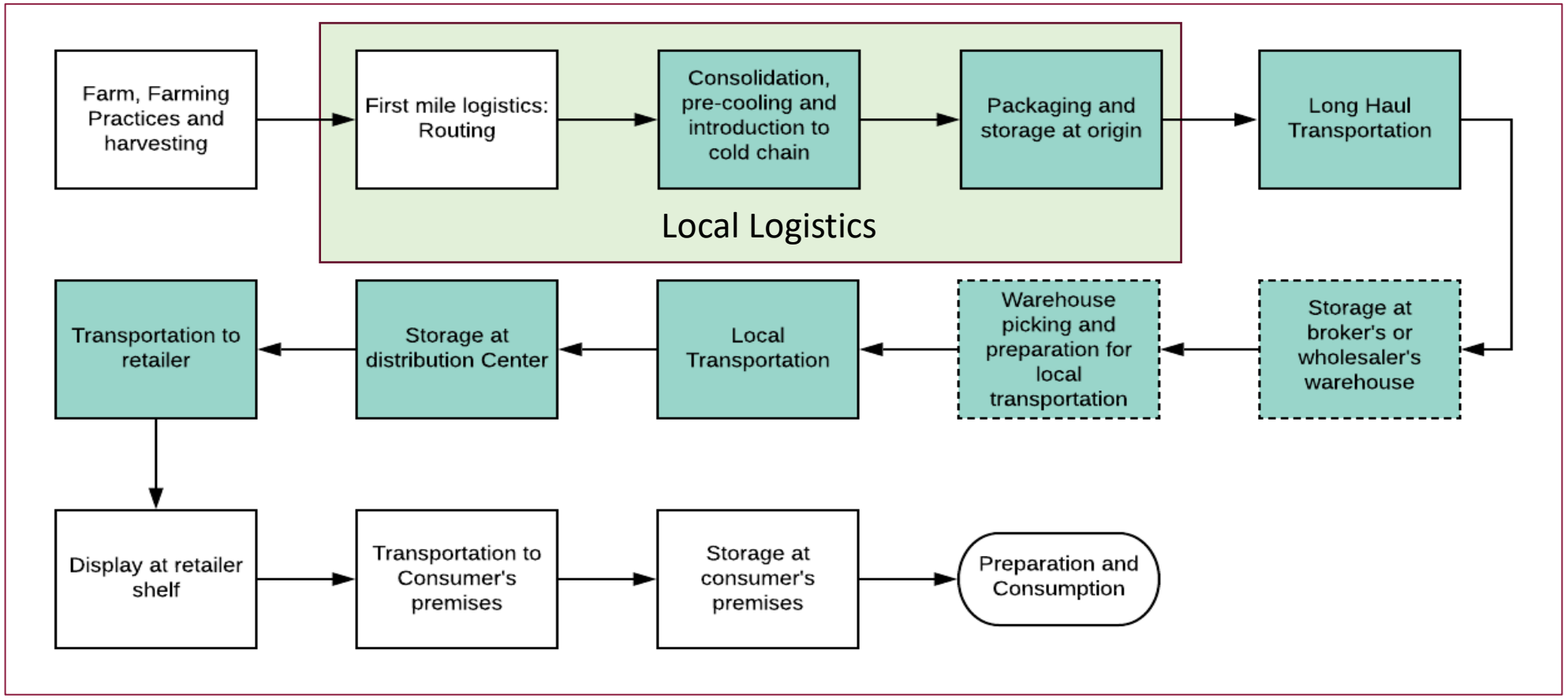
# Schematic of Current Fresh Produce Supply Chain



# Current Situation of Local Cold Logistics: Small Grower Perspective

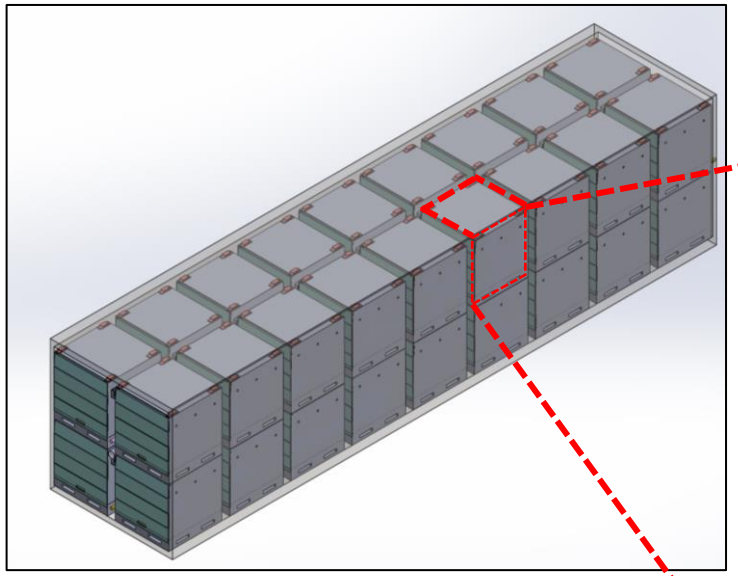
- Lack of logistics capacity and service providers with focus on small growers
- Lack of open-access facilities for processing, packing, pre-cooling, and cold storage
- Lack of critical mass for an individual grower to access efficient logistics (full truck loads, processing, etc.)
- Aggregation of products from different growers in a vehicle made difficult because of regulations and incompatibility of products
- **Not ready for the new market conditions**

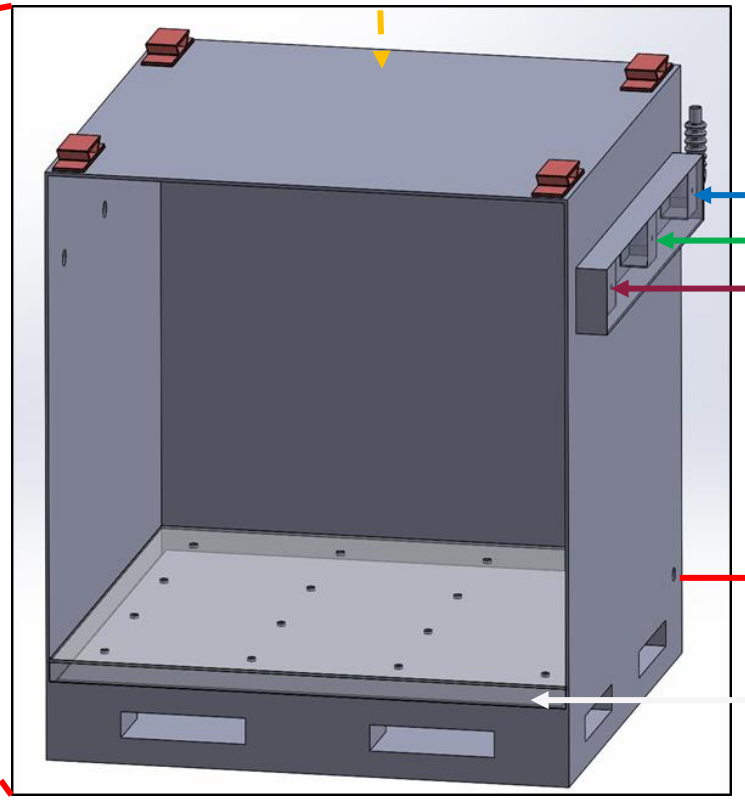
# A Solution: Load aggregation through mini-containers

- Mini-containers are 4 x 4 x 4 $ft^3$, stackable, insulated, environmentally controlled boxes.
- Each mini-container is a cyber-enabled, Lego-like device that can be incrementally connected to other mini-containers to reach just the volume needed to transport a freight load.
- Mini-containers enable capacity sharing of a container among multiple conveyances that may contain several product types under different transportation conditions.
- The combination of mini-containers with efficient refrigeration systems (Central Driving Units, CDUs) reduces logistics costs, food waste and energy/emissions footprint from perishable products.

# Conceptual Design:

## A conditioned box without a dedicated refrigerated system





**Individual traceability sensor in real time:**

- Temperature
- RH
- $CO_2$
- Ethylene
- Vibration
- Location
- Environmental conditions

**Cold Air Supply**

**Humidity/Dehumidify Supply**

**$N_2$ Supply**

**Return Air**

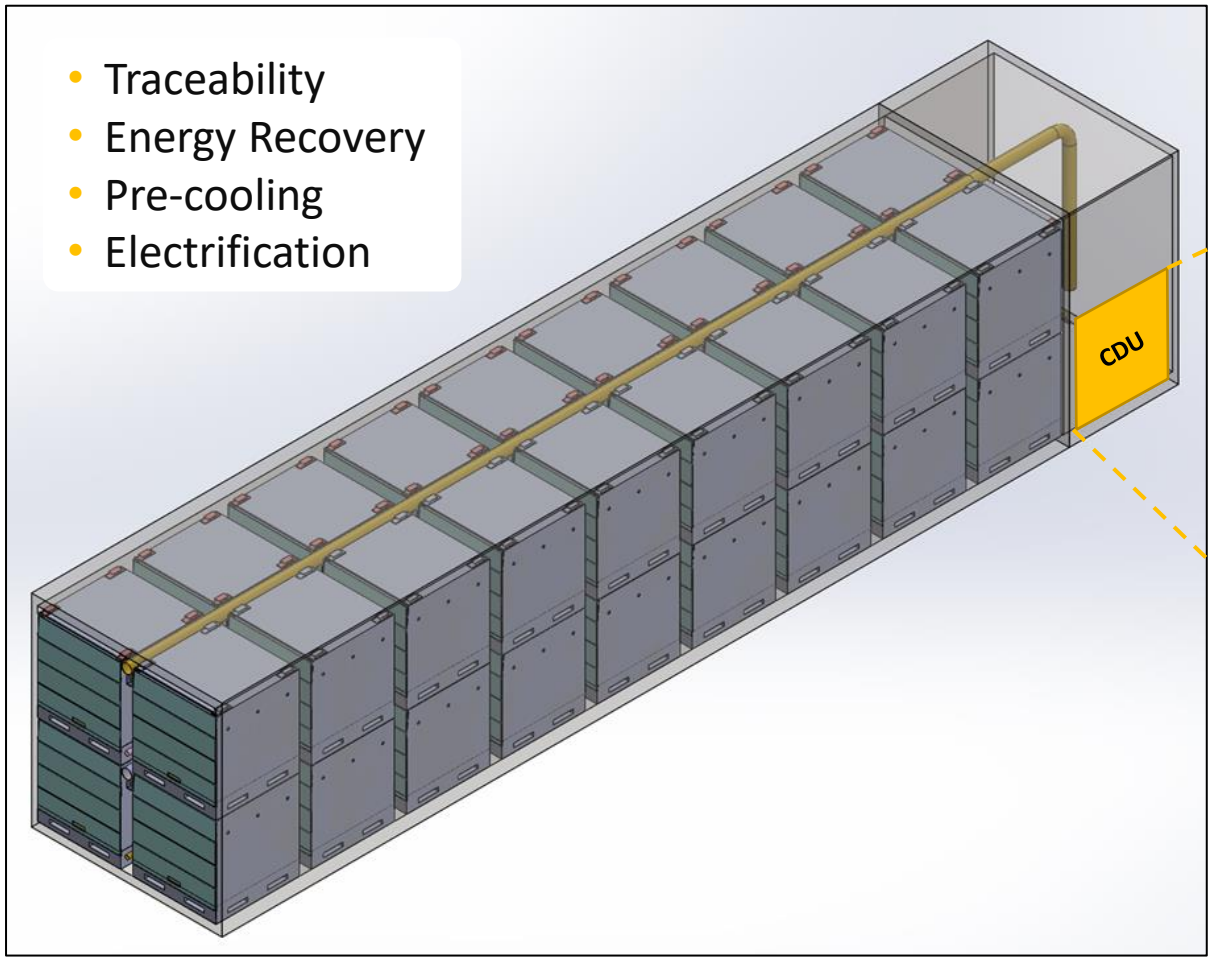
**Water/Debris Collection Area**

International Patent Application No. PCT/US21/37432, entitled "SYSTEMS, METHODS, AND APPARATUSES FOR IMPLEMENTING AGGREGABLE, ENVIRONMENT-CONTROLLED MINI-CONTAINERS FOR THE EFFICIENT LOGISTICS OF PERISHABLE PRODUCTS," filed June 15, 2021.

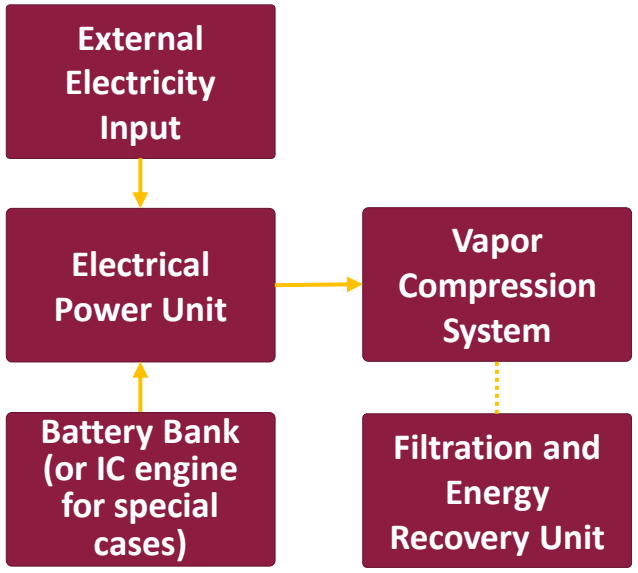
# Conceptual Design:

connected to a Central Driving Unit (CDU) that provides conditioning

- Traceability
- Energy Recovery
- Pre-cooling
- Electrification

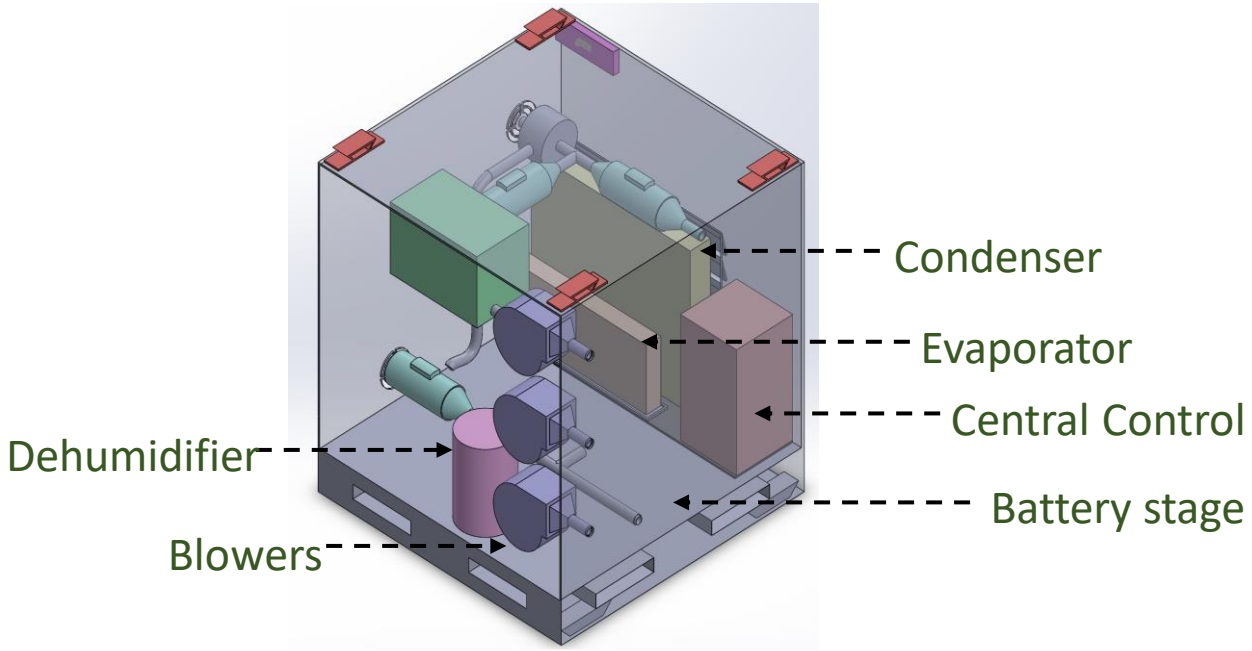



The **Central Driving Unit** (CDU) provides services to mini-containers



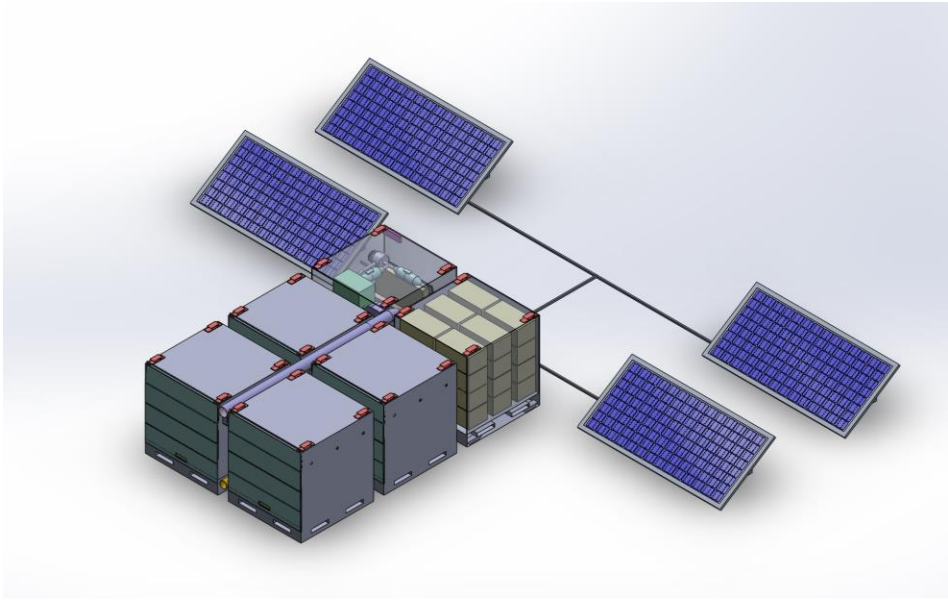
# Conceptual Design:
## the Central Driving Unit (CDU)

### Conceptual Design of the CDU



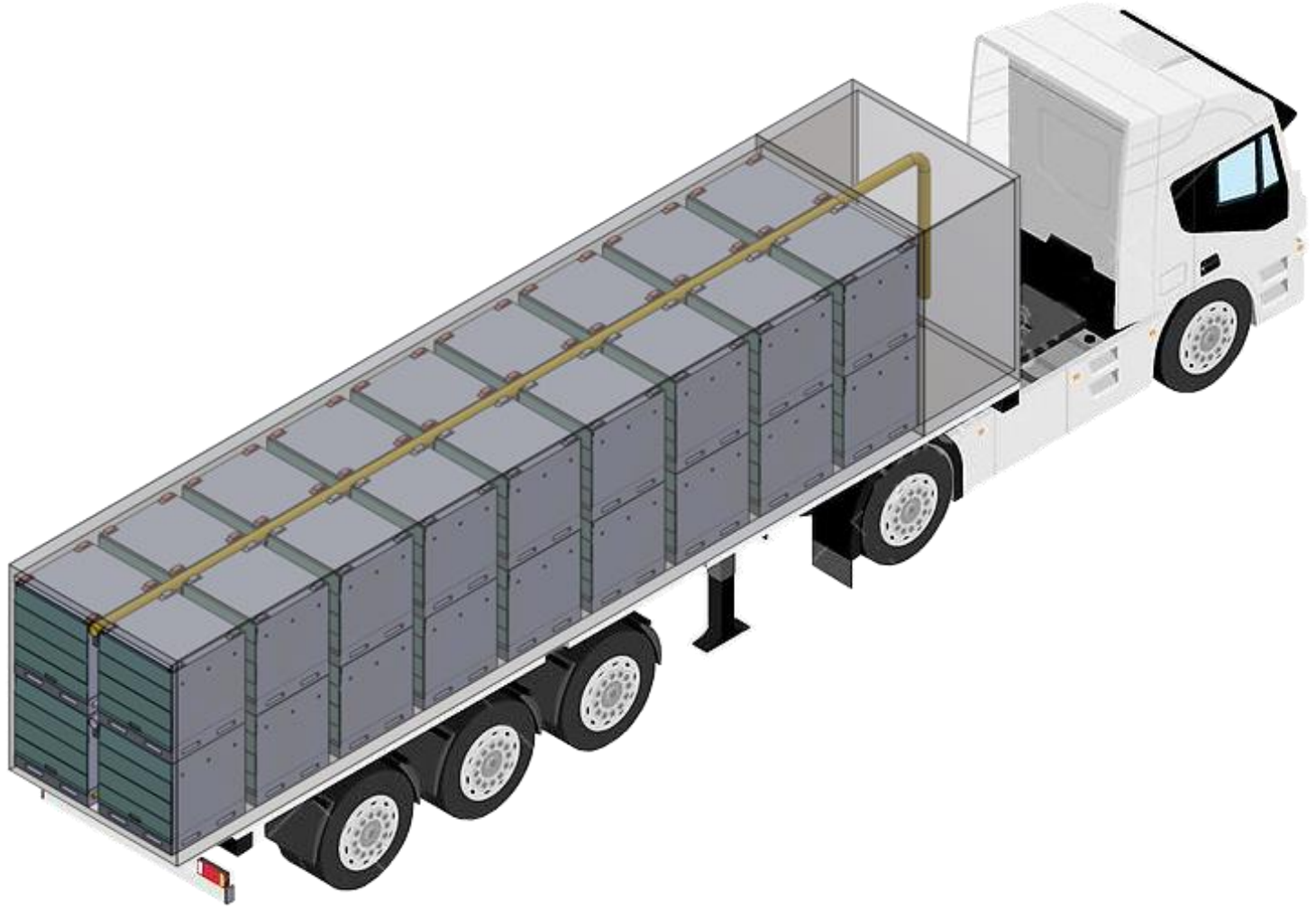

The Central Control Unit interacts with sensors inside the freight mini-containers to provide real-time control and connectivity.

### Solar Electrification Potential

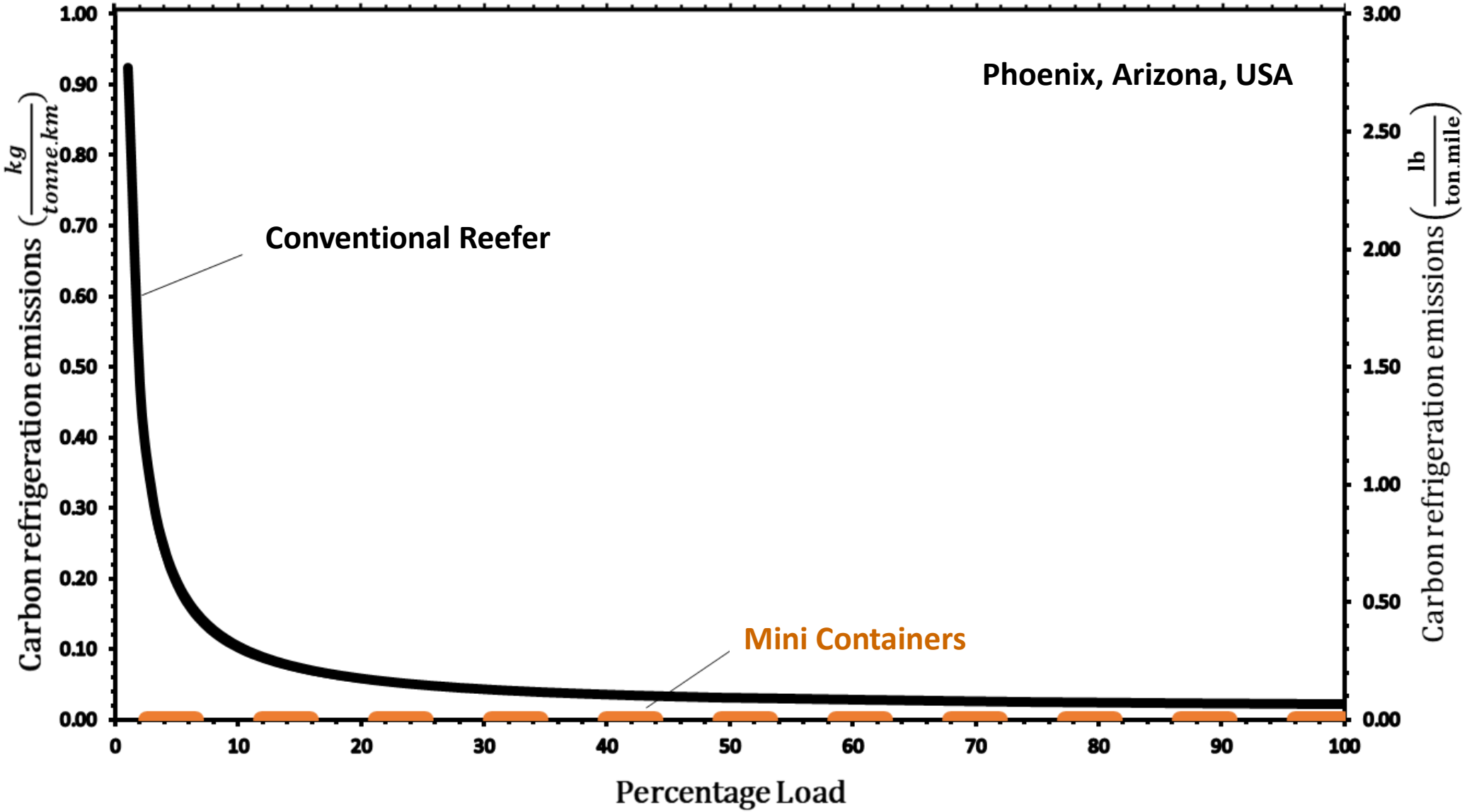


The bundle can be stored at the farm and solar energy can be used to reduce electricity costs.

# 36 MCs on an 18-wheeler



# Indirect Refrigeration $CO_2$ Emissions



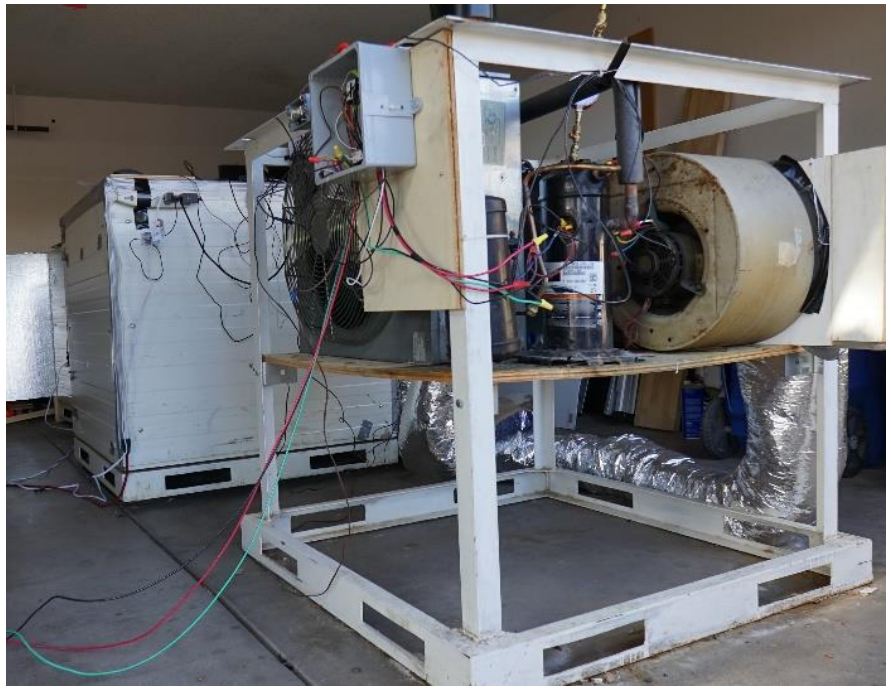

Assumes mini containers are powered by batteries charged with solar energy.

# The Mini-container (FreshKube):

- By using efficient routing, it allows the efficient aggregation of perishable products from different producers at full-truck logistics costs.
- Allows the participation of small producers in the burgeoning direct-to-consumer markets with their own brands, traceable and customized products.
- Provides the standardized unit to make possible the deployment of seamless autonomous and automated logistics, including self-driving freight vehicles.
- Allows the fully verifiable, pristine, unopened, fully traceable journey from producer to consumer.
- Enables integrated decision environments (real time data, controls and predictive/prescriptive analytics) for overall logistics systems improvement.
- Allows share-economies solutions for the small farmers needs in first (and last mile) logistics

# Current State

- Patent application filed on 6/15/21 via ASU.
- Calculations for refrigeration and ventilation requirements.
- Prototype of sensors control scheme design under development based on Raspberry Pi microprocessor.
- A functional full prototype is already available.



# Next Steps

1. Complete energy requirements analysis for refrigeration, environmental control, and air flow.
2. Refine design of individual refrigeration, air purification, and prime mover subsystems.
3. Develop integrated system for packaging CDU in one or two mini containers.
4. Develop technoeconomic models to identify additional market opportunities and focus for future cost-reduction efforts.
5. Alpha prototype testing.
6. Build beta prototype.
7. Develop detailed marketing, financial and management plans.

# Summary of the Benefits of the Mini-Containers

- Allows the transportation of incompatible crops in the same vehicle.
- Allows the creation of temporary cold storage facilities in remote places.
- Allows the immediate precooling of crops at the farmer's premises.
- Fully electrifies the cold chain, enables better vehicle routing, reducing energy waste and carbon emissions.
- Allows more efficient use of freight capacity.
- Enables consumer-direct transactions, skipping intermediaries and inefficient extra handling.
- Allows environmental control, full traceability and real-time tracking.
- Enables last-mile logistics strategies to deliver and position inventory close to the final customer.
- **Provides the basis for upcoming automated and autonomous logistics systems**

# Sponsors Mini-Container Project

## Faculty/Students

**Faculty:**

- J. Rene Villalobos
- Pat Phelan

**Students:**

- Keshawa Bandara
- Levi Siwek
- Derall Riley
- Mahmmoud Shyam
- Sergio Garcia

# Thank you.

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# First Mile Logistics Problems

- **Harvest sizes too small to fill a full truck**
- **Very often regulations mandate that harvests from different growers cannot be consolidated in the same freight vehicle**
- **Lack of logistics agents with focus on harvest aggregation**