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GUEST EDITORIAL

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In several Guest Editorials and earlier articles,[1–4] the connection between climate change and industrial processes has been analyzed in detail. In this editorial, the connections between sustainability and industrial processes are briefly considered.

First, we define the concept of sustainability. Its definition comes from biology: A process is sustainable when it is able to indefinitely produce at a pace, which does not deplete the resources used and it needs to function and does not produce more contaminants than it can be absorbed by its environment (adapted from Cavalcante[5]).

The United Nations introduced a definition of sustainable development in the well-known report entitled *Our Common Future* (or the Brundtland Report), published by the World Commission on Environment and Development in 1987.[6] According to the report, sustainable development "meets the needs of the present without compromising the ability of the future generations to meet their own needs" (p. 16). The modern definition is more holistic: "Sustainability is the ability to achieve sustained economic prosperity over time, while protecting the natural systems of the planet and providing a high quality of life for people."[5]

In addition to environmental sustainability, two other pillars are economic and societal sustainability. In the first case, the proposal is to develop green economy that takes into account the natural capital (plant, animal, soil, and water resources) and the well-being of workers and indeed humanity as a whole. With respect to social sustainability, the idea is to develop fair and ethical trade, to respect clients, to give the same opportunities to all persons, and, besides other possibilities, to contribute to the improvement of society, mainly that of developing countries who are more affected by global warming.

The importance of these three pillars is demonstrated by the need to present to the members of a company (shareholders, etc.) and all of society each year a triple-point balance, not only economic but also environmental and social balances. A relevant reference is the Global Reporting Initiative (GRI), which provides a framework to empower sustainability in an enterprise, industry, or organization: "Sustainability reporting as promoted by GRI Standards is the practice of public reporting by organizations on their economic, environmental and social impacts."[7]

In what follows, we will develop several criteria that need to be taken into account if sustainability is to be considered in an industrial project:

- Define *System boundary* and *flows*. The system needs to be defined with care in order to include all the components, as well as energy, material, water, and communication flows. It must be pointed out that an improvement in the process will be reflected in an increase in efficiency but a decrease in intensity. These improvements normally will also produce reduction in economic costs.
- Fix the *ultimate objective*. The way to arrive at the final fixed objective in efficiency and/or intensity (using, for example, total quality technique) must be clearly defined.
- Establish *continuous improvement* steps in order to tend to new (and better) final objectives.
- Eliminate (or at least reduce) *contamination in all forms*, especially greenhouse gases (GHGs) and black carbon[8,9] that produce global warming. In industrial processes, this can be done mainly by replacing non-renewable fossil fuels with renewable energy sources (e.g., solar, hydro, geothermal, biomass/biofuels, hydrogen, compressed-air).
- Determine the *carbon inventory* of the industry and the *carbon footprint* of a given product/equipment (see, for example, the Green Production Guide,[10] the National Energy Foundation's carbon calculator,[11] and the Carbon Solutions' calculator).[12] In particular, there are International Organization for Standardization (ISO) norms in this respect (series 9000 on quality management, 14000 on environmental management, and 50000 on energy efficiency management) that need to be considered in order to take into account sustainability criteria at all levels. In particular, ISO reports that if the 50000 series norm could be applied all over the world, about 60% of the total energy used could be saved.

Several applications of sustainability criteria at least partially applicable to drying-based industry are detailed as follows in the literature:

1. Low-rank coals are about 45% of the coal world reserves, but before use, they need to be dried since they contain moisture in the range of 30–66%. Jangam et al.[13] have performed theoretical comparisons of different dryer types for coals based on energy utilization and carbon footprints. However, since fossil fuel carbon is a large producer of the most significant greenhouse gas (CO_2), it is necessary to attempt the use of the complementary carbon capture and storage (CCS) technique (see, for example, the book by Qi and Zhao[14]) if low-rank coals are to be used.
2. In the ceramic tile industry, firing and drying are the most polluting processes due to the high energy requirements and the emissions of acidic gases. It has been demonstrated that cost savings of up to 30% and reduction in some of the life cycle environmental impacts of up to 97% can be achieved with such techniques as heat recovery from flue gas and its clean-up with $CaCO_3$ and/or $Ca(OH)_2$.[15]
3. In the production of biofuels/biomass as an energy source, the raw material must be dried in order to increase energy efficiency, improve energy product quality, and reduce emissions during energy conversion.[16]
4. Solar food drying can approach not only ambient but also economic and social total sustainability, as was shown by Aravindh and Sreekumar,[17] who analyzed a solar dryer with a payoff period of only about half a year in India, where about 60% of the total population has agriculture its source of income.

Absolute, or total, sustainability is the ideal. It is, by definition, unattainable in a given time/space, but it is approachable. It is possible to move towards such sustainability if we establish a sequence of steps in the developed processes to achieve the maximum possible target. It is this endless pursuit that would lead to sustainability.

In conclusion, it is recommended that sustainability criteria be applied in all industrial processes, including drying technologies.

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