# Executive Summary

Long-term electricity system planning increasingly requires comparing generation technologies with fundamentally different cost structures, operating characteristics, asset lifetimes, and system roles. While levelized cost of electricity (LCOE) remains a useful indicator of the levelized cost of delivering electricity over an asset's economic lifecycle, it does not, on its own, capture the full range of aggregate system benefits that different resources provide, particularly with respect to grid benefits, environmental, socioeconomic, and policy considerations. Depending on the rigor with which it is carried out, a detailed Integrated Resource Planning (IRP) study reflects many aspects of the system-level contributions. Nevertheless, as the resource mix evolves and non-energy services become more material to system performance, there is a growing need for complementary planning metrics that reflect both cost and system value. These metrics can provide useful information to stakeholders outside of the detailed IRP planning cycle.

This study develops and applies a lifetime-adjusted, multi-criteria framework to assess the comparative aggregate system benefits of four electricity generation technologies: waterpower, gas-fired generation, wind power, and solar power. The analysis combines cost information derived from the IESO 2024 Outlook Planning Report with structured benefit assessments obtained through an Analytic Hierarchy Process (AHP). Aggregate system benefits are evaluated across four criteria groups: grid and system benefits, environmental impacts, socioeconomic considerations, and policy alignment. Benefits are then adjusted over the assumed economic life of each technology to ensure consistency with the lifetime basis of LCOE. Cost ranges reported by international sources such as NREL and Fraunhofer ISE are shown to illustrate the breadth of cost estimates observed across jurisdictions and studies, and to place the IESO assumptions within a broader industry context. These international ranges are not used as inputs to the core analysis. The IESO cost values are adopted as the base case to maintain consistency with Ontario context.

The results demonstrate that cost alone is an incomplete proxy for the aggregate system benefits of a technology. Across the cost–value representations, technologies with similar LCOE or similar cost shares exhibit materially different lifetime-adjusted aggregate system benefits. The study shows that lifetime-adjusted benefits do not scale proportionally with relative cost, indicating that differences in operational role, flexibility, reliability support, and system integration dominate over LCOE in determining aggregate system benefits. This confirms the importance of complementing cost-based metrics with explicit aggregate system value indicators when evaluating long-term investment options.

The lifetime adjustment of aggregate system benefits is shown to be a structural determinant of comparative results. Long-lived assets that provide multiple system services accumulate value across several decades in ways that shorter-lived or more narrowly scoped assets do not. Aligning the time horizon of benefits with the lifetime basis of LCOE materially affects relative technology positioning and avoids systematically disadvantaging long-lived infrastructure assets. The lifetime-adjusted framework therefore represents a core modelling assumption rather than a secondary technical refinement.

Distinct and persistent patterns emerge in the cost–value space. Across all representations, non-dispatchable technologies form a clearly defined low-cost, lower-benefit cluster, while dispatchable technologies occupy distinct and differentiated positions rather than a single cluster. Hydropower consistently occupies the high-cost, high-benefit region of the cost–benefit space and remains well above the value-proportional-to-cost reference line under all scenarios examined. Its position reflects a diversified benefit profile across all criteria

Gas-fired generation occupies an intermediate position, delivering moderate lifetime-adjusted aggregate benefits relative to its cost range. Its relative positioning exhibits greater sensitivity to changes in evaluation priorities compared to other technologies, reflecting the composition of its benefit profile across criteria. Wind and solar power consistently occupy the low-cost, lower-benefit region, reflecting their primary contribution to energy supply and emissions reduction, alongside more limited contributions to system operability.

The sensitivity analysis indicates that while changes in criteria weighting lead to observable shifts in relative system value, the broad ordering, grouping, and cost–benefit positioning of technologies remain relatively stable under plausible variations in evaluation priorities. The comparative structure of the results is therefore robust to changes in weighting perspective. Policy priorities influence relative magnitudes, but do not materially alter the fundamental aggregate system roles or clustering of technologies.

The value-per-dollar representation provides a complementary metric that integrates cost, lifetime, and multi-criteria benefit into a single decision-oriented indicator. The study shows that technologies differ substantially in how effectively aggregate system value is delivered per unit cost (LCOE). This perspective highlights differences in cost effectiveness that are not apparent from LCOE metrics alone and supports interpretation of trade-offs between direct costs and aggregate system benefits.

The analysis has several implications for long-term system planning. First, the results indicate that generation comparison could benefit from explicitly recognizing the long-term value creation associated with technologies that provide benefits in multiple domains, even where upfront costs are higher. Second, the findings suggest that approaches that reflect complementary system roles and other environmental and socioeconomic benefits can complement other approaches that focus primarily on minimizing cost. Finally, the results highlight the value of valuation frameworks that more fully reflect the range of aggregate system benefits provided by different technologies, including reliability, flexibility, and grid support.

This study provides a practical framework for integrating lifetime-adjusted multi-criteria benefit assessment with lifetime-adjusted economic metrics (LCOE) in a transparent and internally consistent manner. The study offers a systematic pathway for developing value-adjusted LCOE measures and for extending traditional comparisons of technologies beyond single-metric comparisons.

Overall, the results indicate that comparisons of technologies could be supported by integrating both cost-based and value-based comparative frameworks. Such an approach enables explicit trade off among affordability, reliability, sustainability, and long-term system resilience, in an evolving electricity system.