Unlock Savings Based on Performance:
The Promise of Population NMEC Approaches

Peng Gong, CPUC, San Francisco, CA
Lullit Getachew, Ken Agnew, DNV, Madison, WI

ABSTRACT

Population-based normalized metered energy consumption (population NMEC) is a performance-based program design developed in California to measure energy efficiency program savings using metered energy consumption rather than relying on prescriptive savings. It measures savings using statistical methods that compare pre- and post-intervention energy consumption of participants and selected non-participants as a proxy for program impacts. Program administrators (PAs) follow the NMEC Rulebook, which provides technical and policy guidance for these methods, when estimating program savings. Evaluators validate the methods developed by PAs (embedded measurement and verification (M&V)) and verify reported savings rather than conducting separate analyses.

Drawing on California's experience of residential and non-residential programs launched between 2019 and 2021, this paper examines both the promise and the practical challenges of deploying population NMEC as an evaluation framework for energy efficiency programs. Key topics include the replicability of the embedded M&V methods, verification of meter-based savings, suitability of the approach for different customer segments, and the need for clear rules regarding exclusions, non-routine events (NREs), and uncertainty calculations.

The advantages of population NMEC include flexible program delivery, lower risk for ratepayers and utilities through verified performance, and improved targeting and program effectiveness. At the same time, successful application requires transparent and replicable methods, robust documentation, rigorous evaluation, and updated regulatory guidance.

For jurisdictions seeking to modernize their efficiency portfolios with transparent, outcome-based approaches, population NMEC offers a promising model. In this context, California's experience provides a valuable case study for designing NMEC programs that are both technically credible and aligned with policy goals.

Introduction

Population NMEC represents a shift toward performance-based energy efficiency, using whole-building, meter-level data to estimate savings. Rather than relying on prescriptive, deemed, or engineering estimates, it attributes impacts through statistical comparisons of energy use before and after interventions, incorporating a matched group of non-participants. This approach supports policy objectives like California's AB 802 and SB 350, which promote pay-for-performance (P4P) structures and encourage the use of metered data for savings estimation. By tying program outcomes directly to measured consumption, population NMEC offers a more transparent and scalable framework for evaluating energy efficiency.

While meter-based site-level programs, such as those implemented by energy service companies (ESCOs), exist in other jurisdictions, population NMEC programs are unique to California. As a regulatory construct, population NMEC ensures that ratepayer funds are invested in programs that deliver verifiable energy savings, and it allows utilities to pay only for savings that are measured at the meter.

This paper draws on findings from an independent impact evaluation of California's population NMEC programs for program years (PY) 2019 through 2021.[1] The evaluation covered three residential pay-for-performance (P4P) programs and one non-residential program, all administered by Pacific Gas and Electric Company (PG&E). The residential programs included HomeIntel, Comfortable Home Rebates (CHR), Home Energy Rewards (HER), while the non-residential program was On-Bill Financing Alternative Pathway (OBF-AP).

The evaluation assessed the replicability and validity of the embedded M&V methods, verified energy savings, and identified key conditions for effective program evaluation. It also provided insight into the practical challenges of implementing population NMEC programs and the regulatory and policy support required to ensure their success.

Building on the lessons learned, this paper offers insights in four areas. In Section 2 (Potential of Population NMEC Methods), it explores the promise of population NMEC, drawing on evaluation findings that demonstrate successful implementation and notable energy savings in the residential P4P programs. In Section 3 (Population NMEC Challenges), it examines the challenges such programs face, with special attention on the non-residential OBF-AP program, including technical, governance, and implementation barriers. In Section 4 (Conditions for Population NMEC Success), it identifies the conditions necessary for success, focusing on program design, M&V approaches, and enabling policy frameworks. Finally, the Conclusion Section synthesizes the findings and considers how population NMEC can evolve to support future program, regulatory, and policy objectives.

Potential of Population NMEC Methods

Population NMEC offers several potential benefits, including reduced stakeholder risk and enhanced performance accountability, improved transparency, and support for a wide range of intervention types and program models. It also holds the potential for significant energy savings.

A central advantage of population NMEC is its alignment with performance-based program design, in which implementer compensation is tied to verified energy savings rather than prescriptive or deemed estimates. This approach directly supports ratepayer protection, outcome accountability, and overall portfolio effectiveness. As such, population NMEC presents an attractive path forward for jurisdictions seeking to transition from prescriptive to dynamic, data-driven program models.

Verified Performance Reduces Risk to Ratepayers

Because population NMEC calculates savings from actual meter data at the program level, it ensures that payments to implementers are only made for demonstrated impacts. In the evaluated programs, implementer compensation was structured to be paid based on verified savings: 100% for HomeIntel and HER, and 50% for CHR, with the remaining 50% issued as direct customer incentives.

This structure effectively shifts performance risk from ratepayers to implementers, promoting accountability and incentivizing improved program delivery. The evaluation confirmed that this framework was implemented as intended across all three residential programs.

To support accurate performance-based savings, participation in population NMEC programs is subject to specific eligibility criteria. For example, savings estimates could only be developed for participants who remain in the same residence following the intervention and do not install onsite solar during that period. As a result, performance-based savings estimates were derived from meter data for approximately 50% to 60% of participants, a proportion consistent with billing analysis practice, which typically relies on 50% to 70% of participant data for impact estimation.

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[1] DNV (2023). "Final population-based NMEC program impact evaluation report: Program years 2019 to 2021." CALMAC ID: CPU0365.01. Prepared for the California Public Utilities Commission.

To further safeguard accuracy and prevent overstatement of savings, the programs' M&V processes incorporated structured exclusion rules. Participants who moved, installed solar, opted out, or enrolled in other programs were conservatively assigned zero savings. These exclusions accounted for 11% to 15% of the total participant population and reflect the added scrutiny appropriate for performance-based programs.[2]

Transparency through Replicable Methods

Population NMEC encourages transparency and replicability by requiring that M&V methods be standardized and well-documented. This was a major focus of the evaluation, which attempted to replicate the PA savings calculations based on the provided data and code. For the P4P residential programs, the evaluation team successfully replicated most savings estimates, although obstacles were encountered, as discussed in Section 3, that require improvement.

This ability to independently reproduce savings calculations increases confidence in reported results and provides a model for how embedded M&V can be validated by third-party evaluators in future implementations.

Improved Targeting and Program Effectiveness

One of the intended advantages of population NMEC is that it allows implementers to focus more directly on delivering measurable results. Because savings are determined from meter data at the population level, implementers have the flexibility to identify and target customers who are most likely to generate verifiable savings through behavioral, operational, or equipment-related interventions. This structure may encourage more outcome-focused program strategies and, potentially, more effective delivery.

In the evaluated programs, implementers employed targeting strategies that appeared to contribute to strong savings outcomes. For example, HomeIntel used smart meter analytics to identify homes with above-average baseline usage and provided customized feedback and virtual coaching. The CHR program combined climate zone targeting with whole-home assessments to identify homes most likely to benefit from HVAC tune-ups or equipment replacement. These delivery approaches were aligned with the NMEC structure, which ties compensation to metered performance and may have encouraged implementers to focus on customers with higher savings potential.

Support for Varied Program Models

Unlike prescriptive programs, population NMEC can support a wide variety of program models, including behavioral, operational, and multi-measure interventions, encouraging offerings that deliver measurable savings.[3] Its flexibility makes it especially well-suited to modern portfolios focused on demand flexibility, decarbonization, and equity-driven outreach, where one-size-fits-all designs may fall short.

Table 1 provides a summary of the primary strategies used in each of the three residential programs.

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[2] These exclusions help ensure that savings are not overstated. However, they may introduce risks by weakening implementer incentives. Future research should examine whether these risks outweigh the benefits NMEC offers to ratepayers and explore alternative approaches for capturing savings from excluded participants, where warranted.

[3] Although opt-in designs can introduce the risk of exogenous factors (efforts not measured by NMEC) being confounded with program impacts, NMEC's use of actual energy consumption offers meaningful advantages over methods based on prescriptive assumptions or deemed savings.

Table 1. Program models and intervention types

Program	Primary delivery model	Key measures/interventions
HomeIntel	Behavioral/virtual audit	Online audits, energy use comparisons, coaching
CHR	Direct install/retrofit	HVAC tune-ups, HVAC replacements, insulation
HER	Marketplace + kit distribution	Smart thermostats, LEDs, faucet aerators, audits

Notable and Robust Energy Savings

Perhaps most importantly, the evaluation showed that population NMEC programs can deliver significant, measurable savings (Table 2). The CHR program achieved 7–9% average electric savings and 3–9% gas savings across the different program years. Similarly, HomeIntel consistently delivered electric savings in the range of 6–8% and gas savings between 3–6%. The savings achieved by the programs were statistically robust, indicating a viable path forward for performance-based energy efficiency strategies.

Table 2. Summary of evaluated savings from population NMEC residential programs

Program	Year	Electric savings (%)	Gas savings (%)
CHR	2020	4.8%	6.4%
CHR	2021	7.2%	9.1%
HomeIntel	2020	7.7%	3.4%
HomeIntel	2021	6.7%	3.5%
HER	2021	1.0%	3.5%

These results are particularly promising when compared to recent evaluations of similar energy efficiency programs, which achieved lower savings outcomes. For example, prior evaluations of statewide residential HVAC, behavioral, and direct install programs have typically found electric savings in the range of 1–3%, depending on the intervention type and participant profile (Table 3).

Table 3. Typical electric savings from past residential non-NMEC energy efficiency programs

Program Type	Typical electric savings	Key characteristics
Behavioral (Home Energy Reports)	~1%	Large population programs, low intensity
HVAC Maintenance & Replacement	1.5–2.5%	Varies by climate zone and system type
Direct Install	1.5–3%	Based on LED, smart plug, and basic retrofits

Population NMEC Challenges

While population NMEC methods offer the potential to deliver meter-based, performance-aligned savings estimates, their implementation during PY2019–PY2021 revealed significant technical and administrative challenges. These challenges included barriers to replicating program-reported results, use of novel modeling methods, the complexities introduced by heterogeneous customer groups, and gaps or

ambiguities in regulatory requirements. More consistent and credible NMEC program execution will require improved tools, documentation, and governance.

Replication and Transparency

One of the core principles of population NMEC is that energy savings should be independently verifiable through replicable and transparent methods. However, in practice, the evaluation found that replicating program-reported results was one of the most difficult components of the study. While replication of the residential P4P programs was ultimately successful, it required multiple iterations, significant interpretation of undocumented modeling steps, and back-and-forth clarification with the PA. In total, the evaluation team conducted three distinct replication cycles to align methods and outputs.

The non-residential OBF-AP program presented even more significant challenges. The PA used different modeling software and methodologies across program years and documentation was inconsistent or incomplete. At times, inputs lacked clear definitions or traceable sources. While general instructions were provided, key elements of the modeling process, such as data transformation steps and core estimation routines, were not fully coded or shared, making replication both cumbersome and time-consuming. These factors increased the burden on evaluators and complicated the process of validating PA-calculated savings. Table 4 provides a summary of the replication challenges, effort levels, and outcomes across programs and program years.

Table 4. Evaluation replication summary and effort level by program

Program and year(s)	Challenges	Evaluation effort	Replication success
Residential P4P (2019)	Missing outputs, inconsistent data handling, and evolving methods requiring multiple replication iterations	High	Partial
Residential P4P (2020–2021)	Challenges applying exclusions, aligning granular profiles, and refining time-of-week data	Moderate	Full
OBF-AP (2020)	Inconsistent exclusions, and reliance on implementer-specific methods that were not fully traceable	Very High	Partial
OBF-AP (2021)	Inconsistent methods across years, unclear handling of NREs, and undocumented exclusions	Very High	Partial

In the table, full success means the evaluation team fully replicated the programs' reported savings and associated uncertainty. Partial success indicates the estimates were close but not identical. There were no cases of complete failure to reproduce the reported results.

Use of Novel Modeling Approaches

The residential programs employed a relatively novel modeling method in energy efficiency evaluation: the use of synthetic controls (SCs). In typical applications, synthetic controls (SCs) are used to construct counterfactuals by creating a weighted average of data from non-participants whose characteristics closely resemble those of treated participants. These counterfactuals are then compared to a weighted average of participant data to estimate the impact of interventions. However, in the population NMEC context, the application of SCs diverged from this traditional approach by using average load profiles of non-participants in regression models alongside individual participant data.

Referred to as granular profiles, these average non-participant load profiles were created within defined segments such as geography, size, and load shape. While this approach was intended to reduce

the need for implementers to access large volumes of individual non-participant data, it is likely to fall short in explaining variation in individual participant-level loads as effectively as synthetic controls do in their original application. Additionally, the use of granular profiles introduces the risk of overstating program savings precision due to the limited representation of variability inherent in individual non-participant data.

The novelty of the method also introduced additional complexity. Because it had not yet undergone public vetting or peer-reviewed validation, questions remained regarding its ability to address non-routine events (NREs) and potential self-selection bias. In the absence of established best practices, it was challenging to assess the reliability of the results produced by these models.

Moreover, while granular profiles addressed implementer access limitations to non-participant data, they introduced additional complexity. Maintaining updated profiles required continuous effort, and any inconsistencies in handling these profiles, such as outdated or misaligned data, jeopardized the reliability of the method and the accuracy of the results.

Customer Heterogeneity and the OBF-AP Program

Population NMEC is most effective when applied to large, relatively homogeneous customer groups where similar end-uses or drivers of consumption allow for effective modeling. The OBF-AP, which targeted a diverse group of non-residential customers, failed to meet this criterion. Participants varied widely in business type and energy consumption. Covering everything from small retail spaces to large industrial facilities, site electric usage ranged from less than 1 MWh per year to over 13,000 MWh. This heterogeneity introduced excessive variability in energy use levels and associated program savings, making it difficult to construct meaningful savings models that meet required precision thresholds.

Relative precision values for the program exceeded 50% in both years, which is well beyond the NMEC 90/25 policy standard. These values indicated a high degree of uncertainty in the savings estimates, stemming from extreme variability in baseline and post-intervention energy usage across sites. Table 5 summarizes participant counts and evaluation metrics for the OBF-AP program, highlighting the variability and precision challenges encountered in PY2020 and PY2021.

Table 5. OBF-AP program participation and precision characteristics (PY2020–PY2021)

Metric	PY2020	PY2021
Number of participants	100	139
Annual site usage range (MWh)	<1 MWh – 13,000+	<1 MWh – 12,000+
Relative precision (electric)	>200%	>50%

Exclusion Criteria and Non-Routine Events

Exclusion rules are critical to any NMEC program, as they define participant eligibility for savings and guide how to handle changes in behavior or operations unrelated to program measures. In the evaluated programs, exclusion criteria varied by program year and were often insufficiently documented. For example, while participants who moved, installed solar panels, or participated in other energy efficiency programs were generally excluded, implementation of these rules was inconsistent across years and PA M&V efforts.

These inconsistencies were especially apparent in the handling of NREs within the OBF-AP program, where the absence of a standardized framework for identifying and adjusting for NREs reduced the reliability of savings estimates. There were sites flagged for exclusion without documentation, which

materially improved savings and precision. Later investigation revealed that these exclusions were due to NREs, but without proper records, it was impossible to assess whether the exclusions were appropriate.

The lack of formal mechanisms for tracking NREs led to delays and increased complexity during evaluation. The lack of clearly defined rules, systematic methods, and formal tracking tools, put the credibility of NMEC savings estimates at risk.

Policy Interpretation and Governance Structures

The evaluation identified several policy-level opportunities that can enhance the effectiveness of population NMEC. These include clarifying guidance around fractional savings uncertainty (FSU), population eligibility criteria, and hourly savings claims.

While ASHRAE methods offer a solid foundation for site-level M&V, their guidance on FSU could benefit from further clarification when applied to population NMEC. The policy appropriately sets a 90% confidence level and a 25% relative precision target, standards well-suited for individual site analysis. However, these thresholds can introduce ambiguity when interpreting requirements for program-level savings estimates. As noted in the Rulebook, "these criteria are based on the best available information we have today but may be adjusted in the future as more is understood regarding their viability."

In response, the CPUC is examining how FSU can be more effectively applied at the population level, distinct from site-level approaches, to support consistent interpretation and implementation. For instance, establishing a more explicit methodology aligned with standard billing analysis practices could improve the accuracy and reliability of savings estimates in population-NMEC programs. Upcoming CPUC evaluations will assess how such refinements might better align policy intent with implementation practices, helping NMEC programs achieve their objectives more effectively.

Moreover, although the policy provides clear definitions for eligible project types, emphasizing the need for relatively homogeneous populations with similar energy use levels and drivers, not all programs fully adhered to this guidance. For example, as indicated above, the inclusion of highly variable customer groups in the OBF-AP program introduced nonconformities that contributed to imprecision and reliability challenges.

Finally, as demand flexibility and peak demand savings become increasingly important, the CPUC is exploring how to clarify guidance on methodologies for estimating hourly energy savings for population NMEC programs. Alongside these methods, establishing precision standards that account for limited hours of observation and portfolio size would help ensure that hourly savings estimates are both reliable and aligned with broader program objectives.

Conditions for Population NMEC Success

Successful application of population NMEC methods requires a combination of technical rigor, transparent processes, and governance structures that support consistency and replicability. Drawing from program experience during PY2019–PY2021 and evaluation observations, five key conditions emerge as foundational to future success.

Ongoing Need for Evaluation

While embedding M&V within program implementation can streamline operations and facilitate real-time savings tracking, it does not eliminate the need for independent evaluation. Evaluators play a critical role in verifying PA-reported savings, ensuring consistency with NMEC rules, and identifying areas for improvement.

The evaluation of the population NMEC programs discussed in this paper revealed that embedded M&V approaches often lacked transparency and consistency. Independent review remains essential for

confirming methods, addressing variability, and maintaining the credibility of savings claims. Future NMEC implementations must prioritize collaboration between evaluators, PAs, and regulators to balance embedded M&V benefits with robust external validation.

As embedded M&V practices evolve, new modeling methods may offer greater flexibility and responsiveness. However, these methods must be carefully reviewed, thoroughly documented, and aligned with industry and regulatory standards to ensure they are both reliable and trusted. Without such safeguards, the integrity of savings estimates and confidence in program outcomes may be compromised.

Documentation and Data Sharing for Effective Evaluation

Comprehensive documentation and data sharing are foundational to credible NMEC programs. As indicated in Section 3, the evaluation identified gaps in access to M&V code, input data, and exclusion justifications, which delayed replication and savings validation, thereby reducing confidence in savings estimates.

These replication difficulties highlight a broader issue: For population NMEC programs, where performance-based payments are made using embedded M&V, documentation quality and process transparency are foundational to credibility. Without standardized packages, including labeled inputs, version-controlled code, and clear logic chains, evaluation becomes overly dependent on PA interpretation. This compromises the independence and timeliness of validation.

The following improvements can strengthen future NMEC evaluations:

- Standardized M&V documentation packages that include data sources, assumptions, and logic.
- Clearly documented and justified adjustments and exclusions.
- Use of version-control tools that enhance replicability and reduce evaluator burden.

Participation Limitations, Including Population Size and Variability

Population NMEC methods are most effective when applied to relatively homogeneous customer groups with a sufficient number of participants to meet precision standards. In contrast, programs serving more diverse or variable populations, such as the OBF-AP program, have encountered significant challenges in achieving reliable and precise savings estimates.

Non-residential billing analysis with a comparison group has historically been rare and risky due to the lack of sufficient uniformity across commercial sites. Achieving acceptable program precision estimates requires relatively homogeneous energy consumption and energy use drivers among participants, as emphasized in the NMEC rules. However, the inherent variability in commercial energy use makes applying population NMEC methods particularly challenging. Table 6 illustrates how this variability impacts savings precision, showing relative precision values for electric and gas savings across two program years. The high percentages reflect the difficulty of achieving reliable estimates in heterogeneous non-residential populations.

Table 6. Impact of population variability on OBF-AP savings precision

Fuel	Year	Relative precision
Electric	2020	238%
	2021	86%
Gas	2020	210%

Fuel	Year	Relative precision
	2021	66%

Recommendations for program performance improvements:

- Programs should establish clear eligibility criteria to ensure customer homogeneity and define minimum population size thresholds to achieve the 90/25 precision standard.
- For heterogeneous customer populations, site-level NMEC or custom approaches may be more appropriate than population NMEC models to determine program savings.

Effective Management of NREs

NREs, such as operational changes or solar installations, can significantly distort energy savings estimates by introducing energy consumption variability unrelated to program measures. These disruptions affect either the baseline period or post-intervention performance period, complicating the task of attributing observed savings to program activities.

The evaluation revealed inconsistencies in how NREs were flagged, documented, and managed across the evaluated programs, particularly in the OBF-AP program. For example, participants who installed solar panels during the baseline period were flagged for exclusion, while those who installed them during the performance period had their savings set to zero. However, the criteria for these actions were not consistently applied or clearly documented across all the PA M&V efforts. This variability in handling solar-related NREs highlighted gaps in consistency and robustness, reducing confidence in the reported savings estimates.

These findings underscore the need for more systematic and well-documented approaches to exclusion criteria and NRE management within NMEC programs. Clear documentation, standardized frameworks, and formal tracking tools are essential to ensure consistency and reliability in savings estimates, enabling NMEC programs to align more closely with industry standards and regulatory expectations.

Table 7 summarizes the key issues identified in the evaluation and outlines targeted recommendations to improve NRE handling and strengthen savings credibility.[4]

Table 7. Key challenges and recommendations for managing NREs

Key challenges	Recommendations
Lack of standardization	Develop consistent frameworks for identifying, quantifying, and addressing NREs.
Incomplete documentation	Require transparent documentation of all NRE-related decisions, exclusions, and adjustments.
Inconsistent applications (e.g., solar exclusions in OBF-AP)	Define clear rules for exclusions in specific scenarios, such as solar installations or operational shifts.
Integration in M&V planning	Require NRE handling to be defined in M&V plans ahead of program implementation.

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[4] Updated M&V plans provided towards the end of the evaluation cycle included a more systematic approach to exclusions and adjustments, addressing some of these challenges. However, these updates came late in the process and could not fully resolve issues that occurred earlier in program implementation.

Strengthening Governance and Ongoing Rulebook Refinement

Rules governing NMEC programs play a critical role in guiding program implementation and evaluation. The evaluation highlighted several areas, detailed in Section 3, where additional refinement of the rules could further strengthen consistency and alignment with policy goals.

Priority areas for refinement include tailoring the FSU calculation methodology to better suit population-level applications, establishing clearer criteria for acceptable levels of population variability, and developing protocols to identify and appropriately account for large or strategic NREs that may impact precision. In addition, there is a need to advance standards for hourly savings estimation, particularly in the context of demand flexibility, that consider limited observation periods and portfolio size constraints to ensure both credible and replicable results. Opportunities for improvement and policy enhancement include the following:

- Develop clear, standardized methodologies for calculating FSU at the population level to support consistent and transparent evaluations.
- Clarify guidance for addressing solar installations and other NREs to improve model reliability and accuracy.
- Establish precision standards for hourly savings estimates that reflect the realities of limited observation periods and varying portfolio sizes.
- Implement structured feedback mechanisms to ensure insights from implementations inform ongoing Rulebook refinements and continuous improvement.

As NMEC methods continue to improve, governance frameworks have an opportunity to grow in parallel, ensuring alignment with emerging industry practices and regulatory expectations. Enhancing governance, through continued investments in evaluation, clear documentation, effective NRE management, and thoughtful rule development will strengthen the reliability, transparency, and scalability of population NMEC programs, supporting their long-term success and impact.

Conclusion

California's early experience with population NMEC reflects a commitment to advancing data-driven, performance-based approaches to energy efficiency. While still evolving, these efforts have yielded important insights that can inform continued program development, regulatory oversight, and evaluation practices, both within California and in other jurisdictions pursuing similar models.

Key observations from California's implementation to date indicate the following:

- **Population NMEC holds strong promise.** Early results, particularly from residential programs, demonstrate the potential for significant energy savings and continued innovation in program design. These outcomes affirm the value of a performance-based framework grounded in real-world energy usage data.

- **Ongoing refinement is essential.** While results are encouraging, most implementation experience to date has been concentrated within PG&E's territory. Expanding NMEC across more PAs, implementers, and customer segments, along with greater consistency in documentation and rule interpretation, will be critical to realizing the full potential of this approach.

- **Strengthening policy and governance frameworks should remain a priority.** Clear, consistent rules and well-defined governance structures are foundational to address challenges such as modeling variability, NREs, and program scalability. Strengthening these foundations will ensure that NMEC programs achieve their full potential.

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