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Submission to Review of the Integrated System Plan framework – Discussion Paper

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While the Integrated System Plan (ISP) is a world-leading exemplar of energy system planning, there remain some weakness in the overall framework which present the optimal development path (ODP) with a false sense of certainty, create reputational risk for the Australian Energy Market Operator (AEMO), and pose a risk to achieving the National Electricity Objective. The computationally complex black-box models underpinning the ISP are slow to run and inhibit AEMO's ability to broadly investigate risks and opportunities to potential development paths, thereby reducing the credibility, robustness, and resilience of the plan.

Our submission covers the following aspects of the ISP framework:

- Modelling the energy system decades in advance involves a very large amount of uncertainty, with no method for generating all possible futures or calculating an objective "optimum" when balancing multiple objectives.
- Given the large uncertainty, energy system planning models cannot make accurate predictions or calculations. It is wrong to claim that one development path is better than another when modelled costs are similar (e.g., within 20–30%). Additionally, simple models (e.g., low temporal, spatial, and technological resolution) are just as accurate within the margin of uncertainty to computationally complex models, but are faster to run and are more understandable.
- Beyond the difficulty of forecasting how much CER and demand-side flexibility will be deployed, there is very large uncertainty about how effectively these resources can be coordinated and accessed to support the grid.
- Simple, openable, manipulable, and understandable models are useful for investigating potential futures, while specific and detailed models provide a consistent starting point for an actionable development path.
- Complex and slow capacity outlook models underpinning the ISP currently overlook important possible futures, including: zero gas, constrained wind and transmission deployment, faster deployment of urban rooftop solar than utility solar, geopolitical constraints on oil or gas deliveries, increased or decreased political will to reduce emissions, faster growth of electric vehicles and data centres, faster growth of consumer batteries, development of several more "Snowy 2.0" sized pumped hydro systems, solar supply chain risks, or different levels of CER coordination among many other possible futures.

The Australian Energy Market Commission (the Commission) presented a set of "strawpeople" within the discussion paper to illustrate potential methods of broadening the ISP planning framework, expressing an interest in making "the national pathway better" and supporting "more efficient decision-making, coordination and investment across the energy system". We argue that expanding decision variable scope to include distribution, demand-side resources, CER, and/or gas network co-optimisation, as proposed in the strawpeople, would be entirely inadequate unless accompanied by far more important changes:

- A simple, openable, and understandable model should be used to **generate a broad suite (thousands) of very different near-optimal development paths** for the plan. It is important

to understand that two very different development paths with modelled costs within 20–30% really do have the same expected cost (within uncertainty) and are equally efficient investment options.
- A much broader identification and investigation of risks and opportunities (recorded in a publicly available register) should be performed on an ongoing basis to incrementally improve the robustness of potential development paths. Simple, openable, and understandable models **tailored to each investigation** should be developed.
- The cost benefit analysis should be adjusted to use a social discount rate (rather than WACC), swap from focusing on a highly uncertain ODP to a broader set of potential futures, and remove the quantitative assignment of probabilities to core development paths based on the Delphi analysis (there is no credible method of assigning probabilities to potential futures in the energy planning problem).
- The Commission should consider future changes to the actionability framework that evaluate seasonal energy storage alongside transmission, as these assets may operate as a natural monopoly during winter in a solar/wind-dominant grid.

In the absence of these important changes, the expansion of decision variable scope proposed in the strawpeople will only drive model complexity up higher, further increasing optimisation time without credibly increasing the accuracy of results or robustness of development paths.

The “Background: Modelling for Investigation and Action” section below provides a description of modelling for investigation and action in the context of the energy system planning problem. We then propose a practical “living plan and action” framework for the ISP that directs attention to the ongoing decision-making processes required to control risks and seize opportunities to produce robust and resilient development paths that achieve the National Electricity Objective, rather than focusing on an enormously uncertain ODP. With reference to the background and proposal sections, we then address the questions asked by the Commission within the discussion paper.

Background: Modelling for Investigation and Action

The concept of “wicked problems” dates back to the early attempts to develop a general theory of planning for cities in the 1960s – the discussions around models at the time reflect the exact same challenges facing energy planners today.[1] Rational calculation models had seen success in fields such as physics and engineering, so other fields sought to employ the same methods to solve their own problems. Lee’s retrospectives on large-scale urban models[2,3] are particularly useful, as they highlight the failure of these expensive, complicated, data hungry, black-box models, such as the San Francisco housing market model, to produce results that were any more useful than earlier methods. These urban models could not successfully perform long-term predictions about a whole host of variables such as transportation usage or land-use intensity. The sheer comprehensiveness of these models made it impossible to perform useful investigations with them either, since the hundreds of first- and second-order effects relating the dozens of variables with each other made it impossible to distil out the important mechanisms driving certain results. Energy system planning has all of the difficulties of urban planning plus more, making it an example of a “super wicked problem”.[4]

Long-term energy system planning models contain an enormous amount of unquantifiable uncertainty because of the multi-decade timelines and the strong coupling with complex economic, political, social, and environmental systems. Potential futures are dictated by unpredictable changes in government policy, geopolitical conflict and its effects on fuel security, supply chain disruptions, and the commercialisation of new technology. A recent study of 31 European countries found a median cost deviation of 59% and a maximum deviation of 305% when comparing energy system model results with real-world energy transition costs for single-year models optimised 25 years in advance.[5] Another analysis determined that some elements of complexity (such as spatial, technological, and temporal resolution) only marginally increase accuracy in energy system models while significantly increasing computation time[6]. Expanding decision variable scope can counter-intuitively increase uncertainty in the results[7], while also driving up computational complexity.

For energy system planning, there are two important functions of modelling activities: performing an investigation of potential futures and initiating action to realise those potential futures. Since the energy planning problem is an example of a super wicked problem, modelling cannot serve the function of calculation or prediction. The following features of the energy planning problem make long-term forecasts futile:

- High equivocality[8]: there is no way to define the complete set of potential futures. Since the energy system is highly coupled with other complex systems such as global politics, economics, and social behaviours, it is impossible to design a highly shielded system where accurate calculation from a model becomes possible over long time horizons, unlike a well-controlled physics or chemistry experiment.[9]

[1] https://doi.org/10.1007/BF01405730
[2] https://doi.org/10.1080/01944367308977851
[3] https://doi.org/10.1080/01944369408975545
[4] https://doi.org/10.1007/s11077-012-9151-0
[5] https://doi.org/10.1016/j.energy.2026.141552
[6] https://doi.org/10.1016/j.apenergy.2019.113783
[7] https://doi.org/10.1126/sciadv.abn9450
[8] https://doi.org/10.5840/pom20022121
[9] Cartwright, N., 1999. *The Dappled World*. Cambridge: Cambridge University Press.

- Deep (or radical) uncertainty[10,11,12]: Even where some potential futures can be defined, there is no credible method for assigning probabilities to those futures to enable predictability. The existing Delphi analysis for assigning probabilities to core scenarios in the ISP for the purpose of weighting scenarios in the cost benefit analysis does not credibly represent the actual probability of these potential futures being realised. There are substantially more than three possible futures (as modelled in the core scenarios) which may eventuate, and the likelihood that one of the core scenarios eventuates at all is vanishingly small when considering all possible futures between now and 2050. Expert opinions on likelihood are not a credible method of quantitatively defining the underlying probability that a possible future will occur.
- Fuzzy evaluation[13]: There is no objective "optimal" value when balancing multiple objectives. Rather, there is a fuzzy range of good enough (i.e., satisficing) development paths. The multiple components of the National Electricity Objective and other goals established by Australia's legislative, treaty, or policy obligations create a balancing act where a least-cost solution cannot be considered "optimal" (but may still exist in the fuzzy range of satisficing development paths).

Although long-term energy planning models cannot be considered predictive, they can still be used for investigation to weakly infer knowledge about the world. It is important for models used for investigation to have the following features:

- Openability[14,15]: black-box modelling is not useful when the outputs do not represent accurate predictions or calculations. Modellers need to be able to open up the model and interrogate its formulation in order to learn anything about why it behaves the way that it does.
- Parsimony: a model can also be a black-box in the sense that it is so complex that it becomes impossible for the modeller to determine what is driving the results upon opening the box.
- Manipulability[16,17]: models are not tools of mere representation or calculation, but must be able to be manipulated to investigate the model world.
- Understandability[18]: designing code and data in a modular way using manageable parts allows modellers and non-technical users to readily understand each component, increasing transparency.

The existing Single-Stage Long-Term, Detailed Long-Term, and Time-Sequential models underpinning the ISP are all highly computationally complex. There are already hundreds of decision variables associated with investment decisions, and millions of decision variables associated with the dispatch of generators (even after applying the temporal aggregation techniques in the capacity outlook models). Technological and spatial resolution are core drivers of complexity, with separate investment and dispatch decision variables for each individual power station across the NEM. This complexity makes it slow to run the optimisations (with the

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[10] https://doi.org/10.1017/S0140525X22001157
[11] Kay, J.A. and King, M.A., 2020. *Radical Uncertainty*. London: Bridge Street Press.
[12] Marchau, V.A., Walker, W.E., Bloemen, P.J. and Popper, S.W., 2019. *Decision making under deep uncertainty: from theory to practice*. Springer Nature.
[13] https://doi.org/10.1017/S0140525X22001157
[14] https://doi.org/10.1016/j.esr.2017.12.002
[15] https://doi.org/10.1016/j.enpol.2016.11.046
[16] Morgan, M.S., 2012. *The World in the Model: How Economists Work and Think*. Cambridge: Cambridge University Press.
[17] Morrison, M. and Morgan, M.S., 1999. "Models as mediating instruments". *Models as Mediators: Perspectives on Natural and Social Science*. Cambridge: Cambridge University Press, pp.10-37.
[18] https://doi.org/10.1088/2516-1083/ad371e

capacity outlook models reportedly taking days to run[19]) and turns the models into black-boxes where the underlying interactions between variables are too complex to meaningfully understand model behaviour. Additionally, although a version of the ISP PLEXOS model is made publicly available, PLEXOS itself is proprietary software. The underlying mathematical equations and implementing code are secret and can only be inferred from the documentation.
The existing ISP models lack parsimony and openability, which hinders their ability to investigate a very broad range of potential futures and their associated risks. The three core scenarios, six sensitivity scenarios, and small number of alternative development path variations evaluated in the ISP represent a negligible portion of potential futures. There would be considerable value in replacing the Single-Stage Long-Term model with a simpler, openable, and understandable model that can be used to explore a broad set (thousands) of potential development paths with costs within 20–30% of the optimum (still much smaller than the total uncertainty in the optimum, as shown in Fossas-Tenas et al.[20]). **We refer to this range of potential development paths that have similar costs to the optimum as the "near-optimal" space.** Evidence of the enormous diversity in near-optimal energy transition pathways is available in the modelling to generate alternatives (MGA) literature[21,22], and we would direct particular attention to Lombardi et al.[23] who provide a good description of the process for non-technical audiences.

Although the Detailed Long-Term and Time-Sequential models are unsuitable for broad investigations, they remain valuable in that they provide the level of specificity needed for decision-makers to take actions. Specificity is needed to determine exactly what transmission line needs to be approved or what region needs REZ planning legislation to fast-track power station approvals. Here, the model serves the function of generating the energy plan itself (all of the written components of the ISP), but the model is only important in-so-far as it allows the plan to be specific and consistent – the specific model acts as glue for the energy plan, rather than as an investigative tool. Inputs to these specific models may be less technocratic and more directly informed by stakeholders. For example, the MGA process may indicate that solar can be added to just about any REZ at similar costs – those REZs that have the strongest stakeholder support and offer the simplest implementation can be selected to define solar capacity inputs for the specific model, rather than focusing on the enormously uncertain "optimal" locations that may be more likely to face opposition. Inputs to the specific models can be further adjusted manually in response to new consultations or investigations of risks.

As highlighted by the Commission, the energy plan ultimately serves the purpose of directly influencing (through the actionability mechanism) and indirectly influencing (through a reduction in information asymmetry) actions by decision-makers. We have adapted a theory of decision-making under radical uncertainty for understanding the relationship between the models used for generating the energy plan, the energy plan itself, and the way decision-makers evaluate the plan to take action.[24] Figure 1 describes the way in which the goals of the energy planner work with a computational model to generate a set of specific potential development paths. These

[19] https://www.aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2024/2026-isp-methodology/isp-methodology-june-2025.pdf?rev=e88a1f1bbeef447ba27692b785069a0a&sc_lang=en

The *2023 ISP Methodology* specifically reported that a single run can take up to three days to complete: https://www.aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2023/isp-methodology-2023/isp-methodology_june-2023.pdf?rev=d1a3b3edfed144a6a4e5a2caa2fb23ed&sc_lang=en
[20] https://doi.org/10.1016/j.energy.2026.141552
[21] https://doi.org/10.1016/j.envsoft.2015.11.019
[22] https://doi.org/10.1016/j.apenergy.2017.03.065
[23] https://doi.org/10.1016/j.joule.2025.102144
[24] https://doi.org/10.1017/S0140525X22001157

potential futures are linked to the real world through the prose of an energy system plan, which incorporates other detail and knowledge about the world that was absent from the model. The energy planner then communicates the plan to stakeholders, who receive fragments of the plan based upon what they read and understand. Those stakeholders affectively evaluate the fragments of the plan with respect to their own goals, then respond to consultations. The energy planner modifies the plan in response to the consultations in order to build a strong coalition of support[25] for the potential development paths. Decision-makers then affectively evaluate the plan with respect to their own goals to determine what actions they need to take: should an investment be made? Is a new policy required to support an enabling technology? Is new planning legislation required?

Some of the characteristics that contribute to a good quality energy system plan include:

- Flexibility and stability: there is a balance between these attributes. The plan must be able to respond to new information, opportunities, and risks, while also remaining stable enough that decision-makers have the certainty required to take action (e.g., invest in a long-term asset).
- Credibility[26,27]: the potential development paths in the energy plan must be consistent (no contradictions), coherent (makes the facts "hang together" in a causal chain), meaningful (makes interesting discoveries in the "model world"), and plausible (model world appears to represent the real world) so as to be considered credible. Computational models have strict rules and constraints, meaning that they guarantee consistency in the development paths. However, models do not necessarily produce plausible potential futures – a development path that requires the construction of 100 GW of solar next year would be implausible and would not represent a credible component of the energy plan. Part of the role of consultation is to adjust the energy plan so that it is considered credible by a broad group of stakeholders, forming a coalition of support to back the delivery of the plan by decision-makers.
- Robustness and resilience: a robust development path remains feasible over a broad range of risks, while a resilient development path can be adapted in response to new risks and opportunities. Consultation may help increase robustness and resilience of the potential development paths, as can additional investigations of risks and opportunities by the energy planner.

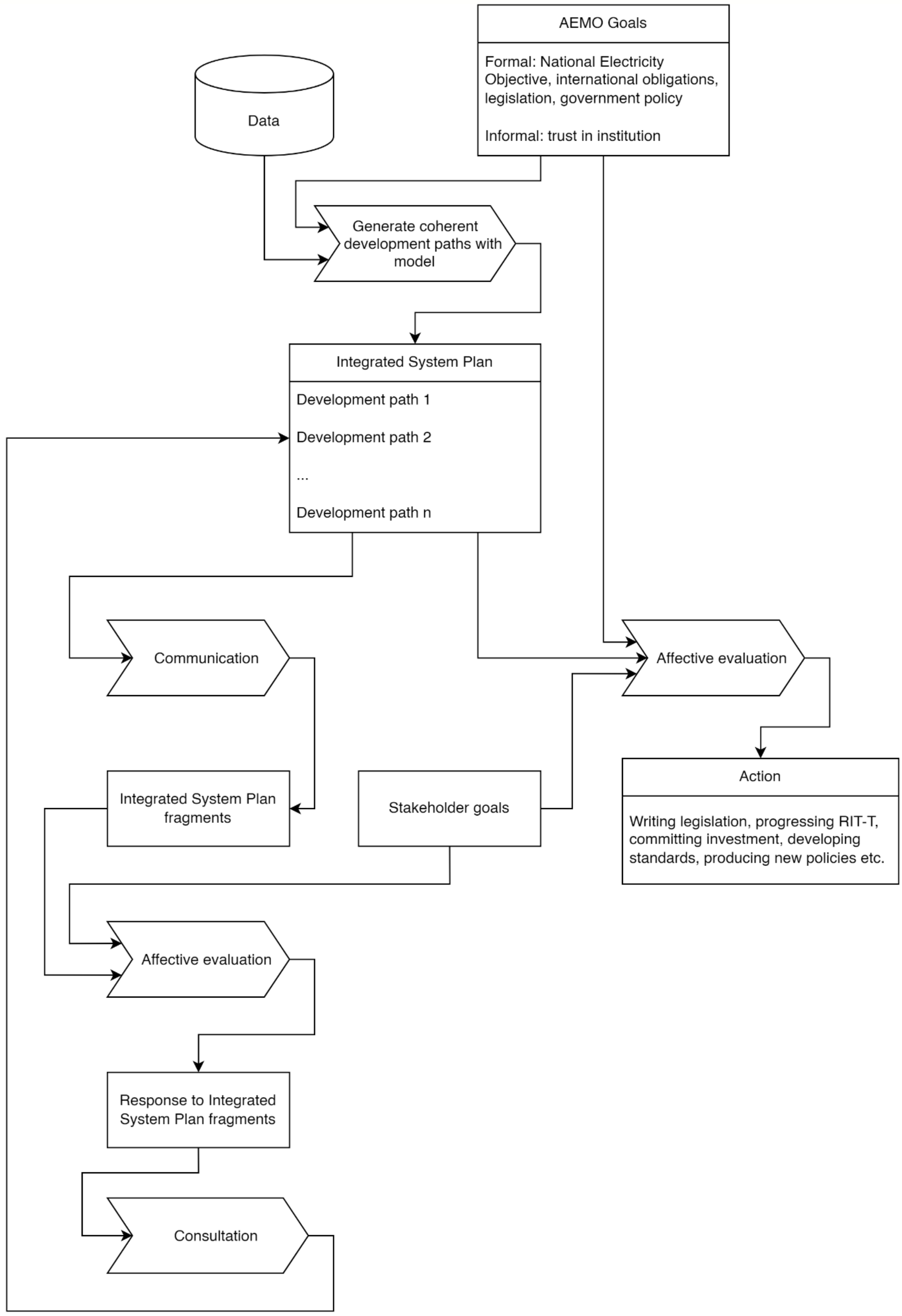
The existing ISP framework produces a stable and moderately credible plan. The detailed computational models impart consistency to the development paths (including the ODP). However, the existing framework is slow to respond to new information (inflexible) and lacks a rigorous investigation of risks and opportunities through just three core scenarios, six sensitivity scenarios, and a handful of alternative development paths (low robustness and resilience). Primarily focusing attention on the highly uncertain ODP lowers the plausibility of the plan. As such, the existing ISP framework centred on the ODP with a narrow uncertainty analysis poses a reputational risk to AEMO and a risk to achieving the National Electricity Objective (among other planning objectives) when the "optimal" pathway does not eventuate.

The existing highly complex ISP models are black-boxes and are too slow to run, preventing AEMO from investigating a broad set of risks and opportunities associated with the development paths. These computationally complex models keep the ISP stuck in a "predict-and-act"[28] framework that is unable to account for a broad set of potential futures. We propose a "living plan and action" framework below as a practical way of modifying the ISP framework to produce a

[25] https://doi.org/10.1007/s11077-012-9151-0
[26] https://doi.org/10.1080/135017800362220
[27] Morgan, M.S., 2012. *The World in the Model: How Economists Work and Think*. Cambridge: Cambridge University Press.
[28] https://doi.org/10.1016/j.techfore.2021.120939

more flexible, robust, resilient, and credible energy system plan by directing attention to the ongoing decision-making processes required to control risks and seize opportunities, rather than focusing on a highly uncertain ODP.

Figure 1. Relationship between modelling for energy plan generation, the energy system plan, and action under the conviction narrative theory framework



Proposal: A Living Plan and Action Framework for the ISP

Under the proposed framework, the computationally complex Single-Stage Long-Term model would be replaced by an MGA process[29] that generates a broad set of near-optimal development paths (within 20–30% of the least-cost path) using a simpler model with low spatial, temporal, and technological resolution. As previously discussed, an energy system model of sufficiently low complexity can retain similar levels of accuracy while substantially reducing computation time[30], allowing a very large number (e.g., thousands) of very different looking development paths to be rapidly explored. The MGA model can retain the existing purposes of the Single-Stage Long-Term model in establishing cumulative emission budgets and indicative generation developments/retirements for the potential development paths. Importantly, the MGA model should be simple enough to not require a "sampled chronology"[31] temporal aggregation method that fails to invest in long-duration energy storage and skews towards gas investment.

Through an analysis of the thousands of potential development paths modelled in the near-optimal solution space, AEMO would be able to establish some initial broad conclusions. For example, if each near-optimal development path describes a very different distribution of solar and wind across the REZs, AEMO may conclude that it does not matter exactly which REZ should be prioritised for investment. Where a broad range of options exist across the development paths (e.g., any REZ can be prioritised for solar/wind investment, any transmission line out west would be just as good as any other for unlocking new solar/wind resources, long-duration storage can take the place of new transmission lines etc.), then AEMO can conduct an initial consultation or perform direct engagement with stakeholders to filter the potential development paths for those that have the most support. For example, if there is strong opposition to solar/wind development in the New England REZ, AEMO may exclude those potential development paths from more detailed evaluation.

A small subset (five or ten) of potential development paths can then be modelled with high specificity (and, therefore, complexity) using the existing Detailed Long-Term and Time-Sequential modelling processes. The subset of development paths should be broader than the existing set of core scenarios and capture distinct future grid configurations that have received stakeholder support (e.g., gas-dependent, 100% renewable, low transmission expansion etc.). Although the development paths would have distinct configurations, there would still be some actionable decisions that are common between them – perhaps most of the development paths include the same transmission line, making the development of that line a fairly straightforward decision that keeps options open. There may be some strictly mutual decisions for pursuing certain development paths – banning gas to pursue the 100% renewables path will necessarily lock-out the gas-dependent pathways. It is not always preferrable to keep options as open as possible; lock-in can be beneficial for preventing important decisions from being unravelled in the future and can provide more certainty to stakeholders[32,33]. The ISP would clearly establish a set of decisions that are mostly common across the pathways and a set that would create lock-in, as well as a discussion of the implications of these major choices.

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[29] https://doi.org/10.1016/j.joule.2025.102144
[30] https://doi.org/10.1016/j.apenergy.2019.113783
[31] Also known as "typical periods" or "representative periods". We investigate the impact of temporal aggregation in the NEM PLEXOS models in:

Weber, T., Cheng, C., Thawley, H., Catchpole, K., Blakers, A., Lu, B., Zhao, J. and Nadolny, A. [in press]. "Replacing Gas with Low-cost, Abundant Long-duration Pumped Hydro in Electricity Systems", *Cell Reports Physical Science*. Pre-print available from: https://doi.org/10.48550/arXiv.2512.20286
[32] https://access.heinonline.com/hol-cgi-bin/get_pdf.cgi?handle=hein.journals/clqv94&section=38
[33] https://doi.org/10.1007/s11077-012-9151-0

A key addition in our proposed living plan and action framework is the introduction of a publicly available risk and opportunities register (the Register). The Register would be a living artefact and could be accompanied by the living Inputs, Assumptions and Scenarios Repository proposed by other stakeholders in the previous consultation. Within the Register, AEMO would update new risks and opportunities, investigate their impact on achieving the potential development paths, and document adaptations to potential development paths that seize opportunities or increase their robustness in the face of new risks. Some items in the Register may trigger actions requiring AEMO to adjust a development path should a risk or opportunity be realised. For example, ongoing delays to the development of new transmission lines and wind farms may trigger AEMO to adapt a potential development path to include a higher fraction of solar. Or risks related to rooftop solar being centralised in cities may require AEMO to increase the amount of energy storage needed to ride through cloudy periods.

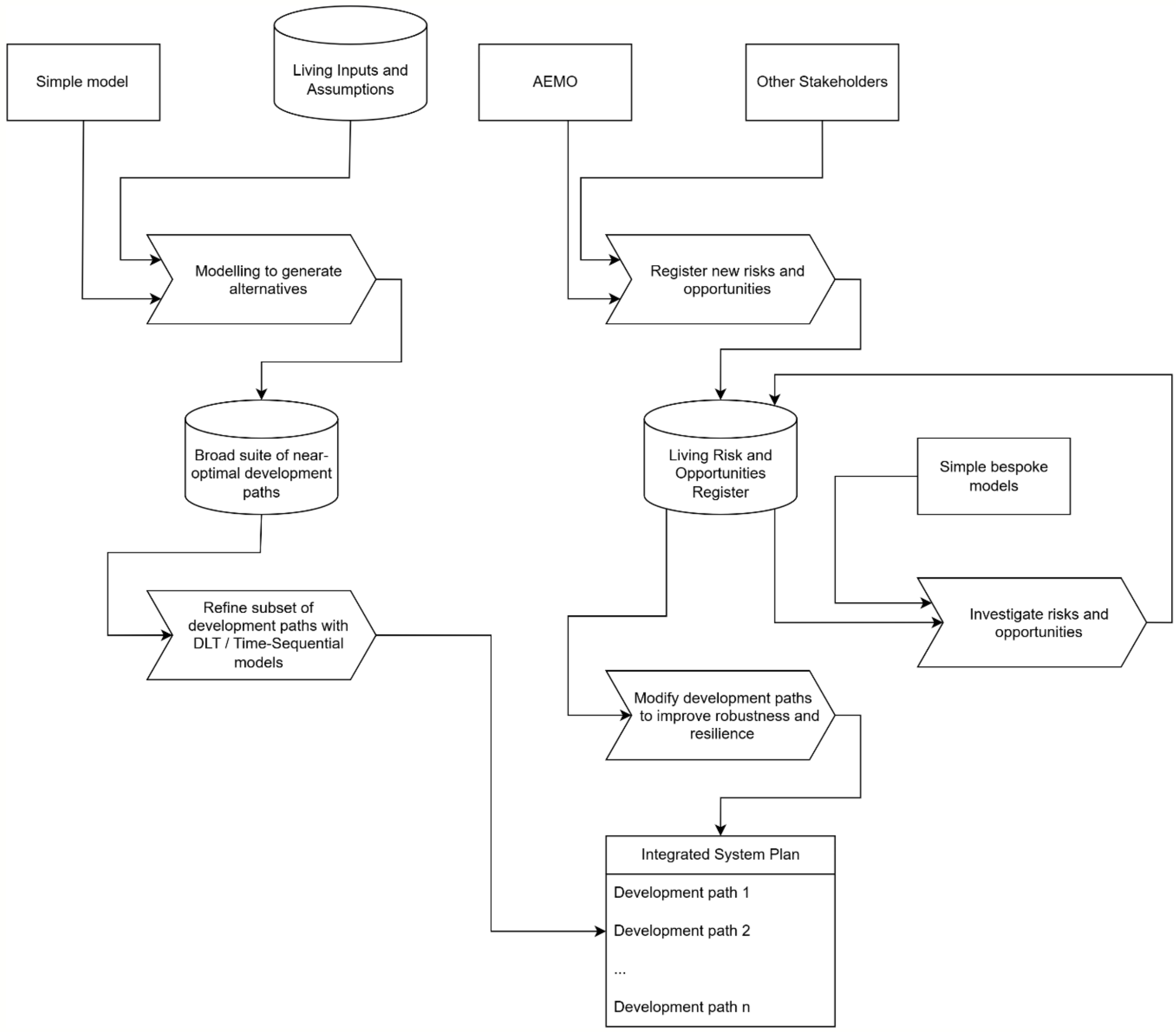
In addition to technical, economic, and policy risks, the Register should explicitly consider risks associated with consumer participation, workforce capability, interoperability readiness, cybersecurity of aggregated DER fleets, and unequal access to orchestration opportunities across communities and jurisdictions. As increasing value is derived from CER and demand-side flexibility, monitoring, communication, feedback, and adaptive program design become important components of system performance. The effectiveness of orchestration depends not only on technology deployment but on the ability of organisations to monitor impacts, communicate with participants, identify emerging issues and adapt programs in response to changing circumstances.

The investigation of risks and opportunities in the living register would be an ongoing process performed by a separate modelling team. Models used for the investigation of individual risks and opportunities ought to be tailored to that particular item in the Register, avoiding reliance on the highly complex proprietary "everything models" that take multiple days to run. For example, a simple agent-based model could be developed to investigate the risk of monopolistic behaviour in seasonal energy storage in 2050, and a set of controls could be developed to address this risk in the potential development paths (e.g., treatment as a regulated asset). Open-source models[34,35] designed for understandability[36] will allow other stakeholders to assess the credibility of AEMO's investigations of risks and opportunities. As a publicly available artefact, stakeholders may also propose new risks and opportunities for addition to the Register, investigate existing risks and opportunities, or suggest adaptations to potential development paths to increase their robustness or resilience.

We understand that the proposed living plan and action framework is broader in scope than the strawpeople presented by the Commission. Adjusting the ISP framework in this (or a comparable) way would require additional rule changes. However, we believe that the proposal would better achieve the Commission's goals of creating an ISP framework with a stronger evidence base and more resilient development paths that result in lower cost electricity for consumers.

[34] https://doi.org/10.1016/j.enpol.2016.11.046
[35] https://doi.org/10.1016/j.esr.2017.12.002
[36] https://doi.org/10.1088/2516-1083/ad371e

Figure 2. Proposed living plan and action framework for the Integrated System Plan. Consultation and actions are assumed to operate in accordance with Figure 1, but are excluded from this figure for simplicity.



Discussion Paper Question 1

Are there additional benefits provided by the ISP that are not explored in this chapter [Chapter 2]?

We agree with the Commission that the original goal of the ISP remains relevant, but that the benefits provided by the plan have expanded since its introduction. We provide some examples below of additional benefits provided by the ISP:

- Data developed for the ISP (e.g., *Inputs, Assumptions and Scenarios Report* datasets) provide a common set of inputs that other researchers, consultants, or government departments use for electricity system modelling. Our own studies have relied upon inputs and models developed for previous ISPs.[37,38]
- The ISP directly informs new government policy and legislation. For example, the *Future Gas Strategy* directly references the need for 14 GW of gas-powered generators within the *Draft 2024 ISP*[39] and legislation/declarations related to renewable energy zones[40] are informed by the ODP. The Rewiring the Nation policy was informed by the need for new transmission lines in the 2024 ISP.[41] There may be feedback loops from both direct interactions (e.g., the Capacity Investment Scheme was partially informed by the ISP *Step Change* scenario[42], and now acts as a constraint in the latest ISP models[43]) and indirect interactions (e.g., the ODP may encourage investment in solar/wind within specific REZs, resulting in more committed and anticipated projects in the next ISP model).
- The ISP consultation process generates coalitions of support for decisions that produce a future grid aligned with our National Electricity Objective. Levin et al.[44] suggest that solutions to super wicked problems (such as the energy planning problem) depend upon finding "plausible logics" for addressing the problem, then focusing attention on building strong coalitions of support through consultation to lock-in paths that are informed by these plausible logics. Lock-in creates a sense of stability necessary for long-term investment decisions, but must be balanced by flexibility to respond to new risks and opportunities.

We believe the ISP could readily deliver the following benefits, but the current framework limits its ability to achieve them:

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[37] https://doi.org/10.1016/j.energy.2020.119678
[38] Weber, T., Cheng, C., Thawley, H., Catchpole, K., Blakers, A., Lu, B., Zhao, J. and Nadolny, A. [in press]. "Replacing Gas with Low-cost, Abundant Long-duration Pumped Hydro in Electricity Systems", *Cell Reports Physical Science*. Pre-print available from: https://doi.org/10.48550/arXiv.2512.20286
[39] https://www.industry.gov.au/sites/default/files/2024-05/future-gas-strategy-analytical-report.pdf
[40] Examples include the NSW *Electricity Infrastructure Investment Act 2020* (https://legislation.nsw.gov.au/view/whole/html/inforce/current/act-2020-044) and the Victorian renewable energy zone declaration orders (https://www.energy.vic.gov.au/about-energy/legislation/victorias-renewable-energy-zone-declaration-orders)
[41] https://www.dcceew.gov.au/energy/renewable/rewiring-the-nation
[42] https://storage.googleapis.com/files-au-climate/climate-au/p/prj2845a19ab92efac40adf8/public_assets/Capacity%20Investment%20Scheme%20-%20Public%20Consultation%20Paper%20-%20August%202023.pdf
[43] https://www.aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2024/2025-iasr-scenarios/final-docs/2025-inputs-assumptions-and-scenarios-report.pdf?rev=63268acd3f044adb9f5f3a32b6880c27&sc_lang=en
[44] https://doi.org/10.1007/s11077-012-9151-0

- Supporting long-term investment decisions (40+ years) beyond transmission infrastructure. Notably, pumped hydro energy storage has a technical lifetime of 150 years (with refurbishment of mechanical components), but is only modelled with an economic lifetime of 40 years and real WACC of 7.5–9.5% equivalent to shorter-term private investor decisions. Given that the ISP is not intended to be a predictive forecast, and the plan is required to deliver on the "long term interests of consumers of electricity"[45], the use of real WACC instead of a social discount rate appears contradictory to the modelling goals. We argue that:

    - Delivering on the long-term interests of consumers should not express a time preference for the current generation over future generations of Australians (or that preference should be negligible, as per the 0.1% pure time preference contribution to discount rate used in the *Stern Review*). WACC typically embeds a higher rate of pure time preference than a social discount rate, since private investors are not as concerned with the welfare of future generations.[46]
    - The majority of pumped hydro investment is not private capital in Australia. Snowy Hydro (Snowy 2.0), Queensland Hydro (Borumba), and HydroTas (Battery of the Nation) are all corporate government entities. As government owned corporations, they have access to very cheap capital (low real bond rates) and assume much longer economic lifetimes (Snowy Hydro uses up to 75 years for civil infrastructure[47]).
    - A social discount rate would be expected to be approximately 3%. The annualised build cost of an investment[48] with a real discount rate of 9.5% and economic life of 40 years is nearly 3x that of a real discount rate of 3% and economic life of 75 years. The capacity outlook models in the ISP heavily skew against long-term investment decisions, such as pumped hydro, because of the use of private investor assumptions for WACC and economic life rather than a social discount rate and longer economic lifetime suitable for public investments (which are typical for large-scale civil infrastructure).

  We are aware that AEMO is required to use assumptions reflecting private investment decisions in accordance with the *Cost Benefit Analysis Guidelines* developed by the Australian Energy Regulator. However, we are flagging that this requirement appears to contradict the goal of delivering a plan that meets the long-term interest of consumers in accordance with the National Electricity Objective.

- Managing uncertainty, evaluating risks, and identifying opportunities related to achieving potential development paths. We discuss these concerns in the "Background: Modelling for Investigation and Action" section and propose a solution in the "Proposal: A Living Plan and Action Framework for the ISP" section.

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[45] https://www.aemc.gov.au/regulation/neo
[46] https://doi.org/10.1080/1351847X.2015.1029591
[47] https://www.snowyhydro.com.au/wp-content/uploads/2026/02/Snowy-Hydro-Annual-Report-2024-25.pdf
[48] Capital costs in the capacity outlook models are annualised since the finite optimisation horizon ends before the full economic lifetime of new investments is realised.

Annualised build cost = discount rate / (1 – [1 + discount rate]$^{\text{lifetime}}$)

Discussion Paper Question 2

1. Have changes in the sector, such as the increasing role of distributed energy resources and consumer energy resources, affected the value of the ISP in its current form?
2. Where do national and jurisdictional planning and delivery frameworks complement one another, and where do they create coordination challenges for planning and investment decisions?
3. What features of the future energy system should the Commission consider when assessing whether and how the ISP framework should be changed to remain effective and resilient across a range of potential futures?

These changes in the sector have highlighted the enormous and unquantifiable uncertainty inherent in the ODP, demonstrating the shortcomings of focusing on narrow set of potential futures with a limited investigation of risks and opportunities. The unexpected surge of new batteries through the Cheaper Home Batteries Program was not captured in earlier iterations of the ISP since it was impossible to predict even a few months in advance.

Since accurate predictions about the future energy system are not possible, the notion of an "optimal" development path holds little meaning. Would the ODP still be optimal if solar panel supply chains were disrupted by geopolitical conflict? Or if international gas fuel prices suddenly increased? The existing ISP framework has the benefit of providing **specificity and stability** to the planned development path which is important for building a cohesive coalition of support, thereby providing policy certainty and facilitating decisions about specific projects. Where the existing framework is limited is in its ability to respond **flexibly** to new opportunities and risks as they arise.

Some examples of risks and opportunities that are currently not considered within the ODP include:

- The faster development time of rooftop solar compared to utility solar, resulting in the centralisation of solar assets in cities. Are there increased risks posed by cloud cover or bushfire smoke when solar assets are more centralised?
- The slow development time of wind and transmission assets. Will the grid likely have a much higher proportion of solar than currently modelled by the ODP?
- The possible commercialisation of ultra low-cost solar and the time this occurs. Would this produce a future grid with a higher solar fraction than the ODP?
- The 17 GW of gas-powered generators in 2050 within the ODP may be used more than expected if unanticipated changes in demand (e.g., large data centre uptake) or weather patterns (e.g., worsening effects of climate change) occur. Alternatively, decarbonisation efforts in other sectors may fail to achieve the negative emissions required to make these greenhouse gas-emitting assets tenable. Would Australia risk missing its net zero emissions target in 2050 in either of these cases, thereby failing to meet the conditions of the National Electricity Objective?
- The level of future CER orchestration and demand-side participation. The value of consumer energy resources depends not only on technology uptake but also on consumer trust, needs and practices, willingness to participate, program design, workforce capability, interoperability standards, and organisational capability to monitor and adapt orchestration programs over time. Even where CER deployment can be forecast, the flexibility available from CER remains uncertain and participation opportunities are not uniformly distributed, creating uncertainty regarding the level of flexibility that can practically be delivered in different parts of the NEM.

A publicly available, living risk and opportunities register would allow stakeholders and AEMO to collectively identify and investigate these challenges on an ongoing basis. Shifting away from an “optimal” development path to a broad set of near-optimal development paths that are adaptive to risks and opportunities would produce a more resilient and robust energy system plan.

Discussion Paper Question 3

1. Do you agree that the plan and the actionability mechanism are the right way to frame the choice of possible purposes for the ISP in the future energy system?
2. Are there other parts of the ISP framework that should be considered alongside the plan and the actionability mechanism in shaping its future purpose?
3. Does the ISP provide sufficient guidance and information to support decisions by parties beyond regulated asset owners? If not: what are the key gaps; and what improvements would enhance its value for these users, particularly unregulated investors?

We agree with the Commission’s framing of possible purposes of the ISP through the plan and actionability mechanisms. This framing for the existing ISP broadly maps on to Figure 1 in the “Background: Modelling for Investigation and Action” section:

- The plan: A set of development paths (including the ODP) generated from the underlying models, modified through consultation, and affectively evaluated by decision-makers with respect to goals in order to take actions such as committing investment or writing legislation.
- The actionability framework: The formalised pathway through which actions about regulated investment (e.g., major transmission) are taken.

We believe the existing plan may provide insufficient guidance and information to investors in the following ways:

- While the ODP is not considered a forecast, it is still defined to be the most probable future through the scenario weightings in the cost benefit analysis. We disagree that the Delphi analysis is a credible method of representing the underlying probability that potential development paths are realised, and would suggest that the full set of potential futures can neither be enumerated in their entirety or credibly assigned probabilities. The ODP is, therefore, presented with a false sense of certainty.
- The three core scenarios, six sensitivity analyses, and handful of additional development paths are an insufficient description of the broad range of very different satisficing development paths and their associated risks. We recommend replacing the Single-Stage Long-Term model with a much simpler model that can generate a very large set of near-optimal development paths. An explanation of the “near-optimal” landscape of development paths is provided in the “Background: Modelling for Investigation and Action” and “Proposal: A Living Plan and Action Framework for the ISP” sections.
- Without insight into a broad range of risks and opportunities, decision-makers (e.g., governments, private investors etc.) may take actions that produce a future grid with low robustness and resilience. We recommend ongoing identification and investigation of risks and opportunities impacting potential development paths, modifying them incrementally to improve robustness. Details are provided in the “Proposal: A Living Plan and Action Framework for the ISP” section.

We would also like to flag one potential item for future consideration under the actionability framework:

- Large-scale assets capable of balancing solar and wind in windless, cloudy winter weeks may operate as natural monopolies in the future. When Snowy 2.0 is complete, it will provide more than 80 per cent of all energy storage in the National Electricity Market. Our analysis indicates that an additional two or three large-scale pumped hydro systems could eliminate gas-powered generators entirely from a future grid.[49] These large-scale infrastructure projects represent billions of dollars of investment each (similar to transmission), with limited competition in windless, cloudy winter weeks. These systems may need to be treated as regulated or semi-regulated[50] assets in the future to both support investment in long-lived assets and protect against monopolistic behaviour during low solar/wind periods. There are already examples of FERC determinations to treat storage as transmission assets in the US[51] and the treatment of pumped hydro as part of the transmission system in China[52], with rate-based cost recovery through transmission tariffs. The existing actionability framework may be a good model for delivering these large-scale regulated seasonal storage systems alongside transmission.

Discussion Paper Question 4

1. Do the purpose statements for SP1-SP4 appropriately describe potential roles for the ISP in the future energy system? If not, how should the purpose be articulated differently?
2. Which of the strawpeople (SP1, SP2, SP3 or SP4) best supports the future energy system and why?
3. Are there elements of more than one strawperson, or an alternative combination of choices on the plan and actionability mechanism, that you would support? Please explain.
4. What broader design features of the ISP framework (across the planning, delivery and governance workstreams) would need to change to give effect to your preferred strawperson? In responding, stakeholders may wish to consider the scale of change required, implementation considerations, and sequencing.

Introducing distribution, consumer energy resources, and demand-side resources into the ISP models as decision variables rather than inputs would allow a broader set of different looking development paths to be investigated. However, we suggest that **expanding the scope of these decision variables would only be useful if it is accompanied by a substantial reduction in computational complexity** for certain modelling activities. Simply adding more decision variables to the already complex Single-Stage Long-Term, Detailed Long-Term, and Time-Sequential models will only drive-up computation time further (it is already several days per capacity outlook optimisation) and further limit AEMO's ability to investigate alternative development paths and risks. As discussed in the "Proposal: A Living Plan and Action Framework for the ISP" section, we suggest replacing the Single-Stage Long-Term model with a "modelling to generate alternatives" activity using a much simpler model (lower spatial and technology resolution).

As discussed in the "Background: Modelling for Investigation and Action" section, framing actions with respect to the ODP alone is likely to overlook significant risks and opportunities related to achieving the National Electricity Objective. The energy planning problem is a super wicked problem featuring high equivocality, radical uncertainty, and fuzzy evaluation. We recommend that the ISP framework introduce a much broader ongoing investigation of risks and opportunities related to achieving potential development paths, making use of simple and transparent models tailored for each investigation. We propose the development of a living risk and opportunities

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[49] Weber, T., Cheng, C., Thawley, H., Catchpole, K., Blakers, A., Lu, B., Zhao, J. and Nadolny, A. [in press]. "Replacing Gas with Low-cost, Abundant Long-duration Pumped Hydro in Electricity Systems", *Cell Reports Physical Science*. Pre-print available from: https://doi.org/10.48550/arXiv.2512.20286
[50] https://doi.org/10.1016/j.enpol.2025.114657
[51] https://hydro.org/wp-content/uploads/2017/08/NHA_PumpedStorage_071212b1.pdf
[52] https://energy.mit.edu/wp-content/uploads/2022/05/The-Future-of-Energy-Storage.pdf

register supported by ongoing modelling investigations, as described in the "Proposal: A Living Plan and Action Framework for the ISP" section.

We propose the alternative future purpose statement, based on SP4:

> *The ISP is the independent, long-term national plan for the efficient development of the whole electricity system in the NEM, including grid-scale generation, storage and transmission, distribution, consumer energy resources and demand-side resources, in the long-term interests of consumers.* **It evaluates risks and opportunities to produce robust and resilient potential development paths***. It triggers project-specific assessment for major transmission projects and other major regulated investments on the* **potential development paths***.*

We believe either SP3 or SP4 represent a direction that best supports the future energy system, **as long as they are accompanied by more important changes related to simplifying the model used to generate initial development path options.** A simpler model replacing the Single-Stage Long-Term model may:

- Reduce the spatial resolution (fewer NEM regions / subregions / nodes);
- Reduce the technology resolution (aggregate power stations of the same technology together within each node);
- Reduce the temporal resolution, while maintaining chronology. This can be done using the "fitted chronology", as per the Detailed Long-Term model. The "sampled chronology" (currently used by Single-Stage Long-Term model) should not be used because of its inability to model long-duration energy storage.

Within the large margin of uncertainty inherent to these long-term planning models, the simple model would be just as accurate as the Single-Stage Long-Term model. However, it would run much faster (allowing thousands of very different near-optimal development paths to be generated) and be more understandable (i.e., more transparent to both AEMO and other stakeholders). The simple model can still serve the role of developing indicative generator investment/retirement plans and establishing the annual carbon budgets over the optimisation horizon for each development path option, as currently performed by the Single-Stage Long-Term model. Ideally, all models in the ISP should shift to be openable (rather than based on opaque proprietary software) and designed for understandability.

In the absence of additional framework changes to generate a large number of near-optimal development path options using a simple model, adding new decision variables is unlikely to increase the value of the ODP. Adding more complexity to the model will not credibly increase the accuracy of the least-cost solution and will only drive computation time up further.

We are also of the opinion that the ISP models should shift from using private investor WACCs to a social discount rate, as this is aligned with delivering on the "long term interests of consumers of electricity" (refer Question 1 response). Furthermore, we suggest the Commission considers including seasonal energy storage in the actionability mechanism in future, though this would depend on additional rule changes that treats it as a regulated or semi-regulated asset (refer Question 3 response).

We understand that our preferred changes to the strawpeople would require additional actions to implement. Some of these changes include:

- Adjustments to the *Cost Benefit Analysis Guidelines* by the AER to use a social discount rate instead of WACC, as well as allowing the use of economic lifetimes consistent with regulated or publicly owned assets where appropriate (such as pumped hydro).
- Changes to the National Electricity Rules to remove the focus on an "optimal development path"; require the development of a living inputs and assumptions database; and mandate a broader, deeper investigation of risks and opportunities to potential

development paths (e.g., the establishment of a risk and opportunities register, along with processes for investigating registered items and updating development paths on an ongoing basis).

- Classification of seasonal energy storage as a regulated or semi-regulated asset, with inclusion in the ISP actionability framework.

Discussion Paper Question 5

1. Do you agree with the Commission's approach to forming an initial preference between the strawpeople?
2. Do you agree with the four factors and the two judgements on their relative weight that underpin our initial preference for SP3? Where you disagree, what evidence supports a different direction?
3. To test the Commission's hypothesis that a broader plan would materially improve the ODP, we are seeking evidence on:
   a. where the current treatment of small distribution, CER and demand-side resources as inputs risks distorting the ODP
   b. which resources would be most material to co-optimise, and which would risk adding complexity without commensurate benefit
   c. what modelling capability, data and governance arrangements would be needed to support broader co-optimisation
   d. the risks a broader plan may create for ODP stability, transparency and accountability, and how these risks could be managed.
4. To test the Commission's hypothesis that a more effective national delivery pathway would materially improve delivery outcomes, we are seeking evidence on:
   a. where the current interaction between the ISP and the RIT-T creates duplication, delay or unnecessary process complexity
   b. what specific reforms could be considered to materially improve the timeliness and efficiency of the RIT-T while preserving appropriate scrutiny
   c. the extent to which a faster and more predictable national pathway would retain more projects within the national framework, rather than moving to jurisdictional pathways
   d. any implementation risks or trade-offs associated with reforming the RIT-T and related processes.
5. Are there features of jurisdictional planning and delivery frameworks that the Commission should consider incorporating into the national framework to strengthen its role alongside jurisdictional pathways?

We conditionally agree with the Commission's initial preference for SP3, but **only if it were accompanied by much more important changes** to the ISP framework:

- The model used for initial generation of potential development paths must be substantially simplified (e.g., technological and spatial aggregation) to reduce computation time, eliminate the need for the "sampled chronology" temporal aggregation which overlooks long-duration energy storage, and allow for a much broader search of the near-optimal solution space (costs within 20–30% modelled optimum).
- Remove AEMO's obligation to select an ODP, since there is an enormous amount of uncertainty inherent to any single potential future. The two additional core scenarios, six sensitivity scenarios, and small number of alternative development paths are inadequate for evaluating risks and opportunities when modelling the grid 25 years in advance. A more diverse set of potential development paths ought to be evaluated in detail, and simple bespoke models should be used to investigate risks and opportunities to incrementally modify potential development paths on an ongoing basis.

In the absence of these additional changes, the increased computational complexity will only further increase computation time, further reducing AEMO's ability to investigate risks and opportunities without providing any credible increase in the accuracy of the results[53]. Purely increasing the number of decision variables will counterintuitively increase uncertainty in the results[54].

We agree with the four factors used by the Commission to evaluate the strawpeople, as reflected in the "Background: Modelling for Investigation and Action" section where we discuss the importance of stability, flexibility, credibility, resilience, and robustness in a good quality energy system plan. We also agree with the two judgements the Commission makes about the relative weight of these factors. While stability remains important for supporting long-term investment, the inability to make accurate predictions when evaluating wicked problems means that the evidence base associated with any one forecast is very weak. As mentioned in the "Background: Modelling for Investigation and Action" section, one study of European countries found energy system model results deviated from real-world transition costs by up to 305%.[55] Additional flexibility allows stakeholders to respond to new risks and opportunities as they arise, since most of them cannot be accurately incorporated into a model.

A broader plan would materially improve the value of the potential development paths. However, we do not agree that it would materially improve the value of the ODP alone. We also do not agree that the co-optimisation of distribution-side assets with grid-scale assets alone, as proposed in SP3, will achieve the Commission's goal of a "broader plan". Developing a broader plan requires expanding the focus of the ISP beyond the ODP to a wider range of near-optimal development path options and requires a more rigorous investigation of risks and opportunities associated with these development paths.

We provide some evidence in response to item 3 below:

- The current treatment of small distribution, CER and demand-side resources as inputs rather than decision variables may be adequate if a range of input values are tested (such as in the existing sensitivity analysis). There is no additional value to treating them as decision variables if the focus is kept on the ODP and a very narrow set of scenarios. There is additional value to treating them as decision variables if the ISP framework is adjusted to perform a much broader investigation of near-optimal development paths (through "modelling to generate alternatives"), since a broad range of solutions with very different configurations of small distribution, CER and demand-side resources can then be evaluated.
- One element of structural uncertainty in the ISP capacity outlook models is the formulation as a least-cost optimisation. Investors do not perform perfect cost minimisation when making decisions since they often have competing objectives – for example, households often invest in rooftop solar and batteries because they care about environmental effects, perceive certain expectations from peers, or want to achieve energy independence, rather than because it is the rational economic choice[56]. Therefore, cost minimisation (the basis of the ODP before the minimum regret analysis) with CER and demand-side resources as decision variables is unlikely to produce a valuable single solution. A broad range of near-optimal solutions would capture different potential development paths where CER and demand-side resource adoption differs from the least-cost optimum due to other consumer preferences.
- Realised flexibility from CER depends on more than the technical availability of CER. Households and businesses do not participate in orchestration programs solely on the basis of economic optimisation. Participation is shaped by trust, perceived fairness,

[53] https://doi.org/10.1016/j.apenergy.2019.113783
[54] https://doi.org/10.1126/sciadv.abn9450
[55] https://doi.org/10.1016/j.energy.2026.141552
[56] https://doi.org/10.1007/s11356-024-32614-5

convenience, needs and practices, advice received from installers and energy advisers, digital capability, and individual preferences. If CER and demand-side resources become decision variables within the plan, then the assumptions underpinning participation in these resources should also be made explicit. Planning outcomes are influenced not only by technology availability but by the social, institutional, and workforce conditions required to realise flexibility in practice.

- Even for classes of investors who may be expected to make more rational economic choices, the ISP modelling does not accurately reflect those decisions. For example, the ODP currently indicates that 16 GWh of additional deep storage (longer than 12 hours) is required by 2050 (excluding Snowy 2.0 and Borumba).[57] However, there is already a development pipeline of 80 GWh of deep pumped hydro.[58] Although not all of these projects are expected to be completed, it is clear that the existing ODP is not an accurate reflection of investor decisions. A broader range of near-optimal development paths would include potential futures where deep storage better reflected existing investment decisions.
- Broader co-optimisation would require simplification elsewhere in the model – the existing capacity outlook models already take multiple days to run. Continued use of the "sampled chronology" method for simplifying time intervals should not be used, since this method is unable to model long-duration storage and skews towards gas[59]. We recommend much more spatial and technological aggregation, as well as the "fitted chronology" method of aggregating time intervals, to reduce complexity of the model used to generate an initial set of near-optimal development paths. It is unnecessary in investigative models to have separate objects for each power station or to have a large number of NEM subregions (spatial nodes).
- Without substantial simplification of the investigative models, broader co-optimisation risks reducing the understandability of the ISP models even further. More decision variables will produce more first- and second-order interactions that dictate results, worsening the black-box nature of the models (lowering transparency). More decision variables will also introduce even greater uncertainty into the models[60].

Discussion Paper Question 6

1. What benefits would extending the ISP's purpose to co-optimise across both electricity and gas infrastructure investment bring? What risks would it introduce?
2. If the ISP's purpose were to extend to gas, what evidence or considerations would be relevant in determining the scope of any associated actionability mechanism?

Extending the ISP's purpose to co-optimise both electricity and gas infrastructure investment may facilitate a better investigation of risks and opportunities related to potential development paths, but may also significantly increase computational complexity. If the gas and electricity

[57] https://www.aemo.com.au/-/media/files/major-publications/isp/2026/supporting-materials/2026-isp-generation-and-storage-outlook.zip?rev=b64eda28a46b4d3eb3e4b3cbafea3f84&sc_lang=en
[58] Calculated from Table 3, excluding Pioneer-Burdekin since this project has since been cancelled: https://www.aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2024/2025-iasr-scenarios/final-docs/ghd-2025-pumped-hydro-energy-storage-cost-parameter-review.pdf?rev=23aa606f804b44c9a60efb1cd078468b&sc_lang=en
[59] Weber, T., Cheng, C., Thawley, H., Catchpole, K., Blakers, A., Lu, B., Zhao, J. and Nadolny, A. [in press]. "Replacing Gas with Low-cost, Abundant Long-duration Pumped Hydro in Electricity Systems", *Cell Reports Physical Science*. Pre-print available from: https://doi.org/10.48550/arXiv.2512.20286
[60] https://doi.org/10.1126/sciadv.abn9450

networks are modelled at a similar level of detail to the existing capacity outlook models, then computation time would greatly increase (already reported as multiple days per run[61]) or may even be infeasible without aggressive temporal aggregation ("sampled chronology" already fails to capture long-duration storage investment in the Single-Stage Long-Term model[62]). Furthermore, mechanisms driving key results could become less understandable with an even larger number of first- and second-order interactions between decision variables.

Assuming the electricity and gas investment model was made much simpler than the existing capacity outlook models through spatial and technological aggregation, some valuable benefits of co-optimisation include:

- The ability to investigate gas shortage risks related to the retirement of coal power stations in the 2030s. Two papers by Simshauser & Gilmore investigate risks related to sequencing coal retirement and the potential for gas market constraints in the 2030s.[63,64] We understand that AEMO currently runs a gas market model to establish daily gas supply constraints in the electricity system models, which is likely just as adequate as co-optimising the networks together for these purposes.
- Fugitive methane emissions could be investigated through a gas market model. Currently, the ISP only considers combustion emissions from gas. Methane has a global warming potential 83 times higher than carbon dioxide over a 20-year horizon[65], and fugitive emissions are likely much higher than reported in UNFCCC reports[66]. Within the existing ISP, a small budget of negative emissions in 2050, based on multi-sector modelling from the CSIRO[67], allows for a small amount of annual generation from gas-powered generators while still achieving Australia's net zero emissions target within the models. If fugitive emissions in from gas infrastructure end up higher than the CSIRO modelling, then the ODP would not be a net-zero pathway. A gas network model within the ISP could investigate the risks posed by these potential futures.
- Gas fuel price forecasts in the ISP are currently based on gas market modelling performed by ACIL Allen[68]. Forecasting gas prices 25 years into the future is just as futile as forecasting electricity system investment because of the enormous uncertainty involved, with gas markets closely coupled to other complex political, economic, and social systems. Incorporating gas network modelling into the ISP would allow AEMO to investigate risks to gas prices. For example, a reduction in gas demand to achieve Australia's net zero targets will mean that gas network costs must be recovered over a smaller volume of gas, and gas fields would no longer achieve the same economies of scale. Would this pose a significant risk to gas prices and, therefore, electricity prices during winter or in contingency events?

Note that none of these benefits necessitate the co-optimisation of the gas and electricity systems in one big "everything model". In most cases, it would be more useful to have simple,

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[61] https://www.aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2024/2026-isp-methodology/isp-methodology-june-2025.pdf?rev=e88a1f1bbeef447ba27692b785069a0a&sc_lang=en
[62] Weber, T., Cheng, C., Thawley, H., Catchpole, K., Blakers, A., Lu, B., Zhao, J. and Nadolny, A. [in press]. "Replacing Gas with Low-cost, Abundant Long-duration Pumped Hydro in Electricity Systems", *Cell Reports Physical Science*. Pre-print available from: https://doi.org/10.48550/arXiv.2512.20286
[63] https://doi.org/10.1016/j.enpol.2025.114940
[64] https://doi.org/10.1111/1467-8489.70065
[65] https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-7/#7.6
[66] https://doi.org/10.1038/s41467-023-40671-6
[67] https://www.aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2024/2025-iasr-scenarios/csiro-2024-multi-sectoral-modelling-report.pdf
[68] https://www.aemo.com.au/-/media/files/major-publications/isp/2025/acil-allen-2024-fuel-price-forecast-report.pdf?rev=3dd0a9e2448f46cabf84196e012eb081&sc_lang=en

targeted models that are tailored to the investigation of a particular risk or opportunity. Potential development paths can be incrementally adjusted in response to these investigations – they do not need to be the raw product of an "everything model".

Discussion Paper Question 7

1. Does the ISP's existing modelling approach reduce the credibility of the ODP? If so, how?
2. How would more comprehensive modelling change the outcomes of the ODP?
3. What further prescription in the NER or guidelines would help the ISP better support investment and policy decisions?

In the discussion paper, the Commission notes that the "ISP's modelling approach and sensitivity analysis should produce a robust ODP that represents a truly least-cost approach to meet power system needs". Other stakeholders expressed concern about the absence of demand-side, distribution network, and gas factor inputs and assumptions, as well as system security and reliability investigations, which they believe reduce the comprehensiveness and robustness of the ODP.

There is a long list of specific risks and opportunities that are not currently investigated with respect to the ODP. We argue that simply providing additional prescriptive guidance to AEMO regarding investigations of specific risks and opportunities (e.g., expanding decision variable scope to include demand-side resources or requiring specific sensitivity analyses) does not comprehensively address the core issues underpinning robustness and credibility of the ODP:

- It is impossible to identify an "optimal" development path, since modelling the grid 25 years in advance is a super wicked problem affected by high equivocality, radical uncertainty, and fuzzy evaluation (refer "Background: Modelling for Investigation and Action" section). There is no credible "optimal" solution, but rather a broad range of very different looking potential futures which cannot be predicted in a quantitative manner.
- The already high computational complexity of the existing capacity outlook and Time-Sequential models prohibits AEMO from comprehensively investigating a broad range of risks and opportunities. There are only six sensitivity scenarios, three core scenarios, and a handful of alternative development paths considered in the cost benefit analysis – these are not representative of the very large set of risks and opportunities that potential development paths are exposed to (e.g., ongoing slow development of wind and transmission infrastructure, supply chain risks to solar components, fuel price and procurement risks for gas-powered generators, reliability risks if rooftop solar centralised in cities dominates compared to utility solar spread across the grid, opportunities for greater solar penetration if ultra low-cost solar is commercialised, the risk of failing Australia's 2050 net zero target if gas-powered generators are used more than expected in 2050 etc.).
- Participation in orchestration should itself be considered a source of uncertainty. Just as future fuel prices, technology costs and policy settings are uncertain, the level of flexibility ultimately available from CER depends on complex interactions between households, businesses, workforce capability, standards, program design and institutional arrangements. Workforce capability is one such risk. Future pathways that rely on high levels of electrification, CER deployment, flexible demand and V2X participation implicitly assume the availability of suitably skilled installers, electricians, advisers and other customer-facing professionals. These workforce assumptions should be made more transparent and tested alongside technology and infrastructure assumptions.

We agree with JEC that AEMO is provided significant flexibility to improve and evolve the ISP, but that additional prescriptive guidance would benefit the process. Our recommendations are for the following changes to the National Electricity Rules to improve robustness and credibility of the ISP:

- Remove reference to an "optimal development path" in the ISP.
- Prescribe an investigation of a broad set of very different looking near-optimal development paths. This should be accompanied by detailed modelling of a subset of different looking potential futures, providing a range of viable options that achieve the National Electricity Objective.
- Prescribe an ongoing process for the identification and investigation of risks and opportunities that affect the feasibility of potential development paths. Potential development paths should be modified on an ongoing basis to respond to the findings of these investigations, thereby increasing their robustness over a broad range of risks and capitalising on new opportunities.

We provide an example of how this ongoing process of identifying and investigating risks can be performed through a publicly available, living risk and opportunities register in the "Proposal: A Living Plan and Action Framework for the ISP" section. The proposed solution would enable other stakeholders to propose new risks and opportunities for addition to the Register, allow both AEMO and other stakeholders to perform an ongoing investigation of registered items, and provide a transparent and structured account of decisions to modify potential development paths in response to investigations. We reinforce the point that simple, bespoke, understandable, and openable models ought to be used for these investigations, allowing stakeholders to interrogate decisions related to development path adaptation, thereby increasing the robustness and credibility of potential development paths.

The proposed expansion of decision variable scope considered by the strawpeople (CER, demand-side resources, distribution, and gas network co-optimisation with the electricity network) may change outcomes of the ODP in the following ways:

- A broader set of near-optimal development paths could be identified if the ISP shifts to performing "modelling to generate alternatives" as its initial modelling activity, as we have recommended. This would need to be accompanied by a substantial reduction in computational complexity through technological, spatial, and temporal aggregation for the MGA model to be feasible. We note that this aggregation is expected to result in a model of similar accuracy to the existing capacity outlook models, but with a much lower computation time. However, other detailed models (such as the Detailed Long-Term and Time-Sequential models) can still be used to refine a subset of potential development paths to have the specificity required for decision-makers to take action.
- Risks related to gas fuel price, fugitive emissions in the gas network, and gas network constraints could be investigated in greater detail, as described in the response to Question 6.

We note that co-optimisation of the proposed decision variables will necessarily increase model complexity. If AEMO does not shift to using much simpler models (lower technological, spatial and temporal resolution) for generating potential development paths and investigating risks and opportunities, then they will necessarily need to perform more aggressive simplification through other methods. Many of these methods can heavily skew results and reduce credibility of the ODP, such as the use of "sampled chronology" which cannot model long-duration storage and skews towards gas investment[69].

[69] Weber, T., Cheng, C., Thawley, H., Catchpole, K., Blakers, A., Lu, B., Zhao, J. and Nadolny, A. [in press]. "Replacing Gas with Low-cost, Abundant Long-duration Pumped Hydro in Electricity Systems", *Cell Reports Physical Science*. Pre-print available from: https://doi.org/10.48550/arXiv.2512.20286

We also recommend the following additional changes to the NER and guidelines:

- Adjustments to the *Cost Benefit Analysis Guidelines* by the AER to use a social discount rate instead of WACC, as well as allowing the use of economic lifetimes consistent with regulated or publicly owned assets where appropriate (such as pumped hydro) (as discussed in Question 1).
- Classification of seasonal energy storage as a regulated or semi-regulated asset, with inclusion in the ISP actionability framework (as described in Question 3).

Discussion Paper Question 8

1. What are examples of how the existing requirement for RIT-Ts to maintain alignment with the ISP would lead to poorer outcomes for consumers? Should flexibility be improved to better enable proponents to efficiently respond to project-specific circumstances and emerging information?
2. Does the reassessment of actionable ISP projects have material consequences for investment certainty? If so, what is an appropriate alternative approach that ensures consumers are protected from inefficient expenditure?
3. Do TNSPs consider there is any duplication between the ISP and RIT-T which materially impacts the timely delivery of projects? If so, how should this duplication be removed?
4. Is there a lack of clarity between treatment of projects that move between, or interact across, the RIT-T and jurisdictional planning pathways that impacts the value of the ISP, and how can clarity be improved?

We do not have a response for Question 8.

Discussion Paper Question 9

1. How do existing accessibility and transparency issues materially impact the value of the ISP? How can elements of the ISP be more accessible and engaging for different stakeholder groups to materially improve the value of the ISP to stakeholders?
2. Can the ISP Consumer Panel effectively input into the ISP process? How could the Panel be better supported?
3. Do network businesses and AEMO consider there are material issues with the existing flexibility of joint planning and information sharing arrangements? If so, what further prescription would improve early collaboration between AEMO and relevant stakeholders?
4. Does the inflexibility of the ISP cycle or ISP update framework to capture new information in a timely way, materially impact the ODP and investment decisions? What are examples of this and how can the framework be more flexible?
5. Is there sufficient clarity over how projects are represented in the ISP? How can clarity be improved?

We agree with other stakeholders that AEMO's engagement currently has good breadth and quality. However, we also agree that there are accessibility and transparency issues that materially impact the value of the ISP:

- The capacity outlook and Time-Sequential models are developed using proprietary software (PLEXOS) and are highly complex. Therefore, the models are black-boxes in two separate ways:

    1. Underlying mathematical equations and implementing code for PLEXOS are secret and cannot be properly interrogated by AEMO or other stakeholders.

2. There are so many decision variables (separate objects for each existing, committed, anticipated, and development opportunity generators/storage systems, as well as actionable or future transmission lines) that it becomes impossible for modellers to understand how all of the first- and second-order interactions actually drive results within the model.

As discussed in the "Background: Modelling for Investigation and Action" section, energy planning models should be openable, parsimonious, manipulable, and understandable. We recommend shifting to modelling frameworks that meet these four criteria for the purposes of generating a broad set of near-optimal development paths and investigating risks and opportunities to achieving those potential development paths. We suggest that specific and detailed models are suitable for refining a subset of different looking development paths to develop a specific, actionable plan for decision-makers. The main purpose of the specific models is to impart consistency to development paths within the plan, not to perform investigations or forecasts.

- As commercial software, many stakeholders do not have access to the expensive PLEXOS licenses required to interrogate the publicly available ISP Model.

- Consultations for the ISP have quite specific scopes and are spread across multiple organisations with differing powers. For example, AEMO does not have the power to modify the *Cost Benefit Analysis Guidelines* developed by the AER or the *National Electricity Rules* developed by the AEMC, but these documents may materially impact the ISP methodology, inputs, assumptions and scenarios that dictate the ODP. While AEMO has the power to select the WACC/discount rate inputs for ISP models, they are required under the *Cost Benefit Analysis Guidelines* to align these inputs with private investor decisions (preventing them from selecting a social discount rate). Consultation on the IASR would seem to be an appropriate place to recommend swapping from WACC to a social discount rate, but AEMO does not have the power to effect this change. **Adding porosity to the various consultations** would allow stakeholder feedback to be transferred to the relevant organisation or consultation process to meaningfully inform future ISP development. For example, a formal process should allow for feedback that AEMO receives through consultation to be passed along to the AEMC or AER for action (and vice versa), and feedback received in the ISP methodology consultation to be transferred to the next IASR or Draft ISP consultation if it is relevant to address there.

Our main concern regarding ISP flexibility is not related to the timelines of the existing cycle or the update framework. Rather, the focus on a very narrow set of potential futures (ODP, two additional core scenarios, six sensitivity scenarios, and a handful of alternative development paths) is itself a source of inflexibility, severely limiting the information available to decision-makers. Due to the energy planning problem featuring high equivocality, radical uncertainty, and fuzzy evaluation (refer "Background: Modelling for Investigation and Action"), forecasting from a model becomes impossible, and simply updating the ODP in accordance with the existing ISP cycle and update framework does not materially improve its accuracy or robustness. We recommend increasing the flexibility of the ISP through an exploration of a broad set of near-optimal development paths using a simple model, and the ongoing identification and investigation of risks and opportunities related to potential development paths (as described in "Proposal: A Living Plan and Action Framework for the ISP").

Discussion Paper Question 10

1. Do stakeholders agree the Review should not further consider the identified issues?
2. Are there any additional issues, that are not outlined in this discussion paper, that materially reduce the ISP's value, and we should consider in the next stage of the Review?

We refer the Commission to our earlier responses regarding model design, the treatment of discount rates in the *Cost Benefit Analysis Guidelines*, the potential for seasonal storage to be considered under the actionability framework, and our proposed "living plan and action framework" for developing a robust and resilient ISP.

Conclusion

The ISP is widely regarded as a world-leading energy system plan. We appreciate the continuing efforts by the Commission to further improve the ISP framework to develop a stable, credible, and robust plan and actionability mechanism that deliver on the National Electricity Objective.

Energy system planning involves managing large amounts of uncertainty about the future. It is impossible to accurately predict the amount of CER uptake, level of demand-side orchestration, investment in both the gas and electricity systems, and factors impacting transmission line development over multiple decades. Because of these challenges, simply adding greater detail to the ISP models will not reveal a more “optimal” development path and will only increase optimisation time. Co-optimisation of new types of decision variables in the ISP models must only be done when combined with a large reduction in computational complexity.

The use of simple, openable, and understandable models to investigate a broad range of good-enough potential futures, new opportunities, and key risks to development paths would greatly improve the transparency, credibility, robustness, and resilience of the plan. A “living plan and action” framework for the ISP would make it responsive to new information and reveal important information to decision-makers.

We hope that our recommendations can help to improve the ISP framework even further. If the Commission has further questions regarding our submission, we are more than happy to discuss them directly with the team.

Kind regards,

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