



Mass & Energy Balancing at LNG Receiving Terminals

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Mass & energy balancing at LNG receiving terminals

- What?
- Why?
- How?

Mass & Energy Balancing

What?



❖ Mass & Energy Balancing – Application Areas

- ❖ Custody transfer handling
- ❖ Inventory monitoring
 - Shipper/owner level
 - Tank composition tracking (overall and/or per tank)
- ❖ Energy consumption & losses
 - Shrinkage
 - Electrical power
- ❖ Instrumentation error identification
- ❖ Send-out Wobbe control
- ❖ Environmental monitoring

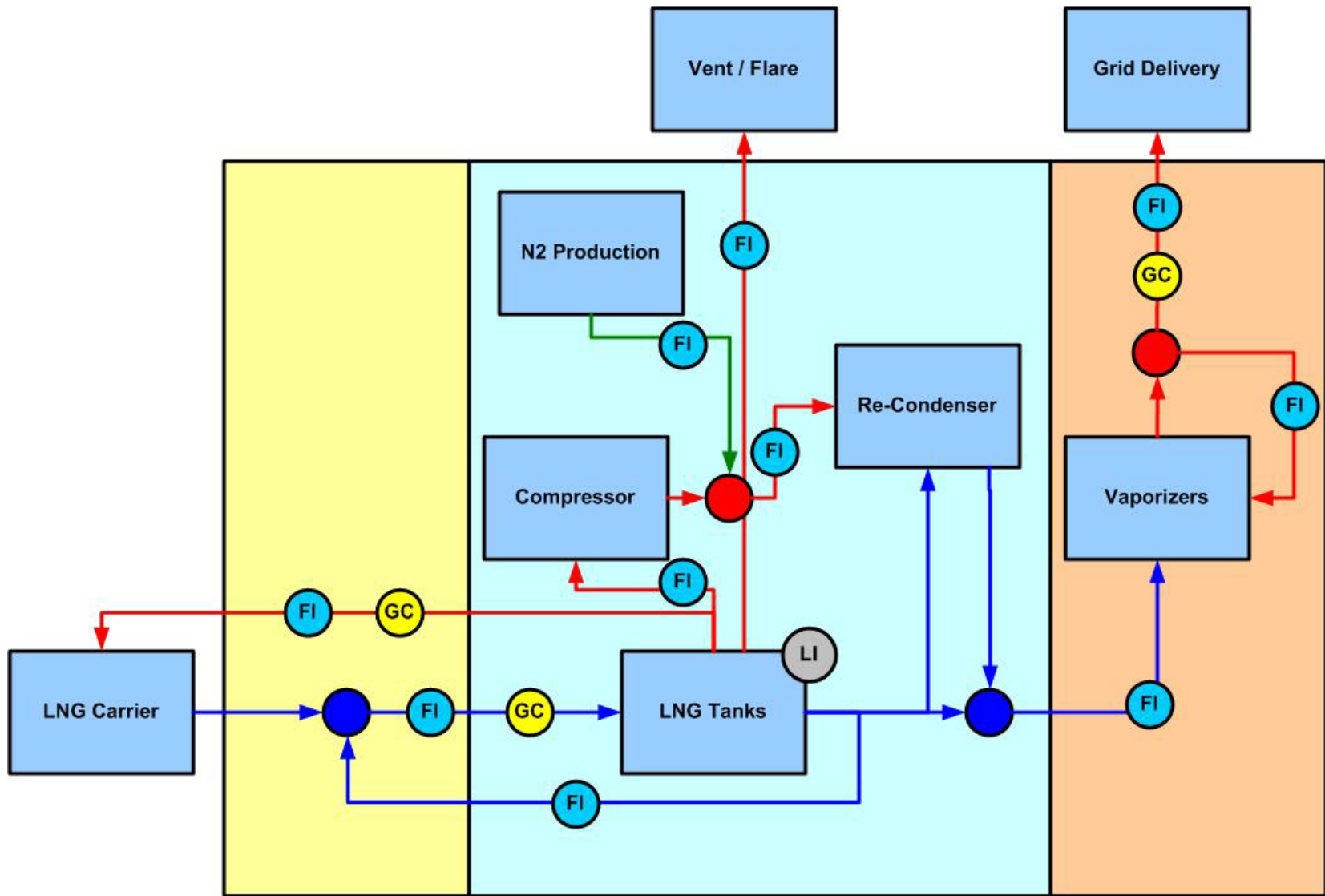
❖ Gas

- Vaporizers (Open Rack vs. SCV or IFV)
- Flare
- Leaks or repairs

❖ Electrical power

- Pumps
- Compressors
- Nitrogen production
- Etc.

LNG Terminal Process – Simplified Main Flows



❖ Mass and Energy Balancing –Subjects to be Considered

- ❖ Main and minor flows (include or not)
- ❖ Measurements available
- ❖ Measurement accuracies
- ❖ Assumptions on composition
- ❖ Operating Modes of LNG Receiving Terminals (**no loading!**)
 - Unloading with send-out
 - Unloading without send-out
 - Send-out without unloading
 - Neither unloading or sending out
- ❖ # Units (simultaneously) used for operations
 - E.g. 2 tanks for unloading, 2 tanks for send-out, and re-circulation between tanks

Mass & Energy Balancing

Why?



❖ Interest in Mass & Energy Balancing (1)

- ❖ Both on liquefaction and receiving / regasification side
- ❖ Changing LNG business
 - Spot
 - Cargo trades
 - Open contracts
- ❖ Multi-user terminals
 - Dedicated with TPA
 - Merchant

❖ Interest in Mass & Energy Balancing (2)

❖ Potentially interested parties

- Shippers (buyers) / terminal users
- Suppliers (sellers)
- Terminal operators
- Society represented by authorities (regulatory compliance)

❖ Depending on contract type

- Incoterms

❖ Contractual arrangements

- Terminal Access Code
- Individual throughput agreements

❖ Interest in Mass & Energy Balancing (3)

- ❖ Net energy amount available to shipper =
Delivered energy amount (carrier unload)
 - Shrinkage (in terminal)
 - ± Inventory corrections (by operator)

Mass & Energy Balancing

How?



- ❖ Location of measurements
- ❖ Quality/accuracy
 - Importance of accuracy based on time line of the purpose (daily, weekly, monthly, annual).
Level measurement most accurate over long period of time
 - Relative error introduced by measurement errors of different devices (e.g. LNG vs gas)
 - Variance in accuracy depending on the state of the terminal at the beginning and end of the (un)loading job (e.g. related to temperature influences on strapping tables)
- ❖ Redundancy of measurements
 - Option to use ship readings and integrate these data in a reconciled mass balance
- ❖ Timing of (un)loading measurements
 - Accuracy in starts/stops of (un)loading phases

❖ How Mass & Energy Balancing

- ❖ Manual
- ❖ Dedicated IT solution for unloading cross-check (Japan)
- ❖ Spreadsheet
- ❖ High level in commercial IT system
- ❖ Detailed in PIMS/MES system

❖ High Level in Commercial IT System

- ❖ Prevailing method ?!
- ❖ Backed by contracts & agreed procedures
 - Terminal Access Codes
 - Individual contracts
- ❖ Unloaded energy amount calculations (simple)
- ❖ Built-in high-level reconciliation methods
- ❖ Manual interventions
 - Inventory / book stock changes
 - Shrinkage figure updates

❖ Detailed in PIMS/MES System

❖ Unloading monitoring

- Composition OK? i.e. cargo acceptable?
- Instrumentation OK? i.e. challenge capability for surveyor report
- Tracking of carrier unloading stages incl. interrupts (can also allow comparison of (un)loading occasions and/or aggregation of (un)loading occasions)
- Determine unloaded amount based on terminal operational status (challenge surveyor report)

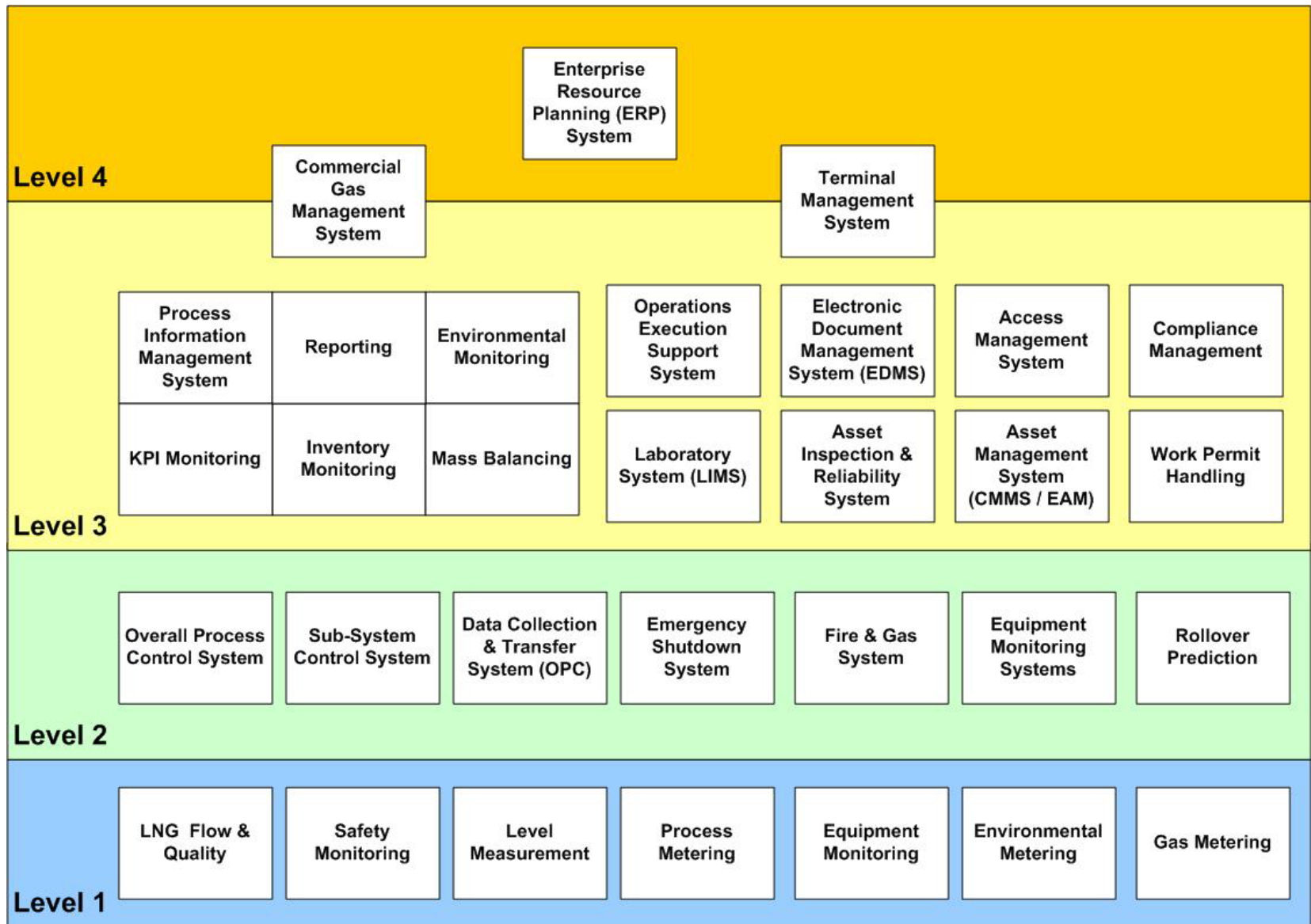
❖ Energy consumption monitoring

❖ Loss monitoring

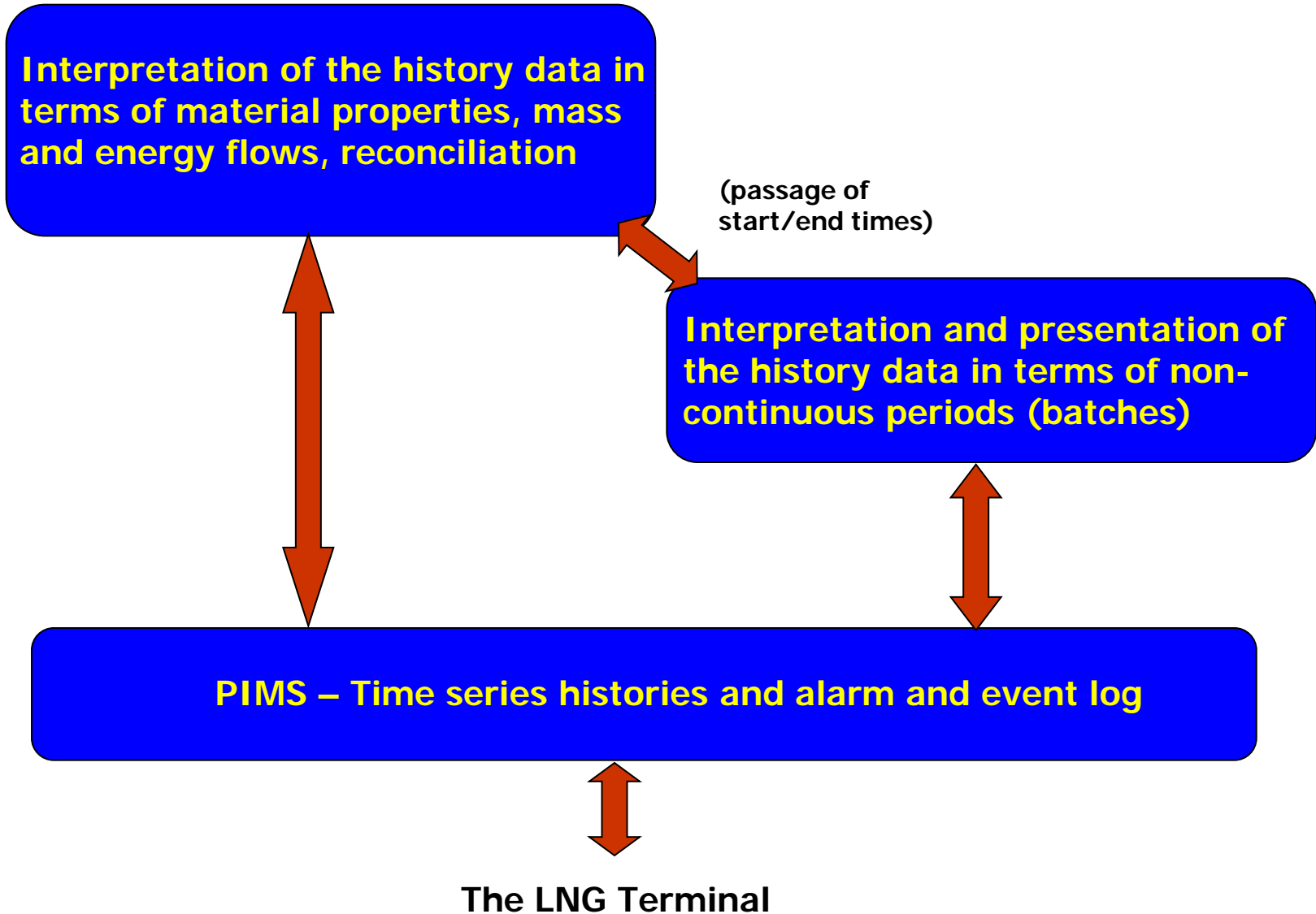
❖ Flare monitoring

❖ Environmental monitoring

LNG Terminal Automation Solution



LNG PIMS - Functional Distribution



- ❖ Data collection of (tag-based) time series data and Alarm & Event (A&E) data
 - Process data from PCS
 - Manual entries
 - Data from other systems
- ❖ Aggregations of time series data
- ❖ Calculations
- ❖ Graphical display of data, trends, etc.
- ❖ Reporting
- ❖ Export capability (e.g. Excel)

❖ Exaquantum Batch @ LNG Receiving Terminals

- ❖ Automatic status-based batch-based collection of information for the LNG unloading process rather than retrospective batch analysis
- ❖ The different stages in the unloading process are tracked allowing even complicated (e.g. interrupted) unloading sequences to be handled
- ❖ Collected information can be made available to other applications e.g. to reconcile ship unloading records
- ❖ Comparison of different carrier unloads based on different properties (carrier, size, volume, etc.)
- ❖ Use of previous carrier data (metering error?)

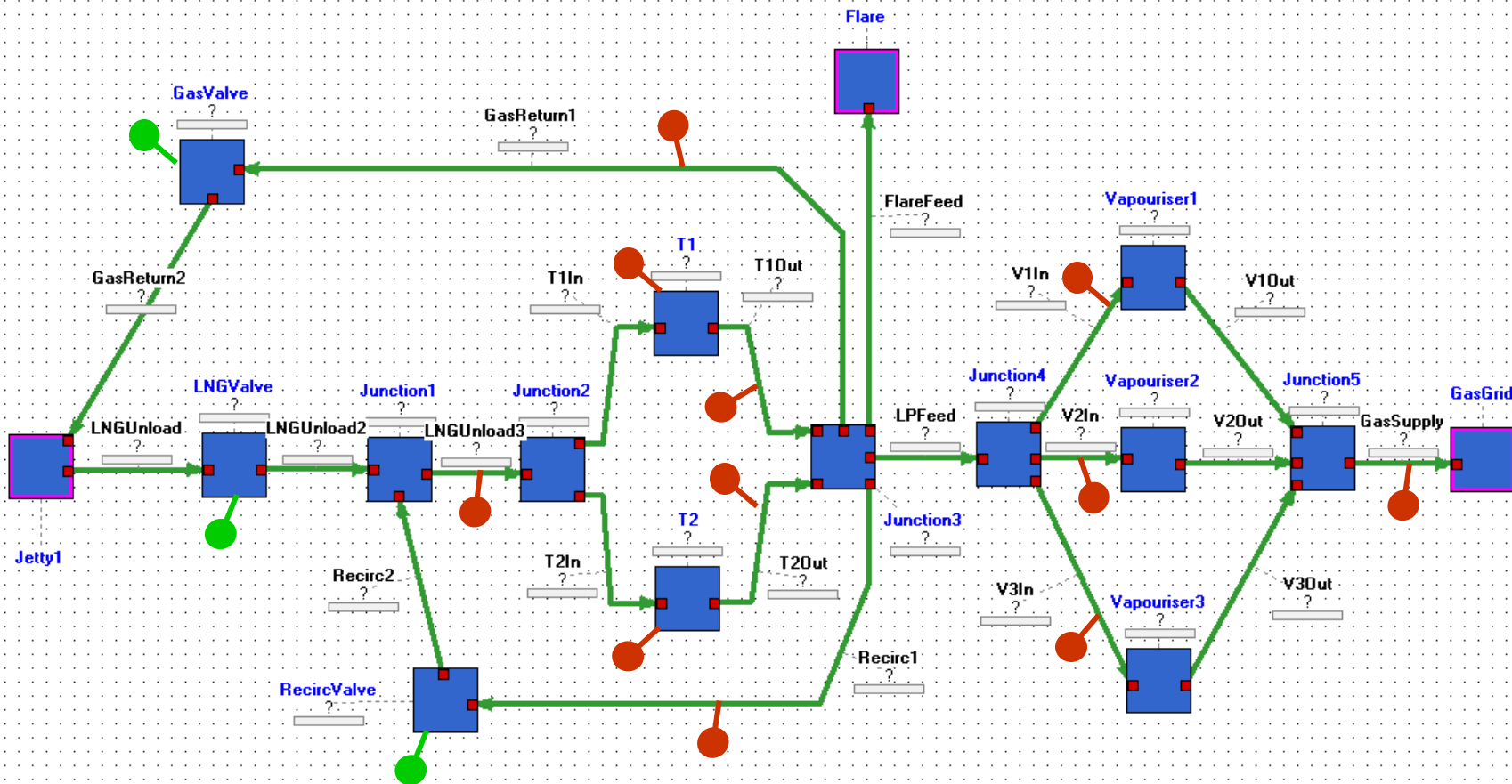
- ❖ The mPower Plant Model-based applications provide self-configuring management level reports based on data from history systems like PIMS, LIMS, logbooks, etc.
- ❖ mPower models the physical plant with a software object structure that understands the key concepts of material location, plant connectivity and containment
- ❖ When this plant model is linked to the lower level data sources, it is simple to define any physical or time boundaries and then request reports based on them

mPower: Plant Model Features

- ❖ Definition of Plant Objects
 - Sites, Plants, Units, Tanks, Streams
- ❖ Definition of Data Sources
 - Within mPower and to legacy software applications
- ❖ Physical Mapping of Plant Layout
 - Units and interconnections to Nodes and Streams
- ❖ Data Conversion to Information
 - Calculation and validation

Example Terminal Model

Eq: Main
Date: 24-Mar-2009 08:21
Maximum Node:
Maximum Stream:



- ❖ **Mass and Energy Balancing** to detect problems quickly when mass balancing shows an inconsistency
 - Leaks
 - Unauthorized removal of material
 - Instrumentation faults or failure
- ❖ **Data Reconciliation** to improve the quality of the process data used by mPower
 - Reports on instrumentation inaccuracies
 - Able to determine missing measurements to reduce the need for instrumentation

1. Collecting measurement information
2. Calculating mass and energy balances
3. Investigating faulty measurements
4. Reconciling redundant measurements discrepancies
5. Reconciling ship unloading records
6. Investigating excessive losses
7. Reporting end of period reconciliation

❖ Purpose

- Online error check and warning/alarm (e.g. instrumentation failures)
- Unloaded amount
- Daily/Weekly/Monthly stock balance

❖ Automatic vs. manual

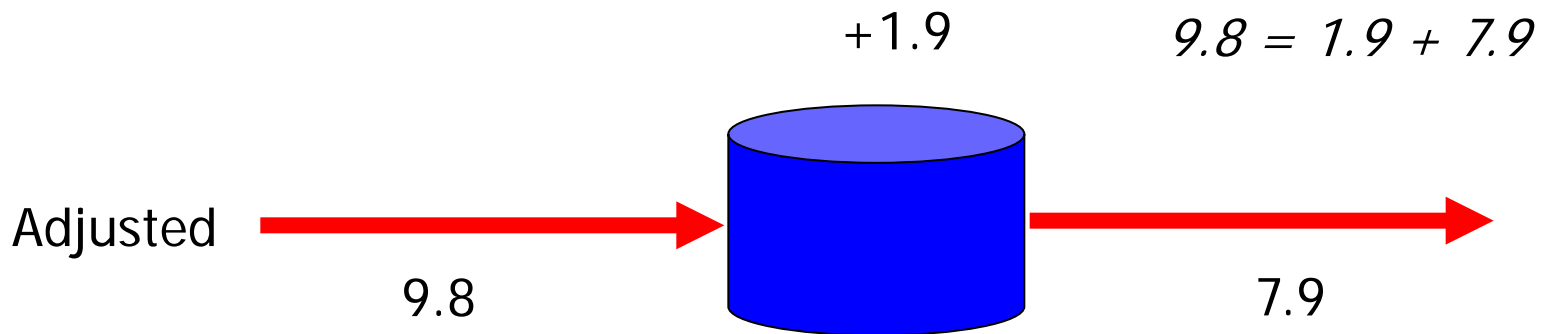
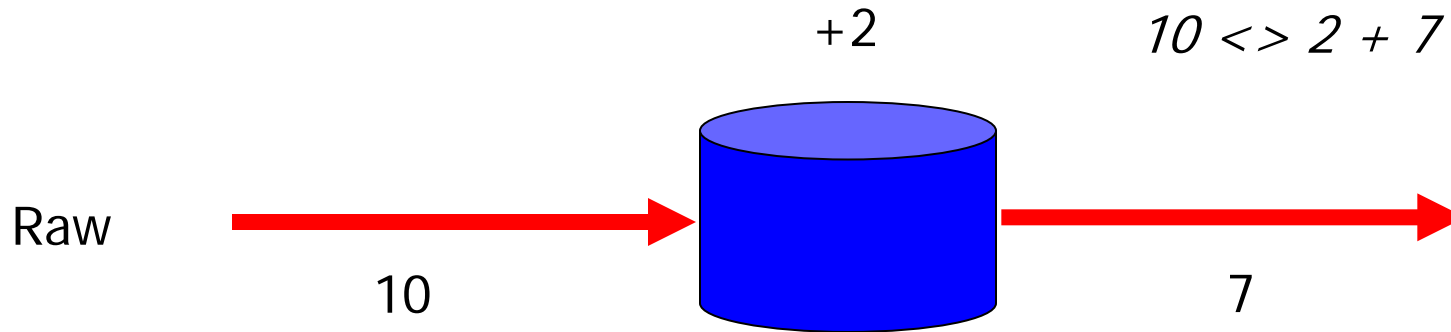
❖ Pre-defined vs user-definable (on the fly)

❖ General reconciliation meanings

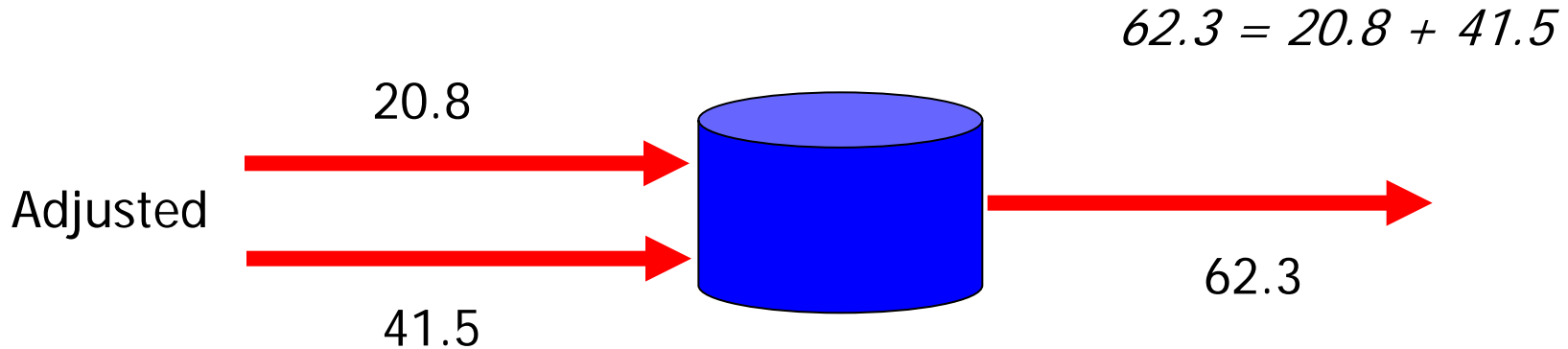
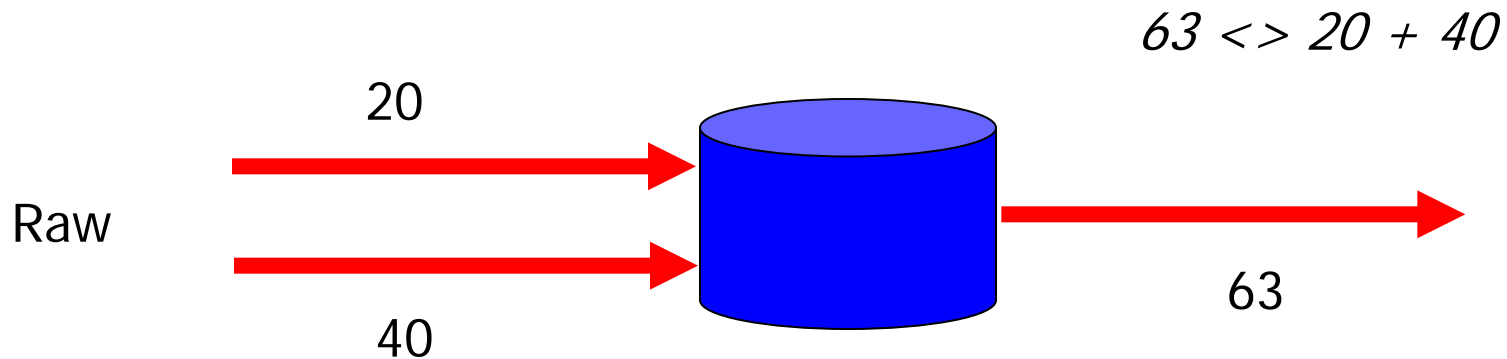
Reconciliation: Two Meanings

1. Adjustment of flows and inventories to values different from the raw measured values so as to achieve a balance (if acceptable)
2. Analysis of the flows and inventories so as to identify “lost” material

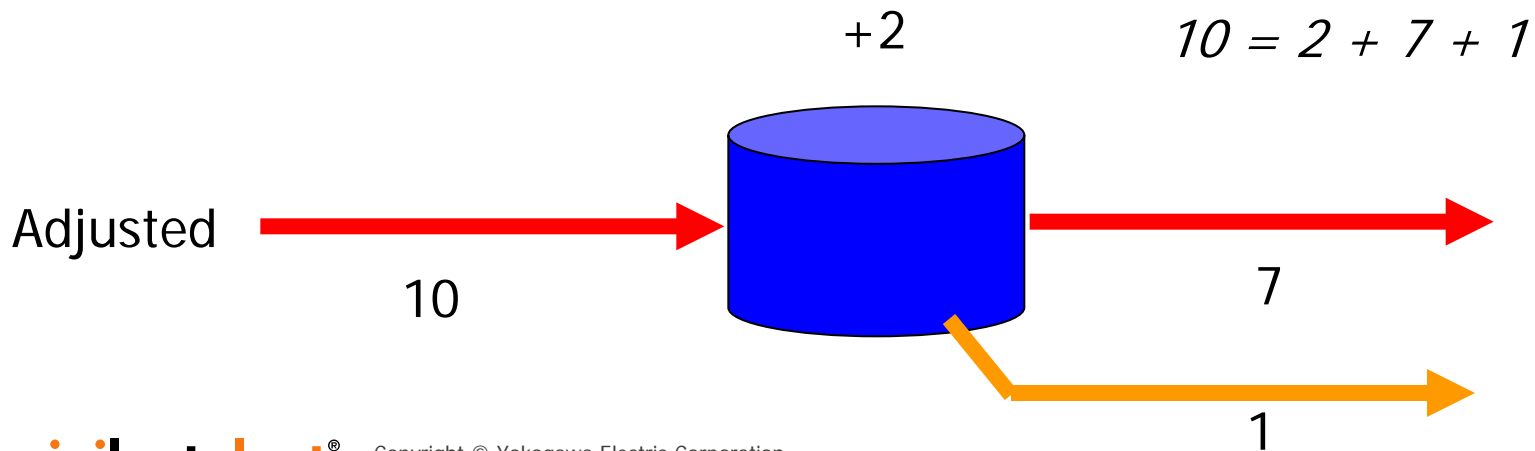
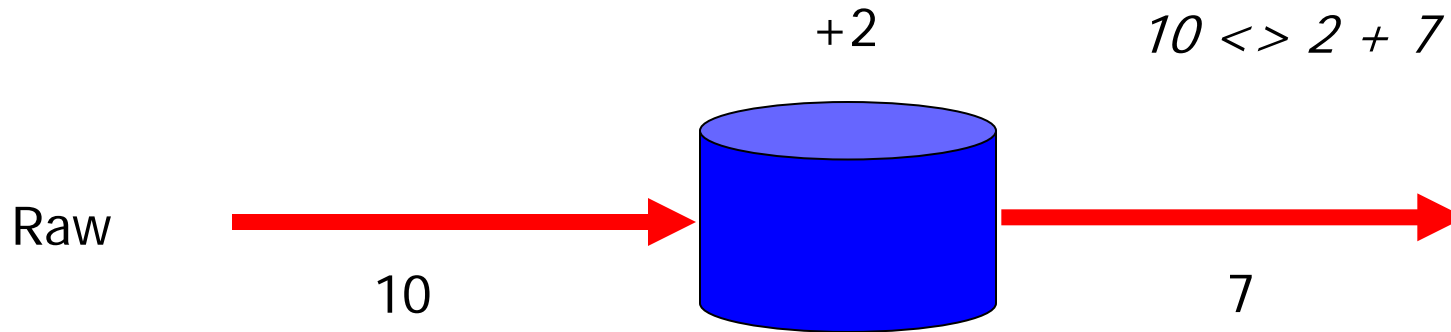
1. Adjusting values to achieve a balance



1. Adjusting values to achieve a balance



2. Calculating loss



Conclusion



- ❖ Mass and energy balancing at LNG receiving terminals is getting more attention
- ❖ The technology to do detailed, automated mass and energy balancing is available
- ❖ It makes more detailed and frequent mass & energy balances possible

Thank you for your attention