PSC REF#:115261

Public Service Commission of Wisconsin
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Advanced Renewable Tariffs in Wisconsin

Special Thanks

- Richard Shaten, UW-Madison
- Sam Braithwait, WI Public Utility Institute
- John Shenot, Public Service Commission
- Doug Reinemann, UW-Madison

Scope and Methodology

- Identify policy objectives
- Use Germany as a case study
  - Why Germany?
    1. Oldest and most effective existing renewable tariff policy
    2. Meeting 75% of EU's Kyoto obligations
    3. Similar renewable resource characteristics as WI
- Address stakeholder concerns
- Use RETScreen to determine energy payments

Global Warming Task Force—Renewable Tariffs

- *"Set technology-specific tariffs at a level which will yield a rate of return comparable to Wisconsin IOUs' (Investor-Owned Utilities') allowable returns"*
  - Wisconsin Global Warming Task Force, 2008

Breakdown of Task Force recommendation

- Alleviate risk to the investor
- Profit based on cost of production, not avoided cost assumptions
  - Do Focus subsidies apply?
  - Is generation taxable income?
  - Who pays for interconnection?
- Guarantee payment for a fixed number of years

What is an Advanced Renewable Tariff?

- Renewable Power Producer sells electricity to utility (the customer)
- Different than net metering and RPS
  - NM: essentially running the kWh meter backwards
  - RPS: regulation of quantity
  - ART: RPP receives payment guarantee for selling electricity to utility
- Encourage small, local generation
- Prices paid go down over time

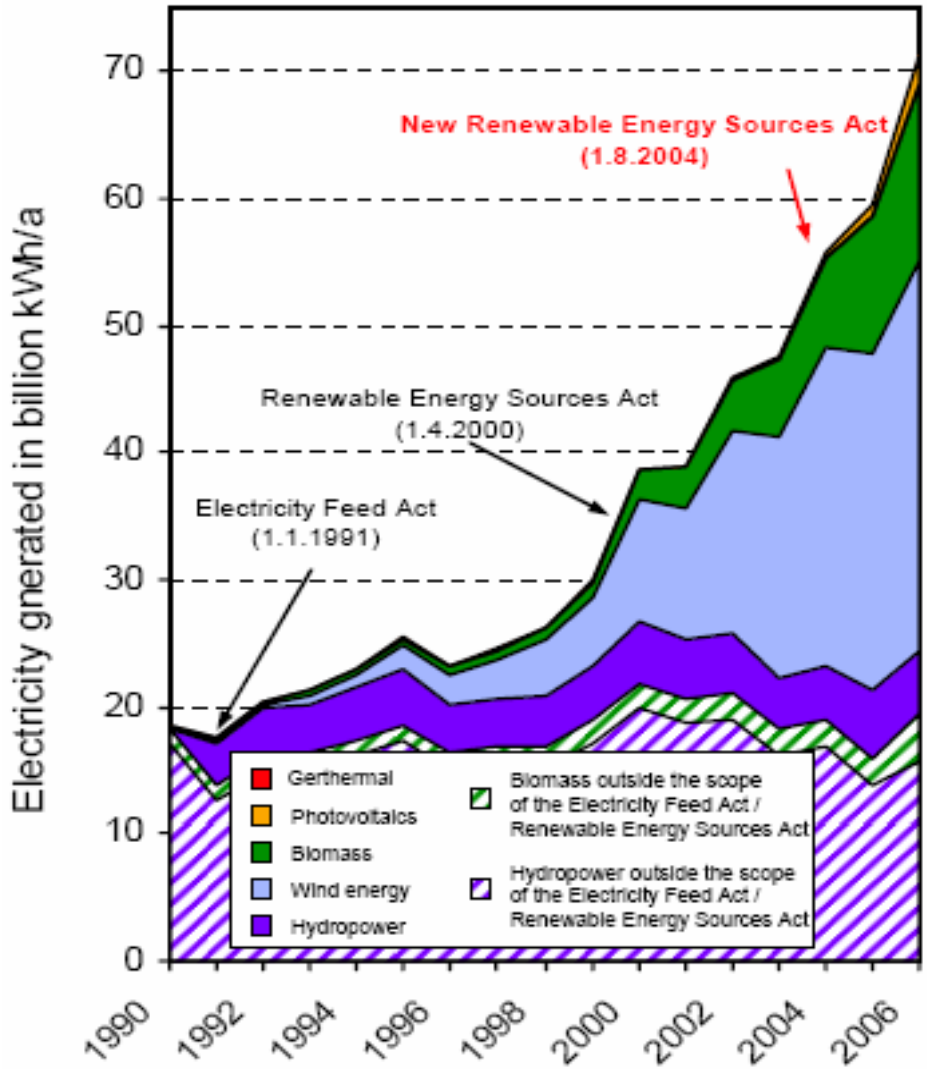
ARTs in the United States

- Legislation Introduced
  - Hawaii
  - California
  - Washington State
  - Oregon
  - Michigan
  - Indiana
  - New Mexico
  - New York
  - Iowa
  - Arkansas
  - Minnesota
- Legislation Drafted and Likely To Be Introduced
  - Ohio
  - Maine
  - Florida (likely part of RPS legislation)
- ARTs by Administrative Action
  - Hawaii PSC (proposed)
  - Wisconsin PSC (proposed)
  - California PUC (passed)

Germany—Renewable Generation

- Renewables are 15.1% of generation
  - 53% of global PV capacity
- 70,000 employed in wind industry
- 40,000 employed in PV industry
- 8,000 employed in biogas industry
- 300,000 employed in renewables sector

Germany—Renewable Generation



- Wind is largest share
  - 40 million MWh in 2007
  - >6% of electric generation
  - No RPS, no project or program caps
- Biomass was about 16 mil. MWh in 2006
- PV was 2.2 mil. MWh in 2006

Source: German Federal Ministry for the Environment, 2007.

Goals & Objectives

- Technology objective
- Price objective
- Grid access objective
- Align policy objectives with broader policy goals
  - Rate impacts
  - Complementing a Renewable Portfolio Standard
  - Greenhouse gas reductions

Technology Objective

- Encourage technologies not likely to be developed from the WI Renewable Portfolio Standard

Technology

- Category 1: cost-effective technologies
  - Utility-scale wind
- Category 2: low market penetration, may be cost-effective depending on subsidies
  - PV, small-scale wind, biomass, biogas
- Category 3: low market penetration, not realistically applicable to Wisconsin
  - Tidal

- ***Category 2 best represents the technology objective***

Germany—Cost for Electricity

- EEG costs German ratepayers 12-25 Euros per household per year
- However, other benefits exist
  - Load alleviation
  - Reduced volatility to spot market
  - Environmental benefits

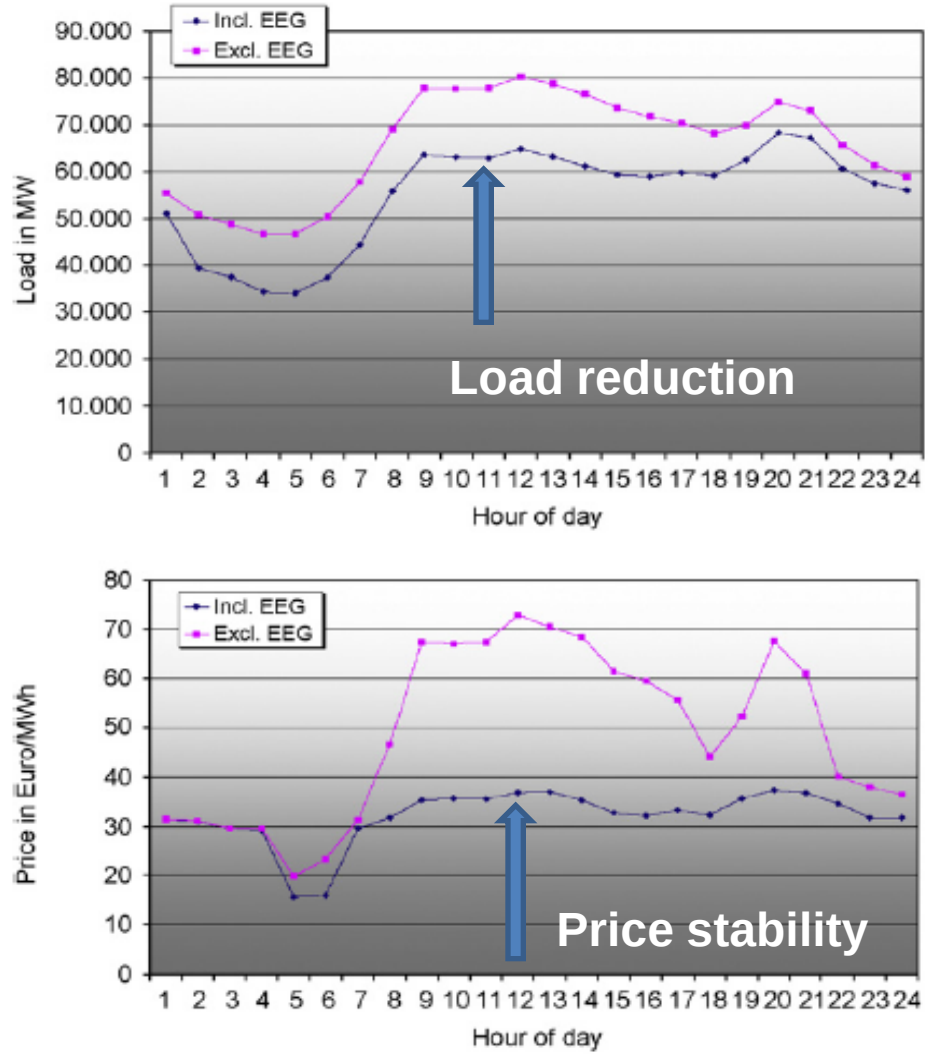
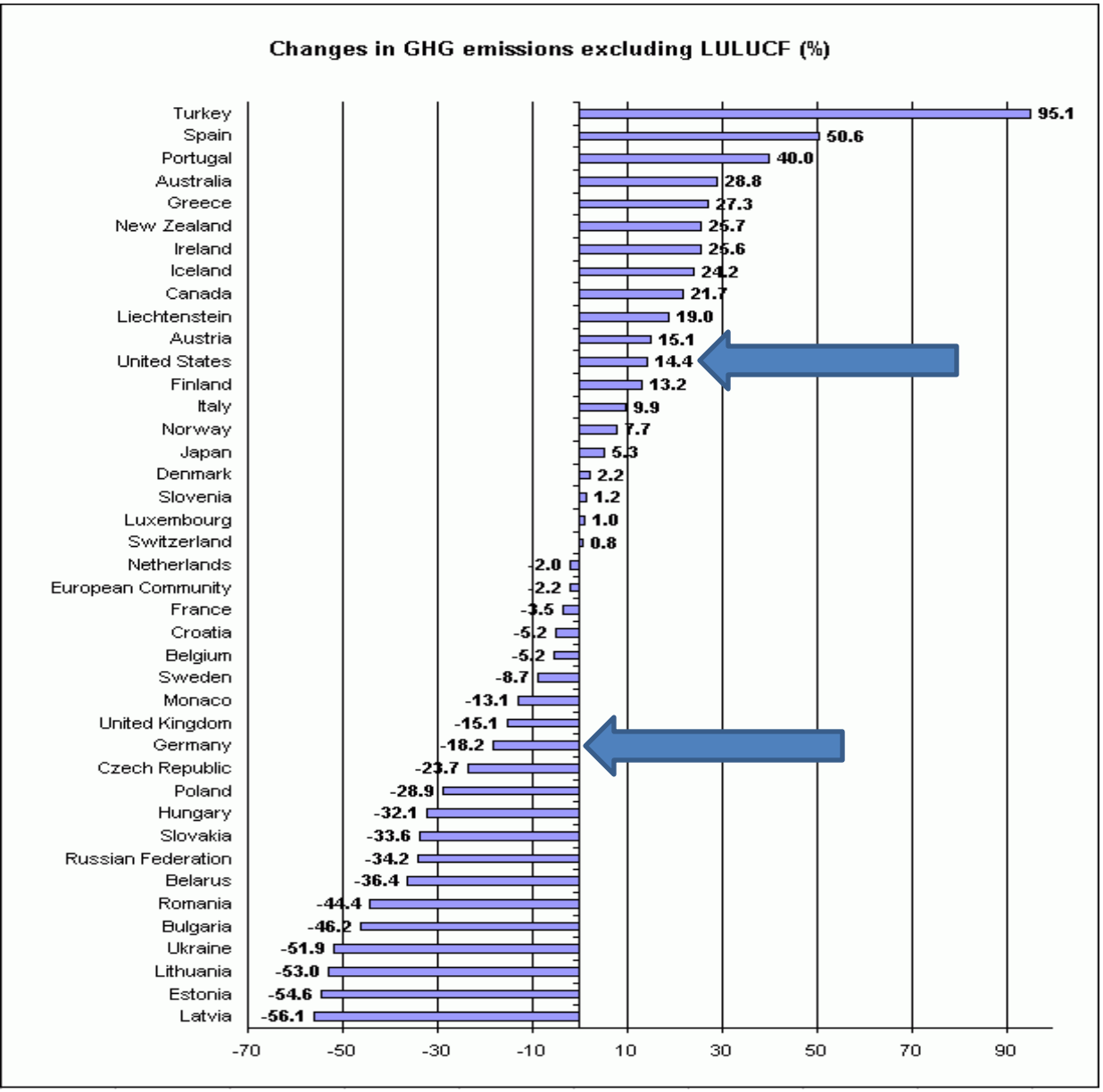


Fig. 3. Comparison of load and prices for one simulated day in October 2006 (two scenarios: one including EEG-renewables, the other excluding EEG-renewables).

Who's meeting the Kyoto target?



- Total aggregate GHG emissions from 1990-2006
- U.S.=14.4% increase
- Germany=18.2% decrease

Source: UNFCCC, 2008

How might WI stakeholders design an ART?

Are existing WI experimental ART's good enough?

Utilizing WI PSC ART Survey Results

PSC Survey Respondents

Submittal due date – 2/17/2009

31 Responses

Advocacy

1. RENEW and Clean Wisconsin
2. WI Cast Metals Association and WI Industrial Energy Group
3. WI Dairy Business Association
4. Wisconsin Farmers Union
5. Eric Nottestad

Biodigester Business

1. AgrEnergy
2. Biomass Solution
3. Clear Horizons
4. Energies Direct
5. GHD, Inc
6. Green Valley Dairy
7. Hanusa Renewable Energy
8. Stormfisher Biogas
9. Suring Digester
10. Tiry Engineering

Government Organizations

1. Dane County Supervisors
2. Dept. of Agriculture, Trade, and Consumer Protection
3. Forest Country Potawatomi Community
4. Wisconsin Legislature Assembly on Agriculture

Utilities and Utility Assoc.

1. Cooperative Network
2. Madison Gas & Electric
3. Municipal Electric Utilities of WI
4. Northern States Power Company
5. We Energies
6. WI Electric Cooperative Assoc.
7. WI Power and Light
8. WI Public Service Co.
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10. WPPI Energy

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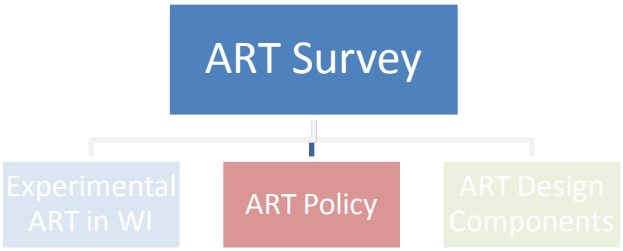
Respondents are:

Primarily agricultural – 14 of 31 respondents are tied to agriculture

Focused on **biodigesters** versus **biomass**

Generally **not** representing **small wind** and **solar**

ART Policy: Design Issues



1. How do we pay for the ART?

- **Industry Groups -** voluntary green pricing programs only

- **Most other respondents** – agree with Task Force that:

  increased costs per unit of electrical output are justified by the economic and environmental benefits

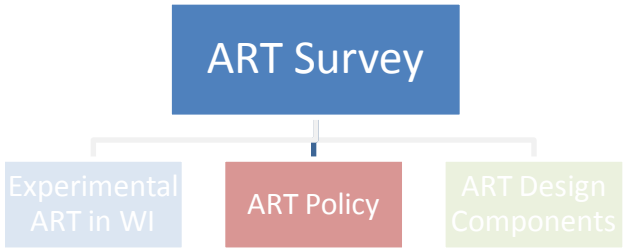
General opinion is:

Everyone receives benefits, so everyone should pay

Main issues:

- **Equitable distribution of costs** – among ratepayers & utilities
- **Impact on sensitive ratepayers** – competitive industries & low income earners

ART Policy: Design Issues



2. Which utilities should participate?

- **General opinion –** all utilities should participate
- **Problem –** Coops prices are not under PSC jurisdiction

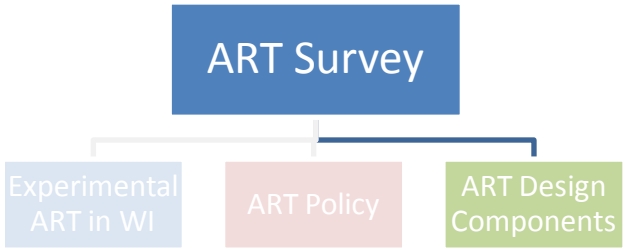
3. Should ART count towards RPS?

- ART should contribute towards RPS
- **Problem:** administrative costs, upward pressure on RPS cost

4. Should ART price reflect available subsidies?

- **Noncompetitive subsidies** – included in our analysis
- **Competitive subsidies –**no double subsidies in our analysis

ART Design Components



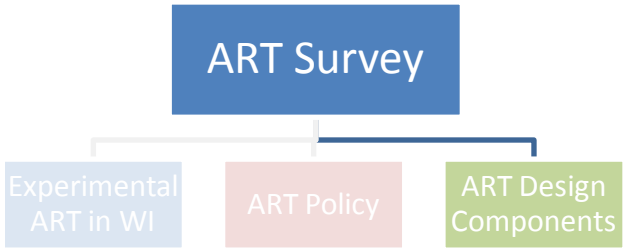
5. What technology should the ART include?

- **Agreement –** generally **solar, wind, biogas, biomass**
- **Open question –** landfill and sewage treatment gas?

6. What renewable energy payment structure is appropriate?

- **Price Level –**provides rate of return similar to utilities'
- **Price Structure –** simplest: fixed energy payment rate ($0.XX/kWh)
- **Disagreement**
  1. **Tariff length** – 10/15/20 years
  2. **Tariff level tied to inflation** – Critical for tech w/ high O&M

ART Design Components



7. How high of a program cap is appropriate?

- **Some argue** – No program cap, the more renewables the better
- **General opinion –** cap is a function of the benefits

8. Who should own environmental attributes?

- **Renewable energy attributes –** Owned by utility
- **Carbon Credits -** disagreement **-** farmers & utilities both want credits

WI ART Policy

Schedule **ART-WI**

Designed using stakeholder input

Energy Payments

•Energy payments designed to provide rate of return comparable to utilities allowed rate of return

	$/kWh	Project Size	Program Cap
Biomass	$0.XX	< XX kW	
Biodigester			
Solar			
Wind			

Contract Lengths

Biomass	Biodigester	Solar	Wind
? Years	? Years	? Years	? Years

I. Participating Utilities

Preferably – **all utilities participate**, PSC jurisdiction is limited though

II. Cost Recovery

All citizens benefit from ART, so costs should be evenly distributed among ratepayers

III. Program Cap

Ideally designed to balance the benefits to WI residents w/ the cost of the program

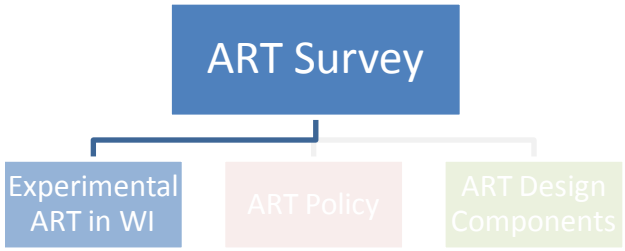
IV. Inflation Adjustments

Critical for technologies with high O&M costs – Biogas & Biomass

V. Environmental Attribute Ownership

- Utilities retain renewable energy attributes
- Owners **may** have option to retain carbon credits - utilities do not currently need credits
- Owners retain other environmental attributes

Experimental ART Experience in WI



- Technologies included: Solar, Wind, Biogas, Biomass

Solar

	$/kWh	Size	Cap	Schedule
DPC				
MGE	$0.25	1-20kW	300kW	Pg-4
NSPW				
WEPCO	$0.225	1.5-100kW	1000kW	CGS-PV
WPL	$0.25	1-20kW	683kW	Pgs-ART
WPSC	$0.25	1-20kW	300kW	PG-Solar

Tariff Full

Tariff Full

Expected full by end of 2009

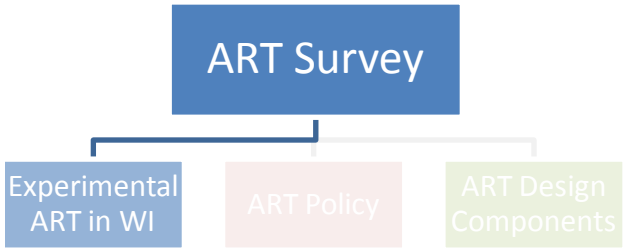
40kW enrollment in first 6 weeks

Cost Recovery – Funded exclusively through voluntary green pricing programs

Price sufficient to spur development **when** combined w/ other incentive (Focus, etc.)

2283kW Total
≈ 0.005% of WI Generation
≈ 2350 mton CO2e Reduction

Experimental ART Experience in WI



- Technologies included: Solar, Wind, Biogas, Biomass

Wind

	$/kWh	Size	Cap	Schedule
DPC	CER $0.065	< 40kW 40kW-2MW	2MW/Feeder	DG-5
MGE	$0.061 Negotiable	< 20kW > 20kW	5 MW	PG-3
NSPW	CER $0.066	< 20kW 20kW-1MW	0.25% retail	Pg-1 Art-1
WEPCO	CER CER	< 20kW 20kW-100kW	25 Customers	CGS 2 Wind
WPL	CER $0.12 on-peak $0.074 off-peak	< 20kW 20kW-1MW	0.5% retail	PgS-3 Pgs-ART
WPSC	CER	< 20kW		PG-4

CER - Customer's Energy Rate

No Participation
Avoided Cost ≈ $0.066

Two customers – 125kW total capacity

Expected to fill in < 2 years

Several tariffs are priced similarly to <u>avoided cost</u>

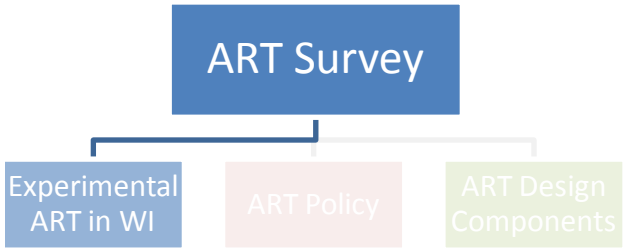
Tariffs unlikely to attract wind participation because:
- Avoided cost rises over time, will eventually be higher than tariff rate
- Even with available incentives tariff is too low

Four Tariff Price Structures – flat, on/off peak, CER, Negotiable.

FourTariff Cap Structures

Cap is a function of:
- distribution grid
- nameplate capacity
- energy generated
- #of customers

Experimental ART Experience in WI



- Technologies included: Solar, Wind, Biomass, Biogas

	Biogas			Biomass			
	$/kWh	Size	Cap	$/kWh	Size	Cap	Schedule
DPC	0.105 on -peak $0.054 off-peak	40kW-2MW	2MW/Feeder	Not Certain	40kW-2MW	2MW/Feeder	DG-5
MGE	Negotiable	> 20kW	5 MW	Negotiable	> 20kW	5 MW	PG-3
NSPW	$0.073	20-800kW	0.25% retail	$0.073	20-800kW	0.25% retail	Art-1
WEPCO	$0.1550 on-pea $0.04 off-peak	<1000kW	10 MW				CGS 5
WPL	$0.12 on-peak $0.074 off-peak	20kW-2MW	0.5% retail	$0.12 on-peak $0.074 off-peak	20kW-2MW	0.5% retail	Pgs-ART
WPSC							

No Enrolled Customers

Three Customers
830kW Installed Capacity

One Customer
190kW Installed Capacity

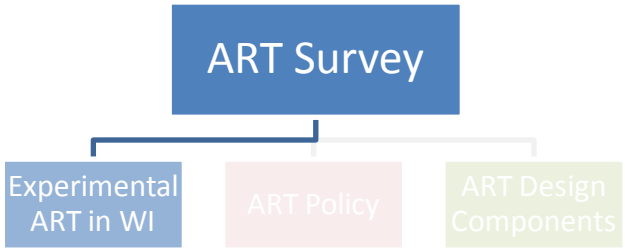
Project size varies from
800kW – 2MW

Some Tariffs differentiate between **biogas** and **biomass**

Tariffs likely to promote some installation of **manure digesters** because

- Farmers receive extra benefits from digesters
- **Incentives plus tariff are *good enough* for some farmers**

Experimental ART Experience in WI



Problems with Existing Experimental ARTs:

- **Price is too low**, grants in combination w/ ARTs are necessary
- ART schedules are **not consistent** or easy to understand
- Costs are recovered primarily through green pricing programs
- **Terms are short** (10 years) & **price is not inflation adjusted**
- **Program cap** may be **too low** to achieve maximal benefits

Existing Experimental ARTs are not sufficient to capture the policy goals identified by stakeholders

ART and Small Biomass CHP in Wisconsin

Natural Resources Canada

Excel-Based Clean Energy Analysis Software

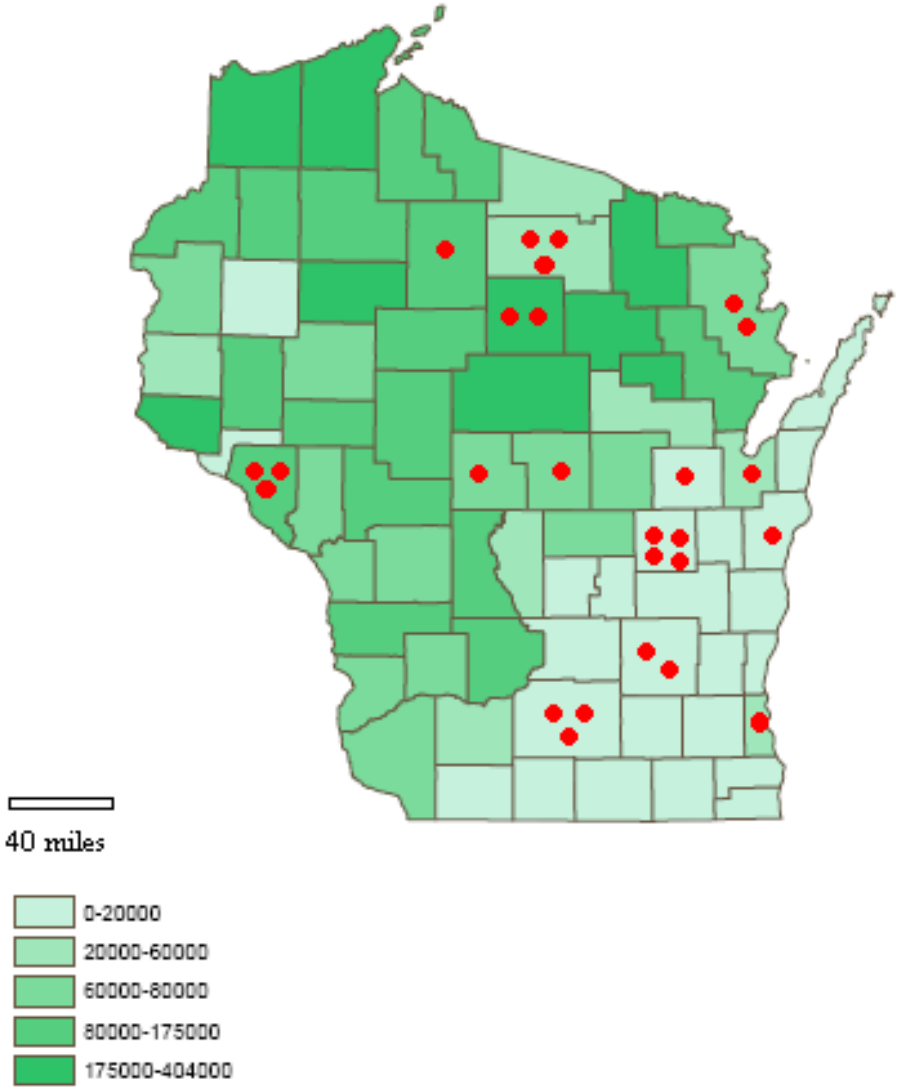
Biomass Potential in Wisconsin

	Biomass [Million Dry Tons]	Capacity [MW]
Corn Stover	6.40	1,726 [1]
Agriculture Crop Residues	4.42	587 [2]
Switch Grass on CRP	3.13	469 [2]
Willow/Hybrid Poplar on CRP	2.91	464 [2]
Forest Residues	2.01	**358** [2]
Total	18.87	3,525 [2]

- Twenty Six ≤ 15MWe Coal Plants (209MWe)

[1] USDA NASS WI (2008)
[2] Milbrandt, A. (2005)

Annual Tree Removal By County in Dry Tonnes & ≤ 15MWe Coal Plants



[1] ORNL 1999
[2] EIA 2007

General Assumptions

Project Size Range

- **< 1MWe**
- **1MWe - 15MWe**

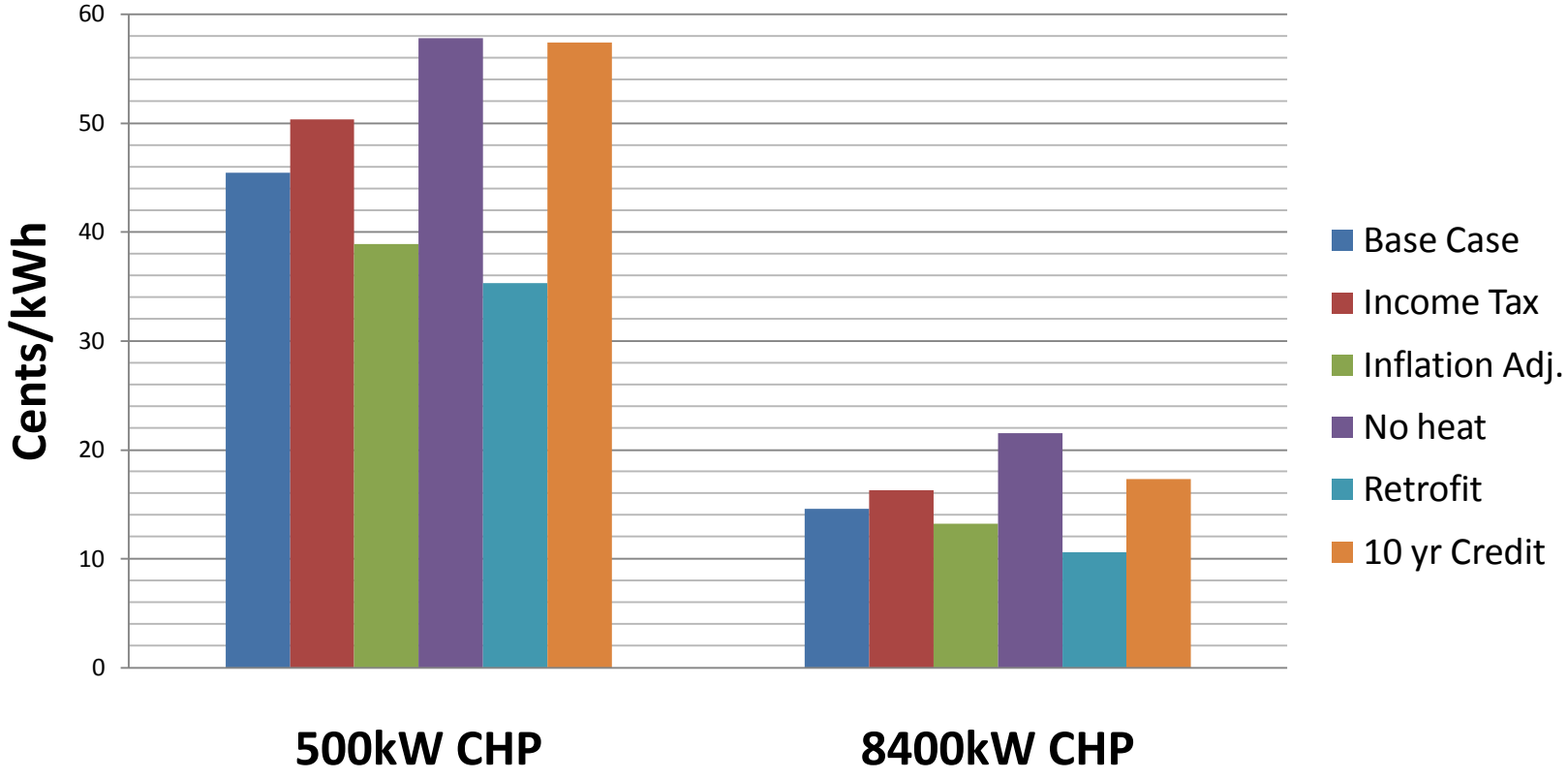
Variable	500kW	5,600kW	8,400kW
Capital [$/kW]	9,161	4,630	4,000
O&M [$/kW-yr]	1,150	284	202

Variable	Value
Project Life	30 years
Biomass (45%)	$15-25/tonne
Natural Gas	$6/MMBtu
Federal Grant	$0.021/kWh for 10 years -or- 10% of Capital Cost

[1] US EPA 2007
[2] Loo and Koppejan 2008

Energy Payment Range

12.5% Expected Rate of Return



WI ART Policy

Schedule **ART-WI**

Designed using stakeholder input

Energy Payments

•Energy payments designed to provide rate of return comparable to utilities allowed rate of return

	$/kWh	Project Size	Program Cap
Biomass	$0.450	< 1MWe	
	$0.150	1MWe – 15MWe	
Biodigester			
Solar			
Wind			

Contract Lengths

Biomass	Biodigester	Solar	Wind
20 Years	? Years	? Years	? Years

I. Participating Utilities

Preferably – **all utilities participate**, PSC jurisdiction is limited though

II. Cost Recovery

All citizens benefit from ART, so costs should be evenly distributed among ratepayers

III. Program Cap

Ideally designed to balance the benefits to WI residents w/ the cost of the program

IV. Inflation Adjustments

Critical for technologies with high O&M costs – Biogas & Biomass

V. Environmental Attribute Ownership

- Utilities retain renewable energy attributes
- Owners **may** have option to retain carbon credits - utilities do not currently need credits
- Owners retain other environmental attributes

Social & Economic Benefits

- Replace coal plants
- 4.9 workers/MW [2]
- $21,000/MW State Tax Revenue[2]

[1] Lin, X. (Boston University 1996)
[2] Morris, G. (NREL 1999)

Takeaways

- Inflation adjusted ART
- Long term ART (20 years)
- Retrofitting coal plants are winners

BIOGAS

- from anaerobic fermentation of organic matter
- major source of organic waste in WI: manure from dairy herds
- costs, benefits, feasibility of anaerobic digesters

Anaerobic Digester - Quantum Dairy.

Photo from Kramer, 2008. Wisconsin Agricultural Biogas Casebook

POTENTIAL Electricity Generation from Dairy Cows Manure utilizing Anaerobic Digesters in Wisconsin

Manure from dairy herds greater than 500 cows:	39[1] MW Potential in WI

[1]*Alliant Energy. 2005. Anaerobic digesters and methane production in the agricultural sector of states served by Alliant Energy. Technical report. Alliant Energy, Madison, WI*

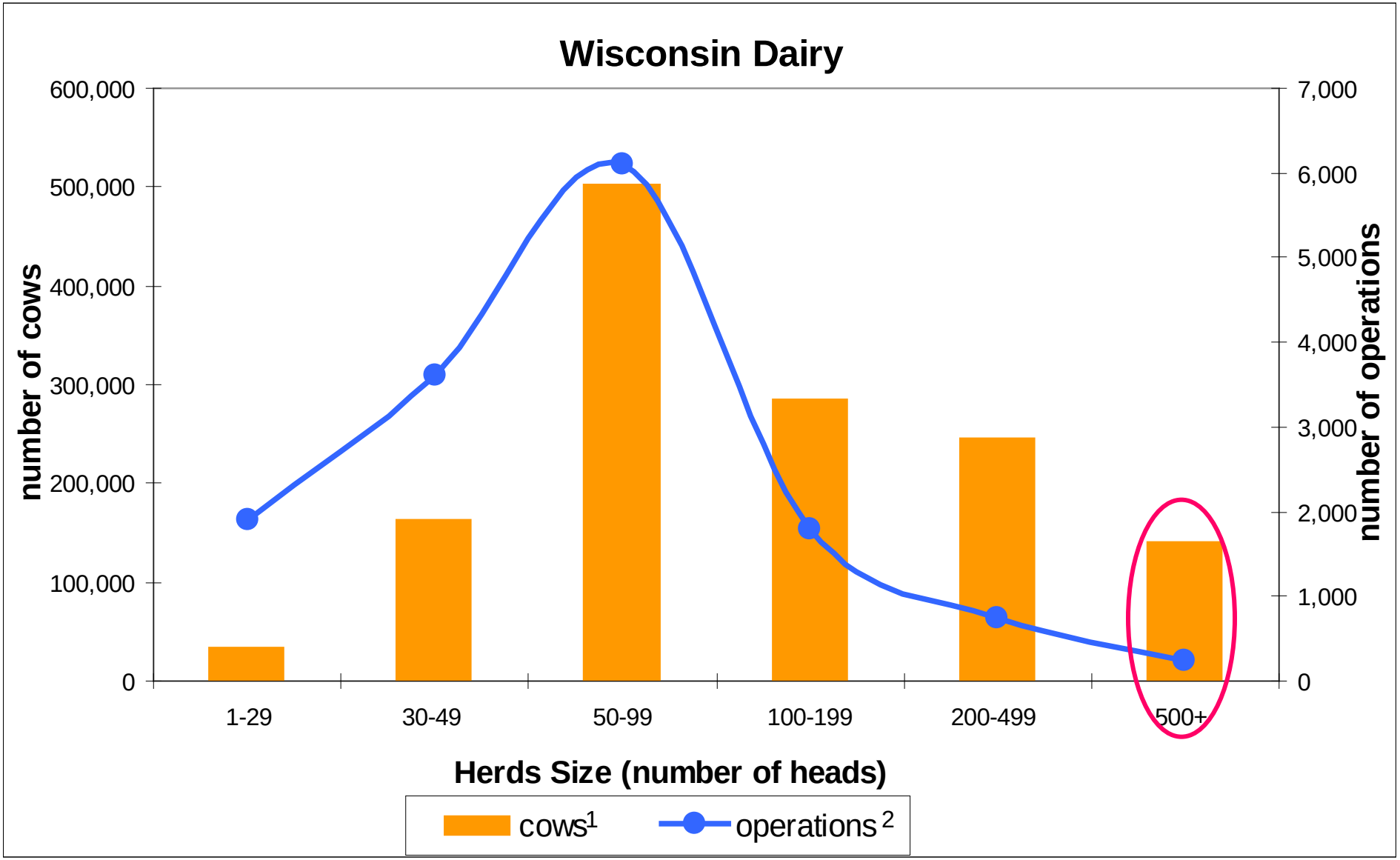
Manure storage lagoon - Larson Acres Farm – 2008 (photo by Thais Passos Fonseca)

- big farms with confined herds have big concentration of manure to deal with
- anaerobic digesters can reduce methane emissions from stored manure

Major Benefits

•Manure management			
•Nutrient management			
•Odor control			
•Greenhouse Gases Emission Reduction			
Methane that can be emitted from stored liquid manure in lagoon (ft3/cow/day)	tCO2 eq./cow/day	tCO2 eq./cow/year	tCO2 eq./kWh
48[1]	**0.01941**	**7.07**	**0.0045**

[1] *48 ft^3/cow/day, based on: Vries, A., Wilkie, A. C., Giesy, R., Nordstedt, R. Spreadsheet to Calculate the Economic Feasibility of Anaerobic Manure Digesters on Florida Dairy Farms. EDIS Publication AN176.*



[1]*Wisconsin Agricultural Statistics Service. 2004.*
[2]*National Agricultural Statistics Service, WI FO. 2007.*

Electric Energy Generation by Anaerobic Digesters in WI Dairy Farms

Installed Capacity			
Generating energy	Number of Farms	Animals	MW
	17	27,442	5.48[1] [7.30]

Herd Size	Number of Farms	Animals	Potential MW
>500 cows	**246**	**187,865**	**37.57[1]**

1based on Alliant Energy. 2005. Anaerobic digesters and methane production in the agricultural sector of states served by Alliant Energy. Technical report. Alliant Energy, Madison, WI

Potential Electric Energy Generation by Anaerobic Digesters in WI Dairy Farms with more than 500 cows

Herd Size	Number of Farms	Animals	Potential MW
>500 cows	**246**	**187,865**	**37.57**
500-999 cows	200[2]	117,085[1]	23.42
>1000 cows	46[2]	70,780[1]	14.15

[1]based on Wisconsin Agricultural Statistics Service. 2004.
[2]based on National Agricultural Statistics Service, WI FO. 2007.

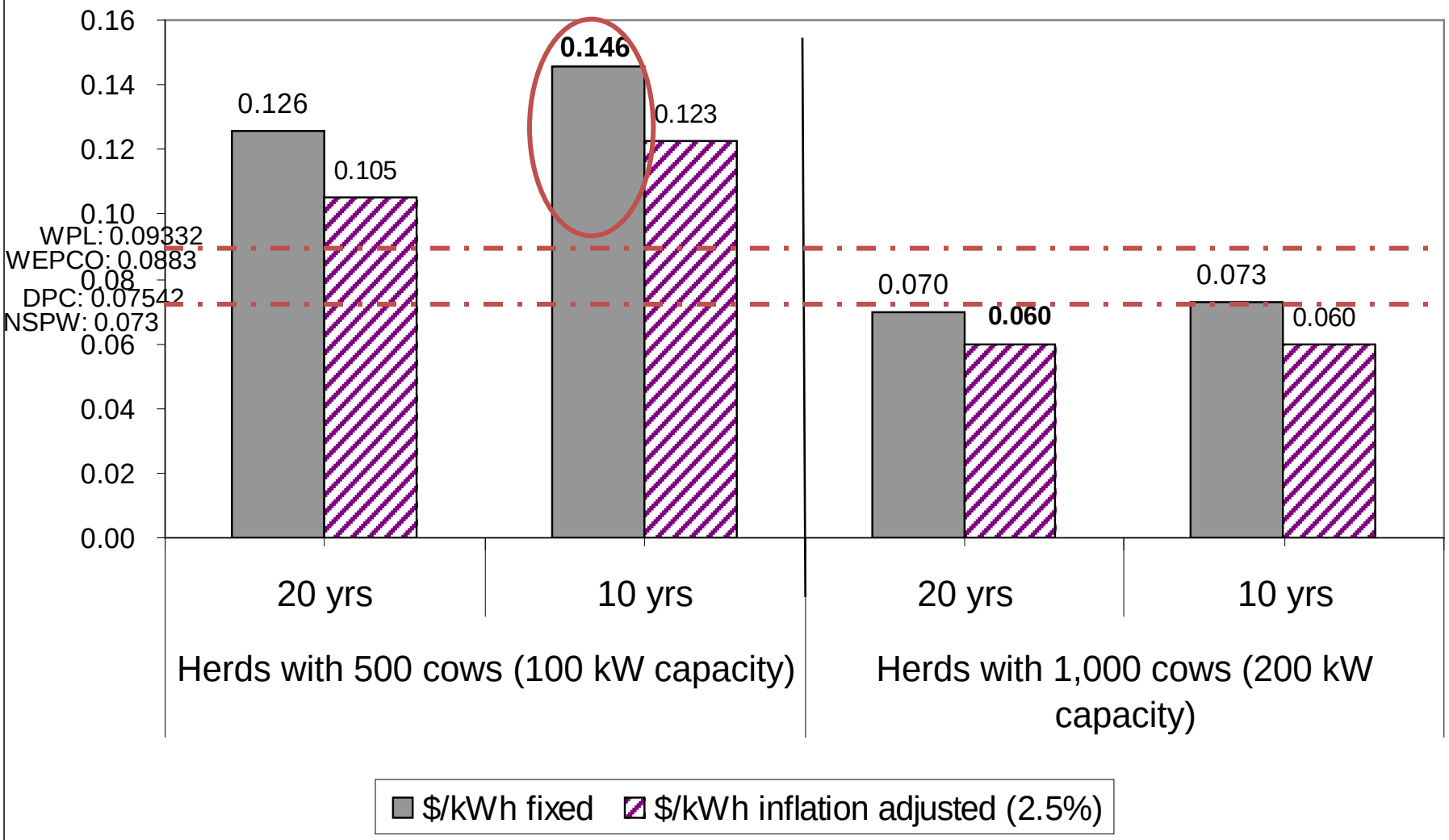
Simulations - RETScreen International® Assumptions:

Power Capacity	0.2 kW/cow[a]
Type of Anaerobic Digester	Plug-Flow
Project Life	20 years
Capacity Factor	90%
Federal Grant (REPI)	$0.021/Wh 10yrs
Bedding Recovery	1.5t/cow/yr[b]
Bedding Value	$20/t[b]
Electricity Export Rate	$0.060/kWh
Inflation Rate	3%
Debt Interest Rate	8%
Debt Ratio	80%
Debt Term	15 years
Internal Rate of Return	12.5%

[a]*Alliant Energy. 2005. Anaerobic digesters and methane production in the agricultural sector of states served by Alliant Energy. Technical report. Alliant Energy, Madison, WI*

[b]*based on Kramer, J. 2008. Renewable Energy: Wisconsin Agricultural Biogas Casebook. Energy Center of Wisconsin, Madison, WI.*

Estimating Anaerobic Digestion Capital Costs for Dairy. Farms. 2009. AgSTAR National Conference, Feb09, Baltimore, MD


Energy Payments providing 12.5% IRR to Renewable Power Producers utlizing Anaerobic Digesters to generate electricity from dairy cows manure [$/kWh]
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
WPL: 0.09332
WEPCO: 0.0883
DPC: 0.07542
NSPW: 0.073
0.126
0.105
0.146
0.123
0.070
0.060
0.073
0.060
20 yrs
10 yrs
20 yrs
10 yrs
Herds with 500 cows (100 kW capacity)
Herds with 1,000 cows (200 kW capacity)
$/kWh fixed
$/kWh inflation adjusted (2.5%)

WI INVESTMENT
- an example -

Herd Size and System Capacity	Term length (years)	Income Taxes	Energy Payment - inflation adjusted (2.5%/yr) -	Investment in reducing GHG emissions[1] ($/tCO2 eq)
500-999 cows < 200kW	20	Exempt	$0.126/kWh	**$14.77[1]**
> 1,000 cows > 200 kW	20	Exempt	$0.070/kWh	**$2.69[1]**

[1] *based on 48ft^3/cow/day, Vries, A., Wilkie, A. C., Giesy, R., Nordstedt, R. Spreadsheet to Calculate the Economic Feasibility of Anaerobic Manure Digesters on Florida Dairy Farms. EDIS Publication AN176*

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	$0.070	> 200kW	
Solar			
Wind			

Contract Lengths

Biomass	Biodigester	Solar	Wind
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Photovoltaics and Small Wind

- Financial input assumptions matter: fewer variables than biopower
- Tariff rates based on high capacity factor and low capital cost

Key Input Variables

- All-in installed cost per kW DC capacity

  $7,900 residential PV instead of $8,400 historical average

- 12.5% return on investment
- Income taxes: applicability & rates may vary
- Debt terms

  10 or 20 years

Aggregate development scenarios:

What might be the total costs to ratepayers?

Aggregate development scenarios:

What might be the total costs to ratepayers?

<u>Depends on:</u>

1. Energy payment levels
2. Program limits

WI ART Policy

Schedule **ART-WI**

Designed using stakeholder input

Energy Payments

•Energy payments designed to provide rate of return comparable to utilities allowed rate of return

	$/kWh	Project Size	Program Cap
Biomass	$0.450	< 1MWe	
	$0.150	1MWe – 15MWe	
Biodigester	$0.126	< 200 kW	
	$0.070	> 200kW	
Solar	$0.53	< 10kW	
	$0.499	10 < 100kW	
	$0.47	100 < 500kW	
	$0.43	> 500kW	
Wind	$0.29	< 20kW	
	$0.22	20 < 100kW	
	$0.15	100kW < 500kW	
	$0.120	> 500kW	

Contract Lengths

Biomass	Biodigester	Solar	Wind
20 Years	20 Years	20 Years	20 Years

I. Participating Utilities

Preferably – **all utilities participate**, PSC jurisdiction is limited though

II. Cost Recovery

All citizens benefit from ART, so costs should be evenly distributed among ratepayers

III. Program Cap

Ideally designed to balance the benefits to WI residents w/ the cost of the program

IV. Inflation Adjustments

Critical for technologies with high O&M costs – Biogas & Biomass

V. Environmental Attribute Ownership

- Utilities retain renewable energy attributes
- Owners **may** have option to retain carbon credits - utilities do not currently need credits
- Owners retain other environmental attributes

WI ART Policy

Schedule **ART-WI**

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Energy Payments

•Energy payments designed to provide rate of return comparable to utilities allowed rate of return

	$/kWh	Project Size	Program Cap
Biomass	$0.450	< 1MWe	2.75% of retail sales
	$0.150	1MWe – 15MWe	
Biodigester	$0.126	< 200 kW	
	$0.070	> 200kW	
Solar	$0.53	< 10kW	0.25% of retail sales
	$0.499	10 < 100kW	
	$0.47	100 < 500kW	
	$0.43	> 500kW	
Wind	$0.29	< 20kW	
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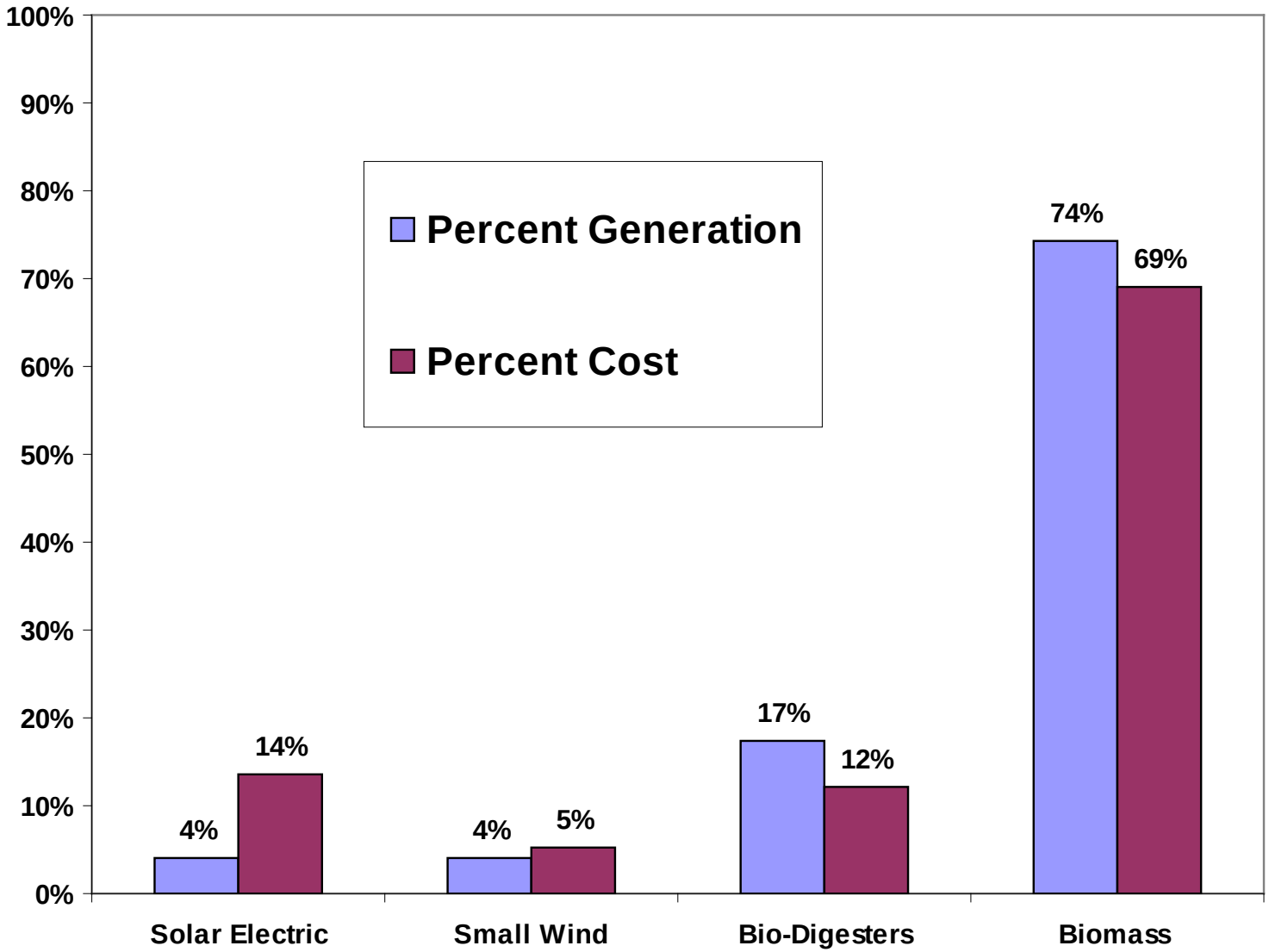
Three Percent Case: ARTs drive development of customer-sited renewables up to three percent of Wisconsin utility generation; pv and small wind limited to 0.25 percent

	Energy Payment	Capacity MW	Generation kWh/Year	Annual Cost
Solar Electric	$0.50	150	71,487,494	$30,024,747
Small Wind	$0.22	112	71,487,494	$11,437,999
Bio-Digesters	$0.15	40	297,840,000	$26,805,600
Biomass	$0.18	182	1,274,884,863	$152,986,184

$221 million per year

approx. 4% of utility retail sales. Household with annual electric bill of $1,000 ART would mean $40 per year

Three percent case: shares of cost and generation



ART Benefits Scenario

1. Carbon market prices
2. Tradable environmental attributes
3. Job creation and economic development
4. Clean power generation
5. Reduced health care costs
6. Less-quantifiable benefits: consumer choice, energy source diversity, risk reduction, less marginal need for transmission, energy independence, air and water quality

Greenhouse Gas Abatement Limitations & Benefits

- PV and small wind:

  Capital cost
- Biogas:

  Number of dairy farms
- Biomass:

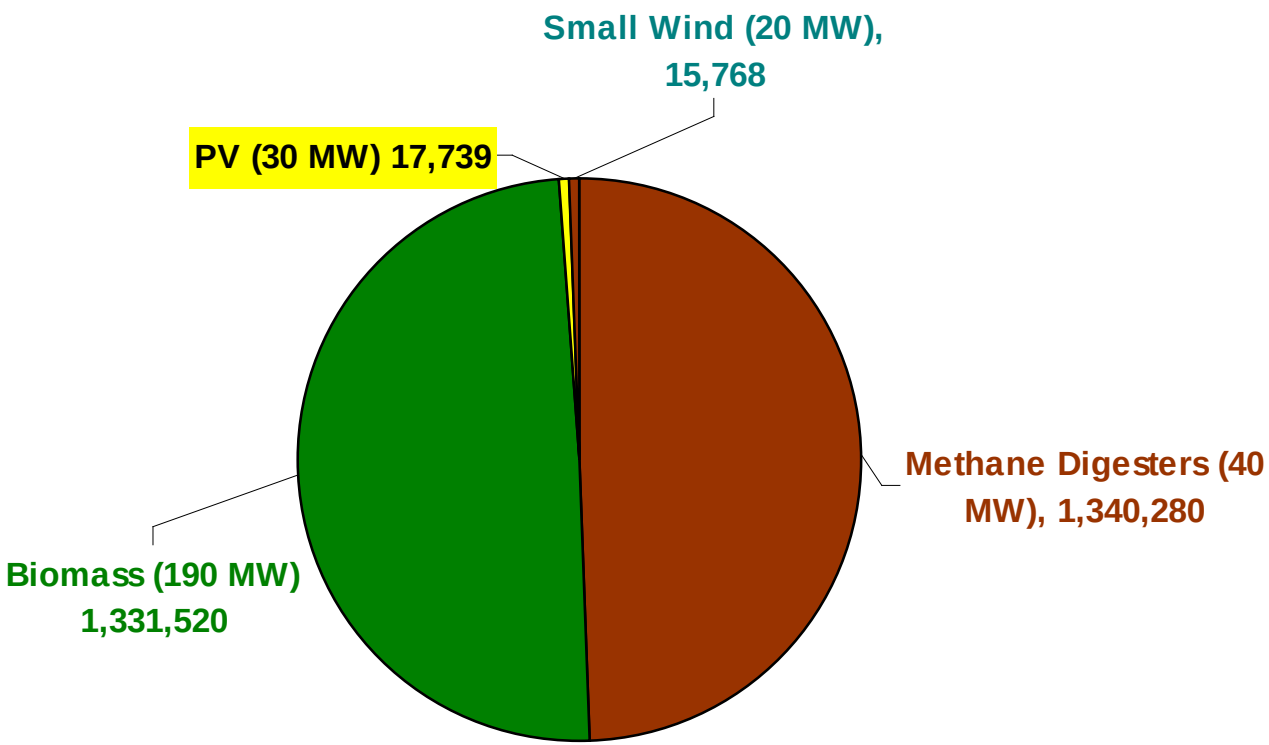
  Fossil fuels used to harvest and transport

  Number of sites with heat demand loads

At $10/ton, 3 percent renewables from ARTs bring in $26 million per year

Methane reductions 4.5X $CO_{2eq.}$ impact

Shares of Carbon Equivalent Reductions
by Technology in Tons/year
Three percent of Wisconsin Utility Retail Electric Generation



Economic Development: Biomass

- Job creation

182 MW new capacity X 4.9 jobs per MW =

500 net jobs in Wisconsin

- Economic multipliers

$150 million per year invested ***mostly in-state***

Buys wood from smaller landowners; local transportation and processing; incentive for manufacturers to locate in WI; energy payments to WI residents

Non-energy Benefits

- Value of reduced air pollution, no mercury emissions, reduced criteria pollutants
- Broader consumer choice
- Wider generation source diversity
- Agricultural sector co-benefits
-

Conclusions & Take-aways

- Rate impacts of ARTs

+ $ greenhouse gas reductions

+ $ energy generated

+ $ jobs & economic development

<u>+ *other non-energy benefits*</u>

<u>Policy question:</u>

Are costs minus quantifiable benefits greater than the *value* to Wisconsin?

Key Input Variables

- All-in installed cost per kW DC capacity
  - $7,300 commercial scale PV
  - $7,900 residential PV
- Assumed rate of return
  - 12.5%
- Income tax
  - 0% to 35%
- Debt terms
  - 10 or 20 years

Aggregate development scenarios:

What is the total cost to ratepayers of ART development of customer-sited renewable power systems in Wisconsin?

Share Of Generation By Technology and Cost Per Kwh

Three Percent Case: ARTs drive development of customer-sited renewables up to 3 percent of Wisconsin utility generation, pv and small wind limited to 0.25 percent

	Tariff > Avoided Gen. Cost/kWh	Capacity MW	Generation kWh/Year	Cost
Solar Electric	$0.42	150	196,590,608	82,568,055
Small Wind	$0.16	112	196,590,608	31,454,497
Bio-Digesters	$0.09	40	297,840,000	26,805,600
Biomass	$0.09	182	1,274,884,863	114,739,638

Total: $255 million per year or ___ cents per kWh retail

ART Benefits Scenario

1. Carbon market prices
2. Tradable environmental attributes
3. Job creation and economic development
4. Clean power generation
5. Reduced health care costs
6. Less-quantifiable benefits: consumer choice, energy source diversity, risk reduction, less marginal need for transmission, energy independence, air and water quality

Carbon Issues by Technology

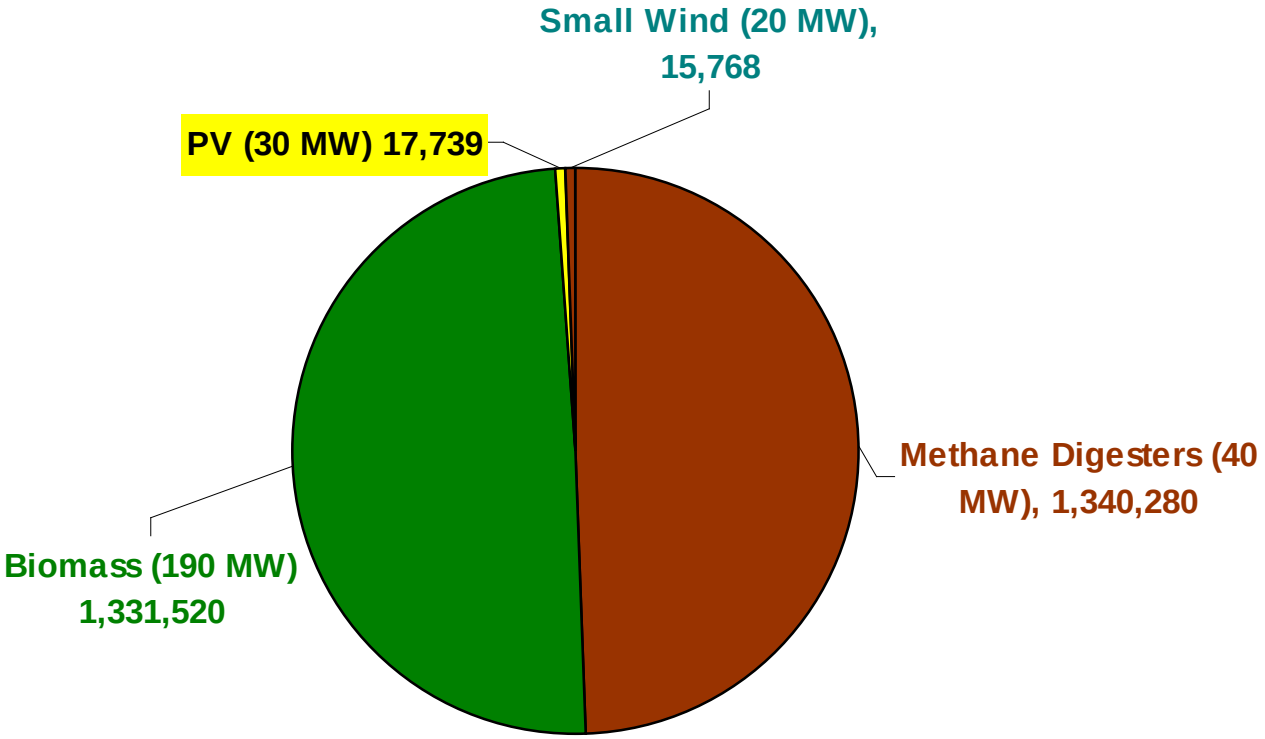
- PV and small wind – high available resource potential, yet costs limit scale without a breakthrough in installed cost per kWh. PV displaces natural gas, not coal.

- Biogas – limited dairy-farm based resource potential, yet high impact per unit due to methane emission reduction and high capacity factor

- Biomass – high available resource potential, but not entirely carbon-neutral due to fossil fuel use for harvest and transport

Methane reductions 4.5X $CO_{2eq.}$ impact

Shares of Carbon Equivalent Reductions
by Technology in Tons/year
Three percent of Wisconsin Utility Retail Electric Generation



Higher Capacity Factors Yield 4X $CO_{2eq.}$ impact

	Resource Potential	Capacity Factor	Carbon Equivalent Emissions Reduction	Climate Impact
Dairy farm biogas	**Limited**	**High**	Very High: Cuts Methane Emissions	**Large**
Biomass	High	High	Medium: Displaces Coal	**Medium**
Wind	High	Low	Low (Displaces Natural Gas)	Tiny
PV	High	Low	Low (Displaces Natural Gas)	Tiny

	Resource Potential	Capacity Factor	Carbon Equivalent Emissions Reduction	Climate Impact
Dairy farm biogas	**40**	**85%**	**10**	**2,978,400**
Biomass	**190**	**80%**	**1**	**1,331,520**
Wind	**30**	**20%**	**0.45**	**17,739**
PV	**20**	**15%**	**0.45**	**15,768**

Economic Development: Biomass

- Job creation: longer value chain than non-combustion renewables.

  Direct vs. indirect job creation.
- Economic multipliers (include #'s from multiple sources) and comment on interp the total. PV manuf in WI? Not competetive. Steam generator mfr?
- $ total for 3%, extreme example

Non-energy Benefits

- Value of reduced air pollution, no mercury emissions, reduced criteria pollutants
- Broader consumer choice
- Wider generation source diversity
- Agricultural sector co-benefits

Policy question:

Are total costs minus quantifiable benefits greater than the *value* we place on positive externalities?

Conclusions & Take-aways

- Rate impacts of ARTs

+ $ carbon emission reductions

+ $ energy generated

+ $ jobs & economic development

+ *other non-energy benefits*