Life Cycle Energy and Carbon Footprint in Midwest Dairies

MIDWEST FARM ENERGY CONFERENCE
JUNE 18TH MORRIS, MINNESOTA

Joel Tallaksen, Brad Heins, Michael Reese

With lot of help from others!

West Central Research & Outreach Center

University Of Minnesota

College of Food, Agricultural and Natural Resource Sciences

University of Minnesota

Energy use in the dairy Sector is high

- Variety of fuels
  - Electricity, diesel, gasoline
- Used for many different activities
  - Feed production, milk harvesting/cooling, transportation
- Heavy use of fossil energy has two major concerns:
  - Expense for producers, which is passes on to consumers
  - Combustion of fossil energy releases CO_2, which is an environmental issue.

TALLAKSEN *et al* 2015

Why Life Cycle Assessments

- Over the last 20 years, people began asking about how products and systems can be compared into terms of impacts on the environmental and community
- There was a needed for a method to quantify the environmental impacts for items and the systems used to build them
- Life cycle assessment selected as an overall scheme for calculating those impacts
  - ♦ Standardized Methods (as well as can be standardized)
  - ♦ Specific defined Impacts

TALLAKSEN *et al* 2015

What is LCA?

- At its core, LCA is an accounting system.
- Calculates a single score or measure of impact
- Complex numeric data is entered into a model that describes the products and processes being examined
- Modeling can be done in custom spreadsheets or specialized software
- Impact values are standardized, thus can be compared

TALLAKSEN *et al* 2015

Common Impact Categories

- Global Warming Potential
- Fossil Energy Use
- Human Health
- Water Use Intensity
- Eutrophication
- Land Use
- Ozone Depletion
- Acidification
- Smog
- Terrestrial Toxicity
- Aquatic Toxicity

TALLAKSEN *et al* 2015

Why Are LCA Studies Matter

- Top level decisions are being made with the data
  - Economic Decisions
  - Production Process Decisions
  - Marketing Decisions
  - Policy Decisions
- Grass roots (consumer) decisions are being made based on claims about product impacts

Worldwide, **AGRICULTURE** is the field where LCA is being used the most and will likely drive future policy and decision making!

TALLAKSEN *et al* 2015

California Air Resource Board Example

- **Renewable fuels get carbon credits based on LCA models**
  - **Global Warming Potential (Carbon Equivalents Emitted in manufacture)**
  - **1st Generation Biofuel- Smaller reduction in GWP**
    - **Gets some credits**
  - **2nd Generation Biofuel- Larger reduction in GWP**
    - **Gets more credits**

This has influenced ethanol producers nationwide!

-Midwestern producers have sued to block this.

TALLAKSEN *et al* 2015

Overview of WCROC LCA Work

- Systems being studied
  - Cropping
  - Swine
  - Dairy
  - Nitrogen Fertilizer
- Base systems are compared with enhanced systems
- Analyze our farming systems to reduce:
  - GWP (carbon footprint)
  - Fossil Energy Use

Choosing Environmental Impact Categories

- Interest in the impact from stakeholders
- Relevant to environmental issues in a specific location
- Significant impact from the system being studied
- Global warming potential and fossil energy use are most relevant to the majority of dairy systems

TALLAKSEN *et al* 2015

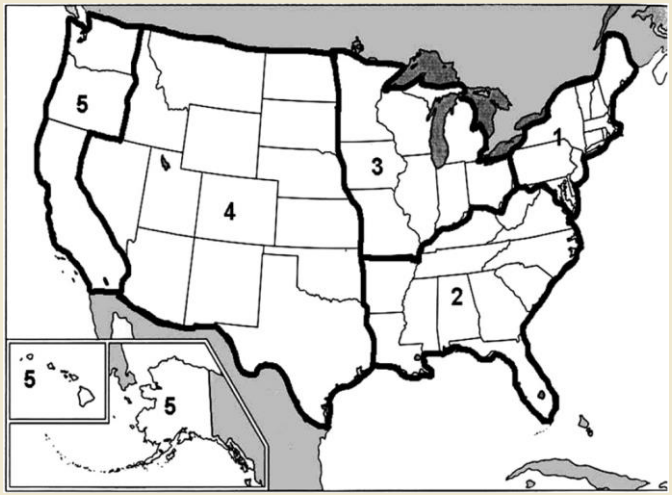
LCA of Dairy Systems

- Examine the all inputs
  - Feed
  - Fuel, electricity, water
  - Any other product or process used in the system
- Examine all the outputs
  - Milk
  - Meat
  - Manure
  - Emissions: CO_2, N_20, Methane
- Evaluate the inputs and emissions per unit of milk sold
  - Assess fossil energy input and carbon dioxide outputs

TALLAKSEN *et al* 2015

National Dairy Impact Assessment

- **Background**
  - ♦ Sponsored by Innovation Center for US Dairy
  - ♦ Conducted by researchers at multiple universities
- **Methods**
  - ♦ National survey data for dairy producers
  - ♦ USDA Data on cropping
- **Cradle to grave**
  - ♦ Starts at farm
  - ♦ Ends when consumers recycle containers
- **Carbon dioxide emissions only**
  - ♦ Partially for consumer outreach efforts



Significant Regional Variation

- Pasture availability
- Grain costs and forage production space
- Access to water

Milk is expensive to transport, so dairies exist close to population centers. Even if resources (feed & water) need to be hauled to the dairies.

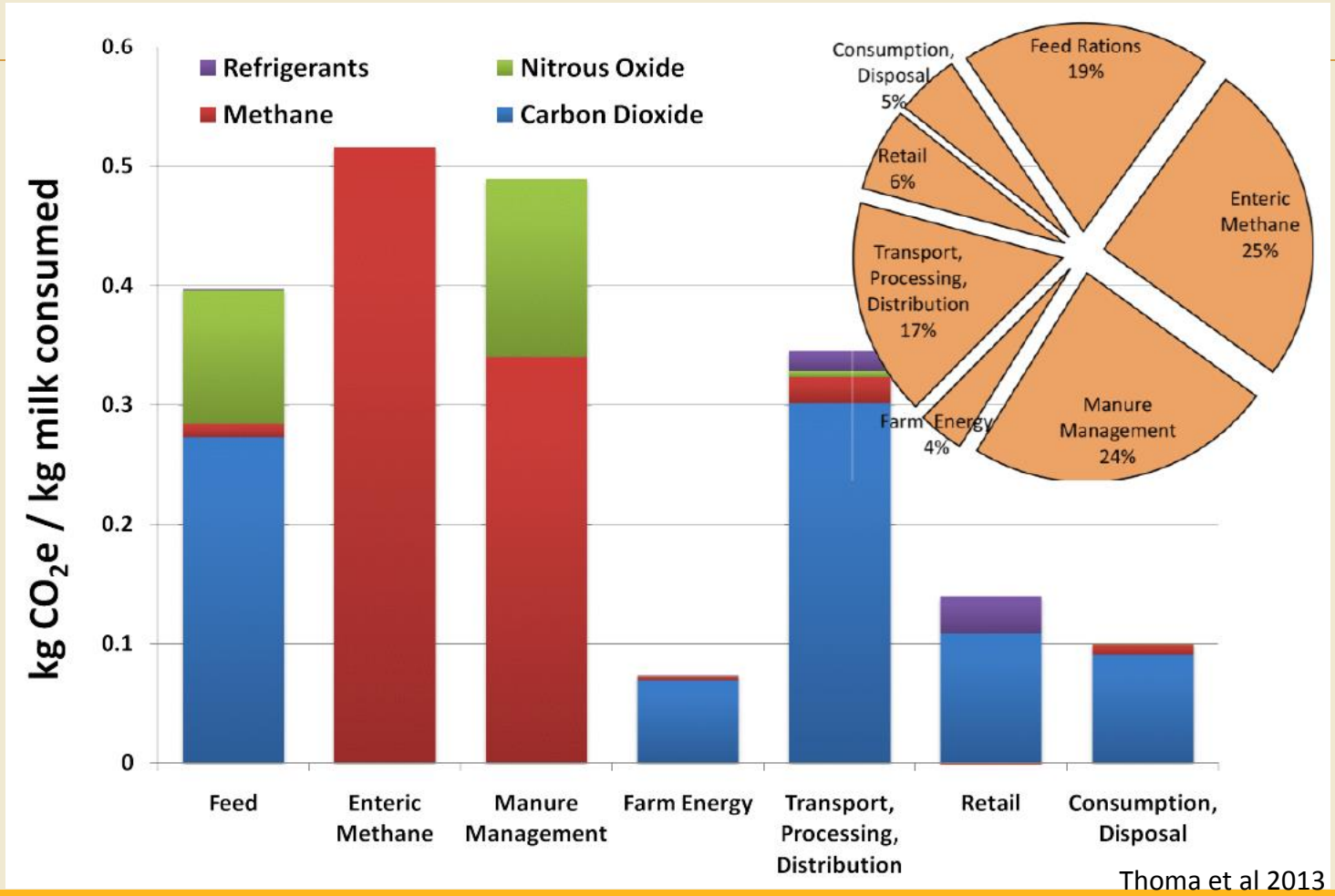
TALLAKSEN *et al* 2015

Findings From the National Study

- Similar to studies in other locations
- Two major carbon emissions that are difficult to control
  - Manure
  - Feed
- Two Carbon emissions that can be impacted
  - Feed system energy use
  - Energy

TALLAKSEN *et al* 2015

National Dairy LCA Carbon Footprint



Thoma et al 2013

Other Dairy Operation Impacts

- Energy
- Eutrophication
- Land Use
- Water Use

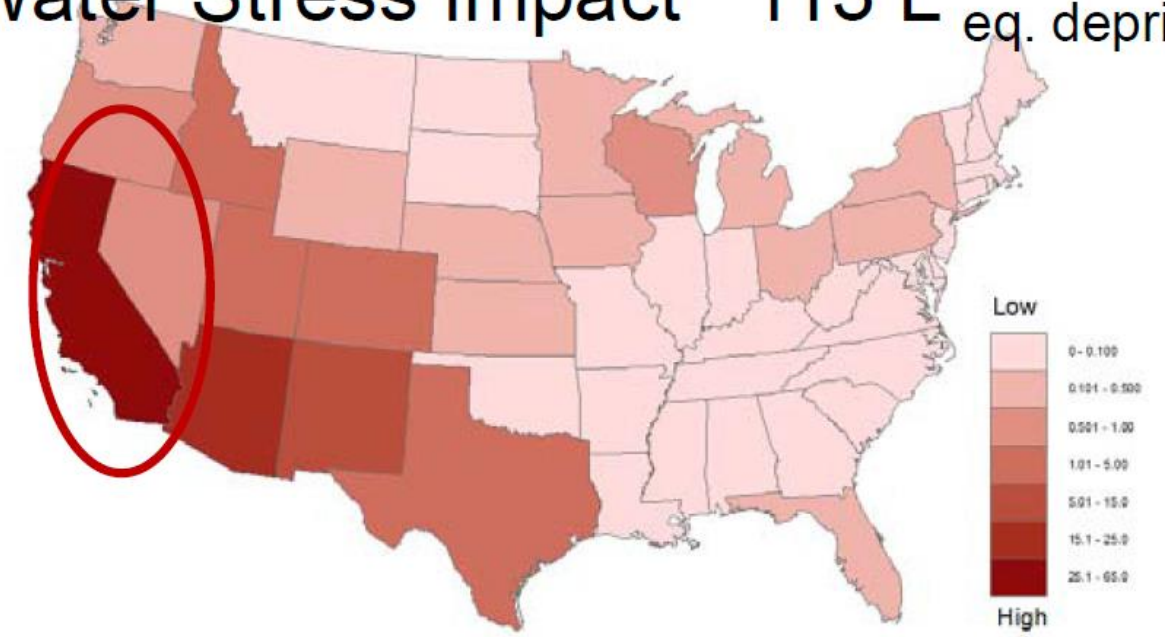
TALLAKSEN *et al* 2015

Water Use is Very Important Regionally

National average of milk water footprint:

Bluewater usage 146 L $_{\text{eq. bluewater}}$/kg $_{\text{milk}}$

Water Stress Impact 113 L $_{\text{eq. deprived}}$/kg $_{\text{milk}}$



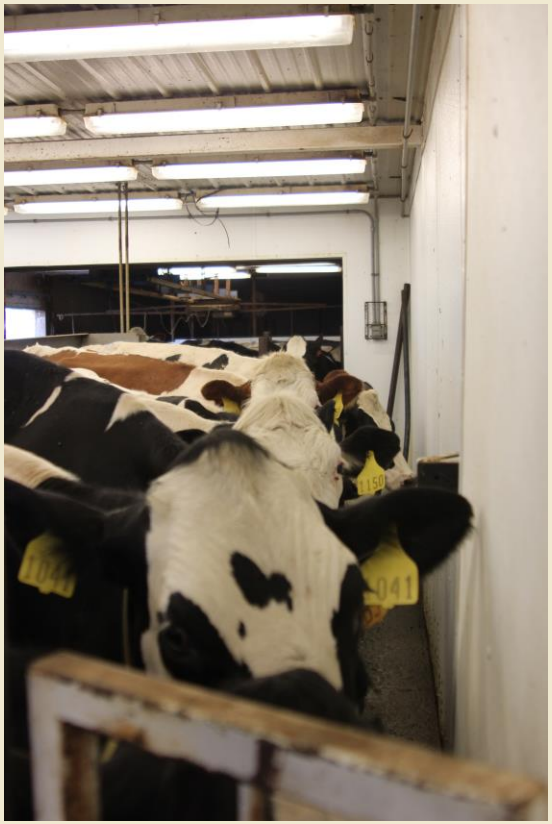
Joliette *et al*

WCROC Dairy Life Cycle Assessment

- Initial work has been to build basic models.
  - Crops
  - Manure
  - Animal husbandry
  - Milking operations
- Organic systems have been completed.
- Data for convention systems will be entered next.
- Energy optimized systems added when data available

WCROC Dairy Systems

- **Organic Herd**
  - Pastured during summer
  - All organic diet
  - No antibiotics
- **Conventional Herd**
  - Feedlot based
  - Antibiotics as needed
- **9 Stall Milking Parlor**
  - Built in 1980's
  - Few updates to equipment



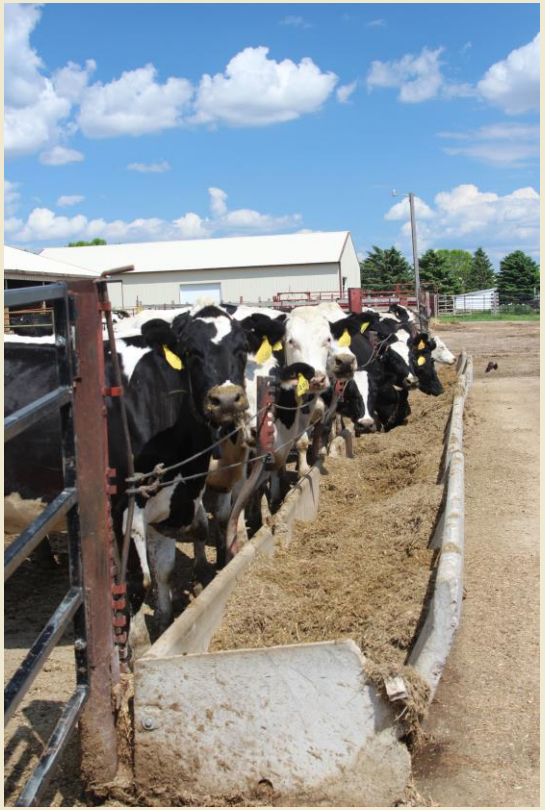
TALLAKSEN *et al* 2015

WCROC Dairy Study Goals

- Identify how changes in milking system technology impact the carbon and energy footprint of the WCROC dairy operation

- Compare the environmental impacts of organic versus convention production systems

- Identify further improvements in the system to reduce environmental impacts



TALLAKSEN *et al* 2015

Energy Optimized Systems

- Increasing Energy Efficiency
- Allowing for Energy Storage
- Adding Renewable Production
- Switching Energy Sources

TALLAKSEN *et al* 2015

- Analysis was cradle to gate
  - Uses WCROC cropping data
  - Stops with milk and meat

LCA Project Scope

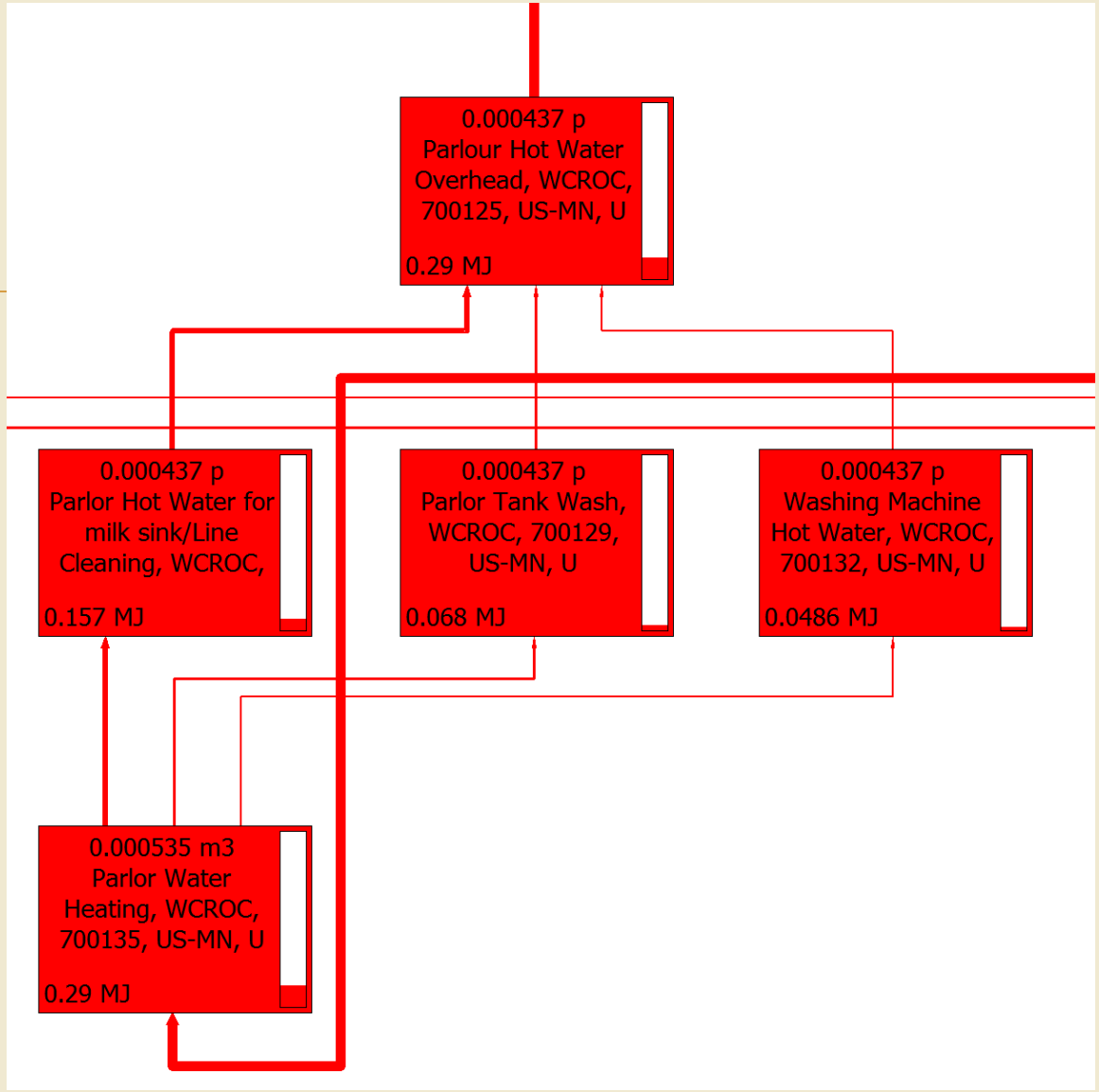
- Allocation (how energy use/carbon emission are divided)
  - Meat production
  - Milk Production
  - Manure emissions (debit to dairy or cropping systems)

Methods

- Crop Data
  - 2 seasons worth of cropping data has been collected.
    - Fuel use
    - Acres farmed and resulting yields
  - Estimates of some crops based on data from other crops
- Equipment Energy Data
  - Time of operation
  - Energy per unit of output
- Manure Calculations
  - Diets for each stage of growth
  - Weight and age data

LCA Calculations

- Energy and carbon data is entered into a database
- Computer software links all the information to come up with an impact assessment value

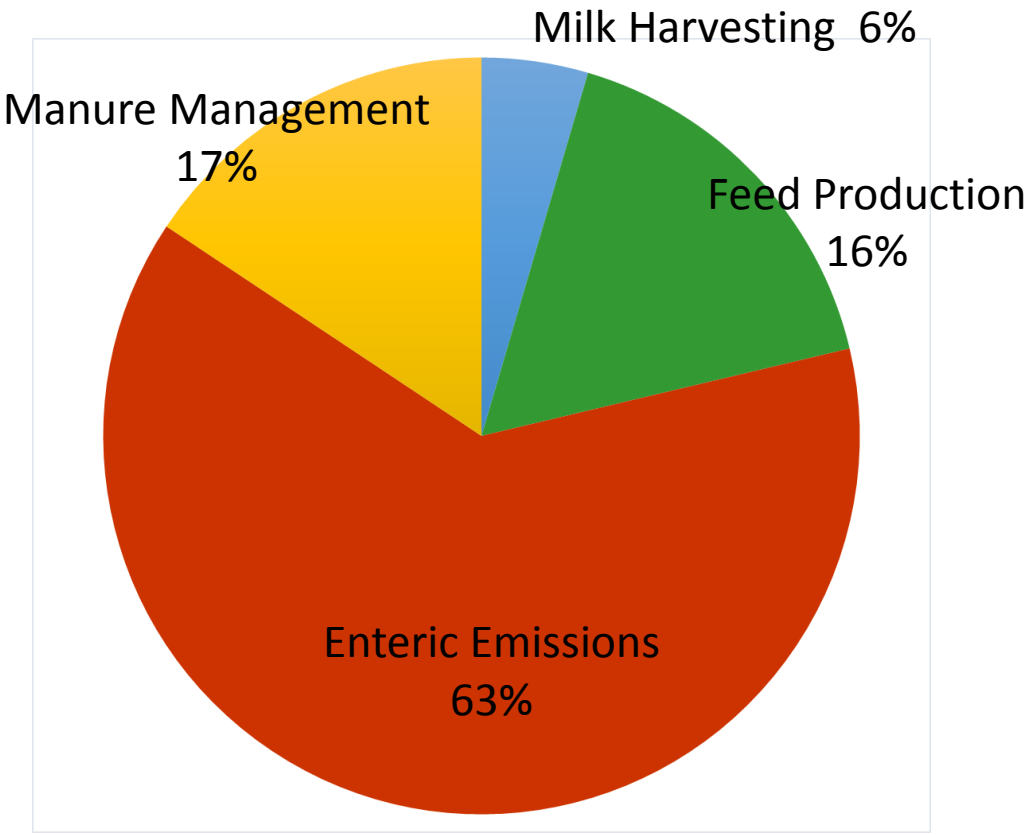


TALLAKSEN *et al* 2015

Overall WCROC Dairy Carbon Footprint

Activity	Kg CO_2 Equiv.
Milk Collection	0.0488
Feed Production	0.1797
Enteric Emissions	0.6768
Manure Management	0.1681

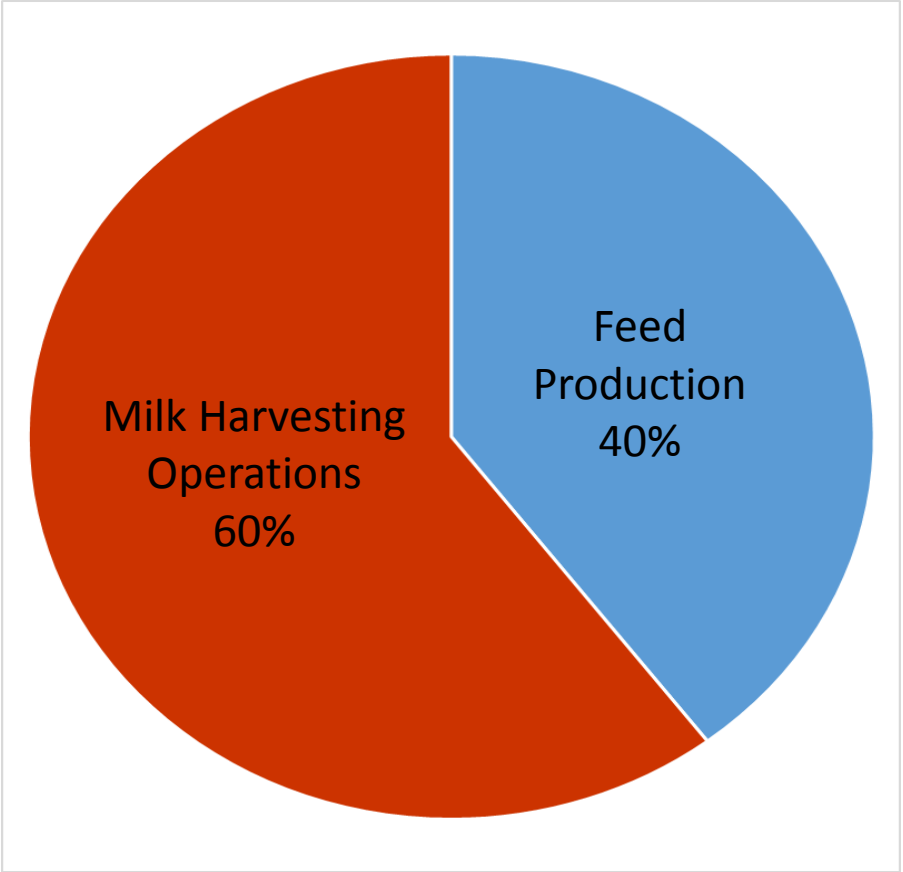
System carbon footprint is:
1.12 Kg



Overall WCROC Dairy Fossil Energy Footprint

Activity	Energy (MJ)
Feed production	0.933
Milk Collection	1.42

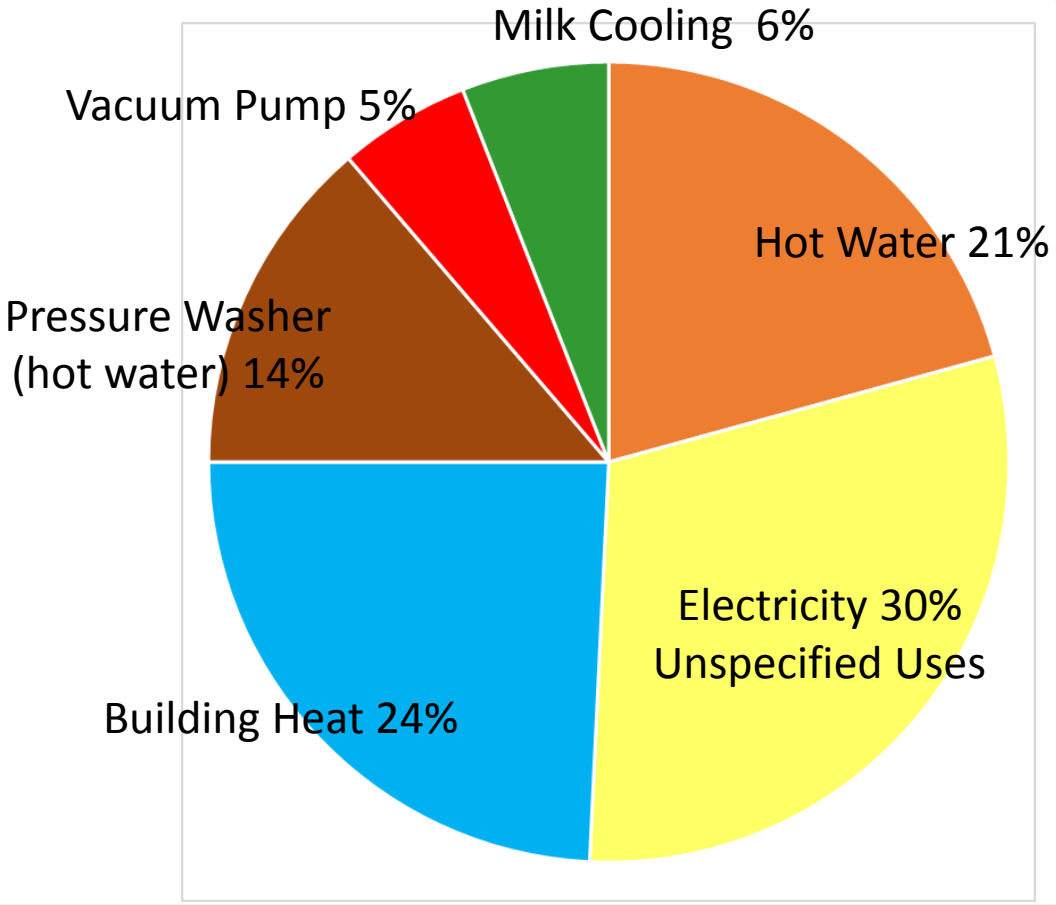
Total system fossil energy use: 2.35



TALLAKSEN *et al* 2015

Energy in WCROC Dairy Milk Harvesting Activities

Activity	Energy (MJ)
Hot Water	0.29
Electricity	0.42
Heating	0.339
Pressure Washer	0.192
Vacuum pump	0.0745
Milk Cooling	0.0832



Comparisons With Other Dairy LCAs

- **The wide range of dairy systems makes direct comparisons difficult.**
  - **Farm size differences – economies of scale**
  - **Feed availability and lifecycle is different**
  - **Inclusion of different variable of in model**
- **The preliminary results are consistent with published values for organic systems.**

Initial Observations

- Preliminary findings from the WCROC dairy system seem reasonable given the large variability in Dairy LCA studies

- Carbon footprint will be difficult to improve due to the amount of enteric and manure storage emissions

- Energy optimization systems will likely change the fossil energy footprint significantly, but have a fairly small impact on carbon emissions.

TALLAKSEN *et al* 2015

Acknowledgements

Funding for the inter-related LCA projects at WCROC has come from a number of sources, including:

- **Legislative Citizens Committee on Minnesota Resources**
- **Swedish Energy Agency**
- **Rapid Ag Response Fund, University of Minnesota.**
- **Xcel Energy Renewable Development Fund**
- **IREE, Univerfsity of Minnesota**
- **The staff at WCROC who have helped collect the data**

Questions?