Gas project - Prognosis

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Short term gas flow forecasts

The objective of this STSM was to identify suitable Neural Network (NN) architecture and training procedures to support the forecast of gas flow. The main goal of the analysis was to compute accurate forecasts for gas flow in the next 24 and 48 hours to support operational decisions.

The STSM has brought the following results:

- Identification of a set of input features to forecast time series;
- Selection of the most appropriate Neural Network architecture.

Among the Neural Network configurations being evaluated there are the Feedforward neural network (FNN), the Recurrent Neural Networks (RNN) and the Radial Basis Neural Networks (RBN). In FNN, activation is "piped" through the network from input units to output units; RNN has (at least one) cyclic path of synaptic connections. RBN are embedded in a two layer neural network, where each hidden unit implements a radial activated function. These methods have been applied on the hourly flow of two different sets of nodes: municipal energy supplier and national cross-border nodes. Results have been compared in terms of performance (RSME - Root Mean Squared Error).

Municipal nodes

Municipal energy suppliers nodes are usually characterised by strong correlation between the flow and the temperature. Municipal nodes have a seasonal

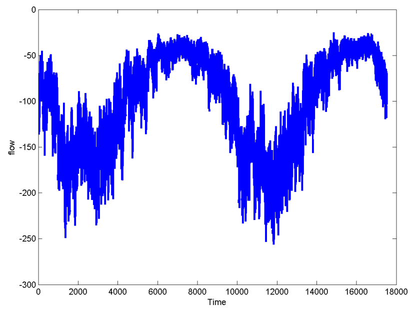

Figure 1: Gas flow of node 1

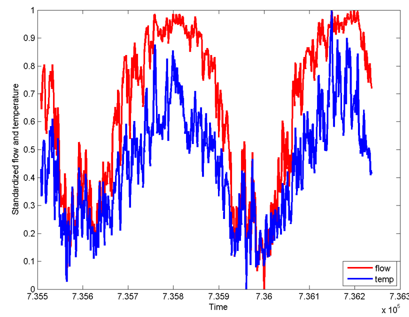

Figure 2: Standardised gas flow and temperature of node 1

behaviour and the demand also depends on the time of the day, on the day of the week and on holidays. Figure 1 shows an example of municipal node which have a cyclical behaviour that can be associated to the presence of a strong seasonal component. The same node is shown in Figure 2 where the gas flow and the temperature have been standardised in order to visualize the correlation. The strong positive correlation between the gas flow and the temperature is due to the fact that gas flow is negative as it is an exit node.

The selected network architecture to forecast gas flow of municipal nodes is the Recurrent Neural Network. The main characteristics of this configuration is the inclusion of a feedback loop that makes them particularly suitable to capture the sequential representation of the data.

The two years dataset has been divided in two parts: one year has been deployed to train the network and the second year to test its performance.

The network is configured as flows: there is only one hidden layer, 2 feedback delays and 8 hidden neurons equal to the number of input variables. The RNN consists of 8 input variables:

- gas flow at the same time of the previous day (numeric)
- gas flow at the same time and day of the previous week (numeric)
- day of the month (numeric)
- hour of the day (numeric)

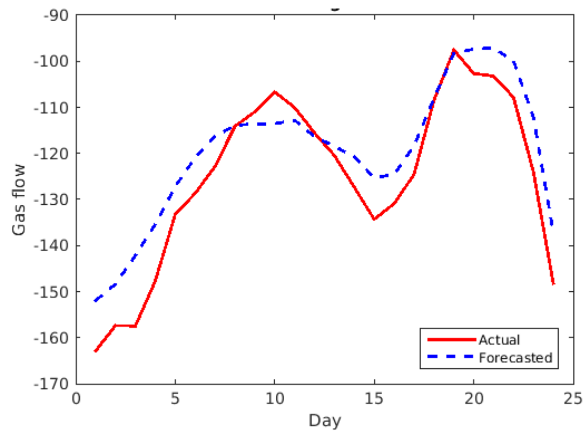

Figure 3: 24-hours gas flow forecast of node 2 - RMSE: 8

- month (numeric)
- day of the week (numeric)
- holiday (binary)
- temperature (numeric)

The RNN performs well in the 24 hours forecast. Using the two years dataset (1.10.2013-30.9.2014) and excluding the last 24 hours, an example of result is shown in Figure 3. The Figure compares the actual and the forecast flow. The RMSE is 8 which indicates good forecast results.

The same trained network is then deployed to forecast gas flow using the live dataset. This dataset consists of the latest available data. Also in this case the results are satisfactory as the RMSE is 34 as shown in Figure 4.

National crossborder nodes

The forecast of national cross border nodes is based on a network similar to the municipal nodes. Several networks configurations were experimented such as the Radial Basis Neural Network as well as different network architectures and input parameters. However for those type of nodes it was not possible to obtain a RMSE minor of 1312.

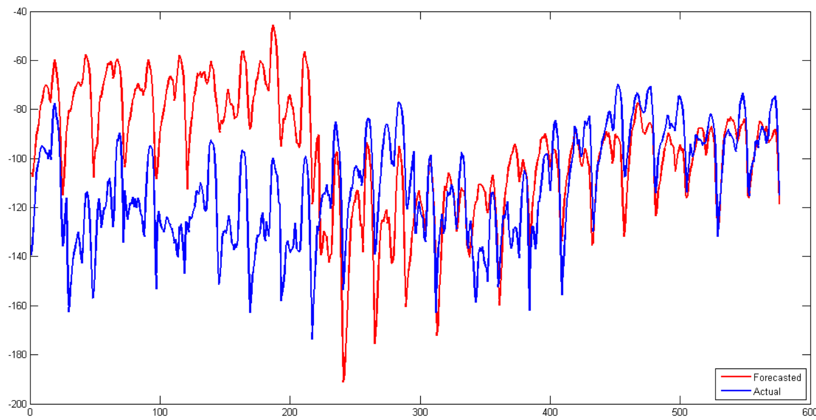

Figure 4: Hourly gas flow forecast of node 2 using the trained network and live data - 3 months. RMSE: 32

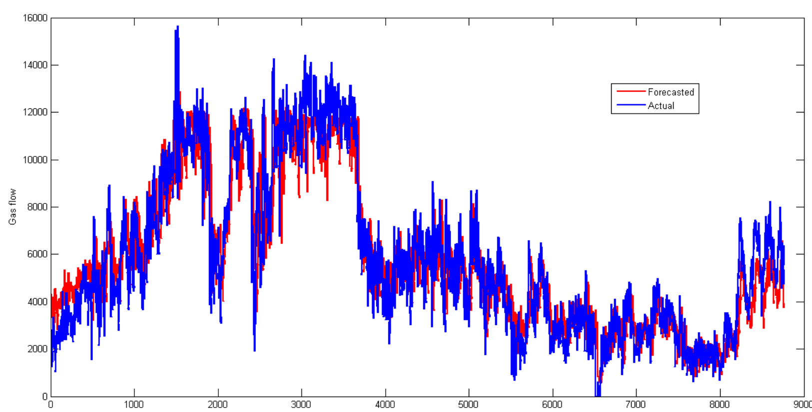

Figure 5: Gas flow forecast of cross border node 3 - 3 months. RMSE: 1312

Figure 5 shows the actual flow compared to the forecast and evidences that the main behaviour of the time series is modelled by the neural network. However, new input features and methodologies to identify the best network parameters should be be identified. For instance, the correlation between the temperature in the main surrounding countries and the gas flow of crossborder nodes has shown that only one node is strongly correlated to all external temperatures.

The work initiated during this STSM is still ongoing. Newly corrected data will be available to test the forecast model. Current activities include improving the performance of crossborder nodes by testing different configurations and training algorithms and identifying new correlated variables.