Predictive Emission Modelling Systems (PEMS)

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PEMS is a alternative or a Supplement to CEMS

- PEMS works on plant process or operating data to link to emissions that are measured through CEMS

- Once calibrated the model is ready for predictions

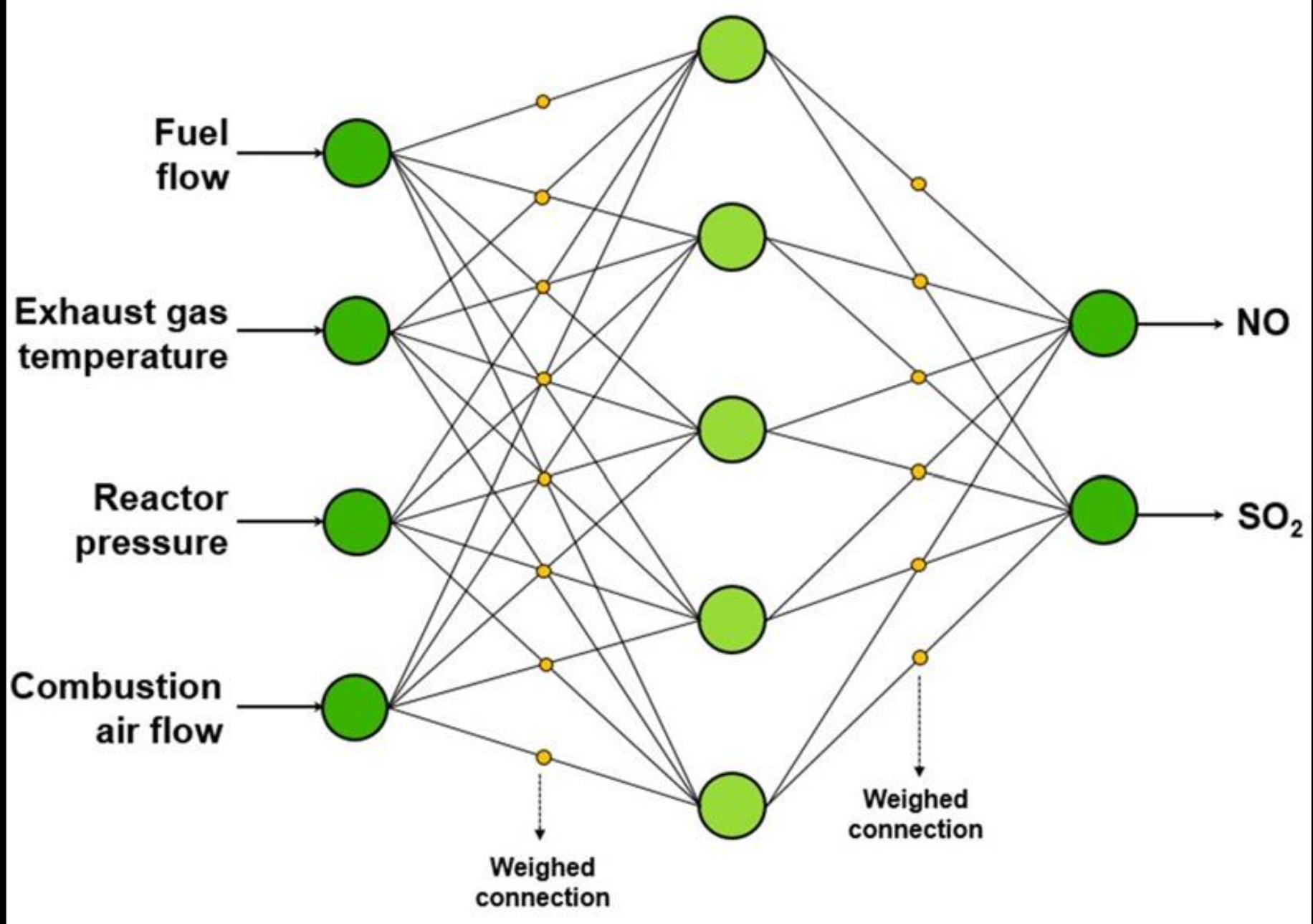- The model is built based on pooling of several parameters

$$Y = mx + c$$

$$Z = a + bx + cy + dxy + ex^2 + fy^2$$

$$X(t) = a + b\,X(t-1) + c\,X(t-2) + X(t-k)$$

Artificial Neural Networks

- In particular, Artificial Neural Networks (ANN) have the flexibility to balance between model performance and robustness, providing accuracy and reliability comparable to hardware-based emission analyzers

Schema based on Artificial Neural Network

Predictive Emission Monitoring System

- Does not measure emissions but uses a computer model to predict emission concentrations based on process data (e.g. fuel flow, load, and ambient air temperature).

- Built in Process of Auto-calibration or Self-learning

- Lot of applications in the field have shown that PEMS provide an accuracy close to that of hardware-based CEMS
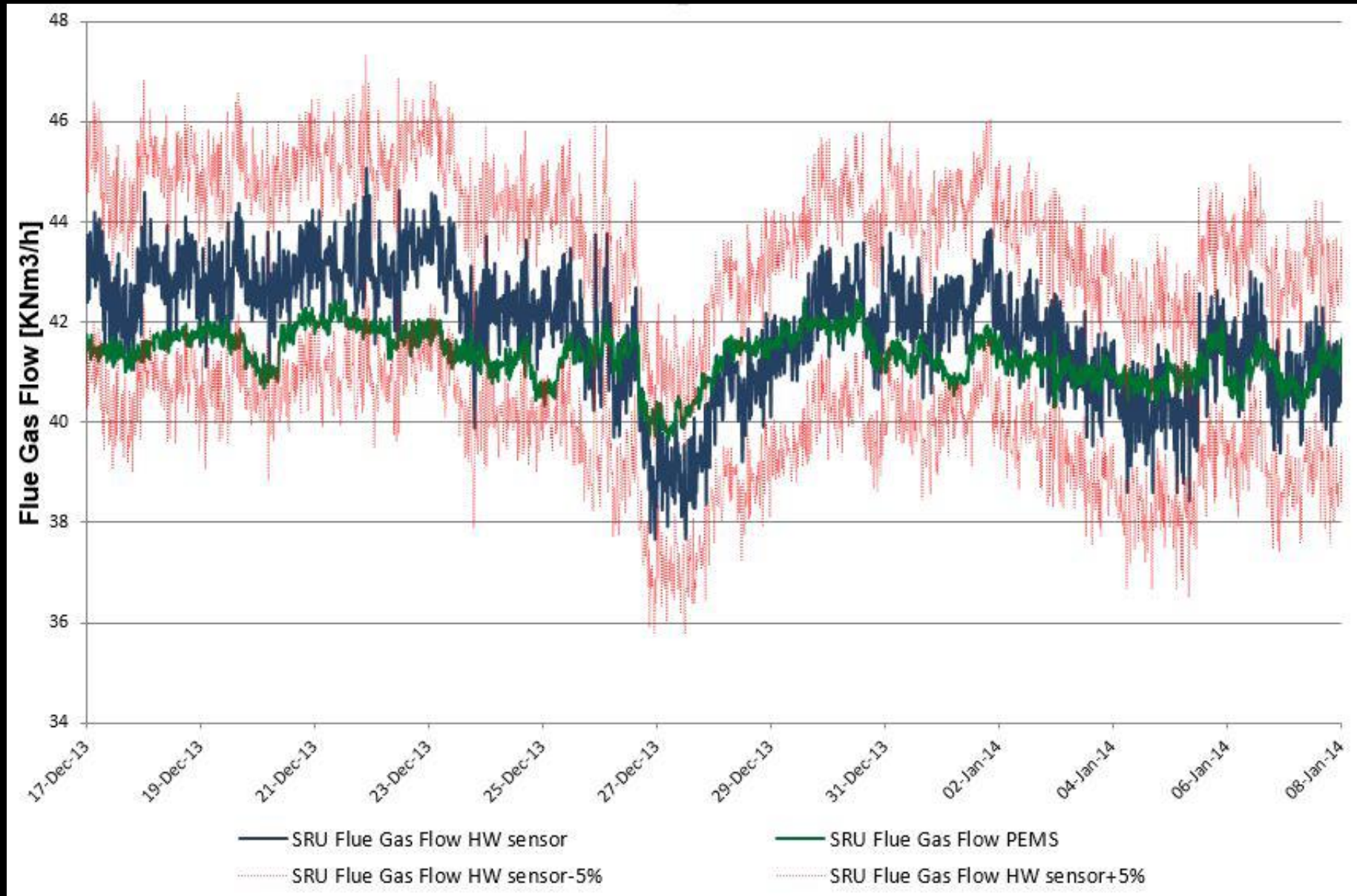
Additional benefits

- Trace back causes of emissions,
- identify key variables;
- Validate sensors automatically
- Reconstruct emission levels from historical data, in case of failure of the hardware device
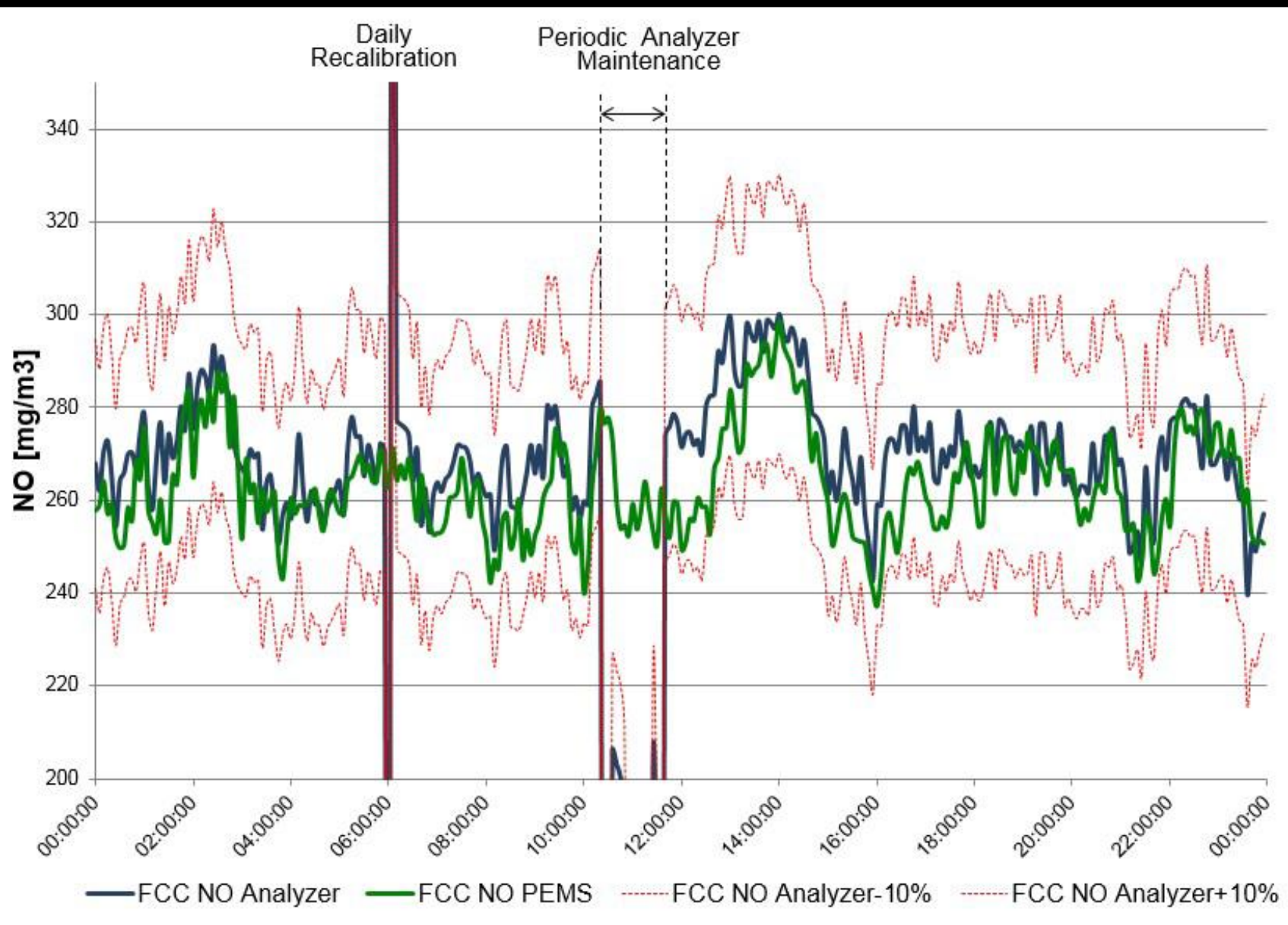
Improve operational efficiency and control

- PEMS can be used for process optimization purposes

- PEMS allows plant engineers to directly correlate the relationship between varying operational parameters, predict emissions at its plant in advance, and to take action to adjust emissions before the violations actually occur. A different form of "early warning system"

Modelling Flue Gas Flow in a Refinery

Modelling NO Emissions

https://library.e.abb.com/public/18c730568997764bc1257d01003a5c20/AT_ANALYTICAL_015-EN.pdf

Limitations:

- To obtain a sufficiently sized data set to develop a Predictive Emission Monitoring, emission and plant operational data have to be collected from a number of tests over a wide range of operating conditions.

- This process can be expensive and time consuming.

- Predictive Emission Monitoring is not a substitute for Continuous Emission Monitoring Systems in cases when Continuous Emission Monitoring Systems is mandated by the applicable regulations.

US and EC and PEMS

- US-EPA legislation recognizes the possibility of adopting PEMS as the primary source for emission monitoring

- European regulation allows the usage of PEMS mainly as a back-up of traditional CEMS

- In both these situations, specific conditions on testing and calibration are imposed

Conclusions

- PEMS has proved to be a highly accurate solution capable of acting as a reliable back up to the traditional CEMS.

- Any discrepancy between the PEMS model output and the analytical measurement can serve as an early warning of measurement drift or malfunction of the hardware devices to trigger maintenance.

- PEMS allows for what if analyses for process optimization and control

- From an economic perspective, the life cycle saving, over a 5-year time-horizon can easily exceed 50% compared to CEMS

Key References used

- ABB is the Market Leader

- https://library.e.abb.com/public/4128e88396a14d83b8116a2a71b5b88f/PB_PEMS-EN.pdf

- https://library.e.abb.com/public/4a8d4951df6f643785257dd30075ff68/FAQ_PEMS.pdf

- http://cdn.cseindia.org/userfiles/predeictive-emission-monitoring-system.pdf