Tāmaki Makaurau Auckland's Green Employment

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Glossary

- **Circular economy:** This is an economic system where waste is designed out, everything is used at its highest possible value for as long as possible and natural systems are regenerated (Circle Economy and UNEP, 2021).
- **Circular jobs:** These are occupations that directly involve or indirectly support one of the strategies of the circular economy, which are: 1) prioritise regenerative resources, 2) stretch the lifetime of products, and 3) use waste as a resource (Circle Economy and UNEP, 2021).
- **Computable General Equilibrium (CGE) Models:** A class of applied economic models often used to illustrate an economy's responses to changes in policy, technology or other external shocks. Typically, CGE models recognise several different types of economic agents (usually different types of industries, households and government), conceptualised as either profit or utility maximisers. Optimisation algorithms are employed to determine the set of prices for all commodities and factors of production that would prevail subject to selected constraints.
- **Enhanced Skills (ES) occupations**: These occupations are expected to require significant changes in tasks, skills and knowledge due to the greening of the economy.
- **Green economy:** This is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (UNEP, 2011).
- **Green jobs:** These are jobs that cannot be performed without extensive knowledge of green skills (MBIE, 2023). Additionally, a green job is defined by O*NET as any job affected by 'greening', which could involve the increased demand of certain occupations by green sectors, changes in worker requirements, and the creation of new occupations (Bowen *et al*., 2018; Dierdorff *et al*., 2009).
- **Green Rival (GR) occupations**: This category refers to a non-green occupation that is not currently included in the enhanced skills (ES), increased demand (ID), new and emerging (NE) occupation categories, but has close occupational links to green occupations based on tasks.
- **Green skills:** These skills enable the environmental sustainability of economic activities (MBIE, 2023).
- **Increased Demand (ID) occupations**: These occupations are associated with existing jobs that are expected to be in high demand due to greening of the economy without any major changes in tasks, skills, or knowledge.
- **Medium-to-long term:** This report refers to the period 2035-2050 as medium-to-long term.
- **New and Emerging (NE) occupations**: These occupations are expected to emerge due to the greening of the economy.

- **Non-Green (NG) occupations**: This refers to occupations not included in the increased demand (ID), enhanced skills (ES), new and emerging (NE) and green rival (GR) occupation categories.
- **O*NET:** The O*NET database contains standardised and occupation-specific descriptors covering approximately 1,000 occupations for the U.S economy. Each occupation is classified as requiring a mix of certain knowledge, skills and abilities, and is performed using a variety of activities and tasks.
- **Regenerative economy:** The economic model proposes that abundance and prosperity result from aligning economic systems with living systems principles (Gibbons, 2020).
- **Short-to-medium term:** This report refers to the 2018-2035 period as short-to-medium term.
- **Transition to low carbon:** shift from an economy which depends heavily on fossil fuels to a sustainable, low carbon economy.

1 Executive Summary

This research builds on national and international literature to provide insight into the 2018 baseline of green and circular employment, and the potential shift to green and circular jobs in Tāmaki Makaurau Auckland.

Definitions

Green jobs are those "that cannot be performed without extensive knowledge of green skills" where green skills "are those that enable the environmental sustainability of economic activities" (MBIE, 2023). Alternatively, a green job is defined by O*NET as any job affected by 'greening', which could involve the increased demand of certain occupations by green sectors, changes in worker requirements, and the creation of new occupations (Bowen *et al*., 2018; Dierdorff *et al*., 2009).

Circular jobs are occupations "that directly involve or indirectly support one of the strategies of the circular economy", which are: 1) prioritise regenerative resources, 2) stretch the lifetime of products, and 3) use waste as a resource (Circle Economy and UNEP, 2021).

Methodology

The methodology used is a combination of employment profiling methods developed and used internationally, using green and circular lenses. A model is then used to produce sector-based forecasts of how the Auckland economy will potentially evolve under the proposed emissions reduction pathways in 'Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan' and the Climate Change Commission's 'Ināia tonu nei: a low emissions future for Aotearoa'. Green and circular jobs have been measured independently with different methodologies. The authors recognise that there is a conceptual cross over between green and circular jobs, but the methods used to generate estimates of each do not allow this intersection to be quantified. Furthermore, this research refers to the 2018-2035 period as short-to-medium term and to the 2035-2050 period as medium-to-long term.

2018 baseline – green economy

The 2018 baseline for Auckland's green economy shows that approximately 17% of Auckland's regional workforce ("the workforce") could currently have green jobs, given that they are classified within the green occupations categories outlined in this report. Out of this 17%, approximately 6% fall under the occupation category 'Increased Demand' (ID), implying they did not need major training to be considered a green job. This is because ID jobs are indirectly green because they support the green economy, but do not involve any green tasks. The remaining 11% of workers fall under occupation categories that imply they required intermediate-to-high levels of training for their green job.

Approximately 39% of the workforce have jobs that are not considered green jobs yet because they do not involve any green tasks and are not part of a greening sector. However, these jobs are closely related to some green jobs based on similar tasks. These findings imply that approximately 56%, or more than half of the workforce could be in jobs directly or indirectly involved in the shift to the green economy in the short-to-medium term (i.e., by 2035).

Transition pathways – green jobs

When enabled by successfully implementing emissions reduction pathways, green technologies could speed up the transition and increase the potential green employment pool in the Auckland region, as depicted in Figure E.1. This modelling includes examples considering electric vehicle fleets for the transport sector, renewable sources of electricity, a methane inhibitor for dairy, sheep and beef. Based on the modelling undertaken, the change primarily occurs in the short-to-medium term (i.e., by 2035) because the jobs closely related to green jobs would likely become green based on their similar skills and tasks, and the assumption that technology is adopted in this time period. Based on the modelled adoption of green technologies by certain sectors, a relatively small change occurs in the medium to long term due to the limited green technological alternatives considered by the Climate Change Commission, particularly those that apply to the largely urban context of Auckland. This change will likely be higher as new green technologies are adopted by various sectors in the Auckland economy.

Due to the employment estimates for green occupations, the sectors with the most potential are construction, manufacturing, and services. Whereas the sectors with the greatest risk are the those that are emissions intensive and highly dependent on fossil fuels. These are conventional pasture-based sectors, sectors that depend on coal and gas, and the transport sector heavily dependent on internal combustion engines.

These transition assumptions do not include the full scope of green jobs, as these jobs would extend well beyond those affected by the transition to a net-zero economy in Tāmaki Makaurau Auckland. For example, urban planners may be required in the future to transition to a green job due to new legislation that requires biodiversity considerations in urban planning. These types of transitions are not captured in Figure E.1.

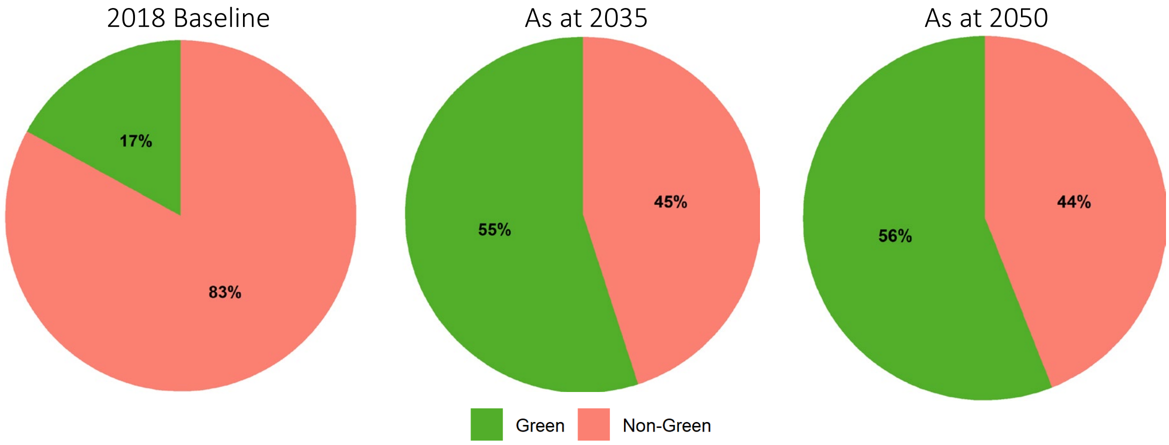

Figure E.1. The potential evolution of Auckland's green workforce enabled by the emissions reduction pathways under Te Tāruke-ā-Tāwhiri as a per cent of total employment in the short, medium and long-term considering a 2018 baseline.

2018 Baseline – Circular Economy

The 2018 baseline for Auckland's circular economy is approximately 15% of Auckland workforce. Of this, 10% are jobs in core circular sectors, and 5% of the jobs are in sectors that enable the move to a circular economy. Furthermore, approximately 21% of Auckland region's workers are indirectly related to the circular economy as they are employed by sectors that indirectly uphold the circular economy. The rest of the region's workforce (63%) are employed by sectors that are considered linear, or in other words not directly or indirectly circular. These are high-level estimates as the methodology used relies on mapping circular principles to sectors as opposed to the more nuanced treatment of green occupations within sectors.

Transition pathways – circular jobs

Based on the methodology used and the low-emission technologies considered, the proportion of circular jobs in most sectors will stay constant as most sectors will not be affected by the specific assumptions from the emissions reduction pathways.

A note on regenerative jobs and skills

While regenerative jobs and skills were considered in the planning phase of this research they were not included in the project's final output. There are several interconnected reasons why providing a regenerative lens was not possible. Firstly, regenerative sectors are emergent in New Zealand's economy. They are considered 'niche' in macroeconomic modelling and make up an exceedingly small percentage of the aggregated macroeconomic sectors used in our model. Secondly, the O*NET database used in this research and globally has not yet defined regenerative skills as they exist well below the level of sectoral aggregation reported in the database. Finally, the modelling work undertaken for the Climate Change Commission's (CCC) model has not included any consideration of regenerative technologies in the emissions reduction scenarios.

Future research

We conclude by noting data limitations that could be addressed as future areas of research. For example, the lack of data to measure the employment potential from the transition to a regenerative economy could be addressed by identifying the sectors with the greatest potential and related occupations, skills and tasks i.e., as per the O*NET green jobs dataset. The lack of data on circular occupations is also identified as an area for further research, specifically there is a need to identify promising circular technologies and their related occupations and tasks. Our study was also limited to the scenarios and set of technologies considered by the New Zealand Climate Change Commission in their initial assessment. This limitation could be addressed by developing an exhaustive assessment of the most promising urban green technologies for Auckland and mapping them to the required occupations.

2 Introduction

Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan ("the plan") is Auckland's roadmap to reach net zero-emissions, and become a resilient and healthier region that is better connected to the environment and able to thrive in the face of ongoing change and disruption (Auckland Council, 2020). The plan sets ambitious goals and targets to:

1. Reduce Greenhouse Gas (GHG) emissions by 50 per cent by 2030 and achieve net zero emissions by 2050, and
2. To adapt to the impacts of climate change by ensuring we plan for the changes we face under our current emissions pathway.

Among the changes considered in the plan is action E4: "Ensure Aucklanders are prepared for the transition to a zero-carbon economy" (Auckland Council, 2020). This includes providing employees with the necessary training; building low carbon and climate-resilient skills into New Zealand's education system; and developing a regional just transition plan for Auckland (Auckland Council, 2020). According to international literature, transitions to a net-zero future will include changes in existing jobs, the creation of new green jobs, and the wind-down of some jobs in carbon-intensive (or sunset) industries (Dierdorff *et al.*, 2009). While a transition to a net-zero future is welcomed, whereby positive environmental and economic transformation can support thriving regions, it is also a disruption that can potentially bring fear and uncertainty to some that may be negatively affected (Just Transitions Aotearoa Group, 2023).

According to the recently published guide developed by the Just Transitions Aotearoa Group (2023), "a just transition can restore and rejuvenate mauri life force to bring social, economic and environmental systems and supports into balance. It is inclusive and based on shared principles, values and visions." A just transition ensures that while working to transition towards a more ecologically-conscious economy, we also plan to achieve positive outcomes for the people negatively affected by the transition (Sharpe and Martinez-Fernandez, 2021). This implies the creation of alternative employment pathways that support a just transition to a low carbon economy.

For the Auckland region to achieve a just transition, it is necessary to characterise green and circular employment within the region. By defining and mapping green jobs and skills to the employment forecasts generated by the Computable General Equilibrium (CGE) model developed for Phase 1 (Monge and McDonald, 2023; Monge *et al.*, 2022), we can then:

- Understand the 2018 baseline of green and circular employment in Tāmaki Makaurau Auckland, and
- Map the potential transition of jobs in the transition to a low carbon economy driven by Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan and the Climate Change Commission's 'Ināia tonu nei: a low emissions future for Aotearoa'.

Our methodology used a combination of employment profiling methods for applying a green lens that have been developed and used internationally. These profiling methods were then used, in conjunction with the CGE model, to produce a 2018 baseline and sector-based forecasts of how demand for certain jobs in the Auckland economy could potentially increase under the proposed emissions reduction pathways.

A note on regenerative practices

While regenerative jobs and skills were considered within the initial scope of this research, there are several interconnected reasons why a regenerative lens has not been included in the final output. Firstly, regenerative sectors are largely emergent in Aotearoa New Zealand's economy. As a result, regenerative jobs or businesses are considered 'niche' as they make up an exceedingly small percentage of the aggregated CGE model sectors. Secondly, the O*NET database used in this research and globally, has not yet tried to define regenerative skills as they exist well below the level of sectoral aggregation reported in the database. Finally, the modelling work undertaken by the CCC model has not included any consideration of regenerative technologies (e.g., biochar and insect-based processing) in the emissions reduction scenarios it analysed. Nevertheless, our research provides a starting point, whereby green and circular jobs are understood on a spectrum from 'do less harm' towards truly regenerative.

Research gaps

Based on the profiling methods and datasets used in this study, a dataset like O*NET's green jobs could be developed to measure the employment potential in the transition to a regenerative economy. This opens a major area for future research consisting of:

1) identifying the sectors that hold the greatest potential to transition based on regenerative technological advancements and future enabling policies,

2) the economic impacts of the transition to a regenerative economy, and

3) the identification of occupational profiles in demand from the sectors with greatest potential.

It is worth reiterating that the O*NET database was developed in the United States, and it is therefore possible that occupations exist that are unique to the New Zealand economy that are not accounted for – we however believe such occupations to be exceedingly small. To further this research, a New Zealand database with locally accurate green jobs, tasks and skills could then be used to remodel Tāmaki Makaurau Auckland's transition potential, as well as Aotearoa New Zealand. The creation of this database would also provide an opportunity to categorise circular and regenerative jobs on the 'green jobs' spectrum.

3 Methodology

3.1 Definitions of Green and Circular Economies

Achieving a sustainable society and economy continues to be one of the most pressing challenges of our century (Markard *et al*., 2012). Due to sustainability's multi-dimensional nature and its different interpretations and applications, various sustainability concepts have been proposed in literature for economic research and modelling. The concepts of green and circular economy are among the most frequently referenced in global research and policy agendas in the last 3-4 decades (D'Amato *et al*., 2017). Both concepts propose to transform the current economic paradigm towards a more sustainable one (D'Amato *et al*., 2017). The green economy, coined in the late 1980's (Pearce *et al*., 1989), can be simply defined as a low carbon, resource efficient and socially inclusive economy (UNEP, 2011). Whereas the circular economy, popularised in the 1990's (Pearce and Turner, 1989), can be defined as an economy that seeks to minimise environmental impacts by closing the life cycle of biological and inorganic raw materials.

Our research builds on a national and international literature review to define and map green jobs and skills within a CGE model. Green and circular jobs are modelled separately due to differing methodologies – see below. The authors recognise that there is a conceptual cross over between green and circular jobs, but the methods used generate estimates of each do not allow this intersection to be quantified. However, high-level assumptions can be made on this premise to determine what percentage of green jobs are circular. These assumptions, and its limitations and implications, are highlighted in the findings further below.

3.2 Defining and Coding Green Jobs

The literature on green skills states that defining green jobs based on the more fundamental concept of skills (or tasks), rather than occupations, will allow policy makers to identify key similarities and differences to determine the training programs needed to move to a green economy (Bowen *et al*., 2018).

In this research, the detailed characterisation of green employment by skills and tasks follows international literature in that is based on the development of the O*NET dataset (O*NET, 2023). By using the O*NET dataset, the green employment definition and characterisation was constrained to the guidelines developed by the US Department of Labour. However, the definition of green jobs used by Aotearoa New Zealand's Ministry for Business, Innovation & Employment (MBIE) is generally aligned to the definition of green jobs by O*NET, as both are defined on either green skills or tasks.

MBIE has defined a green job as one "that cannot be performed without extensive knowledge of green skills" where green skills "are those that enable the environmental sustainability of economic activities" (MBIE, 2023). O*NET's definition of a green job is any job affected by 'greening', which could involve the increased demand of certain occupations by green sectors, changes in worker requirements, and the creation of new occupations (Bowen *et al*., 2018; Dierdorff *et al*., 2009). This definition is not based on skills but on the more granular concept of tasks, which are defined as "specific work activities that can be unique for each occupation" (O*NET, 2023). A green task "is a work activity that makes a positive contribution to the green economy" (Lobsiger and Rutzer, 2021). While skills are characterised as 'critical thinking' or 'programming', for example, MBIE's definition of green skills shares similarities with O*NET's green tasks. For example, a green task for 'Manufacturing Engineering Technologists' is to 'develop sustainable manufacturing technologies to reduce greenhouse gas emissions, minimize raw material use [and] replace non-renewable materials with renewable materials…" (O*NET, 2010). This task helps enable the environmental sustainability of economic activities, as defined by MBIE.

To categorise green jobs the following process was followed (refer to Figure 1 for a diagrammatic representation). Firstly, a concordance was created mapping the industries included in the (CPLAN-based) CGE model with the Australia and New Zealand Standard Industrial Classification (ANZSIC). Next, the type of occupations employed by the different industries in the CGE model were identified using occupational profiles developed by NZ Stats and the Australian Bureau of Labour using the Australia and New Zealand Standard Categories of Occupations (ANZSCO). We then used a concordance map between ANZSCO and O*NET Standard Occupation Classification (SOC) to connect the occupational profiles to the O*NET database using green tasks. The green occupations were categorised as direct or indirect based on the green tasks involved. As outlined below, O*NET counts any occupation that will be affected by the greening of the economy as a green job, which includes the 'indirect' occupations that support a green economy.

Indirectly green (does not involve green tasks):

1. *Increased Demand (ID)*: ID occupations are existing jobs that are expected to be in high demand due to greening of the economy without any major changes in tasks, skills, or knowledge. These jobs are considered indirectly green because they support the green economy, but do not involve any green tasks. Taking the transport sector as an example, occupations such as customer service representatives can use their skills to support the green economy without undertaking green tasks, e.g., they could answer questions about environmentally friendly transport practices without undertaking technical tasks to specifically reduce emissions.

Directly green (involves green tasks):

2. *Enhanced Skills (ES)*: ES occupations are expected to require changes in tasks, skills and knowledge due to the greening of the economy. For example, a decarbonisation initiative in the transport sector might require truck drivers to change the way their existing skills and knowledge are applied, e.g., using a GPS system (existing skills) to plan low-carbon routes (might require on-the-job training).

3. *New and Emerging (NE)*: NE occupations are expected to emerge due to the greening of the economy. For example, a transportation planner may need to be re-trained with new knowledge or skill sets for a role that helps the transport sector to develop and implement new models of low-carbon transportation systems.

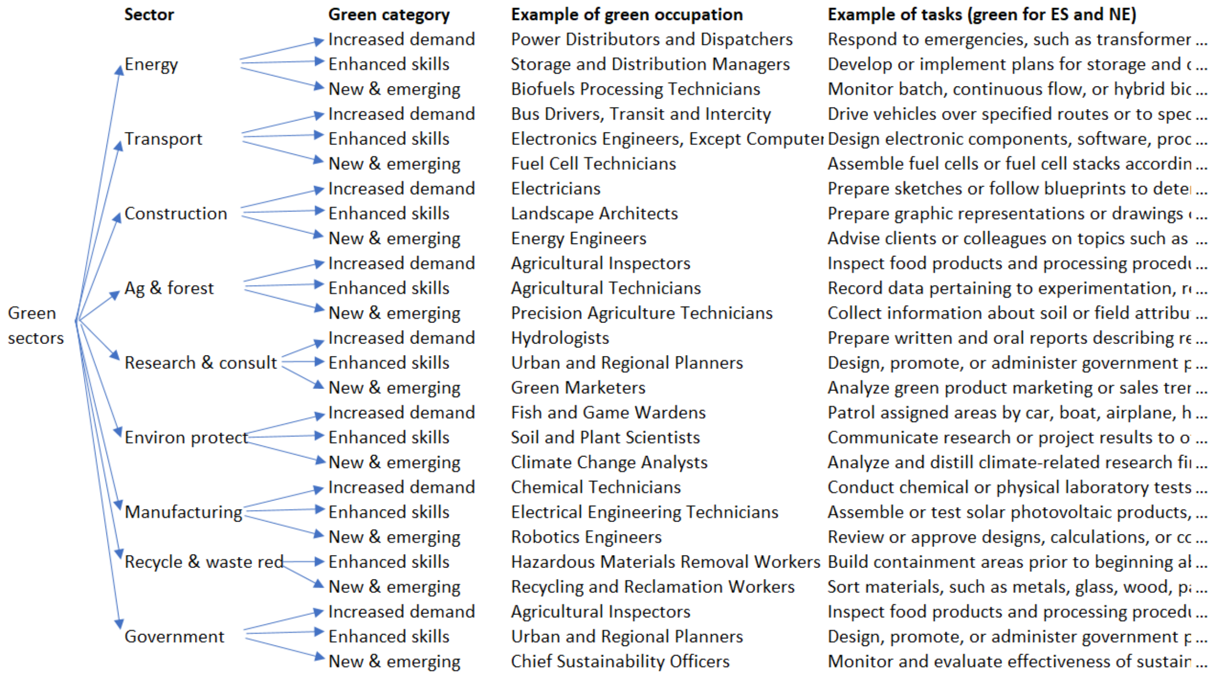

Figure 1: Example occupations and tasks mapped to green categories within green sectors using the O*NET database for green occupations and tasks. Source: Dierdorff *et al*. (2009).

Based on Bowen *et al*. (2018) and using O*NET relational tables, we have also created two new categories – named 'green rival' and 'non-green' – to measure the move from non-green jobs to similar green occupations, and investigate the potential long-term effects of greening the economy. O*NET has developed a list of related occupation links between so-called 'O*NET-SOC occupations'. According to this list, related occupations were "developed using an approach which includes three important contributors to occupational similarity: [i] what people in the occupations do, [ii] what they know, and [iii] what they are called" (Dahlke *et al*., 2022). Based on proximity, O*NET relates each occupation to the five most strongly related occupations (i.e., referred to as 'primary short'), the 6th to 10th most strongly related occupations (i.e., referred to as 'primary long'), and the 11th to 20th most strongly related occupations (i.e., referred to as 'supplemental'). Based on this new set of information, we developed the following new categories:

Not green:

4. *Non-Green (NG)*: The NG category refers to occupations not included in the ID, ES, NE and GR categories. In other words, using O*NET relational data, NG jobs do not have any green occupations in their lists of 20 related occupations (i.e., as defined as 'primary short', 'primary long' and 'supplemental' categories).

   In the following sections, we also assume that the non-green (NG) occupations category will:

   a. Likely stay non-green (NG) if employed in a sector without a green technology up to 2050.
   b. Likely transition to green in the medium-to-long term (i.e., between 2035 and 2050) if employed in a sector modelled with a green technology. We therefore assume that these occupations will become green by 2050.

5. *Green Rival (GR)*: The GR category refers to a non-green occupation that is not currently included in the previous categories (ES, ID, and NE), but has close occupational links to green occupations based on tasks. This category implies that any employee with a green rival occupation could become directly involved in the green economy if they make a 'lateral movement' from a non-green job to a closely related ID green occupation. For example, a retail salesperson is not currently considered a green occupation by O*NET as they are not necessarily supporting the green economy. However, they already possess the skills that could enable them to become customer service representatives, which is considered an indirect green ID occupation by O*NET. GR occupations are more like ID occupations, as ES and NE occupations require changes in tasks, skills and knowledge.

NG differs from the GR category slightly, as GR occupations are currently able to move to jobs indirectly supporting the green economy, based on their existing skills.

Green Job Skills and Tasks

To understand the skills required in these roles, an additional layer of analysis was added based on a literature review. This literature identified the skills and tasks associated with the different green categories. While the green tasks and skills are not mapped against each other, nor weighted against Auckland employment figures, due to the scope of research, this approach still provides an indication of which skills are needed in each green job category.

The skills and tasks composition of these five distinct categories (ID, ES, NE, NG and GR) differ quite substantially. *Skills* are "developed capacities that facilitate learning and the performance of activities that occur across jobs" (O*NET, 2023). *Tasks* are "specific work activities that can be unique for each occupation" (O*NET, 2023).

Using O*NET's skill level data, Bowen *et al*. (2018) identified that most NE jobs are high-skill and that a large percent of ID jobs are low-skill and of a similar level to GR jobs. Using three different skill measures (i.e., education, experience and training), Bowen *et al*. (2018) also identified that among the green categories, NE jobs require the most education, most experience, and the least amount of training (i.e., average of 3–6 months of training).

In regards to tasks, Bowen *et al*. (2018) identified that green NE jobs involve the largest share of green tasks (60%), out of all tasks (green and non-green), followed by ES (30%) and ID jobs (0%). The fact that a significant share of non-green tasks is used in both green and non-green jobs suggest considerable similarities and may facilitate the move from non-green to green jobs. Consoli *et al*. (2016) developed the following five aggregate task categories based on repetition (routine vs. nonroutine), interaction with others (interactive), and degree of physical exertion required (cognitive vs. manual): 1) non-routine cognitive/analytical, 2) non-routine interactive, 3) non-routine manual, 4) routine cognitive and 5) routine manual. Based on these aggregate task categories, Bowen *et al*. (2018) concluded that non-routine tasks (analytical and interactive) are more important for NE jobs compared with other subcategories and that, on average, high-skill NE jobs rely less on manual skills compared to low-skill ID jobs relying the most on manual skills among all job subcategories.

Modelling Caveats for Green Jobs

This research follows Phase 1 by modelling the impacts of a transition pathway for Auckland's economy under the CCC emissions reduction targets. As such, it uses these same CGE model but with additional layers of concordance mapping showing occupations through a green lens. This approach has allowed for a 2018 green jobs baseline (see Section 4) using the O*NET database categories. However, as the model is based on emissions reduction pathways from the Climate Change Commission and Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan, it only produces information about the future potential for the sectors and occupations affected by the transition to low carbon under these pathways.

The demand for green jobs and their tasks and skills required will undoubtedly change with the transition to a low carbon, resilient and regenerative economy. However, the 'green potential' of the broader range of occupations cannot be estimated within the current constraints of this research. Instead, the 2018 baseline developed here provides an initial assessment of all green jobs and their associated tasks. As the O*NET datasets are static, they cannot be used to make robust future projections about the jobs, tasks and skills. Nevertheless, this information may be used to make some near-term assumptions (5 – 10 years from the 2018 baseline) based on a qualitative assessment of Auckland's workforce demand and further research on this topic.

3.3 Defining and Coding Circular Jobs

For the component on circular jobs, this research used the methodology developed by the Netherlands-based Circle Economy 'think tank' (Muñoz H. *et al*., 2022) and an input-output table representing the Auckland region (Smith *et al*., 2015) to characterise circular employment based on the sectors that could directly or indirectly uphold a circular economy.

In contrast to the advanced literature on green jobs, the characterisation of circular employment is still very much in its infancy as it relies on mapping circular principles to sectors, which does not really provide any perspectives on the skills and tasks needed in a potential circular transition. Due to the lack of a dataset mapping circular sectors to skills or tasks, the characterisation of circular jobs is based on the sectors that are considered circular by the Circle Economy.

The Circle Economy and UNEP (2021) and Muñoz H. *et al*. (2022) have developed a methodology to measure the extent of the circular economy based on the following definition using three key strategies. A circular job is any occupation that directly or indirectly involves: 1) prioritising regenerative resources, 2) stretching the lifetime of products, and/or 3) using waste as a resource (Circle Economy and UNEP, 2021).

Based on these three strategies, the Circle Economy defines the following circular job categories:

- *Core circular jobs*: the jobs that are related to either of the three core circular strategies,
- *Enabling circular jobs*: the jobs that enable the acceleration and upscaling of the core circular jobs, and
- *Indirect circular jobs*: the jobs that indirectly uphold the circular economy.

In this research, the first two categories are then mapped to different sectors in the International Standard Industrial Categories (ISIC) which, in turn, can be directly aligned to the Australian and New Zealand Standard Industrial Classification (ANZSIC), and the jobs in the last category (indirect) are estimated using the economic activity generated by the first two categories using input-output analysis (Circle Economy and UNEP, 2021; Muñoz H. *et al.*, 2022). This methodology has been used in various cities and countries in Europe to assess the current extent of the circular economy. Refer to the Circle Economy website (www.circle-economy.com) for access to the list of applications of the circular jobs' methodology.

When estimating indirect circular jobs using input-output analysis, the aim is to capture relationships between different sectors of the economy from a supply chain perspective. For example, flows of outputs from one sector are understood as input in another sector. The circular strategies highlighted above, have a direct impact on the inputs and outputs in all supply chains.

The estimation of circular jobs is also based on the assumption that the volume of monetary transactions is a good proxy for the number of jobs, which implies full proportionality between monetary transactions and employment. For example, the monetary values (in $) of the products supplied by an enabling sector (e.g., wood and paper products) to core circular sectors (e.g., electricity), as recorded in an input-output table, are used as an approximation of the share (or %) of total employment in the enabling sector enabling the circular economy.

Modelling Caveats for Circular Jobs

While this is a useful starting point, it is important to note that the sectors considered circular in the Netherlands might not be the same as the sectors considered circular in the Auckland region or Aotearoa New Zealand. The same applies for green occupations and skills in the United States. However, it is beyond the scope of this research to analyse these differences.

Although circular skills have been mapped to circular sectors in Amsterdam (Circle Economy and EHERO, 2018), which is the city where the methodology was developed; we considered that the application of the methodology at the sectoral level in Auckland region is a good first attempt at identifying an initial 2018 baseline. The methodology maps circular principles to different sectors based on a European context. This mapping might not apply to all sectors in Auckland as sectors considered linear by the methodology might currently be implementing circular principles. Adding an occupational and skills layer to the assumed circular sectors may result in conclusions that are not realistic. For example, categorising potentially circular skills in primary industries as linear as the method considers all primary industries linear. Hence, we decided to undertake the analysis of circular jobs at the sectoral level rather than at the occupational and skill level. The establishment of a 2018 baseline for circular skills would require an additional dataset mapping circular skills and tasks to occupations, which is a possibility for future research.

Due to the use of two methods based on a separate set of assumptions, green and circular jobs cannot be directly mapped together. Instead, circular jobs can conceptually be viewed as a subset of green, and high-level assumptions may be made on this premise to determine what percentage of green jobs are crudely circular. Nevertheless, the two methods rely on a different set of assumptions, and as a result, have their own respective caveats. For example, measurement of circular jobs uses a broad sectoral mapping whereas the one used to measure green jobs uses the more nuanced O*NET mapping of green categories (based on tasks) to occupations and sectors.

3.4 Establishing the 2018 Baseline for Green and Circular Jobs

Using the previous two profiling methods, we quantified the green and circular employment of the Auckland region using estimates from the 2018 New Zealand Census of Population and Dwellings (Stats NZ, 2019). The potential employment implications across time were then simulated using the emissions reduction pathways, based on the Recursive Dynamic, Multi-regional Computable General Equilibrium (CGE) model as developed in the Phase 1 project (Monge and McDonald, 2023; Monge *et al*., 2022).

Transition Modelling Caveats, 2018 to 2050

CGE models have been widely used to analyse employment implications from climate policies (Babatunde *et al*., 2017). Since the CGE model used in this study produced employment estimates at the sector level, it was straightforward to link the modelled employment estimates to national and international standard industry and occupation classifications used in the green and circular jobs literature. However, there are important underlying assumptions upon which CGE models rest i.e., sectors (industry groupings) are highly aggregated in CGE and do not have the occupational detail necessary to directly characterise green and circular employment within the model itself. The aggregate (28 sector) model outputs were disentangled through concordance mappings using the profiling methods described above, e.g., O*NET (green jobs) and the Circle Economy / input-output analysis (circular jobs).[1]

This modelling was entirely based on a top-down approach using national (e.g., input-output tables) and regional statistics (e.g., regional employment). The advantage of this approach is that it is based on up-to-date, reliable, and existing macro-economic data to calculate the number of jobs. Furthermore, the employment characterisations followed national and international industry and occupation classification systems (e.g., ANZSIC and ANZSCO). This allows for easy replication and comparison of results over time and across regions. Although a bottom-up approach to produce tailored skill-occupation-sector mappings for Auckland region would have been a more accurate and arguably more reliable, it would have been time-intensive and costly, which was beyond the scope of this research.

Although the growth of green jobs will potentially be higher by 2050 as different sectors adopt green technologies, our projections are limited to a great extent by the few green technological alternatives considered by the CCC in their initial macro assessment using CPLAN.

[1] A subset of 8 sectors of the original 36 sectors considered in the CGE model in phase 1 were artificially created in the model and do not have historical employment data. Hence, we have used the 28 sectors for which there is historical employment data from the 2018 NZ Census. For example, we have included an aggregate electricity sector in this study, which was originally split into 6 subsectors (e.g., coal, hydro, wind, etc.), as there is historical employment data for electricity. However, we have used modelled employment forecasts for the 6 electricity subsectors to develop transition forecasts for green and conventional electricity.

4 Auckland’s green employment baseline

According to the previous green job definitions, 17% of Auckland’s regional workforce can be classified as having green jobs, based on the 2018 New Zealand Census of Population and Dwellings information (Figure 2). This total encompasses the New Emerging (NE), Enhanced Skills (ES), and Increased Demand (ID) green job categories. Of this, approximately 11% are classified as directly green (NE and ES). In 2018, Auckland region’s workforce had 824,538 jobs, meaning that roughly 90,000 people were employed directly in green jobs. Please refer to Table A.1 in the Appendix for a breakdown on jobs by green and non-green categories and by sector of the Auckland region economy. On the other hand, 83% of the workforce are considered Non-Green (NG) or Green Rival (GR). Of this, 44% are NG and therefore have limited potential of becoming green unless they are jobs affected by green technologies in section 5.

If GR workers however made a lateral movement to a green occupation in the short-to-medium term (i.e., by 2035), approximately 39% could become green. Altogether, this suggests that approximately 56%, or more than half of the workforce could be directly or indirectly involved in the green economy in the short-to-medium term (i.e., by 2035).

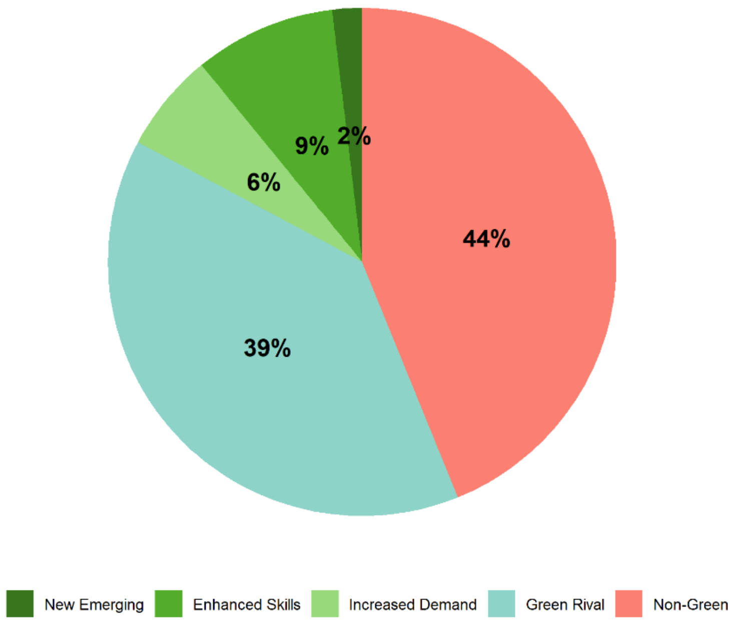

Figure 2. Share of employment under different green occupation categories based on O*NET's green occupations and the 2018 New Zealand Census of Population and Dwellings.

As shown in Figure 2, approximately 6% of the workforce fall under the ID category implying that they did not need major training to be considered a green job. This is because ID jobs are indirectly green because they support the green economy, but do not involve any green tasks *per se*. Approximately 9% and 2% of workers fall under the ES and NE categories, respectively, implying that they required intermediate-to-high levels of training for their role in a green job.

Further disaggregating Figure 2 by occupation categories results in Figure 3 where the green categories have been split into different occupations (i.e., ANZSCO 1-digit occupations). As shown in Figure 3, the occupations with the greatest number of green jobs in 2018 (across the ID, ES, and NE categories) were managers (43,136 jobs), professionals (33,131 jobs), and technicians (23,726 jobs). This is, in part, because these occupations have some of the largest employment levels in the Auckland region.

As shown on the right-hand side of Figure 3, in relative terms, the occupations with the greatest number of green jobs are operators/drivers (31% of jobs), managers (29% of jobs), and technicians (25% of jobs). Operators and drivers did not require a high level of additional training as their green potential is defined by ID and ES, meaning that only some enhanced skills were required. On the other hand, managers would have required medium-to-high levels of additional training as their green potential is defined mainly by ES and NE, meaning that enhanced or new skills were needed.

Please refer to Table A.2 in the Appendix for a more detailed disaggregation of these results.

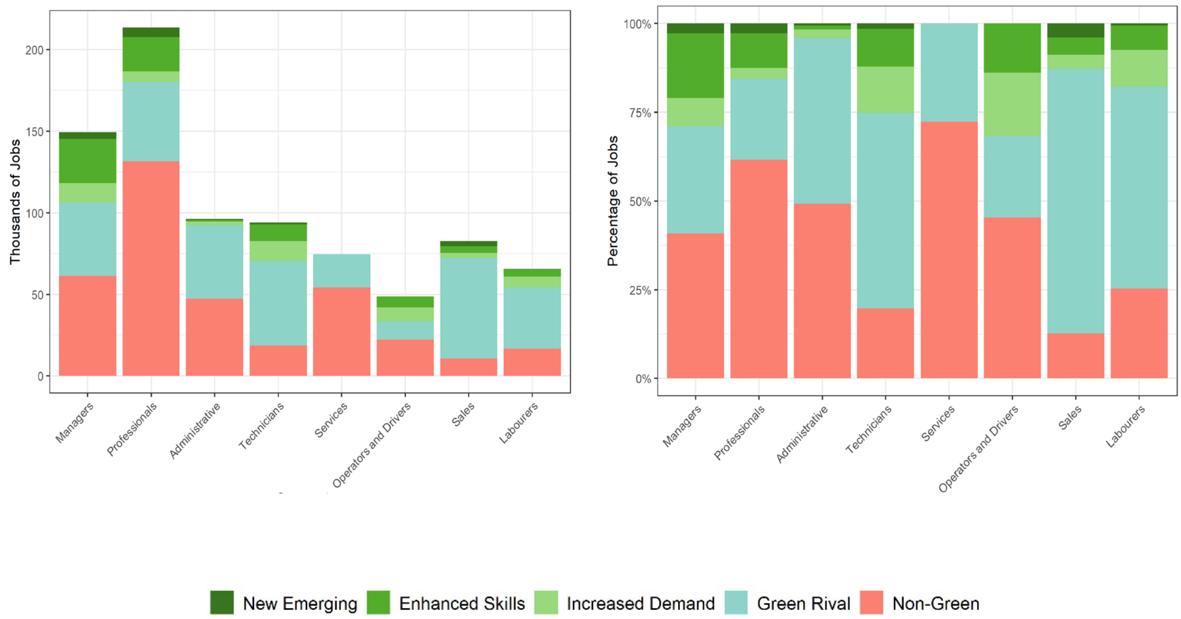

Figure 3. Absolute and relative split of Auckland's green categories by occupation (ANZSCO 1-digit level) based on O*NET's green occupations and the 2018 New Zealand Census of Population and Dwellings.

In absolute terms (left-hand side of Figure 3), the occupations with high levels of GR are sales workers (61,626 jobs), labourers, (37,322 jobs), and professionals (48,761 jobs). In relative terms (right-hand side of Figure 3), sales workers (75% jobs), technicians (55% jobs), and labourers (57% jobs), have the greatest potential to shift from GR to green.

GR workers currently employed in sunset sectors (such as coal which will be phased out in the transition to low carbon), might also be able to move into available and similar green occupations in greening sectors. Depending on the 'greenness' (ID, ES or NE) of the related roles, the training requirements would vary. Based on existing skills, the shift from GR would likely happen to similar ID roles. As such, this category of non-green workers would not be at risk in the transition to low carbon if they wish to stay in roles that require similar skills, and those jobs are available in the market. If not, then those workers in the GR category could be at risk, as a medium-to-high level of training would be required to find employment in an ES or NE role. Refer to Figure 4 for a graphical representation of the shares of GR and NG occupations for various sunset sectors. Furthermore, NG roles in sunset sectors would be the most at risk as they do not currently possess the transferable skills required for the shift to green roles in the transition to low carbon. This is covered more in the following section on Auckland region's potential green transition.

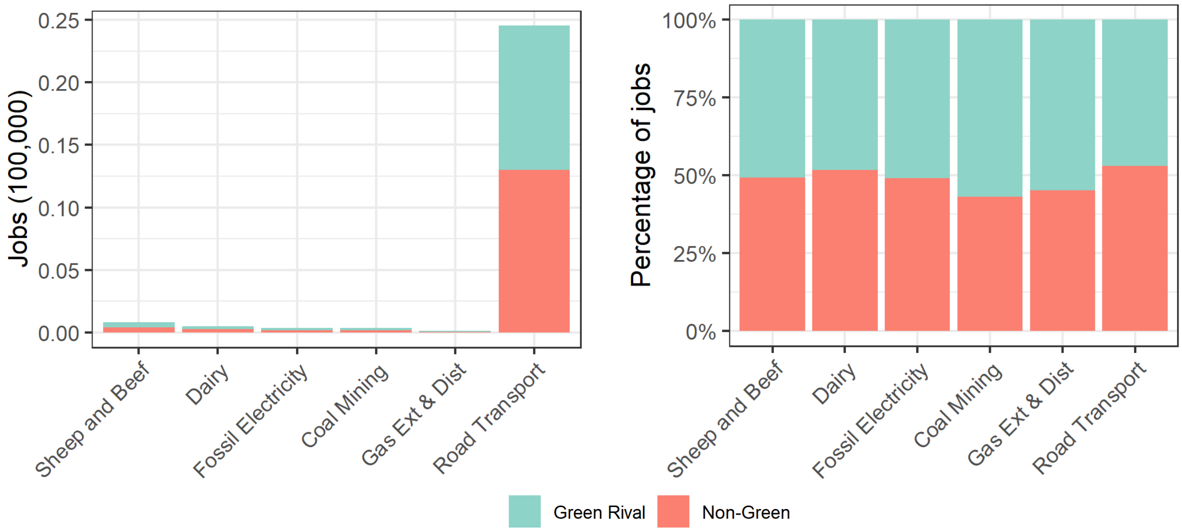

Figure 4. Absolute and relative split of Auckland's non-green categories by sunset sector (following the CGE sectors) based on O*NET's green occupations and the 2018 New Zealand Census of Population and Dwellings.

Disaggregating Figure 2 by Auckland region's major sectoral groups results in Figure 5. In other words, the 28 original CGE sectors are further aggregated into 6 major groups based on the mapping listed in Table A.3 in the Appendix.

Based on the left-hand side of Figure 5, the aggregate sectors that have the most green jobs, in absolute terms, are construction (22,147 jobs), manufacturing (21,087 jobs) and services (83,976 jobs), due to the sheer number of people employed by each industry. However, in relative terms (right-hand side of Figure 5), the aggregate sectors with the greatest share of green workers are construction (30% of jobs), primary industries (32% of jobs), and transport (27% of jobs).

All aggregate sectors have similar shares of GR occupations based on the right-hand side of Figure 5. Although the services aggregate sector is the largest employer in Auckland region, it is the one with the highest share of non-green occupations (48% of jobs). When looking at the NG roles in other sectors, in relative terms the transport, energy and manufacturing sectors also have a high share of NG occupations (~35% of jobs each).

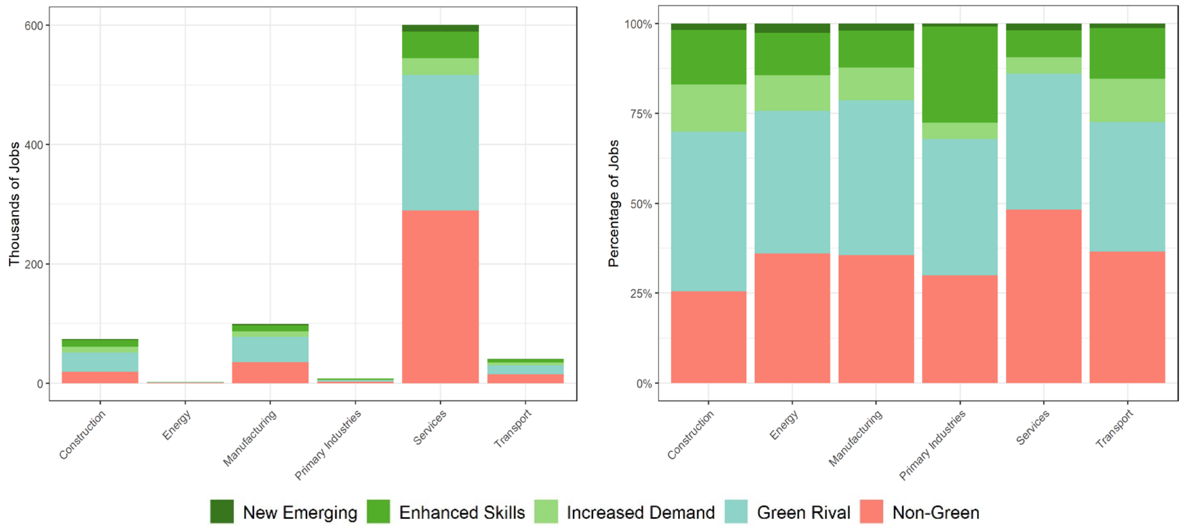

Figure 5. Absolute and relative split of Auckland's green categories by major sectoral group (aggregation of the original CGE sectors into 6 groups) based on O*NET's green occupations and the 2018 New Zealand Census of Population and Dwellings.

By further disaggregating Figure 5 into the occupational profiles of each major sector results in Figure 6, which shows the relative split of green categories for the occupations. As mentioned previously, the aggregate sectors that possess the highest shares of green jobs are primary industries, construction, and transport. This is because primary industries have a large percentage of managerial occupations under the ES category (i.e., some training is needed), construction has a large percentage of technicians, operators/drivers and labourers under the ID category (i.e., no major training is needed), and transport has a large proportion of operator/drivers, technicians, and labourers under the ID category (i.e., no major training is needed).

Considering only green rival (GR), the construction sector has the most potential to increase the number of indirect green jobs without upskilling, as it has a sizeable percentage of technicians, labourers and sales workers.

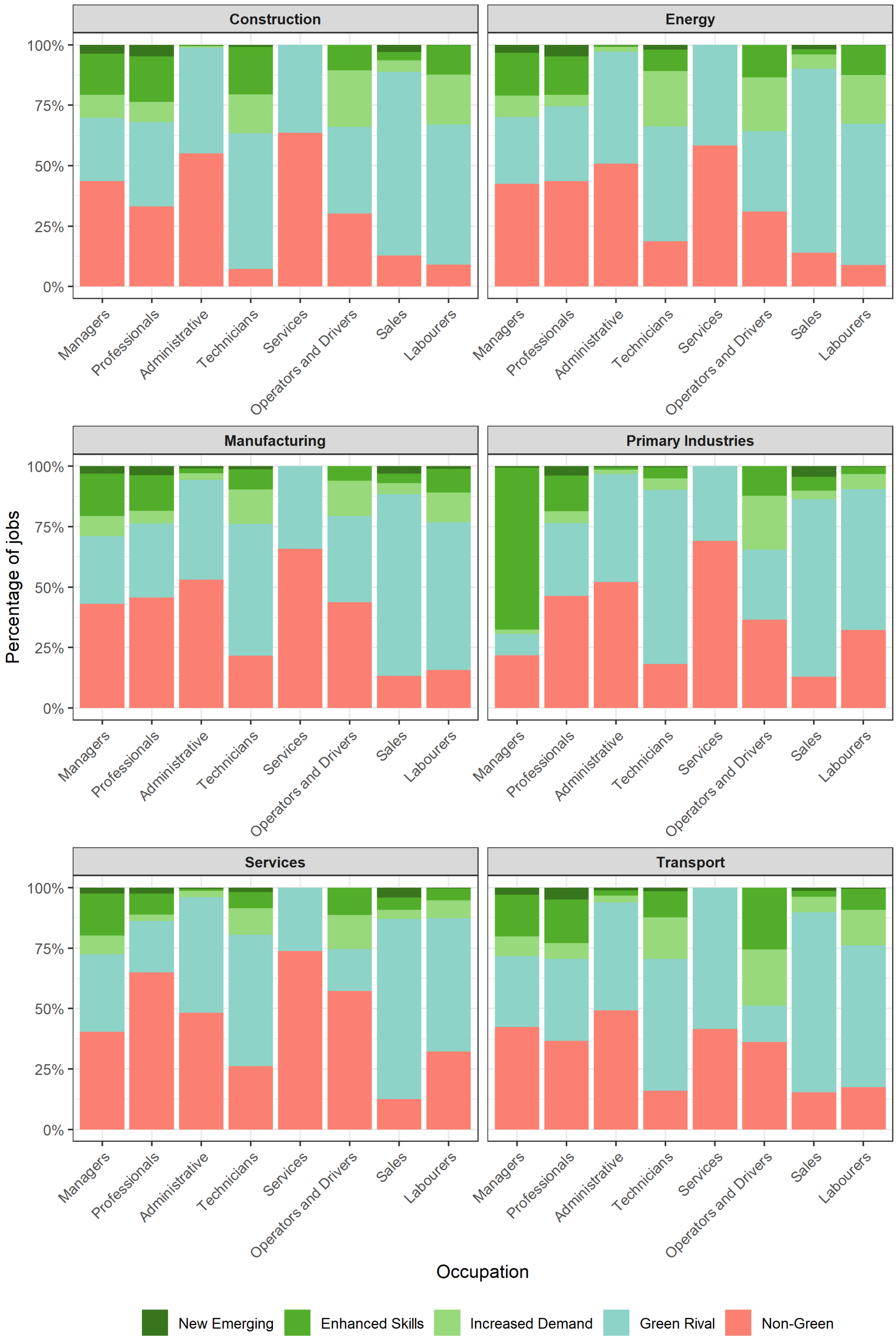

Figure 6. Relative split of green categories by occupation for every major sectoral group based on O*NET's green occupations and the 2018 New Zealand Census of Population and Dwellings.

5 Auckland's green transition potential

This section will outline the potential green employment transition for the different sectors in the Auckland region affected by the emissions reduction pathways. This transition is estimated using the Climate Change Commission's transition pathways in Ināia tonu nei: a low emissions future for Aotearoa (CCC, 2021) and the emissions reduction pathways published in Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan.

To reach these employment projections, Market Economic used the forecasted changes in employment estimated within the CGE model built and used in Phase 1 (Monge and McDonald, 2023; Monge *et al.*, 2022), the emissions reduction/transition pathways, and the relevant green employment profiles detailed in the previous section. Table 1 shows the forecasted employment growth for the sectors representing the Auckland regional economy in the CGE model in three points in time. For a more detailed description of the model and scenarios, please refer to the report developed under Phase 1.

Table 1. Forecasted employment index by Auckland sectors under the proposed emissions reduction pathway in Te Tāruke-ā-Tāwhiri: Auckland region's Climate Plan (2014 base year).

CGE sectors	2014	2018	2035	2050
Other animal prods	1.00	1.11	1.40	1.53
Horticulture	1.00	1.12	1.39	1.53
Forestry	1.00	1.12	1.53	1.97
Fishing	1.00	1.01	1.14	1.45
Coal	0.99	0.94	0.69	0.33
Crude oil extraction	1.00	1.09	1.15	1.20
Gas extraction	1.00	1.00	0.80	0.47
Refined oil prods	1.00	1.08	1.22	1.30
Other mining	1.00	1.12	1.47	1.93
Electricity trans and dist	1.00	1.07	1.39	2.05
Chemical manuf	1.00	1.01	1.12	1.32
Non-metallic minerals	1.00	1.01	1.13	1.35
Fabric metal prods	1.00	1.11	1.49	1.65
Dairy processing	1.00	1.02	1.11	1.20
Meat prods	1.00	1.08	1.18	1.20
Other food prods	1.00	1.12	1.21	1.22
Wood prods	1.00	1.15	1.76	2.42
Motor vehicles	1.00	1.08	1.43	1.82
Other manuf	1.00	1.15	1.43	1.42
Construction	1.00	1.04	1.05	1.14
Accomm and food serv	1.00	1.17	1.88	2.48
Other services	1.00	1.16	1.71	2.10
Water transp – dom	1.00	1.04	1.36	1.85
Air transp – dom	1.00	1.13	2.08	5.70
Water transp – intl	1.00	1.19	2.09	3.41
Air transp – intl	1.00	1.20	2.36	5.31
Dairy farming	1.00	1.00	0.10	0.00
Dairy farm w/inhibitor	0.00	0.00	0.96	1.07
Sheep farming	1.00	1.06	0.24	0.26
Sheep farm w/inhibitor	0	0	1.03	1.11
Road transp	1.00	1.13	1.48	0.00
Electric road transp	0.00	0.00	0.28	1.50
Coal electricity	1.00	0.76	0.00	0.00
Gas electricity	1.00	0.88	0.66	0.00
Geothermal elect	1.00	1.07	0.20	0.00
Hydro electricity	1.00	1.08	1.03	1.09
Wind/Solar elect	1.00	1.00	4.01	11.92
Geothermal w/CCS	0.00	0.00	1.21	1.67
Iron and steel	1.00	1.19	2.23	2.98

The index above shows like-for-like proportional changes in employment, rather than the actual number of increase or decrease on jobs. The sectors that go from red coloured cells to green across time are positively affected by the emissions reduction pathways in the model, in terms of increased employment.

This outcome is also due to the alternative low-emissions technologies in these pathways. For example, the dairy and sheep/beef farming sectors were modelled with a methane-inhibiting technology; road transport with an electric alternative; and high-emitting electricity sectors with low-emitting technologies such as wind/solar, geothermal with Carbon Capture and Storage (CCS) and hydro.

The results show that total employment for dairy farming would shift from a conventional technology with an index of 1 to a methane-inhibiting technology with an index of 1.07 (or an overall 7 per cent increment). Similarly, road transport would increase by 50 per cent with a transition to electric alternatives. Wind/solar electricity is another example, where employment would increase significantly from an index of 1 to 11.92 (or by 1,092 per cent). Sectors that go from green to red are negatively affected by the transition, in terms of reduced employment. For example, gas electricity would reduce from an index of 1 in 2014 to 0 in 2050.

The employment trends are positive with emissions reduction technologies, as demonstrated by the pattern going from red to green. This will, to some extent, affect the employment transitions modelled through time, which will impact the required number of employees with green skills in these sectors. This index also highlights the sunset sectors impacted by the transition to low carbon (green coloured cells changing to red), thus indicating where employment transition support will be required. It is important to note that these employment indices are based on the specific carbon transition pathway modelled in Phase 1. Even though some carbon-intensive industries (e.g., crude oil extraction) may still have an increasing index over time, it is possible that this increase is less than what would have been calculated for a different scenario such as a 'do-nothing' scenario.

Potential green transitions were modelled based on the major green categories described in the previous section, namely green (including NE, ES and ID) and non-green (including GR and NG). Since, the CGE model does not consider occupational profiles for the labour used by different industries, we have made the following assumptions to forecast a potential transition[2] based on the major green categories:

- *Green occupations*: All occupations under the NE, ES and ID categories are currently considered green and will be considered green up to 2050.
- *Green rival occupations*: The share of currently non-green occupations that fall under the green rival (GR) category have a high likelihood to become green based on the low level of additional training required. We have therefore assumed that these occupations will become green in the short-to-medium term (i.e., by 2035) in sectors with green technologies or sectors with positive employment trends under the transition pathways. An exception to this transition would be GR occupations employed by sunset sectors without green technologies as it is likely that employment in these sectors will dwindle down. Hence, the GR occupations employed by sunset sectors will likely stay non-green (NG) in the medium-to-long term i.e., between 2035 and 2050.

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[2] It is important to note that O*NET and the Circle Economy-based 'profiling methods' provide only a 'snapshot' of respectively green and circular jobs as at 6th of March 2018 i.e., at the date of the last census. As part of our study, we also undertook a literature review of methods used to forecast or projecting future green / circular jobs. Unfortunately, our review indicated a severe paucity of forward-looking studies. This is perhaps not surprising as green and, more so circular, jobs are largely emergent. The occupations, skills and tasks associated with these jobs are also yet to fully appear. The method we developed here for crudely looking at transition through time is in alignment with some of the potential transitions suggested by Bowen *et al*. (2018).

- *Non-green occupations:* We also assume that the currently non-green (NG) occupations that fall under the non-green category will:
    - Likely transition to green in the medium-to-long term (i.e., between 2035 and 2050) if employed in a sector modelled with a green technology. We thus assume that these occupations will become green by 2050.
    - Likely to stay non-green (NG) if employed in a sector without a green technology up to 2050.

5.1 Understanding the employment transitions for sectors with emissions reduction technologies

As mentioned previously and shown in Figure 7, a set of low-emission technologies were modelled in the CGE as 'green' alternatives to conventional high-emission technologies and processes to ameliorate the potential economic impacts from the reduction pathways. Not all technologies have a significant impact on the Auckland region, due to its predominantly urban makeup.

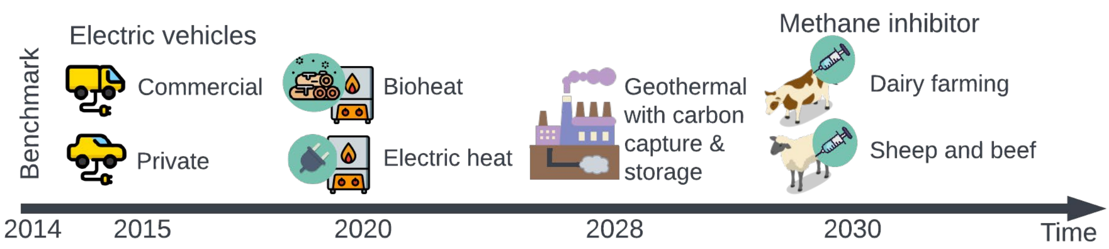

Figure 7. Low-emission technologies included in the modelled emissions reduction pathways for Auckland region from when they are available to implement.

In the case of road transport, internal combustion engine (ICE) fleets are replaced by electric vehicle (EV) fleets. For dairy, sheep and beef farming, current farming systems are replaced with methane inhibiting systems. Coal, gas and geothermal electricity are substituted with renewable and cleaner alternatives such as wind, solar, hydro and geothermal electricity with Carbon Capture and Storage (CCS).

These low-emission technologies have been considered in the green transitioning of their respective sectors, as depicted in the matrix of Figure 8. The employment figures for sectors with conventional technologies are shown in the top row and green technologies are shown in the bottom row.

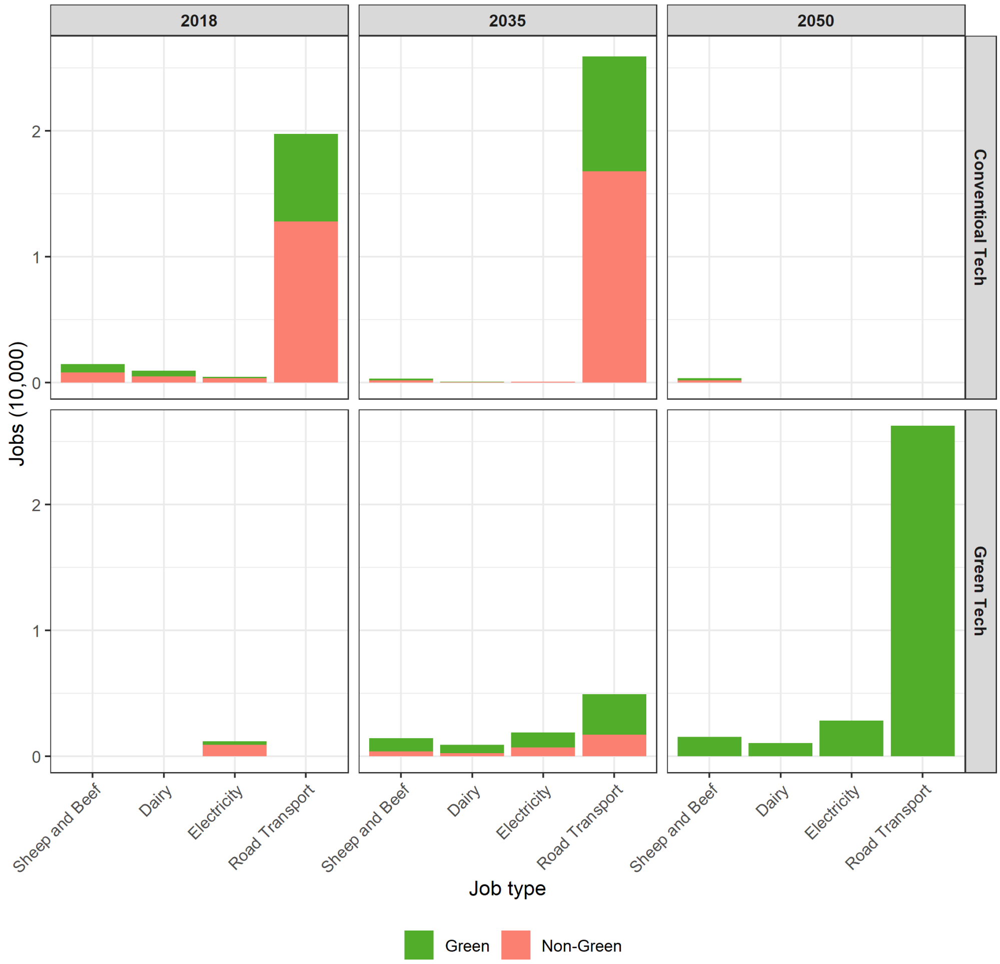

Figure 8. Absolute transition to green employment (in 10,000 jobs) for different conventional and green technologies used by different sectors in Auckland region.

As shown in Figure 8 and listed in Table 2, the sector introducing green emissions technologies with the greatest potential to add green jobs in the Auckland region is the road transport sector. This is due to the sheer number of jobs and the introduction of EV fleets in both baseline and policy scenarios. Overall, employment in this sector under a green technology (i.e., EVs) grows to more than 26 thousand employees in 2050 as listed in Table 2.

Table 2. Auckland region's transition to green employment through sectors employing green technological alternatives, by the number of people employed or projected to be employed.

Sectors with green techs	2035		2050	
	Green	Non-green	Green	Non-green
Dairy farming	678	252	1,042	0
Sheep & beef farming	1,046	387	1,545	0
Road transport	3,218	1,731	26,247	0
Electricity	1,168	719	2,837	0

Note: 2018 data has not been included given that the job numbers are negligible for the reference year.

The number of jobs under the dairy, sheep and beef, and electricity sectors are minor compared to the road transport sector in Auckland region. As the largest urban area in Aotearoa New Zealand, Auckland does not have a large percentage of pastoral farming and Auckland's electricity is mostly imported from other regions. It is for this reason that the absolute transition associated with introduction of green technologies is also comparatively small. Nevertheless, there would be some room for a green transition within the jobs generated by these sectors, as shown in relative terms in Figure 9. For example, the dairy, sheep and beef farming sectors could convert approximately 75% of their workforce into green occupations by 2035 and 100% by 2050, provided green technologies are used in that sector.

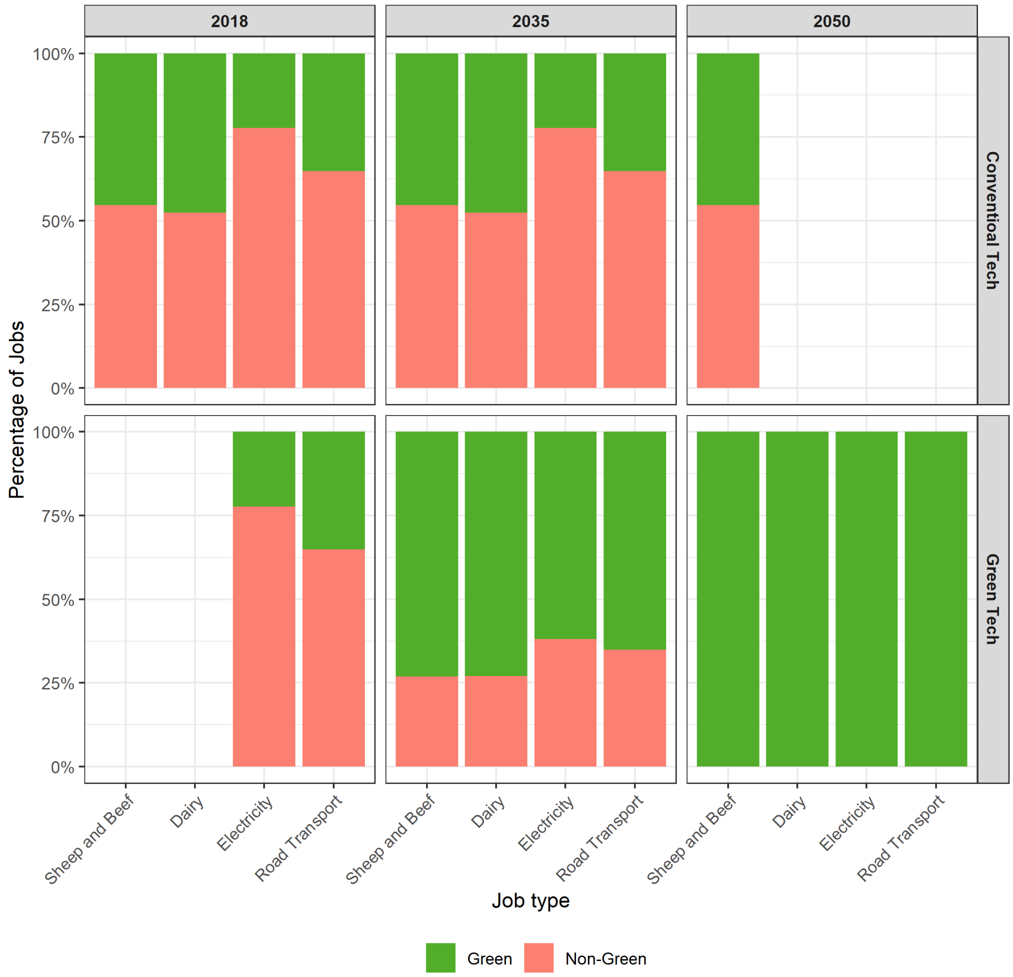

Figure 9. Relative transition to green employment (in percentages) for different conventional and green technologies used by different sectors in Auckland region.

5.2 Sectors without green technologies

Based on the previous assumptions listed earlier in this section, Figure 10 and Figure 11 show the potential green employment transitions for the major sectoral groups in Auckland region in absolute and relative terms, respectively. The results for six aggregate sectors are shown rather than the original 28 sectors. These aggregate sectors exclude dairy, sheep and beef, road transport, and electricity. These are excluded because they were treated separately in the previous section as they were modelled with alternative green technologies (i.e., low emissions). The change modelled in Figures 10 and 11 is driven by the forecasted employment under the modified emissions reduction pathway for the Auckland region, based on Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan. The scenario puts a cap on all GHG emissions for the Auckland region, which was modelled as a 50% reduction between 2022 to 2030 and a net zero goal from 2031 to 2050. Please refer to Table A.4 in the Appendix for a more detailed sectoral disaggregation.

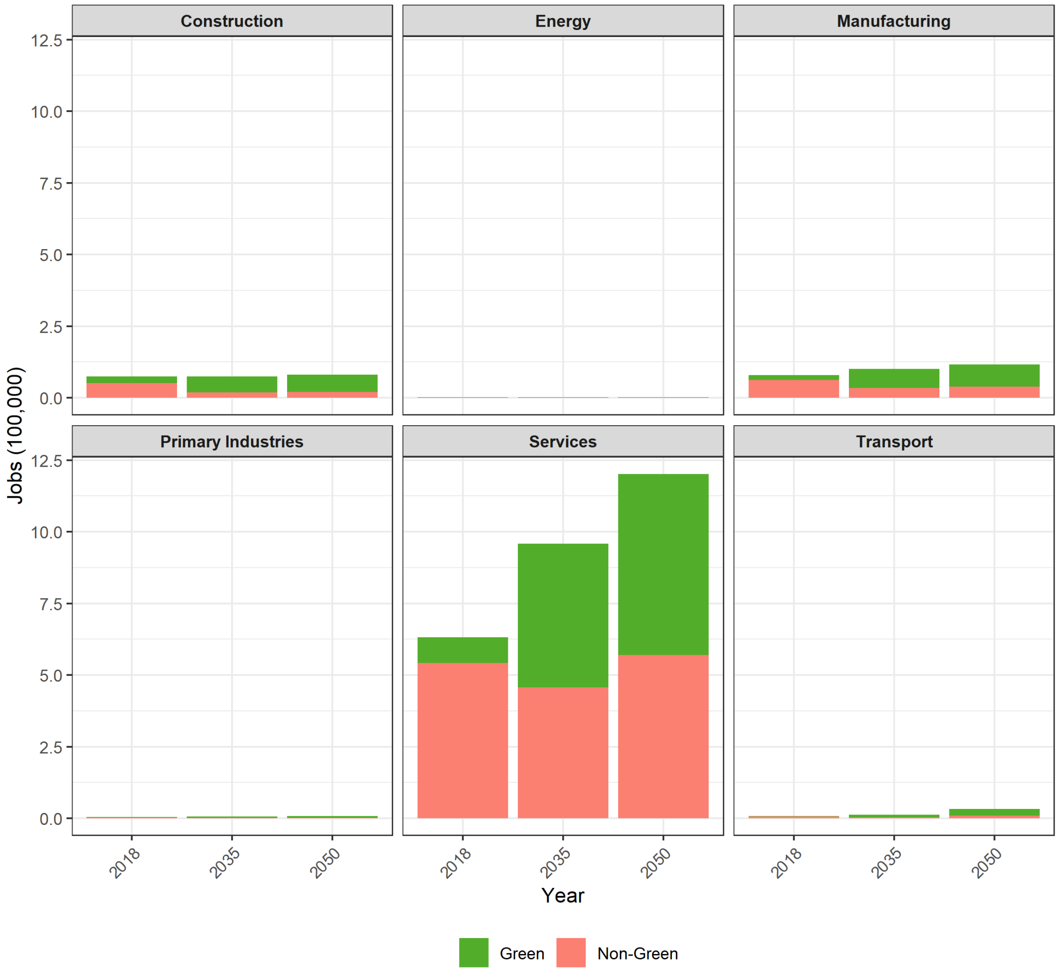

Figure 10. Absolute employment transition (in 100,000 jobs) to a green economy for different major sectoral groups in Auckland region, enabled by the emissions reduction pathways.

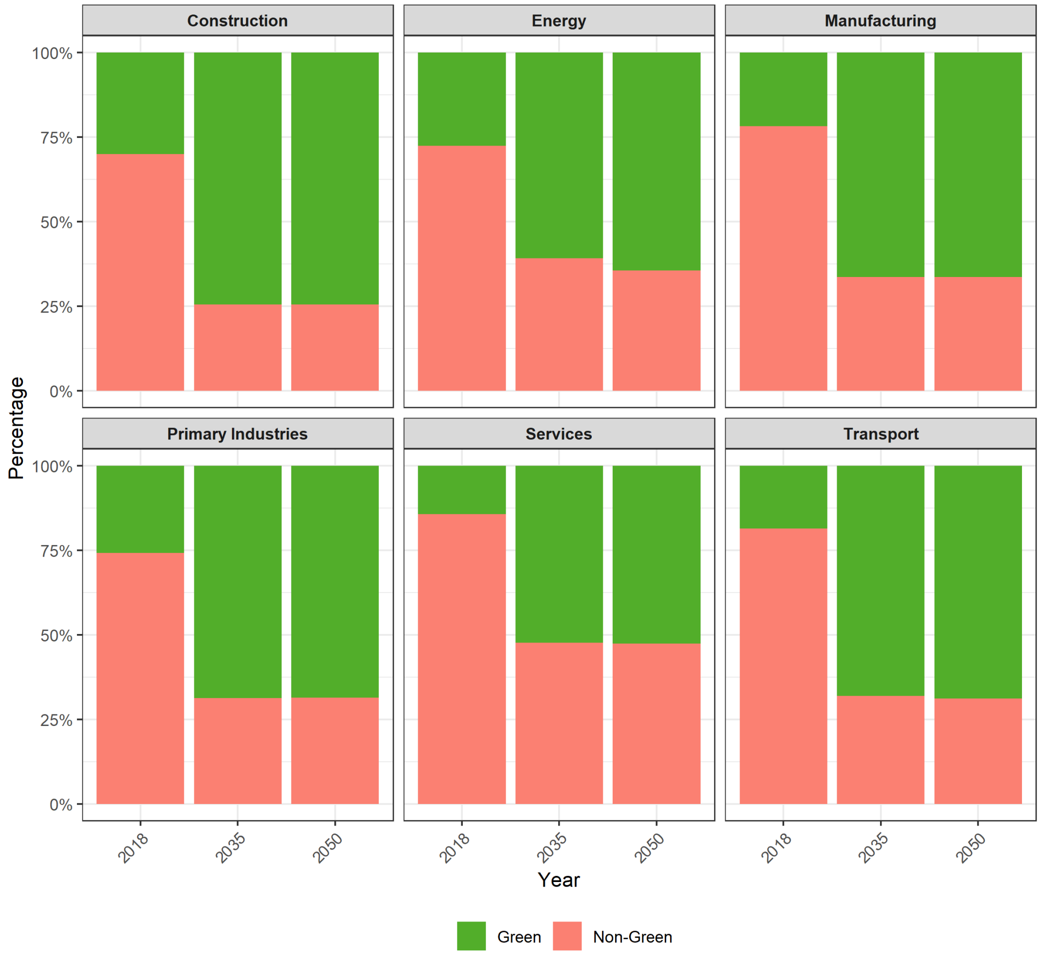

Figure 11. Relative employment transition (in percentages) to a green economy for different major sectoral groups in Auckland region, enabled by the emissions reduction pathways.

Based on sectoral growth, high employment, and high shares of green occupations, Figure 10 shows that the sectors with the greatest potential to transition to a green future are services, manufacturing, and construction. Besides a relatively high proportion of green occupations in the 2018 baseline, these sectors are expected to grow as they will not be heavily affected by the emissions reduction pathways as listed in Table 1. In relative terms, Figure 11 shows that the aggregate sectors with the greatest potential to transition to a green future are the construction and transport sectors (i.e., domestic air and water transport).

The proportion of green jobs for all sectors is the same in the medium (i.e., as at 2035) and long (i.e., as at 2050) term as we have assumed that the proportion of non-green jobs stays constant as these do not transition to green, as opposed to sectors with green technologies where non-green jobs transition to green. The only exception is energy as the proportion of non-green jobs slightly decreases in 2050 because of the decreasing non-green jobs portion (including green rivals) of sunset sectors such as gas and coal.

In regards to the services sector, although it employs a large number of people in green occupations as shown in Figure 10, proportionally the sector also has a large number of non-green occupations that stay non-green across time when compared to the other sectors, as shown in Figure 11. If there are no closely related green occupations for the non-green occupations in services (that stay non-green across time) in the future, it may prove challenging to fully transition the sector to green.

6 Auckland's circular employment potential and transition

This section shows the results of identifying the industries with the greatest potential to transition to a circular economy based the methodology developed by the Circle Economy and UNEP (2021) and Muñoz H. *et al*. (2022). The more developed concept of the circular economy is presented here as a stepping stone to start measuring the current state of the regenerative economy as both concepts have overlapping tenants as mentioned by Alfaro-Pelico *et al*. (2023).

Blick and Comendant (2018) estimated that a circular economy for Auckland would potentially add $6.3-8.8 billion to the regional GDP by 2030. In contrast to Blick and Comendant (2018), this study attempts to measure the employment potential of a circular economy in Auckland region. Besides the different foci, the methodologies used in both studies also differed in that Blick and Comendant (2018) focused on measuring the economic value in sectors that showed the greatest potential to transition to a circular economy (i.e., food, transport and construction) whereas this study has focused on a more systematic approach based on input-output analysis that considers all sectors in the economy.

The Circle Economy and UNEP (2021) and Muñoz H. *et al*. (2022) have developed a methodology to measure the extent of the circular economy based on the following definition "A circular job is any occupation that directly or indirectly involves one of the three following strategies: 1) prioritise regenerative resources, 2) stretch the lifetime of products, and 3) use waste as a resource". Based on these strategies, the Circle Economy defines the following circular job categories:

- *Core*: the jobs that ensure the closure of raw material cycles. This category is formed by the following subcategories:
    - Preserve or stretch the lifetime of products, and
    - Use waste resources as a source of secondary resources.
- *Enabling*: the jobs that enable the acceleration and upscaling of the core circular jobs. This category is formed by the following subcategories:
    - Design for the future,
    - Digital – incorporate digital technology,
    - Knowledge – strengthen and advance knowledge,
    - Collaborate – team up to create joint value, and
    - Rethink the business model.
- *Indirect*: the jobs that indirectly uphold the circular economy.

Different to the more developed concept of the green economy, there are no studies that have identified circular employment based on circular strategies and sectors in Aotearoa New Zealand. Hence, based on the methods above, we mapped the eight circular categories to different industries following the ANZSIC categories, as summarised in Table 3. Refer to Table A.5 in the Appendix for a more detailed mapping. As a result, we have been able to identify the industry sectors with the largest potential to transition to- or support a circular economy.

Table 3. Mapping of the aggregate sectors to the circular employment categories

Aggregate sectors	Core		Enabling					Indirect
	Preserve	Use waste	Knowledge	Digital	Design	Collaborate	Rethink	Indirect
Primary Industries								
Energy		x						x
Manufacturing	x	x	x					x
Construction		x						x
Services	x	x	x	x	x	x	x	x
Transport							x	x

Based on employment estimates for the Auckland region from the 2018 New Zealand Census of Population and Dwellings (Stats NZ, 2019) and the method used, Figure 10 shows that approximately 16% of Auckland's regional workforce could be employed in either core circular sectors (10%) or sectors that enable the transition to a circular economy (6%). Approximately 21% of the region's workers could be indirectly related as they are employed by sectors that indirectly uphold the circular economy. The rest of the region's workers are employed by sectors that are considered linear in this study, or not directly or indirectly circular, accounting for approximately 63%.

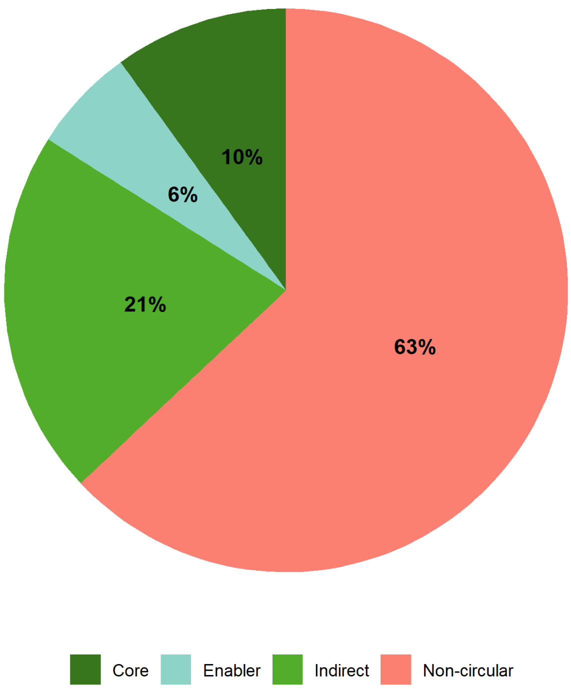

Figure 12: Share of employment under different circular employment categories based on Circle Economy and UNEP (2021), Muñoz H. *et al.* (2022) and the 2018 New Zealand Census of Population and Dwellings.

Figure 12 can be further disaggregated into major sectorial groups as shown in Figure 13. Based on the left-hand side of Figure 13, the aggregate sectors that could have the highest numbers of circular jobs in absolute terms are services, construction, and manufacturing, due to the sheer number of people employed by each industry. In relative terms (right-hand side of Figure 13.) services, construction, and manufacturing also could have high proportions of core circular jobs, which aligns with the green jobs' findings.

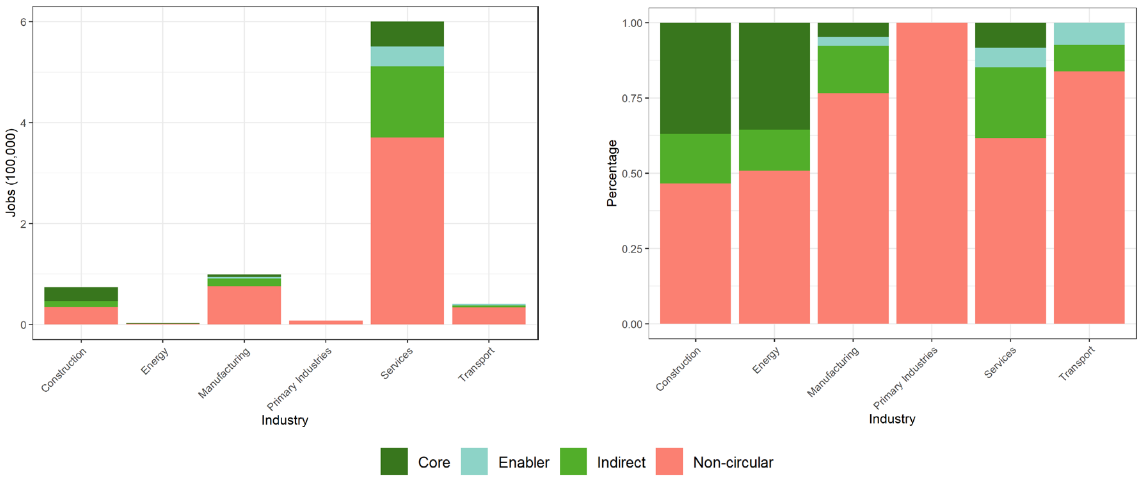

Figure 13. Absolute and relative split of circular job types by sectors from the 2018 New Zealand Census of Population and Dwellings.

Primary industries, and to a lesser extent the transport sector, hold the greatest proportions of linear or non-circular jobs in this modelling. It is worthwhile mentioning that based on the mapping used in this study and developed by Muñoz H. *et al*. (2022), none of the circular principles were mapped to the primary industries. Based on this employment potential, enabling and indirect employment estimates could be measured building on the method used in this study. Please refer to Table A.6 in the Appendix for a higher sectoral disaggregation.

The circularity of various industries shows interesting patterns. The construction and energy sectors show the largest potential to become circular due to the potential use of waste as an input (based on the mapping in Table 3). The services sector shows the largest proportion of enabling and indirectly supporting sectors. Based on Table 3, the services sector is also the only sector that includes all circular employment categories. Transport is the only sector with the potential to become circular by including enabling and indirectly related sectors.

Although these sectors show the greatest potential to transition to circularity based on the methodology used and developed in the Circle Economy (in the Netherlands), the actual context in Auckland might be different. A study based on a 'bottom-up' estimation (as per the study by Blick and Comendant) of the circular employment potential for each of these promising sectors would be an area of future research. This could also include a focus on the employment potential in primary industries based on regenerative practices.

Like the green transitions estimated in the previous sections, we used the forecasted changes in employment estimated with the CGE built and used in Phase 1 which was guided by the emissions reduction pathways in Te Tāruke-ā-Tāwhiri and Ināia tonu nei. Please, refer to Table 1 for the forecasted employment growth for the sectors representing Auckland's regional economy in the CGE model. We have modelled the transitions based on the aggregated categories described above, namely core, enabler, indirect and non-circular. Unlike the green technologies (i.e., by the CCC) explicitly included in the CGE model, we have not modelled any circular technology. Since, the CGE model does not consider occupational profiles for the labour used by different sectors and no circular technologies, we have assumed that the proportion of the different circular categories stay constant across time.

As shown in Figure 14, and based on the expected growth estimates listed in Table 1, most aggregate sectors are expected to grow as they will not be heavily affected by the emissions reduction pathways. The services sector has high 2018 employment and a high expected rate of growth to 2050. In relative terms, Figure 15 shows that the proportions of circular job types remain constant across time for all major sector categories except for energy and transport. Please refer to Table A.7 in the Appendix for a more detailed sectoral disaggregation of the results.

There are changes in the proportion of circular job types over time for energy and transport as these sectors are affected by the emissions reduction pathways. These changes occur despite the assumed constant circular categories within industries because the sectors are aggregated industry groups. The changes in the energy aggregate sector are due to the decreasing dependence on fossil fuels and higher dependence on renewable electricity sources such as wind and solar. The changes in the aggregate transport sector are also due to the impact of the emissions reduction pathways on the road transport sector.

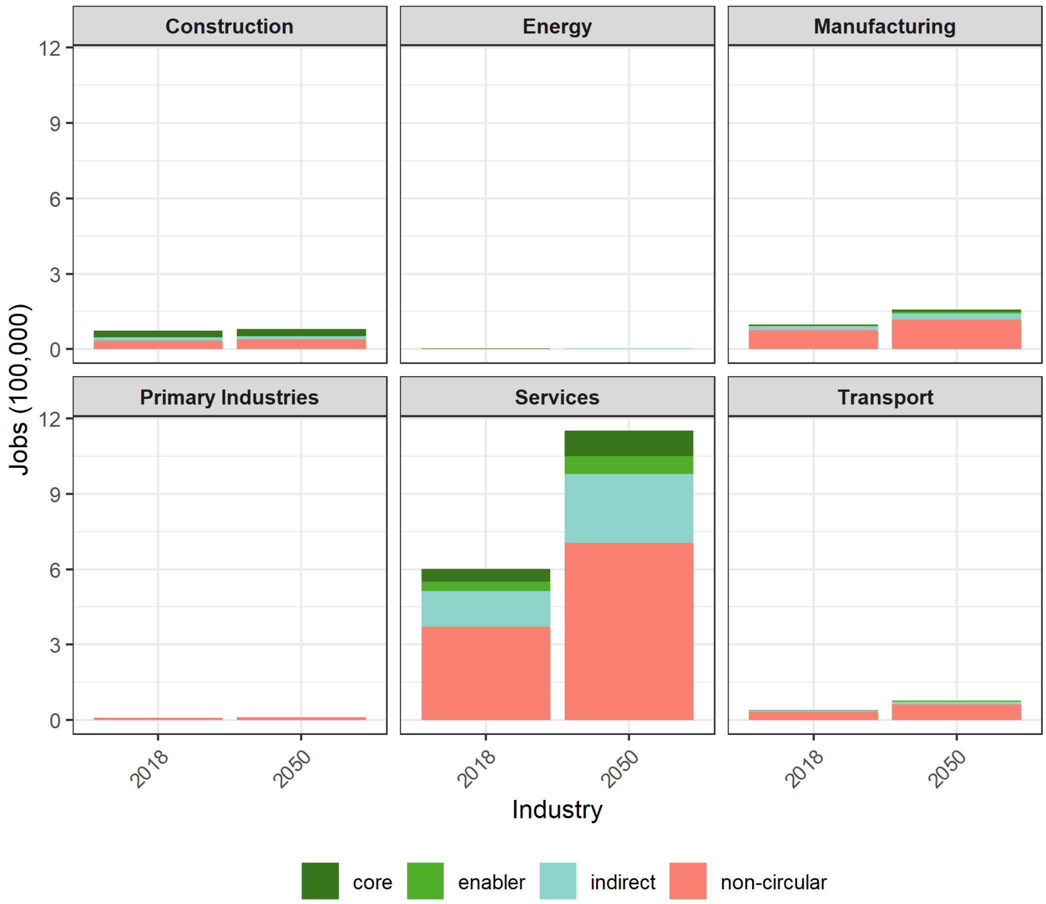

Figure 14. Absolute employment transition (in 100,000 jobs) to circular jobs enabled by the emissions reduction pathways for different major sectoral groups in Auckland region.

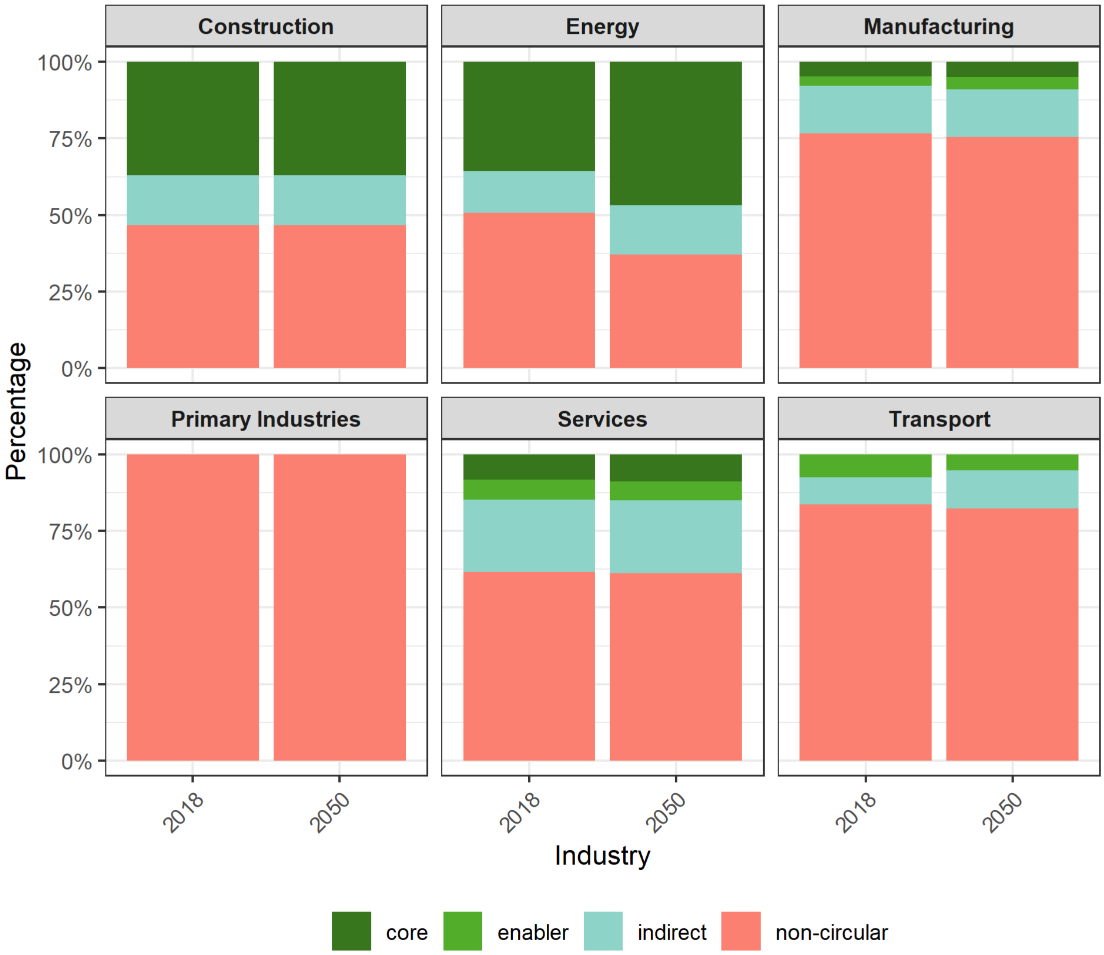

Figure 15. Relative employment transition (in percentages) to circular jobs enabled by the emissions reduction pathways for different major sectoral groups in Auckland region.

7 Conclusions

For the Auckland region to transition towards green and circular economies, it is important to characterise the employment potential within the region, and further understand where to develop the necessary skills to accelerate the transition. The question that we attempted to answer in this study was: What will the transition towards green and circular economies mean for employment in the Auckland region? This research built on national and international literature to provide insight into: 1) the 2018 baseline of green and circular employment in the Auckland region, and 2) the potential transitions to a green and circular economy driven by emissions reduction pathways.

In this study, the sectors with the most opportunities are those with green technological alternatives, namely electric transport and renewable energy. It is worth mentioning that the original set of green technologies was constrained to the ones considered by initial assessment of the New Zealand Climate Change Commission (CCC). The sectors with the most potential are those currently with the highest numbers of occupations under green and green rival categories, including construction, manufacturing, and services. The areas with the greatest risk are sunset sectors or those that are emissions intensive and highly dependent on fossil fuels. This includes sectors that are conventional pasture-based, those that depend on coal and gas, and the sub-components of the transport sector heavily dependent on internal combustion engines.

The combination of green tasks and types of skills required varies across the green job subcategories defined by O*NET, which suggests that 'green' should be considered as a continuum rather than a binary characteristic. It is important to account for this heterogeneity within green and non-green job categories when defining green employment and designing re-training programmes. For example, the further division of current non-green jobs into two distinct subcategories (GR and NG jobs) allowed the quantification of a potential transition from GR jobs to similar green occupations. A significant share of non-green tasks is used in both green and non-green jobs, suggesting similarities that may facilitate the transition. The transition of non-green to directly green jobs will require higher training requirements as the NE category consists of more non-routine tasks (analytical and interactive) and complex skills when compared to low-skill ID and GR jobs relying more on manual tasks. This means, different approaches will be required to support workers to transition. For green-rival jobs, the workforce would need to know what components of their current roles are already transferable to green jobs. For non-green jobs, the workforce would require training pathways to support a shift into green jobs that require new tasks and skills, over the medium-to-long term – by 2050.

Although the model and assumptions used in this study are plausible enough to answer the above research questions to a reasonable extent, we identified gaps that are worth reiterating regarding methodology and data.

The first gap is the lack of data to measure the employment potential from a transition to a regenerative economy. This opens a major area for future research consisting of

1) identifying the sectors that hold the greatest potential to transition to a regenerative future, and

2) development of a similar dataset to O*NET with a regenerative lens.

The second gap is the lack of data identifying circular occupations. To achieve a detailed identification of circular occupations, like the green jobs' literature, these would need to be mapped by developing a comprehensive assessment of the most promising circular technologies fit for Auckland and the occupations required by these new technologies.

The third gap is the scarce literature, not only nationally but internationally, on simulating potential green employment transitions through time based on widely accepted datasets and models. Most of the literature on green employment has focused on measuring current green employment, not transitions based on green occupations, skills, and tasks. To the best of our knowledge, Mayfield *et al*. (2023) is the only study that has attempted to assess the skills required to meet the needs from evolving technological progress and future policies, based on the O*NET dataset and a techno-economic optimisation model. Based on the study presented in this report and the research from Mayfield *et al*. (2023), a detailed assessment of the skills and tasks needed in a transition would be possible by developing an exhaustive assessment of the most promising urban green technologies and mapping them to the required occupations.

A regional consensus should also be reached on the most representative definitions of green, circular and regenerative jobs, skills and tasks for the urban context of Auckland region. We suggest that these definitions should be based on data to empirically measure and monitor progress. If data is not available then protocols should be established, like O*NET's protocols, to categorise and measure green, circular and regenerative jobs based on skills and tasks. For this reason, we suggest moving beyond conceptual studies and start relying on up-to-date, reliable, and existing data that follow nationally and internationally accepted protocols for replication and comparison purposes.

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Appendix

Table A.1. Employment (jobs) by Auckland region sectors under different green job categories in 2018.

Modelled sectors	ID	ES	NE	GR	NG
afs	9,450	15,938	4,407	91,523	71,307
bas	51	610	8	409	398
cns	9,594	11,246	1,308	32,762	18,785
col	8	7	1	21	16
crp	908	886	187	4,012	3,208
cru	6	8	2	20	19
fmp	2,884	2,960	544	11,819	8,674
frs	17	24	3	100	88
fsh	26	59	5	113	91
gas	17	23	4	68	56
hor	196	678	35	1,788	1,269
mil	198	252	56	894	775
mtp	237	275	53	1,456	866
mvh	483	481	84	2,047	1,321
nfm	263	204	38	914	640
nmm	413	460	60	1,491	1,005
oap	44	305	7	327	255
ofd	1,074	1,372	294	6,720	5,195
oil	20	27	6	90	82
omf	379	358	68	1,886	1,421
oxt	64	55	7	170	129
rmk	29	427	6	246	263
rtp	2,938	3,775	247	5,908	6,923
ser	20,736	32,006	7,464	147,172	231,477
wpp	1,019	1,141	204	5,171	4,285
atp	483	515	102	3,112	1,830
ely	137	183	48	652	628
wtp	126	142	23	554	604
Totals	**51,800**	**74,418**	**15,269**	**321,443**	**361,608**
%s	**6%**	**9%**	**2%**	**39%**	**44%**

Table A.2. Employment (jobs) by Auckland region occupations under different green job categories in 2018.

	NE	ES	ID	GR	NG
Managers	4,016	27,214	11,906	45,146	61,053
Professionals	5,865	20,784	6,481	48,762	131,448
Administrative	505	1,009	2,442	44,870	47,355
Technicians	1,313	10,131	12,283	51,824	18,572
Services				20,669	53,963
Operators and Drivers		6,749	8,674	11,224	22,131
Sales	3,229	4,011	3,246	61,626	10,504
Labourers	341	4,520	6,767	37,322	16,582
Totals	**15,269**	**74,418**	**51,800**	**321,443**	**361,608**
%s	**2%**	**9%**	**6%**	**39%**	**44%**

Table A.3. Nomenclature of modelled sectors and aggregations used for the figures.

Code	Sector	Aggregate sector for figures
rmk	Dairy Farming	Primary Industries
bas	Beef and Sheep Farming	Primary Industries
oap	Other Animal Products	Primary Industries
hor	Horticulture	Primary Industries
frs	Forestry	Primary Industries
fsh	Fishing	Primary Industries
col	Coal Mining	Energy
cru	Crude Oil Extraction	Energy
gas	Gas Extraction and Distribution	Energy
oil	Refined Oil Products	Energy
oxt	Other Mining	Energy
crp	Chemical, Rubber and Plastic Products	Manufacturing
nmm	Non-Metallic Minerals (e.g., Cement)	Manufacturing
nfm	Iron, Steel and Non-Ferrous Metals	Manufacturing
fmp	Fabricated Metal Products	Manufacturing
mil	Dairy Processing	Manufacturing
mtp	Meat Products	Manufacturing
ofd	Other Food Products	Manufacturing
wpp	Wood And Paper Products	Manufacturing
mvh	Motor Vehicle and Parts	Manufacturing
omf	Other Manufacturing	Manufacturing
cns	Construction	Construction
afs	Accommodation and Food Services	Services
ser	Other Services	Services
rtp	Road Transport	Transport
wtp	Water Transport	Transport
atp	Air Transport	Transport
ely	Aggregate Electricity	Energy

Table A.4. Potential green transitions for different sectors in Auckland region driven by the emissions reduction pathways (jobs).

Modelled sectors	Green employment categories						
	2018			2035		2050	
	Green	GR	NG	Green	NG	Green	NG
rmk (NG)	463	246	263	48	52	0	0
rmk (green)	0	0	0	678	252	1,042	0
bas (NG)	669	409	398	152	183	167	201
bas (green)	0	0	0	1,046	387	1,545	0
rtp (NG)	6,955	5,903	6,917	9,112	16,797	0	0
rtp (green)	6	5	6	3,218	1,731	26,247	0
ely (NG)	103	182	175	20	71	0	0
ely (green)	265	470	453	1,168	719	2,837	0
nfm	504	914	640	2,637	1,191	3,534	1,596
oap	356	327	255	859	321	943	352
hor	909	1,788	1,269	3,353	1,577	3,680	1,731
frs	43	100	88	196	120	252	154
fsh	90	113	91	229	103	293	131
col	15	21	16	11	27	5	13
cru	16	20	19	37	20	39	21
gas	44	68	56	35	100	20	58
oil	54	90	82	161	92	173	99
oxt	126	170	129	388	169	511	222
crp	1,981	4,012	3,208	6,627	3,547	7,847	4,200
nmm	933	1,491	1,005	2,707	1,122	3,225	1,336
fmp	6,387	11,819	8,674	24,408	11,628	26,902	12,816
mil	506	894	775	1,524	844	1,646	911
mtp	564	1,456	866	2,216	950	2,243	962
ofd	2,740	6,720	5,195	10,268	5,639	10,356	5,687
wpp	2,365	5,171	4,285	11,564	6,575	15,878	9,029
mvh	1,048	2,047	1,321	4,130	1,763	5,238	2,236
omf	805	1,886	1,421	3,354	1,771	3,320	1,753
cns	22,148	32,762	18,785	54,985	18,811	59,999	20,526
afs	29,794	91,523	71,307	194,962	114,594	256,437	150,728
ser	60,207	147,172	231,477	306,863	342,523	375,337	418,953
wtp	291	554	604	1,111	794	1,507	1,078
atp	1,100	3,112	1,830	7,799	3,387	21,315	9,258

Table A.5. Mapping of sectors to circular employment categories.

Modelled	Core		Enabling					Indirect
sector	Preserve	Use waste	Knowledge	Digital	Design	Collaborate	Rethink	Indirect
hor								
bas								
rmk								
oap								
frs								
fsh								
ser	x	x	x	x	x	x	x	x
col								
cru								
oxt								
mtp								x
ofd								x
mil								x
omf								x
wpp			x					x
oil								x
crp		x						x
nmm								x
nfm								x
fmp								x
mvh	x							
ely		x						x
gas								x
cns		x						x
afs	x							x
rtp							x	x
wtp							x	
atp								x

Table A.6. Auckland region's employment (jobs) per modelled sector under different circular employment categories in 2018.

Modelled sectors	Core	Enabler	Indirect	Linear	Total
afs	33,171		58,658	100,795	**192,624**
atp	0		1,269	4,773	**6,042**
bas				1,476	**1,476**
cns	27,207		12,144	34,344	**73,695**
col				51	**51**
crp	311		1,779	7,111	**9,201**
cru				54	**54**
fmp	0		4,299	22,581	**26,880**
frs				231	**231**
fsh				294	**294**
gas	0		37	131	**168**
hor				3,966	**3,966**
mil	0		182	1,993	**2,175**
mtp	0		348	2,538	**2,886**
mvh	4,416			0	**4,416**
nfm	0		600	1,458	**2,058**
nmm	0		861	2,568	**3,429**
oap				939	**939**
ofd	0		2,623	12,032	**14,655**
oil	0		36	189	**225**
omf	0		751	3,362	**4,113**
rmk				972	**972**
rtp	0	1,730	1,335	16,727	**19,791**
ser	15,695	43,868	86,566	292,727	**438,856**
wpp	0	1,197	1,666	8,957	**11,820**
ely	933		284	430	**1,647**
wtp	0	122		1,326	**1,448**
oxt				425	**425**
Total	**81,733**	**46,917**	**173,438**	**522,450**	**824,538**
%s	**10%**	**6%**	**21%**	**63%**	

Table A.7. Circular employment (jobs) transitions from 2018 to 2050 under the emissions reduction pathways.

Modelled sector	2018				2050			
	core	enabler	indirect	linear	core	enabler	indirect	linear
rmk	0	0	0	972	0	0	0	1,042
bas	0	0	0	1,476	0	0	0	1,913
rtp	0	1,730	1,335	16,727	0	2,294	1,770	22,183
ely	933	0	284	430	1,607	0	490	740
oap	0	0	0	939	0	0	0	1,295
hor	0	0	0	3,966	0	0	0	5,411
frs	0	0	0	231	0	0	0	406
fsh	0	0	0	294	0	0	0	424
col	0	0	0	51	0	0	0	18
cru	0	0	0	54	0	0	0	59
gas	0	0	37	131	0	0	17	61
oil	0	0	36	189	0	0	43	229
crp	311	0	1,779	7,111	408	0	2,329	9,310
nmm	0	0	861	2,568	0	0	1,145	3,416
nfm	0	0	600	1,458	0	0	1,496	3,634
fmp	0	0	4,299	22,581	0	0	6,352	33,366
mil	0	0	182	1,993	0	0	214	2,343
mtp	0	0	348	2,538	0	0	386	2,819
ofd	0	0	2,623	12,032	0	0	2,872	13,171
wpp	0	1,197	1,666	8,957	0	2,523	3,510	18,874
mvh	4,416	0	0	0	7,473	0	0	0
omf	0	0	751	3,362	0	0	926	4,146
cns	27,207	0	12,144	34,344	29,729	0	13,270	37,527
afs	33,171	0	58,658	100,795	70,116	0	123,990	213,059
ser	15,695	43,868	86,566	292,727	28,406	79,397	156,677	529,810
atp	0	0	1,269	4,773	0	0	6,423	24,150
wtp	0	122	0	1,325	0	218	0	2,366
oxt	0	0	0	425	0	0	0	733