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IPDI PRODUCTION FROM ISOPHORONE AND CHLORINE

IN THE UNITED STATES

PREVIEW

PREMIUM EDITION

BY INTRATEC SOLUTIONS LLC

COMMODITY PRODUCTION COSTS

REPORTS COLLECTION

BY INTRATEC SOLUTIONS LLC

VOLUME

IPDI PRODUCTION

ISSUE

IPDI PRODUCTION FROM ISOPHORONE AND CHLORINE

COUNTRY OF ANALYSIS

UNITED STATES

SERIES

PREVIEW

EDITION

PREMIUM

DEVELOPED BY

INTRATEC SOLUTIONS LLC

REPORT CODE

INTRATEC-ICC-PREV-294-A-PREM-USA

This report is part of a series of reports prepared by Intratec approaching the production costs of commodities spanning a diverse range of industries: Oil & Energy; Fertilizers & Gases; Olefins & Derivatives; Aromatics & Derivatives; Alcohols & Organic Acids; Polymers; Inorganic Chemicals; Food & Nutrition; Metals & Mining; and Pharmaceuticals.

For information on all Intratec reports, visit: www.intratec.us

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IMPORTANT NOTICE

This document is a preview report provided by Intratec, showcasing the full structure of a cost analysis related to IPDI Production from Isophorone and Chlorine.

To protect proprietary data, numerical values have been replaced with “X” placeholders and charts have been intentionally blurred. Nonetheless, this preview faithfully reflects the structure and depth of the commercial report, including the types of tables, charts, and descriptions presented.

Intratec offers multiple preview and sample reports to support purchasing decisions. Therefore, free trials are not available.

An up-to-date commercial report about this technology can be purchased at www.intratec.us/icc/294-A.

Abstract

This report presents a manufacturing cost analysis of Isophorone Diisocyanate (IPDI) production from isophorone and chlorine. The process examined is a typical phosgenation process. In the process examined, isophorone is reacted with hydrogen cyanide, generating isophorone nitrile (IPN). IPN obtained is then reacted with ammonia to form isophorone nitrile imine (IPNI), which is hydrogenated with more ammonia to yield isophorone diamine (IPDA). Finally, IPDA reacts with phosgene to produce IPDI. The phosgene used is generated from chlorine and carbon monoxid in an on-site unit.

This report examines the capital costs of a IPDI plant and the continuing operating costs associated with the plant. The analysis assumes a plant based in the United States with a capacity of 0.000 mt of IPDI per year and includes:

* IPDI plant capital cost details, including ISBL, OSBL and Contingency; owner's cost; working capital; and costs incurred during industrial plant commissioning and start-up.
* Operating cost, broken down by variable costs (raw materials, utilities); fixed costs (maintenance, operating labor, plant overhead, property taxes and insurance); and depreciation.
* Raw materials consumption, products generation, and labor requirements.
* IPDI production process information including block flow diagram (BFD), process flow diagram (PFD) and description of industrial site installations.

This report was developed based essentially on the following reference(s):

(1) US Patent 9187412 B2, issued to Evonik Degussa in 2015

(2) US Patent 8884063 B2, issued to BASF SE in 2014

(3) US Patent 8563768, issued to Covestro (fromer Bayer MaterialScience) in 2013

Keywords: Isophorone Diisocyanate, IPDI, Isophorone Diamine, IPDA, Phosgenation

Revision Control

The following pages present a history of revisions and main changes made in the last updates of the report “IPDI Production from Isophorone and Chlorine.” The changes in each revision are classified according to the types presented below:

* Fix: errors correction in a released report (e.g., typos, wrong descriptions/economic figures).

* Update: changes made by the Intratec team in the release of a new Series of reports (e.g., change of a technical parameter published in a more recent patent).

* Improvement: structural changes common to all Intratec Commodity Production Costs reports aiming to improve the accuracy of presented estimates or reader’s comprehension of reports.

Report Revision History – Series XXXX

Rev. 0 Original

Report Changes History – Previous Series

The list below presents the main changes made in the "IPDI Production from Isophorone and Chlorine" report released in previous Series.

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Preamble

Understanding Intratec Commodity Production Costs

Reports Organization

Intratec Commodity Production Costs is a set of best-in-class professional reports that can be understood as an encyclopedia approaching plant capital and operating costs of commodities' manufacturing processes. The Intratec Commodity Production Costs reports are organized in a particular fashion, as shown in the diagram presented on the next page. The diagram shows that the reports are organized in Quarterly Series according to the period of the economic analysis presented. Every new quarter Intratec reviews the entire Series – new reports are developed, and existing reports are updated. After the release of a new Series, the reports from previous Series stop being sold. Currently, each Series includes more than 800 reports.

The reports Series are divided into Volumes, with each Volume focusing on processes for manufacturing a specific commodity. The entire Series approaches more than 250 commodities (Volumes), spanning a diverse range of industries. Each Volume, in turn, is composed of Issues, each one targeting a specific industrial process to produce the respective commodity.

Each report is identified by a unique code, containing the information on Series, Volume, Issue, Edition, and Location used as basis in the economic analysis. An example of code is shown below.

INTRATEC-ICC-Q122-001-A-PREM-USA

- Country USA - Country assumed in the economic analysis
- Premium Edition - Code corresponding to the report edition
- Issue A - Manufacturing process approached in the report
- Volume 001 - Target commodity produced
- Series Q122 - Quarter/year assumed in the economic analysis
- Product ICC - Intratec Commodity Production Costs reports

HOW INTRATEC COMMODITY PRODUCTION COSTS REPORTS ARE ORGANIZED

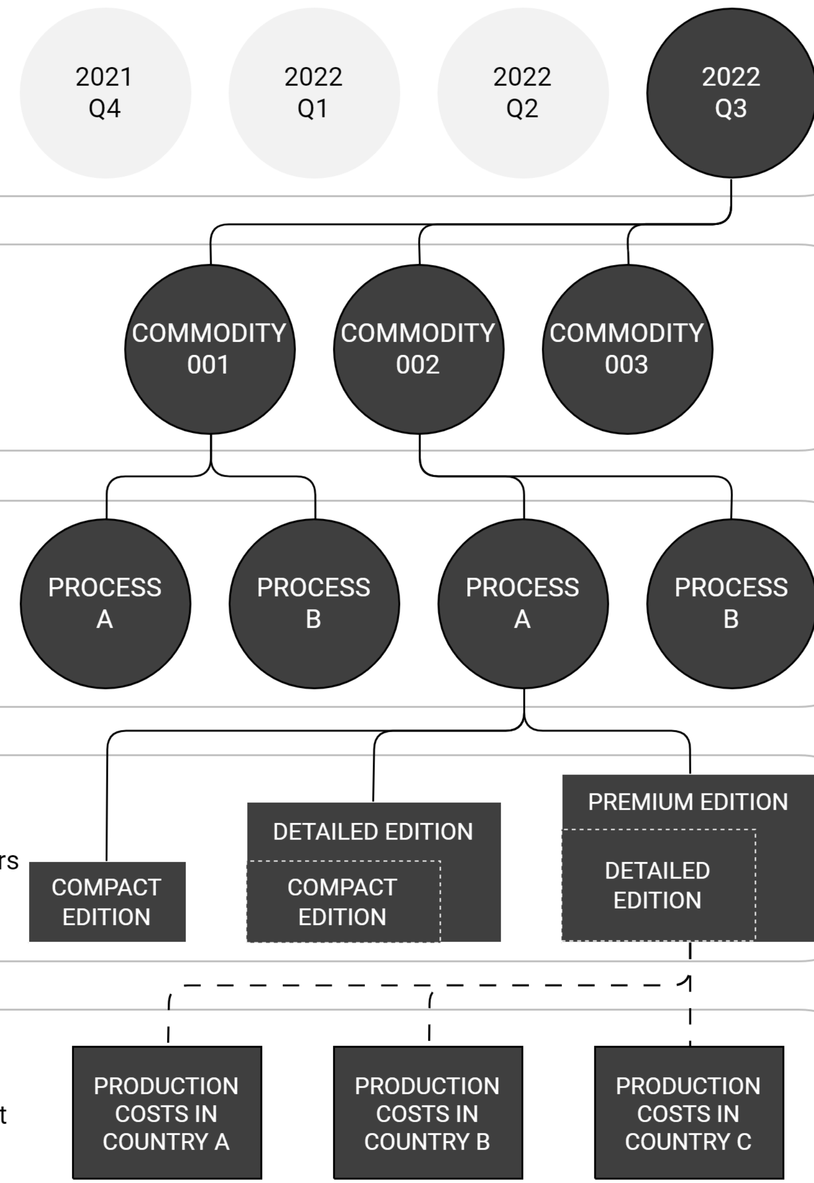
SERIES
Every quarter all reports are updated and the entire series is reviewed. Intratec does not sell reports from previous series.

VOLUMES
Set of issues (reports) targeting the production of a specific commodity.

ISSUES
Each issue approaches an industrial process for the production of the commodity.

EDITIONS
Each issue is offered in three editions designed to attend customers interested in different levels of depth.

COMPANION REPORTS
Companion reports, each one with economic analysis of a different country, are offered as add-ons to the Premium Edition.



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Editions Available

Aiming to attend customers with a wide range of needs, each Issue is offered within three different Editions with increasing levels of depth, as detailed below.

* **Compact Edition.** This Edition describes the industrial plant, including main process units and site infrastructure, and presents an independent economic analysis through summarized figures. It is perfect for those looking for a brief overview of the process, and an objective understanding of its economics.

* **Detailed Edition.** This Edition includes, besides all the content from the Compact Edition, additional assumptions and further details related to the economic analysis. This Edition is suggested for the readers interested in a more comprehensive analysis and concerned in understanding each assumption used in the development of the Issue.

* **Premium Edition.** This is the most popular and detailed Edition offered for a given Issue. It includes everything from the Detailed Edition plus additional economic and technical information about the process, which enables readers to go deeper in their analysis. This version is an excellent starting point for readers interested in checking different scenarios and developing more in-depth studies.

For more information about the content of each Edition, the reader is referred to the Table of Contents of each report.

Intratec Commodity Production Costs Support

Intratec offers technical support via email provided **only for customers who have purchased the Premium Edition** of Intratec Commodity Production Costs reports. The support provided refers exclusively to the content of the report purchased.

Interested in Technical Support?

For information about the terms of technical support (available only in the Premium Edition), customers are referred to: https://intrat.ec/icc-report-support.

To understand how to upgrade to Premium Edition of this report, the reader is referred to: https://intrat.ec/icc-report-upgrade.

Companion Reports

Intratec also offers, as an add-on for the Premium Edition, companion reports with economic data for the manufacturing process assuming other plant locations. More specifically, each companion report has a detailed economic analysis with the same structure presented in the main report, considering a plant in a different country.

Interested in Analysis in Other Countries?

The countries covered by the Commodity Costs of Production reports are: United States, Australia, Austria, Belgium, Brazil, Canada, China, Czech Republic, Finland, France, Germany, Greece, Hungary, India, Indonesia, Italy, Japan, Malaysia, Mexico, Netherlands, Norway, Philippines, Poland, Portugal, Russia, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, and United Kingdom.

About This Report

Identification

This report, "INTRATEC-ICC-PREV-294-A-PREM-USA," corresponds to the Issue A of a set of reports which is part of Volume 294, released in the Series XXXX. More specifically, this report refers to:

Item	Code	Description
Product	ICC	Intratec Commodity Production Costs
Series	XXXX	Quarter (XX) and year (XXXX) used as basis for the economic analysis
Volume	294	IPDI
Issue	A	IPDI Production from Isophorone and Chlorine
Edition	PREM	Corresponds to the Premium Edition of the report
Country	USA	The economic analysis presented in this report is based on a plant located in the United States

How to Use

The main purpose of this report is to assist readers in conducting a preliminary economic evaluation of the industrial process presented. It serves as a valuable tool for studies such as screening investment options, evaluating emerging processes, assessing economic feasibility, cost estimation double-checking, and more.

Readers should keep in mind the limitations of this report, as both the technical data and economic assessment are subject to certain constraints.

Technical Data. The preliminary design of the process is based on fast techniques that rely on reduced design efforts. The goal of such preliminary design is exclusively to represent the process in sufficient detail for supporting capital and operating costs estimation within the accuracy expected: class 4 budgetary estimates. Therefore, the technical data presented must not be confused with an actual conceptual process design and must not be used as such.

Economic Assessment. The report presents an economic assessment for the period XXXX, assuming an industrial facility based in the United States. This means that capital and operating costs estimates presented are based on several general assumptions (e.g., average market figures for raw materials, chemicals and utilities prices, labor costs, taxes, and duties), believed to suitably portray local conditions for the period of analysis informed, on a country-level basis. Accordingly, the economic assessment provided in this report is not meant to fit any specific industrial venture, which would involve a wealth of specific data and assumptions not herein considered.

Finally, it is important to highlight mistakes to avoid when using Intratec Commodity Production Costs reports:

* The reports are not process design packages nor engineering documentation of any kind.
* The reports are not based on surveys, interviews, or confidential information.
* The reports are not based on any kind of confidential information.
* The content of our reports is not tailored to customers' demands. On the contrary, all reports share the same structure (types of graphs, tables, and descriptions) and depth of content, and the content itself is the result of Intratec development methodology.
* Intratec reports are not consulting services, though users are free to use the information in conjunction with their own data or hire consulting firms for specialized analyses.

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Acronyms & Abbreviations

AACE	Association for the Advancement of Cost Engineering
BEQ	bare equipment
BFD	block flow diagram
Btu	British thermal unit
CAPEX	capital expenditures
CW	circulating cooling water
EPC	engineering procurement and construction
FEED	front-end engineering design
ft	feet
G&A	general and administrative
HAZOP	hazard and operability study
HP	high pressure
IC index	Intratec plant construction cost index
ISBL	inside battery limits
IT	information technology
kWh	kilowatt-hour
LP	low pressure
m3	cubic meter
MM	million
MP	medium pressure

mt	metric ton
NASA	National Aeronautics and Space Administration
Nm3	normal cubic meter
OC	owner's cost
Op.	operator
OPEX	operational expenditures
OSBL	outside battery limits
PFD	process flow diagram
R&D	research and development
RF	refrigeration fluid
ROCE	return on capital employed
ST	steam
Sup.	supervisor
t	ton
TFC	total fixed capital
TPC	total process capital
TRL	technology readiness level
wt	weight
yr	year

Chapter 1

Executive Summary

About IPDI

IPDI (a.k.a. Isophorone Diisocyanate) is one of the main aliphatic diisocyanates, being widely employed in polyurethanes production for coating applications. It is highly reactive, so it can undergo several addition reactions across the CN double bond in such a way that a myriad of commercial products can be obtained from reactions with alcohols, carboxylic acids, and amines.

Like other organic isocyanates, IPDI is a hazardous chemical, and its handling is regulated in virtually all industrialized countries. Being sensitive to moisture, IPDI must be stored in a volume tank under dry nitrogen blanketing, or kept in the original containers.

Isophorone diisocyanate is used in the production of aliphatic polyisocyanates and polyurethanes with high stability, with applications in paints; varnishes; elastomers; industrial coating applications; and electrostatic powder coatings.

IPDI Production Process

The present analysis approaches Isophorone Diisocyanate (IPDI) production from isophorone and chlorine.

The process under analysis comprises three major sections: (1) Isophorone Hydrocyanation; (2) Isophorone nitrile (IPN) Amino-hydrogenation; and (3) Isophorone Diamine (IPDA) Phosgenation.

Isophorone Hydrocyanation. Initially, fresh and recycled isophorone are fed to a plug flow tubular reactor, along with hydrogen cyanide (HCN). The reaction is carried out in the presence of caustic soda, under atmospheric pressure. Excess of isophorone is used to avoid undesirable reactions (between HCN and the carbonyl group of isophorone). IPN is recovered from the hydrocyanation effluent after washing, distillation and evaporation steps. Caustic soda and unreacted isophorone are returned to the hydrocyanation.

IPN Amino-hydrogenation. The IPN obtained is mixed with excess ammonia and reacted to form isophorone nitrile imine (IPNI) in the presence of gamma-aluminum oxide catalyst. The product of the imination reaction, comprising IPNI, IPN and unreacted ammonia, is fed to the amino-hydrogenation reactors along with hydrogen and more ammonia. This reaction step occurs in the presence of conventional hydrogenation catalysts, yielding IPDA. Unreacted hydrogen and ammonia are separated from the amination effluent and recycled. The IPDA-rich stream is subsequently submitted to distillation and evaporation steps for purification.

IPDA Phosgenation. IPDA and phosgene are vaporized and superheated, then they are fed to the reactors.The mixture is kept at high temperatures for a short time in order to avoid the generation of side products or the decomposition of phosgene. Solvent is used to condense the isophorone diisocianate formed. The liquid stream is further treated to remove the solvent, as well as light and heavy ends. Finally, the purified IPDI product is obtained. The gaseous effluent obtained after liquefaction of IPDI is further treated, in order to recover phosgene and hydrogen chloride.

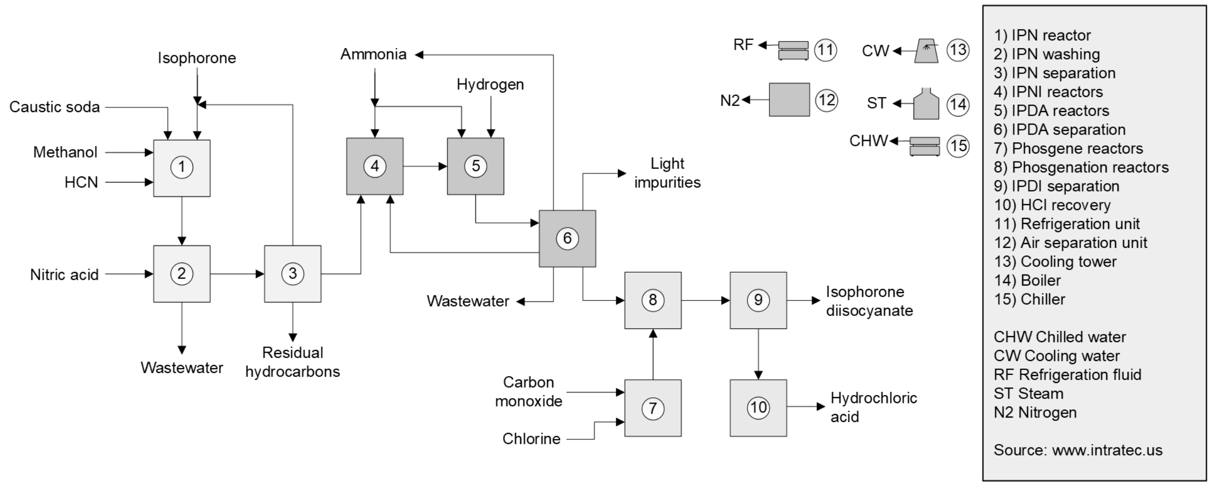


Figure 1.1 Process Schematic Diagram

Economic Analysis

Table 1.1 provides a summary of the IPDI production cost related to the process described in the report, based on a 0.000 mt/yr plant. Also, it presents some remarks about the key aspects surrounding the economic analysis performed.

Table 1.1 IPDI Production Cost Summary

IPDI Production from Isophorone and Chlorine

Plant location	United States	**Capital investment summary**	**MM USD**
Period of analysis	XXXX (IC Index: XXX)	Fixed capital	XXX
Nominal capacity (mt/yr)	0.000	Working capital	XXX
Operating rate (h/yr)	XXX (XXX XXX%)	Additional capital	XXX
Annual production (mt/yr)	XXX	**Total capital investment**	**XXX**

Description	USD/mt	MM USD/yr	%
Net raw materials cost	XXX	XXX	XX
Net utilities cost	XXX	XXX	XX
Operating variable costs	**XXX**	**XXX**	**XX**
Operating fixed costs	XXX	XXX	XX
Operating cash cost	**XXX**	**XXX**	**XX**
Depreciation	XXX	XXX	XX
Total operating cost	**XXX**	**XXX**	**XX**
Corporate overhead	XXX	XXX	XX
ROCE	XXX	XXX	XX
Product value	**XXX**		**XX**

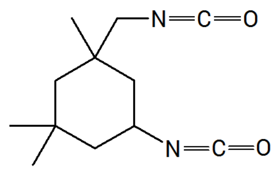
Table 1.1 shows the impact of variable costs in the product value — it represents approximately XX % of the product value. Regarding the capital investment it is worth mentioning that, in order to fulfill the infrastructure requirements assumed in the present analysis, OSBL investment represents about XX% of the IPDI plant cost.

Chapter 2

About IPDI

IPDI (a.k.a. Isophorone Diisocyanate) is one of the main aliphatic diisocyanates, being widely employed in polyurethanes production for coating applications. It is highly reactive, so it can undergo several addition reactions across the CN double bond in such a way that a myriad of commercial products can be obtained from reactions with alcohols, carboxylic acids, and amines.

The structure of IPDI is presented below:



Isophorone Diisocyanate (IPDI)

Figure 2.1 IPDI

Industrial IPDI manufacture is primarily based on the corresponding amine: isophorone diamine (IPDA). The most common method of preparing IPDI on a commercial scale involves the reaction of IPDA with phosgene, yielding a mixture of the two IPDI stereoisomers (25/75 cis/trans). Isophorone Diisocyanate may also be produced from the addition of IPDA to urea and alcohol followed by the decomposition of the intermediate carbamate.

Like other organic isocyanates, IPDI is a hazardous chemical, and its handling is regulated in virtually all industrialized countries. Being sensitive to moisture, IPDI must be stored in a volume tank under dry nitrogen blanketing, or kept in the original containers.

Commercial Forms & Applications

The uses and applications of IPDI may vary according to its specification. The main forms of IPDI are technical grade.

Isophorone diisocyanate is used in the production of aliphatic polyisocyanates and polyurethanes with high stability, with applications in paints; varnishes; elastomers; industrial coating applications; and electrostatic powder coatings.

IPDI can be used in the manufacture of other products, including urethane-acrylate resins.

IPDI Production Routes

The classic route for IPDI commercial production is based on phosgenation, in which IPDA is reacted with phosgene, yielding a mixture of the two IPDI stereoisomers (25/75 cis/trans). This organic isocyanate can also be produced via the so-called non-phosgene routes, based on the reaction of IPDA with urea/alcohol or cabonate.

Figure 2.2 IPDI Production Routes Diagram

Fig. 2.2 comprises a diagram showing different IPDI production processes. This report is part of the Intratec Commodity Production Costs reports, focused on IPDI manufacturing processes.

Intratec has also developed other reports focused on other IPDI production processes. More information about such industrial processes are presented below.

Issue B

It illustrates the Isophorone Diisocyanate (IPDI) production from isophorone and urea. In this process, isophorone diamine (IPDA) is initially obtained from isophorone. Then, IPDA reacts with urea and butanol generating a carbamate intermediate. Then, the carbamate is thermally cracked producing IPDI. See reference:

* Intratec. XXXX. IPDI Production from Isophorone and Urea, Report ICC-XXXX-294-B-PREM-USA. In: Intratec Commodity Production Costs, Series XXXX. Volume 294 (IPDI). Issue B. Premium Edition. Available at: www.intratec.us/icc/294-B.

Chapter 3

Process Overview

This chapter presents an overview of Isophorone Diisocyanate (IPDI) production from isophorone and chlorine.

More specifically, the current chapter approaches technical aspects of the IPDI production process examined including technology maturity assessment and description of the products generated and the process inputs.

Technology Maturity Assessment

The process technology under study was categorized according to its maturity. The technical maturity, while a measure of performance, reliability and operating experience associated with the technology being assessed, serves as an important input in the definition of assumptions that have a relevant impact on process economics (e.g., process contingency, project contingency, costs related to start-up inefficiencies and R&D, etc.).

The process technology maturity is defined by the Intratec team through a method adapted from the so-called Technology Readiness Level (TRL) method, developed by NASA, and nowadays used in a broad range of sectors/industries. There are nine TRLs, which describe the maturity of a technology, from basic technology research to system testing, launch and operations.

Originally intended to support decision-making over research and development activity, the nine technology readiness levels were divided into five major classes to portray the maturity level of chemical process technologies, from “concept” to “established technology.” Table 3.1 describes such five classes according to which the Intratec team classifies technologies being studied, as well as the TRLs included within each class.

Table 3.1 Process Technology Maturity Scale

Technology Status	Description	Scale	TRL
Established (Outdated)	* Existing plants being shut down * No longer adopted in new plants * Obsolete technology	Commercial (at least 1 plant)	-
Established (In Use)	* 2+ commercial plants * Proven technology (successful operations)	Commercial (2+ plants)	9
Emerging	* 1 commercial plant * Basic data for commercial plant * Performance validation * Demonstration plant * Prototype near or at planned operation system	Commercial (1 plant) Demonstration	7-8
Embryonic	* Pilot-scale demonstration * Engineering-scale models / prototypes * Basic data for scale-up * "Proof-of-Concept" validation * Bench-scale demonstration * Lab-scale technology definition * Process modeling * Analytical studies * Active R&D	Pilot Bench Lab	4-6 2-3
Conceptual	* Unproven idea / proposal * No analysis or testing * Paper concept / studies	Concept Idea	1

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Product(s) Description

* Isophorone Diisocyanate (IPDI)

Liquid IPDI is the main product obtained in the process under analysis (purity: 99.5 wt% min.).

* Hydrochloric Acic

Hydrochloric acid (HCl), also known as muriatic acid, is a highly corrosive mineral acid with several industrial applications. The concentration of the hydrochloric acid (HCl) generated in the process is 32 wt%.

Inputs Description

Raw Material(s)

* Isophorone

Isophorone (3,5,5-trimethyl-2-cyclohexen-1-one) is derived from the trimerization of acetone. More specifically, it is produced by the aldolization of acetone under alkaline conditions. This cyclic unsaturated ketone serves as solvent for a range of polymers, resins, fats, oils and agrochemicals. Although it has traditionally been used as a low volatility solvent, it is also an important industrial building block, as a raw material to produce isophorone diisocyanate (IPDI) for the production of light-stable polyurethane.

In the process under analysis, it is assumed that isophorone with purity greater than 99 wt% is available, consisting mainly of alpha-isophorone (less than 1 wt% of beta-isophorone isomer - 3,5,5-trimethyl-3-cyclohexene-1-one).

* Hydrogen Cyanide

Hydrogen cyanide is a volatile, flammable and highly toxic gas in temperatures above 25 ºC. Otherwise, it is a dangerous transparent liquid; its storage and transport are prohibited in certain locations.

HCN's range of applications includes its use as an intermediate in the production of sodium or potassium cyanide. It may also be used as a disinfectant for plague-infected ships and houses.

HCN is obtained in industrial plants by the endothermic reaction between ammonia and natural gas (methane) using a platinum-rhodium catalyst. Such plants are necessarily integrated to consumer facilities.

* Ammonia

Ammonia (NH3) is one of the most produced synthetic chemicals worldwide. The main application of this world class commodity is in nitrogen fertilizers, followed by the synthesis of nitric acid. It is also used, to a lesser extent, in several other applications such as pulping of wood and as ingredient in household cleaners and drugs.

Ammonia produced basically by the reaction between nitrogen and hydrogen, in a 1:3 stoichiometric ratio. Its production routes are related to the source of the hydrogen used, being steam reforming the main one.

In the process under analysis, it is assumed that ammonia with 99.9 wt% purity is used.

* Chlorine

Chlorine figures among the most important chemical commodities. Most of chlorine produced on commercial scale is based on electrolysis of aqueous sodium chloride (brine), which also generates caustic soda and hydrogen as co-products (chlor-alkali processes). In the process under analysis, gaseous chlorine with 99.9% purity is used.

In the process under analysis Chlorine is supplied by a nearby chlorine supplier.

* Carbon Monoxide

Like hydrogen, carbon monoxide is produced industrially from syngas, but it is recovered via cryogenic distillation. Carbon monoxide is used in the chemical industries for the synthesis of several compounds, like acetic acid, polycarbonates, polyketones; and also in the metallurgical industry for the creation of reducing atmospheres.

In the process under analysis carbon monoxide is supplied by a nearby syngas production unit.

* Catalyst & Chemicals

In addition to the main reagents mentioned above, the process also requires hydrogen in one of the reaction steps, as it will be explained further.

Nitric acid, methanol, monochlorobenzene and ortho-dichlorobenzene are also employed in the process. Nitric acid used as scrubbing medium, while methanol and chlorobenzenes are used as solvents.

In the economic analysis, the costs of acquisition of those chemicals, as well as of the catalysts used in the process, are accounted under 'Catalyst & chemicals'.

Utilities

The main utilities consumed in the process are cooling water, refrigerant, process water, inert gas, electricity and steam.

Process Highlights

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Chapter 4

Industrial Site Configuration

This chapter presents the industrial site configuration for the IPDI production process examined. In short, the information presented in this chapter is based on commonly utilized concepts related to the type of installations found within a typical industrial site. These concepts include:

* Process unit. Also known as inside battery units, these installations comprise all main units of the site required to modify the input stream and obtain the target output. These units are located Inside the Battery Limits (ISBL).

Infrastructure. Also known as outside battery units or offsite facilities, these installations do not directly enter into the modification of the process input stream. They are support buildings, auxiliary units used for providing and distributing utilities and storage facilities. These units are located Outside the Battery Limits (OSBL).

In order to make a better distinction between these types of installation, a diagram is presented in Figure 4.1. The diagram also provides an insightful overview of the industrial site as whole, and helps to clarify which raw materials and utilities are supplied to the process unit and which products and utilities are generated.

Figure 4.1 Industrial Site Configuration

Chapter 5

Process Unit

This chapter presents the process unit associated with the Isophorone Diisocyanate (IPDI) production from isophorone and chlorine. The process examined is a typical phosgenation process.

Basically, the process unit is the core of an industrial site. Comprising the site's battery limits (ISBL), it may be complex and involve several pieces of equipment. In this context, to facilitate the understanding, the process unit related to the IPDI manufacturing process under analysis is presented in the next pages through the use of a block flow diagram followed by a comprehensive description.

The information presented in this report was mainly based on:

(1) US Patent 9187412 B2, issued to Evonik Degussa in 2015

(2) US Patent 8884063 B2, issued to BASF SE in 2014

(3) US Patent 8563768, issued to Covestro (fromer Bayer MaterialScience) in 2013

It is important to mention that some aspects of the IPDI production process examined are either industrial secrets, not published in patents, or have changed, but were not reported in the literature at the time this report was developed. That being the case, the design herein presented is partially based on Intratec process synthesis knowledge such that there may be some differences between the industrial process actually employed and the IPDI manufacturing process described in this study. Nevertheless, the design presented suitably represents the technology examined in sufficient detail to estimate the economics of the technology within the degree of accuracy expected from conceptual evaluations.

Block Flow Diagram

In general, block flow diagrams consist of a series of blocks, representing unit operations or groups of equipment, connected by input and output streams. In fact, there are no strict standards according to which such diagrams are made.

To facilitate the presentation of the process unit under analysis, Intratec developed block flow diagrams according to some standards. The process areas represented correspond to a "functional unit." Basically, a "functional unit" is a significant step in the process in which a particular physico-chemical operation (i.e., distillation, reaction, evaporation) occurs. According to this definition, a given functional unit is not associated with a single piece of equipment, but rather with a group of equipment and ancillaries required to perform a particular operation.

The blocks representing process areas also show key technical parameters related to these areas, including: the highest operating temperature and pressure, representative material of construction, and other parameters.

As to the process streams represented, there is an indication of their phase. Also, such streams may provide a global material balance of the process, normalized by the mass flow rate of the product considered in the analysis. In other words, the number near each stream represents the ratio between its mass flow rate and the output flow rate of the product under analysis.

It is worth noting that areas having no significant impact on the economics of the process may not be included in the diagram. Similarly, some streams may also not be represented. Nevertheless, the diagram presented is still extremely useful in providing readers with an overall understanding of the process studied.

The following block flow diagram illustrates the functional units related to the process under analysis.

Further Details

For more information on how the process examined was divided into functional units, the reader is referred to https://intrat.ec/m?f=/icc-methodology.

Figure 5.1 Block Flow Diagram — IPDI (99.5%) Manufacturing Process

> **Further Details**
> For a more detailed diagram presenting pieces of equipment and more process streams, the reader is referred to *"Appendix I. Process Flow Diagram & Equipment List."*

Description

The IPDI production process under analysis is briefly described below. For clarity, the description was divided according to the process areas indicated in the block flow diagram.

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

* XX - XXXXXXXXX

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* XX - XXXXXXXXX

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* XX - XXXXXXXXX

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* XX - XXXXXXXXX

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* XX - XXXXXXXXX

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* XX - XXXXXXXXX

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Chapter 6

Site Infrastructure

This chapter describes the infrastructure requirements associated with the IPDI production process examined. Basically, infrastructure requirements comprise the offsite facilities, or the units located Outside the Battery Limits (OSBL). The OSBL usually have a significant impact on the capital cost estimates associated with any new industry venture. This impact is largely dictated by, among other things: specific conditions where the industrial site will be erected; the level of integration the new site will have with nearby facilities or industrial complexes; and assurance and promptness in the supply of chemicals.

Assumptions

The infrastructure requirements of the industrial site examined were defined according to the assumptions listed below.

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Note

According to the literature focused on the economic analysis of processes, the costs associated with waste treatment typically range from 0.5% to 5% of plant cost per year (See references M14, M15). However, since such costs may significantly vary from process to process and according to plant location, Intratec recommends a specific study for more accurate estimates.

Description

The offsite facilities were divided into areas according to their type/function. These areas are listed in the following pages, as well as a description about the major equipment, systems and facilities included in each of them.

* Area 90 – Storage Installations

Figure 6.1 Area 90 – Storage Installations

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

* Area 91 – Utilities Facilities

Figure 6.2 Area 91 – Utilities Facilities

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

* Area 92 – Support & Auxiliary Buildings

Figure 6.3 Area 92 – Support & Auxiliary Buildings

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

Chapter 7

Process Consumptions & Labor Requirements

This chapter presents the process requirements to operate an industrial site of the IPDI production process examined. More specifically, the next pages provide key process indicators and the operators required to run the process equipment of the IPDI manufacturing process examined (in accordance with the block flow diagram and the global material balance previously presented).

Key Input & Output Figures

The following tables show key process indicators of the technology examined. In other words, these indicators reflect the raw materials consumption in Table 7.1 rates per metric ton of IPDI.

Table 7.1 Raw Materials Consumption

Raw Material	Quantity per metric ton of Product	Unit
XXXXXXXXX	XXX	XXX
XXXXXXXXX	XXX	XXX

It should be noted that estimation of raw material requirements in the conceptual design phase is usually reasonably accurate, but tends to be somewhat understated compared to real operations. Losses from vessel vents, unscheduled equipment, inerting systems, physical property inaccuracies, startup, shutdown, and other process operations not typically addressed in this phase may increase raw materials consumption.

Further Details

For detailed figures regarding utilities consumption, reader is referred to "*Appendix A. Utilities Consumption Details*."

Labor Requirements

Table 7.2 presents the number of operators per shift required to run the equipment of the process examined, as well as the personnel per shift required to directly supervise the operating labor.

Table 7.2 Labor Requirements

Personnel	Workers per Shift
Operators	XX
Supervisors	XX

Chapter 8

Capital Costs Summary - United States

This chapter presents IPDI plant capital costs associated with Isophorone Diisocyanate (IPDI) production from isophorone and chlorine, from design to industrial plant startup.

The costs that comprise the total IPDI plant capital costs are grouped under three major costs:

* Fixed capital. Depreciable capital invested in the construction of the industrial plant and making it operational. It comprises the IPDI plant cost and owner's cost, expenses required to make the plant operational (i.e., initial catalyst load in reactors, prepaid royalties, and miscellaneous costs).

* Working capital. Funds for getting the plant into operation and meeting subsequent obligations. It includes raw materials inventory, products inventory, in-process inventory, supplies and stores, accounts receivable and accounts payable.

* Additional capital requirements. One-time expenses related to bringing a process on stream during plant start-up. These expenses may be related to employee training, initial commercialization costs, operating inefficiencies, and unscheduled plant modifications.

Figure 8.1 illustrates the composition of total capital investment.

Further Details

For more information about how the capital costs were estimated, the reader is referred to https://intrat.ec/m?f=/icc-methodology.

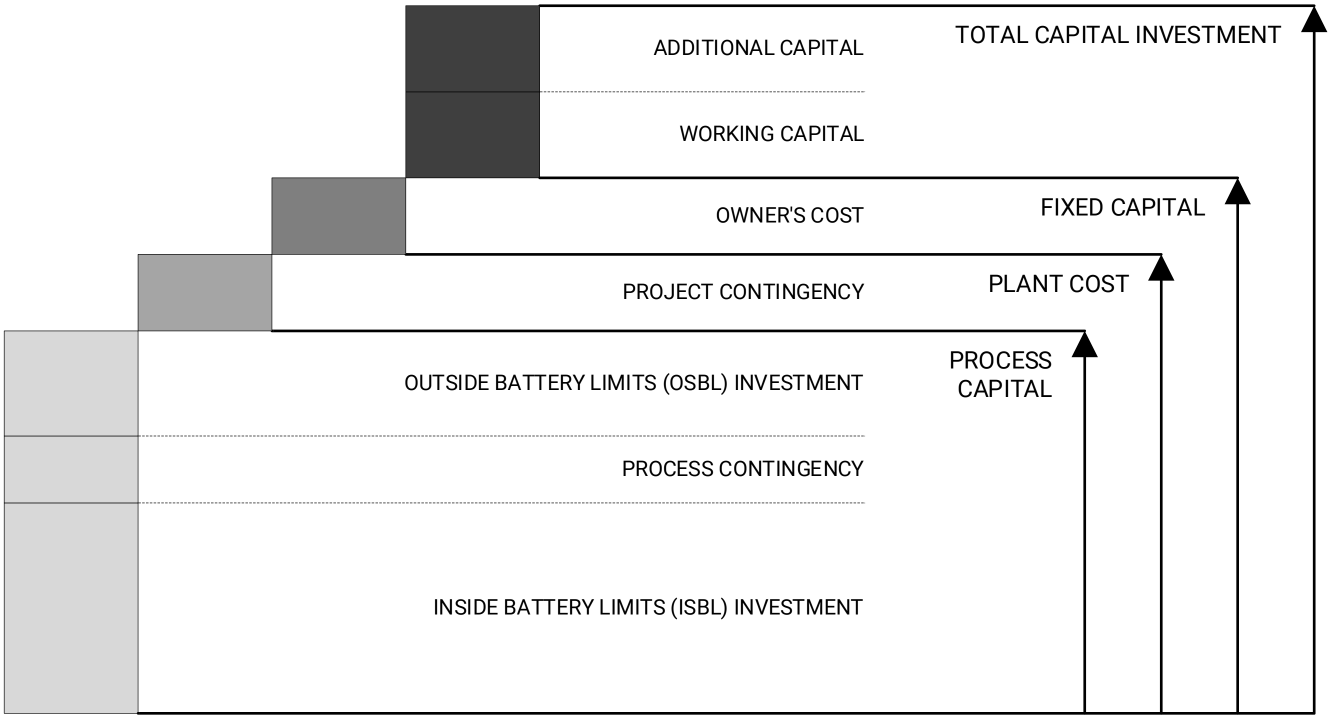

Figure 8.1 Capital Investment Composition

Assumptions

The estimates included in this chapter are based on the following assumptions:

* Plant nominal capacity: **0.000 mt** of IPDI per year
* Industrial plant location: **United States**
* Construction on a cleared, level site
* Period of analysis: XXXX
* IC Index-United States at the period of analysis: XXX

Interested in Adjusting Construction Costs Over Time?
Intratec Plant Construction Cost Indexes (IC Indexes) are multipliers monthly published by Intratec to scale capital costs from one time period to another. For more information, visit https://intrat.ec/industry-economics-worldwide.

Total Capital Investment

Table 8.1 summarizes all major IPDI plant capital costs that comprise the total capital investment, from the design and construction of an industrial site to plant startup.

Table 8.1 Capital Investment Summary

Component	MM USD	%
Plant cost	XXX	XX
Owner's cost	XXX	XX
Total fixed capital	**XXX**	**XX**
Working capital	XXX	XX
Additional capital	XXX	XX
Total capital investment	**XXX**	**XX**

Figure 8.2 presents a graphical representation of the total capital investment breakdown.

Figure 8.2 Capital Investment Summary

Further Details

For the breakdown of fixed capital, working capital and additional capital, reader is referred to "*Appendix C. Capital Investment Details*."

Chapter 9

Operating Costs Summary - United States

This chapter presents ongoing costs required for Isophorone Diisocyanate (IPDI) production from isophorone and chlorine. Also referred to as operational expenditures (OPEX), these encompass costs associated with the plant operation and depreciation. In the current analysis, the operating cost was grouped under three major costs:

* Operating variable costs. Costs directly proportional to the actual operating rate of the industrial site. Such costs include raw materials and utilities (i.e., steam, electricity, fuel, and refrigeration).

* Operating fixed costs. Operating costs directly tied to the plant capacity, but which do not change with the operating level (i.e., operating labor, supervision labor, maintenance costs, plant overhead).

* Depreciation. Refers to the decrease in value of industrial assets with passage of time.

It should be kept in mind that the sum of operating fixed costs and operating variable costs is referred to as "cash cost." The sum of cash cost with depreciation, in turn, is referred to as "total operating cost."

Figure 9.1, on the next page, illustrates the composition of total operating cost.

Further Details

For more information about how the operating cost components were estimated, the reader is referred to https://intrat.ec/m?f=/icc-methodology.

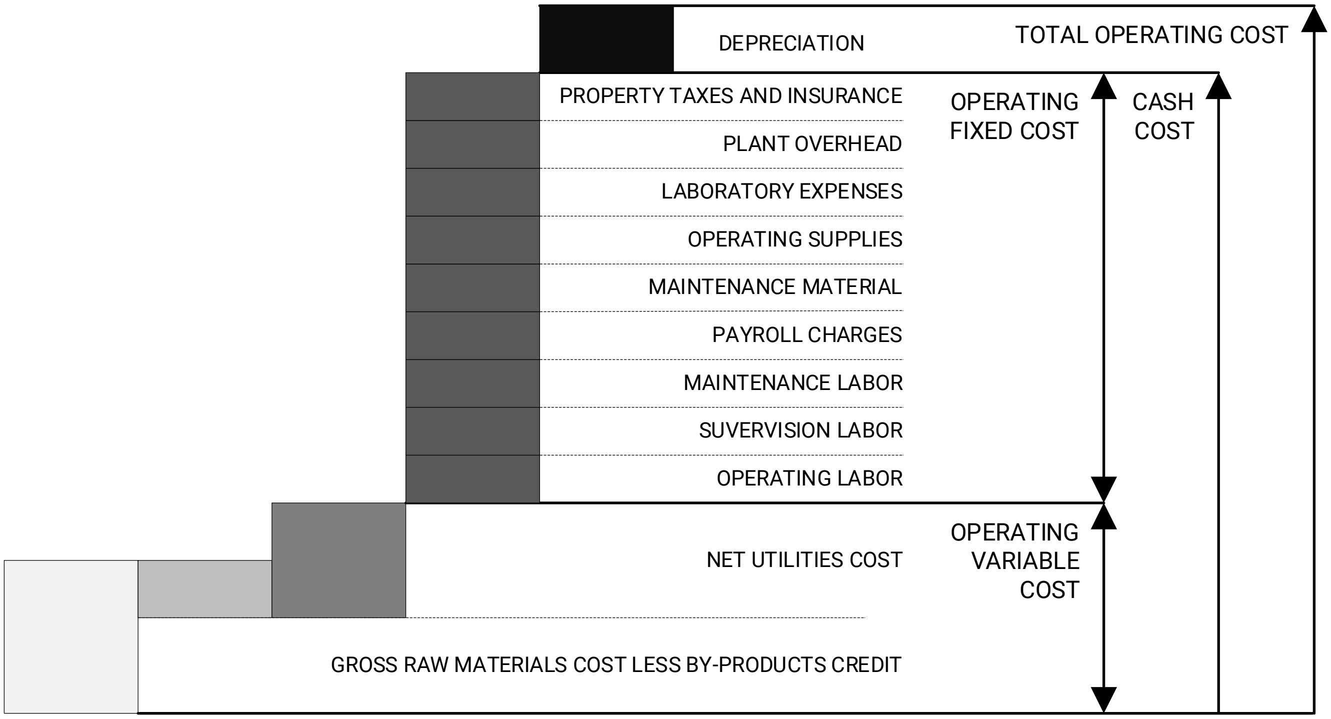

Figure 9.1 Operating Costs Composition

Assumptions

The estimates included in this chapter are based on the following assumptions:

* Industrial plant location: **United States**
* Period of analysis: XXXX
* Plant nominal capacity: **0.000 mt** of IPDI per year
* Plant operating rate (hours per year): XXX

The plant operating rate assumed leads to an annual throughput of XXX metric ton of IPDI. It is important to mention that this rate does not represent any technological limitation; rather, it is an assumption based on usual industrial operating rates.

Operating Variable Costs

Table 9.1 displays the operating variable costs.

Table 9.1 Operating Variable Costs

Component	Quantity	Price	USD/mt	MM USD/yr	%
XXXXXXXXX	XXX XXX	XXX	XXX	XXX	XX
XXXXXXXXX	XXX XXX	XXX	XXX	XXX	XX
Gross raw materials cost			**XXX**	**XXX**	**XX**
Net raw materials cost			**XXX**	**XXX**	**XX**
Net utilities cost			XXX	XXX	XX
Operating variable costs			**XXX**	**XXX**	**XX**

All costs presented in this table are derived from unit consumptions and pricing information.

Total Operating Cost

Table 9.2 summarizes all operating cost by presenting its major components.

Table 9.2 Operating Costs Summary

Component	USD/mt	MM USD/yr	%
Operating variable costs	XXX	XXX	XX
Operating fixed costs	XXX	XXX	XX
Operating cash cost	**XXX**	**XXX**	**XX**
Depreciation	XXX	XXX	XX
Total operating cost	**XXX**	**XXX**	**XX**

Figure 9.2 presents a graphical representation of the operating cost breakdown.

Figure 9.2 Operating Costs Summary

Further Details

For the breakdown of utilities cost, operating fixed costs and depreciation, the reader is referred to *"Appendix D. Operating Costs Details."*

Chapter 10

Product Value Summary - United States

This chapter presents the “Product Value,” a term commonly used wherein all costs associated with the manufacture of a product are combined in order to provide a more consistent economic analysis. It includes operating cost (operating variable costs, operating fixed costs, and depreciation), as well as corporate overhead costs and an expected Return on Capital Employed (ROCE). Figure 10.1 illustrates the composition of the product value.

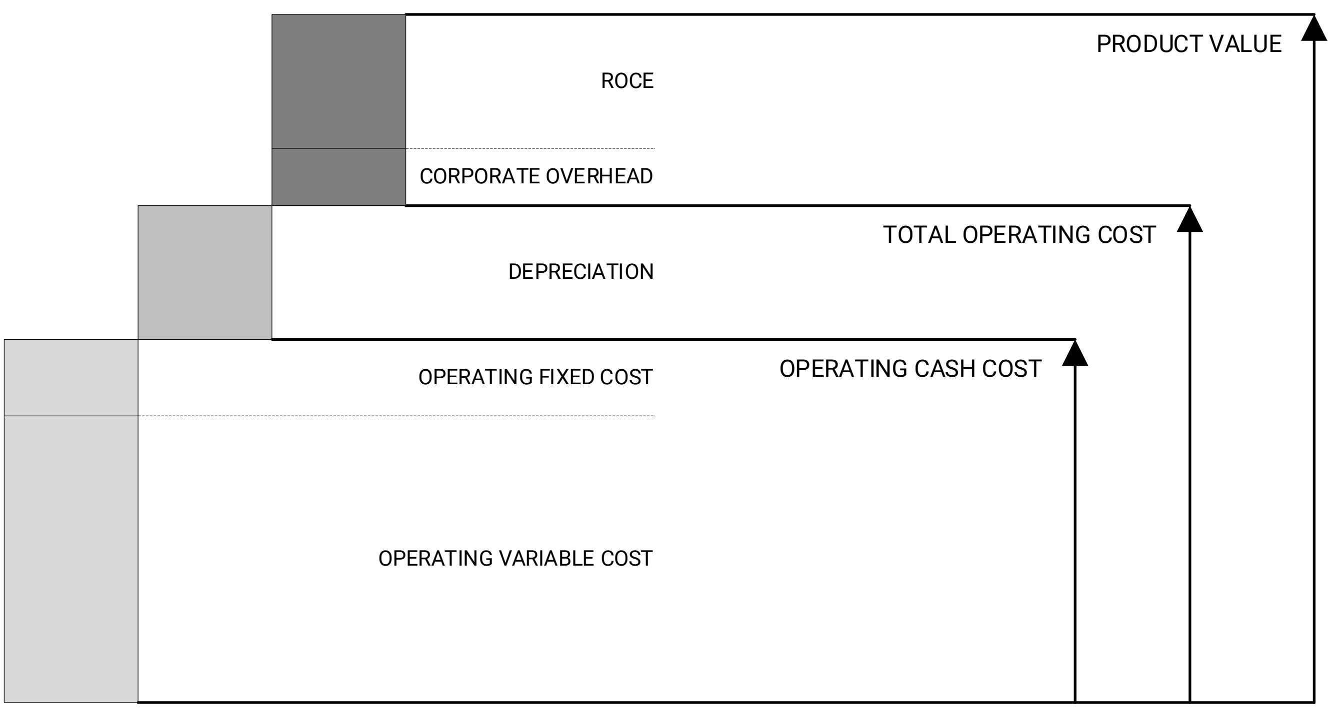

Figure 10.1 Product Value Composition

It is important to mention that product value should not be confused with product price. The product value should be seen as the minimum price for which the product could be sold, so that the plant owner can get the expected ROCE.

Table 10.1 summarizes all costs that comprise the product value in the process examined.

Table 10.1 Product Value Composition

Component	USD/mt	MM USD/yr	%
Operating cash cost	XXX	XXX	XX
Depreciation	XXX	XXX	XX
Total operating cost	**XXX**	**XXX**	**XX**
Corporate overhead	XXX	XXX	XX
ROCE	XXX	XXX	XX
Product value	**XXX**		**XX**

Figure 10.2 shows the impact of each cost component on the product value.

Figure 10.2 Product Value Summary

Chapter 11

Production Costs Summary - United States

This chapter provides a summary of all IPDI production costs related to the process described so far. Also, it presents some remarks about the key aspects surrounding the economic analysis.

IPDI Production Cost Datasheet

Table 11.1 condenses the analysis developed in this report.

Economic Remarks

It should be noted that the risk taken into account in this analysis is limited to the technical risks associated with the process uncertainties or inherent risks associated with the venture's industry sector. Other venture risks, such as business environment, raw materials and product prices variations, change in government policy, shall be evaluated case by case, and are not taken into account here, since this is a general analysis.

It is also important to mention that product value must not be confused with product price. While the product value is calculated based on operating cost and expected ROCE, the product price is the actual value practiced in market transactions.

Table 11.1 IPDI Production Cost Datasheet

IPDI Production from Isophorone and Chlorine

Plant location	United States	**Capital investment summary**	**MM USD**
Period of analysis	XXXX (IC Index: XXX)	Fixed capital	XXX
Nominal capacity (mt/yr)	0.000	Working capital	XXX
Operating rate (h/yr)	XXX (XXX XXX%)	Additional capital	XXX
Annual production (mt/yr)	XXX	**Total capital investment**	**XXX**

Description	Quantity per mt	Price	USD/mt	MM USD/yr	%
XXXXXXXXX	XXX XXX	XXX/XXX	XXX	XXX	XX
XXXXXXXXX	XXX XXX	XXX/XXX	XXX	XXX	XX
Gross raw materials cost			**XXX**	**XXX**	**XX**
Net raw materials cost			**XXX**	**XXX**	**XX**
Net utilities cost			XXX	XXX	XX
Operating variable costs			**XXX**	**XXX**	**XX**
Operating fixed costs			XXX	XXX	XX
Operating cash cost			**XXX**	**XXX**	**XX**
Depreciation			XXX	XXX	XX
Total operating cost			**XXX**	**XXX**	**XX**
Corporate overhead			XXX	XXX	XX
ROCE			XXX	XXX	XX
Product value			**XXX**		**XX**

Further Details

For further clarification about the pricing assumptions used in this analysis, the reader is referred to https://intrat.ec/m?f=/icc-methodology.

Chapter 12

Analysis Methodology Summary

This chapter provides a brief summary of the methodology developed by Intratec for producing its Production Cost Reports. For a more-in-depth comprehension, readers are encouraged to explore the *Intratec Commodity Production Costs – General Methodology Guide*, which can be accessed at:

► https://intrat.ec/m?f=/icc-methodology

The Intratec Commodity Production Costs report is a critical tool for evaluating industrial processes from a techno-economic perspective. Leveraging over a decade of experience in commodities markets and process economics, Intratec has developed a robust and consistent methodology to ensure reliable and comprehensive techno-economic evaluations.

A techno-economic assessment analyzes industrial processes from an economic viewpoint, considering factors such as operating costs, capital investments, and process requirements. This evaluation supports investment screening, process assessment, and the analysis of industrial ventures' economic feasibility.

The primary goal of the report is to deliver best-in-class economic evaluations, summarized as shown in Table 12.1, providing trustworthy estimates for informed decision-making. This approach offers readers clear insights into the economic viability of process technologies in dynamic markets.

To produce high-quality reports, Intratec conducts detailed research into raw materials, products, and processes, including thorough technical analyses of Inside Battery Limits (ISBL) and Outside Battery Limits (OSBL) areas. This analysis is grounded in an extensive bibliography of books, patents, and academic papers.

Table 12.1 Production Cost Datasheet Template

Intratec Commodity Production Costs

Plant location	________	(e.g., USA)	**Capital investment summary**	**MM USD**
Period of analysis	________	(IC Index: ____)	Fixed capital	________
Nominal capacity (mt/yr)	________		Working capital	________
Operating rate (h/yr)	________	(___%)	Additional capital	________
Annual production (mt/yr)	________		**Total capital investment**	________

Description	**Quantity per product**		**Price**		**USD/mt**	**MM USD/yr**	**%**
Raw material 1	_____	mt	_____	USD/mt	_____	_____	___
Raw material 2	_____	mt	_____	USD/mt	_____	_____	___
Raw material 3	_____	mt	_____	USD/mt	_____	_____	___
Raw material 4	_____	mt	_____	USD/mt	_____	_____	___
Gross raw materials cost					_____	_____	___
By-product 1	_____	mt	_____	USD/mt	_____	_____	___
By-product 2	_____	mt	_____	USD/mt	_____	_____	___
By-product credits					_____	_____	___
Net raw materials cost					_____	_____	___
Cooling water	_____	m3	_____	USD/m3	_____	_____	___
Demineralized water	_____	m3	_____	USD/m3	_____	_____	___
Electricity	_____	kWh	_____	USD/kWh	_____	_____	___
Steam (HP)	_____	mt	_____	USD/mt	_____	_____	___
Utilities consumption					_____	_____	___
Fuel credit	_____	MMBtu	_____	USD/MMBtu	_____	_____	___
Steam (LP)	_____	mt	_____	USD/mt	_____	_____	___
Utilities generation					_____	_____	___
Net utilities cost					_____	_____	___
Operating variable costs					_____	_____	___
Operating fixed costs					_____	_____	___
Operating cash cost					_____	_____	___
Depreciation					_____	_____	___
Total operating cost					_____	_____	___
Corporate overhead					_____	_____	___
ROCE					_____	_____	___
Product value					_____		___

Using this technical foundation, key process indicators, site configurations, and labor requirements are defined. These inputs are then applied to calculate capital investment and operating costs. Capital investment is categorized into fixed, working, and additional capital, while operating costs are divided into variable costs, fixed costs, and depreciation.

Accuracy is paramount, and Intratec continuously gathers comprehensive data on commodity prices, utilities, and labor costs for the specific country and period of the study. This data is sourced from both public and private entities, including national statistics bureaus, government agencies, international organizations, market exchanges, and producers.

For simplicity, all cost estimates are consolidated into a single item: the "Product Value." This value combines operating costs (variable, fixed, and depreciation), corporate overhead, and a return on capital employed (ROCE), which reflects the capital investment.

All Intratec reports that approach industrial processes have a common structure, i.e., indexes, tables, and charts share similar standards. This ensures that Intratec's readers know upfront what they will get and, more than that, will be able to compare technologies addressed in different reports.

Our methodology is continuously tested and validated by manufacturers, R&D centers, EPC companies, financial institutions, and government agencies that rely on our reports. Figure 12.1 illustrates the methodology used in this report.

Complementary Documents

In addition to the full analysis methodology (https://intrat.ec/m?f=/icc-methodology), Intratec provides two other documents with complementary information to this report: "Glossary & Abbreviations" and "Unit Conversion."

The "Glossary & Abbreviations" document contains definitions of important commodity market terms found in this report and our other products. Access it at: https://intrat.ec/glossary.

The "Unit Conversion" table presents unit conversion factors for several length, mass, energy units, and more. Access it at: https://intrat.ec/unit-conversion.

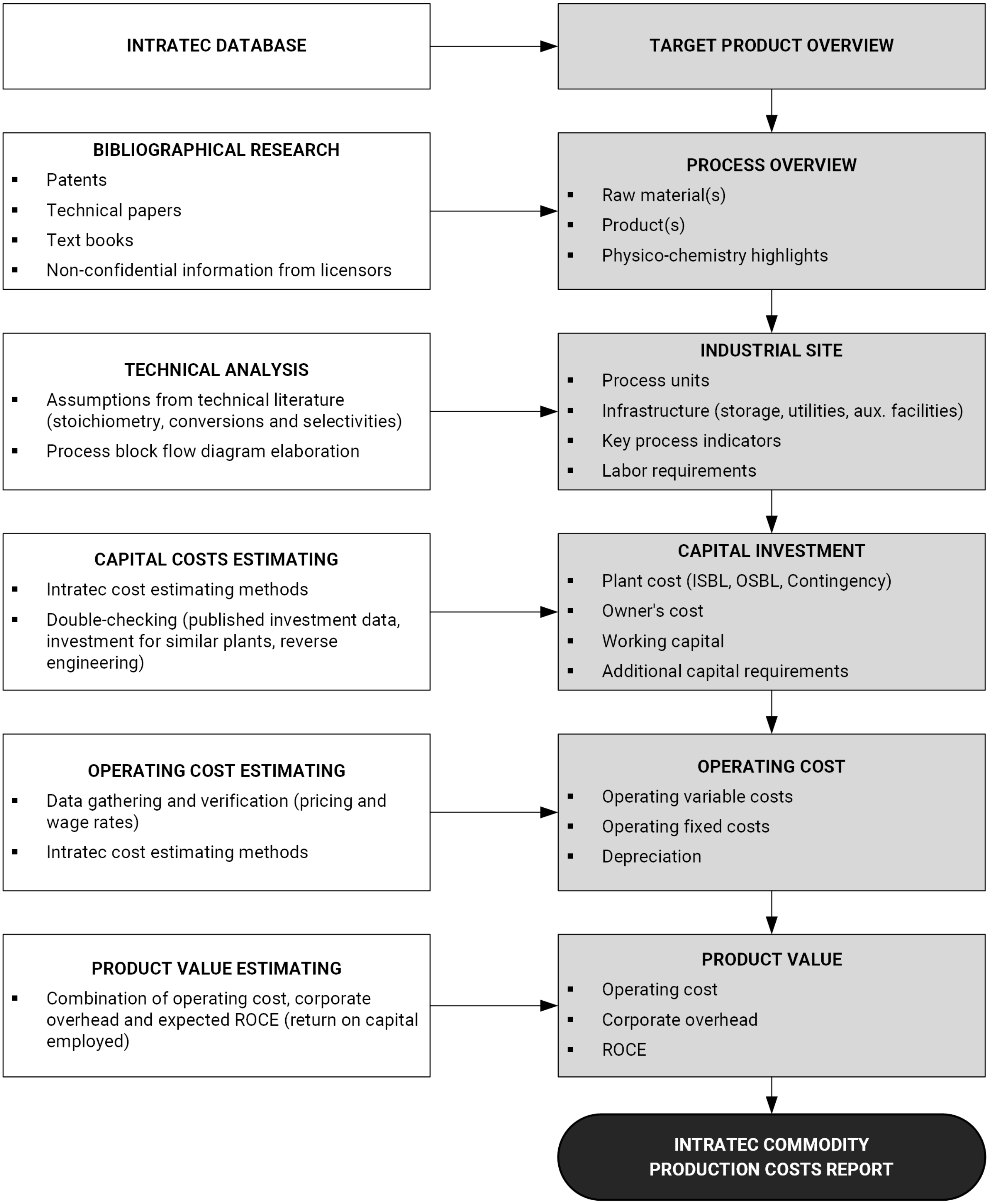

Figure 12.1 Intratec Commodity Production Costs Reports Development Methodology

Chapter 13

References

Methodology References

Intratec has built its knowledge based on the most relevant text books, encyclopedias, and technical papers related to the economic evaluation of industrial processes. Such expertise has established a large foundation that enriches all Intratec reports, in a way that the reader can expect the most trustworthy information.

The methodology references reflect this foundation of bibliographical data, used in the development of all Intratec Commodity Production Costs reports, particularly in the elaboration of the methodology employed, detailed in Chapter 12.

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Analysis References

The analysis references present the foundation of this IPDI production cost report, providing information required to fully understand the industrial process addressed and to formulate the assumptions considered. These references, presented below, may encompass patents, encyclopedias, textbooks, academic or professional researches, technical papers and any other non-confidential information publicly available, duly reviewed by Intratec's team.

[A1] XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

[A2] XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

[A3] XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

[A4] XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

[A5] XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

Appendix A

Utilities Consumption Details

This appendix details the key utilities consumption indicators of the technology examined in the report. In other words, these indicators reflect the net utilities consumption rates per metric ton of IPDI produced presented in Table A.1.

Table A.1 Net Utility Consumption Rates (per metric ton of IPDI)

Utility	Consumption per metric ton
XXXXXXXXX	XXX XXX
XXXXXXXXX	XXX XXX
XXXXXXXXX	XXX XXX
XXXXXXXXX	XXX XXX

It should be noted that estimation of utility requirements in the conceptual design phase is usually fairly accurate, but tends to be somewhat low compared to real operations. Losses from vessel vents, unscheduled equipment, inerting systems, physical property inaccuracies, startup, shutdown and other process operations not typically addressed in this phase may increase utilities consumption.

Appendix B

Material & Utilities Pricing Data - United States

This appendix presents details of the pricing data used in the economic analysis within this report.

Analysis Pricing Basis

The economic analysis presented is based on the prices seen in Table B.1.

Table B.1 Materials & Utilities Prices (United States, XXXX)

Description	Price	Unit	Remark
Raw materials			
XXX	XXX	USD/XXX	XXX
XXX	XXX	USD/XXX	XXX
Utilities			
XXX	XXX	USD/XXX	XXX
XXX	XXX	USD/XXX	XXX
XXX	XXX	USD/XXX	XXX
XXX	XXX	USD/XXX	XXX

Historical Prices

The evolution of material costs over the past three years is depicted in the following pages.

Appendix C

Capital Costs Details - United States

This appendix details IPDI plant cost, working capital, and additional capital, discussed in "*Chapter 8. Capital Costs Summary*."

Fixed Capital Cost Details

Fixed capital constitutes the fraction of the capital investment which is depreciable. It includes the IPDI plant cost and owner's cost.

Plant Cost

The IPDI plant cost, i.e., the cost related to the construction of the industrial site itself, is broken down into the components presented in Table C.1.

Table C.1 Plant Cost Estimate Accuracy Range (USD Million)

Component	Estimate	Lower Limit	Upper Limit	%
Inside battery limits (ISBL)	XXX	XXX	XXX	XX
Process contingency (XX% of ISBL)	XXX	XXX	XXX	XX
Outside battery limits (OSBL)	XXX	XXX	XXX	XX
Total process capital (TPC)	**XXX**	**XXX**	**XXX**	**XX**
Project contingency (XX% of TPC)	XXX	XXX	XXX	XX
Plant cost	**XXX**	**XXX**	**XXX**	**XX**

The lower and upper limits for the IPDI plant cost figures, according to the accuracy range expected from conceptual evaluations presented in this report, are also presented in Table C.1. The presented range is associated with a confidence level of 90%.

Figure C.1 summarizes all items that make up the plant cost.

Figure C.1 Plant Cost Summary

Further Details

For more information about the breakdowns for the IPDI plant capital cost, the reader is referred to *"Appendix F. Plant Cost Breakdowns."*

Owner's Cost

The owner's cost encompasses the expenses required to make the plant operational. Its components are presented in Table C.2.

Table C.2 Owner's Cost Details

Component	Assumption	MM USD	%
Prepaid royalties	XX% of plant cost	XXX	XX
Miscellaneous costs	XX% of plant cost	XXX	XX
Owner's cost		XXX	XX

Fixed Capital Summary

Table C.3 summarizes the fixed capital components that result in total fixed capital.

Table C.3 Fixed Capital

Component	MM USD	%
Plant cost	XXX	XX
Owner's cost	XXX	XX
Total fixed capital	XXX	XX

Further Details

For more information about each cost presented in this appendix, the reader is referred to https://intrat.ec/m?f=/icc-methodology

Working Capital Details

Working capital, i.e., the funds for getting the plant into operation and meeting subsequent obligations, is broken down in Table C.4.

Table C.4 Working Capital Details

Component	Assumption	MM USD	%
Accounts receivable	XX day(s) of total operating cost + corporate	XXX	
Accounts payable	XX day(s) of operating cash cost + corporate	XXX	
Net accounts receivable		**XXX**	**XX**
Raw materials inventory	XX day(s) of raw materials costs	XXX	XX
In-process inventory	XX day(s) of operating cash cost + corporate	XXX	XX
Products inventory	XX day(s) of total operating cost + corporate	XXX	XX
Supplies and stores	XX% of annual operating labor & maintenance costs	XXX	XX
Cash on hand	XX day(s) of operating cash cost + corporate	XXX	XX
Total working capital		**XXX**	**XX**

Additional Capital Requirements Details

Additional capital requirements are one-time expenses related to bringing a process on stream during plant start-up. Table C.5 presents the breakdown of this cost with all its components.

Table C.5 Additional Capital Requirements Details

Component	Assumption	MM USD	%
Operator training	XX day(s) of operating + supervision labor costs	XXX	XX
Commercialization costs	XX% of annual operating cash cost + corporate	XXX	XX
Start-up inefficiencies	XX% of annual operating cash cost + corporate	XXX	XX
Unschd. plant modifications	XX% of plant cost	XXX	XX
Start-up costs		**XXX**	**XX**
Land & site development	XX% of plant cost	XXX	XX
Total additional capital		**XXX**	**XX**

Appendix D

Operating Costs Details - United States

This appendix details utilities cost, operating fixed cost and depreciation, discussed in "*Chapter 9. Operating Costs*."

Utilities Cost Details

Utilities cost component encompasses costs related to a plant's consumption of steam, electricity, fuel, and refrigeration. Table D.1 summarizes net utility costs for this cost analysis.

Table D.1 Net Utilities Details

Utility	Consumption	Price	USD/mt	MM USD/yr	%
XXXXXXXXX	XXX XXX	XXX USD/XXX	XXX	XXX	XX
XXXXXXXXX	XXX XXX	XXX USD/XXX	XXX	XXX	XX
XXXXXXXXX	XXX XXX	XXX USD/XXX	XXX	XXX	XX
XXXXXXXXX	XXX XXX	XXX USD/XXX	XXX	XXX	XX
Net utility cost			XXX	XXX	XX

Further Details

For more information about how the utilities cost components were estimated, the reader is referred to https://intrat.ec/m?f=/icc-methodology.

Figure D.1 illustrates the utilities with greatest impact on the total utility consumption.

Figure D.1 Cost Distribution of Utility Consumption

Operating Fixed Costs Details

Operating costs directly tied to the plant capacity, but which do not change with the operating level. Table D.2 presents the breakdown of operating fixed cost.

Table D.2 Operating Fixed Costs Details

Component	Assumption	USD/mt	MM USD/yr	%
Operating labor	XX operator(s); XXX USD/oper./h	XXX	XXX	XX
Supervision labor	XX supervisor(s); XXX USD/oper./h	XXX	XXX	XX
Payroll charges	related to operating and supervision labor	XXX	XXX	XX
Maintenance labor	XX% of plant cost per year	XXX	XXX	XX
Maintenance materials	XX% of plant cost per year	XXX	XXX	XX
Operating supplies	XX% of maintenance costs	XXX	XXX	XX
Laboratory expenses	XX% of operating labor costs	XXX	XXX	XX
Plant overhead	XX% of operating labor and maintenance	XXX	XXX	XX
Property taxes & insurance	XX% of fixed capital per year	XXX	XXX	XX
Operating fixed costs		XXX	XXX	XX

Depreciation

In this study, the depreciation unit cost corresponds to XXX USD/mt of IPDI produced. This calculation was based on the straight-line method and a project economic life of 10 years for both the core production unit (ISBL assets) and owner's assets, and 20 years for the site infrastructure (OSBL assets).

Further Details

For more information about how operating fixed costs components and depreciation were estimated, the reader is referred to https://intrat.ec/m?f=/icc-methodology.

Appendix E

Product Value Details - United States

This appendix details corporate overhead costs and the return on capital employed, both of which make up the product value, presented in "*Chapter 10. Product Value Analysis*."

Corporate Overhead Costs Details

Corporate overhead is associated with costs incurred by a company's head office. Table E.1 presents a breakdown of corporate overhead costs.

Table E.1 Corporate Overhead Costs Details

Component	Assumption	USD/mt	MM USD/yr	%
Administration costs	XX% of operating labor and maintenance	XXX	XXX	XX
Information & technology	XX% of fixed capital	XXX	XXX	XX
Marketing & advertising	XX% of operating cash cost at full capacity	XXX	XXX	XX
Research & development	XX% of operating cash cost at full capacity	XXX	XXX	XX
Corporate overhead		XXX	XXX	XX

Return on Capital Employed (ROCE)

ROCE assumptions can vary according to the industry sector and technology readiness. For this specific process a ROCE percentage of XX% was assumed. This results in an increment of XXX USD/metric ton in the product value.

Further Details

For more information about ROCE calculation, the reader is referred to https://intrat.ec/m?f=/icc-methodology

Appendix F
Plant Cost Breakdowns

This appendix describes details of the plant cost which comprises the costs, directly or indirectly, associated with the construction of the plant itself. Therefore, different breakdowns are presented for a better understanding of the total cost associated with the construction of the plant under analysis, as follows:

* ISBL cost by functional unit. This section provides the contribution of each functional unit portrayed in the process block flow diagram in the cost of the inside battery limits (ISBL).
* OSBL cost by piece of equipment. This section provides a distribution of the investment required for the construction of the areas that comprise the site surrounding infrastructure, as well as it details the share of the costs of each component included in these areas.
* Plant cost breakdown per discipline. In this breakdown, the plant construction costs are rearranged into an alternative perspective: direct process costs, indirect process costs and project contingency.

ISBL Construction Cost Breakdown

In accordance with all the assumptions presented in this report, a cost estimate was developed for each functional unit inside battery limits (ISBL). Table F.1 shows the share of each functional unit.

Table F.1 Process Unit (ISBL) Construction Cost by Functional Unit

Description	%
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
Process Unit (ISBL) Construction Cost	

Figure F.1 presents an illustration of the construction cost breakdown.

Figure F.1 Process Unit (ISBL) Construction Cost by Functional Unit

OSBL Construction Cost Breakdown

This analysis provides a more detailed explanation of the fixed capital associated with the process described in the report. More specifically, it is focused on the investment required for the construction of the site surrounding infrastructure, also referred to as Outside Battery Limits (OSBL), comprising support buildings, auxiliary units used for providing and distributing utilities and storage facilities. In accordance with the configuration previously presented, a cost estimate was developed for each facility outside battery limits.

Figure F.2 presents OSBL investment broken down into each area. The investment estimated for each area will be further detailed in the next topics.

Figure F.2 Site Infrastructure (OSBL) Construction Cost by Area

Construction Cost: Area 90 - Storage Installations

This section details the cost estimate associated with Area 90 - Storage Installations. The components included in the estimate are detailed in the table below.

Table F.2 Area 90 - Storage Installations: Scope Description

Component	Description
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX

The following chart illustrates how each component impacts the construction cost estimate for this area.

Figure F.3 Storage Installations Construction Cost per Piece of Equipment

The cost of each component was based on the following assumptions:

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

Construction Cost: Area 91 - Utilities Facilities

This section details the cost estimate associated with Area 91 - Utilities Facilities. The components included in the estimate are detailed in the table below.

Table F.3 Area 91 - Utilities Facilities: Scope Description

Component	Description
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX

The following chart illustrates how each component impacts the construction cost estimate for this area.

Figure F.4 Utilities Facilities Construction Cost per Piece of Equipment

The percentage associated with the remaining facilities is divided as follows:

* XXXXXXXXX - XX %
* XXXXXXXXX - XX %

The cost of each component was based on the following assumptions:

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

Construction Cost: Area 92 - Support & Auxiliary Buildings

This section details the cost estimate associated with Area 92 - Support & Auxiliary Buildings. The components included in the estimate are detailed in the table below.

Table F.4 Area 92 - Support & Auxiliary Buildings: Scope Description

Component	Description
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX
XXXXXXXXX	XXXXXXXXX

The following chart illustrates how each component impacts the construction cost estimate for this area.

Figure F.5 Support & Auxiliary Buildings Construction Cost per Piece of Equipment

The percentage associated with the remaining facilities is divided as follows:

* XXXXXXXXX - XX%
* XXXXXXXXX - XX%

The cost of each component was based on the following assumptions:

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

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XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX

Site Infrastructure Cost Summary

Table F.5 Site Infrastructure (OSBL) Construction Cost by Piece of Equipment

Component	% of Total
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
Area 90 - Storage Installations	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
Area 91 - Utilities Facilities	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
XXXXXXXXX	XX
Area 92 - Support & Auxiliary Buildings	XX
Site Infrastructure (OSBL) Construction Cost	100.0

Plant Cost Breakdown per Discipline

Introduction

The primary objective of this analysis is to provide an alternative perspective on the plant capital cost. This analysis presents the plant capital cost divided in three categories: (1) direct costs (all material and labor costs associated with the process equipment); (2) indirect costs (defined by the Association for the Advancement of Cost Engineering (AACE) Standard Terminology as those "costs which do not become a final part of the installation, but which are required for the orderly completion of the installation"); and (3) contingency.

It is important to highlight that the breakdown presented within this analysis refers exclusively to the Plant Cost figure included in the report.

The composition of direct field costs and indirect costs are further detailed in the next topics. Other fixed capital components, such as Owner's Cost, are not included in this breakdown.

The following chart presents the plant cost divided in each category described above.

Figure F.6 Plant Construction Cost Summary

Direct Costs Breakdown

Fundamentally, the direct process costs are the total installed equipment cost (from purchase to installation, including the required installation bulks). They include the following disciplines: bare equipment, equipment setting, piping, civil, steel, instrumentation & control, electrical, insulation, and painting.

Accordingly, the chart below presents the direct costs broken down by aforementioned discipline.

Figure F.7 Direct Construction Costs by Discipline

Indirect Costs Breakdown

The indirect costs account for field indirects, engineering costs, overhead, and contract fees.

Accordingly, the chart below presents the indirect costs broken down by aforementioned items.

Figure F.8 Indirect Costs Summary

Plant Cost Breakdown Summary

The next table presents the detailed plant cost breakdown, based on the direct and indirect costs approach. Two alternative views are presented in the table:

(1) % of BEQ. Each component is presented as a percentage of the bare equipment (BEQ) cost;

(2) % of Total. Each component is presented as a percentage of total plant cost.

Table F.6 Plant Construction Cost by Discipline

Component	% of BEQ	% of Total
Bare equipment (BEQ)	XX	XX
Equipment setting	XX	XX
Piping	XX	XX
Civil	XX	XX
Steel	XX	XX
Instrumentation & control	XX	XX
Electrical	XX	XX
Insulation	XX	XX
Painting	XX	XX
Direct costs	**XX**	**XX**
Engineering & procurement	XX	XX
Construction material & indirects	XX	XX
General & administrative overheads	XX	XX
Contract fee	XX	XX
Indirect costs	**XX**	**XX**
Total Process Capital (TPC)	**XX**	**XX**
Project Contingency (of TPC)	XX	XX
Total Plant Cost	**XX**	**XX**

The absolute cost of the plant is presented in the table *"Plant Cost Summary"* in *"Chapter 8. Capital Costs Summary."* It is worth noting that the process contingency presented in the aforementioned table is included within each component listed in the table above.

Further Details

For further information about the components included in the plant cost breakdown, the reader is referred to https://intrat.ec/m?f=/icc-methodology.

Appendix G

Plant Capacity Assessment - United States

This assessment presents the impact of a plant capacity change on the economic analysis presented in this report. Additional capacity scenarios were analyzed using the same methodology and compared to the base case presented in the report.

The assessment is divided into two parts: (1) a capital investment comparison, examining fixed investment, working capital and additional capital requirements; and (2) an operating costs & product value comparison.

Capital Cost for Different Capacities

The economic analysis presented was reproduced for a range of plant capacities in order to estimate a curve that illustrates how capital investment varies with nominal plant output. This curve is presented in Figure G.1.

The minimum, mid-range and maximum capacities from Figure G.1 are compared in detail in Table G.1, which presents detailed capital cost figures to better portray how economy of scale impacts the process under analysis.

Table G.1 Capital Investment Analysis for Different Capacities (USD Million)

	Smaller Plant	Base	Larger Plant
Capacity (mt/yr)	XXX	XXX XXX	XXX
Inside battery limits (ISBL)	XXX	XXX	XXX
Process contingency (XX% of ISBL)	XXX	XXX	XXX
Outside battery limits (OSBL)	XXX	XXX	XXX
Total process capital (TPC)	XXX	XXX	XXX
Project contingency (XX% of TPC)	XXX	XXX	XXX
Plant cost	XXX	XXX	XXX
Owner's cost	XXX	XXX	XXX
Fixed capital	XXX	XXX	XXX
Working capital	XXX	XXX	XXX
Additional capital	XXX	XXX	XXX
Total capital investment	XXX	XXX	XXX

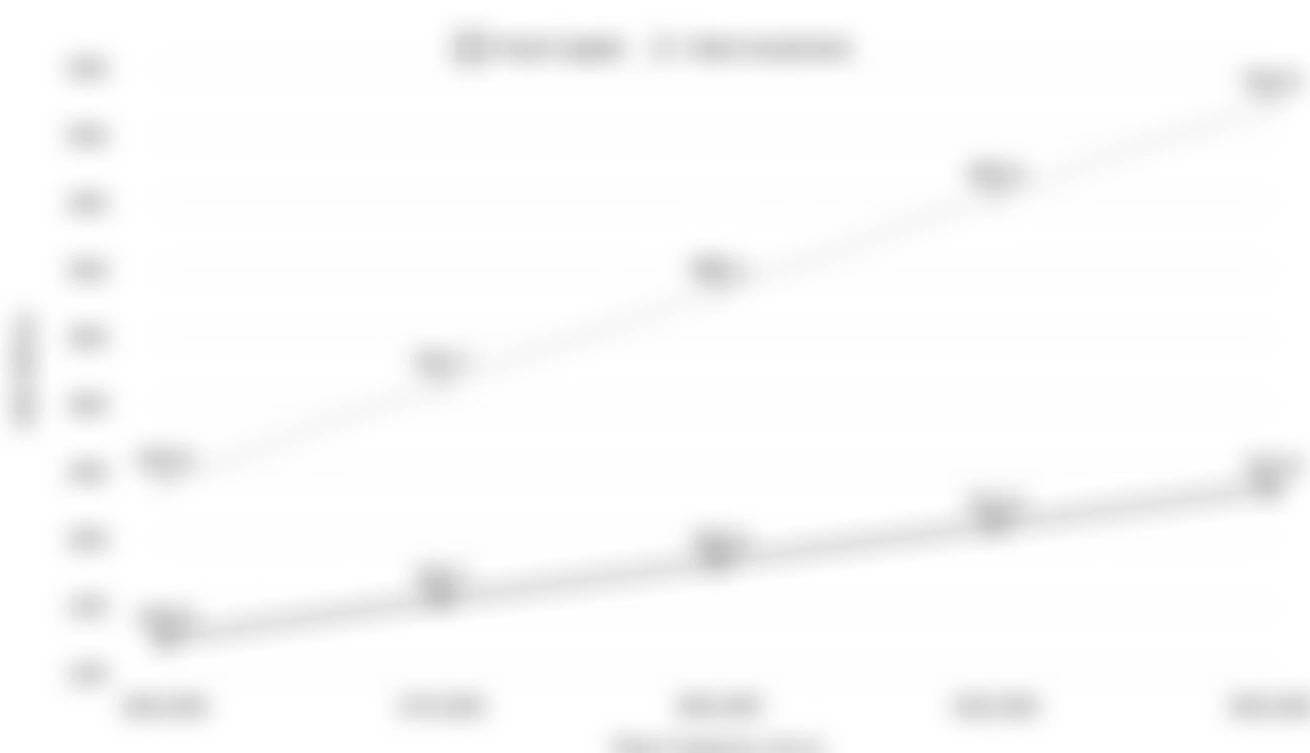

Figure G.1 Capital Investment Versus Plant Capacity

Operating Cost for Different Capacities

The operating costs and the product value were also estimated for a range of plant capacities, resulting in Figure G.2.

A datasheet summarizing the process economics is reproduced in Table G.2, and it includes two additional scenarios evaluated in this assessment.

Figure G.2 Operating Cost Versus Plant Capacity

Table G.2 Operating Cost & Product Value Analysis for Different Capacities (USD/mt)

	Smaller Plant	Base	Larger Plant
Capacity (mt/yr)	XXX	XXX XXX	XXX
Operating rate (h/yr)	XXX	XXX	XXX
Annual production (mt/yr)	XXX	XXX	XXX
Operating costs			
XXXXXXXXX	XXX	XXX	XXX
XXXXXXXXX	XXX	XXX	XXX
Gross raw materials cost	XXX	XXX	XXX
Net raw materials cost	XXX	XXX	XXX
Net utilities cost	XXX	XXX	XXX
Operating variable costs	XXX	XXX	XXX
Operating fixed costs	XXX	XXX	XXX
Operating cash cost	XXX	XXX	XXX
Depreciation	XXX	XXX	XXX
Total operating cost	XXX	XXX	XXX
Corporate overhead	XXX	XXX	XXX
ROCE	XXX	XXX	XXX
Product value	XXX	XXX	XXX

Appendix H

Project Implementation & Construction Schedule

This appendix aims to present a preliminary project implementation schedule, encompassing the period from the decision to invest to the start of commercial production.

This is divided into five major steps:

(1) Basic engineering;

(2) Detailed engineering;

(3) Procurement;

(4) Construction; and

(5) Start-up.

The duration of each project phase is detailed in Table H.1.

Table H.1 Project Phases Schedule

	Phase Start	Duration
	Months after project started	Months
Basic engineering	XX	XX
Detailed engineering	XX	XX
Procurement	XX	XX
Construction	XX	XX
Commissioning & start-up	XX	XX

Since the project phases overlap, the total project duration is not equal to the sum of each phase duration. The Engineering, Procurement & Construction (EPC) period - from the basic engineering start until the end of construction - is about **XX months**. The total project duration, also including commissioning and start-up, is approximately **XX months**.

Figure H.1 illustrates the project implementation and construction schedule and clarifies the overlaps among the distinct project phases.

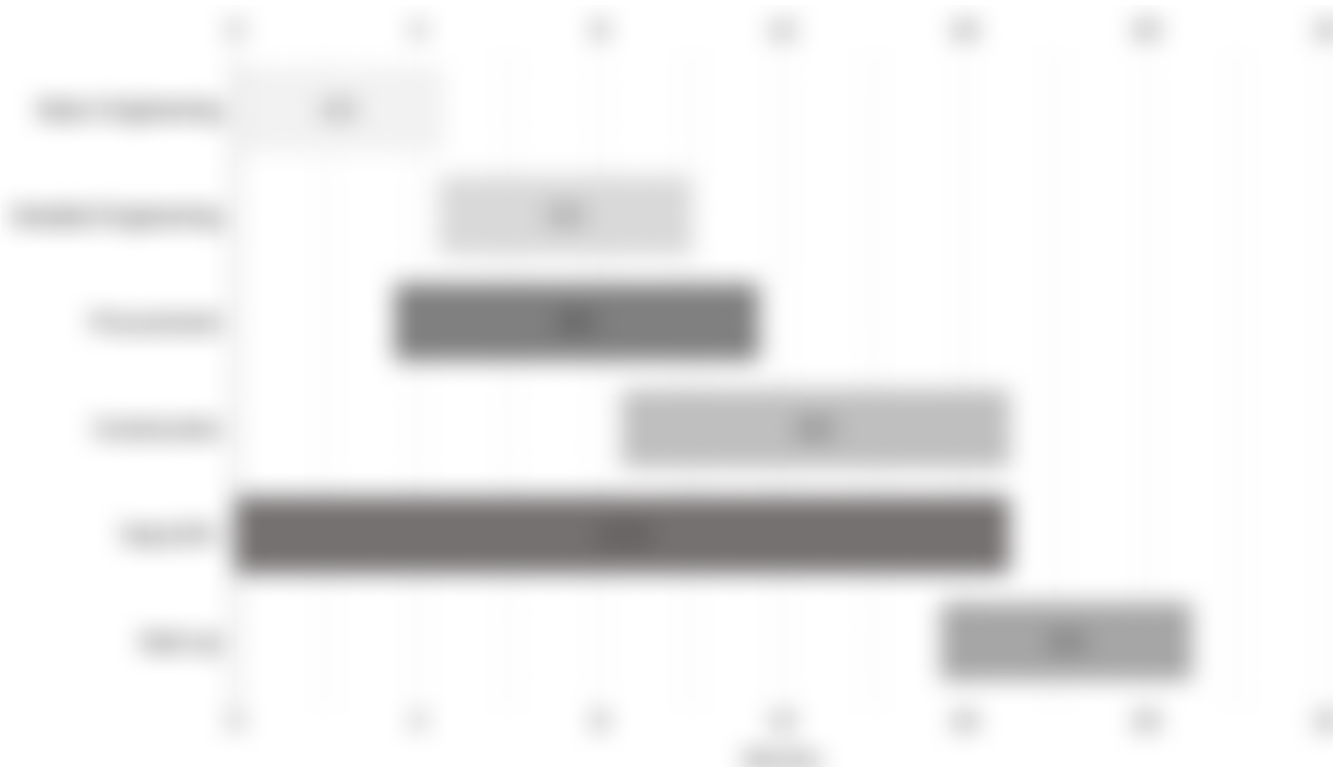

Figure H.1 Implementation & Construction Schedule

Appendix I

Process Flow Diagrams & Equipment List

This chapter comprises a schematic representation of relevant operations of the process examined in this report. It indicates process operations, main process streams, main pieces of equipment and utilities consumed.

For better comprehension, the main conventions for equipment tags and symbols for lines used in the process flow diagram are listed in Figure I.1 and Figure I.2.

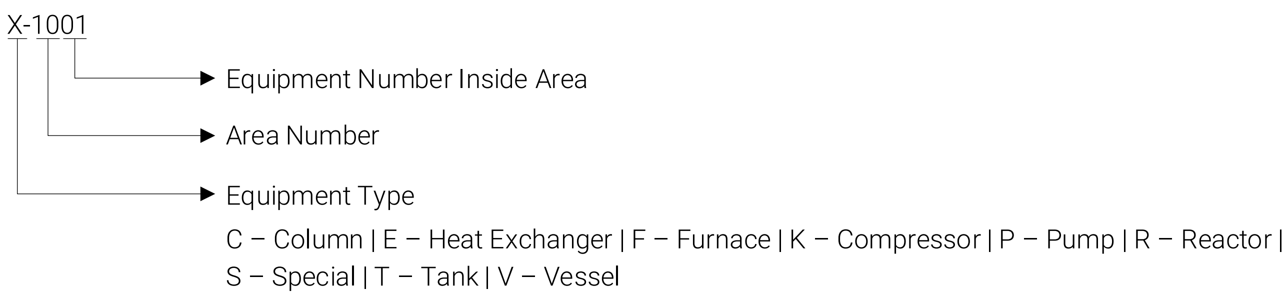

Figure I.1 **Convention for Process Equipment Tags**

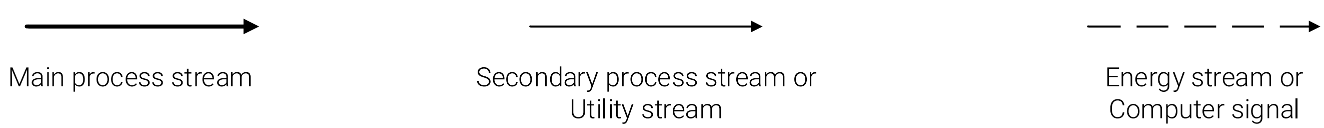

Figure I.2 **Symbols for Lines**

Table I.1 and Table I.2 present the different codes used along with their definitions.

Table I.1 Diagram Legend - Utilities

Code	Definition
BFW	Boiler feed water
CW	Cooling water
DW	Demineralized water
FU	Fuel
HTF	Heat transfer fluid
N2	Nitrogen
O2	Oxygen
PC	Process condensate
PW	Process water
RF	Refrigerant
RW	Refrigerated water
ST	Steam

Table I.2 Diagram Legend - Equipment Type

Code	Definition
C	Column
E	Heat exchanger
F	Furnace
K	Compressor
P	Pump
R	Reactor
S	Special
T	Tank
V	Vessel

Furthermore, most of the symbol standards adopted in the development of the diagram are presented in the next figures.

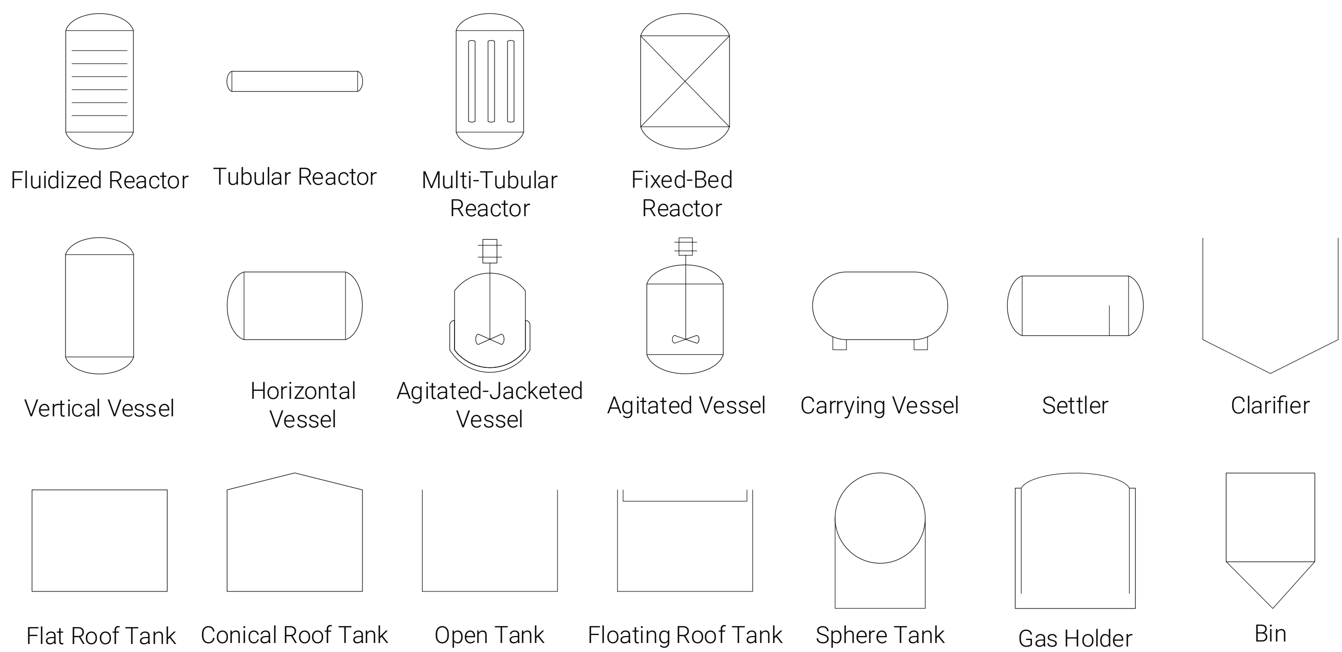

Figure I.3 Equipment Symbols - Reactors & Vessels

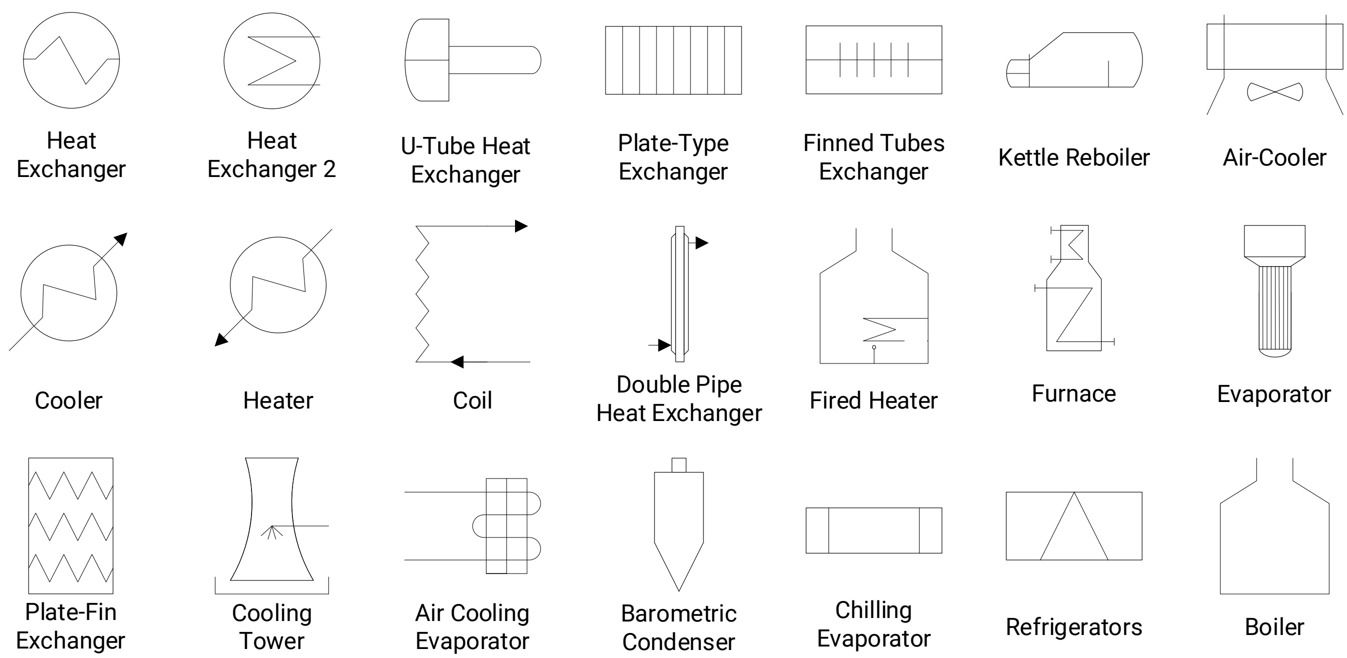

Figure I.4 Equipment Symbols - Heat Exchangers

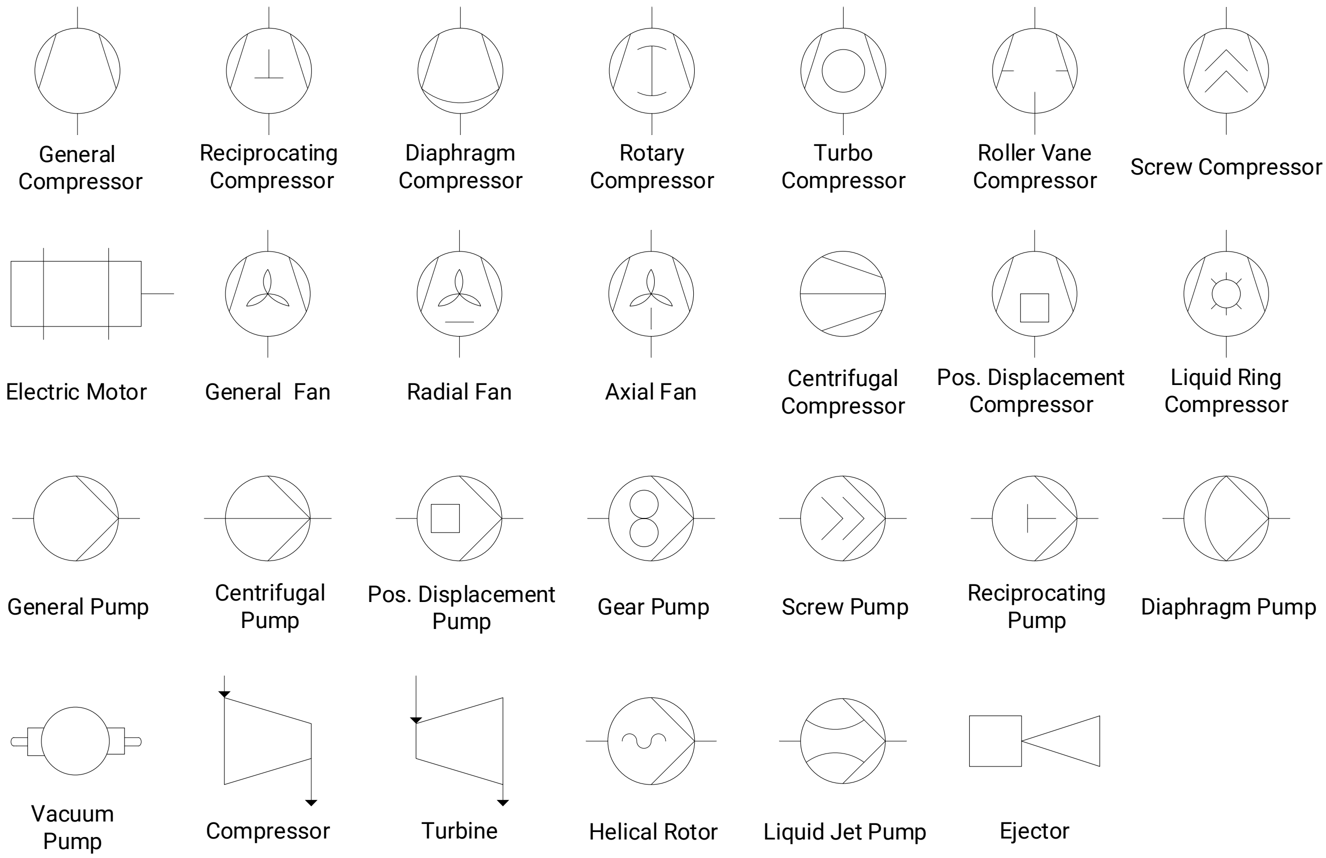

Figure I.5 Equipment Symbols - Compressors & Pumps

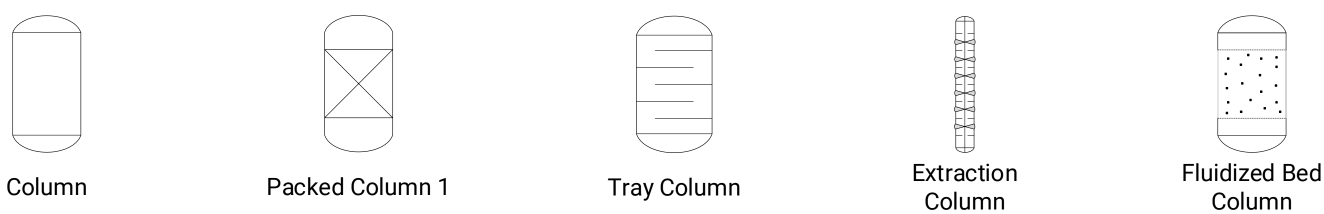

Figure I.6 Equipment Symbols - Columns

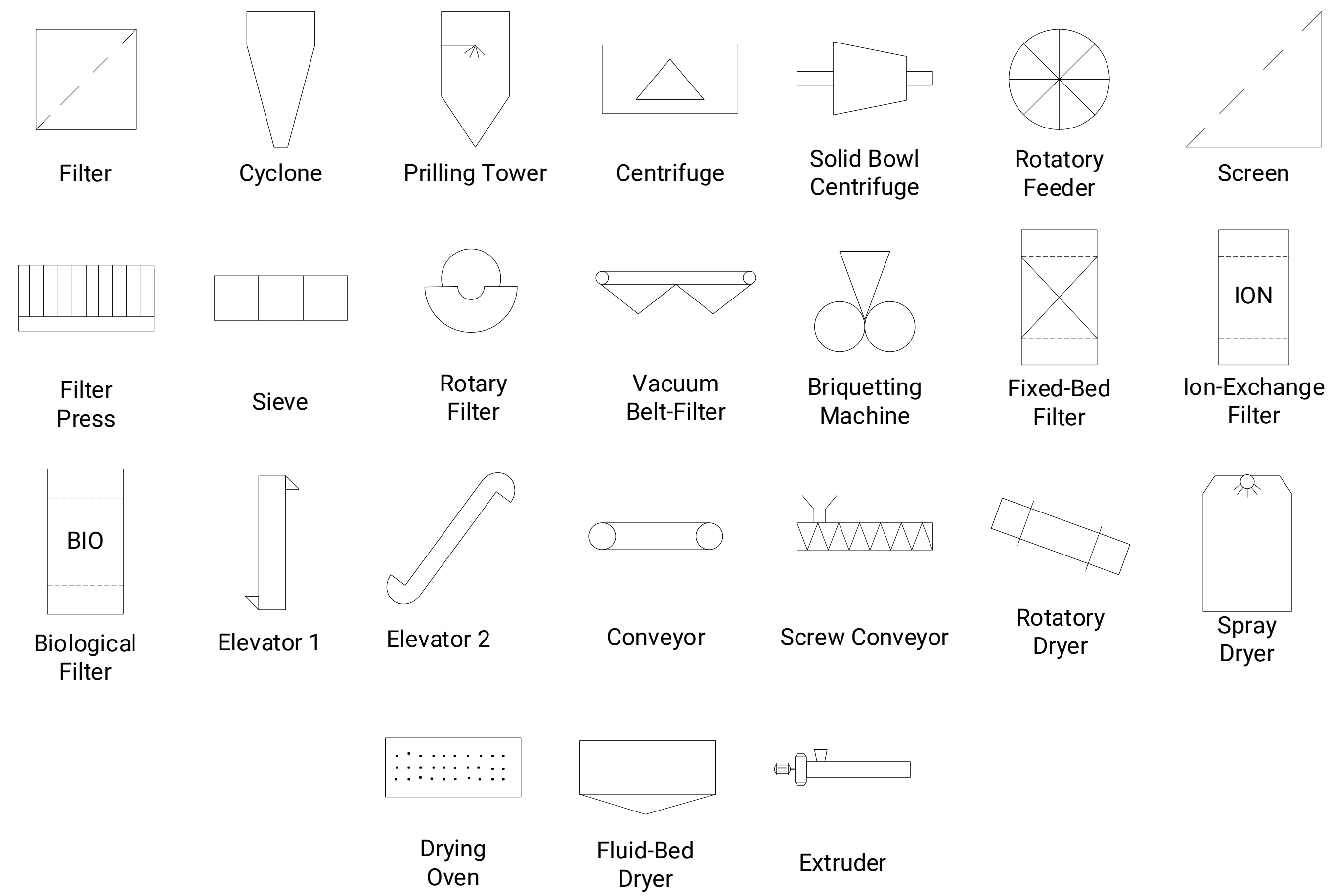

Figure I.7 Equipment Symbols - Solids Processing

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Appendix J

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With well-designed offerings, we serve a diverse group of customers, from Fortune 500 companies and local manufacturers to biotech startups and consultants. Our studies and data have been used in multiple ways, such as:

* To evaluate transaction prices in international markets
* To identify monthly/yearly price trends
* To assess procurement planning performance
* To obtain estimates of capital and operating costs of industrial plants
* To learn about the economic potential of R&D breakthroughs

* To screen and assess industrial investment options

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Our reports detail technologies within a wide range of maturity, from established processes to embryonic/emerging technologies. Also, our reports examine a variety of manufacturing techniques, targeting transformation processes (e.g., nitrile gloves production), processes for fabric and fibers production (e.g., nonwoven, carbon fiber), polymerization processes (e.g., PP, PE, PVC), electrolytic processes (e.g., chlorine, caustic soda), fossil-based/petrochemical processes (e.g., propylene, ethylene), processes for the production of green chemicals from renewable sources (e.g., bioethanol, bio-based succinic acid) and others. Our Reports Library can be found at:

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Intratec Plant Construction Cost Indexes (IC Indexes) are multipliers designed to adjust industrial plant construction costs over time. Unlike other indexes limited to the USA, IC Indexes allow for the updating of construction costs in up to 33 countries, making them suitable for industrial processing plants across various sectors. These indexes offer a monthly series measuring changes in capital expenditure (capex) for building industrial plants, providing an efficient method to instantly adjust past construction cost data to reflect current costs.

* Intratec Plant Location Factors

Intratec Plant Location Factors (IL Factors) are multipliers designed to convert industrial plant construction costs from one country to another. These factors allow for the estimation of capital expenditure (capex) by applying a straightforward calculation: simply multiply the known plant construction cost from a reference country by the corresponding location factor. Suitable for industrial processing plants across various sectors, the IL Factors cover 33 key countries, providing an efficient method for adjusting plant construction costs between different geographical locations.

The reader can check more information about Intratec Industry Economics Worldwide and subscribe online at:

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Appendix K

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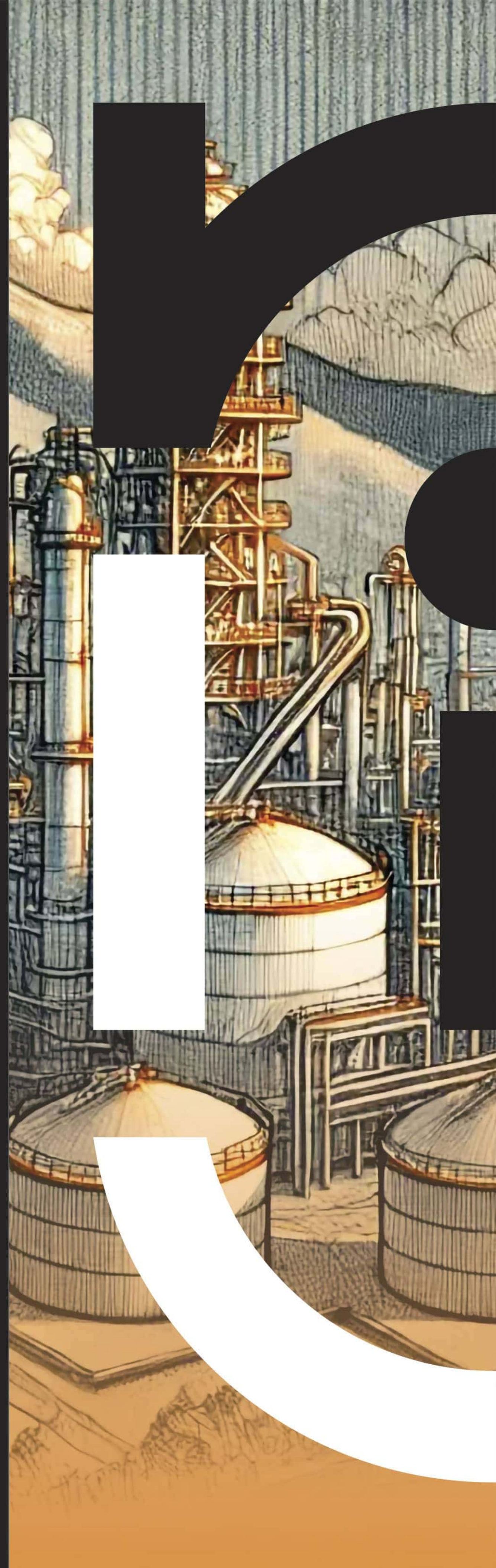

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