Sustainable Gas Systems- New Business Models

Manure-based Anaerobic Digestion In New York State: Where we were, Where we are, and Where we can be

Peter Wright

Agricultural Engineer

Curt Gooch

Dairy Environmental Systems Engineer

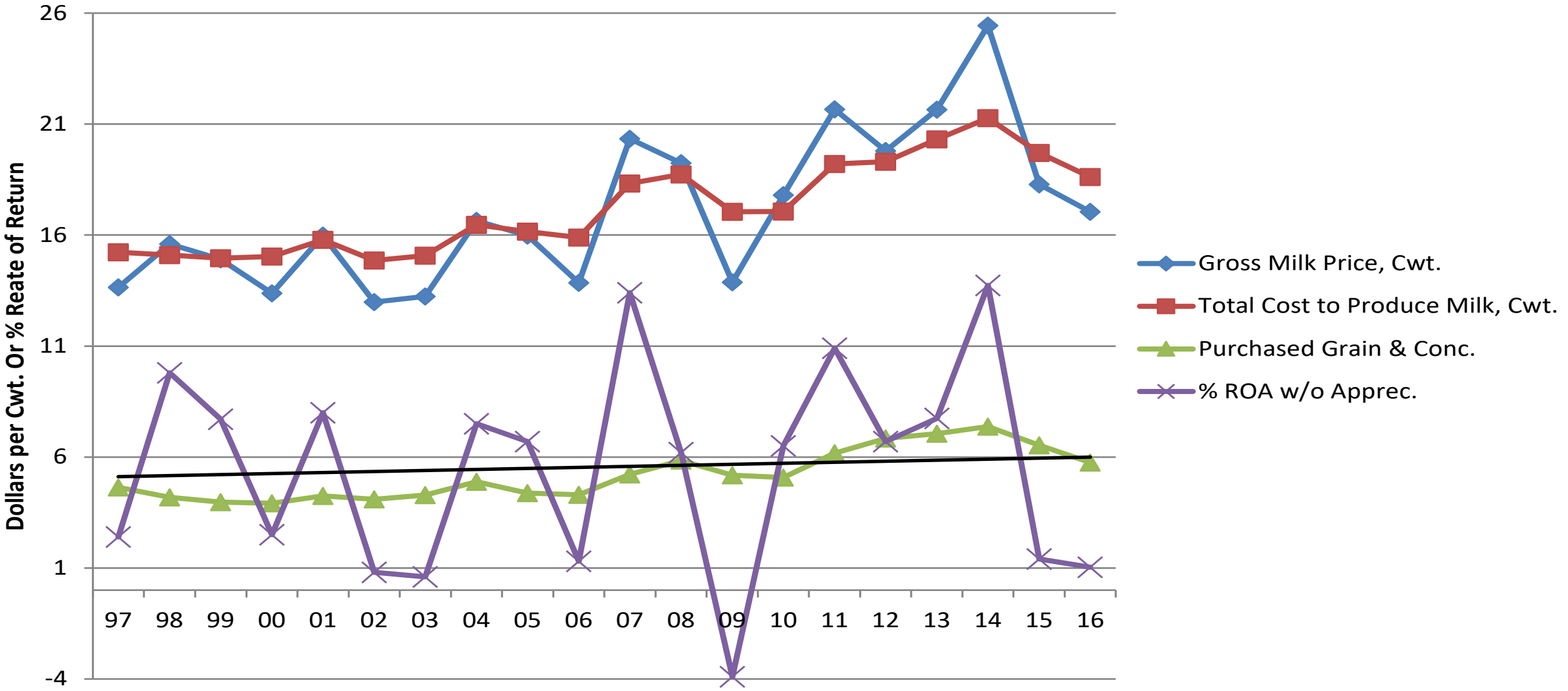
Cornell University

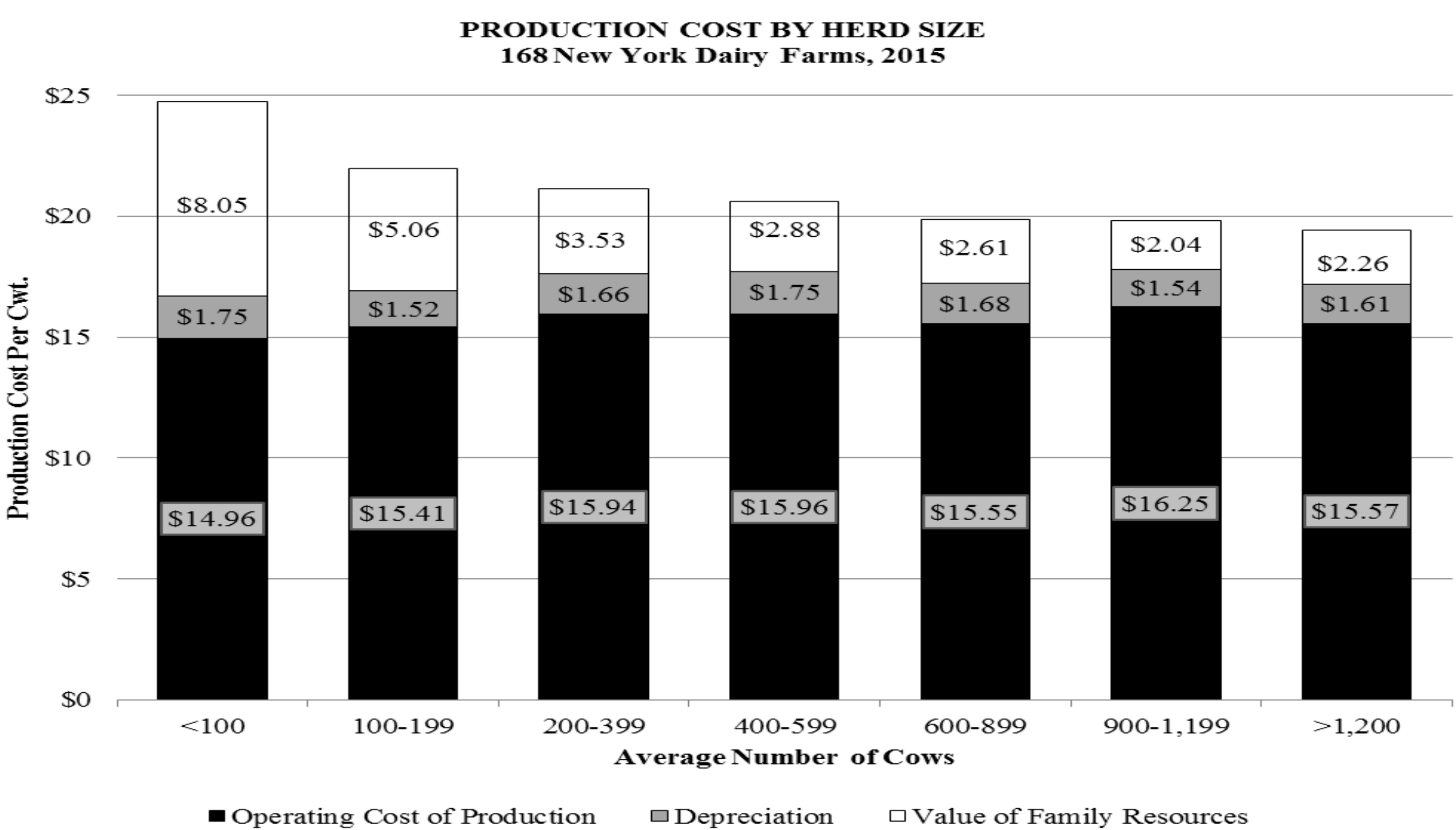
www.manuremanagement.cornell.edu

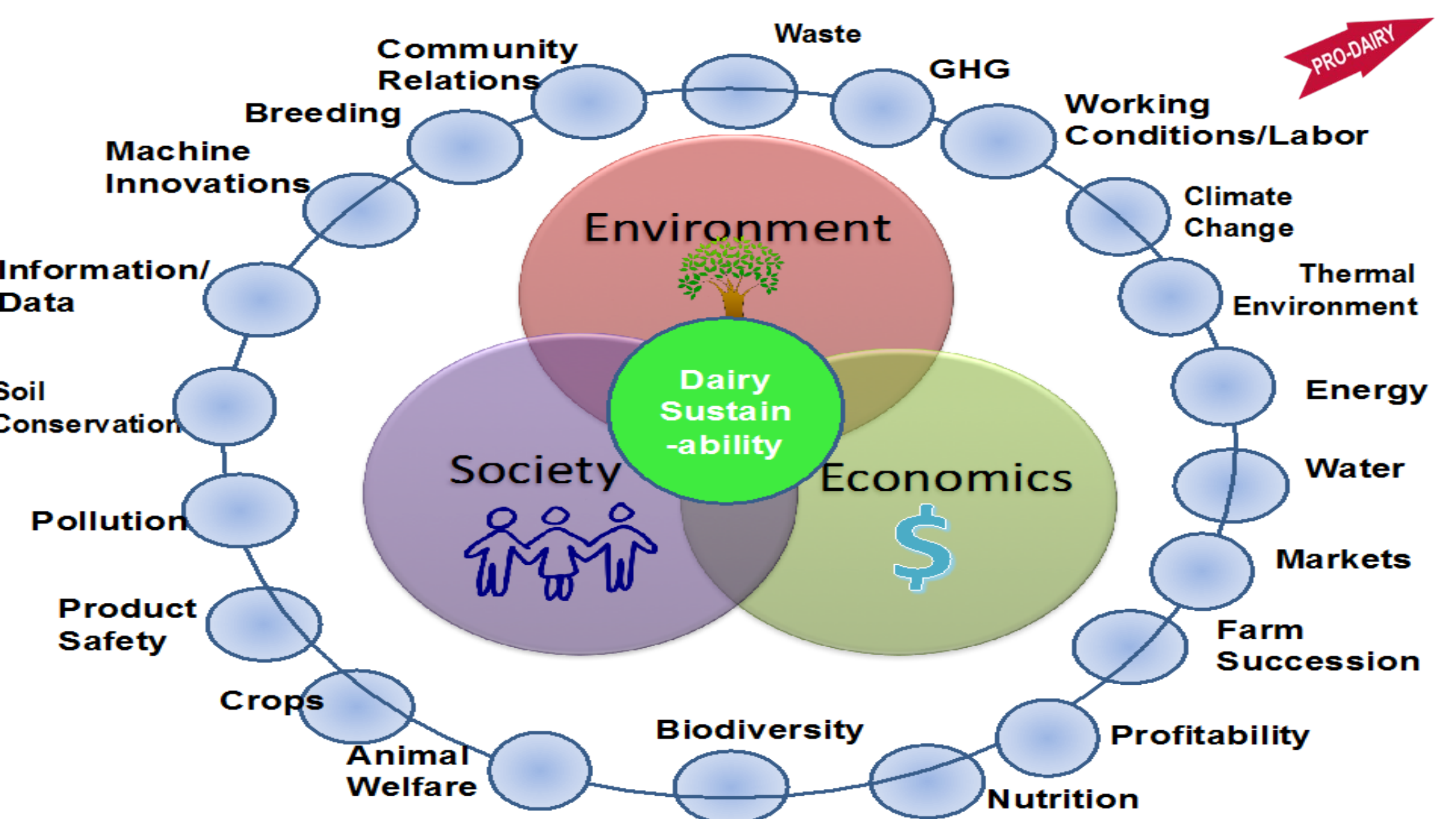
PRO-DAIRY

20 Years of Variability

DFBS Farms, New York State, 1997 - 2016




PRODUCTION COST BY HERD SIZE
168 New York Dairy Farms, 2015
Production Cost Per Cwt.
$25
$20
$15
$10
$5
$0
$8.05
$5.06
$3.53
$2.88
$2.61
$2.04
$2.26
$1.75
$1.52
$1.66
$1.75
$1.68
$1.54
$1.61
$14.96
$15.41
$15.94
$15.96
$15.55
$16.25
$15.57
<100
100-199
200-399
400-599
600-899
900-1,199
>1,200
Average Number of Cows
Operating Cost of Production
Depreciation
Value of Family Resources


PRO-DAIRY
Waste
Community Relations
GHG
Breeding
Working Conditions/Labor
Machine Innovations
Climate Change
Environment
Information/ Data
Thermal Environment
Soil Conservation
Energy
Dairy Sustain -ability
Water
Society
Economics
Pollution
Markets
Product Safety
Farm Succession
Crops
Biodiversity
Profitability
Animal Welfare
Nutrition

Manure Based Anaerobic Digestion

- Reduction of Greenhouse Gas Emissions
- Odor Reduction
- Conservation of Crop Nutrients
- Improvement in Crop Utilization of Manure Nutrients
- Improvement of Water Quality Protection

Manure Based Anaerobic Digestion

- Generation of Renewable Fuel/Energy
- Revenue Potential
- Pathogen Reduction
- Pre-treatment (for advanced manure treatment)
- Co-digestion (landfill organic matter diversion)

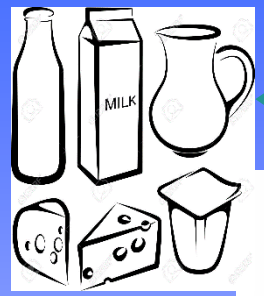
- Despite all of the benefits anaerobic digestion provides to farms and society, adoption has not been wide spread due to economic challenges.
- Existing On-Farm Digesters facing major overhauls are reluctant to reinvest
- Electricity sold at the LMP – Demand Charges

Anaerobic Digestion

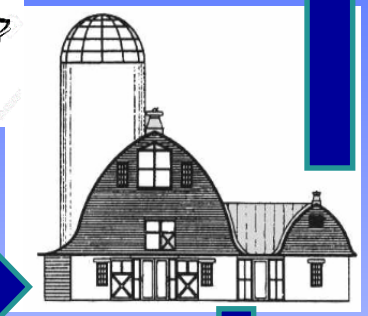
	Directly Monetizable	Society Expectation
• Odor Control	n	Y
• Pathogen Reduction	n	Y
• Renewable Energy	y	y
• Greenhouse Gas Reduction	y	Y
• Water Quality Protection	n	Y
• Fertilizer for Field Crops	n/y	dc
• Low Cost Manure Application	v	dc
• Nutrient Conc./Exportation	p	dc

Farm-based Anaerobic Digestion System

Dairy Environmental Systems Program https://prodairy.cals.cornell.edu/
www.manuremanagement.cornell.edu



Milk Products

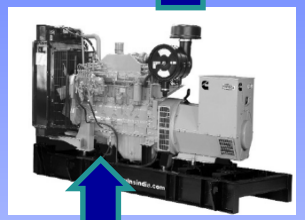


NYS 2030 Goal: 50% Generation of Renewable Energy

Renewable energy

Renewable Energy to the Community

Engine Generator



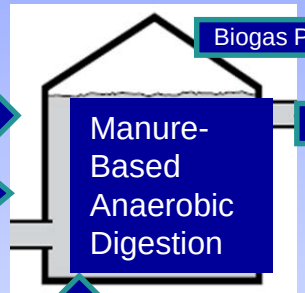
Biogas Produced

NYS 2030 Goal: 40% reduction in Greenhouse Gas Emissions

Purchased Fertilizer Use Reduced

Manure

Food Processing



Manure-Based Anaerobic Digestion

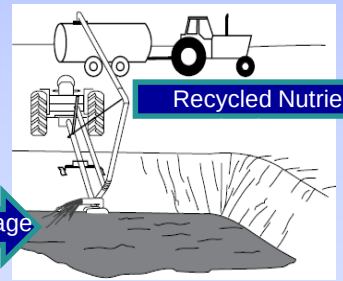
Effluent

Post–Consumer Food Waste

Solid liquid separation

Liquids

Storage



Recycled Nutrients for Crop

Crops for Food, Fiber and Biomass

NYS Goal: Organic Waste Diverted From Landfills

Solids

Sustainable Farming Recycling Nutrients and Energy

Cow Bedding Recovered and Recycled to Barn or Exported as Compost

Crops Fed to Cows

Not Included:

Heat needed and used
- Farm
- Greenhouse
- Aquaculture
- Milk Processing

Gas cleanup and processing
- On-farm use
- RNG (RINS)
- Pipeline

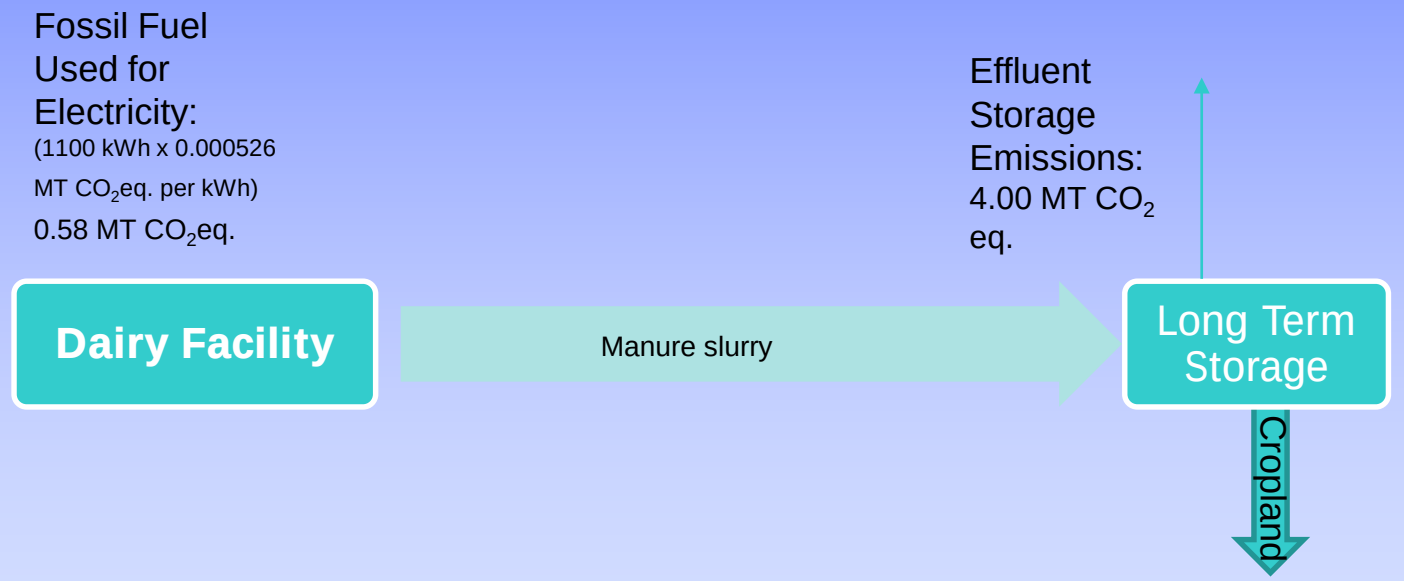
Environmental Values
- Carbon Credit
  - Manure
  - Nutrients
  - Food Waste
- Odor Control

- AD technology is readily available to dairy farms making farmers well-positioned to be key partners with the State in achieving its *renewable energy*, *greenhouse gas reduction*, *landfill organic matter diversion*, and *economic development* goals.

- Development of a manure-based anaerobic digestion industry in NYS is much more than just about renewable energy and greenhouse gas reduction, *it is as importantly about helping to position the NYS dairy industry to be viable and competitive in the years to come*.

Baseline Emissions from Dairy Farm with No Renewable Energy System

(Per cow per year)



Considerations in Calculating Social Cost of Carbon (SCC) Saved for Manure-based ADG Systems

- EPA SCC = $47.82/MT$CO_2e$
  - Average 2017-2019 value used by PSC in Zero Emission Credit From EPA at 3% discount value and adjusted for inflation
- Base Condition: The GHG emissions of the existing system
  - Assumed to be long-term slurry storage (representative of NYS dairy industry situation)
- Losses from ADG technology that may be included

Basis of Calculating Social Cost of Carbon Saved for Manure-based ADG Systems

- Fossil fuel avoided:
  - ((Total kWh-Parasitic kWh) x 0.000526 MT CO_2eq. per kWh)
  - Parasitic electrical energy accounted for - electrical energy *specifically* used to operate an ADG system
    - 0.000526 MT CO_2eq. per kWh (NYS specific value)

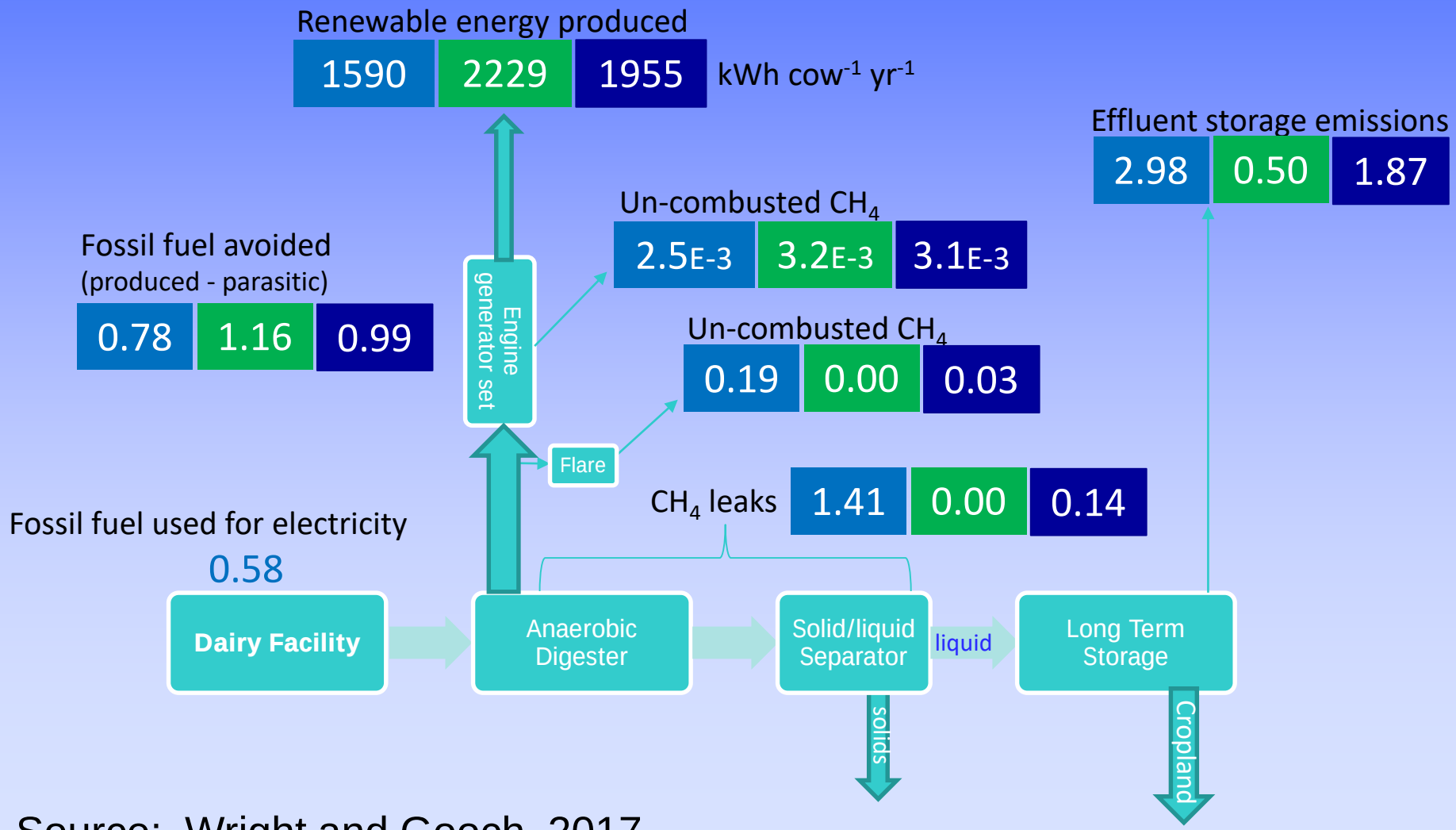
- SCC Saved = $47.82 x (Base Condition - Σ(Losses) + Fossil fuel avoided)

Scenarios

- **CONSERVATIVE** values are those for a digester under normal management with no emphasis on GHG control
- **OBTAINABLE** values are those for a digester under normal management with an emphasis on GHG Control
- **OPTIMUM** values are those for a digester under excellent management with an emphasis on GHG control

ADG System with Solid-Liquid Separation

(MT CO_2e cow^{-1} yr^{-1} unless otherwise noted)



Source: Wright and Gooch, 2017

OBTAINABLE ADG System (includes post-digestion solid- separation) and Emphasis on GHG Control

	Units	Obt
Fossil Fuels Avoided	MT CO_2 eq/cow/yr	0.99
Engine unburnt CH_4	MT CO_2 eq/cow/yr	3.1E-03
Flare unburnt CH_4	MT CO_2 eq/cow/yr	0.03
ADSystem Leaks CH_4	MT CO_2 eq/cow/yr	0.14
Storage emissions CH_4	MT CO_2 eq/cow/yr	1.87
Total CO_2eq	MT CO_2 eq/cow/yr	1.06
Baseline	MT CO_2 eq/cow/yr	4.00
Reduction in CO_2eq	MT CO_2 eq/cow/yr	2.94
SCC Benefit	$ per cow year	$140.52
Gross Electricity produced	kWh/cow/year	1955
Social Cost of Carbon saved	$ per cow year	$ 141
Value of E	$/kWh	$ 0.072

Public Service Commission REV

E_{value} = Fossil fuels avoided

Unwilling to look upstream
Reductions
Augmentations

	Capacity factor	GHG reductions factor	Total capital cost	Adjusted total capital cost[4]
Wind	0.25[a]	1 x (Fossil fuel avoided)	$3.2 million/MW[2]	12.8 million/MW
Solar	0.15[a]	1x (Fossil fuel avoided)	$3.8 million/MW[3]	25.3 million/MW
AD	0.90[b]	3x (Fossil fuel avoided and captured/combusted CH_4 emissions)[5]	$7.2 million/MW[1]	8.0 million/MW

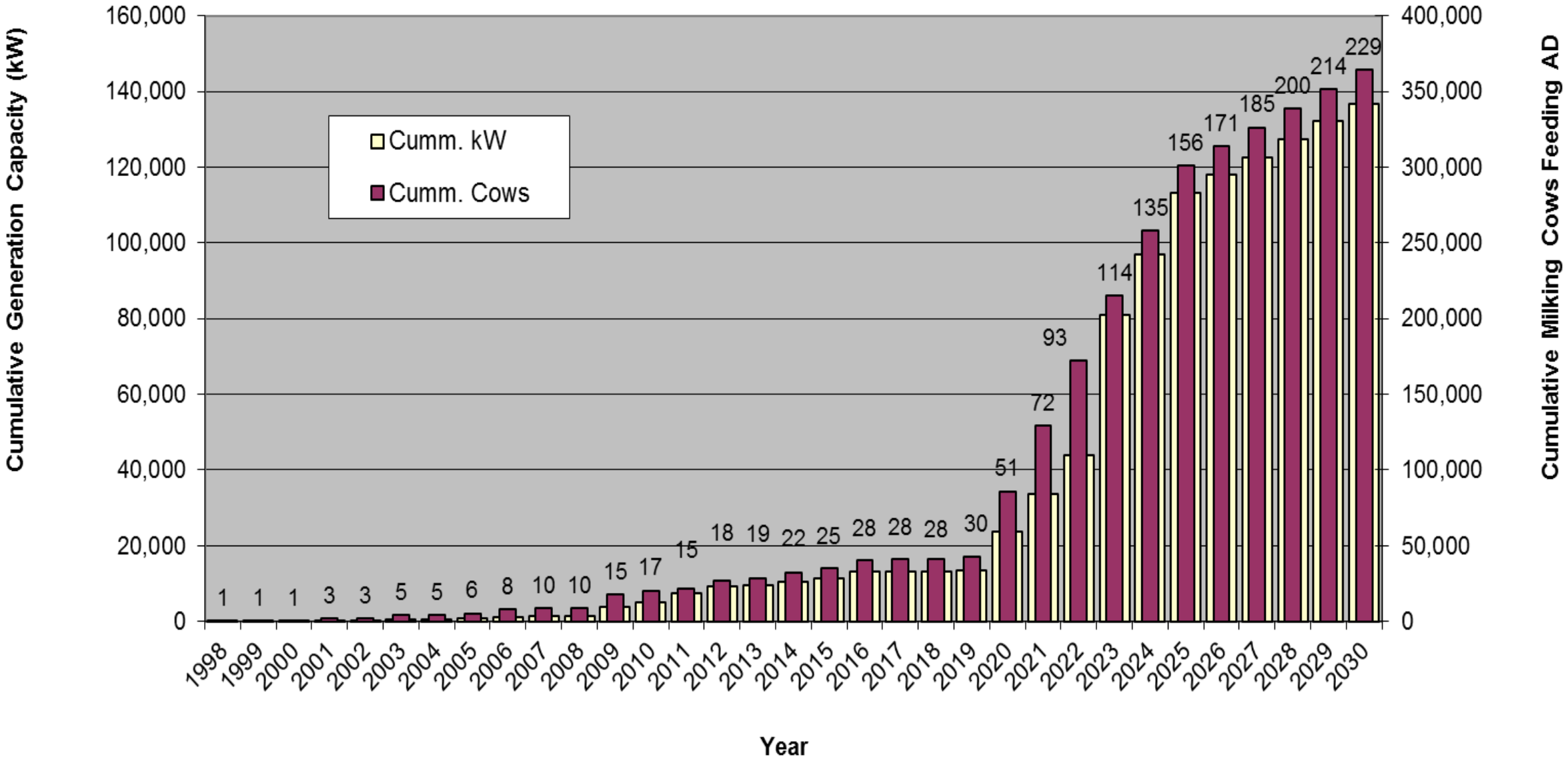
[a] Source: NYISO, 2017
[b] Source: Biogas Weser-ems, 2014
[1]Price in 2012 dollars
[2]Price for commercial level installation, in 2012 dollars
[3]Price for small commercial upstate, in 2012 dollars
[4]Capital cost adjusted for capacity factor to show capital cost per average MW production.
[5]Manure-based systems only

(Source: Pronto et al., 2017)

Initiatives

- Governor's Goals
  - 50% reduction of Renewable Energy
  - 40% reduction in GHG Emissions
- $0.12 kWhr Tariff for On-Farm Anaerobic Digestion
- NYSERDA Aggregation of Design and Operation
- Diversion of Organic Waste from Landfills
- Demand Charge Reduction
- Food Distributed Generation (CDG like)

Dairy Cows Supplying Anaerobic Digesters and Associated In-place Generation Capacity (kW) in New York State by Year



Incremental Cost of Implementing Dairy Sustainability by increasing the price of Exported Renewable Electricity from Manure based Anaerobic Digesters

	Date	Cows	KW	# systems	MWh/yr.	Total cost/yr.	Incremental Increase/kWh consumed in NYS
Estimated	2019	43,000	13,578	30	59,695	$2,900,604	$0.000021
All Large Farms	2025	301,101	74,222	156	564,375	$27,422,987	$0.00019
All Medium Farms	2030	364,066	89,016	229	687,494	$33,405,343	$0.00024

If the Economic Problem was Fixed...
229 NYS Operating AD Systems would...

- Reduce GHG emissions by 1,000,000 $MTC0_2e$ annually, sufficient to remove 225,500 cars from the highway annually
- Generate 528,000 MWh of electricity annually
- Extensive off-farm organic matter imported for co-digestion increasing GHG reductions and renewable energy generation

Questions?

Peter Wright
pew2@cornell.edu