# *OptiRamp* Material Balance Reconciliation

# Measurement Challenges

- Material and energy balances are important in an industry. Material balances are fundamental to the control of processing, particularly in the control of yields of the products.
- Plant sensors contain errors in number, accuracy and precision. The process measurements usually contain substantial systematic errors. Data are always imprecise and inconsistent.
- *OptiRamp* reconciliation algorithm monitors a network with flows and transformations to account for their limitations while closing the constraints associated with material balances and energy balances.
- *OptiRamp* reconciliation algorithm provides a mechanism for plant performance analysis, improves composition and flow estimates of the simulations compared to plant measurements.

*OptiRamp* reconciliation algorithm is used for all types of balancing problems for chemical, refining, gas and oil transportation processes.

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# Material Balancing

- The process is seen as a whole, and it is represented as a box. The mass going into the box must balance with the mass coming out.
- *OptiRamp* computes flowrates which respect the following material keeping constraints:
  - The sum of input flow rates is equal to the sum of output flow rates.
  - The sum of input partial flow rates of the components at each node for each component is equal to the sum of output partial flow rates.
  - Inventory and process losses are also considered for non-stationary processes.

$\Sigma Gi = \Sigma Go + \Sigma Gl + \Sigma dGs$

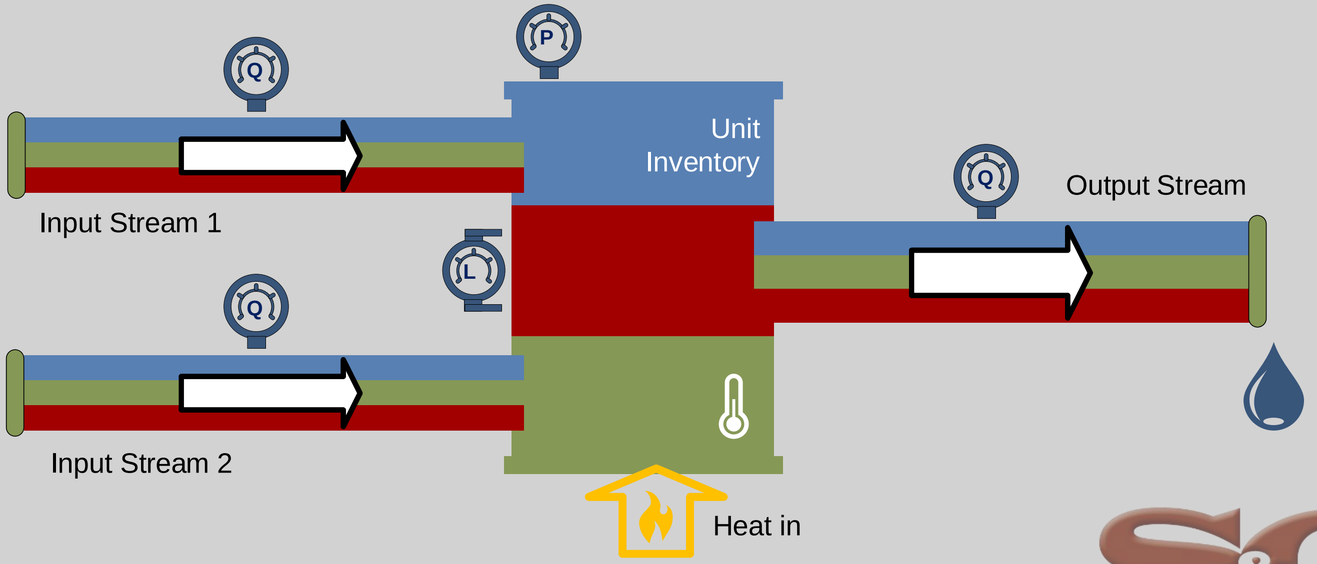
Where

$\Sigma Gi$ – material in

$\Sigma Go$ – material out

$\Sigma Gl$ - losses

$\Sigma dGs$ – delta inventory

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# Energy Balancing

- Energy quantities: described by energy balance model (statement on the conservation of energy).
- The energy coming into a unit operation is balanced with the energy coming out and the energy stored.
- The energy release or use in endothermic and exothermic processes are taken into consideration in the energy balance.

$\Sigma Q_i = \Sigma Q_o + \Sigma Q_l + \Sigma Q_s$

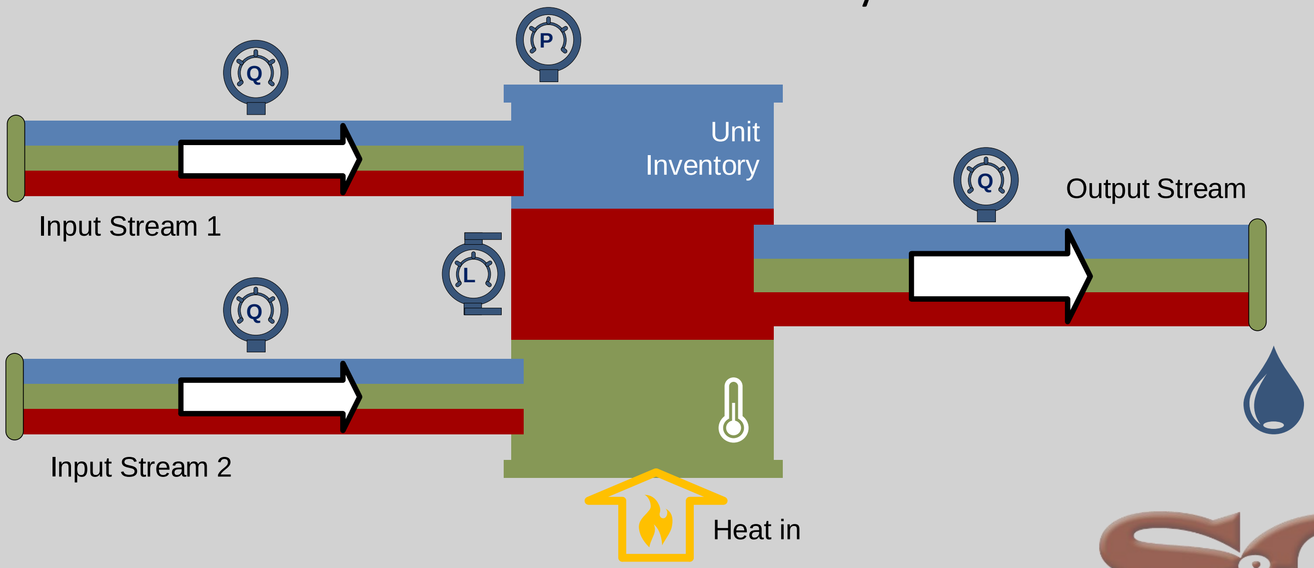
Where

$\Sigma Q_i$ – heat in inlet flow

$\Sigma Q_o$ – heat in outlet flow

$\Sigma Q_l$ – heat losses

$\Sigma dQ_s$ – heat change caused by reactions and conversions

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# Dynamic Modeling

- *OptiRamp* process models (shown diagrammatically as a box) represent functional dependencies between various inputs, outputs and losses
- *OptiRamp* Model is wide array of statistical and mathematical modeling techniques which simulates dynamic behavior of the process.
- *OptiRamp* Model auto-tuning combines model parameter tuning and monitoring techniques to ensure continuous high-fidelity performance of process model.

Go = f(Gi, Pi, Ti)

Qo = f(Gi, Pi, Ti)

Po = f(Gi, Pi, Ti)

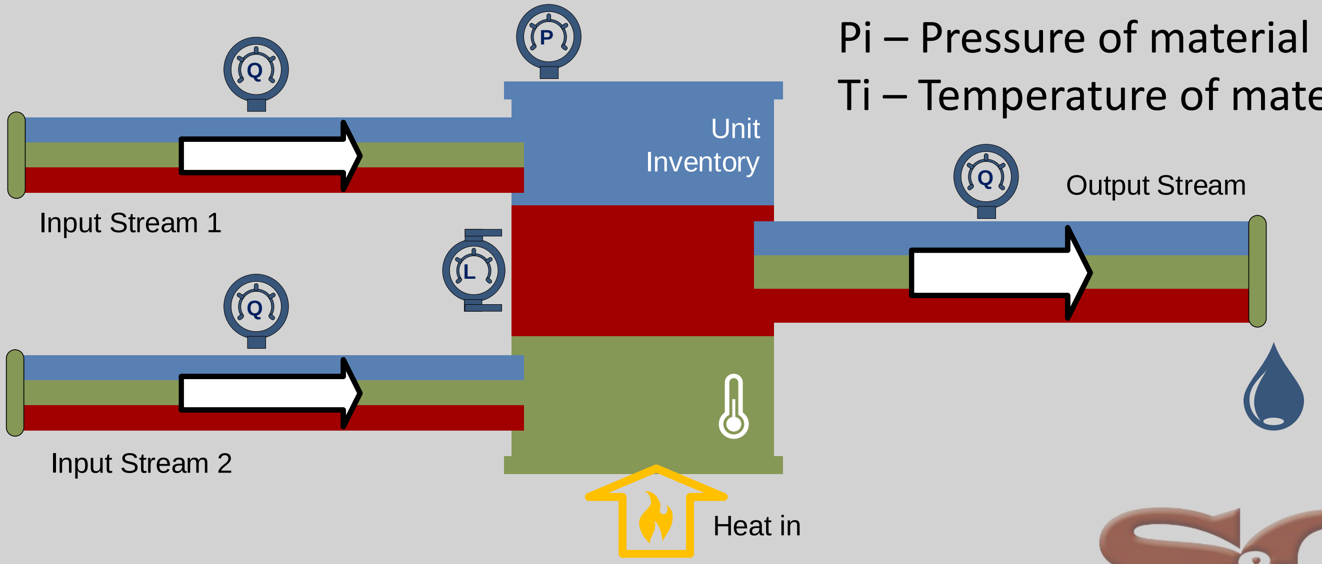
To = f(Gi, Pi, Ti)

Where

Gi – mass of material *i*

Pi – Pressure of material *i*

Ti – Temperature of material *i*

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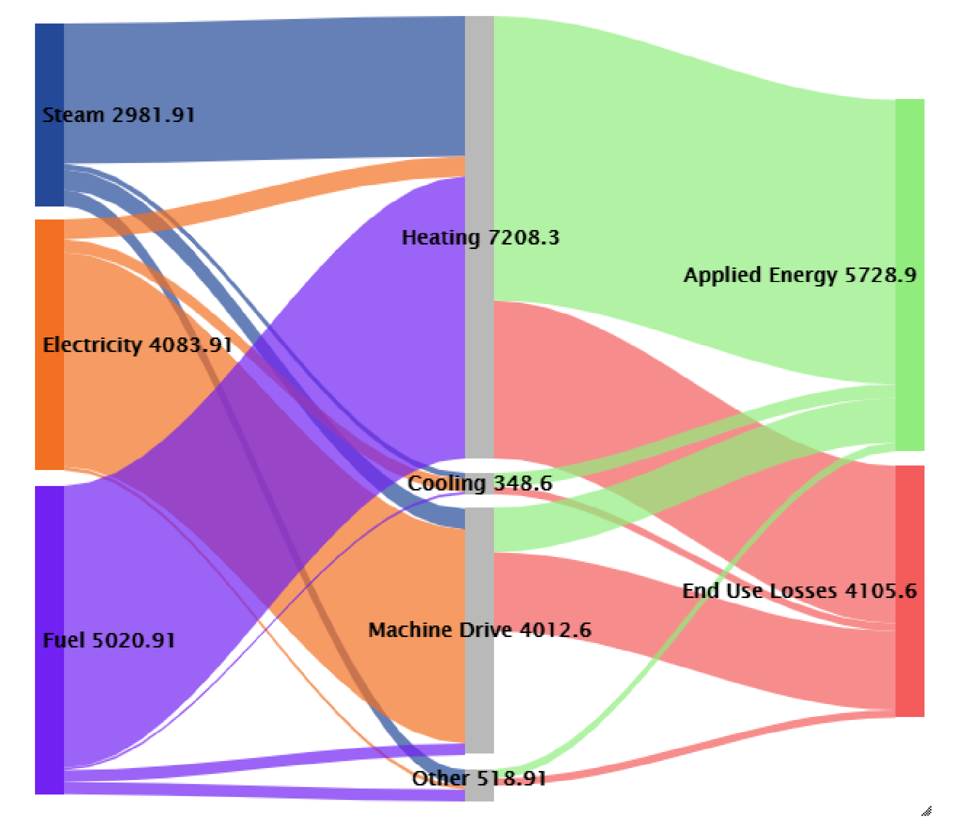
# Sankey Diagram

- Sankey diagrams are flow charts used to visualize material and energy flows with arrows that have a width proportional to the flow quantity.
- The arrows show flows from one node to another node.
- The *OptiRamp* Web Analytics Sankey diagram is useful tool to represent an entire input and output energy and materials flow in any energy equipment or system such as boiler generation, fired heaters, furnaces after carrying out energy balance calculation.

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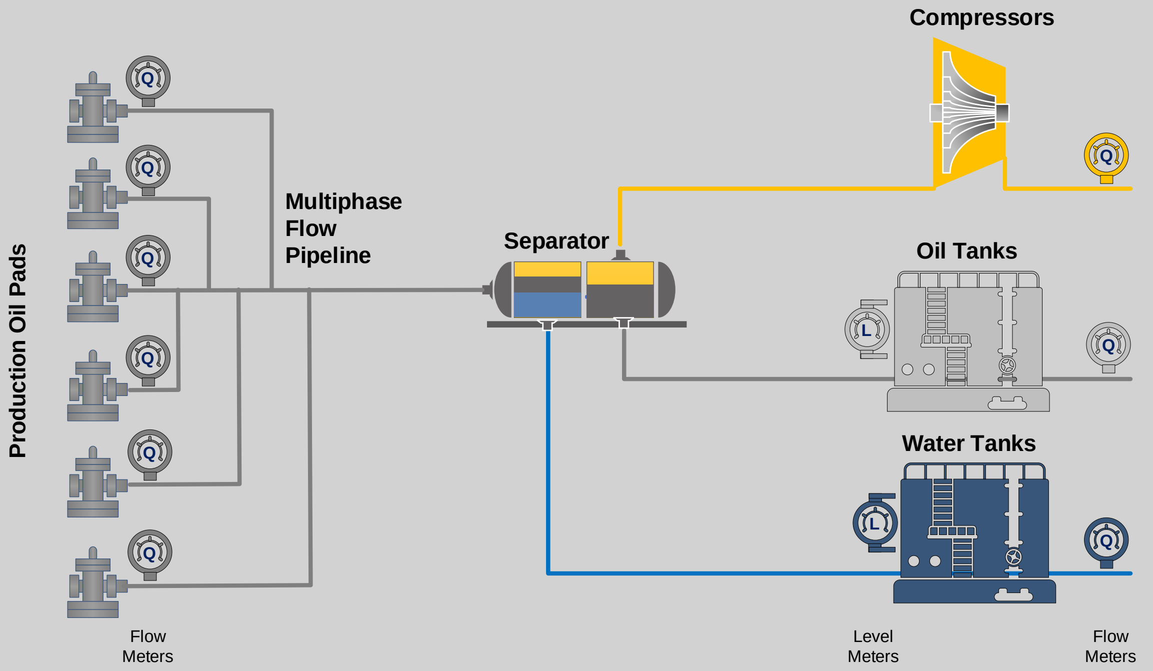
# Example: Allocation Factor

- Algorithm breaks down measured oil pad flows across various contributing wells /well pads
- Production wells deliver oil, water, and gas to a commingled flow and usually no flow measurements exist at a production well/well pad
- Allocation Factor Algorithm needs a measure from total oil / gas/ water pad flows and tank level measurements, along with measurements, or estimates for physical properties of the contributing flows
- Module uses total flow measurements to determine contribution of each producing source
- *OptiRamp* finds the operating scenario to maximize crude oil production rates, delivering more than 3% operational improvements.

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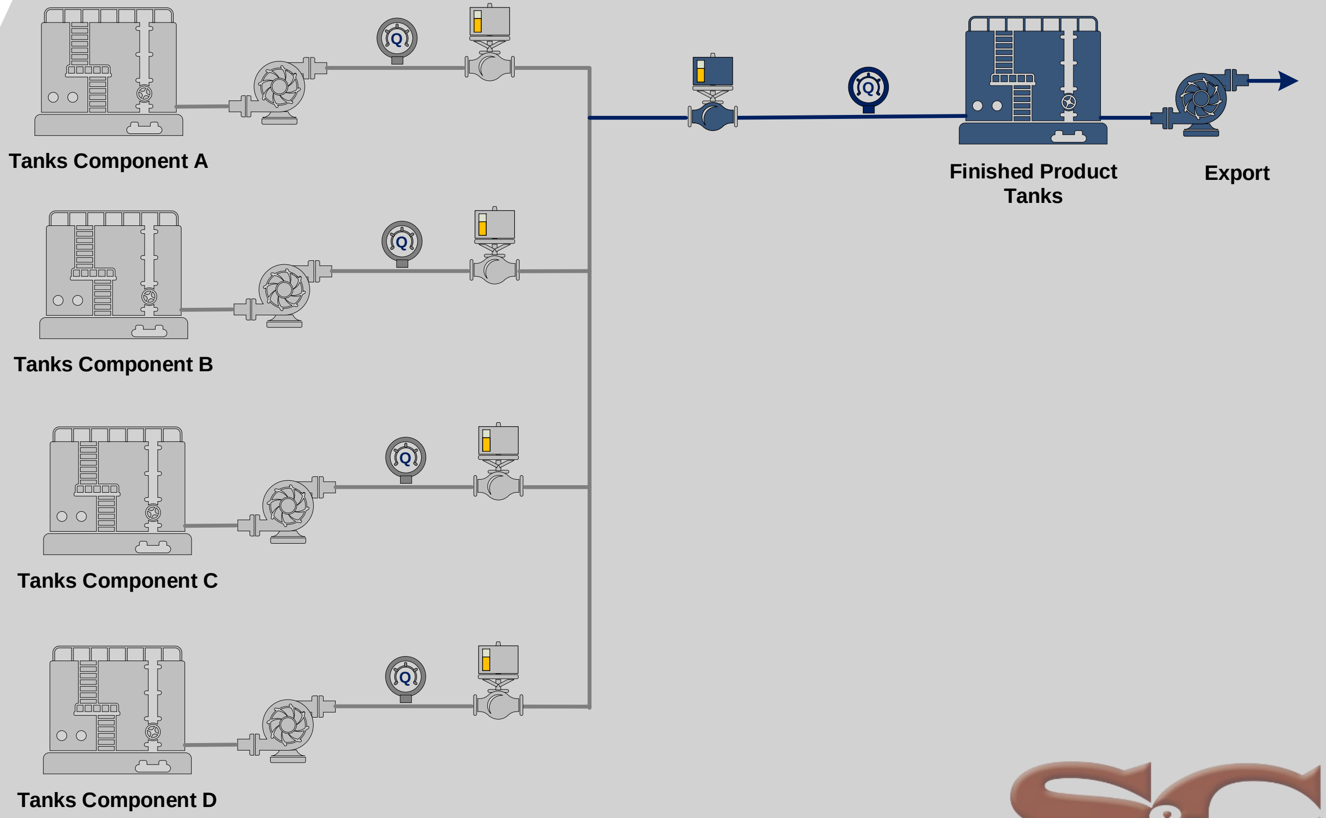
# Example: Blending

- Blending system combines set volumes of multiple gasoline component streams in a header to produce each batch of finished gasoline, which is then routed into a set of tanks.
- Each batch of finished gasoline is made by simultaneously blending component streams in a header. Each component has a flowmeter, a proportional integral derivative (PID) controller and a target ratio set by the control system. A set of online analyzers provide feedback for PID controllers.
- *OptiRamp* reconciliation algorithm  is used in a  system to account for measurement inaccuracy of flowmeters and online analyzers.
- *OptiRamp* determines optimal flow rates to maximize operational objectives subject to multiple economical and inventory constraints  decreasing production costs by 2%.

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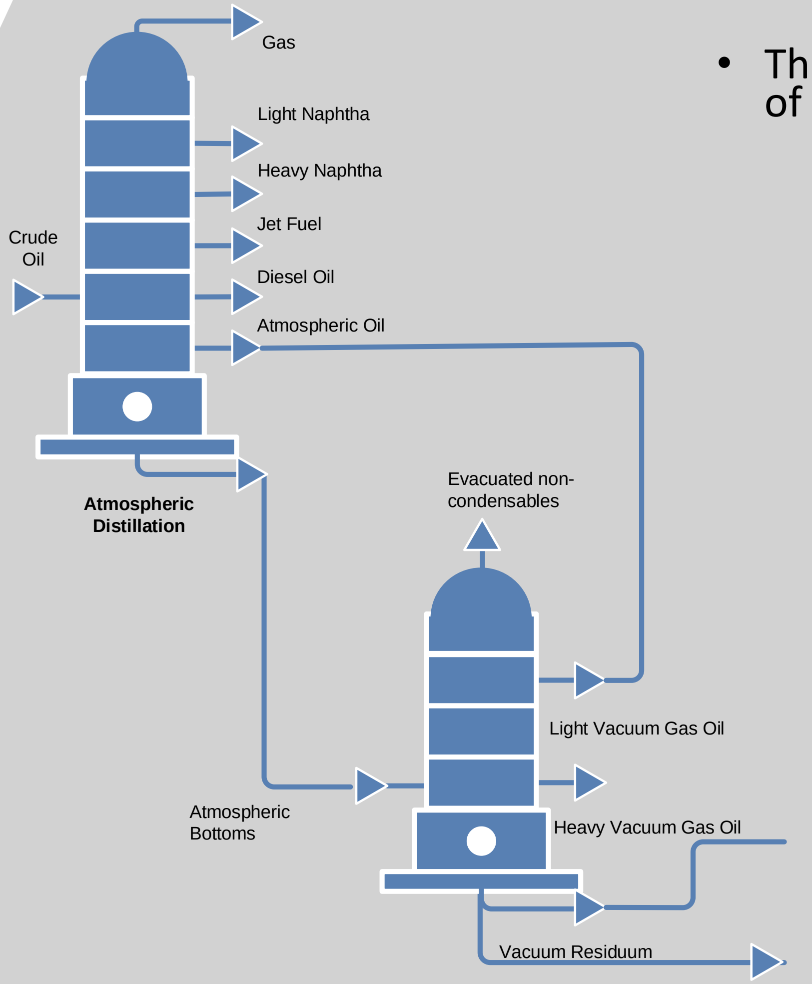
# Example: Refinery

- Petroleum refining is operating with a large number of unit operations (separation and reaction). Its purpose is to separate and enhance the various petroleum products to meet industrial and domestic targets.
- Fractional distillation or rectification is a technique of separation by fractionation of the various constituents of a mixture of miscible liquids with different boiling points. In refining, this fractionation of the crude oil is allowed to separate the hydrocarbon fractions with adequate similar properties to get products with specific characteristics of volatility.
- *OptiRamp* reconciliation algorithm is used in a system for transfer function models to account for measurement inaccuracy of flowmeters and analyzers, delivering more than 3% operational improvements.




- The most common sources of uncertainty:
  - Incoming crude, especially if measured by a ship
  - Water in the crude
  - Variability in crude gravity/properties that do not match the crude assay
  - Insufficient density measurements
  - Natural gas imports
  - Coke
  - Flare
  - Internally generated fuel gas consumed by fired equipment
  - Inventory changes.

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# Benefits

- Produces virtual measurements
- Process model for rate estimation
- Employ optimal material and power resources
- Real-time energy and material flows monitoring, deviations or unexpected events detection and reporting.
- Produces corrected measurements for the optimum use of supply resources to meet the predicted consumption at minimum total cost
- Optimizes running schedules
- Higher energy efficiency

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