

THE CHOICES WE FACE

ECONOMIC SELF-HARM
OR A PRO-HUMAN
FUTURE?

The Case of Australia

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Economic Self Harm or a Pro-Human Future?

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Introduction

The Context: Thirty Years of Economic Self-Harm

Since 2020, a cost-of-living crisis has caused economic pain for many citizens across the West.

The immediate source of the pain was clear: spiralling energy costs due to geopolitical shocks from Russia to the Middle East, coupled with the inflationary fall-out of COVID-19 policies to create a perfect storm. The result has been high inflation, limited growth, and more exposure for economies that are dependent on importing energy.

But scratch beneath the surface and there is more going on. While the global shock may have been catalytic, the vulnerability that many of our nations have shown is of our own making.

The leader of Germany's main industry association has called the German government's energy policy "absolutely toxic".¹ Business confidence is wavering. The German economy fell into recession in 2023. And last summer, the Economist asked: is Germany once again the sick man of Europe?²

Meanwhile, cross the channel, and one finds a similar story playing out in the United Kingdom. Tata Steel shut down. British Steel bailed-out. British industrial energy prices are the highest in the developed world, and Britain's per capita energy consumption has dropped by 40% since 2005.³

In our home country of Australia, the situation is little better. Australia's energy landscape presents a compelling study for nations grappling with the dual challenges of the energy transition and economic resilience. Blessed with vast reserves of coal, gas, uranium, and renewable resources like solar and wind, Australia should be at the forefront of delivering low-cost, reliable energy solutions.

Yet, paradoxically, this resource-rich nation has transitioned from enjoying some of the world's cheapest energy, to grappling with some of the most expensive.

Between the June quarter of 2007 and the June quarter of 2024, nominal electricity prices escalated by 161%, while nominal gas prices surged by 165%. When adjusted for inflation, these increases correspond to real price growth of 65% for electricity and 67% for gas, highlighting a significant rise in the cost of energy.⁴

The nation is now in a cost-of-living crisis and the economy is struggling. In the September quarter of 2024, all five official Living Cost Indexes rose.⁵ Labour productivity growth slipped below 1% in 2022-2023, marking a concerning slowdown,⁶ while the number of businesses entering administration in 2023-2024 surpassed levels seen in the prior year.⁷ Business investment remains tepid and wage growth is projected to decelerate further, with declines expected to persist into at least December 2024.⁸ Compounding these challenges, the Reserve Bank of Australia warns that headline inflation is likely to rebound once household energy subsidies expire, raising concerns about the durability of the current economic relief measures.⁹

Like many of the nations of Western Europe, we have been pursuing a policy of economic self-harm, even unilateral economic disarmament. At a time when many of the nations most hostile to our core values are doubling down on cheap, abundant energy through hydrocarbons, we have allowed luxury beliefs to weaken us¹⁰—with major consequences for individual households, our economies, and ultimately national security.

Overview and Key Insights

There are three parts to this paper as we examine the choices we face in the context of energy policy, with particular reference to Australia.

First, we will consider the fact that energy is the lifeblood of our civilisation, and that failing to provide affordable energy ultimately hits the poorest hardest. Beginning with an examination of data trends which demonstrate the significance of energy for prosperity and economic growth, we will turn to consider how—in Australia specifically—the rising energy costs have had profound implications for the poorest households and the viability of businesses.

The paper will then turn to why this has happened, by breaking down the three domestic drivers of higher energy prices. There is a set of choices to consider here: do we choose reliable or intermittent sources of energy generation? Do we choose dense or decentralised energy systems? And what are we choosing to incentivise through our frameworks for policy and regulation? The balance of considerations between environmental concerns, energy efficiency, and economic imperatives shapes the decisions that are being made here. Prices are being driven higher by a conscious decision to choose the less efficient options in the name of sustainability.

From here, and perhaps most importantly, in partnership with the Page Research Centre and Adept Economics, we have developed a model to attempt to understand the consequences of the different policy pathways that are being proposed for energy in Australia.

We have developed four scenarios, and found that there are diverging possible futures which reflect the reality of the cost trade-offs:

1. The "No Net Zero" scenario, relying on ultra-supercritical coal, presents the lowest capital expenditure at \$103 billion and offers wholesale electricity prices between \$50 and \$100 per megawatt-hour ("MWh"). **Retail prices could drop by as much as 25%**, delivering short-term economic relief.¹¹
2. A technology-neutral approach that incorporates nuclear power presents a compelling alternative. With a capital expenditure of \$163 billion, nuclear provides a relatively modest retail price impact—**ranging from a 4% decrease to a 35% increase**—and wholesale prices between \$100 and \$150/MWh. While the upfront costs are significant, nuclear offers a stable, low-emission energy source. However, the lack of political and regulatory appetite for nuclear energy in Australia makes this pathway an uphill battle.
3. Australia's current policy direction favours a blend of offshore wind, solar, and battery energy storage systems ("BESS"). This approach carries a hefty price tag: \$198 billion in Capex and an additional \$30/MWh in transmission costs, bringing the total to \$261 billion. Retail prices are likely to continue to rise between 30-69%, with wholesale prices ranging from \$150 to \$200/MWh, which could mean a further **reduction of 1.44% to 3.31%** of Australia's future GDP and living standards. Alarming, this pathway may fall short of achieving net zero while compromising energy security—a sobering prospect given the stakes.
4. The most ambitious option—a 100% renewable grid—commands an eye-watering \$255 billion in Capex to replace current baseload power generation

and \$77 billion in additional transmission costs, totalling \$332 billion. Retail electricity prices could **soar by up to 69%**, mirroring Australia's current pathway, with similar concerns about energy reliability. While this scenario aligns with Australia's long-term climate goals, the trade-offs in affordability and grid stability raise serious questions about its feasibility.

The Choices that Lie Ahead

The conclusion of the paper will then explore what might be a better pathway forward.

This is a defining moment for our civilisation, and we have choices to make. The modelling in this paper demonstrates that the economic pain we are feeling will be more-or-less doubled if we do not make the right decisions in the next few years.

Australia's example reveals the daunting question at the heart of energy policy: how best to steward its natural environment, generate affordable energy, and sustain a thriving society?

Cheap energy, natural resources, and high-skilled labour are the foundations that ensured our success. But now with high energy costs, unsustainable dependencies, and a declining birth rate, our nations have a choice to make: **to relay the foundations of our prosperity, or choose deindustrialisation and economic disarmament.**

There is a better story: one that can choose the rebuilding of economies, a strengthening of the social fabric, and the stewarding of our natural world.

This is a turning point—a civilisational moment. We must choose renewal not decline.

Part 1: Energy Is the Lifeblood of Our Civilisation

Why the wrong energy policies hit the poorest hardest.

The Role of Energy in Empowering Lives

The intrinsic link between energy and human potential cannot be overstated. Nations that ensure affordable, reliable energy access unlock pathways for education, entrepreneurship, and innovation, maximising the potential of their citizens.

Conversely, energy insecurity undermines economic opportunity and entrenches inequality, jeopardising the social contract that underpins true prosperity.

Electricity is not just a utility; it is an enabler of opportunity and “an essential driver of economic growth.”¹² From the Industrial Revolution to the digital age, the transition from energy scarcity to abundance has consistently elevated living standards and expanded opportunities. Nations that harness electricity effectively have reaped the rewards of higher productivity and improved quality of life, underscoring its role as an enabler of growth.

In the developed world, the conveniences provided by electricity are so entrenched that their absence is almost unthinkable. Refrigerating and cooking food, lighting homes, powering vehicles, and connecting through communication devices are activities so routine they are often overlooked. Yet, their availability is a testament to the transformative power of energy access.

For those in developing economies, access to affordable and reliable electricity presents an opportunity to break free from subsistence constraints and unlock their full potential. It opens doors to education, workforce participation, and entrepreneurial ventures, particularly for women. This access fosters empowerment, drives innovation, and enhances productivity, creating a foundation for sustained economic growth and development.

International research highlights the economic opportunities created when people are freed to pursue growth, innovation and prosperity, rather than being constrained by the demands of subsistence living. This body of work shifts the focus from income inequality to what might be termed “time inequality”. A study using data from the World Bank and International Monetary Fund illustrates the dramatic shift over recent decades: between 1980 and 2022, the number of hours required to afford basic commodities declined by more than 65% worldwide. This drastic reduction underscores the transformative impact of productivity gains and improved access to resources.¹³

Meanwhile, global energy consumption has risen alongside population growth and rising living standards (Figure 1), even as the energy intensity of economies has declined. The energy required to generate one dollar of gross domestic product (“GDP”) has steadily decreased, reflecting significant advances in efficiency, even when accounting for inflation. This trend suggests that while total energy demand continues to grow, economies are becoming better at using energy to fuel economic output—a promising sign for balancing growth with sustainability.

The proliferation of energy-intensive technologies, such as artificial intelligence and ubiquitous computing, is expected to accelerate this trend. By 2023, global energy use was 2.6 times its level in 1973, reflecting both the growing energy demands of economic development and the technological shifts shaping modern economies.

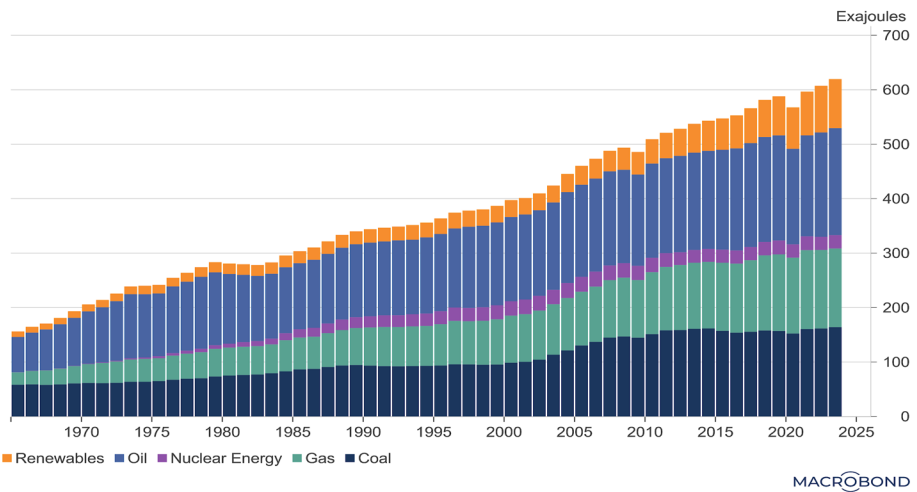


Figure 1. World Energy, Consumption, Exajoules.

Source: BP Statistical Review of World Energy, via Macrobond. Note: 1 unit of exajoules equals 277.8 terawatt hours (TWh).

The Cost of Failing to Understand the Power of Energy

The evidence is very clear that energy, which remains mostly generated by fossil fuels, is the lifeblood of the modern world, as one of the world's leading authorities on the subject, Vaclav Smil, affirms: "We are a fossil-fuelled civilisation".¹⁴ But we have failed to properly tell this story.

Young people, and many in the wider public, today are well-versed in climate change, but they have not all been told the story of energy's role in creating the modern world. Energy policy, which should be at the very heart of economic policy, has been consigned to global talkfests and the tinkering of bureaucrats out of the view of the general democratic debate.

The cost of this is that we have seen rises in energy prices and have failed to appreciate fully why this matters.

Briefly, as a primer, it is worth considering two reasons: first, rising energy prices are a significant constraint on economic growth and the health of our businesses; and second, rising energy prices hit the poorest hardest.

1. Rising Energy Prices Are a Significant Constraint on Economic Growth

Rising energy prices present a significant constraint on economic growth, particularly for energy-importing nations. Research highlights an inverse relationship between energy costs and economic performance: higher energy expenditures as a share of GDP are associated with slower or even negative growth rates.

Experts have suggested that a sustainable range for energy expenditure lies from around 5.7 to 8.7% of GDP.¹⁵ Yet, in recent years, many OECD economies have exceeded this threshold, exacerbating the economic drag. These dynamics are explored further in the accompanying report *Energy is GDP: Building Societies of Superabundance*, which underscores the critical balance policymakers must strike to ensure energy remains an engine of growth rather than a brake on progress.¹⁶

To illuminate this dynamic, it is worth spending a moment to consider the impact on businesses of rising energy prices. Businesses in the commercial, services, manufacturing, and mining sectors collectively consumed nearly four times more electricity than households in 2021–22, underscoring their substantial exposure to rising energy costs (Figure 2).

The Case of Australia

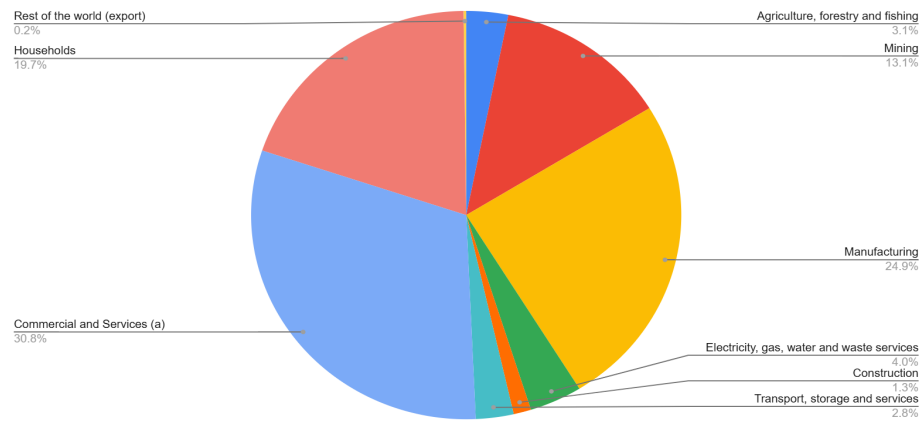


Figure 2. End use of electricity, Australia, 2021-22.

Source: Australian Bureau of Statistics (“ABS”).

Energy-intensive industries, spanning domestic and export production, are particularly vulnerable, but it is worth noting that every industry uses energy.

When businesses raise prices to offset higher energy costs, the resulting reduction in household disposable income acts as a negative demand shock, suppressing consumption. This, in turn, constrains output and revenue for businesses, creating a feedback loop that further strains economic activity. The dual burden on households and businesses, amplified by energy price increases, poses a challenge to maintaining economic stability and growth.

Empirical studies have demonstrated the significant flow-through impacts of rising energy prices on broader economic performance. A 25% shock to electricity prices, for instance, could reduce GDP by 0.8%, while a combined 25% increase in electricity and gas prices would drive a 1.2% GDP contraction.¹⁷

This observation becomes particularly revealing when assessing the current economic health of Australia, which has transitioned from having some of the cheapest energy in the world, to some of the most expensive.

Labour productivity growth, a critical measure of long-run economic health, slipped below 1% in 2022-2023, signalling stagnation.¹⁸ Business investment has remained subdued, reflecting a lack of confidence in the economic outlook. Adding to this bleak picture, in October 2024, Australia recorded over 1,300 business insolvencies—the highest monthly total on record.¹⁹ And this was off the back of 11,000 companies entering external administration in the 2023-24 financial year—a 39% increase from the previous year.²⁰

At the same time, wages growth continues to decline, leaving households with less purchasing power. The September 2024 quarter saw all five official Living Cost Indexes rise, underscoring a pervasive increase in the cost of basic goods and services. For many families, this means tighter budgets and difficult choices as they navigate escalating expenses. These pressures are not evenly distributed, with lower-income households often bearing the brunt of these changes, exacerbating economic inequality.

Another of the pronounced effects of expensive energy is the economic activity that has been lost as businesses collapse due to soaring power prices.²¹

Figure 3 lists several examples of firms that were obliged to shut down their operations due to higher energy costs in recent years.

Firms	Industry description	Energy costs impacts	Annual Revenue Lost (\$ million)	Job losses
Qenos	The only Australian producer and supplier of polyethylene and ethylene.	Energy cost increases could not be passed on to customers as customers could buy foreign goods. In 2024, the company shut down because of high energy prices.	700-900	650 jobs and 350 contractors
Beston Global Food Company	Produces cream cheese and hard cheeses such as gruyere and parmesan. It also produces lactoferrin.	Onerous energy prices were a key factor behind it entering administration. A combination of high operating costs due to energy prices, dairy prices, and a debt burden were the major issues. 22 dairy farmers' providers have been affected due to the lack of payments.	169.6	160 jobs
Incitec Pivot Limited ("IPL")	IPL is a leading manufacturer and distributor of fertilisers on Australia's east coast. The division offers a range of products, including nitrogen and phosphorus fertilisers, and services aimed at enhancing soil health and agricultural productivity.	The rising cost of natural gas—a major input in ammonia production—affected the long-term gas supply. The result was that the Gibson Island manufacturing facility was shut down after more than 50 years.	177.6	170 jobs

Figure 3. Examples of firms’ shutdowns due to energy costs in Australia.

Source: Adept Economics.

Notes: The revenue lost for IPL has been estimated using the Revenue/Employee (around \$1 million per employee) figure from IBISWorld.

Higher energy costs are also deterring investment in Australia. For example, Incitec Pivot Limited diverted a \$1 billion investment to the United States due to Australia's high energy prices.²²

The broader economic impact of business shutdowns due to energy costs is difficult to quantify precisely, but is substantial (Figure 4).

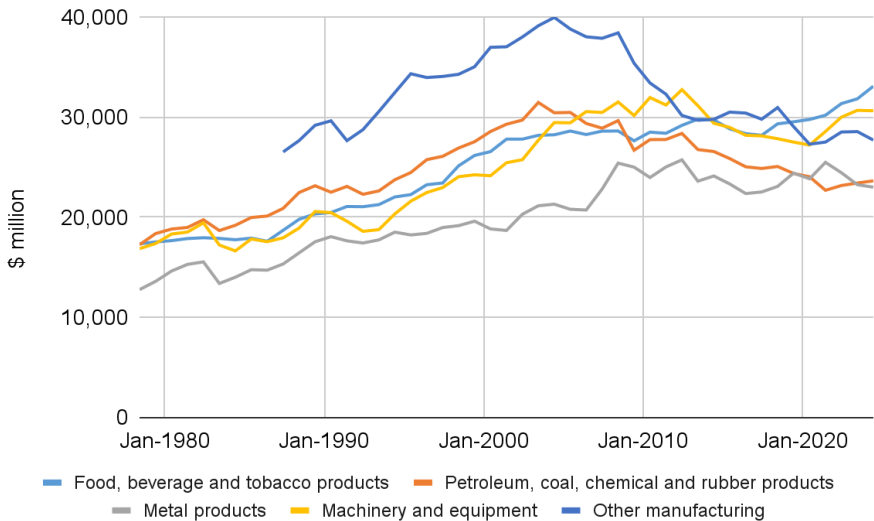


Figure 4. Gross value added by manufacturing sectors, constant prices, yearly.

Source: ABS National Accounts.

Metal manufacturing, a sector highly exposed to energy prices, has stagnated since prices began rising over a decade ago, while petroleum, coal, chemical, and rubber products manufacturing has contracted, though attribution to energy costs alone is challenging.

To estimate the potential impact, if metal manufacturing had continued its pre-2009–10 growth trend, its gross value added (“GVA”) would have been \$30.8 billion in 2023–24, \$8 billion higher than the actual \$23.0 billion. Similarly, if half the contraction in petroleum, coal, chemical, and rubber products was energy-related, an additional \$1.5 billion in GVA may have been lost.

Robson’s computable general equilibrium model estimated that a 25% increase in electricity and gas prices could reduce GDP by 1.2%. With real electricity and gas prices rising 60–70% since the late 2000s,²³ extrapolation suggests a potential **GDP impact of 3%, equating to \$81 billion in 2024–25.**²⁴ While this is illustrative and not a forecast, it underscores the significant macroeconomic risks posed by rising energy prices.

2. *Rising Energy Prices Hit the Poorest Hardest*

Rising energy bills do not only influence the economic health of the nation; they are also a mirror reflecting deeper issues of social justice, economic resilience, and human well-being. They determine whether families can heat their homes or afford the essentials of life. They shape the fate of industries, deciding which thrive and which struggle to survive. And hence they steer the direction of the entire economy, away from innovation and opportunity.

Between June 2007 and June 2024, electricity and gas prices skyrocketed by 161% and 165%, respectively, far outpacing the overall Consumer Price Index (“CPI”) increase of 58% during the same period. Adjusted for inflation, this means real price increases of 65% for electricity and 67% for gas. 59.4% of the increase in electricity prices in real terms has occurred in just the last 10 years

Using the estimates of price changes in Figure 5 and the weights of energy expenditures in the CPI calculation, we can estimate the contribution of energy price increases on CPI inflation and household budgets (Figure 6).

	Electricity	Gas	Auto. fuel	All groups
<i>Changes in prices</i>				
Change in CPI - Jun-07 to Jun-24	161.4%	164.8%	59.2%	58.3%
Real change in prices - Jun-07 to Jun-24	65.1%	67.3%	0.6%	0.0%
<i>Annual averages</i>				
CAGR (nominal)	5.8%	5.9%	2.8%	2.7%
CAGR (real)	3.0%	3.1%	0.04%	0.0%

Figure 5. Energy price changes since the late 2000s, Australia.

Source: ABS.

Notes: CAGR stands for compound annual growth rate.

	Electricity	Gas	Auto. fuel	Total
A. CPI weights out of 100 (as of late-2000s)*	1.63	0.7	3.78	6.11
<i>Contributions to CPI</i>				
B. Change in CPI - Jun-07 to Jun-24**	161.4%	164.8%	59.2%	98.6%
C. Contributions over Jun-07 to Jun-24 (A/100 x B)	2.6%	1.2%	2.2%	6.0%
D. Average annual contributions (CAGR*** of C)	0.1%	0.0%	0.1%	0.2%
<i>Real impact on household budgets</i>				
E. Real change in prices - Jun-07 to Jun-24**	65.1%	67.3%	0.6%	25.5%
F. Impact over Jun-07 to Jun-24	1.1%	0.5%	0.0%	1.6%

Figure 6. Contribution of energy price changes to CPI inflation and real impact on household budgets since the late 2000s, Australia.

Source: ABS.

Notes: *The CPI weights are from the ABS's 15th series, introduced in the September quarter of 2005. These weights were applied at the beginning of the analysis period.

**The total price changes for all household energy groups are calculated as a weighted average of the price changes, weighted by the relative contributions of electricity, gas, and automotive fuel costs to total household energy costs.

***CAGR stands for compound annual growth rate.

Between June 2007 and June 2024, the total increase in the cost of living, measured by the Consumer Price Index ("CPI"), was 58.3%. Out of that total increase, 6.1% came specifically from higher household energy costs. On an annual basis, household energy costs added approximately 0.2% to overall inflation. The real increase in household energy prices over that period—a weighted average of 25.5% across electricity, gas and automotive fuel—effectively meant a 1.6% reduction in household living standards due to higher energy costs. This is because household energy costs amounted to around 6% of household budgets.

Additionally, there were indirect impacts on CPI through the impact of energy prices on the prices of other goods and services purchased by consumers. We have used the Australian Input-Output tables published by the ABS to estimate this impact. Our calculations assume that higher costs are fully passed through to consumers in the long run. Using our model, we estimate that the real increases in electricity and gas prices reported in Table 2.1b lead to an increase in other prices of 0.8%. **This means that the total real reduction in living standards since mid-2007 was 2.4%.** Based on average

household gross income of around \$142,000, **that would correspond to a reduction in living standards of around \$3,400 per household.**²⁵

Temporary measures, like the Energy Bill Relief Fund, have offered short-term respite for households. The government's \$3.5 billion commitment for 2024–25 has helped to soften the blow, but these subsidies are merely a band-aid. The Reserve Bank of Australia has already warned that the expiration of these subsidies will trigger a resurgence in headline inflation. This cyclical pattern highlights the inadequacy of current policy approaches, which fail to address the root causes of high energy costs.

Surging energy prices are taking a heavier toll on Australia's most vulnerable households. Data from Energy Consumers Australia indicate **that households earning under \$40,000 annually allocate upwards of 6% of their income to energy expenses. In contrast, those earning over \$150,000 spend less than 2%.**

Such disparities highlight the regressive nature of energy inflation, which disproportionately affects those least equipped to absorb it.²⁶

A survey by Energy Consumers Australia (Figure 7) reveals stark inequalities: households earning less than \$20,000 annually spent 13.6% of their income on energy by December 2023. Some low-income households have resorted to cutting back on essentials, with adverse consequences for both physical and mental health. A study conducted in 2023 found that a 1% increase in electricity prices prompts low-income households to allocate an additional 0.44% of their budget to energy, while reducing food consumption by 0.09%.²⁷ The trade-off between energy and sustenance is particularly pronounced among the most vulnerable.

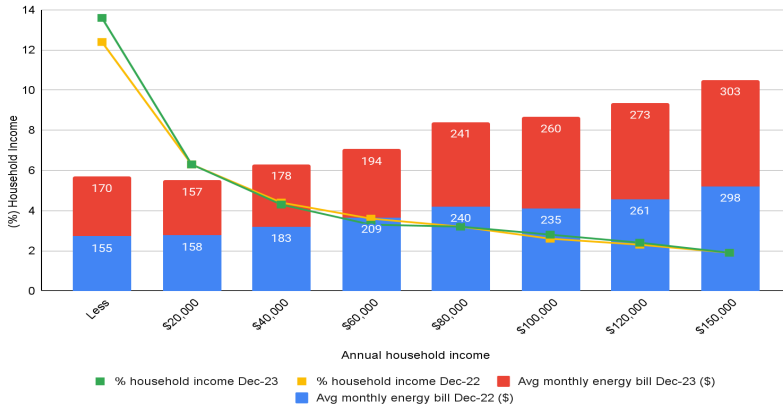


Figure 7. Proportion of Household Income Spent on Energy

Source: Energy Consumers Australia (2023, p. 3).

To make matters worse, as discussed above, the increase of energy prices for businesses are indirectly passed through to consumers through inflation in every area from food to white goods. Once more, it is those who spend more of a higher portion of their disposable income—and therefore the poorest—who are most directly exposed to these types of inflationary hikes.

Conclusion

Energy is far more than a technical issue of watts and volts, or of supply and demand—it is the foundation upon which economies grow, societies flourish, and individuals rise from subsistence to opportunity. Yet, the impact of energy policy extends beyond economics; it is deeply tied to equity, stability, and human potential.

It is important to note that **59.4% of the escalation in electricity prices in real terms has occurred in just the last 10 years**, which coincides with a dramatic shift in Australia's energy mix. Renewable energy's share of electricity generation expanded **from 8% to 34% during this same period**, a rapid transition that came with significant costs. The phase-out of dispatchable coal-fired plants has undermined grid stability, increased market unpredictability, and contributed to the surge in energy prices.

While renewable energy aligns with global climate goals, the speed of Australia's transition has exposed vulnerabilities in the energy market. Without sufficient dispatchable power to back up renewable generation, the grid has become less reliable, and consumers are paying the price. We will explore this dynamic, and how it leads to higher consumer energy prices in the following chapters.

Poorly considered energy policies, driven by short-term agendas or inadequate planning, have left Australia with rising costs, faltering industries, and widening inequality. Businesses struggle to remain competitive, households face impossible choices, and the most vulnerable bear the heaviest burdens. The economic ripple effects, from stifled innovation to reduced GDP, underline the urgency of getting energy policy right.

To ensure Australia thrives in the decades to come, energy policy must return to its rightful place at the heart of economic strategy. Policymakers need to prioritise affordability and reliability, crafting solutions that balance environmental goals with the pressing needs of businesses and households. Failure to act decisively risks entrenching disadvantage and undermining the social and economic foundations of the nation. Conversely, bold, informed energy policy can unlock growth, innovation, and opportunity, reaffirming energy as the lifeblood of a thriving civilisation.

Part 2: Energy Generation, Distribution and Regulation: The Three Decisions Determining Australian Energy Costs

Why have energy bills gone up?

While, of course, there are external forces in play, it is not our intention here to delve too deeply into them, but rather to look at the domestic drivers of prices.

To understand, we first need to unpack the complex machinery behind an energy bill. It is a web of costs—generation, transmission, distribution, retailer fees, and regulatory charges—all flowing through Australia's vast energy network.

The rise in prices is not random; it is the outcome of market shifts, aging infrastructure, and regulatory hurdles. Australia's energy market, once a beacon of affordability, is now hampered by monopolistic behaviours, overregulation, and underinvestment in

dispatchable power in the form of hydrocarbons. Meanwhile, ambitious goals for renewables face practical barriers, pushing costs further upward.

The critical point to note here is that *there are conscious choices being made* in each of the three areas in question.

These are the three areas:

1. **Generation: we must choose between reliable and intermittent sources.**
2. **Transmission and Distribution: we must choose between dense and decentralised energy.**
3. **Policy and Regulation: we must choose what to incentivise.**

The modelling in the following chapter will be informed by each of these areas. Getting this balance right is not just about economics; it is about empowering families, enabling industries, and maximising human flourishing. Affordable, reliable energy is the cornerstone of progress, and Australia's energy future depends on thoughtful, decisive action to unlock it.

Background: The Anatomy of a Power Bill

At first glance, a power bill might seem like a simple exchange for electricity consumed, but it is actually a complex recipe with multiple ingredients.

A typical power bill comprises the cost of:

- Generating the energy consumed (and associated losses);
- Acquiring and surrendering renewable energy certificates;
- The use of the very high-voltage transmission system;
- The use of the distribution system;
- The retailers' costs;
- Metering, market operation, and other costs.

At a power bill's core is the generation of energy, where power plants—whether fuelled by coal, gas, wind, or solar—produce the electricity that one uses. This process is not perfect; some energy is inevitably lost along the way, and those losses are built into the bill.

The next addition to the bill's cost is renewable energy certificates, which reflect the push towards cleaner energy. This is a de facto tax on energy usage, tied to the broader goal of decarbonisation.

Once generated, electricity needs to travel—often hundreds of kilometres—to reach homes and businesses. This is where the high-voltage transmission system comes in, moving large volumes of electricity across vast distances.

From there, distribution networks step in, converting this high-voltage power into the lower voltage used for appliances, lighting, and heating. Transmission and distribution together make up a significant portion of the bill, as maintaining and upgrading these networks is capital-intensive and increasingly expensive.

Then there is the role of retailers, the middlemen who buy electricity on the consumer's behalf from the market, manage customer service, and provide billing services. Retailers compete to win customers, but their operational costs—everything from call centres to marketing campaigns—are factored into the bill as well.

Lastly, there are the smaller but still impactful costs of metering, market operations, and regulatory compliance. Metering ensures that consumption is measured accurately, while market operations include fees for managing the intricate balancing act of supply and demand in the electricity system. Regulatory compliance, on the other hand, includes adhering to government policies, such as environmental protections or safety standards, all of which have their own price tags.

Together, these components create a power bill that reflects not just the electricity that gets used but the infrastructure, policy decisions, and market dynamics that allow the system to function. Understanding this breakdown is essential because each piece offers opportunities for reform, competition, and innovation, paving the way for more affordable and reliable energy.

Figure 8 shows a breakdown of these costs for a typical power bill in suburban Melbourne as of August 2024. The largest single cost is the cost of distribution (30%), followed by generation (28%), and then the retailer costs (21%).²⁸

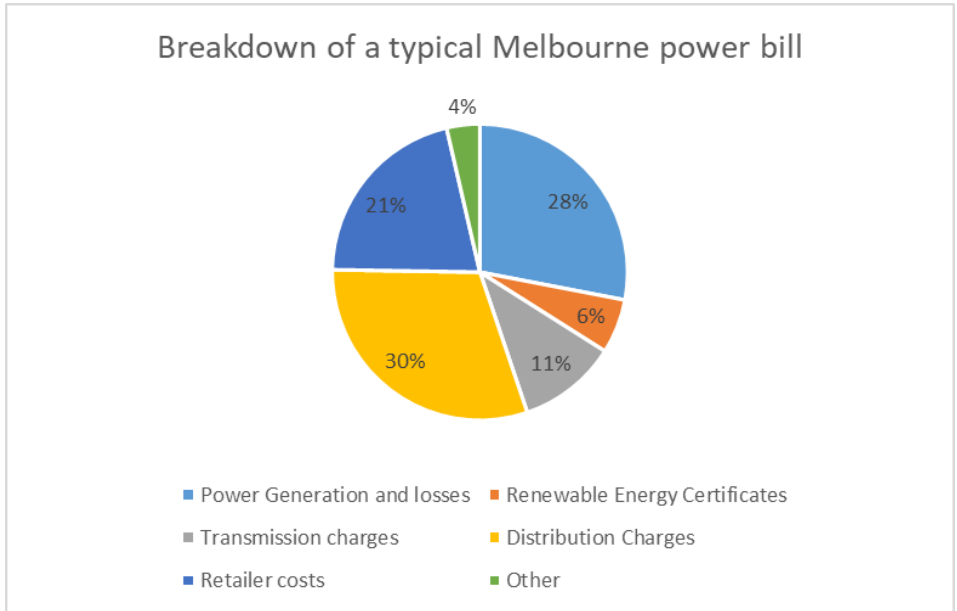


Figure 8. A breakdown of a typical Melbourne power bill.

Source: Arche Energy analysis.

Notes: 18 kWh/day consumption, transmission supply from Richmond, flat residential tariff (Origin Energy Go Variable, Single Rate quoted 28 August 2024), energy futures price accessed 16 August 2024.

Decision 1: Energy Generation: The Trade-Off Between Reliable and Intermittent Generation

Australia's electricity grid, like others worldwide, has traditionally relied on two key principles:

1. Baseload power to meet steady demand; and,
2. Dispatchable power (also known as scheduled generation) to handle variability in demand.

For example, coal-fired plants might run at reduced capacity during midday, when demand is lower, and increase output to full capacity during evening peaks. Gas turbines have also played a crucial role in providing the flexibility needed to manage

these peaks in demand. This interplay between baseload and dispatchable power has underpinned the reliable and affordable energy systems of the modern era.

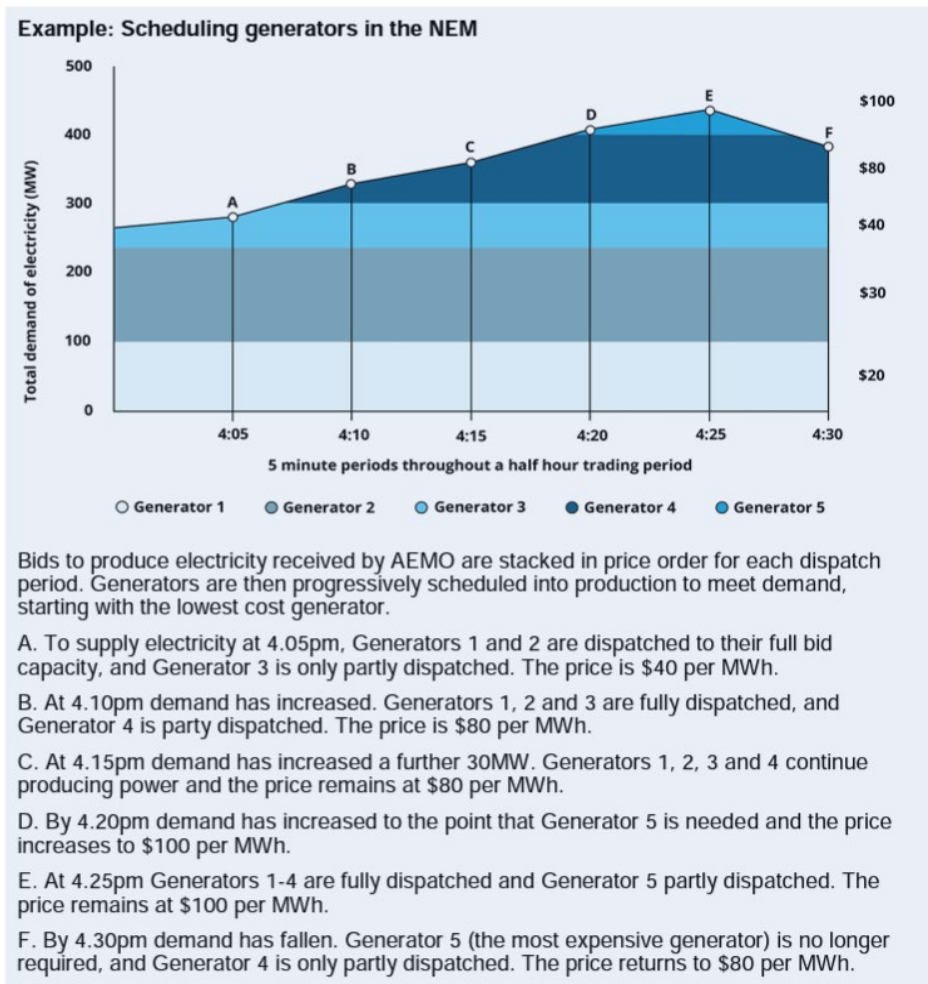


Figure 9. Scheduling Generators in the NEM.
Source: Australian Energy Market Commission, 2017.

However, the rise of renewable energy is transforming this model.

Wind and solar are inherently intermittent. They surge into the grid when conditions allow but vanish just as quickly when the sun sets or the wind slows. This unpredictability forces traditional baseload plants, designed for continuous operation, to cycle on and off, a process that undermines their efficiency and economic viability.

Over the past decade, the National Electricity Market (“NEM”) has seen its nameplate capacity grow by approximately 15,000 megawatts (“MW”). Whilst this may appear an impressive investment in new electricity generation, the majority of this expansion—around 85%—has come from intermittent renewable sources, primarily solar and wind.

In contrast, investment in baseload and dispatchable power—sources that can be controlled to meet demand—has not come close to what is needed.

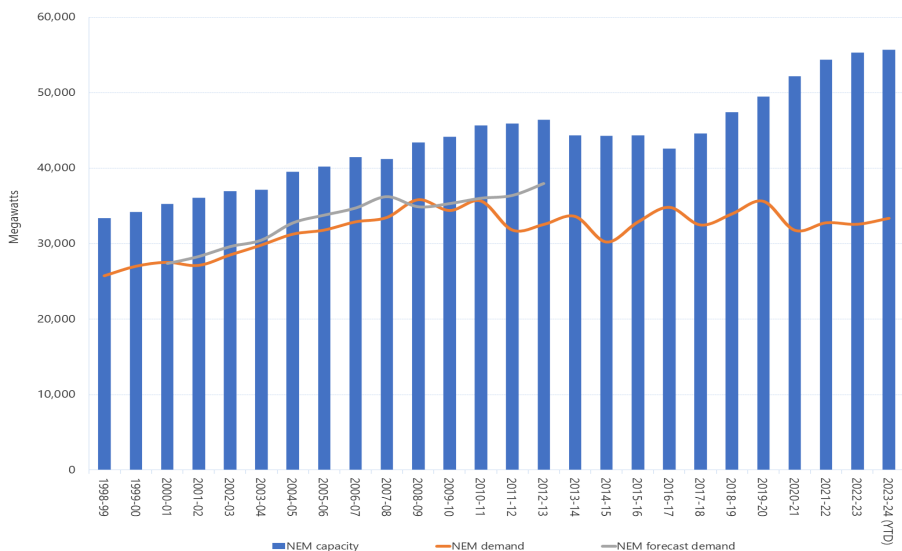


Figure 10. Annual Generation Capacity and Peak Demand—NEM.
Source: Australian Energy Regulator, 2024.

Since 2015, the NEM has only added about 2,150 MW of new dispatchable generation. Yet this modest increase has been overshadowed by the retirement of several key coal-fired power plants, which combined add up to around 4,550 MW.

These closures have resulted in a net *loss* of around 2,400 MW in dispatchable capacity.

Battery Storage and Gas Turbines have made up the majority of the dispatchable capacity that has been added to the grid. But these technologies also have their shortcomings when compared to the coal fired power stations they replaced. Batteries, which now make up 60% of this new capacity, offer only limited energy storage, typically 2 to 4 hours, compared to coal's 24/7 capability.

Gas generation, while more flexible, is significantly more expensive, with short-run marginal costs ("SRMC") ranging between \$80-\$140/MWh, compared to coal's \$16-\$30/MWh. Battery storage, whilst cheaper than gas, also comes out more expensive than coal at around \$40 to \$95/MWh after factoring the cost of charge power divided by round trip efficiency and degradation costs.

The variability of renewables has also introduced greater price volatility into the market. Wholesale prices now experience sharp spikes during low renewable generation periods, as the grid turns to more expensive backup solutions. Conversely, during oversupply, prices can plummet, even turning negative.

This volatility can destabilise the electricity market. High price spikes burden consumers and businesses, while negative prices strain the financial viability of power generators, particularly baseload and dispatchable plants that rely on steady operation.

Traditional generators are finding it harder to compete, as their profitability is undermined during periods of oversupply, even though their role remains critical when renewables fall short.

Price volatility makes long-term planning a significant challenge for policymakers and investors, as the unpredictable pricing environment undermines the ability to justify building new infrastructure that is needed to smooth out these spikes in supply and demand. The risk of never recovering the substantial upfront capital expenditure needed for these projects discourages investment in the very systems required to support a reliable and balanced grid.

For end users, these factors combined translate into higher average costs over time, as utilities pass on the expense of expensive backup generation and grid management, and retailers pass on price spikes. This has borne out in practice, with wholesale electricity prices in the NEM surging 59.4% (adjusted for inflation) over the past 10 years. This is partly the consequence of making a decision in favour of intermittent over reliable generation.

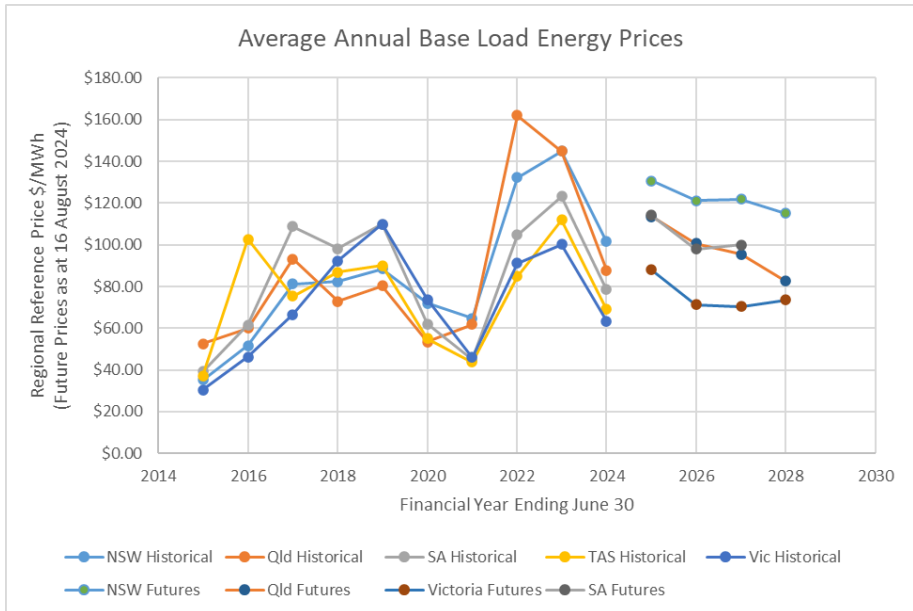


Figure 11. Average Annual Base Load Energy Prices (Historical and Futures).

Source: Futures prices accessed 16 August 2024.

When assessing the array of energy technologies vying for prominence in Australia's grid, policymakers must weigh each option against the twin imperatives of dispatchability and reliability—power that is available on demand, 24 hours a day, 365 days a year. Intermittent renewables like wind and solar falter when the sun sets or the wind abates, requiring backup systems that add complexity and cost. Technologies such as advanced battery storage, gas turbines, and emerging solutions like small modular nuclear reactors offer varying degrees of flexibility and dependability, but none yet match the uninterrupted stability of legacy coal plants. The priority must be a pathway

that guarantees power is not only plentiful but dependable under all conditions. Reliability must trump ideology in the march toward a sustainable energy future.

Decision 2: Energy Transmission and Distribution—Choosing Between Dense and Decentralised

Transmission and distribution are critical components of the electricity supply chain that deliver power from generation plants to consumers. Transmission refers to the high-voltage networks that transport electricity over long distances from power stations to regional substations. Think of transmission networks as the highways of the power system, built to deliver large volumes of electricity efficiently across vast areas, from power stations to regional substations.

Distribution, on the other hand, is the local road network that carries electricity from substations to homes, businesses, and schools. These lower-voltage lines and transformers ensure that power is delivered safely and at the appropriate voltage for everyday use.

Both systems require significant infrastructure investment and maintenance, which are major contributors to electricity bills. Rising costs in these areas reflect the need to expand and upgrade networks to handle growing demand and integrate renewable energy sources, often leading to higher charges for end consumers.

Renewable energy fundamentally reshapes the architecture of the electricity grid, demanding a decentralised network instead of the dense, centralised hubs associated with traditional coal-fired and nuclear power plants. Unlike these legacy power sources, which generate vast amounts of electricity from single, predictable locations, renewables like wind and solar are inherently dispersed.

Solar panels are scattered across rooftops, wind farms spread over vast landscapes, and energy storage systems dot the grid to stabilise supply. This decentralisation requires not only an extensive network of transmission and distribution infrastructure but also sophisticated management systems to handle the intermittent and location-specific nature of renewable generation.

While this shift opens opportunities for local energy independence and community-driven power solutions, it also introduces complexities and inefficiencies, challenging the grid's ability to maintain reliability and affordability. The contrast is stark: dense,

centralised energy systems offer scale, stability, and simplicity, while the decentralised profile of renewables demands a more intricate and costly balancing act.

Energex's 2024–25 pricing proposal, approved by the Australian Energy Regulator (“AER”), will see the average residential customer in Southeast Queensland face an annual increase of \$89.54 on their distribution charges. This represents a 14.9% rise, well above the current inflation rate.²⁹

Transmission charges for a typical Brisbane power bill are also projected to rise sharply, increasing from \$126.36 in the financial year of 2024, to \$171.16 in the financial year of 2025, a 35.5% increase in Powerlink’s cost of supplying electricity to Southeast Queensland.³⁰

This substantial escalation in distribution and transmission costs far exceeds the rate of inflation, underscoring the growing burden of infrastructure expenses on consumers. Such increases highlight the challenges of maintaining affordability as investment in distribution and transmission networks expands to support the transition to renewable energy and meet rising demand. This is partly the result of making a decision in favour of decentralised rather than dense generation.

As Australian policymakers navigate the energy transition, they must grapple with the fundamental trade-off between dense, centralised power systems and the decentralised networks necessitated by renewables. Energy-dense solutions, which deliver high output from a single site, offer a distinct advantage by reducing the need for costly grid expansion and mitigating transmission losses. Prioritising such technologies, whether through advanced nuclear, coal fired power, or high-efficiency gas plants, would not only simplify grid management but also curb the spiralling infrastructure expenses currently passed on to consumers. In the pursuit of affordability and efficiency, the energy transition must lean into density over dispersion.

Decision 3: Energy Policy and Regulation: What do we want to incentivise?

Australia’s energy sector is a paradox of abundance and inefficiency. Blessed with immense natural resources and the potential to lead in innovation, the country finds itself entangled in a web of bureaucratic inertia, monopolistic inefficiencies, and political timidity. Instead of seizing the opportunity to establish itself as a global energy powerhouse, Australia remains stuck in a system that discourages investment, stifles innovation, and fails to meet the challenges of a modern grid.

Developing energy projects in Australia can often be more akin to navigating a labyrinth than fostering progress. Regulatory hurdles, ranging from environmental clearances to native title permissions and water connections, create a seemingly endless maze of approvals. Some of these approvals include but are not limited to:

- Local or State planning approval;
- Environment Protection and Biodiversity Conservation (“EPBC”) Act referral and/or approval;
- Environmental authority approval;
- Vegetation clearing approval;
- Acquisition of offsets;
- Reconfiguration of a lot approval;
- Operational works approval for bulk earthworks;
- Cultural Heritage Management Plan approval;
- Native Title approval;
- Water connection approval;
- Environmental authority approval;
- Generator Performance Standards approval;
- Network connection application;
- Generator design data approval;
- Generator commissioning test approval; and
- Approval of construction environmental management plan and other project-related documents.

These processes are not only lengthy but also inflexible, often locking in outdated designs and discouraging the integration of new technologies. Usually by the time a project clears the bureaucratic bottleneck, years have passed, and costs have soared. Innovation, which should be the lifeblood of energy development, is stifled at every turn.

Government-owned corporations exacerbate the situation by leveraging regulatory advantages to outcompete private developers. Their dual role as regulators and competitors creates an uneven playing field, crowding out private investment and distorting the market. These corporations benefit from reduced sovereign risk and regulatory leniency, enabling them to undertake projects that private entities could never justify under the same conditions. This state-driven interference stifles competition and undermines the broader efficiency of the energy sector.

Adding to the problem is the dominance of natural monopolies in Australia's energy transmission and distribution networks. These entities, managed by Network Service Providers ("NSPs"), operate with inefficiencies that would be untenable in a competitive market. Customer delays, inflated costs, and risk-averse cultures are standard operating procedures. Moreover, NSPs often engage in "gold plating": over-investing in infrastructure to inflate their asset base and profits. This practice leaves consumers footing the bill for unnecessary upgrades, further pushing up power bills.

Layered atop these structural inefficiencies are subsidies for renewable energy projects, which—despite their good intentions—introduce additional distortions into the energy market. The Renewable Energy Target ("RET") subsidy system enables renewable energy generators to remain cash flow positive even when their output drives wholesale electricity prices into the negative. This is because the cost of subsidies, funded through certificates—Large Scale Generation Certificates ("LGCs") for large-scale renewables and Small Scale Technology Certificates ("STCs") for residential rooftop solar—is passed directly to consumers. While this structure incentivises the rapid deployment of renewable energy, it creates market distortions that obscure the true economic value of these assets.

The issue becomes particularly evident with rooftop solar. While consumers with rooftop solar save approximately \$0.23 per kilowatt-hour by offsetting their electricity consumption, the actual value of the energy generated is much lower—around \$0.06 per kilowatt-hour—based on the avoided cost of generation in the wholesale market. The excess subsidy, well above the value the asset produces, artificially supports the economics of rooftop solar and creates imbalances in the system.

A similar issue happens on a larger scale with renewable energy on the grid. Most renewable energy is produced at the same time—when the weather is ideal. This creates an oversupply of electricity, which drives wholesale prices below zero. However, thanks to subsidies under the RET, renewable energy companies can still make money, even when the market value of their power is negative. While this setup might look like it is making electricity cheaper, the truth is that the public pays for these subsidies through higher energy bills and a distorted market that does not incentivise reliable and dispatchable power.

The lack of incentive to build new dispatchable power is compounded by a political climate hostile to modernising fossil fuel technologies. Aging coal plants are being retired without viable replacements, while cleaner coal technologies and carbon capture systems face consistent rejection. Although new baseload coal-fired power

stations could potentially produce electricity at competitive costs below current wholesale prices, the near impossibility of obtaining regulatory approval deters investors, rendering such projects unfeasible.

Gas projects in Australia face similar headwinds, with regulatory disincentives including:

- A moratorium on onshore exploration in Victoria between 2012 and 2021;³¹
- A constitutional ban on hydraulic fracture stimulation and extraction of coal seam methane in Victoria (Premier of Victoria, 2021);
- A ban on seabed petroleum exploration and recovery in New South Wales (“NSW”) coastal waters (NSW Government, 2024);
- The complexity and uncertainty of the Australian environmental approvals processes;
- Legal processes holding up approval schedule timeframes; and
- The threat of a domestic gas reservation policy.

Once a moratorium or ban is in place, investors lose confidence in a jurisdiction and move on to other opportunities. It is very difficult for a state to rebuild confidence in its political stability sufficiently to attract the significant and substantial, long-term investments in development and exploration required to bring new gas reserves to the market.

Then there’s nuclear energy, which remains off-limits in Australia. Despite global advancements in nuclear technology and its potential to provide reliable, zero-carbon baseload power, outdated bans prevent even a discussion of its possibilities. The irony is hard to miss: despite the fact that Australia holds approximately 30% of the world’s known uranium reserves and exports uranium to power nuclear plants internationally, it refuses to use it domestically. This resistance overlooks the critical role nuclear energy could play in stabilising the grid, reducing emissions, and addressing the very reliability issues that threaten the energy system. Australia has made a decision via its legislation and regulations to deny itself the freedom to choose a potentially cost-effective way to have abundant energy while substantially reducing greenhouse gas emissions.

The result is a system that actively works against its own potential. Instead of fostering a competitive, innovative energy sector, Australia has built a framework that rewards inefficiency and penalises ambition. Reform is not just desirable—it is imperative. Bold leadership is needed to cut through the regulatory morass, dismantle monopolistic structures, and embrace a genuinely technology-neutral approach to energy policy.

Without these changes, Australia risks falling further behind, squandering its resources and leaving future generations to deal with the consequences of inaction. The stakes could not be higher.

Conclusion

While the spiralling cost of power in Australia stems from a tangled web of issues—regulatory hurdles, monopolistic inefficiencies, and the decline of dispatchable generation—none of these challenges are insurmountable.

Each represents an opportunity to rethink and reform how energy is produced, delivered, and governed. The stakes are high, but the solutions are within reach.

With bold policy choices and a commitment to innovation, Australia can transform its energy market into one that not only meets the needs of its citizens but maximises their potential. Affordable, reliable, and sustainable energy is not a distant dream; it is the foundation upon which we can build a flourishing, prosperous society.

Part 3: Playing Forwards the Choices we Face: Modelling Australia's Future energy pathways

In the ever-intensifying global debate over the energy transition, much of the focus has centred on comparing the costs of individual technologies, often in isolation from the wider system impacts, and often with the sole focus of decarbonisation ignoring all other potential trade-offs.

But a critical gap remains unaddressed: a rigorous system cost analysis that evaluates energy technologies within a comprehensive framework. This analysis—original in its scope—examines different policy constraints on the grid: a technology-neutral approach that allows for nuclear despite its current ban; the current path of accelerated fossil fuel closures replaced by firmed renewables; a no fossil fuel approach that aims to eliminate gas alongside coal; and a no net zero approach that deprioritises decarbonisation to analyse its impact on prices.

This undertaking is as timely as it is necessary. The energy landscape has been shaped by decades of fragmented modelling approaches that often exclude critical factors such

as transmission infrastructure and energy storage. By omitting these elements, such models have significantly underestimated the true costs of renewable technologies like solar and wind, which require extensive grid upgrades and backup systems to ensure reliability. The result has been a skewed narrative that downplays the economic challenges of a renewable-centric energy strategy.

Our analysis addresses these shortcomings head-on. By including transmission and storage costs—as well as evaluating the scalability and reliability of different technologies—we offer a clearer, more holistic picture of energy economics.

Arriving at Our Costings

In order to analyse the different pathways Australia could choose, we must first assess the different technologies that are available.

We consulted with Arche Energy³² to determine the long-run marginal costs across a range of power generation and infrastructure technologies. Arche is a clean energy, power and infrastructure advisory firm with a depth of experience in supporting the investment community to develop and execute projects. They have been involved in numerous initiatives across Australia, including the Lockyer Energy Project in Queensland, Maryvale Solar Farm in New South Wales and the Supernode Battery Energy Storage System, also in Queensland.

In forming these assumptions, we have relied on current cost data rather than forecasts, minimising the inconsistencies inherent in predicting future market conditions. Scenarios that rely significantly on renewable power also include the cost of upgrading the network (\$30/MWh) based upon the Australian Energy Market Operator (“AEMO”) estimates of additional capacity and network investment required within their planning timeframe. The reader is free to make decisions on factors such as technological improvements and scale of efficiency reducing costs or the impacts of the reduced availability of gas on the domestic market.

Based on Arche Energy’s analysis, we assume the following long-run marginal costs.

- Ultra-super critical coal (mine mouth) \$82/MWh
- Coal with carbon capture and storage (“CCS”) \$166/MWh
- CCS retrofitted onto an existing plant \$113/MWh
- Nuclear (advanced light water) \$121/MWh

● Open cycle gas	\$171/MWh (40% capacity factor)
● Open cycle hydrogen	\$448/MWh (40% cf, \$5/kg)
● Combined cycle gas	\$114/MWh
● Wind (on shore)	\$99/MWh
● Wind (offshore)	\$163/MWh
● Solar	\$58/MWh
● BESS (8 hours)	\$154/MWh (ex-charge energy)
● Pumped hydro energy storage ("PHES")	(\$162/MWh (ex-charge energy (48 hours))
● Blended firm solar/wind/gas	\$125/MWh
● Blended firm solar/wind/hydrogen	\$236/MWh
● Blended firm solar/wind/PHES	\$147/MWh
● Blended firm solar/wind/BESS	\$145/MWh

These assumptions are further detailed in the Appendix.

To arrive at our figures for nuclear and coal, given the lack of recent project data in Australia, we applied the following methodology.

Coal

Aurecon, an international engineering, design and advisory company estimate a capital cost of \$4.7M/MW on the basis of an advanced ultra-supercritical plant (state of the art, excluding land and development costs).³³ However, this is contrasted with more recent benchmarks from India (which continues to build state-of-the-art coal-fired power plants, such as the Kharagone Power Plant in Madhya Pradesh) in the order of \$1.5M/MW for an ultra-supercritical plant.³⁴ If the Indian estimate is doubled to allow for Australia's higher construction costs it is conceivable that an ultra-super critical plant could be constructed for a cost in the order of \$3M/MW.

Benchmarks for non-CCS coal plant data worldwide gives a cost of approx. \$3.7M/MWe in Australia, with a range of as low as \$1.2M/MWe in China and as high as \$7.1M/MWe in the USA (Figure 12).³⁵

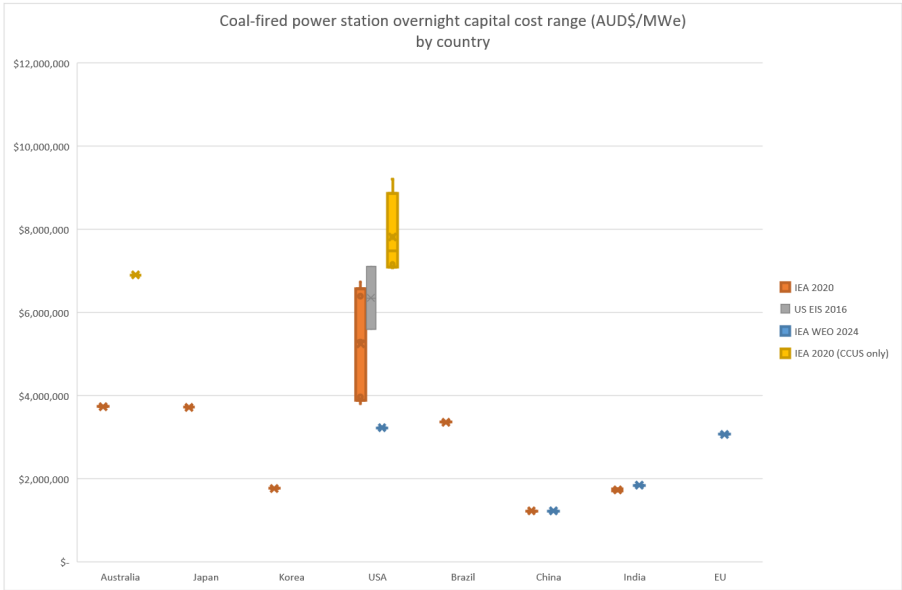


Figure 12. Coal-fired power station benchmark overnight capital costs.

Source: IEA (2020), US EIA (2016), IEA WEO (2024).

Arche estimates the long run marginal cost of a new, state of the art plant operating as a mine mouth power station on an existing site (such as Kogan Creek) could be in the order of \$52 to \$86/MWh. Key assumptions include:

- Caloric value ("Cv"):
 - Cost of mining:
 - Heat rate:
 - Variable O&M:
 - Land and development:
 - Capex (EPC):
 - Fixed O&M:
 - Availability:
 - Life:
 - WACC:
 - A willing and supportive political climate, so the project is not held up by unnecessary delays.
- | |
|-------------------------------|
| 23 GJ/kg (HHV), |
| \$30-50/tonne, |
| 8,548 kJ/kWh HHV, sent out |
| \$4.46/MWh |
| 5% of capital expense (capex) |
| \$3,000,000 to 4,680,000/MW |
| \$39,474 to 56,392/MW/annum |
| 91% |
| 30 to 50 years |
| 8% real |

Coal and Carbon Capture

The deployment of CCS technologies for ultra-supercritical coal plants presents a costly yet low-emission solution. Arche Energy estimates long-run marginal costs (“LRMC”) for new ultra-supercritical coal plants with CCS between 130–190/MWh, with carbon emissions reduced by up to 95%. Retrofitting existing plants, such as Kogan Creek, is slightly cheaper, with an LRMC of 113/MWh.

Nuclear

Like a new coal plant, it is impossible to develop a benchmark competitive cost of construction for a nuclear power plant in Australia without a set of developers, constructors, and regulators who are willing and enthusiastic supporters of the project.

Recent benchmarks from India—which continues to build state of the art nuclear power plants, such as the Karkarapar Power Plant Phase II in Gujarat, a set of Indian Pressurised Heavy Water Reactors (“IPHWR”)—are in the order of \$2.1M/MW for a IPHWR and \$3.4M/MW for a pressurised light water reactor (“PWR”).³⁶

Exhibit 3.6 summarises overnight construction for nuclear, from data gathered over the past 70 years resulting from the Centre for Independent Studies’ (“CIS”) recent survey.

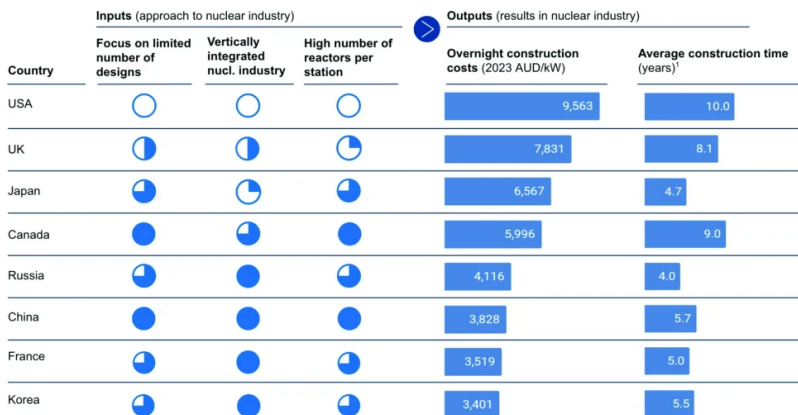


Figure 13. Summary of the CIS’s survey of overnight construction costs for nuclear over the past 70 years.
Source: Morrison, 2024.

Other benchmark data, shown in Figure 14, indicates that overnight capital costs for nuclear power stations range from \$10.6M/MWe from the Slovak Republic in the EU, down to as low as \$3.3M/MWe in South Korea.³⁷

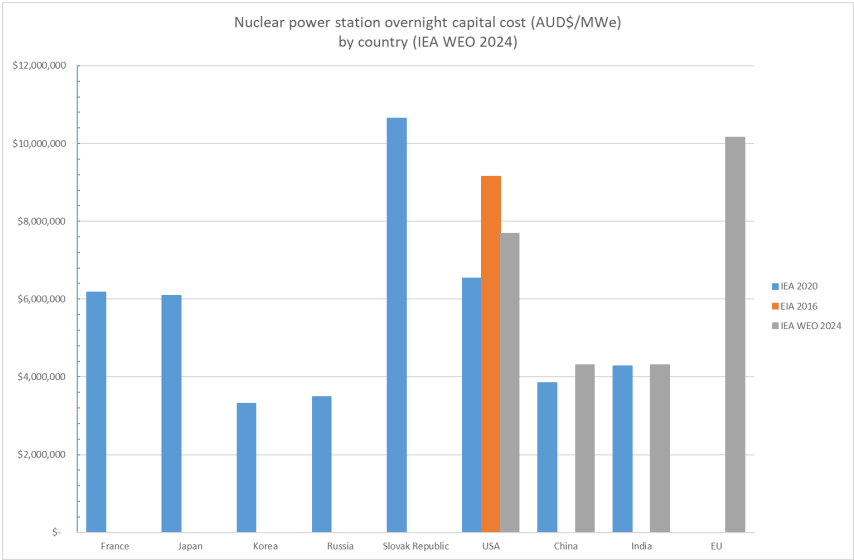


Figure 14. Nuclear power station benchmark overnight capital costs.
Source: IEA (2020), US EIA (2016), IEA WEO (2024).

The above data indicates that, in Australia, a capital cost estimate (nth of a kind, i.e., after the cost of coming down the learning curve) in the order of \$4-7M/MW would be plausible. This results in a long-run marginal cost estimates in the order of \$65 to \$115/MWh based upon the following assumptions:

- Capex: \$4-7M/MW
- Fixed Opex: \$90,000-150,000/MW per annum
- SRMC: \$15 to \$22 per MWh
- Life: 50 years
- WACC: 5% to 8% real
- Availability: 90-95%
- Nth of a kind (i.e., costs after Australia has built several plants and has come down the learning curve).
- Accepting and learning from other projects.

Every Path Has its Trade-Offs

Every energy technology comes with its own trade-offs, and any pathway chosen will involve navigating technical, political, and societal challenges. Expanding coal-fired generation, for example, would necessitate a fundamental reassessment of Australia's emissions reduction targets. Such a shift would require substantial political capital to forge alignment between government priorities and public sentiment. Moreover, to instill the confidence necessary for long-term private sector investment, clear and stable policy signals would be essential—something that has often proven elusive in Australia's energy landscape. Without these assurances, the financial risks of new coal projects could deter investors, leaving the sector mired in uncertainty.

Similarly, pursuing nuclear power as a low-carbon alternative would demand overcoming entrenched regulatory and political barriers. The current moratorium on nuclear energy would need to be lifted, requiring bipartisan federal support as well as significant collaboration between state and local governments. Identifying suitable sites for nuclear plants would also be a contentious process, with considerations spanning environmental impact, community acceptance, and logistical feasibility. Achieving consensus on these fronts would necessitate a unified vision and a well-orchestrated national strategy, ensuring that nuclear energy is not just legally permissible but also practically deliverable within the broader energy transition framework.

At the core of Australia's energy transition lies the challenge of addressing intermittency and differing capacity factors, which fundamentally shape the cost structure of the evolving grid. While modest levels of intermittent renewables can be integrated with relative ease, scaling up to higher penetration levels introduces complexities that require additional infrastructure to maintain reliability. Complementary systems—such as energy storage, upgraded transmission networks, or flexible backup generation—become essential to ensure consistent supply.

Our full system cost analysis stands apart because it accounts for these factors, enabling a detailed understanding of the infrastructure required to reliably deliver 1 MW of power.

For example, consider the challenge of meeting a simple 24/7 baseload demand of 1 MW:

- **Coal-fired generation:** A baseload coal plant operating at full capacity provides the required 24 MWh daily demand with near-perfect demand-supply matching, needing just 1 MW of nameplate capacity.
- **Renewables with gas backup:** A system combining a 1 MW solar farm, a 1 MW wind farm, and a 1 MW gas plant could meet the same demand by balancing their outputs. However, this configuration requires 3 MW of total capacity—triple the coal plant’s capacity—due to the intermittency of solar and wind.
- **Renewables with storage:** Using energy storage instead of gas backup demands an even larger build-out of wind and solar capacity to compensate for storage losses and ensure reliability. Meeting the same 1 MW baseload would require approximately 4.3 MW of generation capacity. Additional storage depth would also be necessary to withstand extended periods of low wind or solar output, further increasing infrastructure needs and costs.

By incorporating these considerations into our modelling, we provide a comprehensive view of the real-world demands—technological, logistical, and financial—of Australia’s potential energy pathways. This approach ensures a clearer understanding of what it truly takes to deliver reliable, affordable energy in a rapidly changing grid.

The Choices Before Australia

This analysis builds on the detailed costings in the previous section to assess the full system cost of the pathways available to Australia. It seeks to model the potential impacts of these differing approaches on retail energy prices and, by extension, the broader economy.

The starting assumption is that the scale of investment will be sufficient to replace the balance of coal-fired capacity currently operating on the National Electricity Market (NEM)—approximately 21,000 MW.

The scenarios before Australia represent starkly different visions of the future:

1. **“No net zero” path:** A pathway in which coal remains the primary energy source, supplemented by gas where necessary, without the imposition of carbon pricing or Safeguard Mechanism constraints. This approach would

likely deliver the cheapest short-term electricity prices but would require a significant political realignment to broker consensus with the public and broader emissions reduction reforms.

2. **Tech Neutral “Low-carbon baseload”:** A technology-neutral pathway prioritising cheap baseload power while leveraging nuclear energy and CCS. This scenario balances decarbonisation with affordability, unlocking nuclear’s potential as a stable, low-emissions energy source.
3. **The Current Trajectory- Renewables with storage:** Reflecting the current trajectory, this approach expands renewable energy generation, complemented by BESS and PHES, alongside accelerated coal fire power station closures. While technologically feasible, it requires substantial investment in transmission infrastructure and energy storage, pushing system costs—and retail prices—higher.
4. **Accelerated renewables:** The most ambitious pathway, this scenario envisions a grid reliant entirely on renewables and storage, eliminating coal, gas, and nuclear energy. It assumes vast expansions of renewable capacity and storage depth, with significant upfront costs, higher risks of supply volatility, and long-term economic consequences.

Scenario 1—“No Net Zero” Path

This scenario seeks to strip back the layers of regulation, subsidies, and policy-driven distortions to reveal the simplest, least restricted pathway for Australia’s energy future. By focusing purely on economic fundamentals—long-term wholesale power prices as the driver of investment—this approach uncovers the cheapest possible route to meeting the nation’s energy needs.

While it does not advocate abandoning net-zero goals, it serves as a comparative analysis of the costs associated with a historically coal-based system versus lower carbon dioxide emitting alternatives.

Under this scenario, ultra-supercritical coal plants, located at mine mouths in regions such as the Surat Basin, Hunter Valley, and La Trobe Valley, would dominate new capacity investments due to their status **as the lowest-cost baseload option**. Long-term average power prices would align with the LRMC of new coal, estimated at \$50–100/MWh.

Replacing the entire 21,000 MW fleet of coal-fired power plants in the NEM with new ultra-supercritical coal plants would require an estimated capital investment of **\$103 billion**.

The scenario underscores the relatively low-cost advantage of coal-based systems in the absence of carbon pricing or emissions reduction incentives, contrasting sharply with the capital-intensive and policy-driven nature of alternative energy systems.

Scenario 2—Technology-Neutral “Low-Carbon Baseload” Path

This scenario assumes a continuation of Australia’s current commitment to Net Zero by 2050 and would require the lifting of the moratorium on nuclear power generation in Australia, as well as a pausing of the current accelerated rollout of renewable technologies. Despite requiring a longer lead in time, this scenario is not only cheaper than Australia’s current trajectory, but would be more likely to achieve a Carbon Neutral energy grid.

To pursue a pathway that prioritises long-term decarbonisation by 2050, Australia would need to reconsider its current renewable energy targets for 2030. These shorter-term goals, while ambitious, risk placing undue strain on households and industry by accelerating the transition within an arbitrary time frame. By shifting the focus to achieving net-zero emissions over a longer horizon, the nation can implement a more measured approach, ensuring that infrastructure is built efficiently, costs are minimised, and energy reliability is maintained.

This revised timeline would align policy objectives with economic realities, mitigating potential price shocks and energy shortages that could arise from a rushed transition. It would also provide industry with the certainty and lead time needed to adapt, allowing businesses to plan investments and operations without the looming pressure of near-term deadlines. Under this scenario, technological neutrality would be key, fostering a diverse energy mix that includes nuclear, renewables, and other low-carbon options while keeping the needs of the general public and industrial competitiveness at the forefront.

Under these conditions, nuclear power, specifically advanced light water reactors in our modelling, emerges as the most cost-effective option for baseload, low-carbon electricity generation.³⁸ Long-term average energy prices for such systems are

projected in the range of **\$100–150/MWh**, according to the cost estimates outlined earlier.

Given the competitive price range, investments in other forms of low-carbon energy—such as wind, solar, and CCS—would also be viable. Projects offering specific advantages, such as superior resources, excellent grid connectivity, access to existing infrastructure, or proximity to carbon sequestration fields, would likely be prioritised over less strategically positioned ventures.

The \$100–150/MWh cost range is expected to foster intense competition among investors and technology providers, incentivizing innovation and cost reductions across the sector.

Replacing the NEM’s existing 21,000 MW fleet of coal-fired power plants with advanced light water reactors would require an estimated capital investment of **\$163 billion**. While the initial costs are significant, such a system could achieve net-zero emissions.

Scenario 3—Current Path: Coal Retirement Replaced with Renewables And Firming

Australia’s current energy trajectory, centred on phasing out coal in favour of renewables and firming technologies, is a paradox of ambition and inefficiency. This scenario lays bare an uncomfortable reality: the path Australia is on is both more expensive than viable alternatives and less likely to achieve the decarbonisation it promises.

While policies at state and federal levels aim to replace coal with a mix of solar, wind, storage, and gas, the costs of this approach—bolstered by the need for extensive new infrastructure—are staggering. At the same time, the reliance on intermittent renewables and insufficient storage raises doubts about its ability to reliably and effectively meet Australia’s climate goals.

State and federal schemes, such as the Capacity Investment Scheme, aim to support specific technologies deemed likely to meet future energy needs. While gas is excluded from the Federal Capacity Investment Scheme, it is assumed that state-level programs, such as New South Wales’ Long-Term Energy Service Agreements (LTESA), will facilitate sufficient gas capacity to supplement renewables and storage.

The shift to renewables will necessitate the development of new Renewable Energy Zones (REZs). Based on publicly available data from the NSW REZ program, the added cost for these zones is estimated at \$10/MWh on a baseload equivalent basis. The system's blended cost profile reveals significant shifts in cost-effectiveness:

- Solar and wind firmed with gas represent the lowest-cost firmed system, with a blended cost of \$135/MWh, including REZ infrastructure expenses. However, with limited new gas resource development, rising gas prices are expected to make BESS and PHES increasingly attractive alternatives.
- Onshore wind availability will face constraints as high-resource sites are depleted and land use or community opposition limits new developments.
- Over time, the marginal new entrant baseload system will likely become offshore wind firmed with BESS, with a new entrant price of \$169.95/MWh, driving long-term average energy prices into the \$150–200/MWh range.

Replacing the 21,000 MW of coal-fired capacity in the NEM with a blended system of offshore wind, solar, gas, BESS, and PHES would require an estimated **\$272 billion** in capital investment. Notably, the storage assumptions in this scenario are based on 8-hour storage durations, raising concerns about the adequacy of storage capacity to manage prolonged periods of low solar and wind availability.

As there is no specific driver for carbon emission reduction, this system would not necessarily achieve net zero.

Scenario 4—Accelerated Path: 100% Renewables, No Natural Gas Firing

This is the vision many advocates of a fossil-free future champion: a bold leap to a 100% renewable energy system, free from coal, oil, and natural gas. This scenario paints a picture of an accelerated transition powered entirely by solar, wind, and storage technologies like batteries and pumped hydro, with hydrogen emerging as the green alternative for firming. It is an ambitious blueprint, reflecting the aspirations of those who seek a complete decarbonisation of Australia's energy system.

Yet, as this analysis reveals, achieving such a future comes with formidable challenges: massive upfront costs, technological constraints, and critical questions about reliability and storage adequacy.

While structurally similar to Scenario 3, this scenario replaces natural gas with green hydrogen, generated from renewable energy. The competitiveness of hydrogen firming depends heavily on production costs. At a price of \$5/kg, hydrogen is unlikely to compete effectively with BESS and PHES. However, if production costs decline to \$2/kg, hydrogen firming could become a viable alternative.³⁹

Long-term prices in this scenario are expected to be driven by the LPMC of blended renewables and storage systems, with outcomes broadly comparable to those in Scenario 3. However, the accelerated nature of the transition introduces potential inefficiencies in project delivery. While these inefficiencies are not quantified, they could raise costs or delay implementation.

Replacing the NEM's existing 21,000 MW coal-fired fleet with a system based entirely on renewables and firming would require significant capital investment:

- \$238 billion: Assumes no offshore wind and all firming provided by BESS.
- \$326 billion: Assumes all wind generation is offshore and all firming is provided by PHES.

The wide cost range reflects the varying infrastructure requirements and technological choices involved in the transition.

As in Scenario 3, storage assumptions rely on 8-hour BESS durations, raising concerns about the adequacy of long-duration storage to address extended periods of low solar and wind output. Insufficient long-term storage capacity remains a critical risk, particularly in a system with no fossil fuel backup.

Based on the projections outlined, the penetration of intermittent renewable energy into the NEM at very high levels is expected to drive long-term average wholesale power prices into the range of **\$150 to \$200/MWh** (inclusive of large-scale generation certificates ("LGCs")). This forecast assumes sufficient availability of land for renewable projects and continued exploration and development of gas fields.

Summary of Scenarios

The "No Net Zero" scenario, relying on ultra-supercritical coal, presents the lowest capital expenditure at \$103 billion and offers wholesale electricity prices between \$50

and \$100/MWh. **Retail prices could drop by as much as 25%**, delivering short-term economic relief.

A technology-neutral approach that incorporates nuclear power presents a compelling alternative. With a capital expenditure of \$163 billion, nuclear provides a relatively modest retail price impact—**ranging from a 4% decrease to a 35% increase**—and wholesale prices between \$100 and \$150/MWh. While the upfront costs are significant, nuclear offers a stable, low-emission energy source. However, the lack of political and regulatory appetite for nuclear energy in Australia makes this pathway an uphill battle.

Australia's current policy direction favours a blend of offshore wind, solar, and BESS. This approach carries a hefty price tag: \$198 billion in Capex and an additional \$30/MWh in transmission costs, bringing the total to \$261 billion. Retail prices are likely to continue to rise between 30-69%, with wholesale prices ranging from \$150 to \$200/MWh, which could mean a further **reduction of 1.44%- 3.31%** of Australia's future GDP. Alarming, this pathway may fall short of achieving net zero while compromising energy security—a sobering prospect given the stakes.

The most ambitious option—a 100% renewable grid—commands an eye-watering \$255 billion in Capex and \$77 billion in additional transmission costs, totalling \$332 billion. Retail electricity prices could **soar by up to 69%**, mirroring Australia's current pathway, with similar concerns about energy reliability. While this scenario aligns with Australia's long-term climate goals, the trade-offs in affordability and grid stability raise serious questions about its feasibility.

Scenario	1. No net zero	2. Technology neutral	3. Current pathway	4. 100% Renewables
Marginal new entrant base load technology	Ultra Super-Critical (USC) Coal	Nuclear	Blended offshore wind and solar firmed with BESS	Blended offshore wind and solar firmed with BESS
Capex to replace 21 GW baseload[1] (\$Bn)	103	163	198	255
New entrant price (\$/MWh)	\$82.35	\$120.77	\$169.95	\$169.95
Wholesale price range (\$/MWh)	\$50 to 100	\$100 to 150	\$150 to \$200	\$150 to \$200
Additional Transmission (\$/MWh)	\$0	\$0	\$30	\$30
Retail price impact [2]	-25% to 13%	-4% to 35%	30% to 69%	30% to 69%
Other comments	For comparison only.		Will not necessarily meet net zero. Likely reductions in energy security.	Likely reductions in energy security.
Additional transmission CAPEX (\$Bn)			63	77
Total additional CAPEX (\$Bn)	103	163	261	332

Figure 15. Summary of scenarios

Notes: (1) Generation capex only; excludes transmission costs. Ignores relative lifetimes of different technologies. (2) (%) of usage charge of a typical Melbourne household power bill.

Conclusion—Abundant Energy and a Pro-Human Future

Australia stands at a crossroads. It seeks low emissions but is sacrificing cheap energy and a thriving society. The narrow pursuit of a grid dominated by intermittent renewables without considering low emissions technologies such as nuclear or coal with CCS has revealed cracks in the form of soaring costs and questions about reliability.

The stakes are far greater than electrons and watts; this is ultimately a debate about lives—about whether we enhance human potential or hold it back in the name of narrow priorities. Energy is the lifeblood of progress, driving everything from education to healthcare, from industrial innovation to basic household comforts. When energy is abundant and affordable, societies flourish. When it is scarce or expensive, the ripple effects stifle opportunity, deepen inequality, and constrain the human spirit.

Australia does not have to choose between low emissions and both cheap energy and a thriving society. A technology-neutral approach—free from self-imposed and economically harmful constraints—can deliver a system that meets environmental goals without pricing ordinary people out of a prosperous future. A truly balanced energy policy must embrace the full spectrum of solutions, from renewables and advanced battery technologies to clean coal and, critically, nuclear power.

The energy transition is not just about meeting carbon targets; it is about building a system that enhances lives. Wise policies that welcome innovation and prioritise human flourishing can foster environmental stewardship, cheap energy, and a thriving society simultaneously. The real question is not whether we can achieve this balance; it is whether we will choose to.

Appendix. Arche Energy's Cost Estimate Assumptions and Results

LEMIC Calculations									
	OCGT Hydrogen	Source	CCGT	Source	BESS 8 Hour	Source	PHES 48 hours	Source	Solar
Calorific Value (GJ)									
MJ/kg (HHV)	141.7 Fact			1.11 Assumption					
HHV/LHV	1.18 Fact								
MJ/kg (LHV)									
Efficiency									
Heat Rate (LHV Sent out)	9,766 Assumption			85% Aurecon					
Heat Rate (HHV Sent out)									
Fuel rate				6,385 Aurecon					
Fuel cost									
Fuel cost	\$5,000 Assumption								
Fuel cost	\$35 Calculation			\$12 Assumption					
Exchange rate (AUD/USD)									
Fuel cost	0.65 Assumption			0.65 Assumption					
Variable Operations & Mtce costs (VOM)	\$406.92 Calculation			\$85.05 Calculation					
CO2 storage and transport cost (10 km)	\$7.70 Assumption			\$3.90 Aurecon					
CO2 rate									
CO2 recovery									
CO2 storage and transport cost (200 km)									
SRMC	\$414.62			\$88.95					
Capex (EPC)	\$1,040,000 Assumption			\$1,950,000 Aurecon					
Landed and development									
Total capex	\$1,092,000 Calculation			5% Assumption					
Fixed operations & mtce costs (FOM)	\$13,360 Assumption			\$2,047,500 Calculation					
Life	25 Assumption			\$11,560 Aurecon					
WACC (Real)				25 Aurecon					
Capital charge				8% Assumption					
Total	\$102,297.23 Calculation			\$191,807.30 Calculation					
Capacity factor				\$430,452.30 Calculation					
Production	\$115,657.23 Calculation			\$450,152.90 Calculation					
Fixed costs	40.0% Assumption			33.3% Aurecon					
SRMC	\$304 Calculation			8322 Calculation					
LCOS (ex-charge costs)	\$33.01 Calculation			\$24.44 Calculation					
Net carbon intensity	\$414.62 Calculation			\$88.95 Calculation					
Cost of carbon abatement v USC Coal	\$447.62 Calculation			\$113.39 Calculation					
Base load capacity to be replaced									
Capex									

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⁵ “Selected Living Cost Indexes, Australia”, *Australian Bureau of Statistics*, accessed November 2024, <https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/selected-living-cost-indexes-australia/latest-release>.

⁶ “Productivity”, *Australian Bureau of Statistics*, accessed November 2024, <https://www.abs.gov.au/statistics/measuring-what-matters/measuring-what-matters-themes-and-indicators/prosperous/productivity>.

⁷ “ASIC insolvency data shows in increase in companies failing”, *Australian Securities and Investments Commission*, accessed November 2024, <https://asic.gov.au/about-asic/news-centre/find-a-media-release/2024-releases/24-077mr-asic-insolvency-data-shows-increase-in-companies-failing/>.

⁸ “Australian forecasts – inflation slowing but not fast enough, govt spending props up economy”, *AIGroup*, accessed November 2024, <https://www.aigroup.com.au/resourcecentre/research-economics/economics-intelligence/2024/australian-forecasts-november-2024/>.

⁹ Ibid.

¹⁰ See: Rob Henderson, “The Grand Canyon-Sized Chasm Between Elites and Ordinary Americans”, *Rob Henderson’s Newsletter*, <https://www.robkhenderson.com/p/the-grand-canyon-sized-chasm-between>.

¹¹ All calculations of cost in this paper are in Australian dollars (“AUD”).

¹² Robert Bryce, “Powering the Unplugged: Overcoming the Barriers to Electrification in the Developing World”, *Alliance for Responsible Citizenship*, October 2023, p.4, <https://www.arcforum.com/research-papers/powering-the-unplugged>.

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¹⁴ Vaclav Smil, *How the World Really Works: A Scientist’s Guide to Our Past, Present and Future*, 2022.

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¹⁸ “Productivity” *Australian Bureau of Statistics*, accessed November 2024, <https://www.abs.gov.au/statistics/measuring-what-matters/measuring-what-matters-themes-and-indicators/prosperous/productivity>.

¹⁹ G. Bullo, A. Chinnery, S. Roche, E. Smith, & P. Wallis, (2024). “Small business economic and financial conditions” *Reserve Bank of Australia: Bulletin*, 17 October 2024, <https://www.rba.gov.au/publications/bulletin/2024/oct/small-business-economic-and-financial-conditions.html>.

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²¹ The higher energy costs are also an important factor that restrains the development of small firms, which are around 98% of total businesses in Australia. Higher logistics, energy, and insurance costs are contributing factors of elevated operating costs for small firms, as noted by the Small Business Finance Advisory Panel, see: G. Bullo, A. Chinnery, S. Roche, E. Smith, & P. Wallis, (2024). “Small business economic and financial conditions” *Reserve Bank of Australia: Bulletin*, 17 October 2024, <https://www.rba.gov.au/publications/bulletin/2024/oct/small-business-economic-and-financial-conditions.html>.

²² Alex Robson, “It doesn’t have to be this way: Australia’s energy crisis, America’s energy surplus” *United States Studies Centre at the University of Sydney*, December 2018.

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²⁴ This is based on Australia having an estimated \$2.7 trillion yearly GDP as reported by the ABS in the National Accounts.

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²⁷ Jane Fry, Lisa Farrell, and Jeromey Temple, “Energy poverty and food insecurity: Is there an energy or food trade-off among low income Australians?” *Energy Economics*, 2023-07, Vol. 123, p. 106731-15, Article 106731.

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³² See <https://archeenergy.com.au/>

³³ “AEMO Costs and Technical Parameter Review”, *Aurecon*, 2024, <https://www.aurecongroup.com/projects/energy/aemo-cost-parameters-report>.

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³⁹ The theoretical limit of the minimum power required to electrolyse 1 kg of hydrogen is 39.4 kWh; meaning that the maximum cost of power required to achieve \$2/kg (if all other costs, including capital are zero) is \$50.70/MWh, less than the LRMC of a new solar farm.



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