

Optimization of the energy consumption of the LAAS-CNRS micro and nanotechnologies platform

Granier Hugues 1, Eric Tasselli 1, Guillaume Tanneau 1, Emmanuel Vialan², Laurent Bouscayrol¹

1-LAAS-CNRS, University of Toulouse, CNRS, Toulouse, France

2- CNRS Regional Delegation Occitanie-ouest, CNRS, Toulouse, France

Type of Contribution: oral

Abstract:

Taking environmental issues into account in the activities of micro and nanotechnology platforms has become a priority. They are complemented by a strong economic dimension, accentuated even recently. There are three ways to address them; the management of projects with environmental applications, the development of a "green" microfabrication, the optimization of the energy consumption of the platforms.

Based on the example of the LAAS-CNRS micro and nanotechnology platform, we will show how work on the infrastructure has reduced electricity consumption by nearly 30% and gas consumption by nearly 80%.

In the first part of the presentation, we will briefly present the structure of the platform commissioned in the mid-2000s.

We will detail in the following parts the work that led to the results displayed.

Implementation of modular extraction registers, controlled by operators. Heat recovery systems on extractors to supply air handling units. Installation of a centralized supervision and counting system for optimized management. Replacement of obsolete equipment, and overhaul of the laws of piloting facilities. Photovoltaic production and recovery of waste heat from chilled water production.

Through the presentation of the evolution over the years of electricity and gas consumption we will show the impact of this successive work

Finally, we will give some avenues that we intend to explore in the years to come, in order to continue the optimization already very advanced.

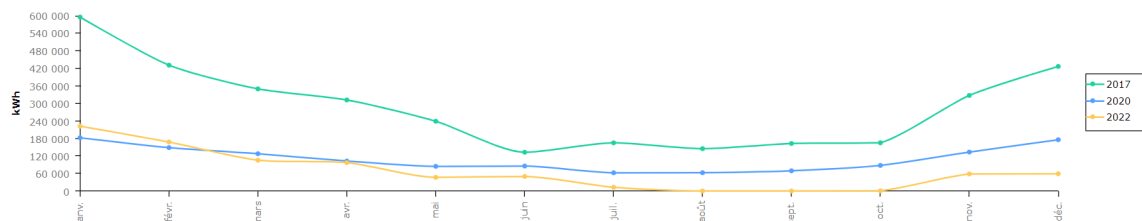


Fig. 1. Evolution of the gas commission of the LAAS-CNRS

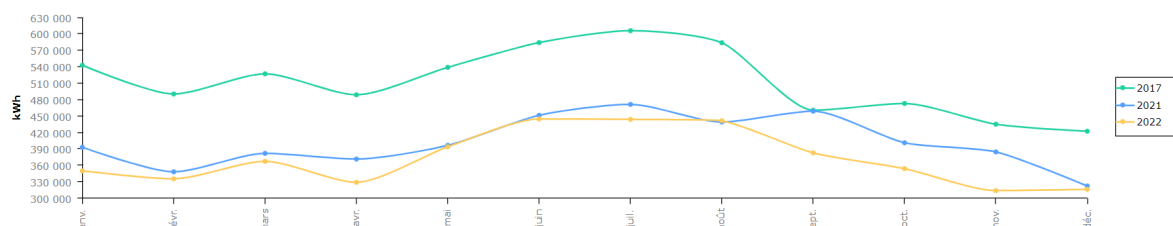


Fig. 2. Evolution of the electricity commission of LAAS-CNRS

Corresponding author: Hugues Granier, LAAS-CNRS 7, avenue du Colonel Roche BP 54200 31031 Toulouse cedex 4, France – granier@laas.fr - + 33 561 336 434

Acknowledgement: The activities of the platform are supported by French National Renatech network

Optimization of the energy consumption of the LAAS-CNRS micro and nanotechnology platform

Granier Hugues¹, Éric Tasselli¹, Guillaume Tanneau¹, Emmanuel Vialan², Laurent Bouscayrol¹

1-LAAS-CNRS, University of Toulouse, CNRS, Toulouse, France

2- CNRS Occitanie-Ouest Regional Delegation, CNRS, Toulouse, France

May 16th 2023

LAAS clean room ID card

- > **1600 m² including 1500m² clean room**
 - Total LAAS 22,000 m² Clean room = 7% of LAAS
- > **200+ users**
- > **160+ projects / year** (average 2014-2022)
 - 80 internal 80 exogenous
- > **18 000 h / year** average annual use
- > **40 M€ of equipment**
 - 220+ tools
 - <https://lims.laas.fr/WebForms/Equipment/EquipmentList.aspx>
- > **Budget ≈ 2.5M€ / year**
 - Operational average: 1.5 M€/year
 - Investments (2014/2022) ≈ 1+ M€/year



Contact : renatech@laas.fr

Issues and findings

- > **Environmental issues**
 - Climate change
 - Societal demand

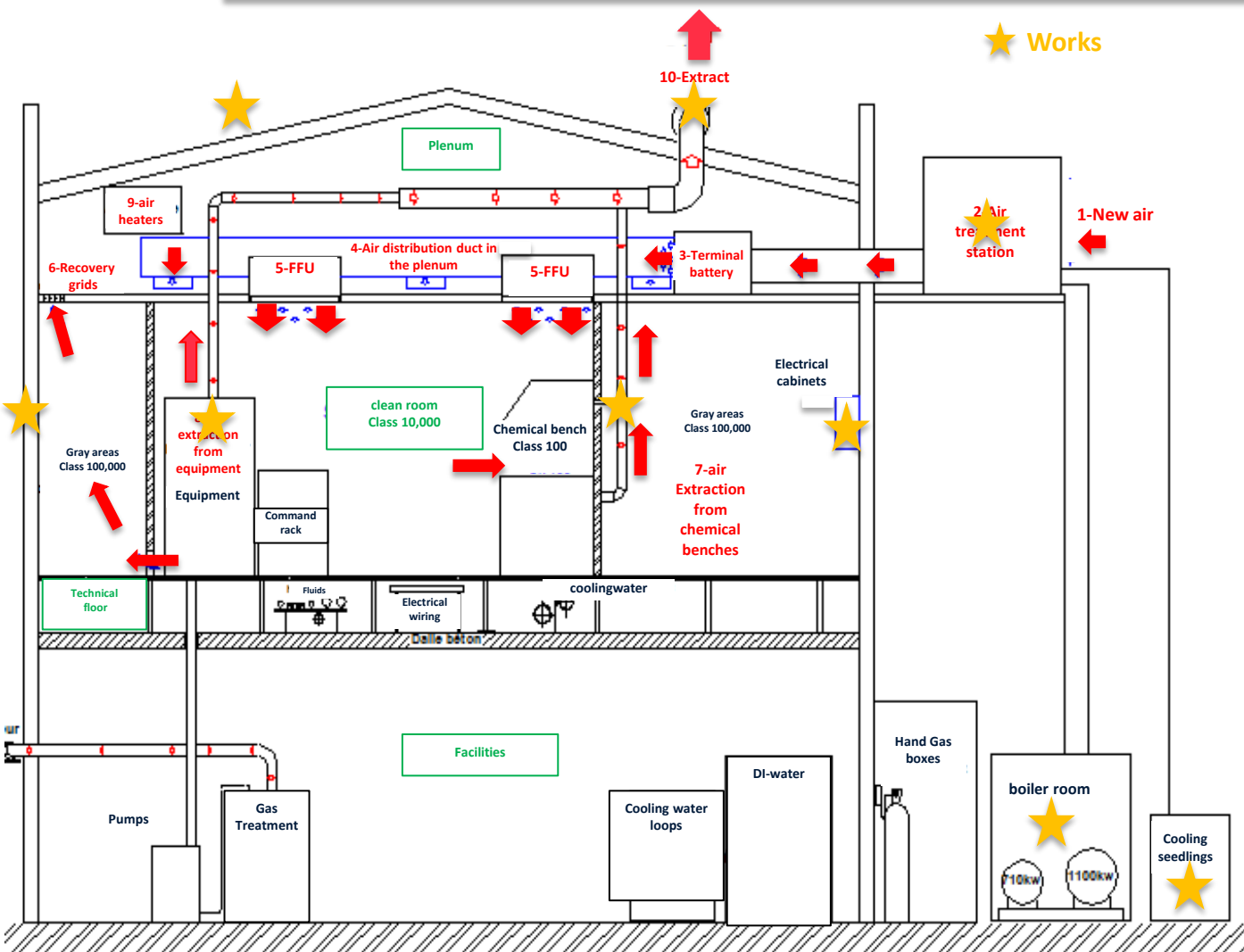
- > **Economic issues**
 - One of the main expenditure items
 - Energy crisis

- > **Observation: Clean rooms are very energy-intensive**
 - In 2015 a study imputed **80% of LAAS energy consumption to its clean room which represents 7% of its surface**

- > **Two areas for improvement**
 - Maintaining conditions in
 - Temperature 21°C +/- 1,
 - Hygrometry 55% +/- 5,
 - Aeraulic (overpressure)
 - Optimization of the use of microfabrication equipment

- > **Our actions focused on maintaining the T°/H% and P conditions**

Before the renovation works: ventilation circuit



1. New air (66,500 m³/h)
2. 5 pre-treatment plants (prefiltration/dehumidification)
3. 5 terminal batteries (T°/rehumidification)
4. Air distribution in the plenum
5. FFU: H10 filtration and blowing in the clean room (129 FFU - mixing > 15,000 m³/hour)
6. Partial recovery under partitions (recirculation)
7. Extraction of chemical fume hoods (security)
8. Extraction of equipment (security)
9. Control unit heater (plenum temperature)
10. 4 Extractors (60,000 m³/h)

Installation of modulating registers

> Situation before works

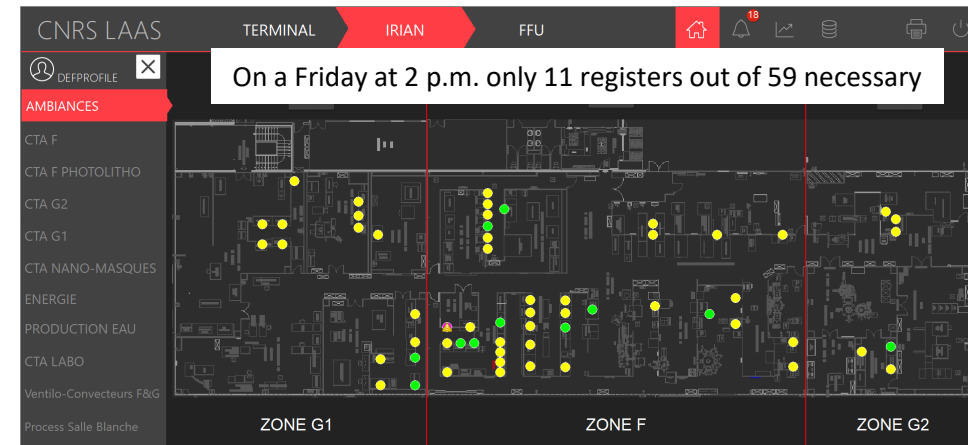
- Fixed extractions on all hoods and equipment
 - **60,000m³/h - 24/24 – 7/7 - 100%**
 - Regulated by duct diameter and partial manual registers
- **Imposes maximum and continuous operation**
 - Energy intensive
 - Premature wear of HVAC equipment

> Works

- **59 modulating registers driven by users**
 - Rest mode: at minimum flow to ensure safety
 - Working mode:
 - Activation / deactivation by the operator at the rate necessary for safety
 - Automatic deactivation at 9 p.m. in case of forgetfulness
 - Forced march possible on 1 day cycle
- **27 constant registers**
 - According to the manufacturer's recommendations.

> Results

- **Savings estimate: 41%**
- **Heel extraction of 18,000 m³/h**
 - Unoccupied (night, WE, holidays = 70% of the time)
- **Never 100% of requested capacity**
- **Safety: visualization of the status of each extraction**



Heat recovery on extractions

> Situation before works

- All year round, loss of calories extracted at 20-22°C

> Works

- **Calorie recovery** between the exhaust air and the fresh air via a heat pump allowing the transfer of heat and cold.
- **Variable debit pumps and two-way valves**
 - Flow /2 = power consumption /8
- **Exchangers** corrosion resistant
- **Circulation circuit** biosourced glycol water

> Results

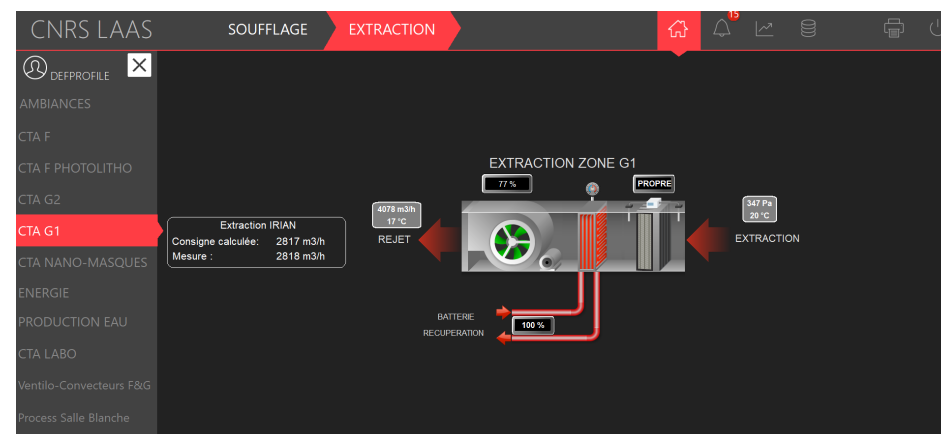
- **Savings estimate**
 - Coupled with that linked to registers
 - 76% on gas
 - 265 MWh on electricity



Recovery (extractor)



Exchange (CTA entry)



Fatal heat recovery

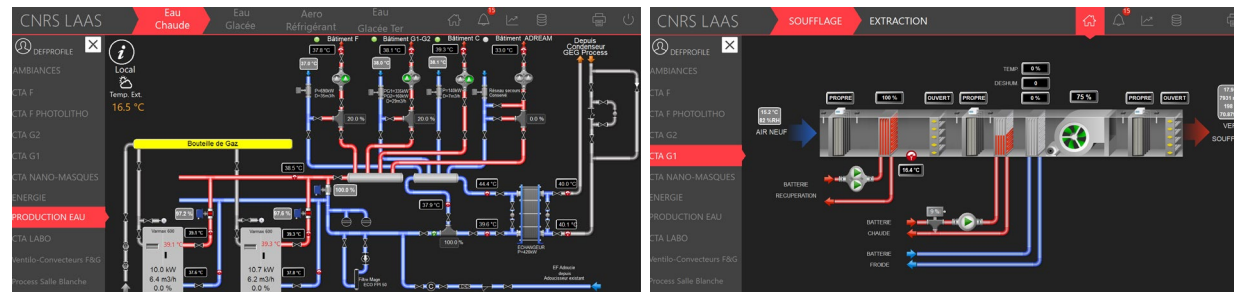
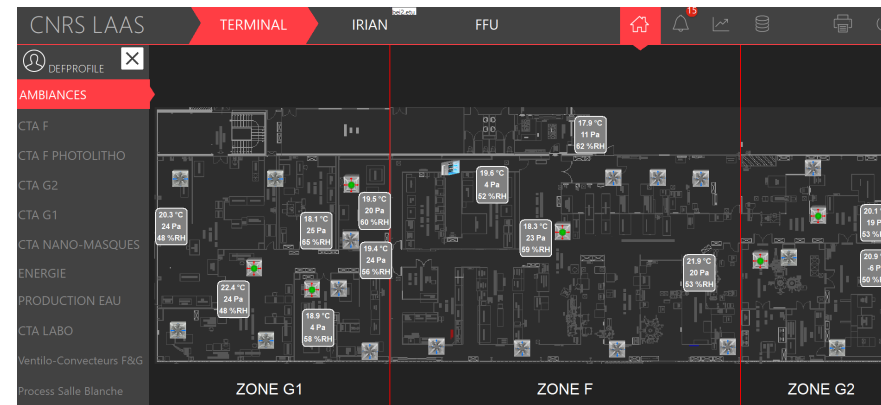
- > **Fatal heat:** Heat lost at cooling units condensers during chilled water production
- > **Installation of refrigeration units and air condensers with recovery**
 - **Summer:** fresh air reheating after dehumidification by recovery on process chilled water production
 - **Winter:** heating by recovery on the production of chilled process water.
- > **Boiler room retrofit**
 - Condensing boilers
 - Installation of a waste heat recovery exchanger
- > **Estimated result**
 - 91% of remaining gas consumption



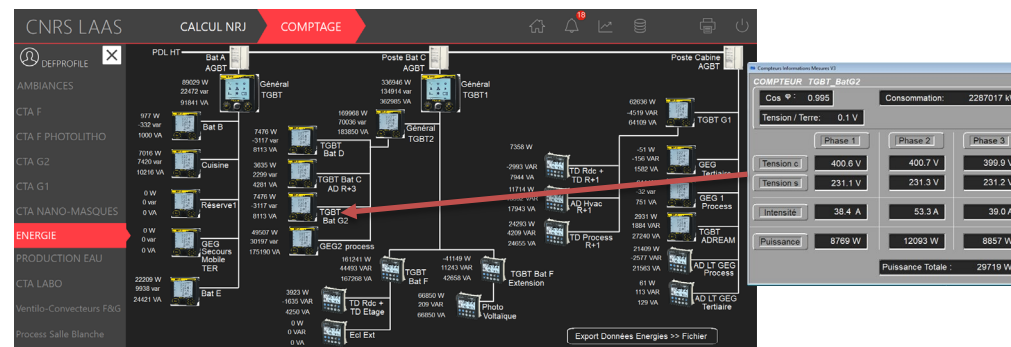
Monitoring and metering

- > **Before work:** Follow-up of installations by
 - Occasional visits
 - General fault summary
 - General energy metering at the laboratory level and some sub-stations

- > **Works**
 - Setting up a **Remote Monitoring System**
 - Continuous monitoring and management of the
 - HVAC installations
 - Registers
 - Facilities
 - Detail of defects
 - Remote monitoring
 - Energy metering
 - by building and type of energy



- > **Results**
 - Fine control of installations
 - Detailed analysis of consumption with the aim of improving
 - Augmented **Safety**



Photovoltaic production and LED luminaires

> Situation before works:

- No output
- Neon lights



> Works

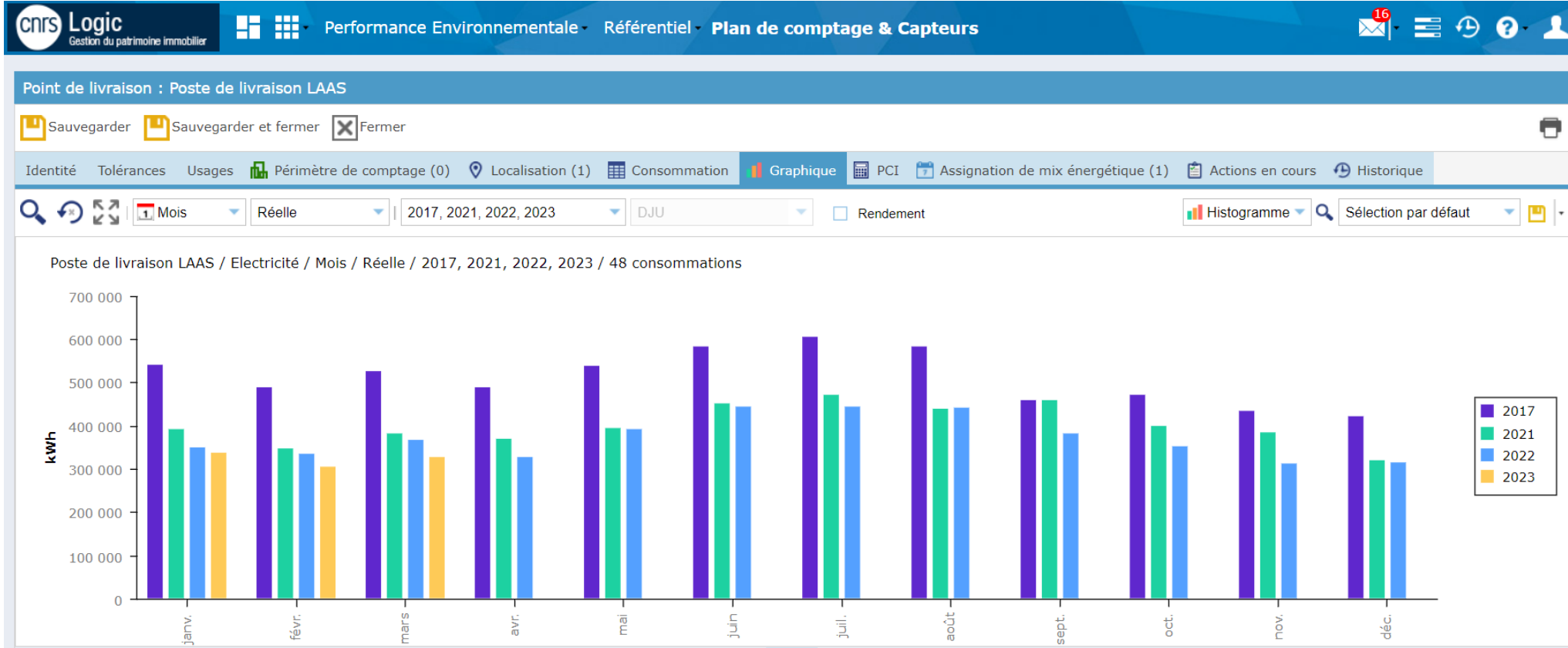
- Installation of photovoltaic generators on the roof
 - In the shade on the south-west openings
- Change of neon lights by **LEDs**



> Results

- Overall power: 100 kW peak
- Production 09/22 to 04/23: 50MWh
- Self-consumption

Electricity results



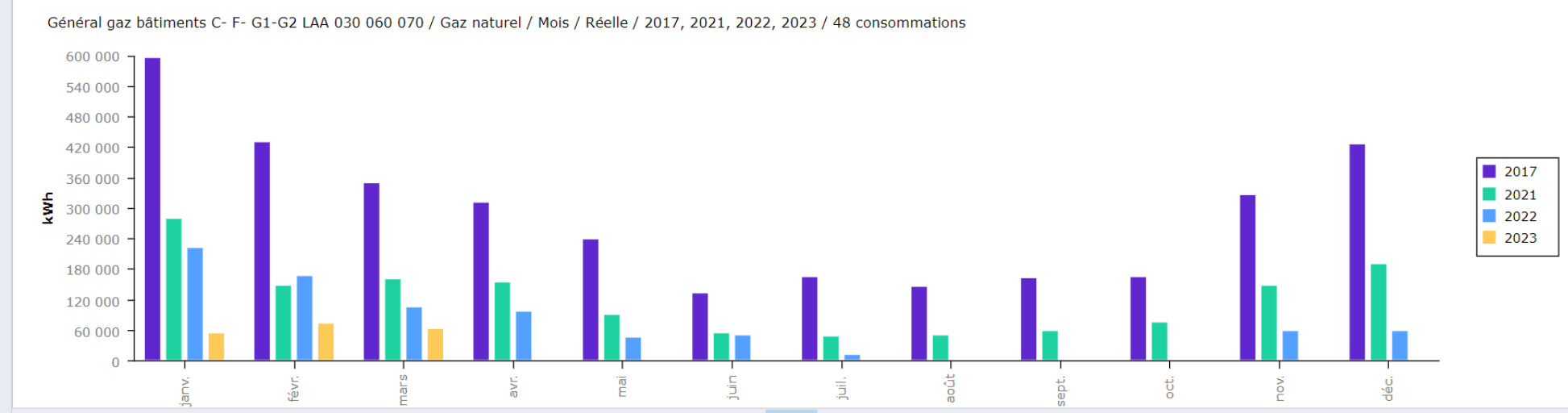
> In the first months of 2023: gain of around 35 to 40%

Point de livraison : Général gaz bâtiments C- F- G1-G2 LAA 030 060 070

Sauvegarder Sauvegarder et fermer Fermer

Identité Tolérances Usages Périimètre de comptage (3) Localisation (1) Consommation Graphique PCI Assignation de mix énergétique (0) Actions en cours Historique

Mois Réelle 2017, 2021, 2022, 2023 DJU Rendement Histogramme Sélection par défaut



- > Gas consumption almost exclusively for the building housing the clean room
- > **In the first months of 2023: division of consumption by a factor of 8 to 10**
- > **Between May and October zero consumption** thanks to sufficient waste heat recovery

Return on investment

> Cost of improvements

- **2018 / 2019: 0.615 M€ CNRS real estate scheduled maintenance loan (over 3 years)**
 - Shutdown of the clean room: 2 months in 2018 3 months in 2019
 - Modulating registers
 - Change of the main Air treatment station (38,000 m³/h) by more recent technology and terminal battery adapted to a temperature regime compatible with recovery (50°C instead of 70°C)
 - Installation of a RMS
 - Heat recovery

- **2022-2023: 1.355 M€ recovery plan**
 - Optimization of chilled water production and waste heat recovery
 - Boiler room renovation
 - Photovoltaic
 - LED lights
 - RMS extension and metering

- **Total amount of works: 1.97 M€**

- **Recovery in Energy Saving Certificate managed directly by the CNRS: 0.375 M€**

- **Total investment amount: 1.6 M€**

Return on Investment

> Energy costs (elements taken into account)

- The 2022-2023 works will only have their final visible effects in 2023
- Taking into account some other work on the tertiary sector of the laboratory

Calculations on the laboratory because no details before the end of 2022
Integrated tariff shield

▪ Differences 2017-2022 (actual invoices)

	2017 kWh	2022 kWh	Gain %	2017 k€	2022 k€	Gain %	Gain k€
Gas	3 449 542	818 980	76%	151	49	67.5%	102
Electricity	6 115 904	4 470 951	26,9%	551	436	20.9%	115
Total	9 565 446	5 289 931	44.7%	702	485	30.9%	217

▪ Difference at constant energy cost (2017)

	2017 k€	2022 (price 2017) k€	Gain %	Gain k€
Gas	151	36	76%	115
Electricity	551	402,8	26.9%	148,2
Total	702	438,8	37.5%	263,2

▪ Difference at constant consumption (2022)

	2017 kWh	2017 (2022 price) k€	2022 real k€	Gain K€
Gas	3 449 542	207	49	158
electricity	6 115 904	596.4	436	160,4
Total	9 565 446	803,4	485	318,4

> Return on investment

- **5 years to 2022 energy costs**
- **2023 sharp increase in energy unit prices**
 - Significant reduction in return on investment time

Next steps?

- > **Changing outdated ATs**
 - Three of the 5 ATs based on old technology, that of asynchronous motors. Replacing them with ATs with electronically commutated (EC) motors would optimize their consumption by up to 40%.

- > **Photovoltaic cover on the technical terrace (estimate 60 KWp)**
 - Self-consumption production
 - Protection of equipment to improve its longevity

- > **Replacement of FFUs**
 - New technology that shows a reduction in electricity consumption of 20 to 25%.
 - This new generation can be connected to the RMS, which will allow finer individual control of the T° setpoints by zone

- > **Deployment of electrical meters in clean room areas.**
 - Would allow precise analyses by type of equipment to refine the savings strategy on the process part

- > **Changing the dry air compressor**
 - Based on old technology. Its replacement would allow an optimization

- > **Decoupling of luminaires by clean room zones**

Next steps?

- > **Lowering the setpoint by 1° in winter and increasing it by 1° in summer results in 5 to 7% savings on air treatment**
 - Once the CR has stabilized after the current works test these modifications
 - Qualification process before and after modifications to see their impact
 - We do 1° , if no process modifications we do another 1°
 - Without impacting comfort
 - These changes would be manually triggered on the RMS

- > **Watch making clean room conditions**
 - By RMS programming, the T° and H% constraints are released during periods of inactivity
 - During working days
 - At 8 p.m., the constraints of X° and Y% are released
 - At 6.30 a.m., the initial conditions are restored
 - During the WE
 - On Friday evening we release the constraints of X° and Y%
 - Until Monday morning 6:30 a.m.
 - During the annual closing
 - Same as WE
 - X° and Y% determined with the design office so as not to:
 - Put the installation at risk
 - Overconsume to return to optimal conditions

Findings

- > **Achieved improvements have demonstrated their energy, economic and environmental efficiency**
- > **In line with the 2030 European targets for reducing consumption (-40%)**
 - 2017-2021 gains: 466 Co₂eqT/year (gas) + 112 Co₂eqT/year (electricity) = 578 Co₂eqT/year
 - 2021-2022 gains: 149 Co₂eqT/year (gas) + 29 Co₂eqT/year (electricity) = 178 Co₂eqT/year.
 - Note that waste heat recovery has only been operational since August 2022
- > **Partial compensation of current additional costs = control of operating costs**
- > **New infrastructure works are possible**
- > **Develop the detailed metering to deepen the part related to the processes**
- > **Complexification of installations = need for skills and internal management to ensure proper operation**

Thank you for your attention

We will be happy to discuss our respective experiences to continue these actions.