

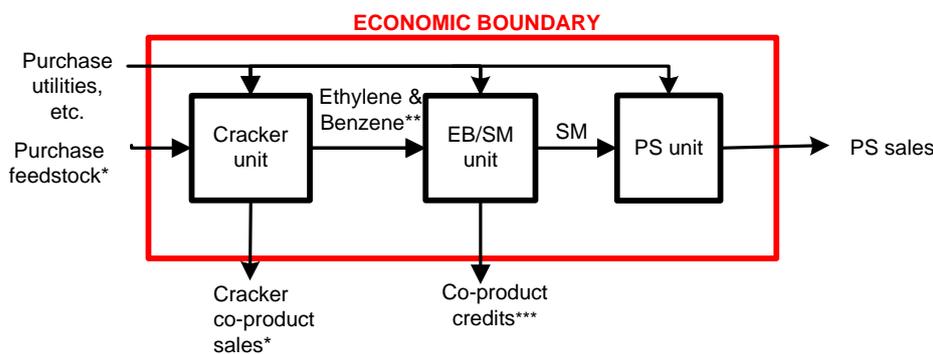
### ICIS Margin – Polystyrene (PS) US Methodology

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

#### THE BUSINESS MODEL

The diagram below shows the main method of making polystyrene (PS) 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 toluene and fuel byproduct). The styrene is then polymerised (with a small amount of mineral oil) to produce general purpose polystyrene (GPPS), or polymerised with a small percentage of polybutadiene to produce high impact polystyrene (HIPS).



- \* 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 GPPS margin is calculated using an ethane feed. The figures refer to averages for contract sales values for 2010. Figures indicated in red are those found in the tables of the margin report; others relate to underlying assumptions of the model.

## GPPS margin calculation - averaged for 2012

### Integrated margin (ethane feedstock)

	cts/lb PS	
GPPS contract price	93.01	
Logistics costs/netbacks	<u>(11.44)</u>	
Net selling price		81.57
Purchase feedstock (ethane) <sup>1</sup>	(4.92)	
Purchase benzene	(46.48)	
Mineral oil	(1.60)	
Co-product sales/tonne of GPPS produced <sup>2,3</sup>	2.85	
Variable cost of ethylbenzene/styrene/PS units <sup>4</sup>	<u>(2.84)</u>	
		(52.99)
<b>Integrated margin</b>		<b>28.58</b>

## Standalone margin

		cts/lb PS
GPPS contract price		93.01
Logistics costs/netbacks		<u>(11.44)</u>
Net selling price		81.57
Styrene price		(74.25)
Freight/terminalling saving		
for not exporting	<u>4.51</u>	
Net styrene price paid	(69.74)	
Net styrene price paid		
/tonne GPPS produced <sup>3</sup>		
ie purchase feedstock styrene	(68.35)	
Mineral oil	(1.60)	
Co-product sales/tonne		
of GPPSproduced	-	
Variable cost of PS unit <sup>4</sup>	<u>(0.75)</u>	
		<u>(70.70)</u>
<b>Standalone margin</b>		<b>10.87</b>

<sup>1</sup>The model assumes 1.266 tonnes of ethane are required to produce 1 tonne of ethylene and 0.29 tonnes of ethylene and 0.79 tonnes of benzene are required to produce 1 tonne of styrene and 0.98 tonnes of styrene are required to produce 1 tonne of GPPS. The average net ethane price (excluding freight costs) for 2012 was 39.90 cents/US gal (13.43 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 byproduct from the styrene unit.

<sup>3</sup>The model assumes 0.29 tonnes of ethylene and 0.79 tonnes of benzene are required to produce 1 tonne of styrene and 0.98 tonnes of styrene are required to produce 1 tonne of GPPS.

<sup>4</sup>Includes power and catalysts/chemicals,

## DIFFERENCE BETWEEN NON-INTEGRATED AND INTEGRATED

- Non-integrated or standalone: market participant involved with PS production only. The business model is to buy styrene (or, for HIPS, styrene and polybutadiene), convert it into PS and sell the PS. Our margin model assumption is that the plants are co-located and the styrene is transferred at FOB values.

- Integrated: market participant involved with ethylene, benzene, styrene and PS (GPPS and/or HIPS) 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 dehydrogenate it into styrene monomer. The final process is polymerisation into PS and sell both the PS and cracker co-products.

## 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 tonne of ethylene produced, a cracker requires 1.266 tonnes of ethane feedstock, and will produce 0.02 tonnes of co-product propylene in addition to the 1 tonne 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 – PS 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

Margins are calculated on a weekly basis. The following pricing inputs are used to generate the full content of the ICIS Margin – PS US report:

- Polystyrene (GP) in US Gulf Contract Bulk (from 1 July 2011, previously Polystyrene (GP) in US Gulf Domestic Bulk (ICIS pricing) (cts/lb)
- Polystyrene (HIPS) in US Gulf Contract Bulk (from 1 July 2011, previously Polystyrene (HIPS) in US Gulf Domestic Bulk (ICIS pricing) (cts/lb)
- Styrene in US Gulf contract FOB (ICIS pricing) (cts/lb)
- Styrene in US Gulf spot FOB export (ICIS pricing, weekly average)(cts/lb)
- Ethane Mt Belvieu FOB USG Spot (ICIS pricing, 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)
- Paraffinic Base Oils (FOB) in US Gulf Spot Neutral 150 (ICIS pricing, weekly average) (\$/US gal)
- Polybutadiene Rubber low-cis grade in Asia Pacific spot CFR NE Asia [based on a US import formula] (\$/tonne)
- Polybutadiene Rubber high-cis grade in Asia Pacific spot CFR NE Asia [based on a US import formula] (\$/tonne)



- 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)

### **Conversions**

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 pricing methodology associated with each individual pricing quotation referenced above can be found in the free access methodology area of [www.icispricing.com](http://www.icispricing.com)

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 – PS US report is denominated in US cents.

### **LONGER RANGE VIEWS:**

#### **ETHANE VERSUS NAPHTHA MARGIN (INTEGRATED)**

This provides a weekly comparison of the calculated margin for ethane-based PS production minus naphtha-based production. When this differential provides a positive numerical output, this implies that ethane-based PS production derives a higher margin for an integrated producer than naphtha-based production. Similarly, when this differential provides a negative numerical output, this implies that ethane-based PS production derives a lower margin for an integrated producer than naphtha-based production.



### **STANDALONE CONTRACT vs BUY SPOT STYRENE/SELL CONTRACT MARGIN**

This provides a weekly comparison of the calculated margin for contract-based PS sales measured across the PS unit versus the margin achieved by selling PS at contract prices using purchased spot styrene feedstock.

The ICIS Margin – PS US report will provide longer range views for GPPS and HIPS 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 – PS 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 day of publication may be subject to revision particularly around public holidays.

\*Published monthly from June 2014; previously weekly. Margins continue to be calculated 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/>

