Nuffield Health

Greener theatres

Reducing carbon emissions in operating theatres during out of hours ventilation shutdown

Introduction

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Achieving net-zero emissions in healthcare requires sustained innovation, where novel ideas are translated into evidence-based practices capable of delivering measurable impact. Operating theatres represent a significant source of hospital greenhouse gas emissions, largely due to the continuous energy demands of ventilation and air handling systems. Decreasing energy consumption within these settings offer considerable potential for carbon reduction.

This study investigates the effects of safely deactivating theatre ventilation systems during periods of non-use, specifically during overnight periods and for the duration of each Sunday. Monitoring equipment was installed to capture minute-by-minute energy consumption associated with air handling units, enabling detailed analysis of energy use, carbon savings, and associated cost reductions. In parallel, comprehensive surveillance of healthcare-associated infections was undertaken to ensure that patient safety was not compromised.

The findings demonstrate that infection rates remained stable throughout the study period, with no evidence of increased risk, while substantial reductions in electricity and gas consumption, carbon emissions, and operational costs were achieved. These results highlight a scalable, evidence-based intervention with the potential to support widespread decarbonisation across the healthcare sector.

Overnight shutdown in

1 theatre

for

1 year

SAVES...

52.5k kWh in **GAS** usage

AND

13.1k kWh in **ELECTRICITY** usage

12 tonnes CO_2e in **CARBON** emissions

£6.7k in **COSTS***

*https://www.ofgem.gov.uk/news/changes-energy-price-cap-between-1-october-and-31-december-2025

Project infrastructure

James Walker
Group Energy Manager

The facility

Nuffield Health York Hospital, located at Haxby Road, Clifton, York YO31 8TA, comprises four operating theatres. Each theatre contains four dedicated utility metering systems. Specifically, every room is fitted with anaesthetic, frost, heating, and preparation meters, all powered by gas, as well as a cooling meter powered by electricity. Additionally, each room is served by two supply fans and two extraction fans powered by electricity.

Installation of electrical power and heat meters

Modbus-enabled electrical power and heat meters were fitted for all theatre heating and cooling systems to provide real-time, high-accuracy monitoring of energy consumption and thermal energy.

Specifically, heat metering was installed on the main heating, frost and cooling coils locally at each air handling unit (AHU), as well as to subsequent reheat coils that that serve theatre specific anaesthetic and preparation rooms. All heat metering was installed downstream of the coil control or diverter valve, to ensure that the meter only recorded energy consumption when there was active flow through the coil (i.e., when the coil was in use).

The electrical power meters were installed on all three phases of the electrical drive motors. These monitored both duty and standby motor current and voltage levels continually for each AHU and ventilation system.

Callback switch

In the event of a theatre needing to be used during a shutdown period, localised callback switches and indication lamps were installed on strategically placed nurse base control panels. These provided a specialised monitoring and control system for each AHU and were only active outside of normal operating hours, allowing staff to reactivate the theatre AHUs during shutdown periods. The theatre returned to acceptable ventilation and environmental conditions within 30 minutes.

The building management system control strategy was adapted to enable sequential reactivation of each theatre ventilation system in response to use of the callback switch during shutdown periods. On reactivation of each ventilation system, conditions that may affect the plant performance or suite environment were monitored to identify faults. In the absence of any faults, the ventilation system would continue to run until the next scheduled shutdown period.

Control panel installed at nurses station

Alternatively, if a fault is indicated by the running (green light) and fault (red light) status, the system would disable this AHU and progress to reactivating the next AHU in the strategy queue, continuing this process until reactivation has been attempted for all AHUs. If all ventilation systems were to develop a fault during reactivation, then the control strategy would default to enable all ventilation systems in the callback control strategy. As part of the startup process of theatre ventilation systems while in callback mode, the associated recovery ventilation plant would also be automatically activated and monitor for fault conditions.

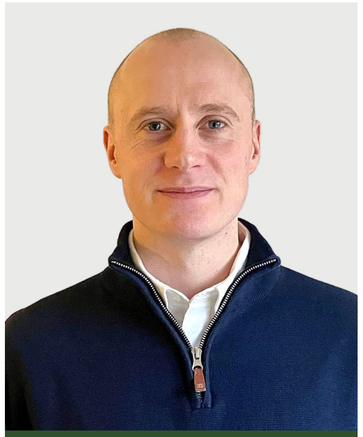
Theatre ambient temperature monitoring

Ambient temperatures were monitored to ensure that each theatre suite and recovery area remained within the recommended range during the shutdown periods. As part of the system control strategy, ventilation systems were programmed to automatically reactivate in circumstances where the ambient temperature for the associated theatre breached the upper or lower limits of the recommended temperature parameters. The ventilation system would then automatically deactivate again once the ambient temperature was back within the recommended range.

Data collection

All electrical power and heat meters were connected to the centralised building management system to enable continual data collection. The use of this system also enabled remote monitoring and spot checking of system compliance to the designed control strategy.

Theatre shutdown intervention



Kevin Deighton, PhD
Head of Evidence & Analytics

Schedule

At the Nuffield Health York Hospital, theatre meters and ventilation systems have historically operated continuously, 24 hours a day, even during night-time hours and each Sunday when the theatres are not in use. Since 20 January 2025, a new operational schedule has been implemented whereby theatres are shut down out of hours, during the night (specifically from 22:00 to 06:00) and each Sunday, throughout the year (Figure 1).

To quantify the impact of this intervention in terms of energy usage and associated CO_2 savings, we employed degree day analysis. Energy consumption data were collected at 15-minute intervals from 15 February 2024 to 20 January 2026 to understand changes in response to the out-of-hours shutdowns. The data were categorised by energy type – gas and electricity – to enable a more accurate analysis of both cost implications and associated CO_2 emissions.

Degree day overview

Degree day analysis is a method used for assessing the energy performance of buildings which relates energy consumption to outdoor temperature, typically through heating degree days (HDD) and cooling degree days.

A HDD is defined as a day in which the average outdoor temperature falls below a specified base temperature – commonly 18.5 °C in hospitals in the UK. The HDD value for a given day corresponds to the number of degrees by which the average temperature is below this threshold. For example, if the average temperature on a particular day is 18.0 °C, it would contribute 0.5 HDDs to the total. Since York experiences average temperatures below 18.5 °C for most of the year, our analysis was based on HDD.

Establishing the relationship between HDDs and energy usage provides an understanding of consumption across a range of external temperatures. This can then be used to monitor changes in energy usage in response to interventions while controlling for any influence of changing external temperatures. For this analysis, we investigated the effects of out-of-hours theatre shutdown on energy usage compared with expected values from the pre-shutdown period based on external temperatures.

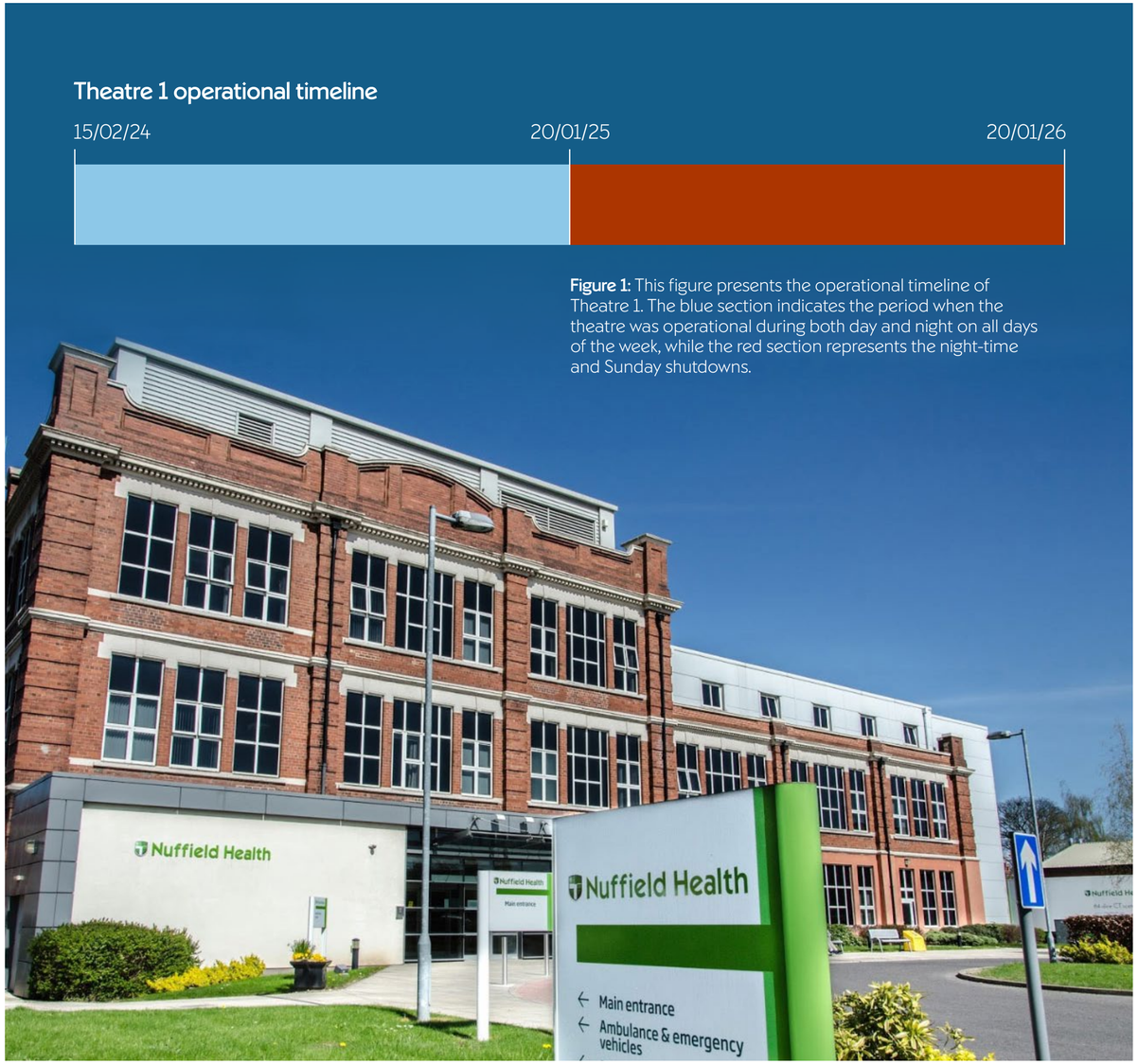


Figure 1: This figure presents the operational timeline of Theatre 1. The blue section indicates the period when the theatre was operational during both day and night on all days of the week, while the red section represents the night-time and Sunday shutdowns.

Analysis

Establishing gas usage prior to out-of-hours theatre shutdown

External temperature and theatre gas consumption were collected from the hospital monitoring systems between 15 February 2024 and 19 January 2025 to understand the relationship between HDDs and gas usage prior to out-of-hours theatre shutdown.

The relationship between HDDs and gas consumption during this period is provided in Figure 2, which demonstrates consistently higher gas usage in response to a higher number of HDDs (i.e., colder external temperatures). The red line in Figure 2 represents the overall trend line for the data which can be used to predict the expected gas usage for the theatre at each number of HDDs.

Figure 3 demonstrates the accuracy of this trend line as all points (except for two outliers) from the pre-shutdown period are close to the values generated from the trend line and within the limits of expected variation.

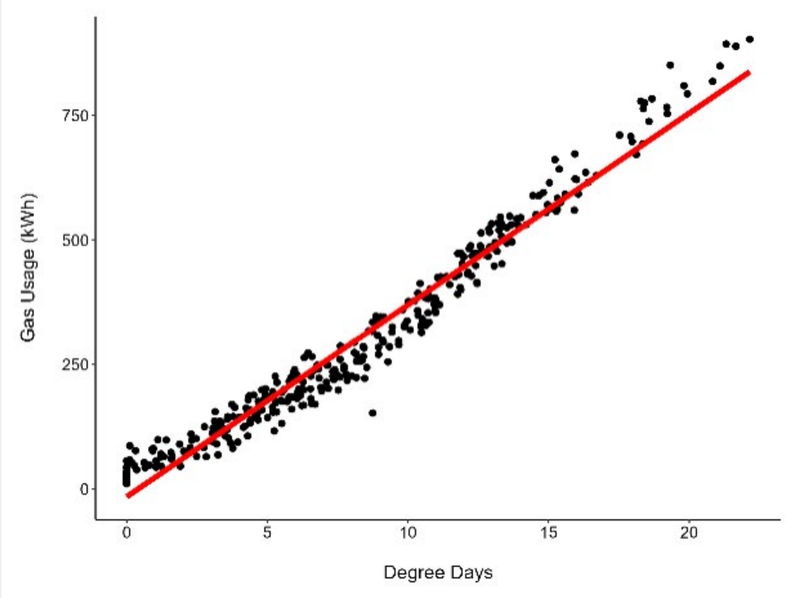


Figure 2:
Relationship between gas consumption (y-axis) and degree days (x-axis) using data from the pre-shutdown period. The red line represents the performance trend line, indicating how gas usage varied with changes in heating demand.

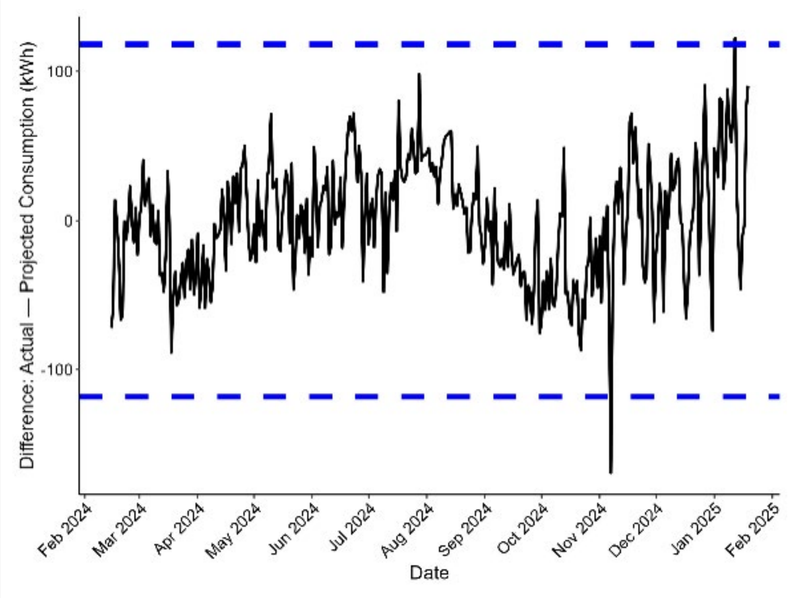


Figure 3:
Plot showing the difference between actual and predicted gas usage during the pre-shutdown period. The blue dashed lines represent the ±3 standard deviation confidence intervals, highlighting the expected range of variation in consumption.

Out-of-hours theatre shutdown reduced gas consumption

In response to the implementation of out-of-hours theatre shutdown there was a clear and marked decrease in gas usage compared with the forecasted values from the pre-shutdown period (Figure 4a). The cumulative effect of this sustained reduction in gas usage after the out-of-hours theatre shutdowns is shown in Figure 4b, with a 52,520 kWh decrease in gas usage across the year. This equated to a CO_2 saving of 9,590 kg and a financial saving of £3,304 based on average gas consumption costs of 6.29p per kWh.

Notably, gas consumption during the summer months (June – August) after shutdown returned to values similar to the pre-shutdown period, before decreasing again during autumn and winter (Figure 4a). This is also represented by a plateau in the cumulative reduction in gas usage during the summer months after shutdown in Figure 4b. These observations are expected due to the warmer summer temperatures negating the need for heating and therefore temporarily pausing the benefits of the out-of-hours shutdown.

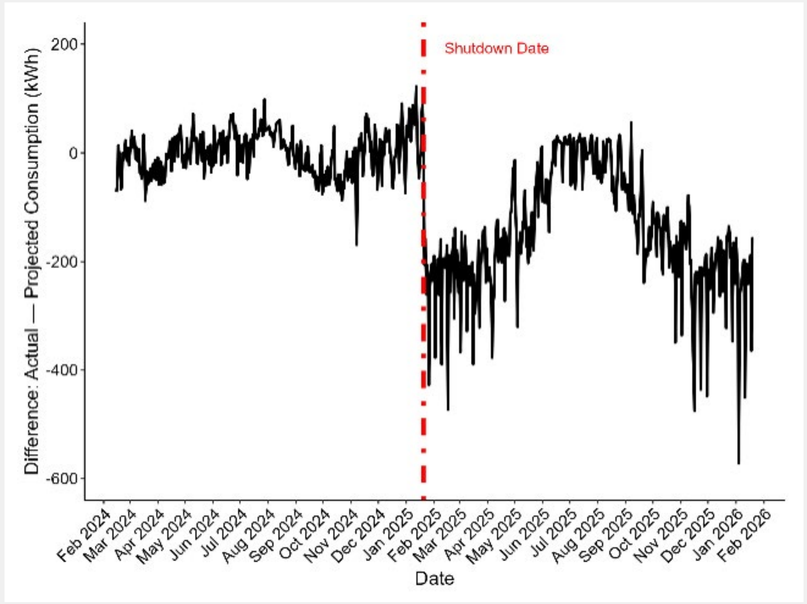


Figure 4a:
Theatre 1 gas consumption compared with expected values based on external temperatures from 15 February 2024 to 20 January 2026, showing a clear decrease after the shutdown (vertical red line).

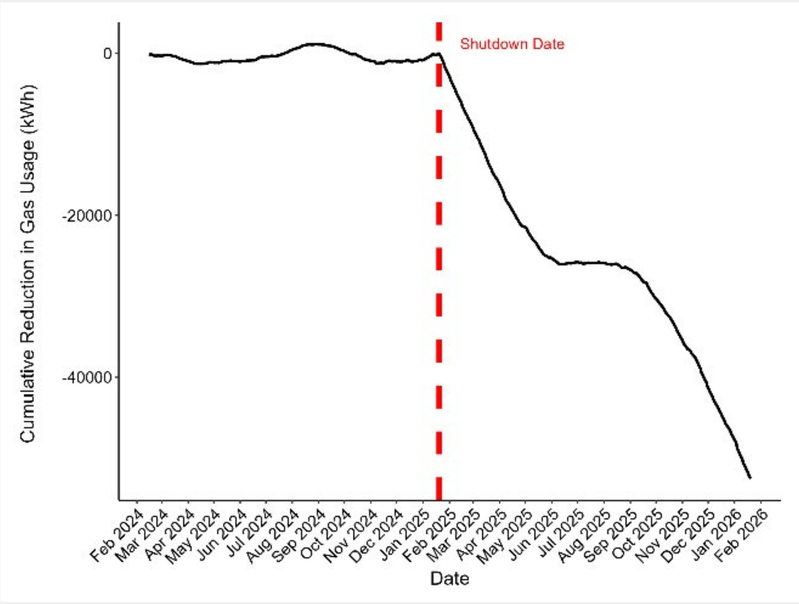


Figure 4b:
Cumulative sum of differences between actual and projected gas consumption used by the heating system for Theatre 1.

Out-of-hours theatre shutdown reduced electricity consumption

Out-of-hours theatre shutdown also created a large reduction in electricity usage from supply and extraction fans within Theatre 1. These fans operated continuously prior to the shutdown intervention regardless of external temperatures, as these do not function to heat or cool the theatre.

In response to the implementation of out-of-hours theatre shutdown there was a clear and marked decrease in electricity usage from supply and extraction fans compared with the pre-shutdown period (Figure 5a). The cumulative effect of this sustained reduction in electricity usage after the out-of-hours theatre shutdowns is shown in Figure 5b, with a 13,076 kWh decrease in electricity usage across the year. This equated to a CO_2 saving of 2,287 kg and a financial saving of £3,446 based on average electricity consumption costs of 26.35p per kWh.

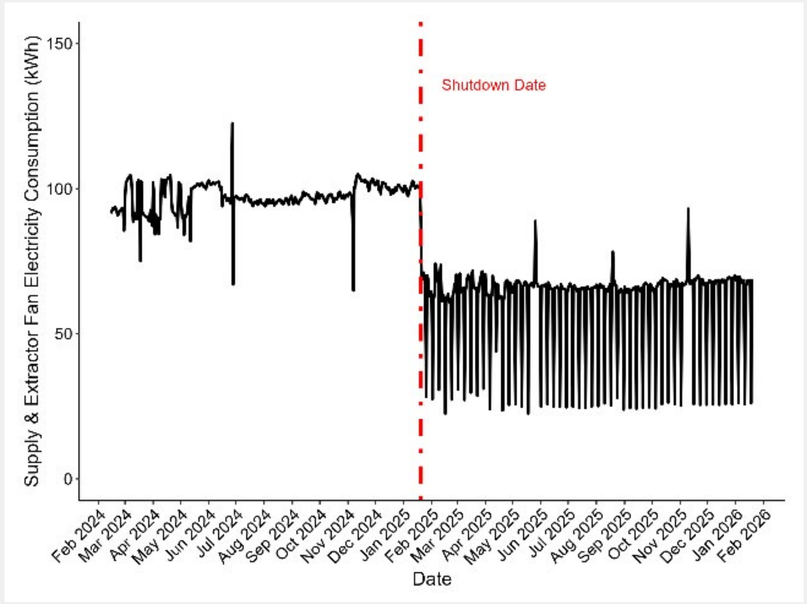


Figure 5a:
Theatre 1 electricity consumption from supply and extraction fans from 15 February 2024 to 20 January 2026, showing a clear decrease after the shutdown (vertical red line).

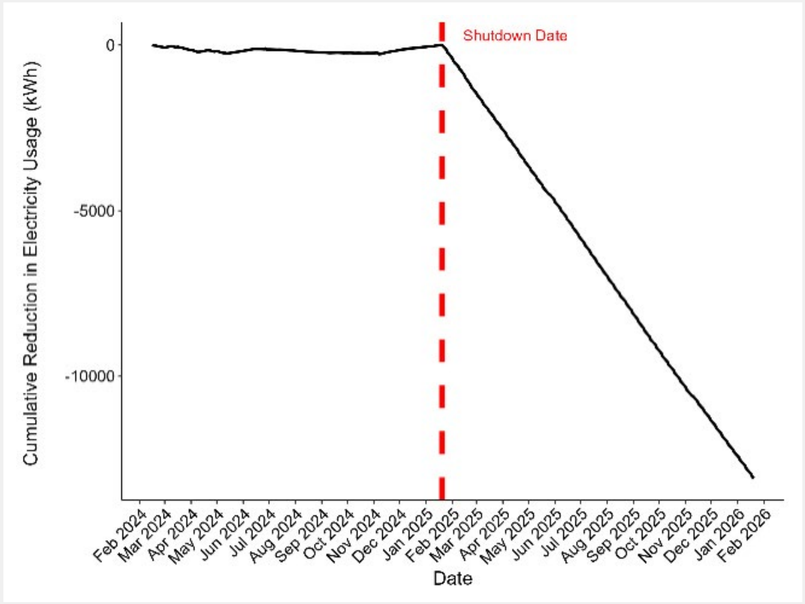


Figure 5b:
Cumulative sum of differences between pre- and post-shutdown electricity usage from supply and extraction fans for Theatre 1.

Key outcomes

Out-of-hours theatre shutdown reduced annual gas consumption for heating by ~52,500 kWh and annual electricity consumption for supply and extraction fans by ~13,100 kWh. Together, these changes reduced annual carbon emissions by ~12 tonnes, as well as generating financial savings of ~£6,750.

Importantly, infection rates for patients remained unchanged during the 12-month intervention compared with the previous year. These findings support out-of-hours theatre shutdown as being environmentally and financially beneficial, while protecting patient safety.

An infrastructure cost of ~£20,000 was invested at York Hospital to install the control panels and callback switches. This enabled the theatres to be reactivated during shutdown periods.

Based on this cost, shutdowns of theatre ventilation systems in a hospital containing four theatres would provide:

- **a return on investment within nine months, as a result of the associated gas and electricity savings**
- **an annual carbon emissions reduction of ~48 tonnes.**

*https://www.ofgem.gov.uk/news/changes-energy-price-cap-between-1-october-and-31-december-2025

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Nuffield Health

Greener today for a healthier tomorrow

Contact

If you'd like to hear more about our work, please contact:

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