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Sustainable Cleaning Processes / 1

An Overview of Environmental and Economic Benefits

Introduction

Sustainability in industrial cleaning processes is often viewed exclusively from an environmental perspective—that is, in terms of factors such as energy, water, and resource consumption.

In fact, however, almost every sustainable measure can also be justified on economic grounds: Saving energy, water, chemicals, or maintenance costs simultaneously reduces operating expenses. Sustainability and cost-effectiveness are thereby not opposites in cleaning technology, but rather two sides of the same coin.
The following overview categorizes the most important levers across the areas of **cleaning systems, cleaning detergents, and temperature**, and illustrates for each which environmental benefit goes hand in hand with which economic benefit.

1. Selection of Cleaning Systems

Material Selection, Service Life, and Maintenance
The foundation for sustainability is laid right from the design phase of the system (“Design for Sustainability”). Low-maintenance, long-lasting components—such as magnetically coupled, maintenance-free pumps instead of mechanical seal pumps, fixed piping instead of flexible hoses, and high-quality, durable valves—often entail higher initial costs but significantly reduce maintenance, downtime, and replacement part costs over the system’s service life. Material compatibility is also crucial: Materials must be compatible with the chemicals used, the contaminants to be removed, the interactions that occur, and the temperature requirements. This is the only way to achieve a design that is easy to maintain, durable, and therefore cost-effective.

Energy-Efficient Components
A system’s energy consumption can be significantly reduced through the targeted use of efficient components, for example:

- **energy-saving motors**
- **Heating on demand:** Heating the process chamber (heating it up as needed before use) generally consumes significantly more energy than continuous, uniform heating in the tank
- **Efficient drying systems**

Practical Tip:
In most cases, a quick look at the size of the plug and power cord is enough to estimate a component's approximate power consumption.

Water- and Chemical-Saving Technologies
Improved drainage performance – such as through the lotus-leaf effect on surfaces or sufficient slope in the drain lines – as well as intelligent control software reduce so-called carryover (the transfer of cleaning detergent from the process, e.g., into the rinse cycle). The less cleaning solution is carried over, the lower the consumption of cleaning solution, water, and disposal costs – a direct benefit for both the environment and operating costs.

2. Properties of Cleaning Detergents

Raw Materials and Packaging
When selecting materials for cleaning detergents, it is worth taking a nuanced approach to renewable raw materials. The use of renewable raw materials offers little benefit if the cleaning detergent’s service life in the bath is short. In this case, the CO_2 emissions associated with the production and disposal of the total amount consumed must be taken into account. All in all, it may be more sustainable and cost-effective to rely on traditional – but longer-lasting and more efficient – raw materials rather than automatically opting for “bio-based raw materials.”

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Conductance of the cleaning detergent

The goal of a cleaning process is to remove contaminants and conductive residues, as well as to establish the necessary surface tension. The conductivity is usually not considered until the rinse process. However, it makes much more sense to take it into account when selecting the cleaning detergent itself. Low-conductivity cleaning detergents are more sustainable and cost-effective for several reasons:

- They require **significantly less water** in the final rinse process, which noticeably reduces water treatment and disposal costs.
- They allow for the **use of tap water** at room temperature in the first rinse step (e.g., in assembly cleaning processes), whereas highly conductive cleaning detergents usually require warm (approx. 30–40 °C), fully demineralized water in the first rinse. This **saves on treatment costs** for fully demineralized water, **energy costs** for heating the water, and additional investments in plant engineering. Furthermore, when using tap water for the initial rinse, the use of defoamers is not necessary in most cases.

3. The Importance of Temperature

Cleaning processes that use lower temperatures consume less energy than processes that require high temperatures—both for heating up and for maintaining the target temperature. Energy consumption increases disproportionately as the temperature difference from the ambient environment increases. High temperatures also entail a number of other cost and effort drivers:

- **Higher investment in plant engineering** (thermal insulation of process chambers, tanks, and supply lines; larger heating units; extraction systems for generated vapors)
- **Higher media consumption** due to evaporation – even during standby operation
- **Greater monitoring effort:** While modern cleaning detergents remain stable in their formulation at low temperatures (up to 45 °C), high-temperature detergents must be continuously monitored and their concentration readjusted; either automatically (additional investment in plant engineering) or manually (additional labor costs)
- Shorter maintenance intervals due to **greater wear and tear on equipment**

Moderne, niedrigtemperaturbasierte Prozesse arbeiten beispielsweise in folgenden Bereichen:

- Stencil cleaning: 20 °C to 40 °C
- Maintenance cleaning: 20 °C to 40 °C
- Assembly/PCBA cleaning: 35 °C to 45 °C

Low-temperature cleaning also protects sensitive electronic components, as it subjects them to less thermal stress, and saves a significant amount of energy compared to high-temperature methods, since high temperatures do not need to be generated and maintained.

Conclusion

The examples from plant engineering, cleaning detergent, and temperature control reveal a consistent pattern: Virtually every measure that conserves resources also reduces operating costs.

- **Less energy** → lower energy costs
- **Lower water and chemical consumption** → lower procurement, treatment, and disposal costs
- **Less maintenance and longer service life** → lower maintenance and replacement part costs
- **Less investment in auxiliary equipment** (heating, cooling, monitoring) → lower capital requirements

Sustainable cleaning processes are therefore not merely a cost factor in the sense of a “green” additional investment, but generally represent an economic advantage with added environmental benefits.

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