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AN ANALYSIS OF THE UNITED STATES WINDOW INDUSTRY

by

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on November 16, 1990 in partial fulfillment
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The US homebuilding industry has been described as non-innovative. However, windows, a major component of any home, have exhibited significant innovation.

The purpose of this thesis is to analyze the window industry. Specifically, to determine if the innovation exhibited by this industry can be expected from other building component industries in the future.

The following conclusions are reached:

Homeowners replace windows for one of two reasons: 1) they are an inexpensive way for an owner to personalize the purchase of an existing home and / or, 2) the improved thermal performance of the new windows reduces future heating bills which may eventually offset the initial investment.

The combined market characteristics of new construction buyers and replacement / remodeling buyers are beneficial for window manufacturers. Together, the segments provide a relatively constant, positive growth window market.

The competitive forces shaping the window market are unlike most other components of the homebuilding industry's 'value-added' chain. The window business is a hard business to enter and an easy one to leave. The result is a very lucrative environment for existing, well-run, window manufacturers.

Innovation is directly linked to differentiation. Companies that produce commodity products do not see the profits necessary to attempt new ideas. On the other hand, products that are seen as differentiated have the luxury of commanding larger margins, which, in turn, allow the manufacturer to experiment with new processes, new materials and new products.

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Introduction

The prevalent view of the US homebuilding industry is of an industry that has failed to innovate; failed to use new technologies and failed to try new products. Many of the materials used in today's homes -- bricks, concrete and lumber for example -- were also used on homes built before the turn of the century. The same can be said for the building processes and labor required in homebuilding. Most of the physical effort needed to produce a home is still taking place at the worksite. The foundation is poured; the walls are built; the plumbing, electrical work and trim is installed and the walls finished at the worksite.

It is easy to take the position that the homebuilding industry is not innovative. A few mavericks have argued otherwise but it has been an uphill battle. However, there is one component of a home which convincingly breaks this 'non-innovative' stereotype: the window. The entire 'value-added' chain: the technology, the manufacturing process, its marketing and finally -- distributing the window, has radically changed from what it once was. Today, windows are manufactured in highly-automated plants, incorporating 'state of the art' technology, hundreds of miles away from the worksite. Before they were built on-site, by the carpenters, to any size that looked about right. The marketing of windows, nonexistent before, is now a multi-million dollar,

national business. The same is true with distribution systems. Before, when windows were built on-site, there was no need for a distributor. But today, windows are manufactured primarily in the mid-west and distributed all over the country and even as far away as Japan.

Are the forces that propelled windows from a commodity item, manufactured at the work-site to a technically advanced, specialty product, fabricated in a few automated plants across the country, unique only to windows? Or can the homebuilding industry expect to see the same transformation in other building components in the future?

The purpose of this chapter is threefold. First, provide a brief history of the evolution of both glass and windows. Second, outline each of the following chapters and indicate, in general terms, how they interrelate so that the readers know before they start where this study is going and how it plans on getting there. Finally, present the conclusions now so that the reader will be better able to evaluate those facts and arguments, developed in the subsequent chapters, that lay the foundation for those conclusions.

Glass and Windows

It is believed that the Syrians started manufacturing glass around 3000 B.C. using a mixture of soda ash, lime and sand. Glass was probably first used in windows in Pompei, before the birth of Christ.

The Syrians first made 'flat' glass by the 'crown process', in the 7th century. A bubble of molten glass was blown using an iron blowpipe. The bubble was split circumferentially, and spun until centrifugal force flattened it into a disk. The disk was then cut into the desired window shape.

At about the turn of the century sheet glass and plate glass eliminated the crown glass method of producing flat glass.

Sheet glass was made by blending the ingredients in a power mixer. The resulting batch then traveled along a broad conveyor, almost a quarter mile in length, and entered a furnace. The batch was then heated and cooled. An iron bar was dipped into the molten batch, gathered up the glass, and pulled it over a bending roll, then transferred it to a unit called the 'lehr' for cooling.

Plate glass, originally invented by French artisans in 1688, became popular in the 1930's after developments in technology lowered its cost. Plate glass is rolled, ground and polished; these processes are what separate plate glass from sheet glass.

The latest technology for production of flat glass is the float glass process developed in 1959 by the Pilkington Brothers of England. It produces nearly flawless glass at a fraction of the cost of plate glass. Today, practically all glass currently made in the US is made by this process.

In the float glass production process, molten glass is placed on a tin bath; because it is lighter than the tin, it floats, making a smooth, even surface. The glass is then allowed to cool, hardening it. This process makes it possible to manufacture a glass that is perfectly flat with parallel surfaces; there is no need to grind or polish the finished product.

There are some refinements of the float glass process in the works but no revolutionary developments are expected.¹

Windows

Prior to the turn of this century windows were almost an afterthought in the homebuilding process. Carpenters decided what size opening 'looked about right' in the wall and built windows, at the work site, to fit the opening.

In 1905 Hans Andersen realized that he could build windows cheaper and better in his warehouse if he could only convince builders and builder suppliers to use standardized dimensions. Apparently he was persuasive. His Andersen Corporation is now the largest window manufacturer in the industry and his heirs are one of the richest families in the country.

Over the next 50 years windows became a commodity item, produced, at that time, by small companies such as Andersen,

¹All of the information recited on the history of flat glass came from Franklin E. Williams, "Flat Glass Technology," Construction Review (March/April 1990): iii.

Pella and other local mill shops.

Virtually no housing was built during WW II. The demand during the post-war years, created by GI's home from the war, for affordable housing was enormous. The building industry, primarily in the form of William Levitt, responded with mass-produced communities like Levittown on Long Island, in New Jersey and in Pennsylvania. At the height of production, 36 houses were being completed every day in these communities.²

The demand for windows was equally as great and the market grew to a point where a significant capital investment was now warranted for machinery to mass-produce windows. Those far-sighted companies, who could afford it, invested the capital and began to produce quality windows at a price the local millshops had trouble beating. This era marked the birth of the national firms such as Andersen, Pella and Marvin.

The oil crisis in the mid-70's accelerated the consumer demand for energy efficient windows. Fortunately, a number of the national window manufacturers had grown to a point where they could afford to dedicate a substantial portion of their profits towards the development or refinement of new and existing window technologies. This marked the beginning of the most technologically innovative period in the history of the window. Advances included low-emissivity glazing, gas-

²Michael T. Kaufman, "Tough Times For Mr. Levittown," The New York Times Magazine (September 24, 1989): 43.

filled windows and thermal breaks within the sash -- to name only a few.

Chapter Synopsis

Studying any industry requires data and an organized framework for deciding what is particularly important and how best to analyze it. I have chosen the collecting techniques and analyzing framework that Michael Porter developed in his two books: Competitive Strategy and Competitive Advantage to accomplish this.

Chapter 2 develops the evolution of windows from the single glazing window introduced by the Syrians thousands of years ago to today's typical 'upscale' product which is a double glazed, low-E, vinyl-clad window. It also discusses the revolutionary products that are in the research labs or on their way to the market place as this chapter is being written. Products that react positively to the amount of sunlight striking the window; windows that change their opacity at the flip of a switch and windows that are able to turn a corner without losing their transparency.

Chapter 3 analyzes the window market by partitioning it according to buyer and product segments and developing a window market segmentation matrix. There are three discrete buyer segments: 1) those buying for new homes, 2) for replacement or remodeling projects and 3) those consumers purchasing storm windows.

The chapter then divides the market into segments based

on product categories. The primary division among products is a standard window versus an upscale window. The standard window is the minimally acceptable window for 85% of the consumers. It is a double-glazed product with an insulation value of 2. It is a commodity item manufactured by hundreds of small millshops across the country.

The upscale window category is further divided into 4 segments: premium, custom-made, high-performance and commercial. Premium windows are a double-glazed, low-E, low-maintenance product with an insulation value of 4. Custom-made windows are built to satisfy any and all demands of the consumer. The sizes, shapes, tints, etc. are built to the customers specifications. High-performance windows are the most technologically advanced windows with a top R-value of 8 and a steep purchase price. Finally, commercial windows are their own category because they must meet stricter construction specifications than residential windows.

The market is further divided by the type of material used in the frame and sash. The options include aluminum, which is strong and requires little maintenance but is a poor insulator. Vinyl, which requires little maintenance and is easily adaptable to existing window openings. Wood and the cladding's, both aluminum and vinyl, which dominate the 'upscale' market.

The final portion of this chapter examines the different consumer preferences for windows based on the region

of the country their home is situated in. Wood is very popular in the Northeast and aluminum in the South and the West.

Chapter 4 examines the different growth rates the window industry has seen and anticipates in the immediate future, for each buyer segment: new construction, remodeling/replacement and storm windows.

Chapter 5 uses Porter's Competitive Forces model to examine the forces that shape the degree of competition in the industry and determine the overall profitability for window manufacturers. According to Porter it is the interaction of these 5 forces: entry barriers, threat of substitution, buyer and supplier power as well as internal rivalry, which set the ceiling for what a firm can accomplish in an industry.

Chapter 6 examines five leading window companies: Andersen, Ply-Gem, Marvin, Pella and Hurd. It explores their history, where they are now and what direction they appear to be going.

Andersen is the countries largest and most profitable window manufacturer with 10% of the overall \$10 Billion market. They are more than twice the size of their nearest competitor. They mass produce a premium, vinyl-clad, low-E window in a few specific sizes and shapes. Andersen's market was primarily the Northeast and North Central regions but they are now expanding into the South with a new product

line.

Ply-Gem is a publicly owned company which is very unusual in this industry. It has two subsidiaries, SNE and Great Lakes Windows, which produce a wide assortment of window types for both the new construction and remodeling buyer. They recently stopped short of buying a third window company.

Marvin is the industry leader in custom-made wood and aluminum-clad windows. They have grown from \$40 Million to \$300 Million in total sales during the last decade. If it is something unusual -- Marvin is the place to go.

Pella started as a commercial and residential aluminum-clad window producer but has since expanded into the custom-made wood window market. This expansion began a turf war with Marvin.

Finally, **Hurd**, the smallest of the five companies, produces the most advanced window on the market. Their Insol-8 has an R-value of 8, more than twice the insulating value of a typical, premium window.

The chapter concludes by mapping the companies onto the segmentation matrix developed in Chapter 3.

Chapter 7 presents the conclusions of this paper and proposes related areas and questions which may warrant further investigation.

Conclusions

The following conclusions are presented to the reader

now so that they may knowingly evaluate the forthcoming arguments.

There are two reasons why windows are the most likely building component to be replaced by a homeowner: 1) they are a relatively inexpensive way for an owner to personalize the purchase of an existing home and, 2) the improved thermal performance of the new windows reduces future heating bills which may eventually offset the initial investment.

The combined market characteristics of new construction buyers and replacement/remodeling buyers are beneficial for window manufacturers. Together, the segments provide a relatively constant, positive growth window market. A market that allows a manufacturer to take prudent financial risks with regards to expenses such as plant construction and product development.

The competitive forces shaping the window industry are unlike most other components of the homebuilding industry's 'value-added' chain. The window business is a hard industry to enter and an easy one to leave. Buyers and suppliers have little influence over the window companies. Finally, the market is segmented in such a way that there is little direct competition among the leading national, upscale companies. These forces combine to make the window business a lucrative environment for well-run companies.

Innovation is directly linked to differentiation. Companies that produce commodity products do not see the

profits necessary to attempt new ideas. On the other hand, products that are seen as differentiated have the luxury of commanding larger margins, which, in turn, allow the manufacturer to experiment with new processes, new materials and new products.

Window Technology

(Chapter 2)

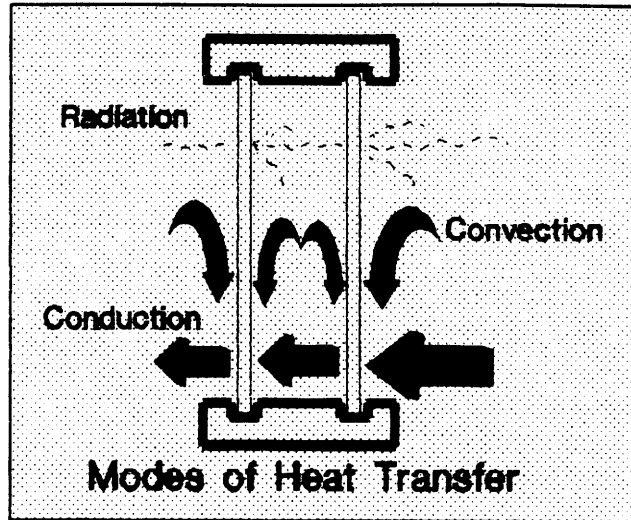
This chapter traces the evolutionary and revolutionary developments of window technology in the last 20 years. The initial sections outline the evolutionary progress made in minimizing heat transmission through glazings. The final sections detail the revolutionary products and processes that are in the laboratories or on their way to the market.

Modes of Heat Transfer Windows transmit heat through conduction, convection, radiation and air leakage. Heat transmittance through glazed areas is usually referred to in terms of U-values. A U-value is the heat which is conducted through one square foot of glazing area in one hour when the temperature difference between the inside and outside of the glazing is one degree Fahrenheit. In simpler terms, it is a numeric representation of the heat-loss characteristics of the window. The units are BTU/hr/sq ft/F.

Conduction Heat Loss When there is a temperature difference across a glazing, heat will flow from the high side to the low side. During the winter, heat will flow from the warm interior of the building to the colder outside. The opposite will happen during the summer. The most effective and economical way to reduce conduction heat loss through a glazed area is to use double-glazed units with an airspace in the middle. This type of unit has about twice the U-value as a single-glazed unit.

Convection Heat Loss

Convection heat loss is caused by air moving across the surfaces of the glazing. Effective methods to minimize this loss are to recess the windows in the outside walls of the structure and to use blinds or drapes on the inside.



Radiant Heat Loss Long wave infrared radiation (radiant heat) is emitted by all room-temperature objects: walls, furniture, people, etc. Glazing absorbs radiant heat and then reradiates it in all directions--both inside and outside. Radiant heat loss accounts for one-half to two-thirds of the total heat loss through glazing. Minimizing radiant heat loss has required the development of low-emissivity (low-E) glazing which will be discussed later in this chapter.

Air Leakage Cold air leaking into a building will require *sensible* heat to raise the room temperature back to its desired setting. Additionally, winter air does not normally contain much water vapor so when it is heated to room temperature the relative humidity often drops. To raise the humidity level it is necessary to use heat to evaporate water. This is known as *latent* heat. The energy losses due to sensible and latent heat can add up. Some estimate that

energy loss due to air leakage approaches the heat loss due to conduction. Careful installation and good seals are the most effective way to control air leakage.

Fabric Fading A final concern that has driven a portion of the technological evolution is concern for fabric fading. Shortwave, ultraviolet (UV) light makes up only 2% of the light that enters through glazing but causes 60% of the fading damage. Minimizing UV fading has required the development of UV blockers that work with glazing.

Glazing Technology

Single-Glazed The single-glazed window has been with us for centuries. It has an average U-value of 1.12 BTU/hrs/sq ft/F. To place this in perspective, a moderately insulated wall has a U-value (the U-value is the reciprocal of a wall's R-value) of about .091 BTU/hrs/sq ft/F. A single-glazed window is only 10% as thermally efficient as the adjacent wall.¹

Double-Glazed The double-glazed window, patented in 1865, was the first step in improving energy conservation in windows. A typical double-glazed window has two glazings separated by 1/2 an inch of dead air space. This air space serves as an insulator. By reducing the heat loss due to conduction and convection this window improved its U-value to about .50. A triple-glazed window with two 1/2 inch air

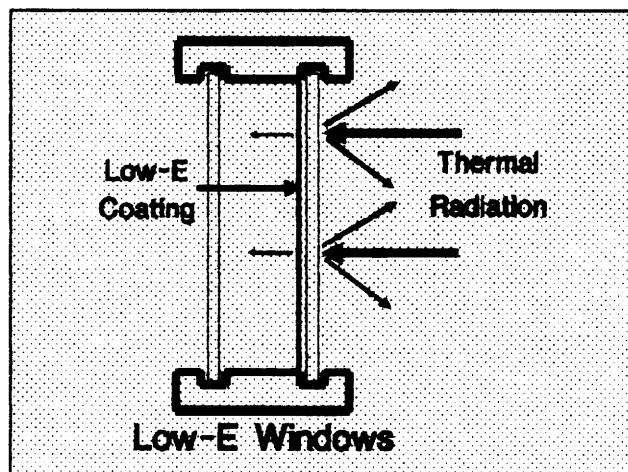
¹Steve Andrews, "Window Shopping," Builder, September 1986, 67.

spaces has a U-value of .35. The use of sealed, insulating glass has increased from 68% of the total residential construction market in 1982 to 85% in 1989.²

Low-Emissivity Windows

Minimizing heat loss due to conduction and convection is important but one-half to two-thirds of all heat loss through glazing is due to radiant heat transfer. Minimizing this loss led to the introduction in 1978 of low-emissivity coatings and films. Emis-

sivity refers to the heat-emitting or radiating propensity of a surface. The emissivity number compares a given surface with that of a perfect radiator--a blackbody with an emissivity number of 1. A



blackbody absorbs 100% of the thermal radiation that strikes it and reradiates the radiation in all directions.

Typical window glass has an emissivity number of .84. It will absorb and reradiate 84% of the radiant heat. But by placing a low-E coating on that glazing or a low-E film in front and the rating drops to a range of .05 to .40. This means that the low-E glazing will reflect between 60 and 95%

²Ibid., 68.

of the radiant heat generated within the room, back -- into the room. Also, low-E glazings designed for warmer climates will reflect the radiant heat generated by objects outside of the house, such as sidewalks and driveways, away from the house.³

Low-E glazings are spectrally selective. They reflect between 60 and 95% of the long wave radiation, transmit about 72% of the visible light and reflect about 51% of the short-wave ultraviolet rays -- the rays that cause fading.

There are two basic low-E coating products today. The most prevalent form has the coating applied, by one of three processes, directly to the outside surface of the inside glazing of a double-glazed window (for Northern climates; the reverse is true for Southern climates). The other product is called Heat Mirror and was developed by Southwall Technologies. A Heat Mirror is actually a polyester film with a low-E coating on one side. The film is suspended between the two glazings in a double-glazed window.⁴

The low-E coating is an atoms thin layer of conductive metal, usually silver, sandwiched between two layers of a metal oxide. The metal layer reflects light because it has free electrons. These electrons are not attached to an atom,

³Noel Valdes, "How Much Do You Know About Low-E?," Glass Digest, 15 February 1987, 97.

⁴Don Best, "Window Shopping," Practical Homeowner, " 11 March 1990, 40.

therefore they are capable of moving around. When a wave of radiation passes from air, which does not have free electrons, to the metal layer, which does, the electric field of the wave accelerates the free electrons in the metal layer. The collision of the accelerated free electrons and the wave results in the wave reflecting backwards.⁵

The quantity of collisions between the free electrons and the propagating wave and therefore, the amount of reflection depends on the wave's frequency. There is a limit, depending on the type of metal, to the amount of acceleration of the free electrons. The longer the wavelength (infrared) the lower the waves frequency. The lower the waves frequency the greater the opportunity for a free electron to collide and reflect the wave. Consequently, infrared radiation with its associated long wavelengths and lower frequency is reflected more than visible light with a shorter wavelength but high frequency.

There are three manufacturing processes used to apply the low-E coating to glazing or film. The most prevalent process is called 'sputtering' and produces a 'soft-coat' product. The process takes place off-line, totally separate from the glass making operations, in a high-vacuum chamber. The metal is deposited on the glazing or film an atom at a time by bombarding the metal with ionized argon gas. The

⁵Valdes, 97.

positive argon atoms are shot like a bullet towards the metal. When an atom hits the target it knocks loose an atom of metal. The atoms fly out and coat everything in the chamber to include the glazing or film.⁶

This sputtering process produces the most effective coating. A low-E coating made like this will reflect between 85 and 95% of radiant heat. The color and clarity are excellent and, because it is an off-line process, the development of new products is easier. The drawback is that the final product is sensitive to moisture and abrasion. Therefore, it can only be used within a double-glazed window.⁷

Low-E glazing manufactured with the sputtering process have competition. It is a low-E glazing whose coating is as tough as the glazing itself. The product is called pyrolytic low-E glazing. The process consists of spraying a liquid metal or a metallized powder directly on the surface of hot glass. As the glass cools, the metal coating becomes an integral part of the glass and forms an extremely tough and durable coating (hard-coat). The major advantage to this product is that it can be used in single-glazed windows and as storm windows. The disadvantage is that the emissivity number is generally in the range of .3 to .4. Although, a European product reportedly has a low-E value of .15. The

⁶Ibid.

⁷Ibid, 98.

price for pyrolytic glazing is equivalent to sputtered glazing.⁸

Just recently Libbey Owens Ford, a glass manufacturer, introduced a new 'hard coat' product that offers improved emissivity numbers (.15 to .19), U-values (.35 to .38) and eliminates the coloration problems that have plagued the original pyrolytic glazing. In effect, a compromise between the two existing products. Pella Rolscreen will probably be the first major window manufacturer to adopt this new technology.⁹

The performance of low-E glazing is so impressive that it is expected to become the industry standard for premium windows in the 90's. Andersen Corporation, the countries largest window manufacturer, is already in the process of switching over entirely to low-E windows. However, consumers can expect to pay an additional 5 to 20% for these windows. The payback period on this initial cost increase is, depending on the climate, from 2 to 6 years.¹⁰

Low-Conductivity Gases

While scientists were developing low-E glazing to minimize radiant heat loss others were investigating methods to minimize conduction and convection heat loss. The initial

⁸Ibid, 97.

⁹"LOF Energy Balance," an informational pamphlet by Libbey Owens Ford.

¹⁰Best, 41.

product was the double-glazed window. This window improved U-value performance from a 1.12 to a .5. Triple-glazed windows have a U-value of .35. Some companies even developed quadruple-glazed windows.

Scientists then began looking at the insulating material between the glazings. Dead air was good but they found that low conductivity gases, such as argon and krypton were even better. Argon was first used in European windows back in the 1970's. Initially U.S. window manufacturers held off to see if the seals would hold. A gas-filled window is only as good as its seals. The Europeans experienced a low failure rate which served as the impetus needed for the US companies. There is a 13% improvement in U-value between two identical double-glazed windows when one window has argon as the insulating material while the other has air. Because argon is plentiful and inexpensive, some of the largest window makers like Marvin and Norco now offer it at no extra cost with their low-E lines.¹¹

Low conductivity gases are an improvement but a vacuum between the glazings is thought to be the optimal solution. A vacuum eliminates the heat transfer that occurs from molecule to molecule in a gas-filled unit. Two products are currently in the development stages. The first fills the space between the glazings with a highly insulating material

¹¹Best, 42.

called aerogel. The aerogel is dried by a process that prevents shrinking and leaves behind a material that is about 95% air. A one-half inch layer of aerogel at a pressure of .1 atmosphere has a U-value of .1. The advantage of aerogel is that it is relatively easy to vacuum seal because the aerogel acts as a spacer between the glazings. The disadvantage is that current samples can look like a dirty windshield against a dark background. This product's future may lie in the glass-block arena rather than with windows.¹²

The second product has a vacuum between the glazings. The problem has been to form a permanent, airtight seal around the edges. The Solar Energy Research Institute (SERI) in Golden Colorado has developed a method of laser welding the edges of the two glazings at 565 degrees C, creating a leakproof seal. Glass beads only one-half millimeter in diameter act as spacers to counteract atmospheric pressure and keep the two glazings apart--despite the vacuum within. The practical problem has been in developing a cost-efficient mass-manufacturing process. If the manufacturing problem can be solved the result will be a window with a U-value of .067.¹³

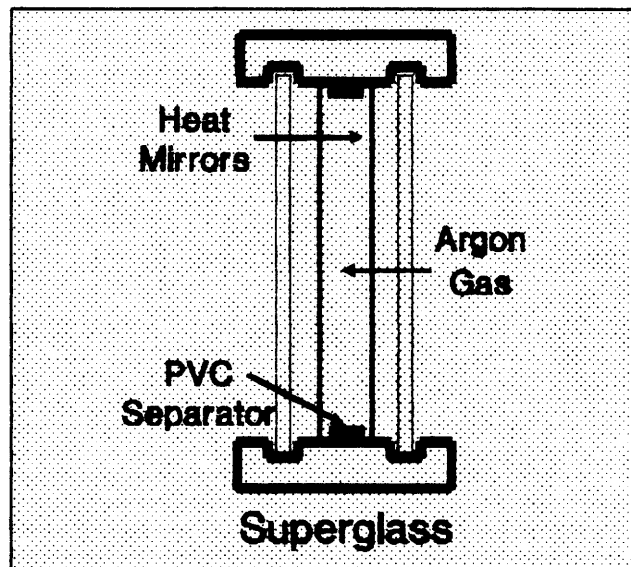
¹²Dawn Stover, "Amazing Glazing," Popular Science, August 1988, 52.

¹³Best, 43.

Superglass

The current 'state of the art' window is called Superglass; developed by Southwall Technologies and manufactured by Hurd Millwork as InSol-8. It is a combination of the best technological innovations discussed above coupled with new innovations developed by Southwall. It has a U-value of .125. Superglass is a

double-glazed unit with two Heat Mirror films in between the glazings. Each low-E coated surface faces outward; one towards the exterior of the building and one towards the interior. The two films are



1/8th of an inch apart. The three spaces within the window are filled with argon, a low-conductivity gas. The overall thickness of Superglass is one inch.¹⁴

Two new innovations that Southwall has incorporated into their Superglass is the '3 spacer system' and a 'UV blocker'. The way the edge of a glazing unit is made can have a significant degrading effect on the overall U-value. Most multi-glazed units use metal spacers at the edges between the glazings to provide support. These metal spacers, which are

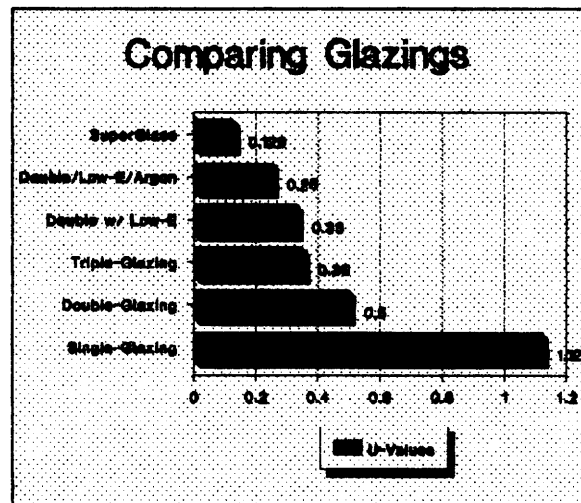
¹⁴Barnaby Feder, "Smart Windows, Intriguing Potential," The New York Times, 8 April 1990, sec F, p.11.

excellent heat conductors, act as a bridge between the interior and exterior of a room. An improvement in U-value would be realized if this metal bridge was broken. Southwall did it by placing a 1/8 inch wide PVC insulating foam separator between the edges of the two Heat Mirrors.¹⁵

The second innovation was to modify their low-E coating so that it was better at reflecting ultraviolet rays. These UV rays are responsible for 60% of fabric fading. A typical double-glazed unit only blocks 40% of the UV rays. The standard Heat Mirror reflected 70% of the UV rays. But an improvement was still needed. To improve the ultraviolet performance they added a UV blocker composed of cyclic imino ester. This blocker had the necessary resistance to heat and oxidation that the company felt was critical in a window.¹⁶

The final result is a double-glazed window that is one inch thick, has a U-value of .125 and reflects 99.5% of the ultraviolet rays.

This chart depicts the improvements in glazing U-value over the last 20 years.



¹⁵Timothy O. Bakke, "Windows of Opportunity," Popular Science, May 1990, 108.

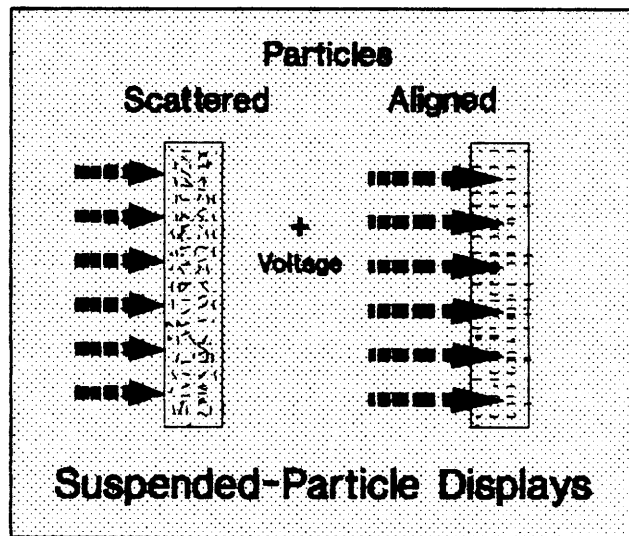
¹⁶Ibid.

Smart Windows

Smart Windows allow the owner to vary, either automatically or manually, the amount of solar radiation that enter a room through the glazing. The products can be divided into processes that use voltage to vary the glazings opacity and those that do not.

Voltage

Research Frontiers Inc. of New York has licensed their **suspended-particle displays (SPD)** to two Japanese companies who hope to have commercially viable products by 1992. The basic principle of SPD was patented by Edwin Land, founder of Polaroid, in 1934. The particles are suspended in a solution that is sandwiched between plates of glass. In the glazings off-state the needle-like particles zigzag randomly due to Brownian movement - the continuous colliding of the particles and the liquid's molecules. In this state the particles block light. When a voltage is applied (on-state), the particles align with the electric field and allow light to pass.¹⁷



¹⁷Ken Schachter, "Continuously Variable Glazing," Popular Science, November 1989, 74.

Taliq Corporation of California is developing a product based on liquid crystals. Their glazing is a sandwich configuration comprising two sheets of polyester film with an emulsion film consisting of liquid-crystal droplets in between. When a voltage is applied the liquid crystals line up in rows allowing the light through. When the voltage is turned off the liquid crystals scatter and the glazing becomes opaque. The current cost of this product is in excess of \$100 a square foot.¹⁸

Electrochromic glass was first developed in the late 1960's at SERI. The process works by electronically altering the light absorptive properties of the electrochromic material (usually molybdenum trioxide). This product allows you to control the degree of opaqueness by adjusting the amount of voltage applied to the glazing. It also has 'memory'. Once the desired setting is achieved the voltage is turned off but the 'tint' remains. By reversing the polarity the process is then reversed.

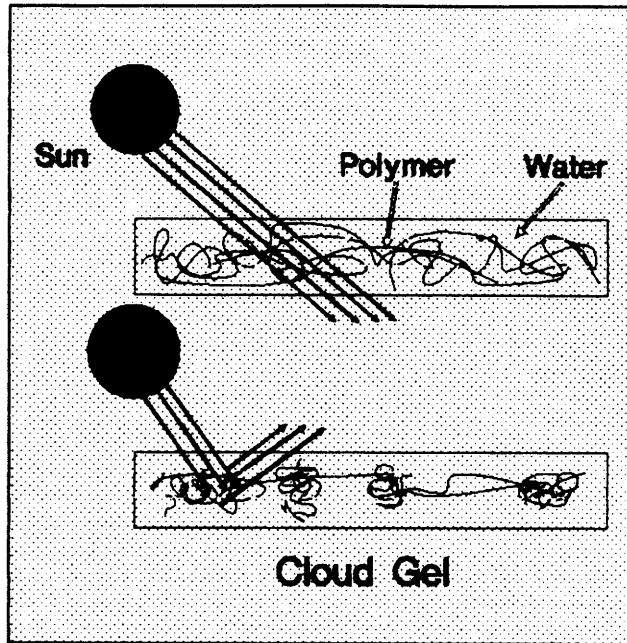
Foreign companies, utilizing a liquid electrolyte, appear to have the edge in bringing the product to market. However, US scientist do not believe the liquid electrolyte will last long enough to be commercially viable. US companies are using a solid state electrolyte material which lasts

¹⁸Stover, 52.

longer. The goal is to produce a product that costs less than a dollar per square foot.¹⁹

Non-Voltage

Cloud Gel, a product that is being developed by Suntek Inc. of New Mexico is based on a 1971 invention by Day Chahroudi. It is a polymer-water solution sandwiched between plastic films. When the solution is cool the polymers are elongated with their diameters much smaller than the wavelengths of solar energy. Consequently, light passes through the glazing. When the solution warms with the rising sun,



the polymers curl up and the resulting globs are larger than the wavelength of light. As much as 80% of the solar radiation is then reflected.²⁰

Cloud Gel transitions from being transparent to reflective over a two degree span. By adding salt to the polymer-water solution the transition point can range from 65 to 85 degrees. Suntek hopes to have a product, with a

¹⁹Ibid., 70.

²⁰V. Elaine Smay, "Thinking Window Can Switch Off the Sun," Popular Science, March 1984, 102.

life-span of ten years, commercially available, at a price of \$3 a square foot, by the end of this year. Suntek feels their product has a distinct competitive advantage over the products previously mentioned because Cloud Gel does not require electricity to work.²¹

A final product is called **photochromics** and has been used in sunglasses for years. It reacts slower than Cloud Gel to a warming sun and may have applications in conjunction with skylights.

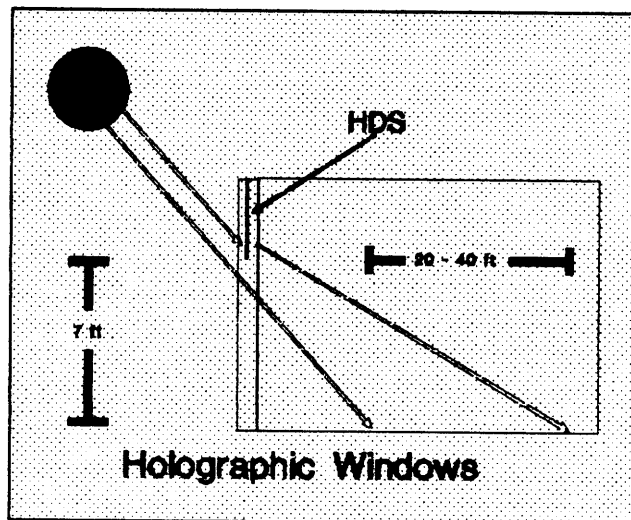
Miscellaneous Technologies

Studies show that 40 to 50% of electrical use in an office building is for lighting and the associated cooling load. Armed with this knowledge the Advanced Environmental

Research Group of Cambridge, Massachusetts is developing a **holographic diffractive structure**

(HDS). An HDS actually bends light, in this case from a window to a dark portion of the room. The

product consists of two panes of glass with the HDS in between. Because the HDS bends light it cannot be used at eye level without distorting the view out the window. It has been



²¹Ibid., 104.

successful in bending the light anywhere from 20 to 40 feet farther into a room, depending on the design of the HDS.²²

Because it is a passive design (active attempts to redirect sunlight have proved too costly) the potential for inexpensive, mass production is there. Problems the scientists are working on include reinforcing the fragile makeup of the film and searching for a mass production technique. Currently, HDS can only be made with the aid of a laser.²³

Additional new glazing technologies include Marvin's angle window. The product is a one-piece corner window with continuous glass that bends to any angle. The bending process is two-phased. During the first phase the glass is held horizontally and preheated to 500 F. During the second phase the glass is heated to 1100 F. and then an electric coil applies additional heat to the bending area. The glass bends under its own weight. The angle is determined by computers which control the amount the supporting frame will bend.²⁴

Advancements in sealants have made authentic divided-light windows a reality. A divided-light window is composed of multiple individual panes of glass assembled with wood muntins. The secret has been the use of dual sealants; one is impervious to water in a liquid state and the other to

²²Sabra Morton, "Holographic Windows," Popular Science, February 1990, 80.

²³Ibid., 82.

²⁴Bakke, 113.

water in a vapor state. Neither sealant will perform both functions adequately.²⁵

The final innovation in glazing technology is a direct result of the overall success the industry has had. Ventilating windows have become a necessity because the housing envelope has become too tight. A company in Canada is marketing their laminar air flow super window. An opening at the bottom of the window allows air into the space between the middle and outer glazings. A humidity controlled air intake expands and allows this fresh outside air into the room. Once the humidity in the room has dropped the air intake closes and reseals the window. The company is planning on charging an additional 7% for the ventilating feature.²⁶

Frame and Sash

To this point, most of the research done on windows has focused on the glazing. Consequently, U-values have improved from 1.12 for a single-glazed unit to .125 for superglass. However, these values do not include the heat loss through the window's sash and frame. Half of the heat lost through modern windows today is through the edge. Consequently, the industry is undergoing a significant revision in how U and R values are calculated. The new method, which incorporates the U-values of the frame and sash, becomes the industry standard

²⁵Ibid., 112.

²⁶"Windows Intended to Leak," Popular Science, December 1989, 38.

in 1990.

There is no ideal window framing material. The options are wood (which include aluminum and vinyl-clad wood frames), aluminum, vinyl and recently fibron, made by Owens Corning Fiberglass. Wood frames made up 48% of the 1989 new construction and remodeling market; aluminum was 35% and vinyl 17%. Aluminum dominates the storm window market with 96% of the market share.²⁷

Each has advantages and disadvantages. Wood is a fair insulator but swells and shrinks with a changing moisture content in the environment. It is the most maintenance intensive and does require painting. There is also no easy way to adjust a wood frame to a preexisting wall opening. A wood frames strongest selling point is its' aesthetic appeal. Consumers like the look of wood frame windows. However, some consumers consider the look of wood to be too bulky. Wood frames are very popular in the Northeast and North Central regions.

Aluminum has serious heat conduction problems and can be very expensive. Until the recent development of 'permacoat paint' it was not recommended for use near salt water. Despite these problems they are still very popular in certain regions of the country. They own 50% of the market share in the South, 63% in the South Central and 75% in the West.

²⁷Ducker Research Company, Inc., Industry Statistical Review and Forecast (Des Plaines, Illinois: AAMA-MIR, April, 1990), 6.

Vinyl is not inherently strong or rigid. However the frame dimensions are flexible and the vinyl is maintenance free. Until recently these frames were only offered in 4 colors. They are now offered in over 50. Vinyl frames are easily adapted to existing wall openings with unusual dimensions. They have over 70% of the replacement market in Western Europe and are expected to grow at 15% for the remaining decade.

Most upscale residential windows have frames made of either wood or wood with aluminum or vinyl cladding. This is an effort to combine the strength, insulating characteristics and pleasing aesthetics of wood with the low maintenance requirements of aluminum or vinyl.

The heat transfer coefficients for the primary framing materials are:²⁸

| | |
|---------------------------------|-----------------------------|
| Aluminum, without thermal break | 1.9 |
| Aluminum, with thermal break | 1.0 |
| Wood with aluminum cladding | 0.4 |
| Wood with vinyl cladding | 0.4 |
| Wood | 0.4 |
| Vinyl | 0.3 |
| Fibron | Not Available ²⁹ |

Fibron, the newest framing material, is a pultruded fiberglass composite with a core of high density pink fiberglass insulation. It has intrinsic properties that are

²⁸Bakke, 113.

²⁹"Andersen High-Performance and High-Performance Sun Windows Shine In Any Light," informational pamphlet produced by Andersen Corp., 130.

valuable in windows: high flexural strength, conducts little heat and can be painted. It also has the same thermal expansion rate as glass. This makes sealing much easier. Since fibron is also made out of the same fiberglass that is used extensively in insulating walls and roofs, it has good insulating properties.³⁰

The process used to manufacture the fiberglass frame is called pultrusion. Glass strands are pulled through a tub of resin and formed in a preformer. The form is then pulled into a heated die where a chemical reaction, a cross-linking, occurs. This reaction hardens the material. This is still a new technology. Owens-Corning Fiberglass, one of only two manufacturers, has just begun marketing their product in five states in the mid-atlantic region.³¹

The next significant evolutionary step in improving the overall thermal efficiency of windows will, most probably, concern the sash and/or frame.

³⁰Bakke, 113.

³¹Ibid.

Segmenting The Window Market (Chapter 3)

The window market is not uniform. The wants and needs of consumers vary by price, by geographical region, by proximity to the sea and by personal taste. A manufacturer succeeds by identifying a particular requirement that is not being filled to the satisfaction of the consumer and producing a product that does satisfy.

The two crucial strategic questions facing a firm are where in an industry to compete and in what segments will 'focus' strategies be sustainable. To answer these questions an analysis must be done on the segments within the industry. An industry segment is always a combination of a product variety and some group of buyers who purchase it.¹

The purpose of this chapter is to conduct just such an analysis. I will examine the varieties of windows that are produced, the types of consumers who purchase them and, finally, the impact of geography on consumer preferences.

Buyer Segments The profile of a typical buyer fits one of these scenarios. He is purchasing windows for a new home (**new construction**) or to **replace** the ones he has now or to add **storm windows**. Each of these three segments has its own particular characteristics and requirements. And each

¹Michael E. Porter, Competitive Advantage: Creating and Sustaining Superior Performance (New York: The Free Press, 1985), 231.

responds differently to an economy that is growing, in a recession or even a depression.

Windows, sold primarily for new construction, have maintained a consistent sales rate of 18 million units per year over the last decade. This consistency is in spite of an overall decline in new residential construction in the latter part of the decade. Aluminum and wood, to include vinyl and aluminum-cladding, continue to dominate this market with 98% of the sales. Wood windows are clearly the product of choice for premium homes--the only segment of the home building market which is on the rise. Aluminum windows are the preference in the Southeast -- where new construction, unlike the rest of the country, is still growing.²

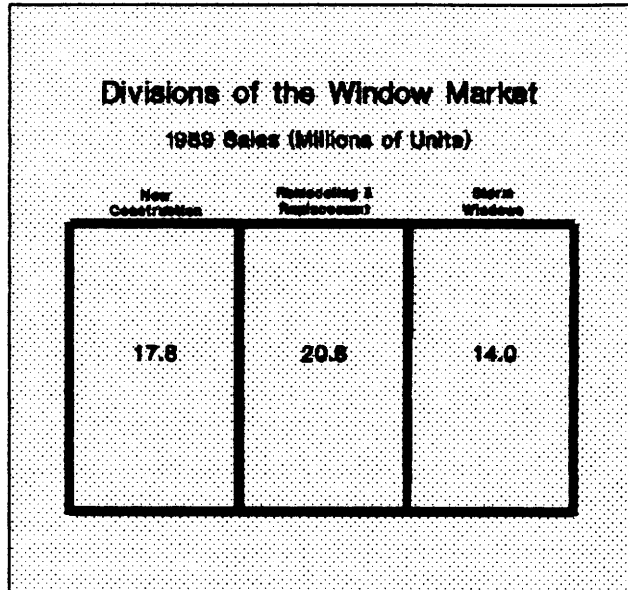
The replacement and remodeling division has shown significant growth over the decade going from 13.6 to 20.8 million units. The reason is two fold. First, the sales of existing homes has been strong and continues to be a strong segment of an otherwise lackluster real estate market. Second, upgrading a home's windows -- both thermally and aesthetically -- is a relatively inexpensive way for a new owner to personalize the purchase of an existing home.

Vinyl windows, primarily because of their ease in adjusting to the 'rough opening' in an existing home and their low maintenance requirements, have gained a consider-

²Ducker Research Company, Inc., Industry Statistical Review and Forecast (Des Plaines, Illinois: AAMA-MIR, April, 1990), 6.

able position in this market. Over the last decade vinyl windows have come from 5% of the replacement market to 29% - mostly at aluminum's expense.³

Sales of storm windows have been declining since their 1978 peak of 17.6 million units ('89 sales - 14 million units) and the decline is expected to continue. The use of sealed insulating glass has increased from 68% in residential construction in



1982 to 85% in 1989. This increase has relegated storm windows to the shrinking 'low-cost housing' and 'mobile home' market. The aluminum sash and frame does dominate this division with 96% of the market share.⁴

The chart above depicts the three divisions of the window market by buyer profile and the number of units sold, by division, for 1989.⁵

Product Segments Structural or value chain differences which produce different products define product segments.

³ Ibid.

⁴ Ibid., 7.

⁵ Ibid., 6-7.

Proxies that assist in defining product segments in the window industry include: price level, features, technology and performance. The price level is a self-explanatory criteria.

Features include the aesthetics of a window -- how neat and trim does it look or how appealing the wood frame may be? The sizes and shapes that are offered. The aesthetics involved in the glazing options. Is tinting offered? can you get a light blue window, does the window tilt in for ease of cleaning?

Technology includes low-E glazing. Is argon, krypton or a vacuum offered as an option? Does the frame have a PVC separator serving as a thermal-break? Is ultra-violet screening an option?

Performance includes the amount of maintenance required, the overall R value and the windows warranty.

I have identified 5 different product segments: standard, premium, custom, high performance and commercial windows. Each segment emphasizes a different proxy or combinations of proxies. The endless combinations of frame material, low-E, gas-filled, heat mirror, bow windows, etc. can all be placed into one of these product segments.⁶

There are over 150 window manufacturers and most serve a local market with a standard window product. 85% of the

⁶Porter, 241.

residential market requires at least a sealed insulated glass product. This consumer is sophisticated enough to realize the value of double-glazing but does not value or may not be able to afford a low-E, gas-filled unit. The average R-value for a window in this segment is about 2. The proxy emphasis is clearly on price level.

The premium category is best typified by Andersen. Andersen's standard window line is low-E, double-glazing with a vinyl-clad sash and frame. This window has an R value of 4. The quality of the materials and workmanship is excellent and backed by a 20 year warranty -- the best in the business. However, the selection of window types, sizes and shapes as well as the glazing options, are limited. The emphasis is not so much price level over technology as it is on a balance between all the proxies.⁷

The high-performance segment is intended for knowledgeable customers who can afford to pay a premium price for the most advanced windows on the market. Hurd's Insol-8 is a product that fills this segment perfectly. Insol-8 has two heat mirrors (low-E), argon gas between the compartments and a PVC separator to break the thermal bridge. It has an R value of 8 -- the highest in the market. The emphasis is definitely on performance and technology regardless of the price level.

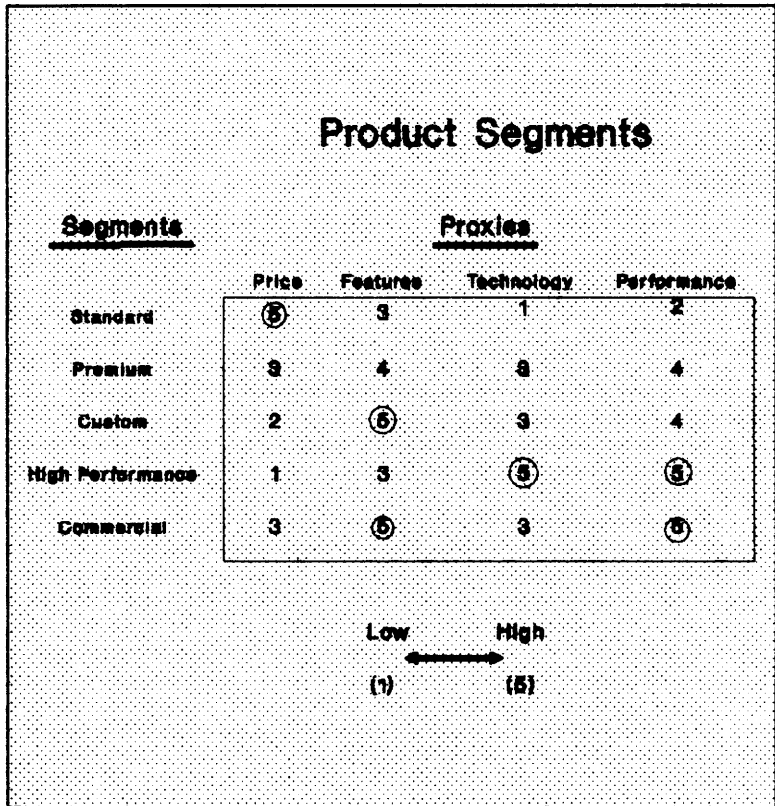
⁷Carl M. Cannon, "Golden Shackles," Business Month, September 1988, 56.

The custom category is best exemplified by Marvin. Marvin's goal is to "never have to say no to a customer". They have 9 glass options and, with an in-house department of architects, will build any size and shape window that a customer requires. The emphasis is on features over the other three proxies.⁸

The commercial category includes units for retail shops and high-rise office buildings. This is a special category because of the more

stringent building codes which apply. Many of the premium window manufacturers have windows that meet the initial code requirements but none of them has a product that passes all code requirements. The Pella corporation was

initially in this segment but has since branched out into the residential market. The focus is on features and performance.



⁸ John Harris, "The Window Frame as Fashion Item," Forbes, 30 April 1990, 125.

The previous matrix summarizes the emphasis placed on each proxy for every product segment.

Sash & Frame A second dimension to product segments is the material a window manufacturer uses for his sash and frame. There are two primary reasons why the sash and frame add a second dimension to this market. First, most of the technological developments in this industry have been at the instigation of the suppliers. Few suppliers are willing to limit their potential market by licensing their technology to only one manufacturer. Consequently, there is little proprietary knowledge owned by the manufacturers. Every major national company offers a double-glazing, low-E, gas-filled window. Trying to differentiate themselves based on the thermal performance of their windows alone is almost fruitless.⁹

The second reason is the tremendous overhead which would be required to construct a facility which is capable of producing any type of window frame. The decision on the frame material and associated manufacturing process to use is reached early in a window manufacturers life. Having made the decision -- the manufacturer must now build a plant to produce the desired frame product. Once built it is not possible, without considerable expense, to switch to another frame type. This is because the processes required to produce

⁹Ron Sanchez, "A Case Study in Onsite-to-Offsite Technological Innovation".

a vinyl frame are completely different than what is required to produce a wood or aluminum-cladding frame. Whereas the adding or dropping of a new glazing process may interrupt a node on the manufacturing line -- it doesn't stop the entire process nor require the large initial capital investment.

However, there is a certain amount of manufacturing synergism present in producing vinyl-cladding and wood frames or aluminum-cladding and wood frames. Most national manufacturers producing a quality window do offer two of these three frame options. One company, Ply-Gem, owns 3 subsidiaries which produce all of the window frame options -- but at different plants under different companies.¹⁰

Sash and Frame Options There are five primary sash and frame material options: aluminum, vinyl, wood, aluminum-cladding and vinyl-cladding. Chapter 2 discussed the advantages and disadvantages of each material.

Most quality residential frames are either wood or wood with aluminum or vinyl-cladding. This is an effort to combine the strength, insulating characteristics and pleasing aesthetics of wood with the low maintenance requirements of aluminum or vinyl. The thermal properties of all three systems are equivalent. The choice of one of these three systems is the critical decision faced by any window manufacturer trying to pursue the upscale market.

¹⁰Minda Zetlin, "Ply Gem: A Jewel in the Home Improvement Industry," Management Review, December 1988, 14.

In the '50's the Andersen Corporation chose a vinyl-clad window sash and frame after considering an aluminum-clad. According to their salesman their big concern at the time was how to attach the aluminum-cladding to the wood. Unlike aluminum, vinyl is extruded completely around the sash. There is no edge or lip which would require a mechanical fastener (screws or nails), glues or sealants. Vinyl-cladding also requires minimum maintenance and presents a neat, trim look.¹¹

The drawback to vinyl-clad windows according to Andersen's competitors is the very fact that the vinyl completely encircles the wood. According to them, the wood will still shrink and swell somewhat which will force the vinyl to do the same. Eventually the vinyl will crack and expose the untreated wood to the elements -- leading to rotting.¹²

A second concern is the long term affect ultraviolet radiation will have on the vinyl-cladding. Andersen has conducted accelerated UV studies which resulted in no unusual deterioration. They have also been producing vinyl-clad windows since 1966. However, there is still some concern among researchers that the vinyl may begin to crack.

¹¹Conversation with Bob Schwartz, sales representative for Andersen, on 6 September 1990.

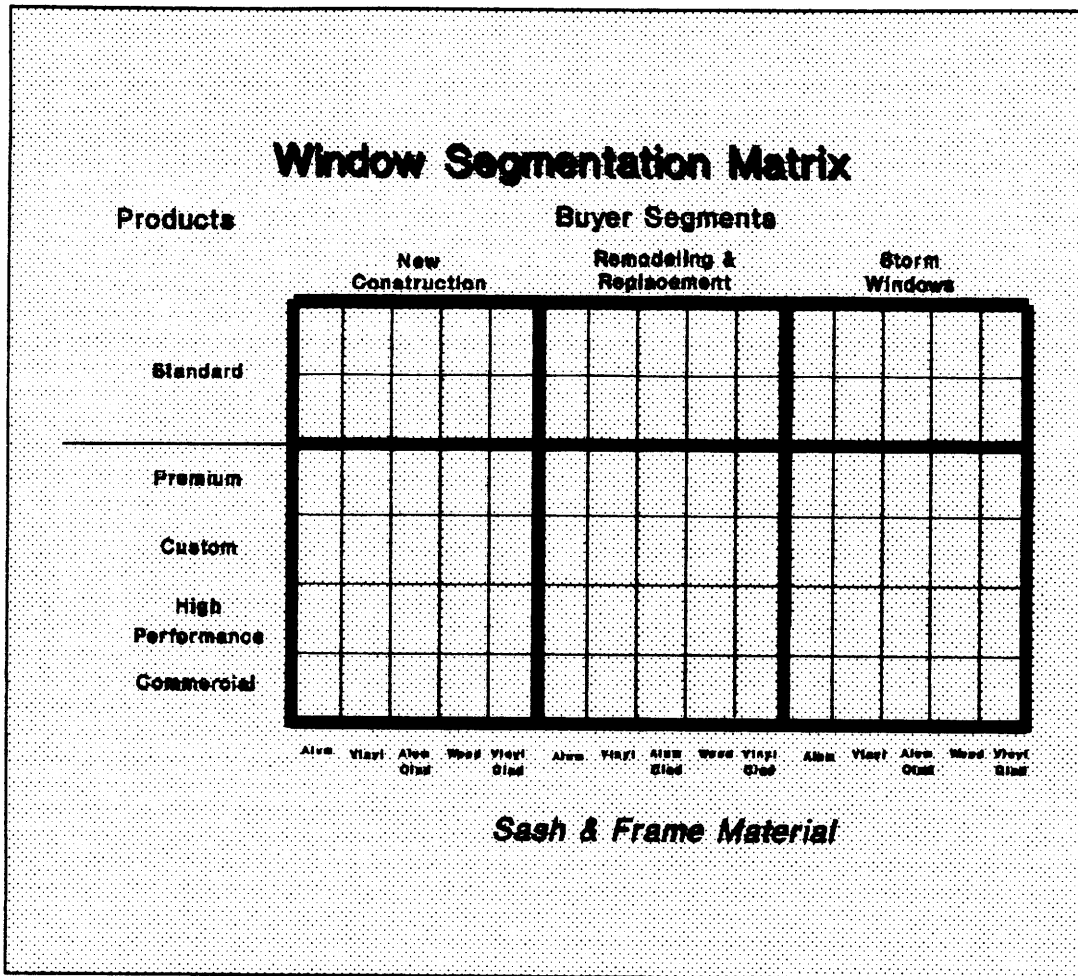
¹²Conversation with the local Pella Window Store salesman of 6 September 1990.

Many of the arguments for or against vinyl-clad frames work in reverse for aluminum-clad. Aluminum-cladding does not completely surround the wood frame. The advantage is that there is no harm done to the cladding when the wood shrinks or swells. The problem is attaching the end of the aluminum to the wood. This is accomplished a number of ways. Pella, the largest maker of aluminum-clad windows, uses a butyul sealant. Andersen has a valid concern when they state that this connection will always be a design weakness which can be exploited by water.¹³

Until recently, the aluminum-cladding was limited to only 4 colors. There are now over 50 options. However, fading is still a concern. Unlike vinyl-cladding, if UV radiation begins to take a toll, the aluminum-cladding can be repainted. Also, until the advent of Pella's permacoat paint, aluminum-clad windows were not recommended for use around salt-water. They now are. The same trim lines and neat look that consumers find appealing with vinyl also applies with aluminum.

A completed segmentation matrix for the window industry is depicted on the following page. The product segments and sash and frame materials are mapped onto the three buyer segments. This matrix will be used in Chapter 6 to position individual companies within the industry.

¹³Ibid.

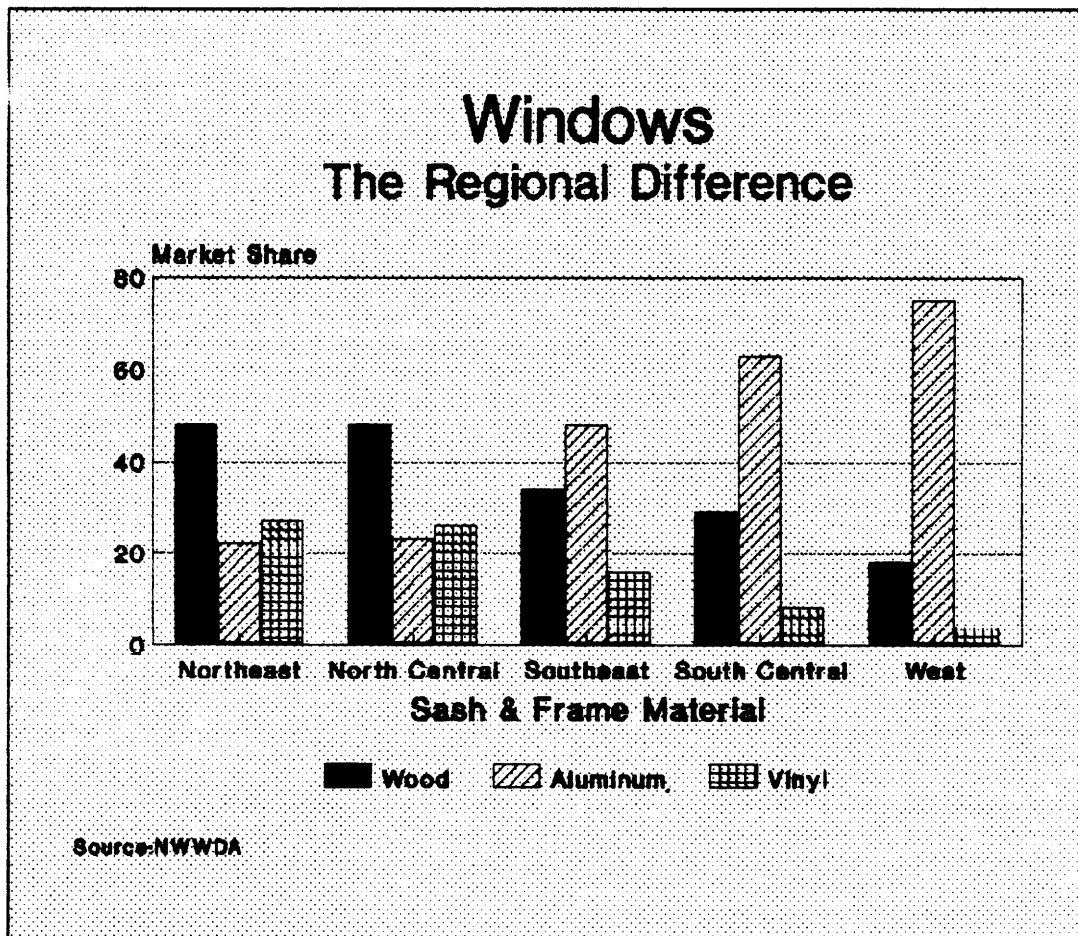


Regional Window Markets The final dimension in the window market is regionality. The popularity of a product is a reflection of the attributes consumers within the region value most. It can be based on weather, local customs or government regulations. An example is low-E glazing. In the North low-E glazing is most productive when facing the inside of a home. This keeps the radiant heat inside the home. In the South the opposite is true. The low-E glazing is most productive facing the outside and preventing radiant heat

from entering the home.¹⁴

In the window industry it is the popularity of the sash and frame material which varies most from region to region.

Wood windows (including vinyl and aluminum-cladding) are very popular in the Northeast and North Central regions. This product controls 48% of the market in both areas. Alum-



inum controls the market in the remaining regions of the country: 48% in the Southeast, 63% in the South Central and

¹⁴Porter, 246.

75% in the West. Vinyl has made inroads in the Northeast and North Central regions with 26% of both markets, but is not a significant factor in the rest of the country.¹⁵

Summary The window industry courts three buyer segments: those involved in new construction, those in the process of replacing or remodeling their existing home and those placing storm windows on their home.

The product segments include the standard window which is the minimum acceptable product for 85% of today's consumers; the premium window which achieves a balance of all four proxies; the custom window which focuses on features preferred by customers; the high performance window which maximizes performance and technology at the expense of price and finally the commercial segment. Additionally, each product segment is divided along the 5 sash and frame options: aluminum, vinyl, wood and both claddings.

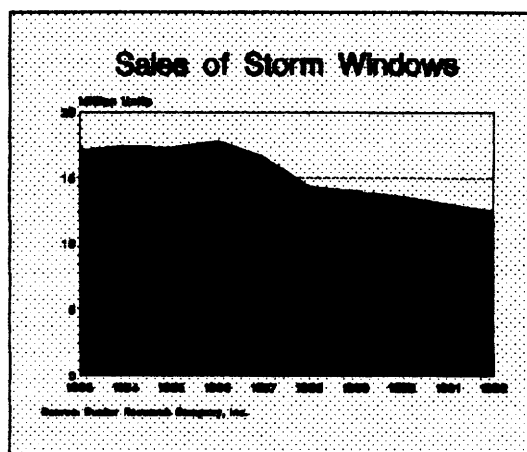
Finally, preferences for a particular frame type vary sharply between regions of the country. Wood is very popular in the Northeast and North Central. Aluminum is strong in the remaining parts of the country. However, vinyl windows are becoming popular everywhere at the expense of aluminum.

¹⁵Basic Supply Home Centers.

Growth in the Window Market (Chapter 4)

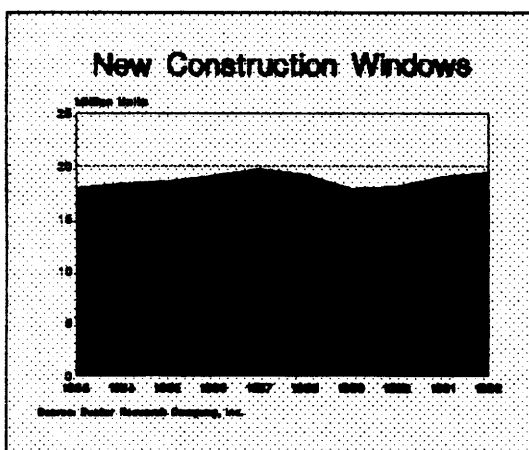
This chapter examines the growth trends in the window market during the past decade, predicts the direction the market will head, and addresses a fundamental reason why window manufacturing has gone from a largely on-site process to primarily off-site.

Growth trends in the window industry vary directly with the three buyer segments discussed in the previous chapter. Storm windows have continued to decline since their peak year of 1978 when 31.1 million units were sold. The forecast for 1990



anticipates 13.5 million units and is expected to drop another million units by 1992.

The above graph illustrates the loss in sales over the last decade.¹

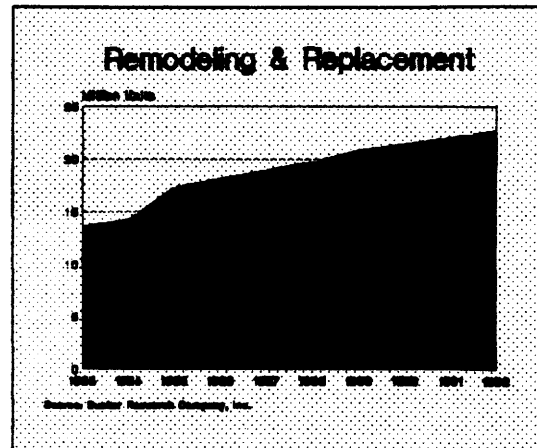


The outlook for the new construction segment is more promising than for storm windows -- but still not a vibrant mar-

¹Ducker Research Company, Inc., Industry Statistical Review and Forecast (Des Plaines, Illinois: AAMA-MIR, April, 1990), 7.

ket. In 1983 17.9 million windows targeted for the new construction market were sold. There was a gradual rise to 19.6 million units by 1987 and then a decline back to 1983 levels. This segment is expected to increase by a million units during the next couple of years.²

Unlike the two previous segments, remodeling and replacement windows have enjoyed significant growth during the period. In 1983 only 13.6 million units were shipped but this is expected to rise by over 40% to 22.7 million units by 1992.³



Due to the continued decline in the storm window segment and the fact that none of the major manufacturers target this market in particular the remainder of this chapter will focus on 'prime windows'.

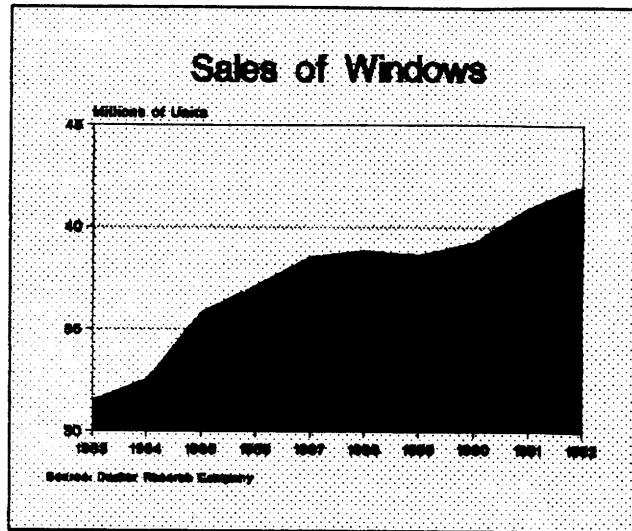
The 'prime' window market (new construction and replacement and remodeling) has enjoyed considerable growth during the past decade. It jumped from 31.5 million units in 1983 to 38.8 million units in 1988 according to an industry forecast by the Ducker Research Company. Due to the countries economic slowdown and the subsequent dropoff in residential

²Ibid., 6.

³Ibid.

construction the market leveled off from 1987 to the present. The forecast, which is depicted in the following chart, anticipates a return to a growing market in the immediate future (1990 - 1992).

The significant fact about the leveling off of the window market from '87 till now is not the 'no growth' aspect but rather the 'no negative growth' aspect. The window manufacturers, unlike almost any other component of the



housing 'value-added' chain, has not undergone a downturn in recent years. Why?

The decline in residential construction and, you would expect, the window market, has been partly offset by the continued growth in both the premium home construction and the replacement market.⁴

The number of windows per home can serve as an indicator of the quality and type of home being built. Additional windows add to the construction costs, add to the aesthetic value and consequently, raise the selling price of a home. The more windows in a home the more expensive it will

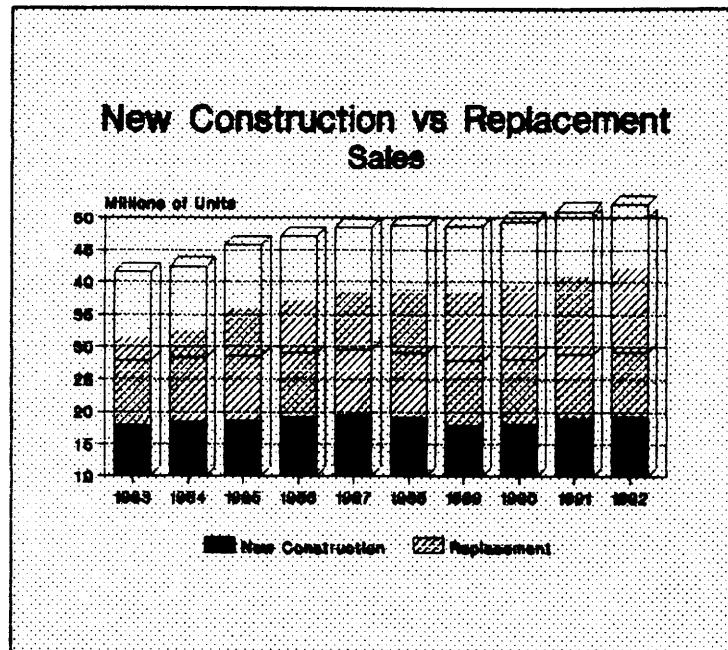
⁴Building Supply Home Center, "Get in Step with Regional Trends," Wood Windows and Doors.

be. In 1984 the average single family home had 12.5 windows. In 1988 the average had risen to 14.7. This rise in the number of windows per home parallels the reported rise in the construction of high-end, single family homes -- a segment of the housing industry that is less cyclical than most. Individuals with large incomes, who can afford to purchase high-end homes, are better insulated from the negative effects of economic cycles. Consequently, the increase in the construction of high-end homes (which have more windows) has mitigated the affects of the overall slowdown in residential construction for window manufacturers. This partly explains why the window industry has been able to avoid the effects of the weak residential construction market the country is currently experiencing.⁵

The second reason is the strong remodeling and replacement market. A relatively inexpensive way to personalize the purchase of an existing home as well as improve the overall thermal performance of the home is to replace the existing windows. There are about 75 Million existing homes in this country with about 1.5 Million new homes adding to the number each year. If just 2% of the owners of existing homes replaces their windows each year the replacement demand will equal the total number of windows being placed in new homes. This numeric advantage may explain why in 1988, for the first

⁵Ducker.

time, sales for remodeling and replacement (19.7) windows exceeded new construction sales (19.1). With reports of strong sales of existing homes, this trend is expected to continue.⁶



The strong remodeling and replacement market coupled with the trend towards the construction of larger, high-end single family homes has kept the window market moving in a positive direction despite the overall negative growth of the residential construction market. These two factors have insulated the window manufacturers from the cyclical nature of residential construction.

On-Site to Off-Site "By the 1970's, essentially all production of residential windows had shifted from jobsites to offsite shops or factories." This shift occurred for many reasons. One of the most important was the assurance of a steady market.⁷

⁶Building Supply Home Center.

⁷Ron Sanchez, "A Case Study in Onsite-to-Offsite Technological Innovation".

A manufacturer cannot risk a large capital investment to build a plant which produces a product that may not have a market in a year. He must have some confidence that the demand for his product will be, at a minimum, reasonably consistent.

This is the case with windows. As the economy expands and new construction flourishes the demand for windows is great. However, during a recession, when new construction drops the remodeling market rises and is able to sustain a demand for windows.

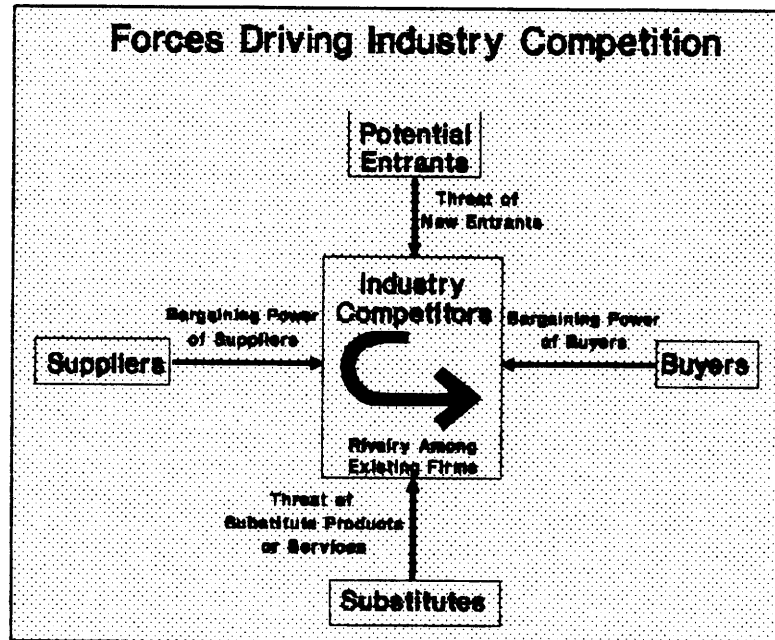
These two segments work well together and allow a manufacturer to take a reasonable risk and invest time and capital in the construction of a factory that is capable of servicing a region if not the entire country.

The 5 Competitive Forces (Chapter 5)

This chapter identifies the key structural features of the window industry that make it profitable. The analysis follows the framework established by Michael Porter in his 1980 book, Competitive Strategy. The five competitive forces: entry, threat of substitution, bargaining power of buyers, bargaining power of suppliers and rivalry among current competitors, work together to determine the intensity of industry competition and profitability.¹

The window market is divided into two broad quality segments: standard and upscale (Chapter 3). Some of the forces that have made the upscale market so profitable are not relevant to the standard market. This analysis focuses on the upscale market.

Barriers to Entry High 'barriers to entry' discourage



¹Michael E. Porter, Competitive Strategy, (New York: The Free Press, 1980), 4.

new companies from entering an industry. This limits the amount of competition for a particular market and usually results in higher profit margins for those companies that are in the industry. Of the six major sources of barriers to entry identified by Porter, four are particularly vital in limiting competition within the window industry. Those four are economies of scale, product differentiation, capital requirements and the expected retaliation of existing competitors.

Economies of Scale Economies of scale occur when there is a decline in unit cost as the amount produced increases. An industry which exhibits economy of scale forces a new competitor to do one of two things. He can enter the industry on a large scale which requires a sizable capital investment and may provoke sharp retaliation by the established companies. Or he can enter on a small scale, where he is not noticed and won't draw much attention but also suffers the unit cost disadvantage associated with economy of scales.

Andersen uses a two-step distribution system so that they achieve economy of scales. Their personnel concentrate on simple assembly to optimize production runs at their Bayport, Minnesota facility. Their distributors do all the fabricating and modifying required by Andersen's customers.

The window industry enjoys economy of scales.²

Product Differentiation Achieving product differentiation requires producing a quality product, educating the consumer through advertising of the relative merits of their product versus the competitors and providing reliable service after the buyer has purchased the product. As discussed in Chapter 3, there is little proprietary technology developed by the window manufacturers. Almost all of the new products in the industry are either a result of supplier innovation or research accomplished at the universities. The suppliers, unwilling to limit their potential market to a few companies, license their innovation to any interested manufacturer. Consequently, most companies have equivalent products.

Differentiating windows through advertising has gone from a secondary consideration in the early 1980's to a major expenditure recently. A review of the 1987 advertising budget for a few of the major companies indicates just how important this has become. Peachtree, a relatively new entry into the upscale window market, spent \$4 million, Pella spent \$10 million and Andersen, who gets much of the credit for escalating the advertising battle, spent \$12 million.³

But the amount of advertising is not the sole change in

²Gregory Nejineh, "Andersen: A Window of Opportunity," A Shearson Lehman Hutton Report on Morgan Products Ltd. (April 6, 1989): 52-53.

³Kate Fitzgerald, "Ad storm hits window/door field," Advertising Age, October 24, 1988, 12.

the industry. The companies have also become very sophisticated at how, where and when they market their product. Marvin caters to specific buyer segments with individual ad campaigns, segment-specific sales tactics at trade shows and product literature addressing the various categories' concerned.⁴

Differentiating a new companies window from the products of the existing national companies would require a significant investment in both manufacturing costs to produce, at a minimum, an equivalent product and advertising costs to inform and educate the consumer. A new competitor, trying to break into the upscale market, would have to invest millions in advertising, a sunk, unsalvageable cost, with no guarantee of results. Achieving product differentiation would be both costly and risky.

Capital Requirements Entering the upscale window market requires a large capital expenditure. A significant investment is required to build a "highly-automated plant" such as Andersen's or develop a window CADD system and carry a department of architects as Marvin has. At least the plant has some salvage value. The financial stake needed for R&D to produce a superior window has no value if the final product is not a commercial success. Also, the money spent on advertising is a sunk cost if the company fails. The total

⁴"Marvin: Real-World Window Sales," Business Marketing, October 1989, 52.

financial risk involved with the plant, R&D and the ad budget combine to deter many mildly curious companies from entering the market.⁵

Expected Retaliation The final barrier to entry of particular importance to a company analyzing the window industry is the retaliation that a newcomer can expect by the established firms. Examining the reaction of the major firms in the past in response to a new competitor is the best indicator of what to expect in the future.

Andersen and Pella, both originally window specialist, have recently moved into the door manufacturing business. In response to their move, Peachtree, the leading door manufacturer, retaliated by moving into the window business. Pella's primary market was aluminum-clad commercial windows but later moved into the custom-made wood window market. Marvin, the industries leading wood window manufacturer retaliated by producing aluminum-clad commercial windows.⁶

Companies with a history of actually moving into a different, though related, industry to attack a newcomers original market would not appear to be sympathetic when a startup company enters their market.

The upscale window industry possesses a number of high barriers to entry. The manufacturing process enjoys economy

⁵Carl M. Cannon, "Golden Shackles," Business Month, September 1988, 63.

⁶Fitzgerald.

of scales. The established companies spend millions each year ensuring their product is perceived as 'state of the art'. There is a large and risky initial capital investment on plant facilities, R&D and advertisement. Finally, a new competitor can expect the major companies to retaliate if and when they enter the market. All combine to make this industry a risky venture for a new company.

Intensity of Rivalry Among Existing Competitors

Intense rivalry within an industry can be a 'double-edged' sword. When competitors use price competition to compete the entire industry can suffer. "Price cuts are quickly and easily matched by rivals, and once matched they lower revenues for all firms." On the other hand, if competitors use advertising as the medium through which to compete all companies may benefit. The advertising educates the consumer on the merits of quality windows which, in effect, expands the demand. Consequently, all firms benefit from the growing market.⁷

There are numerous factors which have combined to determine the 'intensity of competition' within the window industry. However, in the upscale segment of this industry, the lack of intensity is probably more appropriate.

Dominated by a Few Competitors According to the August 1990 Remodeling magazine there are at least 161 residential

⁷Porter, 17.

window manufacturers in the United States. This, by most standards, would constitute a fragmented industry -- an industry where competition would be fierce. However, the fragmented window industry is clearly dominated by a few. Additionally, those few dominant companies have positioned themselves in different segments of the overall window market (Chapter 3) allowing them to avoid much direct competition. This allows the respective segment leader to have a coordinating role within his segment and impose discipline, through devices such as price leadership, on the smaller companies.

Andersen has 10% of the total window market but owns almost the entire premium, vinyl-clad window segment, Marvin has 5% of the total market but dominates the custom-made wood window segment and Pella, with 6% of the market, controls the aluminum-clad segment. Each of the 'big three' is positioned so they do not compete against each other directly.

However, when a particular product does compete directly against a competitor's the segment leader sets the price and the other follows. As an example, whenever Marvin's windows compete directly with an Andersen window Marvin follows the industry leader and sets the price accordingly (actually a couple of dollars more). However, on a custom window that doesn't have a close Andersen alternative Marvin adds 10 to 20% to the price. Everyone follows the segment

leader and they all make a handsome profit.⁸

Rapid Industry Growth A company, staying within one industry, can grow in one of two ways. The first is to gain market share at the expense of the competition. The market is a zero sum game; for every new customer I win one of my competitors has lost a customer. A volatile growth strategy which invites fierce competition from the companies in the industry.

The second strategy is to just grow with the industry - providing the industry is growing. "Rapid industry growth insures that firms can improve results just by keeping up with the industry and where all their financial and managerial resources may be consumed by expanding with the industry." This is a much more stable strategy.⁹

Chapter 4 outlines the tremendous growth in the window industry during the 1980's. Total sales increased 23% from 1983 to 1989. This growing industry has allowed companies such as Andersen and Marvin to focus more on growing with the industry than competing against each other. This lack of internal competition results in a 'Kinder, gentler' industry with higher profit margins for all.

Differentiated Products The window industry is not homogeneous and windows are not perceived as commodities by

⁸John Harris, "The window frame as fashion item," Forbes, April 30, 1990, 125.

⁹Porter, 18.

the informed consumer. Chapter 3 outlines the various segments within the industry. On a macro level it breaks out into standard and upscale windows. The upscale segment is further subdivided into premium, custom, high-performance and commercial windows. Each of the major firms

Window Segmentation Matrix

| Products | Buyer Segments | | | | | | | | | | | |
|------------------|------------------|--|--|--|--------------------------|--|--|--|---------------|--|--|--|
| | New Construction | | | | Renovating & Replacement | | | | Store Windows | | | |
| Standard | | | | | | | | | | | | |
| Premium | | | | | | | | | | | | |
| Custom | | | | | | | | | | | | |
| High Performance | | | | | | | | | | | | |
| Commercial | | | | | | | | | | | | |

Seal & Frame Material

fills a specific segment within the overall industry. Their product is differentiated from the competition by thermal performance, maintenance requirements, aesthetics and the warranty. This differentiation is maintained by million dollar advertising campaigns. The result are buyers with preferences and loyalties for a particular company. Consumer loyalty and preference creates layers of insulation against competitive warfare. Time and money is needed if a company hopes to overcome established consumer loyalty for a particular brand name. Even then, there is no guarantee that the consumer will change his preferences.¹⁰

Exit Barriers High exit barriers, whether they are economic, strategic or emotional, keep companies in an

¹⁰Porter, 19.

industry even though they are making little, if any, profit. Porter identifies 5 sources of exit barriers: specialized assets, fixed costs, emotional barriers, strategic interrelationships and government restrictions.

Government restrictions seldom apply in the United States and definitely do not apply in this industry. Strategic interrelationships are relevant if a business unit is but a piece of a parent corporations overall strategy. Since almost all of the window manufacturers are family owned, private companies -- strategic interrelationships are not relevant.

Specialized assets in the form of industrial machines for cladding extrusion, injecting argon gas between the glazing and quality assurance are a necessity in the upscale window industry. However, most companies minimize their investment in these 'hard' assets by operating their plants 24 hours a day, 7 days a week.¹¹

There are always costs associated with exiting an industry. However, the window manufacturers have done their best to minimize the contracts and agreements that may affect their decision to leave the industry. For example, Andersen does not have a contractual distribution agreement with their largest distributor, Morgan Products. A 60 day notice is all the advance warning Andersen needs to give to Morgan before

¹¹Cannon, 63.

stopping production.¹²

The one exit barrier that does exist would be emotion. Andersen was founded by Hans Andersen in 1903 and has been run by family members or close associates ever since. The Andersen Corporation is synonymous with Bayport, Minnesota. The company employs about 20% of the towns citizens and annually injects over \$200 million into the local economy. Four Andersen controlled foundations with a total endowment of \$240 million contribute substantially to local civic events and charitable causes. The Marvin Lumber Company was founded by George Marvin in 1906 and is being run by his grandson Frank today. Pride, family tradition and loyalty to the local community would make leaving the window industry for families such as the Marvin's and Andersen's an emotional one.¹³

However, emotion aside, there are no staggering exit barriers which would force an unprofitable company to stay in the industry and fight for every point of market share it can get. This ease of exit allows the unprofitable companies to get out gracefully leaving the market to only the most efficient and hence, profitable firms.

The combination of a segmented industry with a few major companies, each occupying a different division; an

¹²Shearson Lehman Hutton.

¹³Harris, 125.

expanding market that affords firms the option of concentrating on growing with the industry rather than battling the competition; a differentiated product and low exit barriers unite to create an industry where competition is best described as 'gentlemanly'.

Pressure from Substitute Products A viable substitute product impacts an industry by placing a ceiling on what manufacturers can charge for their product. Once a manufacturer exceeds that ceiling consumers will switch to the substitute product.

There are two substitutes for upscale windows: no windows and standard windows. Windows certainly add much to a home. They are functional -- allowing the surrounding environment to be enjoyed by the inhabitants. They also allow the owner to customize his home and have it reflect his personality. But they are not a necessity. If prices were to become outrageous the home builder could respond by building homes with fewer windows. Or, if premium, thermally efficient windows required an upfront cost that the consumer would not recoup in the foreseeable future it wouldn't be to their economic benefit to purchase them. They would buy the standard, local windows and just pay the higher heating bills each year. Consequently, the upscale manufacturers such as Andersen and Marvin would price themselves right out of the market.

Internal greed is the only concern premium window

manufacturers must guard against. There is no direct substitute outside the industry for windows. But consumers do have alternatives if prices become too high. They can use fewer windows in their homes or they can forego the pricier, quality windows for simple, standard models.

Bargaining Power of Buyers Buyers can compete with the industry by forcing down prices, bargaining for higher quality or more services and playing competition against each other -- all at the expense of industry profitability.¹⁴

The consumer has little leverage while negotiating with the window manufacturers. The home building industry is too fragmented (estimated at 100,000 firms) to demand concessions from the manufacturers based on the quantity of their purchases. On average, windows comprise about 3% of the final cost of a home. This amount isn't large enough to expect builders to spend an inordinate amount of time searching for a better deal.¹⁵

In fact, the only real power a window buyer has is that there are no switching costs. He can purchase Andersen windows for one home and Marvin windows for the next. There are no inherent disadvantages which may prevent him from going from one brand to another.

Bargaining Power of Suppliers Strong bargaining power

¹⁴Porter, 24.

¹⁵Building Construction Cost Data 1989, (Kingston, MA: R.S. Means Company, INC., 1988), 192.

by suppliers reduce margins by raising costs when the industry cannot pass those additional costs along to the consumers and still successfully compete against substitutes.

The primary materials required to produce a window are all commodities except for the glazing. Aluminum, vinyl, wood and argon are all common, readily available materials. Therefore, the suppliers of these materials have little leverage when negotiating contract prices with window manufacturers. If an argon gas supplier tries to raise his price a window manufacturer will simply find a second supplier. After all, argon is one of the cheapest and most plentiful elements on earth.¹⁶

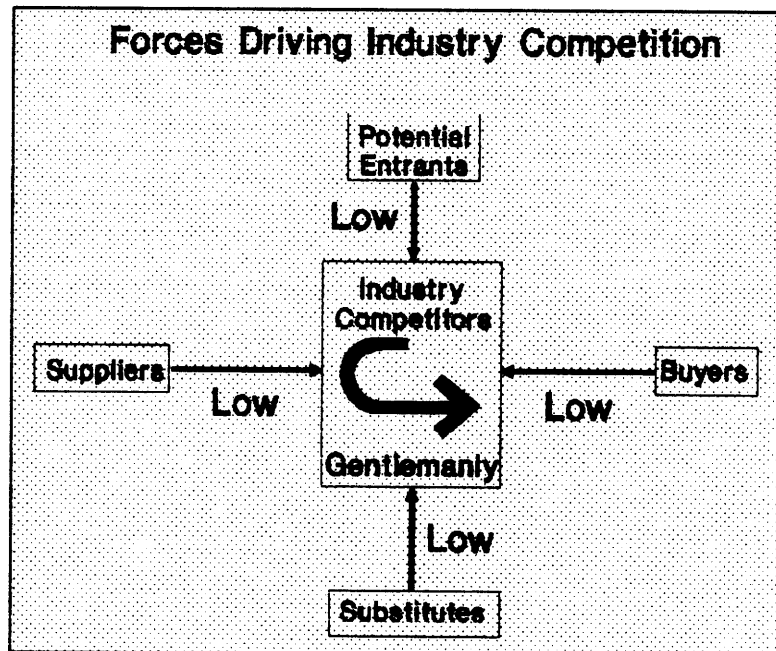
Even suppliers of glazing and low-E processes cannot afford to raise prices without a rationale. Numerous companies continue to develop and improve new techniques for producing both hard and soft coat low-E products.

The one supplier that does exert great pressure on the window industry is labor. Despite the new technology and the highly automated facilities, labor still has a major role in the manufacturing of windows. So much so, that Andersen, in particular, goes out of its way to keep their employees happy. In 1912 Hans Andersen instituted the first profit-sharing plan for his employees. In 1987 the typical employee received a \$27,000 bonus check which brought the companies

¹⁶Steve Andrews, "Window Shopping," Builder, September 1986, 67.

average pay for the year up to \$60,000. "In return for their generous compensation package, Andersen expects employees to be loyal and quiescent." Even back in 1912 Andersen realized the bargaining power of labor and decided to pay his employees handsomely to ensure their support.¹⁷

Summary The collective strength of the five competitive forces determines the ultimate profit potential of any industry. This analysis of the window industry has indicated why the window manufacturers have realized excellent profit margins over the years.



Both supplier and buyer power are low. The biggest concern are labor problems and the companies prevent these by taking excellent care of their employees.

The only substitute for quality windows is to use inefficient windows or nothing at all. This has placed a ceiling on the prices the manufacturers can charge for premium

¹⁷Cannon, 60.

windows.

The entry barriers are significant. A new firm would have to enter this industry in a large way to enjoy economy of scales. This would require a substantial initial investment. Additionally, advertising is a requirement if the company wants to pry consumers away from existing firms. A risky expense with no salvage value. The exit barriers are low which allow the inefficient companies to leave gracefully.

Finally, because of the segmented nature of this industry and the relatively unopposed positions each of the major firms have taken -- there is no cutthroat competition. All of these factors combine to make the window industry hard to get into, but once in, a profitable place to stay.

Company Analysis (Chapter 6)

Chapter 2 identified the relevant current and future window technologies; chapter 3 partitioned the total window market by buyer and product segments; chapter 4 examined the growth of the industry and chapter 5 examined the competitive forces that have determined the ultimate profitability of the industry. This chapter analyzes the notable national window manufactures. It identifies where they are within the industry; how they got there and where they appear to be going. Finally, it combines all of the market segment information presented in earlier chapters and the individual company positions developed here to produce a strategic map of the overall industry.

The companies analyzed are Andersen Corporation, Ply-Gem Industries Incorporated, Marvin Lumber & Cedar Company, Rolscreen Company (Pella) and Hurd Millwork Company.

Andersen Corporation

History In 1903, Hans Jacob Andersen established the Andersen Lumber Company in Hudson, Wisconsin. However, the lumber industry had already reached its peak and Andersen realized he needed to do something different if he was going to succeed.

His plan was to mass-produce door and window frames, a novel concept at the time. In those days, doors and windows typically were built by carpenters on the construction site to whatever dimensions looked right. If Andersen could persuade the local builders and building sup-

pliers to accept a few standardized dimensions, he could mass-produce window frames. The first year the company marketed its new products (1905), Andersen and his sons broke even. The second year, their production doubled. In 1907, it doubled again and Andersen Lumber was on its way.¹

Hans Andersen ran the company up until his death in 1914 -- long enough to instill his business philosophy throughout. "Make a product that is different and better. Hire the best people and pay top wages. Provide steady employment insofar as humanly possible." This emphasis on taking care of the employees produced a number of innovative employee welfare initiatives. In 1916 Andersen started one of the first Company Health and Life Insurance programs; in 1923 everyone in the company was authorized a two week paid vacation and in 1924 each hourly employee had the opportunity to earn bonus pay based on productivity.²

The present day results of these and other innovations is a company that is harder to get into than many colleges. Once an employee, always an employee. Turnover is practically nil; nepotism encouraged and loyalty required. The financial payoff is exceptional -- an annual paycheck of over \$60,000 for the typical employee. The payoff for the Andersen Family has also been exceptional. A recent Forbes article estimates

¹Carl M. Cannon, "Golden Shackles," Business Month (September 1988): 60.

²Ibid., 61.

the family fortune at \$450 Million.³

In 1913, Hans Andersen moved his company across the river out of Wisconsin and into Bayport, Minnesota. They haven't moved since and currently dominate the western bank of the St. Croix river with an automated plant which sits on a 100 acre industrial site.

It is at this site, over the last 80 years, that Andersen, working closely with their suppliers, developed many revolutionary window products. In 1937 they began marketing double-hung windows, in the 1940's it was sliding glass doors, in the 1950's awning windows and in 1966 the introduction of vinyl-clad windows under the 'Perma-Shield' name. Perma-Shield, a vinyl-clad sash and frame window, is still Andersen's standard product. Recently, Andersen added low-E glazing to their Perma-Shield line. An option of injecting argon gas between the glazings is also available.

Product development is not the only area where Andersen has been innovative. They are given the credit for igniting the current advertising battle among the upscale window manufacturers. In 1987, Andersen spent \$12 million on advertising to include television ads -- an industry first. They also have just signed contracts with their distributors to place billboards on the sides of distribution trucks. This will ensure constant, mobile advertising. With initiatives

³Harold Seneker, "Family Fortunes," Forbes (October 22, 1990): 282.

such as these it is no surprise that Andersen enjoys unsurpassed brand recognition.

Their two-step distribution system is also very innovative. Andersen only produces a discrete number of different window sizes and shapes. However, their advertisements emphasize the numerous ways these shapes can be placed together to give the appearance of custom-designed windows. The reason they limit the variety of their windows is so they can achieve economy of scales in the production process. They then rely on their distributors, working in one of the 120 national distributor warehouses, to fabricate or modify these standard shapes to satisfy the demands of the consumer.

Current Situation Andersen has 10% or \$1 billion of a \$10 billion industry. They are at least twice the size of their nearest competitor -- in a very fragmented industry. To say they dominate the vinyl-clad window segment of this industry would be inaccurate. A more appropriate statement is that they are the premium, vinyl-clad window producer for both new construction and replacement window buyers.

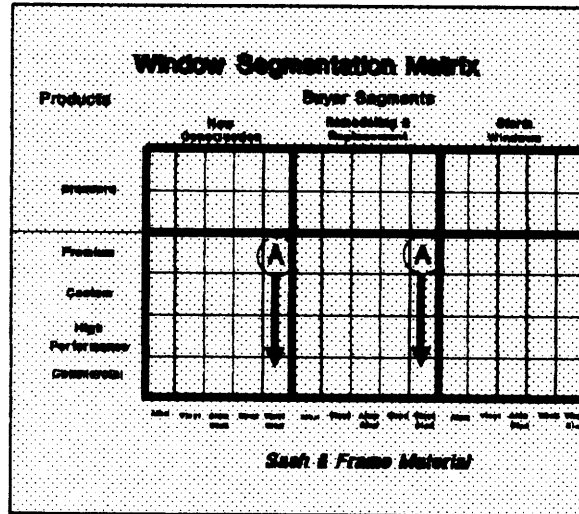
75% of Andersen's current sales occur in the Northeast and North Central regions of the country but they are positioning themselves to expand both geographically and by product line. By placing the low-E coating on the inside of the outside glazing of their Perma-Shield window, Andersen has a product specifically designed for warmer climates. Ideal for the South -- where much of the current housing

growth is located.

They have also introduced a new 'Flexiframe' product line which was designed for the different 'stationary' window shapes and sizes which may be desired. The operable word is stationary -- the flexiframe windows will not operate (ie. open and close). However, this may signal Andersen's intention of eventually moving into the full-fledged 'custom-made' product segment.⁴

Andersen has also committed itself to exploring the commercial market. They have an "in-house group of architects who review large commercial products and evaluate how compatible various Andersen products would be." They have also developed a proprietary CADD-I computerized detail file to simplify the design process and post design production.⁵

The adjacent matrix depicts Andersen solidly positioned in the premium, vinyl-clad segment of the industry for both the new construction and remodeling buyer segments. The arrows represent Andersen's move into both the custom-made and commercial



⁴"A Complete Guide to Andersen Windows & Patio Doors.," (brochure), (Andersen Corporation, Bayport, MN., 1989): 113.

⁵Ibid.

segments of the industry.

Hans Andersen believed that "6% was a reasonable return for those who created and managed the Company, he figured; the rest should go to the workers." This philosophy appears to still be the guiding light at Andersen. A review of the revenues and employee bonuses substantiates this and gives an indication of the overall profit margin that Andersen enjoys.⁶

Andersen's competitors estimate that the industry leader has a profit margin somewhere between 20 and 30%. In 1987 Andersen reported total sales of \$964 Million. The 6% 'return on investment' for the company according to Hans Andersen would be about \$58 Million. We also know that the average employee received a \$27,000 bonus check, based on Company profits, at the end of the year. There are approximately 4000 Andersen employees for a total bonus payoff of \$108 Million. If Hans Andersen's philosophy is still being followed then the total of 1) company return on investment plus 2) the bonus payoff -- divided by the total sales -- should give us at least the minimum profit margin for the company in 1987.⁷

(6% ROI + Bonuses) / Sales = Profit Margin

(\$58 M + \$108 M) / \$964 M = 17%

⁶Cannon.

⁷Cannon, 56.

This 17% profit margin represents the minimum margin the company must be seeing. Besides the bonus checks there is also an Employee Stock Ownership Plan which was initiated in 1975. Today the Andersen employees own 30% of the company. There are also four Andersen controlled foundations with a total endowment of \$240 Million which make significant contributions to the local communities. Taking these additional factors into consideration the profit margin generated at Andersen is probably in the low to mid twenties -- consistent with what their competitors assumed.

Summary Andersen is easily the largest and probably the most profitable of all US window manufacturers. They have positioned themselves well to expand both geographically (South) and into other market segments (custom-made and commercial). They demand much from their employees but reward them accordingly.

But Andersen may be heading for trouble. It appears that Andersen improves their overall productivity primarily by squeezing more and more effort from their employees. By all accounts, working for Andersen is a very demanding and grueling job. Bonus pay is a direct function of a team of employees exceeding their quota for the shift.

However, there are definite limits or ceilings to what human beings can physically accomplish. The 9 second 100 meter dash is one example. After 80 years, Andersen employees must be approaching this productivity ceiling. If so, then

Andersen must allocate resources to research and development of new technology which, hopefully, will improve their overall worker productivity. They cannot expect to continue growing by demanding more from their employees alone; they must either assist their people by providing them with new technology which makes the individual worker more productive or invest in another plant -- thereby increasing overall capacity.

PLY-GEM

History Ply-Gem Industries of New York City is an atypical window manufacturing business -- it is a publicly traded company. The company was founded in 1943 as a small wood products firm and continued as such until the early 1980's. In 1982 Jeff Silverman became CEO of the company and almost immediately started on an acquisition campaign.

During the last seven years Ply-Gem has examined over 350 firms; seriously attempted to purchase 12 of them and was successful on 11 occasions. The company is now best described as a manufacturer and distributor of Do-It-Yourself home-improvement products.

However, Silverman is not looking for commodity manufacturers but for companies that produce specialty items with leadership or potential leadership positions in growth niches. "We want companies whose products have some quality that allows them to command a higher price than the standard product in the industry. Not only does this tend to preserve

the companies' profitability, it reduces the likelihood of 'cannibalism' -- competition among subsidiaries.⁸

He is also a firm believer in synergy. There must be a mutual benefit for both the acquirer and the acquiree. This ranges from shared customer lists to access to wider distribution channels. He even went so far as to create a Vice-President of Synergy.⁹

Three of the twelve firms that Ply-Gem attempted to buy were window manufacturers: SNE, Great Lakes Windows and Wolverine Technologies. They were successful in 1986 with Great Lakes Windows and in 1989 with SNE. If they had succeeded with Wolverine Technologies it would have made Ply-Gem the country's largest producer of vinyl windows.¹⁰

SNE SNE, located in Wassau, Wisconsin, produces primarily wood windows (85% of sales) for both the new construction and remodeling market. They are expecting sales of \$130 Million in 1990. This places SNE fifth on the list of the largest window manufacturers in the country. They market their windows under the Crestline and Vetter brand names.

SNE has just begun to produce their 'Renaissance' window line which has a vinyl frame and a wood sash. The

⁸Minda Zetlin, "Ply Gem: A Jewel in the Home Improvement Industry," Management Review (December 1988): 14.

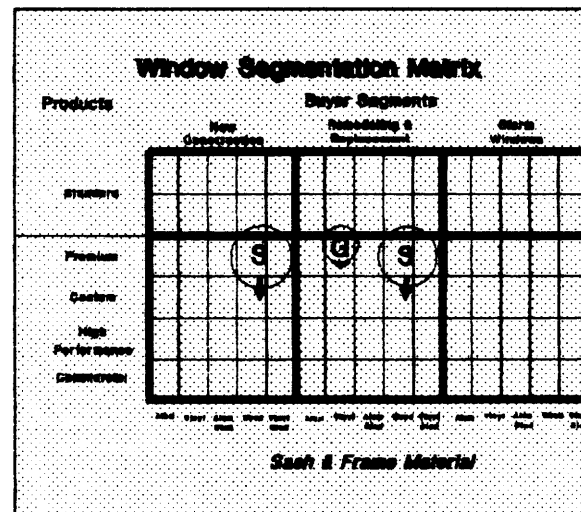
⁹Ibid., 16.

¹⁰Silverman made a bid of \$18.50 a share, then withdrew when a higher bidder appeared at the last minute. (Zetlin.)

vinyl frame allows for easy modification to the existing opening in a wall and the wood sash gives the consumer the beauty of wood. It appears to be an ideal product for the remodeling segment. They have also recently honed their 'custom-made' capability and are about to enter that segment of the industry.

Great Lakes Windows Ply-Gem believes that vinyl is the building material with the greatest potential for growth in the 'Do-It-Yourself' window market. They base this belief on the above average growth it has shown, at aluminum's expense, in the recent decade and its track record in Europe (Chapter 5). With this in mind, Silverman went looking for a vinyl window manufacturer and found Great Lakes Windows. Ply-Gem paid \$18 Million in 1986 for Great Lakes Window the third largest producer of vinyl windows. The company is rare -- it markets a premium, all vinyl window. Almost all of the other companies in this segment of the industry market a wood or wood clad window. In 1989 they started producing a low-E, vinyl window.

The adjacent matrix depicts SNE (S) positioned in the premium, wood window segment for both new construction and remodeling. The arrows



indicate the move into the 'custom-made' market. The circular boundaries encroach into the vinyl-clad segment which represents the 'Renaissance' window line. Great Lakes Windows (G) is transforming itself from a standard manufacturer into a premium, vinyl window company.

The immediate future of Ply-Gem is geographic expansion. They are a major force in 16 of the largest 42 housing markets and are currently moving into 10 more. They appear to have all of the premium window segments covered but, as they proved with Wolverine Technologies, gaining market share through acquisition is a viable strategy.

Marvin

In 1906, George Marvin started a lumber company in Warroad, Minnesota. The business remained lumber until about 1947 when they began building window frames to keep the workers busy. William Marvin, the founder's son, hit upon a strategy of building windows to the specifications of the builder or architect. The strategy has remained unchanged.

Flip through Marvin's 2 inch-thick price book. The choice is mind-boggling. There are curved-glass windows, windows with round tops, even reproductions of the 16-pane windows found in many Boston colonial saltbox houses. Marvin will produce them all to a builder's or architect's specifications. Marvin will even make a window with glass bent to a right angle for corners, unavailable elsewhere. Marvin makes standard sizes, too, but only to order. Marvin has nine different glass options, from insulating glass to tinted panes, compared with four at Andersen. The whole idea is to offer so much that

we never have to say no to an inquiry.¹¹

Marvin has been the fastest growing window manufacturer during the last decade. Sales have gone from \$40 Million in 1980 to an anticipated \$300 Million this year. The companies understanding of construction industry dynamics -- and its response to them, via segmentation marketing -- has strongly contributed to their success. In the early 1980's, Marvin identified builders, dealers, remodelers and architects as influence groups and created ads to reach them more effectively. By 1984 it was also running a campaign to reach building owners. They study trade publishers' research and conduct awareness surveys to understand the segments interests and what causes their reaction. It formulates messages for each customer group based on the findings.¹²

The marketing program has been successful. In 1982 57% of the architects in a survey were aware of Marvin's products; 95% responded positively last year. Builders' awareness has also risen from 50 to 88% over the same period. Susan Marvin sums it up when she says, "I'm a firm believer that if people don't know you exist, they can't buy from you."¹³

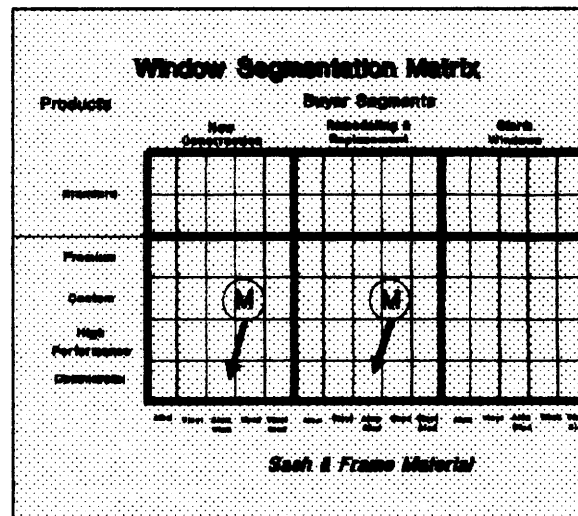
¹¹John Harris, "The Window Frame as Fashion Item," Forbes (April 30, 1990): 128.

¹²"Marvin: Real-World Window Sales," Business Marketing (October 1989): 52.

¹³Ibid.

Marvin controls the custom-made, wood window segment of the industry. Depending on the source, they are either the second or third largest manufacturer, behind Pella, within the industry. They sell their windows through a narrow network of 90 distributors in all 50 states. This control over distribution and a policy of not discounting helps Marvin maintain a 9% profit margin.

Marvin, besides wood, also offers an aluminum-clad frame. Also, partly because of the in-house architectural staff required for 'custom-made' windows that they already employ -- Marvin is moving into the commercial



segment. The commercial segment requires architectural expertise. The previous chart depicts Marvin's positioning within the industry.

Earlier in this chapter Andersen's future productivity was examined. It appears that they will soon have to look elsewhere, besides their work force, for productivity gains. Andersen's total sales are approximately \$1000 Million with a 4000 person workforce. Dividing the sales by the number of workers gives a sales per worker ratio of \$250,000/Worker. On the other hand, Marvin's total sales was about \$300 Million

and they have 3000 workers. This produces a sales per employee ratio of \$100,000/Worker. The worker productivity gap between the two companies is, I feel, quite amazing. I would expect Marvin's 'custom-made' windows to require some additional labor but certainly not 2.5 times as much.

I am convinced that Andersen will not get much more from their workforce alone. They need to turn to technology for future productivity gains. Likewise, Marvin cannot stay competitive for long with their worker productivity. If Andersen has reached the ceiling then Marvin has a long way to go, even with 'custom-made' windows, before they have squeezed all of the capacity from their plant and people.

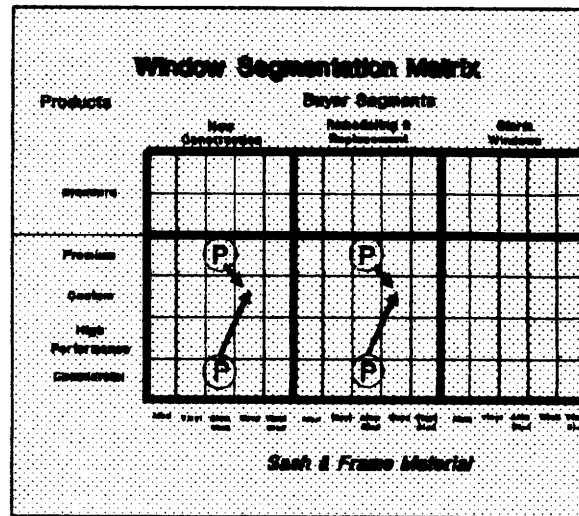
Rolscreen Co. (Pella)

The Rolscreen Company manufactures and markets their windows under the Pella brand name at their facility in Pella, Iowa. The company has been making windows for over 65 years. They have about 2800 employees and expect sales somewhere between \$200 and \$350 Million in 1990. Pella's primary product is a premium, aluminum-clad window. Initially their market niche was commercial windows but they have since moved into the premium, residential segment also.

Unlike Andersen, which sells its windows through a network of building supply centers and lumberyards, Pella sells their windows exclusively through 450 franchised outlets -- The Pella Window Store. Not only do they market their windows; they also market their 'windowscaping design

services'. According to their brochures, Pella is committed to **supporting** design professionals, builders and homeowners. They engineer integrated product systems -- not only windows but accessories which ensure easy and proper installation. I am not sure if their design and customer service capabilities are any greater than Andersen or Marvin but their emphasis on these services in their advertising certainly is.

In response to Marvin's move into the commercial, aluminum-clad segment, Pella is moving into the 'custom-made' wood window market. The adjacent chart depicts this.



Hurd Millwork

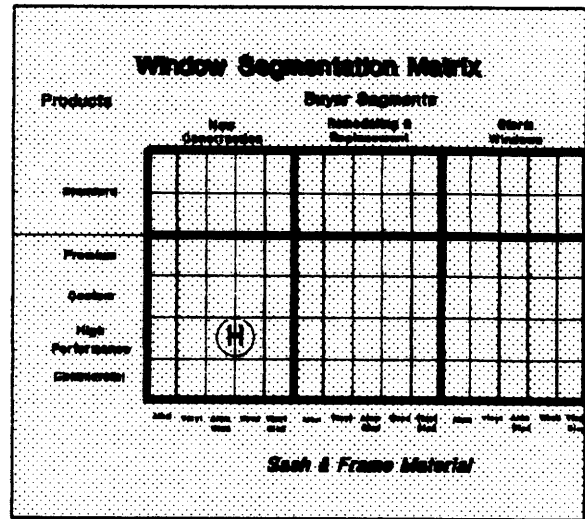
Hurd Millwork of Medford, Wisconsin is a subsidiary of a private company, United Industrial Syndicate based in New York and owned by Harry Lebensfeld. The company was established in 1917 as a lumber company. It began producing 'custom-made' windows in the late 1960's. They have about 900 employees and expect total sales to be somewhere between \$65 and \$100 Million.

Hurd has always focused on the super-energy efficient window and, with Southwall Technologies, developed 'Super-

glass' (chapter 2) which they market as Insol-8. They focus on the high-end of the new construction market. Wood and aluminum cladding are the frame and sash material the company uses. Except for two company owned stores in Wisconsin the remaining sales are through distributors in 48 states, Japan and Canada. The adjacent chart positions Hurd in the high-performance / aluminum-cladding and wood segment of the new construction market.

Hurd is dedicated to producing the most energy efficient window. Consequently, they maintain a close relationship with those comp-

anies and universities conducting research in this area. Their future is where the technology takes them.



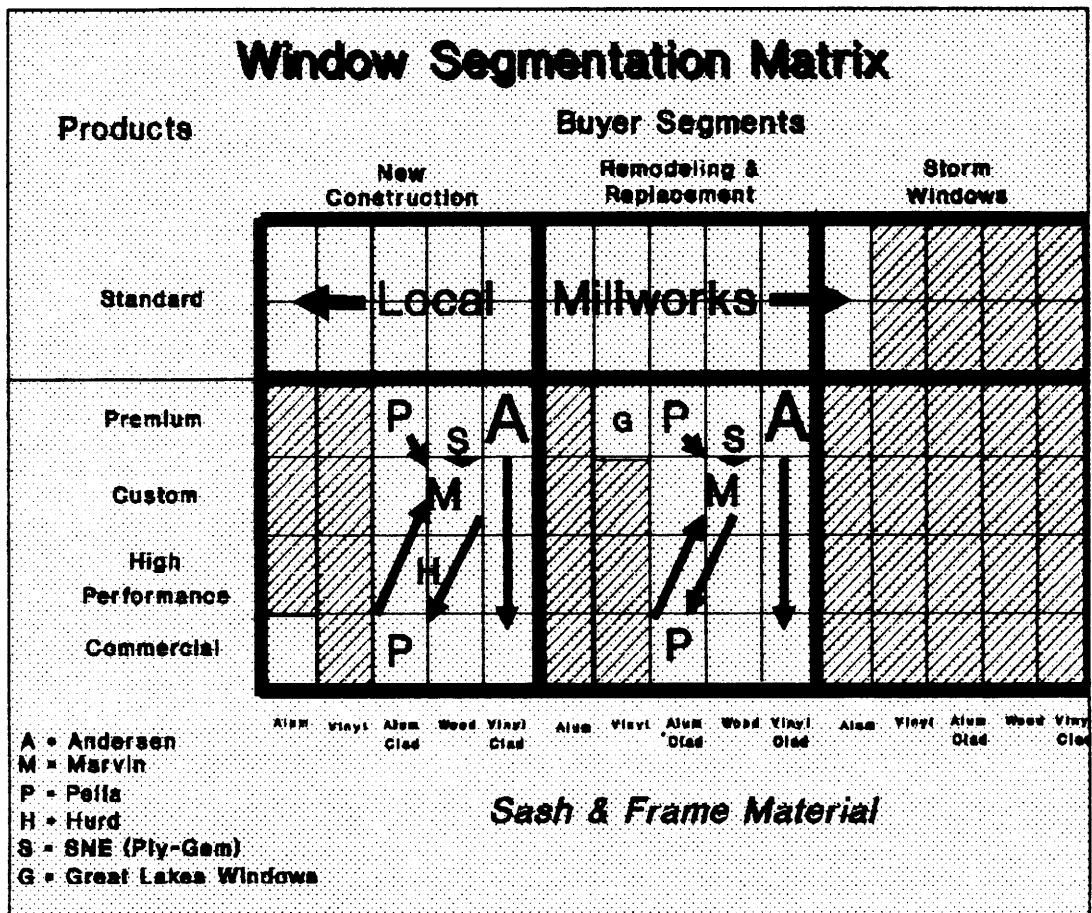
Strategic Mapping

This section strategically maps all of the companies that have been examined to this point on one segmentation matrix. It also eliminates those superfluous sections of the Window Industry Segmentation matrix.

Storm Windows Aluminum windows are 96% of the entire storm window market. There are also no companies producing 'upscale' storm windows. What remains of the market is controlled by the local millworks.

Remodeling & Replacement Vinyl windows have just recently become a viable premium, replacement segment product. I have found no manufacturer producing an 'upscale' aluminum window for this segment.

New Construction Vinyl windows have not penetrated the 'New Construction' segment. Aluminum is a popular commercial window but is not successful as an 'upscale' residential product.



The shaded areas on the industry matrix depict those segments discussed above, which, for one reason or another,

are not relevant. Also, all of the companies analyzed earlier in the chapter are placed, concurrently, on the one matrix. A companies's expansion into new segments of the industry is indicated with an arrow.

It is interesting to note that most of the national, upscale window companies have found market niches without direct competition.

Conclusion

The purpose of this paper has been to analyze the window industry. That has been accomplished -- hopefully to the satisfaction of the reader. But the goal of this effort was not simply to learn more about windows. It was also to determine if there were any particular characteristics that encouraged innovation within the industry. If there are vital characteristics are they an aberration of this industry alone or will similar changes follow in parallel industries associated with the homebuilder's 'value-added' chain?

The purpose of this chapter is far more substantial than merely summarizing the high points made in previous chapters. It does outline the characteristics which have allowed innovation to flourish for window manufacturers. But more importantly, it contrasts the innovative success of the window industry with similar, parallel industries associated with homebuilding.

Replacement / Remodeling

The statement that 'windows are the single most likely building component to be replaced by a homeowner', plays a pivotal role in many of the following conclusions. As such, the validity of the statement deserves to be examined again.

The October 1990 Remodeling magazine is dedicated to the initial project costs of 11 popular projects versus their eventual added value to the home. Of the 11 projects only two

deal with a single component of the 'value-added' chain: siding and windows. The remaining projects involve remodeling existing rooms or entire room additions.

Of the two 'component' projects only windows were readily accepted as a viable project. Many of the 175 real estate agents from 60 cities that participated in the survey felt that new siding wouldn't add enough value to the home to warrant the initial expense. The siding was most popular in the upper Midwest, 'where installation provides maintenance-free protection from harsh winters'.

This debate reinforces the point that windows are, by far, the most common building component replaced by homeowners. Only two projects in the survey dealt with discrete entities of the value-added chain and even then, siding was not a popular choice.

The popularity of the window project was based primarily on the rising energy prices prevalent throughout the country. New windows give a house, which is up for sale, the competitive edge. "Low-maintenance, energy-efficient windows can speed a sale, especially if the seller can show pre and post-window utility bills to buyers."¹

Theoretical Framework

To properly evaluate any industries tendency to innovate some theoretical background or framework must be

¹Katrina R. Mason, "Cost vs Value," Remodeling (October, 1990): 100.

used. In his book, The Economics of Industrial Innovation, Christopher Freeman develops 10 characteristics of innovative firms. I have chosen the most applicable characteristics for our purpose. They are:

- 1) A large enough size to finance heavy R & D expenditures over long periods of time.
- 2) A strong, in-house, professional R & D staff.
- 3) A strong management nucleus which is able to effectively coordinate R & D, production and marketing.

He also reaches the following generalization: Those industries in which small firms contributed much less than their share of output or nothing at all, correspond broadly to industries of high capital intensity.²

Freeman's characteristics will be used as the 'yardstick' with which to measure the window industry's propensity for innovation and, simultaneously, validate his conclusions.

The Window Industry

The following paragraph summarizes the evolution of windows from commodity items to sophisticated and differentiated products valued by consumers.

Initially, the post WW II housing boom provided the assurance window manufacturers needed before they would expand their facilities to service a large regional or national market. After the boom it was the complimentary

²Christopher Freeman, The Economics of Industrial Innovation, 1986, 2nd edition, p.112.

dynamics of the new construction and replacement / remodeling markets which gave window manufacturers a consistent, positive growth market. This consistent market also allowed them, with a reasonable amount of risk, to invest in automated plants and advertising. The plants gave the companies economy of scales and the advertising increased buyer awareness of their products and subsequently raised demand. Both resulting in larger companies with an increased 'return on investment'. The additional profits then allowed the companies to hire in-house R & D professionals and architects to develop new products and pursue new uses for existing products. This also resulted in larger companies.

Freeman's characteristics of an innovative company include being large enough to finance a longterm R & D program. The combination of the post WW II housing boom and the consistent demand for windows produced a fertile environment, one which allowed a number of firms to grow rapidly. They soon reached a point where they were big enough to afford the necessary overhead that comes with a R & D program.

A second characteristic is a strong, in-house R & D staff. The major, national, window manufacturers have evolved to a point where they no longer rely solely on their suppliers for innovation. They can now afford and have employed a professional R & D staff as well as architects to expand their market.

istics. Their R & D staff has effectively refined window innovations that have been successful in the marketplace. Their production and distribution functions are as efficient as the current technology will allow them to be and their advertising programs are professionally choreographed and persuasive.

Few will contest that the window industry has been very innovative over the past 40 years. Not surprisingly though, many of the characteristics that Freeman has found in innovative firms and industries are also intrinsic characteristics of the window industry. Freeman's framework indicates that the window industry has the potential to be innovative and this study has shown just that.

Other Industries

Do other industries, those paralleling the window manufacturer in the homebuilder's 'value-added' chain, have similar innovative characteristics?

To properly address this question we must first define and categorize the building products. A straightforward breakdown would be construction materials versus finished products. A listing of those items found in a typical home, by category, follows:

Construction Materials

concrete
rebar
lumber
plywood
insulation
vapor barriers
roofing materials
brick
rough plumbing
rough electrical
finish trim
ventilating equipment

Finished Products

cabinets
sink fixtures
lighting fixtures
bathroom fixtures
fireplaces
finished flooring
siding
doors
kitchen appliances

Those products that fall under the 'construction materials' category could easily be described as commodity products. Commodity products compete on price alone. This reduces profit margins for all companies and aids in industry fragmentation and the prevalence of the small company. The reduced profit margins of the small companies are not significant enough to support R & D expenditures. Manufacturers that produce these types of products, small companies with low profit margins, fail to satisfy a fundamental characteristic of innovative firms.

The items that fall under the 'Finished Product' category are not commodity items. Their market is segmented, much like the window market. Examples of premium 'finished products' include Price Pfister and Delta faucets, Valli & Colombo door-handles, Majestic fireplaces and Peachtree Doors. The same favorable attributes offered by segmentation that applied to windows also apply to these products. Rivals avoid direct competition which increases their profit. The

increased profit allows them to invest in new facilities and R & D. The new facilities and increased research effort lead to further and more rapid innovation.

An example of this is the innovation made in faucets. Not long ago the market consisted of only two-handle, rubber washer faucets. Now, one of the premium manufacturers, Price Pfister only offers a single handle, washerless faucet. They also have expanded their market by offering matching bathroom accessories like the towel bars and toothbrush holders.

Manufacturers of 'finished products' have the characteristics, according to Freeman, necessary for innovation and they have exhibited practical, market-oriented, product innovation.

Can we expect to see innovation of building components in the future? Yes, if the product is not perceived as a commodity. Commodity items are doomed to compete on a 'low-cost' basis. Consequently, these companies simply cannot afford to attempt new ideas. On the other hand, products that are seen as differentiated have the luxury of commanding larger margins, which, in turn allow the manufacturing company to experiment with new processes, new materials and new products.

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