



Renewable energy systems for the defossilization of an experimental dairy cattle farm

For the defossilization of an experimental dairy cattle farm, renewable energy systems (RES) were combined to provide electrical power for various devices as well as to replace diesel-powered machines with ones that can use biomethane instead.

The RES on this farm include a biomethane upgrade plant, a former diesel tractor that was converted to run on compressed natural gas (CNG), a sensor-operated tube ventilation and cooling system for a dairy barn, and a set of photovoltaic thermal (PVT) panels with a heat storage tank.

The base for this was an existing biogas plant with a combined heat and power plant (CHP) that is already able to provide the farm with electrical power and sells excess electricity to the national grid. In addition, the CHP provides thermal energy for heating the farm's office buildings. The biogas plant is fed with the slurry of the dairy cattle on the farm, and the dairy cows are housed in naturally ventilated barns. Since heat stress has become an issue in dairy cows increasingly, the barn was equipped with a combined tube ventilation and cooling system that operates sensor-based and detects climate conditions that lead to heat stress. Based on environmental sensors that track temperature, relative humidity, and gas concentrations in the barn, the natural ventilation of the barn is supported by injecting ambient air from outside the barn through ventilation tubes with exhaust nozzles above the lying cubicles and the feed table as soon as a first temperature threshold is exceeded. When the temperature rises further, additional ambient air can be pre-cooled in evaporative cooling pads and mixed into the ventilation airflow to drop the air outlet temperatures and mitigate heat stress conditions in the barn. The heat stress situations naturally are more prominent in the warmer half of the year, which allows the use of a PVT system as a synergy. The solar panels provide extra electricity at the time when it is needed for the barn climate system. In addition, the PVT system provides thermal energy that can be used to partly replace the boiler that supplies hot water that is regularly used e.g. for cleaning milking equipment.

The farm tractor that is regularly used to feed the dairy cattle had its diesel engine converted to now use CNG. The conversion process kept the tractor's power level and improved the emission level. The CNG is provided by the biomethane upgrade plant that uses a single membrane and a dual-purpose compressor to concentrate the biogas to a methane content of at least 95 % and store the then-compressed gas at a pressure of 250 bar. The prototype scale plant already produces more than enough CNG to run a tractor.

Integrated RES systems at the LVAT dairy cow farm

- A PVT system with a solar station providing an average electrical energy of 4.50 MWh per year and an average thermal energy of 24.75 MWh
- Thermal energy short term storage tank with 1,500 L capacity
- Prototype off-grid BioCNG upgrade plant with a capacity to produce up to 10 Nm³ h⁻¹ CNG with at least 95 % methane content at a storage pressure of 250 bar, with on-farm filling station
- A diesel farm tractor converted to use CNG from renewable sources
- Sensor-controlled tube ventilation and cooling system for a dairy barn

