Quantifying the Impact of Emergency Energy Conservation Measures over two winters: Evidence from Geneva's Response to the 2022-2024 Energy Crisis

Authors : Cabrera Daniel, Hollmuller Pierre, Schneider Stefan, Pehle Hannah, Bertholet Jean-Luc, Bhadbhade Navdeep, Rinaldi Arthur, Legendre Thibaud, Patel Martin, Strobel Jérôme

University of Geneva

Corresponding author email : daniel.cabrera@unige.ch

This study evaluates the emergency energy conservation measures deployed in Geneva during the winter seasons 2022–2023 and 2023–2024, a period characterized by acute energy security challenges in Europe. In response to the crisis, a comprehensive suite of intervention measures was implemented with the ambitious goal of reducing natural gas consumption by 15% and electricity usage by 10%, while ensuring uninterrupted economic activity and preserving thermal comfort. The primary interventions included: (1) mandating indoor temperature reductions to 20°C in administrative and educational buildings, 17°C in sports facilities, and 23°C in healthcare facilities; (2) delaying the heating season start to October 15 or later depending on weather conditions; (3) implementing nighttime setbacks and weekend temperature reductions in non-residential buildings; (4) reducing or eliminating hot water distribution in administrative buildings; (5) decreasing public swimming pool temperatures to 27.0°C; and (6) curtailing nighttime lighting in public buildings and reducing street lighting intensity where technically feasible.

Data from multiple sources were integrated into our analytical approach. Cantonal hourly gas consumption and quarter-hourly electricity data from the utility provider were combined with meteorological datasets from the national weather service. Also, variations in economic activity were considered by accounting for day-type differences. In addition, anonymized customer-level consumption records provided granular insights into the variability of energy use patterns across different sectors. Complementary to these datasets, sector-specific data were obtained for cantonal administration, autonomous public institutions, businesses, municipalities, and collective housing. The evaluation further benefited from qualitative data collected through surveys and in-depth interviews with building managers, facility operators and energy managers.

Our analytical framework employed a two-stage approach to isolate energy conservation effects from exogenous variables. In the first stage, we calibrated baseline models using pre-crisis data (2021-2022) to establish normal consumption patterns under varying conditions. These models incorporated multiple explanatory variables including meteorological factors (temperature, solar diffuse and global radiation, wind speed), activity indicators (working days, weekends, holidays), and building thermal dynamics (using lagged temperature values to capture inertia effects). The modeling approach was tailored to each context: at the cantonal level, we used multilinear regression for gas consumption and ARIMA techniques for electricity; for sector-specific analyses, we employed XGBoost machine learning for autonomous public institutions (which have complex operational variables like passenger counts or event schedules), multivariate regression for commercial and administrative sectors, and energy intensity indicators normalized to heating degree days for residential buildings. In the second stage, we applied these calibrated models to the intervention periods (2022-2023 and 2023-2024) using actual weather and activity data to predict what consumption would have been without conservation measures. Energy savings were then calculated as the difference between these model predictions and actual measured consumption. For instance, if models predicted 100 GWh based on weather conditions but actual consumption was 93.3 GWh, the 6.7 GWh difference represented the conservation achievement. This methodological diversification, while maintaining computational consistency, enabled us to capture the unique operational contexts of each sector and aggregate results.

After adjusting for meteorological effects, variations in economic activity, and other external factors, our analysis indicates total net savings of 6.7% in gas consumption and 3.0% in electricity usage during winter 2023-2024 compared to the reference winter of 2021-2022 (pre-crisis). These results represent an improvement from winter 2022-2023, when savings reached 6.2% for gas and 2.8% for electricity. Although these weather-normalized savings fell short of the initially targeted reductions (15% for gas, 10% for electricity), they represent substantial improvements in energy efficiency and point to the potential for long-term adoption of such measures.

A detailed sectoral breakdown of energy savings further illuminates the heterogeneous impact of the conservation measures. During the winter 2023-2024, the cantonal administration, benefiting from enhanced control protocols and monitoring systems, achieved gas savings of 14.3%, while autonomous public institutions recorded a 6.7% reduction in electricity consumption. In the commercial sector, we find gas savings of approximately 8.9% paired with a modest 2.5% reduction in electricity usage. Municipalities demonstrated a 6.1% reduction in gas consumption alongside a 1.0% decrease in electricity, and collective housing realized annual gas savings of around 10.1%. These sector-specific findings underscore the critical role of organizational capacity and technical infrastructure in mediating the effectiveness of energy conservation strategies.

The surveys and interviews revealed that stakeholder collaboration played a decisive role in both the implementation and acceptance of the conservation measures. Government agencies, the utility company, and local institutions worked in concert to rapidly disseminate technical guidelines and best practices, which facilitated the implementation of measures. Information campaigns fostered broad public acceptance. Notably, the systematic reduction of indoor temperatures emerged as the most effective intervention. A coordinated 20-degree heating standard across all stakeholders facilitated temperature reductions. By lowering the average building temperature from a pre-crisis baseline of 21.8°C to 20.6°C during the winter of 2023–2024, approximately 84% of the observed gas savings were achieved solely by this measure. This was accompanied by a significant reduction in occupant complaints and increased acceptance of the measures. Complementing this temperature adjustment, the coordinated postponement of the heating season contributed to nearly 6% of the overall reduction.

Surveys further revealed multiple implementation barriers despite these promising outcomes. Technical constraints included outdated heating systems lacking modern control technologies and uneven thermal distribution in older buildings. Another limitation was the conservatism observed among certain heating technicians who remained anchored in pre-existing practices. Moreover, the process of coordinating efforts among a diverse array of stakeholders—each with varying technical capacities, resource constraints, and priorities—posed an additional layer of complexity. Although phased implementation and targeted communication strategies eventually mitigated some of these issues, the experience highlighted the need for technical upgrades and more harmonized operational protocols.

In conclusion, while the observed savings did not fully meet the ambitious reduction targets, the significant and sustainable improvements achieved in Geneva offer a compelling blueprint for future demand-side management initiatives. Our methodological framework—integrating regression models, machine learning algorithms, and sector-specific evaluation approaches—combined with diverse data sources and strengthened by active stakeholder engagement through structured surveys and technical interviews, enhanced the accuracy of our evaluation and provided critical insights into the operational challenges and opportunities inherent in large-scale energy conservation programs. The lessons learned from Geneva's response to the 2022-2024 energy crisis emphasize the importance of modernized technical regulation, enhanced stakeholder coordination frameworks, and sustained public communication strategies. These findings offer valuable guidance for policymakers and facility managers striving to enhance energy security and comply with climate commitments in an increasingly complex energy landscape.