Incorporating Realistic Constraints in Planning Models

by Ryan Fulleman and Rachel Moglen

KEY INSIGHTS

- Realistic constraints can be expressed in capacity expansion models through changes to data inputs or model formulations. Data analyses designed to support theses changes are discussed in this study.
- Top-down constraints (e.g., annual build limits) are widely used. Complementing this approach with bottom-up modeling may help capture practical bottlenecks in plan implementation.
- Historical data show resource deployment timelines vary widely and often face year-long delays. Observational data of this type may help parameterize candidate unit "first available dates" in models.
- Geospatial analysis can inform siting by modeling land-use constraints and exclusions.

Research Overview

Energy sector decarbonization and growing electricity demands are leading to plans for a record buildout of new energy resources. Real-world challenges in implementing resource plans—both present-day and anticipated—pose practical constraints for planners. Omission of these constraints can lead to infeasible or more costly buildout plans.

Results from capacity expansion models (CEMs), which help identify potential resource portfolios, are sensitive to input data and assumptions. This research examines how real-world implementation constraints may be integrated into CEMs. Six primary types of realistic constraints are outlined in Figure 1.

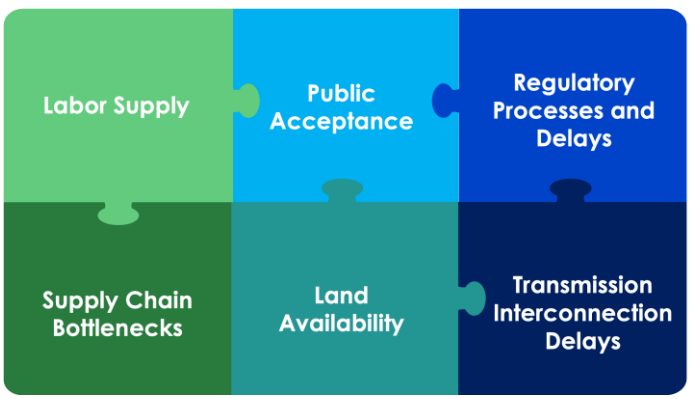

Figure 1. Six primary factors impacting resource plan implementation

Summary of Findings

- A review of 20+ integrated resource plans (IRPs) and other long-term plans found that an annual installable capacity limit is the most common practice used to represent realistic constraints. Less commonly, delays from permitting or construction are modeled via higher costs; later start dates for candidate units are also sometimes used to reflect technology readiness or interconnection delays.
- The following are general strategies for representing realistic constraints in capacity expansion models:
  - **Top-down planning constraints** describe outcomes enforced on the modeled system, and not on a specific resource. E.g., annual build limits.
  - **Bottom-up constraints** involve modeling limiting features of individual existing and/or candidate generators. E.g., candidate units with defined start dates.
  - **New model definitions and equations**, which may adjust the model formulation or introduce separate modeling processes. E.g., Modeling a queuing process for interconnecting generators.

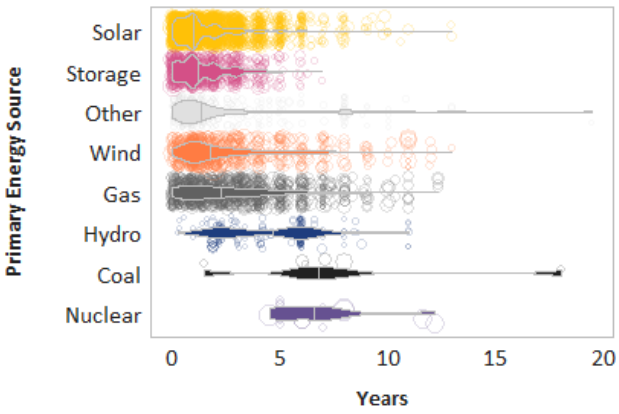

Figure 2. Deployment timelines over the past 10 years by primary energy source

- Deployment timelines can be modeled using first-available dates for candidate units, which can be informed by historical timelines. Figure 2 shows an analysis of U.S. Energy Information Administration (EIA) data, describing the range of historical deployment timelines by resource type.
- Siting constraints may also be included in a CEM through a process for evaluating site suitability and resource quantity that:
  1. Defines the region under consideration
  2. Defines exclusion screens (e.g. topography, proximity to infrastructure, protected areas)
  3. Combines these screens within the region
  4. Assumes energy density by resource type

This research highlight is based on EPRI Report "Incorporating Realistic Constraints in Planning Models," Product ID 3002031457

RESEARCH CONTACTS
Ryan Fulleman
rfulleman@epri.com
Rachel Moglen
rmoglen@epri.com

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