Biomass:
Market Drivers and Outlook

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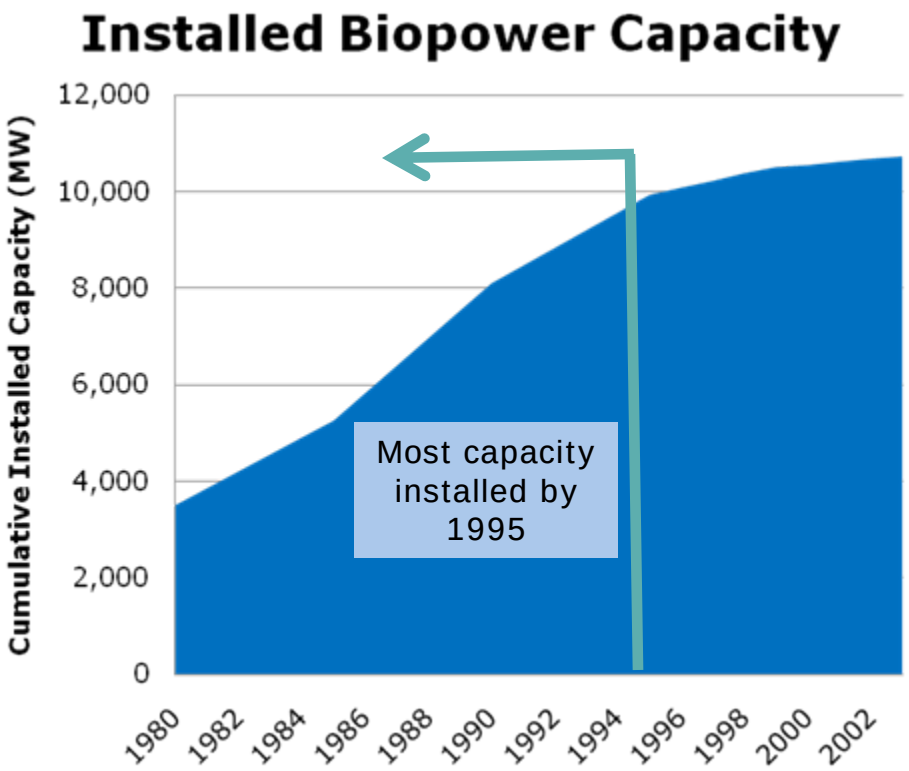
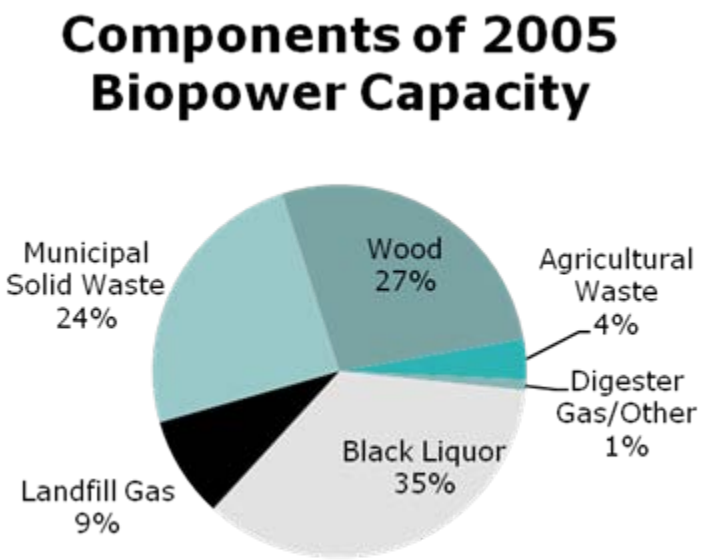
Unlike Other Clean Energy, Growth in Biopower Capacity Has Slowed



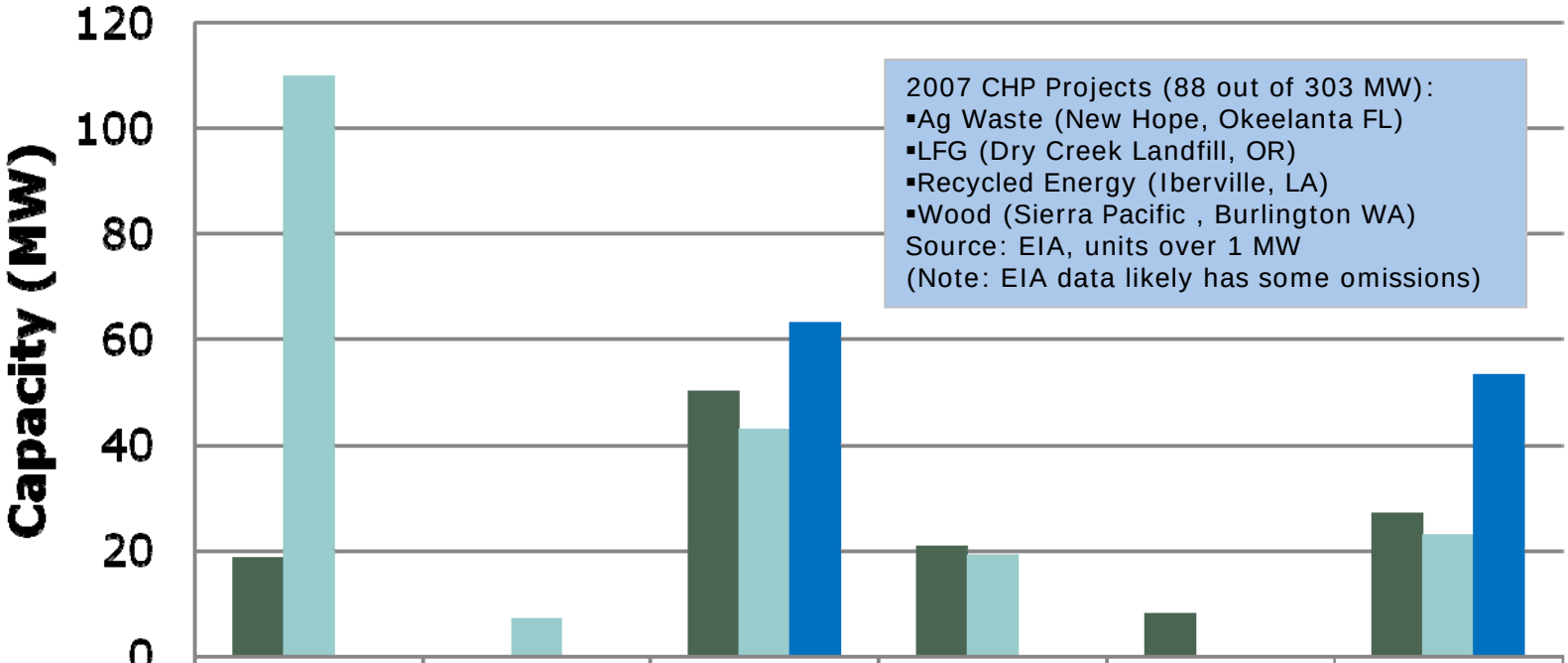
Source: NREL REPIS Database



Source: EIA 860 Data, Units Over 1 MW

One third of existing biopower employs CHP

Recent Biopower Capacity Additions: Diverse and Employs CHP



	Agricultural Waste	Black Liquor/Biomass Liquids	Landfill/ Digester Gas	Municipal Solid Waste	Recycled Energy	Wood/ Wood Waste
2006	18.6	0	50.2	20.8	8	27
2007	110	7	43	19	0	23
2008	0	0	63.1	0	0	53.2

Almost one third of new biopower employs CHP

Recent Biomass Project Announcements

Project	Capacity (MW)	CHP?	Location
Lakeview Biomass / Collins Lumber	13	Yes	Lakeview, OR
Seneca Sawmill	18.8	Yes	Eugene, OR
Stoltze Land and Lumber	12	Yes	Flathead, MT
Roseburg Forest Products	10	Yes	Weed, CA
Simonds Int. / Fitchburg Airport Industrial Park	15	Yes	Fitchburg, MA
ADAGE / Energy Northwest Partnership	5 x 50	No	MT, ID, OR, WA
Oglethorpe Power Georgia Power	3 x 100 96	No	GA
American Renewables / Nacodoches Power	3 x 100	No	TX, FL

Sources: Company presentations and press releases covering units with expected operation between 2010 and 2017

New Biomass Challenges, and Role for CHP

- Currently, many new biomass projects are either dedicated power generation or thermal only
- Ideally, power and thermal output can be used on site for maximum value
  - Obtaining host for thermal output improves economics but can make siting challenging
  - Thermal only projects can add backpressure turbines to become CHP
- Issue of carbon neutrality has raised uncertainty and may favor CHP
  - Manomet study found carbon neutrality from biomass power using forestry biomass established only after a lengthy period
  - Many industry stakeholders took exception to findings

EPA Position on Biomass Carbon Neutrality

- Biomass energy use is not inherently carbon neutral
- EPA has yet to establish a formal recognition of biomass carbon neutrality
  - Biomass emissions do not count toward GHG reporting threshold
  - Facilities in GHG Reporting Program must report biomass emissions
- Call for Information (CFI) indicates that more input and deliberation is necessary

Speaker Introductions

Wastewater Treatment Facilities: Opportunities for CHP

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2007 WWTF Report

- Established rule of thumb for potential electricity and thermal outputs from CHP based on flow rate
  - Each 4.5 MGD can produce approximately 100 kW of electricity and 12.5 MMBtu/day via biogas CHP
- Presented emission reduction and cost-effectiveness benefits associated with CHP at WWTFs
  - All WWTFs over 5 MGD represent approximately 340 MW of CHP capacity, in terms of technical potential
  - This potential could offset 2.3 million metric tons of CO2 annually

2010 Report Update

- Draw from updated CWNS data (2008)
- Update the 2007 technical potential, and expand it to smaller 1-5 MGD sites
- Re-evaluate CHP technology and update costs
- Examine economic potential of CHP applications considering differences in state electricity pricing
- Interview WWTFs using CHP to determine:
  - What project development and operational strategies were faced during key decisions
  - What market drivers, benefits, barriers, and lessons learned were important to implementation

The WWTF Market

Based on the 2008 and 2004 Clean Watersheds Needs Surveys

- There are 17,000 operational WWTFs in U.S.
- About 3,500 (20%) are over 1 MGD, which is seen as the threshold size for economic CHP
  - Roughly 63 percent of all wastewater flows from these sites employ anaerobic digestion, and have biogas production on-site
  - Only 22 percent of the wastewater flows from these sites produce and use the biogas, and the remainder are assumed to flare their biogas
- Data on CHP population indicates that 122 WWTFs use CHP, and 97 use biogas CHP

Technical Potential for Biogas CHP at WWTFs

WWTF Facility Characteristics	Wastewater Flow (MGD)	Electric Potential (MW)	Thermal Potential (MMBtu/ day)
Anaerobic Digestion and No Gas Utilization	12,874	286	35,760
Anaerobic Digestion and Gas Utilization (no current CHP)	2,119	47	5,900
No Anaerobic Digestion	11,649	259	32,360
Total	**26,642**	**592**	**74,020**

- Technical potential is based on producing enough biogas to fuel small CHP unit
- Highest potential is sites where anaerobic digestion already in place (333 MW total potential, 56 percent)

Economic Potential Approach

- For each facility over 1 MGD:
  - Apply typical load profile to derive electricity consumption
  - Apply state electricity pricing to estimate electric bill before and after CHP
  - Employ typical CHP system installation and maintenance costs to calculate payback and cost to generate
- Three heat recovery scenarios evaluated:
  - Case 1: Site already utilizes all of their biogas so no thermal benefit is seen from incorporating CHP
  - Case 2: Site uses biogas to heat the digester, so CHP would avoid natural gas for space heating
  - Case 3: Site flares ADG. CHP thermal energy displaces natural gas for all facility thermal needs

System Options Based on Sizes Available and Most Common Choices

CHP Technology	Min Size (kW)	Max Size (kW)	Modeled Installed Cost ($/kW)	Maintenance ($/kWh)	Thermal Output (Btu/kWh)	Electric Efficiency (%)	CHP Efficiency (%)
Small Microturbine	30	60	4,800	0.03	5,971	24	66
Larger Microturbine	65	250	4,000	0.025	5,118	26	65
Small Engine	300	900	3,300	0.02	4,446	33	76
Large Engine	1,000	4,800	2,500	0.016	4,114	34	75
Combustion Turbine	4,000	16,000	2,100	0.012	3,899	35	75

- In smaller sites, engines becoming available but microturbines have been common choice
- In larger sites, multiple engines can be employed but combustion turbines becoming more commonplace
- Fuel cells considered, but economics are not typically most attractive due to higher installed cost, unless state incentives applied

Cost to Generate Drops Considerably for Larger Systems

CHP Technology	Size Range (kW)	Estimated Cost to Generate w/ADG (cents/kWh)	Number of States with Supporting Sites
Small Microturbine	30-60	7.6	46
Large Microturbine	65-250	6.4	46
Small Engine	200-1,000	5.2	39
Large Engine	1,000-4,000	4.0	21
Combustion Turbine	4,000-16,000	3.2	5

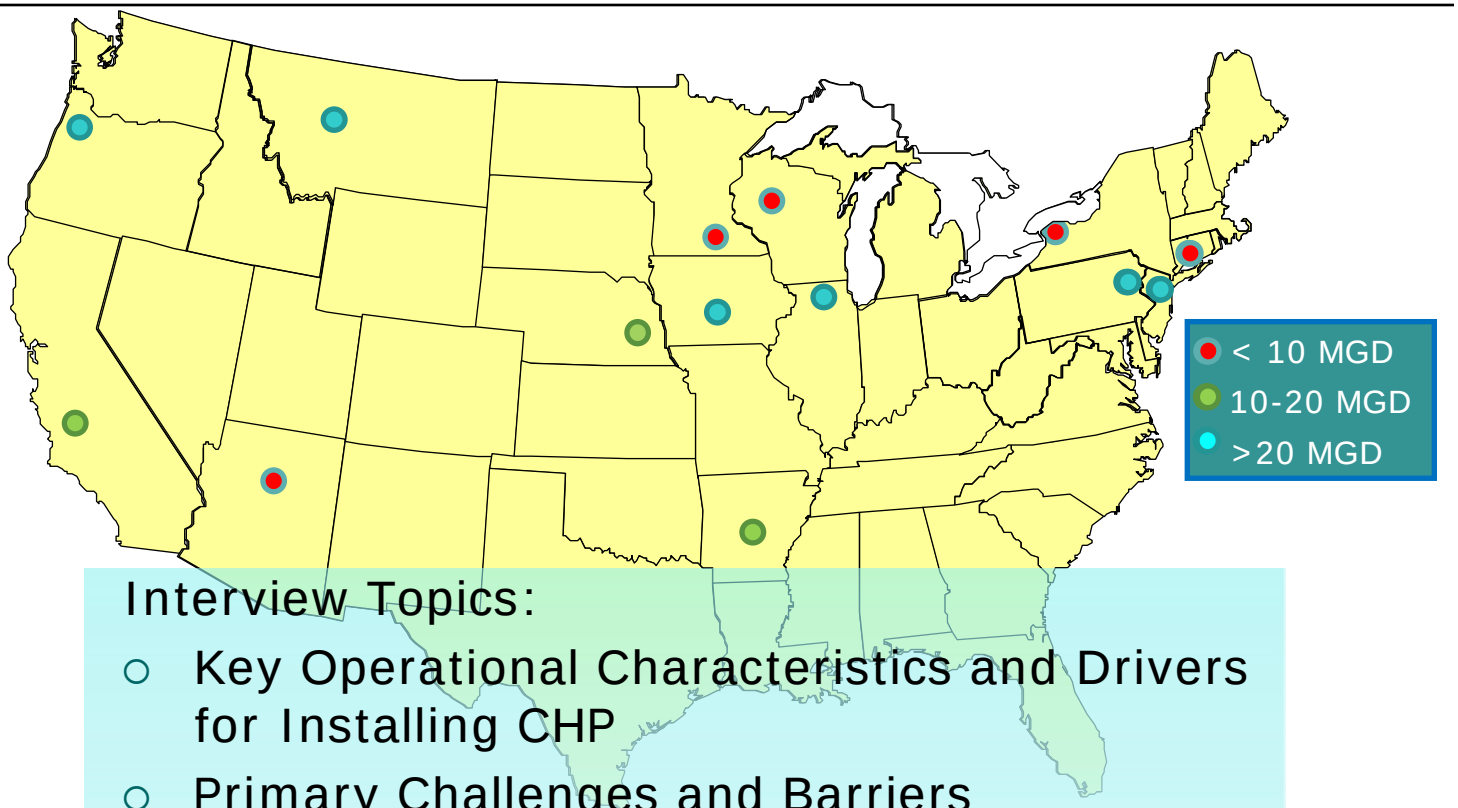
- Based on capital costs spread over 20 year period at 8 percent interest, plus maintenance costs of 1-3 cents per kWh depending on technology and size
- Fewer states have sites that support larger systems, most states have sites that could support a small or large microturbine

Economic Market Potential Depends on Heat Recovery, Nears Technical Potential

Current ADG Utilization Case	Number of Facilities with Potential*	Potential Capacity (MW)*
Case 1: ADG Fully Utilized for Heat	137	133
Case 2: ADG Heats Digester Only	525	218
Case 3: ADG Not Utilized (Flared)	833	272
*Note: Number of facilities and potential capacity not additive, each WWTF site is counted in all three cases.		

- The more heat recovered and used to displace natural gas, the better the economics and thus more economic potential
- The Case 3 economic potential of 272 MW is over 80 percent of the technical potential of 333 MW (for sites over 1 MGD with digesters that are not using CHP)
- Economic potential is usually a smaller fraction of technical potential, so this is an indicator of a market where CHP is a good fit throughout

Interviews with Fourteen WWTFs Across U. S.



Interview Topics:

- Key Operational Characteristics and Drivers for Installing CHP
- Primary Challenges and Barriers
- Experience with Local Utility
- Local Support Received and Incentives
- Benefits Achieved and Lessons Learned

Interview Findings

- CHP implemented for a range of reasons
  - Sustainability and beneficial use of renewable biogas were clearly drivers
  - Cost savings were significant and prevalent at many but not all sites
  - Some cited cost control even though savings were small
- Design issues
  - Fuel treatment came up almost every site
  - Better design practices, including adequate sizing of system and knowledge of gas contaminant levels would help
- Need to understand and plan for maintenance issues

Interview Findings

- Partnerships
  - Coordination with the local utility is highly recommended
  - Identifying opportunities to work with the local utility can be highly beneficial (e.g., master energy savings agreement, sale of RECs, other ownership/O&M agreements)
- Organizational acceptance
  - High-level buy in for CHP can greatly facilitate project approval. A CHP champion is needed to get the project off the ground and for continual successful operation.
  - Aligning the project with community goals for renewable energy/energy efficiency can serve as a great justification for project.

For More Information

Combined Heat and Power Partnership
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WWTF Opportunities for CHP: Questions?

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