
# Driving down greenhouse gas emissions while saving cost on anaesthetic agents

**A case study using Carestation Insights™ Agent Cost Application**

GE HealthCare


*Porta Sole Clinical Institute staff including Carlo Ciarapica on the left and Dr. Gianfranco Toni on the right*

*The Porta Sole Clinical Institute in Italy is using Carestation Insights Agent Cost application to optimise the benefits of low-flow anaesthesia, reducing both the cost of anaesthetic agents and greenhouse gas emissions. Clinic owner Marco Cucchia, anaesthesiologists Dr. Chiara Piergiovanni and Dr. Gianfranco Toni, and Carlo Ciarapica, operating room (OR) nursing staff lead and OR activities coordinator, describe the positive impact of implementing change management using the Agent Cost application.*

**The Porta Sole Clinical Institute is a private clinic in Perugia, Italy, with a strong focus on digitising healthcare services, including tools that enable the sharing of information between all users along the clinical care pathways. The clinic's core activities include orthopaedic and abdominal surgery, plus general, gynaecological, ophthalmological and urological procedures. A team of five anaesthesiologists work across four operating rooms, equipped with the Aisys™ CS² with End tidal Control (EtC) and Avance™ CS² anaesthesia delivery systems. The clinic prefers to use the Aisys CS² with Et Control in higher acuity cases where more precise delivery and control of the anesthesia is needed to deliver customized care. The clinic performed a total of 3,380 procedures in 2022.**

## Looking to a greener, more cost-effective future

Maintaining a balance between cost and revenue is an essential part of budget allocation but, at the same time, it is vital that the quality and safety of patient care is never compromised. Porta Sole sought to optimise its economic resources by reviewing its costs to reduce unnecessary expenditure, improve efficiency and standardise anaesthesiology practice. Porta Sole Clinic was able to take advantage of the National Plan Industry 4.0 funding incentives to increase the level of technology in its operating rooms (ORs) to further enhance clinical outcomes through data connectivity and integration. Volatile anaesthetic agents are among the most expensive drugs available and are the biggest ongoing costs associated with anaesthesia units. Hospitals can be spending an extra 30 to 40 %[1] on anaesthetic agents due to the use of high fresh gas flow rates. However this can be reduced without having a negative impact on the patient by using EtC on the Aisys CS² machine. This, of course, is not the only consideration in an ever-more environmentally conscious world; sustainability and the impact of anaesthetic agents on the climate are also concerns. Anaesthetic agents are known to be potent greenhouse gases, and their release into the atmosphere can contribute emissions equivalent to up to 350 cars a year.[2,3] Cutting the amount of anaesthetic agents used could, therefore, have a direct effect on the reduction of carbon dioxide ($CO_2$) emissions.

## Driving change management with Aisys CS² anaesthesia machine and Carestation Insights applications

The clinic's goal has always been to use the most advanced technologies for its patients' care. Consequently, Port Sole Clinical Institute has invested heavily in innovative solutions that help improve perioperative workflows, while maintaining safe surgical and anaesthesia practices. This now includes the use of the Aisys CS² anaesthesia delivery system with Et Control and Carestation Insights applications for OR analytics. The Aisys CS² Anaesthesia Delivery System is a clinically advanced workstation that allows automation of low-flow anaesthesia to help reduce the consumption of anesthetic agent (consequently total cost) and $CO_2$ emissions. In May 2021, the Aisys CS² workstations were connected to the Carestation Insights Agent Cost application, creating a digital OR ecosystem for decision support. The Carestation Insights suite of applications store and process anaesthesia machine data in the cloud and provides a retrospective analysis. The Agent Cost application displays flow rates at both the induction and maintenance case phase separately, as well as showing anaesthetic agent use, associated costs and equivalent greenhouse gas emissions across the operating rooms, to help clinicians with low-flow anaesthesia practices.

*"Our goal is always to use the most advanced technologies for our patients' care. This solution allows us to use automatically controlled anaesthesia to reduce anaesthetic agent costs and $CO_2$ emissions."*

*"I'd like to say this is a win-win opportunity, where you can save money and contribute to a greener world, so what are you waiting for?"*

***Mr Marco Cucchia,***
*Clinic Owner, Porta Sole Clinical Institute, Perugia, Italy*

The clinic's anaesthesiologists have been using the Aisys CS² machine with EtC since June 2021. EtC software automatically adjusts fresh gas concentrations to quickly and efficiently achieve and maintain oxygen and end-tidal agent targets. Using EtC has been shown to reduce agent costs by 27 % and greenhouse gases by 44 % in one study.[4] Data regarding the clinic's use of anaesthetic agents and the resulting emissions were analysed over a 12-month period from June 2021 to May 2022. The data was reviewed using the Carestation Insights Agent Cost application *(Figure 1)*. Using the Carestation Insights Agent Cost application, the data was analyzed starting in June 2021 and showed that the fresh gas flow rate (FGF) and the consumption of anaesthetic (Figure 1 - Blue boxes) was significantly higher in comparison to other (Figure 1 - Green boxes). This along with the related $CO_2$ emissions could be reduced by optimizing anaesthesia practices.

*"I think it's time now for everyone running surgery and anaesthesia activities to realise the positive impact we can have on the environment. …this was only possible thanks to the collaboration between our team and GE HealthCare, with whom we have started a journey that has led us to improve our daily clinical practice."*

***Mr Carlo Ciarapica,***
*OR nursing staff lead and coordinator of OR activities,*
*Porta Sole Clinical Institute, Perugia, Italy*

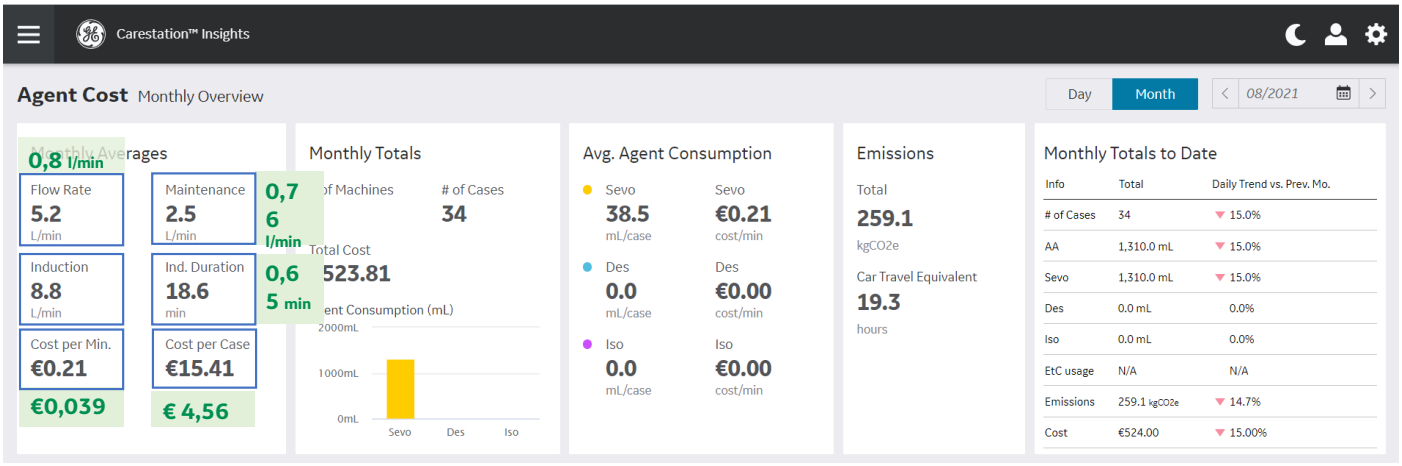


*Figure 1: Porta Sole baseline measurements in Blue squares compared to best practice from other hospitals using Carestation Insights in Green boxes.*

## Optimising anaesthesia practices

After reviewing the data, the clinic began a collaboration with GE HealthCare to leverage the use of the Aisys CS² machine with EtC and Carestation Insights analytics to improve financial outcomes by focusing on reducing anaesthetic agent waste, which can subsequently help reduce the OR's carbon footprint. Low-flow anaesthesia was already being practiced to a certain extent with FGF around 2 l/min during the maintenance phase. The objective for the clinic was to further reduce FGF to 0.5 l/min. Nursing staff and anaesthesiologists engaged in discussions and training sessions – both internally and with GE HealthCare representatives – to learn more about: 1) low-flow anaesthesia, 2) the EtC safety features, 3) how best to utilize the EtC software.

Prior to the utilization of EtC and the Carestation Insights Agent Cost application, high flows were maintained for many minutes after induction, resulting in a higher consumption of inhalational anaesthetic agents that would go to waste and be expelled into the atmosphere. For this reason, it is important that EtC function is activated directly after intubation and when switching to mechanical ventilation. The combination of automated delivery of FGF with EtC along with advanced patient monitoring solutions helps clinicians ensure that lower flows do not pose an additional safety risk to the patients.

This confidence allowed the anaesthesia providers to quickly adopt the new 0.5 l/min protocol after a short period of time.

## Demonstrated success

Prior to introducing the new protocol, Porta Sole was consuming 189 bottles of Sevoflurane a year at a cost of €14,553, with a weighted average cost per OR case of €12.82. The 1° change management (Figure 2) began in March 2022, with staff encouraged to adopt the new protocol using EtC to reduce FGFs during the maintenance phase. Agent consumption and emissions were also tracked using the Carestation Insights Agent Cost Application. The education was repeated in July, when the 2° change management was done to help reinforce the benefits of this behavioural change. The average agent cost per case fell to €9.89 and remained consistent in this cost range *(Figure 2)* until the end of the study.

*Original protocol data*

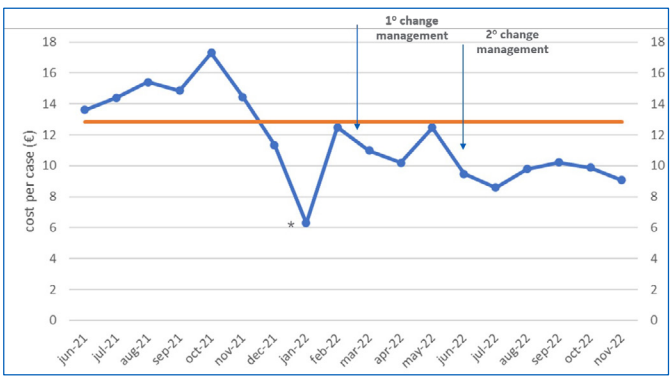


*Figure 2: The impact of implementing the new protocol and calculating cost using the Carestation Insights analytics to show the average agent cost per case.*

Using the Carestation Insights Agent Cost app helped visualize the flow rates during the induction and maintenance phases. When the new low-flow protocol was implemented, the Agent Cost app analysis showed a considerable decrease of 64% *(Figure 3)*. *Table 1* shows a decrease in the initial induction time for the 2022 protocol compared to the 2021 protocol, but a 34% increase in induction flow rates. However, published data suggests that if the induction flow rate of 11.4 l/min was further reduced to between 4 and 6 l/min[5,6], then there could be additional improvements in cost savings. Fortunately, there was a 31 % reduction in the maintenance flow rate down to 1.87 l/min in the new protocol, resulting in a 34 % decrease in total agent cost/min and carbon emissions/min *(Table 1)*.

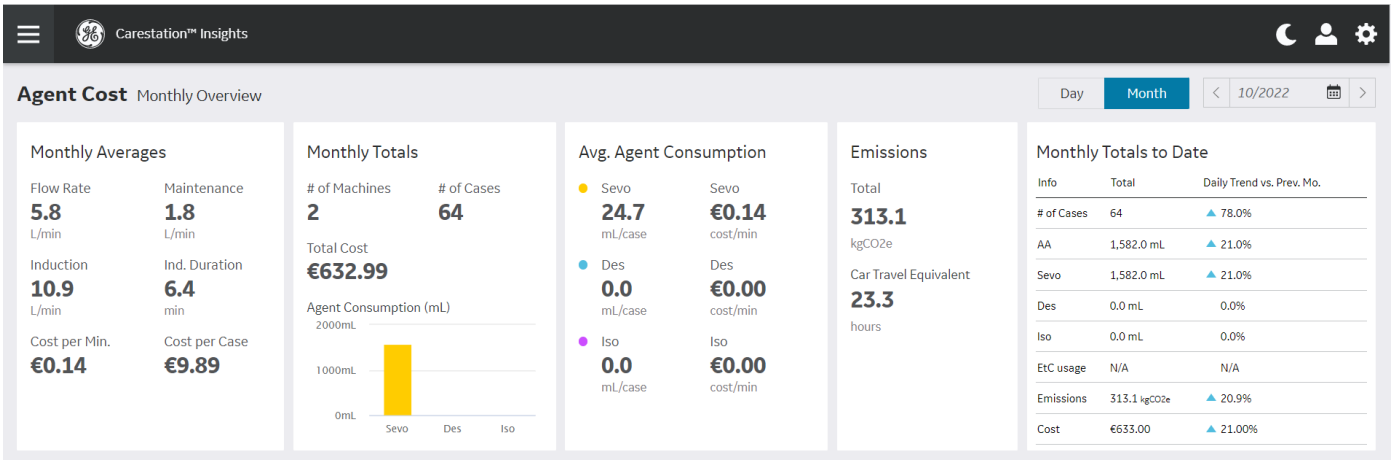


*Figure 3: The Agent Cost application showing improvements in flow rates, agent consumption, costs and emissions using new protocol.*

| Period | # Cases | Induction Flow Duration (Avg min/case) | Induction Flow Rate l/min (Time weighted) | Maintenance Flow Rate l/min (Time weighted) | Agent Cost €/min | Emissions $kgCO_2e$/min |
|---|---|---|---|---|---|---|
| 01/06 - 31/10/2021 | 280 | 18.63 | 8.53 | 2.71 | 0.207 | 0.102 |
| 01/06 - 31/10/2022 | 255 | 6.68 | 11.39 | 1.87 | 0.136 | 0.067 |
| | | **- 64%** | **34%** | **- 31%** | **- 34%** | **- 34%** |

*Table 1: Drivers of total flow reduction.*

Comparison of the period from June-October 2022 with the same period in 2021 (Table 1) showed that the anaesthetic agent cost and $CO_2$ emissions per minute had dropped by 34 % making the process more cost effective and sustainable than the previous practices. This amounted to a savings of €1,850 on anaesthetic agents on the two Aisys $CS^2$ anaesthesia machines in just over five months. Since only one anaesthetic agent, Sevoflurane, was used, the reduction in gas flow means that the decrease in the cost per minute of anaesthetic agent is virtually equal to that of $CO_2$ emissions per minute.

## Conclusion

**This 5-month comparative study showed that reducing FGF rates from 2.0 l/min to 0.5 l/min by automatically delivering $EtO_2$ and EtAA targets using the Aisys $CS^2$ EtC software helped Porta Sole Clinic reduce agent spend and waste.**
**The Carestation Insights Agent Cost App was used to track these improvements with a simple, visual dashboard analysis. Using EtC enables safe low-flow anaesthesia, while the Carestation Insights Agent Cost application provided the perfect tool to understand current protocols, so that the clinic could now 1.) identify opportunities for improvement, 2.) monitor the effects of behavioural change when adopting new protocols, and 3.) show positive progress to the anaesthesia staff on the benefits of practicing new low-flow protocols over time.**
**A 34 % decrease in anaesthetic agent cost per minute and $CO_2$ emissions was achieved in just five months, without compromising quality and safety, contributing to more sustainable healthcare.**
**It's a win-win situation when hospitals have access to programs such as the National Plan Industry 4.0 and the European Fund for Sustainable Development Plus (EFSD+), to help invest in sustainable solutions today.**

*"…we understood that switching the EtC on as soon as possible after switching to mechanical ventilation is of paramount importance. Before, we used to remain at high flows after induction for many minutes, during which the agent consumption was very high."*

*"Preserving the environment is everyone's duty and doing this while maintaining safe and efficient anaesthesia is invaluable."*

***Dr. Chiara Piergiovanni,** Anesthesiologist,*
*Porta Sole Clinical Institute,*
*Perugia, Italy*


1 GE Healthcare. Hospitals can be spending an extra 30-40 % for anesthetic agents in an OR due to high flow estimates derived from the GE Healthcare ecoFLOW Calculator. Data on file GE HealthCare Accessed 23 February 2023.

2 Environmental Protection Agency. Emissions facts: greenhouse gas emissions from a typical passenger vehicle. https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle. Accessed 23 February 2023.

3 Ryan SM, Nielsen CJ. Global warming potential of inhaled anesthetics: application to clinical use. Anesth Analg. (2010) 111(1):92-8. doi:10.1213/ANE.0b013e3181e058d7

4 Tay S, Weinberg L, et al. Financial and environmental costs of manual versus automated control of end-tidal gas concentrations. Anaesth Intensive Care. (2013) 41(1):96-101. doi:10.1177/0310057X1304100116

5 GE HealthCare. Hospital leverages Carestation Insights to reduce average fresh gas flow rates (JB48535XX) https://www.gehealthcare.co.uk/products/perioperative-care/www.gehealthcare.co.uk/-/jssmedia/gehc/us/files/products/anesthesia-delivery/carestation-insights_white-paper__agent-savings_jb56479us.pdf?rev=-1&hash=E1D19EEA8EBEDD7FFAC956E0ABEC8AB2. Accessed 23 February 2023

6 Kennedy RR, French RA et al. The effect of fresh gas flow during induction of anaesthesia on sevoflurane usage: a quality improvement study. Anaesthesia. (2019) 74(7): 875-882. doi:10.1111/anae.14669





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