

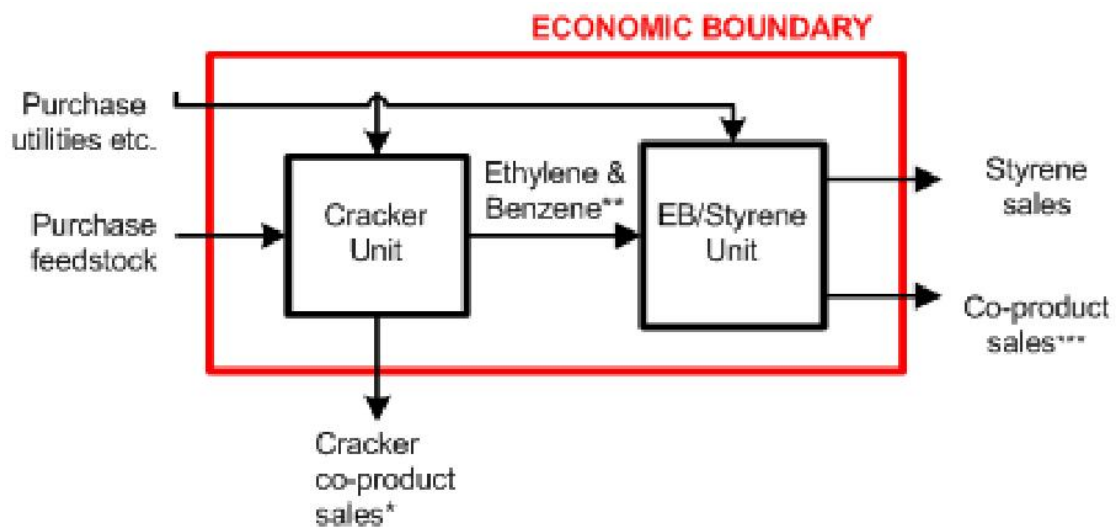
**ICIS Margin – Styrene US Methodology**

This document is intended to provide methodology support for customers receiving the ICIS Margin – Styrene US report.

**THE BUSINESS MODEL**

The diagram below shows the main method of making styrene monomer (SM) from ethane (derived from natural gas reserves) or naphtha (a product mainly derived from crude oil).

Ethane (or naphtha) with steam is fed into the cracker unit where ethylene and co-products (propylene, butadiene, benzene, etc.) are made. The ethylene and benzene from the cracker are then further processed (catalytic alkylation) to make ethylbenzene. This is then fed into a dehydrogenation reactor to make styrene (with minor co-product benzene and toluene). The styrene is then typically piped to other chemical plants where it is further processed into derivative products such as polystyrene.



\*Cracker co-product yields depend on type of feedstock

\*\*For naphtha cracking, benzene is transferred from the cracker unit; for ethane cracking, benzene is purchased

\*\*\*Includes minor amounts of toluene

## THE MARGIN CALCULATION

- Margin measure provides assessment of the ex-works cash margin obtained for the product over raw material costs and key variable manufacturing costs, such as power, steam, catalysts and chemicals. This measure can also be termed as a variable margin, contribution or benefit.
- It represents a cash margin measure available for supporting the direct and allocated fixed manufacturing costs, working capital, taxes, royalties, corporate costs, debt service costs, capital costs and owner's returns from the business.
- This margin measure provides simple signals on the direction of business margins, as dictated by the environment alone, thus informing market positioning by sellers, buyers and traders.
- ICIS chooses not to model beyond raw material costs and key variable manufacturing costs as this ceases to be generic to the integrated industry and highly specific to individual business operations, their site structure, location, ownership and financial structures. Such detail would not fairly reflect or be applicable in a wider industry context. It may also be more subjective, open to fair challenges and not feasible to reference in commercial discussions.
- Plant manufacturing and feedstock yield model data have been provided for the cracker unit by Linde Engineering, a division of Linde AG. Linde Engineering ([www.linde-engineering.com](http://www.linde-engineering.com)) is a leading international chemical plant designer, process engineering, procurement and construction contractor. It has extensive experience in ethylene plant design.
- The process model is generic and not referenced to any individual operation, so that the contribution measure is only indicative. It can be most valuably referenced in index and step change terms as opposed to absolute value terms.
- Ex-works product price assessments are linked to ICIS pricing quotations for large volume commodity products with netbacks assessed using typical logistic cost assessments.

Below is a detailed calculation of how the styrene margin is calculated using an ethane feed. The figures refer to averages for contract sales values for 2010; the calculation for spot sales values is similar.



**Styrene margin calculation - averaged for 2010**

<b>Integrated margin (ethane feedstock)</b>	<b>cts/lb SM</b>
Styrene price	64.37
Logistics costs/netbacks	<u>(5.50)</u>
Net selling price	58.87
Purchase feedstock (ethane) <sup>1</sup>	(7.50)
Benzene	(35.19)
Co-product sales/lb of styrene produced <sup>2,3</sup>	1.90
Variable cost of ethylbenzene/styrene unit <sup>4</sup>	<u>(3.13)</u>
	(43.92)
<b>Integrated margin</b>	<b>14.95</b>

<b>Standalone margin</b>	<b>cts/lb SM</b>
Styrene price	64.37
Logistics costs/netbacks	<u>(5.50)</u>
Net selling price	58.87
Ethylene price	(45.90)
Freight/terminalling saving for not exporting	<u>4.42</u>
Net ethylene price paid	(41.48)
Net ethylene price paid/lb styrene produced <sup>3</sup> i.e. purchase feedstock ethylene	(12.03)
Purchase benzene/lb of styrene produced	(35.19)
Co-product value of toluene and fuel by-product /lb of styrene produced	0.96
Variable cost of ethylbenzene/styrene unit <sup>4</sup>	(3.13)
	(49.39)
<b>Standalone margin</b>	<b>9.48</b>

Figures indicated in red are those found in the tables of the margin report; others relate to underlying assumptions of the model.

**Styrene margin calculation - averaged for 2010**

<sup>1</sup> The model assumes 1.266 lb of ethane are required to produce 1 lb of ethylene and 0.29 lb of ethylene and 0.79 lb of benzene are required to produce 1 lb of styrene.

The average net ethane price (excluding freight costs) for 2010 was 59.98 cents/US gal (20.18 cents/lb).



<sup>2</sup> Co-product sales include credits for propylene, C4s, pygas and a fuel import balance from the cracker and credits for toluene and fuel by-product from the styrene unit.

<sup>3</sup> The model assumes 0.29 lb of ethylene and 0.79 lb of benzene are required to produce 1 lb of styrene.

<sup>4</sup> Includes power and catalysts/chemicals for the ethylbenzene/styrene.

## **DIFFERENCE BETWEEN NON-INTEGRATED AND INTEGRATED**

- Non-integrated or standalone: market participant involved with styrene production only. The business model is to buy ethylene and benzene, convert it into styrene and sell the styrene. Our margin model assumption is that the plants are co-located and ethylene and benzene are transferred at FOB values.
- Integrated: market participant involved with ethylene, benzene and styrene production. Buy ethane (or naphtha) feedstock, process it into ethylene, benzene and other cracker co-products, convert the ethylene with the benzene into ethylbenzene and then styrene monomer, and sell both the styrene and cracker co-products.

## **WHY INTEGRATED ANALYSIS**

- Most US styrene plants are integrated back to cracker sources of ethylene and benzene. This may be co-located and/or connected by pipeline and with common equity ownership across both assets in the supply chain, that is, the economic boundaries for the majority of the industry producers are bigger than a standalone styrene unit.
- The margin is therefore measured across the supply chain from cracker feedstock (ethane or naphtha) through to styrene and cracker co-products.
- This analysis demonstrates the volatility of the business and the influence of price floors that can lead to an uneconomic integrated margin, and generally forcing a reduction in supply.

## WHY NON-INTEGRATED ANALYSIS

- Standalone, or non-integrated, analysis considers the styrene unit in isolation, which may be useful for understanding marginal opportunities where optimisation processes could result in ethylene and benzene being preferentially used for other derivative products. However, analysis of standalone historical data does show lower margins, which may not justify fresh business investment to meet growing market demands.

## MODEL YIELD PATTERN AND CALCULATION

Plant manufacturing data relates to the variable cost components of the chemical unit operations. Yield pattern data relates to the overall material balance of the cracker unit, for example, for 1 lb of ethylene produced, a cracker requires 1.266 lb of ethane feedstock, and will produce 0.02 lb of co-product propylene in addition to the 1 lb of ethylene. This plant manufacturing and feedstock yield model data for both the ethane and naphtha cracker units have been provided by Linde Engineering, a division of Linde AG.

The exact yield pattern used cannot be published in an unrestricted document such as this methodology statement. However, for ICIS Margin - Styrene US report subscribers with a specific requirement to see this data, it can be shared on a case-by-case basis.

Please contact the [Global ICIS Customer Support Centre](#) if this data is required.

## ASSESSMENT INPUTS

The following pricing inputs are used to generate the full content of the ICIS Margin - Styrene US report:

- Styrene in US Gulf contract FOB (cts/lb)
- Styrene in US Gulf spot FOB export (weekly average)(cts/lb)
- Ethane Mt Belvieu FOB USG Spot (weekly average) [from 1 August 2011, previously Ethane Mt Belvieu FOB USG Pipeline Spot (Reuters, weekly average)] (cts/US gal)
- Naphtha in US Gulf Spot Del USG Paraffinic (ICIS pricing, weekly average) (\$/tonne)
- Ethylene – Net US Gulf Contract Delivered (ICIS pricing) (cts/lb)



- Ethylene in US Gulf Spot Del (Pipeline) (ICIS pricing, weekly average) (cts/lb)
- Propylene in US Gulf Contract P Grade (ICIS pricing) (cts/lb)
- Propylene (P Grade) in US Gulf Spot Pipeline (ICIS pricing, weekly average) (cts/lb)
- Butadiene in US Gulf Contract FOB USG (ICIS pricing) (cts/lb)
- Butadiene in US Gulf Spot CIF (ICIS pricing, weekly average) (cts/lb)
- Crude C4s in US Gulf Spot CIF (ICIS pricing, weekly average) (\$/tonne)
- Benzene in US Gulf Contract FOB (ICIS pricing) (\$/US gal)
- Benzene in US Gulf Spot FOB Barges (ICIS pricing, Friday assessment) (\$/US gal)
- Toluene (N grade) in US Gulf spot FOB barges (ICIS pricing, weekly average) (cts/lb)
- Gasoline Premium Unleaded (Pipeline) in US Gulf Spot US Gulf (ICIS pricing, weekly average) (cts/US gal)
- Residual Fuel Oil: FOB US Gulf (barges) Spot No 6 1.0% (ICIS pricing, weekly average) (\$/bbl)
- NYMEX Henry Hub Natural Gas forward month (ICIS energy, weekly average) [from 25 March 2013, previously Henry Hub Natural Gas (Reuters, weekly average)] (\$/MMBtu)

The following conversions are used:

- Ethane: 742.2 US gal per tonne
- Benzene: 299 US gal per tonne
- Gasoline: 358.8 US gal per tonne
- Residual Fuel Oil: 264 US gal per tonne (42 US gal/bbl)

The ICIS methodology associated with each individual pricing quotation referenced above can be found on the compliance website: <https://www.icis.com/compliance>

A key objective of the calculation procedure is to provide a weekly summary that is most strongly aligned to the reported market price positions on the date of publication.

Where ICIS price quotations are not available for individual weeks due to public holidays, then prior week data is carried forward for the specific purpose of populating the model and preventing model inconsistency. This form of data interpolation is inferring some limited data points that may not be market derived, and customers should be aware of this assumption.

All data in the ICIS Margin – Styrene US report is denominated in US cents.

## LONGER RANGE VIEWS:

### SPOT VERSUS CONTRACT MARGIN (INTEGRATED)

This provides a weekly comparison of the calculated margin for spot-based styrene sales minus contract-based sales.

This switch of ICIS pricing reference is also considered for the ethane (or naphtha) cracker products, so the analysis is deeper than a simple comparison of spot versus contract styrene price netbacks. When this differential provides a positive numerical output, this implies that spot-based styrene sales derive a higher margin for an integrated producer than contract-based sales. Similarly, when this differential provides a negative numerical output, this implies that spot-based styrene sales derive a lower margin for an integrated producer than contract-based sales.

For the avoidance of any doubt, the basis on which ICIS pricing data is utilised for each of these respective models is summarised in the table below. For more detailed information about these quotations, please refer to the assessment inputs section above.

ICIS price	Spot Margin Model	Contract Margin Model
Styrene	Spot	Contract
Ethane	Spot	Spot
Naphtha	Spot	Spot
Gasoline	Spot	Spot
Fuel oil	Spot	Spot
Ethylene	Spot	Contract
Propylene	Spot	Contract
Gasoline	Spot	Spot
Butadiene	Spot	Contact
Crude C4	Spot	Contact
Benzene	Spot	Contract
Toulene	Spot	Spot

### SPOT VERSUS CONTRACT MARGIN (STANDALONE)

This provides a comparison of the calculated margin for spot-based styrene sales minus contract-based sales measured across the styrene unit. When this differential provides a positive numerical output, this implies that spot-based styrene sales derive



a higher margin than contract-based sales. Similarly, when this differential provides a negative numerical output, this implies that spot-based styrene sales derive a lower margin than contract-based sales.

The ICIS Margin – Styrene US report will provide a spot versus contract margin (integrated) and a spot versus contract margin (standalone) chart on alternate months.

### **READING THE CHARTS**

In the short-term charts and longer range margin views, the integrated margin is derived by reading the top of the wedge, the sum of the ethylene margin per tonne of styrene (yellow) and the standalone styrene margin (blue). Where the standalone margin is a loss (red), the integrated margin is read as the top of the yellow wedge or, where there is no yellow wedge, the bottom of the red.

### **PUBLISHING FREQUENCY – MONTHLY\***

The ICIS Margin - Styrene US report is produced on a Monday using data from the last Friday of the month close of business in the US and distributed to customers on the following Tuesday, subject to schedule planning. The report is not published on some public holidays. Holiday dates and days of publication may be subject to revision.

\*Published monthly from September 2014; previously weekly. Margins continue to be published on a weekly basis.

Find more information about ICIS' full portfolio of margin reports, visit:

<http://www.icis.com/chemicals/channel-info-about/margin-reports/>

