PRODUCT RANGE AND THE COMPETITIVE POSITIONING OF POLYETHYLENE PRODUCTION TECHNOLOGIES

By

Ken Sinclair, Principal Consultant, EnerChemTek, Inc., Lacey, WA
Mauricio Dávila, Managing Director, EnerChemTek, Inc., Toronto, Canada

Introduction

Modern polyethylene production processes have been scaled to enormous capacities of about 420 to 650 kilotons per year per line and, all things being equal, they are all closely cost competitive. The cost of PE production determines the baseline competitive position of every PE producer and it is common practice to assess these costs based on two factors: nameplate capacity and process employed. However, there is a third and very important dimension to costs that is seldom considered: the specific PE grades that the plant actually produces, and without this third dimension cost comparisons can be very misleading.

Depending on the specific process used in a plant, its production rates in tons per hour can vary by as much as 25-30% from one grade of PE to another *in the same plant*. It is therefore essential to relate baseline economics of each production line to the product grades produced. Bearing in mind that each production line may make about 3 to 30 different grades and that many plants comprise multiple production lines, a meaningful analysis of the cost positions of all suppliers to a regional PE market can be very complex. This paper describes this complexity and a new and powerful tool to deal with it, generating fine-grained analyses of PE competitors and process technologies that include all three dimensions of production costs.

Competition In Polyethylene Markets

The PE market in any specific region is always in a state of pseudo-equilibrium, with the demand for each specific grade of PE being balanced by supply from the PE producers that offer that grade. The supply/demand balance is a multi-element matrix of supply by plant or production line against demand by PE grade, as illustrated in the following figure.

Figure 1 - Conceptual Supply/Demand Matrix in a Regional Linear PE Market

PE Demand by Grade / PE Supply by Plant		Resin Class Application Grade Density, kg/m3 Melt Flow, dg/min:	HDPE Blow Mld HIC 948-964 0.15-0.6	HDPE Blow Mld IBC 944-954 7F-10F	• • • • •	HDPE Injection Crates 954-964 8-10	• • • • •	LLDPE Film C6 918-920 0.5-1.2	• • • • •	Total Linear PE Supply Kilotons
		Capacity kta	Market Share Distribution							
Polyolefin Producer I										
Line A	Gas Phase Fluid Bed	250	---	XXX	•	XX	•	---	•	225
Line B	Gas Phase Fluid Bed	400	---	---	•	---	•	XXXX	•	365
Line C	Slurry Loop Bimodal Cascade	235	XXXX	XX	•	---	•	---	•	220
•	•	•	•	•		•		•		•
•	•	•	•	•		•		•		•
•	•	•	•	•		•		•		•
Polyolefin Producer N										
Line A	Gas Phase Fluid Bed	350	XXXX	---	•	XX	•	X	•	315
Line B	Solution - Cooled Loop Reactor Cascade	300	---	---	•	XXXX	•	XXXXX	•	280
Line C	Slurry Loop Bimodal Cascade	450	---	XXX	•	XXX	•	---	•	440
Line D	Slurry Stirred Tank - Hexane Diluent	200	X	XXXX	•	XX	•	---	•	180
		10,000								
	Total Linear PE Demand, Kilotons		1,550	400	•	635	•	2,000	•	9,200

Source: EnerChemTek

On average, the supply/demand matrix in a regional market is in equilibrium, with the sum of demand for each grade equal to the sum of sales by each producer of that grade, and with the total sales from each production line across each's entire product portfolio being at a level that the owner considers to be consistent with the overall supply/demand environment. The equilibrium is unstable, however, for two reasons: producers are never satisfied with their market shares nor their total sales revenues, and customers are continually being enticed to switch suppliers of each grade they buy with offers of higher quality, performance, service or price.

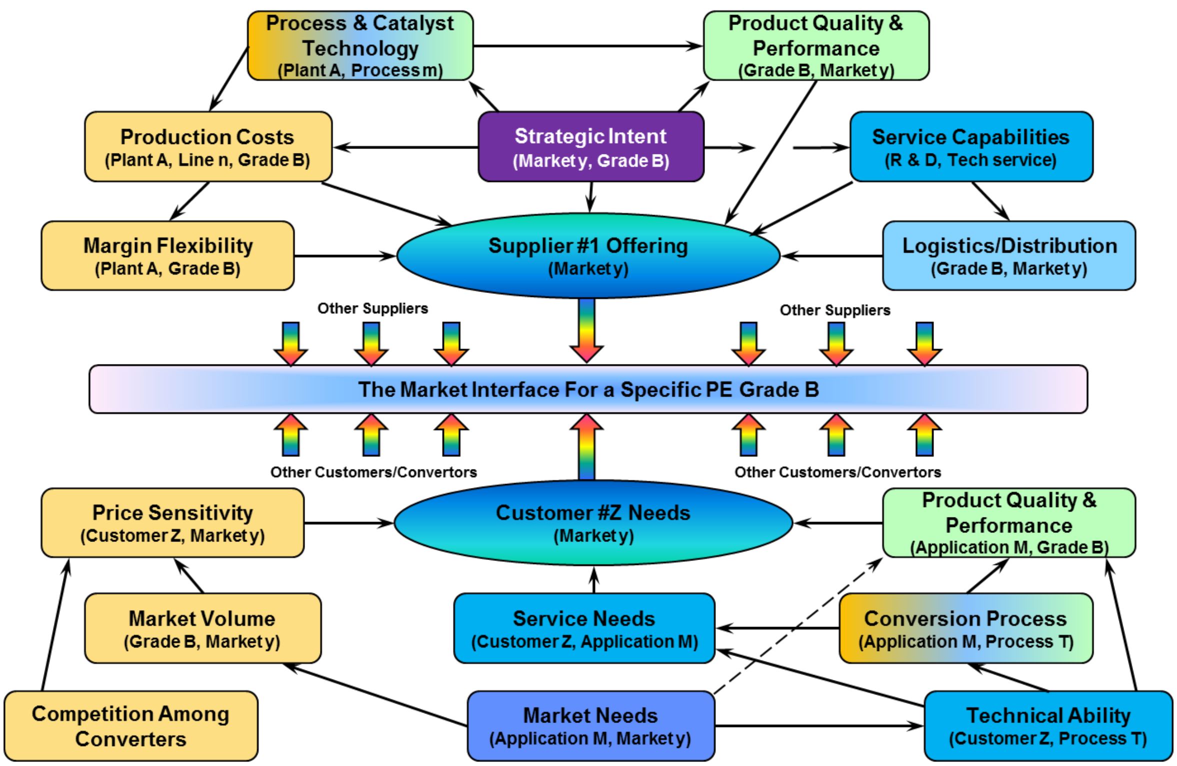
In other words, each producer attempts to improve market share for those grades that offer better opportunities for his plants or that are otherwise of strategic importance to him. Producers may introduce upgraded resins or provide better services to make their offerings of some grades better than they were in the past. Other producers may debottleneck plants or bring on line new PE capacity and will aim to sell the increased output in markets that match the new plant's capabilities. The net result is that market shares are continually shifting like an enormous game of "whack-a-mole," with gains of one producer matched by losses of competitors, who then increase their own shares in other markets where they have better competitive strengths.

Obviously, this shuffling of market shares is not random. Each producer has a set of plants with specific capabilities to excel in supply of some grades more than others, and each producer has marketing strategies to exploit these strengths of his plants in achieving the best overall result for the business, hopefully with improved sales volume & improved profitability. The restraints on his strategies are the strengths of his competitors: one supplier's gain is another's loss since the total value of the market is fixed by total volumes & prices. For this reason, every competitor in PE supply must regularly undertake assessments of competitor positions in markets for each grade or type of PE.

Structure of Competitive Interactions

There are many factors that define the structure of competition in markets for each grade of PE (see Figure 2 below.) The product/price/service offering of each producer is matched to the needs of the market as seen through the eyes of resin converters: their sensitivities to price and supplier responsiveness, requirements for product quality & performance, and their needs for technical and other services. The match between supplier offerings and customer needs is the ultimate determinant of the success of the strategic intent of each competing supplier, on a grade-by-grade basis.

Figure 2 – Structure of Competition In Polyethylene Markets



Source: EnerChemTek

In developing his strategies, a PE producer looks at the needs of customers for each grade. The intended conversion process for a grade and the product quality & performance required will generally determine which technologies the producer can use to meet these needs: each production process/catalyst combination has specific product quality capabilities that vary from grade to grade and between technologies. Customer price sensitivity will influence the producer's selection of the optimal production line to make the grade: high price sensitivity requires the lowest possible production costs for the grade, implying the use of perhaps the largest and newest production line that has the required process/catalyst/product capabilities. Overall, service and other "soft" aspects aside, the producer's strengths in supply of a grade depend on the plants and technologies he has to make the grade. His relative competitive strength depends on how these same aspects compare to those of his competitors. Analysis of production cost by grade is necessarily an important element in strategy development.

Capacity to Produce

The capacity of a PE producer's plants and those of his competitors are obviously important factors to consider in strategy development and competitor analysis. A simple listing of plants and annual capacities is a useful starting point but can lead to significant distortions in assessing the actual capacity to produce PE. This is because the rate at which a plant can make PE usually varies from one grade to another: some grades are "slow" and incur relatively high fixed cost allocations per ton produced while other grades are "fast" for which fixed cost contributions can be minimized. For example, a specific plant may be designed to make a specific Grade A at a rate of, say, 300 kilotons per year or about 37 tons per hour, but the same plant, without any modifications, may be able to make 400 kilotons per year of Grade B, or about 50 tons per hour. Such a variation can lead to serious misjudgment of the cost-competitive position of the plant depending on the assumed basis for the definition of the plant's listed capacity.

In general, publicly listed capacities of PE plants are the expected averages of production at full output with the planned product portfolio over one year. They are the volume weighted averages of all the fast and slow grades that the producer hopes to sell in the coming year and as such are merely estimates based on the market strategies of the specific plant owners. If the market strategy or product portfolio changes, the capacity of the plant to make PE will change, in line with the new strategy.

As we have seen, assessment of production economics on a grade by grade basis is necessary for fine grained strategy development. Costs vary with plant throughput, so costs by grade depend on throughput by grade. Plant capacity to produce depends on what grades are being produced. Thus, we come back to the competitive matrix illustrated in Figure 1: to analyze the cost structure of the matrix we need to know not only the sales portfolio from each production line, but also the production rates for each grade from each line. In our example above, we need to know how much of Grade A is being produced and how much of Grade B. If the split is 50/50, the overall capacity to produce will be 350 kta. A 30/70 split will yield 370 kta and an 80/20 split 320 kta. So whatever the listed capacity of a plant, we need to know what product portfolio this capacity relates to as the starting point for competitor analysis and strategy development.

Of course there are also variable cost differences between grades that depend on product compositions and process configurations. For example, co-polymers such as LLDPE or plastomers cost more to make because they contain higher levels of expensive co-monomer than high density grades or homo-polymers: co-monomer content may range up to 30 wt.% or more for some grades. Other grades may demand higher utility consumptions – more electricity or steam per ton of PE produced – or higher catalyst system costs per ton. All these possible variations underpin the need for grade-by-grade cost analysis.

Technology Selection for New Plants

Part of strategy development for existing PE producers, and prospective new producers, is the assessment of potential for new plant additions. Part of this assessment is an analysis of production economics. From the above, it is clear that, in terms of production economics, there is a built-in potential for errors of the order of 25% to 30% when selecting the process technology to be used in a new PE plant. The lowest cost grade from one process will often be different from the lowest cost grade made by another process, so direct cost comparisons could be invalid if they are based only on the lowest-cost grade.

The best route to selection of the optimal technology is to compare economics for viable product portfolios from each process, with each portfolio designed to match targeted market needs. Viable portfolios from a slurry process will likely be different from portfolios designed for solution processes or gas phase processes, but in every case the portfolio will match market needs. Such an analysis requires more attention to detailed costs for each grade in each portfolio, but the end result is a better and well-founded process technology decision that could mean $ millions in higher profitability over the life of the plant.

The Proliferation of Process Technologies

Over the 83 years since PE was discovered, a range of modern, low-cost processes for PE have evolved which are now all closely competitive. This evolution has incorporated ingenious mechanical and chemical engineering designs that have opened up new fields of knowledge in chemical technology: large scale equipment designed for continuous operation at pressures of up to 3,400 bars, the loop-reactor slurry-phase polymerization system, gas-phase fluidized-bed polymerization technology, and many more. Innovators have continuously refined production processes to reduce investments and improve operating efficiency, developing scores of technology variations for PE production.

Take, for example, high pressure free radical initiated processes for production of LDPE. These were the first PE technologies to be commercialized in the late 1930s and early 1940s. The first decade of commercial development seems to have been a rather haphazard boot-strap phase, but by the early 1950s the first generation of efficient, continuous LDPE processes had been developed. These were then made available for license in two basic configurations: autoclave reactor and tubular reactor configurations. High pressure plants worldwide are still listed as either autoclave reactor plants or tubular reactor plants. Things are not quite so simple, however, since many companies have introduced proprietary versions of these technologies that are in some way different from the rest of the pack. This broad range of variations is illustrated in Table 1.

Table 1 – Variations in High Pressure LDPE Technologies In Commercial Operation

	High Pressure Processes	
Braskem	Braskem Atochem	High Pressure - Tubular Reactor
	Braskem Dual Autoclave	High Pressure - Autoclave Reactor Cascade
Dow	Dow	High Pressure - Autoclave Reactor
	Dow	High Pressure - Autoclave/Tubular Cascade
	Dow	High Pressure - Tubular Reactor
	Dow	High Pressure - Tubular Reactor - Split Recycle
	Dow Leuna/Polymir	High Pressure - Tubular Reactor
	Dow Union Carbide	High Pressure - Tubular Reactor
	Dow/Imhausen	High Pressure - Tubular Reactor - Multi Feed
DuPont	DuPont	High Pressure - Autoclave - Fully Backmixed
	DuPont	High Pressure - Autoclave Reactor Cascade
ExxonMobil	ExxonMobil	High Pressure - Autoclave Reactor
	ExxonMobil	High Pressure - Tubular Reactor - Multi Feed
	ExxonMobil/Mitsubishi	High Pressure - Autoclave Reactor - Metallocene
	Retrofit	High Pressure - Autoclave Reactor - Tubular Tail
Japan PE	Mitsubishi	High Pressure - Tubular Reactor - Multi Feed
LyondellBasell	Equistar Tube	High Pressure - Tubular Reactor
	Lupotech A	High Pressure - Autoclave Reactor
	Lupotech T	High Pressure - Tubular Reactor - Front Feed
SABIC	SABTEC CTR	High Pressure - Tubular Reactor - Clean Tube
Simon Carves	ICI/Simon Carves	High Pressure - Autoclave Reactor
Sumitomo	Sumitomo	High Pressure - Autoclave Reactor
	Sumitomo	High Pressure - High Conversion Autoclave Cascade
	Sumitomo	High Pressure - Tubular Reactor
Versalis	Versalis ANIC	High Pressure - Tubular Reactor
	Versalis CdF	High Pressure - Autoclave Reactor
	Versalis CdF	High Pressure - Autoclave Reactor - Ziegler
Various/Proprietary	Arkema Atochem	High Pressure - Tubular Reactor
	Atochem	High Pressure - Tubular Reactor
	Borealis Union Carbide	High Pressure - Tubular Reactor
	CP Chem Gulf	High Pressure - Autoclave Reactor
	Imhausen	High Pressure - Tubular Reactor - Multi Feed
	Polymir	High Pressure - Tubular Reactor
	Uhde Ruhrchemie	High Pressure - Tubular Reactor

Source: EnerChemTek

In addition to these 34 variations, plants of any one variation may differ among themselves in terms of copolymer production capability.

The situation with low pressure linear PE technologies is similar, with multiple variations in configuration having been developed within each of the three primary groupings: gas phase, solution phase and slurry phase. This is illustrated in the following Tables 2, 3 & 4.

Table 2 – Gas Phase Linear PE Processes In Commercial Operation

Gas Phase Processes			
Borealis	Borstar	Supercritical Slurry/Gas Phase Fluid Bed	Bimodal
	Borstar 2G	Supercritical Slurry/Gas Phase Fluid Bed	Multimodal
	Borstar 3G	Supercritical Slurry/Gas Phase Fluid Bed	Multimodal
Ineos Technologies	Innovene G	Gas Phase - Fluid Bed	Dry
	Innovene G EHP	Gas Phase - Fluid Bed	Supercondensed
LyondellBasell	Hyperzone	Gas Phase - Fluid Bed/MZCR	Multimodal
	Spherilene C	Gas Phase - Fluid Bed	Bimodal
	Spherilene S/Lupotech G	Gas Phase - Fluid Bed	Dry/Condensed
Mitsui	Evolue	Gas Phase - Fluid Bed	Bimodal
Univation	Unipol	Gas Phase - Fluid Bed	Dry
	Unipol	Gas Phase - Fluid Bed	Condensed
	Unipol	Gas Phase - Fluid Bed	Supercondensed
	Unipol II	Gas Phase - Fluid Bed	Bimodal
	Unipol Prodigy	Gas Phase - Fluid Bed	Bimodal
Various/Proprietary	Getech GMZ	Gas Phase - Fluid Bed	
	Nova	Gas Phase - Fluid Bed	
	SABIC	Gas Phase - Fluid Bed	Supercondensed
	Sinopec	Gas Phase - Fluid Bed	Condensed
	Sumitomo	Gas Phase - Fluid Bed - Staged	Bimodal
	Sumitomo	Gas Phase - Fluid Bed	

Source: EnerChemTek

Table 3 – Solution Phase Linear PE Processes In Commercial Operation

Solution Phase Processes			
Borealis	Borceed	Solution - Single Stage Adiabatic	Unimodal
Dow	Dowlex CSTR	Solution - Cooled Low Pressure Cascade	Bimodal
	Dowlex CSTR	Solution - Cooled Low Pressure Converging Cascade	Multimodal
	Dowlex II	Solution - Cooled Loop Reactor Cascade	Bimodal
ExxonMobil	Ethylene Elastomer	Solution - Cooled Low Pressure Cascade	Bimodal
FasTech	Ethylene Elastomer	Solution - Low Pressure	Mono/Bimodal
LyondellBasell	Equistar Solution	Solution - Medium Pressure Converging Cascade	Multimodal
Mitsui	Ultzex/Tafmer	Solution - Medium Pressure Cascade	Mono/Bimodal
Nova	Sclairtec	Solution - Medium Pressure Cascade	Mono/Bimodal
	Sclairtec AST	Solution - Medium Pressure CSTR Cascade	Bimodal
SABIC	SABTEC Compact	Solution - Single Stage Adiabatic	Unimodal
SK Innovation	Nexlene	Solution - Loop Reactor Cascade	Bimodal
Sumitomo	Ethylene Elastomer	Solution - Low Pressure Cascade	Mono/Bimodal

Source: EnerChemTek

Table 4 – Slurry Phase Linear PE Processes In Commercial Operation

Slurry Phase Processes			
CP Chem	MarTECH SL	Slurry Loop Reactor - iso-Butane Diluent	Unimodal
CP Chem/Total	MarTECH ADL	Slurry Loop Reactor Cascade - iso-Butane Diluent	Bimodal
Ineos Technologies	Innovene	Slurry Loop Reactor - iso-Butane Diluent	Unimodal
	Innovene S	Slurry Loop Reactor Cascade - iso-Butane Diluent	Bimodal
Japan PE	CSTR Slurry	Slurry Stirred Tank - Hexane Diluent	Bimodal
	Japan PE AMSLP	Slurry 3-Loop Reactor Cascade - iso-Butane Diluent	Multimodal
	Japan PE/Mitsubishi	Slurry Stirred Tank - Hexane Diluent	Bimodal
	Japan PE/Nippon Oil	Slurry Stirred Tank - Hexane Diluent	Bimodal
	Japan PE/Showa	Slurry Loop Reactor - iso-Butane Diluent	Unimodal
LyondellBasell	Equistar Slurry	Slurry Horizontal Loop Reactor - iso-Butane Diluent	Unimodal
	Equistar-Maruzen	Slurry Stirred Tank - Hexane Diluent	Bimodal
	Hostalen	Slurry Stirred Tank - Hexane Diluent	Bimodal
	Hostalen ACP	Slurry Stirred Tank - Hexane Diluent	Trimodal
Mitsui	Mitsui CX	Slurry Stirred Tank - Hexane Diluent	Bimodal
Various/Proprietary	Asahi	Slurry Stirred Tank - Hexane Diluent	Bimodal
	Braskem	Slurry Stirred Tank - Hexane Diluent	Bimodal
	Chisso/Amoco	Slurry Stirred Tank - Hexane Diluent	Bimodal
	FasTech	Slurry Stirred Tank	
	Getech SCZ	Slurry Stirred Tank - Hexane Diluent	Bimodal
	Ruhrchemie	Slurry Stirred Tank - Hexane Diluent	Bimodal
	Sinopec	Slurry Stirred Tank - Hexane Diluent	Bimodal
	Versalis	Slurry Stirred Tank	Elastomers

Source: EnerChemTek

The Complexities of Grade-By-Grade Analysis

Overall, there are at least 89 different process technologies used to make PE. All of these are in commercial operation and their characteristics and product range capabilities are important to their owners and their owners' competitors. A few may be used in only one or two production lines, while others have been widely licensed and are used in multiple lines worldwide. No matter the semi-ubiquity of leading technologies, all 89 technologies are important to strategy development and competitor analysis in at least one regional market.

The catalyst technologies that are available to each PE producer play a critical role in facilitating differentiation and establishing competitive advantage. The potential product portfolio of the producer is defined by the combination of his process and catalyst technologies as applied in his specific plant configuration. Catalysts are the tools he can use to make those PE grades that have the specific molecular structures that result in differentiated end-use performance or processing characteristics. Thus, catalyst-product relationships are another important dimension in competition in the industry, adding to the complexity of analysis.

The grade-by-grade competitive matrix analysis is of particular importance when new players and/or new plants are entering the arena. For example, Braskem-Idesa (B-I) has recently started production at its 1 million ton/year

PE complex in Mexico. It is an unknown entity in the North American market, so its competitive behavior and market strategies cannot be predicted with confidence. Its impact on competitors is no doubt causing some pain to those that previously served its target markets. Where will these affected competitors go to make up for sales lost to B-I? Furthermore, B-I will soon be joined by CP Chem, Dow, ExxonMobil and later Formosa, all with large new plants using advanced technologies. These four are more or less known in terms of competitive behavior, but where will be their market focus: what grades and for which applications? Who will be most affected by each of these very large new sources of supply? A grade-by-grade competitive matrix analysis is a good way for competitors to evaluate these questions, using several “what-if” cases to examine different offensive & defensive market strategies and to see where these new plants might fit in.

Then there are the new unknowns: Shell & PTT Marubeni as well as Sasol (and probably others) will enter the North American market for the first time. A significant proportion of their production may end up in export markets, but they will try to maximize their local sales for the best netbacks. We may know which technologies these companies have selected, but we have no idea which markets they will focus on, with which product grades. A grade-by-grade matrix analysis is the best way to examine these aspects so that competitors can be ready to make way for, or oppose, the newcomers; also, so that the newcomers can develop market entry strategies of least resistance and optimal profitability.

Bearing in mind that each PE plant in a region may make between about 3 and 30 basic PE grades (depending on the process and the local competitive environment), a thorough assessment of PE competitors in a market may require cost estimates of several tens of grades from multiple plants in the regional supply structure. There are theoretically an infinite number of portfolio options open to each producer, and examination of several strategic offensive and defensive options will often be necessary. Thus, in order to make well-founded strategic decisions, a PE producer may need to make hundreds or thousands of cost estimates for different PE grades from competing plants as part of the annual or semi-annual competitive assessment activity. Multiply this by the number of price scenarios being considered and it is clear that a detailed and robust cost estimating system is required. Evaluating so many cases can be an expensive and time-consuming activity for PE producers.

A Means to Tackle These Complexities

As illustrated in Figure 2, there are many aspects of competition that must be evaluated in competitor analysis in the PE industry. Many of these aspects are “soft” such as market needs for services, the service emphasis of suppliers, competitor strategies, as well as some aspects of product quality & consistency. The “hard” aspects are sales & demand volumes in tons, the prices for individual grades, and the production costs for these grades, all on a grade-by-grade basis. These hard aspects underwrite the profitability of each PE producer.

As discussed, these hard aspects are the most difficult to evaluate due to their complexity. To address this complexity, EnerChemTek, in cooperation with software developers Advanced Technical Support, Inc., is developing a web-based cost estimating application that meets these needs for grade-by-grade analysis of production costs from competing PE producers and competing process technologies. It easily executes, stores and collates hundreds or thousands of cost estimates, and allows the analyst to compare and adjust these estimates as needed to reflect changing price environments and changes in product, process or catalyst technologies. The final results are better decisions and improved competitive positioning. This can save $ millions per year by optimizing plant investment decisions and maximizing sales margins & revenue through well-informed marketing strategies and product pricing decisions.

In the first phase of system development, the cost estimation platform covers 14 basic process technology variations that include the most important licensed and proprietary technologies as well as technologies that are generically similar to other groups of technologies, as outlined in Table 5 below. The intention is to not only add details of remaining processes in the second and subsequent phases, including new processes that are still under development, but also to update the system technologies on a periodic basis as may be necessary to reflect new developments.

Table 5 - PE Technology Variations Evaluated – Phase I

Process & Variations	Modeled On:	Product Range							Catalysts		
		Unimodal HDPE	Bimodal HDPE	LLDPE	VLDPE	Plastomers Elastomers	LDPE	EVA	Ziegler	Cr-Oxide	SSC
A. Gas Phase Processes											
1. Gas Phase Fluid Bed	Unipol	✓	✓	✓					✓	✓	✓
2. Gas Phase Fluid Bed	Innovene G	✓		✓	✓				✓	✓	✓
3. Gas Phase Fluid Bed Cascade	Spherilene C	✓	✓	✓					✓	✓	✓
B. Slurry Phase Processes											
1. Slurry Loop Reactor - iso-Butane Diluent	MarTECH SL	✓				✓			✓	✓	✓
2. Slurry Loop Bimodal Cascade - iso-Butane Diluent	Innovene S	✓	✓						✓	✓	
3. Slurry Loop Bimodal Cascade - iso-Butane Diluent	MarTECH ADL	✓	✓	✓					✓	✓	✓
4. Slurry Stirred Tank - Hexane Diluent	Hostalen ACP	✓	✓						✓		
5. Slurry Stirred Tank - Hexane Diluent	Mitsui CX	✓	✓						✓		
C. Solution Phase Processes											
1. Solution - Cooled CSTR Cascade	Dowlex	✓	✓	✓	✓	✓			✓		✓
2. Solution - Cooled Loop Reactor Cascade	Dowlex II	✓	✓	✓	✓	✓			✓		✓
3. Solution - Medium Pressure Cascade	Sclair	✓	✓	✓	✓	✓			✓		✓
D. High Pressure Free Radical Processes											
1. High Pressure Tubular Multizone	Lupotech T						✓	✓			
2. High Pressure Compartmented Autoclave	Versalis						✓	✓			
3. High Pressure Autoclave Cascade	Sumitomo						✓	✓			

Source: EnerChemTek

Other important processes that will be added to the system during Phase II and subsequent phases include the Borstar, Evolue, Hyperzone and Sinopec gas phase technologies, the triple-loop slurry process, and the Sabtec Compact and SK Nexlene solution phase processes. The high pressure technology additions will include variations incorporating new reactor circulation & cooling systems, hybrid autoclave/tube reactors and production of acid & acrylate co-polymers.

The cost analysis system contains a model of each of the above processes comprising a process description, flowsheet, recipe generator and a process economics calculation module. There are built-in recipes for a selection of standard PE grades that each process can produce. The recipe generator estimates resin characteristics (Mw, MWD, composition) and plant operating parameters for other grades as may be specified by the user. The output is the estimated production cost tabulation for each selected PE grade plus summary details of production rates, materials & utilities consumptions, capital- & labor-related costs, and profitability.

The system contains recipes for standard grades typical of the product portfolios of each process technology. The grade definitions are the same for different processes if these processes normally serve the same market, but the portfolio coverage of each of the processes may vary where product range capabilities are different. For example, solution processes do not produce very high molecular weight polymers so these grades are not included in solution process product portfolios. The range of standard grades includes those listed in Table 6.

Table 6 – List of Standard Grades Having Fixed Recipes

Standard Grade Variations	
HDPE Blow molding - Bottle grade - C4, C6	MDPE Extrusion - C4, C6
HMW HDPE Blow molding grade - C4, C6	MDPE Rotomolding
HDPE Film - Cast	LLDPE Film - C4, C6, C8
HMW HDPE Film - Blown	mLLDPE Film - C6, C8
HDPE Injection Molding	LLDPE Injection Molding
HDPE Injection Molding - Bimodal	LLDPE Rotomolding - C4, C6, C8
HDPE Pipe - PE100	mLLDPE Rotomolding - C6, C8
HDPE Pipe - PE80	Plastomers - C4, C6, C8
HDPE Pipe - Unimodal	Elastomers - C4, C6, C8
LDPE Homopolymers - Film & Extrusion	EVA Copolymers - 3% to 36% VA

Source: EnerChemTek

If the user wishes to evaluate the costs of a grade that is not included in the above list, the system allows the user to enter a new grade definition by specifying the basic properties such as melt index and density and the application or other structure indicators such as narrow MWD, unimodal, bimodal, etc. The recipe generator translates these data into a custom cost estimate for the user-defined grade, including factors such as production rate, estimated composition, utilities consumptions, etc.

There are many other aspects of the cost analysis that are customizable by users in preparing proprietary result sets that may reflect user-confidential aspects, such as for example catalyst yields and prices or utilities or raw material consumptions or prices. All this is facilitated by the user-friendly on-line interface that we consider to be one of the most important aspects of the program.

As far as we are aware, this cost analysis platform and the associated interactive analysis service is the only published source that provides the flexibility of use and the relevant depth of technical information required for detailed competitive analysis in the PE production industry. The web-based interactive ability to compare costs for essentially any user-defined grade of PE made in plants of any size & configuration using any process and catalyst technologies on a directly comparable basis is a uniquely useful contribution to knowledge of the industry. The results are extremely useful both in selecting technology for a new production facility, and in assessing the competitive strengths of existing and future suppliers to regional PE markets.