# PHOTONICS IN AUSTRALIA & NEW ZEALAND

## LIGHTING ECONOMIC GROWTH

AN INDUSTRY REVIEW 2020

# EXECUTIVE SUMMARY

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## THE PHOTONICS SECTOR IN AUSTRALIA AND NEW ZEALAND CONTRIBUTES A$5.4B TO THEIR ECONOMIES AND EMPLOYS OVER 12,000 PEOPLE THROUGH OVER 500 COMPANIES

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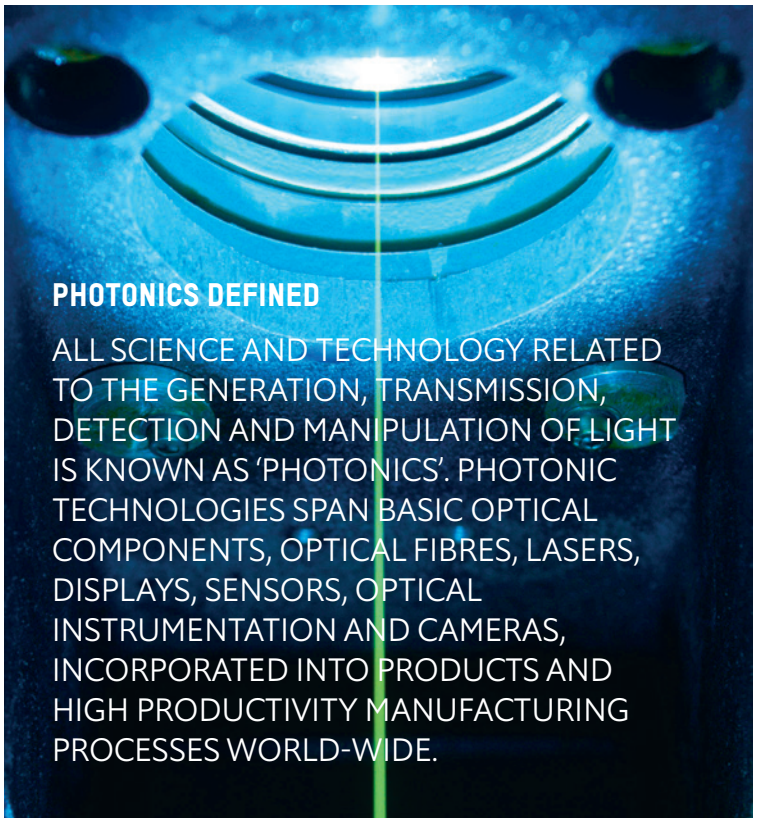
EMPLOYS 12,000 PEOPLE
OVER 500 COMPANIES
A$140K PER EMPLOYEE



# PHOTONICS IN AUSTRALIA AND NEW ZEALAND – AN UNRECOGNISED STRENGTH

**Photonics worldwide has been described as a 'hidden economy' and this is equally true in Australia and New Zealand. The photonics sector of the economy encompasses the production of goods and services which are enabled by both visible and invisible light.**

Whilst the importance of the invention of the laser more than 60 years ago is widely appreciated, the importance of the photonics sector to the current and the future economy, which was stimulated by this invention, is less well recognised. New photonic technologies are constantly being developed to improve the generation, guiding, and detection of light. These technologies have revolutionised the healthcare, defence and communications sectors, as well as leading to new consumer devices which are now ubiquitous.



**PHOTONICS DEFINED**

ALL SCIENCE AND TECHNOLOGY RELATED TO THE GENERATION, TRANSMISSION, DETECTION AND MANIPULATION OF LIGHT IS KNOWN AS 'PHOTONICS'. PHOTONIC TECHNOLOGIES SPAN BASIC OPTICAL COMPONENTS, OPTICAL FIBRES, LASERS, DISPLAYS, SENSORS, OPTICAL INSTRUMENTATION AND CAMERAS, INCORPORATED INTO PRODUCTS AND HIGH PRODUCTIVITY MANUFACTURING PROCESSES WORLD-WIDE.

Australia and New Zealand have economies which differ widely in many respects, and which are both dominated by non-manufacturing sectors. However, while manufacturing is a minor export earner in both countries, it is recognised as a key to future prosperity. This survey has shown that the photonics sector is a vibrant and rapidly growing part of the manufacturing sector here, as it is in countries which have economies dominated by manufacturing.

In New Zealand for example, the total size of the photonics based industry sector is A$1.1b (approximately NZ$1.2b), which is comparable to that of the wine industry or the electronics and electrical equipment manufacturing sector. While the success and rapid growth of the wine industry is well documented, much less is known about the photonics sector which employs over 2500 people in over 120 companies.

Similarly, in Australia the photonics-based industry sector accounts for around A$4.3b of economic activity, similar in size to Australian dairy production, and the mining and construction equipment sector, and employs nearly 10,000 people in 465 companies.

Building on a system developed by SPIE, the international society for optics and photonics, a robust methodology has been developed to estimate the size of the industry which accurately estimates production from highly diversified companies engaged in the production of goods and provision of services in an industry for which there is no one standard industrial classification (SIC) code.

Australia and New Zealand have world-leading research institutions in the photonics sector, and have been innovative in developing new startup companies in this area, whilst also engaging increasingly with established companies working in other sectors of the economy. Photonics will power the development of new communications technologies, new healthcare instrumentation, high productivity manufacturing systems, and new sensing systems with wide application. The relatively recent recognition of the opportunities available in this sector by venture capital companies, will enable a rapid expansion of the photonics sector in the next decade.

# INTRODUCTION

## THE PHOTONICS INDUSTRY COMPRISES COMPANIES MANUFACTURING SYSTEMS AND DEVICES USING LIGHT BASED TECHNOLOGY, TOGETHER WITH SERVICE INDUSTRIES DEPLOYING AND SUPPORTING THESE TECHNOLOGIES

# PHOTONIC AND OPTICAL TECHNOLOGIES ARE USED ON A DAILY BASIS BY EVERYONE IN NEW ZEALAND AND AUSTRALIA

## Photonic and optical technologies are ubiquitous throughout New Zealand and Australia.

Light-enabled products affect every facet of modern life. The value of these products has recently been reliably estimated at just over 10% of the world's economy[1], and is growing at a significantly faster rate than the average compound annual growth rate (CAGR) of manufactured products.

To understand the ubiquity of photonics, consider for a moment the act of watching a video on a smartphone or tablet.

The phone's display is a photonics device and is produced using photonics systems for machining and assembling. The aluminium or glass case is machined using high-power lasers, as are many of the circuit boards within the body of the phone. The high-performance cameras in the modern phone are marvels of photonics design, as are the face-recognition systems used to unlock the latest generation of phones. Even the silicon chips within the phone are patterned and machined using lasers.

Whilst the phone connects wirelessly to the internet, the internet backbone is built on laser light guided through optical fibres whether to the next town or suburb, or to another continent through the vast network of undersea optical fibre cables that encircle the globe.

A single optical fibre can support up to 20,000 Gbit/sec of data (that's 1,000,000 simultaneous HDTV signals) compared to the 80 Gbit/sec of current communications satellites such as the Australian NBN's Sky Muster satellites.

The data centres which send the video to the phone also rely on optical fibre connections between the individual servers within the centre, as well as relying on the same chip-manufacturing processes based on high-performance lasers. Even data-storage within a data centre is starting to use ultra-fast lasers to store the massive volumes of data now generated every day[2].

Moving away from communications, the defence sector employs photonic systems widely in applications as broad-ranging as avionics, ordnance-guidance, night-vision systems and perimeter monitoring; mining increasingly relies on photonics for exploration and machinery monitoring, whilst drones, increasingly used in both agriculture and mineral exploration, rely on photonic techniques such as LIDAR, hyperspectral imaging and high-performance cameras to accurately map and quantify whatever they're measuring.

Health systems also rely in photonics, whether for simple devices such as a hand-held remote temperature sensor or a finger-clamped blood oximeter, through to specialised diagnostic tools as well as high-precision manufacturing for medical devices and surgical tools produced using laser machining systems.

As can be easily seen from the above, the smooth functioning of society depends on photonics, but since highly visible devices like smartphones, TVs and computer displays are not manufactured locally, it is easy to understand why the Australian and New Zealand photonics sectors, which comprise a few large companies and many small to medium sized enterprises, are largely invisible.

This report provides an in-depth assessment quantifying the size of the Australian and New Zealand photonics industry based on the latest robust methodologies developed using internationally recognised data sources. The methodologies are designed to tease out the contribution of photonics from the dispersed and largely hidden nature of the industry.

A detailed analysis of the many different applications of photonics in industry and of the different sectors impacted by these technologies in Australia and New Zealand is beyond the scope of this report. However, independent international analysis identifies ten major photonics-enabled market segments with a combined global market value of US$1.8 trillion covering end use sectors as diverse as advanced manufacturing, biomedical, defence and communications, underpinning 11% of the global economy[3].

[1] *https://spie.org/news/2020-optics-and-photonics-industry-report?SSO=1*
[2] *https://www.microsoft.com/en-us/research/project/project- silica/*
[3] *https://www.novuslight.com/trends-in-the-photonics-industry_N10078.html*

# THE AUSTRALIAN PHOTONICS INDUSTRY

## The Australian photonics industry produced goods and services worth A$4.3b in 2018.

The Australian photonics industry comprises some 465 companies and contributes just over 1% of the total value-add manufacturing within Australia. It provides 1.1% of the total manufacturing employment, with a gross value added (GVA) per employee of around A$125k, which is in line with the average for Australian manufacturing companies. The photonics industry's GVA is of similar size to the mining and construction equipment sector and the surgical and medical equipment manufacturing sector.

In common with the majority of developed economies this activity is dominated by the value-add associated with optical communications, whether in long-distance or intra-continental networks, or networks within towns and cities, or within a single office-building or data centre.

The value-add captured in this report is primarily through the design, construction and maintenance of optical communication networks, but Australia also maintains some significant manufacturing capacity in optical communications with local companies, mostly subsidiaries of larger, multinational corporations, providing subsystems and value-add products for both the domestic and export markets.

The importance of photonics to communications cannot be overstated – it is the core technology which underpins the high-speed data transmission capability of the internet, video networking and digital connectivity bonding Australians and New Zealanders with each other and to the world through the vast network of optical fibre cables. Nothing moves data faster than light, and we depend on optical communications increasingly as an essential service enabling people to both work, and be entertained when and where they wish.

In common with New Zealand, whilst there are a small number of companies which are exclusively photonics companies, the largest companies contributing to the total production are generally involved in the production of goods and services which are enabled by photonics technologies. In addition to communications, this includes companies in the mining, lighting and, increasingly, remote surveillance and monitoring (via cameras, LIDAR and hyper-spectral imaging) using both airborne (eg drones) and ground-based systems.

**FINISAR AUSTRALIA – A HOMEGROWN GLOBAL CHAMPION.**

Finisar Australia is a world leader in the development and manufacture of Wavelength Selective Switches (WSS) which are the elements in an optical network that route the high-capacity optical signals to where they are required. From its beginnings as an Australian start-up in 2001, Finisar Australia has grown to be one of the two largest developers and manufacturers of WSS in the world, with nearly A$1.5b in exports to date from its factory in Rosebery, a suburb of Sydney. Employing 250 people with over 120 graduates, including nearly 30 PhDs, Finisar Australia is an example of the type of high-value-add manufacturing industry possible in the photonics space.


**TERRA15 – ENHANCING PRODUCTIVITY IN THE MINING AND RESOURCE INDUSTRIES**

Founded in 2017, Terra15 is a Perth-based start-up which is making a name for itself in the area of vibration and acoustic sensing for the mining and resource industries. Terra15's technology can connect to any standard fibre optic cable and use the cable as thousands of vibration sensors, with every metre of the cable functioning as both an acoustic pickup and a seismic sensor. This technology is already in use at some of the largest companies in Australia.

# THE NEW ZEALAND PHOTONICS INDUSTRY

## The New Zealand photonics industry produced goods and services worth NZD1.2b in 2018.

NZ$1.2b is a significant contribution to the New Zealand economy generated from over 100 companies distributed across the country. In common with other developed countries, the industry is characterised by many small to medium sized enterprises, with a small number of large companies.

Of equal significance is the estimated gross value added per employee (>NZ$150k), which shows that the sector not only has high productivity, but also is the kind of industry that is needed to transition the country into a future economy which is not dominated by primary industries.

The New Zealand photonics industry, unlike that of more industrially focused countries, does not have a significant photonics component manufacturing sector. Instead, the local industry is focused on developing products and services enabled by photonic technologies. The country depends on agriculture as its largest export sector, and accordingly many companies have developed to either service this sector or leverage it to develop photonics-based instruments in the agtech sector. Other companies utilise photonic sensors in a range of applications in the medical, environmental monitoring and construction industries.

Whilst there are a small number of companies which are exclusively photonics companies, the largest companies contributing to the total production are generally involved in the production of goods and services which are enabled by photonics technologies. The methodology used in this survey ensures that the proportion of production which is enabled by photonics is carefully apportioned. As an example, in the telecommunications sector, the service-based part of the industry is excluded, but the economic contribution of installation and configuration of optical fibres is included as a proportion of the total workload of companies involved in this work.

**ENGENDER – SPERM CELL SORTING TECHNOLOGY**

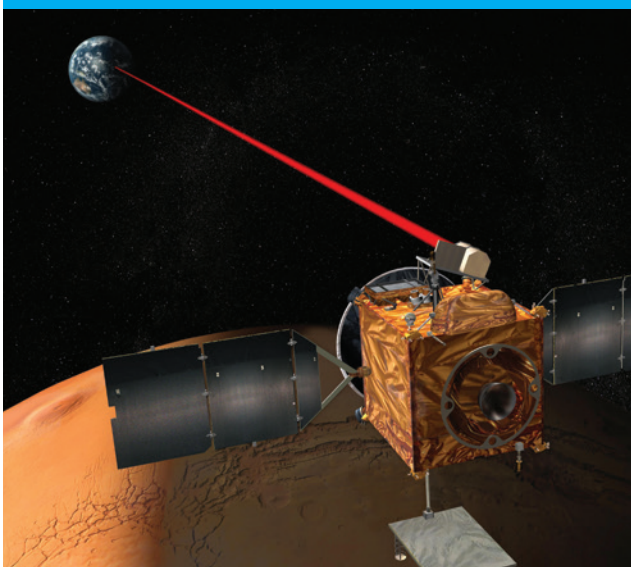
Engender Technologies Ltd is a New Zealand company that has developed an innovative method to separate X- and Y-bearing bovine sperm cells.

This technology utilizes high-tech microfluidic and photonic chips that are expected to sort sperm in a cost effective way, without negative impacts on fertility so as to create a valued product for all dairy (bovine) farmers. In November 2018, Engender was purchased by the global animal genetics company CRV, with the research and development team still based in New Zealand.

**COHERENT SOLUTIONS- DEVELOPING AND MANUFACTURING WORLD-LEADING PHOTONICS TEST AND MEASUREMENT SOLUTIONS.**

Coherent Solutions was founded as a spin-out company from Southern Photonics (itself a University of Auckland spin-out) in 2012, and has grown steadily to employ nearly 50 staff in 2020.

Initially formed to specialise in test equipment for coherent optical communications systems, the company now manufactures a range of equipment for electrooptical semiconductor testing, lidar and hypervelocity measurements, and free space optical communications systems.



# METHODOLOGY

## BUILDING ON WORK BY SPIE (2016), THE INTERNATIONAL SOCIETY FOR OPTICS AND PHOTONICS, A METHODOLOGY HAS BEEN DEVELOPED TO ESTIMATE THE SIZE OF THE AUSTRALIAN AND NEW ZEALAND PHOTONICS INDUSTRY, ACCOUNTING FOR ITS HIGHLY DIVERSE NATURE.



**The photonics industry does not have a dedicated standard industrial classification (SIC) code and this is a challenge that has long hindered efforts to accurately quantify the size of the industry around the globe.**

Several other factors add to the complexity of analysis, since many companies involved in manufacturing photonics products do so alongside producing non light-based products. Furthermore, a large number of photonics companies are SMEs and therefore report only abbreviated accounts.

The methodology for this report was developed initially for the UK photonics industry[4] to meet these challenges and modified slightly to address the specific structure of the Australian and New Zealand economies. In particular, it provides a valid, representative estimate of the photonics industry size, without the need to resort to confidential data. It also provides a framework to facilitate future reporting.

The methodology is outlined below.

**STEP 1: COMPILE A COMPREHENSIVE LIST OF COMPANIES ENGAGED WITH PHOTONICS:**

Data was gathered from sources including attendance records from international photonics-focused events, regional photonics networks memberships, industry and academic experts and down selected using knowledge of the local industry This was augmented with key word searches of New Zealand Companies Office, Australian Business Register and regional internet searches of company names containing common photonics term e.g. optics, lighting, laser, fibre and photonics, filtering out excluded groups e.g. dispensing opticians.

[4] *https://photonicsuk.org/wp-content/uploads/2018/05/UK_Photonics_The_Hidden_Economy.pdf*

**STEP 2: ESTIMATE OUTPUT, PROFIT AND EMPLOYMENT FIGURES:**

a Data on output, profit and employment for companies engaged in photonics manufacturing was obtained from Dunn and Bradstreet, based on matching the company name and Australian or New Zealand company number and postcode.

b Diversified companies producing both photonics and other products: the proportion of total company output categorised as specifically photonics was estimated by expert panels in both New Zealand and Australia. (Companies deemed by the panel to be photonics users but not explicitly photonics manufacturers were excluded from the analysis, e.g. dispensing opticians).

c The company's reported total output, profit and employment figures were then adjusted according to the proportion of photonics-specific activity, as estimated by the panel.

**STEP 3: ESTIMATE GROSS VALUE ADDED (GVA):**

GVA was taken as the sum of apportioned profits plus the apportioned employee benefit expenditure for all photonics companies.

The benefit expenditure per company (salary plus other benefits paid direct to employees) was based on the number of employees and the average benefit paid in the industry. The latter was taken from the reported total benefits paid and employee count of those large listed companies, e.g. Chorus, who report such data in their annual reports. The average benefits used were A$99,353 for Australia and NZ$88,041 (A$83,452) for New Zealand

Profit estimates were taken first from data provided by Dunn and Bradstreet where such data was available.

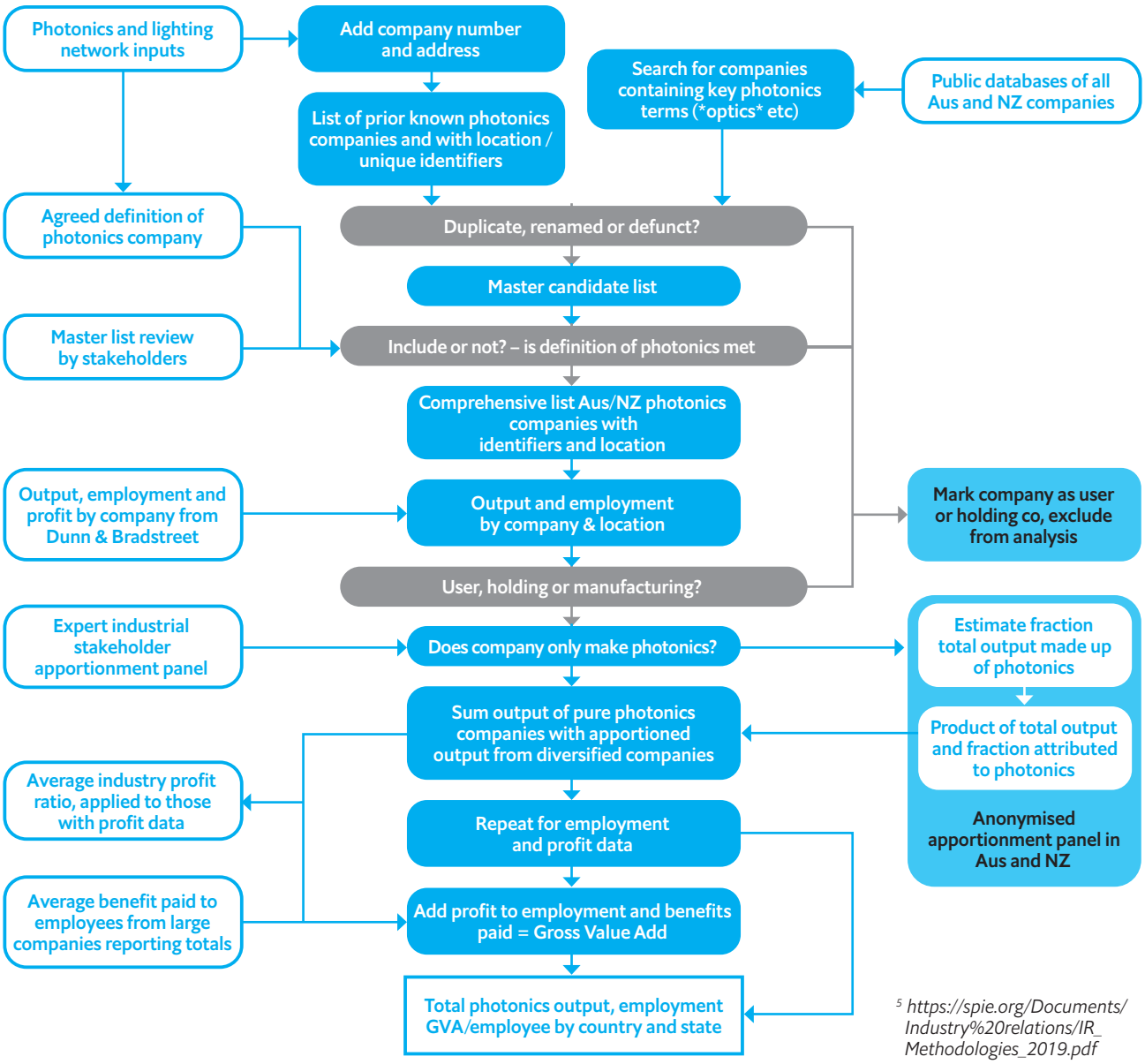
An average profit to turnover ratio for the industry was calculated based on the same data (8.09%). This ratio was then applied to companies where direct profit data was not available. All profit estimates were apportioned in the same fraction as turnover and employment. A common profit ratio was used for Australia and New Zealand. A small number of venture capital backed companies in start-up mode (e.g. Baraja) reporting losses greater than turnover were excluded from GVA analysis.

This methodology was designed to enable the inclusion of highly diversified companies, without over-attributing the value of their output to photonics and companies where profit and employee benefit data are not openly available.

In contrast, previous analyses of industry size carried out in other sectors have often been conducted using selected SIC codes alone, therefore reporting data based on the total company output. Such methodologies risk overestimating the industry size by failing to account for any output value that may have been generated by a diversified company's activities outside the sector of interest.

The present method yields a more reliable, representative assessment of the Australian and New Zealand photonics industry size and is especially suited to industries for which no one single applicable SIC code exists. It is also closely aligned to the method used by SPIE in estimating the global photonics size, facilitating international comparisons[5].

## METHODOLOGY FLOW CHART




[5] *https://spie.org/Documents/Industry%20relations/IR_Methodologies_2019.pdf*

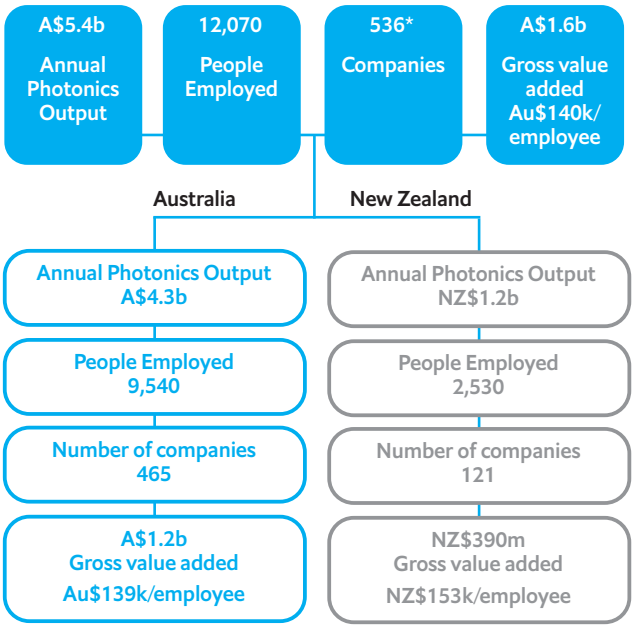
# REGIONAL DISTRIBUTION ANALYSIS

## The industry is concentrated in the main population centres in both countries but shows significant dispersion into smaller centres.

Across Australia and New Zealand, photonics generates over 12,000 jobs and over AD5.4b in economic outputs. The size distribution of the companies and their contribution to the economy is remarkably similar despite the different dependencies of Australia and New Zealand on natural resources and primary production respectively. There is a great opportunity to build both the size and number of small photonics companies utilising the well educated workforce which is being produced by the tertiary institutions in both countries.

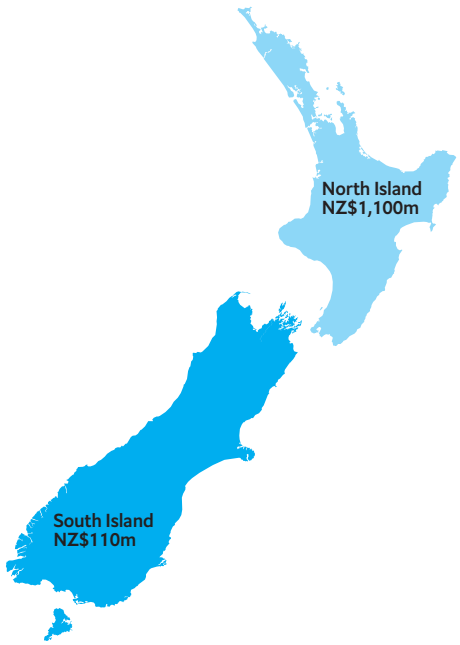
The figures show the regional distribution of the photonics industry in both countries. These maps need to be interpreted with caution since their reliability depends on identifying the geographic location of a company's photonics manufacturing activities, and some companies have head offices in main centres while the actual manufacturing may be conducted elsewhere. It is clear however, that there is economic activity in the photonics sector across the entire country both in Australia and New Zealand.

**PHOTONICS IN AUSTRALIA AND NEW ZEALAND**
LIGHTING ECONOMIC GROWTH





AUSTRALIA




NEW ZEALAND

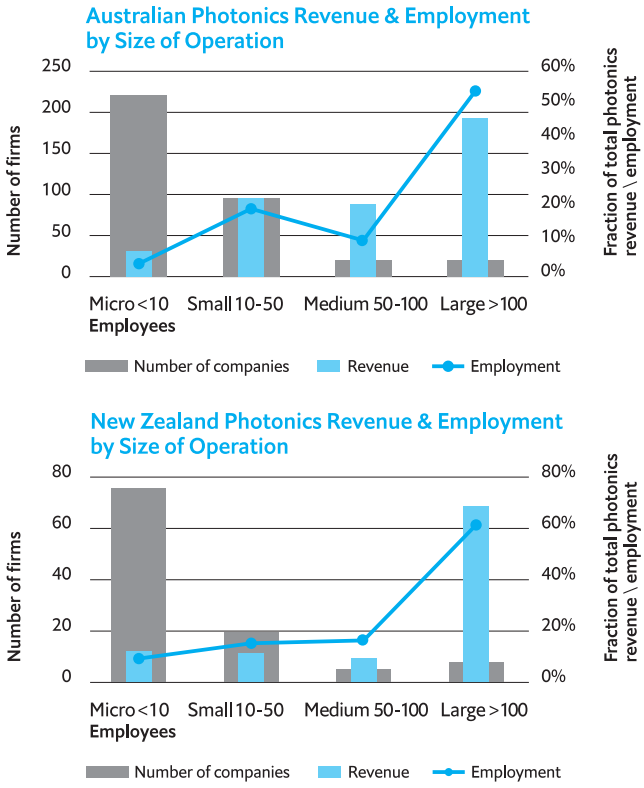
# COMPARATIVE PERFORMANCE OF AUSTRALIA & NEW ZEALAND PHOTONICS

**Manufacturing industries do not dominate the economies of either Australia or New Zealand but they are crucial to the transformation of the economy away from reliance on mining and primary industries. The photonics industry is a key component of manufacturing in both countries, generating significant growth.**

Across Australia and New Zealand combined, the sector generates A$5.4bn in economic output and generates over 12,000 jobs. Relative to the whole economy, in both Australia and New Zealand, the photonics sector accounts for just over 1 in 100 manufacturing jobs and just over 1% of total manufacturing gross value added (GVA), with a significantly higher productivity (GVA/job) than general manufacturing. The photonics industry value chain starts with the manufacture of components, which are used in photonics products. These photonics products enable other products and services, adding value through the chain. Whilst in both Australia and New Zealand there are only a few component manufacturers, there are a significant number of manufacturers of photonic products which are used directly or integrated into other systems, together with a number of companies providing photonics enabled services.

This is in contrast to the economies of some other countries, where component manufacturing is significant. It has been estimated for example, that only 1% of the world component production occurs outside Asia, North America and Europe. Asia accounts for more than 50% of all component manufacturing, with the remaining production distributed between North America and Europe. As detailed in the methodology section, the estimates of the industry size in this report are derived from the specifically photonics-related workforce, and this enables an estimate of the Gross Value added per employee.

Of particular interest is the large number of small companies identified in the survey which located 465 companies in Australia and 121 such companies in New Zealand. Whilst many of these have few employees and do not contribute significantly to the overall economic output of the sector, they represent an important resource with great potential for future growth. This is a common pattern around the world where a small number of large companies account for the bulk of the output. Globally 107 large organisations generate 78% revenue, while 3000 small companies (<US$10m) generate 2.5% revenues (SPIE).




In comparison with the rest of the world, the photonics sector is already seen to form an important and growing component of the economy. The total size of the sector across the world has been estimated A$421b by SPIE and A$730b by the Photonics21 organisation. The size of the sector in other countries varies according to the methodology used, but in the UK which has a more advanced development of the sector, it was estimated to produce A$24.7b and employ 69,000 people using the same methodology as that applied here.

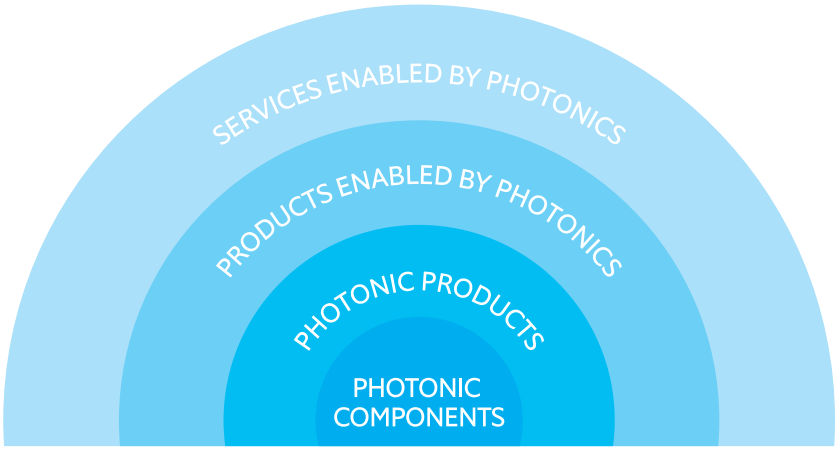
# GLOBAL RELATIONS & FUTURE GROWTH POTENTIAL

## Optics and photonics empowers the global economy.

Devices enabled by photonic technologies are ubiquitous and contribute to nearly all aspects of society. Solar power systems provide a rapidly growing component of the total electric power generation capacity of the globe as the world moves away from fossil fuel usage. Light emitting diodes convert electricity into light with unprecedented efficiency and are rapidly displacing other illumination systems. A vast range of instruments used in the life sciences depend on lasers and optical detection systems. New image sensors enable not only the cameras on smart phones but also a whole range of dedicated imaging systems operating at different wavelengths. New displays get larger and more detailed every year while the data to refresh them is transmitted through high-speed optical communication systems using optical fibres. New machine tools depend on high power lasers to cut and otherwise process materials while new scientific tools enable hitherto impossible measurements using state of the art lasers. The combined optical components and subsystems businesses in each of these sectors enable vertical markets each worth trillions of dollars annually.

The optics and photonics ecosystem is global, a manufacturer may source materials or components from one geographic region, assemble them in another and deliver them to a customer in yet another region. There are many examples of New Zealand and Australian companies who manufacture and sell in this way, and the potential for growth is huge. Small and mid-sized companies are estimated to comprise 90% of the total number of companies in the photonics industry worldwide, and this is also a characteristic of the Australian and New Zealand industry sector. These small companies are sources of innovation, responsive to customer requirements, and serve niche markets that larger companies ignore. Several of these companies are the large companies of the future however, and they also provide resources sought by larger companies as a merger or acquisition. This dynamic market place is ideal for the development of new companies, utilising the skills of graduate students trained in world-class photonics research laboratories in both Australia and New Zealand.

Small and medium-sized companies are a feature of the local economy in general, and there is tremendous growth potential in the photonics sector if the publicly funded research capabilities in universities can be effectively transferred to industry. The bulk of investment in research and development in the sector comes from a mix of corporate research and development funds and venture capital funding but government funding in the sector is essential to develop the next generation of technologies through curiosity driven research.




INDUSTRIAL VALUE CHAIN

# INNOVATION IN AUSTRALIA AND NEW ZEALAND & FUTURE OPPORTUNITIES

## Optics and photonics hold the key to future economic and social developments.

Both Australia and New Zealand have exceptional resources for technological innovation in photonics and related disciplines, developed through several decades of world-leading research in universities throughout the region. The number of published papers per head of population in the area of optics and photonics is larger than in most economically developed countries, and the challenge is to utilise this resource to generate increased economic production and social wellbeing.

Australia and New Zealand are remarkably similar in terms of total economic contribution with photonics, which accounts for close to 1% of all manufacturing production in both countries. This is equivalent to the production of the medical equipment manufacturing sector in Australia, while in New Zealand it is equivalent to the size of the electrical and electronics manufacturing sector.

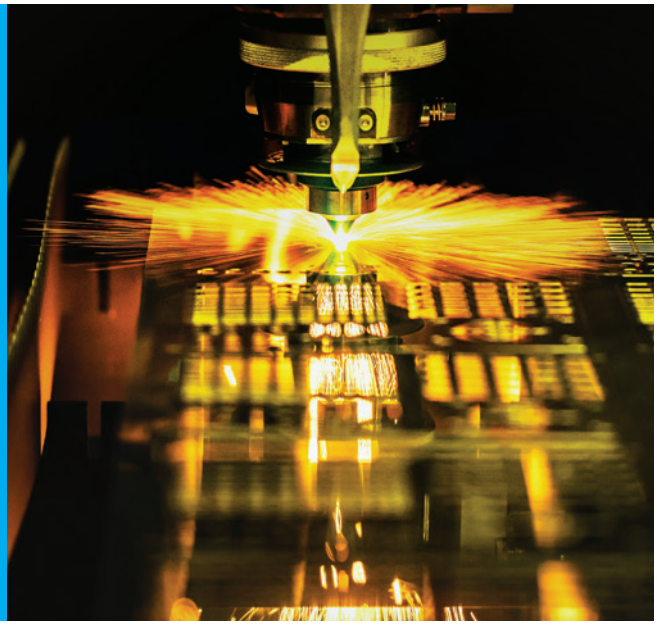
The substantial output of both research papers and well trained graduate students in the area of photonics, has enabled the development of a local photonics-based industry which is growing steadily as recognition of the opportunities in the area becomes more widespread. Increased venture capital funding for new enterprises, and the diffusion of staff from successful photonics companies into new companies is fuelling this growth. The lower barriers to entry for the formation of photonics-enabled companies has also assisted, and there is an outstanding opportunity to contribute to the future economic growth of both countries in this way.

Many countries have outlined 'Grand Challenges' which need to be addressed for society and photonics can contribute in a host of ways to these issues. Successive governments in Australia and New Zealand have also recognised the need to move the economy from reliance on primary production (in New Zealand) and minerals (in Australia) to more environmentally sustainable growth sectors, such as high-value manufacturing. The high-value manufacturing sector is particularly appropriate for development in both countries, in view of the highly educated workforce, and the high intrinsic value of the goods produced, ensuring low freight costs from a globally remote location. Most photonic products and systems include sophisticated electronics and embedded intelligence. The parallel development of the IT and electronics sectors in recent years emphasises the importance of high value manufacturing to the future economy. The photonics industry can play a key role in growing the high-value manufacturing sector, and contributing to the economic development of both countries.



**LIGHT ENABLED TECHNOLOGIES ARE KEY TO MANY OF THE ISSUES IDENTIFIED AS 'GRAND CHALLENGES' IN NEW ZEALAND**

The National Science Challenges are cross-disciplinary, mission-led programmes designed to tackle New Zealand's biggest science-based challenges. Photonic technologies are playing key roles in supporting teams working in seven of the eleven challenges identified in 2014, and smaller roles in several of the others. Photonic systems enable much of the research in the 'Science for Technological Innovation' challenge, new healthcare systems and devices are crucial to the two healthcare related challenges ('Aging well' and 'Healthier Lives') while photonic sensing and communications technologies permeate the 'Building Better Homes, Towns and Cities' challenge. New photonic sensing technologies are also essential to monitor environmental conditions in the two challenges 'Our Land and Water' and 'The Deep South'.



During the course of preparing this report, the authors identified a number of opportunities to stimulate the growth, vitality and recognition of the Australian and New Zealand industry activities in photonics. There is tremendous potential for growth in this area, and drawing on experience gained in other countries, where the photonics industry sector has been developed further, the following ideas should be considered:

- The visibility of the photonics industry should be increased through an appropriate extension of the ANZSIC classification system to recognise the importance of the sector as an industry category.
- In the current ANZSIC classification, the only optical manufacturing code is 2411 (Photographic, Optical and Ophthalmic Equipment Manufacturing), with lighting covered under 2432 (Electric Lighting Equipment Manufacturing). Much of the manufactured output has to be classified in electrical or other manufactured categories.
- Current networks linking companies within the industry are largely informal. To improve the overall industry performance, a regional and/or sectoral approach (with some level of national coordination) should be developed to generate an intra-industry network. This will improve information sharing, provide networking opportunities, and increase the industry visibility.
- The photonics industry can benefit greatly from expanded interaction with the research activities within the tertiary sector. Increased use of internships and other opportunities (eg ARC Linkage Grants and CRC(P) programs in Australia, Callaghan internships and career grants in NZ) to increase these linkages would be beneficial. This will benefit both industry and academia.
- As in other countries (eg UK), this report should be revised on a bi-annual cycle to update the industry picture and track the development of the industry over time. The industry network proposed above could provide significant assistance in this endeavour.

# SUMMARY

**Photonics in Australia and New Zealand is a significant and rapidly growing component of the economies of both countries, with a combined economic output of A$5.4b. The workforce is predominantly employed in SMEs with a small number of large firms responsible for producing the majority of the ouput.**

While the development of the photonics sector in Australia and New Zealand has lagged behind that in Europe and other northern hemisphere countries, it is now growing rapidly, and is underpinned by substantial research revenue invested in the photonics sector in tertiary institutions across the region.

This report is being written during lockdown caused by Covid-19. The sector has become pivotal to the ability to preserve education and productivity during the lockdowns imposed in many counties (including Australia and New Zealand) during the the coronavirus crisis. Even a decade ago, before the widespread access to broadband was enabled by fibre-optic rollouts, the economic and social havoc caused by the virus would have been much more severe. Indeed this crisis has changed the perception of high speed connectivity, which is now seen as an essential utility on a par with power and water supplies in many countries. Both countries now have increasing access to high speed fibre-optic enabled data connections in the majority of residential and business properties, and this will underpin the economic recovery from the current crisis.

The sector is characterised by a large number of small enterprises often started up in an entrepreneurial fashion by graduates having a clear understanding of the economic potential of photonics. This awareness has been engendered by exposure to the much larger photonics ecosystems overseas on display at major international trade shows associated with academic conferences. The sector is remarkably interconnected, with competitors and customers working in a synergistic way to develop the industry.

The global economy depends on advances in photonics technology to shrink distances and improve productivity in key industries including agriculture, manufacturing, mining and healthcare. In research, Australia and New Zealand are renowned contributors to world knowledge, leading to a nascent high knowledge industry that already employs 1 in 100 people in manufacturing. It is vital to continue to feed this local knowledge pipeline with continued strong support for photonics research and collaborations, within and between both countries. The economic opportunity is, however, far greater.

It is important to support the growth of small photonics companies in both countries to facilitate their transition into globally important players. In many end applications Australia and New Zealand have the advantage of scale (e.g. in natural resources) and /or proximity (to Asia). Enhanced connectivity within the photonics industry will assist with ensuring domestic adoption of the latest photonics tools, synchronising demand with technology supply.

Economic resilience depends on access to enabling capability. Never has there been a more appropriate time to support the domestic photonics industry which will develop resilience and provide a platform for the transformation of our economies with an impact extending far beyond the direct photonics industry.

**PHOTONICS IN A PANDEMIC**

The pervasive importance of the photonics industry has been brought into sharp focus by the 2020 coronavirus crisis. Demand for UV LEDs for disinfecting surfaces has surged while the standard PCR based test for the corona virus utilises a fluorescent dye, activated by LEDs and detected by photodiodes. Several of the proposed antibody tests similarly rely on fluorescence. Thermal imaging cameras detecting IR radiation are being deployed worldwide on country borders. Blood oximeters based on light absorption are crucial monitors of lung function, while bronchial inspection systems rely on fibre optic light delivery and image capture.

Most important of all is of course the internet. Lockdown without it is hard to imagine, with instant communication and entertainment, available throughout a world cocooned in a web of fibre optic cables.

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