Kennedy Wunsch Lecture 17 May 2023

Introduction

Kia Ora Tena Koto Tena Koto Katoa

It is a great honour and privilege to be invited to present the 2023 Kennedy Wunsch lecture. I was fortunate enough to be present at the inaugural lecture in 2010. Thanks to the Board of IChemE in NZ for granting me this opportunity.

I have chosen to reflect on my journey as a chemical engineer predominantly working in the NZ Dairy Industry during times of significant change.

The talk covers the last 50 years of an industry experiencing huge growth, structural change and massive technological step changes. The key areas I will cover are

- The Changes and The Scale
- Design Progress
- Calculations and Communications
- New Construction Approaches
- Process Plant
Evaporation and Drying Technologies
- Change Accelerators
Electrical Engineering Automation and Instrumentation Advances.
- NZ Successes

In closing I would like to offer some observations as to why I consider this transition was so successful, leading to NZ still being a globally dominant exporter of quality protein foods and ingredients. The industry delivers a large portion of NZs GDP.

Background

I expect my accent easily identifies my country of origin, so just a little background on how I came to be here today.

I left school at fifteen studied predominantly part time while working, and gained a diploma in Chemical Engineering.

Initially I worked in a Food Research and Development Plant and, post my diploma in the vegetable processing industry. This was prior to departing for NZ on my OE. I was granted leave from my employer the NZ Co-Op Dairy Company for further study and gained an honours degree in Chemical Engineering. With the exception of three years in the Netherlands and the UK completing the degree and working for a company Stork Friesland on drying and evaporating projects I have spent 50 years in NZ. Over those years I have had the privilege of working both here and all over the world on many drying and evaporation projects.

From 1992 until 2018 Anne and I developed a Hamilton based Consulting Engineering Practice - PDV Consultants. Since our retirement the company has continued to grow now having close to 40 employees based in New Zealand, Australia and Northern Ireland.

The New Zealand Dairy Industry Changes and Challenges.

Scale, Capacity, Companies
The Structure

The industry today bears no resemblance to that of the late 1960s early 1970s. Subsidy removal, Government restructuring and significantly, the demise of the single desk marketing unit the NZ Dairy Board brought changes. These changes resulted in huge industry consolidations and mergers. Post the Dairy Industry restructuring act regulations (DIRA) a strong growth of second tier nonlegacy companies occurred. The multiple cooperative companies of the sixties and seventies predominantly merged into one large co-operative, Fonterra.

Fonterra now handles over 80% of NZ total milk production capacity. This large entity is complimented by several companies such as Westland, Open Country Dairies, Synlait, Oceania and others. These companies operating under various private / cooperative hybrid business models. Many of these companies have components of overseas ownership as part of their structure. One stand out small cooperative remains. The Tatua Co-Op Dairy Company a uniquely successful speciality products company who boasts at the same time as being both the second largest and perhaps the smallest cooperative operating in New Zealand with 100 suppliers. Fonterra has approximately 9,000 farmer suppliers.

In the Waikato region there were a significant number of small dairy factories still operating in the early 70's, however, rapid consolidation as a result of the amalgamations closed many plants. The evidence of these small factories is still to be found today in some regional towns, some facilities occasionally remaining in a somewhat depressing state.

Capacity

Using Milk Powder Production as a metric the change in output of the Diary Sector can clearly be seen.

Milk Powder Production Mid 1960s = 100,000 t per year

Milk Powder Production in 2021 = 2,200,000 t per year

The growth in powder production capacity being reflected in the increasing size of installed Spray Drying Plant.

1968 The NZCDC Te Rapa commissioned three 2.5tph GEA Niro two stage driers.

1978 The NZCDC Te Awamutu installed 7.5 tph Stork Tetra Pak whole milk powder drier. During commissioning what was the largest dairy spray drier in the world at the time – I thought this is as big as it gets. How wrong was I.

2014 to 2018 brought the Installation of several 25 to 30 tph capacity driers at sites such as Hawera, Darfield and Lichfield. Many of these multistage units being capable of 24/7 operation.

Supporting the changes

Engineering Design and Drafting

In those early days at the Co-Op, as the NZCDC was known we relied on extensive site measurements, used drawing boards, and utilised fairly basic tools of calculation. The design of facilities and plant installations required a significant amount of detailed site measurement and significant drafting skills. *I remember being told by a senior design draftsman to measure everything once and then measure it all again. Then measure everything associated with what you are working on - just to be sure you have captured all the information required, and then remember you will still probably have missed something.*

Integrating plant and building layouts required painstakingly incorporating plant drawings details into complete factory drawings. This was a manual operation. Without careful scrutiny of the output and rigorous change control errors could lead to significant problems when installing the plant.

Positive change was on the horizon. We progressed with the introduction of early CAD packages and computer-based drafting options. These were welcomed changes. The end of the era of leaking ink pens, scratching out of errors on drawings and the removal of the smell of ammonia print chemicals was welcomed by us all.

CAD programmes improved and progressed. Packages such as those from Auotodesk starting to offer the ability to merge and integrate discrete drawings together. These packages have continued to develop and now offer us the opportunity to communicate designs in 3 D. Walk through rendered models of plant and factory layouts are now common. These developments have significantly improved the communication of designs to a wider community of stakeholders. More understanding and a wider engagement with the designs overall has led to improvements in outcomes. As a result of these design packages plant and facilities can easily be assessed for access and serviceability.

We have more recently progressed to using digital scanning techniques which capture plant images and their dimensional relationships. A system using Scanning / Lidar cameras captures 360-degree photos and point cloud data with the ability to take measurements within 1mm accuracy.

These scans can then be exported to most modelling software. Such systems, now widely used, prove to be especially useful when retrofitting or upgrading plant in existing facilities.

Calculation

From the log tables to slide rules and fairly complex single topic mechanical devices progressing to calculators. Mechanical calculators for steam systems and control valve selections complemented the traditional pen paper and equations-based calculation methods. These tools were rapidly replaced by programmable calculators, simple computer spreadsheets, progressing to more complex Excel models. Computational Fluid Dynamics tools and bespoke proprietary calculation packages became readily available. We still use the same engineering mathematics and physics rules. However, the means we now have at hand allow us to deliver more accurate solutions in much shorter timeframes.

Communication

Early days we used letters, local and regional phone calls and oacssioanlly, if urgent, a telegram.

If working in Hamilton one needed an operator to connect you to an Auckland number. We were warned to use toll calls sparingly.

A significant device used when dealing with overseas entities was the telex. By typing and punching tickertapes beforehand were able to feed tapes these through the telex machines to transmit messages on dial up phone lines.

I consider despite all that has occurred recently the Fax machine perhaps heralded the most significant changes to our operational practices as engineers. For the first time we could communicate sketches drawings and grainy photographs instantly. The Telex machine was rendered redundant over a very short period of time.

The Internet and Mobile phones further enhanced our abilities to effectively and rapidly communicate and access knowledge, but on balance over the last fifty years I consider the fax becoming available was a significant transitional moment.

Construction and Safety

Increasing factory capacities and the installation of ever-increasing sizes of powder drying plant required a change in design and construction methods. Predominantly the dairy industry consisted of fairly low height buildings for processing butter, cheese, casein etc. Early drier buildings were just a few stories high and constructed of steel and timber frames - often clad with coloured steel profiled sheeting. Such constructions, if internally clad created ledges and cavities potential areas for contamination.

Local plants such as the Fonterra Te Rapa facility and others heralded the introduction of new construction techniques. Poured concrete walls and prestressed concrete floors, integrated structural steel designs appeared.

More stringent earthquake requirements were increasingly impacting designs especially with increasing building heights. Designing and building drier towers is challenging as they have little inherent support / bracing opportunities due to large hollow volumes required to accommodate spray drier chambers. Newer methods to deliver tower construction strength were required.

The result of these design challenges was the increasing use of concrete tilt panel constructions with integrated shear wall / column structures providing stability and earthquake resilient designs. An additional benefit of these concrete panel installations was noise attenuation and a generally sanitary crevice free surface. This being a highly desirable feature in food factories. The use of composite coated poly panel interior walls was also helpful and speeded up construction of sanitary internal constructions. These panels were used in packing rooms laboratory areas etc. It was quickly learnt, to the industry cost, that these panels were a potential fire hazard. To overcome this risk fire retardant polyurethane fills for the panels were developed.

Above ground improvements were complemented by improvements in underground systems. Industry factory drainage had been problematic for many years as a result of the traditional use of glazed ceramic drainage pipes and fittings. The Dairy Research Institute (DRI) spent much time in investigating suitable materials resistant to the acid and alkali chemicals used in dairy plant cleaning. A combination of above ground stainless piping and the underground use of vinyl ester fibre drainage systems became the norm. As a result, the risk of contaminating the ground and ground water under and near factories was significantly reduced.

Erection of the facilities changed also, the early use of the drag lines, pulleys and winches to erect buildings and plant was superseded by tower, lattice, portable hydraulic cranes and many other devices. Cranes not just used for building structures erection but also for installing the process plant in parallel with the building works.

I would be remiss if I not mention site construction safety improvements as an area of significant and positive change over the past fifty years.

A not uncommon sight in the seventies was to see riggers riding crane hooks onto building structures. Also, riggers with no harnesses wedging their feet within structural beams as forms for purchase whilst erecting structures. (I witnessed such activities). Thankfully we have progressed significantly. Scaffolding, safety nets and effective barriers have become an integral part of safe construction. Significantly designers now are much more aware of how they can positively impact on H and S by careful attention to design and construction methods. This leads to safer builds across the industry. The understanding of ergonomic and environmental risk to personnel in the construction industry has also significantly improved working conditions over this time.

The Process Plant

While acknowledging there were significant parallel process changes occurring in butter cheese and other milk products manufacturing, I will for this talk, focus on the Milk Powder Manufacturing process.

Although the reception and wet processing areas of dairy factories grew significantly in size during this time the plant and equipment remained

Key Areas

Evaporation

Prior to spray drying milk is concentrated from 12.5% solids content to about 50% in an evaporation process. The higher the solids the more efficient the process.

Evaporator designs have changed significantly in New Zealand over the past 50+ years. From two and three effect units with evaporation efficiencies of 0.5 to 0.35 kg of steam per kg of water evaporation in the sixties to multiple effect thermo vapour recompressed units (TVR). These TVR having efficiencies ranging from 0.09 to 0.12 kg steam per kg of evaporation depending upon configuration. Plants of this type mainly being constructed in Europe (predominantly because of the oil shocks of the eighties).

Uniquely many companies in NZ operated what were known as direct heated units (DH) which did not use recycled vapour as used in TVR units. These DH evaporators were often installed as condensers as part of integrated cogeneration plants. NZCDC Sites such as Te Rapa, Te Awamutu, Waitoa, Waharoa and Kerepehi operated these plants for many years. This was long before cogen became the buzzword of the nineties. NZ Companies using the milk evaporators as condensers for turbine exhaust from an electricity generator. This generation occurring in combination with the provision of process steam. A portion of the high-pressure steam (35 to 45 bar) by-passing the turbines to be used for spray drier air heating. As a result of these combinations overall factory energy efficiencies were significantly improved.

In the early seventies NZCDC owned several coal mines. Utilising coal from their own or other mines was for many companies a winning formula.

European manufacturers could not understand our desire for such (DH) units often trying to convince us that we should purchase their higher pressure more efficient (TVR) evaporators, which to them on paper seemed more efficient.

The Introduction of MVR Technology

The step change in evaporator design performance came with the use of mechanical vapour recompression units (MVR), developed by companies such as Weigand, MKT, Niro (GEA) and Stork (Tetra Pak). Initially various compressors were used from Rootes style lobe blowers, to high-speed turbo compressors and turbofans. Turbo compressors could deliver an operating Δ T of 8 to 12 ^{o}C and were initially preferred. However, operational difficulties experienced with the higher compression machines (yes here too in NZ) quickly caused suppliers to select the more stable and secure turbofans as the prime movers. These fans manufactured by companies such as Piller and Schiller in Germany and Flakt Woods in Finland. These turbo fans could be operated in single or series mode to deliver Δ Ts of 4 to 8 ^{o}C respectively.

The key difference in MVR design when compared to DH or TVR units being reflected in the size of their evaporating calandria. DH and TVR Units delivering overall Δ T of up to 35 ^{o}C. had much smaller surface areas overall albeit in many smaller discrete bodies.

Considering my favourite equation $Q = U*A*\Delta T$ when U is fixed it can easily be seen what is the effect on calandria surface area A when Δ T is reduced from 35 to 5 ^{o}C. Much larger calandria heat exchangers were needed.

Due to their increased efficiency when compared to the traditional DH or TVR units, MVR evaporators have completely dominated NZ plant supplied over the past 20 years. In some cases, large MVR plants oacssioanlly being supplemented by small scale TVR finishing units required for higher solids concentration.

As a comparison an MVR Evaporator uses about 12 to 14 kW per tonne of evaporation. A seven effect TVR would use approximately 65 kW per tonne evaporation. A nominal COP advantage of 5.

Operating savings for an MVR when compared to that of DH or TVR units are substantial despite requiring a somewhat higher initial capital outlay

Spray Drying Advances

Initial Spray driers used in NZ were generally of American design. The plants operated as single stage drying units with low air and particle residence times. Drying air temperature profiles typically operating at 220 ^{o}C. at the inlet to 95/100 ^{o}C at the outlet. Drying the concentrate from 48% solids to 96.5% solids that is 3.5% moisture content. This drying occurring predominantly in the main chamber. The advent of the two and three stage drying process led to much more efficient spray drier performances. In multistage drying we can utilise greater temperatures profiles for the main drying air. As an example, multistage drying allows for an increase in the available drying air Δ T from 100 to 125. Such an operation required larger drying chambers, with longer residence times and both internal and or external fluidised bed drying units. These beds removing the final hard to remove moisture. (Decreasing drying rates occurring in the falling rate period of the process). Powder moisture from a single stage drier would be between 2.5 to 3.8% H_2O. As a comparison powder from the first stage (the chamber) of a two-stage process being 5 to 6 % moisture.

Two, and latterly, three stage drying plant with internal and external fluidised beds improved drying efficiencies significantly. When fluidised beds were integrated into the drying chambers this led to lower drier heights overall. This feature reducing the capital costs of the buildings.

Atomisation

The successful atomisation of the concentrated liquids is key to the operation of spray driers. In the 1960s high pressure (HP) nozzle spray atomisation predominated. Progressively mechanically driven rotating disc atomisers became more widely used in the NZ market. Some of the largest rotary atomisers installed in NZ were powered by 185 kW motors and required sophisticated vibration monitoring, cooling circuits and pressurised lubrication units.

The traditional basic whole and skim milk dried powders often used in a recombination process could repeatedly and reliably be manufactured on rotary disc driers but the market was changing.

The use of increasingly large rotary atomisers in spray driers slowed in NZ when the need to develop more functional powders gained prominence. It is widely acknowledged that high pressure nozzle HP atomisation allows for flexible particle size manipulation and more controlled agglomeration. These features being required to meet the increasing demand for the production of “instant” powders. New HP nozzle atomisation systems designs were also driven by the growth of powdered infant formula manufacturing and the requirement for the more functional performances for such powders.

These powders often used for the direct-to-consumer sales markets.

Summarising the differences between rotary and nozzle atomising designs

Discs Atomisers. Advantages

- Repeatable and reliable day to day operation
- Rapid changeover of units possible, leading to shorter drier downtimes.
- Lower number of failure modes than Nozzle units

Discs Atomisers. Disadvantages

- High Speed mechanical devices. If they fail it can be catastrophic with broken shafts, discs falling off or even flying to pieces.
- Little ability to alter powder properties.
- Have limitations when fed with increasing viscosity concentrates.

Nozzle Atomisers Advantages

- Powder Properties manipulation possible
- A more controlled Agglomeration process if required
- Larger sized multi nozzle units can operate continuously
- Can handle higher viscosity concentrates

Nozzle Atomisers Disadvantages

- Many degrees of freedom in set up possibilities can create mistakes
- There are very many more points of failure in nozzle systems incorrect nozzle assembly leaky valves leading to potential fires and explosions.
- Much more manual input needed to service the multiple nozzle units.
- Potentially requires more High-Pressure equipment: pumps, piping heaters and associated connections.

Change Accelerators

Electrical Automation Instrumentation and Control Advances.

An area of phenomenal change.

In the sixties and seventies with the exception of the rare and ocassional star delta starter unit nearly every motor and drive was started direct on line. As a result, to handle the load we ended up with massively oversized drives (and at times placed stress on the local power companies).

In the seventies we had difficulty in sourcing large motors. For example, a 150 hp exhaust fan had to be driven by two parallel 75 hp motors. This requiring heavy pulleys and belt systems tandem driving to a single fan shaft. It worked, but it was not unusual to have the ocassional belt fires, and if we did not have on site power, incomer trips of the local substations. Iron bars instead of pole fuses in a Reporoa drier commissioning comes to mind. If we did have on site power, we had to inform the energy centre team when we were starting large drives or bringing on steam systems. Quite a few irate calls about turbine trip issues and almost primed boilers if we forgot. Cold starting large plant was difficult.

A significant change that was of great help with this problem was the development of soft starts and variable frequency drives (VFD). Local innovative companies such as PDL took the lead in this and our industries continued rapid development owes much to these companies and their supporting Universities who helped in the development. In partnership with the dairy industry and others NZ and Australian users PDL were able to develop world beating VFD units. Inevitably due to their competitive advantage in many areas of the market led to PDL's takeover over by multinationals. These multinationals promised continued support of the local product however that support did not last long. Local manufacture and development unfortunately ceased.

Automation and the PlC

Factories of the early seventies were predominantly controlled by pneumatic analogue sets of discrete controls. Manual switches used for starting fans pumps and drives. However, a rapid transition to plc-controlled systems occurred.

Early PLC's such as those supplied by ISSC and Honeywell were the forerunners of the modern PLC systems we see today from Rockwell-Allen Bradley, Schneider, and to a much lesser extent in NZ, Siemens.

I recall the NZCDC Electrical Department constructing a fairly rudimentary early digital output device. The unit consisted of multiple, solenoid operated air pressure regulator sets. Each output with an increasing pressure to mimic the normal analogue 3 to 15 PSI output signals to control valves. The various air sets being turned on and off digitally. As can be imagined this was a fairly bumpy method of control.

Punched card driven CIP controllers appeared in some factories but these were soon replaced by simple PLC units. Today we have fully integrated PLC networks and supervisory control systems with on board optimisations and management tools (SAP and others).

Modern software packages both proprietary (Pavilion Rockwell) and in house optimisation control strategies were developed. Some by companies such as Fonterra. These leading to improved operation, overall process control improvements and improved assets management. Such developments reducing losses, improving yields, lowering manufacturing and distribution costs.

To deliver these automation systems New Zealand developed a highly competent set of systems integrators and programmers delivering complex control systems and software, both domestically and overseas. Much of the competency and skill sets these companies use now were nurtured through their engagement with, and development of, the New Zealand Dairy Industry.

The tremendous advances in process control delivered by PLC systems would not have been possible without a parallel development of instrumentation and real time measurement devices.

Measurement Improvements

In the early 1970s only three parameters were easily directly measured, controled and reported. These were: pressure, temperature and volumetric flow. Mass being calculated by formula derived from differential orifice plate transmitting devices.

Evaporator Control

Developing a solution for solids (density) control by improved measurement.

Control systems for evaporators require an accurate measurement of product output density (solids). A concentrate of 48% solids often presented a liquid with a viscosity of say 20 cp whereas 52% solids could for certain products give a viscosity of well in excess of 1000 cp. Such high viscosities block evaporators and cause huge problems for the drying process. The industry needed an accurate measure of solids content. Hand held refractometers were used as a guide but due to seasonal inconsistencies in milk sugars they needed almost constant laboratory calibration. In addition, at this time refractometers were still hand held off line devices. An inaccuracy of one or two percent solids in the measurement was the difference between an operating or a blocked evaporator. A cautious approach to control was therefore needed. An added complexity was the excessive lag time for the evaporation process, often exceeding ten minutes for some evaporators.

The industry was fortunate to be able to progress from the hygrometer and refractometer to the Gravitrol beam weighing systems outputting varying density signals to our control systems. These signals could be easily referenced to total solids levels. We progressed to the use of higher accuracy nuclear density meters (We nearly lost a nuclear device when a factory was being refurbished it was panic stations for a while but we found it). Finally, the safer and more accurate Coriolis effect mass and density meters became available. These latter mass flowmeters could accurately output density and more recently with correct set up viscosity, a great help in controlling plant. Plants operated much more efficiently and under improved control as a result of these and other new instruments.

Further measuring improvements included on line conductivity, pH, turbidity, Infra-red moisture, and even rapid COD measurement. We had a lot more measuring capabilities available to us.

Spray Drier Control

As noted, powder properties and functionality were becoming increasingly important to the industry. Control of powder moisture off the plant required constant off line monitoring with heat lamp, weigh scales, ovens, IR devices etc.

Fortunately, we have available today many tools that can monitor these important factors in real time. I reference one of these the GEA Powdereye unit. This unit can monitor pour and bulk density, particulate shape, and optically potential product contamination. This optical signal providing warning signs of possible early combustion problems within a drier. These monitoring units can also continuously measure the moisture, protein, lactose and fat content of dried products.

Further advances have allowed for the on-line humidity monitoring of the drier inlet and outlet air streams. This has proved a very useful parameter helping prevent drier blockages such often resulting from rapid humidity changes in ambient air conditions. Triboelectric particulate analysers can warn of fugitive powder emissions from driers and help quantify losses. These powder emissions units offering early warnings and continuous product loss monitoring. These warnings preferable to having an irate local resident complaining that he has milk powder flakes on his roof or on his car or ultimately in his drinking water tank.

Some New Zealand Success Stories Along the Way

Increasing Capacity Drives Peripheral Plant Development.

High-Capacity Milk Powder Packaging Plants were needed to meet the outputs of the new mega factories some factories having several large driers operating continuously.

From the early Hamilton developed Packway bag filling machine progression to the Avalon Engineering designed automatic powder bag filling machines was fairly rapid. Post takeover by GEA the latest Avapak high-capacity 12 tph units have been developed. These and other New Zealand designed systems such as those supplied by Technopak deliver high throughput 25kg sanitary, dual gas, bag filling and sealing machines. These machines kept pace with the rapidly increasing powder plant outputs. The companies mentioned continue deliver packing lines both for domestic and overseas clients. A far cry from manual filling and sealing with strong rubber bands - very hard on the hands.

Nucon, Now Nucon GEA leaders in powder handling equipment, locally developed powder transport plant and equipment. Sanitary rotary valves, multiple destination tube selector valves and blowers for pneumatic powder transport systems. Nucon developed several medium pressure blowers that were part of the early powder transport systems widely used in NZ. Their success lead eventually to their takeover again by the company GEA.

Robot Palletising systems have been developed by several NZ companies. One such company being JMP Engineering who have a grown a hugely successful global business grounded on much NZ based development work.

Heavily focussed on powder this journey would not be complete without acknowledging other advances and developments achieved by the industry

Plant such as the Cheddarmaster the Dairy Research Institute (DRI) patented hugely successful cheese curd conditioning and processing equipment is worthy of mention. Many NZ manufactured Cheddarmaster units being sold globally to many companies. ICS a New Zealand company still manufacturing these units in Hamilton for sale to overseas markets.

The Product Story

This story mainly focusses on the engineering transitions of the industry. However, it would not be complete without a significant reference to the parallel product development that occurred over these times. World leading Instant whole milk powder, functional Infant formula, the development of whey and other milk proteins. The whey and protein story well documented in the exceptional book "Whey to Go" published in 2014 by industry leaders of the time providing a history of these products.
NZ led the way in the designing process for the extraction of high value products from the oft regarded waste stream of cheese and casein manufacturing About 30% of the solids in milk lost in the cheese and casein processes. In addition the lactose company of NZ, now owned by Fonterra pioneered the manufacture of specialty products over many years. Examples being non caking lactose, tabletting lactose and more recently the manufacture of excipients.

The innovation in this area of dairy manufacturing started and nurtured by Duncan Sandys-Wunsch at the NZ Milk Sugar Company in Edendale the forerunner of the Lactose Company, continues today.

The What and the Why

The scale and scope of the transition is hopefully clear.

I can close by briefly explaining why I consider the transitions were successful.

I suggest the following were strong contributors

- Predominantly a Cooperative Industry with NZ community spirit. Even among the fiercest domestic competition for projects and product orders there was always an underlying spirit of cross industry support when the need arose. Companies helping out when breakdowns impacted on processing especially during times of constrained capacity in the peak seasons. Handshake agreements held sway.

- In the early days the NZ Dairy Board, as a strong single desk seller and marketer, built a globally competitive industry. This body removed the potential for internal NZ domestic competition which would have driven down international prices. This was truly NZ Inc.

- The NZ Dairy Research Institute (NZDRI) an exceptional world renowned and published Industry research centre. The NZDRI highlighted the quality and technical competency of our industry and its processes. It provided the strong technical support needed to develop the unique features of the NZ dairy sector we see today.

- A fundamentally strong base infrastructure available to be leveraged by industry. A legacy of the former Ministry of Works (MOW) and the New Zealand Electricity Department (NZED) developments.

- The exceptional skills of NZ manufacturing a "we can make it here" and "how do we do it differently with what we have at hand" Many developments occurring during times of stringent import controls tariffs and tight government restrictions. (Transport Duties etc)

- An environment of learning from others in the wider engineering community. Companies and staff always prepared to share knowledge and skills and importantly take calculated risks. Strong support of initiative and a culture of empowering staff to deliver. A truly cooperative industry.

A very big thanks to the NZ Board of IChemE for granting me this opportunity to share a snapshot of the industry in which I have been privileged to work. Through researching and writing this presentation I have been reminded as to what a great career and life the NZ Dairy Industry afforded myself and our family. Many many thanks to all the engineers managers scientists and colleagues who made my shared journey in this industry so rewarding and such great fun.