Draft Inputs and Assumptions Report – Stage 2

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About the Justice and Equity Centre

The Justice and Equity Centre is a leading, independent law and policy centre. Established in 1982 as the Public Interest Advocacy Centre (PIAC), we work with people and communities who are marginalised and facing disadvantage.

The Centre tackles injustice and inequality through:

- legal advice and representation, specialising in test cases and strategic casework;
- research, analysis and policy development; and
- advocacy for systems change to deliver social justice.

Energy and Water Justice

Our Energy and Water Justice work improves regulation and policy so all people can access the sustainable, dependable and affordable energy and water they need. We ensure consumer protections improve equity and limit disadvantage and support communities to play a meaningful role in decision-making. We help to accelerate a transition away from fossil fuels that also improves outcomes for people. We work collaboratively with community and consumer groups across the country, and our work receives input from a community-based reference group whose members include:

- Affiliated Residential Park Residents Association NSW;
- Anglicare;
- Combined Pensioners and Superannuants Association of NSW;
- Energy and Water Ombudsman NSW;
- Ethnic Communities Council NSW;
- Financial Counsellors Association of NSW;
- NSW Council of Social Service;
- Physical Disability Council of NSW;
- St Vincent de Paul Society of NSW;
- Salvation Army;
- Tenants Union NSW; and
- The Sydney Alliance.

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The Justice and Equity Centre office is located on the land of the Gadigal of the Eora Nation.

Contents

1 Introduction

The Justice and Equity Centre (JEC) welcomes the opportunity to respond to the Australian Energy Market Operator's (AEMO) Draft 2025 Inputs and Assumptions Report Stage 2 (the draft report).

We reiterate the perspectives provided in response to Stage 1 of this process in relation to the plausibility of scenarios. Stage 2 introduces much more detail about assumptions relating to hydrogen and carbon sequestration. These do not alter our assessment that neither of the Green Energy variants are plausible, or our position that if one must be taken forward it should be the Green Energy Industries variant.

However, with the full details of the scenario now available, we consider the Green Energy Industries variant can be rendered plausible by:

- substantially reducing the expectations concerning the deployment of hydrogen and direct air capture (DAC),
- increasing the expectations in other pillars – notably take up of energy efficiency and electrification, and
- removing the assumptions of technological breakthroughs in hydrogen and DAC and replacing them with assumptions of technological breakthroughs in areas where they are both much more likely to happen – storage and energy efficiency – and face much lower barriers to efficient deployment when they do.

We also caution against using carbon budgets in isolation from other modes of investment option assessments on the grounds that doing so risks embedding complacency in planning and subverting the intentions of the emissions reduction element of the National Electricity Objective. As we will show, that intention is for energy planning and governance to be proactive rather than reactive, driving decarbonisation of the wider economy.

2 Scenarios and sensitivities updates

Consultation question:
Do you have any further views on the proposed sensitivities? What additional uncertainties are valuable to explore with sensitivity analysis?

In our submission to IASR stage 1, we argued that neither of the two green variants are plausible. We noted that if one was to proceed to the Delphi Panel process, it should be the Green Energy Industries variant.

We maintain this position, but provide further detail below on the implausibility of the two variants in light of the information provided in IASR stage 2.

In addition, we make recommendations to improve the plausibility of the Green Energy Industries variant – namely by revising upwards the assumptions relating to electrification and energy efficiency and assuming technological breakthroughs in areas where they are likely to occur.

The JEC supports the inclusion of a scenario that is based on the emergence of technological breakthroughs. To assume there will be none is, itself, unreasonably pessimistic. However, it is much more likely that the material technological breakthroughs that will impact the period to 2050 are in areas already benefiting from substantial innovation and commercialisation, namely storage and energy efficiency. Importantly, these are areas where there are few barriers to efficient deployment of breakthroughs, unlike hydrogen and carbon sequestration.

2.1 Multi-sectoral modelling

Consultation question:
Are the key assumptions and outcomes described in Table 15 suitably aligned with scenario definitions?

While the consultation question does not invite comment on the plausibility of the assumptions listed in table 15, we consider an assessment of this necessary and the central question to any scenario analysis. We will also respond to additions throughout IASR stage 2 relating to hydrogen in this section.

Fuel-switching to alternative gaseous fuels

The draft includes assumptions regarding hydrogen which are not plausible. There are inadequate economic use cases for hydrogen to absorb the depth of hydrogen take up assumed in the Green Energy variants. We note the following critical factors supporting our assessment:

- **Hydrogen cannot be deployed for use in households and many industrial settings.** This is not due primarily to issues relating to blending – though the blending assumption should be reduced further from the 10% assumption that has been transferred forward from the 2023 IASR – but rather because appliances designed for methane gas are not compatible with the use of hydrogen as an alternative, even as a blended ingredient.

  Steel, as an important example, is brittle, and steel appliances will be damaged beyond safe usefulness after exposure to hydrogen combustion. Household use of hydrogen must be ruled out altogether, and a large proportion of industrial use should be ruled out on the grounds that it will require bespoke apparatus. Investment in bespoke apparatus for industrial uses will often not be economic when compared with electrification alternatives. There will be hard to electrify commercial and industrial uses where it will be economic to invest in bespoke infrastructure (very likely including both pipeline and appliance infrastructure), but the volume of hydrogen consumed by these sectors will be substantially below the amounts assumed in the Green Energy scenarios.

- **Hydrogen density is substantially lower than methane.** A replacement of 10% of a given volume of methane in the gas network with hydrogen will result in a lower energy density in the gas supply. That is hydrogen delivers only 30-40% of the energy that an equal volume of methane would. This has two opposing impacts on the volume of hydrogen demanded. On the one hand, it increases the amount of hydrogen demanded to replace uses that would otherwise have been supplied by methane alone. On the other, it increases the cost of replacing methane with hydrogen sharply, meaning that uses that are close to the margin between continuing to use gas and electrifying will be pushed towards the latter option for economic reasons.

- **The time horizon for the deployment of hydrogen is implausibly optimistic.** Despite more than six decades of hydrogen research and development, including huge amounts of subsidy and investment in the last ten years, the fuel does not yet have a material commercial use. This includes the use of hydrogen for transport, which the Green Energy Industries places particular emphasis on. This is due to two seemingly intractable issues and one less intractable one: high energy loss factors in all identified uses, storage, and leakages from distribution pipes and in appliances. No path to overcome either of the first two obstacles has emerged. In the case of distribution, the issues are solvable, but the costs associated with solving them increase the costs of using the hydrogen to the point that, like the other issues, poses a barrier for the take-up rates assumed in the Green Energy variants.

The assumptions that the Green Energy variants make about hydrogen in this context are substantial:

- That technological breakthroughs adequate to address these issues and bridge the gap will occur in the very near term, and
- that the depth of rollout – including the construction of bespoke pipeline and use infrastructure – will result in the demand volumes required for either Green Energy variant.

Neither assumption is plausible.

Carbon sequestration across NEM states

The Green Energy variants depend on the substantial use of sequestration, most importantly land-based sequestration and, from the late 2030s, direct air capture (DAC).

Land-based sequestration is technically plausible, but it is much less plausible to assume successful, economic deployment at the scale required. Existing schemes have struggled to meet targets, even those involving a relatively low proportion of emissions capture and sequestration. Further, issues relating to verification and the resultant recent collapse of the offset market persist in the sector. These issues are not necessarily insurmountable. However, they should inform a substantially more circumspect set of assumptions and minimal reliance on land-based sequestration, particularly given the material impact a failure to deliver on assumptions would have on meeting emissions parameters.

The assumptions about DAC in the draft paper, by contrast, are not plausible at all. DAC is extremely unlikely to be economically viable, in the sense of being the lowest cost mode of carbon abatement, until very substantially into the transition, certainly beyond 2050 when the value of emissions withdrawal is materially higher.

DAC technologies face substantial, if not insurmountable, technical and economic hurdles to commercial viability. They must be powered using renewable generation and the embedded emissions in both the generation and energy distribution infrastructure as well as in the DAC technology itself must be offset before a positive contribution can be established. In addition to this, the cost of each unit of carbon captured must be cheaper than an alternative investment, such as replacing a unit of emitting generation with a unit of renewable generation or storage, energy efficiency measures, electrifying a consumption or production use, or offsetting through land sequestration. In simple terms, it is inherently more efficient to do almost any other emissions reducing activity than to undertake DAC, until all other emissions producing avenues have been pursued. This will be the case until well after most of the globe achieves net zero, which will not be before 2050.

Electrification, excluding road transport, across NEM and WEM

The assumptions relating to electrification in the Green Energy variants can be substantially increased, up to an order of magnitude or more. This is because the drivers to electrify, both in the household and industry sectors goes far beyond those listed in table 15 and the timeline at which electrification decisions are assumed to occur is unreasonably conservative.

Electrification drivers

The reasons for electrification provided in table 15 are limited to economic efficiency on a user-by-user basis. For this reason, industry is expected to electrify at a faster rate than the household sector. This assessment is unreasonably narrow. It reflects previous errors in assumptions regarding the adoption of household solar, where future installation rates (based narrowly on assessments of potential household cost-benefit and investment payback) were consistently and substantially under-estimated.

To avoid repeating this mistake the full range of household drivers for electrification and improved energy efficiency should be considered, including:

- To improve health;
- To increase housing comfort;
- To leverage prior investments in consumer energy resources (rooftop solar and batteries);
- For environmental reasons – that is, to contribute to decarbonisation; and
- To increase energy independence – that is, as the impacts of climate change appear, the value of being able to rely on energy produced locally will increase, either to provide shelter or maintain commercial operation during outages.

Speed of electrification

The assumptions regarding electrification should also involve a greater pace of take-up. Drivers for this are as follows.

- **The Green Energy variants undervalue the potential of policy as a driver of more rapid electrification.**
  While federal and jurisdictional investment in electrification has not been consistent or at sufficient scale yet, an intent has been demonstrated[1] and there is substantial latent potential in governments to drive electrification by reducing up-front costs through contributions or cost-smoothing assistance.

  There is a strong incentive for governments to use this lever. The economic case for electrification (and energy efficiency) as an alternative to renewable generation increases as the cost of energy goes up. With settings that allowed investment in electrification and energy

[1] NSW Government: NSW Consumer Energy Strategy, 2024

efficiency to be considered as alternatives to supply side augmentation, governments are incentivised to bring forward these investments.

This is true particularly during the period of transition while energy prices remain high and volatile, creating a driver to bring electrification and energy efficiency investments forward. It is also true for later stages of the transition, where the cost of further emission abatement becomes more expensive, and the attractiveness of electrification and energy efficiency increases, creating a driver for greater depth of investment in these areas later in the time horizon.

- **The assumption that households only electrify at the point of appliance end of life is inaccurate.**
  Aside from positively seeking the benefits of electrification listed above (and so proactively rather than reactively electrifying), households may electrify appliances when it is inefficient to leave only one appliance on gas, or as part of larger renovations or improvements. That is, it may be efficient to electrify all appliances at once, rather than waiting until each one reaches the end of life. By 2030, end of life upgrades are only expected to account for around 20-25% of electrification decisions. As the draft report only appears to consider this one motivation, the assumptions concerning the number and rate of electrification decisions in households can be increased substantially.

Energy efficiency

We contend that energy efficiency is subject to similar drivers as electrification and many of the same arguments can be made for a more aggressive set of energy efficiency assumptions.

In addition, it is reasonable to assume that the technology breakthroughs in energy efficiency that have occurred in the last two decades will not cease in 2025; indeed it is more plausible that they will accelerate. Recent areas of technological improvement include:

- (Electric) Induction cooktops
- Split system air conditioning (including improvements in the coefficient of performance)
- LED lighting
- Heat pump hot water and air conditioning
- Flatscreen televisions and laptops.
- Advanced glazing solutions
- Home energy management and flexible demand control.

Many of these have become so embedded in a short space of time that they are often not even considered energy efficiency investments anymore, merely ‘standard’ choices.

It is safe to assume that further breakthroughs in energy efficiency for both households and industry will occur in the near- and medium-terms, and that these will be deployed with at least the same rapidity that recent efficiency innovations have been, if not faster.

Storage

Table 15 omits storage as a pillar of decarbonisation on which the scenarios may differ. This should be amended. The technological breakthroughs in storage are accelerating and have continually defied prediction. As importantly, there are clear, established pathways (and powerful incentives) for further breakthroughs to occur.

Unlike hydrogen and DAC, there are few barriers relating either to infrastructure or organisation that preclude swift deployment of breakthroughs in storage.

We also note that it is reasonable to assume that efficiency gains in renewable generation technologies will continue to be found, and that these are likely to outstrip the efficiency improvements in more established generation technologies, such as gas- and coal-burning.

Of the two, technological breakthroughs in storage hold the greatest potential to have transformative impacts on the path of the energy transition, as storage appears as the direct competitor to not only new transmission and distribution projects, but also shaping generation (peaking gas generation) and the provision of ancillary market services.

The potential for different rates of storage up-take should be introduced as a pillar on which the scenarios in the 2025 IASR differ.

Reforming the Green Energy Industries variant

The way the scenarios are constructed – starting with an exogenously given parameter in a quantum of global warming beyond pre-industry – enables adjustments in one pillar to be compensated by adjustments in the others.

While we have made the case that the assumptions that have been made in relation to fuel-switching and carbon sequestration within the Green Energy variants are implausibly ambitious, we have provided a parallel case that the assumptions relating to electrification, energy efficiency, and storage can reasonably be strengthened.

In particular, we have argued that while it is appropriate to include the possibility of technological breakthroughs occurring in the coming years and decades, the Green Energy Industry scenario should be based on assumptions of this occurring in areas where it is most likely to: energy efficiency and storage. It should not rely on what amounts to the 'hope' of technological breakthroughs occurring where they are very much less likely to occur – hydrogen and DAC – and in which there are sizeable barriers to deployment at scale and at pace even if such breakthroughs were to occur.

We recommend changes to the assumptions underpinning the Green Energy Industries variant, to ensure it is a more robustly plausible scenario.

3. Carbon budgets

Consultation question:
Do you consider the proposed carbon budgets to be appropriate?

The JEC supports the use of carbon budgets and sees them as a useful articulation of Australia's emission reduction point in time targets in conjunction with the International Energy Authority's World Energy Outlook (WEO) 2024 scenarios.

The use of carbon budgets has the potential to add positively to energy planning. However, there is a risk that, if used in isolation from other modes of analysis, such as expected value (EV)-based analysis, the carbon budgets may function as a ceiling for aspiration rather than a baseline. This may produce perverse outcomes, such as not making positive EV investments due to a given carbon budget already being achieved.

Importantly, such an approach may not accord with the intentions of the legislators who introduced the emission-reduction element to the National Electricity Objective, (as indicated in their comments in second reading speeches). A use of carbon budgets that allows the NEM to become a 'backstop' for economy-wide emission reductions rather than the driver of economy-wide decarbonisation would be counter to the stated intention of the added emissions objective.

We explore this in more detail in this section.

The amended Nation Energy Objectives

The intent of the legislators of the *Statutes Amendment (National Energy Laws) (Emissions Reduction Objectives) Act 2023* (South Australia) (the Act) is critical when formulating the scenarios in this process.

The intent of the legislators when amending the national energy objectives was for the market bodies to consider options for decarbonisation of the energy sector in relation to the impacts to the entire economy not only the energy sector.[3]

The Act focuses on consideration of achieving specific emissions reduction targets by market bodies exercising their decision-making functions and powers.[4] The intent gives scope to the market bodies on how to trade off the other elements of the Objectives on a case-by-case basis.

This can be seen in key parts of the second reading speech:

> As currently framed, the energy objectives do not refer to emissions reduction either directly or indirectly. Changing this will send a clear signal to wider industry, market participants, investors and the public, of governments' commitments to achieve a decarbonised, modern and reliable energy system that contributes to the achievement of Australia's emissions targets.
>
> […]
>
> The Bill frames the emissions reduction objective by reference to the achievement of targets set by a participating jurisdiction, be it the Commonwealth, a state or a territory, for reducing or that are likely to reduce Australia's greenhouse gas emissions.[6]

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[3] See s. 7, *National Electricity Law - schedule to the National Electricity (South Australia) Law 1996* (**NEL**); s. 23, *National Gas Law – schedule to the National Gas (South Australia) Law 2008* (**NGL**)

[4] 2nd Reading SA House of Assembly 14 June 2023, Hansard pp.4378-4379, 4381-4382; 2nd Reading SA Legislative Council 31 August 2023, Hansard pp.3544-3545.

[6] 2nd Reading SA House of Assembly 14 June 2023, Hansard pp.4378-4379, 4381-4382; 2nd Reading SA Legislative Council 31 August 2023, Hansard pp.3544-3545.

Namely, the aim of amending the Objectives is that the market bodies' task is to implement the transformation of the NEM as the driver to decarbonise the wider economy.

Impact of the amendment of the Objectives on the purpose of the ISP

The amendment of the Objectives has significant implications for the ISP which are not yet widely appreciated.

Up until the 2024 iteration, the intent of the ISP has been to describe the least-cost paths for energy infrastructure (specifically transmission) development under a range of scenarios and sensitivities. Chief among these is the speed at which the wider Australian economy is decarbonised. The implication of this was that if the wider decarbonisation occurred more slowly than anticipated, the consumer benefit from investments in new infrastructure in the NEM would be maximised by taking a slower path, and vice versa.

The demand to make the NEM the driver decarbonisation of the wider Australian economy reverses this implication. If the wider economy decarbonises at a slower rate than is anticipated within a given central scenario, the value of more rapid investment in and transformation of the NEM goes *up*, as it makes wider and more rapid decarbonisation more attractive.

Using carbon budgets in the ISP

Carbon budgets should not be used in isolation from other modes of analysis of development paths, and should not be treated as ceilings for ambition. We support the use of carbon budgets in the ISP. In particular, as the Consumer Panel has noted, they elevate the path taken to key target points, such as net zero in 2050. However, the risk of embedding complacency in energy planning, rather than embedding ambition, as was intended by the legislators, must be carefully avoided.

Using the backstop approach – rather than seeking to optimise net benefits - may result in sub-optimal choices from the perspective of consumers. For example, a use of a carbon budget that 'trades off' a higher penetration of renewable generation for lower investment in household efficiency may foreclose investments that (a) return net benefits to consumers when considered in isolation and (b) are both financeable. That is, there is a risk that carbon budgets become a ceiling on the speed or depth of the transition, rather than a baseline.

Using carbon budgets in isolation from other modes of analysis may also produce distortionary effects, such as implying that the risks of overinvestment and underinvestment in energy capacity are equal. While this may be true if the sole metric is the achievement (or not) of carbon budgets, when risk of cost incursion is included, they are very unequal.

4. Electric vehicles

Consultation question:
Is the projected long-term trend of PHEV reasonable? Is the projected split of higher public charging and lower unscheduled charging reasonable?

The data behind the figures should be provided in the report. The figures do not appear to be internally consistent in that they imply a large share of both internal combustion engine (ICE), and hybrid cars will remain in the fleet for twenty years or more. While this may be the case in outliers, it will not be for the number of cars needed to reconcile the two figures. The average life of a contemporary ICE vehicle is around eight years.

The assumption that enough fuel cell electric vehicles will be produced and sold to warrant inclusion in the figure is overly optimistic – having no solid grounding in existing evidence – and should be removed.

Figure 25 shows the forecast sales share and fleet share across vehicle types for the Step Change scenario. The label indicates that the left figure is sales share and the right figure is the fleet share, when the reverse is true. This should be corrected.

5. Energy efficiency

Consultation questions:
Are the energy efficiency savings projected by the consultants suitable for their respective scenarios? Are SPR's results sufficiently aligned with the role of energy efficiency in optimised decarbonisation pathways (as revealed by CSIRO's multi-sectoral modelling approach)? What other considerations may influence energy efficiency?

See comments above in section 2.1.

6. New entrant generator assumptions

Consultation questions:
Do you consider the installation cost escalation forecasts for each technology to be reasonable? Do you support AEMO's proposal to apply lead time adjustments in the Constrained Supply Chains sensitivity?

No comment.

7. Production cost and capabilities

Consultation question:
Do you agree with the assumed portion of on-grid electrolysers by region?

The assumptions regarding the utilisation rates of electrolysers are implausible given they are based on the assumption their system utility lies predominantly in absorbing very cheap excess energy created in a renewable generation-based system. In the current system, this implies a utilisation rate of around 20%. This will go up over time, but will only ever reach a ceiling in the 30-40% range in the mid 2030s.

Electrolysers currently cannot compete at 100% utilisation. The assumption that they will be competitive or commercially viable at utilisation rates below 40% by the mid-2030s is not plausible even if an implausible improvement in the efficiency and cost of electrolysers was assumed.

Second, the hydrogen assumptions appear to be driven by government policy. The key existing federal policy - the Hydrogen Production Tax Incentive- takes the form of a tax offset. This could only appear as a benefit to a hydrogen project producing taxable income and, to be meaningful, profit. This is not currently possible or likely in the short term.

The draft report should be amended to include analysis of the limits of this policy tool, in terms of a cap on the scheme or an anticipated target of hydrogen production it expects to enable over a clearly defined timeline.

The impacts of the policy, and the two jurisdictional policies listed on page 40, on AEMO's forecasts for hydrogen development should be stated clearly.

8. Gas Infrastructure

Consultation question:
Do you have feedback on the hydrogen supply pathways for use in the ISP model? If so, please address this feedback to the ISP Methodology consultation. Do you have feedback on the location of candidate hydrogen hubs and ports?

The assumptions regarding hydrogen blending should be substantially reduced.

We detailed the limitations in use value listed in the subsection 'Fuel-switching to alternative gaseous fuels' above. In addition to the points made there, we note the advice from the Australian Hydrogen Centre cited on page 69 of the draft report. They claim that hydrogen's commercially viable uses are likely to be limited to bespoke hydrogen infrastructure (ie. 100% hydrogen pipes).

Considering this, an upper limit of 2% blending should be assumed, which recognises the technical possibility of blending that has been established in existing trials to date, but does not overstate the potential value from hydrogen for use in non-bespoke gas infrastructure. This would also enable more accurate relative assessment of the negligible emissions reduction potential of hydrogen blending.

9. Other matters

End-use fuel consumption and energy intensity dynamics

We commend AEMO for the inclusion of the 'End-use fuel consumption by scenario' figures on page 24 of the draft report. However, the figure is dense to the point that it confuses more than it reveals, and we recommend expansion into a series of figures in order to clarify this.

The inclusion of electricity and hydrogen as 'fuels' is confusing. Electricity is not a fuel but the outcome of burning fuel. Hydrogen is both a fuel and a mode of storing energy, which comes from burning fuels.

There are also two possible interpretations of the figures presented:

- The first, which is intuitive but unlikely, is that all the 'fuels', including electricity and hydrogen, are distinct from one another throughout the production and consumption chain. That is, 'electricity' really refers to 'electricity produced using fuel sources not included elsewhere on the figure (so renewables, coal and storage)' and 'hydrogen' really refers to 'hydrogen exclusively produced using coal, renewables and storage'. These are obviously not meaningful categories, so we can reject the interpretation.

- The second interpretation is that the categories are not distinct from one another, meaning that some of the fuels appear as inputs to the other fuels in the figure. In this case, the viewer is left without data regarding the changing composition of inputs for the production of electricity and hydrogen over time. This is an important component of the story, and the absence of that data reduces the effectiveness of the figures substantially.

There is also inadequate information provided to back up the claims regarding material productivity provided (which the draft report is referring to as 'energy efficiency' and 'energy intensity'). According to the paragraph on page 23, this is the main aim of the section. To make any claims about material productivity we need data about the input as well as the end-use consumption.

We agree with AEMO that increased material productivity of energy is an important dynamic of the energy transition and that it is a metric on which the scenarios differ.

We support the section remaining in the IASR, but it requires the addition of necessary data to make the claims meaningful.

Policy settings

The JEC approves of the move on page 40 of the draft report to critique the NSW Hydrogen Strategy.

The decision to adopt a more critical approach to policy commitments is a welcome and necessary change in AEMO's approach. The practice of assessing inputs and assumptions to the ISP on the grounds of plausibility should be extended to all government policies.

However, these assessment should be done in a transparent and systematic way. Criteria should be established and consulted on regarding how AEMO will assess the plausibility of government policies.

Figure 8

Figure 8, on page 64, provides a visual representation of the carbon sequestration by category in the NEM for the Step Change scenario. It should be accompanied by equivalent figures for the other scenarios and variants.

10. Continued engagement

We welcome the opportunity to meet with AEMO and other stakeholders to discuss these issues in more depth. Please contact Michael Lynch at mlynch@jec.org.au regarding any further follow up.