UNIVERSITY OF CALIFORNIA HEALTH

REPORT

TRANSITIONING TO A PORTABLE SYSTEM FOR NITROUS OXIDE DELIVERY

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1. Introduction

The negative health impacts of climate change are intensifying in California and globally. Climate change increases exposure to extreme temperatures, catastrophic weather events, and disease, leading to exacerbation of illnesses, injuries, and deaths [1]. In the United States, the healthcare sector is responsible for 8.5% of all greenhouse gas emissions [2]. To mobilize climate actions from US healthcare, the Department of Health and Human Services (HHS) initiated a voluntary health sector decarbonization pledge in 2022 [3]. As of 2024, 139 organizations representing 943 hospitals have signed on to the pledge to reduce greenhouse gas emissions by 50% by 2030 and achieve net-zero emissions by 2050 [3].

A notable component of onsite greenhouse gas emissions from healthcare systems is anesthetic gases. Inhaled anesthetics, including halogenated gases and nitrous oxide, can account for 50% of perioperative emissions, 5% of emissions from hospitals, and 3% of total national healthcare emissions [4]. Anesthetic gases are potent greenhouse gases with significantly higher global warming potentials than carbon dioxide. In most healthcare facilities, N_2O is delivered to points of clinical care, such as operating rooms, via an integrated, piped central supply system. A centrally located, medical gas storage room houses high-volume compressed N_2O gas cylinders or large cryogenic N_2O containers attached to a central pressure manifold, followed by a complex downstream delivery system of pipes, valves, gauges, outlets, couplings, and anesthesia machines. Each of these components has the potential to leak under the constant pressurization of the central supply system, leading to large discrepancies

between the amount of N_2O supplied to the central system and the amount clinically used.

An effective and simple solution to combat the unnecessary loss of N_2O is to transition to a portable supply system utilizing small, portable gas tanks, called e-cylinders, that attach to individual anesthesia machines at the point of care. The leak rate of the smaller e-cylinder is significantly lower compared to larger cylinders [5]. The transition to a portable N_2O supply does not restrict or eliminate clinical access to N_2O and can be accomplished with minimal workflow changes to the clinician and no change in patient care. Following the establishment of a portable supply system, the original central piped supply system can be deactivated by disabling N_2O alarm panels, wall outlets, and zone valves, removing central supply cylinders/containers, and clearly labeling central supply components as inactive.

2. Background

The University of California Health is comprised of five major health systems, numerous hospitals, outpatient surgery centers, and clinics. Significant discrepancies were found while reviewing the past five years of clinical utilization from Electronic Health Record (EHR) and purchase data of nitrous oxide (N_2O) from 2018 to 2022 at the five surgical sites at UCSF Health. Only 10%-20% of purchased N_2O was delivered to patients, indicating that the majority of the procured N_2O was lost. Over 80% of the purchased nitrous oxide, a potent greenhouse gas, leaked into the atmosphere, directly undermining the aggressive emission reduction goals that many hospitals, including the UC Health system, have committed to. As part of the Transforming UC Health Systems to Reduce the Impact of Climate on Vulnerable Populations project, UC Health developed a goal to transition to a portable system for nitrous oxide delivery to reduce direct greenhouse gas emissions.

2.1. The Environmental Impact of Nitrous Oxide

Nitrous oxide has a global warming potential (GWP) that is 273 times higher than that of carbon dioxide on a 100-year scale, with an atmospheric lifetime of 114 years [6]. In addition to its high GWP and long atmospheric life, it also contributes to the destruction of the ozone layer that protects us from harmful ultraviolet radiation. Nitrous oxide is used as an adjunct to general anesthesia or as an analgesic for labor and delivery, and pediatric and dental procedures. Nitrous oxide's low clinical potency results in the need to administer it at a higher concentration to achieve the desired effect. As a result, its emissions burden is similar to desflurane, which has a global warming potential 2540 times higher than carbon dioxide on a 100-year scale [6]

Owing to its limited clinical utility, especially with the emergence of newer volatile anesthetics, coupled with the risk of adverse effects, and concern regarding occupational exposure, several studies have confirmed the decreasing clinical use of N_2O in anaesthesia over the past decade [7]. Nonetheless, despite the decrease in clinical utilization, nitrous oxide still accounts for the largest portion of healthcare-specific anesthetic gas emissions, contributing to 2% of the National Health Service England's total carbon footprint and 75% of the total emissions from anesthetic gases [8]. A majority of these nitrous oxide emissions result from loss that occurs in the piped delivery system. Given the long-lasting and potent impact that nitrous oxide has on the environment, healthcare facilities must address the unnecessary waste generated by inherent inefficiencies in the central piped delivery system.

2.2. Benefits of Deactivating Central Piped Nitrous Oxide

There are several environmental, financial, and safety benefits for deactivating the central pipe nitrous oxide system and switching to portable cylinders to supply nitrous oxide at the point of care. The primary benefit is the significant reduction in direct emissions generated from anesthetics onsite. Deactivating the central pipe system also enhances safety, as it reduces the potential occupational health hazards associated with exposure to leaked nitrous oxide [9]. Additionally, the portable cylinders are much lighter and easier to exchange compared to the large tanks, reducing the potential risks for physical injury. Cost savings can also be expected from the transition. Significantly less nitrous oxide needs to be purchased; there are also fewer costs associated with pipe maintenance, with additional savings from avoided costs by excluding the central piping in designs for new healthcare facility construction. For example, UCSF Health eliminated the central piped nitrous oxide delivery system from the design plans for the New Hospital at Parnassus Heights and the new Bayfront Medical Building, resulting in an estimated $1.2 million in avoided costs. With all the tangible benefits mentioned above, no clinical, operational, or logistic challenges have been noted by institutions that have completed the transition.

2.3. The Deactivating Process

Building Your Team

The first step of a successful transition to a portal system is to establish a multidisciplinary workgroup that is in frequent communication. The table below lists all the key stakeholders, color-coded with the level of involvement based on the experience of the five UC health systems. Coordinated efforts and communication among the workgroup with the understanding of their role, responsibilities, and tasks will ensure a smooth and safe transition and minimize disruption to clinical care.

Roles	Responsibilities
Clinical Lead	1. Identifying key stakeholders 2. Creating awareness and urgency among team members 3. Soliciting ideas and feedback from team members 4. Identifying and gathering clinical utilization and procurement data 5. Coordinating the transition efforts with the facilities team 6. Providing training and support to the perioperative team 7. Continuing the feedback and engagement through the transition process 8. Communicating post-implementation successes
Facilities Lead	1. Coordinating with the anesthesia team 2. Gathering central supply design and inventory 3. Overseeing the deactivation of the central system 4. Adhering to safety and compliance (NFPA 99)

Informatics	Extracting clinical utilization data and generating reports
Anesthesia Workroom Technicians	Managing the portable N_2O cylinder workflow and daily machine checks
Procurement	Providing N_2O purchase and cost records by year, location, and types
Fire Marshall	Coordinating with facilities for storage compliance for oxidizing gas (NFPA 99)
Medical Gas Contractor	Coordinating with facilities to deactivate the central system and ensure regulatory compliance
Clinical Engineering	Providing information on manufacturer alarm guidelines and anesthesia machine retrofitting (if needed)
Sustainability Lead	Aligning with institutional and national goals for emission reduction and reporting
Environmental Health & Safety	Providing safe handling guidelines, workgroup coordination
Design & Planning	Supporting new construction

Table 1. Stakeholders who should be involved in the multidisciplinary workgroup. Red, yellow, and green indicate critical, essential, and peripheral team members, respectively.

The following table describes the four phases of the deactivation process, the stakeholders involved, and the key tasks in each phase.

Elements of Transitioning

	Stakeholders	**Key Tasks**
Phase 1: Assess Opportunity	Clinical Leads Perioperative Informatic Material Service Personnel Facilities Leads	1. Obtain N_2O clinical usage data from EHR (by rooms, by providers) 2. Obtain N_2O procurement data 3. Compare the discrepancy between clinical usage and procurement

		4. Calculate the emissions reduction cost savings of the transition to the portable system
Phase 2: Engage Stakeholders	Clinical Leads Sustainability Officers Facilities Leads	1. Obtain leadership and departmental chair support for resources 2. Establish a multidisciplinary task force
Phase 3: Establish the Portable System	Fire Marshall Anesthesia Techs Clinical Leads	1. Calculate the exchange frequency for the e-cylinders to estimate par-level 2. Work with clinical technology and anesthesia techs to establish a protocol for e-cylinder change (at what pressure) 3. Educate the providers on workflow change regarding nitrous use
Phase 4: Deactivate the Central System	Facilities Leads Anesthesia Techs Clinical Leads	1. Disable the alarm panels 2. Turn off the source equipment 3. Abandon the pipe distribution system 4. Document all changes in the status of all components of the Nitrous Oxide system 5. Inform the clinical team of the completion to introduce the new workflow for nitrous use

		6. Continue monitoring workflow change

Table 2. Phases of deactivation, stakeholders that need to be involved, and key tasks in each phase.

Phase I: Assess Opportunity

Assessing the institution-specific opportunities for transitioning to a portable system for N_2O delivery will present a strong case to leadership and stakeholders for the potential benefits in emissions reduction and cost savings, and will provide specific data for target education and storage consideration.

Clinical Utilization Data

In a facility that uses the Electronic Health Record (EHR), the first step is to work with your informatics team to obtain N_2O clinical utilization data from the EHR. If available at your institution, SlicerDicer and AdaptX are both useful tools for data aggregation. Detailed information on N_2O utilization by surgical sites, operating rooms, and individual providers can provide insight into N_2O usage patterns by location and personnel.

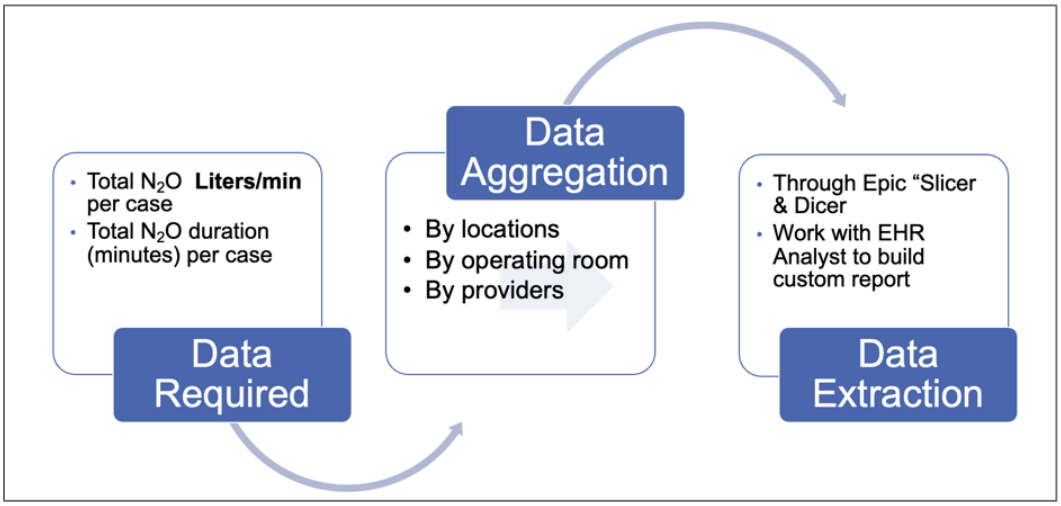
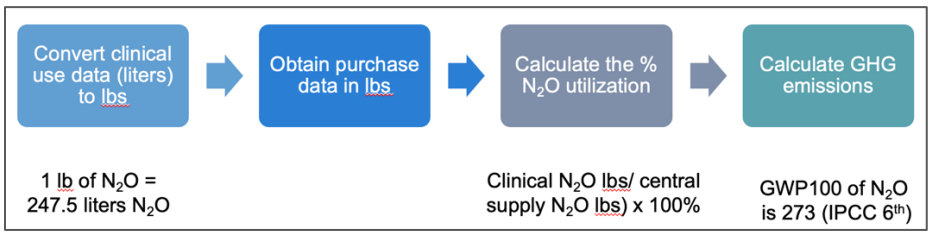


Figure 1. Process of obtaining N_2O clinical utilization data from the Electronic Health Record.

Procurement Data

N_2O purchase data in volume and different types of cylinders can be directly obtained from medical gas vendors or your hospital's distribution center. Unit conversion will be required to calculate the discrepancy, as the clinical usage data obtained is in liters of N_2O delivery, whereas the purchase data is most likely in pounds (lbs). The percentage of N_2O utilization and greenhouse gas emissions from purchased N_2O can also be calculated as illustrated below.



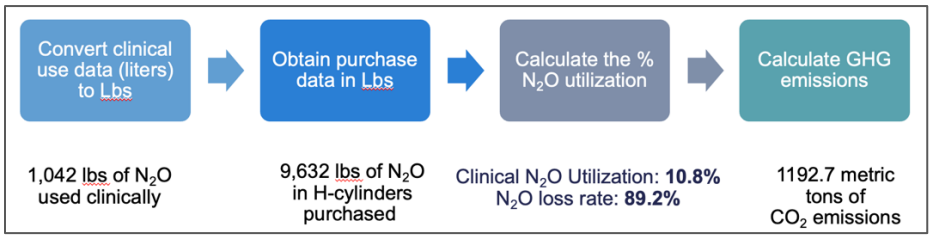


Figure 2. Process for calculating procurement/clinical utilization discrepancy and emission impacts, and an example with UCSF Health data from Calendar Year 2022.

If there are plans for new hospital or surgical site constructions, eliminating the central pipe system for N_2O delivery in the design plan can result in substantial savings in construction. Get in touch with your design team for new constructions to see if there is an opportunity to eliminate the pipe system for N_2O delivery from the design plan.

In the case that retrofitting the anesthesia machines to accommodate portable cylinders for N_2O delivery is necessary, some initial upfront capital cost will be required. Targeting operating rooms with high N_2O usage for retrofitting will provide more yield on return on investments.

Phase 2: Engage Stakeholders

Education

Education is a key component to getting peers in the anesthesia department to be comfortable with the transition and engaging other stakeholders throughout the process. Socializing the idea and addressing specific concerns early on is critical in ensuring a smooth transition. Education should be led by the Clinical Leads to convey the need and the urgency for the transition and communicate the anticipated changes in workflow

when transitioning to a portable system. Some common education tactics include grand round presentations, departmental emails, curbside conversations, and laminated signage on the anesthesia machine. The target audience should be the entire anesthesia department, including providers, trainees, anesthesia technologists, and the facilities team.

The overarching aims of the education for all personnel involved in the transition include:

- Understand the environmental impact of N_2O as an anesthetic gas
- Understanding the design of the current central delivery system inadvertently contributes to systemic loss, leading to the significant discrepancy between procurement and clinical use
- Understand the detailed steps of the transition plan, the environmental, financial, and safety benefits of the transition
- Understand that the transition is safe, feasible, and has been successfully accomplished by multiple healthcare institutions in both community and academic settings without any impact on patient care

In addition to communicating the aims above, the figure below illustrates the specific education required for each group, including anesthesia providers, anesthesia technologists, and the facilities team.

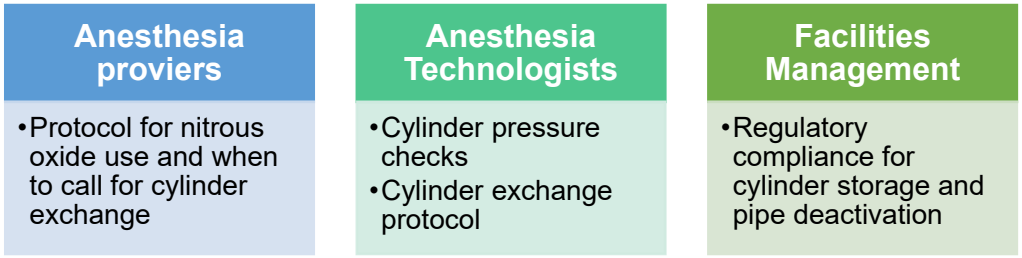


Figure 3. Group-specific education required for the transition.

Phase 3: Establish the Portable System

Establish a par-level for the cylinders

Before deactivating the piped delivery system, a portable system and a new workflow should be established. Based on the N_2O clinical usage per operating room, the estimated portable cylinder exchange frequency and the required inventory can be calculated as demonstrated below. Note that N_2O is an oxidizing gas, therefore, the storage capacity of the portable e-cylinders will need to comply with regulatory requirements. Consult with facilities management and the fire marshal for specific code requirements and storage capacity. To increase storage for N_2O cylinders, adjustments in other oxidizing gas cylinder storage, such as oxygen, might be necessary.

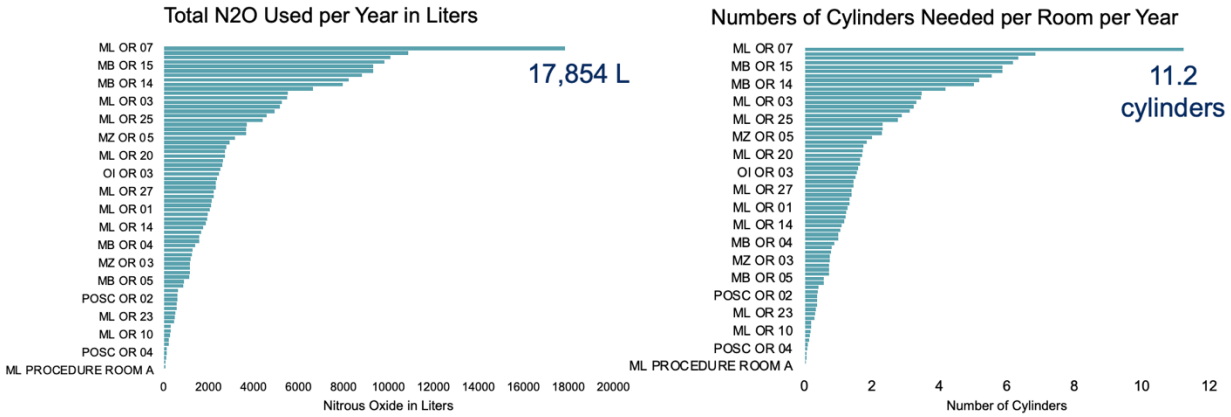


Figure 3. Calculating cylinder exchange frequency per room to consider par-level for N_2O e-cylinders

Establish a workflow for cylinder change

Another aspect is to establish a workflow with anesthesia providers and technicians for e-cylinder exchange. The anesthesia machine will alarm when the N_2O cylinder pressure is below a certain pressure threshold. The alarm will need to be disabled. Check with the clinical technology team and the user manual to see if adjusting the alarm threshold is necessary. Depending on the comfort level, the department can decide on a protocol for cylinder exchange. UCSF Health found that when the pressure is below 100 PSI, the cylinder can no longer consistently deliver N_2O at the commonly used flow rate. Based on that information, it was decided that providers should call for a cylinder exchange when the pressure is between 100-150 PSI to have ample time for the cylinder exchange. The figure below illustrates the provider workflow for nitrous use.

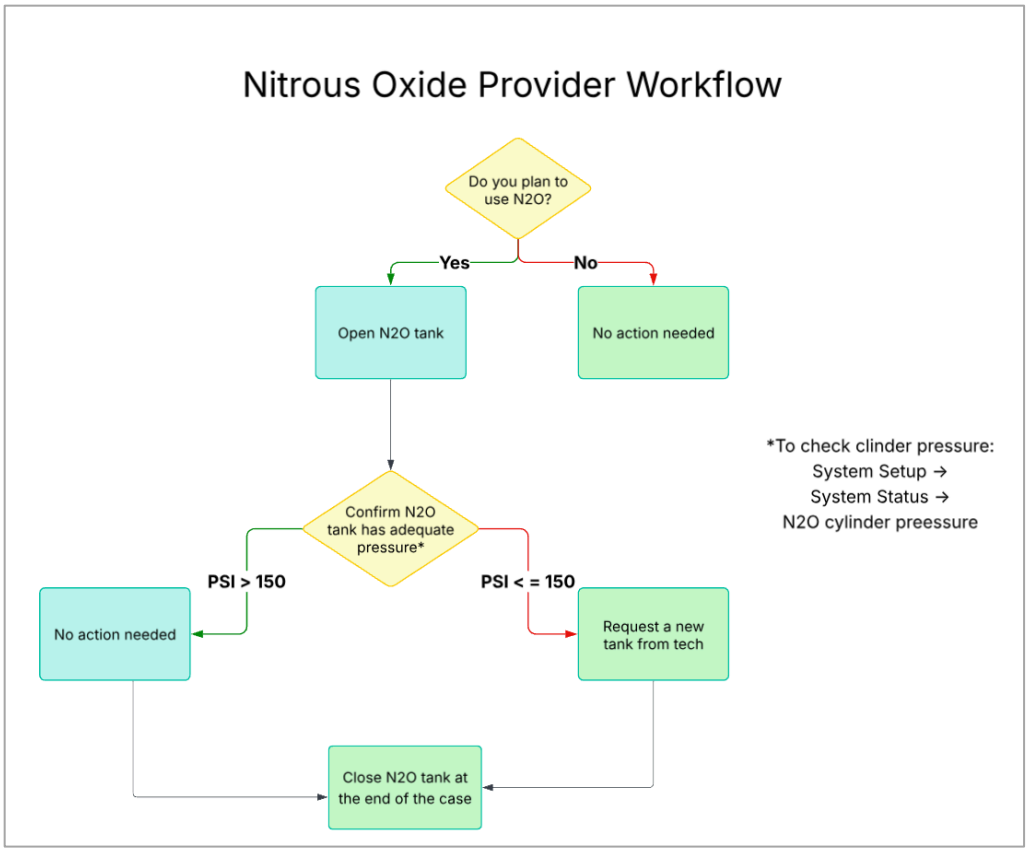


Figure 4. This figure illustrates a decision process at UCSF Health created for providers when considering N_2O for clinical use.

Phase 4: Deactivation of the Central System

Before the deactivation of the central system, the facilities team should notify the clinical team to ensure all necessary preparations have been completed for the transition. The deactivation steps follow the checklist below.

Step One: Disable all alarm panels

1. Disable all N_2O audible and visual indicators for:
   a. Master alarm panels
   b. Area alarm panels
   c. Area alarm panel pressure indicators
2. Apply an “OFF” label to any alarm component abandoned in place

Step Two: Turn off the source equipment

1. Electric power to be turned off at the applicable supply circuit breaker by facilities staff
2. Turn off the source valves. Label “Abandoned”
3. Turn off the cylinders at the flexible connectors
4. Release the N_2O pressure from the source equipment and through the vent
5. Remove all flexible connectors and header bars

Step Three: Abandon the Piping Distribution System

1. Outlets
   a. Remove all outlet latch/trim plates
   b. Remove any hose as applicable
   c. Install blank trim plates at each abandoned outlet
   d. Place in a box for the facilities staff when finished
2. Zone Valves
   a. Remove gauge from valve piping
   b. Install a threaded plug in place of the gauge
   c. Remove the handle for each N_2O valve
   d. Relabel the zone valve location sign with OFF, indicating the pipes are no longer in service
   e. Remove all N_2O labels from the pipe at the location along with the area served sign
   f. Place in a box for the facilities staff when finished

Local and regional medical gas vendors might help in providing technical and operational support, regulatory compliance, and verification for the deactivation tasks.

After the deactivation, facilities management should return all large cylinders to medical gas vendors. The anesthesia workroom manager should be responsible for maintaining the e-cylinder inventory and par-level.

3. Common Questions & Answers

1. Who are the key members to be included in the deactivation team?

Different health systems have approached the deactivation process in various ways. Based on the experience of the five UC Health systems, Table 1 was developed, listing all stakeholders, color-coded by their level of involvement: critical, essential, and peripheral. The clinical lead and facilities lead are identified as the two most critical members of the team.

2. Do I need a sustainability officer?

If your health system has a sustainability officer or lead, involving them can help communicate the institution's sustainability goals and ensure strategic alignment and leadership support for the deactivation efforts. They can also coordinate efforts across departments and serve as a project manager. However, a sustainability officer is not essential for success. Several community hospitals have successfully completed the transition without a dedicated sustainability lead.

3. Should the transition be led by top-down support or bottom-up support?

At UC Health locations, deactivation was successfully achieved using both top-down and bottom-up leadership strategies. Top-down support from the C-suite and the anesthesia department chair was instrumental in initiating the deactivation process, as their roles are critical in making executive decisions and allocating necessary resources. Bottom-up support from end-users played a key role in ensuring a smooth transition, as it helped minimize resistance to changes in workflow.

4. How do I convince C-Suite leadership?

Most organizations have sustainability goals related to emissions reductions. Aligning the deactivation project with these goals, specifically by estimating potential emissions reductions, can help gain leadership support. Additionally, evaluating potential cost savings and presenting the case that deactivation will improve overall organizational safety and reduce long-term maintenance costs can further strengthen your argument.

5. What is the most important part of getting a consensus from the anesthesia department?

To gain internal buy-in from the anesthesia department, it is important to introduce the concept of deactivation early. Support from the department chair can be especially helpful in building consensus. Educating providers about the environmental benefits and reassuring them that clinical practice will remain unchanged is critical. The anesthesia department should be informed and actively engaged throughout the entire deactivation process to proactively address any workflow changes, such as those involving e-cylinder exchange.

6. What education and engagement strategies should be used for the anesthesia department's internal buy-in?

Hosting a grand rounds education session is highly effective for increasing internal buy-in. Ideally, present your institution's own clinical nitrous oxide usage versus purchasing data; however, external references are available if internal data is not. Peer engagement within the anesthesia department is also crucial. Appointing sustainability champions to distribute educational materials and address concerns is a proven strategy. Regular updates via newsletters or email communications regarding the deactivation timeline and process are essential for keeping the department informed about the transition and any upcoming workflow changes. If provider-specific nitrous oxide usage data is available, it may be helpful to engage high-usage providers directly to address their specific concerns.

7. How do you facilitate the transition with challenging departments (Pediatric, Labor and Delivery, and Dentistry, etc.)?

Some departments may be more resistant to the transition than others. For instance, Pediatric Surgery may oppose switching to a portable N_2O supply due to their higher nitrous oxide utilization compared to adult surgery. Labor and Delivery units, which may rely on central piping for labor patients, might also resist the change.

To support these departments through the transition, consider the following strategies:

- *Organize targeted educational sessions.*

- *Collaborate with stakeholders to design an e-cylinder workflow that maintains adequate inventory and ensures uninterrupted clinical use.*
- *Pilot the transition in a single room to evaluate feasibility and build confidence.*

One example of tailoring the workflow is ensuring that Labor and Delivery department has enough Nitronox machines for patient care. Additional machines may be needed to accommodate the new workflow.

8. Do I need a medical gas vendor?

Deactivation tasks can be completed with or without a MedGas vendor. The decision to involve one depends on your budget and the bandwidth and expertise of your facilities management team. At some UC locations, facilities teams with sufficient capacity and operating on smaller budgets completed the transition themselves and then engaged a MedGas vendor to perform a post-transition verification check for regulatory compliance. Other sites with limited internal resources contracted a MedGas vendor to manage the entire transition process.

9. Will transitioning to a portable delivery system increase costs?

In general, deactivation leads to long-term cost savings by reducing nitrous oxide (N_2O) consumption, as the delivery system becomes significantly more efficient. On average, UC Health has reported savings of approximately $10,000 per health system due to reduced N_2O purchases.

There may be upfront costs if a medical gas consultant is contracted for the transition. Additionally, some anesthesia machines may need to be retrofitted to accommodate portable N_2O cylinders. This retrofit can be done internally by Clinical Technology teams or outsourced to vendors. Retrofitting costs—including both materials and labor—typically range from $2,200 to $3,500 per machine, depending on the machine type. However, not all anesthesia machines need to be retrofitted; focusing on operating rooms with high N_2O usage provides the greatest cost-benefit. In addition, new construction projects can realize even greater savings by excluding central piping infrastructure.

10. Does transitioning to portable e-cylinders require more labor?

In the short term, the facility's workload may increase to support the deactivation process, particularly if a medical gas vendor is not contracted. However, over time, the overall maintenance workload will decrease while also improving organizational safety by reducing the risk of gas leaks. Anesthesia technicians will be responsible for performing pressure checks, maintaining the cylinders, and managing cylinder exchanges.

11. How do I know if my state requires a detailed action plan as a formal proposal before deactivation?

The first step is to identify your Authority Having Jurisdiction (AHJ) and reach out to them for guidance. This could be your State Department of Health or the local fire marshal. Your facilities management personnel responsible for the medical gas supply

system are likely familiar with the appropriate contacts, or you can consult your local medical gas provider for assistance. When contacting the oversight entity, be sure to have a comprehensive transition plan prepared.

12. What regulations are required to be met when transitioning to portable e-cylinders?

The Facilities Guidelines Institute (FGI), which provides guidance for healthcare facility construction, does not mandate a centrally piped nitrous oxide system in hospitals. Therefore, each hospital can determine whether a central system is necessary based on clinical needs. Most states have adopted some version of FGI as their construction standard. For independent states, you may need to review your state statutes.

The National Fire Protection Association (NFPA) sets regulations for the storage, handling, and use of medical gas cylinders, as well as some language around labeling and deactivation of central medical gas systems. Final deactivation requires some interpretation of NFPA 99 to ensure proper labelling, with the primary concern being that people assume that a deactivated system remains active. Formulating a plan, a combination of proper labelling and deactivation or removal of some system components, to clearly communicate that the central system is deactivated, is crucial. The entire pipe system is not required to be removed.

13. What is the recommended storage for N_2O portable e-cylinders?

The National Fire Protection Association's NFPA 99 Health Care Facilities Code specifies storage limits for oxidizing gases. Different types of rooms in hospitals are approved for various capacities. Include your fire marshal, anesthesia technologists, procurement team, and facilities staff in discussions about storage to ensure all regulations and operational needs are met. Additionally, a PAR (Periodic Automatic Replenishment) level should be established for each location. Carefully account for the stored volume in each location and adjust PAR levels of other oxidizing gases as needed to allow for additional N_2O cylinder storage (N_2O e-cylinder contains 56 ft^3, which is more than an oxygen cylinder (23 ft^3), stored volumes are specific for the size of cylinder and the type of gas.)

14. What is the recommended protocol for e-cylinder exchange?

A full N_2O e-cylinder contains approximately 1,590 liters of N_2O at 750 PSI. The pressure gauge will continue to read 750 PSI as long as liquid N_2O is present. Once the liquid is depleted, still at 750 PSI, only about 400 liters of gaseous N_2O remain.

The low-pressure alarm for Aisys machines activates at 381 PSI, which corresponds to about 200 liters of gas, or 12.5% of tank capacity. At a flow rate of 2 L/min with an 80% N_2O / 20% O_2 mixture, an anesthesia provider would theoretically have about 125 minutes of gas left. However, internal testing has shown that Aisys machines cannot reliably deliver continuous N_2O flow at pressures below 100 PSI.

Recommended protocol:

- *Request a replacement cylinder when N_2O pressure falls between 150–100 PSI. This allows for optimal use of the remaining gas while ensuring time for replacement.*
- *Alternatively, for a more conservative approach, your department may opt to replace the cylinder once pressure drops below 750 PSI, ensuring uninterrupted care.*

15. When should eliminating the piped system for N_2O delivery be discussed for new construction projects?

Discussion around eliminating the piped system nitrous oxide delivery should begin as early as possible during the planning phase of new construction. Central piping systems for nitrous delivery are typically included by default in early-stage designs and are often treated as the industry standard unless otherwise specified. Omitting the central pipe system during planning can lead to significant avoided costs. UCSF Health excluded nitrous piping in both the New Hospital at Parnassus Heights and the new Bayfront Medical Building, saving approximately $1.2 million. UC Davis Health also removed central piping from two major projects, saving about $400,000 in avoided costs.

16. What are strategies to overcome common barriers?

    Some common barriers include:

    a) *Concerns about the quality of care.*
    b) *Concerns about cylinders being replaced in time.*

c) *Concerns about changes in workflow.*

Strategies to address these concerns:

d) *Socialize the idea early so the transition doesn't come as a surprise.*
e) *Educate providers on the benefits of the transition and reassure them that patient care will not be compromised.*
f) *Establish workflows early in the process to provide clarity and structure.*

17. What are the top three recommendations for a successful transition?

a) *Find your allies: Gain support before proposing the transition.*
b) *Socialize the benefits early: Involve many stakeholders to ensure comfort with the transition and highlight success stories from institutions that have already deactivated.*
c) *Reassure and start small: Emphasize that clinical practice and patient safety will remain unchanged. Reference other successful examples and start with a pilot program in 1–2 operating rooms before rolling out facility-wide.*

18. What can I anticipate after deactivation?

Continuous monitoring post-transition is critical. At UCSF Health, providers are instructed to turn on the valve of the e-cylinders for nitrous usage at the start of cases and close the valves at the end of the case. Some providers may forget to turn off the cylinder valve at the end of the case. To mitigate this, anesthesia technicians are also

instructed to check that all valves are closed at the end of the day and check the pressure of the tank at the beginning of the day.

A decrease in N_2O clinical usage is often observed after the transition, as some providers stop using it altogether due to the added step of turning on the valve. This is seen as a positive side effect of transitioning to e-cylinders. In the future, removal of the portable cylinders in low-usage rooms should be evaluated.

19. What should I do with the nitrous cylinders after the deactivation?

After deactivation, the partially full N_2O cylinders should be disconnected from the manifold and returned to the vendor. The vendors will vent out the remaining N_2O to ensure the chain of custody of the cylinders is maintained.

20. How do you measure nitrous oxide usage?

Procurement data for nitrous oxide is typically reported in pounds. Clinical N_2O utilization is reported in liters. To compare purchase data to usage data, the unit of the nitrous oxide data will need to be converted to calculate the discrepancy.

21. What is the conversion rate from pounds of nitrous oxide to liters?

*Conversion rate: 1 pound of N_2O = 230.6 liters of N_2O**

** Based on gas density of 1.967 g/liter (Merck Index) and converting pounds to grams (0.002205 pounds/gram)*

4. Conclusion

Six months after the deactivation of the central piped N_2O system, UC Health saw a significant decline in N_2O clinical usage. Some outpatient surgical centers saw the usage decline by almost 90% due to the extra steps providers must take to open the e-cylinder for utilizing nitrous oxide. The providers sometimes need to be reminded to close the cylinder valves after nitrous use via emails or laminated signage at the anesthesia machine. No additional workflow issues have been reported. Transitioning to a portable source for nitrous delivery is a safe, effective way to reduce emissions without compromising patient care. This toolkit is intended to present a convincing case for the deactivation central piped nitrous oxide systems and provides the necessary framework for completing the transition to a portable N_2O supply.

5. Future Work

Considering that N_2O clinical use decreases following transition to a portable supply, the next phase of this project will be to assess whether the nitrous oxide supply can be removed entirely from certain operating rooms that demonstrate little to no N_2O use, especially in adult outpatient surgical centers.

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UC San Francisco Health
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