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

THE BUSINESS MODEL

The main method of ethylene manufacture is by the thermal cracking of hydrocarbons. Both gaseous and liquid hydrocarbon feedstocks are used in the US, so this report examines two typical models: manufacture from ethane (derived from natural gas reserves) and from light naphtha (derived from crude oil). The ethane or naphtha is fed into the cracker unit where ethylene and other co-products are made. The co-products and amounts of each depend on the type of feedstock used. The ethylene from the cracker unit is separated from the co-products and then typically piped to other chemical plants where it is further processed into derivative products such as polyethylene. The other co-products are also separated and sold for use in other chemical plants or used for fuel.

A simplified illustration of material flows is as follows:

THE MARGIN CALCULATION

- Margin measure provides assessment of the ex-works cash margin obtained for the product over raw material costs, credit for selling co-products and key variable manufacturing costs such as power and steam. 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, credit for selling co-products and key variable manufacturing costs as this ceases to be generic to the 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 has been provided by Linde Engineering, a division of Linde AG. Linde Engineering (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 ethylene margin (ethane feed) is calculated for the US.

The figures refer to averages for contract sales values for 2011*; the calculation for spot sales values is similar, as is that for the ethylene margin (light naphtha feed). Figures indicated in red are those found in the tables of the margin report; others relate to underlying assumptions of the model.
Ethylene margin (ethane feed) calculation (cents/lb) – averaged for 2011*

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylene contract price</td>
<td>54.43</td>
</tr>
<tr>
<td>Netbacks/logistics costs</td>
<td>(5.10)</td>
</tr>
<tr>
<td>Net ethylene selling price</td>
<td>49.33</td>
</tr>
<tr>
<td>Purchase feedstock (ethane)¹</td>
<td>(32.94)</td>
</tr>
<tr>
<td>Co-product sales²</td>
<td>5.09</td>
</tr>
</tbody>
</table>

**Ethylene margin (ethane feed)**

21.48

¹The model assumes 1.266 lb of ethane are required to produce 1 lb of ethylene. The average ethane price (excluding freight costs) for 2011 was 76.56 cents/US gal (25.77 cents/lb).

²Co-product sales include credits for propylene, C4s and pygas, but allow for a fuel import balance.

*Revised 2 December 2011 (see below)

**MODEL YIELD PATTERN AND CALCULATION**

Plant manufacturing data relates to the variable cost components of the cracker 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 data for both the ethane and naphtha models has been provided by Linde Engineering, a division of Linde AG.

- Due to the different cracker yield patterns for using ethane or naphtha feedstocks, this comparative analysis is not a simple case of comparing feedstock price differences; it takes into account the different co-product credits.

- This analysis demonstrates the volatility of the business and the influence of price floors since an uneconomic margin generally forces supply reductions.

The exact yield patterns used cannot be published in an unrestricted document such as this methodology statement. However, for ICIS Weekly Margin – Ethylene 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.

PLEASE NOTE: ICIS pricing revised the US ethane and naphtha cracker models on 2 December 2011 to value fuel balances on a natural gas basis rather than a fuel oil basis. The change resulted in a revision of ethylene margins back to 2000. In the more recent period, the change resulted in an upward revision of ethylene margins based on an ethane feed because of the typical net energy import requirement and a downward revision of ethylene margins based on a naphtha feed reflecting the typical net energy export position.

ASSESSMENT INPUTS

The following 14 pricing inputs are used to generate the full content of the ICIS Weekly Margin – Ethylene US report:

- 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 (weekly average) ($/tonne)
- Ethylene – Net US Gulf Contract Delivered (cts/lb)
- Ethylene in US Gulf Spot Del (Pipeline) (weekly average) (cts/lb)
- Propylene in US Gulf Contract P Grade (cts/lb)
- Propylene (P Grade) in US Gulf Spot Pipeline (weekly average) (cts/lb)
- Butadiene in US Gulf Contract FOB USG (cts/lb)
- Butadiene in US Gulf Spot CIF (weekly average) (cts/lb)
- Crude C4s in US Gulf Spot CIF (weekly average) ($/tonne)
- Benzene in US Gulf Contract FOB ($/US gal)
- Benzene in US Gulf Spot FOB Barges (Friday assessment) ($/US gal)
- Gasoline Premium Unleaded (Pipeline) in US Gulf Spot US Gulf (weekly average) (cts/US gal)
- Residual Fuel Oil: FOB US Gulf (barges) Spot No 6 1.0% (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)
- Natural Gas: 0.0173 tonnes of fuel oil equivalents per MMBtu

The methodology associated with each ICIS pricing individual pricing quotation referenced above can be found on the ICIS Compliance and Methodology website.

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 price quotations are not available for individual days or weeks due to public holidays, then prior day or 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 Weekly Margin – Ethylene US report is denominated in US cents (with the exception of the naphtha price displayed in US dollars).

SHORT TERM CHANGES

A contract versus spot (ethane) chart will be published each week. A contract versus spot (naphtha) chart will be published once every two weeks, alternating with a chart showing a comparison of contract margins (ethane) with contract margins (naphtha).

LONGER RANGE VIEWS:

ETHANE VERSUS NAPHTHA FEED

This provides a weekly comparison of the calculated spot naphtha-based ethylene margin minus the calculated spot ethane-based ethylene margin. When this differential provides a positive numerical output, this implies that naphtha feedstocks derive a higher margin for a cracker operator compared with an ethane feedstock. Similarly, when this differential provides a negative numerical output, this implies that naphtha feedstocks derive a lower margin for a cracker operator compared with an ethane feedstock. This chart will alternate with...
...CONTRACT VERSUS SPOT (ETHANE)

This provides a comparison of the calculated margin for spot-based cracker product sales (ethylene plus co-products) minus contract-based sales. When this differential provides a positive numerical output, this implies that spot-based cracker product sales derive a higher margin compared with contract-based sales. Similarly, when this differential provides a negative numerical output, this implies that spot-based cracker product sales derive a lower margin compared with contract-based sales.

CONTRACT MARGIN (ETHANE) and CONTRACT MARGIN (NAPHTHA)

These two charts, published on alternate weeks, provide a longer range view of the contract margin and the spot price for each of the two feedstocks.

For the avoidance of any doubt, the basis in 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.

<table>
<thead>
<tr>
<th>ICIS price</th>
<th>Spot margin model</th>
<th>Contract margin model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethane</td>
<td>Spot</td>
<td>Spot</td>
</tr>
<tr>
<td>Naphtha</td>
<td>Spot</td>
<td>Spot</td>
</tr>
<tr>
<td>Gasoline</td>
<td>Spot</td>
<td>Spot</td>
</tr>
<tr>
<td>Residual Fuel Oil</td>
<td>Spot</td>
<td>Spot</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Spot</td>
<td>Spot</td>
</tr>
<tr>
<td>Ethylene</td>
<td>Spot</td>
<td>Contract</td>
</tr>
<tr>
<td>Propylene</td>
<td>Spot</td>
<td>Contract</td>
</tr>
<tr>
<td>Butadiene</td>
<td>Spot</td>
<td>Contract</td>
</tr>
<tr>
<td>Benzene</td>
<td>Spot</td>
<td>Contract</td>
</tr>
<tr>
<td>Crude C4</td>
<td>Spot</td>
<td>Spot</td>
</tr>
</tbody>
</table>

PUBLICATION FREQUENCY

The ICIS Weekly Margin – Ethylene US report is produced on a Friday at the close of business in the US and distributed to customers on the following Monday, subject to schedule planning. When the Monday is a public holiday in the UK, the report is distributed on the Tuesday. The report is not published on some public holidays. Holiday dates and days of publication may be subject to revision.

For more information about ICIS’ full portfolio of margin reports, visit: [http://www.icis.com/chemicals/channel-info-about/margin-reports/](http://www.icis.com/chemicals/channel-info-about/margin-reports/)