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**Bio Ethylene Business Case**

# Evaluation of an investment in a 500 kta Ethanol to Ethylene plant to be built along side the ARG Ethylene Pipe Line

**Prepared By Accenture**

07 December 2009

Executive Summary

# High Level Business Review shows potential for Significant Impact with Pragmatic Road Map

**Significant Impact**

## High Level Business Case shows potential of the Bio Ethylene route

- Quantitatively Significant contribution towards set targets
- Proven Technology available – with low conversion cost and CAPEX requirements
- Use of proven “intermediate” which can be used as a drop in product

**Pragmatic Road Map**

## Road Map for leveraging existing infrastructure and proven technology is available

- Ethanol to Ethylene **Technology appears adequately proven** – with low specific CAPEX and low Conversion cost
- **Ability to build volume over time** by sharing across down stream users and to target multitude of applications
- **Leverage existing infrastructure** to (1) provide sea access and (2) inland converter access

**Moving Forward**

## Business Case has identified key issues to be addressed going forward

- Landed **Ethanol cost and applicable duties** will drive require premium over conventional Ethylene market price. Depending on Scenario – Bio Ethylene can be justified at a **Premium** of 15—40% relative to Ethylene Market price
- Different End Market are expected to show different “profile” with respect to (1) **Ability to carry price premium** (impact on cost price) and (2) **Potential to leverage “Green” branding opportunity** by communicating the “Bio Ethylene” value proposition to End Customers

# Accenture has developed a business case to support evaluation of a potential ethanol to ethylene investment

## Background and Context

**Bio-renewable Resource Platform Target**

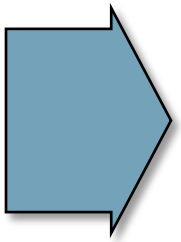
- Facilitate 30% of energy needs of The Netherlands will come from Bio Renewable resources by 2030
- To make a positive contribution to the economy while utilizing Bio Renewable Resources

**Quantifying Target – 30% corresponds to 1'000 PJ**

- 80 m ton of $CO_2$ equivalent
- 25 m ton of Fuel equivalent
- Equivalent to 4 m hectares of traditional farming

**Bio Ethylene could be a significant contributor**

- Technically Proven route from Ethanol
- Quantitative contribution will be very significant
- Connection with ARG could provide unique multi derivative – multi customer platform



## Bio Ethylene Business Case

**Scope and Objective**

- Assess Economic Feasibility of significant size Ethanol to Ethylene plant
- Leverage ARG infrastructure to be able to target an array of potential downstream applications

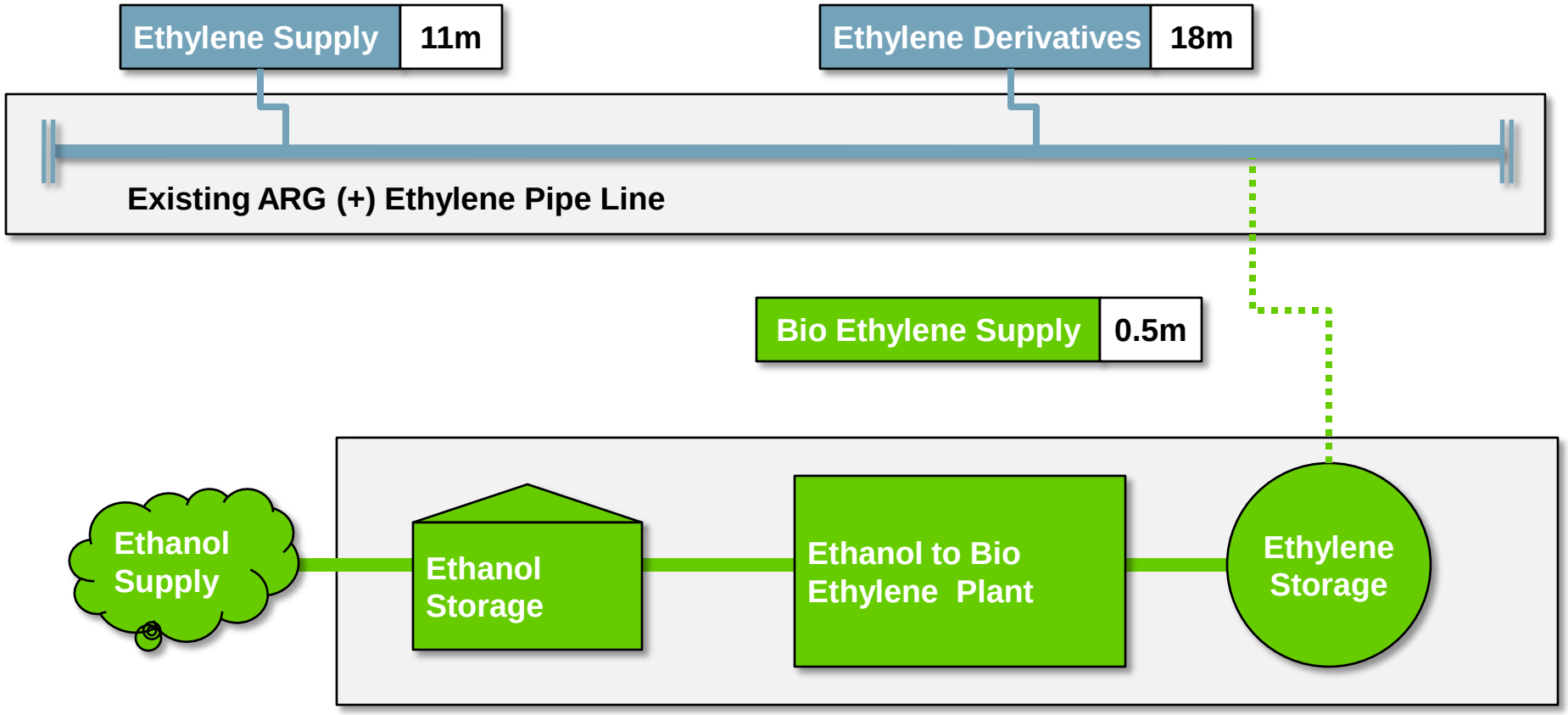
**Approach Followed**

- Understand Business Context – Downstream Users, Process Technology and Economics, Logistics
- Develop Business Case and Sensitivity Analysis
- Propose potential Next Steps

*SCOPE OF BUSINESS CASE STUDY – NOVEMBER 2009*

Business Case Scope

# Scope is for a 500 kta Ethanol to Ethylene plant to be build with connection to the ARG Pipe Line system



## Understanding Stakeholders

# As part of the Business Case, discussions have been conducted with various stakeholder throughout the value chain

| Stake Holders | | Interviews Held | Role |
|---|---|---|---|
| Government, Policy and Trade | Local | | |
| | European DG's Trade / Agriculture / Environment | Cefic | Director Industrial policy |
| Chemical Industry | Ethanol Producers/Traders | Alcogroup | Sales director |
| | Ethylene Producers/Oil refining Sector | Consultant<br>Industry Experts | Partner<br>Carbon manager<br>Project leader |
| | Ethylene Distributor | ARG | Managing director |
| | Ethylene Consumer | Tessenderlo<br>Solvay<br>CMAI<br>Confidential<br>Borealis | Sales director<br>Project responsible<br>Director chlor alkali and polyolefins<br>Bio ethylene Project Lead<br>Ex VP, Business development mgr |
| Downstream Customers | Retailers | P&G<br>PepsiCo | Responsible corporate communication, Customer team lead |

1 **Business Context**

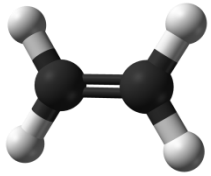
2 Bio Ethylene Business Case

3 Moving Forward

## 1 – Downstream Users

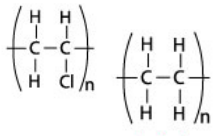
# Large number of end markets exist for ethylene derivatives, key to success will be to identify price insensitive end products

### Ethylene



- Ethylene is a global market with North America the biggest producer
- European market uses Naphtha for its ethylene production
- The Ethylene market is mature and expected to grow with GDP

### Ethylene derivatives



- Main outlet for ethylene are polymers (>70%) that are used in a wide variety of end markets
- Other outlets included Ethylene Glycol and Vinyl Acetate

### End Markets

- Mostly end up in non durable consumer goods – mostly as packaging
- Represent high share of cost of processors – not necessarily of OEM / consumer product producer
- Example: detergent industry spends less than 2% of its revenue on plastics

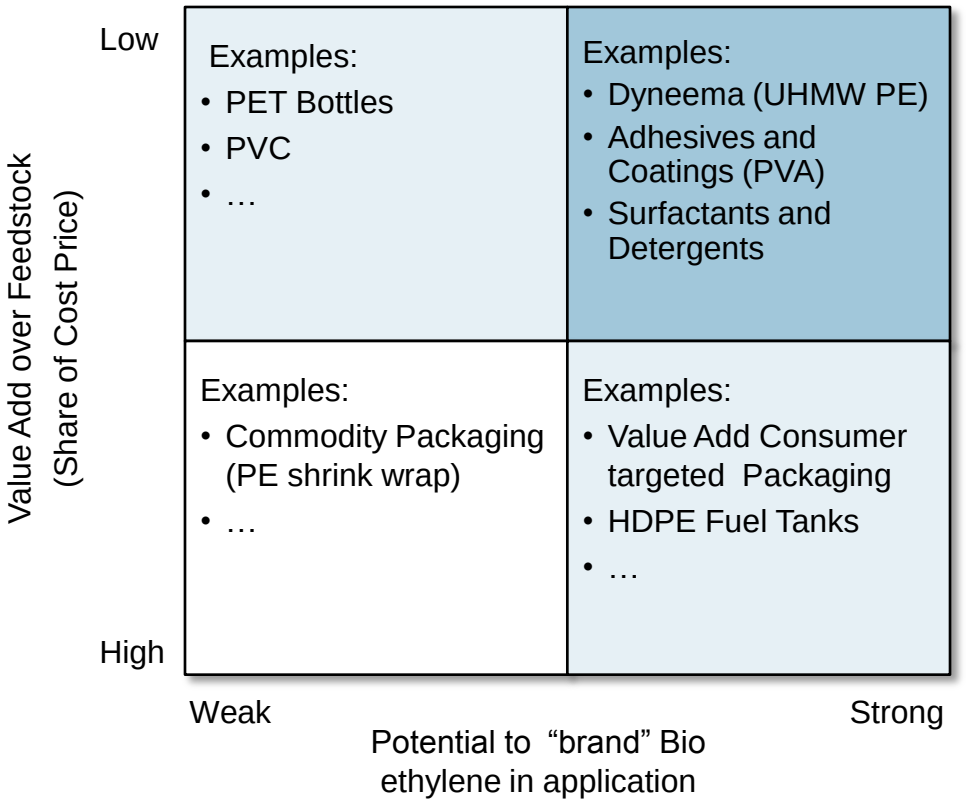
### Consumers


- Increased focus on sustainable and environmental friendly products
- Consumers are willing to pay premium for ‘greener’ products

- Polyethylene, PVC and other plastics seem the most logical outlets for ‘green’ ethylene
- End markets for ethylene derivatives are plentiful and include: packaging, bottles, coatings, glue
- Cost contribution of ethylene in final end product is low – 1 to 5%
- Typically a price premium for Bio ethylene will have limited impact on price of end product

# Target consumers of bio-ethylene should be those with low relative ethylene consumption consumer oriented application

**ASSESSMENT OF POTENTIAL ATTRACTIVENESS FOR BIO ETHYLENE**




- Ethanol based Ethylene (Bio Ethylene) will probably need to be priced at a premium over Ethylene to justify investments
- Investment along side ARG will allow the targeting of an array of potentially attractive downstream products (ethylene derivatives)
- Downstream products with the highest potential will probably combine

  (1) a relatively low sensitivity to the additional cost of Bio Ethylene and

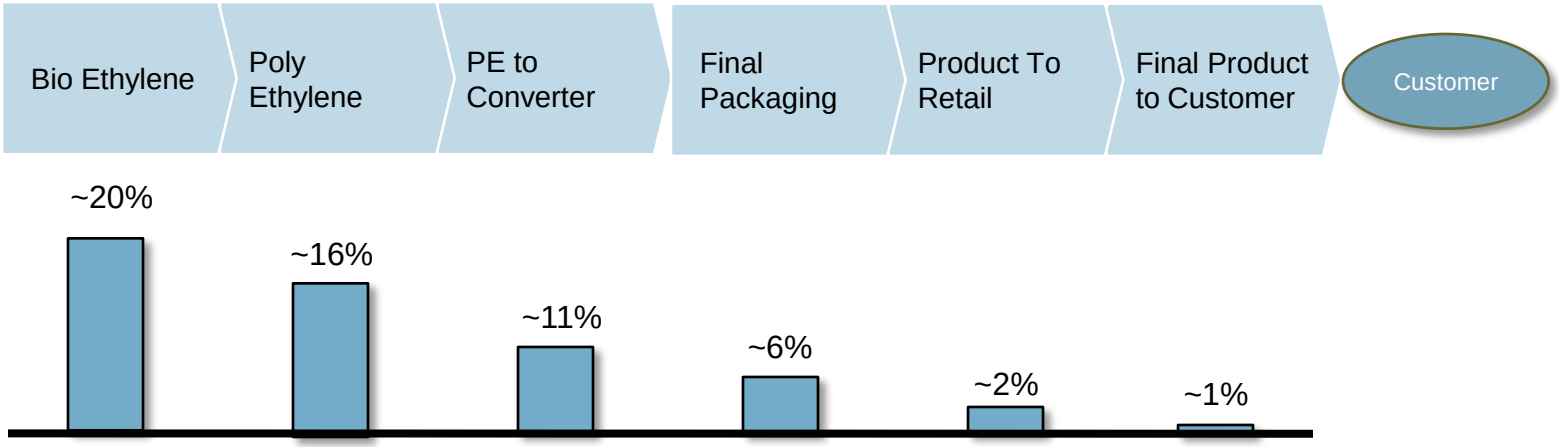
  (2) provide for an opportunity to benefit from end customer (consumer) targeted "Green" branding

# Targeting the right applications will allow to obtain “Green” branding at small cost impact to end customer

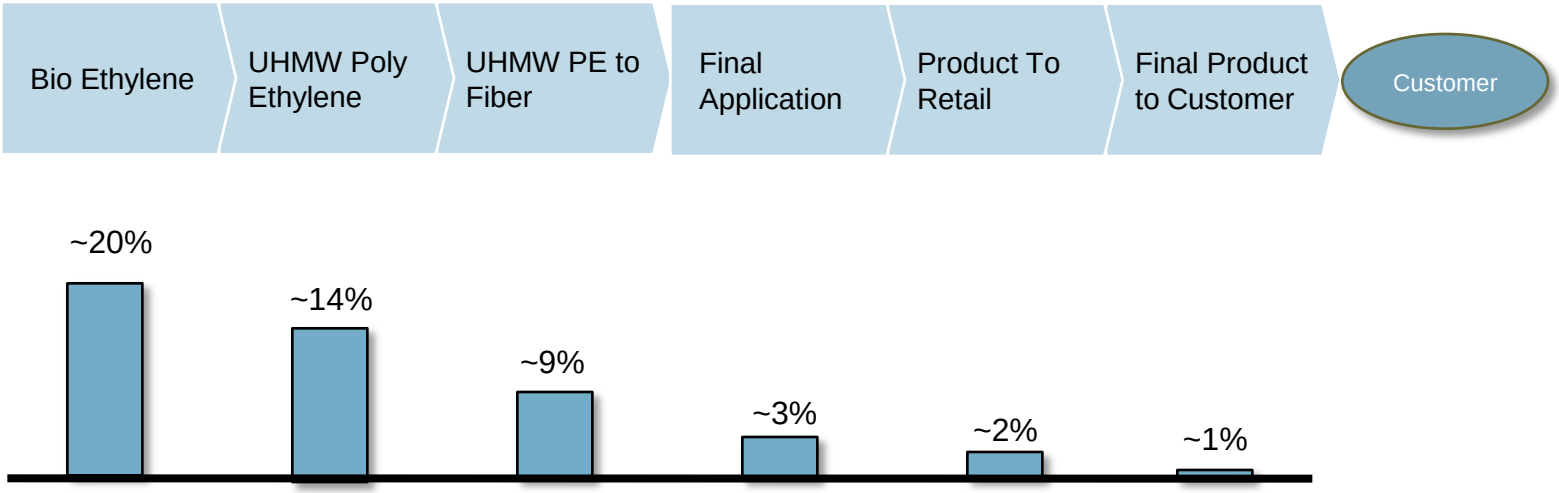
**COST IMPACT OF TYPICAL BIO ETHYLENE PRICE PREMIUM**

***ESTIMATES***

**CONSUMER PACKAGING (BOTTLE) – Simplified Value Chain**

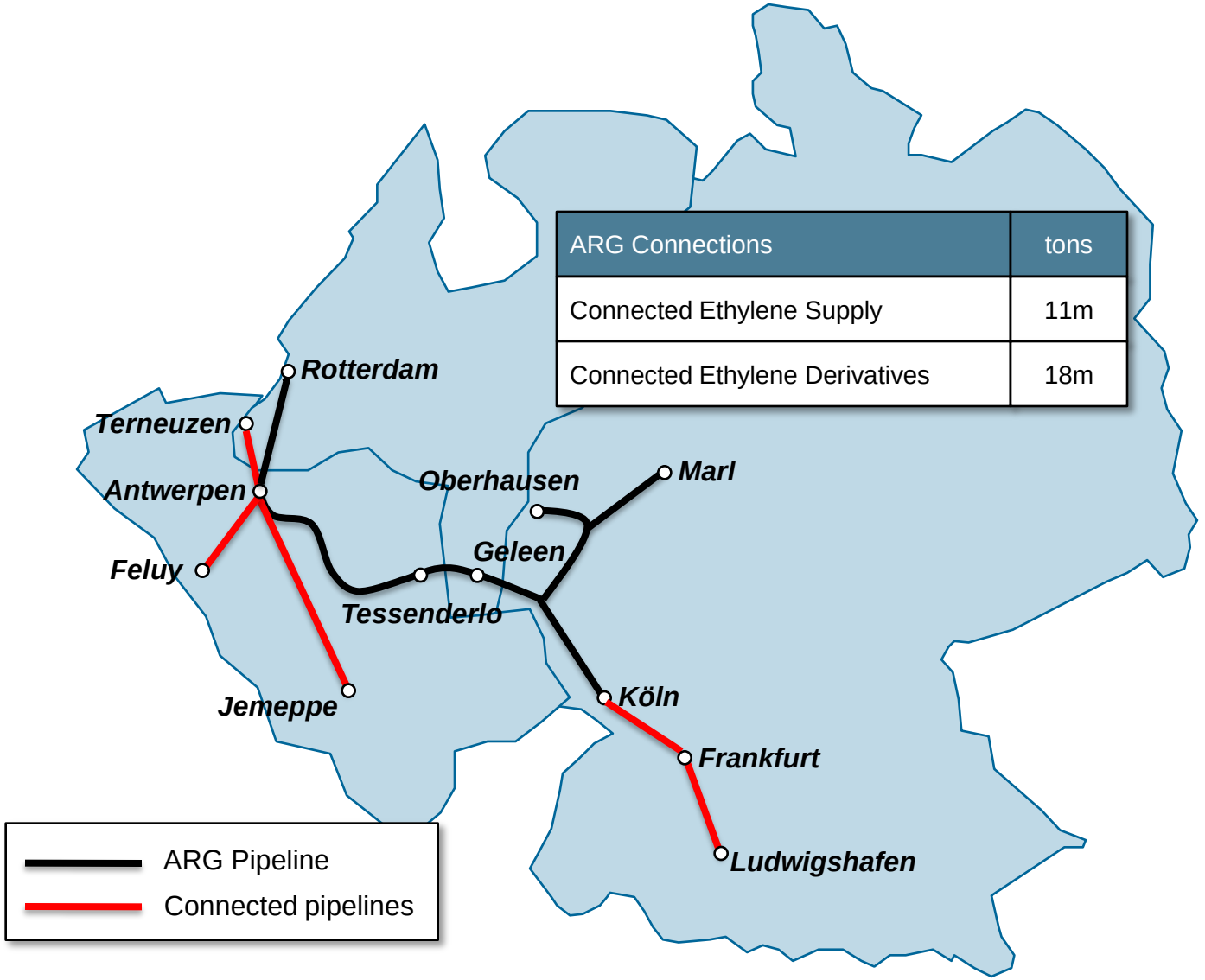



**HIGH PERFORMANCE PE FIBER – Simplified Value Chain**



## 2 – Ethylene Logistics (ARG)

# The ARG pipeline and associated pipelines connects about 18 million tons derivative capacity




| ARG Connections | tons |
|---|---|
| Connected Ethylene Supply | 11m |
| Connected Ethylene Derivatives | 18m |

- Ethylene pipelines connect the major petrochemical clusters of NW Europe – connected ethylene conversion capacity is ~11m tpa
- The majority of this network is owned and operated by the ARG – ARG transports about 2m tons annually
- Some important extensions to ARG exist; Antwerp-Terneuzen; Moerdijk-Terneuzen; Antwerp-Feluy; Antwerp-Jemeppe; Wesseling-Frankfurt-Ludwigshafen
- We have performed capacity and ethylene gap analysis the sections excluding Frankfurt-Ludwigshafen

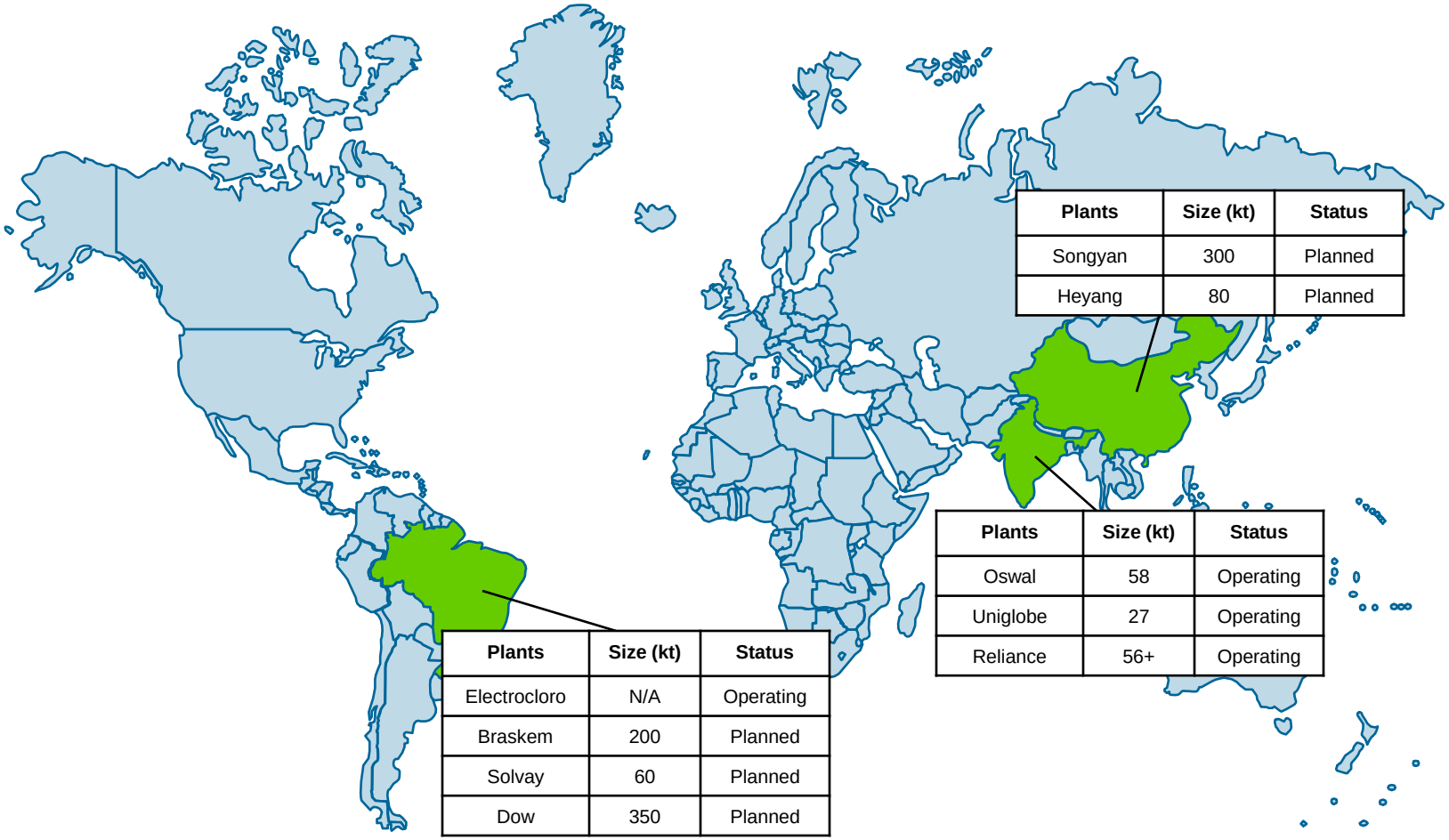
## 2 – Ethylene Logistics (ARG)

# More than 20 different companies producing a broad array of products are connected

| | Production | Consumption (derivative tons) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Company | ETHYLENE | EB | EDC | EO | EPDM | HDPE | LDPE | LLDPE | TOTAL DERIVATIVES |
| BASF | 1,700 | 1,490 | | 755 | | | | | 2,245 |
| BAYER | | 390 | | | | | | | 390 |
| BOREALIS | | | | | | 220 | 26 | | 246 |
| BP | 1,065 | | | | | | | | |
| CELANESE | | | | | | 40 | | | 40 |
| DOW | 1,700 | 1,240 | | 160 | | 280 | 260 | 500 | 2,440 |
| DSM | | | | | 150 | | | 60 | 210 |
| DUPONT | | | | | | | 39 | | 39 |
| EVONIK DEG | | | 120 | | | | | | 120 |
| EXXONMOBIL | 505 | | | | | | 830 | 60 | 890 |
| INEOS | 1,155 | 420 | | 730 | | 440 | 400 | 228 | 2,218 |
| LANXESS | | | | | 70 | | | | 70 |
| LYONBASELL | 1,040 | 390 | | | | 450 | 835 | 15 | 1,690 |
| POLIMERI E | | | | | | | 140 | | 140 |
| SABIC | 1,250 | | | | | 595 | 600 | 185 | 1,380 |
| SASOL | | | | 210 | | | | | 210 |
| SHELL | 1,420 | 640 | | 305 | | | | | 945 |
| SHINETSU | | | 880 | | | | | | 880 |
| SOLVIN | | | 890 | | | | | | 890 |
| TESSENDERL | | | 1,180 | | | | | | 1,180 |
| TOTAL PC | 882 | | | | | 690 | | | 690 |
| VESTOLIT | | | 500 | | | | | | 500 |
| VINNOLIT | | | 570 | | | | | | 570 |
| Total | 10,717 | 4,570 | 4,140 | 2,160 | 220 | 2,715 | 3,130 | 1,048 | 17,983 |

## 3 – Ethanol to Ethylene Manufacture

# Rapidly growing base of operating experience – typically close to ethanol source



| Plants | Size (kt) | Status |
|---|---|---|
| Songyan | 300 | Planned |
| Heyang | 80 | Planned |

| Plants | Size (kt) | Status |
|---|---|---|
| Oswal | 58 | Operating |
| Uniglobe | 27 | Operating |
| Reliance | 56+ | Operating |

| Plants | Size (kt) | Status |
|---|---|---|
| Electrocloro | N/A | Operating |
| Braskem | 200 | Planned |
| Solvay | 60 | Planned |
| Dow | 350 | Planned |

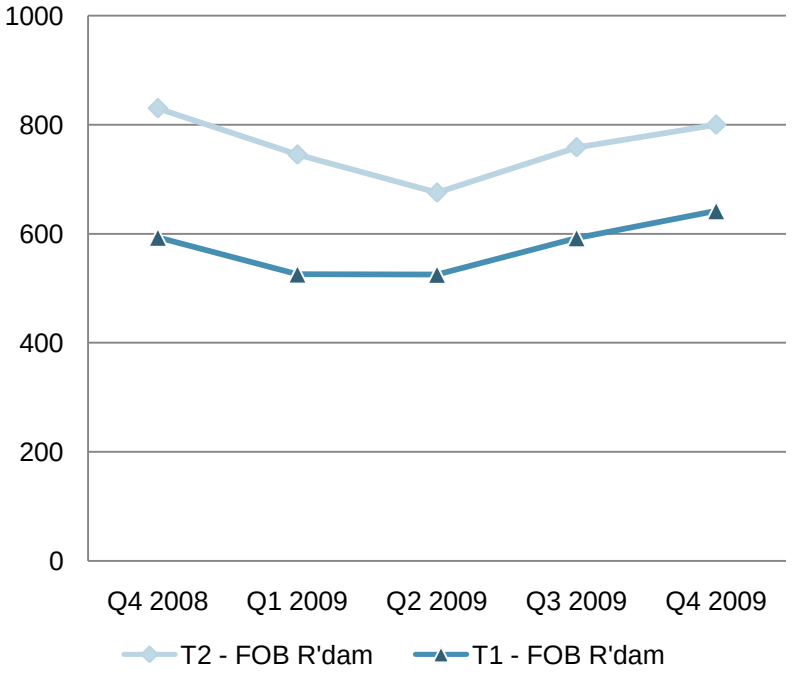
Source: Accenture Research

- Proven Technology: All current technology is based on fixed bed catalytic dehydration of ethylene
- The only investment currently announced is the green PVC plant of Solvay in Brazil (120 kta)
- Investment ranges quoted are in Euro 0.2 – 0.4m per kiloton (compare conventional ethylene at 1—2m)
- Typically Cash Cost (excluding) Ethanol are 60—100 Euro/t (compare conventional ethylene at 500—700 Euro/t)

# Ethanol source and Import duties will have significant impact on Bio Ethylene economics

**Ethanol Price – FOB Rotterdam**

Euro/ton




Source: ICIS Data, Accenture Analysis

**Ethanol Sources and applicable duties**

- Considering the ethanol volume the plant requires the most likely source of ethanol will be Sugar Cane ex-Brazil (T1 Ethanol)
- This has added advantage of most significant carbon footprint improvement
- Applicable import duties will have a significant impact on landed cost of Brazilian Ethanol in Europe

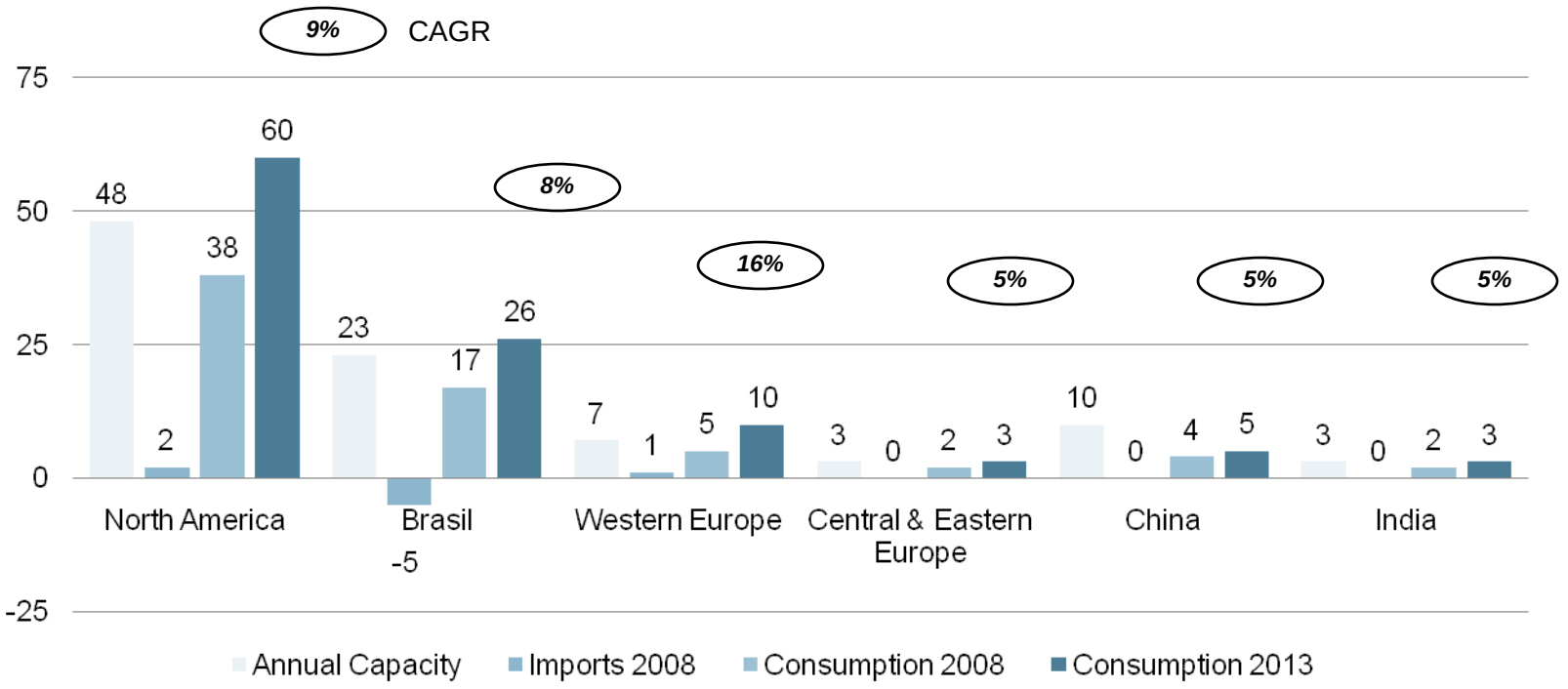
| Ethanol Import Duty | Low* | High** |
|---|---|---|
| Per Cubic Meter | 102 | 192 |
| Per Ton | 129 | 244 |

* De-naturated ethanol
** Undenatured ethanol

# Demand for ethanol is expected to grow significantly mainly driven by increased demand for bio-fuels

## Ethanol Supply and Demand

Cubic Meter (millions)




- Bio fuel requirements will continue to push demand for ethanol – at double digit CAGR
- Project demand growth will out strip current supply by 2010
- Potential BC2 plant will consume significant Ethanol volume relative to market – ~1.2m CBM for 0.5m ton of BC2

Source: Accenture Research

| | |
|---|---|
| 1 | Business Context |
| **2** | **Bio Ethylene Business Case** |
| 3 | Moving Forward |

# Business Case has been developed around a number of key assumptions

## General Assumptions

- Three (fixed) Crude Oil scenarios: US$ 60, 90 and 120 per barrel
- Plant capacity of 500 kta with 3Y plant loading ramp up (100 – 300 – 500 kta)
- Project Duration – 15Y with 3Y investment horizon
- Marginal Tax Rate: 30%
- Euro is 1.5 US$ (fixed)

## Ethanol to Ethylene Manufacture

- Base Case: Ethanol price based on market prices (T1 and T2) – translated to link to Crude Price
- Long Range Case: Ethanol price based on long range anticipated Sugar Cane based Ethanol manufacturing cost – at 85% of Base Case (1)
- Bio ethylene manufacturing cost based on Aker Study – modified based on Accenture project experience

## Ethylene Product Pricing

- Ethylene based on WE market – translated into link to Crude Price (Brent)
- Bio Ethylene market price based on Ethylene plus a range of “green” price premiums – none, 20% and 25%
- Distribution of final product via ARG and connected pipeline systems

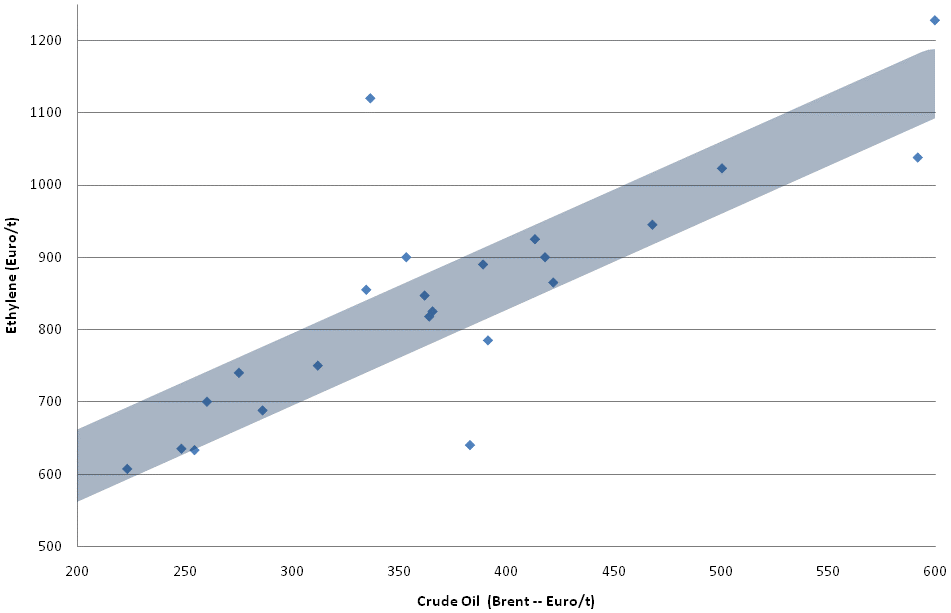
(1) Reference: Biomass and Bio Energy 33 (2009)

# To facilitate Business Case modeling we have used simplified relationships between Ethylene and Ethanol and Crude price

**BASE CASE**

## Relationship between Crude and Ethylene

(Euro per ton)

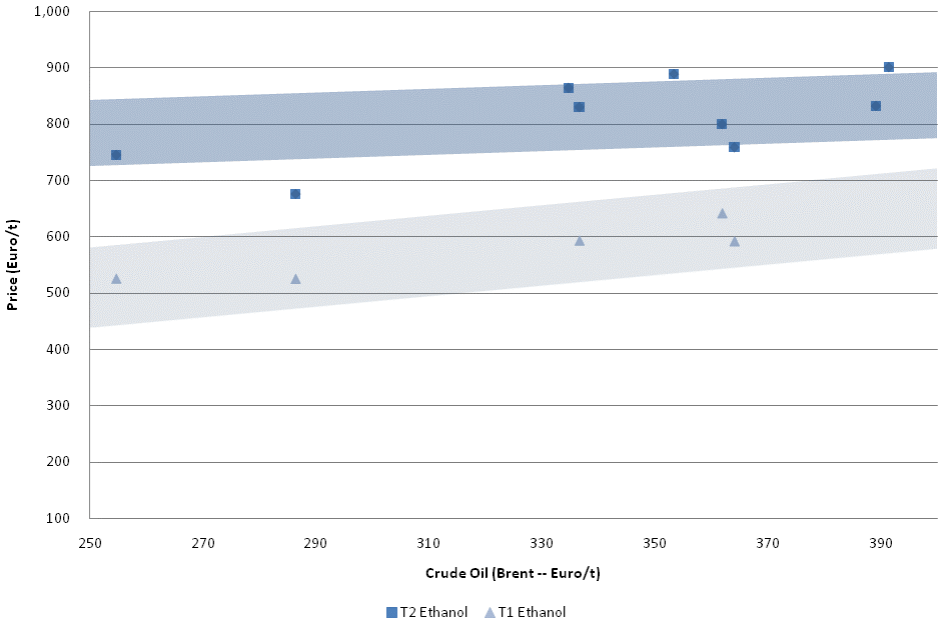



Related Ethylene pricing to crude pricing (basis Rotterdam).

Simplified relationship used in context of this document: Ethylene = 1.4 x Crude + 320 (Euro per ton)

## Relationship between Crude and Ethanol

(Euro per ton)




Related Ethanol T1 (Brazil source) and T2 (EU Source) pricing to crude pricing (basis Rotterdam).

Simplified relationship used in context of this document: T1 Ethanol = 0.9 x Crude + 150 (Euro per ton) – excluding duties

Source: ICIS data, Accenture Analysis

# Manufacturing Cost have been estimated basis Aker input and Accenture project experience

## Bio Ethylene Manufacturing Cost

(Euro per ton)

| Manufacturing Cost | Business Case | Note (Source) |
|---|---|---|
| Plant Capacity (kta) | 500 | Typical range new projects 300 – 500 kta |
| Plant CAPEX (Euro m) | 200 | Aker + 30% contingency |
| Ethanol to Ethylene Yield (t/t) | 1.8 | Typical range 1.7 – 1.9 |
| | | |
| **Variable Cost** | **900** | |
| • Ethanol | ~840 | Strongly dependent on Ethanol price and duty |
| • Other Variable Cost | 60 | Aker + 20% contingency |
| **Fixed (Cash) Cost** | **15** | |
| • Operations and Maintenance | 11 | Accenture Estimate |
| • Supply Chain, Commercial and General | 4 | Accenture Estimate |
| **Depreciation** | **20** | Based on 5% pa |
| | | |
| **Manufacturing Cost** | **935** | |
| | | |
| **Manufacturing Cost = 1.8 x Ethanol +** | **95** | |

## Business Case – Cash Flow Model

# A Cash Flow model was used to determine NPV and Internal Rate of Return for different Scenarios

## Bio Ethylene Cash Flow Model

**EXAMPLE**

| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
| CAPEX | Euro m | 20 | 80 | 100 | | | | | | | | | | | | |
| **Volume** | **'000 tons** | | | | **100** | **300** | **500** | **500** | **500** | **500** | **500** | **500** | **500** | **500** | **500** | **500** |
| | | | | | | | | | | | | | | | | |
| Ethylene Price | Euro/ton | 1,052 | 1,052 | 1,052 | 1,052 | 1,052 | 1,052 | 1,052 | 1,052 | 1,052 | 1,052 | 1,052 | 1,052 | 1,052 | 1,052 | 1,052 |
| Ethanol Price (Base) | Euro/ton | 464 | 464 | 464 | 464 | 464 | 464 | 464 | 464 | 464 | 464 | 464 | 464 | 464 | 464 | 464 |
| **Revenue** | **Euro m** | - | - | - | **105** | **316** | **526** | **526** | **526** | **526** | **526** | **526** | **526** | **526** | **526** | **526** |
| | | | | | | | | | | | | | | | | |
| Manufacturing Cash Cost | Euro m | - | - | - | 94 | 281 | 468 | 468 | 468 | 468 | 468 | 468 | 468 | 468 | 468 | 468 |
| Depreciation | Euro m | | | | 2 | 6 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| **EBIT** | **Euro m** | - | - | - | **10** | **29** | **49** | **49** | **49** | **49** | **49** | **49** | **49** | **49** | **49** | **49** |
| | | | | | | | | | | | | | | | | |
| Tax | Euro m | - | - | - | 3 | 9 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| **Operating Profit** | **Euro m** | - | - | - | **7** | **20** | **34** | **34** | **34** | **34** | **34** | **34** | **34** | **34** | **34** | **34** |
| | | | | | | | | | | | | | | | | |
| Depreciation | Euro m | - | - | - | 2 | 6 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Net working capital | Euro m | - | - | - | 8 | 25 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| Net working capital change | Euro m | | | | 8 | 17 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (42) |
| **Cash Flow After Tax** | **Euro m** | **(20)** | **(80)** | **(100)** | **0** | **10** | **27** | **44** | **44** | **44** | **44** | **44** | **44** | **44** | **44** | **86** |
| | | | | | | | | | | | | | | | | |
| NPV Discount Factor | | 1.00 | 1.08 | 1.17 | 1.26 | 1.36 | 1.47 | 1.59 | 1.71 | 1.85 | 2.00 | 2.16 | 2.33 | 2.52 | 2.72 | 2.94 |
| PV | Euro m | (20) | (74) | (86) | 0 | 7 | 18 | 28 | 26 | 24 | 22 | 20 | 19 | 17 | 16 | 29 |
| **NPV** | **Euro m** | **(20)** | **(94)** | **(180)** | **(180)** | **(172)** | **(154)** | **(126)** | **(101)** | **(77)** | **(55)** | **(34)** | **(16)** | **2** | **18** | **47** |

| | | |
|---|---|---|
| **Net Present Value (8%)** | **Euro m** | **47** |
| **Net Present Value (8%)** | **Euro/t** | **9** |
| **IRR** | **%** | **11.3%** |

We have used a pragmatic cash flow model to understand return on investment as a function of key input variables

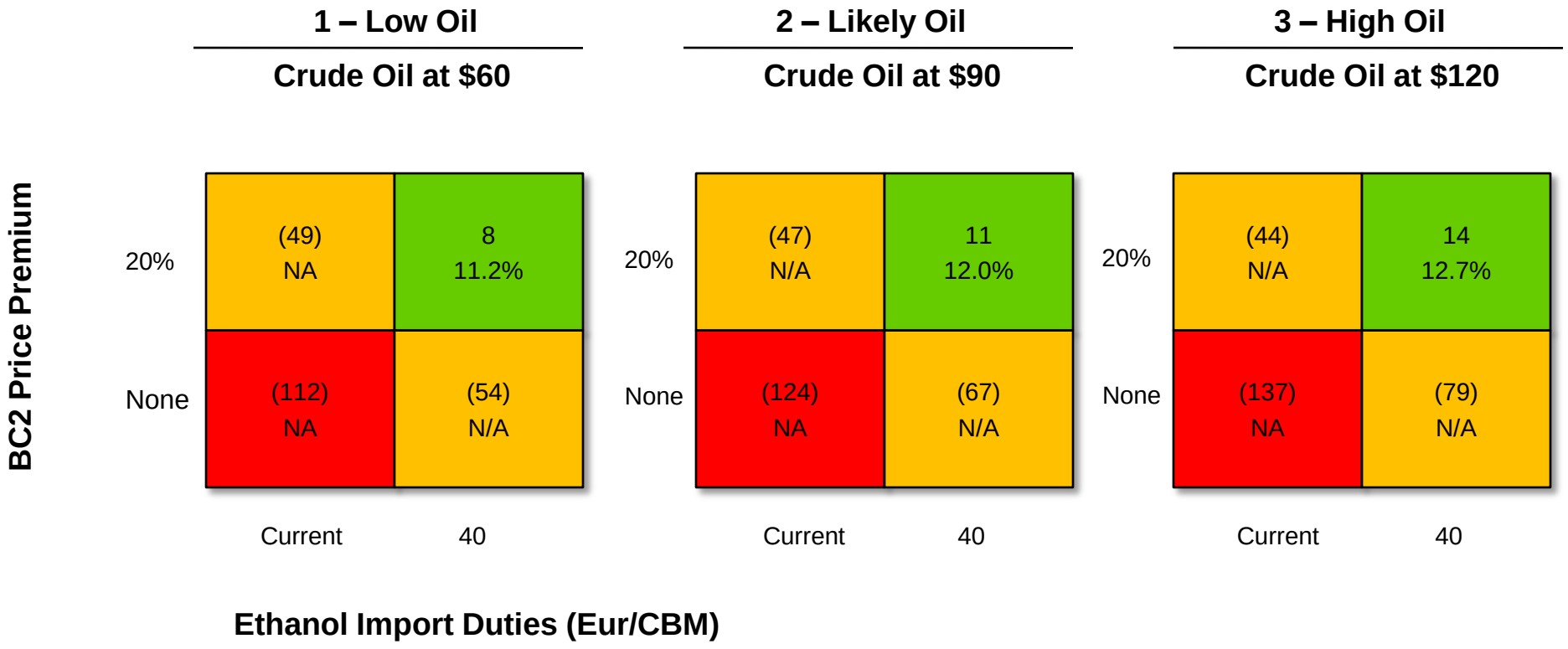
Key variables that have been evaluated are Crude Oil Price, Ethanol Import Duty and Bio Ethylene Premium.

# Sensitivity analysis shows that a combination of price premiums and reduction of import duties is needed to get positive financials

## Bio Ethylene Business Summary

BASE CASE

NPV (Euro/ton – 1) and IRR (%)




Note 1 – NPV (Euro/t) is NPV divided by accumulated production volume of the evaluation period.

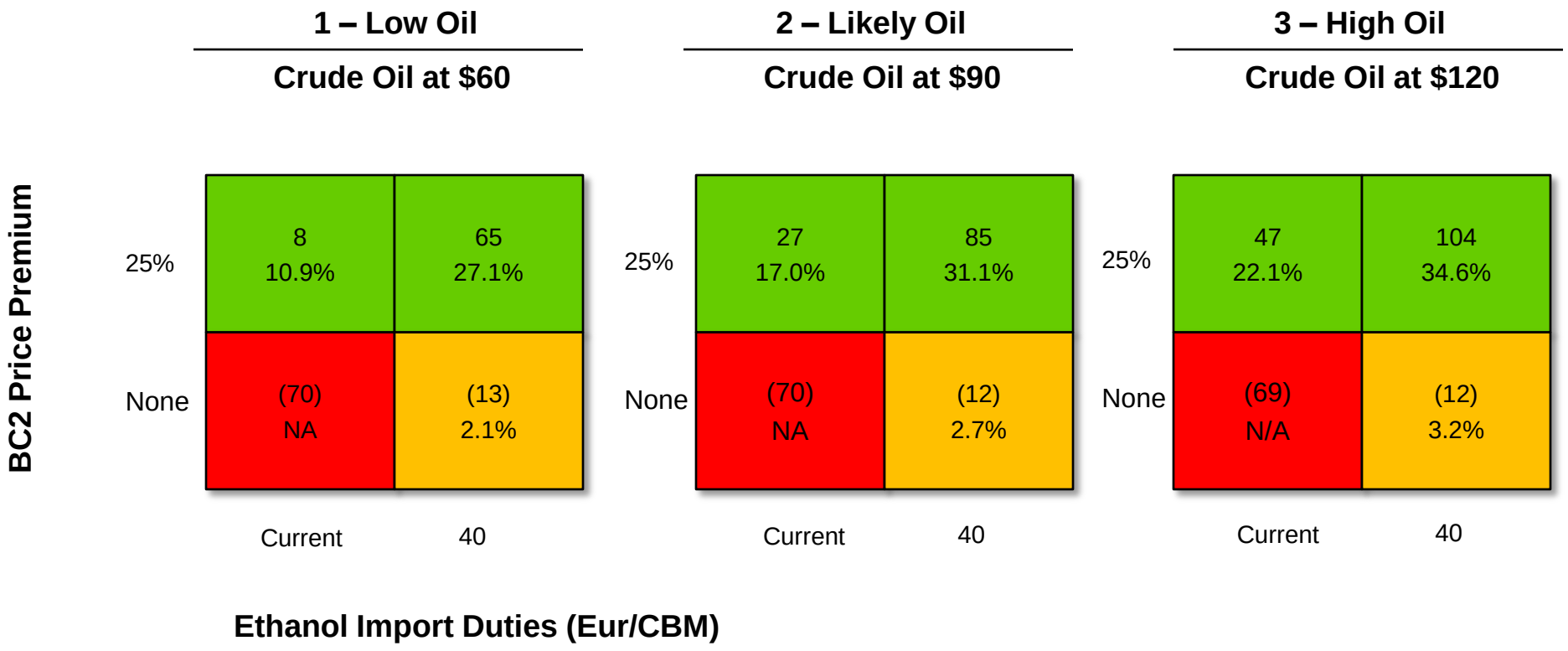
Note: Ethylene at 1.4 x Crude plus 320; Ethanol at 0.9 x Crude plus 150. Other Assumptions: Business Case Base Case (see page)

# We expect Future Outlook may drive increased premium and lower Ethanol costs – driving investment attractiveness

## Bio Ethylene Business Summary

FUTURE OUTLOOK

NPV (Euro/ton – 1) and IRR (%)




Note 1 – NPV (Euro/t) is NPV divided by accumulated production volume of the evaluation period.

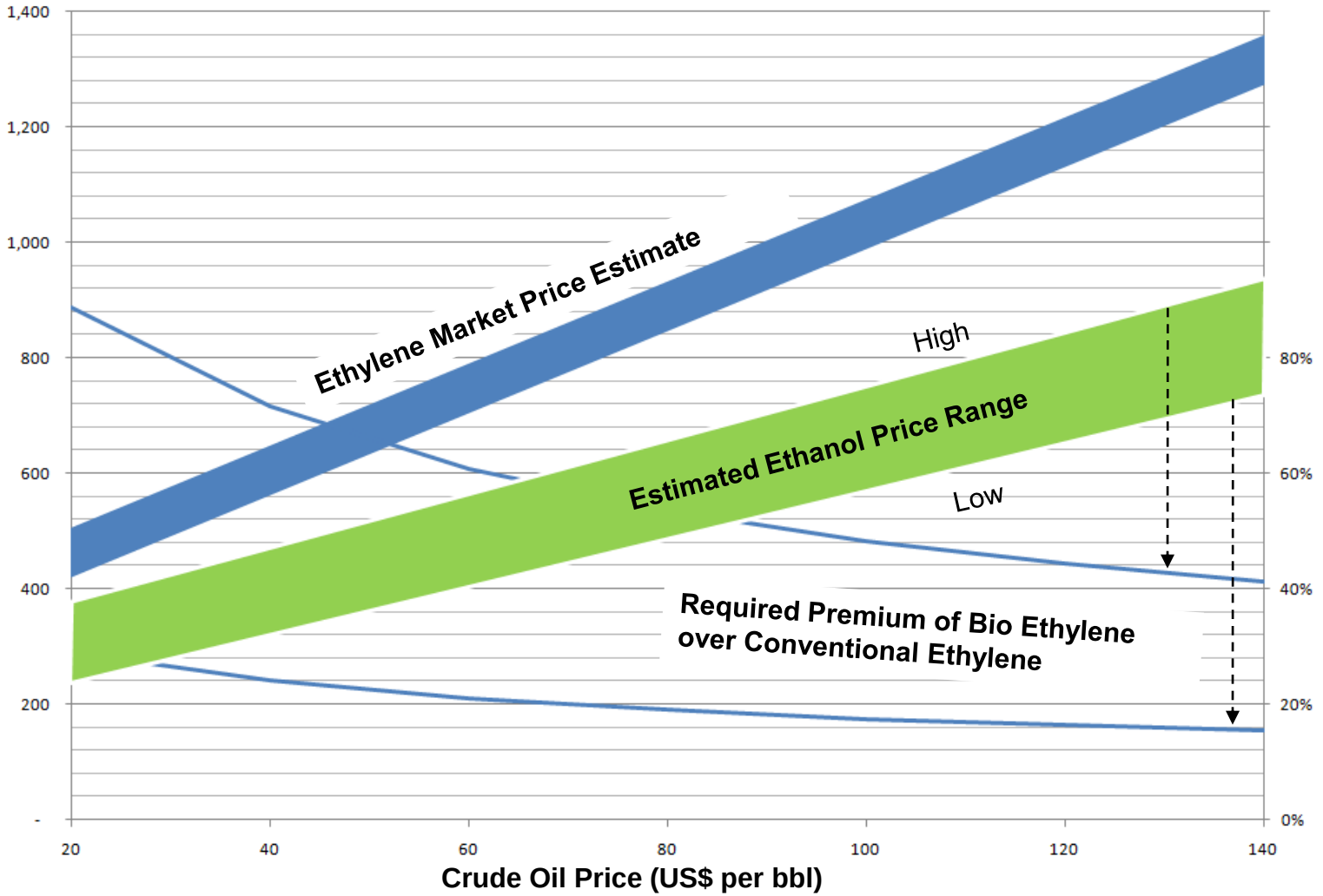
Note: Ethylene at 1.4 x Crude plus 320; Ethanol at 85% of (0.9 x Crude plus 150). Other Assumptions as in Business Case Base Case

# We expect Future Outlook may drive increased premium and lower Ethanol costs – driving investment attractiveness

## Bio Ethylene Break Even Analysis

(Euro/t) and (% Premium)

**SIMPLIFIED**

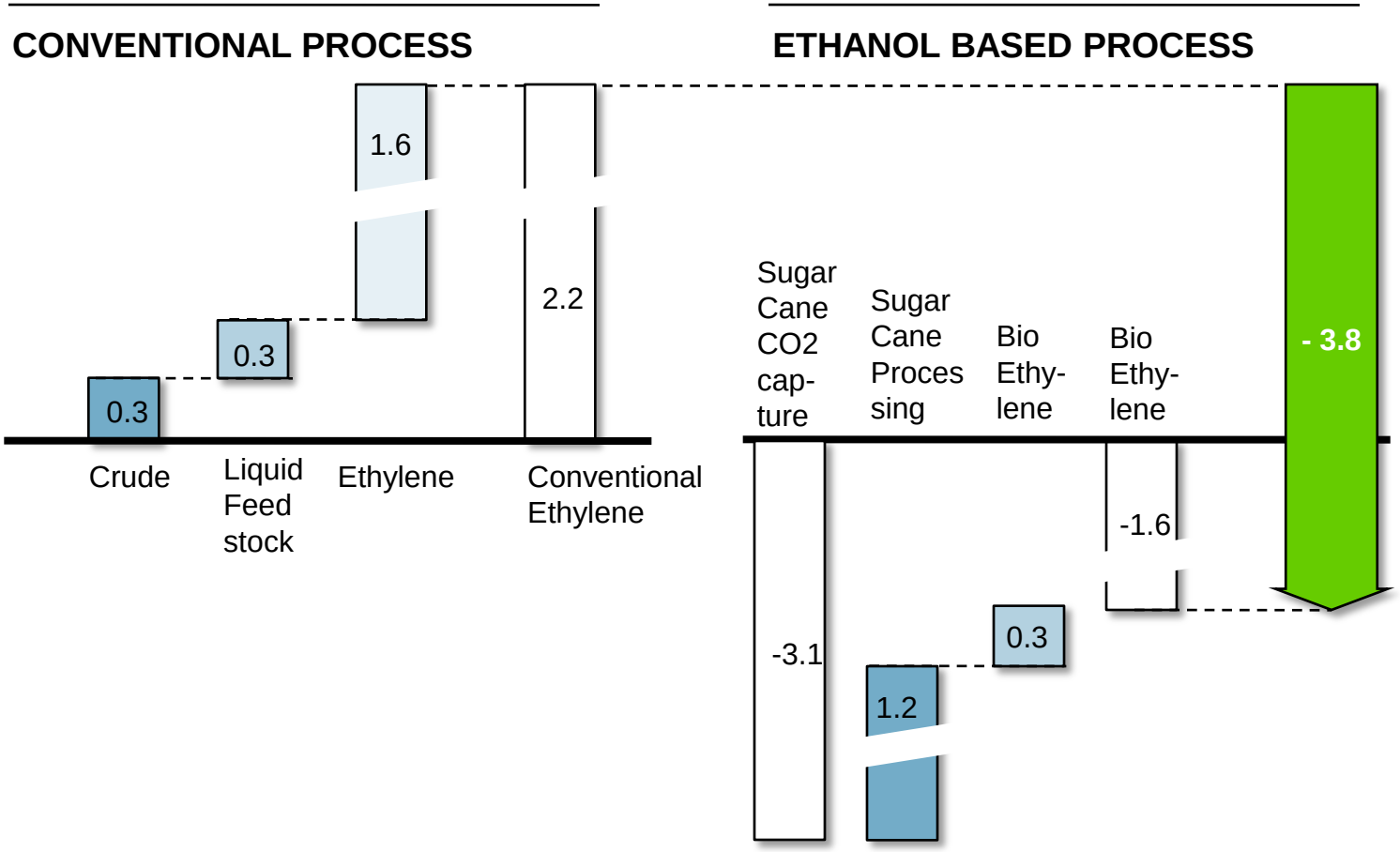



- We have also analyzed the Break Even Bio Ethylene "premium"
- Higher Oil price scenario will reduce the required "premium" needed to justify the investment
- From an oil price of $ 80 onwards – depending on Ethanol pricing scenario – Bio Ethylene premium appears acceptable

# Bio ethylene route leverages renewable feedstock and demonstrates lower "carbon footprint"

**CARBON FOOTPRINT**
(t $CO_2e$)

**ESTIMATES**




- We have also analyzed the relative Carbon Footprint of the alternative manufacturing processes
- The Ethanol based process has a substantially lower carbon footprint – greatly driven by carbon capture in photosynthesis
- Taking into consideration a realistic Carbon ($CO_2$) price would support a Ethanol based investment

| | |
|---|---|
| 1 | Business Context |
| 2 | Bio Ethylene Business Case |
| **3** | **Moving Forward** |

Moving Forward

# Business Case has provided some clear suggestions for Follow Up actions

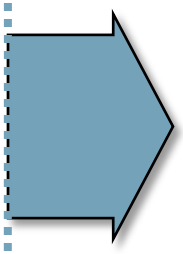
## Business Case Conclusions

- **Ethanol to Ethylene Technology** appears adequately proven – with low specific CAPEX and low Conversion cost
- Plant would require significant volume of **Ethanol Supply** relative to global market
- Landed **Ethanol cost and applicable duties** will drive require premium over conventional Ethylene market price
- Depending on Scenario – Bio Ethylene can be justified at a **Premium** of 15—40% relative to Ethylene Market price
- Different End Market are expected to show different "profile" with respect to …

  (1) Ability to carry price premium (impact on cost price) and

  (2) Potential to leverage "Green" branding opportunity by communicating the "Bio Ethylene" value proposition to End Customers

  … and hence different adoption potential



## Follow Up

1. Address Feedstock Challenges – Cost and Duties
2. Address Target Market Question
3. Update Business Case based on (1) and (2)
4. Work with players across the Value Chain to build a feasible proposition
5. Develop Integrated Business Plan

Moving Forward

# Initial discussions with broad group of representatives across the Value Chain also did not indicate real "Show Stoppers"

## STAKEHOLDER INTERVIEW SUMMARY

| | Bio-Ethanol Industry – Sustainability experts | Petrochemical Players | Ethylene Consumers | End Customers |
|---|---|---|---|---|
| What is your interest in 'Bio Ethylene' | • Very willing to look into potential projects. | • Very little interest<br>• Other opportunities for carbon footprint reduction exist. | • Yes, some of our customers may be interested – but not at a price premium.<br>• Yes, we would, could take up to 10 % of our consumption. | • Sustainability is 'hot' in the retail sector |
| What are potential constraints and bottlenecks | • Import tariffs on imported Brazilian Ethanol<br>• Economically viable production of bio-ethylene will require end consumer demand or regulatory pressure | • Middle Eastern low cost capacities of Ethylene<br>• Negative publicity around bio-fuels is hurting its green image<br>• Bio-ethanol for chemical use is competing directly with bio-ethanol for fuel usage, making the price of the resulting ethylene too expensive to be competitive | • Is it a sustainable process from a life cycle perspective?<br>• Will it be competitive with naphtha based ethylene?<br>• Labeling of end products and working with key customers will be crucial to getting acceptance from the end consumers and the intermediate producers in the value chain. | • Commitments quite often are driven by economics (i.e. reduction of resources, energy, emissions)<br>• Life cycle perspective is taken into account (example for fatty acids: palm oil sustainability is scrutinized) |
| Wat would be the best market segments to be targeted | | | • Products that are closest to the consumer goods / retail sector (packaging etc)<br>• Products with lowest Ethylene content in final end product | • 'Future friendly products': packaging and products that are sold to consumers as 'green'.<br>• Labeling can help…but then labels need to become generally accepted! |
| Potential for price premium for Bio Ethylene | | | • No, we will take the bio-ethylene at the same price as we currently source from our traditional suppliers.<br>• Yes, From the final customer's perspective…however in B2B environment harder to achieve | • Yes, customers are willing to pay extra if it's green… |

Moving Forward

# We recommend to move forward and start addressing the key questions raised by the “Business Case”

| Area | Follow Up | Suggested Timing |
|---|---|---|
| 1. Feedstock Availability and Economics | • Confirm Feedstock availability<br>• Confirm Feedstock Landed Cost – Pricing and applicable duties | December 09 – January 2010 |
| 2. Targeting of High Potential End Markets | • Refine initial ideas on targeted End Markets – understanding :<br>1. Ability to carry price premium;<br>2. Potential to leverage “Green” branding opportunity | |
| 3. Refine Business Case | • Update Business Case based on revised inputs from (1) and (2)<br>• Ensure full alignment with broader “Bio-renewable Resource Platform Targets” | January – February 2010 |
| 4. Set Up Project Consortium | • Based on improved understanding – work to develop a consortium based on workable set of stakeholders, likely across feedstock supply, technology, incumbent ethylene producers and high potential market segments | February – March 2010 |
| 5. Develop Integrated Business Plan | • Work with Consortium Partners to develop an Integrated Business Plan | Q2 2010 |

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| **A1** | **ARG Pipe Line details** |
| **A2** | Bio Ethylene Derivative Yields |
| **A3** | Potential Pricing Mechanism – “Green Certificates” |

## A1 – Ethylene Logistics (ARG)

# The ARG pipeline and associated pipelines connects about 18 million tons derivative capacity

| Company | PRODUCT | ANTWERP | BEEK | BERINGEN | BOTLEK | FELUY | GELEEN | GELSEN.BUE | JEMEPPE | KNAPSACK | KOELN | LILLO | LUDWIGSHAF | LUELSDORF | MARL | MEERHOUT | MOERDIJK | OBERHAUSEN | RHEINBERG | ROTTERDAM | TERNEUZEN | TESSENDERL | WESSELING | ZWIJNDRECHT | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BASF | EB | 890 | | | | | | | | | | | 600 | | | | | | | | | | | | 1.490 |
| | EO | 410 | | | | | | | | | | | 345 | | | | | | | | | | | | 755 |
| BAYER | EB | | | | | | | | | | | | | | | | | | | 390 | | | | | 390 |
| BOREALIS | HDPE | | | 220 | | | | | | | | | | | | | | | | | | | | | 220 |
| | LDPE | 26 | | | | | | | | | | | | | | | | | | | | | | | 26 |
| CELANESE | HDPE | | | | | | | | | | | | | | | | | 40 | | | | | | | 40 |
| DOW | EB | | | | | | | | | | | | | | | | | | | | 1.240 | | | | 1.240 |
| | EO | | | | | | | | | | | | | | | | | | | | 160 | | | | 160 |
| | HDPE | | | | | | | | | | | | | | | | | | | | 150 | 130 | | | 280 |
| | LDPE | | | | | | | | | | | | | | | | | | | | 260 | | | | 260 |
| | LLDPE | | | | | | | | | | | | | | | | | | | | 500 | | | | 500 |
| DSM | EPDM | | 150 | | | | | | | | | | | | | | | | | | | | | | 150 |
| | LLDPE | | | | | | 60 | | | | | | | | | | | | | | | | | | 60 |
| DUPONT | LDPE | 39 | | | | | | | | | | | | | | | | | | | | | | | 39 |
| EVONIK DEG | EDC | | | | | | | | | | | | | 120 | | | | | | | | | | | 120 |
| EXXONMOBIL | LDPE | | | | | | | | | | | | | | | 500 | | | | | | | | 330 | 830 |
| | LLDPE | | | | | | 60 | | | | | | | | | | | | | | | | | | 60 |
| INEOS | EB | | | | | | | | | | | | | | 420 | | | | | | | | | | 420 |
| | EO | 440 | | | | | | | | | 290 | | | | | | | | | | | | | | 730 |
| | HDPE | | | | | | | | | | | 440 | | | | | | | | | | | | | 440 |
| | LDPE | | | | | | | | | | 400 | | | | | | | | | | | | | | 400 |
| | LLDPE | | | | | | | | | | 228 | | | | | | | | | | | | | | 228 |
| LANXESS | EPDM | | | | | | | | | | | | | | 70 | | | | | | | | | | 70 |
| LYONBASELL | EB | | | | | | | | | | | | | | | | | | | 390 | | | | | 390 |
| | HDPE | | | | | | | | | | | | | | | | | | | | | | 450 | | 450 |
| | LDPE | | | | | | | | | | | | | | | | | | | | | | 835 | | 835 |
| | LLDPE | | | | | | | | | | | | 15 | | | | | | | | | | | | 15 |
| POLIMERI E | LDPE | | | | | | | | | | | | | | | | | 140 | | | | | | | 140 |
| SABIC | HDPE | | | | | | 320 | 275 | | | | | | | | | | | | | | | | | 595 |
| | LDPE | | 600 | | | | | | | | | | | | | | | | | | | | | | 600 |
| | LLDPE | | | | | | | 185 | | | | | | | | | | | | | | | | | 185 |
| SASOL | EO | | | | | | | | | | | | | | 210 | | | | | | | | | | 210 |
| SHELL | EB | | | | | | | | | | | | | | | | 640 | | | | | | | | 640 |
| | EO | | | | | | | | | | | | | | | | 305 | | | | | | | | 305 |
| SHINETSU | EDC | | | | 880 | | | | | | | | | | | | | | | | | | | | 880 |
| SOLVIN | EDC | | | | | | | | 480 | | | | 0 | | | | | | 410 | | | | | | 890 |
| TESSENDERL | EDC | | | | | | | | | | | | | | | | | | | | | 1.180 | | | 1.180 |
| TOTAL PC | HDPE | 510 | | | | 180 | | | | | | | | | | | | | | | | | | | 690 |
| VESTOLIT | EDC | | | | | | | | | | | | | | 500 | | | | | | | | | | 500 |
| VINNOLIT | EDC | | | | | | | | | 570 | | | | | | | | | | | | | | | 570 |
| Grand Total | | 2.315 | 750 | 220 | 880 | 180 | 440 | 460 | 480 | 570 | 918 | 440 | 960 | 120 | 1.200 | 500 | 945 | 180 | 410 | 780 | 2.310 | 1.310 | 1.285 | 330 | 17.983 |

## A1 – Ethylene Logistics (ARG)

# The ethylene conversion capacity of these companies is ~11 million tons

***Ethylene consumption capacities on the ARG pipeline or connected pipelines***

| Company | PRODUCT | ANTWERP | BEEK | BERINGEN | BOTLEK | FELUY | GELEEN | GELSEN.BUE | JEMEPPE | KNAPSACK | KOELN | LILLO | LUDWIGSHAF | LUELSDORF | MARL | MEERHOUT | MOERDIJK | OBERHAUSEN | RHEINBERG | ROTTERDAM | TERNEUZEN | TESSENDERL | WESSELING | ZWIJNDRECH | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BASF | EB | 231 | | | | | | | | | | | 156 | | | | | | | | | | | | 387 |
| | EO | 344 | | | | | | | | | | | 290 | | | | | | | | | | | | 634 |
| BAYER | EB | | | | | | | | | | | | | | | | | | | 101 | | | | | 101 |
| BOREALIS | HDPE | | | 231 | | | | | | | | | | | | | | | | | | | | | 231 |
| | LDPE | 27 | | | | | | | | | | | | | | | | | | | | | | | 27 |
| CELANESE | HDPE | | | | | | | | | | | | | | | | | 42 | | | | | | | 42 |
| DOW | EB | | | | | | | | | | | | | | | | | | | | 322 | | | | 322 |
| | EO | | | | | | | | | | | | | | | | | | | | 134 | | | | 134 |
| | HDPE | | | | | | | | | | | | | | | | | | | | 158 | 137 | | | 294 |
| | LDPE | | | | | | | | | | | | | | | | | | | | 268 | | | | 268 |
| | LLDPE | | | | | | | | | | | | | | | | | | | | 465 | | | | 465 |
| DSM | EPDM | | 60 | | | | | | | | | | | | | | | | | | | | | | 60 |
| | LLDPE | | | | | | 56 | | | | | | | | | | | | | | | | | | 56 |
| DUPONT | LDPE | 40 | | | | | | | | | | | | | | | | | | | | | | | 40 |
| EVONIK DEG | EDC | | | | | | | | | | | | | 35 | | | | | | | | | | | 35 |
| EXXONMOBIL | LDPE | | | | | | | | | | | | | | | 515 | | | | | | | | 340 | 855 |
| | LLDPE | | | | | | 56 | | | | | | | | | | | | | | | | | | 56 |
| INEOS | EB | | | | | | | | | | | | | | 109 | | | | | | | | | | 109 |
| | EO | 370 | | | | | | | | | 244 | | | | | | | | | | | | | | 613 |
| | HDPE | | | | | | | | | | | 462 | | | | | | | | | | | | | 462 |
| | LDPE | | | | | | | | | | 412 | | | | | | | | | | | | | | 412 |
| | LLDPE | | | | | | | | | | 212 | | | | | | | | | | | | | | 212 |
| LANXESS | EPDM | | | | | | | | | | | | | | 28 | | | | | | | | | | 28 |
| LYONBASELL | EB | | | | | | | | | | | | | | | | | | | 101 | | | | | 101 |
| | HDPE | | | | | | | | | | | | | | | | | | | | | | 473 | | 473 |
| | LDPE | | | | | | | | | | | | | | | | | | | | | | 860 | | 860 |
| | LLDPE | | | | | | | | | | | | 14 | | | | | | | | | | | | 14 |
| POLIMERI E | LDPE | | | | | | | | | | | | | | | | | 144 | | | | | | | 144 |
| SABIC | HDPE | | | | | | 336 | 289 | | | | | | | | | | | | | | | | | 625 |
| | LDPE | | 618 | | | | | | | | | | | | | | | | | | | | | | 618 |
| | LLDPE | | | | | | | 172 | | | | | | | | | | | | | | | | | 172 |
| SASOL | EO | | | | | | | | | | | | | | 176 | | | | | | | | | | 176 |
| SHELL | EB | | | | | | | | | | | | | | | | 166 | | | | | | | | 166 |
| | EO | | | | | | | | | | | | | | | | 256 | | | | | | | | 256 |
| SHINETSU | EDC | | | | 255 | | | | | | | | | | | | | | | | | | | | 255 |
| SOLVIN | EDC | | | | | | | | 139 | | | | 0 | | | | | | 119 | | | | | | 258 |
| TESSENDERL | EDC | | | | | | | | | | | | | | | | | | | | | 342 | | | 342 |
| TOTAL PC | HDPE | 536 | | | | 189 | | | | | | | | | | | | | | | | | | | 725 |
| VESTOLIT | EDC | | | | | | | | | | | | | | 145 | | | | | | | | | | 145 |
| VINNOLIT | EDC | | | | | | | | | 165 | | | | | | | | | | | | | | | 165 |
| Total | | 1.548 | 678 | 231 | 255 | 189 | 448 | 461 | 139 | 165 | 868 | 462 | 460 | 35 | 459 | 515 | 423 | 186 | 119 | 203 | 1.347 | 479 | 1.333 | 340 | 11.340 |

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|---|---|
| A1 | ARG Pipe Line details |
| A2 | **Bio Ethylene Derivative Yields** |
| A3 | Potential Pricing Mechanism – “Green Certificates” |

# Target consumers of bio-ethylene should be those with low relative ethylene consumption consumer oriented applications

## ETHYLENE TO DERIVATIVE YIELD

(T Ethylene/T Derivative)

| Monomer | Derivative | Yield (kg ethylene/ kg end product) | End Product Example |
|---|---|---|---|
| Ethylene | HD/LD-PE | 0.9 | Bags, bottles, parts |
| Ethylene | LLDPE | 0.9 | Stretch wrap |
| EDC - VCM | PVC | 0.3 | Soft PVC compounds |
| Ethylene Oxide | MEG | 0.20 | PET bottles |
| Vinyl Acetate | PVA | 0.1 | Glues, coatings, … |

## ETHYLENE CONSUMPTION PER DERIVATIVE

(kta)

| PRODUCT | Grand Total | % Green market potential | Green ethylene tons | End product example | Derivative price Nov 09(eur/t) | Ethylene content | Price premium derivative (est) | Price premium C2 |
|---|---|---|---|---|---|---|---|---|
| EB | 1,188 | | | | | | | |
| EDC | 1,201 | 5% | 59 | soft PVC compounds | 350 | 0.29 | 5% | 16% |
| EO | 1,814 | 8% | 95 | automotive antifreeze | 950 | 0.84 | 10% | 12% |
| EPDM | 88 | | | | | | | |
| HDPE | 2,851 | 10% | 119 | milk bottles, rigid pipes | 1,050 | 1.05 | 15% | 14% |
| LDPE | 3,224 | 9% | 107 | bottles, plastic bags | 1,030 | 1.03 | 15% | 15% |
| LLDPE | 975 | 10% | 119 | stretch wrap | 1,120 | 0.93 | 15% | 16% |
| Grand Total | 11,340 | | 499 | | | | | |

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|---|---|
| A1 | ARG Pipe Line details |
| A2 | Bio Ethylene Derivative Yields |
| A3 | **Potential Pricing Mechanism – “Green Certificates”** |

A3 – Ethylene Pricing

# “Green Certificates” provide a potential pricing mechanism for Bio Ethylene

- Government to set target for chemical / petrochemical industry on sustainable raw material consumption (or ‘voluntary targets’)
- This system is actually a ‘mass balance system’.
- Regulator controls –
  1. Accreditation body is needed - ARG could play this role, does not need to be a government body
  2. Regulator should also set sustainability criteria - level of ‘Greenness’ can be different depending on raw materials, transport, etc – life cycle considerations
- How do the ethylene producers achieve targets
  1. Produce themselves ‘green ethylene’ : Regulator certifies that producer produces X tons of Green ethylene– get X green certificates.
  2. Buy green certificates from the green producer ‘Newco’
  3. Price setting is done through auctioning - similar to green electricity certificates