Dairy Info Day 2014

Can novel manure treatment technologies result in new revenue streams?

B. Laarveld and A. Olkowski

Department of Animal and Poultry Science
University of Saskatchewan, Saskatoon, SK

Canada

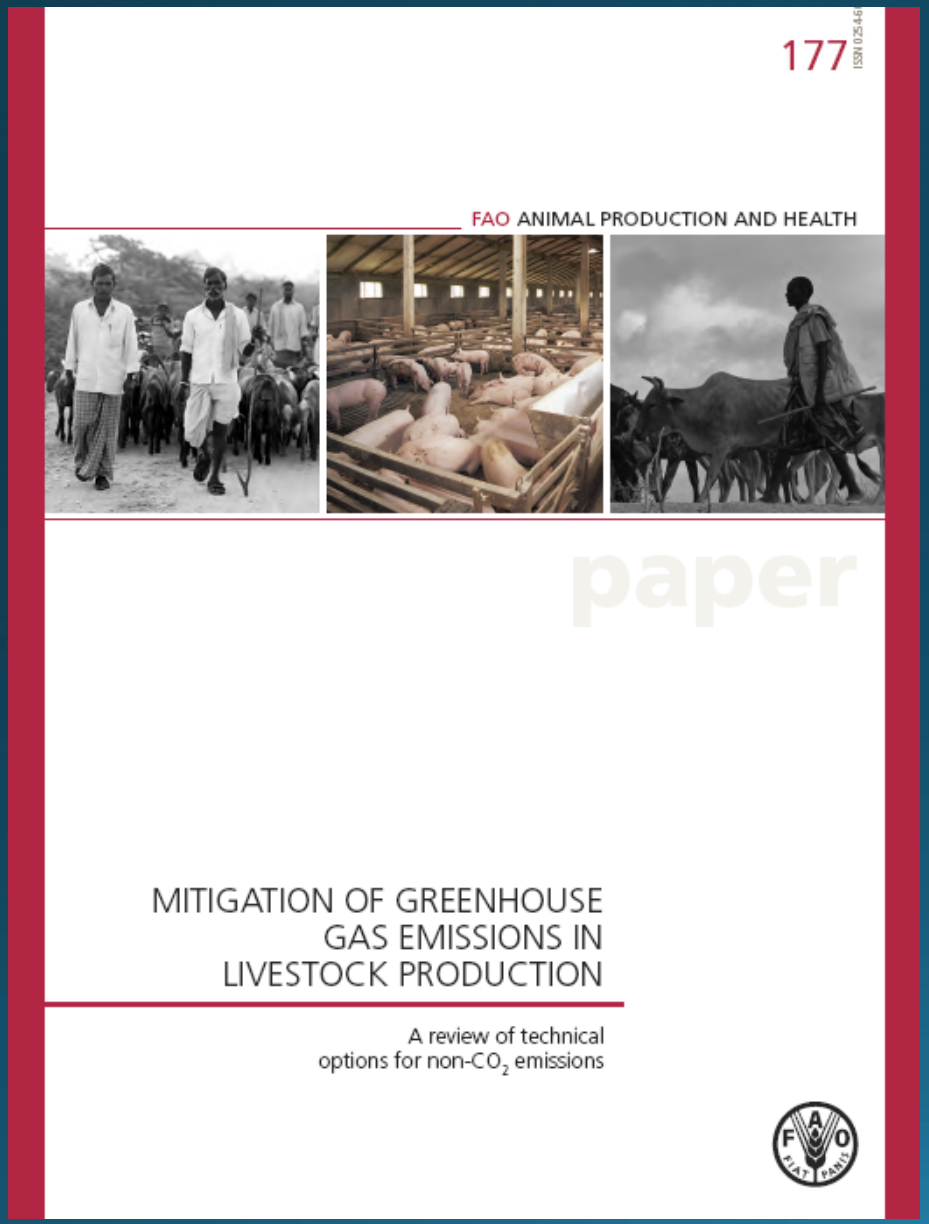
Dairy manure as a waste product

- Odour (sulfurous compounds, ammonia)
- Public Health - Pathogens:
  - Bacteria (i.e. E. coli O157:h7; Salmonella, Campylobacter
  - Parasites (Cryptosporidium); Viruses (Rota and Norovirus)
  - Anti-microbial resistant pathogens
- Environmental impact:
  - Contamination of water resources (phosphorous, nitrates, hormones, antibiotics, veterinary drugs)
  - Greenhouse gas emission (methane, nitrous oxide, carbon dioxide)
  - Air pollutants (sulfurous compounds/gases)
- Manure value:
  - Fertilizer and organic matter for field application
  - Water content for recycling

Future Outlook on Manure – Waste product with Negative Value

- Increasing public concern and pressure to address public health risk factors and environmental impact of manure
  - In densely populated areas with land use conflict
  - For example areas within the EU and USA
- Increasing Regulatory and Legislative pressure on use of manure - increased standards for emission
- Increased research activity to support regulatory and legislative development objectives
- Compliance increases cost of production
- Production limitations for certain locations
- Decreasing public support for livestock production

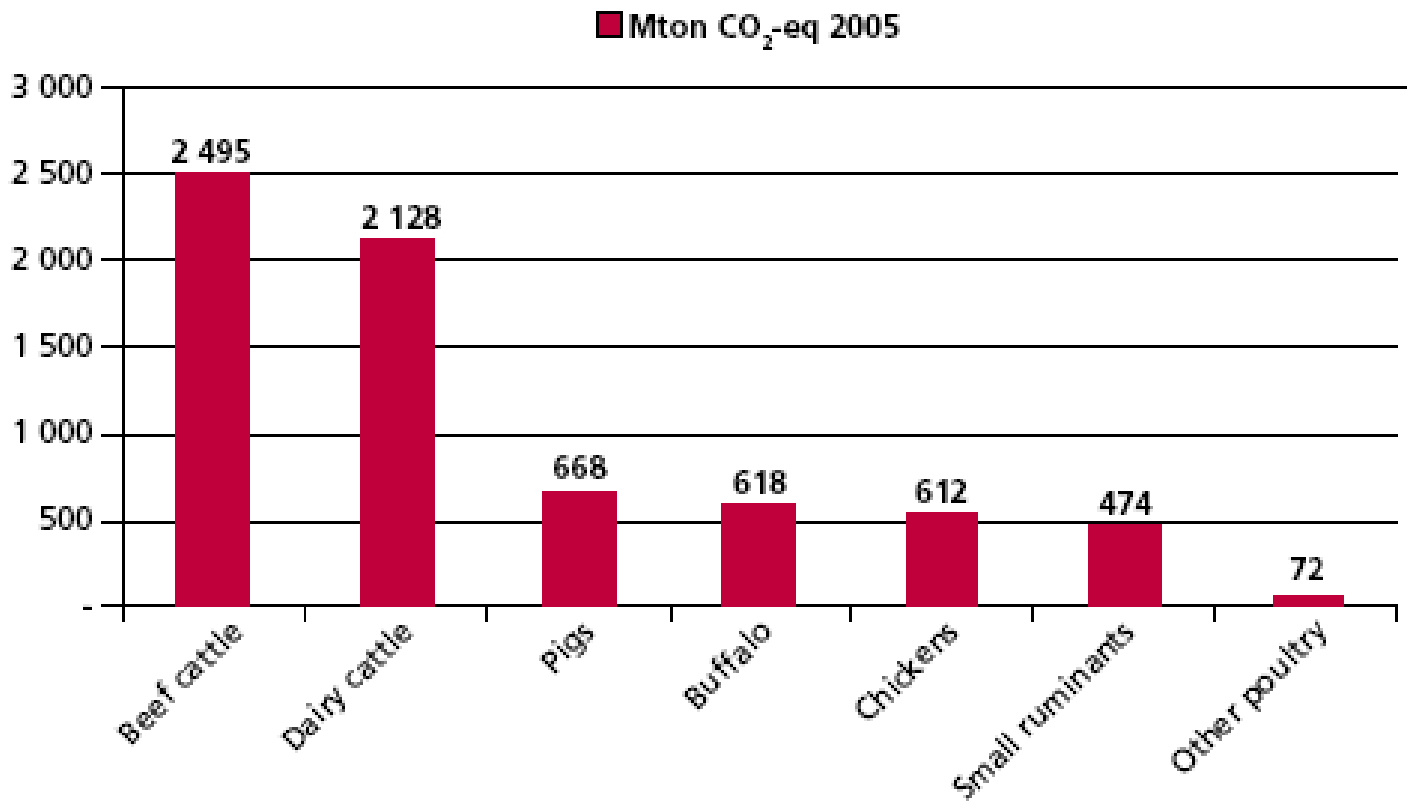
Much recent emphasis on policy development



Editors
Pierre J. Gerber, Benjamin Henderson and Harinder P.S. Makkar

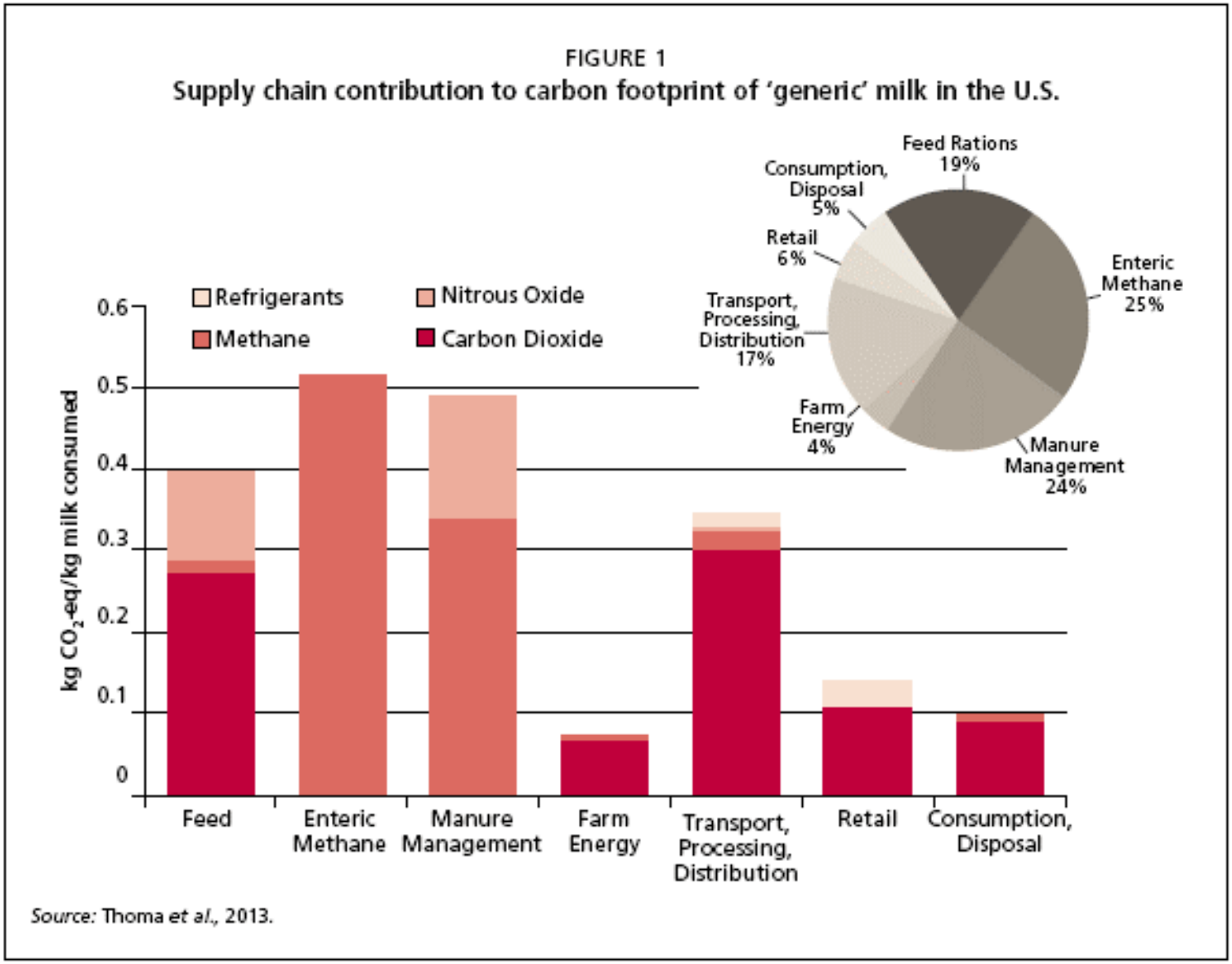
Rome, 2013

FIGURE 2
Total emissions from the global livestock sector, by main animal species and commodities



Source: Gerber *et al.*, 2012.

Gerber, P., MacLeod, M., Opio, C., Vellinga, T., Falcucci, A., Weiler, V., Tempio, G., Gianni, G. & Dietze , K. 2012. Greenhouse gas emissions from livestock food chains: a global assessment. Bratislava, EAAP.



Thoma, G., J. Popp, D. Nutter, D. Shonnard, R. Ulrich, M. Matlock, D. S. Kim, Z. Neiderman, N. Kemper, C. East, F. Adom. 2013. Greenhouse gas emissions from milk production and consumption in the United States: A cradle-to-grave life cycle assessment circa 2008. Int. Dairy J. 31 (Supplement 1): S3-S14.

United States Environmental Protection Agency

Literature Review of Contaminants in Livestock and Poultry Manure and Implications for Water Quality

July 2013

Regulation

Manure Processing Activities in Europe - Project reference: ENV.B.1/ETU/2010/0007

FUTURE TRENDS ON MANURE PROCESSING ACTIVITIES IN EUROPE

28-10-2011

Technical Report No. V to the European Commission, Directorate-General Environment

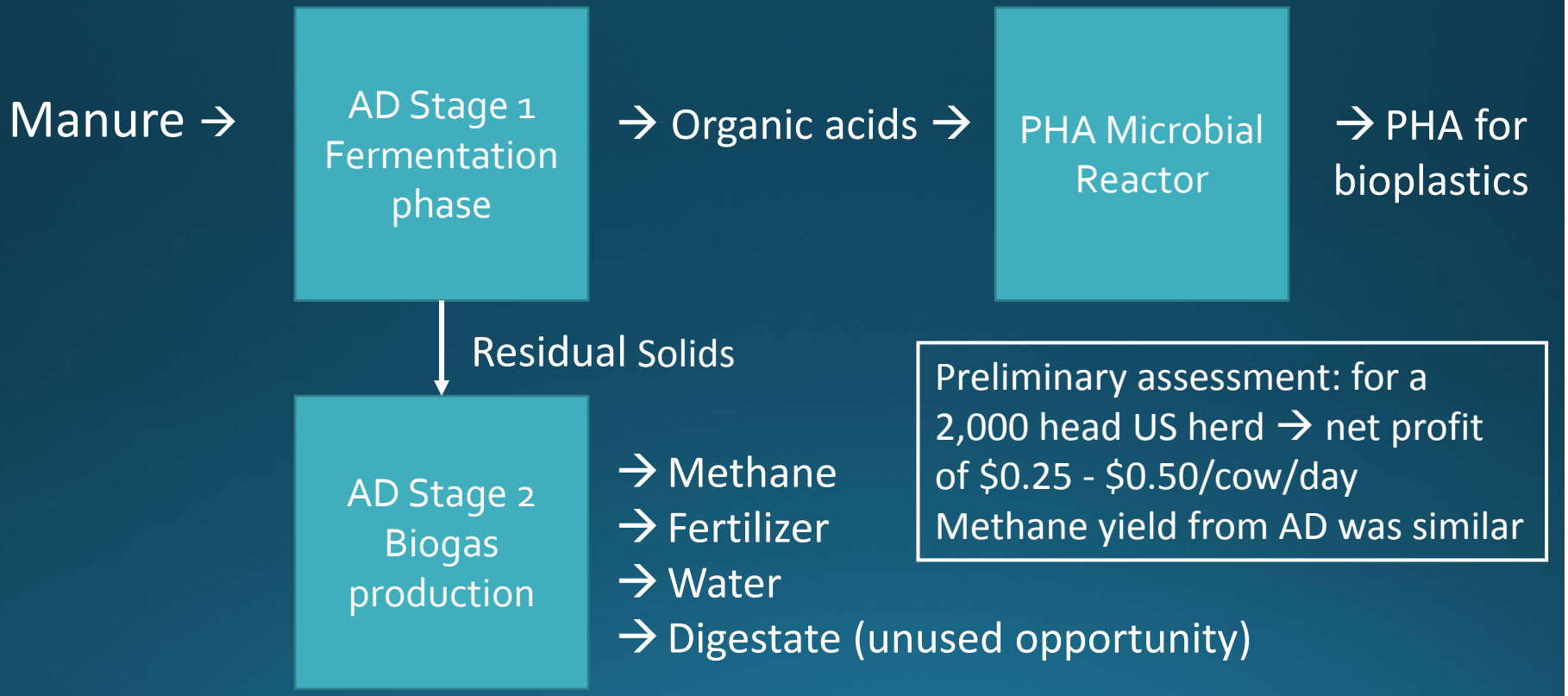
Linking environmental standards to research and development of more environment friendly manure processing

Dairy Manure Potential Revenue Flows*

- Liquid manure for fertilizer and organic matter – low value
- Physical treatment – low to intermediate value
  - Manure separation
  - Manure bedding
  - Manure composting
  - Manure pelletizing
- Manure for energy – intermediate value
  - Combustion (gasification and co-firing)
  - Biological conversion (anaerobic digestion – AD) for biogas
- Manure for biorefining – high value but still experimental
  - Platform chemicals, bioplastics, alcohol
  - Lignin
  - Cellulose
  - Unique biochemicals

*Modified from: G. Beatty and H. Zygmunt. 2001. Alternative technologies/uses for manure. EPA http://www.epa.gov/npdes/pubs/cafo_report.pdf

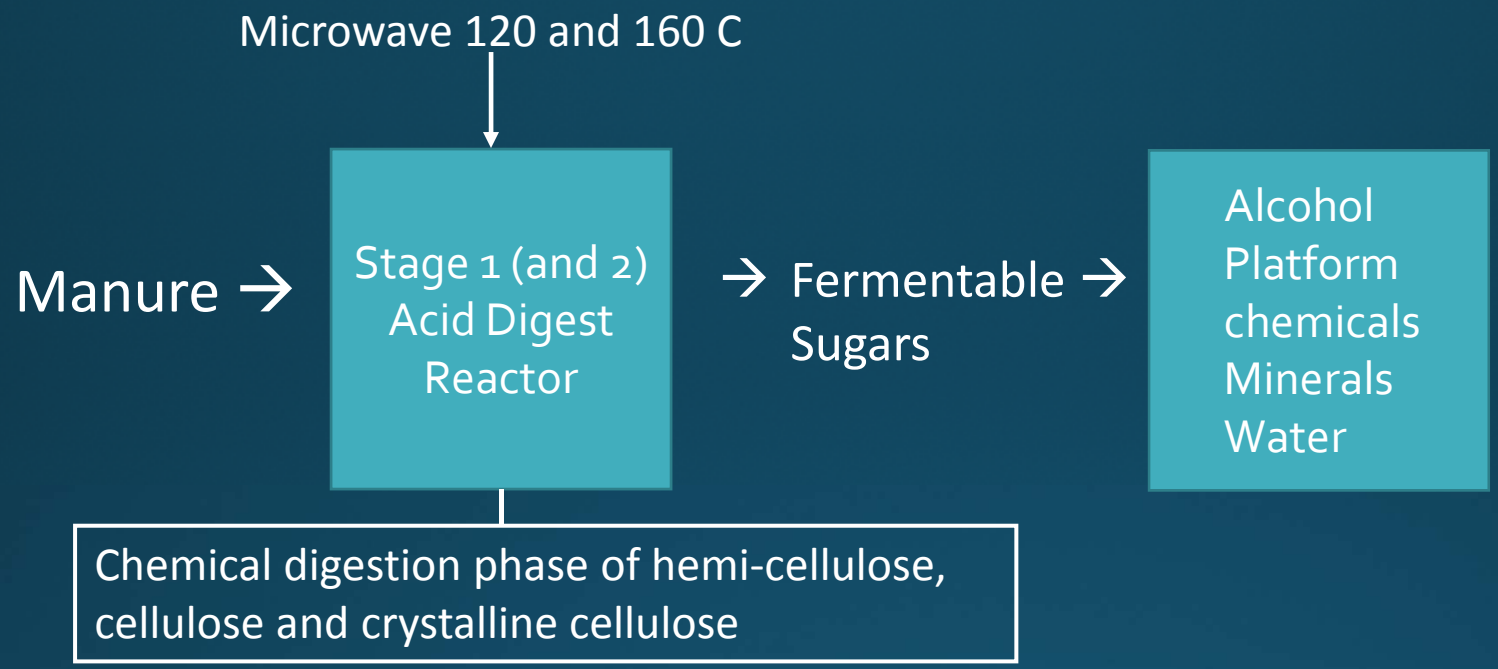
High Value Opportunities – AD coupled with microbial production of PHA (polyhydroxy alkanoates)*



Preliminary assessment: for a 2,000 head US herd → net profit of $0.25 - $0.50/cow/day
Methane yield from AD was similar

*E.R Coats. 2011. Toward implementing an integrated set of processes for upcycling dairy manure and minimizing environmental emissions. Pacific NW Animal Nutrient Conference October 4-5, 2011, Portland, OR, USA

- Acid Hydrolysis of Manure (simplified)

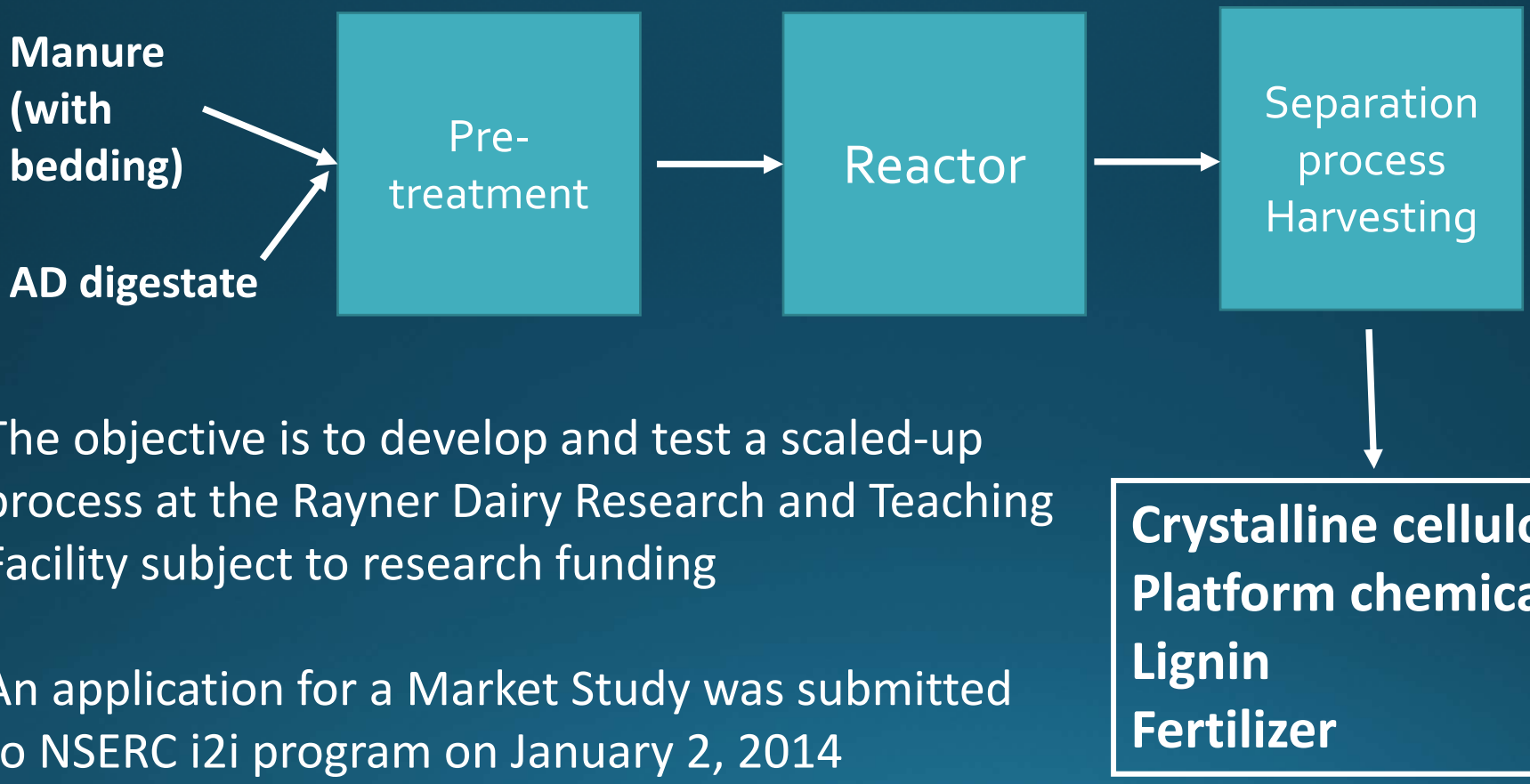


This process addresses the problem that the manure components are difficult to break down including in biogas production → chemical hydrolysis for more complete digestion.

The resulting sugars could be used for a variety of processes including fermentation depending on economics.

1. K. Yawson, P. H. Liao, K. V. Lo. 2011. Two-Stage Dilute Acid Hydrolysis of Dairy Manure for Nutrient Release, Solids Reduction and Reducing Sugar Production. Natural Resources, 2, 224-233.
2. Chen, S. et al. 2003. Value added chemicals from animal manure: Final Report. Washington State University and Pacific Northwest National Laboratory, PNNL-14495.

- Chemical treatment and biorefining of dairy manure (simplified)



The objective is to develop and test a scaled-up process at the Rayner Dairy Research and Teaching Facility subject to research funding

An application for a Market Study was submitted to NSERC i2i program on January 2, 2014

A. Olkowski and B. Laarveld. 2013. Agricultural Development Fund Project # 20110148 Enhanced Processing of Manure Using a Catalytic Reaction. $43,000.

What is the potential gross value of dairy manure?

Dairy manure composition range % dry	
Hemicellulose	14.4 - 20.8
Cellulose	16.1 - 27.4
Lignin	12.1 - 19

Selected literature values USA

Dairy manure composition	% dry	$/kg	$/T dry manure
Hemicellulose	16	0.75	$ 96.00
Cellulose	22	3	$ 528.00
Lignin	16	1.25	$ 160.00
Fertilizer			
Total value that can be generated per T dry manure*			$ 784.00
Calculations assume 80% conversion			

*These are simple estimates of recoverable gross value in biomass

Value of anaerobic digestate?

Dairy AD Digestate*	% dry	$/kg	$/T dry digestate
Hemicellulose	16.5	$0.75	$99.00
Cellulose	38.7	$3.00	$928.80
Lignin	23.4	$1.25	$234.00
Fertilizer			
Total value per T dry digestate			**$1,261.80**

Calculations assume 80% conversion

- **Demonstrates potential high value present in digestate**
- **To biorefine or put on field or convert to energy?**
- **What is the best value proposition?**

*Zhengbo Yue, Rui Chen, Fan Yang, James MacLellan, Terence Marsh, Yan Liu, Wei Lia. 2013. Effects of dairy manure and corn stover co-digestion on anaerobic microbes and corresponding digestion performance. Bioresource Technology 128, 65–71. (Michigan State University)

Conclusions

- Increased Regulatory need and pressure has led to more research
- Many of the current technologies have variable results and are economically challenging - this will limit adoption rate
- Increased value generation from manure may provide a better economic underpinning to be able to address the current concerns about manure
- The new technologies reviewed are in the research phase and remain to be proven at the practical level
  - A limiting factor, as for all technologies, is the scale requirement for optimal use and economic return
  - Research should be done to establish suitable working models for smaller operations

Acknowledgements

- Funding for the research was provided by the Agriculture Development Fund, Ministry of Agriculture, Government of Saskatchewan.
- Rayner Dairy Research and Teaching Facility, University of Saskatchewan was the source of the dairy manure and the location for the small pilot scale research.