Technical Overview

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Energy Consumption of the Agilent 1260 Infinity III Prime LC System

Abstract

The Agilent 1260 Infinity III Prime LC System features the Agilent InfinityLab Assist—a module that automates tasks, facilitates maintenance, and assists in troubleshooting, thereby increasing the system's operational efficiency and uptime. To assess the energy consumption of these added benefits, the 1260 Infinity III Prime LC System was compared with the Waters Alliance iS HPLC System. The energy use was measured during different operational states of a typical laboratory day. Results indicate that the Agilent system consumed less energy across all states compared to the Waters system, making it a superior choice for laboratories seeking to work more economically and sustainably.

Introduction

Modern HPLC systems are more than sheer sample analyzers. Instrument sensors collect nonanalytical data to monitor the wear and tear of consumable parts such as pump seals, needle seats, or detector lamps, and notify users if a change is due. Control software integrates features that facilitate system equilibration, shut down the system after analysis, or automate daily tasks such as priming the pump.

The InfinityLab Assist elevates this assistance to the next level. This slim module added to the LC stack features a dedicated processor and large touch screen, which makes interacting with the LC system faster, more accessible, and more convenient than interacting through a PC–independently of the chromatography data system (CDS) connected to the LC. Automated tasks to start up and shut down the system, guided maintenance, and assisted troubleshooting are just three of many exciting features of the InfinityLab Assist described in a dedicated white paper.[1]

All the benefits of saved time, increased confidence, and ease of use with the InfinityLab Assist might be contrasted with how much the extra module will add to the energy consumption of the LC. To shed light on this question, this technical overview presents the energy consumption of the 1260 Infinity III Prime LC System under typical use conditions. The same conditions are applied to the Waters Alliance iS HPLC—a competitor system that also features a touch screen for easier operation. As in previous Agilent publications discussing energy consumption of LC systems[2,3], the analytical method was not optimized to the lowest energy consumption possible but was intended to represent a realistic use case over a typical day.

Experimental

Instrumentation

Energy consumption of the UHPLC systems was measured using a CLM 221 power meter (Christ Electronic Systems, Memmingen, Germany) and an ALMEMO 2590 data logger (Ahlborn, Holzkirchen, Germany). All measurements were conducted at room temperature (23 ± 2 °C).

The 1260 Infinity III Prime LC consisted of the following modules:

- Agilent InfinityLab Assist Upgrade (product number G7178A), consisting of an InfinityLab Assist Interface (product number G7179A) and InfinityLab Assist Hub (product number G7180A)
- Agilent 1260 Infinity III Flexible Pump (product number G7104C)
- Agilent 1260 Infinity III Vialsampler (product number G7129C)
- Agilent 1260 Infinity III Multicolumn Thermostat (product number G7116A)
- Agilent 1260 Infinity III Diode Array Detector HS (product number G7117C) with 10 mm standard Agilent InfinityLab Max-Light Cartridge Cell (part number G4212-60008)

The same experiments were conducted on a Waters Alliance iS HPLC System, comprising a Waters ACQUITY Quaternary Solvent Manager, Sample Manager with Flow-Through Needle, Column Heater, and Tunable UV Detector. The method parameters and column used were identical to the experiments on the Agilent LC system.

Column

The column used in this study was the Agilent ZORBAX RRHD Eclipse Plus C18, 2.1 × 50 mm, 1.8 µm (part number 959757-902).

Software

The 1260 Infinity III Prime LC was controlled by Agilent OpenLab CDS software, revision 2.7. The Waters LC was controlled using Waters Empower software, revision 3.8.

Solvents

All solvents used were LC grade. Fresh ultrapure water was obtained from a Milli-Q Integral system equipped with a 0.22 µm membrane point-of-use cartridge (Millipak).

Sample

The Agilent RRLC checkout sample (part number 5188-6529) was used as a standard sample for separation on each of the LC systems.

Method settings

The energy consumption of each instrument was measured during three states of operation over a day in the laboratory: "Idle," "Ready," and "Run" (see Figure 1 for exact conditions). A typical day in the laboratory was defined to comprise 8 hours of actual analysis time on each system (Run), with an additional 2 hours for priming, purging, equilibration, as well as waiting for sample submission (Ready). For the remaining time of the day, the system was presumed to be in standby, meaning the pumps, column oven, and detector lamp were switched off, but the sample thermostat was still cooling the samples (Idle).

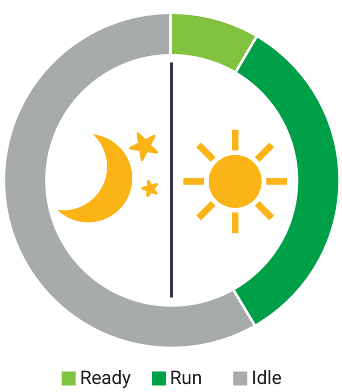
Both LC systems were switched on and left in Idle state overnight to allow homogeneous cooling of the samples. In addition to the sample, each autosampler held 64 vials filled with 1.5 mL of pure water to simulate a realistic fill state. On the following day, energy consumption during Idle state was measured for 2 hours.

After measuring the energy consumption in Idle state, the systems were prepared for analysis using the respective local user interfaces. To purge and equilibrate the system, the InfinityLab Assist features a "Make Ready" task that can be prepared, stored, and scheduled to run, for example, each morning at 7 am.[1] The procedure on the Waters LC required more interaction, as the user needs to define each step every time the procedure is started. Upon starting the preparation, the energy consumption was again measured over 2 hours, representing the Ready state during which the pump, column thermostat, and detector lamp were switched on.

Finally, a sequence of 30 injections was submitted. During this Run state, the chromatographic conditions listed in Table 1 were applied on each system to separate the sample. These conditions represent a typical application employing a fast gradient, short run time, and high pressure (approximately 630 bar). The energy consumption was measured over the entire sequence of 30 injections. For the final evaluation, however, only the number of samples completed within 2 hours and the energy consumed during this time was recorded.

Table 1. Chromatographic conditions.

Parameter	Value
Mobile Phase	A) Water B) Acetonitrile
Flow Rate	0.9 mL/min
Gradient	Time (min) %B 0.0 30 2.0 95 Stop time: 3 min Post time: 1 min
Injection Volume	2 µL
Column Temperature	40 °C
Sample Temperature	4 °C
UV Detector	240 nm, 40 Hz data rate



	Idle	Ready	Run
Mains	On	On	On
Sample Thermostat	On	On	On
Column Thermostat	Off	On	On
Pump	Off	On	On
Detector Lamp	Off	On	On
Autosampler (Injecting)	Off	Off	On

Figure 1. Assumed operational states of an LC system over the course of a typical lab day.

Results and discussion

A standard sample was separated on the Agilent 1260 Infinity III Prime LC and the Waters Alliance iS HPLC System using the same method and column. The energy consumption over different operational states (Idle, Ready, and Run) was measured for 2 hours each. Within 2 hours run time, the sample was injected 24 times on the 1260 Infinity III Prime LC and 23 times on the Waters system. This difference is caused by the different overhead times required to inject the sample. The measured numbers were extrapolated to get an idea of the overall energy consumption per day and per sample during a typical day of operation.

The energy consumption of each HPLC system in each operational state is depicted in Figure 2. The Waters system consumed between 370 and 500 kJ more than the Agilent system. As expected, the energy consumption was higher during Ready and Run states than during Idle state. On the Agilent system, the Run state consumed less energy than the Ready state, whereas the energy consumption of the Waters system was identical in both states. The difference on the Agilent system can be explained by the average system pressure: while in ready state, the pump delivers mobile phase with highly aqueous composition, creating high pressure. During the run, the organic percentage of the mobile phase increases with the gradient, causing a gradual pressure decline and a lower average pressure over the entire run. In Agilent pumps, the energy consumption correlates with the system pressure, whereas the Waters pump uses different technology that seems to operate at the same power, independent of the system pressure.

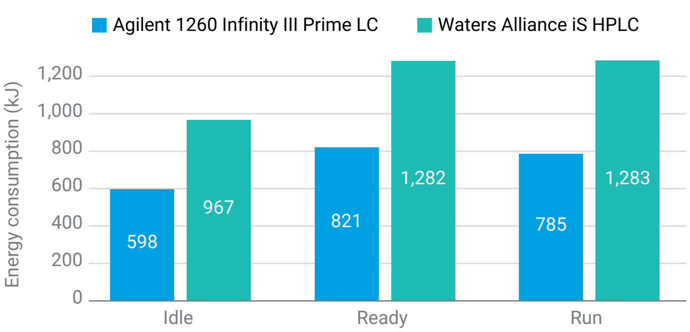


Figure 2. Energy consumption (kJ) of the Agilent 1260 Infinity III Prime LC and the Waters Alliance iS HPLC per hour in Idle, Ready, and Run states.

Assuming a daily schedule of 8 hours of sample measurement (Run), 2 hours of preparation and system equilibration (Ready), and 14 hours of idle time (Idle), the total energy consumption per day can be calculated as 4.5 kWh for the Agilent system and 7.3 kWh for the Waters system (Figure 3). In laboratories operating with high sample throughput, the time during which the LC is measuring samples is likely longer than 8 hours per day. With an assumed 16 hours of sample measurement, 2 hours of preparation and equilibration, and 6 hours of idle time, the total energy consumption would increase to 4.9 and 8.0 kWh for the Agilent and Waters systems, respectively (Figure 3). This is an increase in energy consumption of less than 10% even though the sample measurement capacity has doubled. This calculation underlines that an LC system is most efficiently used if its operational time is spent analyzing samples.

The InfinityLab Assist can help operate an LC system more efficiently. It shows the efficiency of use and notifies the user if it falls below a defined percentage of time spent analyzing samples versus preparing, flushing, or running idle. Programmable tasks help start up and shut down the system automatically according to user schedules (running samples overrule the schedule). Assisted maintenance and troubleshooting reduce downtime to a minimum. More information can be found in a previous white paper.[1]

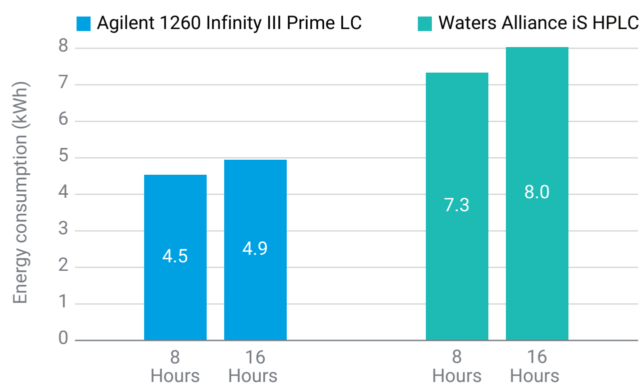


Figure 3. Energy consumption (kWh) of the Agilent 1260 Infinity III Prime LC and the Waters Alliance iS HPLC per day, assuming 8 or 16 hours of sample measurement per working day.

While the daily energy consumption may seem high, the cost of operating an LC system also depends on the number of samples measured with the system. Both the Agilent 1260 Infinity III Prime LC and the Waters Alliance iS HPLC are UHPLC systems capable of running fast gradients at high pressure (800 and 689 bar, respectively). These properties enable the analysis of more samples per day compared to midperformance systems operating at lower pressure. The energy consumption of different Agilent InfinityLab LC systems is discussed in another publication.[2] Consequently, to get a fair picture of actual energy consumption per sample, the daily energy consumption must be divided by the number of processed samples per day.

With an estimated 8 hours of sample measurement per day, under the experimental conditions described in this technical overview, the Agilent system manages 96 samples per day, while the Waters system processes 92 samples within the same time. These numbers result in 170 and 287 kJ per sample, respectively (see Figure 4). Assuming a high-throughput operation with 16 hours of sample measurement per day, the energy consumption declines to 93 and 155 kJ per sample, respectively.

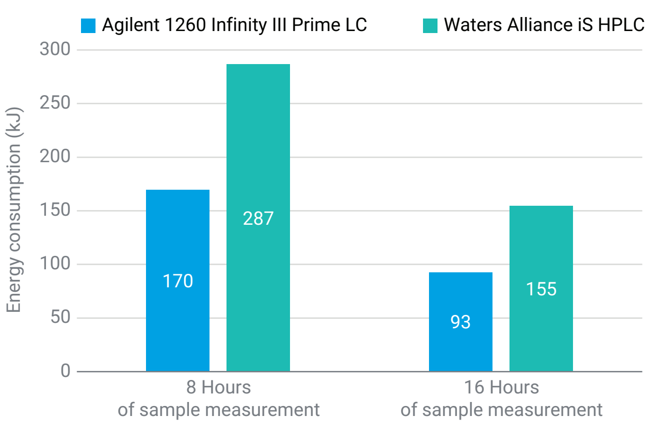


Figure 4. Energy consumption (kJ) of the Agilent 1260 Infinity III Prime LC and Waters Alliance iS HPLC per sample, assuming 8 or 16 hours of sample measurement per working day.

Conclusion

The energy consumption of the Agilent 1260 Infinity III Prime LC System was measured during Idle and Run states, applying typical conditions of an analytical UHPLC method. For comparison, the same method was run on a Waters Alliance iS HPLC System. Energy consumption in different operational states (Idle, Ready, and Run), as well as overall consumption per day and per sample was lower on the Agilent system. Doubling the number of measured samples per day resulted in an energy consumption increase below 10%, which underlines that an LC is most efficiently used if it measures samples all day instead of running idle. The InfinityLab Assist can help increase the uptime of the LC by adding automated tasks, maintenance feedback, and assisted troubleshooting to increase confidence and ease of use.

References

1. The Agilent InfinityLab Assist: A Local User Interface to Control and Automate Your HPLC System. *Agilent Technologies white paper*, publication number 5994-7572EN, **2024**.
2. Do You Know the Environmental Impact of Your HPLC? Energy Consumption of Four InfinityLab LC Systems During Routine Operation. *Agilent Technologies technical overview*, publication number 5994-2335EN, **2022**.
3. Comparing the Energy Consumption of Different UHPLC Systems. *Agilent Technologies technical overview*, publication number 5994-6214EN, **2023**.

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