Modelling of a steam network using data reconciliation as a management tool

Stéphane L. Bungener*[a], Greet Van Eetvelde[b], François Maréchal[a]

[a]Industrial Process and Energy Systems Engineering, Institute of Mechanical Engineering, Ecole Polytechnique Fédérale de Lausanne (EPFL), CH1015 Lausanne, Switzerland

[b]Center for Mobility and Spatial Planning, Faculty of Engineering and Architecture, Ghent University, Vrijdagmarkt 10-301, B-9000, Gent, Belgium

1. Introduction

Motivation:

⟶ Manage and allocated costs of industrial steam network.

⟶ Evaluate optimisation strategies to improve performance.

Context:

⟶ Inaccurate measurements.

⟶ Unmeasured flowrates and thermodynamic properties.

⟶ Few models

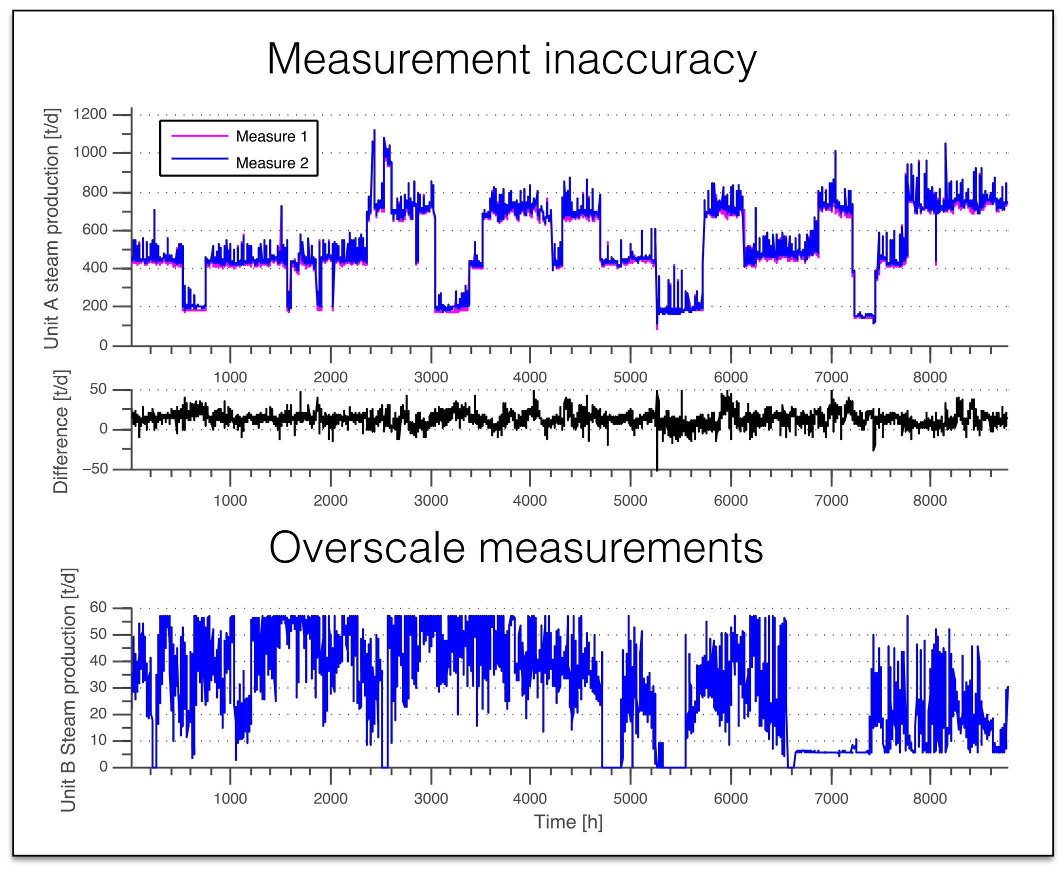
⟶ Open mass and energy balances.

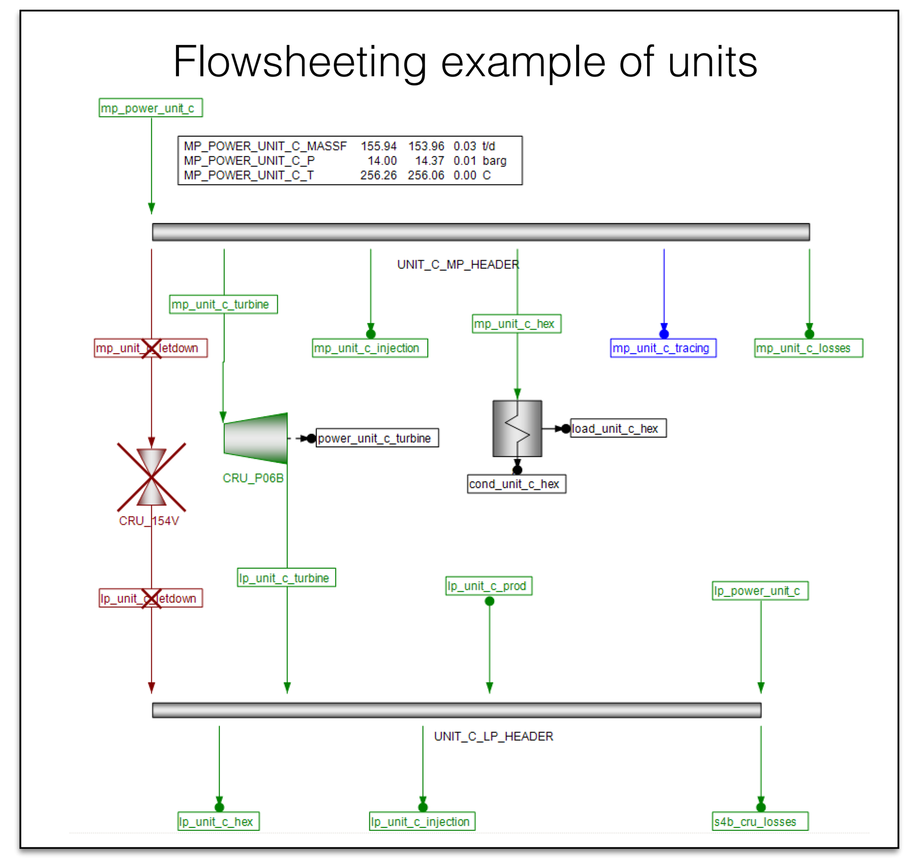
Objectives:

⟶ Calculate unknowns and Key Performance Indicators.

⟶ Use date reconciliation to improve measurement accuracy

⟶ Pave way for optimisation studies.





2a. Methodology

⟶ Construct physical model.

⟶ Associate weight/certitude (***σ***) to each measurement/estimation (***X***)

⟶ ***X'*** is the reconciled value of ***X***.

⟶ Objective function (1) is to create a physical solution, while minimising the penalty (***p***) associated with reconciling ***X***.

$$\min \quad p = \sum \frac{(X - X')^2}{\sigma} \qquad (1)$$

2b. Case Study

⟶ Study carried out on major refinery and its utility system.

⟶ Process and utility modelled via a flow sheeting tool with data reconciliation engine using PIDs and surveys.

⟶ 435 online measures and 78 estimations were modelled.

Table: Weights and modelling technique for each type of measurements

Input data	Modelling	σ
Condensation losses	Based on surface area and external temperature	30% estimate
Leaks	Each leak is a consumer, flow rate relative to pressure	60% estimate value
Turbopumps/compressors	Nominal flows of turbines as well as process load	30% nominal flow
Orifice plates measures	Geography of site respected	5% measure
Venturi tubes measures	Geography of site respected	2% measure
Unmeasured flow	Modelled using design data	20% design
T & P measures	Geography of site respected	1% measure
T & P estimates	Modeled using design data	10% design

3. Results

⟶ Reconciled and closed mass balance of the steam network.

⟶ Unknowns calculated (mass, temperature, pressure,efficiencies).

⟶ Reconciled measurements with improved certitude.

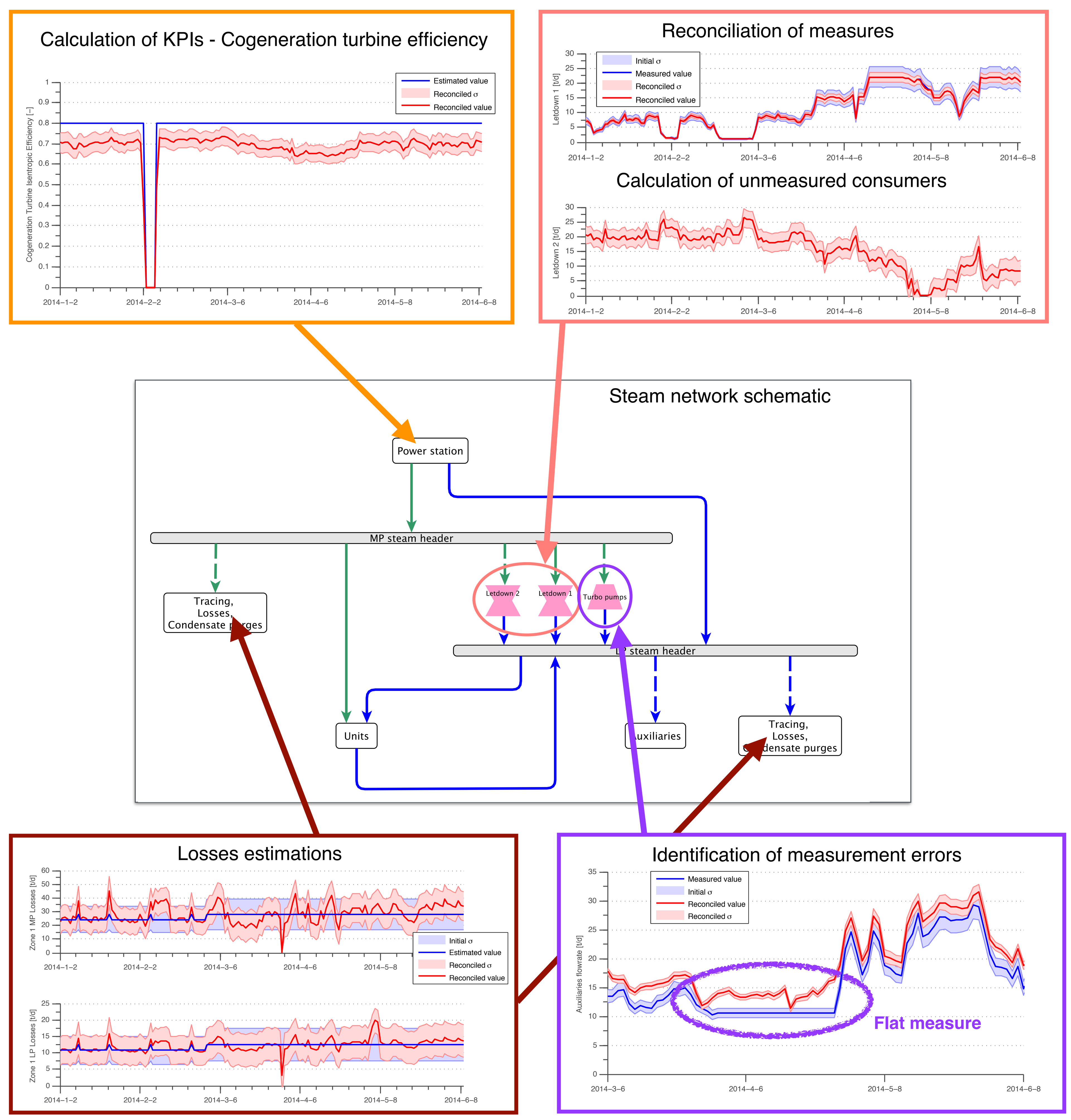
⟶ Identification of erroneous measurements.

⟶ Estimation of onsite leaks made possible.

⟶ Calculation of KPIs.

⟶ Cost allocation improvement.

⟶ Improved understanding of network challenges.



4. Conclusion and Outlook

⟶ Reconciled mass balance leads to improved cost allocation.

⟶ Understanding and measurements of key network properties.

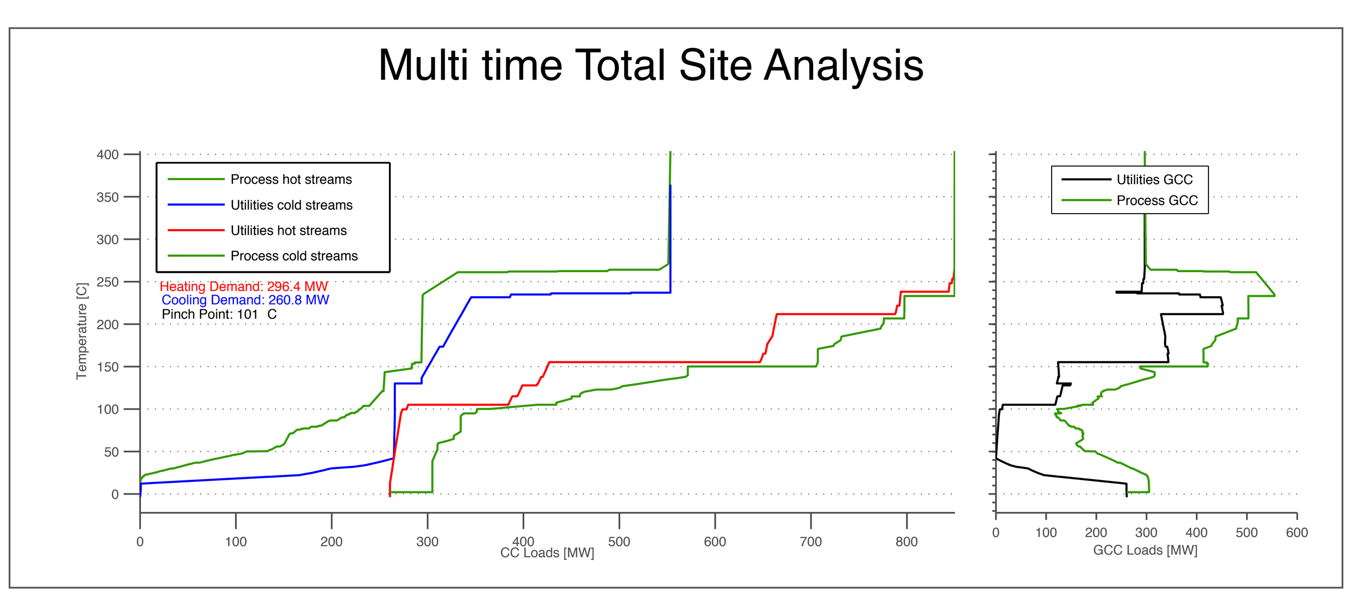
Optimisation studies underway:

⟶ Total site analysis. Energy integration study to optimise heat exchanges and the utility system.

⟶ Low pressure steam decongestion through operations optimisation.

⟶ Improving the quality of the steam in certain areas of the refinery.

⟶ Tracking of the steam losses reduction through maintenance.



References

Heyen, Georges, Eric Maréchal, and Boris Kalitventzeff. "Sensitivity calculations and variance analysis in plant measurement reconciliation." Computers & chemical engineering 20 (1996): S539-S544.

Bungener, Stéphane L., Greet Van Eetvelde, and François Maréchal. "A methodology for creating sequential multi-period base-case scenarios for large data sets." CHEMICAL ENGINEERING 35 (2013).