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Utilisation of meteorological forecasts for the prediction of milk yield and renewable energy generation in dairy production

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This study investigated the utilisation of meteorological forecasts for the prediction of energy consumption (milk yield load) and energy generation (renewable energy) in dairy production. Part one of this study analyzed the effect of adding meteorological information to the training process of milk production forecast models. Two milk production forecast models (the nonlinear auto-regressive model with exogenous input and the multiple linear regression) were selected and tested using seven different meteorological data input treatments. Different combination of precipitation, sunshine hours and soil temperature were select as input treatments. Lactation data from 39 individual cows were extracted from a sample herd of pasture-based Holstein-Friesian cattle located in the south of Ireland. The models were trained using three years of historical milk-production data and were employed for the prediction of the total daily milk yield. An improvement in forecast accuracy was observed in 60% to 70% of test cows, albeit a modest improvement with result varying for different treatments. Sunshine hours was shown to be the most effective weather factor as a training input. However, the addition of meteorological data to the milk production forecasting process only resulted in small increases in accuracy in the short-term, while little or no increases in accuracy were observed for long-term forecasts. Part two of this study focused on forecasting climate variables, which were used to predict short-term renewable energy (wind and photovoltaic) power output. The climate variables were forecasted using an assemble of time series modeling techniques including; seasonal autoregressive integrated moving average models (ARIMA), linear regression models and regression models with ARIMA errors. A statistical comparison and cross validation of the forecasted data were carried out by employing weather forecast data from the European Centre for Medium-Range Weather Forecasts (ECMWF) with empirically obtained records from the Cork Institute of Technology NBERT meteorological station. The most suitable model for the prediction of each climatic variable (irradiance, wind speed and ambient temperature) was then employed to generate a short-term forecast for that particular variable. These forecasts were then fed into wind and photovoltaic models in order to simulate photovoltaic array and wind turbine power outputs over the forecast horizon. The percentage reduction of mean absolute percentage error relative to ECMWF forecast errors ranged from -317.69% to 6.18%, -0.01% to 1.81% and -234.38 to 20.41 for temperature, irradiance and wind speed, respectively. The results of this study showed that the utilisation of meteorological forecasts has highly beneficial for the prediction of renewable energy production, however only minor improvement were observe for milk production prediction.