IEA Bioenergy
Technology Collaboration Programme

Task 44 Flexible Bioenergy and System Integration: Best Practices

Biomass hybrid dryer

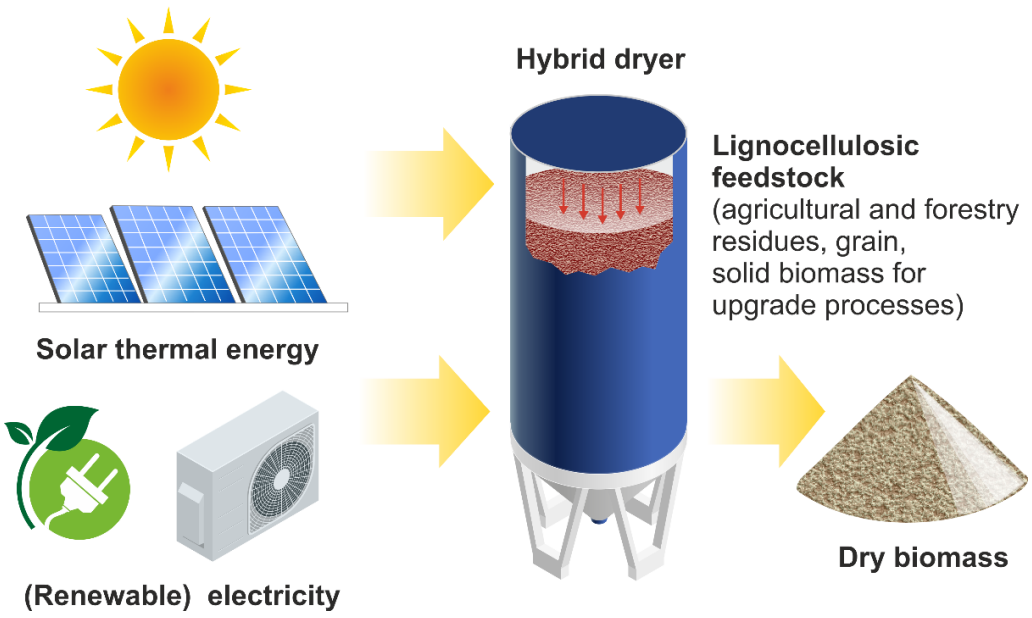
January 2022

Jyväskylä, Finland

BIOMASS HYBRID DRYER - COMBINING SOLAR COLLECTORS AND A HEAT PUMP

VTT's pilot hybrid dryer combines solar collectors and a heat pump in an efficient and flexible way. Various drying modes, such as solar alone, pump alone or solar and pump together, can be applied, depending on the availability of solar irradiation and electricity price. Especially, when electricity is cheap, this dryer is economical. Solar energy can always be utilized to boost the drying process. The control system allows flexibility between different operating modes.

The flexible up-take of electricity and irradiation enables cost-effective drying and seasonal storage of energy in dry biomass. Distributed drying also decreases transportation costs and emissions.



Base information	
Contact person, email:	Jyrki Raitila, jyrki.raitila@vtt.fi
Location	Jyväskylä, Finland
Owner/Operator	VTT
Technology supplier	VTT, Koja (air supply unit), Rivacold (heat pumps), Sundial (solar collectors)
Facility planned since/Start of the project	4/2018
Construction year	2021
Status	proof-of-concept/pilot
Feedstock	solid biomass such as wood chips and grain
Products	dry wood chips, agricultural products
Size	5-10 m^3 per day
Type of flexibility provided	feedstock flexibility, flexible up-take of electricity, demand-side flexibility, seasonal storage of energy
Flexibility characteristics	
Minimum load	2-3 m^3
Start-up time	weather dependent, with pump mode 1-3 h
Investment cost of the plant	EUR 130,000; USD 140,000 (2021)

Technical and Commercial Details

Using solar heat and cheap electricity to dry biomass is a possible way to store energy in solid fuels. Increasing the heat value and improving the quality of solid fuels by drying helps fuel management, particularly in winter when large fuel storages and better-quality fuel are needed during high energy demand. Lower moisture content of biomass prevents from dry matter losses on one hand, and less material is needed for energy production on the other hand. If biomass is dried close to the harvesting site, significant cost reduction on road transportation can be attained. Recent development in the efficiency and cost of solar systems makes solar drying more feasible in different applications. On the other hand, prospects for the developments of energy systems highlight the increasing demand for seasonal storages of energy (cf. power-to-gas).

Storage of solid biomass fuel plays an important role in all bioenergy supply chains. Usually storage is needed to even out unequal demand during the year on one hand and to decrease the moisture content of fresh biomass by seasoning on the other. In practice the most feasible way to apply solar or hybrid drying and to store dried biomass is to do it in small units, for example at farms, where biomass sources are closer and all logistical solutions are easier than in urban areas.

VTT has studied biomass drying for many years. As a direct continuation to lab-scale equipment, VTT has built a pilot hybrid dryer for solid biomass drying. In the dryer solar collectors (24 m^2) and a heat pump (25 kW), integrated into an air supply unit, are placed in a freight container. A parallel container serves as a drying chamber for biomass. The pump is primarily used to remove moisture from the drying air and to provide initial heat if necessary. The dryer can be run on a solar or pump mode or on both of them. Algorithms follow the electricity price and determine which is the most economical mode to operate. If the electricity price fluctuates during the day, drying can be halted and continued when economical again. Cheap energy, whether solar or power, can be stored in dried biomass. The whole system is movable and scalable in modules.

VTT designed and configured the dryer in collaboration with commercial engineering companies and constructed the dryer from existing components. However, air supply required special attention and is based on VTT's invention.

Market opportunities

The dryer utilizes effectively fluctuation in power prices and also enables storage of intermittent solar energy in biomass. Flexible use of different operating modes allows choosing the most economic way to run the dryer, depending on the electricity price and availability of irradiation. Energy of renewable electricity can be stored in biomass through this process as well. Storage is particularly important in countries like Finland where high demand for heating takes place in winter and alternative energy sources are expensive. Solar energy is mostly available during summer months and the hybrid dryer enables its seasonal storage for high demand periods.

The concept suits best in rural areas such as farms and small enterprises, close to dispersed biomass sources. It should also be noted that fossil fuel is most often used for drying grain at farms. Grain and other crops can also be dried with this kind of hybrid dryer and thus it decreases the need for fossil fuels. With this concept all that fuel can be substituted with renewable alternatives.

Scaling up is also possible, for example in biomass terminals where handling, storage and logistics are more efficient. As a whole, hybrid drying adds value to the energy carrier or agricultural product, and it is cost-effective compared to most fossil fuels. Investment subsidies, often available in rural areas, and benefits of scale would greatly improve the system economy.

Lessons to Industry

Transportation of wet biomass is expensive. Decentralized drying saves both transportation and storage costs. If wet biomass is stored, significant dry matter loss takes place during the storage months. Raw materials and products, such as grain, requiring immediate drying, can be dried economically and without fossil fuels.

So far VTT has run the dryer as a batch dryer which poses a few problems. The process has to be stopped for reloading and then time and energy is wasted. In professional use the dryer should be able to run continuously. For this some further development for the drying chamber and biomass conveyors is needed. Without interruption operating algorithms function as designed and the whole process runs smoothly.

VTT's hybrid dryer

Fig. 1. Solar collectors on top of the container where the air supply unit is mounted. Source: VTT

Fig. 2. Air supply unit and integrated heat pump with radiators in the container (left). The other container serves as a drying chamber (right). Biomass can be moved and circulated with a bottom agitator and chain conveyor. Source: VTT

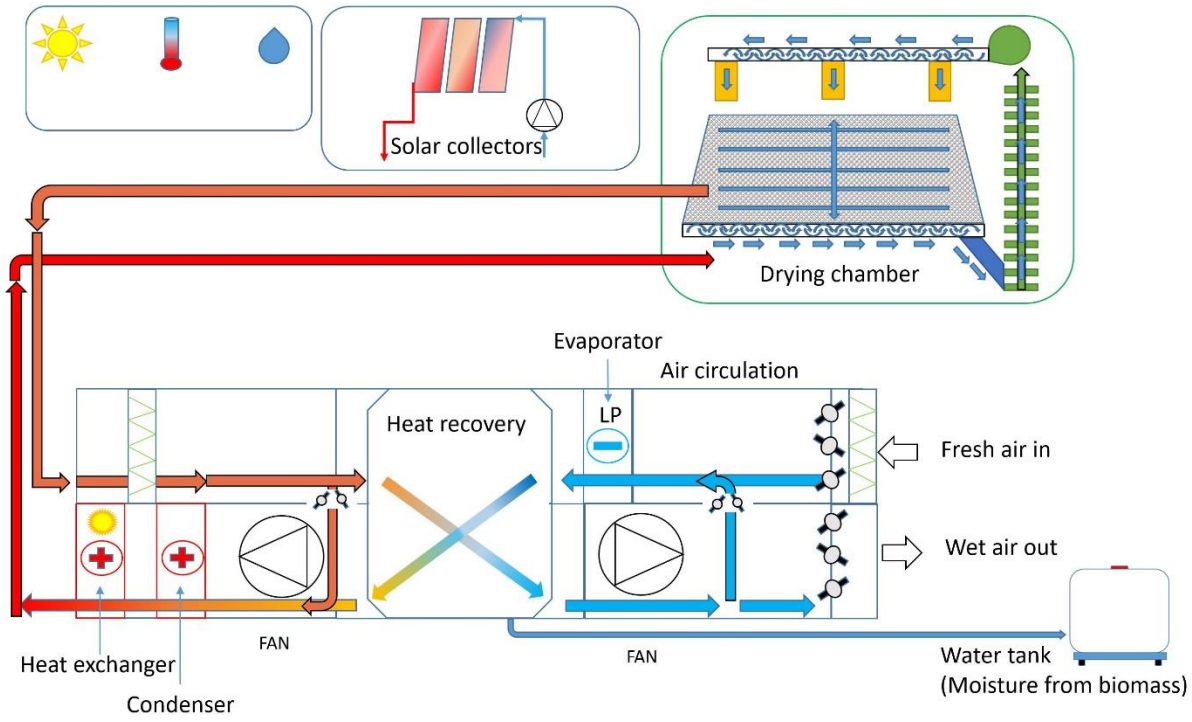


Fig. 3. Process flow chart. Source: VTT