CRA Charles River Associates



Beyond validation: Integrating transmission intelligence throughout the IRP

How transmission analysis can improve scenario development, portfolio design, portfolio evaluation, and investment decision-making

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Executive summary

Integrated Resource Planning (IRP) has traditionally focused on identifying resource portfolios that meet future customer needs at the lowest reasonable cost while maintaining reliability. Transmission constraints may be represented in planning models, but transmission is often treated as a downstream validation step after candidate generation portfolios have been developed.

However, that sequencing may become harder to sustain as rapid changes in electricity demand, generation, and power flows make **location** increasingly important.

A resource's value is determined not only by its cost and operating characteristics, but also by where it is located, how it uses the network, and whether its output can reach customers when it is needed.

CRA's recent work for utilities, investors, developers, and large-load customers indicates that transmission analysis can create value when it is used early and iteratively. Studies that begin with questions about headroom, congestion, deliverability, or interconnection costs often reveal broader implications for load growth, resource siting, portfolio risk, customer costs, and long-term investment needs. Transmission can therefore be treated not only as a constraint to test, but also as a source of planning intelligence throughout the IRP lifecycle.

This white paper, the second of a series of four, presents a transmission-integrated IRP framework organized around four planning stages:

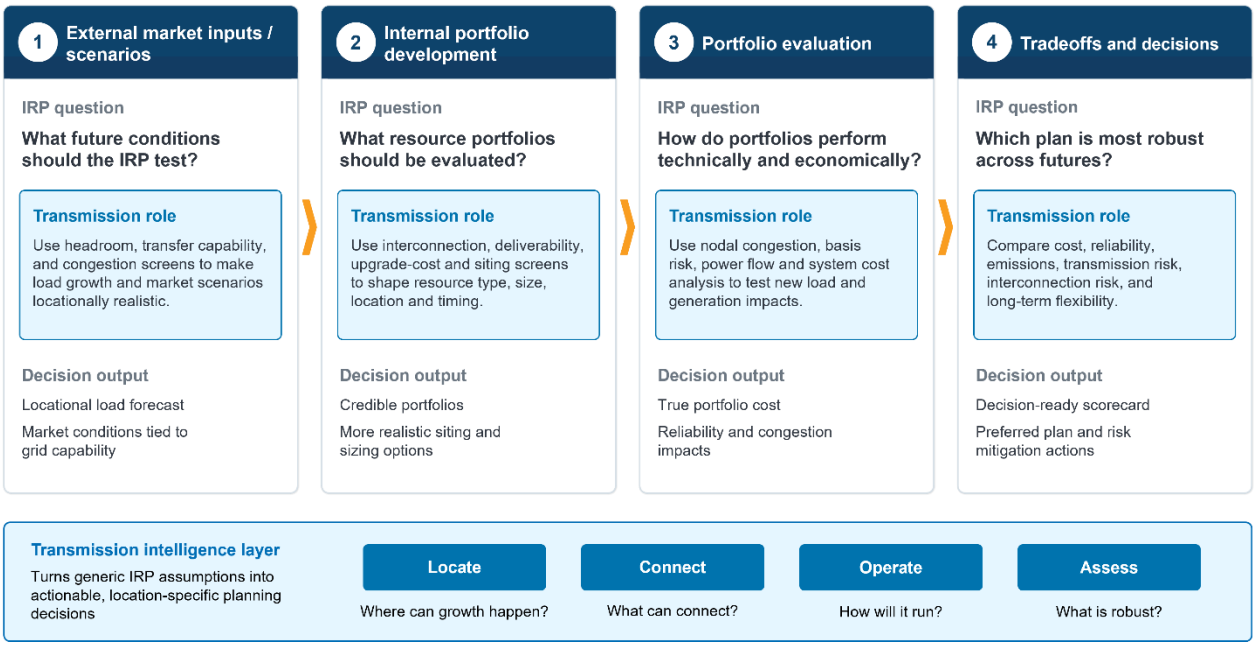
- Scenario development
- Portfolio development
- Portfolio evaluation
- Investment decision-making

Transmission analysis adds a continuous layer of locational, economic, operational, and implementation insight that can improve assumptions, portfolio choices, and capital decisions.

CRA perspective: A transmission-integrated IRP framework

As transmission becomes more consequential to generation development, load growth, customer costs, and resource adequacy, planners can expand its role within the IRP process. Figure 1 summarizes a framework in which transmission analysis is integrated throughout the IRP process, helping to (i) develop external scenarios; (ii) construct alternative portfolios; (iii) evaluate full portfolio costs and performance; and (iv) support complex decision-making.

Figure 1: Transmission intelligence integrated throughout the IRP process



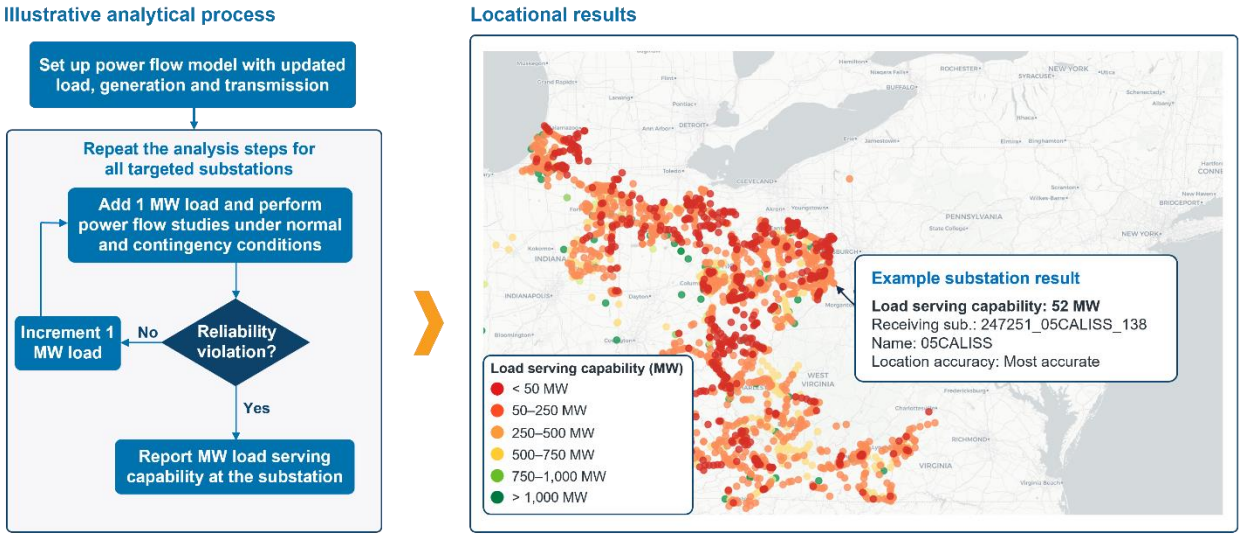
Step 1: Transmission-informed scenario development

The purpose of scenario development is to define the future *external* conditions that resource portfolios must be capable of addressing. Traditional scenarios focus on uncertainty related to fuel prices, technology costs, environmental policy, market design, and demand growth.

In recent project assignments, we have found that transmission analysis integration can add an important locational element to the development of the load forecast. For data centers, electrification, and large industrial developments, network capability can influence project timing, cost, and location. Headroom assessments, transfer capability evaluations, power flow screening, and congestion analysis can help planners test the geographic feasibility of alternative futures. Transmission analysis can test where forecast growth is feasible, identify areas where enabling investment may be needed, and provide actionable siting signals to large-load customers and developers.

This approach is especially relevant for large industrial facilities and data centers for which available transmission capability may be a major siting consideration. CRA headroom studies for large-load and infrastructure investors illustrate how locational capability can identify development opportunities and support more geographically realistic planning scenarios. Figure 2 shows an illustrative headroom-screening process and output.

Figure 2: Transmission headroom results highlighting areas capable of supporting future load growth



- *The analytical process produces a substation-level view of load-serving capability across the study footprint.*
- *Each circle (bubble) represents a substation.*

Step 2: Transmission-informed portfolio development

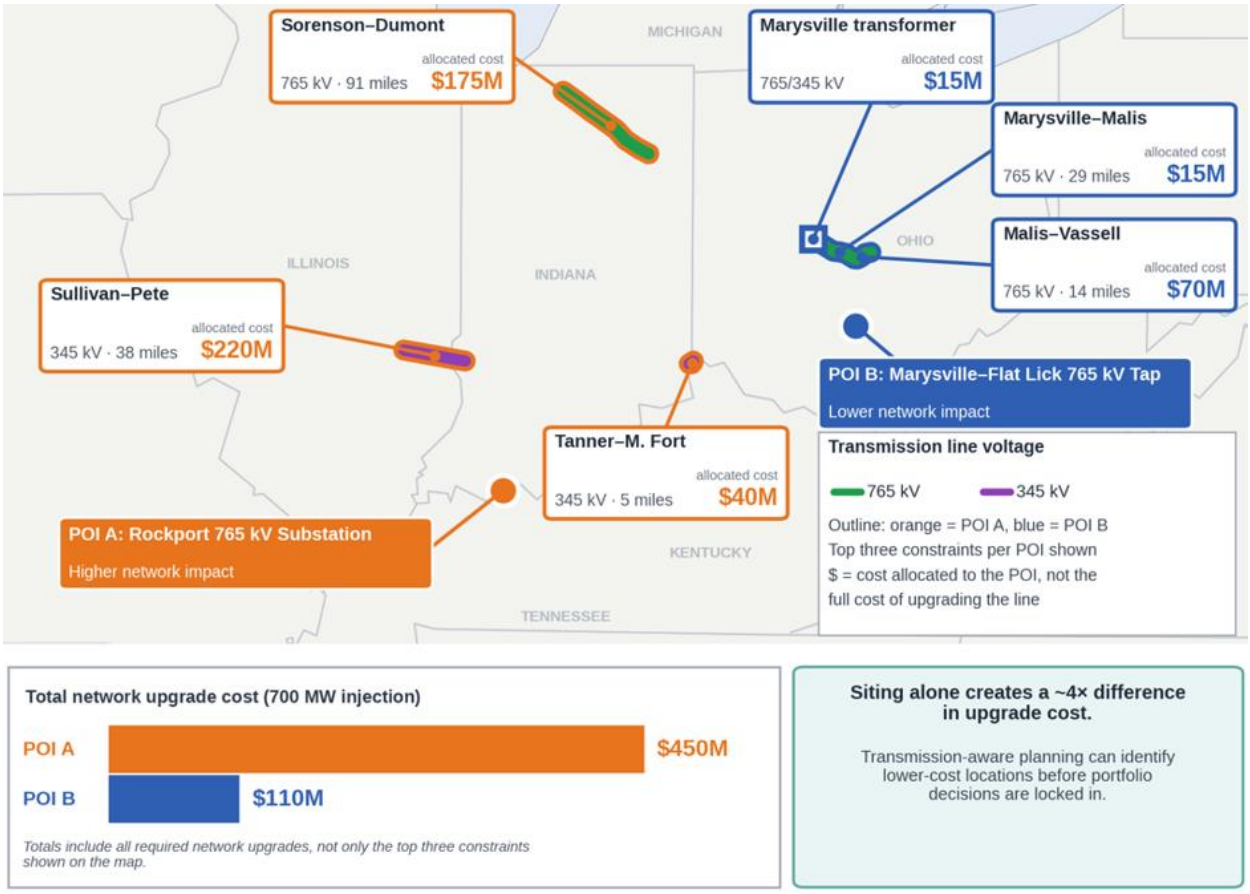
Once scenarios have been established, utilities develop candidate resource portfolios to evaluate. In many IRP processes, the primary focus is on identifying resource technologies, unit costs, and capacity quantities needed to satisfy future demand.

Transmission intelligence expands portfolio development by adding locational feasibility. Where resources should be sited, how readily they can interconnect, and what network upgrades may be required can be as important as technology type, capacity, and unit cost.

Deliverability assessments, interconnection screening, and upgrade-cost analysis can identify locations more likely to deliver durable customer value. Early screening also helps avoid portfolios that appear attractive in a system-level model, but carry material schedule, cost, or feasibility risk because of network limitations.

CRA's generation interconnection and transmission screening work shows that network conditions can materially affect both project location and optimal size. Figure 3 illustrates how two candidate points of interconnection can produce substantially different network upgrade requirements. The labeled boxes on the map identify the top three transmission constraints for each point of interconnection, and the cost allocated to that point of interconnection, while the bar chart compares total network upgrade costs, including additional upgrades beyond these three. Incorporating these transmission-driven capital costs during portfolio development supports a more realistic comparison of candidate resources.

Figure 3: Comparison of network upgrade costs for two candidate points of interconnection



Step 3: Transmission-informed portfolio evaluation

Portfolio evaluation is often the most analytically intensive stage of an IRP. Capacity expansion, production cost modeling, and resource adequacy assessments provide critical information regarding economics and reliability.

Transmission analysis complements capacity expansion, production cost, and resource adequacy modeling by showing how portfolios interact with the physical grid. Nodal congestion analysis, basis-risk assessment, power flow studies, and customer-impact analysis can reveal costs and risks that are not visible in zonal or system-level models.

This distinction is particularly important for portfolios with large load additions or significant renewable development. Two portfolios with similar system-level cost and reliability results may perform very differently once locational factors and the costs and constraints of delivering power across the system are taken into account.

CRA portfolio studies involving large load growth and associated generation development have shown that congestion and nodal pricing can materially affect customer costs, with results depending on resource location and development timing. For example, even if the costs of new generation and transmission infrastructure required to serve new large loads are fully allocated to new large load customers, system changes may have effects on locational marginal prices (LMPs) at specific load and generator nodes that indirectly impact legacy customer costs. In other words, the location of generation and load can create price impacts that are not apparent in zonal models, and those impacts may be concentrated in a limited number of hours, introducing risks and opportunities for utility planners. Figure 4a displays how a resource or load addition may impact nodal prices across a regional system, while Figure 4b illustrates the impact at a selected node at various levels of granularity.

Figure 4a: Illustrative geographic distribution of nodal price impacts

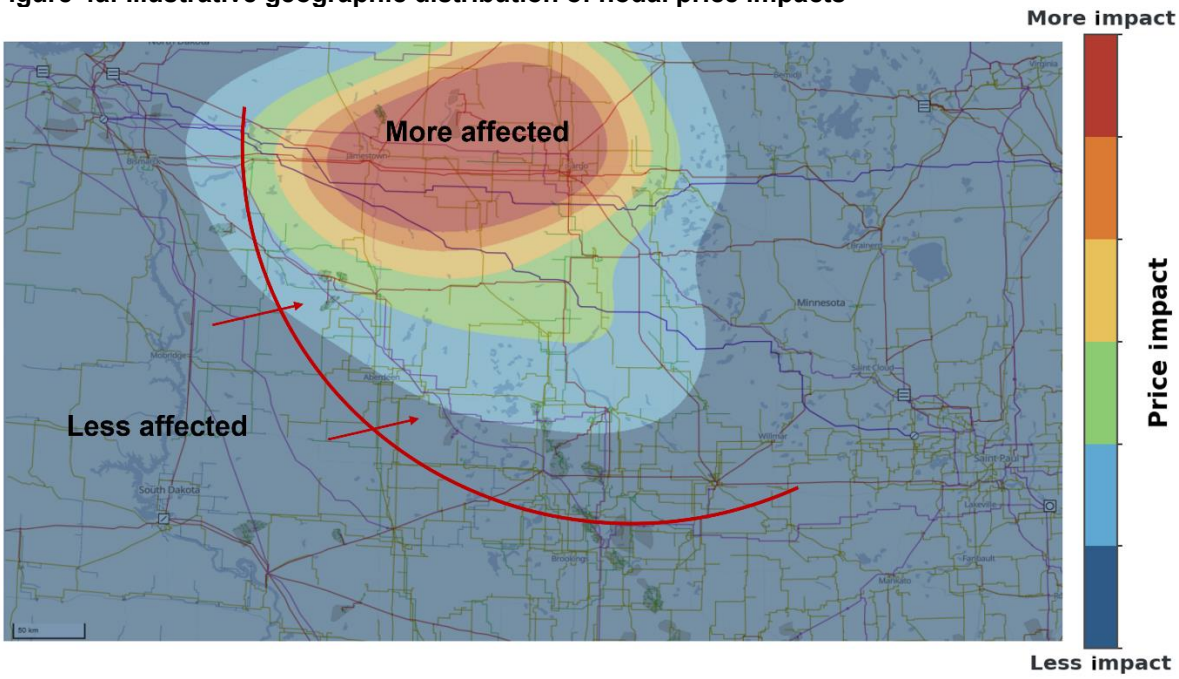
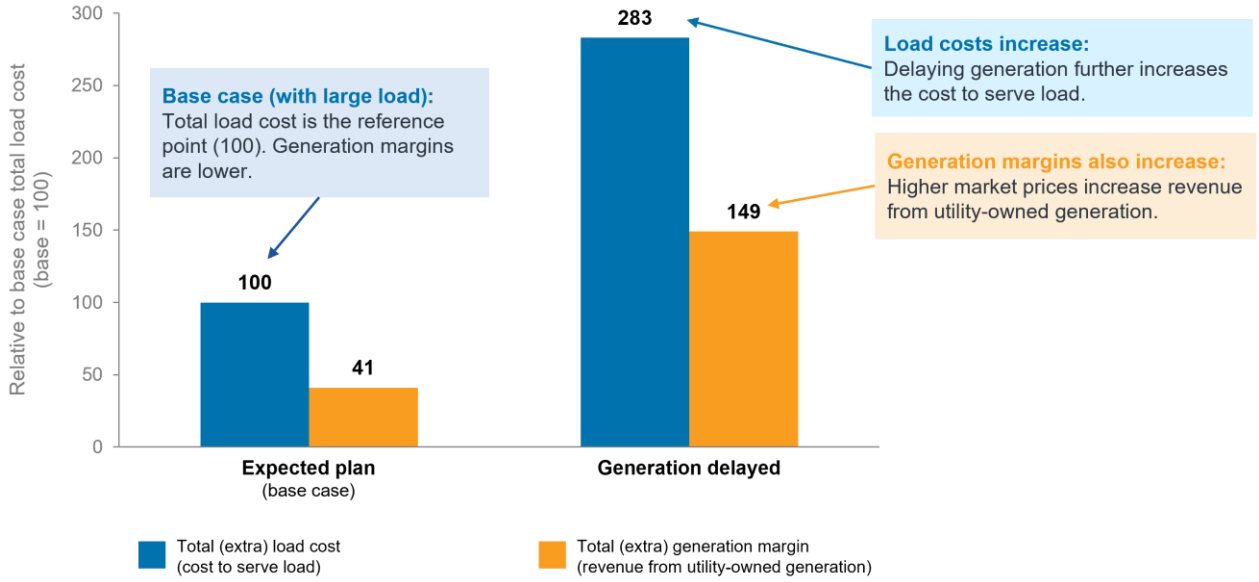


Figure 4b: Illustrative price-impact profile for a selected node



Price impacts like those shown in Figures 4a and 4b can be reflected directly in portfolio economics. In organized wholesale markets, for example, a utility may evaluate net portfolio cost by comparing the cost of serving load with net energy margins earned by utility-owned generation. Large new loads can increase both the cost of serving load and generation margins. As illustrated by the nodal modeling results in Figure 5, delayed generation can further increase both impacts. In a zonal model, however, differences between load costs and generation margins may be less visible and may partially offset when aggregated. Nodal analysis can capture these locational differences and provide a more granular view of portfolio exposure.

Figure 5: Incremental load costs and generation margins from large load addition under expected and delayed generation conditions



Step 4: Transmission-informed decision-making

The final stage of the IRP process compares candidate portfolios and identifies a preferred plan. Traditional metrics such as cost, reliability, and environmental performance remain essential. A transmission-integrated approach broadens the discussion by considering implementation risk and future flexibility. Portfolios can be compared not only on economic performance, but also on transmission readiness, including congestion exposure, interconnection risk, deliverability constraints, future transmission investment requirements, and the ability to accommodate future growth, while properly accounting for transmission-related costs.

In this framework, transmission becomes a source of strategic information rather than simply a pass-or-fail constraint. Decision makers can distinguish portfolios that remain robust across a range of network and market conditions from those that depend on favorable siting, timing, or upgrade assumptions.

CRA's transmission investment evaluations and integrated planning roadmaps indicate that important insights emerge when generation, transmission, and other system investments are evaluated together. This integrated perspective supports better sequencing, clearer risk ownership, and more disciplined capital allocation. Figure 6 illustrates a portfolio scorecard in which transmission readiness criteria, including congestion exposure, interconnection risk, deliverability constraints, future transmission investment requirements, and the ability to accommodate future growth, are considered alongside traditional cost, reliability, environmental, and social criteria when comparing candidate portfolios.

Figure 6: Illustrative portfolio comparison incorporating traditional IRP objectives and transmission-informed readiness criteria

Evaluation criterion	Portfolio A	Portfolio B	Portfolio C
Traditional IRP objectives			
Affordability	Moderate	Leading	Strong
Rate stability	Moderate	Moderate	Leading
Reliable, flexible & resilient supply	Strong	Strong	Strong
Environmental sustainability	Moderate	Leading	Strong
Positive social & economic impact	Moderate	Strong	Strong
Transmission readiness			
Congestion exposure *Price separation and curtailment risk*	Moderate	Moderate	Leading
Interconnection risk *Upgrade cost and schedule to connect*	Moderate	Below avg.	Strong
Deliverability constraints *Ability to move output to load when needed*	Strong	Moderate	Leading
Future transmission investment *Additional network build the portfolio triggers*	Moderate	Below avg.	Strong
Ability to accommodate future growth *Headroom for new load and resources*	Moderate	Moderate	Leading

Relative performance: Leading · Strong · Moderate · Below avg.

Illustrative ratings. Higher is better for every row (e.g., lower congestion exposure or interconnection risk scores higher).

Conclusion

A transmission-integrated IRP connects capacity expansion, production cost, power flow, financial, and resource adequacy analyses through a common set of scenarios, assumptions, locations, and decision criteria, creating a more integrated foundation for planning and investment decisions.

The central idea is simple: transmission assessments can be integrated throughout the traditional planning process. Used throughout scenario development, portfolio design, portfolio evaluation, and trade-off assessment, transmission intelligence can help planners identify strategies that are more feasible, resilient, and valuable to customers.

The result is an evolution from transmission-constrained planning to transmission-informed planning, in which generation, load, and network decisions are evaluated as an integrated system.

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