Digital Twin for Energy and Emissions Management

The energy landscape is evolving, with energy costs fluctuating over a wide range. Serious consideration for reducing greenhouse gas (GHGs) emissions while controlling costs is a worldwide concern. Traditional energy sources, such as coal and nuclear, have declined in importance, while supplies from natural gas and renewables are growing consistently. Manufacturers are aware of the role of energy in overall cost structures and emissions, so they are continuously trying to reduce both.

While overall consumption has somewhat recovered since the COVID-19 pandemic, traditional fuels may never return to their previous usage and are expected to decline over time. This is due to the growth of competing options (i.e., renewables) and their decreasing costs.

Manufacturing facilities need to consider producing, distributing, and mixing the available energy vectors, either traditional or renewable sources. If their choice does not work within their current energy system, they will need to reformulate. The objective is to reduce both cost and GHGs emissions.

When companies calculate consumption in real-time, it is possible to significantly reduce total energy use with just a few available actions. Area-by-area, quick improvements to improve efficiency and reduce consumption and emissions are possible. On the other hand, large-scale improvement projects, such as building an in-house cogeneration system, need thorough examination for cost/benefit potential.

Consider hydrogen production; traditionally, the least expensive way for a plant to generate hydrogen is by reforming methane. However, this process produces carbon dioxide as a by-product usually vented into the atmosphere. If the plant wants to eliminate carbon dioxide, it can use electrolysis instead. This costly approach breaks down water into oxygen and hydrogen ("green hydrogen"). Deciding if this is advantageous highly depends on the power source.

Suppose the electricity used to electrolyse water comes from a coal-fired power plant. In that case, the amount of carbon dioxide produced per unit of hydrogen is probably worse than just reforming methane. But the economics could change if generated by renewable sources or surplus output from the facility's cogeneration system. This approach produces less (or zero) carbon dioxide, uses no methane and might be less expensive. These conditions might not be available all the time, but a given industrial site should be able to take advantage of them when possible.

The ability to make this determination requires detailed knowledge of the sources and uses of energy for the facility at any given moment. It is necessary to coordinate information, forecasts, scheduling, regulations, reporting, trading, and control activities, as well as the appropriate set of software tools, as presented in Figure 1.

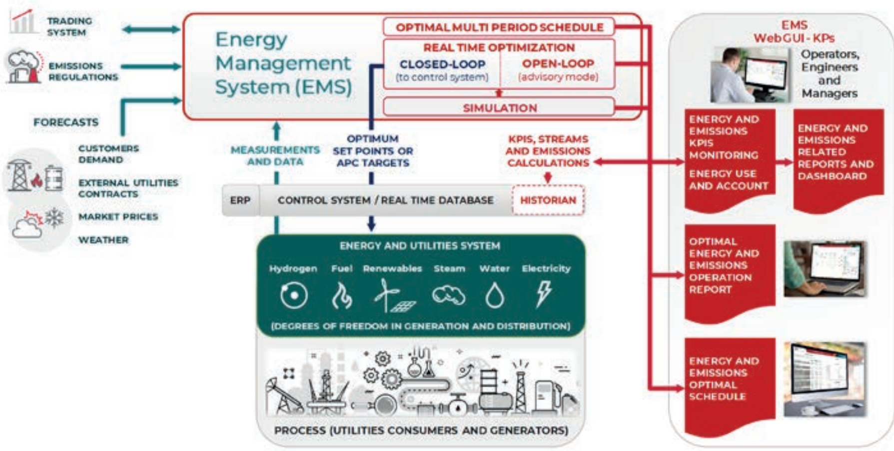

Figure 1: A modern Energy Management System

When data models and software tools are used, energy usage can be optimised based on the digital twin approach to minimise cost and emissions. However, few sites can perform such an evaluation automatically and in real-time. Even large and energy-intensive facilities may not have the expertise nor suitable software systems to gather all the supporting data and put it to work.

The analysis and quantification of all possible options determine which energy source should be used at any given time. Making the proper decision requires knowing the fuel and operating costs compared to the current cost of running off the grid. These values can fluctuate in time, depending on power price, weather conditions, renewable source availability, etc.

This kind of analysis is impossible to do manually for a large and complex facility to the extent and with the speed necessary. However, by using a real-time, model-based digital twin approach, companies can consider both the sources and uses of energy to substantially reduce the overall cost and GHGs emissions.

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