ENGINEERS AUSTRALIA

Draft 2022 Integrated Systems Plan consultation
Australian Energy Market Operator
By email: ISP@aemo.com.au

11 February 2022

Re: Draft 2022 Integrated Systems Plan consultation

Dear Sir or Madam,

Engineers Australia is the peak body representing the engineering profession in Australia. We are the voice of over 100,000 individual members working in every sector of the economy, with expertise across all disciplines and branches of engineering.

Engineers Australia welcomes the opportunity to participate in the consultation concerning the Draft 2022 Integrated Systems Plan (ISP). The ISP and associated modelling outline an ambitious path for the energy transition underlined by the need to reach the Net Zero by 2050 target. Engineers Australia congratulates AEMO on that ambition and acknowledges the scale and complexity of the task at hand. A task that will require a national effort to achieve in the timeframes required. The Draft 2022 ISP brings the challenge into stark contrast, and reinforces the critical work being undertaken through the NEM Engineering Framework to identify the issues that need to be addressed to ensure system stability and security.

Summary

The ISP could be enhanced through:

- Providing more complete and transparent modelling, particularly demand modelling that includes worst case scenarios for minimum and coincident minimum demand, as well as worst case scenarios for renewable generation. It is not always apparent how the conclusions contained in the ISP have been drawn. It would be greatly beneficial to provide enough detail that experienced engineers can validate the credibility of the ISP scenarios.
- Maintaining and improving the reliability and security of the power system by prioritising the technical requirements and system control engineering ahead of 'market' concerns. Without appropriate primary controls in place the system will be vulnerable.
- Providing end-to-end costings to bring greater clarity on the total impact on future delivered electricity costs.
- Providing greater confidence in the ISP through contextualisation in the broader Australian context, such as key interfaces, relationships and dependencies.
- Greater consideration of the impact of the rapid increase in DER on distribution network regulatory frameworks and market models, particularly as DER penetration increases.

Further, while beyond the mandate of the ISP, Engineers Australia believes an urgent review of the current energy workforce and a gap analysis is required to ensure the transition outlined in the ISP is achievable.

Summary of recommendations:

1. Place greater emphasis on power system control engineering and ensure the technical requirements maintain an appropriate primacy over market considerations.
2. Recommendation: Provide greater emphasis on minimum demand, particularly coincident minimum demand, and provide greater clarity on the demand modelling methodology employed; and clarify the worst-case assumptions for the minimum renewable supply for seasonal conditions, daylight and night time supply.
3. Recommendation: Work with distribution network owners to set the boundaries on power reversal.
4. Recommendation: Provide more detail on DER integration and market models in the distribution network, particularly as penetration increases.

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5. Recommendation: Provide more guidance on the best DER integration pathway for DNSPs.
6. Recommendation: Improve interaction with and obtain more extensive load / generation data from DNSP's.
7. Recommendation: Review the purpose of the ISP to better contextualise the "Power System" in the broader Australian operational energy context, explicitly identifying key interfacing systems and agencies as well as socio-technical interfaces and imperatives.
8. Recommendation: Provide greater clarity on the basis and validity of the models, techniques, governance, tools and data employed.
9. Recommendation: In the future, it is recommended that information covering customer energy use, capacity factors, storage performance, environmental performance and security of supply be included in the ISP spreadsheets.
10. Recommendation: Enhance the ISP financial analyses to incorporate all electricity costs, report on customer delivered costs in units of $/MWh each year through to 2050 and provide a NPV analysis in a way that all scenarios can be compared directly with each other.
11. Recommendation: Build an end-to-end costing methodology and include additional information covering financial performance in the ISP spreadsheets.
12. Recommendation: Clarify the assumptions underlining the impacts on Humelink of retaining or developing new dispatchable capacity, and the specific circumstances that might lead to these projects not proceeding as flagged in the Draft ISP.
13. Recommendation: Clarify the rationale behind the proposed timing of the Marinus Link augmentations, and their expected impact on the NEM.
14. Recommendation: Clarify the rationale for the QNI Connect Stage 2 timing.
15. Recommendation: Broaden the ODP to a national transmission development plan, including an integrated approach to connecting Renewable Energy Zones and further consideration of the integration of DER.
16. Recommendation: Further emphasis on the importance of social licence, including proactive engagement, integrated land-use and a review of the remuneration for hosting transmission infrastructure.
17. Recommendation: Conduct a national gap analysis of the energy workforce to put a plan in place for the energy transition.

1. Fit for purpose

The ISP's prescribed purpose in accordance with the NER 5.22.2 is "… *to establish a whole-of-system plan for the efficient development of the power system that achieves power system needs for a planning horizon of at least 20 years for the long-term interests of the consumers of electricity*." The power system requirements are stated to be the "reliability and security needs for operating a power system within the operating limits and in accordance with operating standards".

The ISP therefore should describe the development of the power system across the 20 years period for the consumers of electricity as a critical capability within the Australian energy context that underpins economic well-being. While the ISP covers an extraordinary volume of appendices and data assumptions and describes "modelling," the presentation of the findings appears to lack transparency as how the conclusions have been drawn and raises questions on the methodologies from a power system planning perspective. Engineers Australia acknowledges the role and constraints of AEMO and the ISP, but the draft also appears to be developed in the absence of a broader operational and environmental context, which makes it hard to understand how it fits in to the political and technological landscape.

Electricity is an instantaneous product which calls for clear descriptions of the expected forecast minima and maxima across the forecast period. To meet the ISP purpose, the report ought to clearly articulate whether the expected demand will be supplied, the reserve maintained, and the power system operated to the standards and remain within the operational and forecast limits. This requires not just the average operating conditions, but also an assessment of worse case contingencies (note: worse case contingency in accordance with the Power System Stability Guidelines 2012). While actual dynamics of the future system are not available, the underlying methodologies adopted in the "modelling" require explanation and clarification that worse case operating scenarios have been considered.

The results should reassure the reader that there is an understanding of and a plan for the management of such operating conditions. A reader should be able to draw the same conclusions as the author, given the context, the data and the logic that underpins the conclusions. The Draft ISP does not provide the reader with sufficient transparency for the conclusions provided. Nor does it layout the plan for the management of the future possible operating conditions.

The ISP does not articulate how the power system requirements are being met across the planned period. While it presents a lot of forecast energy figures, there are threats to the power system hidden within this data that do not appear to have been identified and the management of excess energy is not clearly articulated.

Key areas which have not been adequately addressed include:

- The management of minimum demand and the likelihood of coincident minimum demand in all regions is not addressed, the consequences of which will threaten system security.
- Appendix 7 on system strength should be updated with respect to available controls of grid forming inverter technology, they have been proven and are available and do provide "strength", inertia and a number of other control characteristics.

2. System control engineering

In order for the future transition to be undertaken in an orderly fashion it is critical to appreciate key elements that underpin management of the power system. It is observable in both the ISP and the Engineering Framework that belief in "operability" has become a key focus. In terms of power system control philosophy, it is important to appreciate that primary controls occur in time frames faster than human cognitive capability, always have and always will, so there is no operator that can "fix" something on the power system unless the controls are in place to isolate, stabilise and respond. Operators, armed with forecast information, act to prepare the power system operating conditions particularly in times of expected abnormal conditions, such as bushfires or extreme weather. An operator has limited actions that they can take following an event and can only act to return a line to service, by switching a reactive device or other supportive directives, but after the primary controls have acted. Failure to have the primary controls in place leave the operators and the system exposed to failure. This function remains critical. The technical requirements of the system have primacy and therefore set the limits on what the market is allowed to do.

Hence, it is time to place the planning and system control engineering problem at the forefront of the power system transition. The lack of transmission planning coupled with the disenfranchisement of system control engineering have led to an operating environment with little or no system control engineering support. The philosophy and the hierarchy of control for the power system has been weakened without an adequate appreciation of the consequences of decisions made in the decades of market implementation.

Recommendation: Place greater emphasis on power system control engineering and ensure the technical requirements maintain an appropriate primacy over market considerations.

3. Complexity into context

It is evident that society needs to adopt energy supplies that will not exacerbate or contribute further to climate change and global warming. Coupled with this urgency is the need to ensure that the nation can protect its arable land and water supplies for future food security. The ISP must integrate into the broader Australian context to ensure sustainable resilience

Looking at the question of system strength and the concerns raised over low fault levels and the operation of inverter-based generation, it is reasonable to observe that the areas where renewable projects are connecting to the power system are in rural regions, where there is sparse population (less housing), and the land is "available". Most of these areas have had transmission provided through the 1960s and '70s for rural electrification, the lines are long ac transmission lines with limited capability to transmit power. The "heat maps" provided on "system strength" would look like this regardless of connections simply due to their distance and design. The large investments being made to connect into the NEM do not eliminate the fundamental design of these transmission lines.

Therefore, taking a step back from the projects presented in the Draft ISP, it is worthwhile asking the following questions:

- Do the projects proposed contribute to strengthening the power system?
- What is being done to improve the reliability and strength of the transmission to connected generators?
- What primarily drives the selection of the proposed projects?
  - Is this due to market forces? (a cluster of proposed developments in an area?)
  - Will these developments enable or detract from the overarching needs of the nation?
- Should network planning now consider rural zoning to protect food security and set transmission plans in place for the provision of grid scale solar generation from marginal (unproductive) land?

4. Distribution networks

There is a lack of focus on distribution networks (particularly around Distributed energy resources (DER) integration and impacts of Electric Vehicles). The Draft ISP assumes that all DER generation can be exported into the network; this is not going to be possible without additional investment in the distribution network (either through traditional network capacity augmentation, investment in energy storage or through the development of more innovative 'active management' approaches such as dynamic network monitoring, state estimation and dynamic operating envelopes).

5. Minimum demand

Examining the commentary and analysis of the forecast minimum demand fails to address problems that arise from a power system point of view.

Minimum demand on the High Voltage (HV) transmission system presents a significant stability issue. Excessive reverse power from regions in excess of the operational demand is likely to cause unintended consequences. Generators have reverse power protection, and once reverse power is detected the units will trip. The minimum demands forecast in the step change scenario are presented for each region but no diversity factor between timing in each region is provided nor any discussion of what would happen if the minima coincided.

Assessing the actual minimums that currently occur, show that Victoria and SA minimums are coincident for 12:00 to 13:00 with SA extending through to 14:00. In NSW (and as reported in the Q4 2021 market dynamics report), the demand is reducing and minimum demand decreasing. While this minimum still occurs around 03:00 to 04:00 the demand around 12:00 is approaching the 03:00 minimum. Similar reduction is also occurring in Tasmania. If this trend continues, it will mean that NSW will coincide with Vic and SA minimums. Engineers Australia understands that some distribution parts of QLD have regulations in place to prohibit distributed residential PV from exporting, some parts do not, which explains why the minimum in QLD remains at or about 03:00. The trend therefore is to have an early morning (03:00) minimum and a midday minimum due to solar PV. The greater volume of residential solar PV, the wider the minimum demand commencing at 12:00.

If the minimum demand in SA, Vic and NSW is so low that these areas export and if QLD demand is low in the coincident period, there will be excess power in the system derived mainly from relatively uncontrolled small PV systems with distribution systems exporting into the HV transmission system. Energy exported into the transmission system with insufficient load cannot currently be managed. This situation is developing at pace and if left without controlled storage / load devices absorbing the excess energy, will cause a significant risk to the security of the system.

Given the rapid pace of this development, appropriately engineered controls coupled with significant distribution network analysis is required to best advise the equipment and investment required to manage the power reversal. Proposals for AEMO to manage “behind the meter” residential PV is an unnecessary overreach into the distribution system. Also, behind the meter solutions are likely to cause significant customer dissatisfaction and may not result in an optimal control solution. The distribution network owners and distribution controllers require technical leadership to set the boundaries on power reversal, and this report is silent on the problem.

The impact of a daily minimum demand caused by the increase of rooftop solar uptake affects the distribution network at three levels, all of which will affect capital expenditure:

- System level – Oversupply during the middle of the day may force large solar generators to be switched off as ramp up times are quicker than coal fired power stations.
- Zone Substation level – Cyclic issues due to reverse flow may reduce the life of zone substation transformers.
- Feeder level – May impact the stability of individual feeders causing voltage fluctuations which, in turn, impact protection settings at a feeder level.

Rooftop PV is driving an increasingly rapid change in the load on the network from the day to night. This may give rise to an expanded role for fast ramping but more expensive generators to manage the transition and supply overnight, potentially limiting the economic viability of existing baseload and new renewable generators, increasing the cost of wholesale energy. Managing the transition may necessitate greater dynamic reactive plant and give rise to challenges in system operation.

Distribution networks are experiencing a rapid reduction in minimum demand, along with growth in maximum demand. It would be beneficial to include greater consideration and guidance on these issues in the Draft ISP.

Recommendation: Provide greater emphasis on minimum demand, particularly coincident minimum demand, and provide greater clarity on the demand modelling methodology employed; and clarify the worst-case assumptions for the minimum renewable supply for seasonal conditions, daylight and night time supply.

Recommendation: Work with distribution network owners to set the boundaries on power reversal.

6. Distributed energy resources

Consumer-led rooftop PV, small-medium DER resources and distributed storage are expected to form 20% of capacity by 2050. While Engineers Australia acknowledges the work done as part of the AEMO Engineering Framework, we believe these critical issues need further attention to ensure this is driven by technical leadership and not market priorities.

While virtual power plants (VPPs) can be used to harness distributed capacity in a market sense by aggregation, this does not address the engineering, market or sustainability issues posed by extensive penetration of DER. Each DER connection to a distribution system poses technical issues that must be addressed at the point of connection, as with a large generator connection at the transmission level.

However, a large volume of distributed connections must be dealt with differently to a small volume of large, localised connections.

The engineering challenges are highly significant once DER penetration reaches a threshold which varies depending on the proposed point of connection. Challenges include:

- Distribution Network Service Providers (DNSP) will need to make additional investments to allow for two-way power flows without any direct way of signalling that once local DER saturation is reached, whether due to equipment capacity, voltage regulation, fault levels or other power quality issues.
- Additional investments are increasingly inefficient. The cost impacts of local investment are felt across the entire distribution network cost model unless they are fully customer funded.
- The distribution use of systems (DUOS) model means that customers who opt for inefficient capacity investments may drive up costs for other consumers due to avoided DUOS charges.
- Truly cost-reflective connection charges and time of use (ToU) tariffs for DER may send the appropriate signals but they will not be welcomed by consumers, and while a transition to these is possible over a long time it may be too late to arrest significant investments which prove to be inefficient over their asset lives. This means cross-subsidisation of DER may persist until appropriate and transparent costs and benefits are established through regulatory change. The long-term impact of this is to reduce asset utilisation and drive-up electricity prices.
- These issues have the potential to seriously undermine the National Electricity Objective, so some cohesive planning needs to be undertaken to optimise the value of consumer-led capacity investments. VPPs are one way to harness capacity but they do not necessarily make inefficient investments efficient or make surplus capacity valuable.
- Similarly, electrification of personal transport poses significant challenges. If the point of connection and timing of charging/discharging vehicle batteries are not controlled or at least strongly influenced by a distribution network operator it makes capacity planning and system operation/security an impossible task. While the Draft ISP acknowledges this, greater consideration is needed.

It may be appropriate for the next ISP to examine how transmission investments potentially become less efficient once a consumer led DER threshold is reached. For example, if consumer-led capacity reached 50% it would likely reduce the return on investment on the new transmission links proposed in the ISP as well as significantly increasing electricity prices for a sizeable portion of the market.

Given the rapid and ongoing increase in small to medium scale DER projected in the ISP, it is suggested that serious and urgent consideration be given to distribution network regulatory frameworks and market models to ensure an orderly transition and value creation consistent with the National Electricity Objective.

There does not appear to currently be consistency and coordination and between how each of the DNSPs are managing the challenge of DER integration. It would be beneficial to see some focus from AEMO in the ISP on outlining what the best DER integration pathway would be for DNSPs moving forward.

Recommendation: Provide more detail on DER integration and market models in the distribution network, particularly as penetration increases.

Recommendation: Provide more guidance on the best DER integration pathway for DNSPs.

Recommendation: Improve interaction with and obtain more extensive load / generation data from DNSPs.

7. Systems engineering approach

In broad terms three key areas are identified for your consideration regarding a systems engineering approach, particularly with respect to power systems theory and control practice:

a) Clarity on the demand modelling:

The ISP appears to be focused on capacity to deliver but is (relatively) silent on the approach or specific projections of future energy requirements to be met. Engineers Australia acknowledges that many documents are referenced regarding forecasting demand, but greater clarity on the source of future energy projections and methodology is required.

b) A Systems Approach:

- Expanding the considerations to explicitly contextualise the "systems of systems" of interest to explicitly identify the (ISP) boundary, the operational environment and key interfaces, agencies, relationships and dependencies would be beneficial, especially so in relation to the activities of related agencies.
- Analysis and synthesis to explicitly establish system boundaries, relationships and the environmental context would improve clarity of the ISP content and scope, as well as minimise the risk of a mismatch with related agencies and of unintended outcomes from interfaces and interoperability.
- We acknowledge the role of AEMO and the ISP, nevertheless, greater contextualisation would provide confidence in the ability to answer questions around policy and political implications, such as the need for subsidies on EVs or energy storage to kick-start innovations and their uptake; the implications on critical infrastructure / sovereign capabilities; and is the ISP consistent with associated initiatives across all applicable agencies and domains, and how the integrity of this consistency will be managed.

c) Modelling, Simulation and Analysis

- The use of Modelling, Simulation and Analysis is foundational to the ISP, however greater clarity on the basis and validity of the models, techniques, governance, tools and data employed would allow others to review and validate outcomes.
- The data provided would be improved by baseline data in addition to the predictions for 2030 and 2050.
- It is imperative that the ISP demonstrates that it has enough year-by-year capacity to supply the forecast loads with a reasonable margin of safety, particularly in periods of wind drought and low solar radiance as did occur in June 2017 and at other times.

Recommendation: Review the purpose of the ISP to better contextualise the "Power System" in the broader Australian operational energy context, explicitly identifying key interfacing systems and agencies as well as socio-technical interfaces and imperatives.

8. Enhancing the credibility of the ISP scenarios

From the information provided, some Engineers Australia members have found it hard to understand how the ISP has reached the conclusions it has. For example, they cannot see how some of the ISP scenarios have enough generation and storage to supply the nominated forecast loads.

It would be greatly beneficial to provide enough detail that experienced engineers can validate the credibility of the ISP scenarios.

Recommendation: Provide greater clarity on the basis and validity of the models, techniques, governance, tools and data employed.

Recommendation: In the future, it is recommended that information covering customer energy use, capacity factors, storage performance, environmental performance and security of supply be included in the ISP spreadsheets.

9. End to end costing

Advice received from AEMO that behind the meter costs of solar PV and battery storage do not form part of the ISP net present value (NPV) analysis is a limitation. While the NPV costing of Scenarios provided in the ISP is useful for comparing variations in transmission development pathways, it does not convey the total impact on future delivered electricity costs.

It also appears that augmentation of low voltage (LV) systems, medium voltage (MV) systems and subtransmission systems have not been included. If the goal of the draft ISP is simply to find the best transmission plan within a specified scenario, what has been undertaken within the ISP will assist, but this does not cover off on the stated Purpose. A direct consequence of this approach is that the NPVs calculated for each of the scenarios will not be comparable with each other or provide guidance on which scenario provides the best outcome for customers.

The financial analysis needs to go beyond what has been provided in the draft ISP. The ISP aim should be to minimise the total cost of electricity supply to customers, not just to minimise the NPV cost of transmission, HV generation and grid storage. The scope of the electricity costs should include:

- Grid connected generation (both DNSP and TNSP).
- Transmission.
- Grid connected storage (both DNSP and TNSP).
- All subtransmission.
- All LV and MV distribution.
- All behind the meter generation and battery storage.
- Retail and Metering

The ISP should show comparable HV and LV customer delivered costs in $/MWh for each year through to 2050 for all the scenarios. These costs could be based on 2022 prices with a nominated weighted average cost of capital (WACC) of say 6% or similar. All scenario costs and NPVs need to be on a common base so that they can be directly compared. This approach would deliver more fully on the Purpose of the ISP and deliver better value to the public for the investment made in building the plan.

In the NEM, electricity supply costs are driven by investments by generators, TNSPs, DNSPs, retailers, meter Service Providers and customers. For customers, the supply cost contributions are mostly by way of rooftop solar PV and small-scale battery storage. The aim should be to build ISP scenarios to assess and minimise the ongoing delivered costs of energy. Small scale behind the meter Solar PV and battery storage needs to be treated as just another NEM resource. Use of this methodology is unlikely to change the rankings of exiting transmission recommendations made in the ISP, but it will open up a new informed conversation and provide a more valuable contribution to the community.

Recommendation: Enhance the ISP financial analyses to incorporate all electricity costs, report on customer delivered costs in units of $/MWh each year through to 2050 and provide a NPV analysis in a way that all scenarios can be compared directly with each other.

Recommendation: Build an end-to-end costing methodology and include additional information covering financial performance in the ISP spreadsheets.

10. Comments on specific ODP transmission projects

Humelink

Humelink operation by 2027 or later seems to be a limiting factor for Snowy 2.0 pumped hydro dispatch when it starts operation in 2025/26. Network limitation may lead to curtailment for Snowy 2.0 in these years.

It would be helpful to understand more about the assumptions underlining the impacts on these projects of retaining or developing new dispatchable capacity, and the specific circumstances that might lead to these projects potentially not proceeding as flagged in the Draft ISP.

Recommendation: Clarify the assumptions underlining the impacts on Humelink of retaining or developing new dispatchable capacity, and the specific circumstances that might lead to these projects not proceeding as flagged in the Draft ISP.

Marinus Link

The timing for Marinus Link Stage 1 and 2 needs updating, as noted in the Draft ISP. 2029 and 2031 seem more realistic and this will need to be updated in the final Plan.

In terms of network augmentations, the rationale behind the proposed timing would be helpful to understand, as well as their expected impact on the NEM.

Recommendation: Clarify the rationale behind the proposed timing of the Marinus Link augmentations, and their expected impact on the NEM.

QNI Connect

The rationale for the QNI Connect Stage 2 timing and additional network capacity is not clear. It is mentioned that Stage 2 is to string a second circuit to the same 330 double-circuit line, and it would make sense to consider this capacity in Stage 1. Addressing these details would avoid any confusion moving forward for the modellers and stakeholders.

Recommendation: Clarify the rationale for the QNI Connect Stage 2 timing.

11. General comments

The ISP outlines a huge task that will require a national effort to achieve in the timeframes required, including:

- A significant and growing increase in renewables and firming capacity. Engineers Australia acknowledges and welcomes the Connections Reform Roadmap. However, this requires significant additional focus to achieve grid connections at the pace needed.
- The 10,000kms of transmission needs a nationally coordinated approach to deliver effectively and efficiently but is only part of the solution required. Renewable energy will be connecting into parts of the transmission system that were fundamentally designed around rural electrification around 50 years ago and not for bulk transmission of power to load centres. These are high impedance circuits that by the very nature of their design, are “skinny” and long and prone to voltage fluctuations. We acknowledge that the role of the ISP is to identify solutions that target net market benefits. However, a national transmission development plan, including an integrated approach to connecting Renewable Energy Zones and further consideration of the integration of DER is required.
- As acknowledged in the ISP, social license has the potential to become a significant barrier to transmission infrastructure. Early proactive engagement and integrated land-use planning are required. The system of remuneration for hosting transmission infrastructure needs to be reviewed.
- Most importantly from an Engineers Australia’s perspective, we need the personnel to implement the works required. The supply of necessary skills, particularly engineering skills, is both critical and

concerning. Infrastructure Australia is forecasting an unprecedented wave in public infrastructure projects over the next five years for which we do not have the skills, with engineers of particular concern. We need to understand the current energy workforce and to put a plan in place for the future that enables the energy transition.

For these and other reasons Engineers Australia joins a growing chorus of voices calling for a comprehensive national energy transition strategy to address all these issues. While we acknowledge this does not sit within the domain of AEMO and the ISP, it is nevertheless a critical issue that needs to be acknowledged and addressed to achieve the future outlined in the ISP.

Recommendation: Broaden the ODP to a national transmission development plan, including an integrated approach to connecting Renewable Energy Zones and further consideration of the integration of DER.

Recommendation: Further emphasis on the importance of social licence, including proactive engagement, integrated land-use and a review of the remuneration for hosting transmission infrastructure.

Recommendation: Conduct a national gap analysis of the energy workforce to put a plan in place for the energy transition.

To discuss further, please contact either Jane MacMaster, Engineers Australia Chief Engineer, at chiefengineer@engineersaustralia.org.au, or Grant Watt, Senior Policy Advisor, at policy@engineersaustralia.org.au.

Yours sincerely,

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