

SIGMAFINE[®]

Transforming Data into Digital Assets



Sigmafine in Utilities networks

Introducing Sigmafine

Sigmafine ...

... applies a **Data Reconciliation analysis** to a **Model** that represents a facility or a network.

Data Reconciliation is...

... finding **minimal** adjustments to measured data to satisfy the balance equation.

$$\text{Inputs} - \text{Outputs} - \text{Accumulation} = 0$$



How Sigmafine works

Model Based

- Digital representation of the mandate
 - Plant, Boundary, Process unit, Business Unit, Equipment, Process, Utility network, etc.

Apply Engineering Principles

- Automate basic calculations
 - PT Compensations, UOM, M to V conversions, Simple expressions
- Implement complex calculations
 - Equation of states, Steam tables, Correlations for specific industries

Apply Conservation Principles

- $\sum In - \sum Out - \sum Accumulation = 0$
 - Analysis Rules: Mass, Volume, Energy, Composition, Properties

Perform Statistical Analysis

- Minimization of the SSR
$$\text{Minimize } \sum_{i=1}^N \left(\frac{\text{Raw}_i - \text{Reconciled}_i}{\text{Tolerance}_i} \right)^2$$

Sigmafine in Utility networks

Typical utility networks where Sigmafine is applied

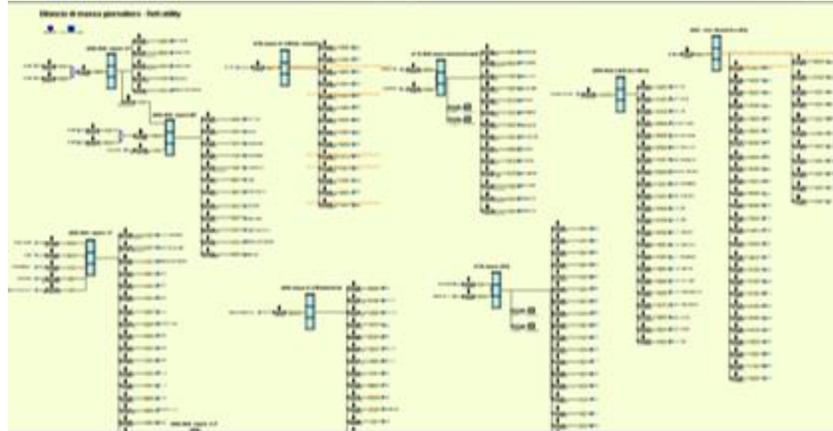
Utility
Fuel Oil / Fuel gas
Natural gas
Steam at different conditions
Water
Air / Nitrogen
Power

Typical Balance type
Mass and/or Energy
Mass or (Std/Normal) Volume
Mass and/or Energy
Volume
Std/Normal Volume
Energy (e.g. KWh)

Utilities cost allocation

Prior to Sigmafine

- Utility data (raw and validated) archived with multiple **Excel Files**
- Utility networks balanced on monthly basis only

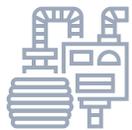


With Sigmafine

- All utility networks modeled
- Data archival on SF database (one version of the truth)
- Data aggregation at reporting level (daily and monthly)



Fuel Oil/Gas



Natural Gas



Steam



Water



Air



Nitrogen



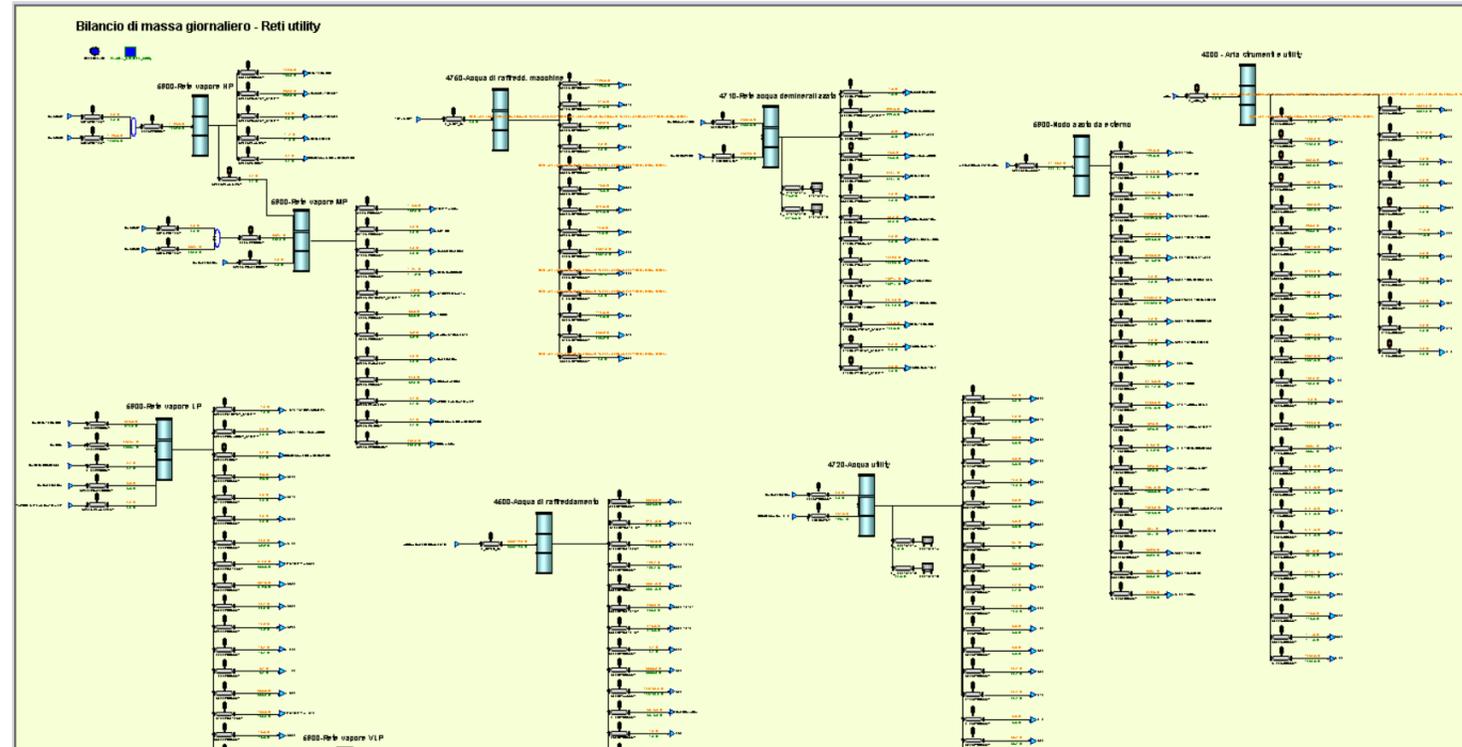
Hydrogen



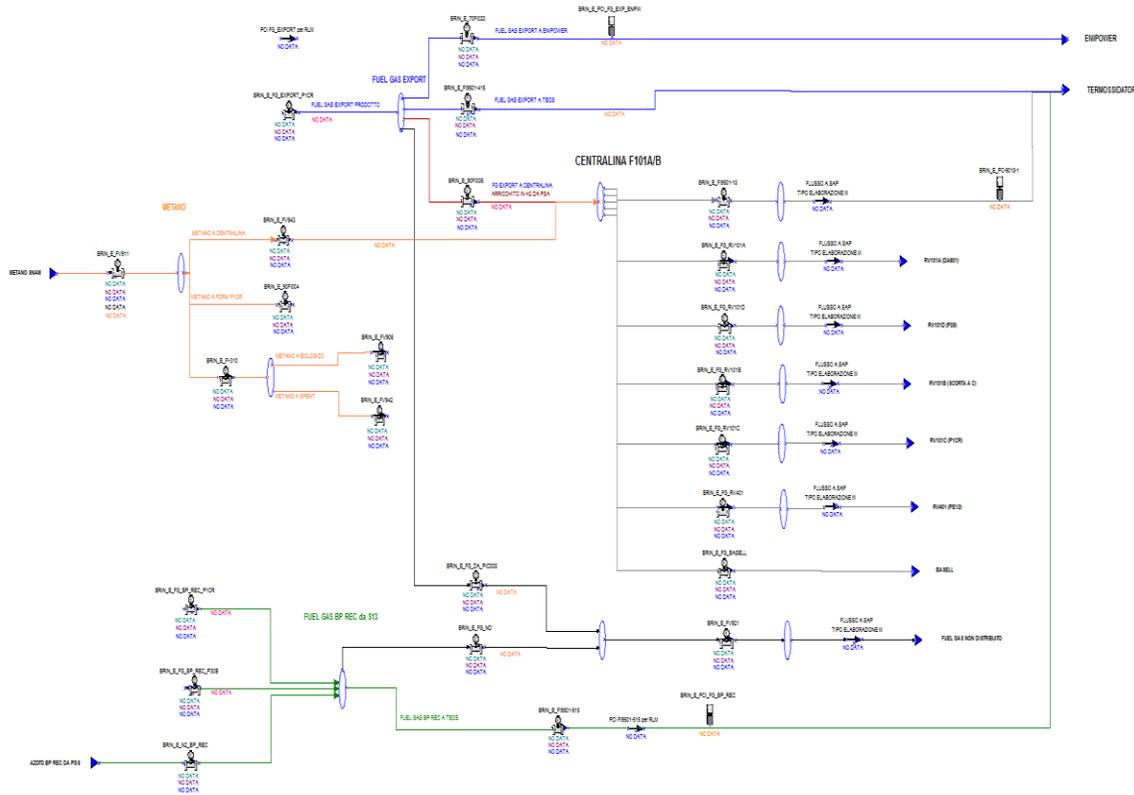
Power

Summary of benefits

- Support all utility networks
- Identify bad measurements on both production and consumption sides
- Provide «one version of the truth»
- Auditable system with known and explicit rules
- All manual changes are tracked
- Serve as objective data basis for discussion between the parties
- Provide accurate data to financial systems



Fuel Gas Network

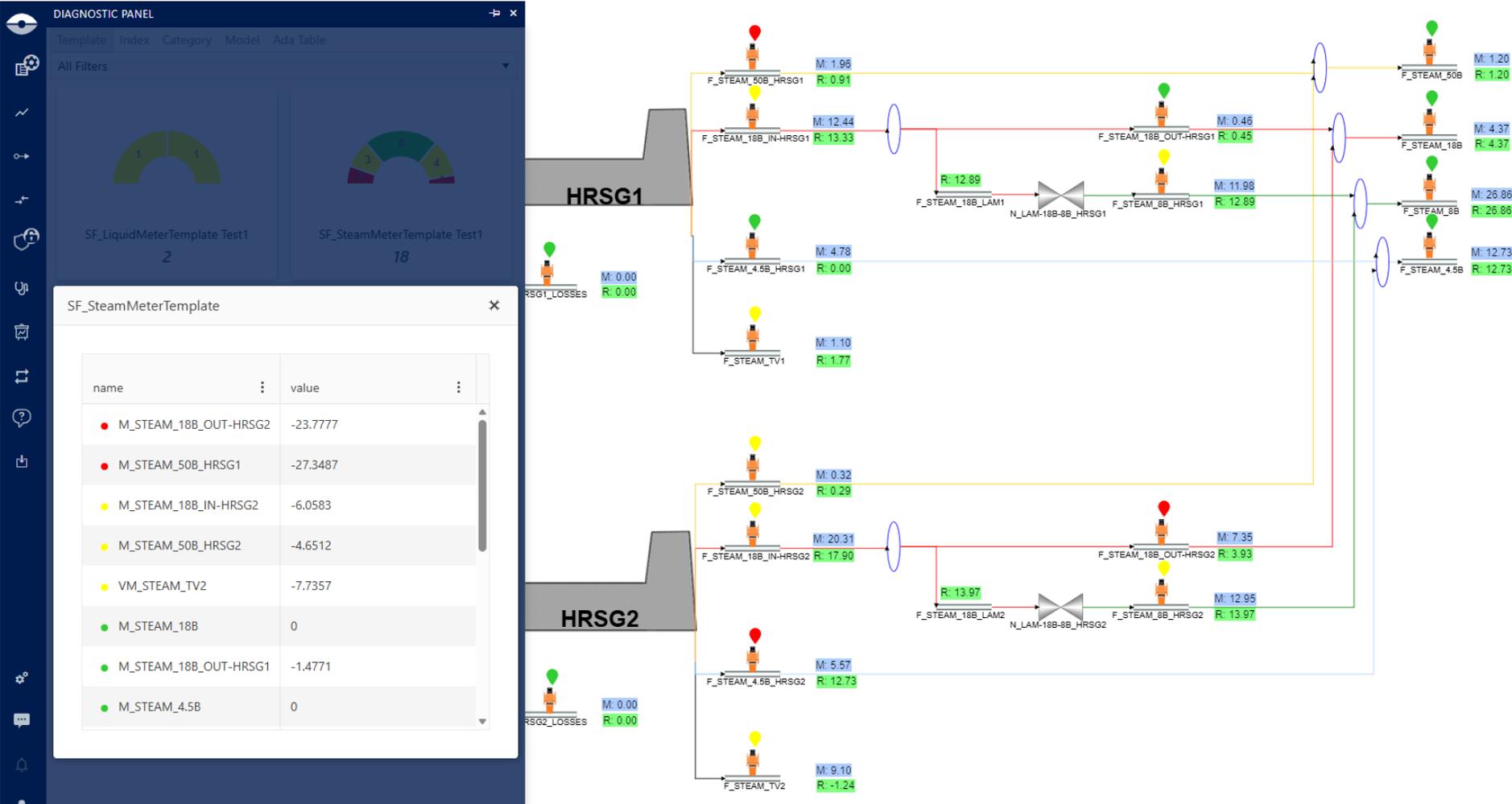


Combine mass/volume flow meters with gas analyzers to evaluate LHV/HHV

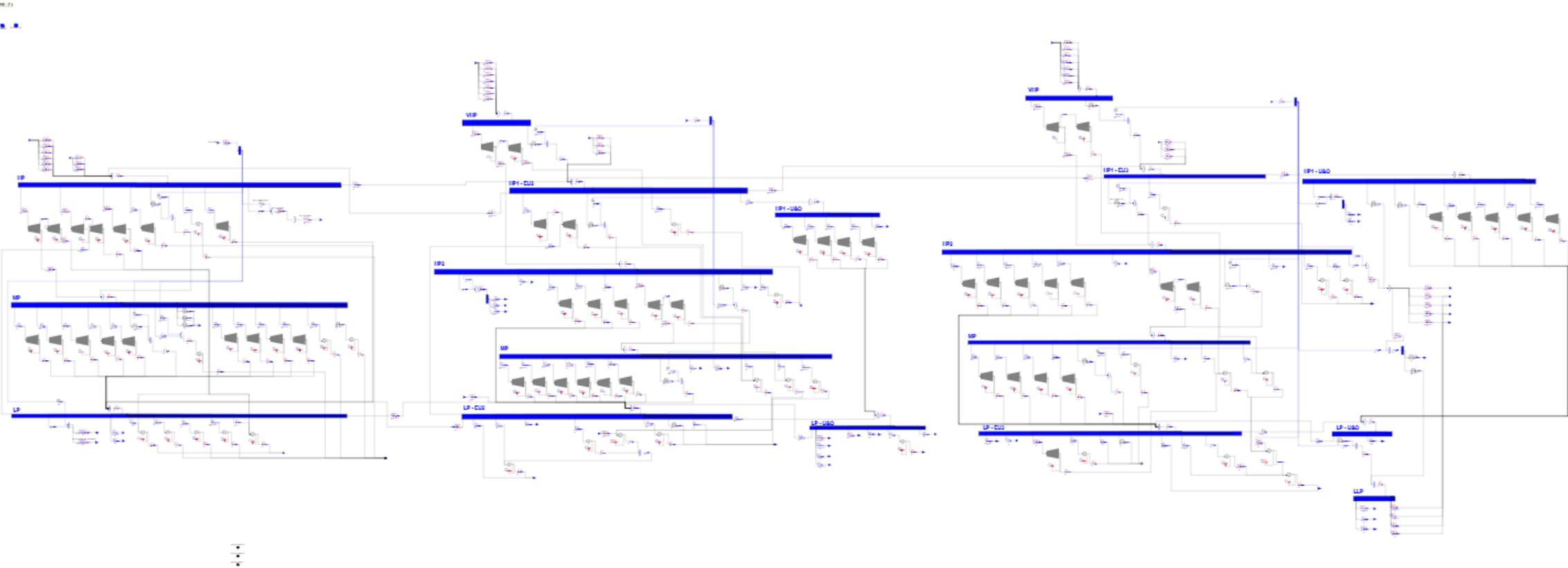
Energy balance of the network:

- Sources: natural gas, fuel gas, etc.
- Destinations: all the consumers (process units, flares, boilers, etc.)

Steam balance network



Steam networks can be very wide

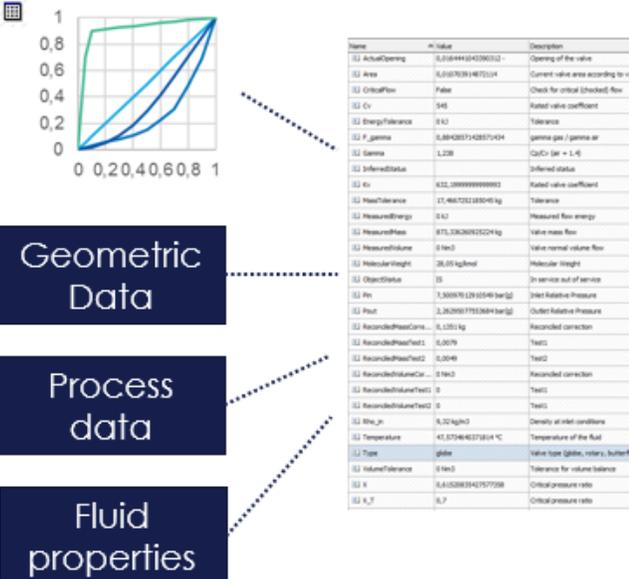


How to supply data when direct measurements are not available

Evaluation of unmeasured streams from valve opening

Use Sigmafine PI AF templates for valves supporting ISA-like calculation based on valve type and characteristics (e.g. flare flows)

Include tables in PI AF to look up for flows according to valve opening (e.g. steam let down stations)



Let down stations
Turbine extraction
Minor consumers



Mass and Energy balance

Increase redundancy of information by exploiting also temperature / pressure information

Use steam tables to evaluate enthalpy

Sigmafine Meets GHG Core Functionality



Protocol Selection

- **Sigmafine is an open framework which allows the selection of the preferred GHG protocol**
- **GHG formulas, CO2 equivalent calculations, timeframe can be easily configured**



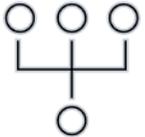
Model Based Validation

- **Balance unit definition is open: unit-based or site-based**
- **Balance is based on minimization on the sum of errors**
- **Balance time frame is open: hourly, daily, monthly, adhoc**



Model Constructs

- **Inputs & Outputs**
- **Process Unit & Inventories**
- **Meters, analyzers**
- **Flows & transfers**
- **Virtual meters & estimates**



Model Calculations

- **Mass, volume or energy basis**
- **Native imbalance calculations for all balance points**
- **Native data quality indicators**
- **Configurable CO2 equivalent calculations**

GHG Compliance: Identification of Uncertainties

Ranking

DIAGNOSTIC PANEL

Template Index Category Model Ada Table

ADA Impinger Server

Sort ↑ Export

Meter	Status	Meas...	RecMass	Correc...	Tolera...	Test1
IS	IS	2.6 t	2.51 t	0 t	0 t	0
IS	IS	0 t	0.01 t	0 t	0 t	0.05
IS	IS	0 t	0 t	0 t	0 t	0
IS	IS	0 t	0 t	0 t	0 t	0
IS	IS	39.1 t	39.09 t	0 t	0 t	0
IS	IS	34 t	33.31 t	-0.6 t	0.7 t	-0.96
IS	IS	5.1 t	5.78 t	0.7 t	0.1 t	6.48
IS	IS	0 t	0 t	0 t	0 t	0
IS	IS	0 t	0 t	0 t	0 t	0
IS	IS	0.2 t	0.2 t	0 t	0 t	2.85
IS	IS	1.9 t	2.88 t	1 t	0 t	27.6
IS	IS	5.9 t	-0.38 t	-6.3 t	0.1 t	-54.29
IS	IS	3.1 t	1.88 t	-1.3 t	0.1 t	-20.47
IS	IS	7.7 t	1.2 t	-6.5 t	0.2 t	-43.04
IS	IS	0.3 t	0.29 t	0 t	0 t	-2.83
IS	IS	0 t	0 t	0 t	0 t	0
IS	IS	0.7 t	0.64 t	-0.1 t	0 t	-6.76
IS	IS	36.5 t	35.82 t	-0.6 t	0.7 t	-0.9
IS	IS	-14.8 t	-19.84 t	-5 t	-0.3 t	-5032347653

Graphical



Reporting

DETAIL PANEL

ObjectStatus IS

N_S1_J1801A

SF_NodeTemplate

Quick Summary More

ReconciledMassTest3
S1.047

For adding a quick summary go to the [User setting](#) Section

Inputs:

Total Input: 2 Measured: 11.1 t Reconciled: 0.0 t

Name	Template	Meter	Measured	Reconciled	Test	Source
E_S1_CC2...	..	M_S1_CC...	0.0 t	0	0	R_S1_CC2...
E_S1_MP...	..	M_S1_MP...	0.0 t	-51.0469		MAN_S1_...

Outputs:

Total Output: 1 Measured: 0.0 t Reconciled: 0.0 t Balance UOM: [Dropdown]

Name	Template	Meter	Measured	Reconciled	Test	Source
E_S1_LP J...		M_S1_LP_...	0.0 t	0.0 t	0	N_S1_LP_In

Balance Summary

Show Reconciled Residual:

Total Measured: 11.07 t Total Reconciled: 0.00 t

CO₂ emission calculation in Sigmafine

CO₂ emissions are calculated for each CO₂ producer according to a specific formula provided by the customer. The formula considers the properties of the stream (*e.g. Net Heating Value, Emission Factor, Oxidation Factor*) and it is proportional to the reconciled quantity of the stream itself.

$$E_{\text{CO}_2} \left[\frac{\text{kg}_{\text{CO}_2}}{\text{day}} \right] = \text{rec.mass of the producer} \left[\frac{\text{t}}{\text{day}} \right] * NHV \left[\frac{\text{GJ}}{\text{t}} \right] * EF \left[\frac{\text{kg}_{\text{CO}_2}}{\text{GJ}} \right] * OF$$

The total amount of CO₂ produced by each source (Natural Gas, Fuel Gas, Fuel Oil...) is calculated as the sum of the emissions of all producers that belongs to that source.

The total amount of the CO₂ produced by the plant is calculated as the sum of the emissions of all the sources

Note: there is the possibility to distinguish different types of emissions (e.g. emissions from combustion and emissions from processes).

Sigmafine calculations can be customized according to the rules of the specific environmental agency

CO₂ uncertainty estimation

For each fuel k , uncertainty for producer j is calculated as:

$$u_{j,k} = \sqrt{u_{rec.mass,j}^2 + u_{NHV,j}^2 + u_{EF,j}^2}$$

- Uncertainty for fuel k of all N producers:

$$u_k = \sqrt{\sum_{j=1}^N \left(\frac{rec.mass_{j,k} \cdot u_{j,k}}{\sum_j^N rec.mass_{j,k}} \right)^2}$$

- Uncertainty of total M fuels:

$$u = \sqrt{\sum_{k=1}^M \left(\frac{u_k \cdot E_{CO2,k}}{\sum_k^M E_{CO2,k}} \right)^2}$$

GHG compliance: Example of CO₂ Emission Report

CO2 producer	Description of CO2 producer	Measured Mass (tons)	Reconciled Mass (tons)	Emission (T CO ₂)	NHV (GJ/T)	Emission Factor (KGCO ₂ /GJ)	Oxydation Factor	Emission Uncertainty (%)
TOTAL COMBUSTION		835.0	14697.5	2448				0,74%
FLARE COMBUSTION			13807,3	43	0,00	0,0	0,000	0,02%
...	...		13807,3	43		0,0	0,000	0,02%
FUELGAS COMBUSTION		404,4	456,9	1210	49,50	53,8	0,995	0,49%
...	...	0,0	0,0	0				
...	...	5,3	5,3	14	47,74	56,0	0,995	2,14%
...	...	3,2	3,2	9	50,64	52,4	0,995	1,30%
...	...	1,5	1,5	4	47,74	56,0	0,995	2,14%
...	...	22,2	22,2	59	47,74	56,0	0,995	2,14%
...	...	32,1	32,1	86	47,74	56,0	0,995	2,14%
...	...	54,5	54,5	145	47,74	56,0	0,995	2,14%
...	...	19,8	19,8	53	47,74	56,0	0,995	2,14%
...	...	18,0	18,0	48	47,74	56,0	0,995	2,14%
...	...	0,0	0,0	0				
...	...	13,4	13,4	35	50,64	52,4	0,995	1,30%
...	...	67,4	67,4	178	50,64	52,4	0,995	1,30%
...	...	21,7	21,7	57	50,64	52,4	0,995	1,30%
...	...	0,0	0,0	0				
...	...	0,0	0,0	0				
...	...	79,2	79,2	209	50,64	52,4	0,995	1,30%
...	...	0,0	0,0	0				
...	...		39,3	104	50,64	52,4	0,995	1,30%
...	...		13,2	35	50,64	52,4	0,995	1,30%
...	...	11,9	11,9	31	50,64	52,4	0,995	1,30%
...	...	19,8	19,8	52	50,64	52,4	0,995	1,30%
...	...	0,0	0,0	0				
...	...	9,1	9,1	24	50,64	52,4	0,995	1,30%
...	...	25,3	25,3	67	47,74	56,0	0,995	2,14%
...	...	0,0	0,0	0				
...	...	0,0	0,0	0				
NG COMBUSTION		433,3	433,3	1195	49,57	55,9	0,995	1,44%
...	...	217,9	217,9	601	49,57	55,9	0,995	2,08%
...	...	206,1	206,1	568	49,57	55,9	0,995	2,08%
...	...	0,0	0,0	0				
...	...	0,0	0,0	0				
...	...	4,2	4,2	12	49,57	55,9	0,995	2,08%
...	...	0,0	0,0	0				
...	...	3,3	3,3	9	49,57	55,9	0,995	2,08%
...	...	1,8	1,8	5	49,57	55,9	0,995	2,08%
VGO COMBUSTION		0,0	0,0	0				
...	...	0,0	0,0	0				



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