Clean Energy Development for Thurston County

Phase 1: South County
Community Digester Project Opportunities

Final Report
May 2016

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  LOTT Clean Water Alliance
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Symbols and Abbreviations

Btu	British thermal unit (1 Btu = 1.055 kilojoules)
^oC	Degrees Celsius (°F = 9/5°C + 32)
CH_4	Methane
CO_2	Carbon dioxide
cf	Cubic foot or feet
cfd	Cubic foot or feet per day
cfh	Cubic foot or feet per hour
cfm	Cubic foot or feet per minute
DGE	Gallons of diesel-equivalent
°F	Degrees Fahrenheit [°C = 5/9 (°F - 32)]
ft	Foot or feet (1 ft = 0.3048 meter)
gal	Gallon (1 gal = 3.785 liters)
GGE	Gallons of gasoline-equivalent
gpd	Gallons per day
H_2O	Water
hr	Hour
H_2S	Hydrogen sulfide
kW	Kilowatt
kWh	Kilowatt-hour
L	Liter (1 L = 0.2642 gallon)
lb	Pound (1 lb = 0.4536 kilogram)
mg	Milligram (1 mg = 0.0154 grain)
MMBTU	Million Btu (as in a thousand thousand Btu)
MW	Megawatt
MWh	Megawatt-hour
Nm^3	Normal (dry standard) cubic meter (1 Nm^3 = 35.31 normal cubic feet)
O_2	Oxygen
ppb	Parts per billion
ppm	Parts per million
psi	Pounds per square inch (1 psi = 0.06804 atmosphere)
tpd	Tons per day (1 tpd = 0.9072 megagram per day)

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Executive Summary

During Phase 1 of the Clean Energy Development Project for Thurston County, an Anaerobic Digestion Technical Advisory Group (AD TAG), made up of representatives of Thurston County solid waste and water resources departments, the Evergreen State College, LOTT Clean Water Alliance, and Puget Sound Energy, engaged with the WSU Energy Program to investigate potential opportunities for anaerobic digester (AD) development in the county.

Starting with a detailed analysis of the available organics residual resources suitable for anaerobic digestion, the project team found that Thurston County has significant volumes of dairy and chicken manure; pre-consumer and post-consumer food residuals from residential, commercial, and industrial sources; and other organics, such as restaurant grease trap waste. Considering the geographical distribution of these digestible organic materials, especially the location of larger dairy farms, the project team, in consultation with the AD-TAG, identified an area near Grand Mound that offered a promising combination of agricultural, commercial, and institutional materials and interests that could form the basis of one or more successful AD projects.

The Phase 1 study evaluated two models for AD development – a single dairy farm-based digester and a larger, multi-farm, community-scale digester. Potential key partners in a farm-based or community digester project include:

- One or more area dairies
- One or more poultry farms
- The Chehalis Tribe, which has interests in the Great Wolf Lodge, Lucky Eagle Casino, and other area properties
- Dept. of Corrections, which has the Maple Lane and Cedar Creek correction facilities
- Thurston County, which operates the Grand Mound wastewater treatment facility
- Agricultural producer members of the Bountiful Byway agritourism zone in south county

Each of these potential partners might find it beneficial to participate because they could provide AD feedstocks or use outputs from a digester project, and gain important economic, environmental, and social benefits for their operations. The study found that each of the modeled opportunities is made stronger and more viable by combining individual interests into partnerships that share the costs, benefits and risks.

Major community-wide benefits of a successful AD project in this area include:

- Dairy nutrient management with reduced odors and pathogens
- Production of clean renewable energy from biogas
- Significant reduction of local greenhouse gas emissions
- Potential for greater community resilience, with baseline renewable energy

With creativity and community input, an AD project could contribute many agritourism benefits throughout the Bountiful Byway region of south Thurston County, such as:

- Production of clean biofertilizers for local farms
- Generation of new value-added soil products from digested materials
- Production of renewable energy/heat and carbon dioxide (CO_2) for greenhouses or food processing
- Important improvements and support for dairy production and processing

Water quality protection is another value-added environmental and community benefit that closely aligns with the missions of clean water agencies and environmentally friendly nonprofits and investors. Examples of these benefits include:

- Containment of raw manure in the digester tanks
- Significant pathogen reductions in dairy manure kept in open storage after digestion
- Reduced odor and pathogens in dairy manure nutrients spread on local croplands
- These dairy manure improvements protect the Chehalis River and adjacent floodplain

Purpose and Intent

In 2012, the Thurston County Commissioners created the “Agritourism Overlay District” to develop agricultural resources in the south county. They later added the “Bountiful Byway” to draw visitor traffic from Interstate 5 into all parts of rural Thurston County. This area in south Thurston County, around Grand Mound and Rochester (I-5 at Exit 88, as shown in Figure 1), supports most of the county’s dairy farms. Additional agricultural businesses, including creameries, wineries, nurseries, and organic vegetable production, are also growing in number and size in this area.

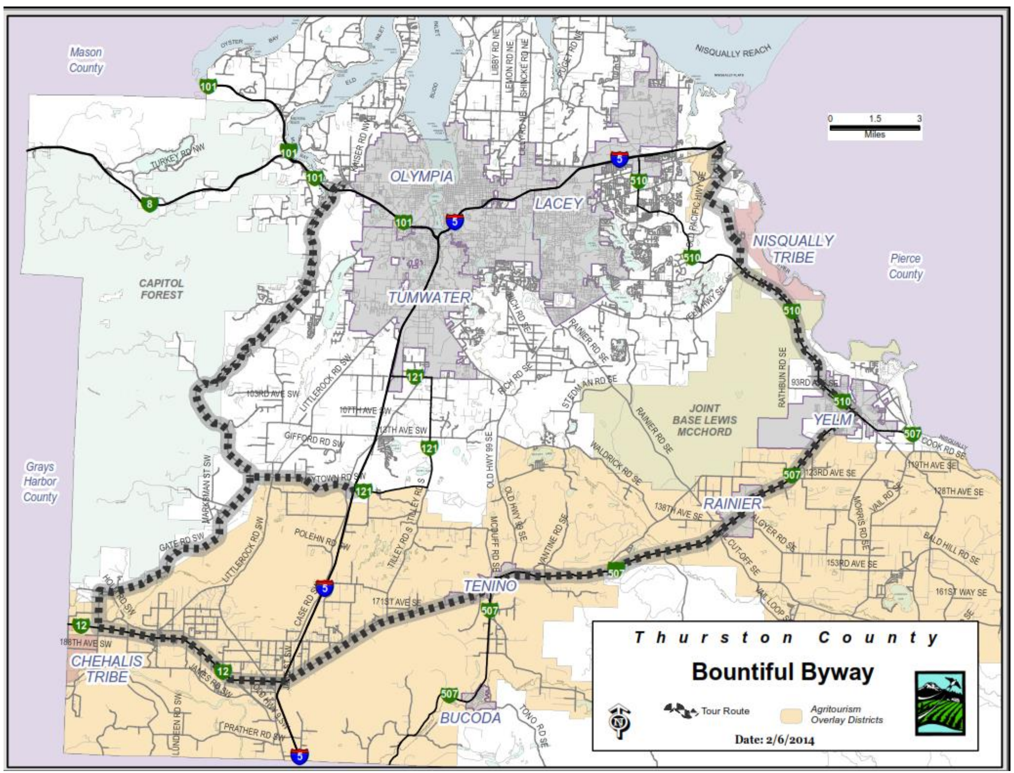


Figure 1. Map of the Thurston County Bountiful Byway (Thurston County, 2014)

The potential for conflict arises when, in the course of regular operations, dairy producers use nice, dry, sunny days to spread stored manure as fertilizer for feed crops. Some believe the best opportunity to address the odor conflict that results is through anaerobic digestion, which reduces odors and produces renewable biogas and other marketable products. Farmers can still get the nutrients for crops and make compost or other “bountiful” consumer products for visitors on the byway without also creating an atmosphere that is unpleasant for visitors.

Anaerobic digestion provides many valuable community benefits, starting with reductions of odors and pathogens commonly attributed to dairy manure management. In addition, community-scale digester projects support food waste recycling for nearby food processors, institutions, and resorts; reduce area greenhouse gas emissions; and produce renewable energy for project partners and biofertilizers for area farms.

During Phase 1 of this project, the Thurston County Commissioners' office convened a county-wide stakeholder group to study the feasibility of developing one or more anaerobic digesters to treat agricultural manures, solid waste materials, and other organics residuals in Thurston County. Broadly inclusive of local and tribal governments, state agencies, and private enterprise, this stakeholder group encouraged further study. This led to formation of the Anaerobic Digestion Technical Advisory Group (AD-TAG) with a group of county departments, the Evergreen State College, LOTT Clean Water Alliance, and Puget Sound Energy acting as sponsors. They invited the Washington State University (WSU) Energy Program to research and analyze the potential of anaerobic digesters to cost effectively address a range of local issues and produce economic and environmental benefits .

Completing this type of techno-economic feasibility analysis requires that potential project developers and interested stakeholders look at the big picture of a possible project, while also looking at individual puzzle pieces—how they fit together and the synergy that emerges when a project is fully implemented. Feasibility studies consider and narrow the broad range of different alternatives to a problem. They formalize decision-making processes, while addressing and mitigating possible risks. They identify any potential fatal flaws that could stop a project early on. Finally, they help to document the different analyses needed to secure project partners and potential capital investments or grant support.

Project Approach

Working in cooperation with the AD-TAG, the project team proceeded with three major activities:

- **Task 1**: Complete an inventory of organic materials that could be used as feedstock for a digester project. The inventory of organics residuals and resources considered manures (dairy and chicken) and food residuals from food processors, fish and seafood producers and breweries. The inventory estimated scraps from food service facilities, schools, and other campus-type facilities. It also considered fats, oils, and greases and other materials of interest to the LOTT Clean Water Alliance. Septage, however, was not studied during Phase 1.
- **Task 2**: Create and analyze the two basic models—single, farm-based and community-scale digesters—for potential projects in south Thurston County. This involved research into existing successful digester projects, combinations of feedstock materials, and potential locations. To assess potential opportunities, the project team explored and analyzed opportunities for significant power/fuel offsets, use of digested nutrients, environmental benefits, co-products development and use, workforce development, and other project co-benefits.
- **Task 3**: Engage with community members in south Thurston County, and meet with potential collaborators to identify possible mutual interests and any concerns. The team explored potential opportunities for partnerships. Prepare recommendations and a plan for the next phase of clean energy development in Thurston County was included as a project deliverable.

The project team met twice with the AD-TAG to provide key information and share conclusions. After concluding the study, the AD-TAG and project team shared the results of the study at a public meeting in May 2016.

Task 1: Feedstock Inventory: Materials and Sources

The feedstock evaluation conducted for this study inventoried various organics residuals available in Thurston County as potential feedstock for an AD project. The feedstock inventory evaluated different residual materials considering these criteria:

- Types
- Sources
- Quantity/volume
- Characteristics

Evaluating the variety of available feedstocks is important because co-digesting a mix of materials can increase the yield of biogas and contribute significant revenues (tipping fees) from taking in and processing waste residuals. Figure 2 shows the potential biogas yield from various types of organics residuals, some of which are available in Thurston County or surrounding areas.

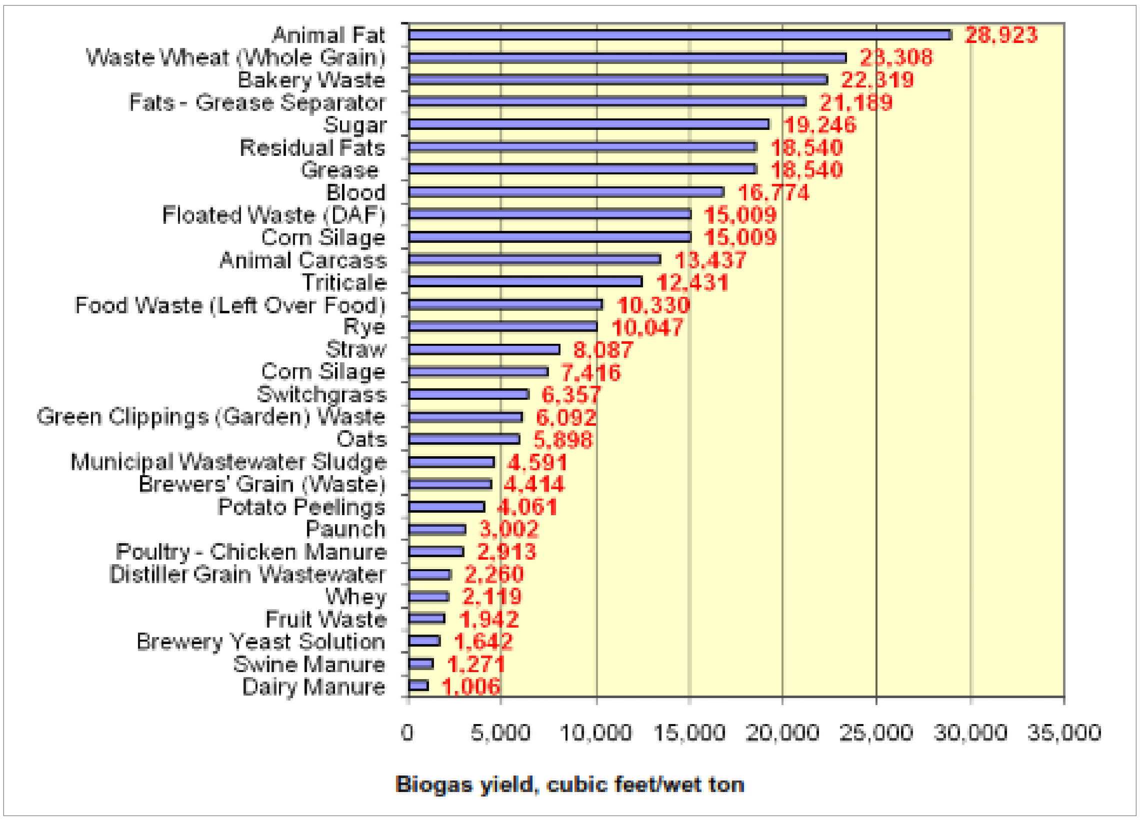


Figure 2. Biogas yield from a variety of organic feedstock materials (TetraTech, 2011)

Thurston County Dairies

The project team began by looking at available data about dairy farms in Thurston County. The concerns expressed about potential odors associated with using dairy manure nutrients as fertilizer on crop fields started the process of looking at AD as a possible solution. The team found 12 active dairy farms in the county. All are in south Thurston County, with most near Grand Mound and Rochester, west of Interstate 5. Of these, four dairies are considered large by industry standards, with more than 700 cows. The largest dairy, James Road Dairy, just south of Grand Mound, milks close to 1,500 cows. The total number of cows at all county dairies is close to 4,500. Though the project team could find no formal studies of the current cost of managing manure for the dairy producer, it has been informally estimated by a dairy industry professional to be as much as $0.50 per gallon.

Milk is the second largest agricultural commodity in Washington, contributing more than $1.6 billion in farm gate revenue to the state's dairy producers. Additional, indirect economic effects bring the overall impact to more than $3 billion. With 12 active dairies, Thurston County cows produce more than 12 million gallons of milk annually, with a combined value in 2014 of $20 million. Dairies support as many as 10 to 20 employees at each facility.

Reviewing various sources of data about manure production and characteristics, including the Washington Biomass Inventory, the project team estimates that at 14 gallons per day, Thurston County's 4,500 cows generate an estimated 92,000 tons of liquid manure and urine per year. At 8-12% solids, this is equal to 8,300-11,500 dry tons per year. The estimated methane yield from digesting all this manure would be 135,000 to 230,000 cubic feet per day (cfd).

The AD-TAG agreed that James Road Dairy (given its size and location near Grand Mound) could be a central location for hosting an AD project in this area. Other dairies along Scatter Creek and Moon Road could possibly host a digester or be connected via underground manure pipelines to a central digester project. The other two larger dairies in this area – Beaver Creek Dairy and Plowman Dairy – could also be host sites for digesters or could contribute to a larger community digester via short-truck hauls.

Through interviews with local dairy producers and other dairy industry stakeholders, additional observations were made about the local dairy community. These include:

- The original odor issue has subsided some with better management, but hauling raw manure along county roads and highways is still common in the area.
- Environmental pressures on manure management and storage and on spreading manure as fertilizer continue to grow.
- Nitrogen and phosphorus are conserved in anaerobic digesters, and pass through in more plant-available forms, requiring effective management of these nutrients after digestion.
- There is little contamination of manure by plastic or chemicals, though in some parts of the U.S., concern has been expressed about antibiotics in manures.
- Two Thurston dairies are co-located with creameries, producing yogurt and cheeses.
- The Darigold plant in Centralia is the major milk processor in the area.
- Low energy prices mean that end products from AD liquids and solids or environmental credits from AD become more important as revenue sources.

Poultry Farms

Three major poultry facilities are located in the south Puget Sound area. These include the Briarwood and Steibrs farms in south Thurston County, and Wilcox Farms in Pierce County. Potential digester feedstocks from these facilities are dry manure, wet manure, liquid egg waste, and mortalities. Talking with managers at these facilities, the project team made the following observations:

- Dry manure is likely too valuable as an existing organic fertilizer for crops to be available for a digester project.
- Wet manure collected separately in new cage-free facilities might be available and would significantly increase both biogas production and the creation of nutrients that require export from the host site. It is estimated that there is a minimum of 2,912 wet tons per year available from these local facilities.

- Liquid egg waste from cracked, spoiled, broken, or otherwise wasted eggs (with or without shells) could supply valuable feedstock. There is a minimum of 676 wet tons per year available.
- Mortalities require careful management. It was reported to project staff that poultry mortalities are currently rendered or cremated at significant expense. Some of this material may currently be transported out of Thurston County. It is estimated that a minimum of 1,700 tons per year of mortalities are disposed in this way.
- Recent cases of avian flu in various parts of the country have resulted in new and expanded efforts at biosecurity around layer facilities. This disease threat could require changes to any of these existing manure or mortality procedures in the future.
- Because of biosecurity concerns, these facilities would not make good locations for hosting a digester project.

Management costs were not shared with the project team. However, with the exception of dry chicken manure as fertilizer, each of these waste products likely has significant costs to manage and some recognizable value. Other observations about the local poultry industry include:

- Chicken manure has all 13 nutrients used by plants, and little known contamination
- Dry manure is valuable, and is currently sold as organic fertilizer
- Wet manure has good biogas potential, as does egg breakage waste
- Mortalities are a disposal problem, but very challenging for an AD project
- High nitrogen levels in poultry manure can be inhibitory to AD, so small amounts need to be combined with other feedstock materials
- Nitrogen and other nutrients pass through a digester, requiring active management

Organics from Municipal Solid Waste

Food residuals still make up a significant portion of the municipal solid waste (MSW) collection and processing system in Thurston County. The data provided in this section was gathered by Thurston County Solid Waste. If collected separately, food wastes with high liquid content can be processed into a manure-like slurry. However, most of these materials are currently collected in combination with yard debris and other pre- and post-consumer organics. This potential source of AD feedstock has a high potential for physical contamination and salts content.

Recovered organics from MSW currently cost $54 to $85 per ton to recycle into compost products. Potential sources of recovered organics as currently collected are shown in Figure 3:

- Residential = 18,495 tons/yr
  - Waste Connections Residential = 13,435 tons/yr
  - Olympia Residential = 5,060 tons/yr
- Commercial = 1,589 tons/yr
  - Waste Connections Commercial = 965 tons/yr
  - Olympia Commercial = 624 tons/yr
- WARC Self-Haul = 5,763 tons/yr
- Pick-Line Wood = 1,617 tons/yr

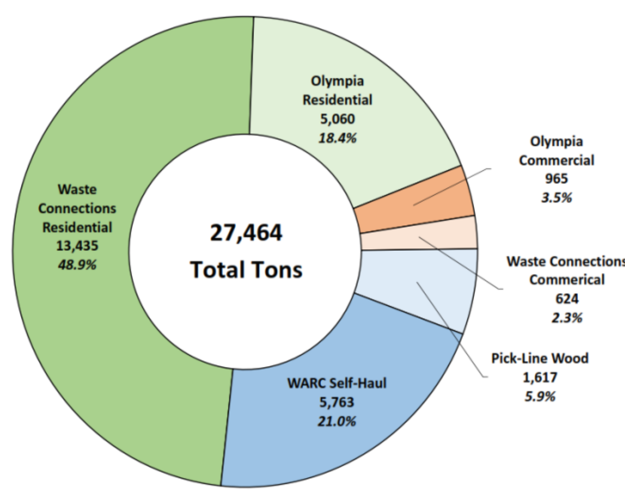


Figure 3: Sources of recovered organics from MSW

The distribution of organic materials currently recovered by the recycling system now is illustrated in Figure 4. It includes 17,051 tons/yr of separated organics (mostly yard and garden debris) that go to the Silver Springs composting facility. Material that contains more food waste or compostable paper is accepted and delivered to Royal Organics Composting (eastern Washington) or Lenz Composting (Stanwood, WA). They currently receive 1,790 tons/yr. The highly woody organics fraction is processed as mulch (1,999 tons/yr) or hog fuel (i.e., wood chips for boilers) (6,624 tons/yr).

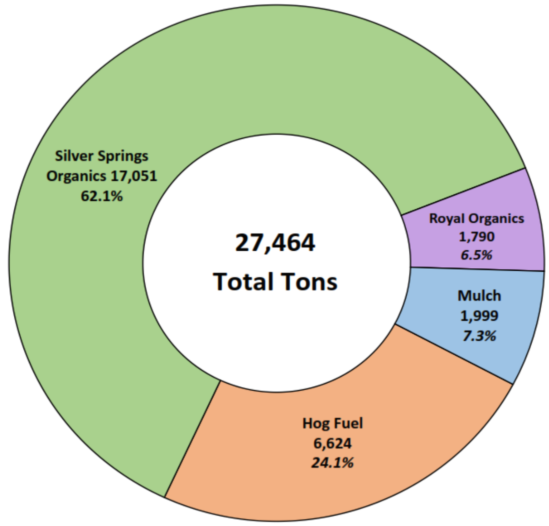


Figure 4. Distribution of organics for recycling

Costs for recycling these various organics residuals are as follows:

- Silver Spring Organics + mulch/hog fuel: ~$52-54/ton = $1.4 million/yr
- Organics to Lenz/Royal Organics: $85.00/ton = $152,150/yr

It is worth noting that, while the food-rich materials that go further distances for processing are higher in unit cost to process, they represent a smaller portion of the overall MSW cost. Processing any of these mixed materials in an AD project would be subject to a solid waste handling permit, and facility designs to mitigate odors or other impacts of handling such mixed materials (e.g., an enclosed receiving structure with odor controls).

Organics residuals that are not separated and collected for recycling but that go to the landfill could also be considered as a source of AD feedstock. These landfill organics total 52,660 tons/yr. Individual types of landfilled organics, illustrated in Figure 5, include:

- Yard waste, wood, and compostable paper = 25,830 tons/yr
- Food waste = 26,830 tons/yr, which is half of landfilled organics and approximately 16% of all disposed waste
  - Residential = 15,673 tons/yr
  - Commercial = 11,157 tons/yr

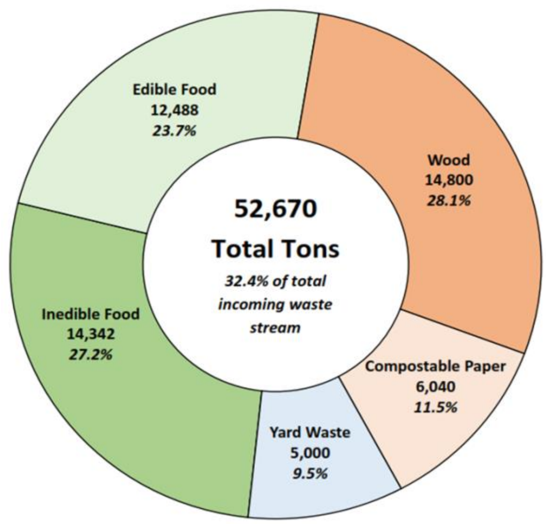


Figure 5. Organics residuals still landfilled

Commercial organics still being landfilled are particularly attractive to potential AD projects. Estimates from previous waste sorting studies indicate the commercial organics sector will contain large volumes of collectible easier-to-separate, pre-consumer food scraps from a fewer number of commercial locations. Pre-consumer vegetative produce wastes collected separately from grocery stores or big box stores like Costco, Fred Meyer, and Walmart are examples. Non-organic contamination from these sources could be easier to control, leading to more successful co-digestion.

Learn more about Thurston County's solid waste and recycling programs and data at their website: www.co.thurston.wa.us/solidwaste

Conversely, residential organics come in small volumes that are not easy to collect separately. To capture biogas from the organics waste stream as it is currently collected would require evaluating AD systems designed specific for these combinations of food scraps, grass clippings, garden debris, wood material, etc. They have much higher solids content and require more processing and handling, increasing sorting and handling costs. Although there are high-solids AD systems in use and development in cities around the U.S., the AD-TAG did not feel a high-solids system should be part of the evaluation at this time.

The project team did a tour and considered the opportunity to incorporate an AD facility at the Thurston Waste and Recovery Center (WARC). It does appear that the WARC has areas of solid ground that could accommodate an AD facility. However, the opportunity to blend digester gas with remaining landfill gas is dwindling as the production of landfill gas is falling quickly. Anaerobic digester development is not in anyone's current work plan. The preference for Thurston County solid waste officials currently leans toward greater diversion of organics residuals away from the WARC. For example, the organics recovery systems promoted by WISErg, a Washington-based company, are getting some interest from these and other solid waste managers who hope that the WISErg systems can keep more organics out of MSW streams. If a Thurston County community digester could also steer more organics residuals away from the WARC, this would be viewed as a positive development.

Industrial Food Processing Sources

This category of organics residuals focuses on the food processing sector. Food processing is a significant part of the Thurston County economy. According to the Washington Department of Agriculture, Thurston is among the top food processing counties in the state. Washington departments of Revenue and Employment Security data from 2012 puts the value of the food processing industry in Thurston County at $387 million and includes an estimated 567 jobs. This places Thurston County among the top counties statewide for revenue.

Interest by AD developers in this sector is strong because of the potential to receive single-source, easy-to-collect, pre-consumer vegetative materials that are relatively free of contaminants. They are also interested in liquid waste streams (e.g., dairy products, whey, brewery by-products, and off-date beverages, to name a few). These would likely be very compatible with most typical AD projects.

The industrial food processing industry is also a challenging sector for information about organics residuals. Solid waste professionals believe that many food processors are able to avoid the conventional solid waste handling system and the associated costs. Experience of the industry suggests these businesses have options for distributing their organics residuals for livestock feeding or land application as crop fertilizers.

Without a single source of data for food processors and challenged by the potential for overlap with commercial MSW routes, the project team developed an estimate of the potential volume of organics residuals in the industrial food processing sector. The team borrowed methodologies used by previous solid waste studies conducted in Massachusetts, New Jersey, Connecticut, and Portland, OR, among others. These earlier studies developed estimates of the food scrap potential of different types of businesses using standard industry classification codes. Food scrap estimates were expressed on a per-establishment or per-employee basis. Using available data from Washington's Department of Employment Security, the team was able to plot how Thurston County fared next to these previous studies. The results of the analysis are shown in Table 1.

In the specific food manufacturing sector, Thurston County data showed 21 establishments with 350 employees. It is estimated that these sources could generate 3,260 to 7,216 tpy of organics residuals. These food manufacturing establishments include:

- Fruit and vegetable food processing
- Animal and poultry slaughter
- Brewery waste
- Seafood and fish processing

There is some evidence of fish farming and seafood processing, but our research so far is inconclusive about the availability of these resources in Thurston County. Fish and seafood waste has a high biogas yield, and some existing farm digesters get seafood scraps from the region. This may still be a promising category as AD development proceeds.

Institutional Food Scrap Sources

Government and tribal institutions, hotels and resorts, hospitals, and large school campuses constitute another category of food scrap generation. They may have extensive organics separation and collection programs, often bolstered by zero waste goals. As performed with the industrial food industry, estimates of potential food scrap generation, including pre- and post-consumer scraps, was based on analysis of business industrial codes and employment data. In Thurston County, it is estimated that a minimum of 982 tpy is generated. The institutional source category may also generate horse manure, landscaping debris, and biosolids due to the nature of their individual activities. Potential for generating tipping fees could be high, as the competition for recycling or disposal at the WARC is relatively expensive.

One potential challenge of accepting organics from institutional facilities are the solid waste rules that exclude co-digestion substrates from any type of municipal solid waste source, that is, residential or commercial food scraps.

Commercial FOG

The organics category known as FOG (fats, oils, and greases), describes many different materials. FOG is considered brown grease, with high potential for physical and chemical contamination. The nutrient loading varies significantly, which presents processing challenges. Competition for FOG, which can also be used to produce biodiesel or other products, means there is competition for revenue and tip fees.

Figure 6. Grease trap waste collection (Oregon Oils, Inc.)

One of the more promising sources of FOG for AD projects may be grease trap waste (GTW), shown in Figure 6. Grease trap wastes have among the highest biogas yields per ton. Every restaurant or food service facility uses grease traps to keep drains and sewer pipes clear. They are emptied, depending on size, by commercial grease trap waste haulers. In Thurston County, restaurant grease traps are emptied by private, licensed haulers including Baker Commodities, Darling International, FloHawks, RotoRooter, Oregon Oils, AAA Champion, Envirotech Septic Solutions, JMS Septic Service, and Affordable Septic.

Table 1. Analysis of potential food residuals in industrial food sectors in Thurston County

					Massachusetts Study		Portland Study		New Jersey Study		Minnesota Study	
SIC	NAICs	Category	Number of Establishments*	Total Employment*	Food scraps tons/yr per establishment	Food Scraps TOTAL tons per year	Food scraps tons/yr per employee	Food Scraps TOTAL tons per year	Food scraps lbs/yr per employee	Food Scraps TOTAL tons per year	Food scraps lbs/yr per employee	Food Scraps TOTAL tons per year
20	311	Food Manufacturing	21	350							820	143.5
	3111	Animal food Manufacturing	0	0								
	3112	Grain & Oilseed Milling	0	0								
	3113	Sugar/Confectionary	*	*								
	3114	Fresh-Frozen-Dried, Fruit & Vegetable, Merchant Wholesalers, Canners	3	37	656	1,968	17.0	629.0				
	3115	Dairy Product Manufacturing	*	*			2.5	0.0				
	3116	Animal-Poultry Slaughter-Processing	3	81	656	1,968						
	3117	Seafood Product Preparation & Packaging	0	0			9.8	0.0				
	3118	Retail-Commercial Bakeries, Pasta, Tortillas	8	81								
	3119	Other Food Manufacturing	5	118	656	3,280	22.3	2,631.4				
20	312	Beverage and Tobacco Product Manufacturing	11	274							820	112.3
	3121	Beverage Manufacturing (includes breweries and distilleries)	11	274								
51	424	Merchant Wholesalers, Nondurable Goods	64	1,053							800	421.2
	4244	Food, Grocery & Related Product Wholesalers	23	530	147	3,381	6.2	3,291.3	3,000	795.0		
	4248	Beer and Wine Merchant Wholesalers	3	88								
	4249	Flower, Nursery Stock Wholesalers	17	162								
54	445	Food and Beverage Stores	107	2,170							2,500	2,712.5
	4451	Grocery Store/Supermarket/ Convenience Retail	64	1,683	222	14,208						
	4452	Specialty Foods: Meat, Seafood, Fruit-Veg, Baked Goods, Other Food Stores	29	251	43	1,247						
	4453	Beer, Wine, and Liquor Stores	14	236								
82	611	Educational Services	133	9,695							260	1,260.4
	6112	Community colleges	*	*								
	6113	Colleges and universities	14	1,285	242	3,388						
80	622	Hospitals	3	2,734							80	109.4
	6221	Hospitals, general	3	2,734	117	351						
	6222	Hospitals, cont.	0	0								
	6223	Hospitals, cont.	0	0								
80	623	Nursing and Residential care Facilities	89	2,023							80	80.9
	6231	Nursing homes	8	992	54	432						
	721	Accommodation	35	978								
	7211	Large Hotels & Casinos			61	2,135			1,500	733.5		
58	722	Food Services and Drinking Places	545	7,012							2,200	7,713.2
	7223	Food Service, Caterers, Mobile Food	25	212					2,200	233.2		
	7224	Drinking Places	30	226								
	7225	Full-Service Restaurants	490	6,574	51	24,990			3,000	9,861.0		
					TOTAL	57,348	TOTAL	6,551.7	TOTAL	11,622.7	TOTAL	12,553.4

SIC = Standard Industrial Classification
NAICs = North American Industrial Classification System
* includes both public and private establishments
** Screened for confidentiality

Sources:
Massachusetts: Draper/Lennon, Inc., 2002. *Identification, Characterization, and Mapping of Food Waste and Food Waste Generators in Massachusetts.* Massachusetts Department of Environmental Protection
Portland (Oregon): Martin Lott, et al., 2010. *Portland Metropolitan Industrial Food Waste Study Report*. Energy Trust of Oregon (adjusted for grocery)
New Jersey: Mercer, Arnold, 2013. *Assessment of Food Waste Generation in Mercer County, New Jersey*. Rutgers New Jersey Agricultural Experimental Station.
Minnesota: Foth Infrastructure & Environment, LLC., 2009. *Source Separated Organic Materials Anaerobic Digestion Feasibility Study*. Ramsey/Washington County Resource Recovery Project.

The project team understands that GTW may be included for consideration as a co-digestion feedstock within the 30% of outside substrates accepted while maintaining solid waste exempt status.

According to the frequently referenced study of FOG generation by National Renewable Energy Laboratory (NREL), Americans produce on average approximately 1.88 lbs of FOG/capita/year. Applying this same data for Thurston County residents provides an estimated generation of 230.47 tons/yr (Wiltse, 1998).

One additional item of potential interest is generated by the LOTT Clean Water Alliance. At LOTT, organics-rich scum material is collected from various pumping stations around the county, totaling an estimated 975 to 3,600 gallons per day (460,940 gal/yr wet, 117,000 gal/yr dewatered). The volume and characteristics are highly variable. As an AD feedstock this material would have a high potential for physical, chemical, and fecal contamination. This would cause significant impacts for permitting and nutrient loading potentials. The AD-TAG agreed to leave out further consideration of this material.

Learn more about different types of biomass resources through the Washington State Biomass Inventory.

Summary

All the potential AD feedstocks and sources, as determined by the project team, described above and listed in Table 2, include:

- Dairy: 12 farms (4 large), approx. 4,500 cows = 92,000 wet tons per year (tons/yr)
- Poultry: 3 area farms, liquid manure, egg breakage, and other residuals = 5,500 tons/yr
- Municipal solid waste (all organics at the WARC): 27,000 tons/yr recovered, 53,000 tons/yr landfilled—current food waste collected estimated 1,589 tons/yr; which could be enhance through greater collection efforts to about 5,578 tons/yr
- Industrial food processing scraps: estimated 3,000-7,000 tons/yr
- Fish/seafood: inconclusive
- Brewery residuals: estimated 200 tons/yr
- FOG: estimated 230 tons/yr
- LOTT scum: volumes vary; regulatory red flags

Table 2. Potential energy production from AD feedstock sources

MATERIALS	TONS/yr	METHANE (MMBTU/yr)	POWER (kWh/yr)	RNG - FUEL (GasGalEqv/yr)
Dairy manure	92,000	57,086	4,818,000	444,000
Poultry manure	2,912	5,232	441,000	41,000
Other poultry	2,376	19,692	1,662,000	153,000
Food-current collection	1,589	10,124	854,000	78,000
Food-enhanced collection	5,578	35,540	2,999,000	277,000
Food processing materials	3,260	20,771	1,753,000	162,000
Food scraps from campuses	982	6,257	582,000	49,000
Brewery residuals	200	545	46,000	4,000
Fats, oils, and greases	230	3,006	254,000	23,000

Task 2: Comparison of Conceptual Digester Models

Anaerobic Digestion Fundamentals

Anaerobic digestion is a form of decomposition, similar to composting. While composting is an aerobic process, anaerobic digestion occurs in the absence of oxygen. During the process, methane-producing bacteria convert decomposing organic materials into biogas—a mixture of methane, CO_2, and other trace gases.

Natural gas (“fossil methane”) is found in underground reserves formed millions of years ago. Biogas continues to form naturally in bogs and swamps (hence its common name, “swamp gas”). Biogas is also a natural by-product of burying organic materials in landfills or of keeping liquid manure in storage lagoons. Biogas produced from different sources will have varying concentrations of methane. Biogas is most often found to have between 50% to 65% methane, with corresponding energy values of 500 to 650 BTU per cubic foot.

Table 3. Aerobic vs. anaerobic decomposition

COMPOSTING	ANAEROBIC DIGESTION
Aerobic (Oxygen)	Anaerobic (No Oxygen)
Balance carbon and nitrogen Balance moisture Volume Time and temperature	Balance carbon and nitrogen Balance moisture Volume Time and temperature
Produces compost	Produces solid and liquid soil amendments
Emits carbon dioxide + trace gases	Produces biogas: methane (50-70%) + carbon dioxide (30-49%) + trace gases (1-2%)

In the last century, scientists and engineers found economic value in treating sewage wastewater solids through the same anaerobic digestion principles that produce biogas. More recently, engineered anaerobic digestion systems have begun to be used to convert a wider range of organic waste resources, including livestock manures (notably dairy and swine manures) and food processing wastes, into biogas and a range of valuable co-products.

Controlled anaerobic digestion is widely acknowledged to have a positive impact on reducing odors by 80% to 90% (Iversen and Davis, 1999). Catherine Keske, Colorado State University, explains that the digester “removes organics as it converts them to methane, while conserving nutrients (nitrogen and phosphorus). The end product is a low odor, high nutrient, stabilized waste suitable for land application as fertilizer.” She argues that anaerobic digestion could be an effective means to reduce the potential for nuisance lawsuits, “AD technology becomes economically feasible when agricultural producers are in a position to mitigate lawsuits that might otherwise result from odor and waste management” (Keske, 2012).

Anaerobic digestion systems have been proven to result in significant reductions of harmful bacteria found commonly in raw manure. This reduces the loading rate of harmful bacteria to agricultural lands (Kearney, et al., 1993). Recent research conducted by WSU finds that these pathogen reductions can persist even after subsequent storage and application of the digested materials. Their research report states: “AD treatment of manure and pre-consumer food wastes reduced bacteria (pathogens and indicator bacteria) in the liquid, solid, and composted solid fractions of post-AD manure….When surface water run-off was monitored from grass fields that had applications of AD or non-AD lagoon-origin manure, fewer surface water samples were positive for total coliforms from AD amended grass plots than from non-AD amended” (Harrison, 2011).

Although initial interest in anaerobic digestion may have been for managing municipal wastewater for odor control, health, and environmental safety, the similarity between biogas and natural gas was not lost on practitioners. As a result of experimentation and technological innovations, biogas has been used in the same ways one might use natural gas – to fire stoves, boilers, furnaces, engines, generators, and as transportation fuel.

Figure 7 shows a typical process flow for AD projects installed at nearly 250 farms around the U.S. (AgSTAR, 2016). The anaerobic digester receives manures and other organics residuals suitable to the mostly liquid environment of a farm-based digester. The digester produces biogas that can be converted into several different forms of useful energy. After digestion, the material that leaves the digester tank, also known as digestate, is commonly separated into solid and liquid fractions. The solid fraction contains significant amounts of fibrous material from the dairy feed, left unconverted either by the cow or the digester. The digested fiber is sometimes used as bedding for cows or other animals. It may also be composted or processed as peat moss replacements or as other value-added products. The liquid fraction contains soluble nutrients from the manure and other feedstocks fed into the digester. The liquid fraction can be applied as liquid fertilizer on crop lands or the nitrogen and phosphorus nutrients can be extracted into fertilizers that may be easier to export from the farm to end users.

The demand for, and the value of, renewable energy has gone up and down in recent years. Interest from dairy producers in developing AD projects has seen similar swings. The interest from dairy producers includes AD’s ability to reduce odors and pathogens in manures as social and environmental regulatory pressures continue. The value of green energy and other co-products also helps increase individual project feasibility.

As shown in Figure 8, Washington is home to eight dairy manure-based AD facilities. Roughly half of the projects involve some cooperation with or combined digestion of manures from more than one farm. Most of the existing projects co-digest additional pre-consumer organic substrates from food processors. The most recent digester became operational in 2012. No new digesters have been installed in Washington since then. This trend has been observed nationally as well, due in large part to the fall in electricity and fossil fuel prices.

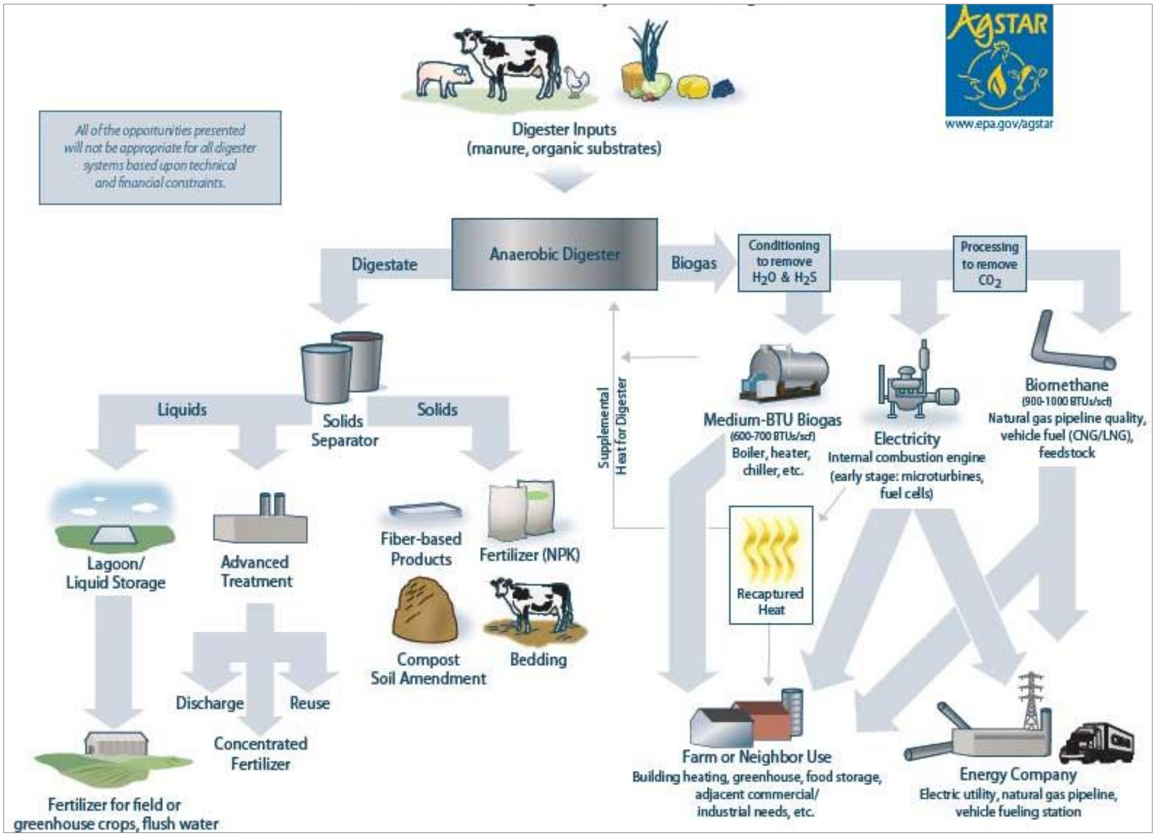


Figure 7. Basic anaerobic digestion system flow diagram (AgSTAR, 2016)

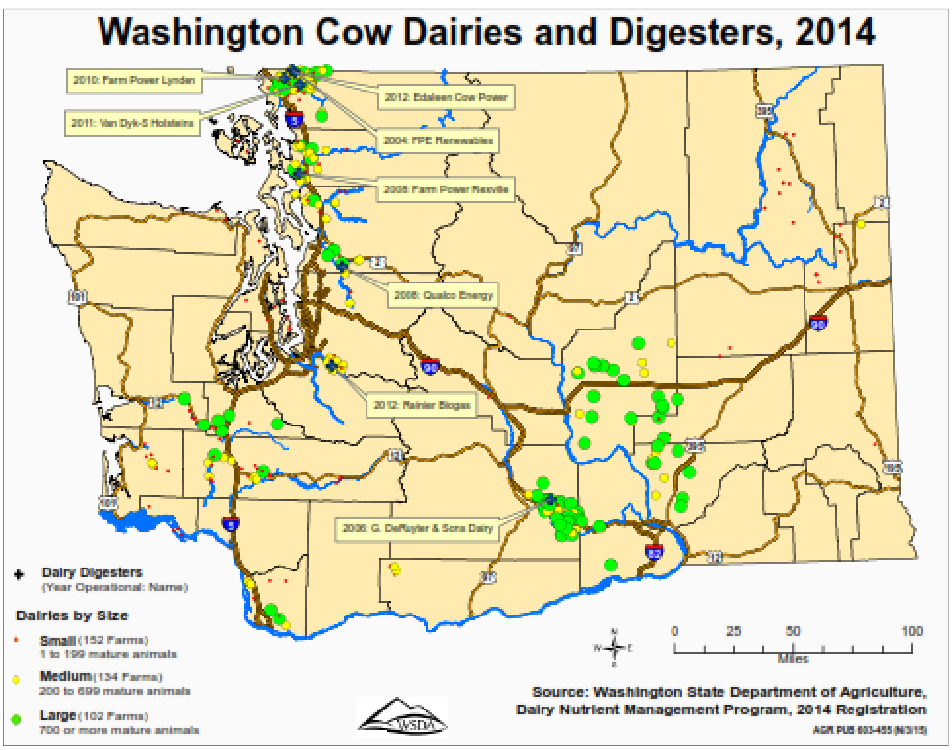


Figure 8. Farm-based AD projects in Washington (WSDA, 2014)

Markets for Digester Products

With businesses and consumers enjoying relatively low energy prices for electricity and fuels in Washington today, the potential for success in AD projects depends even more on gaining revenue from a variety of sources. In the next section, we look at various revenue streams and markets for products from a local AD project. AD projects can produce at least 10 potential revenue streams from:

1. Clean, renewable energy, for electricity, renewable natural gas (RNG), or transportation fuel;
2. Surplus heat from power production for digester heating, on-farm use, greenhouse or other uses;
3. Tipping fees for accepting and recycling organics residuals;
4. Digester effluent solids (fiber), suitable for bedding, compost, peat replacement, etc.;
5. Digester effluent liquids, suitable for land application as irrigation water and crop fertilizer;
6. Recovered nitrogen fertilizer;
7. Recovered phosphorus fertilizer;
8. Renewable energy credits (RECs) or fuel credits in the form of Renewable Identification Numbers (RINs);
9. Carbon offset credits, tradeable in voluntary or compliance markets and; and
10. Possible water quality and/or water quantity benefits or credits.

Energy Pathways

AD projects focusing on livestock manure have identified a variety of methods to get the most profitable benefit from the production of biogas (depicted in Figure 9). Biogas can be combusted directly in heaters, stoves, or boilers to provide useful thermal energy, or converted by various types of generators, turbines, or fuel cells into renewable heat and electricity (also known as Combined Heat and Power, or CHP). As renewable electricity, the green power can be used as an off-the-grid resource, but is more commonly added to the electricity grid through Power Purchase Agreements (PPAs) with local utilities. Through biogas upgrading steps, the methane contained in the biogas can also be separated from the CO_2 and other trace gases into a more pure form of biomethane or RNG. RNG may be injected into the natural gas grid pipeline system, or compressed or liquefied and used directly for transportation fuel, as at CNG filling stations.

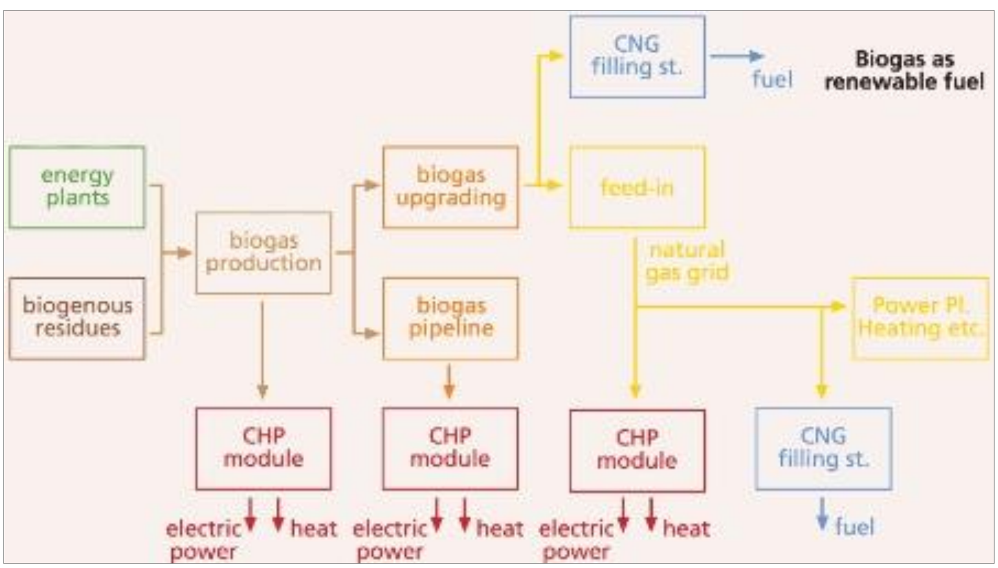


Figure 9. Energy pathways for biogas from digesters (Kabasci, 2009)

Each of these biogas energy pathways has its advantages and disadvantages. CHP generation of electricity is often thought of as the default use for digester biogas. A project developer can earn revenue for renewable electricity and still use heat recovered from the generator to keep the digester operating efficiently and for other valuable uses. As transportation fuel, biogas helps reduce dependence on fossil fuels and foreign sources of petroleum. Using it to replace gasoline or diesel provides additional air quality benefits, including reductions of particulate matter and other air pollution from vehicles.

The ultimate end use of the biogas from a digester has a major impact on the extent of upgrading or treatment given to the biogas. For example, boilers and CHP generators can use gas with lower BTU values (meaning more CO_2). The first step, after removing water vapor from biogas, is "desulfurization," that is, reducing the level of hydrogen sulfide (H_2S) to less than 1,000 parts per million (ppm). H_2S adversely impacts engine components regardless of engine type and burning without removal can increase air pollution. Siloxanes, a by-product of the use of health and beauty products, may be found in landfill, wastewater, and sometimes digester biogas. They are highly corrosive and require removal prior to use in engines or vehicles.

For RNG, the CO_2 must be removed. The methane percentage must be over 90% for most vehicles and over 99% for injection into natural gas pipelines. After this conditioning, RNG is compressed to appropriate pressure levels for fuel tanks or for pipeline injection.

Learn more about producing renewable heat and electricity using CHP systems through the **NW CHP Technical Assistance Partnership**.

Electricity Markets

Puget Sound Energy (PSE) is the local utility supplying electricity and natural gas for the south Thurston County area. PSE has been a strong partner with most of the existing AD projects at Washington dairies, including the Qualco CHP project (Figure 10). Adding renewable electricity onto the electrical grid in partnership with PSE is a well-developed process. The systems for making the grid interconnection have been tried and tested. PSE has established a standard offer contract for projects to connect to the grid.

Figure 10. CHP plant, Qualco digester project (WSU Energy Program)

The terms and payments of the PSE offer are reflected in Schedule 91 of its Electric Tariff, approved by the Washington Utilities and Transportation Commission (WUTC). For cogeneration and small power production, the current Schedule 91 offers prices ranging from \$61.19/MWh (2016) to \$88.62/MWh (2031) for biogas power. That is equivalent to \$0.062 to \$0.089/kWh. This offer price also reflects the value of the renewable energy credits that can be monetized from this power resource. The standard offer is updated each year with the initial price and subsequent annual values going up or down depending on current conditions. The values in the contract are fixed for a negotiated length of term. For project developers it is a bit of a gamble taking on the set values in the Schedule 91 during the year they are ready to build and commission their project.

Who produces the renewable electricity is another option for consideration. For the farm-based model this could be the dairy that hosts the digester and produces the biogas. It could also be a facility in the neighborhood of the farm that would benefit from both the clean power and surplus heat from CHP production. This facility would need to be within a short distance, easily reached by a low-pressure biogas pipeline. It would install the CHP unit and pay for the ongoing operation and maintenance. It would pay the farm a negotiated price for the biogas it uses. This is one way of establishing an effective partnership that spreads the costs and benefits of the project, while maintaining a level of separation and independence between the partners.

RNG Markets

Currently, RNG used as transportation fuel enjoys a potentially significant advantage over renewable electricity production. In addition to the value of the fuel, RNG used in vehicles earns renewable fuel credits that, depending on market conditions, have been even more valuable than the fuel itself. Like putting renewable electricity on the electrical grid, injecting RNG into the natural gas pipeline system has advantages for the AD project developer. Chief among them is opening the market for the RNG to a larger number of buyers connected by the pipeline system (Jensen, et al., 2011).

For consideration in Thurston County, electricity production may be more preferred by PSE than pipeline RNG. The natural gas pipelines maintained locally by PSE are distribution lines that supply gas directly to individual local customers. They are smaller and carry smaller volumes of gas than intrastate or branch gas lines. As a result, distribution lines are more at risk for impacts arising from mixing renewable gas with fossil natural gas. The impacts might include fluctuations in BTU content, and contaminants or trace gases, such as oxygen. The standards that would need to be met by an RNG project for the gas injected into a PSE distribution line have not been finalized or approved as yet by the WUTC.

AD project developers have other alternatives for distributing RNG for transportation. Constructing a compressed natural gas (CNG) fueling depot at an existing fuel station or on site at the digester facility makes compressed RNG available to a private fleet or to the public at large (see Figure 11). If this option is too remote or otherwise not convenient, the RNG can be compressed into tube trailers and delivered by truck to customers in the region. For a single, fixed customer, tube trailers of compressed RNG can be switched when empty to provide a constant supply for vehicle needs. This is a more expensive solution but may be necessary to capture the value of the renewable fuel credits.

Like electricity, the RNG fueling opportunity is one that can be operated and maintained by the digester facility or out-sourced to a neighbor or third party. One such company – Untapped Fuel – finances, builds, operates, and maintains the entire RNG fueling infrastructure. It pays the digester project for the biogas, collects the value of environmental fuel credits, and charges the fuel user a low fixed price for the fuel throughout the term of their RNG concession, after which time the facility is transferred to the digester project.

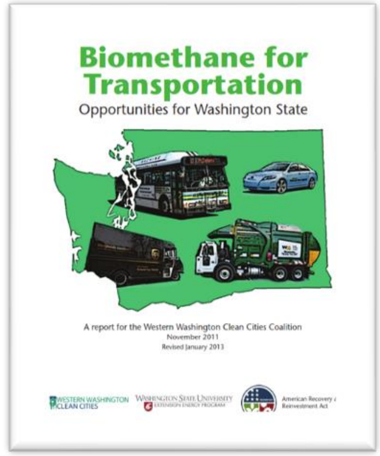
Figure 11. CNG fueling pump (WSU Energy Program)

Environmental Attributes

Renewable Energy Credits

Renewable energy credits (RECs) are tradeable instruments that monetize the environmental and social benefits of renewable electricity. One REC is equal to the benefits generated by production of one megawatt hour (1 MWh) of renewable electricity. In Washington, these credits are linked to the requirements of the state's Energy Independence Act (Initiative 937), passed by voters in 2006. The act requires electric utilities with more than 25,000 customers to use eligible renewable resources to meet set annual targets for renewable electricity.

Though the targets are increasing, significant investments in wind and solar energy have kept the demand for RECs in Washington lower than in other states. Power purchase agreements offered by utilities for dairy biogas electricity almost always include the value of all the RECs.



Learn more about biomethane for transportation in Washington state from the **market assessment** by Western Washington Clean Cities.

Renewable Fuel Credits (also knows as RINs)

Marketable credits for the production and sale of renewable fuels are generated through the federal renewable fuel standard (RFS), created by Congress in 2005 and updated in 2007. The new standard, known as RFS2, sets annual mandates for four types of alternative fuels: renewable fuel, advanced biofuel, biomass-based diesel, and cellulosic biofuel. The RFS2 mandates are adjusted annually.

The mechanism for monetizing the value of renewable fuels is through renewable identification numbers (RINs), which are generated for each unit of alternative fuel produced. RNG qualifies as either cellulosic biofuel or advanced biofuel under EPA's regulations. The value of RINs moves higher or lower as market conditions change. In the near term, RINs are proving to be a very valuable and attractive incentive for the use of biogas in transportation. The current RFS2 expires in 2022, which increases potential exposure for long-range planning or investment for the transportation fuel value.

Carbon Credits

Dairy-based anaerobic digestion projects also offer significant potential to earn revenue from agricultural greenhouse gas (GHG) reductions. Marketable carbon offset credits are generated by the verified reduction of methane from documented baseline emissions caused by storage of liquid dairy manure in open storage facilities or lagoons. The methane generated and captured by digesters and subsequently destroyed in engines or flares is matched against the baseline emissions to determine the volume of carbon credits generated.

Figure 12. Plug-flow digester at the Vander Haak Dairy (WSU Energy Program)

The Vander Haak digester project near Lynden, WA (Figure 12) was one of the first dairies to earn revenue for carbon credits issued by the Chicago Climate Exchange (CCX) in 2005. Though the CCX closed in 2010, Washington digesters are still likely to benefit most from existing voluntary or compliance-based carbon credit markets. Voluntary carbon markets are built on decisions by utilities, corporations, and other businesses to offset their carbon footprint impacts through the purchase of third-party verified carbon credits. The voluntary market includes non-profit and for-profit organizations that bring sellers and buyers together. The value of these offsets varies, depending on the appetites and budgets of the buyers.

The compliance market opportunity refers to cap-and-trade programs established by state governments to reduce GHG pollution. These are formal regulatory systems. The California cap-and-trade market, established by Assembly Bill 32 (AB 32) and administered by the California Air Resources Board (ARB), is a strong opportunity for Washington projects.

Among farm digester project developers, interest in the California market is guarded. Agricultural methane capture and destruction is one of just four approved offset categories. The demand for these offsets could become strong, and the rules allow projects from any state to participate. On the other hand, the up-front costs for monitoring equipment can be significant, with additional costs every year for verification and registration. These monitoring and transaction costs tend to favor projects with larger livestock numbers (1,500 or more milking cow equivalents) and farms that store all their manure in open lagoons.

Water Quality Credits

Ecosystem market trading programs involving water quality or quantity have been developed in various regions of the country, including areas around Chesapeake Bay and more locally the Willamette River watershed in Oregon. No similar programs exist in Washington at this time. However, programs by the Washington Department of Ecology and other agencies or groups to protect water resources vital to endangered or threatened fish or other wildlife may provide monetary support for benefits generated by digester projects in the future.

Tipping Fees

Tipping fees is a term derived historically from the act of tipping garbage into a landfill pit. Tipping fees describes the revenue earned by a waste or recycling facility for managing organic residuals received from outside parties. Tipping fees can apply to solid or liquid materials that are received for processing. Many of the digesters in Washington receive these outside substrates. They typically increase the generation of biogas, and they earn tipping fees. This process of co=digestion of manures with other substrates has successfully improved the economic viability of farm digesters. An economic analysis on a 700-cow dairy digester project concluded that co-digesting manure with 16% organic wastes more than doubled biogas production. The study conducted by WSU economists, found that co-digestion nearly quadrupled annual digester revenues compared to a manure-only baseline. In this case, 72% of all revenues could be attributable to the addition of organic wastes (Bishop and Shumway, 2009).

Digester Effluent Products

At the same time that development costs are rising, the value of biogas in energy markets is being challenged by the current downturn in natural gas and oil prices. In general, digester projects in the U.S. do not receive the same level of incentives as projects in Europe. Combined with lower revenue projections from biogas generated electric power or transportation fuel, these restrictions on revenue put greater emphasis on increasing value from other value added revenue streams created by digester projects.

As more livestock-based digester projects are developed and built by third-party developers, they increasingly use a whole systems approach, where individual product streams are managed for greatest profit by the operator. This approach holds the promise that what remains after digestion, the digestate effluent, will play a larger role in offsetting weaker performance in energy revenues.

Fiber Solids

The anaerobic digestion process itself adds value to dairy manure in several key ways. Anaerobic digestion reduces pathogenic contaminants, odor, and helps destroy weed seeds in manure. Digestion also reduces volatile solids, with the remaining solids yielding higher cellulose, hemicellulose, and lignin content. This makes for an even higher value-added fiber material (Jensen, et al., in review).

Dairies with anaerobic digestion systems – whether using manure only or co-digesting multiple feedstocks – will typically perform at least a basic level of separation of the digester effluent into liquid and solid fractions (Figure 13). This first level of nutrient separation produces a solids fraction that is moist and fibrous.

Figure 13. Post digestion: separated dairy manure solids (WSU Energy Program)

One common use of the AD fiber is as replacement for sawdust, straw, or other material for livestock bedding. One estimate of the value of AD fiber as a bedding replacement was completed by Informa Economics in a report to the Innovation Center for U.S. Dairy. It calculated values for several of the top dairy states based on the average costs for various bedding types and adjusting for regional differences. They estimated that the annual value of AD fiber as replacement bedding will vary from $53 per head in Washington to a high of $143 per head in Pennsylvania.

Another common method to add value to the separated AD fiber is through conventional composting methods – adding aeration under controlled conditions for sufficient time – to produce marketable compost. Composting stabilizes the carbon and other nutrients in the fiber material. It darkens the fiber, making it look more like soil, and reduces the volume and weight by evaporating some of the moisture, producing a product that is easier to handle and less expensive to transport. After composting, the darker, composted fiber is a desirable ingredient in blended nursery and garden soil mixes.

Because of its high fiber content, texture, and physical similarity with peat moss, the idea of using AD fiber as a direct replacement for peat moss in nursery and horticulture mixes took hold among some project developers. WSU was an early source of research and growth trials about this opportunity. They found that AD fiber, yielded material with consistent physical properties (total porosity, air filled porosity at saturation, and water holding capacity) to perform satisfactorily as horticulture media. Their growth trials showed that with minimal post-digestion treatment, AD fiber amended with gypsum and sulfur performed as a replacement in soilless mixes, producing fresh weight and greenness, as well as aerial and root systems, equal to peat (Jensen, et al., in review).

AD fiber as a high-value peat replacement has both a lower cost and environmental appeal. In North America, most horticultural peat is mined from ancient bogs in Canada. Consumer awareness regarding the adverse environmental impacts from peat mining is leading to demand for more sustainable alternatives.

Liquid Nutrients

The liquid fraction of digester effluent or digestate contains substantial quantities of nitrogen and phosphorus, which pass through the digester process. The co-digestion of additional outside substrates, typically increases the levels of these nutrients. To stay within agronomic application rates on croplands, the dairy producer or AD operator will need additional storage and additional acreage to use these nutrients effectively. Whether the operator uses these liquids on owned acreage or as a fertilizer service to neighboring acres is not a critical factor as long as the value received can cover the storage and application costs or earn a profit.

As the size of any single AD project grows, the option to find additional land for nutrient application becomes less practical. At the same time, the opportunity to invest in nutrient recovery systems, such as that shown in Figure 14, becomes more viable. Nutrient recovery typically occurs in stages, starting with separation of solids and liquids, followed by varying levels of nutrient recovery. The additional nutrient recovery systems often operate in series.

Figure 14. Nutrient recovery systems, Seebreeze Dairy, Delta, BC (WSU Energy Program)

The nutrients most valued for further separation include phosphorus and nitrogen. More options for separating phosphorus exist. Costs for phosphorus recovery start modestly and increase as the recovery of marketable phosphorus fertilizer improves. Recovery of nitrogen is costly from the start and increases with greater recovery. Recovered nitrogen is costly relative to the value of conventional nitrogen fertilizer in the marketplace.

In a report prepared for the Innovation Center for U.S. Dairy, WSU researchers provided the results of a technical-economic review of emerging nutrient recovery technologies for farm-based anaerobic digesters. They describe three clear combinations of systems deployed in ways to optimize or maximize nutrient recovery. These include the following levels of nutrient recovery action:

1. Advanced solids and P recovery, typically using a polymer type approach.
2. Solids and P recovery plus advanced N recovery.
3. Solids and P recovery plus membrane treatment for salts recovery and clean water.

According to the report, “Between the first and second levels, total recovery of N and P goes from 50-60% to 70-80%, but with a three to four-fold increase in combined operating and capital costs. This cost increase implies that without cost decreases or improvements in N product markets, this technology is currently applicable only to areas with severe N or ammonia concerns…. Between the second and third levels, total recovery of combined N/P increases to 95%, with additional recovery of salts plus clean water, but with an additional four to five fold increase in operating and capital costs…. If clean water and salt removal are not a priority, then an AD plus NR platform, via several different technical platforms is capable of: A combined N/P removal of approximately 50-80% at operating costs of $50-200 cow” (Ma, et al., 2013).

Markets for these recovered fertilizers will need to be developed in local areas. Working prior to project development with other local farmers, especially organic growers in south Thurston County, could help establish mutually beneficial end uses for common liquid nutrients or for these newly recovered phosphorus and nitrogen fertilizer products. Such cooperation would be a significant benefit to a local AD project.

Digester Models Studied for South Thurston County

After completing the feedstock inventory, the project team, in consultation with the AD-TAG, created two basic models of AD development to analyze for technical and economic feasibility. For the sake of this study, these two models are referred to as the farm-scale digester and community digester. While they both include livestock manure as key motivation and ingredients for digestion, one is modeled as a single-farm project located on the farm (farm-based model), while the other involves manure from multiple farms and may be located separate from a farm (community digester).

The elements of each model are described along with key input, output and economic parameters. Financial summaries for each model will guide community consideration of the pros and cons of each.

The model digester analyses (Excel-based) were developed by the project team using data and formulas from many existing resources, such as Extension resources, AgSTAR and other industry guides, feasibility studies for digesters around the country and interviews with industry professionals. See the Reference Materials for more details.

The project team also used existing AD analysis tools as resources. These included the following:

- **Co-Digestion Economic Analysis Tool (Co-EAT),** available from EPA Region 9
- **Iowa Biogas Assessment Model (IBAM),** available from the EcoEngineers and the state of Iowa
- **REL-Cost Financial Model,** available from the NW CHP Technical Assistance Partnership

Each of these tools has their advantages and limitations. The Co-EAT model was originally developed to consider the benefits and costs of adding food scrap residuals to existing waste water treatment digesters. The REL-Cost Financial Model is especially designed to evaluate the financial feasibility of a new project. Developed originally to evaluate new CHP, the tool has applicability for other projects also.

The results of the models prepared by the project team were compared with the results obtained by using Thurston County-specific data in the **Anaerobic Digester (AD) System Enterprise Budget Calculator**, developed by Gregory Astill at Washington State University. This tool is intended for use by dairy owners, AD system industry experts, and AD researchers to explore project-specific AD opportunities. Together these models and tools form the conclusions presented about a farm-based or community digester in Thurston County.

Model: Farm-Based Digester with Renewable Power

For the farm-scale AD model, the James Road Dairy, south of Grand Mound, was used as a proxy for dairy farms generally in south Thurston County. While it is the largest of the area dairies, its dairy methods and practices are similar to other area producers. Here are the elements of the farm-based AD concept:

- Single dairy farm location to supply manure and host the AD facility (James Rd Dairy)
- Co-digest pre-consumer food, up to 30% allowed under exemption from solid waste permitting
- Plug-flow or continuous mix digester system
- Renewable electricity, supplied to grid through a standard PSE power purchase
- Surplus heat used to heat digester, offset farm propane costs, and for other uses
- Liquid effluent containing digested nutrients applied to greater acreage
- Digested fiber solids used as bedding and/or sold as value-added product (e.g., peat replacement)

Figure 15 shows the location of James Road Dairy in relation to other interests in the area. The photos in Figure 16 show scenes from the James Road Dairy.

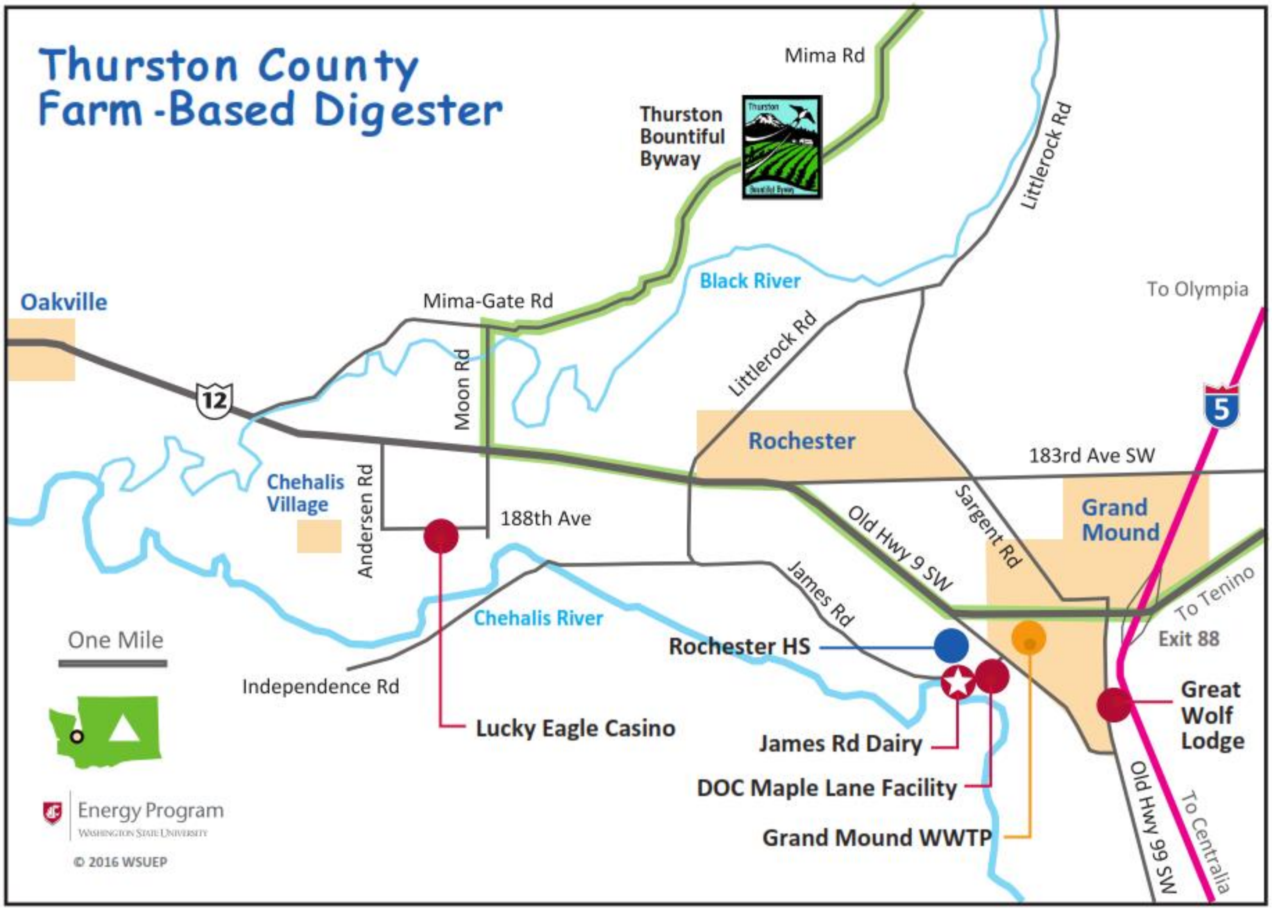


Figure 15. Area associated with a farm-based digester near Grand Mound, WA

Figure 16. James Road Dairy, owned and operated by Hank Doelman (WSU Energy Program)

The James Rd Dairy, owned and operated by Hank Doelman, was used as a kind of proxy in this analysis. The farm-based digester model and results would be relevant to other dairies in the area also.

The James Rd Dairy is located centrally among several vital community assets in south Thurston County. The dairy has a milking herd of approximately 1,500 Holsteins. Manure is currently stored on site in three lagoons and off-site in a 2-million gallon circular tank off of Moon Rd. The dairy currently owns or leases sufficient acreage for land-applying its dairy nutrients. The fuel costs for hauling manure to its offsite locations and to land-application sites are significant

As shown in Figure 15, the dairy shares a property line with the Dept. of Corrections Maple Lane facility. Once a juvenile detention facility and high school, Maple Lane is in a period of transition. In the next 5-10 years, Maple Lane may reopen as an adult facility capable of housing 1,000 inmates. In the past, Maple Lane has operated its own boiler facility. The design process for a new Maple Lane facility is in its early stages. State law requires new state-funded building projects to meet the Silver Standard under the Leadership in Energy and Environmental Design (LEED) Program (www.usgbc.org). No decision has been made about including renewable energy production or use into the facility development plans.

Each active Correctional facility generates pre- and post-consumer food waste and FOG. Estimated quantities range from 1 to 2 tons per day. At the existing Cedar Creek facility, in Littlerock, WA, Corrections operates a wastewater treatment facility, which produces low-grade biosolids. That facility also operates a rotating drum-style composting system for food waste materials separated in the dining facilities. The compost program is said to have additional capacity.

Sustainability goals have been established for the Dept. of Corrections, which has an extensive plan for making sustainability improvements at their facilities. For energy use, Corrections has a goal of keeping electricity demand to a maximum of 45 kWh per offender per day in minimum security settings, 60 kWh per offender per day in higher custody settings. Even at the lower demand rate, the biogas from a farm-based project would provide up to one-quarter to one-third of the electricity demand. More analysis would be required to determine how much of the thermal energy demand – hot water, laundry washing and drying, or district heating – could be met by a CHP project for the facility.

The Dept. of Corrections also has programs to provide sustainability-related activities and training to their inmates. These activity programs are known to include greenhouse production.

The people of the Confederated Tribes of the Chehalis Reservation have lived in the area around the Chehalis River for many centuries. Today, the tribe owns and operates the Eagle Creek Casino and the Eagle Landing Hotel. The tribe is also a major partner of the Great Wolf Lodge Resort located near I-5. The tribe has land holdings throughout the area. The Grand Mound Development Plan was completed by the tribe in 2009. It describes a plan to develop land and other resources in the area. As a digester project develops, coordinating with emerging development plans, such as a new hotel near I-5, Exit 88, is important.

The tribe's various hospitality and food service facilities would generate significant quantities of pre- and post-consumer food waste and FOG. The existing facilities already participate in some food waste diversion efforts. Estimated quantities range close to 1-2 tons per day.

While detailed energy use data was not easily available, it is clear that these facilities are significant consumers of electricity and other fuels. The Great Wolf Lodge consumes major quantities of natural gas, while the casino consumes significant amounts of propane.

The tribe operates a large fleet of buses and shuttle vans to serve their village and various properties and to bring guests to their properties. The tribe might benefit from energy efficiency assessments at their various facilities.

In addition to these major partners, Figure 15 shows the nearby location of the Grand Mound wastewater treatment plant. Thurston County provides water and sewer services in Grand Mound. It owns the Grand Mound wastewater treatment facility, which is operated by the County's Public Works Department. The elected Board of County Commissioners sets policy and approves the budget for the system. Anticipating future growth in the area, the facility has excess treatment capacity. The County's ownership of land and facilities for treating wastewater and its proximity to the potential anaerobic digestion opportunity must be noted.

Any of these potential partners could benefit from various aspects of an AD project. Their participation could be as a supplier of feedstock materials or as end user of the products of digestion or energy production. They might participate by providing space for digester or energy activities, or for some other end use activity. If the interests align, they might also contribute as an investor partner in some way.

For each of the models, a table showing the inputs-outputs, costs and revenues is provided. Table 4 shows the results of the farm-based digester model.

Model: Community Digester

A community-scale project would combine manure from multiple dairies (transported via truck or pipeline) and include other outside sources of organics residuals such as poultry manure and egg breakage waste, food processing scraps, FOG, and other organics residuals. It will be helpful to consider the costs-benefits of obtaining a solid waste handling permit to accept a broader selection of organics residuals than what is currently considered, in exchange for higher tipping fees. Other elements of a community digester project could include:

- A special-use permitted location at a dairy farm or an off-farm industrial location
- Likely developed as a multi-tank, continuous-flow digester system, with receiving tanks for the manures and other feedstocks
- Biogas converted to renewable, grid-connected electricity, using a CHP system; or treated and compressed for RNG transportation fuel
- Liquid effluent containing digested nutrients that can be applied to local farm acreage
- Separated fiber solids that may be used at dairies as bedding or sold as value-added products
- Advanced recovery of nitrogen and phosphorus as biofertilizer products for regional markets

Figure 17 shows the locations of area dairy farms and egg farms in relation to the other community interests in south Thurston County.

Table 4. Model: farm-based digester with renewable electricity

Inputs	Manure (from 1 dairy farm) - 1,500 cows	30,000+	tons/yr	
	Pre-consumer food residuals - Up to 30% vol	10,000+	tons/yr	
	• 27 tons/day			
	• 3-4 truckloads			
	Digester volume (21 days retention)	1.25 million	gallons	
Outputs & Revenues	Biogas production	142,200	cu. feet/dy	
	Electricity (700kW genset)	4,687,000	kWh/yr	$333,000
	Renewable Energy Credits (RECs)	4,687	credits/yr	
	Surplus heat propane offset	6,000	gal/yr	$9,000
	Tipping fees	11,000	tons/yr	$271,000
	Nutrients: nitrogen fertilizer	317	tons/yr	$54,000 (nitrogen and phosphorus combined)
	Nutrients: phosphorus fertilizer	62	tons/yr	
	Digested fiber solids (composted)	8,213	cu. yards/yr	$53,000
	Carbon credits	5,250	credits/yr	$55,000
	WA renewable energy rebate			$5,000
				$780,000
CAPEX*	Digester system ($2.09 million)			
	Power systems ($1.62 million)			**$3.71 million**
OPEX*	Digester ($75,000)			
	Power system ($117,000)			
	Other ($159,000)			**$351,000**
Financial Summary	Earnings: EBITDA*		annual	**$429,000**
	10-Year NPV* (4%)		10 years	**-$231,000**
	10-Year IRR*		10 years	**2.73%**
	20-Year NPV (4%)		20 years	**$2,121,582**
	Adjustments:			
	Production tax credit incentives		per year	>$100,000
	Potential grants		total	>$1 million
	Simple payback		years	8.65
	Grant-supported payback		years	3.72

** CAPEX = Capital Expenses; OPEX = Annual Operation & Maintenance; EBITDA = Earnings before interest, taxes, depreciation, and amortization; NPV = Net Present Value; IRR = Internal Rate of Return*

The model presents a kind of hard case scenario. Payback, NPV and IRR will all improve with the addition of grants or incentives that bring down the capital cost. Similarly, extending the length of the project (many digesters may have a life closer to 15 or 20 years) will improve the rate of return and long-term profitability.

As shown in Figure 17, the opportunities to involve more of the community in this scale digester improve significantly. In addition to the James Rd Dairy, Dept. of Corrections, and the Chehalis Tribe, the additional dairy farms in the area and the egg farms at Briarwood and Stiebrs could provide substantial feedstock to the area. Local food processors, seafood processors, and grocery supermarkets from Olympia to Centralia, plus commercial collectors of FOG, could play important roles.

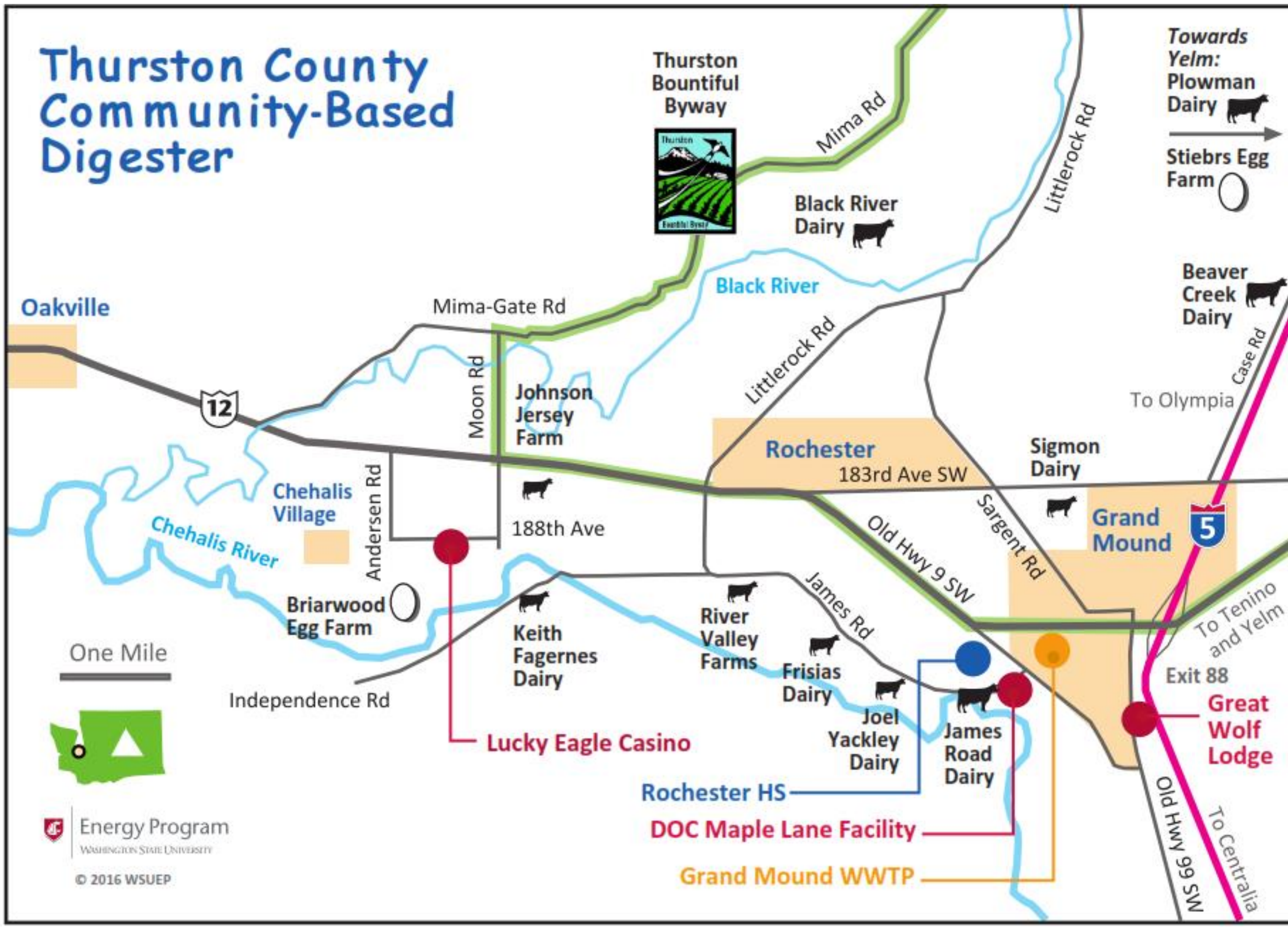


Figure 17. Area associated with a community digester project in south Thurston County

Two Options for Community-Scale Energy Conversion

The default concept for the community digester is for renewable electric power production through a CHP system. The total energy development includes biogas to CHP and surplus thermal heat. The alternative energy conversion model is for RNG fuel (such as the facility shown in Figure 18). Here it can be used for transportation, especially for project-related manure hauling or substrate needs, and for local shuttle fleet services. The total energy picture for this model might also include creating two valuable gas resources (methane for energy and CO_2 for greenhouses or other uses).

Figure 18. Biogas treatment towers produce RNG, Seebreeze Dairy, Delta, BC (WSU Energy Program)

Table 5 presents data to compare the opportunities and choices available. Table 6 and Table 7 present data to evaluate the feasibility of a community digester for renewable electricity and renewable fuel production.

Table 5. Compare elements of renewable power versus renewable fuel

Renewable Power (CHP)	Renewable Fuel (RNG)
• More than a decade of Washington experience • Competing solar and wind coming on the grid • Tied to utility for grid access, standard power purchase agreement • Low efficiency without uses for heat • Preference in federal USDA grants • Production or incentive tax credits apply to renewable electricity • I-937 credit and bonus (<5MW), wrapped into power purchase	• Still need to heat digesters • Direct use offsets retail cost purchases • Require new or retrofitted natural gas vehicles • Pipeline = flexibility of markets • Higher efficiency of natural gas equipment/vehicles • Left out of federal USDA grants • Fuel credit = $0.50/GGE • Infrastructure incentives available • Can generate renewable fuel and carbon credits

Table 6. Community digester for renewable electricity

Inputs	Manure (from multiple dairy farms) – 3,525 cows	80,000+	tons/yr	
	Pre-consumer food residuals – up to 30% vol	25,000+	tons/yr	
	• 70 tons/day			
	• 6-8 truckloads			
	Digester volume (21 days retention)	3.0 million	gallons	
Outputs & Revenues	Methane production (94.8 cf/cow, 60% CH_4)	334,170	cf/dy	
	Electricity (1,800 kW genset)	11,630,826	kWh/yr	} $825,000
	Renewable Energy Credits (RECs)	11,630	credits/yr	
	Surplus heat propane offset		MMBTU/yr	51,000
	Tipping fees ($0.05/gal)	~25,000	tons/yr	$637,000
	Effluent fertilizer ($0.01/gal)	12.7 million	gal/yr	} $573,000
	Recovered nitrogen fertilizer	1,499	tons/yr	
	Recovered phosphorus fertilizer	3,385	tons/yr	
	Digested fiber solids (composted) ($3-$10/cy)	19,299	cu. yards/yr	$125,000
	Carbon credits (3/cow @ $10.50)	8,813	credits/yr	$111,000
	WA renewable energy rebate			$5,000
				$2.33 million
CAPEX*	Digester system ($5.86 million)			
	Power systems ($2.90 million)			**$8.76 million**
OPEX*	Digester ($193,000)			
	Power system ($351,000)			
	Nutrient management ($757,000)			
	Other ($270,000)			**$1.57 million**
Financial Summary	Earnings: EBITDA*		Annual	**$756,000**
	10-Year NPV* (4%)		10 years	**-$2.63 million**
	10-Year IRR*		10 years	**-2.59%**
	20-Year NPV (4%)		20 years	**$1.52 million**
	Adjustments:			
	Production tax credit incentives		per year	>$100,000
	Potential grants		total	>$1 million
	Simple payback		years	11.6
	Grant-supported payback		years	6.5

** CAPEX = Capital Expenses; OPEX = Annual Operation & Maintenance; EBITDA = Earnings before interest, taxes, depreciation, and amortization; NPV = Net Present Value; IRR = Internal Rate of Return*

Table 7. Community digester for renewable fuel

Inputs	Manure (from multiple dairy farms) – 3,525 cows Pre-consumer food residuals – up to 30% vol • 71 tons/day • 6-8 truckloads Digester volume (21 days retention)	80,000+ 25,000+ 3.0 million	tons/yr tons/yr gallons	
Outputs & Revenues	Methane production (94.8 cf/cow, 60% CH_4) Renewable fuel ($2.00/DGE) Renewable Fuel Credits (RINs) ($0.75/RIN) Tipping fees ($0.05/gal) Effluent fertilizer ($0.01/gal) Recovered nitrogen fertilizer Recovered phosphorus fertilizer Digested fiber solids (composted) ($3-$10/cy) Carbon credits (2.5/cow @ $10.50) WA renewable energy rebate	334,170 799,534 1.34 mil ~25,000 12.7 mil 1,499 3,385 19,299 8,813	cf/dy DGEs/yr RINs/yr tons/yr gal/yr tons/yr tons/yr cu. yards/yr credits/yr	 $1,599,000 $1,008,000 $637,000 $573,000 $125,000 $88,000 $5,000 **$4.04 million**
CAPEX*	Digester system ($5.86 million) Power systems ($3.65 million)			**$9.51 million**
OPEX*	Digester ($293,000) RNG fuel system ($256,000) Nutrient management ($757,000) Other ($758,000)			**$2.23 million**
Financial Summary	Earnings: EBITDA* 10-Year NPV* (4%) (RINs constant) 10-Year IRR* (RINs constant) 10-Year NPV (4%) (RINs expire 2022) 10-Year IRR (RINs expire 2022) *Adjustments:* Renewable fuel incentives Potential grants Simple payback Grant-supported payback		annual 10 years 10 years 10 years 10 years per year total years years	**$1.80 million** **$5.12 million** **13.73%** **$1.43 million** 7.56% >$100,000 >$0.5 million 5.3 4.7

** CAPEX = Capital Expenses; OPEX = Annual Operation & Maintenance; EBITDA = Earnings before interest, taxes, depreciation, and amortization; NPV = Net Present Value; IRR = Internal Rate of Return*

Again the models present hard case scenarios. Payback, NPV and IRR will all improve with the addition of grants or incentives that bring down the capital cost. Extending the length of the project (many digesters may have a life cycle closer to 15 or 20 years) improves the rate of return and long-term profitability of either of these examples.

Task 3: Community Involvement

The feasibility of AD projects goes beyond technical and economic factors. An important element of feasibility can be found in the communities surrounding the project. Will the project be welcomed? Are there stakeholders in the community that could find sufficient mutual benefit to become a partner or investor in the project?

In addition to these potential partners discussed with the AD-TAG and in the sections on digester model development, the project team developed a list of other potential stakeholders that might have some interest in the development of AD resources or that could contribute in some way to a successful AD project. The project team maintained a detailed e-mail contact list. The list of stakeholders included:

- Colleges and schools
- LOTT Clean Water Alliance
- Water Resources Program and floodplain management – Department of Ecology
- Cities of Grand Mound and Rochester
- Thurston Conservation District (nutrient management)
- EPA – Region 10
- Thurston Economic Development
- Lewis Economic Development
- Thurston Agritourism Zone
- WA State Dairy Federation
- Puget Sound Energy (green power partner)
- TransAlta & Centralia Coal Transition
- Carbon credit partner (e.g., The Climate Trust, ClimeCo, Native Energy)
- Local organic farm producers
- Local breweries
- Local dairy and food processors
- Greenhouse agriculture
- Local fish farming
- Weyerhaeuser nurseries

To generate interest and gather information from stakeholders the project team in cooperation with the AD-TAG conducted stakeholder meetings open to the public. The project team also gathered information and data about a wide range of community interests and did targeted interviews and phone conferences with members of the community and other stakeholders.

Community Benefits

The larger community can expect many benefits from anaerobic digester project development, not least of which would be much improved management of dairy manure resources. Raw manure will be contained in the digester and stored manure will have been treated to control pathogens and odors. This can protect water resources in the case of major flood events as well as generally during the growing season when dairy nutrients are applied as fertilizers.

The clean, renewable energy produced by a digester development would be enough to supply electricity for 900 to 2,000 Washington homes or fuel for more than 1,700 cars. The greenhouse gas reductions from controlling methane and producing green energy would be like removing 2,000 cars from the road.

One could also expect significant economic activity from moving forward on a digester project. This would include jobs in construction and 1 to 10 permanent jobs, depending on the scope and scale of the project. Additional economic activity can be expected from keeping energy and resource dollars close to home whether that comes from purchasing renewable fuels or from purchasing locally available soil amendments or biofertilizers.

Agritourism along the Bountiful Byway can be enhanced by a new, exciting destination with a unique draw and valuable educational opportunities. The project can be expected to protect the existing local dairy economy and even give support to enhancements in terms of milk and dairy processing opportunities. New ag ventures could partner with the project in the development of new products and by using the clean electricity, heat, or fuel in ag or food processing ventures or by using the CO_2 from the project in greenhouse production.

A community AD could also enhance community resilience as a large renewable energy production facility that operates 24/7, is near I-5, and close to Great Wolf Lodge.

Figure 19. Groundbreaking ceremony at Rainier digester project, King County (WSU Energy Program)

To achieve its own groundbreaking in the future, a successful AD development will strive to provide broad-based benefits to the larger community while focusing on the specific opportunities that align most closely with the financial requirements and goals of the project partners.

Phase 2: Recommendations and Next Steps

All of the work described in this report was completed as part of Phase 1. The success of the three Phase 1 tasks encouraged Thurston County stakeholders to continue toward development of an AD project.

With the support of the WSU Energy Program, potential activities for Phase 2 have been identified:

1. Continued location and site analyses, especially if a community digester is located on a site separate from a dairy farm
2. More detailed engineering plans and project budgets based on a preferred site
3. Market analyses of potential value-added end uses of the digester products, such as greenhouse production using project thermal energy, CO_2, and high-value biofertilizers
4. Solidify relationships with key targeted project partners, as well as other community partners
5. Prepare the enterprise business plan
6. Clarify the permitting and construction timelines
7. Identify public and private project financing options

Leadership for Phase 2 will continue to be provided by:

- Thurston County Commissioners
- Thurston County Sustainability and Economic Development Office
- WSU Energy Program
- The Evergreen State College
- The AD Technical Assistance Group, which includes:
    - Thurston County Solid Waste
    - Thurston County Water Resources
    - LOTT Clean Water Alliance
    - Puget Sound Energy
    - The Evergreen State College

Collaborators and supporters that might provide additional support include:

- Thurston Conservation District
- Chehalis Tribe
- WA Dept. of Commerce
- WA State Dept. of Agriculture
- EPA Region 10
- USDA Rural Development
- Washington State Dairy Federation

Refine Project Plan and Select Approach

The feasibility of an AD project depends on site-specific factors that influence the amount and quality of biogas generated, variability in electricity prices, availability of incentives, and financing rates. In Phase 2 of project planning, the team will evaluate several versions of project plans and refine assumptions until the best possible AD project for south Thurston County is identified.

Some of the key ways to improve project economics at this stage include:

- Increasing income from electricity sales (e.g., tariffs for biogas) or other types of energy sales
- Getting direct financial assistance for feasibility studies and/or up-front costs
- Using creative financing mechanisms such as tax credits and low interest program investment loans

- Seeking additional revenue-generating options (e.g., finding additional uses for on-farm heat, accepting off-farm wastes for tipping fees, and concentrating nutrients for fertilizer products
- Implementing different business models, such as third-party build/own/operate models

Figure 20. Aerial view of the JC Biomethane digester project (Oregon Dept. of Energy)

Another opportunity for community members of south Thurston County is to consider AD development as part of a broader conversation about energy efficiency and renewable energy development in the area. Seek funding to do more ongoing clean energy development in the area. For example, conduct energy efficiency analyses of the communities, businesses, and institutions in south Thurston County, including Chehalis Village. Look for additional renewable energy opportunities, especially community solar projects. Such a project could incorporate energy issues into education and workforce training in south Thurston County. Provide energy efficiency and renewable energy technical assistance as a component of economic development throughout the Bountiful Byway.

One excellent opportunity to generate more community engagement around clean energy in general and for an AD project specifically would be to conduct one or more workshops on energy issues in south Thurston County (perhaps at Great Wolf Lodge).

Policy Drivers

A number of additional policy issues and directives could have a positive effect on the development of AD projects in the coming years. See the following list for policy drivers currently affecting the scope and viability of AD projects in Washington state:

- WA renewable energy (I-937) – targets for renewables continue to grow
- WA clean air/carbon plans – dairy digesters will be an offset opportunity
- EPA renewable fuel standard – special credits for biogas as transport fuel
- WUTC developing rules for PSE transporting biogas in their pipelines
- California carbon market and clean fuel standard
- Landfill costs and regulations
- Organic waste disposal bans
- Renewable energy portfolio standards
- Standard offer power purchase agreements
- Feed-in tariffs for utilities
- Other energy policies
- Agricultural and land use policies
- Economic development policies
- Taxation related policies

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APPENDIX: Additional Supporting Information

Funding, Finance, Grants, and Incentives

An AD project developed for south Thurston County will require an owner. The study presumes the owner will not be the county government, but that the county may play a significant role in other ways. The project owner could be the participating dairy farm, especially for the farm-based model project. The owner could be a consortium of partners from the area. Qualco Energy, one of the successful dairy-based digesters currently operating in Washington, is a partnership of local dairy interests (Sno/Sky Agricultural Alliance) with the Tulalip Tribes, and Northwest Chinook Recovery, a Puget Sound salmon organization.

While this study considered a single owner for simplicity, many different ownership models (e.g., partnerships, joint ventures, etc.) could lead to successful development. Independent, third-party development of the digester project is another model that has worked in Washington. Farm Power NW owns and operates three digester projects in Washington (i.e., Rexville, Lynden, and Rainier). Each project operates independently on behalf of groups of dairy producers. The JC Biomethane project near Eugene, OR, is an independent, merchant digester serving a diverse set of customers from those who supply the organic residual feedstocks to those who purchase the energy and other products or benefits of the AD project. Joint ventures have been created whereby one entity focuses attention on operating the digester and handling manure inputs and outputs and another entity focuses on producing and selling the renewable energy resource. This has worked for projects making renewable power as well as RNG fuel.

As will be noted, because a number of the significant incentives available from federal departments include tax credit opportunities, having a partner or equity stakeholder that can fully use the benefits of such tax incentives is worth consideration.

AD project financing is a creative endeavor. The ratio of equity to debt will be arrived at as part of the development process and in response to requirements set by lenders and others. For equity, AD projects can be good investments for their participating partners. The benefits to their businesses can be very important. Find additional funders with a strategic reason to be involved, e.g., lenders with existing relationships to project partners or potential stakeholders in the project who can lend money or make investments.

An AD project can also be valuable to private investors, especially impact investors who emphasize societal benefits as well as personal financial benefits in their investment choices. AD project often have good background stories with lots of potential for community benefits – big upsides – that attract impact investor interest.

Loans to cover capital costs for the AD project can be obtained through conventional channels or from any of a number of public low interest or favorable term programs. Regional banks are a natural fit for the size and types of projects involved in AD.

Loan Programs

In the public sector, here are three government loan support programs of note:

Business and Industry Guaranteed Loans, U.S. Dept. of Agriculture, Rural Energy for America Program (REAP)

Guarantees are available for loans for capital acquisitions and improvements for up to 75% of loans. The maximum amount of federal assistance is $25 million. The eligible costs are detailed in the REAP program announcements, but can include working capital and land acquisition, with some restrictions. If applicants are also asking for or receiving a REAP grant or other federal grant plus a guaranteed loan, they may only combine federal money up to 75% of the total eligible project cost.

Contact: Randy Baird, USDA Rural Development, 1606 Perry Street, Suite D, Yakima, WA 98902-5798; 509-454-5743; randy.baird@wa.usda.gov

Sustainable Energy Trust Lending Program, Washington State Housing Finance Commission
WSHFC is now providing direct loans to eligible energy projects, including anaerobic digesters. Loan amounts are up to $500,000. Terms are generally limited to 10 years and the terms and rates get more favorable for speedier repayment.

Contact: Juliana Williams, WSHFC, Seattle, WA; 206-254-5359; juliana.williams@wshfc.org; or
David Clifton, WSHFC, Seattle, WA; 206-287-4407; david.clifton@wshfc.org

Clean Energy Fund Program, Washington State Department of Commerce
The Dept. of Commerce has a couple of Clean Energy Funds, which can supply loans for clean tech projects. The loans are coordinated through conventional banks. The terms are not necessarily low-interest, but the state's participation can make the conventional lender more willing to grant loans to such renewable energy projects.

State Tax Incentives

Washington State provides a couple incentives that help those financing AD projects. They include:

Renewable Energy Sales and Use Tax Exemption
The sales of equipment used to generate electricity using fuel cells, wind, sun, biomass energy, tidal or wave energy, geothermal, anaerobic digestion or landfill gas is eligible for a 75% exemption from sales tax. The tax exemption applies to labor and services related to the installation of the equipment, as well as to the sale of equipment and machinery. Purchasers of the systems listed above may claim an exemption in the form of a remittance. Eligible projects use at least half of the AD feedstock is livestock manure. See the Dept. of Revenue's information and instructions for details, as some industry observers might see what constitutes a "digester" differently.

Renewable Energy Cost Recovery Incentive Payment
This is an investment cost recovery incentive based on the energy produced from solar, wind, or biogas power. Producers of grid power from digesters may be eligible for .15¢/ kWh incentive payments of up to $5,000/year from their intertied utility. Incentive payments are currently scheduled to expire on June 30, 2020.

Federal Tax Incentives

Federal government tax incentives for renewable energy projects can be generous, but they seem to come and go year after year.

Renewable Electricity Production and Investment tax credits
The Production Tax Credit program provides a credit against federal tax obligations. It is calculated annually for production of renewable electricity based on the type of renewable resource. Biogas projects are typically called "open loop biomass" or "trash" energy facilities.
At the end of 2015, Congress reauthorized the tax credits retroactively for all of 2015, and forward through December 31, 2016.

The investment tax credit, in lieu of the production tax credit uses a similar formula, but is a one-time payment for up to 30% of eligible capital costs of the renewable energy project.

A qualifying project owner needs to have made significant investment (at least 5%) in the initial construction of the project and make continuous effort toward development to keep their eligibility for the credit. Projects have to be operational within three years.

Project ownership and related tax liabilities are key issues to consider to get the full benefit of these federal programs.

New Market Tax Credit
Tax credit 39% of investment; claimed over seven years. The New Market Tax Credit brings low-cost capital to qualified projects. They can be paired with other fund programs. They have nearly zero cost. Facilitate investments in qualified businesses located in eligible census tracts (QALICBs). Census-tract driven Low-Income Community eligibility can be limiting. Investors receive tax credit, in exchange for equity investments in CDEs, which provide financing to QALICBs. CDEs control allocations.

Bonds

Bond financing may be a viable approach for AD project development, especially for the larger, community-scale digester project. Here are a few bond programs that have been used for AD projects previously:

Qualified Energy Conservation Bonds, Washington State Housing Finance Commission
This is a taxable bond for which the State Treasurer would reimburse up to 3% of a loan interest cost. This makes interest costs very low for a significant project. An AD project might potentially be included as part of a larger green community program through a governmental entity. All the QECB authority in Washington has been used, but it is possible that if other states do not use all of their bonding capacity that more resources become available to Washington.

Industrial Revenue Bonds, WA State Housing Financing Commission, *WA Economic Development* ***Finance Authority (WEDFA), or other local industrial development corporations***
This is a private equity bond for up to $10 million for manufacturing and processing facilities that have total CAPEX under $20 million. IRBs have the potential to reduce interest rate costs by 25-30%. As a tax exempt financing tool, it provides no income tax liability for investors. IRBs are limited in scale, and they cannot be combined with exempt facility bonds

Here is an example. A state or local entity issues the bonds (but does not actually make the loan). Instead an investor buys the bond and provides the funding for the loan. The state or local entity actually owns the facility or physical equipment (i.e., anaerobic digester) for the length of the bond/loan. There may be some property tax relief to the farm operator during the time the state or local entity technically owns the facility.

Exempt Facility Bonds, WA Economic Development Finance Authority (WEDFA)
Private activity bonds routinely used to underwrite public infrastructure projects, including airports and solid waste disposal facilities. Bonding limits are determined by the project's capital costs (<$50 million = 100%, $50-75 million = 90%, $75-100 million = 80%, >$100 million = 70%). Interest rates vary depending upon a number of criteria, and are currently in the range of 3.5-4.5%.

Grants

Project developers will want to take advantage of the variety of grants that could bring down the initial capital cost of the AD project. Here are several of the important grant programs that support AD.

Rural Energy for America grants, USDA Rural Development, Rural Energy for America Program (REAP)
This grant if approved can provide up to 25% of eligible costs, up to maximum of $500,000. Eligible costs include new, refurbished project equipment, construction, facility improvements, professional services, and permits, among others. What is not eligible includes: used equipment, vehicles, and lease payments. Must have a complete application into REAP before incurring any eligible costs!

Value-Added Producer grants, USDA Rural Development, Rural Energy for America Program (REAP)
Grant funding of up to $100,000 for planning and $300,000 in working capital directly related to processing and/or marketing value-added agricultural products, including farm-based renewable energy, such as that generated by an anaerobic digester. Requires a completed business plan and independent feasibility study. This grant requires cost share of at least 50%.

Environmental Quality Incentive Program (EQIP), USDA Natural Resources Conservation Service (NRCS)
Under EQIP, 1- to 10-year contracts can provide financial assistance to implement conservation practices. An individual or entity may receive up to $300,000 in direct or indirect payments for all contracts, except for anaerobic digesters, which may receive up to $450,000.

Conservation Innovation Grants (CIG), USDA Natural Resources Conservation Service (NRCS)
These grant fund 1- to 3-year projects targeting innovative conservation practices, including pilot projects and field demonstrations. Grants can be up to $1 million, but must be matched 50:50 with non-federal funds. These grants research and development for new AD system designs or components, or new product developments.

Tribal Energy Program, U.S. Dept. of Energy
Federal agencies, including the U.S. Department of Energy Office of Indian Energy, provide grant, loan, and technical assistance programs to support tribal energy projects.

The DOE Office of Indian Energy has developed a 5-step project development and financing process that focuses on key decision points and outlines a chronological path to smart renewable energy development. Tribes can get help with each step by applying for available federal grant, loan, and technical assistance programs. Prioritizing the tribal goals for a project through a tribal leader and community-driven strategic energy plan can help shape the project.

Tribal renewable energy projects offer many benefits, from more stable energy costs and enhanced energy security to higher-quality jobs and a stronger economy.

Centralia Coal Transition Grant Program
This program is funded by an agreement to discontinue the use of coal for making electricity at the Centralia Power Plant. Annual payments for the three program funding boards have been made for the past three years with the last payment due Dec. 31, 2023. The funding boards will have an opportunity to start flowing dollars into projects starting December 31, 2015. Here are the three funding boards:

- Weatherization Board: weatherization projects
- Economic & Community Development Board: established to fund education, retraining, economic development, and community enhancement in Lewis/S. Thurston counties
- Energy Technology Board: established to fund energy technologies with the potential to create environmental benefits to Washington

For more information, see the program website: http://cctgrants.com

Regulatory Framework

Anaerobic digesters are subject to local, state and federal regulatory and permitting requirements for air, water and solid waste. The requirements vary by location and change frequently. State agencies administer federal regulations and have their own air, solid waste, and water permitting requirements that may apply to anaerobic digesters.

Air Quality

EPA's National Ambient Air Quality Standards – Identifies emissions standards for criteria air pollutants (ozone, PM, CO, NO_x, sulfur dioxide, and lead). The EPA Office of Air Quality Planning and Standards (OAQPS) has set National Ambient Air Quality Standards for six principal pollutants, which are called "criteria" pollutants: carbon monoxide, lead, nitrogen dioxide, particulate matter (PM_{10}), particulate matter ($PM_{2.5}$), and ozone. ***Primary standards*** set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. ***Secondary standards*** set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. Units of measure for the standards are parts per million (ppm) by volume, milligrams per cubic meter of air (mg/m^3), and micrograms per cubic meter of air ($\mu g/m^3$).

State air permits may be required if on-site combustion devices trigger federal emissions thresholds and other federal regulatory permitting requirements. Combustion devices with air emissions below federal thresholds may avoid permitting requirements. Federal thresholds are documented in the following regulations:

- Control of Emissions from New and In-Use Nonroad Compression-ignition Engines, provides federal emission standards for non-road internal combustion engines. (40 CFR Part 89)
- Standards of Performance for New Stationary Sources (40 CFR Part 60)
- *Standards of Performance for Stationary Spark Ignition Internal Combustion Engines (40 CFR Part 60, Subpart JJJJ)*
- Standards of Performance for Stationary Compression Ignition Internal Combustion Engines (40 CFR Part 60, Subpart IIII)
- Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units (40 CFR Part 60, Subpart Db)
- Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units (40 CFR Part 60, Subpart Dc)
- *Industrial, Commercial, and Institutional Boilers and Process Heaters (40 CFR 63, Subpart DDDDD)*
- Stationary Internal Combustion Engines (40 CFR Part 63, Subpart ZZZZ)
- Emissions Standards for Boilers and Process Heaters and Commercial / Industrial Solid Waste Incinerators

State-specific thresholds contained in WAC 173-400-110(5) require that anaerobic digesters that emit more than a de minimis amount of air pollution annually must be permitted as a new source and requires a Notice of Construction air quality permit. Air quality permitting is handled by local air quality agencies, including the Puget Sound Clean Air Agency (PSCAA), which serves Snohomish, King, Pierce and Kitsap counties and the Olympic Region Clean Air Agency (ORCAA), which serves Clallam, Grays Harbor, Jefferson, Mason, Pacific, and Thurston counties. This project would require an Air Operating Permit for the digestion project, including the engine generator and emergency biogas flare equipment.

In Washington, anaerobic digester projects with digester-gas fueled engine generators and produce between 20,000 and 400,000 cubic feet per day of biogas and meet requirements for solid waste exemption, must comply with the rules in the General Order of Approval No. 12AQ-GO-01 (Dept of Ecology, Jan. 2012).

The General Order sets out emission point location and height requirements, engine-generator emission criteria, flare criteria, and requires the prevention of odors from non-manure waste usage. All emission limitations included in the General Order have been met in practice by one or more dairy manure anaerobic digester systems currently in operation in Washington (including the Van Dyke dairy project) or match performance guarantees provided to Washington system owners from engine–generator manufacturers.

Washington state air quality regulations do not contain any emission standards applicable to reciprocating engines other than the applicable federal regulations that have been adopted in state rule and specific requirements for diesel engines producing emergency power. For anaerobic dairy manure digestion and electricity production systems, the emission requirements are those found in federal regulations for spark ignition engines and those determined through the Best Available Control Technology (BACT) analysis.

During development of the General Order, the three local agencies (NWCAA, PSCAA, and YRCAA) directly involved in its development did not identify any agency specific regulations or requirements applicable to anaerobic dairy manure digester systems beyond the regulations and requirements described.

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Solid Waste

Federal laws do not require solid waste permits for manure. However, the acceptance of other organics may designate the anaerobic digester as a waste processing facility. Waste processing facilities are required to meet some federal regulations, as follows:

- Managing Non-Hazardous Municipal and Solid Waste, Resource Conservation and Recovery Act (RCRA) Subtitle D
- Criteria for Municipal Solid Waste Landfills, 40 CFR Part 258

In Washington, the process for anaerobic digesters needing a solid waste permit is regulated by the WA Dept. of Ecology, it is described on Ecology's Waste 2 Resources Permitting Process web page.

The Washington Legislature passed a law in 2009 (Chapter 70.95.330 RCW) that provides an exemption from solid waste permitting for dairy manure anaerobic digesters that meet certain conditions (contain at least 50% manure and no more than 30% other organic waste). In 2013, Ecology updated the rules for Solid Waste Handling Standards (Chapter 173-350 WAC), to include permitting requirements for solid waste anaerobic digesters. You can find the law and rules as follows:

- The law, RCW 70.95.330
- The rule, WAC 173-350-250

In Washington, manure-only anaerobic digesters are exempt from solid waste permitting requirements.

Clean Water

A National Pollutant Discharge Elimination System (NPDES) permit(38 pp, 217K) is required for Concentrated Animal Feeding Operations (CAFOs) that discharge or propose to discharge to U.S. waters, including:

- Inappropriate land application of manure

- Discharge to waters of the United States through a manmade device or through direct contact of the animals with waters of the United States.

This federal requirement administered through state agencies, including the WA Dept of Ecology..

NPDES Implementation Information

- Large CAFOs that discharge must be permitted and develop and maintain Nutrient Management Plans to ensure appropriate land application of manure.
- Smaller farms also may be required to comply with the rule if they discharge to waters of the United States through a manmade device or through direct contact of the animals with waters of the United States.
- Certain states may also include smaller farms in their animal feeding operations programs.

The Washington State Department of Ecology administers water quality permitting under the federal Clean Water Act. Ecology is currently rewriting the rules governing Confined Animal Feeding Operations (CAFOs).

- Anaerobic digesters operating at permitted CAFOs do not need an additional permit if the system is digesting only manure.
- *Codigestion:* If the system is digesting organic wastes in addition to manure, the Nutrient Management Plan must be modified to reflect these wastes.