Quantity data flow in the natural gas & LNG supply chain

The “bottom line”: correctness of natural gas & LNG quantity data values

Version History

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00	2012-07-09	First published
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Contents

1. Management Summary

From the well head to end consumers, oil and gas supply chains are amongst the most complex in the world. Within all this complexity, QuantityWare focuses on a single important aspect - the measurement and subsequent calculations of product quantity value data – in this document, we focus on quantity value data of LNG (Liquefied Natural Gas).

These calculations are the "bottom line" of all oil & gas producing, processing and sales operations. Without this information being available to your business departments via their ERP systems in timely, accurate manner with controlled, reliable content, your business cannot grow net earnings, or reduce costs in any meaningful manner.

Whether you are implementing existing business processes or looking to leverage an existing investment in SAP ERP products, if your business is about natural gas in any form, centralised natural gas and LNG product calculations within the SAP Oil, Gas, & Energy solution are an essential component to business process optimisation and profit maximisation. This component can only be supplied "out-of-the-box" by QuantityWare Bulk Calculations - Gas (BCG), developed as an SAP Certified Add-On, a fully integrated solution, designed and built to meet your most critical business needs.

2. Introduction

Based upon the principles described in our working paper "Quantity Data Flow in the Oil & Gas Supply Chain", we strongly recommend the adoption of QuantityWare's integrated quantity data flow model when connecting central ERP systems to the operational world.

The integrated quantity data flow model provides a way for energy enterprises to cater for increasingly stringent GRC expectations by ending reliance on a simple one-way quantity data flow from the operational measurement world into the central ERP system. It defines and explains the necessity for a single, state-of-the-art, secure and reliable calculation engine within the central business instance (e.g., ERP system), that is capable of universally performing calculations for all:

- Unit of measure systems
- Calculation measurement standards

Within this model, data passed from an ERP-"external" system, such as a tank gauging system, can easily be controlled and enriched with additional data in a transparent and secure manner. Business users (inventory managers, schedulers, tank farm managers, sales specialists, to name but a few) should have this data at their fingertips within an integrated system to work with maximum efficiency such that e.g.:

- Invoices are based on good quantity data
- Excise duty is calculated with high accuracy
- Transparency is achieved throughout the supply chain
- Enhanced security is achieved reducing risk of possible data manipulation

In this working paper, we explain the integrated quantity data flow model for the natural gas & LNG supply chain. This supply chain is - due to the physical properties and measurement challenges of natural gas & LNG - even more complex when compared to the typical crude oil & product quantity data flow.

3. The Simplified Natural Gas & LNG Supply Chain

As a basis for our discussion, a graphical representation of a simplified natural gas & LNG supply chain is depicted down below:

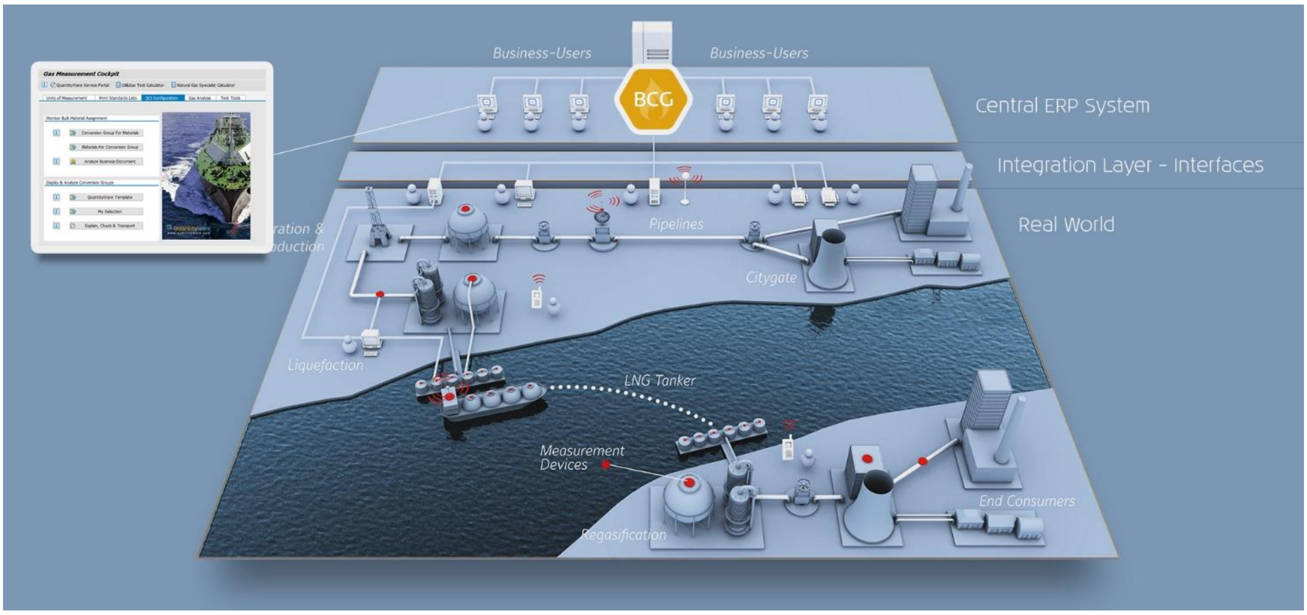

Figure 1: The simplified natural gas & LNG supply chain

In the upper part of the graphic, business users are assumed to operate business transactions within a highly integrated, central ERP system (central box).

In the lower part, our simplified supply chain graphically illustrates the natural gas & LNG product flow from the natural gas well head to industrial and private end consumers.

Natural gas is extracted from reservoirs via various commonly used techniques in production countries. Impurities and commercially valuable by-products (e.g., NGL – Natural Gas Liquids) are removed, creating a dry natural gas for transmission via pipeline (high pressure regime) to industrial consumers and households. If transmission via pipelines is not possible due to geographical (e.g., oceans) or political barriers, dry natural gas can be shipped as LNG (Liquefied Natural Gas) using LNG tankers.

3.1. A Vital and Expanding Business

In 2004, LNG accounted for 7% (188 billion cubic meters (m³)) of the world's natural gas demand. This markets' development from its early market stages in 1970, when global LNG trade was around 3 billion cubic meters (m³), to [2021 where trade volume]() had increased to 520 billion cubic meters (m³) – and shows a dynamic and increasingly important energy market.

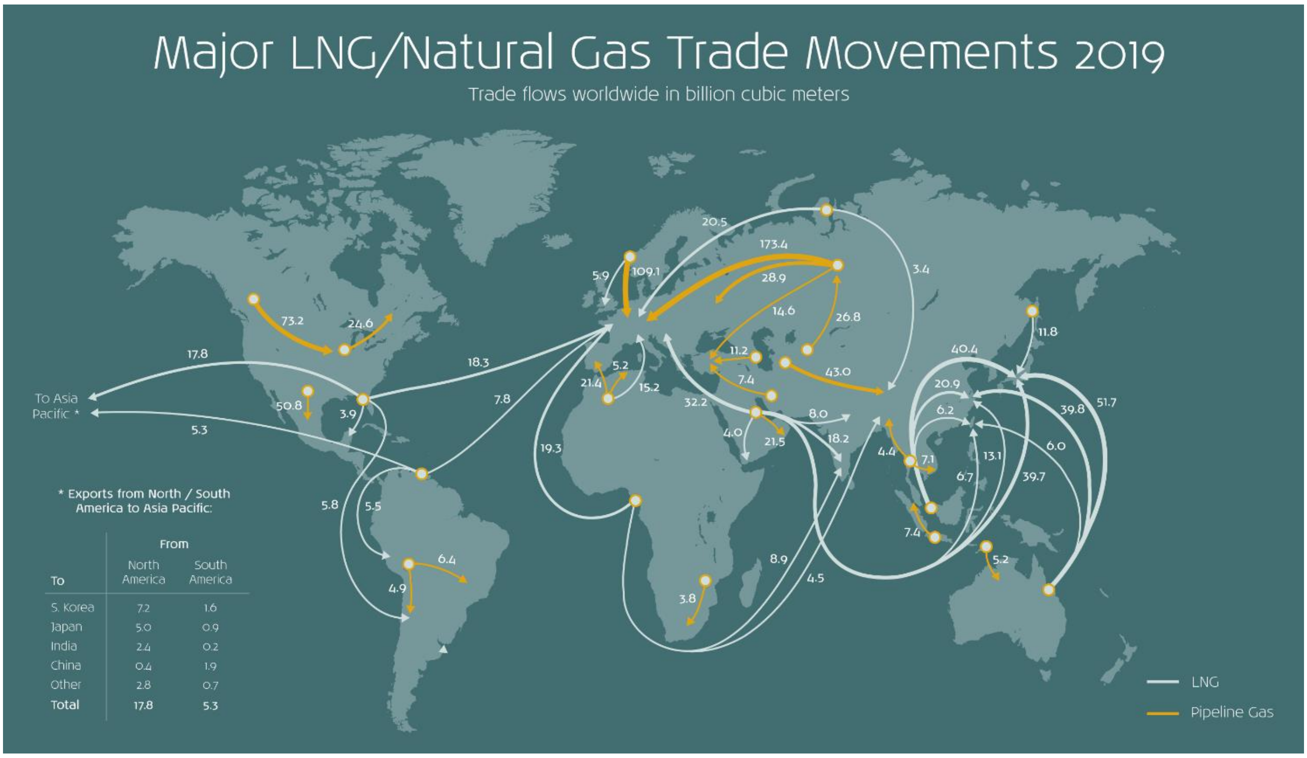

Figure 2: Major natural gas & LNG trade movements 2019

3.2. Measurement and Calculation

It is general practice that at each custody transfer point, dedicated measurement points (e.g., compressor stations), as well as each point where the mode of transport changes, sophisticated measurement devices (orifice flow meters, gauging systems, density meters, etc.) are in use. Such devices may be manufactured by one or more suppliers, who all may incorporate quantity calculation procedures of varying sophistication, typically based on measurement standards, allowing the determination of several product characteristics. Such measurements are not only technically motivated, but exact quantity data is also necessary within the governing business processes to determine transfers of ownership throughout the supply chain – prices, taxes, and tariffs are based upon this data.

3.3. What is LNG (Liquified Natural Gas)?

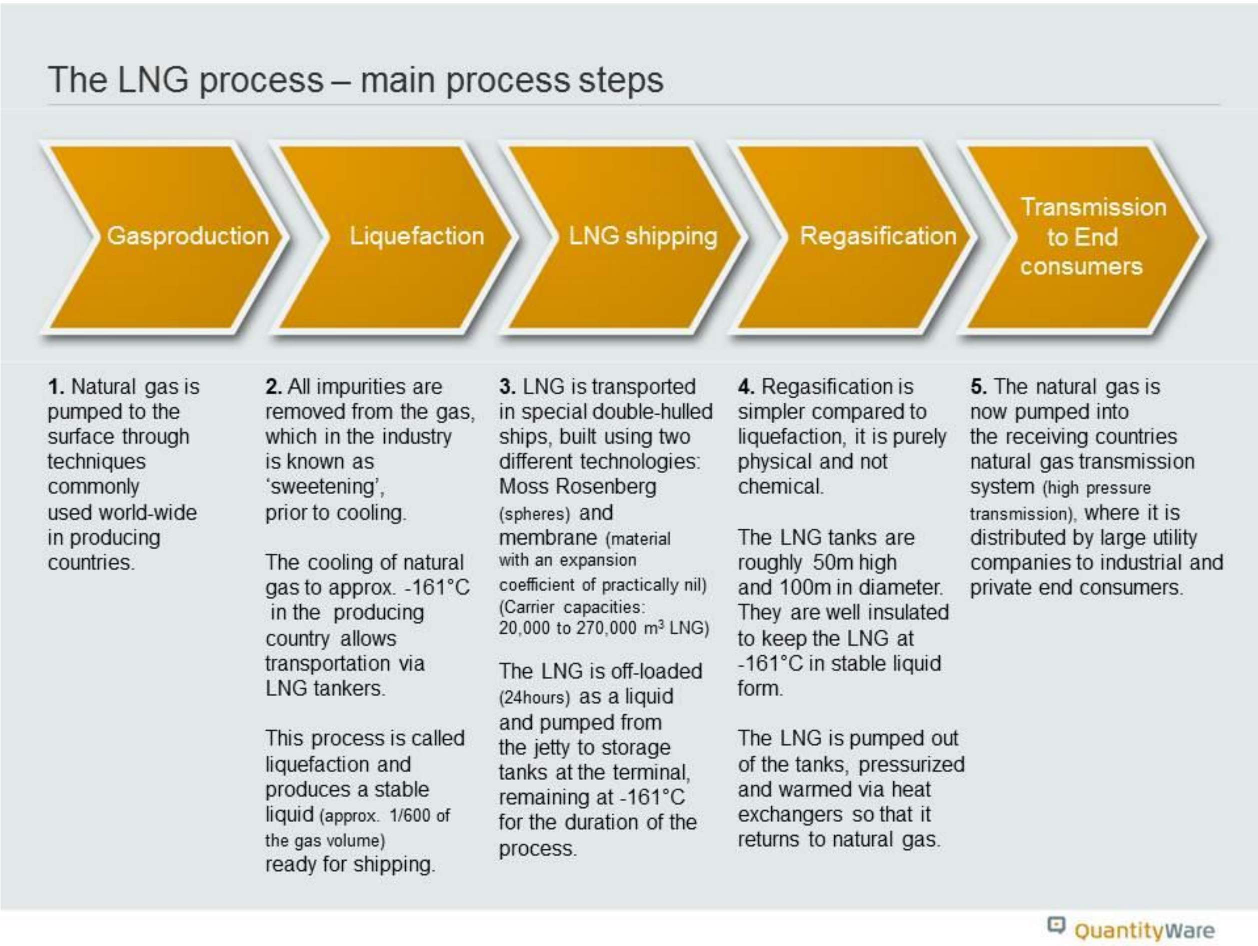

Figure 3: The LNG process – main steps

As described in the process steps of Figure 3, LNG is basically sweetened natural gas, which is cooled using expensive refrigeration technology so that the natural gas condenses into the liquid state. Like water, which boils at 100 °C at sea level, natural gas also boils, but at a temperature of approximately -161 °C. As a liquid, LNG possesses a very high energy density and can be transported using special, highly insulated LNG tankers across oceans, allowing production and consumption regions, which cannot be directly linked via pipelines due to their geographic locations, or intervening political reasons, to be connected, forming a market.

LNG liquefaction, shipment and regasification are extremely asset intensive and require massive capital investments relying on sophisticated IT landscapes to enable monitoring and control of product quantity flow - an essential factor to business success. In the next chapter, we provide a straightforward and short deep dive into the quantity data and physical property data handling of natural gas and LNG.

4. Natural Gas & LNG Quantities – Deep Dive

Fundamental for accurate natural gas and LNG measurement is the exact knowledge of the chemical composition of the natural gas or LNG being handled within the system; such chemical composition data is typically determined via gas chromatography. Measurements of natural gas temperature and pressure are required at measurement points, along with (gaseous) volume flow rates to allow the calculation of energy, mass and volume quantities at standardized conditions (metering and combustion temperature as well as pressure reference values). Details concerning these measurements and subsequent calculation challenges can be found in our BCG Documentation Manual.

Here, we use a typical business document, a "Certificate on Loading" for LNG, to demonstrate how calculation challenges can be solved:

ATTACHMENT B **PART III** **CERTIFICATE ON LOADING**

TO:
ATTENTION:
FROM:

1. IDENTIFICATION

(a) Name of LNG Tanker:
(b) Cargo Number:
(c) Date and time Loading completed:

2. BASIC DATA

(a) LNG Cargo Composition:

Component	*Mole percent*
Nitrogen (N_2)	___ . ___
Methane (C_1)	___ . ___
Ethane (C_2)	___ . ___
Propane (C_3)	___ . ___
Iso-butane (iC_4)	___ . ___
Normal-butane (nC_4)	___ . ___
Pentane Plus (nC_{5+})	___ . ___

(b) Impurities:

Hydrogen sulphide	___ . ___ mg/m³(st)
Total sulphur	___ . ___ mg/m³(st)

(c) Volume loaded	___ . ___ m³
(d) Average temperature of the LNG loaded	___ . ___ °C

3. RESULTS

(a) Wobbe Index	___ . ___ MJ/ m³ (st)
(b) LNG density	___ . ___ kg/ m³
(c) Gross Calorific Value (Volumetric)	___ . ___ MJ/ m³ (st)
(d) Gross Calorific Value (Mass)	___ . ___ MJ/ kg
(e) Total quantity of LNG loaded	___ . ___ MJ
	___ . ___ MMBtu

Figure 4: Certificate on loading

Simply put, LNG adds an additional dimension of complexity when compared with natural gas calculations:

For natural gas, we are interested in the heat released via combustion (the natural gas' energy), the volume and the mass of gas which we trade. These quantity values can be calculated if we know the chemical composition of our gas, based on various physical property data standards of the components and natural gas measurement standards. So, where is the "added dimension"?

Since LNG is present as a liquid, we also need to know the "liquid" density of LNG, so that we can calculate the equivalent natural gas mass, gaseous volume, and energy.

As is shown in Figure 4, the basic LNG data is the measurement data of our cargo. As explained beforehand, LNG must be kept at extremely low temperatures during shipment. Although at a very low temperature, the LNG is basically a boiling liquid during shipment, which leads to LNG "ageing" during shipment, i.e., lighter components may boil-off in a larger fraction then heavier components, therefore the measurement data must be determined at loading, as well as unloading, resulting in the section "Basic Data" in Figure 4. Once we know the chemical composition of our LNG load, as well as the average temperature during loading and the liquid volume loaded, we can calculate all business relevant properties (e.g. the LNG density, heating values and Wobbe index) and energies, in various units of measure which are then entered in the "Results" section in Figure 4; in addition, masses and the equivalent gaseous volumes which we will obtain after regasification of our LNG load are also calculated. If this sounds complex then you have the correct impression - such integrated calculations are among the most complex that need to be performed within the natural gas & LNG supply chain however, with QuantityWare BCG, these calculations are readily available to be seamlessly integrated into your SAP ERP LNG processes.

In the following Figures 5a, b, c and d we demonstrate for a load of 50 000 m³ (liquid) LNG, how SAP Oil, Gas, & Energy, when used in conjunction with the QuantityWare Bulk Calculations Solution (BCS), can calculate, in one “single step”, all:

- Relevant physical properties (superior and inferior heating values = gross and net calorific values, Wobbe index, densities)
- Masses,
- Energies (at various combustion conditions),
- And standardized liquid and equivalent gaseous volumes (also at various standard conditions)

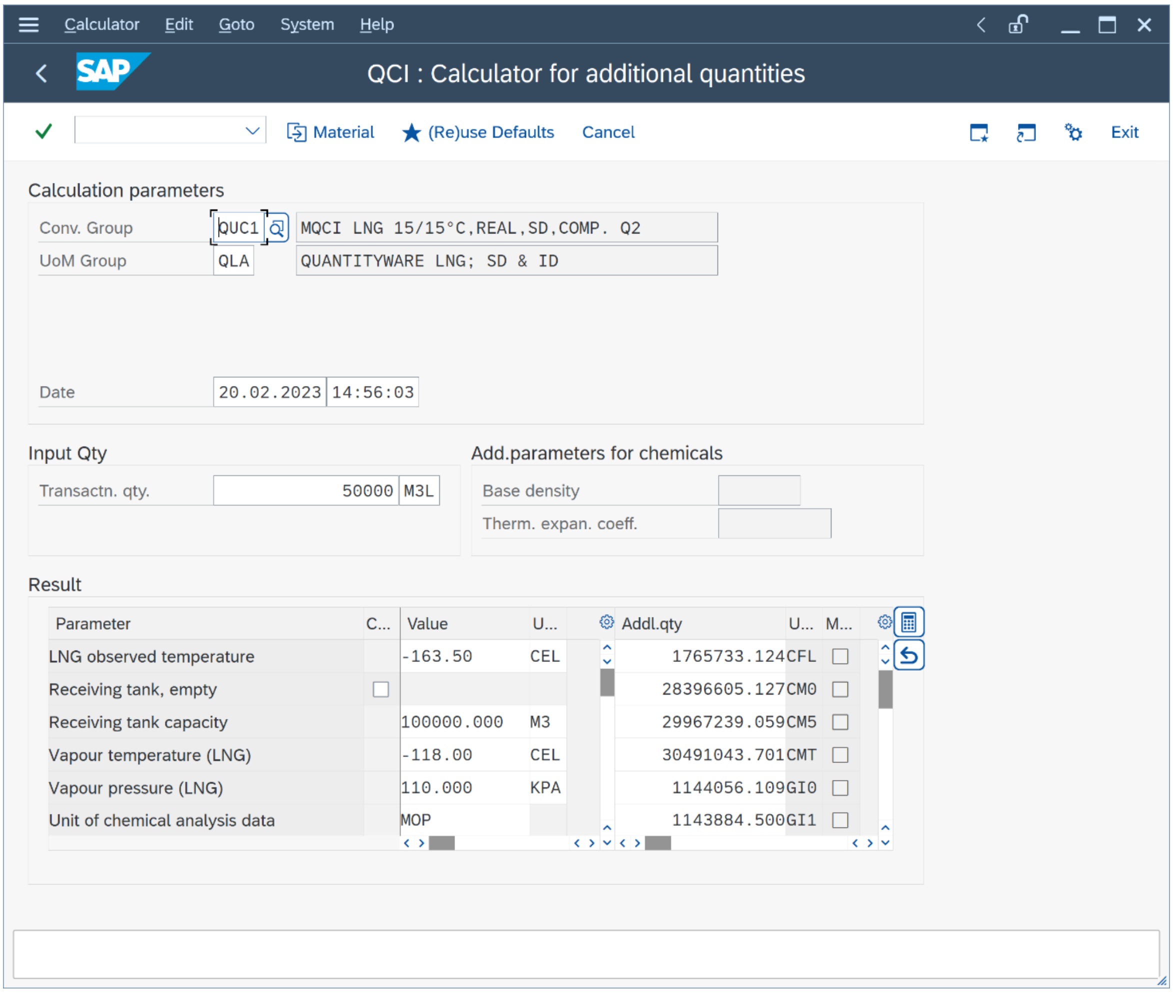

Figure 5a: Input parameters in SAP Oil, Gas, & Energy

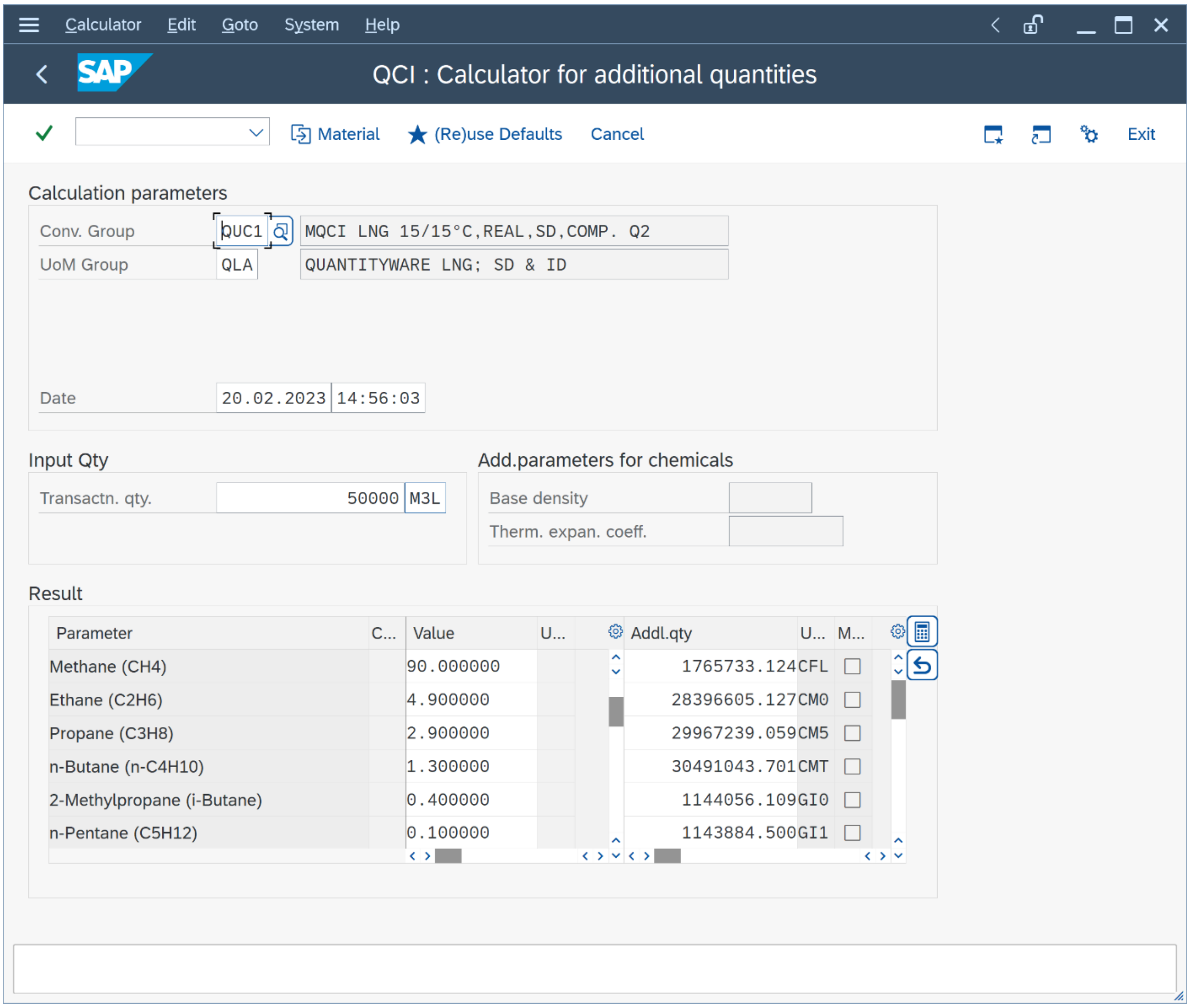

Figure 5b: Input composition data

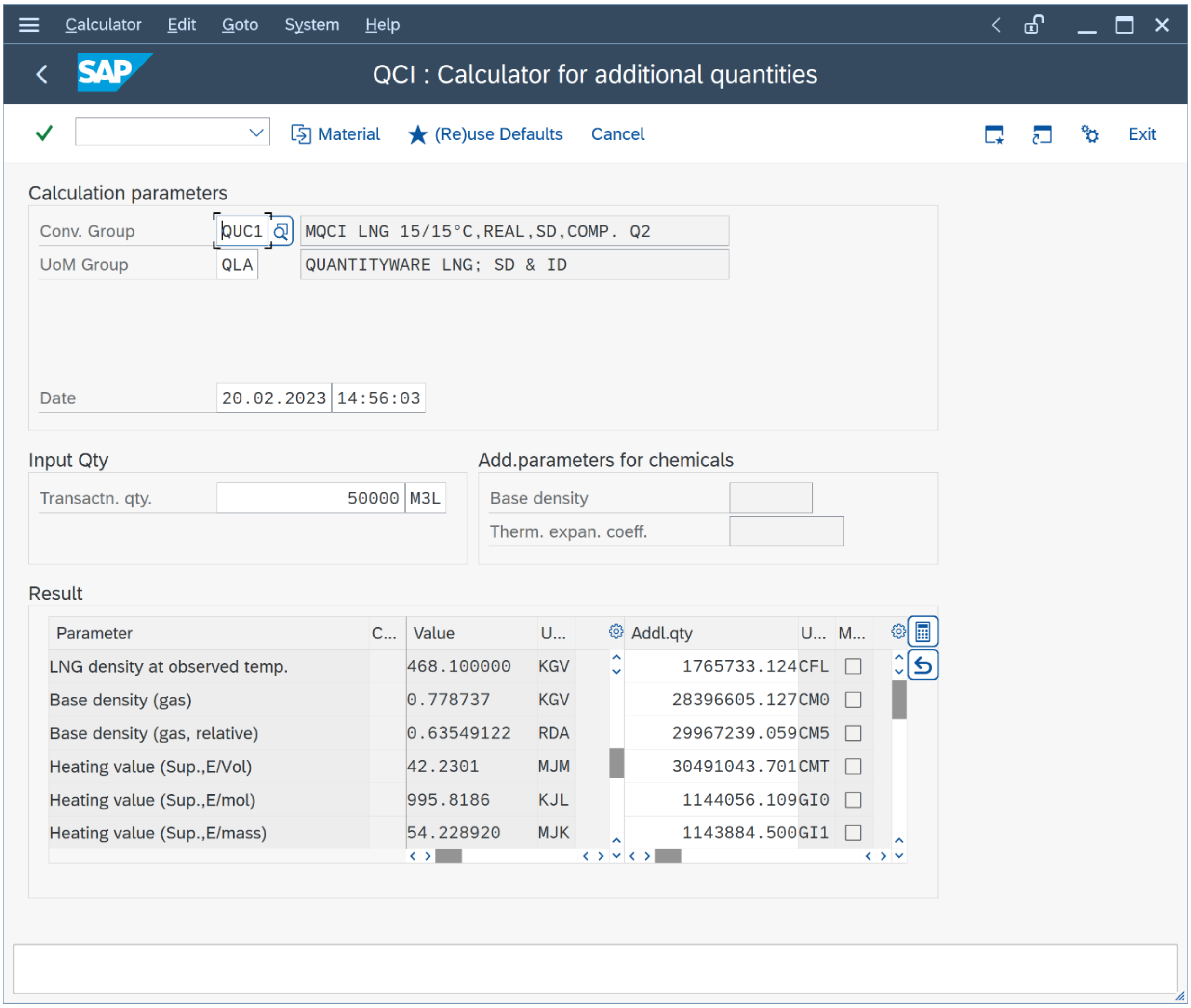

Figure 5c: Calculated LNG liquid density, gas densities and heating values

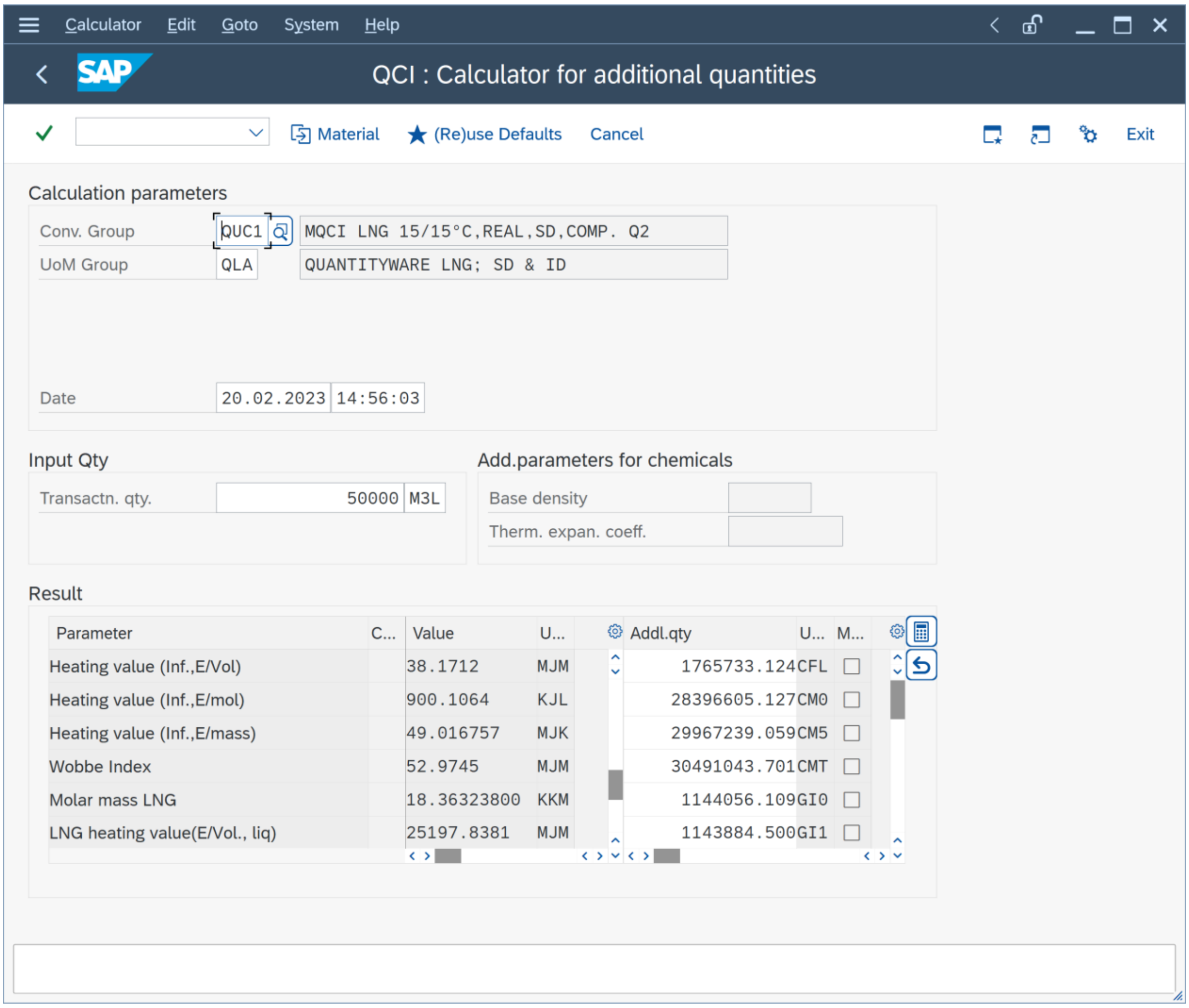

Figure 5d: Calculated heating values and Wobbe Index – masses, energies and volumes are calculated in the "Addl. qty" column.

As demonstrated above, QuantityWare BCS provides SAP Oil, Gas, & Energy with the ability to calculate all relevant quantity value data, allowing business agents to complete, print and distribute the certificate on loading document from within the ERP system, to all relevant business partners.

5. Conclusion

In this working paper we have described why it is imperative for any quality- and profit-orientated natural gas company to focus on the overall quantity data product flow within their complex supply chain, especially if LNG processing is relevant. We have demonstrated how this can be readily achieved by combining the SAP Oil, Gas, & Energy solution and QuantityWare BCS.

While there is huge potential to leverage fully integrated ERP solutions for gas businesses, existing environments can also harness the dormant processing power of any ERP system (process redesign, utilization of new ERP based process capabilities, addition of missing process solutions e.g., in the trading area). In both scenarios, any investments should be accompanied by a critical review of the existing quantity data flow capabilities. At the simplest level, this formula explains why:

> "Product A" Profit = ("quantity value data of product A" x "price") - "costs".

SAP ERP for Oil & Gas helps you to define and manage "product A", as well as to optimize the complex "price" and "cost" variables.

If you do not have absolute transparency in your **quantity value data**, your company is not "simply" possibly loosing profit – it is exposed to extensive risk affecting financial, contractual, and legal areas – which can disturb both daily trade and financial market value. "Intangibles" such as trust and reputation can also be severely damaged if your organisation is shown not to have total control over the quintessence of its existence – its product quantity value data.

QuantityWare provides you with mechanisms to ensure "good" quantity value data – the source of your companies' financial stability and business health.

6. References

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