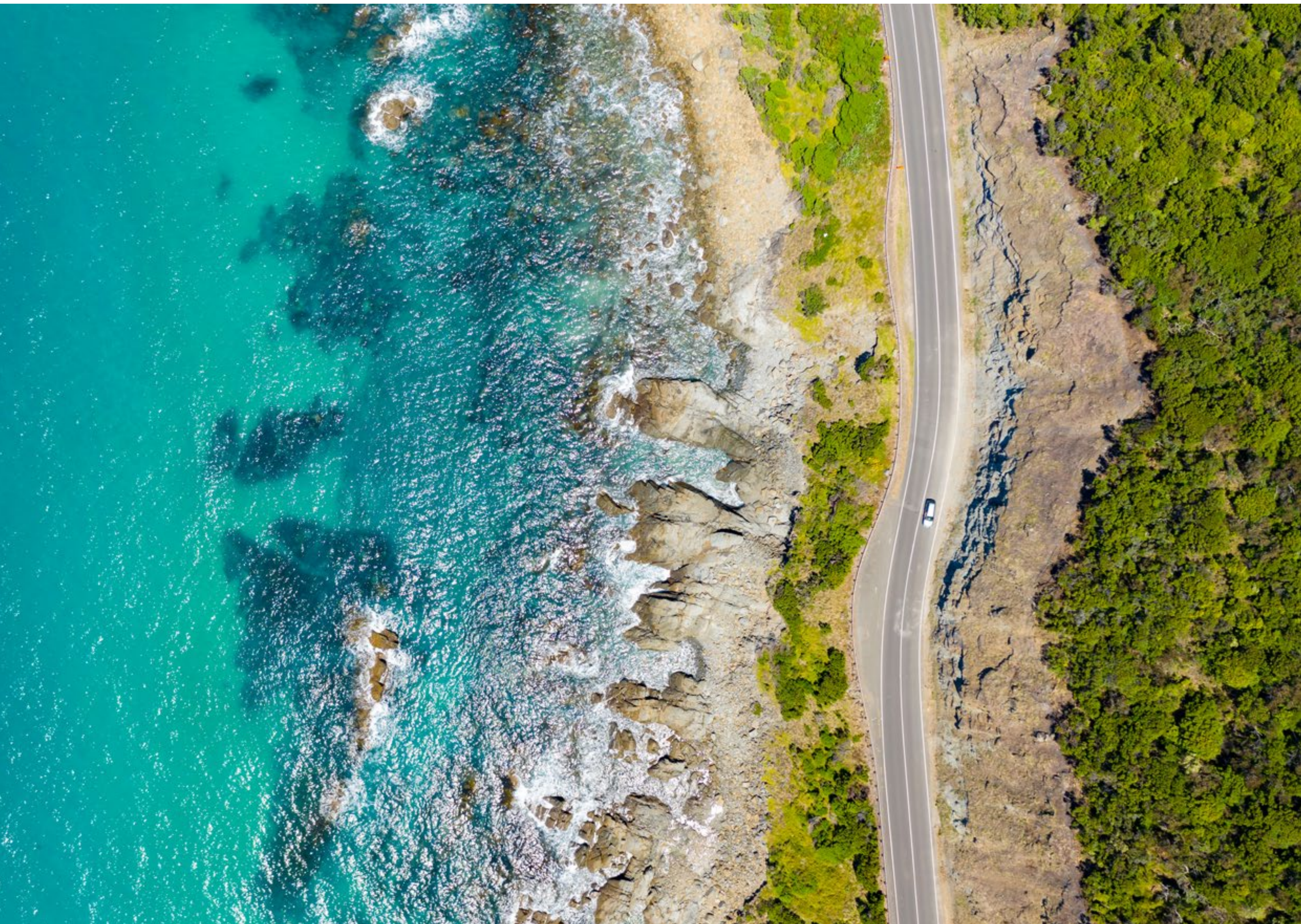
Australia's National
Science Agency

Circularity metrics for Australia's states and territories

Sub-national material flow accounts and circularity metrics, 2010–2024

May 2026



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Conflict of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could reasonably be perceived to have influenced the work described in this report.

Important disclaimer

Acknowledgement of Country

CSIRO acknowledges the Traditional Owners of the lands, seas and waters of the area that we live and work on across Australia and pays its respects to Elders past and present. CSIRO recognises that Aboriginal and Torres Strait Islander peoples have made, and will continue to make, extraordinary contributions to Australian life including in cultural, economic, and scientific domains.

Contents

1 Executive summary

Australia's transition toward a circular economy is underway, but it remains at an early and uneven stage across states and territories. This report presents the first comprehensive sub-national system of economy-wide material flow and circularity accounts for Australia, covering 2010–2024. It establishes a robust and comparable evidence base that enables benchmarking performance, understanding the structural drivers of material use, and designing informed circular-economy strategies tailored to jurisdictional contexts. Overall, the findings demonstrate that Australia's material metabolism continues to be dominated by extraction, mining waste, and the ongoing accumulation of long-lived physical stocks (e.g., buildings), with limited reintegration of secondary materials back into the economy.

Nationally, material throughput has grown along with rising population and economic activity. Domestic extraction increased by 47% between 2010 and 2024, driven largely by sustained expansion in Western Australia's metal ore production and Queensland's fossil fuel and minerals sectors. Western Australia exhibits particularly high per-capita extraction rates, underscoring its central position within global mineral supply chains. In contrast, several eastern and southern States, including New South Wales, Victoria, and South Australia, show stable or modestly declining per-capita extraction for various material groups. Nonetheless, the extraction of non-metallic minerals, primarily used in construction, increased in almost all jurisdictions, reflecting the strong influence of infrastructure development and housing demand on Australia's material profile.

Domestic material consumption, namely the mass of materials managed within the Australian economy, also increased moderately over the period. Non-metallic minerals account for the largest share, underscoring the centrality of the built environment in shaping material demand. Although per-capita domestic material consumption declined slightly, total consumption continued to rise, indicating that efficiency gains have not yet led to absolute reductions in material use due to population growth and continued stock expansion. Consumption-based indicators show the same trend: Australia's overall material footprint increased by 29% between 2010 and 2024. Much of this increase is driven by construction-related materials, confirming that the built environment, comprising buildings, infrastructure, and long-lived assets, is the primary domain of Australia's material demand and associated environmental impacts.

Waste generation follows patterns consistent with the material footprint and domestic material consumption results. Core waste volumes, which include municipal solid waste, commercial and industrial waste, and construction and demolition waste, rose in most jurisdictions. Construction and demolition waste remains the dominant waste stream nationally. While improved recycling infrastructure has raised recycling rates in nearly all states and territories, secondary material supply remains insufficient to meet the growing demand for primary materials. As a consequence, circularity rates remain low, typically around 4% in major States, with only the Australian Capital Territory exceeding 15%. These results highlight structural constraints: the rapid expansion of material stocks in buildings and infrastructure far outpaces the production of recycled materials.

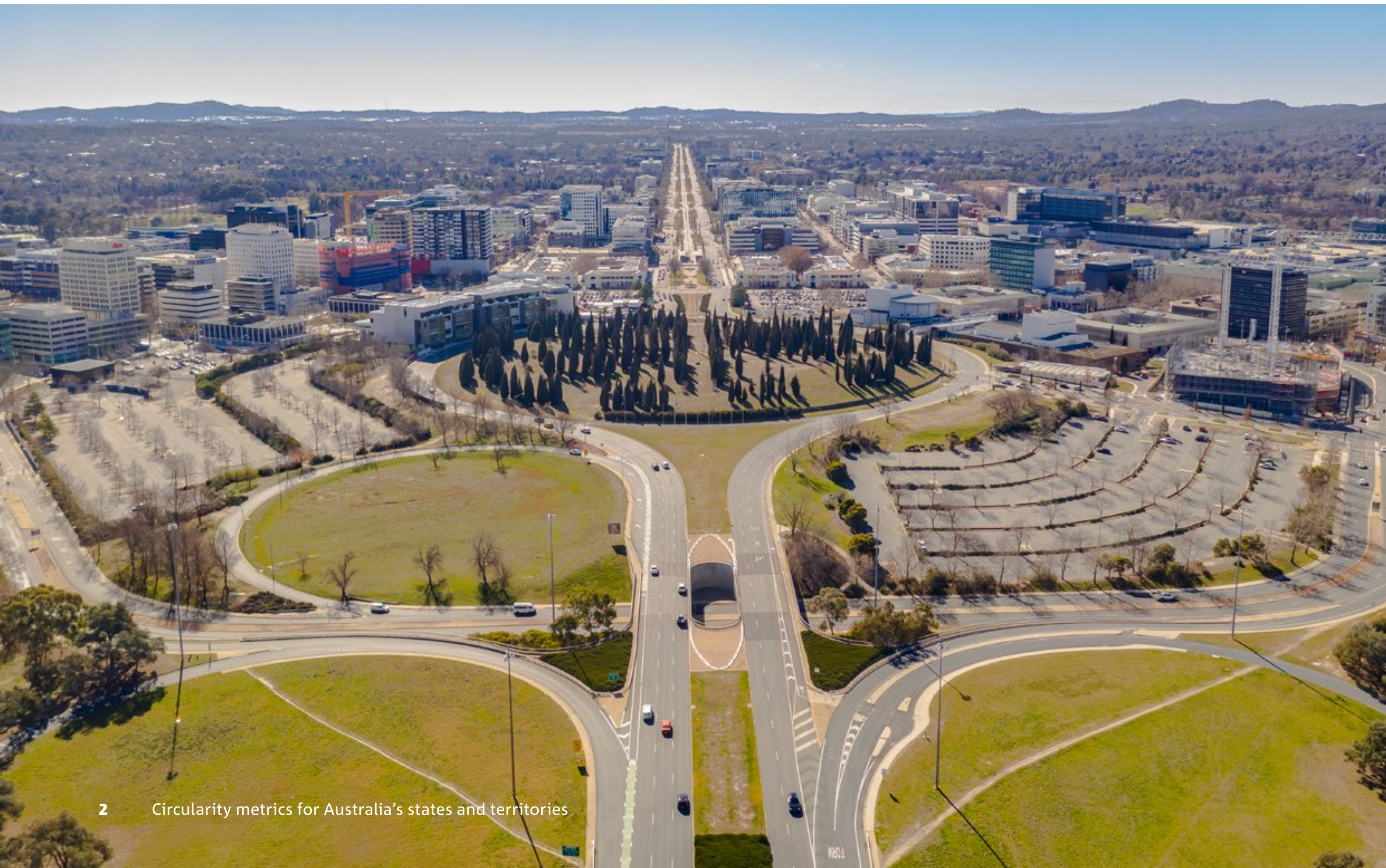
Greenhouse gas emissions and air pollution indicators show progress, but with significant regional variation. Jurisdictions undergoing electricity-sector transformation – particularly South Australia, Victoria, and New South Wales – demonstrate substantial reductions in emissions. In contrast, emissions in Western Australia and the Northern Territory remain high or continue to rise due to persistent growth in resource extraction and related industrial activity. Air pollutant emissions, such as sulfur dioxide (SO_2) and carbon monoxide (CO), have declined nationwide, driven by cleaner fuels and improved industrial practices. However, particulate matter (PM10) and nitrogen oxides (NO_X) emissions remain elevated in regions with intense mining, transport activity, and land disturbance.

Taken together, these indicators confirm that Australia's circular economy transition is progressing, but it remains structurally constrained and slow to counteract the upward pressure from population growth, economic structure, and expanding material stocks. Incremental improvements in recycling and waste management, while necessary, are insufficient to achieve national circular-economy objectives. A key insight from the analysis is that material demand is increasingly driven by the dynamics of long-lived stocks, especially in the built environment. Downstream waste interventions alone cannot meaningfully alter this trajectory.

Sub-national differences are substantial and have important policy implications. Resource-intensive states and territories in the west and north exhibit high extraction intensity, high material consumption, and low circularity, reflecting economies centred around mining and heavy industry. More urbanised and service-oriented jurisdictions exhibit lower direct material use but rising material footprints linked to construction activity and imports. These divergent profiles underscore that a single national pathway toward a circular economy is unlikely to be effective. As such, we recommend the creation of differentiated strategies aligned with each particular economic structure, population growth, and industrial composition.

Achieving meaningful progress will require a shift in policy focus from downstream waste treatment toward upstream material efficiency, reduced material demand, longer asset lifetimes, and systemic transformation of key industrial sectors, particularly the built environment. Stronger market-pull mechanisms, such as recycled-content requirements, design for disassembly, right-to-repair, procurement mandates, and circular-design guidelines, will be critical for enabling recycled materials to compete with primary materials at scale.

This report provides the empirical foundation necessary for such a shift. By enabling consistent longitudinal comparisons across states and territories, it supports evidence-based policy design, greater transparency and accountability, and the development of differentiated regional strategies aligned with Australia's long-term circular economy targets.



2 Introduction

Australia has committed to a national transition to a circular economy (Australian Department of Climate Change, Energy, the Environment and Water, 2024), recognising that such a shift is essential for decoupling economic prosperity from resource use and environmental harm. Achieving this transition requires a robust measurement system that can track progress, identify gaps, and set expectations. Metrics are essential instruments for monitoring progress. At the same time, they are critical tools that underpin evidence-based policymaking and help establish a shared trajectory.

This report delivers the first set of sub-national material flow and circular economy accounts for Australia's states and territories. It provides an empirical foundation for benchmarking across jurisdictions, enabling policymakers, businesses, and communities to compare performance, identify leading practices, and adapt strategies to regional contexts. Such benchmarking is vital to ensuring that all parts of Australia contribute meaningfully to the national circular economy effort while accounting for diverse economic structures and demographic realities.

2.1 Australia's circular economy metrics

The analysis is aligned with the Measuring What Matters Framework of the Australian Treasury (Australian Treasury, 2024), which sets out headline circular economy metrics to assess progress: (1) circularity rate, (2) material footprint per capita, (3) domestic material consumption per capita, (4) material productivity, (5) waste generation per person and (6) proportion of waste recovered for reuse, recycling or energy.

The circularity rate measures the share of secondary materials relative to total material use. Material footprint per capita captures the total mass of materials required to meet an individual's consumption, regardless of where those materials are extracted or processed. Domestic material consumption per capita measures the quantity of materials directly used within the national economy per person, accounting for domestic extraction and trade. Material productivity reflects the amount of economic output generated per unit of material input. Waste generation per capita represents the mass of materials entering waste management systems. The final metric measures the share of waste that is recovered through reuse, recycling, or energy recovery.

The analysis informs several of the Sustainable Development Goals (SDGs), particularly #8 'Decent Work and Economic Growth,' #12 'Responsible Consumption and Production,' and #13 'Climate Action.'

2.1.1 A set of 3R-aligned circularity metrics

Australia's circularity metrics align closely with the 3Rs hierarchy of Reduce, Reuse, Recycle (Takiguchi & Takemoto, 2008), mapping each principle to a distinct stage of the material life cycle. Taken together, the indicators presented above provide a coherent, policy-relevant framework that extends beyond waste management to capture upstream drivers of material demand, midstream production and use efficiency, and downstream material recovery (DCCEEW, 2024).

At the top of the hierarchy, Reduce is primarily addressed through Material Footprint per Capita and Domestic Material Consumption (DMC) per Capita. The material footprint captures the full upstream raw material requirements embodied in final demand (Lenzen et al., 2022), including those that occur outside Australia's borders. It thus aligns directly with reduction strategies aimed at lowering overall material demand through changes in consumption patterns and product design. DMC complements this metric by measuring direct material use within each State and Territory (Karakaya et al., 2021), making visible the domestic pressures associated with domestic material management. Together, these indicators signal whether Australia is achieving absolute or relative reductions in material throughput, an essential condition for a credible transition to a circular economy.

The principle of Reuse is most clearly reflected in Material Productivity, which quantifies the relationship between economic output and material input (Aydin et al., 2024). Higher material productivity indicates that existing materials, assets, and stocks are being used more intensively and effectively to generate value. This increased productivity may be achieved through longer product lifetimes, higher utilisation rates, repair, refurbishment, and service-based business models. In this sense, material productivity captures the economic expression of reuse, even where reuse does not involve a physical recycling loop. It also provides a critical bridge between circular economy objectives and economic policy, demonstrating whether prosperity can be maintained or enhanced with lower material inputs per unit of output.

Finally, Recycle is addressed directly through the Recycling Rate and Waste Generation per Capita. Waste generation per capita measures the scale of residual material flows that escape productive use, providing an indicator of system losses. The recycling rate then captures the extent to which these residuals are recovered and reintroduced into the economy as secondary materials. Interpreted together, these two metrics distinguish between systems that merely manage waste more efficiently and those that genuinely reduce material loss. Importantly, their position at the bottom of the hierarchy reinforces that recycling, while necessary, is insufficient on its own if upstream material demand continues to grow.

In combination, these five metrics operationalise the 3Rs in a quantitative, hierarchical, and policy-relevant manner. They enable policymakers to diagnose whether progress is occurring where it matters most, namely at the level of material demand reduction and asset utilization, rather than relying solely on downstream recycling performance. By embedding the 3Rs principles across the material system, Australia's circularity metrics provide a robust basis for aligning circular economy policy with broader goals of resource security and sustainable development (Miatto et al., 2024).

These five metrics, together with the circularity rate introduced in Section 2.1.2 below, provide a comprehensive view of circular economy performance across environmental, economic, and social dimensions. They quantify the efficiency of resource use, the effectiveness of waste prevention and recycling systems, and the capacity to reduce environmental pressures while maintaining living standards.

2.1.2 Circularity rate

As mentioned in Section 2.1, the circularity rate summarises the share of total material inputs supplied by secondary (i.e., recycled) materials. As such, it does not replace the more detailed indicators aligned with the 3R hierarchy framework of Reduce, Reuse, and Recycle; instead, it integrates their combined effects into a single, easy-to-communicate headline metric. While Material Footprint and Domestic Material Consumption diagnose pressure on the system, Material Productivity captures efficiency of use, and Waste and Recycling track losses and recovery, the circularity rate answers the strategic question: to what extent is the economy still fundamentally linear, and how far has it progressed toward tightening material loops?

The value proposition of the circularity rate lies in its ability to set ambitions and track long-term structural change. Consistently low circularity rates across Australian states and territories make the scale of the transition challenge evident and signal that incremental improvements in recycling will not be sufficient (Miatto et al., 2025). Because the metric is sensitive to both secondary inputs and total material demand, it implicitly reinforces the priority of the upper tiers of the 3R hierarchy. Rising circularity rate solely through increased recycling, while total material throughput continues to expand, will remain limited; sustained improvement requires simultaneous action on material demand reduction, product lifetime extension, and waste management (Miatto et al., 2025).

From a governance perspective, the circularity rate functions similarly to economy-wide indicators such as emissions intensity or energy productivity (Fischer-Kowalski et al., 2011). It provides a shared reference point that can align policy across sectors and jurisdictions without prescribing specific instruments. States and territories can contribute to improving the national circularity rate through pathways such as urban planning, construction codes, industrial symbiosis, product stewardship, and secondary material markets, while remaining accountable to a common outcome metric.

In this sense, the circularity rate complements the 3R-aligned metrics by offering a strategic compass rather than a diagnostic tool. It helps policymakers, industry, and the public understand where the economy sits on the linear–circular spectrum, benchmark progress over time, and raise ambition in line with Australia's broader commitments on climate, biodiversity, pollution, and sustainable resource use.

2.1.3 Comparison and benchmarking of best practices

This report enables systematic intra-national comparison and strengthens the evidence base for action by presenting results at the State and Territory level. It supports target-setting and accountability by providing metrics, facilitating the policy discourse across jurisdictions. In doing so, it helps align regional efforts with national priorities while recognising local differences.

The establishment of such metrics is a precondition for Australia to credibly pursue circular economy goals and integrate them into broader sustainability strategies, including climate action, biodiversity conservation, pollution reduction, waste avoidance, and sustainable production and consumption. Material flow metrics inform Australia's progress to meeting the SDGs, particularly Target 12.2 to 'by 2030, achieve the sustainable management and efficient use of natural resources' and Target 12.5 to 'substantially reduce waste generation through prevention, reduction, recycling and reuse by 2030.' By providing these subnational accounts, the report strengthens the evidence base for decision-making and positions Australia among global leaders in circular economy measurement.

2.2 Australia's population trends and their implications for a circular economy

Australia is a federated nation with significant variation in population size, economic activity, and industrial structure across its eight states and territories. Understanding these differences is essential for interpreting circular economy performance and for designing policies that are both effective nationally and responsive to regional contexts.

At the most basic level, population size and density shape both the scale and type of material demands. New South Wales and Victoria together account for over half of Australia's population, creating substantial concentrations of consumption and service-based economic activity. In contrast, States such as Western Australia and Queensland are resource-extractive regions, with smaller populations but massive contributions to national production through mining, energy, and agriculture. The Northern Territory, with a very small population base, has high per capita material use and waste generation due to its reliance on resource extraction and remote logistics.

Between 2010 and 2024, Australia's population increased steadily from approximately 22.0 million to 27.2 million, an increase of just over 5 million (Figure 1). Population growth was broadly consistent over the period, with a temporary slowdown around 2020–2021, the beginning of the global pandemic, followed by a resumption (ABS, 2024). The highest population growth between 2010 and 2024 occurred in the Australian Capital Territory (+32%), while the lowest was in Tasmania (+13%), with a national average of 23%. This demographic expansion provides a critical backdrop for interpreting material use, waste generation, and circularity performance, as rising population levels place upward pressure on housing demand, infrastructure provision, mobility, and service delivery, all of which are highly material-intensive (Miatto et al., 2024).

Population growth was unevenly distributed across states and territories, reinforcing long-standing structural differences. New South Wales and Victoria together absorbed a substantial share of absolute population growth, accounting for close to half of Australia's population change throughout the period.
Queensland and Western Australia experienced the next-largest absolute population growth, with Queensland increasing from some 4.4 to 5.6 million residents and Western Australia from 2.3 to just under 3.0 million.

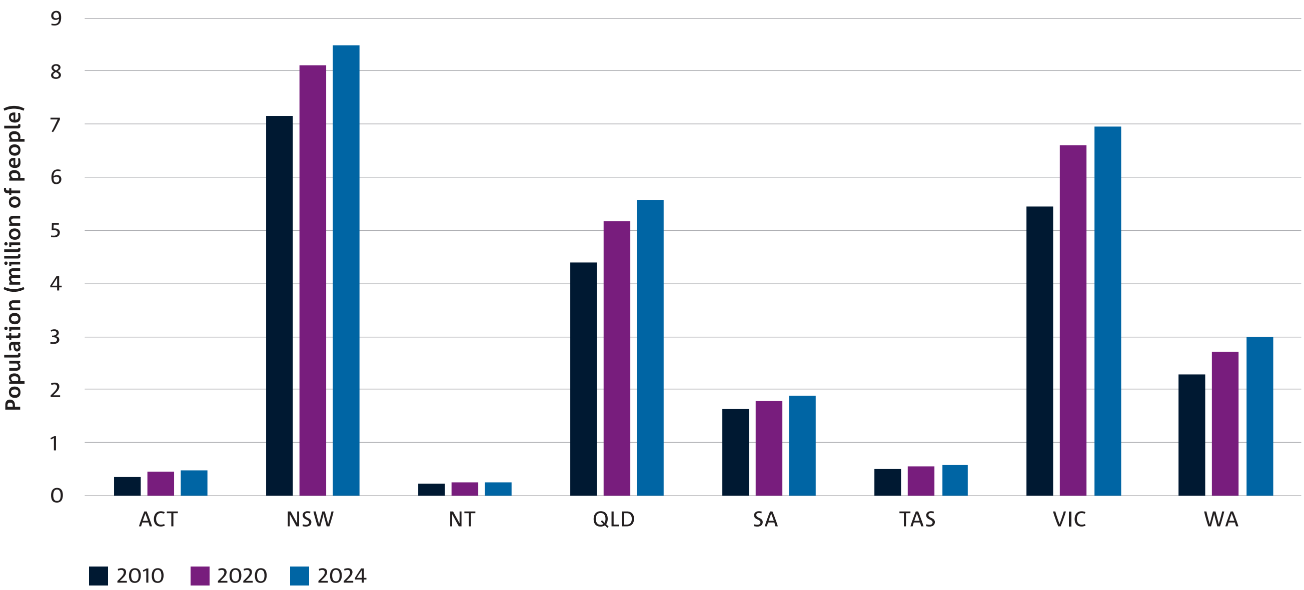


Figure 1. Population for Australia's states and territories, 2010, 2020, and 2024, in million people. Source: ABS (2024).

These states combine strong migration inflows with expanding resource and construction sectors, amplifying demand for new housing and infrastructure. By contrast, South Australia and Tasmania experienced more moderate growth. At the same time, the Northern Territory remained small in absolute terms, with population levels stabilising below 0.3 million despite fluctuations linked to project-based economic activity.

From a circular economy perspective, these population dynamics are highly consequential. Rapidly growing jurisdictions face the dual challenge of meeting housing and infrastructure needs while avoiding detrimental lock-in to high material throughput and future waste liabilities. Slower-growing or more stable regions, by contrast, have greater scope to focus on lifetime extension and adaptive reuse rather than continuous stock expansion. The population data, therefore, underscore how demographic growth is a key driver of material demand. However, its impacts on circularity outcomes depend critically on how growth is accommodated through policy, planning, design, and service provision systems.

2.3 Economic activity differences between Australia's states and territories and their implications for a circular economy

Gross state product (GSP) provides a complementary lens on economic scales (ABS, 2025b). The large eastern States dominate national output in absolute terms, but their economies are diversified, spanning finance, manufacturing, services, and knowledge-intensive industries. Western Australia and Queensland, while smaller in population, generate disproportionately high GSP per capita, reflecting their resource-export orientation. Tasmania and the Australian Capital Territory, by contrast, have distinctive structures: Tasmania with a strong emphasis on forestry, aquaculture, and tourism; and the Australian Capital Territory with a service economy centred on public administration, higher education, and research.

Figure 2. Gross State Product for Australia's states and territories, 2010, 2020, and 2024, absolute values (left) and per-capita values (right). Chain volume estimates 2025 AUD. Source: ABS (2025b).

Across 2010–2024, GSP increased in all jurisdictions (Figure 2), but with markedly different growth rates and sectoral drivers. The largest economies, New South Wales and Victoria, expanded from roughly $550bn to $761bn (+38%) and $403bn to $564bn (+40%), respectively, while Queensland rose from $343bn to $481bn (+40%). The fastest growth, in absolute and relative terms, occurred in Western Australia, which went from about $270bn to $440bn (+63%), reflecting the sustained strength of its resource-export economy. Smaller jurisdictions also grew strongly: the Australian Capital Territory rose from around $33bn to $53bn (+61%), while South Australia and Tasmania experienced more moderate absolute growth, consistent with their smaller and more slowly expanding economic bases. The time series also shows short-term volatility around 2020–2021 in several jurisdictions, consistent with pandemic-era disruption and subsequent recovery.

In terms of structure, services dominate GSP in every jurisdiction, and overwhelmingly so in the Australian Capital Territory, New South Wales, and Victoria, where service sector output grows steadily across the period and underpins most of the total GSP growth. By contrast, mining is the defining differentiator between resource-exporting and more diversified economies: it is persistently large in Western Australia and Queensland, sizable in New South Wales, comparatively small in Victoria, South Australia, and Tasmania, and absent in the Australian Capital Territory. Manufacturing is substantial in New South Wales and Victoria but shows a flat-to-gently declining profile over the period, indicating longer-run structural change toward services and higher-value-added activities. Construction is economically significant everywhere and exhibits cyclical behaviour, with strong growth in some years (notably in Victoria and New South Wales) and pronounced swings in Western Australia, where construction activity rises early in the period and then moderates, consistent with changing phases of resource investment and housing cycles.

These economic trends are important for interpreting the circularity metrics because they clarify why material use and circularity differ across jurisdictions. Resource-intensive states with large mining sectors (Western Australia, Queensland, and, to a degree, the Northern Territory) tend to generate value from activities that are materially and energetically intensive and are exposed to global commodity volatilities. At the same time, service-oriented economies (the Australian Capital Territory, New South Wales, Victoria) can display higher material productivity even when absolute material footprints remain elevated due to infrastructure expansion and consumption-driven demand.

These structural differences are critical for circular economy analysis. A subnational perspective enables circular economy performance to be interpreted in light of regional economic structures. It highlights where resource productivity diverges from national averages and establishes a meaningful basis for benchmarking progress. In this way, the subnational lens becomes essential to a coherent national circular economy strategy, ensuring that metrics and targets reflect the specific conditions of each State and Territory while supporting a more resource-efficient Australian economy.

3 Direct material flows, or a perspective on domestic material management

This section provides an overview of Australia's material metabolism from a domestic perspective, focusing on the physical flows of resources that underpin economic activity. Four key indicators are used: domestic extraction (DE), imports, exports, and domestic material consumption (DMC). Each indicator describes a material flow and has distinct implications for circular economy performance, economic policy, and environmental outcomes.

3.1 Domestic extraction

Domestic extraction (DE) refers to the raw materials physically harvested from Australia's natural environment, such as biomass, fossil fuels, metal ores, and non-metallic minerals, that supply the economy with primary inputs. Australia's high levels of resource extraction highlight its dependence on virgin resource use, which runs counter to the circular economy's ambition to reduce pressure on natural systems by substituting primary materials with secondary, improving efficiency, and extending product lifetimes. From an economic perspective, resource extraction is a cornerstone of employment and export earnings in resource-rich States. Nevertheless, it also exposes Australia to global commodity price fluctuations and indirectly hampers diversification into less material-intensive activities. The environmental implications are significant, as intensive extraction contributes to land disturbance, biodiversity loss, water stress, and greenhouse gas emissions (Lèbre et al., 2020).

Figure 3 provides state-level extraction of primary raw materials in Australia across three benchmark years: 2010, 2020, and 2024. It captures four broad material categories representing the primary sources of domestic resource extraction:

- biomass (agricultural, forestry, and wild fishery products)
- metal ores (iron ore, bauxite, copper, and other metallic minerals)
- non-metallic minerals (construction materials such as sand, gravel, limestone, salt, and industrial minerals)
- fossil fuels (coal, petrol, and gas).

Values are presented in thousands of tonnes, disaggregated by Australian state and territory (Australian Capital Territory, New South Wales, Northern Territory, Queensland, South Australia, Tasmania, Victoria, and Western Australia).

3.1.1 Key features and trends

Between 2010 and 2024, Australia's extractive profile reveals an apparent intensification, with total domestic extraction increasing by 47%, from over 1.8 billion tonnes in 2010 to more than 2.7 billion tonnes in 2024, alongside regional concentrations of material production, with pronounced contrasts across states and material types. Western Australia stands out as the dominant contributor, driving a rapid expansion in metal ore extraction, which more than doubled from 579 million tonnes in 2010 to over 1.2 billion tonnes in 2024. This growth underscores the state's central role in meeting global demand for iron ore and emerging battery minerals. Queensland remains the second-largest producer, maintaining high levels of fossil fuel extraction alongside substantial metal ore output, reflecting the state's dual dependence on mining and energy exports.

In contrast, the traditionally industrialised states of New South Wales and Victoria show more balanced extraction portfolios, dominated by non-metallic minerals and biomass. These categories support domestic construction, infrastructure, and agricultural activity rather than export-oriented mining. Both states exhibit moderate growth in non-metallic minerals and gradual declines and plateauing in biomass extraction, suggesting productivity gains and shifts in land use. South Australia, though smaller in total output, has demonstrated growth in metal ore production in recent years, primarily driven by developments in copper and, to a lesser extent, gold and uranium mining. At the same time, its fossil fuel extraction has declined substantially in line with the broader energy transition towards renewable energy.

Fossil fuel extraction across Australia peaked around 2020 before declining by 2024, a trend driven by structural changes in the national energy mix and international decarbonisation pressures. Western Australia and Queensland expanded production through liquefied natural gas and coal exports, while Victoria's and South Australia's outputs fell sharply due to coal phase-outs. This divergence illustrates the uneven nature of Australia's transition, with some regions accelerating toward low-carbon economies and others remaining reliant on fossil exports.

Biomass extraction remained largely stable nationwide, indicating mature agricultural systems constrained by land availability and ecological limits. Non-metallic mineral extraction increased consistently across nearly all jurisdictions, mirroring the infrastructure boom and urban expansion associated with population growth and Australia's trend toward very large homes (Marcos-Martinez et al., 2025).

Overall, the dataset reveals an economy still anchored in resource extraction but gently shifting away from it. Growth is concentrated in the mining-intensive western and northern states, whereas the southern and eastern states exhibit relative diversification and early decoupling between material use and economic growth. These spatial and sectoral shifts have direct implications for regional development and transition planning.

The per capita extraction data (Figure 4) reveal a nuanced picture of how Australia's material production relates to its population and regional economic structures. Between 2010 and 2024, the country experienced diverging trajectories across states, reflecting differences in industrial orientation, demographic change, and progress toward resource efficiency. Western Australia remains an extreme outlier, with per capita metal ore extraction soaring from about 253 tonnes in 2010 to more than 415 tonnes in 2024. This growth far exceeds population increases and underscores the state's dependence on bulk mineral exports, which are driven by international market demand. The persistence of such high per-person extraction intensity stresses the challenge of decoupling resource throughput from economic demand in mining-dominated regions.

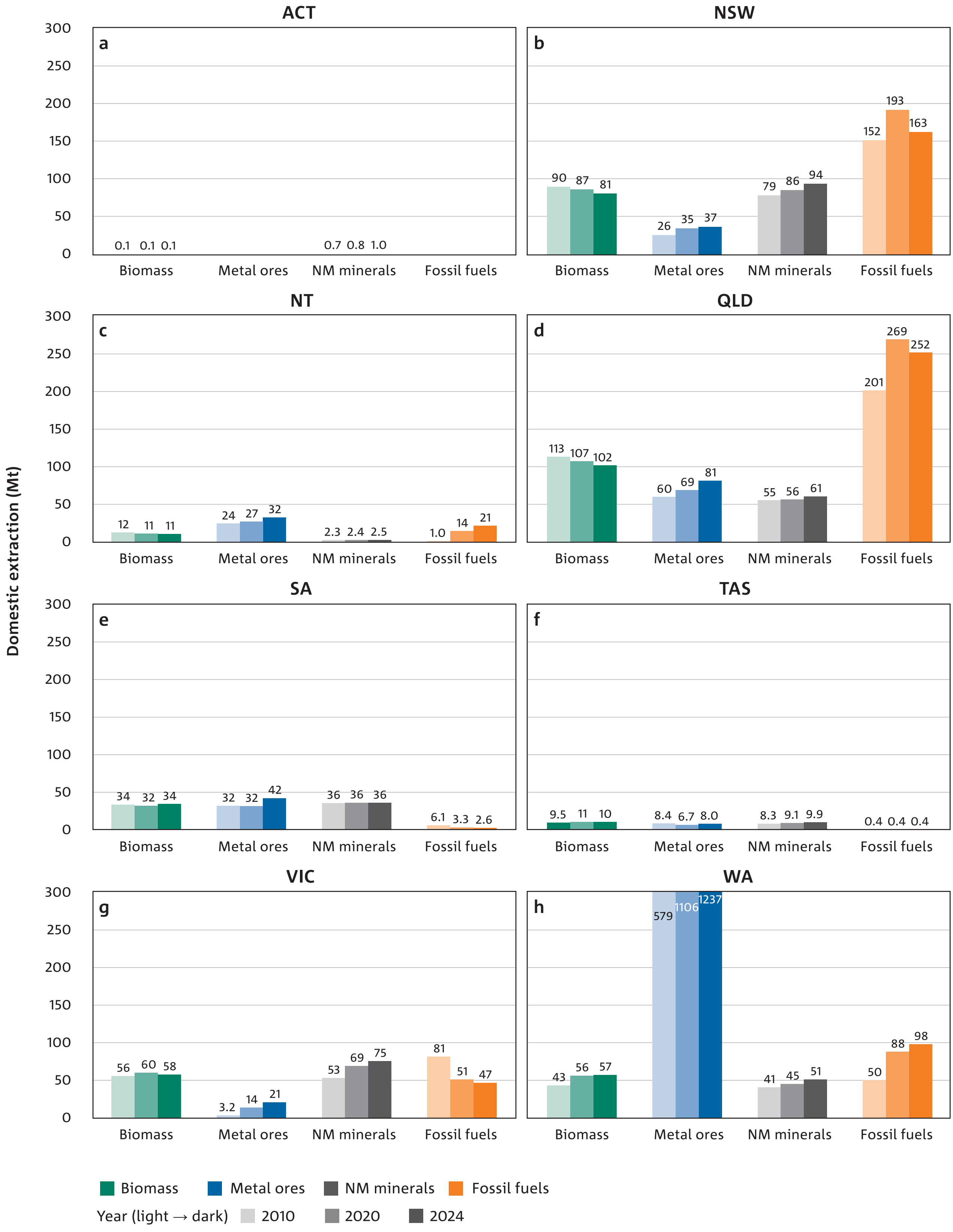


Figure 3. Domestic extraction (DE) of materials for Australia's states and territories, 2010, 2020, and 2024, absolute values. Units: million metric tonnes (Mt).

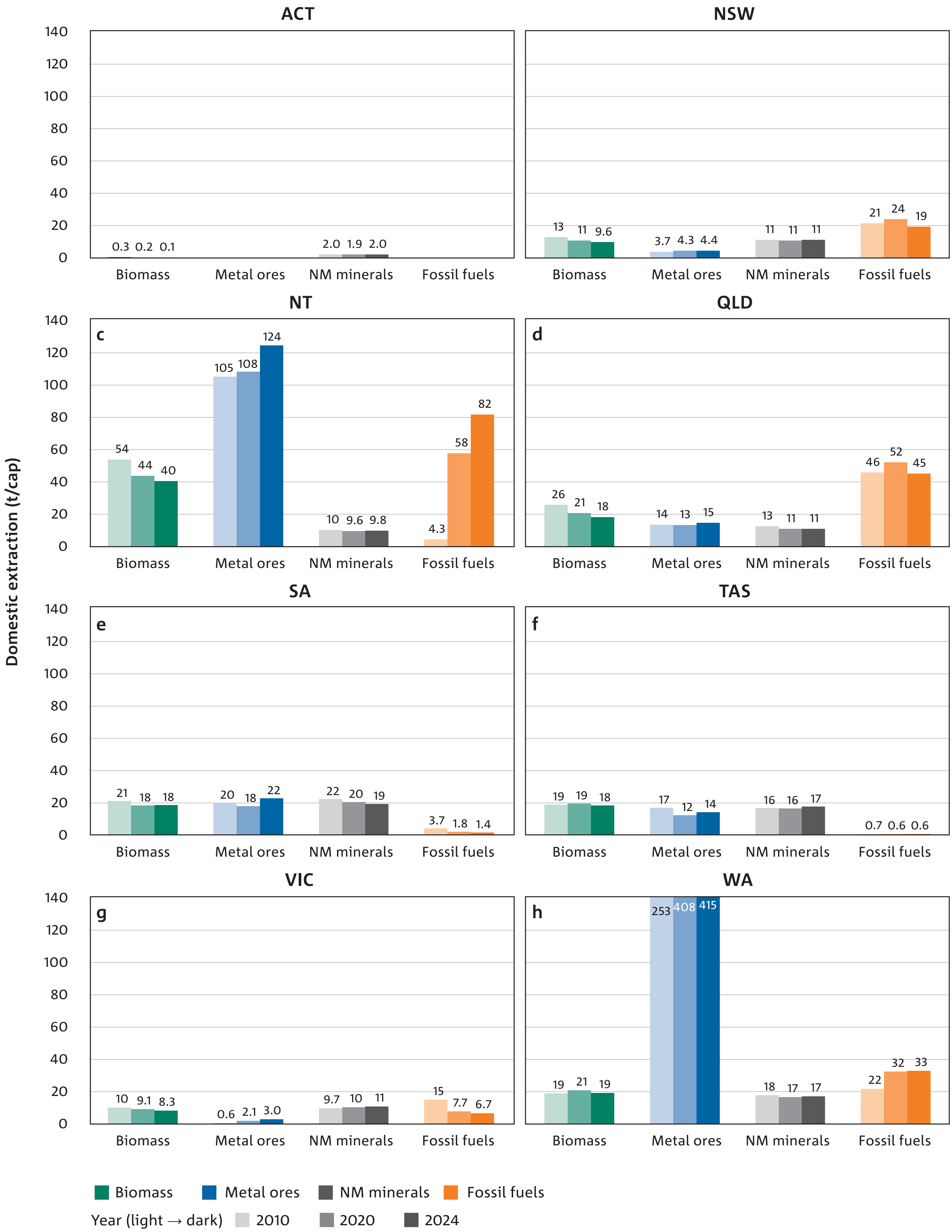


Figure 4. Domestic extraction (DE) of materials for Australia's states and territories, 2010, 2020, and 2024, per capita values. Units: metric tonnes per capita (t/cap).

Queensland and the Northern Territory also exhibit very high per capita rates of material extraction, particularly of fossil fuels and metal ores. In the Northern Territory, metal ore extraction per person rose from 105 to 124 tonnes. In contrast, fossil fuel extraction increased nearly twentyfold, highlighting the rapid expansion of extractive industries relative to a small population base. This pattern points to economic concentration and limited diversification, leaving these jurisdictions highly exposed to fluctuations in global commodity demand. Queensland, though larger in population, shows similar trends, maintaining per capita extraction rates above 40 tonnes for fossil fuels and above 10 tonnes for metal ores – levels consistent with an export-oriented resource economy.

In contrast, the southeastern states display substantially lower extraction intensities and a gradual convergence toward moderate per capita levels. New South Wales and Victoria both record declining per capita biomass and fossil fuel extraction, suggesting that population growth outpaced extraction while production processes became more efficient. In Victoria, per capita fossil fuel extraction fell from 15 tonnes to under 7 tonnes, reflecting the decline in brown coal mining and a broader transition in the state's energy system. These reductions signal structural decoupling between material extraction and population growth.

South Australia and Tasmania present relatively stable per capita trends, with modest growth in metal ores offset by slight declines in non-metallic minerals and fossil fuels. Their extraction profiles suggest small but diversified economies in which resource use is less directly tied to population growth. The Australian Capital Territory, with negligible extractive industries, remains almost entirely service-based, with per capita extraction levels near zero, thereby representing the endpoint of post-extractive development.

Taken together, these per capita trends reveal a widening divide between Australia's high-extraction regions in the west and north and its more diversified, lower-intensity regions in the east and south. From a policy perspective, this divergence highlights the need for differentiated strategies: resource-intensive jurisdictions require policies that foster economic diversification to shield them against market volatility and aid circular industrial development. At the same time, more urbanised regions should prioritise material efficiency and demand reduction. Nationally, declining per-capita extraction in several states indicates early signs of decoupling. Still, the persistence of extremely high rates in mining regions suggests that Australia's overall material intensity remains far above sustainable levels.

3.1.2 Policy-relevant insights

The observed trends highlight important implications for resource governance, regional development, and Australia's transition toward a more circular economy. The strong concentration of extraction activity in Western Australia and Queensland reinforces these states' pivotal role in the national economy, yet also exposes them to trade tensions. Moreover, there is a heightened transition risk as global markets shift toward low-carbon technologies and reduced material intensity, potentially leading to a decline in demand. This geographic concentration of extractive industries underscores the need for forward-looking diversification strategies that promote value addition and, indirectly, regional resilience. Investment in local manufacturing and skills development could help ensure that these regions benefit from rather than bear the costs of global decarbonisation.

The decline in fossil fuel extraction observed in Victoria and South Australia illustrates the early stages of industrial restructuring aligned with national energy transition goals. These changes provide valuable lessons for managing the social and economic impacts of declining industries, including the importance of proactive planning, worker retraining, and community-led approaches to just transition. Coordinated federal and state policy frameworks are needed to manage uneven regional trajectories and ensure that the benefits of low-carbon transformation are broadly shared.

Stability in biomass extraction, despite continued economic and population growth, points to partial decoupling between resource use and economic output. This decoupling indicates progress toward improving efficiency in agricultural and forestry systems, but it also highlights the limits of productivity-driven sustainability. Maintaining or enhancing ecological integrity will require integrated land-use and resource management policies that balance food production with ecosystem limits.

The continued absolute increase in non-metallic mineral extraction across all states reflects sustained infrastructure and housing demand, suggesting that material efficiency in construction remains an underdeveloped policy area. Addressing this challenge requires a shift toward circular construction practices, including the reuse of building materials, design for disassembly, and stronger recycling markets (Nicholson & Miatto, 2024).

Taken together, these trends demonstrate that Australia remains a resource-intensive economy navigating structural change. The country's future competitiveness and environmental performance will depend on how effectively it aligns its regional industrial base with global sustainability trends. Policies that promote circularity by reducing material throughput and fostering innovation in clean industries will be essential to achieving the dual goals of economic prosperity and environmental stewardship.

3.2 Interstate and international imports

Imports capture the physical inflows of raw materials and manufactured products from abroad and other States. They reveal the extent to which each State's economy relies on supply chains to satisfy its demand. In circularity terms, a high reliance on imports underscores vulnerabilities that circular strategies such as local recycling, product repair, and design for longevity can help mitigate. From an international trade perspective, reliance on imports raises concerns about resource security and exposure to global supply chain shocks, pointing out the importance of strengthening local industries that can substitute for or complement imports. Although importing may ease pressure on Australia's natural environment, the environmental costs are effectively shifted overseas, raising broader questions of global responsibility and embodied impacts in traded goods (note that the material footprint addresses this aspect, Section 4). The following data illustrate how the composition and scale of Australia's imports have evolved over time and across material categories, providing insights into changing patterns of dependence and opportunities for circular economy action.

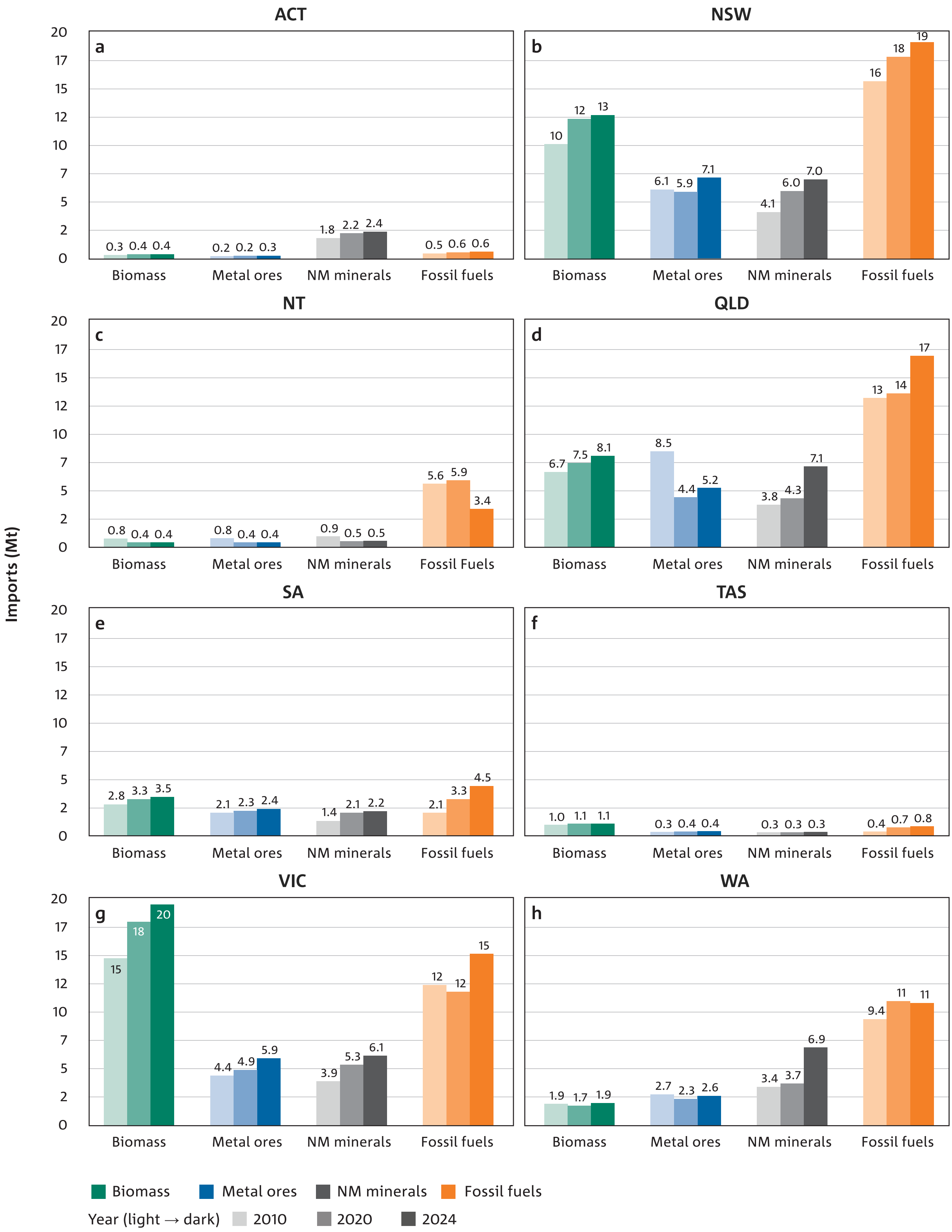


Figure 5. Imports (IM) of materials and products for Australia's states and territories, 2010, 2020, and 2024, absolute values. Unit: million metric tonnes (Mt). Note that these values include both international and interstate trade.

3.2.1 Key features and trends

Between 2010 and 2024, total material imports to Australia from overseas increased from 87 to 108 million tonnes (+24%). These flows were supplemented by 55 million tonnes of interstate imports in 2010 and 68 million tonnes in 2024. Growth was broad across material groups, but most pronounced for non-metallic minerals (+45%) and biomass (+33%), followed by fossil fuels (+21%), while metal-ore imports remained largely stable. New South Wales, Victoria, and Queensland together accounted for about 70% of total international imports in 2024, reflecting their larger populations and industrial bases. New South Wales, Queensland, and Victoria led fossil fuels and biomass imports, while we observed the sharpest rise in imports of non-metallic minerals in Western Australia and Queensland. Fossil fuels continue to dominate total imports, reflecting ongoing dependence on transport and industrial energy. However, non-metallic minerals have become Australia's fastest-growing import class, roughly doubling in Queensland and Western Australia and rising strongly in New South Wales and Victoria (Figure 5). Biomass imports increased steadily in all jurisdictions except for the Northern Territory, consistent with population growth and rising demand for food and bio-based products. The Northern Territory shows declining fossil-fuel and mineral imports after 2010, while South Australia and Tasmania exhibit modest growth across all material types. Overall, the data suggest that while total import volumes have expanded in line with economic activity, the structure of imports has shifted away from raw mineral inputs toward higher inflows of processed and construction-related materials.

When adjusted for population growth, which increased from 22 million in 2010 to 27 million in 2024, total material imports per person increased slightly, from about 6.3 to 6.5 tonnes per capita. The composition, however, has evolved. Fossil-fuel imports per person remained high in New South Wales (circa 2.3 t cap^{-1}) and Victoria (about 2.2 t cap^{-1}) but declined in Western Australia and the Northern Territory, suggesting improved domestic sourcing or efficiency (Figure 6). Biomass imports per person were relatively stable nationwide (1.5–2 t cap^{-1}), with Victoria and Tasmania maintaining the highest levels. Non-metallic mineral imports per person rose markedly in Western Australia (from 1.5 to 2.3 t cap^{-1}) and Queensland (from 0.9 to 1.3 t cap^{-1}), reflecting ongoing construction and infrastructure investment. The Northern Territory's per-capita imports of fossil fuels declined sharply, from 24 t cap^{-1} in 2010 to 13 t cap^{-1} in 2024, indicating a smaller resource throughput per capita. These figures show that Australia's import intensity per person has largely plateaued, even as the import mix has tilted toward energy and construction-related goods.

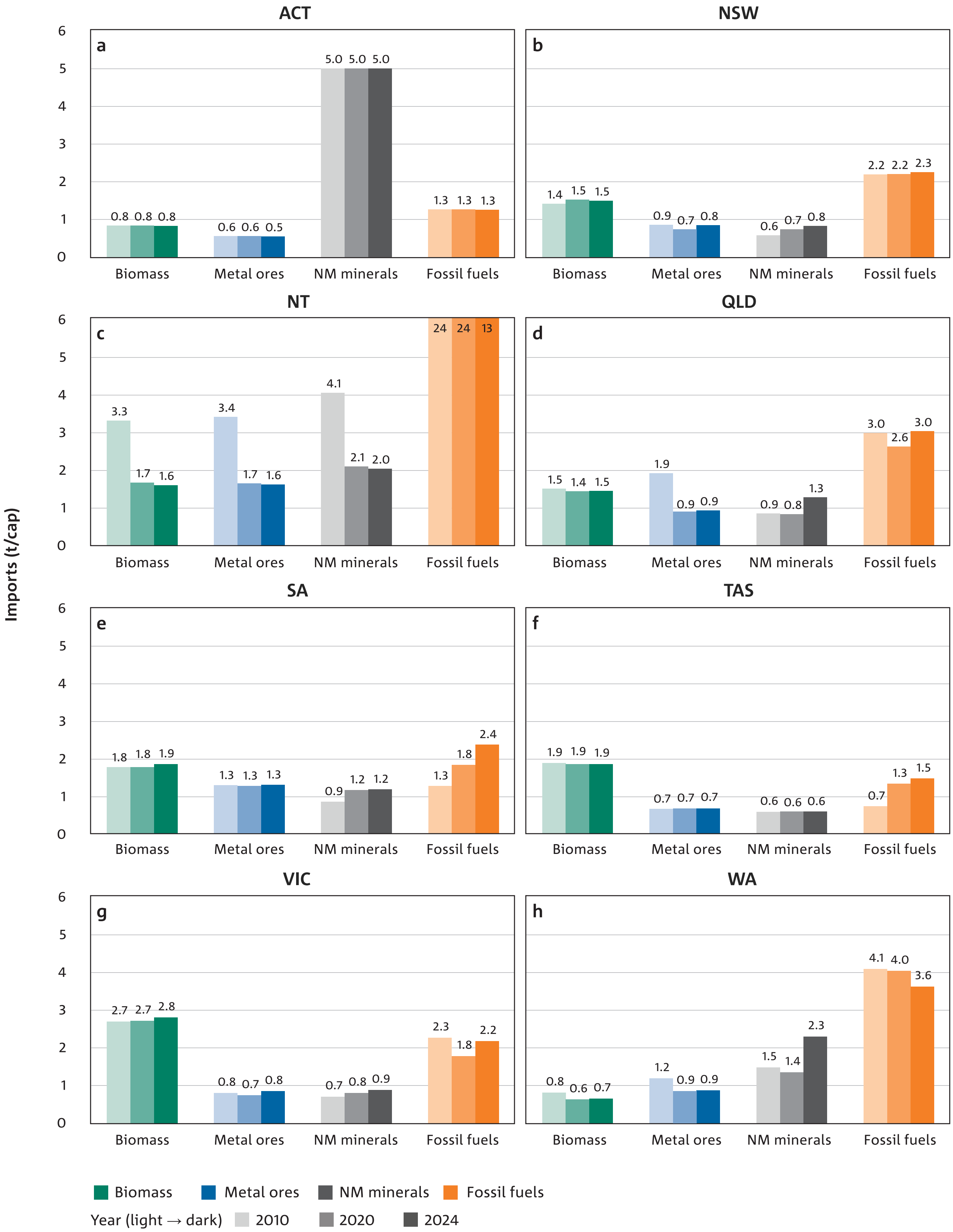


Figure 6. Imports (IM) of materials and products for Australia's states and territories, 2010, 2020, and 2024, per capita values. Unit: metric tonnes per capita (t/cap). Note that these values include both international and interstate trade.

3.2.2 Policy-relevant insights

The evolving pattern of material imports has significant policy implications. Reliance on internationally imported fossil fuels and construction minerals leaves the national economy exposed to global market volatility and supply risks. Reducing this dependence through accelerated investment in renewable energy, domestic industrial capacity, and circular material systems would strengthen resource security and national resilience.

The strong growth in non-metallic mineral imports underscores the need to expand circular economy substitution pathways. Greater use of recycled aggregates, supplementary cementitious materials, and reused building components can moderate demand for imported virgin materials. At the same time, it can create domestic employment and innovation opportunities within construction and waste-management value chains.

Rising imports of biomass and manufactured products signal underdeveloped domestic industrial capabilities. Enhancing Australia's bio-based manufacturing could capture more value locally, reduce exposure to international supply chains, and support regional economic development. Although imports relieve pressure on Australia's own environment, they externalise environmental costs by generating environmental impacts elsewhere. Integrating embodied-impact accounting into procurement policies would help align Australia's consumption with global sustainability goals.

Marked regional differences also suggest that circular economy interventions should be tailored to local realities. Renewable-fuel substitution and industrial symbiosis offer particular potential in New South Wales and Victoria; construction-material recovery and reuse are emerging opportunities in Queensland and Western Australia; and regional bio-processing could be expanded in South Australia and Tasmania. Collectively, such place-based strategies can reduce Australia's exposure to global material risks while advancing progress toward industrial resilience.

3.3 Interstate and international exports

International exports measure the physical outflow of materials and products from Australia to the rest of the world. Interstate exports, on the other hand, measure how much each state trades with its domestic partners. Australia is a major resource exporter, particularly of fossil fuels and ores, and these exports generate substantial national income and employment. However, from a circular economy perspective, such one-way flows raise the issue of whether Australia captures sufficient value from its material endowment, or whether more value could be retained through local refining and manufacturing. For economic policy, strong export dependence brings benefits but also significant risks, especially as global demand shifts with decarbonisation and changing trade patterns. The environmental consequences of export-driven extraction are substantial as local ecosystems bear the burden of mining and processing, while exported fossil fuels contribute to global emissions, even if those emissions occur outside Australia's borders.

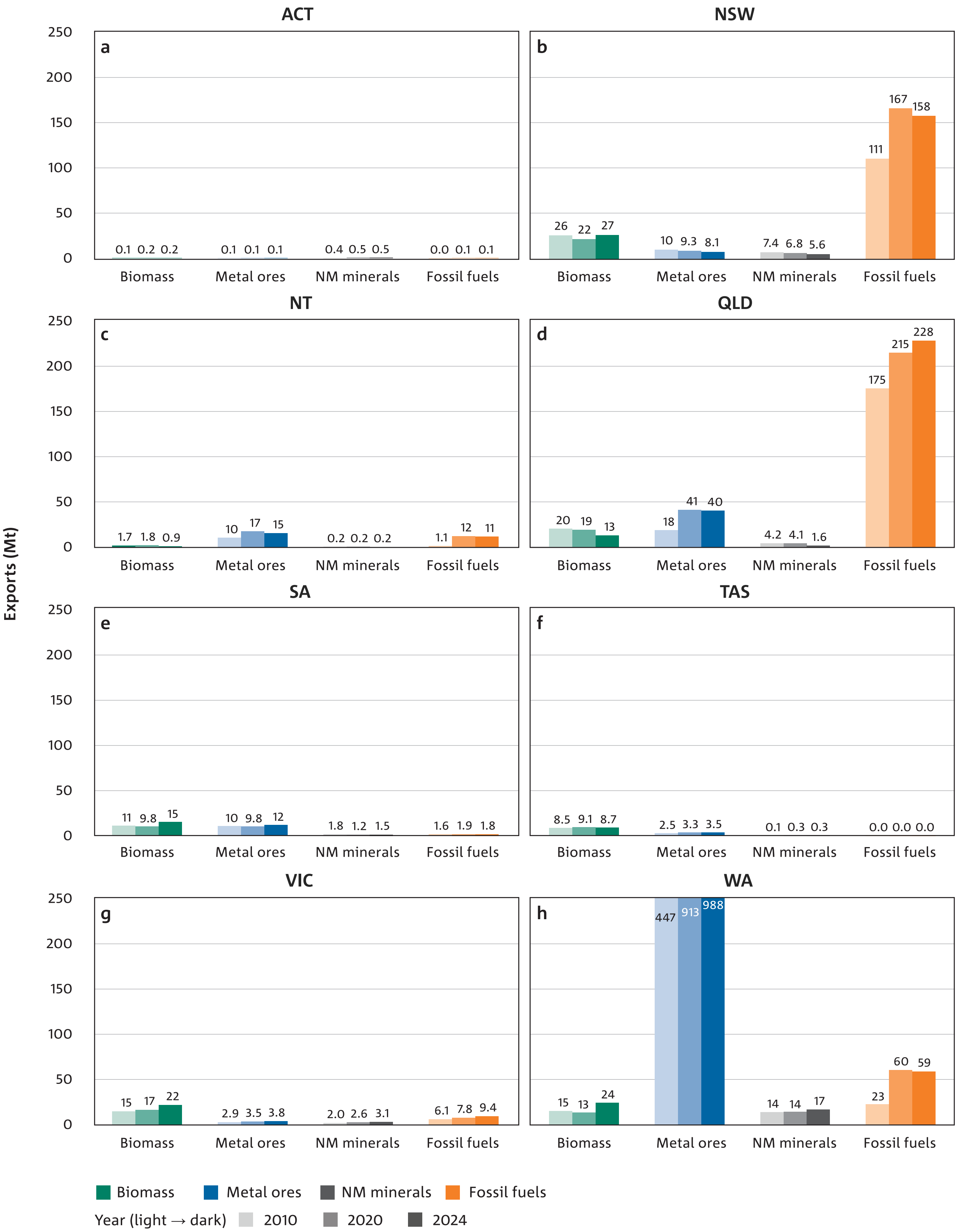


Figure 7. Exports (EX) of materials and products for Australia's states and territories, 2010, 2020, and 2024, absolute values. Units: million metric tonnes (Mt). Note that these values include both international and interstate trade.

3.3.1 Key features and trends

Between 2010 and 2024, Australian States' total material exports (i.e., the sum of their international and interstate exports) increased from approximately 731 million tonnes to over 1 billion tonnes, marking a rise of around 40%. This growth was driven primarily by metal ores and fossil fuels, which together accounted for nearly 90% of total exports by 2024 (Figure 7). Western Australia overwhelmingly dominates national export volumes, contributing more than two-thirds of Australia's total exports, primarily through iron ore and liquefied natural gas shipped internationally. Queensland follows as the second-largest exporter, driven by coal, bauxite, and other mineral commodities.

At the state level, metal ore exports rose most sharply in Western Australia (from 447 million to 988 million tonnes, +121%), reflecting sustained demand from Asian steel industries. Fossil fuel exports also expanded significantly in Queensland (+30%) and New South Wales (+40%), consolidating these states' roles as energy exporters. While biomass exports – mainly agricultural products – remained stable or grew modestly, non-metallic mineral exports declined in several jurisdictions, particularly Queensland and New South Wales, as domestic construction absorbed more of the output.

Regional contrasts are pronounced. The Northern Territory shows a sharp increase in both ore and fossil-fuel exports between 2010 and 2020, before stabilising in 2024 (+52% and +956%, respectively). South Australia and Tasmania maintain modest but steady export levels, while Victoria displays gradual growth in biomass and fossil-fuel exports alongside emerging niche mineral products. Overall, Australia's export profile remains dominated by unprocessed raw materials, underscoring the limited domestic value addition along global resource supply chains.

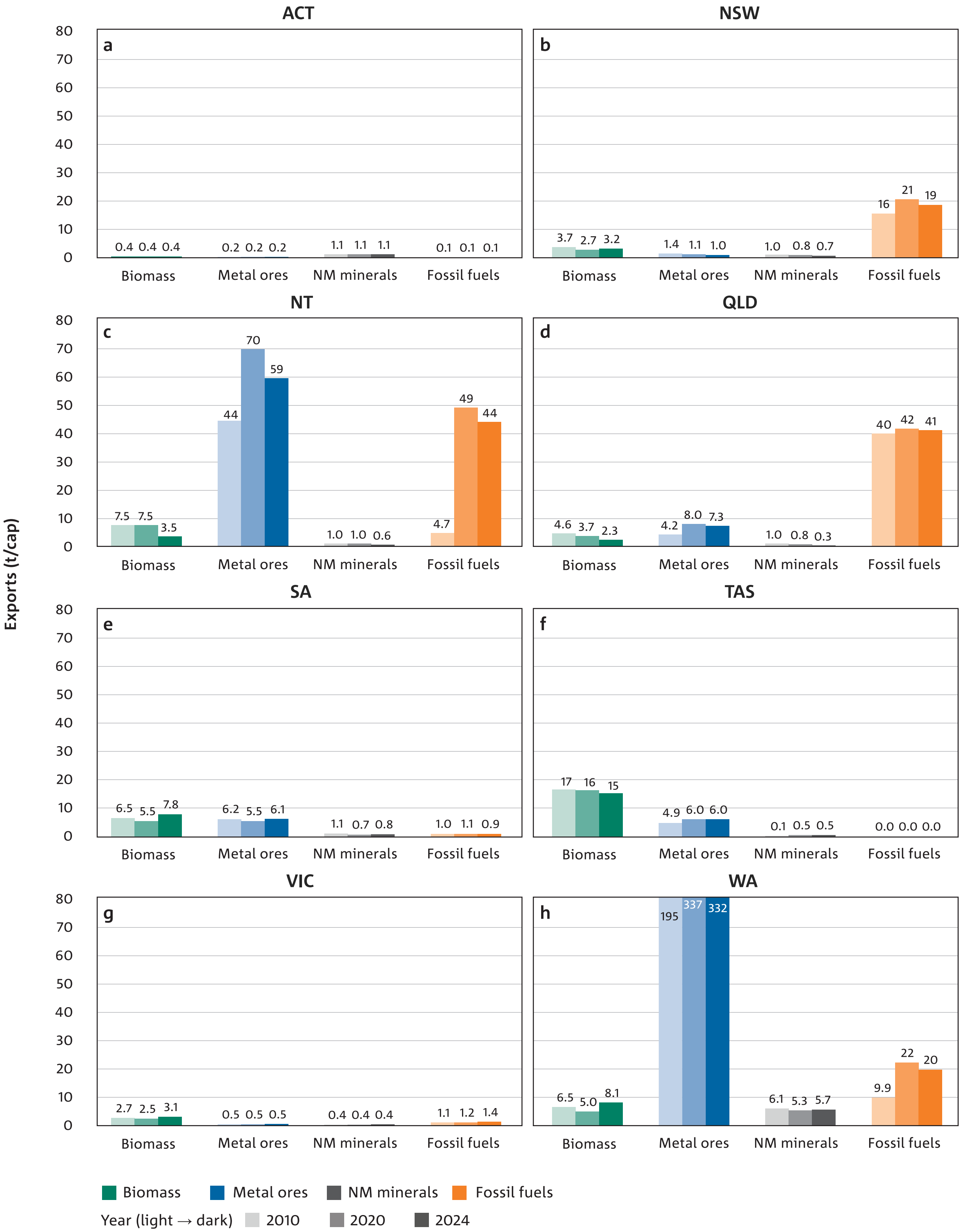


Figure 8. Exports (EX) of materials and products for Australia's states and territories, 2010, 2020, and 2024, per capita values. Units: metric tonnes per capita (t/cap). Note that these values include both international and interstate trade.

When adjusted for population, total material exports rose from roughly 32 tonnes per person in 2010 to 40 tonnes per person in 2024, indicating that export intensity per capita continues to climb. Per-capita metal-ore exports reached extraordinary levels in Western Australia, rising from 195 to over 330 tonnes per person, by far the highest in the country and among the highest globally (Figure 8). Queensland and the Northern Territory also show elevated per-capita export intensity, exceeding 40 tonnes per person in recent years, driven by fossil-fuel extraction. In contrast, more populous states such as New South Wales and Victoria exhibit lower export intensity (below 20 tonnes per person), reflecting their more diversified, service-oriented economies.

These per-capita patterns reveal how a handful of resource-rich states underpin national export performance, while the others rely more heavily on imports and domestic materials. This result highlights the spatial asymmetry of Australia's resource economy: high extraction and export dependence in the west and north, coupled with high consumption and import dependence in the east and south.

3.3.2 Policy-relevant insights

Australia's strong export performance has been a major source of economic prosperity, but it also exposes significant structural vulnerabilities. Continued dependence on fossil-fuel and raw-material exports leaves the economy sensitive to global commodity cycles and transition risks associated with decarbonisation. As international markets shift toward low-carbon production, the value of traditional energy exports is expected to decline, underscoring the urgency of diversifying export portfolios and developing new domestic capabilities in clean materials, renewable energy, and manufacturing.

From a circular economy perspective, Australia's export profile reflects a system of high throughput but limited domestic value retention. Most exports leave the country at early stages of the value chain with minimal local processing. Expanding onshore processing of ores and bio-based materials could create higher value, reduce trade exposure, and generate skilled domestic employment. Recycling and remanufacturing industries can also serve as complementary pathways, allowing more materials to circulate within domestic systems before being exported as finished or intermediate products.

The environmental implications of export-led growth are considerable. Resource extraction for export drives substantial land disturbance, pollution, water use, and biodiversity loss domestically, while the combustion of exported fossil fuels contributes to global emissions outside Australia's boundaries. A comprehensive sustainability framework for trade that integrates embodied emissions and material footprints would help ensure that Australia's export model aligns with its climate and biodiversity commitments.

Finally, policy responses should recognise regional differentiation. Western Australia and Queensland will require targeted transition strategies to manage the economic risks of declining global demand for coal and conventional ores, while leveraging their strengths in renewable energy and critical minerals. In the southern and eastern states, opportunities lie in developing advanced recycling, sustainable manufacturing, and bio-based exports. Through such place-based approaches, Australia can shift from a predominantly extractive export model toward a resilient, low-carbon trade system that maintains economic value while reducing environmental pressure.

3.4 Domestic material consumption

Domestic material consumption (DMC) represents the total volume of materials directly used by the economy, calculated as domestic extraction plus imports minus exports. It is often considered the headline measure of material use, as it reflects the apparent consumption of resources by residents and industries. For circularity, DMC is crucial because lowering consumption while maintaining or improving well-being signals genuine progress towards decoupling resource use from prosperity. From a policy standpoint, high levels of DMC may indicate inefficiency, reliance on resource-intensive sectors, or unsustainable consumption practices. Lowering DMC through efficiency gains, material substitution, reuse, and recycling strengthens competitiveness and resilience in the long run. Environmentally, material consumption drives energy demand, emissions, waste generation, and land degradation, making the reduction of DMC central to achieving climate targets, protecting biodiversity, and reducing pollution.

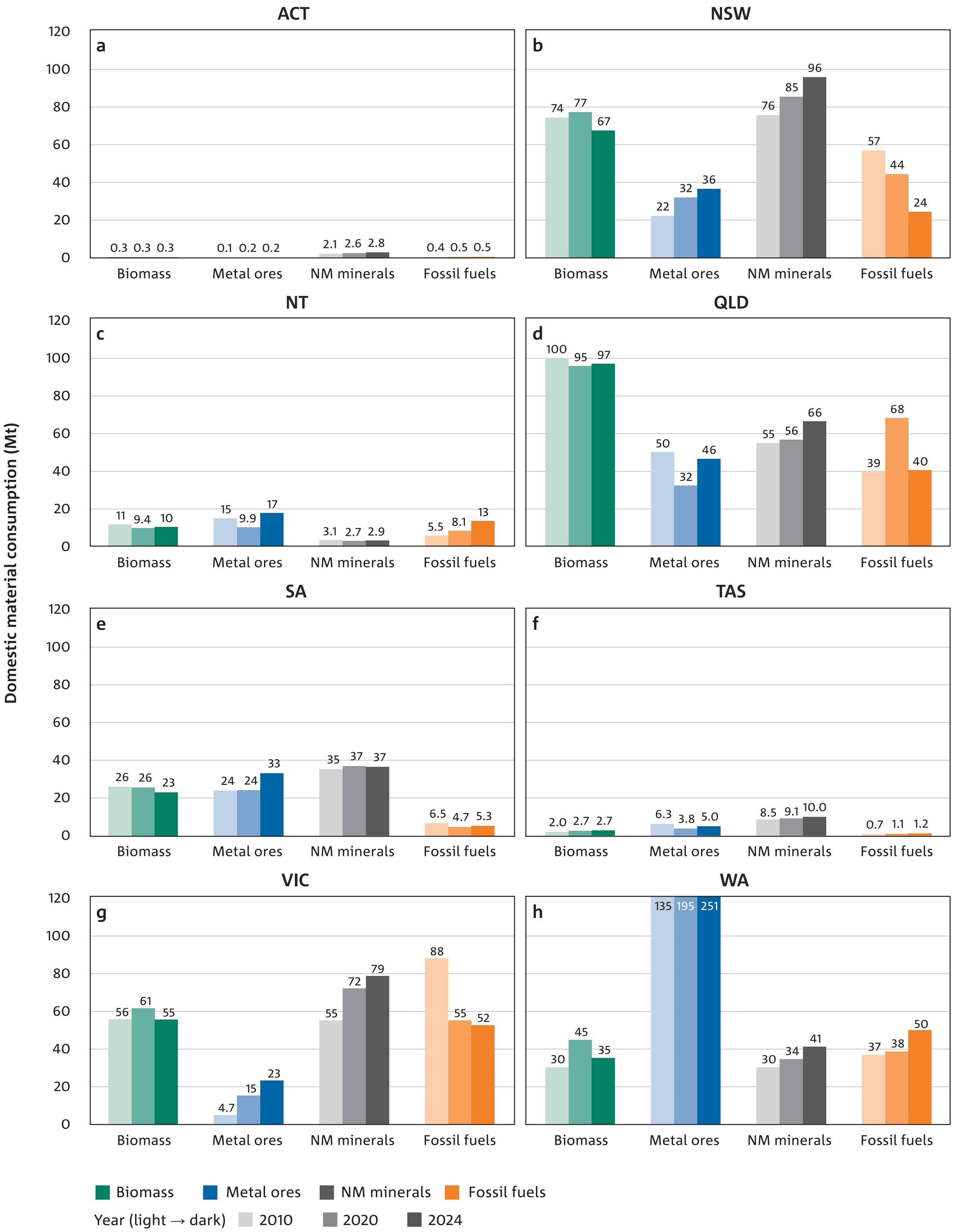


Figure 9. Domestic material consumption (DMC) for Australia's states and territories, 2010, 2020, and 2024, absolute values. Unit: million metric tonnes (Mt).

3.4.1 Key features and trends

Between 2010 and 2024, Australia's total domestic material consumption grew moderately, from around 790 million tonnes to 935 million tonnes (+18%). Growth was uneven across material categories: non-metallic minerals increased the most (+25%), reflecting ongoing construction and infrastructure expansion, followed by metal ores (+20%) and biomass (+10%), while fossil-fuel consumption decreased by 20%.

At the state level, Queensland, New South Wales, and Western Australia together accounted for more than half of the total DMC, though their material profiles differ markedly (Figure 9). Queensland's consumption is broad-based, with large shares of biomass and minerals; non-metallic minerals and industrial materials dominate New South Wales's DMC; and Western Australia's high DMC reflects its mining-intensive economy and ample internal demand for construction inputs. The Northern Territory, though small in population, shows high per-capita values due to resource-project activity, while Victoria displays a balanced but slightly declining DMC linked to a shift toward service industries.

Across Australia, non-metallic minerals form the largest component of DMC, rising from about 264 million tonnes in 2010 to 334 million tonnes in 2024, followed by biomass (290 million tonnes). Fossil fuels' DMC, on the other hand, went from 234 million tonnes to 187 million tonnes. The data indicate that the domestic economy remains heavily construction-driven, with material throughput closely tied to population and infrastructure growth. In contrast, fossil-fuel consumption has declined in some eastern states, consistent with the energy transition and efficiency improvements in industry and transport.

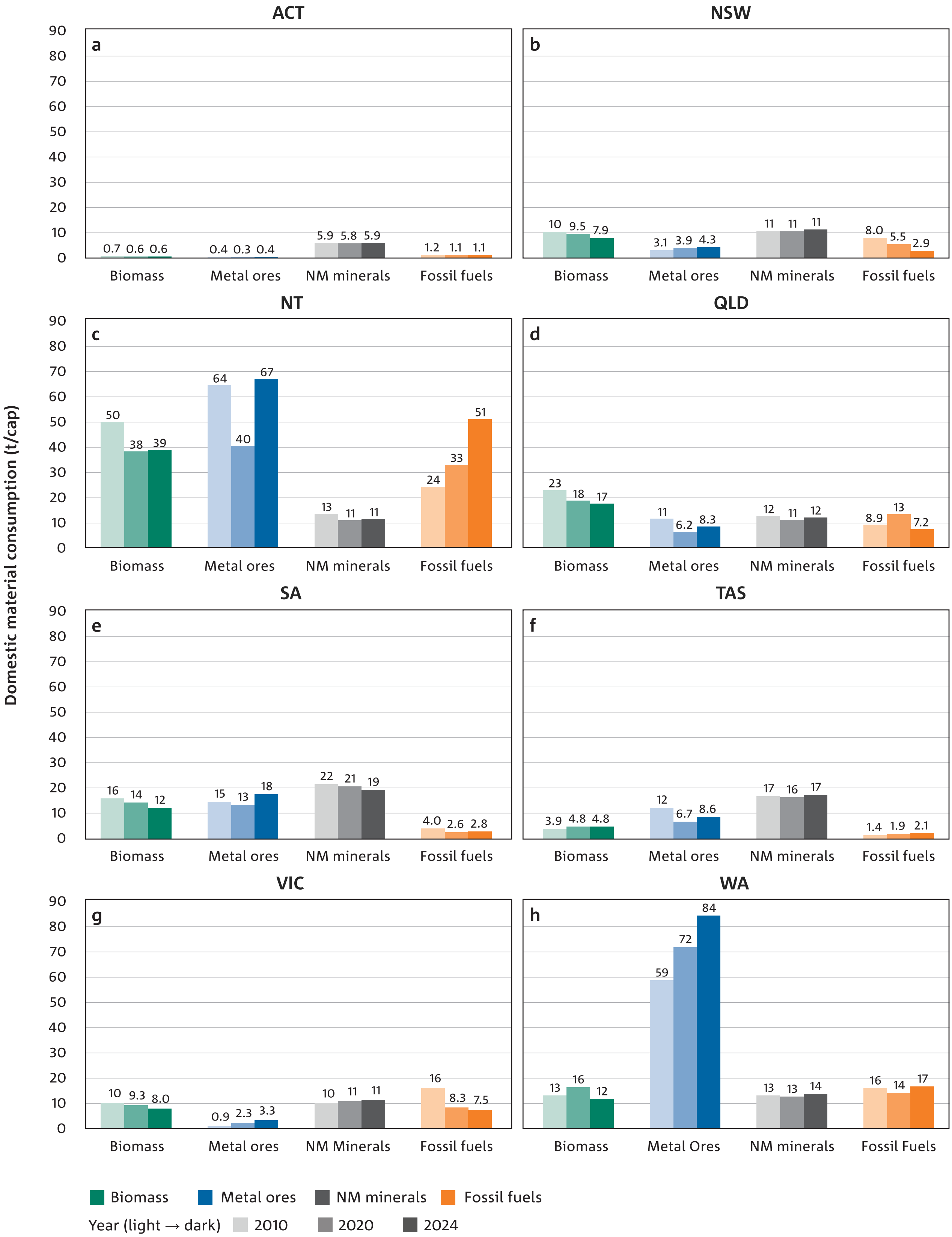


Figure 10. Domestic material consumption (DMC) for Australia's states and territories, 2010, 2020, and 2024, per capita values. Unit: metric tonnes per capita (t/cap).

When adjusted for population growth – from 22 to 27 million people – the overall per-capita DMC declined slightly, from around 36 tonnes per person in 2010 to 34 tonnes in 2024. This decline suggests partial decoupling of material use from population growth, though not yet from gross domestic product (GDP). Compositionally, non-metallic minerals per person rose slightly (about +5%), while fossil-fuel and biomass consumption per person fell (Figure 10). Western Australia remains by far the most material-intensive jurisdiction, exceeding 125 tonnes per person in 2024, largely due to high mining-related demand. Queensland and the Northern Territory also display elevated per-capita DMC (40–50 t cap^{-1}), whereas New South Wales and Victoria fall below 30 t cap^{-1}. These differences underscore the structural diversity of Australia's economy, where some regions are extractive, export-oriented, while others are consumption-based and service-intensive.

3.4.2 Policy-relevant insights

Trends in DMC highlight both progress and persistent challenges for Australia's circular economy transition. The modest decline in per-capita consumption points to early signs of material efficiency, yet total use continues to rise, driven by population growth and the related construction demand. Achieving absolute decoupling will therefore rely on accelerating material substitution, extending product lifetimes, and increasing the use of secondary materials across industrial systems.

The dominance of construction minerals in DMC underscores the strategic importance of the built-environment sector for circularity. Expanding recycling of demolition waste, adopting modular and lightweight design, extending building lifespan, building smaller homes, and increasing the use of secondary aggregates can significantly reduce demand for virgin materials. Biomass consumption patterns suggest potential for bio-based substitution and improved food-system efficiency, while declining fossil-fuel use indicates the emerging effect of the energy transition and electrification.

From a policy perspective, lowering DMC while retaining economic prosperity will have positive outcomes on national objectives for emissions reduction, productivity growth, and resource security. Integrating material-efficiency targets into planning and procurement can accelerate progress, while improved data on material flows enables more effective monitoring. Regional diversity also calls for differentiated approaches: Western Australia and Queensland will benefit from industrial symbiosis and resource-efficiency programs within mining and processing; New South Wales and Victoria can focus on circular construction and consumer-goods recovery; and smaller jurisdictions such as South Australia and Tasmania can advance niche strategies in renewable materials and recycling innovation.

Overall, Australia's DMC trends indicate a gradual yet discernible shift toward greater efficiency. However, maintaining this trajectory in the face of population and economic growth will require a concerted policy effort, linking material-use reduction to broader sustainability goals and ensuring that gains in circularity directly contribute positively to intended outcomes.

4 Material footprint, or a perspective on material requirements to fulfil final demand

While domestic material consumption (DMC) (cf. Section 3.4) measures the direct use of materials within Australia's borders, the material footprint extends this perspective by attributing global raw material requirements to the goods and services consumed by final users, regardless of where in the world those resources are extracted.
In practical terms, the material footprint captures the upstream extraction of materials embodied in imports to the domestic extraction, subtracts the resource requirements embodied in exports, and thus reflects the full resource intensity of final demand.

Therefore, one could argue that the material footprint provides a more comprehensive lens on circularity because it links domestic consumption patterns – in this report, Australian patterns – to environmental pressures occurring both domestically and abroad, driven by domestic final demand. For instance, a product imported from overseas may require substantial amounts of raw materials during its production (e.g., an electric car), even though these flows are not visible in domestic material flow statistics.
By accounting for such embodied resource use, the material footprint highlights the global dimension of a country's material dependency. In this report, the material footprint attributes final demand to each State and Territory, accounting for both international and interstate trade.

From a circular economy perspective, the material footprint provides evidence for systemic interventions beyond national borders. It illustrates how consumption in urban centres such as Sydney may drive resource extraction in distant regions, and it highlights the importance of product design in final material demand. Circularity strategies, such as extending product lifetimes, increasing repairability, designing products not meant to be disposable, and substituting high-footprint materials with locally recovered secondary materials, directly contribute to reducing Australia's material footprint.

For economic policy, the material footprint aligns with resilience and sustainability goals by revealing the externalised resource requirements embedded in trade. Policymakers can use the metric to evaluate exposure to global resource risks or identify opportunities for value creation in domestic processing and recycling industries. Moreover, the difference between DMC and material footprint shows whether consumption-driven environmental costs are simply shifted offshore rather than tackled at the root.

In environmental terms, the material footprint makes clear that Australia's ecological impact extends well beyond its borders. It captures resource use and associated emissions across global supply chains and highlights Australia's role in addressing global sustainability challenges. Reducing the material footprint is therefore essential for aligning national consumption with planetary boundaries and for ensuring that progress in domestic circular economy policies translates into genuine environmental benefits.

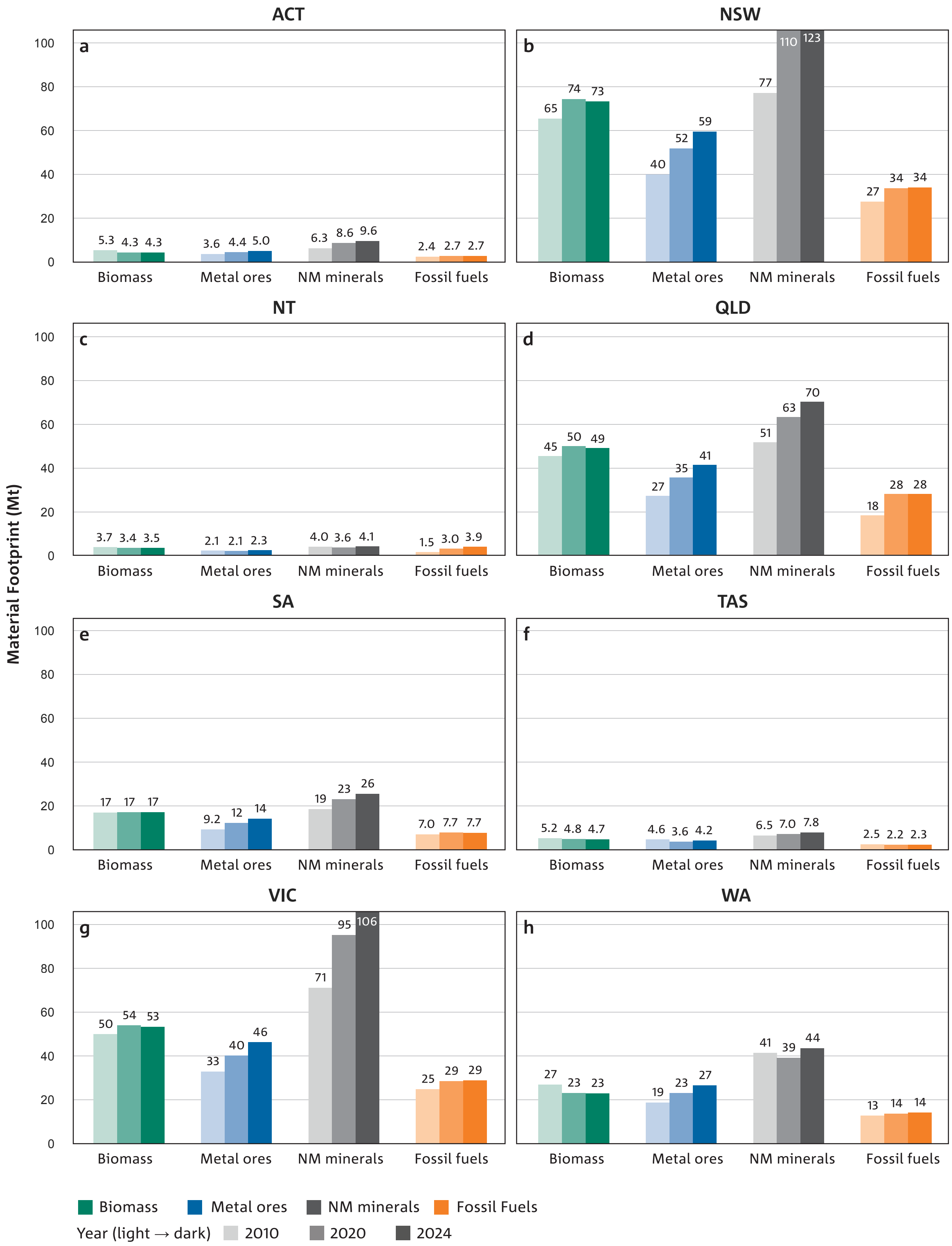


Figure 11. Material footprint for Australia's states and territories, 2010, 2020, and 2024, absolute values. Unit: million metric tonnes (Mt).

4.1 National material footprints

4.1.1 Key features and trends

Material footprints[1] across Australian states and territories increased markedly between 2010 and 2024, with the national material footprint increasing by 208 Mt (29%), indicating a continued rise in the materiality of domestic consumption. In absolute terms, growth is dominated by non-metallic minerals, with the national total increasing from 12.6 tonnes per capita in 2010 to 14.2 tonnes per capita in 2024. Metal ores are the second most important contributor, while biomass and fossil fuels play a comparatively smaller and more stable role. This composition reflects the centrality of construction, infrastructure expansion, and capital formation in shaping material demand over the past decade.

The largest absolute material footprints are observed in New South Wales, Victoria, and Queensland throughout the period (Figure 11). By 2024, total material footprints in these states reached levels well above 200 million tonnes, driven primarily by sustained increases in non-metallic minerals used in the construction of both buildings and infrastructure. Non-metallic mineral footprints grew by roughly half or more compared with 2010 levels in most jurisdictions, highlighting the material consequences of continued urban expansion and renewal. Metal ore footprints also rose steadily, particularly in states with strong manufacturing and construction demand, reflecting the upstream material requirements embodied in final consumption rather than local extraction alone.

Biomass footprints exhibit more heterogeneous patterns. In several jurisdictions, including the Australian Capital Territory, Tasmania, and Western Australia, absolute biomass footprints declined slightly over time, whereas they remained broadly stable elsewhere. This result suggests that growth in food and biomass-based consumption has been modest relative to population and income growth. Fossil fuel footprints increased in absolute terms in most states, particularly in Queensland and the Northern Territory, indicating continued reliance on energy-intensive consumption and on indirect fossil fuel inputs embedded in material supply chains.

1 Calculated absolute material footprint values differ from the *Measuring What Matter*s figures due to ongoing work on the nested input-output tables used (See Section 11.4 Material Footprint). A material footprint-focused update is planned to be released in 2026, but it is expected that, while absolute values may vary, general features and trends of the state-level material footprints will remain consistent.

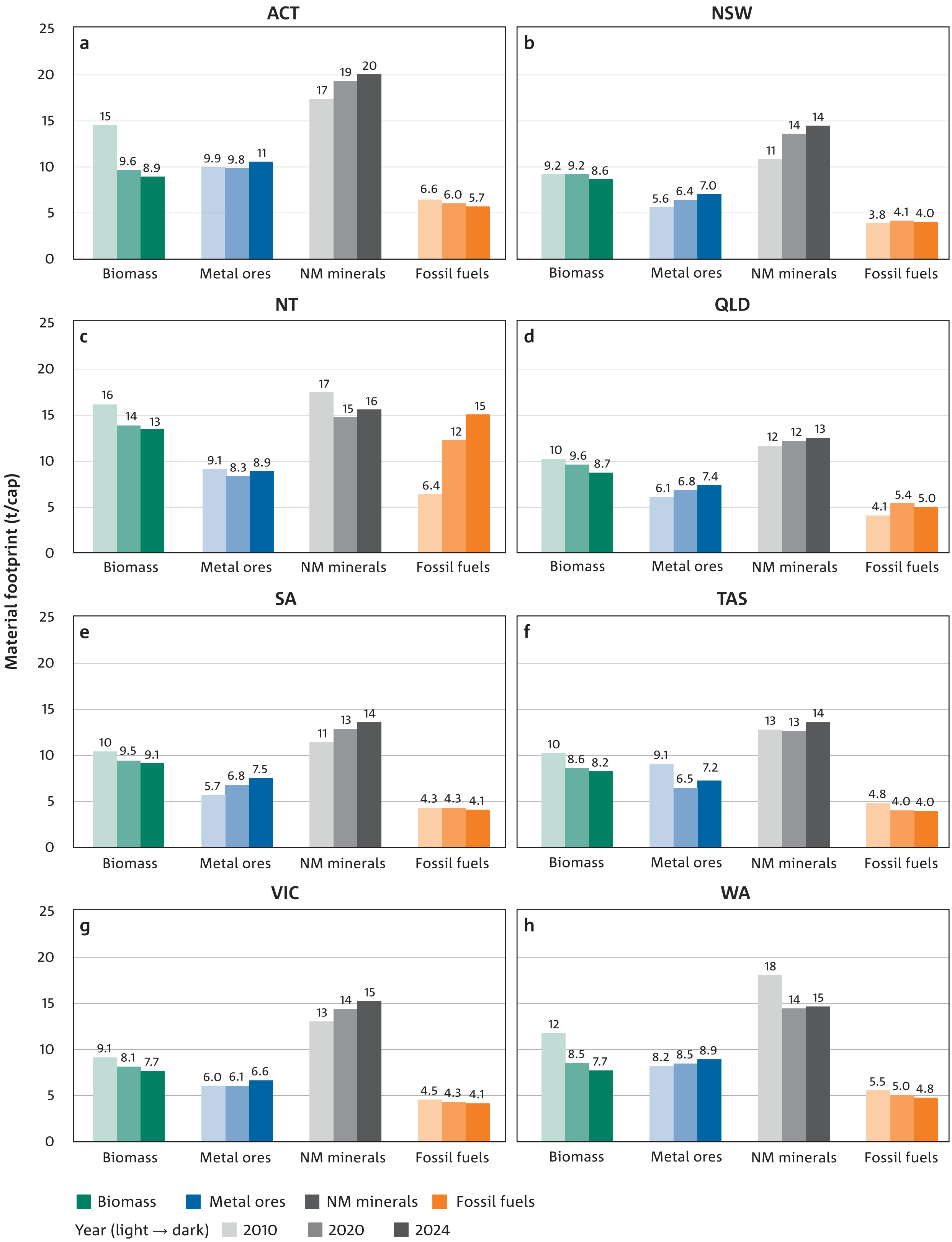


Figure 12. Material footprint for Australia's states and territories, 2010, 2020, and 2024, per capita values. Unit: metric tonnes per capita (t/cap).

When assessed on a per-capita basis, material footprint trends reveal important structural and distributional dynamics that are not visible in aggregate totals. Per-capita biomass footprints declined consistently across nearly all states and territories between 2010 and 2024, pointing to a degree of relative decoupling between population growth and biomass-based consumption (Figure 12). In contrast, per-capita non-metallic mineral footprints increased in every jurisdiction, except for Western Australia and the Northern Territory, reaching approximately 14 to 20 tonnes per person by 2024. This trend indicates that, even where population growth is strong, material demand for buildings and infrastructure continues to rise faster than demographic change.

Per-capita metal ore footprints show moderate but widespread increases, particularly in the larger eastern states, reflecting growing upstream material requirements embodied in construction materials, manufactured goods, and durable capital. Fossil fuel footprints per capita remained broadly stable or declined slightly in most jurisdictions, suggesting some success in reducing direct and indirect fossil fuel intensity. A notable exception is the Northern Territory, where fossil fuel footprints per capita increased sharply over the period, reflecting the influence of energy- and resource-intensive activities relative to a small population base.

Overall, per-capita indicators point to partial relative decoupling in biomass and fossil fuels, but continued intensification in construction-related materials, especially non-metallic minerals.

4.1.2 Policy Relevant Insights

From a policy perspective, the sustained increase in absolute material footprints indicates that Australia's consumption-based material demand remains on a growth trajectory, with no evidence of absolute dematerialisation at either the national or state level. The dominance of non-metallic minerals points out the built environment as the primary leverage point for material-efficiency and demand-reduction strategies. Policies targeting this domain, especially housing and transport infrastructure, therefore, have the greatest influence on overall material footprints.

The magnitude and persistence of growth in construction-related materials suggest that marginal efficiency improvements will be insufficient to offset rising demand. Transformative interventions are required, including material-efficient building design, increased utilisation and lifetime extension of existing building stock, reuse and remanufacturing of construction components, and planning approaches that reduce per-capita infrastructure requirements. States with the largest absolute footprints, particularly New South Wales, Victoria, and Queensland, represent high-impact entry points for such measures.

Per-capita material footprint patterns provide additional insights relevant to equity and long-term sustainability. Rising per-capita non-metallic mineral footprints indicate that current service provision models for housing and mobility remain highly material-intensive, even in densely populated jurisdictions. At the same time, declining biomass and largely stable per capita fossil fuel footprints demonstrate that relative decoupling is achievable in certain material categories, providing empirical support for policies that reshape consumption without undermining living standards.

Marked differences between states and territories also point to the importance of place-based policy approaches. Smaller or resource-intensive jurisdictions exhibit higher per-capita footprints in specific material categories, suggesting that uniform national targets may mask significant structural variation and may be easy to attain in certain jurisdictions and nigh impossible in others. Per-capita material footprint indicators are therefore particularly valuable for designing tailored policy responses that align material demand reduction with population growth, economic structure, and wellbeing objectives.

Taken together, the material footprint evidence reinforces the conclusion that achieving Australia's sustainability and circular economy ambitions will require structural change in material-intensive provision systems, particularly in the built environment, rather than relying solely on incremental efficiency gains. Moreover, state-specific goals aligned with the national policy might need to be set.

5 Material outputs, or flows back to nature

Material flow outputs comprise all flows originating from human-made activities and returned to nature: waste (Section 5.1), greenhouse gas emissions (Section 5.2), pollutants (Section 5.3), and seeds and fertilisers (Section 5.4).

5.1 Waste and recycling

Waste generation and recycling are the most visible aspects of the circular economy, shaping how materials are managed at the end of their useful life. Together, these indicators reveal both the scale of residuals that must be handled by waste systems and the extent to which materials are recovered for productive use rather than lost to disposal.

Waste generation measures the total mass of materials discarded by households, businesses, and industry (Figure 13; Figure 14). High levels of waste may signal inefficiencies in production and consumption systems, whether from excessive packaging, short product lifespans, or limited repair and reuse. For circularity, reducing waste is a primary objective, as it reflects progress in preventing resource loss and closing material loops upstream. From an economic policy perspective, high waste volumes translate into increased costs for collection, treatment, and disposal, and they highlight opportunities for innovative solutions. Environmentally, waste management has wide-ranging impacts: landfill operations generate greenhouse gas emissions and potential leachate; incineration, while reducing volume, contributes to air pollution; uncontrolled waste disposal damages ecosystems and human health; and recycling, while typically preferable to virgin material extraction, is often associated with intensive energy and chemical processes.

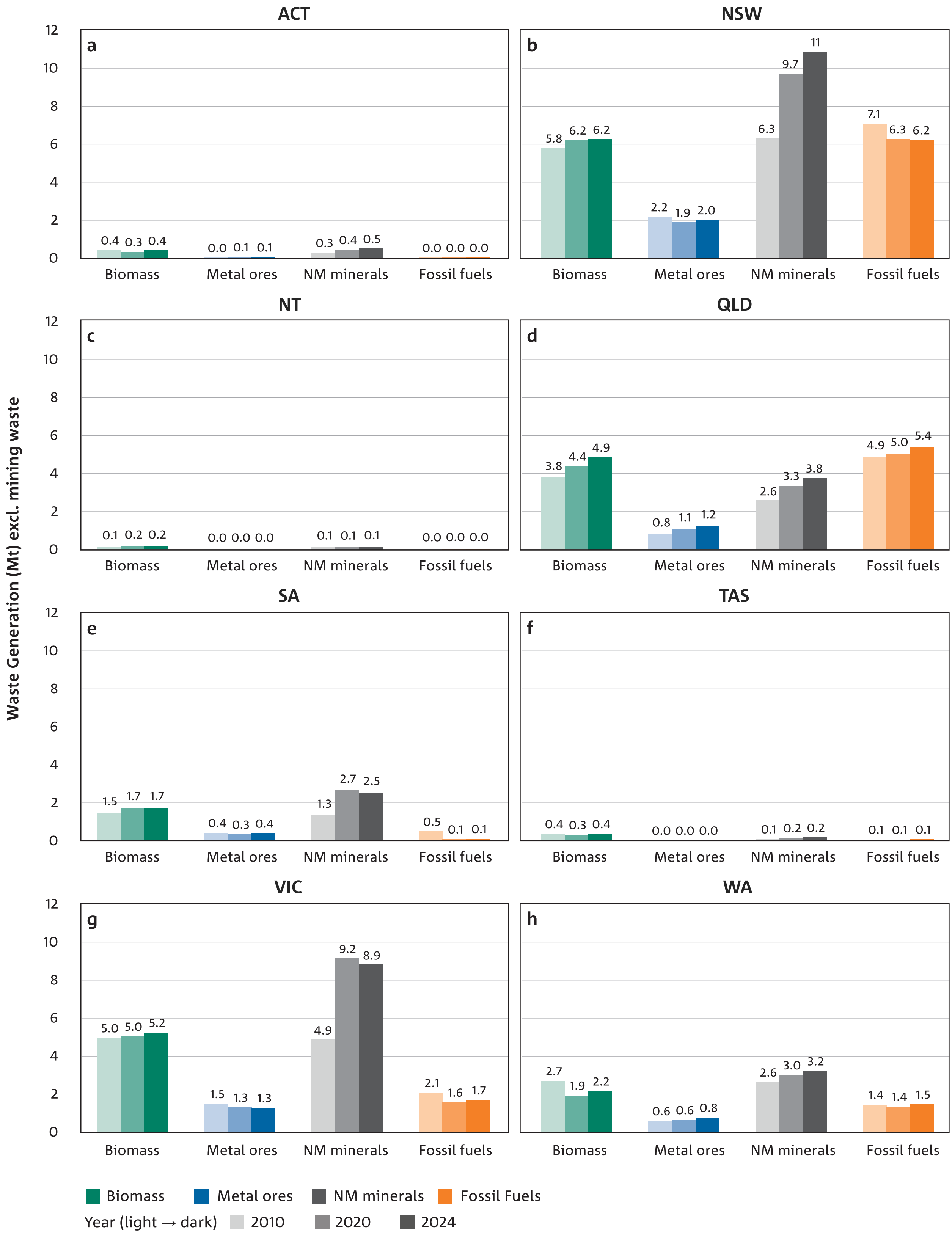


Figure 13. Total waste generation excluding mining waste (i.e., core waste) for Australia's states and territories, 2010, 2020, and 2024. Absolute values. Unit: million metric tonnes (Mt).

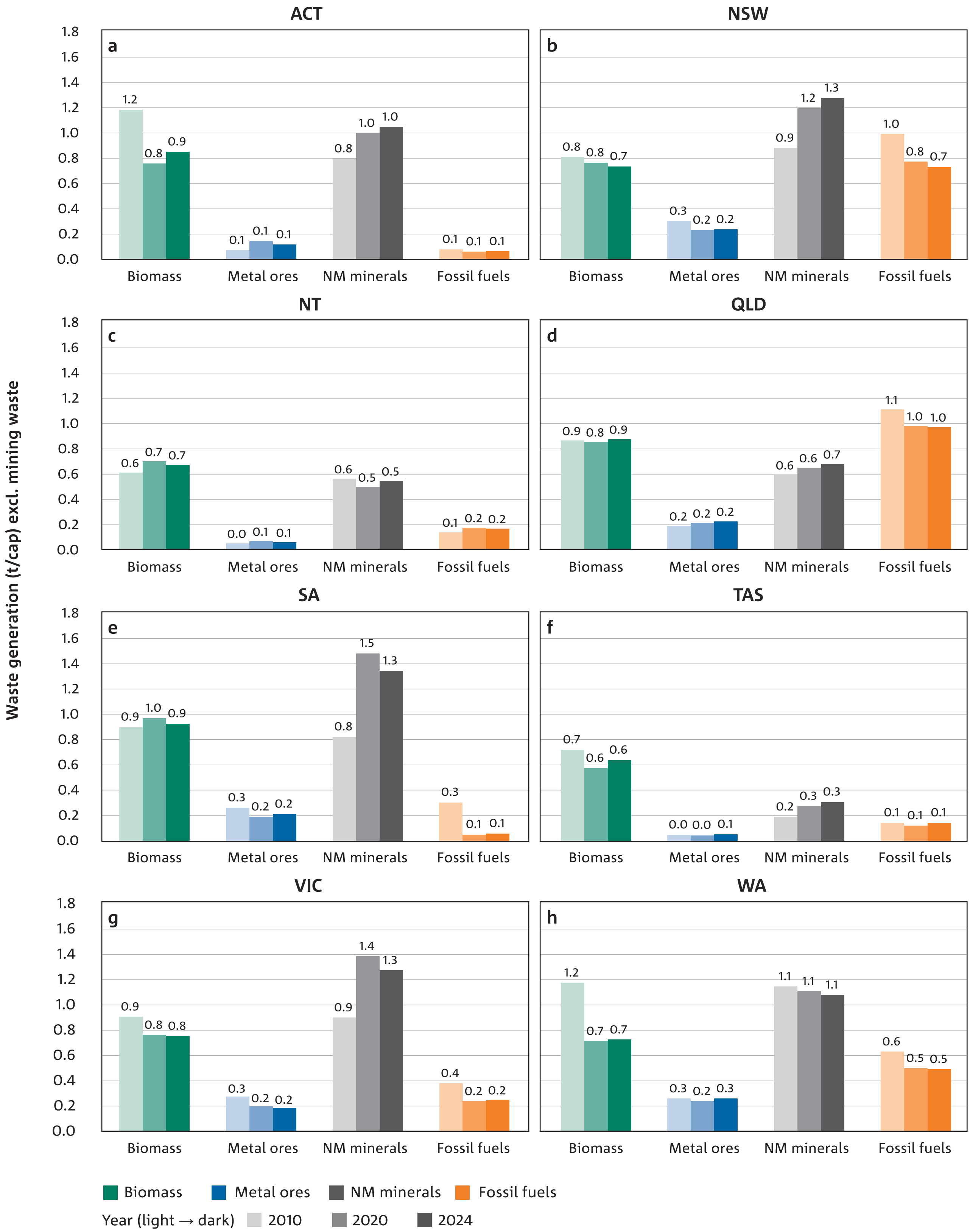


Figure 14. Waste generation excluding mining waste (i.e., core waste) for Australia's states and territories, 2010, 2020, and 2024. Per capita values. Unit: metric tonnes per capita (t/cap).

Recycling rate captures the proportion of discarded materials that are collected, processed, and reintroduced into productive use (Figure 15; Figure 16). A high recycling rate indicates a stronger ability of the economy to capture secondary resources, reducing demand for virgin inputs. For circularity, recycling is a key mechanism for extending material lifecycles and building domestic resource security, though it is only one element of the broader circular economy hierarchy, which prioritises reduction, reuse, and repair. In economic terms, recycling systems create local jobs, stimulate innovation in reprocessing industries, and provide a domestic supply of secondary raw materials.

At the same time, relying solely on recycling without reducing overall waste volumes risks "downstream fixes" rather than systemic change. From an environmental standpoint, higher recycling rates reduce the need for extraction, limit landfill use, and decrease associated emissions, though the quality and contamination of recycling streams remain critical determinants of environmental benefit.

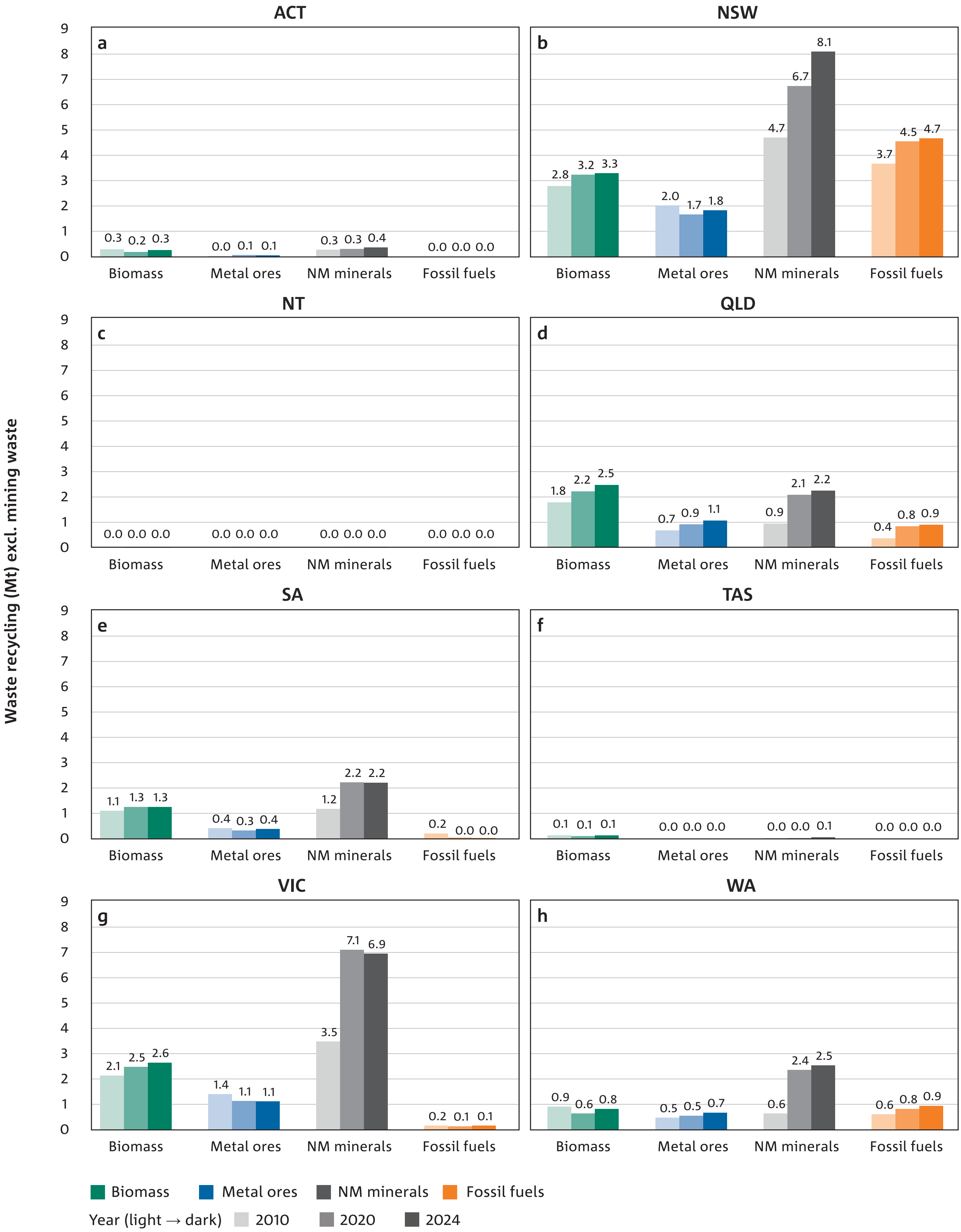


Figure 15. Recycling (secondary materials use) for Australia's states and territories, 2010, 2020, and 2024, absolute values. Unit: million metric tonnes (Mt).

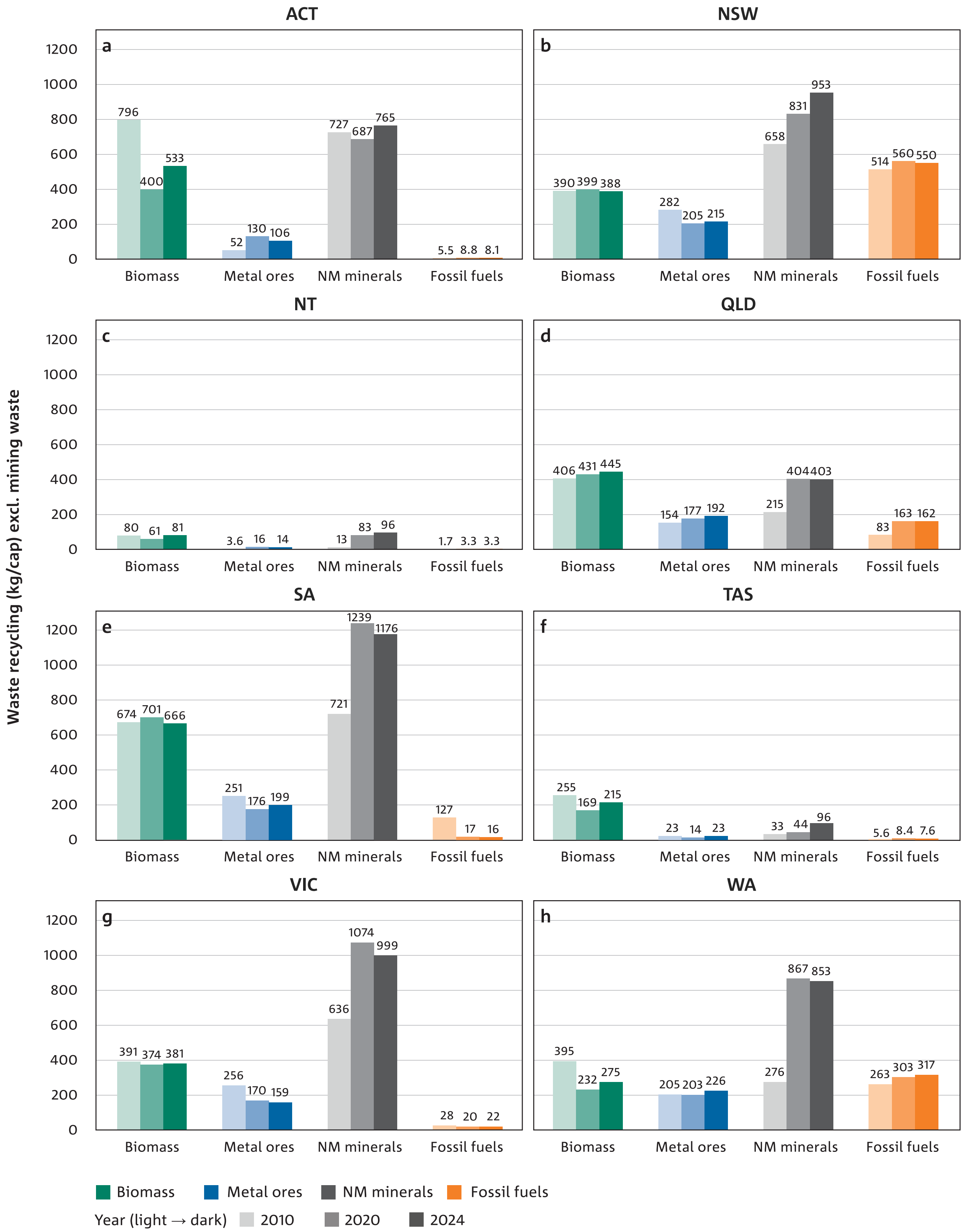


Figure 16. Recycling (secondary materials use) for Australia's states and territories, 2010, 2020, and 2024, per capita values. Unit: kilograms per capita (kg/cap).

Together, waste generation and recycling provide a practical measure of how far Australia's states and territories are advancing along the circular economy pathway. Jurisdictions with lower waste intensity and higher recycling rates demonstrate both stronger prevention strategies and more effective recovery systems. Conversely, high waste generation and low recycling rates point to systemic inefficiencies and missed opportunities to retain value.

As with material productivity, these indicators need careful interpretation. A rising recycling rate may indicate progress, but if total waste volumes are increasing at the same time, overall pressures on the environment remain unsustainable. Similarly, strong waste reduction achievements may be masked if materials are exported for processing overseas without clear accountability for environmental standards. For this reason, waste and recycling data must be viewed as part of a wider system of material flow and footprint indicators to provide a comprehensive assessment of circular economy performance.

5.1.1 Key features and trends

Australia's waste generation shows a clear dominance of non-metallic mineral waste, reflecting the material intensity of construction and demolition activities across all jurisdictions. In absolute terms, New South Wales, Victoria, and Queensland account for the largest volumes of waste generation, consistent with their population size, economic activity, and scale of built-environment turnover (Figure 13). Smaller jurisdictions such as the Australian Capital Territory, Tasmania, and the Northern Territory generate substantially lower absolute quantities, but display similar structural patterns in waste composition.

From 2010 to 2024, total waste generation increased in most jurisdictions, particularly for non-metallic mineral waste. This trend is most evident in New South Wales, Victoria, Queensland, and South Australia, where non-metallic mineral waste rose markedly between 2010 and 2020 and remained at elevated levels in 2024. These dynamics point to sustained construction activity and infrastructure investment, as well as limited material recovery at scale for mineral fractions.

Biomass waste represents the second-largest waste stream in most states and territories. Biomass waste levels increased moderately over time in New South Wales, Queensland, Victoria, and Western Australia, while remaining broadly stable in Tasmania and the Australian Capital Territory. These patterns reflect a combination of population growth, food system throughput, and land-use related waste streams, with limited evidence of absolute reductions over the period.

Fossil fuel – related waste shows a more heterogeneous pattern. In New South Wales and Victoria, fossil fuel waste declined between 2010 and 2024, suggesting structural change in energy systems and industrial processes. By contrast, Queensland and Western Australia show stable or slightly increasing fossil fuel waste generation, consistent with their continued role in energy and resource extraction. South Australia exhibits a marked decline after 2010, stabilising at a low level by 2024.

Metal ore waste remains comparatively small across all jurisdictions, both in absolute and per-capita terms, and shows limited variation over time. Note that these data do not include waste generated at the mining site and are limited to core waste, which is the sum of municipal, construction and demolition, and commercial and industrial waste. In other words, the bulk of mining-related waste is generated at extraction sites and is not fully captured in core waste statistics, underscoring the importance of upstream material footprint indicators for assessing resource intensity.

On a per capita basis, differences between jurisdictions narrow considerably, but important contrasts remain. Non-metallic mineral waste per capita is highest in states with high construction intensity relative to population, notably Western Australia, South Australia, and Victoria (Figure 14). Fossil fuel waste per capita remains elevated in Queensland and Western Australia, while New South Wales and Victoria show clear reductions over time. Biomass waste per capita is relatively stable across jurisdictions, indicating limited progress in absolute waste prevention despite policy efforts focused on recycling and diversion.

Overall, the waste data reinforce the findings from the material footprint analysis: Australia's material system remains dominated by stock-building and stock-turnover processes, with waste generation closely coupled to construction activity and infrastructure renewal. The persistence of high mineral waste volumes highlights the need to complement downstream waste management policies with upstream material-efficiency measures, particularly through recycling and material substitution strategies.

5.1.2 Policy relevant insights

The waste generation patterns clearly indicate that end-of-pipe waste policies alone will be insufficient to achieve material-efficiency and circular economy objectives. The dominance and continued growth of non-metallic mineral waste show that construction and demolition activities remain the primary driver of Australia's waste challenge. Policy efforts focused primarily on recycling and landfill diversion targets risk addressing symptoms rather than underlying structural drivers.

We identify a series of policy-relevant insights. First, the strong growth in non-metallic mineral waste points to the need for upstream intervention in the built environment. Priority policy levers include extending building lifetimes, incentivising adaptive reuse, standardising modular and design-for-disassembly approaches, and embedding material-efficiency criteria throughout all the stages of a construction project. Without such measures, recycling capacity will struggle to keep pace with rising volumes of mineral waste.

Second, the relative stability of biomass waste per capita across jurisdictions suggests limited progress in waste prevention in food and organic material systems. This result indicates that demand-side measures might be better suited for achieving desirable outcomes. These strategies include reducing food waste, improving supply-chain coordination, and incentivising the valorisation of unavoidable organic waste.

Third, the divergent trajectories of fossil-fuel-related waste across states reflect uneven progress in energy system transition. Jurisdictions with declining fossil fuel waste demonstrate that structural change in energy production and industrial processes can translate into measurable reductions. This reduction reinforces the importance of aligning waste policy with energy, climate, and industrial transition strategies, particularly in resource-intensive states.

Fourth, the omission of mining waste in end-use waste accounts underscores a critical policy blind spot. Many of the environmental impacts associated with metal extraction occur upstream and are not reported in core waste statistics. This omission strengthens the case for complementing waste indicators with material footprint and stock-based metrics to inform policy, especially for export-oriented resource sectors.

Finally, the convergence of per-capita waste levels across jurisdictions suggests that structural factors dominate over individual behaviour in shaping waste outcomes. This convergence implies that policy effectiveness will depend less on consumer-focused interventions and more on systemic measures targeting production systems, infrastructure investment, and material stocks.

Taken together, the waste analysis reinforces a central conclusion: reducing waste at scale requires shifting policy emphasis upstream, toward material efficiency, stock management, and circular design across key provision systems – particularly housing, infrastructure, and energy – rather than relying predominantly on improvements in waste treatment and recycling performance.

5.2 GHG emissions

Greenhouse gas emissions, which include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (F-gases), are a central indicator of the sustainability of economic development and the pace of the low-carbon transition. They capture the cumulative climate impacts of energy use, industrial production, land use, and consumption patterns, while also reflecting the effectiveness of policy interventions and technological change. Analysing both absolute and per capita emission trends is essential for distinguishing between scale effects driven by economic and population growth and genuine reductions in carbon intensity. This section examines recent developments in greenhouse gas emissions, highlighting key patterns across jurisdictions and drawing out their implications for climate mitigation and long-term transition pathways. To remain consistent with material flow analysis standards (Eurostat, 2018; UNEP, 2023b; United Nations et al., 2014), greenhouse gases are presented in actual tonnes of emissions rather than carbon dioxide equivalents of global warming potentials.

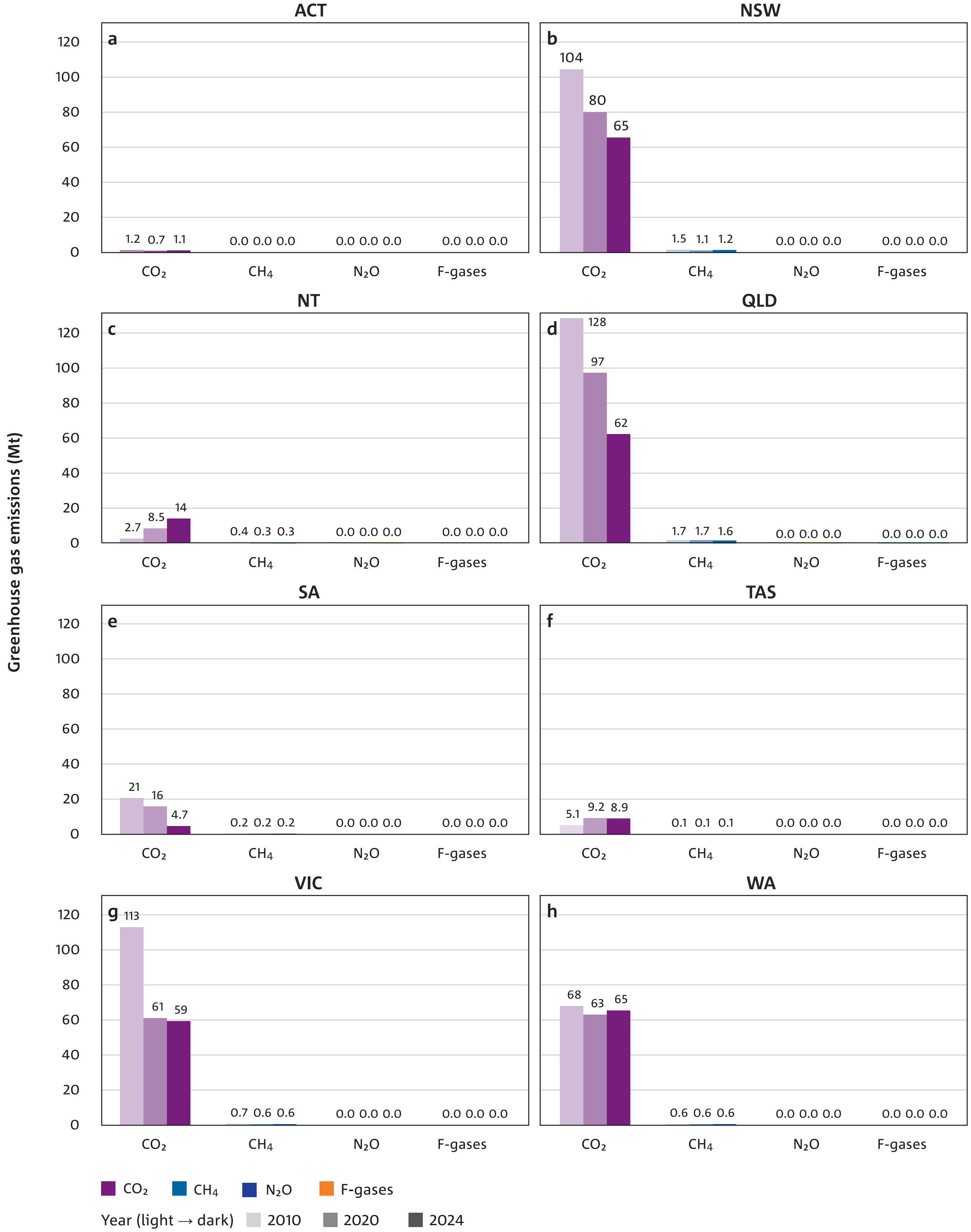


Figure 17. Greenhouse gas emissions for Australia's states and territories, 2010, 2020, and 2024, absolute values. Unit: million metric tonnes (Mt).

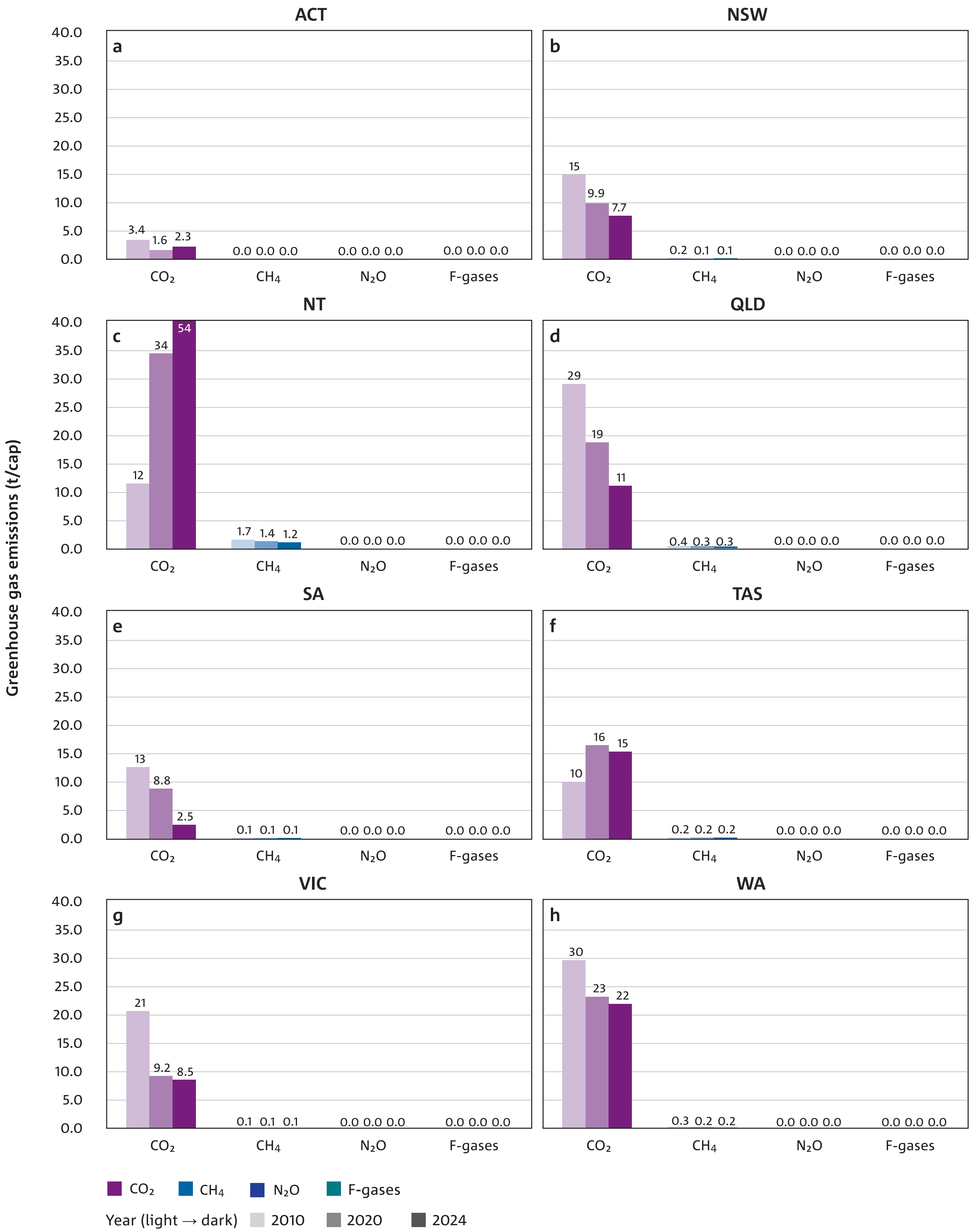


Figure 18. Greenhouse gas emissions for Australia's states and territories, 2010, 2020, and 2024, per capita values. Unit: metric tonnes per capita (t/cap).

5.2.1 Key features and trends

Across Australia's states and territories, total greenhouse gas (GHG) emissions are overwhelmingly dominated by CO_2, with CH_4 playing a secondary but non-negligible role and N_2O and F-gases remaining marginal throughout the period. Between 2010 and 2024, most jurisdictions exhibit a clear decline in absolute CO_2 emissions, although the timing and magnitude differ substantially (Figure 17). The largest absolute reductions are observed in traditionally high-emitting states – Queensland, Victoria, and New South Wales – reflecting structural changes in electricity generation, industrial activity, transport modes, and energy efficiency. In contrast, the Northern Territory stands out for a strong increase in absolute CO_2 emissions over the period, more than quintupling from 2010 to 2024.

Queensland and Victoria were the largest absolute emitters in 2010, but by 2024, both states show pronounced downward trends in CO_2 emissions, converging to around 60-65 million metric tonnes, which is on par with the emissions of New South Wales and Western Australia. South Australia shows the most dramatic relative reduction, with CO_2 emissions in 2024 less than one quarter of their 2010 level, consistent with its early and sustained shift towards renewable electricity. Tasmania presents a contrasting pattern: an increase between 2010 and 2020, followed by only a slight reduction by 2024, resulting in higher emissions than at the start of the period. Western Australia displays relative stability in absolute emissions, with modest fluctuations rather than a clear downward trend. The Australian Capital Territory has low absolute emissions overall but shows a partial rebound in CO_2 emissions between 2020 and 2024.

Methane emissions decline modestly in most states, though trends are less uniform than for CO_2. Queensland and New South Wales continue to exhibit relatively high CH_4 emissions, reflecting the importance of agriculture and resource extraction. In several jurisdictions (e.g., South Australia, Tasmania), CH_4 emissions remain broadly stable or increase slightly by 2024, indicating limited progress in these sectors. N_2O emissions are consistently low and largely stable across all states, while F-gases remain negligible in both absolute and per-capita terms.

Per capita CO_2 emissions fall markedly in the most populous states, reinforcing the picture of structural decarbonisation alongside population growth. Victoria, New South Wales, Queensland, and South Australia all show substantial reductions in per capita CO_2 between 2010 and 2024 (Figure 18). By contrast, the Northern Territory exhibits a sharp increase in per capita CO_2 emissions, rising from an already high level in 2010 to the highest nationally in 2024. Western Australia continues to have persistently high per capita emissions despite modest absolute reductions, whereas Tasmania's per capita emissions increased between 2010 and 2020 and have remained elevated since then. Per capita CH_4 emissions are low across all states but remain higher in the Northern Territory and Queensland.

5.2.2 Policy relevant insights

The data indicate that Australia's emissions-reduction trajectory is driven primarily by a subset of states, most notably South Australia, Victoria, New South Wales, and Queensland, where electricity-sector transformation and industrial change have delivered substantial CO_2 reductions. However, the persistence of high or rising emissions in the Northern Territory and the relative stagnation in Western Australia highlight the limits of a uniform national narrative and point to the need for differentiated, regionally tailored mitigation strategies.

Per capita emissions unearth structural dependencies that are masked in absolute terms. The very high and rising per capita emissions in the Northern Territory, and the persistently high levels in Western Australia and Queensland, reflect resource-intensive production systems, export-oriented industries, and dispersed settlement patterns. From a policy perspective, these results suggest that deep structural interventions, including industrial transformation, demand reduction, and alternative development pathways, are required to tackle this problem at its roots.

While CO_2 reductions dominate overall progress, relatively modest changes in CH_4 emissions suggest untapped mitigation potential, particularly in agriculture and fugitive emissions from extractive activities and waste. Given methane's considerable short-term global warming potential, targeted CH_4 policies could deliver near-term climate benefits, especially in Queensland, New South Wales, and the Northern Territory.

South Australia and the Australian Capital Territory demonstrate that smaller jurisdictions can achieve rapid per capita and absolute reductions through coherent policy frameworks, renewable energy deployment, and demand-side measures. Although their contribution to national totals is limited, these cases provide important policy test beds for accelerated decarbonisation pathways.

The divergence in trends suggests that national climate policy ought to balance consistency with flexibility. Strong national targets and market frameworks are necessary to sustain overall emissions reductions, but complementary state- and territory-specific instruments are essential to address local structural conditions, particularly in high-per-capita and resource-dependent regions.

5.3 Pollution

Air pollution remains a critical interface between environmental sustainability, public health, and economic activity. Key air pollutants we cover are particulate matter (PM2.5 and PM10), nitrogen oxides (NO_X), sulphur dioxide (SO_2), and carbon monoxide (CO). Consistent with what we did in Section 5.2 for greenhouse gases and with international standards, pollutants are reported in their actual mass. Air pollution reflects both the scale of material and energy use in the economy and the practices that organise production and consumption. Examining pollution trends alongside population change provides insight into whether observed improvements stem from genuine structural transformation or from relative effects such as efficiency gains and demographic growth. This section analyses recent developments in key air pollutants across Australian states and territories, distinguishing between absolute emission levels and per capita outcomes to identify progress, persistent pressures, and implications for policy design.

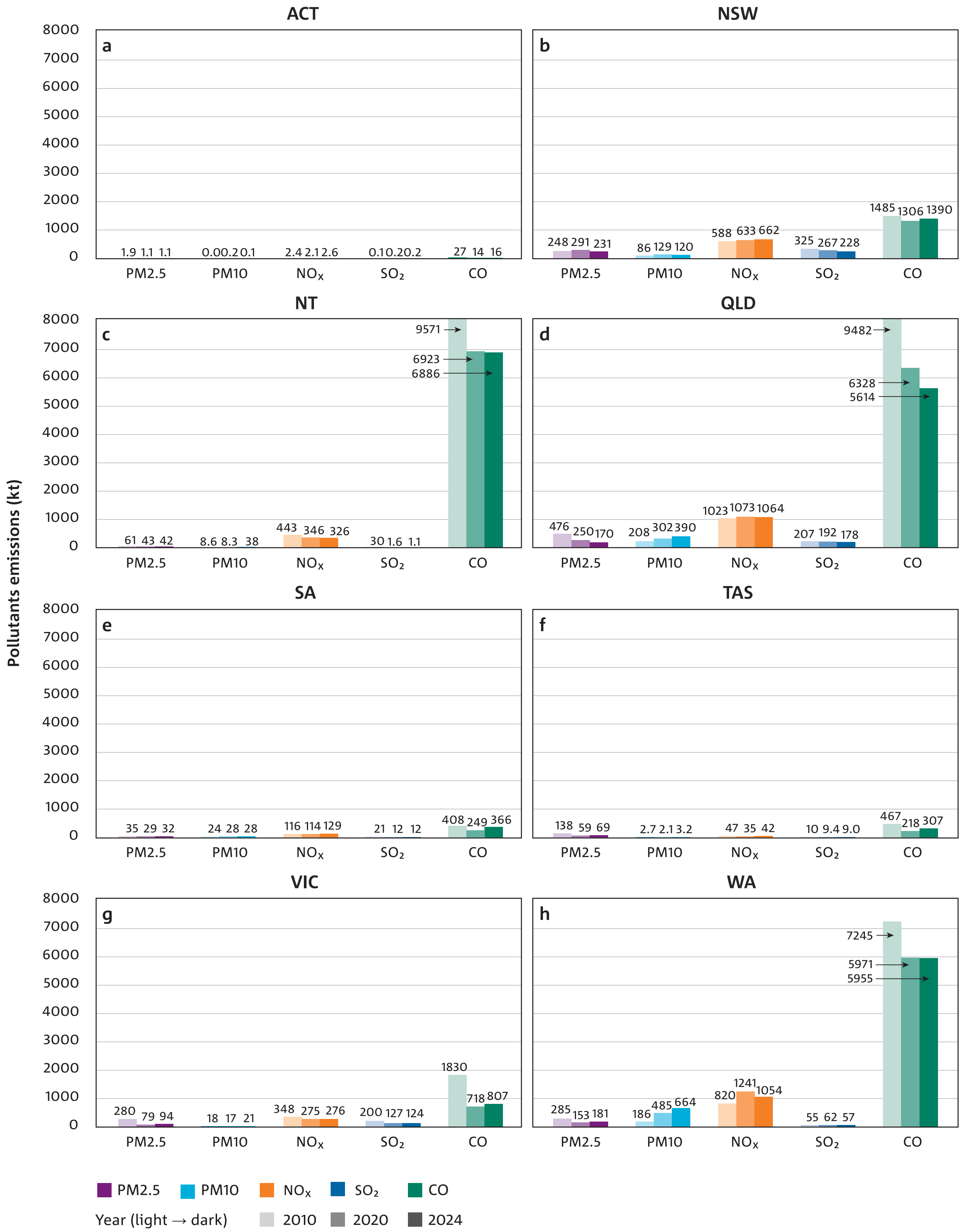


Figure 19. Pollutants for Australia's states and territories, 2010, 2020, and 2024, absolute values. Unit: thousand metric tonnes (kt).

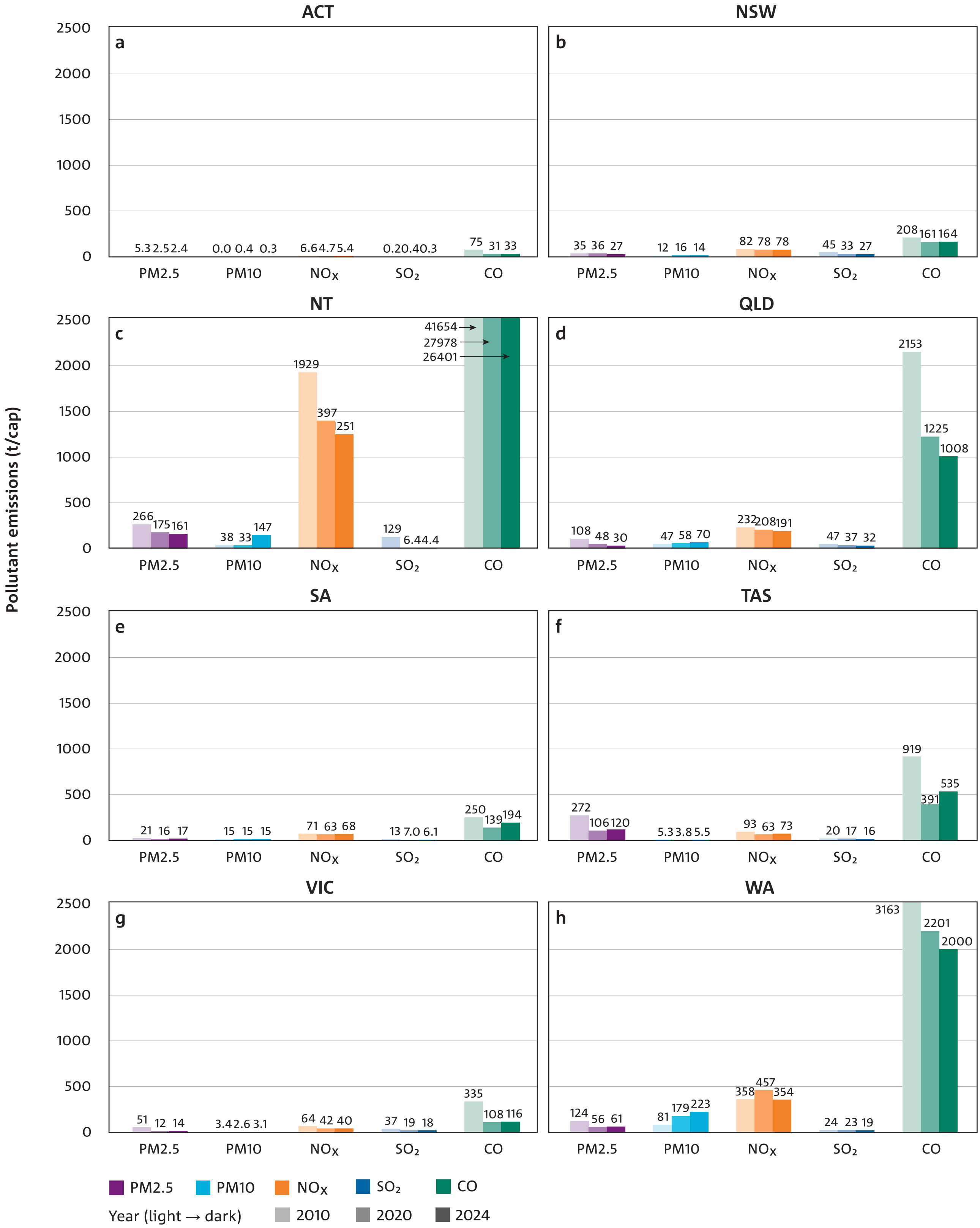


Figure 20. Pollutants for Australia's states and territories, 2010, 2020, and 2024, per capita values. Unit: metric tonnes per capita (t/cap).

5.3.1 Key features and trends

Across Australian states and territories, 2010–2024 is characterised by substantial reductions in most air pollutants, albeit with notable heterogeneity across pollutant types and jurisdictions (Figure 19).

Absolute PM2.5 emissions decline markedly in most states between 2010 and 2024, with particularly large reductions observed in Queensland, Victoria, Tasmania, and Western Australia. New South Wales shows a peak around 2020 followed by a clear decline by 2024, while South Australia and the Australian Capital Territory exhibit relatively stable but low absolute levels. PM10 displays a more mixed pattern: while several jurisdictions record reductions or stabilisation, PM10 emissions increase strongly in Queensland, Western Australia, and the Northern Territory, suggesting growing contributions from dust-intensive activities, land-use change, or resource extraction.

NO_X emissions remain comparatively high in absolute terms and show less consistent improvement. Several states (New South Wales, Queensland, Western Australia) experienced increases between 2010 and 2020, followed by partial stabilisation or modest declines by 2024. Victoria and the Northern Territory show clearer downward trends. Overall, NO_X reductions lag those observed for particulate matter, indicating slower structural change in combustion-related activities, particularly transport and heavy industry.

SO_2 emissions decline strongly across nearly all jurisdictions over the period, with especially sharp reductions in the Northern Territory, New South Wales, Victoria, and South Australia. This pattern is consistent with improvements in fuel quality, tighter emission standards, and structural changes in electricity generation and heavy industry.

CO emissions declined substantially across all states between 2010 and 2020, with partial rebounds or stabilisation by 2024 in several jurisdictions (e.g., New South Wales, South Australia, Tasmania, Victoria). Despite these rebounds, 2024 levels remain well below 2010 values in all cases, indicating long-term improvements in combustion efficiency and vehicle emission controls.

Overall, in absolute terms, air pollution pressures have declined significantly since 2010, but progress is uneven across pollutants, with PM10 and NO_X emerging as areas of relative persistence or reversal in some regions.

Normalising emissions by population reveals stronger, more systematic improvements, while also highlighting distributional and structural differences across jurisdictions (Figure 20).

Per capita PM2.5 emissions fall sharply across all states and territories between 2010 and 2024, often by more than half. Large reductions are evident in Queensland, Tasmania, Victoria, and Western Australia. Nevertheless, per capita PM2.5 remains comparatively high in sparsely populated jurisdictions (the Northern Territory, Tasmania, and Western Australia), reflecting the dominance of resource-based activities relative to population size. PM10 per capita declines or stabilises in most states, but by 2024 increases markedly in the Northern Territory and Western Australia, reinforcing concerns about dust-related emissions in low-density, resource-intensive regions.

Per capita NO_X emissions decline in most jurisdictions over the full period, even where absolute emissions remain stable or increase. This reduction indicates a degree of relative decoupling between population growth and NO_X emissions, particularly in New South Wales, Queensland, and Victoria. However, per capita NO_X levels remain very high in the Northern Territory and Western Australia, stressing the outsized role of mining, energy production, and long-distance transport.

SO_2 per capita shows consistent and often dramatic declines across all jurisdictions, converging toward relatively low levels by 2024. This convergence represents one of the clearest success stories in the dataset, both in absolute and population-normalised terms.

CO per capita emissions decline strongly everywhere between 2010 and 2020, with modest rebounds in some states by 2024. Despite this, per capita CO emissions in 2024 are substantially below 2010 levels, indicating sustained improvements in vehicle fleets and combustion technologies. As with other pollutants, per capita CO remains orders of magnitude higher in the Northern Territory and Western Australia than in the eastern states.

In summary, per capita indicators show broad-based improvements and partial convergence but also reveal persistent structural asymmetries between populous urbanised states and resource-intensive, low-population jurisdictions.

5.3.2 Policy-relevant insights

Based on the analysis of pollutant emissions in Australia from 2010–2024, we draw five insights. First, the data indicate that Australia has achieved substantial reductions in air pollution over the past decade, particularly for SO_2, CO, and PM2.5. These gains are visible in both absolute and per capita terms. While regulatory standards, fuel quality improvements, and technology upgrades likely played an important role, other factors, such as structural economic change and shifts in activity levels, may also have contributed.

Second, the divergence between absolute and per capita trends, especially for NO_X and PM10, highlights the importance of structural drivers. Population growth masks progress in some states, while resource-intensive production leads to high per capita emissions in others. As such, one can assert that national averages can obscure region-specific challenges and that policy design must remain spatially differentiated.

Third, the persistence or growth of PM10 and NO_X in several jurisdictions points to the limits of end-of-pipe and efficiency-focused approaches. These pollutants are closely tied to freight transport, mining, land disturbance, and energy systems, suggesting that further reductions will require systemic interventions such as shifts in transport, energy generation, industrial structure, and land-use management, rather than incremental emission controls alone.

Fourth, the strong performance on SO_2 demonstrates the value of clear regulatory targets combined with structural energy transitions. Similar clarity and ambition may be required for NO_X and particulate emissions if co-benefits for health, climate mitigation, and ecosystem protection are to be realised.

Finally, the stark per capita disparities between states open the door to an equity-relevant conversation about air pollution policy. Jurisdictions with small populations but high per capita emissions play a disproportionate role in national pollution profiles. This fact raises questions about the allocation of mitigation responsibility and strengthens the case for integrating air pollution control with circular economy, industrial-transformation, and regional-development strategies, rather than treating pollution solely as an environmental externality.

5.4 Seeds and fertilisers

Seeds and fertilisers, in an economy-wide framework, are considered outflows from the socio-economic system to the environment that are intentionally returned to nature to sustain agricultural production. Unlike waste or emissions, these flows are applied productively, yet they still represent a considerable flow that affects biomass production and its related environmental pressures. Reporting the tonnage of seeds and fertilisers used each year helps to show the scale of material inputs required to maintain Australia's agricultural system and the extent to which food and fibre production depends on managed flows.

This section includes seeds used for agricultural activities, synthetic fertilisers, and manure, with the latter expressed in dry weight. From a circular economy perspective, seeds and fertilisers are relevant because they reveal how agricultural production is supported, whether through recirculated biomass, such as manure, or through manufactured inputs, such as mineral and synthetic fertilisers. Their use therefore provides insight into the balance between regenerative nutrient cycling and dependence on externally supplied materials.

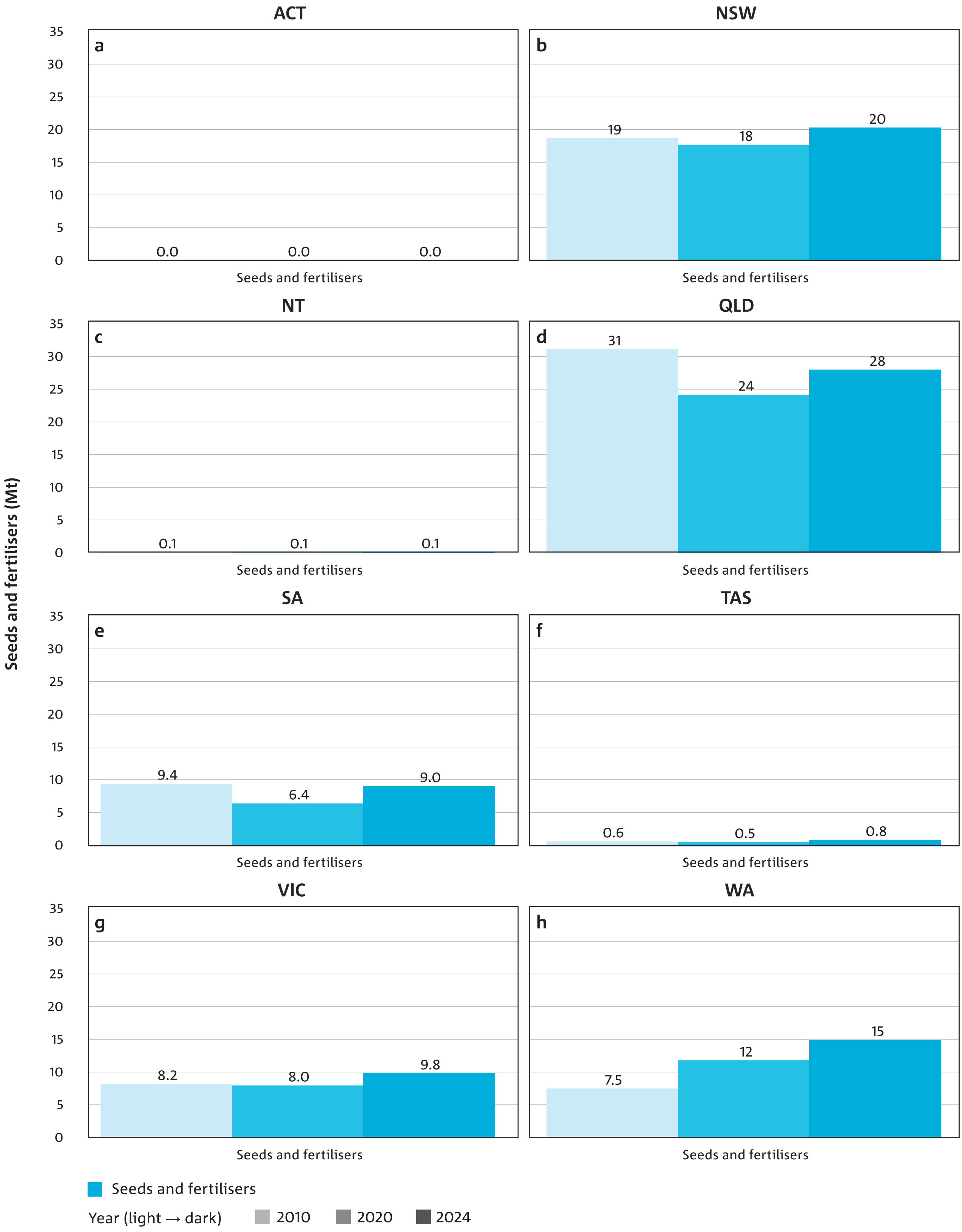


Figure 21. Seeds and fertilisers used in Australia's states and territories, 2010, 2020, and 2024, absolute values. Unit: million metric tonnes (Mt).

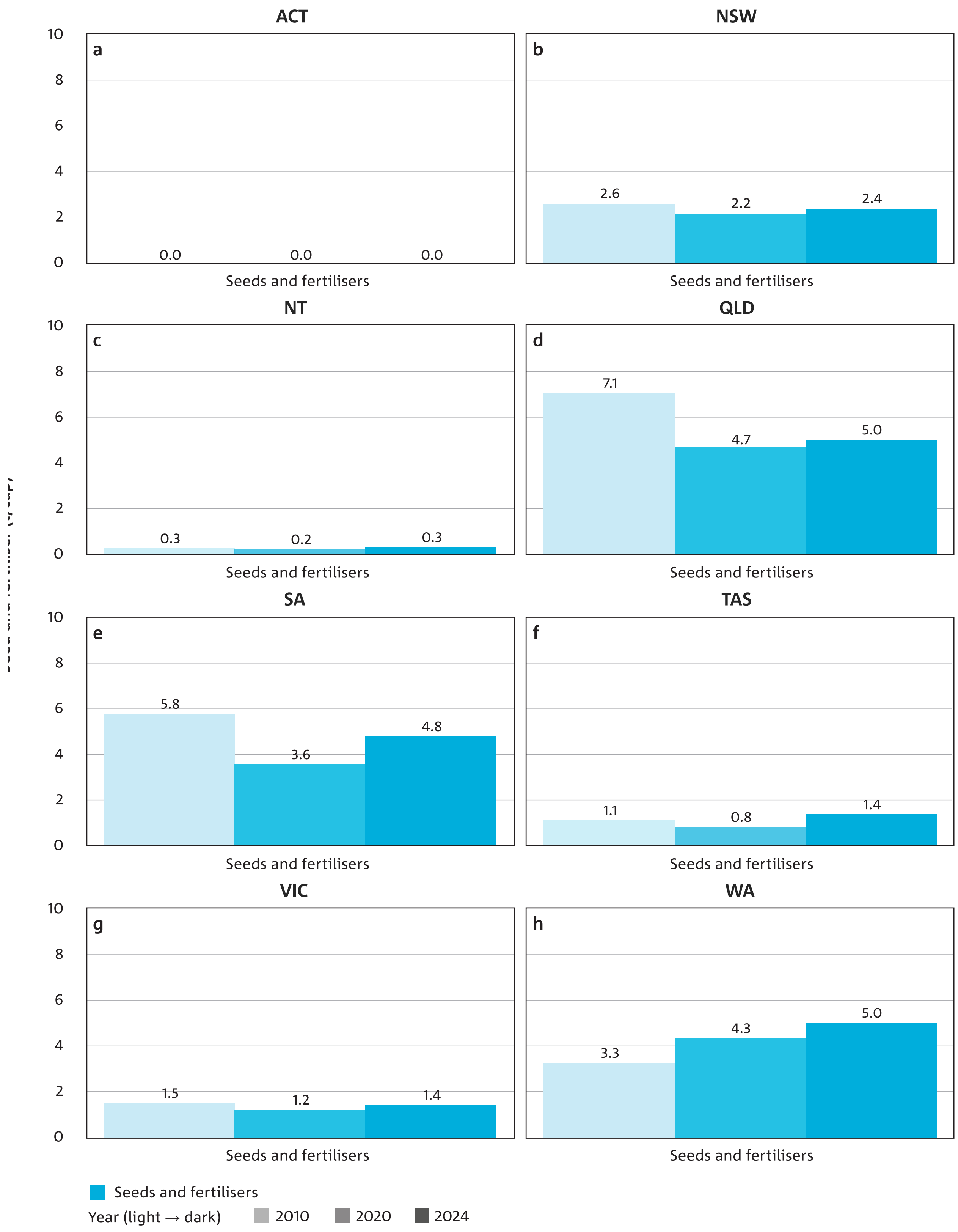


Figure 22. Seeds and fertilisers used in Australia's states and territories, 2010, 2020, and 2024, per capita values. Unit: metric tonnes per capita (t/cap).

5.4.1 Key features and trends

Australia's seed and fertiliser use is predominantly in States with heavy agricultural activity, such as New South Wales and Queensland (Figure 20). In 2010, the three major users of seeds and fertilisers were Queensland (31 Mt), New South Wales (19 Mt), and South Australia (9 Mt). By 2024, Queensland remained the dominant "emitter" in this category, but its total output decreased to 28 Mt (-10%). New South Wales retained second place, with its use increasing moderately to 20 Mt (+9%). South Australia was no longer the third-largest user of seeds and fertilisers, as its use remained practically unchanged at 9 Mt, whereas Western Australia recorded about 15 Mt of these materials released into the environment, marking a 100% increase over the period of this analysis. Victoria's use is very comparable to that of South Australia for the whole 2010–2024 period.

The Australian Capital Territory makes virtually no use of seeds and fertilisers because of its extremely limited agricultural activities. The Northern Territory's use was below 0.1 Mt, while Tasmania recorded around 0.6 Mt. It is also worth noting that the 2024 data indicated a 39% increase over its 2010 usage.

In per capita terms, things look somewhat different (Figure 21). In 2010, Queensland was the State with the highest per capita use of seeds and fertilisers, at 7.1 t cap^{-1}. However, by 2024, its use had markedly decreased to 5.0 t cap^{-1} (-29%). In the meantime, Western Australia also recorded 5.0 t cap^{-1} in 2024, but in this case, it arrived at this result after a sharp increase in use (+54%). South Australia also reports similar per capita use in 2024, at 4.8 t cap^{-1}. New South Wales fluctuated around 2.4 t cap^{-1} for the whole period, while Victoria (1.4 t cap^{-1}), Tasmania (1.1 t cap^{-1}) and the Northern Territory (0.3 t cap^{-1}) show much more moderate amounts. The Australian Capital Territory, as was the case for the absolute values, reports nearly nil use of seeds and fertilisers.

5.4.2 Policy-relevant insights

Seed use reflects the scale and structure of agricultural activity. Growing seed use may indicate expansion in cropping establishment, but at the same time, it can also be a sign of lower germination rates. For circularity, seed flows matter not only in quantitative terms but also in relation to resilience and, to an extent, resource efficiency: varieties that resist droughts or pests can support productivity while reducing losses. Economically, seeds are a critical input cost and a foundation of agricultural output.

From an environmental viewpoint, seed use is not directly linked to pollution. Rather, their role indicates broader patterns of land use, biodiversity impacts, and the level of dependency on primary inputs of the farming system.

Fertiliser use captures the mass returned to soils to sustain biomass growth and compensate for nutrient removal through harvest. This category includes both synthetic fertilisers and manure, the latter representing a form of secondary material flow within the bioeconomy that, by definition, is not captured in the circularity rate. Fertiliser supports agricultural productivity, but high use may correlate with farming systems that are substantially dependent on external nutrient inputs or that tend to exceed the soil's natural regenerative capacity. In circular economy terms, the distinction between synthetic fertilisers and manure is important: manure can contribute to closing nutrient loops, whereas synthetic fertilisers generally depend on energy-intensive industrial production and imported mineral resources. From an economic perspective, fertilisers are among the major production costs for biomass. From an environmental perspective, excessive or poorly managed fertiliser application can lead to nutrient runoff, eutrophication of waterways, soil acidification, and air emissions, including ammonia and nitrous oxide (Luna Juncal et al., 2023; Pan et al., 2022).

Taken together, seeds and fertilisers provide a useful measurement of the major inputs into agricultural production. Jurisdictions with large agricultural sectors will naturally record higher use, so these indicators should not be interpreted simply as measures of poor performance. Rather, they need to be read in the context of land use, agricultural specialisation, climatic conditions, and crop yield. Higher use may reflect the scale of agricultural activity, but it may also reveal areas with the largest opportunities to improve input efficiency. Therefore, as with the other indicators in this report, careful interpretation is required. Rising fertiliser use may signal intensification and higher output, but it can also signal growing environmental risks if nutrient surpluses are poorly managed. For this reason, seeds and fertilisers should be considered alongside broader indicators of biomass production, pollution, greenhouse gas emissions, land management, and land-use change in order to provide a fuller picture of circular economy performance in agriculture.

6 Material balance

A comprehensive view of material use requires bringing together inflows, outflows, and material accumulation within the economy. The material balance provides this system-wide perspective (Figure 23). It shows how domestic extraction and imports supply materials to the economy, how exports and waste streams represent outputs, and how the remainder accumulates as stock in buildings, infrastructure, machinery, and durable goods.

At its core, the material balance ensures consistency between the different flow-based indicators presented in earlier sections. It relies on the principle of mass balance: every tonne of material entering the economy must either leave as an output or accumulate as stock. This accounting framework is essential for identifying inefficiencies and clarifying where materials ultimately reside in the socio-economic system.

From a circular economy lens, the material balance is particularly important because it reveals the dynamics between stocks and flows. Australia's high levels of material accumulation in construction and infrastructure mean that large reservoirs of resources are locked in long-lived assets. While these stocks currently require significant input flows to operate and maintain, they also offer potential for secondary resource recovery once buildings and infrastructure reach the end of their lifespans. Understanding the material balance, therefore, allows policymakers to plan for long-term urban mining strategies and anticipate future recycling potentials.

From an economic policy standpoint, the materials balance sheet highlights trade-offs between short-term growth and long-term sustainability. States with rapid infrastructure expansion, such as Queensland and Western

Australia, exhibit high levels of accumulation, which may boost current economic activity but also increase future waste management challenges. More service-oriented States, such as Victoria and New South Wales, may show slower accumulation but higher dependence on imported materials. Policymakers can use material balance data to design strategies that optimise material inflows, reducing unnecessary stock build-up while improving the efficiency of asset use.

Environmentally, the material balance underscores the full life cycle implications of resource use. Material inflows generate extraction and production pressures, while outflows contribute to waste and emissions. Accumulated stocks, though less visible, represent embodied environmental impacts and future liabilities when they are eventually dismantled. By making these flows and stocks explicit, the material balance supports more informed decisions on land use, resource planning, and waste management.

In summary, the material balance integrates extraction, trade, consumption, waste, and stock dynamics into a single coherent framework. It provides the essential link between annual flow indicators and the longer-term evolution of material stocks, enabling Australia's states and territories to track not only how resources are used today but also how they shape the material foundations of tomorrow's economy.

Australia, 2024

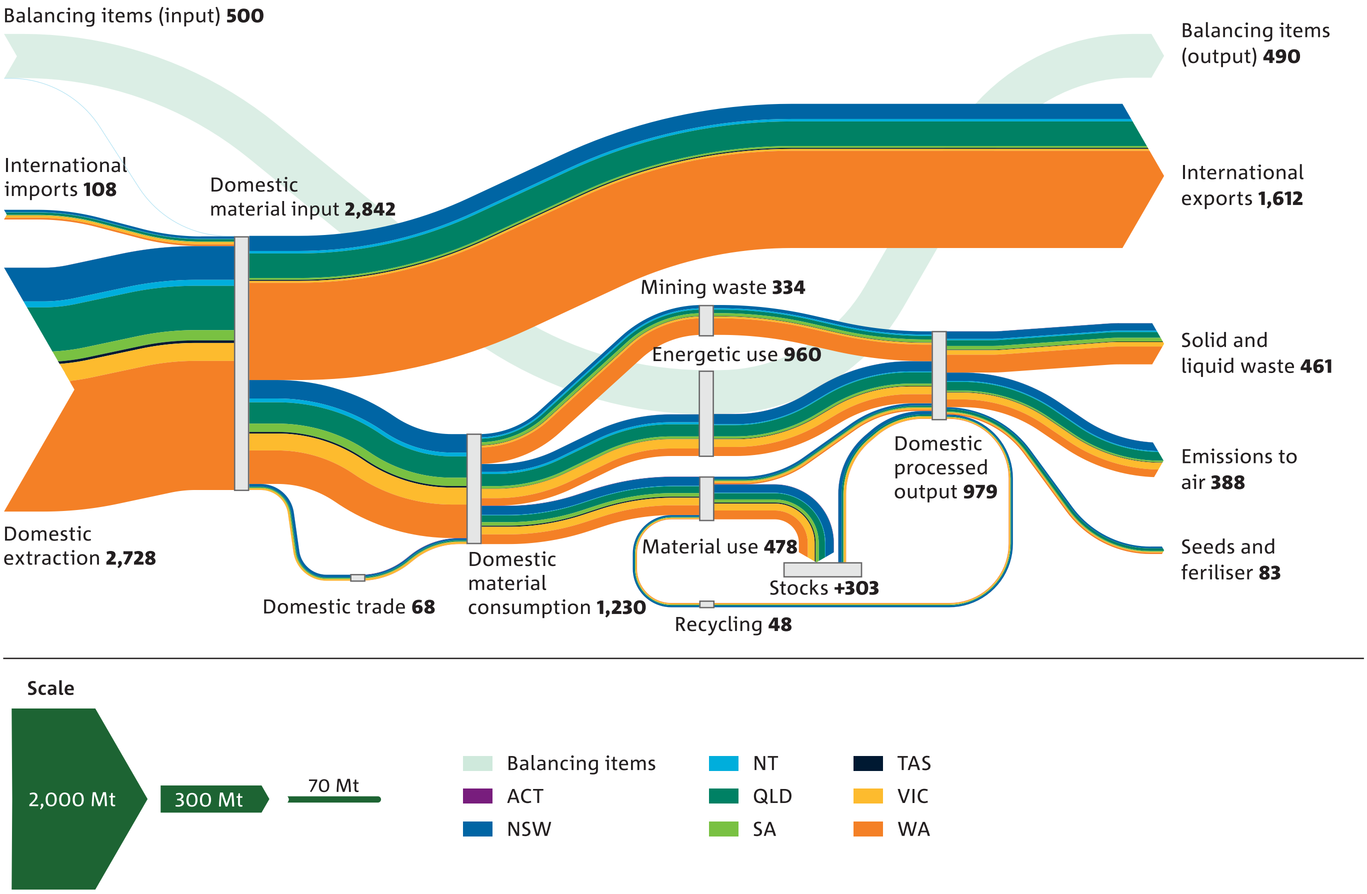


Figure 23. Material flows in Australia in 2024, coloured by State and Territory. Unit: million metric tonnes (Mt). Note that a breakdown of these flows by State and Territory is present in the annex of this report.

7 Resource efficiency

Beyond tracking the scale of material flows, it is equally important to understand how effectively resources are converted into economic value. Material productivity provides this lens by relating economic output to material input, most commonly expressed as gross domestic product (GDP) per unit of domestic material consumption (DMC). In this case, because we focus on states and territories rather than an entire country, we measure resource efficiency as the gross state product (GSP) per unit of DMC. In essence, resource efficiency answers the question: *how much economic value does each tonne of material consumed generate?*

As an indicator, material productivity sits at the heart of circular economy measurement. Higher values indicate that an economy is using resources more efficiently, extracting greater economic benefit with fewer material inputs. Conversely, low material productivity signals a reliance on material-intensive growth, where economic expansion is closely tied to rising material use.

From a circularity perspective, improving material productivity reflects the decoupling of prosperity from resource throughput. It demonstrates that economies can sustain or grow wellbeing while reducing their material footprint, a central ambition of circular strategies. For example, designing products that last longer, using recycled inputs, or shifting towards service-based business models can all increase productivity while lowering material input requirements relative to output.

In economic policy, material productivity serves as both a performance benchmark and a guide for industrial transformation. Jurisdictions with high productivity often have diversified economies, skilled labourers, and strong service sectors. By contrast, States heavily reliant on resource extraction may exhibit lower productivity, suggesting opportunities for diversification, value addition, and innovation in resource efficiency. Tracking productivity over time also helps policymakers assess whether investments in circular business models are translating into measurable gains.

The environmental outcomes of higher material productivity are profound. By achieving more economic output per tonne of resource, pressures on ecosystems can be reduced even as economies grow. However, material productivity must be interpreted carefully: increases may

sometimes reflect economic structural change rather than absolute reductions in resource use. For example, growth in high-value service industries can boost productivity metrics even if total material use remains high. This caveat underscores the need to view productivity alongside absolute indicators like DMC and the material footprint.

Ultimately, material productivity provides a crucial bridge between economic and environmental policy goals. It integrates the efficiency imperative of circularity with the competitiveness agenda of economic policy, while signalling progress towards the broader objective of sustainable prosperity within planetary boundaries.

7.1 Key features and trends

Material productivity in the Australian Capital Territory is significantly higher than in any other jurisdiction, at $13.98/kg in 2024, due to the Australian Capital Territory's service-based economy and minimal primary sector activity. Outside the urban enclave of the Australian Capital Territory, material productivity is highest in New South Wales and Victoria, the states with more diverse economies and developed service sectors, and lowest in the Northern Territory and Western Australia, due primarily to the low utilisation of mining waste for economic activities.

Overall material productivity increased nationally from $1.68/kg in 2010 to $2.05/kg in 2024, indicating sustained efficiency gains in resource use and a decoupling of material consumption from GDP. Productivity increases between 2010 and 2024 were most pronounced in the Australian Capital Territory (+$2.72/kg) and New South Wales (+$1.00/kg), followed by Victoria (+$0.71/kg), Queensland (+$0.52/kg), Tasmania (+$0.42/kg), and South Australia (+$0.20/kg). Material productivity in Western Australia and the Northern Territory peaked in 2014 and 2017, respectively, before returning to 2010 levels, a trend primarily driven by the expansion of the mining industry in both jurisdictions, which is associated with low levels of material productivity.

7.2 Policy relevant insights

Material productivity gains across most jurisdictions show that current policy, coupled with industry-wide efficiency gains, has increased material productivity. Material productivity is highly dependent on the economic structure, and states with significant primary sectors, such as Western Australia, will be unable to reach the same levels of productivity as a service-based jurisdiction such as the Australian Capital Territory. However, the low levels of material productivity in Western Australia and the Northern Territory suggest significant economic opportunities to use resources more effectively through value-adding endeavours, such as increasing manufacturing and remanufacturing capabilities. Significant opportunities exist in other states to increase material productivity by pursuing industrial symbiosis, renewable-fuel substitution, construction-material recovery, and regional bio-processing.

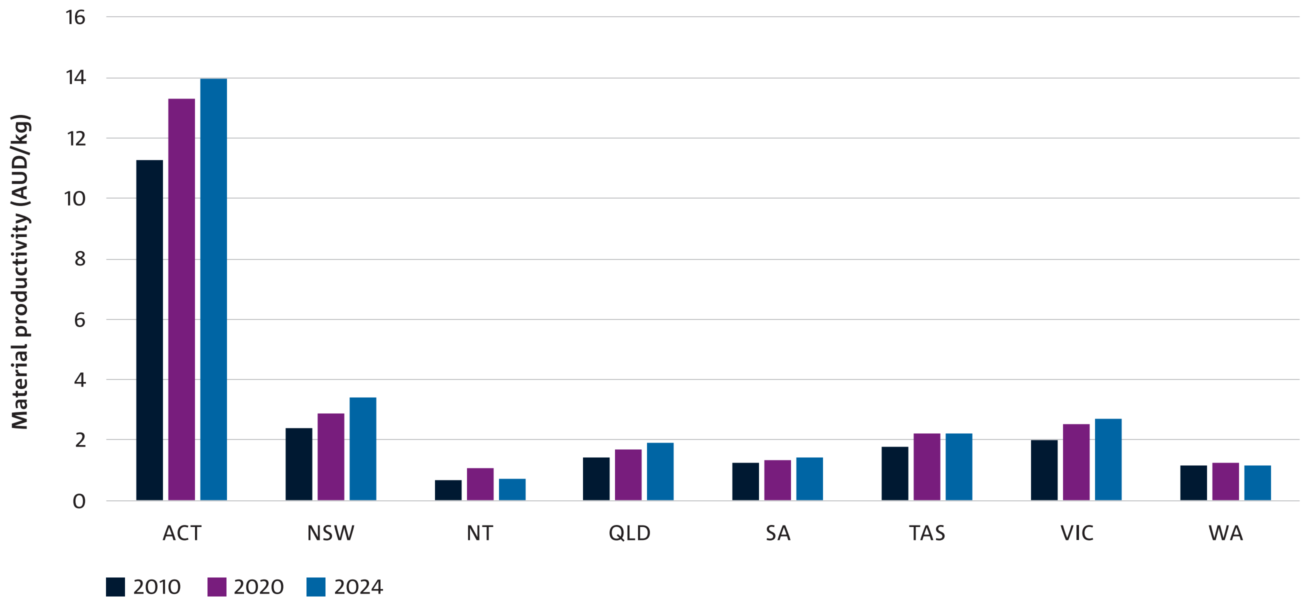


Figure 24. Material productivity for Australia's states and territories, 2010, 2020, and 2024. Unit: AUD per kilogram of materials used (AUD/kg).

8 Circularity rate

The circularity rate is a synthetic indicator that captures the share of secondary (i.e., recycled) materials in total material use. It is calculated as the ratio of recycled inputs re-entering the economy to the economy's overall material use. In simple terms, it measures how much of the material base is derived from recycled resources rather than from newly extracted raw materials.

From a circular economy perspective, the circularity rate is the most direct marker of progress, albeit one could argue that other metrics are equally important. A higher rate indicates that a greater proportion of material demand is met by circulating resources already in the system, reducing the need for virgin extraction and lowering environmental pressures. It also reflects the maturity of waste management systems and the ability of industries to close material loops.

For economic policy, the circularity rate functions as both a benchmark and a strategic target. It provides a headline figure that governments can use to communicate progress, set ambitions, and compare performance. States and territories with high circularity rates often have strong recycling infrastructures, well-developed secondary markets, supportive policy frameworks, and a strong tertiary sector. Conversely, those with lower rates may face challenges in collection systems, low demand for secondary resources, or be dependent on industrial structures that limit opportunities for circular use. Improving the circularity rate is not only about waste management but predominantly about industrial transformation, policy, product design, and consumer practices (Miatto et al., 2025).

The environmental outcomes of higher circularity rates are significant. Greater reliance on secondary resources reduces extractive pressures on natural ecosystems, lowers greenhouse gas emissions associated with extraction, diminishes waste volumes requiring final disposal, and may create local jobs related to remanufacturing activities. However, interpretation must be cautious: the circularity rate is sensitive to the overall size of material flows. If total material use continues to grow, even a rising circularity rate may not lead to absolute reductions in resource use or environmental impacts. Furthermore, to calculate the metrics presented herein, we made two assumptions due to limited data availability. First, the global circularity rate was used to estimate recycled content in imports from overseas; second, exports were assumed to contain negligible recycled material due to the dominance of raw materials such as metal ores and coal in exports.

As a unifying measure, the circularity rate integrates many of the dimensions explored in previous sections (i.e., extraction, consumption, waste, recycling, and productivity) into a single metric. It thus provides a concise yet powerful way to assess the extent to which Australia's states and territories are moving towards a truly circular economy.

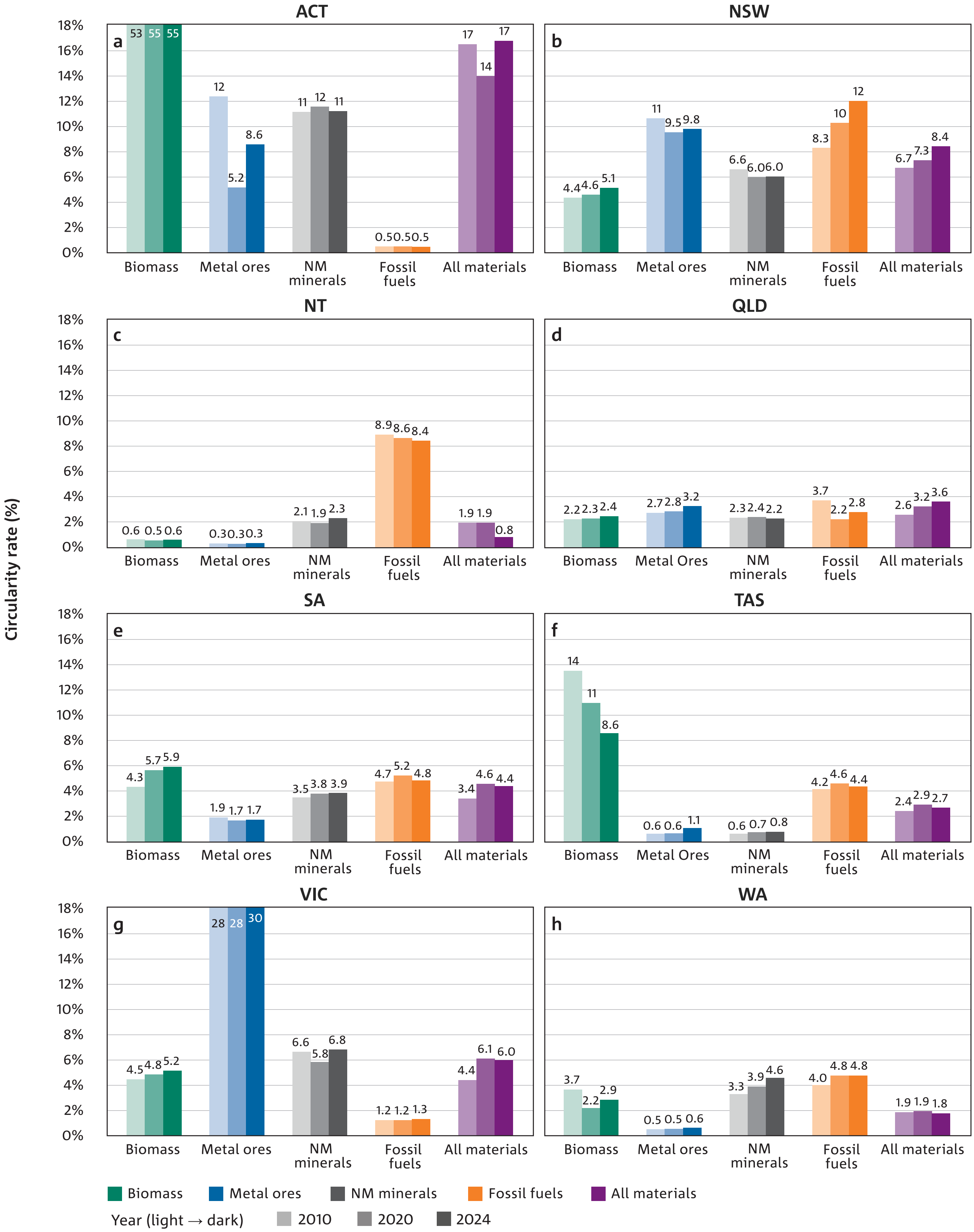


Figure 25. Circularity rate for Australia's states and territories, 2010, 2020, and 2024. Unit: percentage (%).

8.1 Circularity rates and implications for waste and material use

Across all states and territories, overall circularity rates remain low, indicating that only a small share of material inputs is supplied through secondary materials. In 2024, circularity rates range from below 1% in the Northern Territory to around 17% in the Australian Capital Territory, with most large states – including New South Wales, Victoria, and Queensland – remaining below 10% (Figure 25). While incremental improvements are visible over time in several jurisdictions, with a national increase in circularity from 3.8% in 2010 to 4.4% in 2024, these gains are modest relative to the scale of material throughput and waste generation documented in the preceding sections.

From 2010 to 2024, gradual increases in circularity are observed in New South Wales, Victoria, Queensland, and South Australia. New South Wales increased from around 6–7% to above 8%, while Victoria rose from approximately 4–5% to around 6%. These improvements coincide with expanded recycling infrastructure and policy attention to resource recovery, yet they remain insufficient to offset rising material demand and waste volumes, particularly for non-metallic minerals.

The Australian Capital Territory consistently exhibits the highest circularity rate, fluctuating between 14% and 18% over the period. Note that the very high circularity of biomass in the Australian Capital Territory, around 55%, is due to the near absence of agricultural activities paired with recycling of paper and timber, and, as such, cannot be taken as a blueprint for other states. Such high circularity reflects structural characteristics rather than scale effects, including a service-oriented economy, marginal industrial activity, and a non-trivial reliance on secondary materials in construction and municipal waste systems. However, even at these higher levels, circularity remains far below what would be required to decouple economic activity from primary material extraction.

In contrast, resource- and infrastructure-intensive jurisdictions – notably Western Australia, Queensland, and the Northern Territory – display persistently low circularity rates, generally below 4% and, in some cases, below 2%. This pattern mirrors the results of the waste analysis (Section 5.1), in which high volumes of mineral- and fossil-related waste coexist with limited reintegration of secondary materials into production systems. The data suggest that structural economic composition exerts a stronger influence on circularity outcomes than incremental improvements in waste management performance.

Overall, the circularity trends reinforce a key insight from our mapping of waste flows: while recycling and recovery efforts are necessary, they are not yet translating into system-wide circularity gains. Rising material stocks, continued construction activity, short asset lifetimes, and rising demand for housing and infrastructure limit the extent to which secondary materials can substitute for primary inputs.

8.2 Policy-relevant insights from circularity performance

The circularity rate data provide several clear implications for policy design and prioritisation. First, the consistently low circularity rates indicate that Australia's material system remains predominantly linear, despite decades of waste and recycling policy. This linearity suggests a need to recalibrate policy ambition away from marginal efficiency gains toward structural change in material demand, particularly in the built environment provision system.

Second, the weak relationship between rising waste volumes and improvements in circularity highlights a disconnect between waste generation and increasing use of secondary materials. Policies that expand recycling capacity without simultaneously creating stable demand for secondary materials are unlikely to lift circularity rates at scale. Stronger market-pull mechanisms, such as minimum recycled-content standards, public procurement requirements, and material performance certification, are therefore critical to ensuring the successful reintegration of secondary materials into the economy.

Third, the pronounced differences between jurisdictions signify the importance of tailored policy approaches. High-circularity jurisdictions benefit from economic structures that are more amenable to material recirculation and less dependent on primary material extraction, while resource-intensive states face deeper structural constraints. National policy frameworks should therefore differentiate targets and instruments, recognising divergent starting points while maintaining a common direction of travel.

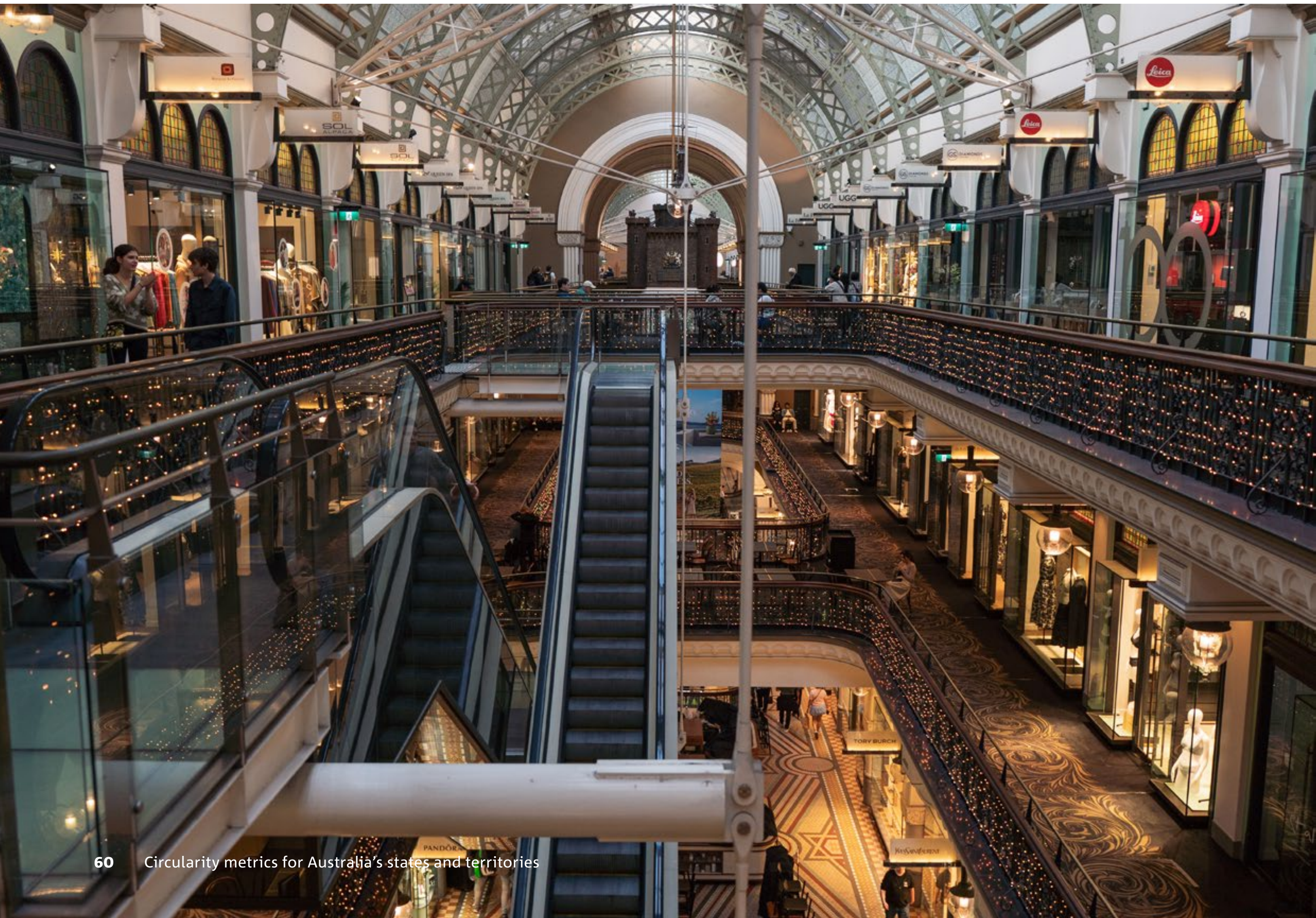
Finally, when interpreted alongside material footprint and waste indicators, the circularity data confirm that recycling alone will not deliver sustainability outcomes. Meaningful reductions in environmental pressure will require combining circularity strategies with absolute reductions in material demand and longer asset lifetimes.

9 Conclusions

This report establishes the first comprehensive, sub-national system of material flow and circular economy accounts for Australia, enabling consistent comparison across states and territories and revealing the structural drivers that shape material extraction, use, waste, and circularity outcomes. Viewed together, the indicators tell a coherent story: Australia's material metabolism is dominated by extraction, stock accumulation, and throughput, with circular feedbacks remaining weak relative to scale.

Across domestic extraction, trade, consumption, and waste, non-metallic minerals emerge as the defining material category. Their growth reflects continued investment in housing and infrastructure, but it also signals rising future maintenance and waste streams, as well as long-term locked-in liabilities. While such stock-building underpins economic activity and service provision, it also locks Australia into high material demand unless asset lifetimes are extended and utilisation rates improved.

The juxtaposition of Domestic Material Consumption and Material Footprint indicators shows that apparent domestic efficiency gains can mask rising global resource dependence. States with lower direct extraction often exhibit growing consumption-based footprints, illustrating how environmental pressures are increasingly displaced through trade. This result reinforces the importance of consumption-based metrics for policy evaluation and global responsibility.



Waste and recycling indicators confirm that improvements in recovery systems, while necessary, are insufficient in isolation. Waste volumes continue to rise in most jurisdictions, and circularity rates remain low despite some of the world's highest national recycling rates (>60%). The analysis demonstrates that circular economy progress is constrained less by technical recycling capacity than by structural demand for virgin materials, especially in construction and infrastructure provision systems.

Material productivity indicators provide evidence of partial decoupling in some jurisdictions, largely driven by economic structural change rather than absolute reductions in material use. These results highlight both the potential and the limits of productivity-led strategies. Without complementary measures to stabilise or reduce material demand, productivity improvements alone will not deliver sustainability outcomes consistent with climate, biodiversity, and pollution objectives.

A key conclusion is that place matters. Australia's states and territories face fundamentally different circular economy challenges and opportunities. Resource-exporting regions require transition pathways that combine diversification, local processing and manufacturing, value addition, and circular industrial development. Urbanised regions must focus on demand reduction, material-efficient service provision, maintenance of the existing built environment rather than its replacement, and circular construction strategies. National coherence will depend on recognising these differences while aligning all jurisdictions around shared long-term goals.

In conclusion, the report demonstrates that Australia now has the empirical basis to move from aspirational circular economy commitments to evidence-based policy design and accountability. We interpret the metrics presented herein as governance tools. Their greatest value lies in informing upstream policy intervention, supporting differentiated strategies across jurisdictions, and tracking whether Australia is genuinely reducing material pressures while sustaining economic prosperity and wellbeing.

10 References

ABS. (2024). *Table 4. Estimated Resident Population, States and Territories (Number) – December 2024 Australian Bureau of Statistics (ABS).* https://www.abs.gov.au/statistics/people/population/national-state-and-territory-population/dec-2024/310104.xlsx

ABS. (2025a). *Australian Agriculture: Livestock. Retrieved 24 December 2025 from* https://www.abs.gov.au/statistics/industry/agriculture/australian-agriculture-livestock/latest-release

ABS. (2025b). *Australian National Accounts: State Accounts. Retrieved 24 December 2025 from* https://www.abs.gov.au/statistics/economy/national-accounts/australian-national-accounts-state-accounts/latest-release

ABS. (2025c). *Australian State and Territories International Trade Data (commissioned dataset).*

Australian Bureau of Agricultural and Resource Economics. (2025a). *Agricultural commodities and trade data.* https://www.agriculture.gov.au/abares/research-topics/agricultural-outlook/data

Australian Bureau of Agricultural and Resource Economics. (2025b). *Australian forest and wood products statistics.* https://www.agriculture.gov.au/abares/research-topics/forests/forest-economics/forest-wood-products-statistics#production-and-trade-to-202324

Australian Department of Climate Change, Energy, The Environment and Water. (2025a). *Australian Energy Statistics.* https://www.energy.gov.au/energy-data/australian-energy-statistics

Australian Department of Climate Change, Energy, The Environment and Water. (2025b). *Australian Petroleum Statistics.* https://www.energy.gov.au/energy-data/australian-petroleum-statistics

Australian Department of Climate Change, Energy, the Environment and Water. (2025c). *Australia's National Greenhouse Accounts. Retrieved 24 December 2025 from* https://www.greenhouseaccounts.climatechange.gov.au/

Australian Department of Climate Change, Energy, the Environment and Water. (2025d). *Waste Reports, Data and Tools. Retrieved 24 December 2024 from* https://www.dcceew.gov.au/environment/protection/waste/publications/national-waste-reports

Australian Department of Climate Change, Energy, the Environment and Water. (2024). *Australia's Circular Economy Framework.* https://www.dcceew.gov.au/sites/default/files/documents/australias-circular-economy-framework.pdf

Australian Treasury. (2024). *Measuring what matters. Retrieved 01 August 2024 from* https://treasury.gov.au/policy-topics/measuring-what-matters

Aydin, M., Degirmenci, T., Erdem, A., Sogut, Y., & Demirtas, N. (2024). From public policy towards the green energy transition: Do economic freedom, economic globalization, environmental policy stringency, and material productivity matter? *Energy, 311, 133404.* https://doi.org/https://doi.org/10.1016/j.energy.2024.133404

Circularity Gap Reporting Initiative. (2024). *The Circularity Gap Report 2024. Retrieved 12 July 2024 from* https://www.circularity-gap.world/2024

Department of Mines, Petroleum and Exploration. (2025). *Major commodities data file.* https://www.wa.gov.au/government/publications/major-commodities-data-file

Department of Natural Resources and Mines, Manufacturing and Regional and Rural Development. (2025a). *Quarry production in Queensland.* https://www.data.qld.gov.au/dataset/quarry-rock-resource-statistics/resource/b7f142b0-23cc-4b4c-97ae-5951c6a53dc8

Department of Natural Resources and Mines, Manufacturing and Regional and Rural Development. (2025b). *Queensland Annual Mineral Production Statistics 1989 to 2021.* https://www.data.qld.gov.au/dataset/annual-mineral-and-metal-statistics/resource/8cb20226-eed5-4d02-a379-5f4b6d40eff1

Eurostat. (2018). *Economy-wide material flow accounts handbook. Publications Office of the European Union.* https://doi.org/https://doi.org/10.2785/158567

Fischer-Kowalski, M., Krausmann, F., Giljum, S., Lutter, S., Mayer, A., Bringezu, S., Moriguchi, Y., Schutz, H., Schandl, H., & Weisz, H. (2011). Methodology and Indicators of Economy-wide Material Flow Accounting. *Journal of Industrial Ecology, 15(6), 855-876.* https://doi.org/10.1111/j.1530-9290.2011.00366.x

Government of South Australia Energy & Mining. (2025). *Resource production statistics.* https://www.energymining.sa.gov.au/industry/minerals-and-mining/invest/resource-production-statistics

Higgins, A., McFallan, S., McKeown, A., Bruce, C., Marinoni, O., Chilcott, C., Stone, P., Laredo, L., & Beaty, M. (2017). *TraNSIT: Unlocking options for efficient logistics infrastructure in Australian agriculture.* https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/ag-food/publications/transit-agriculture-final-report.pdf

International Fertilizer Association. (2025). *Fertilizer production and trade. Retrieved 24 December 2025 from* https://www.ifastat.org/databases/supply-trade

Karakaya, E., Sari, E., & Alatas, S. (2021). What drives material use in the EU? Evidence from club convergence and decomposition analysis on domestic material consumption and material footprint. *Resources Policy, 70, 11, Article 101904.* https://doi.org/10.1016/j.resourpol.2020.101904

Lèbre, É., Stringer, M., Svobodova, K., Owen, J. R., Kemp, D., Côte, C., Arratia-Solar, A., & Valenta, R. K. (2020). The social and environmental complexities of extracting energy transition metals. *Nature Communications, 11(1), 4823.* https://doi.org/10.1038/s41467-020-18661-9

Lenzen, M., Geschke, A., Abd Rahman, M. D., Xiao, Y., Fry, J., Reyes, R., Dietzenbacher, E., Inomata, S., Kanemoto, K., Los, B., Moran, D., Schulte in den Bäumen, H., Tukker, A., Walmsley, T., Wiedmann, T., Wood, R., & Yamano, N. (2017). The Global MRIO Lab – charting the world economy. *Economic Systems Research, 29(2), 158-186.* https://doi.org/10.1080/09535314.2017.1301887

Lenzen, M., Geschke, A., West, J., Fry, J., Malik, A., Giljum, S., Milà i Canals, L., Piñero, P., Lutter, S., Wiedmann, T., Li, M., Sevenster, M., Potočnik, J., Teixeira, I., Van Voore, M., Nansai, K., & Schandl, H. (2022). Implementing the material footprint to measure progress towards Sustainable Development Goals 8 and 12. *Nature Sustainability, 5(2), 157-166.* https://doi.org/10.1038/s41893-021-00811-6

Lenzen, M., Geschke, A., Wiedmann, T., Lane, J., Anderson, N., Baynes, T., Boland, J., Daniels, P., Dey, C., Fry, J., Hadjikakou, M., Kenway, S., Malik, A., Moran, D., Murray, J., Nettleton, S., Poruschi, L., Reynolds, C., Rowley, H., . . . West, J. (2014). Compiling and using input–output frameworks through collaborative virtual laboratories. *Science of The Total Environment, 485-486, 241-251.* https://doi.org/10.1016/j.scitotenv.2014.03.062

Luna Juncal, M. J., Masino, P., Bertone, E., & Stewart, R. A. (2023). Towards nutrient neutrality: A review of agricultural runoff mitigation strategies and the development of a decision-making framework. *Science of The Total Environment, 874, 162408.* https://doi.org/10.1016/j.scitotenv.2023.162408

Marcos-Martinez, R., Soonsawad, N., Emami, N., Schandl, H., Whitten, S., Fasanella, Y., & Miatto, A. (2025). Embodied impacts of Australian building materials highlight trade-offs for sustainability policy. *Cell Reports Sustainability.* https://doi.org/10.1016/j.crsus.2025.100580

Miatto, A., Emami, N., Goodwin, K., West, J., Taskhiri, M. S., Wiedmann, T., & Schandl, H. (2024). Australia's circular economy metrics and indicators. *Journal of Industrial Ecology, 28(2), 216-231.* https://doi.org/10.1111/jiec.13458

Miatto, A., Schandl, H., Yamashita, N., & Fishman, T. (2025). Detailed waste flows and circularity rates reveal the limits of the circularity gap concept. *Resources, Conservation and Recycling, 219, 108319.* https://doi.org/10.1016/j.resconrec.2025.108319

Mudd, G. (2023). *A Comprehensive Dataset for Australian Mine Production, 1799 to 2021.* https://doi.org/10.25439/rmt.22724081.v2

New South Wales Government Department of Primary Industries and Regional Development. (2025). *Non-Metallic Mineral Production NSW.*

Nicholson, V., & Miatto, A. (2024). Architects as catalysts of reuse in construction. *Nature Cities, 1(3), 179-181.* https://doi.org/10.1038/s44284-024-00042-8

Northern Territory Government Department of Mining and Energy. (2025). *Mineral production data.* https://dme.nt.gov.au/mining/mineral-production-data

Pan, S.-Y., He, K.-H., Lin, K.-T., Fan, C., & Chang, C.-T. (2022). Addressing nitrogenous gases from croplands toward low-emission agriculture. *npj Climate and Atmospheric Science, 5(1), 43.* https://doi.org/10.1038/s41612-022-00265-3

Resources Victoria. (2025). *Annual statistical reports.* https://resources.vic.gov.au/legislation-and-regulations/regulator-performance-reporting/annual-statistical-reports

Takiguchi, H., & Takemoto, K. (2008). Japanese 3R Policies Based on Material Flow Analysis. *Journal of Industrial Ecology, 12(5-6), 792-798.* https://doi.org/10.1111/j.1530-9290.2008.00093.x

Tasmanian Government Department of State Growth. (2025). *2010-2024 Production Data*.

UNEP. (2022). *Global Material Flows Database*. https://www.resourcepanel.org/global-material-flows-database

UNEP. (2023a). *The Use of Natural Resources in the Economy: A Global Manual on Economy Wide Material Flow Accounting. Nairobi, United Nations Environment Programme*

UNEP. (2023b). *The Use of Natural Resources in the Economy: A Global Manual on Economy Wide Material Flow Accounting (DEW/2356/NA).* https://wedocs.unep.org/20.500.11822/36253

United Nations, Eurostat, Food and Agriculture Organization of the United Nations, Organisation for Economic Co-operation and Development, & World Bank. (2014). *System of environmental-economic accounting 2012 – Central framework*. *United Nations Organisation*. https://digitallibrary.un.org/record/767283/files/SEEA_CF_Final_en.pdf?ln=en

United Nations Food and Agriculture Organization. (2025). *Food and agriculture data. Retrieved 24 December 2025 from* https://www.fao.org/faostat/en/#home

11 Appendix 1 – Methods and data sources

This appendix provides an overview of the approach used to assemble material flow accounts for Australia's states and territories. The analysis was conducted in line with the methodology set out by the United Nations Environment Programme (UNEP, 2023a), to ensure that the approach is consistent with international standards and aligns with the International Resource Panel's *Global Material Flow Database* (UNEP, 2022).

We assessed material consumption for four material categories: biomass, metal ores, non-metallic minerals, and fossil fuels. The major components of these four categories are listed in Table 1.

Table 1. Major components of the four material categories present in this study.

CATEGORY	MATERIAL COMPONENTS
Biomass	Crops: cereals, rice, wheat, maize, roots, tubers, sugar crops, pulses, nuts, oil-bearing crops, vegetables, fruits, fibers, spices, pharmaceutical crops, tobacco Crop residues: straw, other crop residues, fodder crops, grazed biomass Wood: timber, wood fuel Wild harvest: wild fish catch, all other aquatic animals catch, wild aquatic plant harvest, wild terrestrial plant harvest not elsewhere classified (incl. gathering), wild terrestrial animal catch (incl. hunting)
Metal ores	Iron ores Aluminum ores All other metal ores: silver ores, gold ores, chromium ores, manganese ores, nickel ores, lead ores, platinum group metal ores, tin ores, titanium ores, uranium ores, zinc ores, other metal ores not elsewhere classified
Non-metallic minerals	Ornamental or building stone Carbonate minerals important in cement: chalk, dolomite, limestone Chemical and fertiliser minerals Salt Gypsum Clays: structural clays, Specialty clays Sand and gravel: industrial sand and gravel, sand and gravel for construction Other non-metallic minerals not elsewhere classified
Fossil fuels	Coal and peat: brown coal, hard coal, peat Crude oil, natural gas, and natural gas liquids: crude oil, natural gas, natural gas liquids

11.1 Domestic extraction

Domestic extraction data were gathered from multiple sources, including company reports, official government statistics, grey literature, peer-reviewed research, and triangulation with industry experts. The primary sources are listed in Table 2 below. Where gaps existed in the time series, linear interpolation and extrapolation techniques were applied to estimate missing values.

Table 2. Major data sources for material extraction.

CATEGORY	ORGANISATION/AUTHOR	DATASET/DOCUMENT
Biomass	Australian Bureau of Agricultural and Resource Economics (2025a)	Agricultural commodities and trade data
	Agricultural commodities and trade data	Australian forest and wood products statistics
Fossil fuels	Department of Climate Change, Energy, the Environment and Water (2025a)	Australian Energy Statistics
	Australian Energy Statistics	Australian Petroleum Statistics
Metallic ores	RMIT University (Mudd, 2023)	A Comprehensive Dataset for Australian Mine Production, 1799 to 2021
Non-metallic minerals	Resources Victoria (2025)	Annual Statistical Reports
	Tasmanian Government Department of State Growth (2025)	2010-2024 Production Data (Unpublished)
	New South Wales Government Department of Primary Industries and Regional Development (2025)	Non-Metallic Mineral Production New South Wales (Unpublished)
	Northern Territory Government Department of Mining and Energy (2025)	Mineral production data
	Department of Natural Resources and Mines, Manufacturing and Regional and Rural Development (2025a)	Quarry production in Queensland
	Department of Natural Resources and Mines, Manufacturing and Regional and Rural Development (2025b)	Queensland Annual Mineral Production Statistics 1989 to 2021
	Department of Mines, Petroleum and Exploration (2025)	Major commodities data file
	Government of South Australia Energy & Mining (2025)	Resource production statistics

11.2 Trade data

The Australian Bureau of Statistics supplied data on international imports and exports for each state and territory (ABS, 2025c). A portion of the dataset, 11% of exports and 7% of imports by weight, was classified as confidential, with only total weights and trade directions available. About 40% of the confidential export flows were allocated by identifying likely trade flows through comparisons with other trade statistics, such as USGS commodity reports. The remaining 60% of export and import flows constituted a small residual that was allocated proportionally across the four main material categories, using domestic extraction patterns as an approximation. This approach ensured the trade matrices were complete while maintaining consistency with observed production patterns.

Interstate trade flows were sourced from the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Transport Network Strategic Investment Tool (TraNSIT) (Higgins et al., 2017), which draws on business surveys to provide detailed freight movement data. As TraNSIT data are available for only one reference year, these flows were extrapolated across the time series by assuming proportionality with state and territory population growth. While this assumption introduces some uncertainty, particularly in resource-intensive regions, it offers a transparent and consistent method for representing interregional material movements in the absence of longitudinal freight datasets.

11.3 Waste and emissions

Waste data were drawn from the National Waste and Resource Recovery Reporting dataset (DCCEEW, 2025d), covering state and territory waste generation and treatment from 2006-23. Because figures are reported by financial year, calendar-year estimates were calculated by averaging adjacent years. For 2024, where data are not yet published, waste generation was projected by multiplying the average per capita waste from 2018–2023 by the 2024 population.

Waste was categorised into four sectors: municipal solid waste, commercial and industrial waste, construction and demolition waste, and mining waste. Biomass wastes are defined using the National Waste and Resource Recovery Reporting material categories "Organics" and "Paper and cardboard," which capture biogenic materials managed through the waste and resource recovery system (for example food waste, garden organics, timber residues and paper products). The analysis uses the core National Waste and Resource Recovery Reporting database time series to ensure consistency across years. Supplementary estimates of upstream agricultural or food production wastes discussed in some National Waste and Resource Recovery Reporting reports are not included, as these are not consistently available across the time series.

Mining waste is largely absent from national datasets, with partial data only for 2018–19 and 2020–21. To fill this gap, estimates were made for each metal by calculating the share of extracted ore discarded before export, using coefficients from Mudd (2023) and additional coefficients for iron, aluminium, and copper based on resource-specific knowledge.

Mining waste is only partially captured in the National Waste and Resource Recovery Reporting (NWRRR) dataset for two non-consecutive years (DCCEEW, 2025d). While this reports estimates mining waste generation, there is currently no consistent national dataset that reliably captures the recovery or recycling of mining wastes in a manner comparable with the core waste and resource recovery sector. As a result, recycled mining wastes are not included in the circularity calculations presented in this report. This limitation means that some recovery activities associated with mining wastes may not be reflected in the reported estimates.

Emissions data covered greenhouse gases, air pollutants, and dissipative flows of materials such as seeds and fertilisers. State and territory data on greenhouse gases and air pollutants were sourced from national inventories (DCCEEW, 2025c). As seed and fertiliser use were not reported at the state level, national totals were downscaled using each state's share of crop production. Seed data were sourced from the United Nations Food and Agriculture Organization (2025), synthetic fertiliser use from the International Fertilizer Association (2025), and manure estimates were based on livestock statistics (ABS, 2025a) combined with Eurostat conversion factors (Eurostat, 2018).

11.4 Material footprint

Material footprints were estimated using an environmentally extended input–output (EEIO) framework. The analysis relied on multi-regional input–output (MRIO) tables for 2010–2020 from the Industrial Ecology Virtual Laboratory (IELab) (Lenzen et al., 2014). These tables link Australian subnational data with global MRIOs from the GLORIA database (Lenzen et al., 2017), enabling consistent tracking of material use across international supply chains. Current material footprint results are provisional as these tables are under revision.

For 2021–2024, material footprints were projected using the 2020 MRIO structure, the latest harmonised subnational tables available. This projection assumes short-term stability in inter-industry relationships, a common approach when more contemporaneous data is lacking. Material extension vectors for Australian jurisdictions were based on domestic extraction data, while non-Australian extensions came from the IELab database to maintain global consistency.

11.5 Metrics

Material footprint per capita was calculated by dividing consumption-based footprint estimates (Section 4) by state and territory population data (ABS, 2024). This normalised indicator enables comparison of material demand across jurisdictions with different population sizes.

Material productivity was calculated as real gross state product (GSP) divided by domestic material consumption (DMC), representing economic output per unit of material use. GSP figures were sourced from national accounts and converted to chain-volume 2025-dollar estimates (ABS, 2025b). DMC, expressed in tonnes, served as the denominator in line with international definitions of material productivity. The formula is shown in Equation (1).

$$mat\ prod = \frac{GSP}{DMC} = \frac{GSP}{DE + imp - exp} \qquad (1)$$

In Equation (1), material productivity (mat_prod) is defined as GSP divided by DMC for each state and territory. DMC equals domestic extraction plus imports minus exports, representing the total material mass used within the economy.

The circularity rate indicates the proportion of secondary materials in total material input, relative to all materials managed in the economy. It is calculated as shown in Equation (2) in accordance with the reporting of Measuring What Matters (Australian Treasury, 2024).

$$circ\ rate = \frac{sec\ mat}{DMC + recyc_{dom}} = \frac{recyc_{dom} + recyc_{imp} - recyc_{exp}}{DE + imp - exp + recyc_{dom}} \qquad (2)$$

The circularity rate is defined as the ratio of secondary materials to domestic material consumption (DMC). Secondary input includes domestically recycled materials (*recyc_dom*), recycled content in imports (*recyc_imp*), and excludes recycled content in exports (*recyc_exp*). Total material input (DMC) is calculated as domestic extraction (DE) plus imports (imp) minus exports (exp).

Due to limited subnational data on recycled content in traded goods, two assumptions were applied: (1) recycled content in imports was set equal to the global circularity rate for the year (Circularity Gap Reporting Initiative, 2024; Miatto et al., 2025), reflecting average global supply chain recycling, and (2), exports were assumed to contain negligible recycled content, as they are dominated by primary raw materials such as coal and metal ores. While these assumptions introduce uncertainty, they align with Australia's export profile and provide a transparent, conservative basis for estimating circularity at the state and territory level.

12 Appendix 2 – State and Territory Sankey diagrams

We report here the Sankey diagrams of material flows for each Australian State and Territory in 2024 (Figure 26 to Figure 33). Given the wide differences in mass among States, each figure is plotted on its own scale, which is shown in the bottom-left corner. Hence, a direct visual comparison among these figures should be conducted with caution.

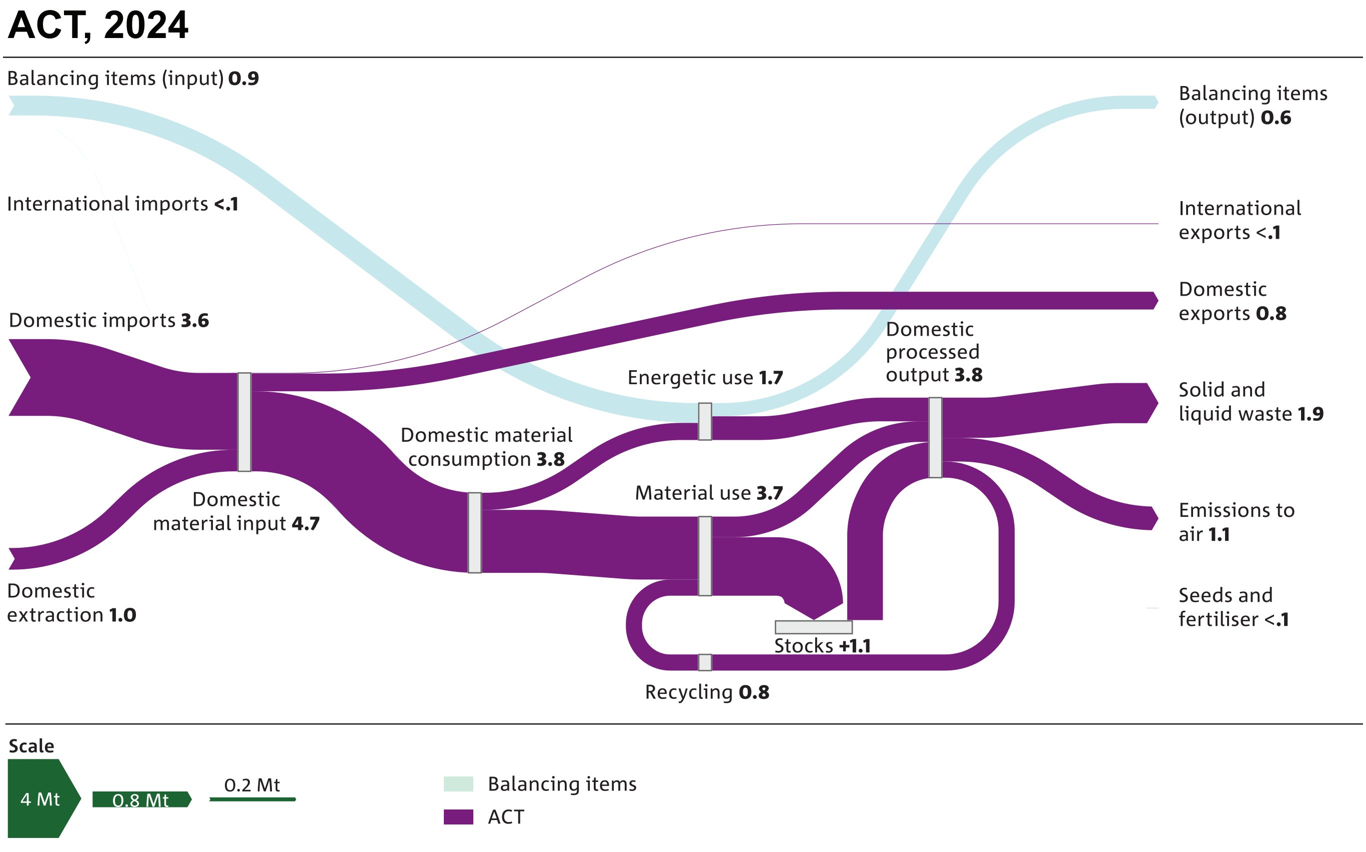


Figure 26. Material flows in the Australian Capital Territory in 2024. Unit: million metric tonnes (Mt).

NSW, 2024

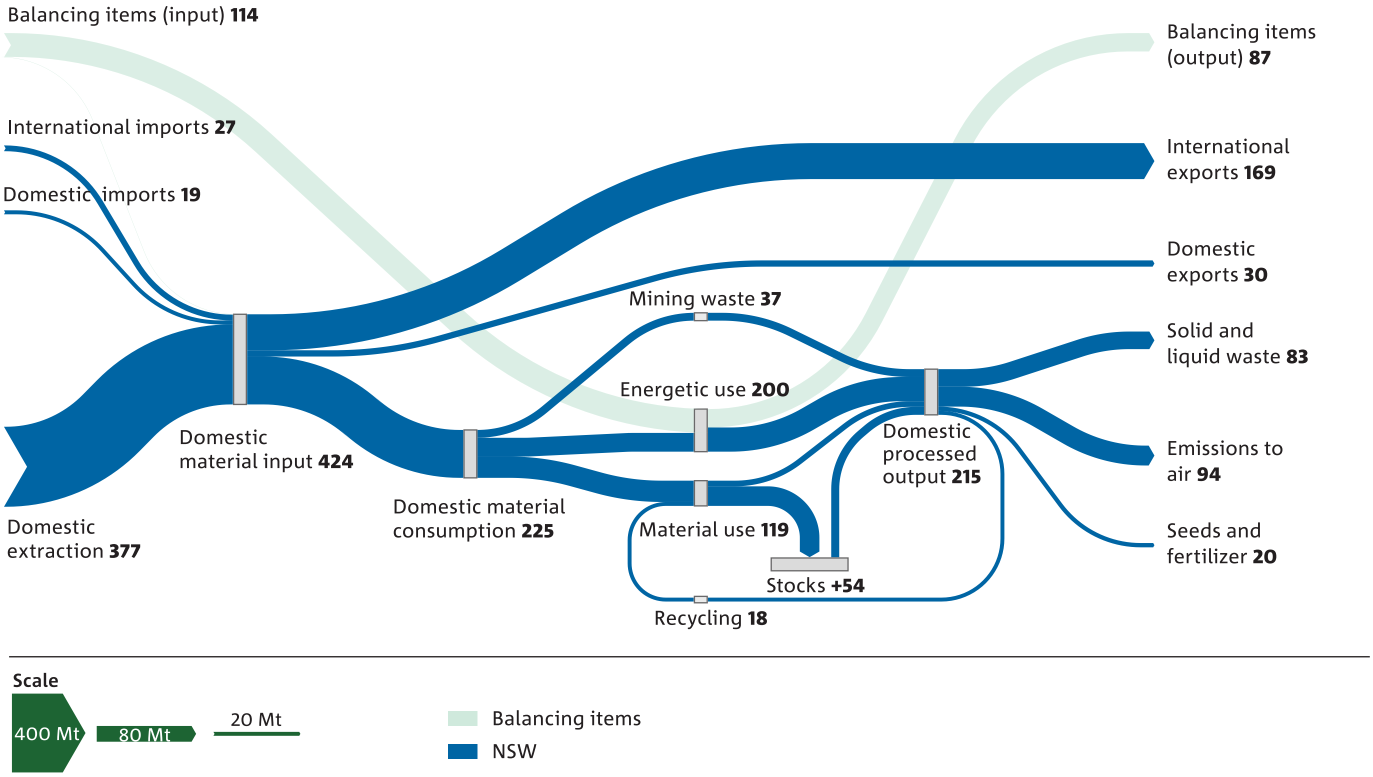


Figure 27. Material flows in New South Wales in 2024. Unit: million metric tonnes (Mt).

NT, 2024

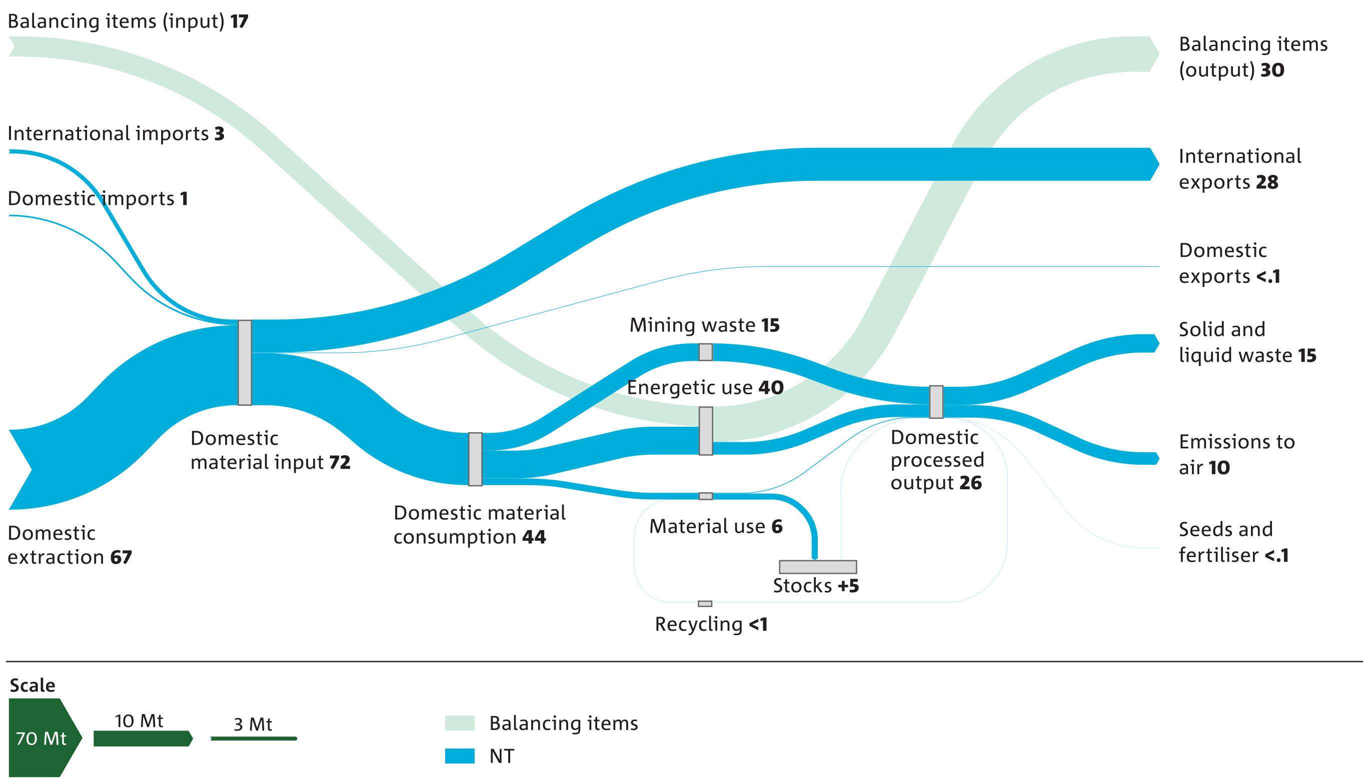


Figure 28. Material flows in the Northern Territory in 2024. Unit: million metric tonnes (Mt).

QLD, 2024

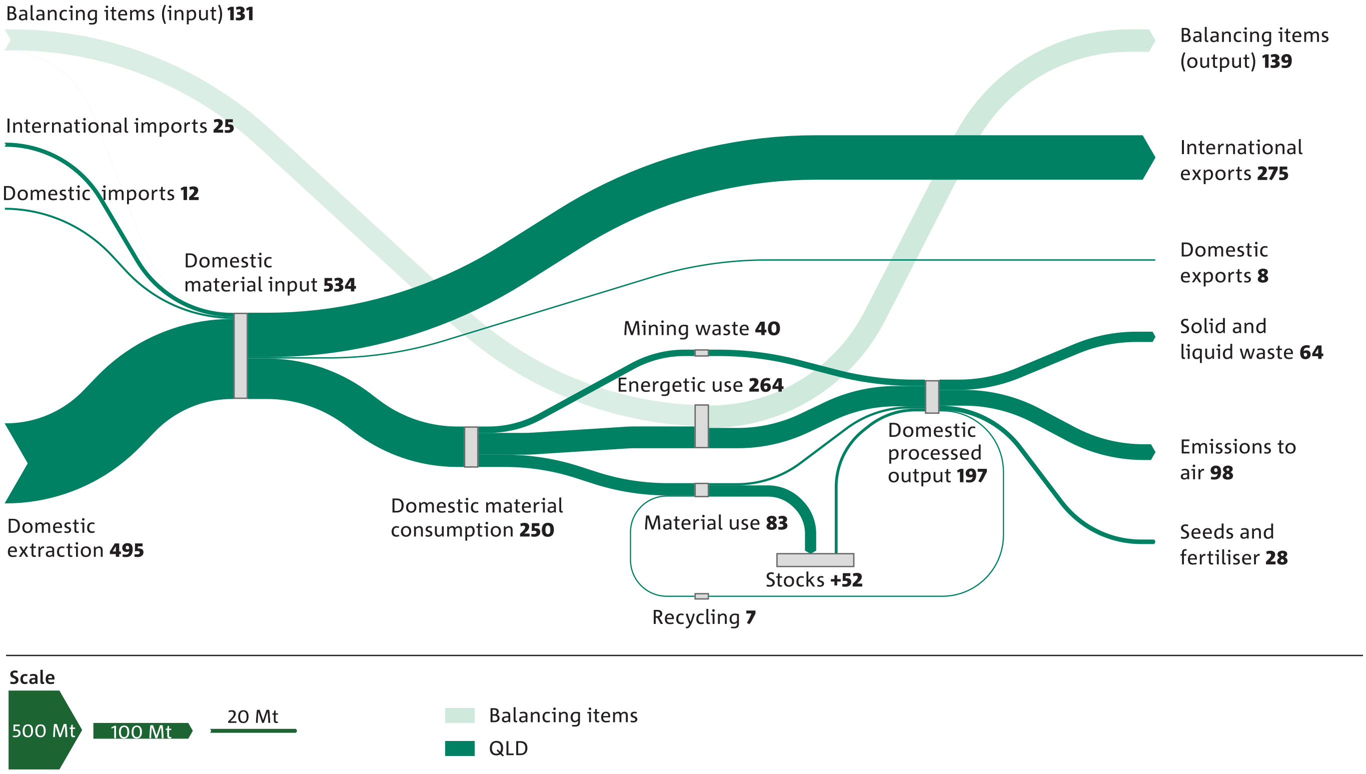


Figure 29. Material flows in Queensland in 2024. Unit: million metric tonnes (Mt).

SA, 2024

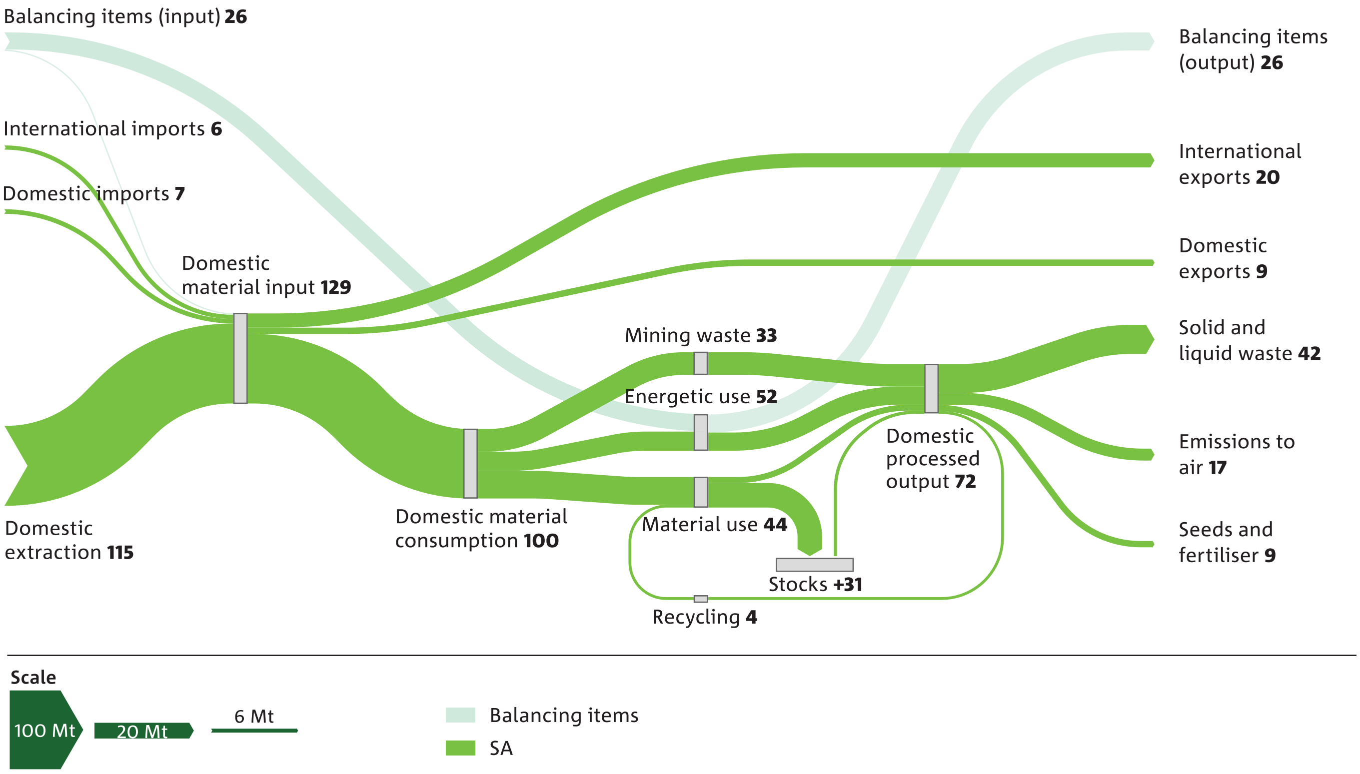


Figure 30. Material flows in South Australia in 2024. Unit: million metric tonnes (Mt).

TAS, 2024

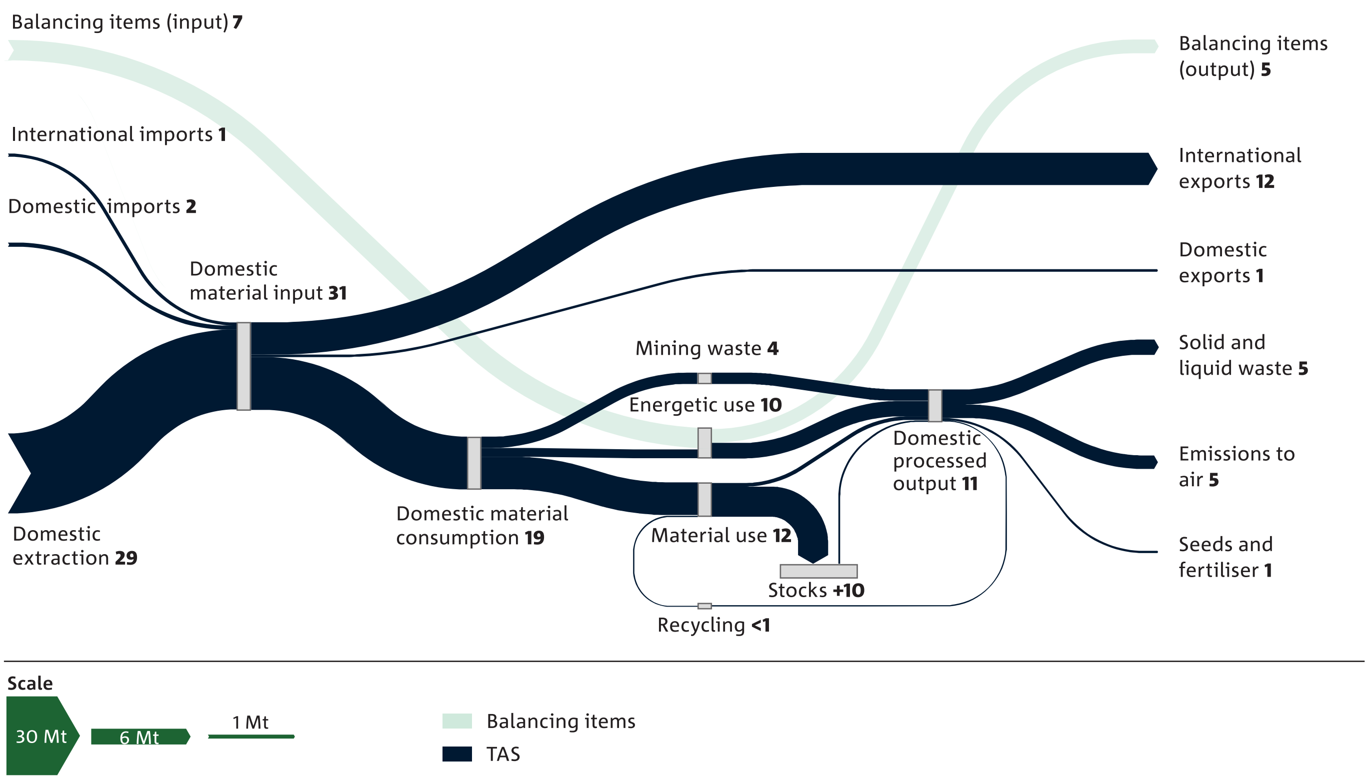


Figure 31. Material flows in Tasmania in 2024. Unit: million metric tonnes (Mt).

VIC, 2024

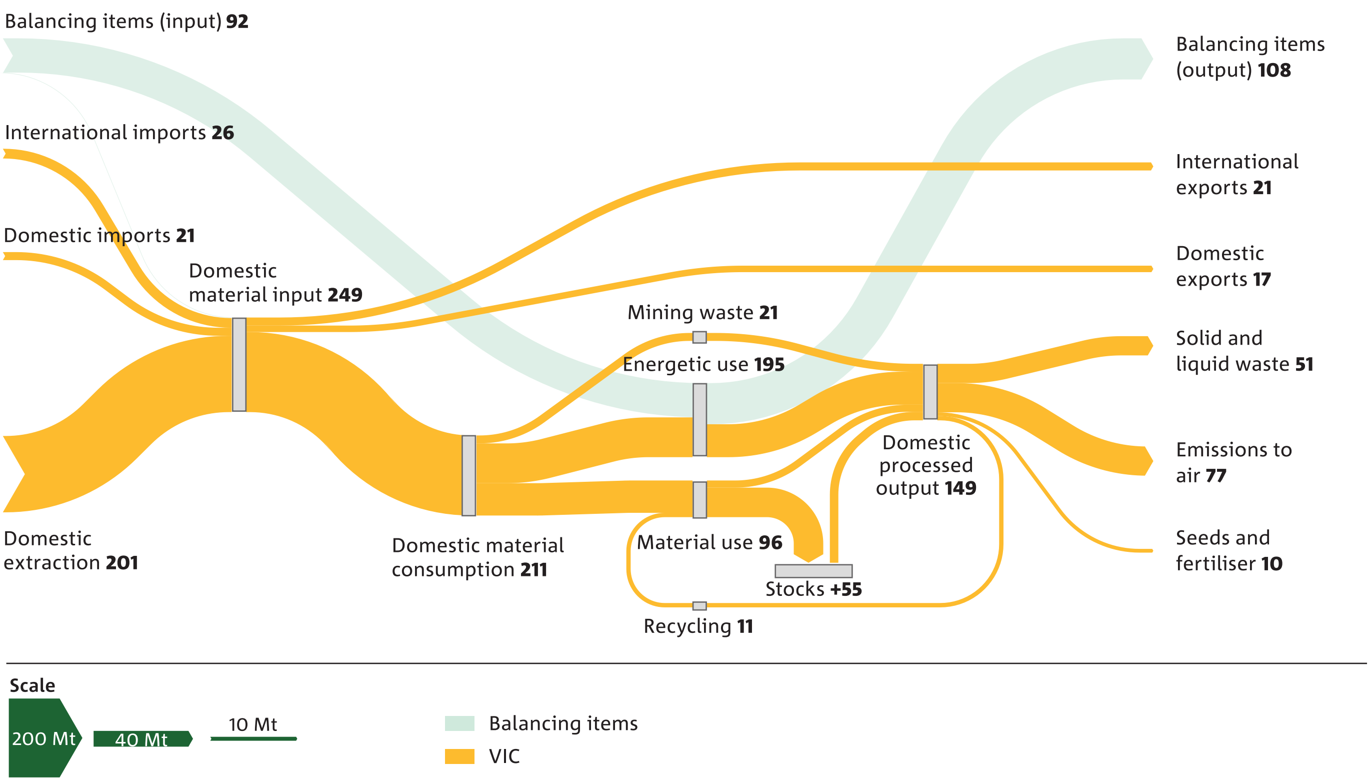


Figure 32. Material flows in Victoria in 2024. Unit: million metric tonnes (Mt).

WA, 2024

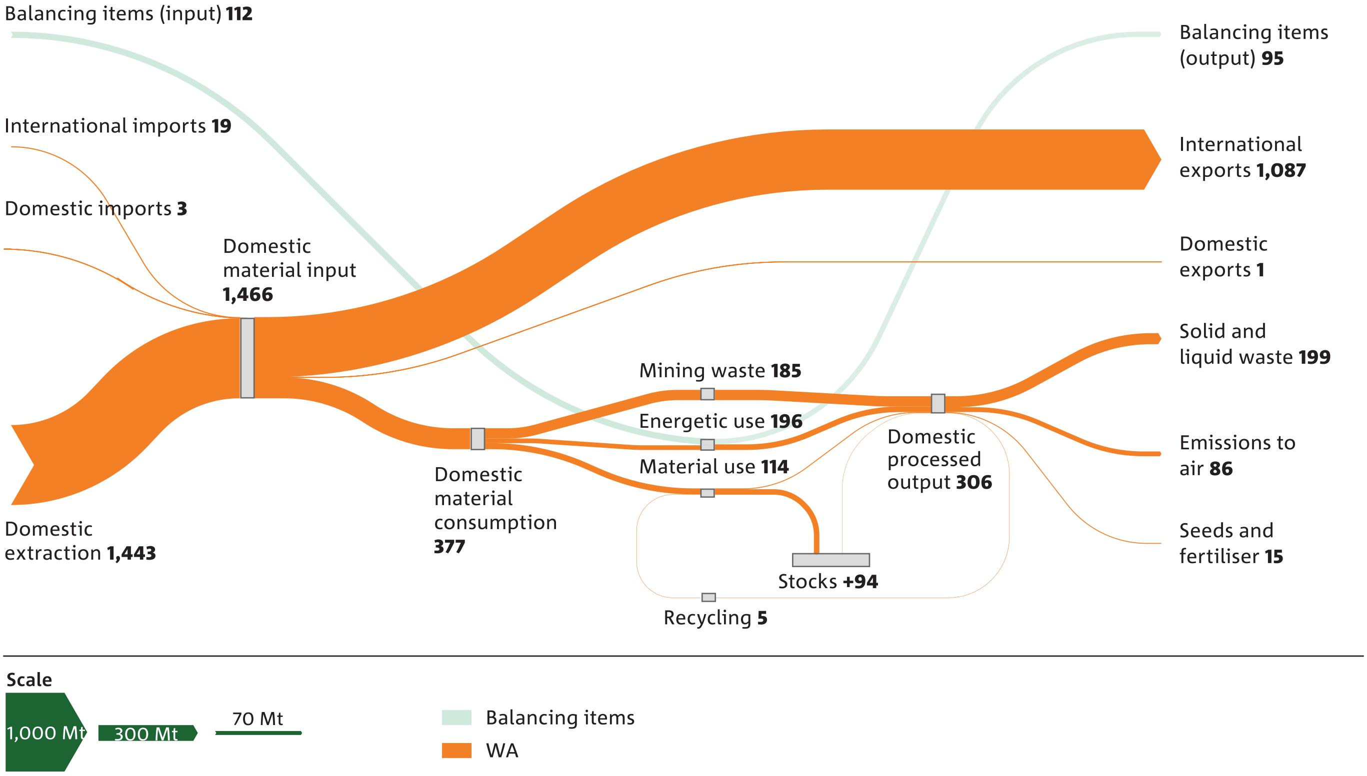


Figure 33. Material flows in Western Australia in 2024. Unit: million metric tonnes (Mt).

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For further information
Environment
Alessio Miatto, PhD
alessio.miatto@csiro.au
csiro.au/circular-economy

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