



INPUTS
 OUTPUTS
 PROCESSING FACILITY

AD = Anaerobic Digestion; NR = Nutrient Recovery; RNG = Renewable Natural Gas

DAIRY WASTE BIOREFINERY

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Washington State is tenth in the nation in milk production, with its 420 commercial dairies producing more than 700 million gallons in 2011. Unfortunately, these cows also produce manure. If not effectively managed, this manure can contribute to degradation of soil quality (accumulation of nutrients), water quality (eutrophication and pathogens), and air quality (greenhouse gas emissions, volatile organic compounds, particulate matter, and odors). Anaerobic digestion can mitigate many of these issues, while also producing renewable energy and other valuable products. Through the integration of multiple additional technologies, more products and improved economic and environmental sustainability can be achieved—advancing the adoption of AD in the state. This new vision of an integrated dairy waste biorefinery located on a dairy includes four key operations, each of which is still being refined:

Anaerobic Digestion

Dairy manure will be digested together with offsite organic substrates to produce biogas and remediate odors, greenhouse gases and pathogens

Benefits include:

- Reduction in odors, pathogens, and greenhouse gas emissions
- Sustainable management of organic waste

Outputs include:

- Biogas can be burned in a generator set to produce combined heat and power, or, as described below, upgraded to renewable natural gas
- Valuable treated fiber can be used as a bedding material for livestock or (with additional treatment) as peat moss replacement

Renewable Natural Gas

Biogas impurities are removed (carbon dioxide, hydrogen sulfide, and water vapor) via different upgrading techniques. Biogas can then be used as a transportation fuel or injected directly into natural gas pipelines

Benefits include:

- Higher value fuel compared to burning biogas to generate electricity
- Removal of impurities that hamper energy output (CO₂) and ruin equipment (H₂S)

Outputs include:

- Renewable and cost-competitive transportation fuel
- Eligible for carbon credits, renewable identification numbers, low carbon fuel standard credits

Co-digestion

Co-digestion of offsite organic substrates (e.g. food scraps, food trap grease) increases energy production.

Benefits include:

- A tipping fee will often be collected for accepting the organic wastes
- Diverts food scraps from entering landfills

Outputs include:

- Biogas production could be significantly enhanced compared to dairy manure only
- Improves project economics

Nutrient Recovery

After anaerobic digestion, the effluent will be sent to a nutrient recovery system that will strip out nitrogen (N) and phosphorus (P) to produce soil amendments.

Benefits include:

- Reductions in N and P release to surrounding environment
- Effluent hauling distances reduced due to lower nutrient concentration in effluent

Outputs include:

- Valuable soil amendments can be sold offsite where nutrients are most needed
- Recovery of usable dilution water that can be recycled to the biorefinery, reducing overall water consumption

Synergies and eco-service credits between and from these technologies are key to reducing capital and operation costs and minimizing the use of energy and water — thus providing much needed renewable energy, biologically based products, and greater sustainability for dairies