WHITE PAPER

Energy Optimization for the Rising Pharmaceutical Sector:

How to Balance Energy Use and Efficiency While Meeting Quality and Quantity Standards

Sunil Hardikar
Director – Consulting Practice
Hitachi Vantara

Sumon Chakroborty
Manager – Consulting Practice
Hitachi Vantara

Sharad Nigam
Vice President
Hitachi India

Table of Contents

Executive Summary

With a growing population comes a growing need for healthcare services. One of the most important entities of the healthcare value chain is the pharmaceutical industry, and as the consumption of pharmaceuticals increases, so does the need for energy to produce these pharmaceuticals.

Energy optimization is the practice of decreasing the amount of energy used to meet the same quality and quantity of output by more efficient means. When properly implemented, it results in increased economic, environmental and social value. Facing increasing production costs, pharmaceutical manufacturers must consider energy optimization to improve their manufacturing efficiency and maintain sustainable production.

This white paper will introduce the pharmaceutical industry and its current challenges, followed by best practices for analyzing energy consumption and identifying areas of improvement. Finally, it will present solutions and case studies that can benefit pharmaceutical manufacturers hoping to achieve energy optimization.

Achieving Energy Optimization in New and Existing Pharmaceutical Plants

While it's important for both new and existing pharmaceutical plants to strive for energy efficiency, their energy optimization strategies should not be the same.

Process design and equipment selection can play a vital role in preventing energy waste, which means that energy optimization can be achieved from the start when a new plant is being designed. But it's challenging to meet these objectives in existing plants that already have legacy infrastructure, tools and machinery deployed at different levels of maturity.

Unfortunately, most of today's pharmaceutical leaders are primarily focused on innovation, strategy and bringing products to market quickly. Energy optimization is not considered a priority. But this is a mistake, as improving energy efficiency in pharmaceutical operations is one of the most effective ways to reduce operating costs and meet sustainability goals.

Energy Optimization in Existing Plants

Most pieces of equipment in existing plants are energy intensive because they are from an older generation. In most cases, they stand alone and are not connected to a central monitoring system. There are cases where pharmaceutical companies calculate energy consumption by volumetric production ratios and run hours, but given the significant energy cost contribution to the cost of goods sold (COGS), this data might be incorrect in competitive market scenarios.

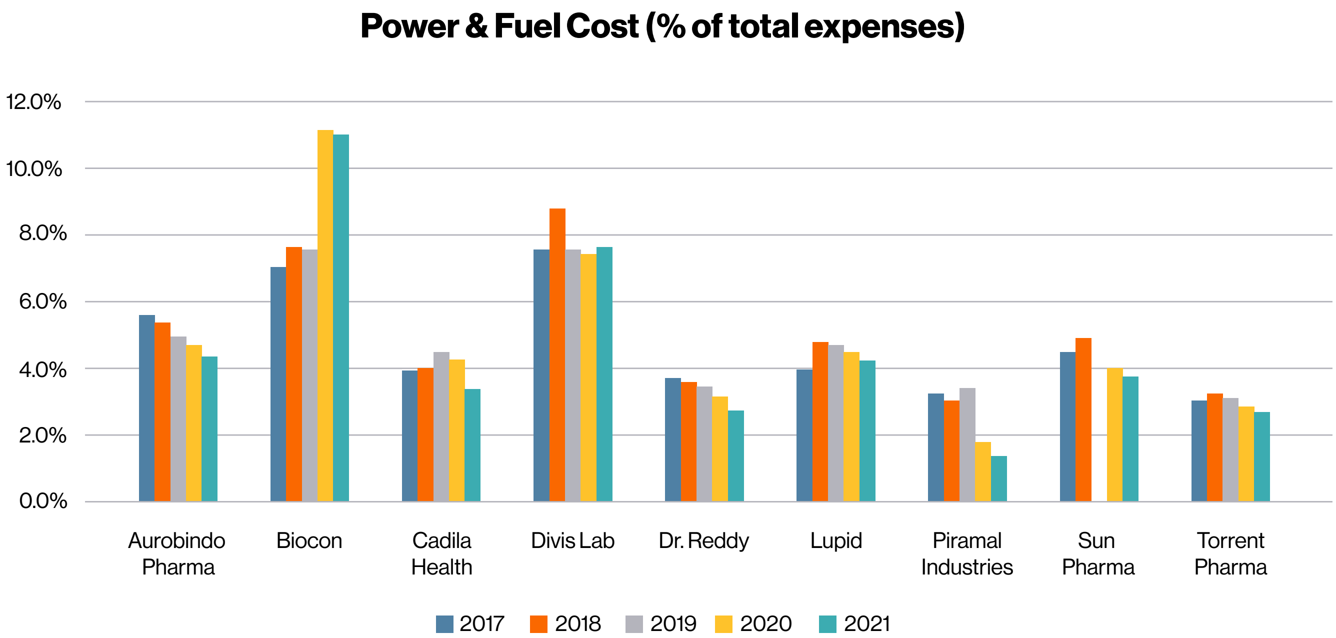


Fig. 1 Power and fuel expenses in the pharma Industry
Source: https://www.moneycontrol.com/

The illustration above depicts power and fuel expenses for 13 pharmaceutical companies over a five-year period. There is substantial variability in their consumption percentages, which suggests that energy optimization could be a potential area for recurring savings.

In existing plants, taking advantage of the benefits of natural lighting to help reduce energy usage can be challenging, but it's not impossible. Conducting an energy audit is an essential first step for understanding an existing plant's current level of energy consumption, as well as identifying priorities for improvement and defining a roadmap for implementation. The outcome benefits of the audit can then be used to calculate ROI and prioritize initiatives.

6 – 10 WEEKS	6 – 12 MONTHS
Initial assessment phase depending on the size of the plant and scope of activities	Detail design and implementation phase depending on the scope and activities

Value Chain

The value chain in pharmaceutical plants is long and involves numerous processes, from raw material refining to the finished product.

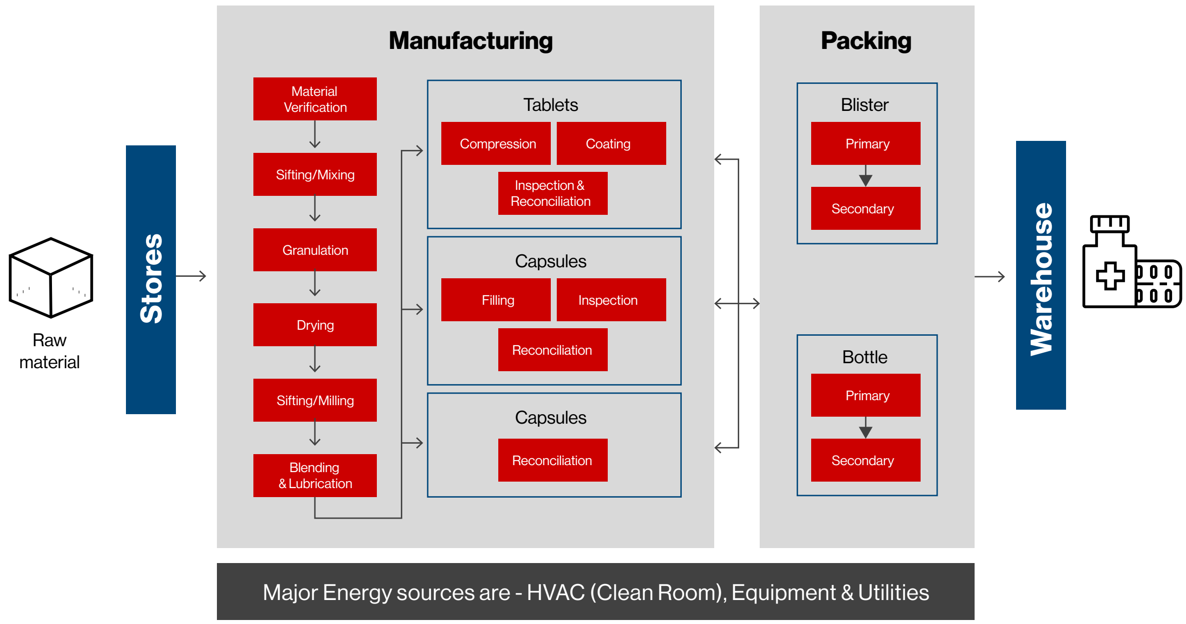


Fig. 2 Typical pharma (generic) manufacturing value chain

Energy Audit

For pharmaceutical leaders looking for more advanced energy management solutions, whether it be alternative fuel and energy supply options or on-site generation, conducting an energy audit is the best place to start.

Below is an illustration of energy distribution in a typical pharmaceutical plant, organized by processes and by consuming departments.

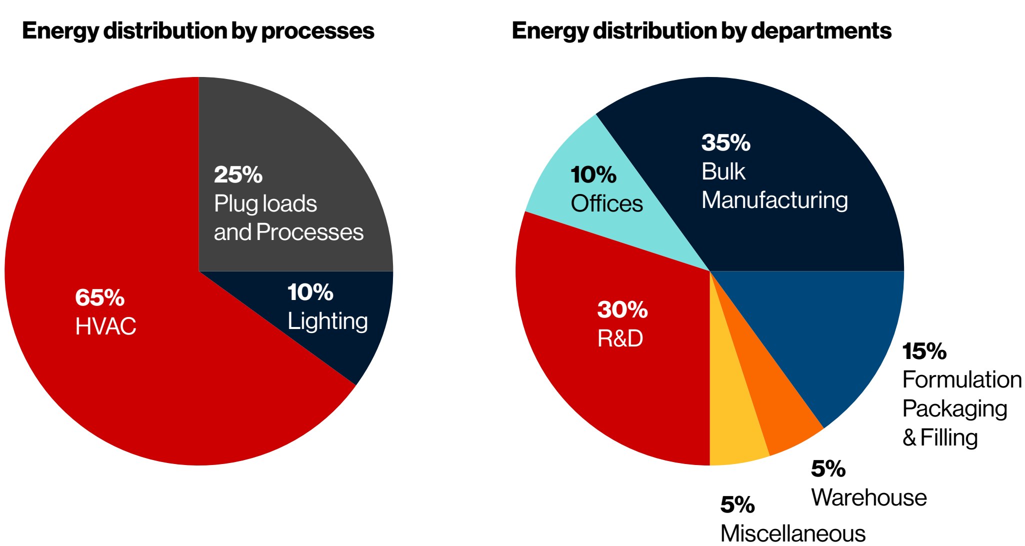


Fig. 3 Energy distribution of a typical pharmaceutical company[1]
Source: https://www.osti.gov/servlets/purl/923192-3bA1yb/

In most cases, there is no mechanism to capture energy data automatically in existing plants — energy monitoring devices must be deployed to capture and analyze data. Industrial internet of things (IIoT), together with an energy meter, can help achieve this kind of energy monitoring and help further optimization.

High energy consumption can be attributed to factors such as:

- Inefficient machinery.
- Non-uniform usage patterns and process inefficiencies.
- Process or equipment failure.
- Unplanned shutdowns.
- The use of non-required lighting and air handling unit (AHU) systems.

Such factors can be uncovered through process study techniques such as Gemba or Day in the Life of (DILO). An assessment report can create a baseline of energy consumption which can then be evaluated against global benchmarkings to find a potential opportunity for energy savings.

The future high-level state can be aligned as per guidelines issued by energy performance indicators (EnPIs) and the U.S. Department of Energy.

Calculate Benefits, ROI and Feasibility to Define Priorities

Assessment report briefs can help clarify the details of energy consumption analysis in existing plants, including identifying energy intensive equipment and processes. The results can be compared with baseline data to arrive at energy savings from the respective energy consumption elements. Recurring savings forms the basis for calculating ROI on a longer term. Periodic analysis of the past energy data via data analytics platforms can help compute benefits over time and display them in reports and dashboards.

Considering these usage factors in an energy audit can help determine the feasibility of the below actions.

Replace Equipment With Newer Technology.

Replacing energy-intensive equipment such as reactors, distillation columns and encapsulators with comparatively lower energy consumption equipment can help cut energy costs significantly. Calculating the net present value (NPV) of new equipment and comparing it to savings on energy cost can help determine feasibility. If the NPV of older machinery is greater than the new, it may be time to replace equipment.

NPV old machinery (high maintenance + high running costs) > **NPV new machinery** (lower maintenance + lower running costs)

NPV calculated for targeted ROI period

Change of Equipment for Adequate Capacity Alignment.

As per the research[1] carried in pharmaceutical manufacturing, 60% to 70% of energy cost belongs to motors' energy cost. Unnecessarily higher rated motors contribute more to the delta energy cost. Detecting equipment and aligning it with adequate capacity would help in reducing energy cost.

Fine-tuning of Process Parameters to Reduce Consumption.

Equipment such as reactor furnaces in pharmaceutical manufacturing are process intensive and the tuning of process parameters can reduce energy costs substantially. Real-time capturing of the process parameters and statistical analysis of the data — using a technique like design of experiments (DOE), for example — can offer insight on optimal parameter values.

Energy Savings During Non-operating Hours.

AHUs in areas such as formulation manufacturing rooms can be turned off automatically during non-required durations. These time periods can be identified and a strategy can be developed to automate scheduled use.

1 Variable Frequency Drive, "Variable frequency drive in pharmaceutical industry", http://www.vfds.org/variable-frequency-drive-in-pharmaceutical-industry-760075.html

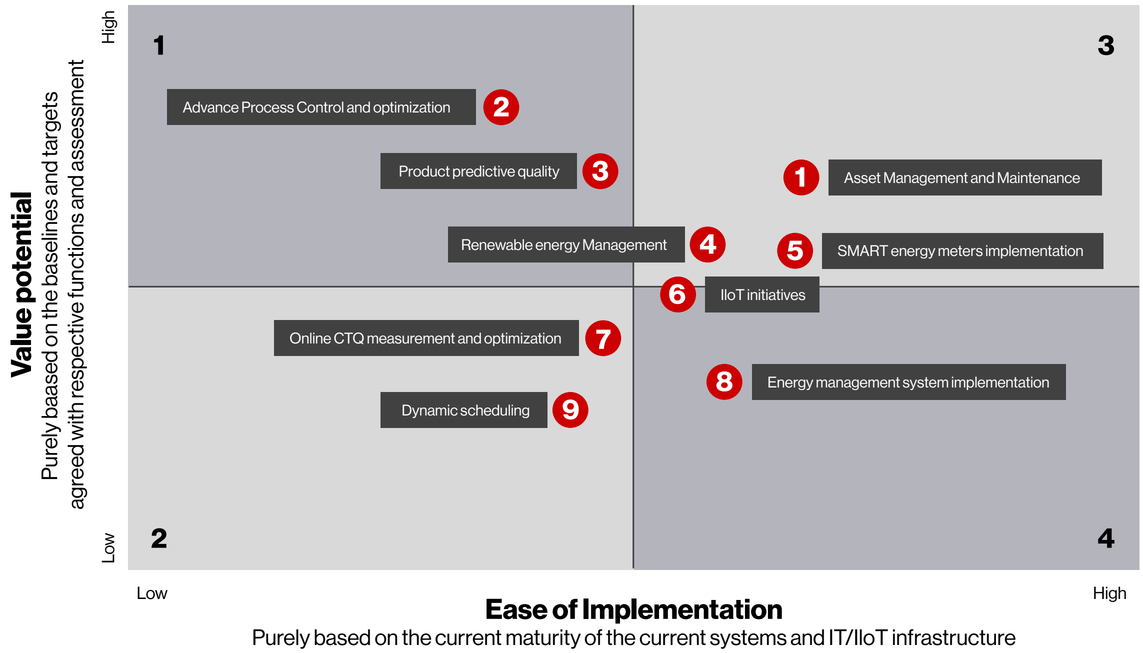


Fig. 4 Illustrative Prioritization Matrix

The illustration above evaluates the value potential and ease of implementation of the following energy optimization initiatives.

1. **Asset Management and Maintenance.** Old equipment is prone to more energy consumption with mechanical jam and inertia. A tool to carry structured maintenance schedules linked with real-time monitored parameters can help to reduce energy and maintenance costs, and minimize losses due to unplanned stoppages.

2. **Advanced Process Control and Optimization.** Optimization of the processes vis-à-vis process parameters can help reduce energy costs.

3. **Product Predictive Quality.** Predictive quality analytics can help reduce waste or batch rejection. Essentially, the rejected product contributes to the cost rather than the revenue. Techniques such as Pareto or 5 hys analysis can be used to perform root cause analysis of quality issues and reduce rejection.

4. **Renewable Energy Management.** Renewable energy management can contribute to long-term energy cost savings.

5. **Smart Energy Meters Implementation.** Smart energy meters can help with real-time monitoring and provide notifications for unusual or excessive energy usage.

6. **IIoT Initiatives.** Such platforms can help collate energy data centrally, analyze and detect anomalies, and enable decision support mechanisms. Energy monitoring can also be extended to a closed-loop system where integration with a business management system (BMS) can create a closed loop to optimize energy consumption.

7. **Online Critical to Quality (CTQ) Measurement and Optimization.** Online systems such as energy metering systems (EMS) and distributed control systems (DCS) can help collect data and align it for the desired business CTQ on energy consumption.

8. **Energy Management System Implementation.** An EMS can connect all energy consumption sources and collect, analyze and report the energy data. (See Figure 5: Illustrative Energy Management System)

9. **Dynamic Scheduling.** Dynamic scheduling can help maximize the utilization of the manufacturing room, which can help optimize overhead energy costs.

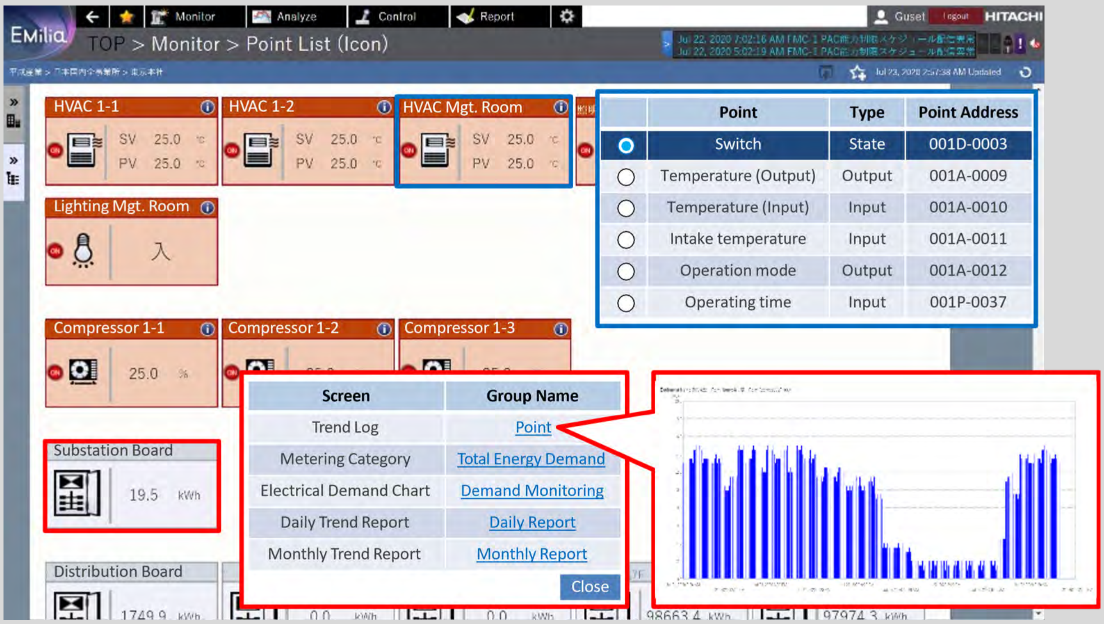


Fig. 5 Illustrative Energy Monitoring System

Implementation Optimization

Once the priorities are identified, implementation can be planned utilizing initiatives such as:

- IT infrastructure built for continuous energy data capture and support of decision support system (DSS).
- Repairing energy-intensive equipment, such as machinery, and infrastructure elements, such as steam and hot water utility pipeline insulation.
- Process optimization.
- Replacement of large equipment or inefficient processes.

Validate Benefits and Control the Initiatives

In the validation step, comparison of the target versus the actual outcomes enables pharmaceutical manufacturers to derive achievements from the implementation. Once certain improvements are achieved, measures can be initiated to ensure the sustainability of implemented initiatives. On a sustained new baseline, additional assessment enables further scope of energy optimization. This cycle continues for an extended period until the key performance indicator (KPI) is achieved. A periodic assessment and energy audits by a competitive organization (such as Hitachi Energy audit as a service) would help with continuous improvement and to sustain energy management initiatives.

Energy Optimization for a New Plant

In the case of a new plant, there is an opportunity to architect the energy management system without impacting operations. The Industry 4.0 maturity model (Figure 6: Illustrative Industry 4.0 Digital Maturity Model) approach is relevant here to connect, collect and visualize the energy data, and then step in for the advance analytics to optimize further.

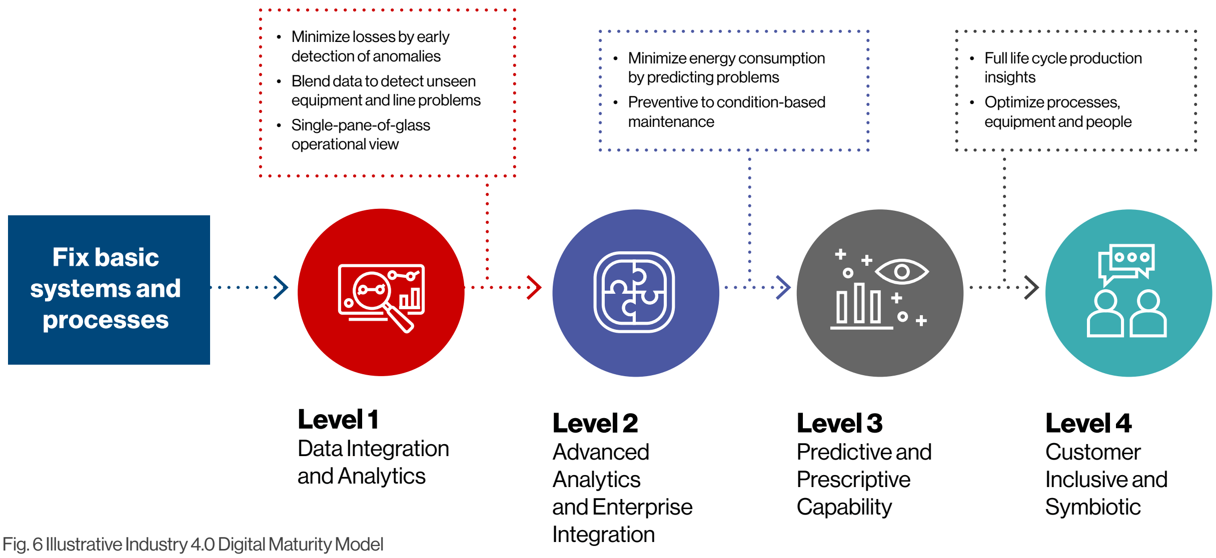


Fig. 6 Illustrative Industry 4.0 Digital Maturity Model

An energy waste prevention approach can be planned for each of the following areas:

MACHINERY
A selection of machinery can be aligned with future capacity requirements. The carrying costs of equipment can be determined based on the desired ROI period. Machinery should have provisions to capture and share real-time energy consumption data.

LIGHTING SYSTEMS
Many sections of manufacturing plants demand high energy for illumination and airflow, which can be planned ahead of time to maximize the use of natural resources.

UTILITIES
Careful selection of utility and HVAC equipment is a highly efficient way to reduce energy consumption, as these pieces of equipment can consume a significant amount of the energy in pharmaceutical manufacturing. During the design of a plant, setting up a mechanism for process and operations monitoring can help save energy costs.

PROCESS
During the process design, priority needs to be given to lower energy consumption for long-term benefits. The energy-intensive process leads to an increase in overheads and manufacturing costs.

Before going into detailed design, it's important to understand the business requirements and make proper equipment selections. Many organizations give little weight to energy management and fail to complete a business requirement document (BRD), which outlines project objectives and requirements. But completing this exercise is vital for any new plant focused on achieving energy optimization, as it can serve as a blueprint and help finalize the procurement processes. The below pictorial depicts the BRD concept.

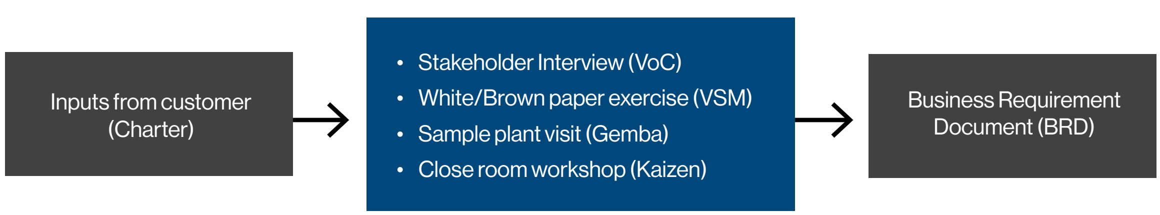


Fig. 7 Business requirement document

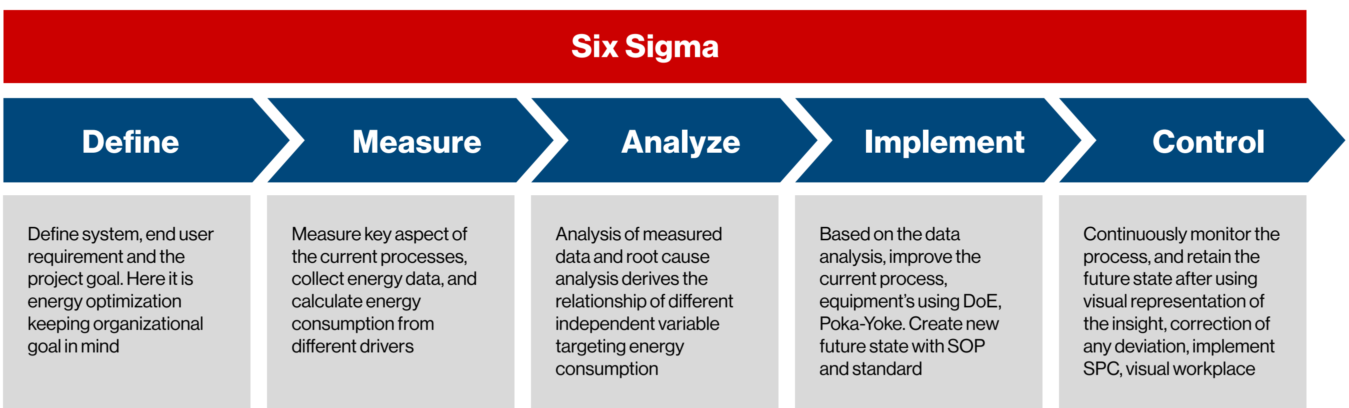
Approach and Solutions

In general, any type of optimization can reduce energy waste and improve energy efficiency. Lean Six Sigma is a popular business approach designed to help companies identify and eliminate energy waste to improve performance. It follows a five-phase road map of key stages of called DMAIC (Define, Measure, Analyze, Improve, Control) to meet the desired future state.

Using the DMAIC Model for Energy Optimization

The most commonly used Six Sigma methodology, DMAIC is comprised of the following steps:

1. Define the Problem and Goals for Improvement. Achieve energy optimization while keeping organizational goals in mind.
2. Measure Process Performance. Determine current baselines for energy consumption.
3. Analyze the Process. Identify root causes and collect and analyze data pertaining to energy waste.
4. Improve the Process. Implement solutions for improvement using quality control techniques such as DOE or poka-yoke. Document desired future state win standard operation procedures.
5. Control the Improved Process. Continuously monitor new processes, making corrections and adjustments when necessary. Implement statistical process controls (SPC) when cycle is complete.



Case Study: Novartis Reduces Carbon Footprint Through Optimized Energy Consumption [2]

In an effort make its manufacturing processes more resource-efficient, Swiss multinational pharmaceutical company Novartis wanted to gain a deeper understanding of its energy consumption and identify energy efficiency measures on that basis. The company has successfully recorded, measured and analyzed key energy consumers and evaluated possible measures from an economic point of view. In 2021, more than 40 energy-saving projects were successfully implemented at the Austrian Kundl and Schaftenau locations of Novartis, including:

Project 1

- By optimizing the stirrer configuration in the penicillin fermentation, a reduction in stirring energy of up to 15% was obtained on a pilot scale. Subsequently, a large-scale fermenter was equipped with the corresponding stirrer setup and a stirring energy savings of as much as 25% was subsequently achieved. As a result of this major success three large-scale fermenters were equipped with this new agitator configuration (installation of new axial agitators) in 2021.
- The company also had plans to upgrade all 10 large-scale digesters. On completion, the company expected to save electrical energy equivalent to the requirements of 1,135 average households (average household consumption of 4.5 MWh/year).

Project 2

- With the planned installation of a large-scale heat pump system, which is currently ongoing, Novartis expects to reduce natural gas requirements for hot water generation by around 11,000 MWh/year in the future. Commissioning of the system was planned for the second quarter of 2022 and the expected savings is equivalent to the heating energy requirements of an average of 500 single-family homes.

Outcome

An upgrade to the solvent process at its Kundl site in Austria led to a reduction of 8,500 tons of carbon dioxide (CO_2) annually. The site in Huningue, France, reduced 19% of its annual energy consumption — equivalent to 1,600 tons of CO_2 — through a more energy-efficient system.

- It has been observed that for Novartis, the energy usage has declined from 12.75 million GJ in 2019 to 9.77 million GJ in 2021. Similarly, the Scope 1 and Scope 2 GHG emissions were also reduced from 888.9 [thousand tCO2e] in 2019 to 645 [thousand tCO2e] in 2021.
- However, Scope 3 GHG was 7,776.9 [thousand tCO2e] in 2019: 7,274.5 [thousand tCO2e] in 2020 and 7,337.5 [thousand tCO2e] in 2021.

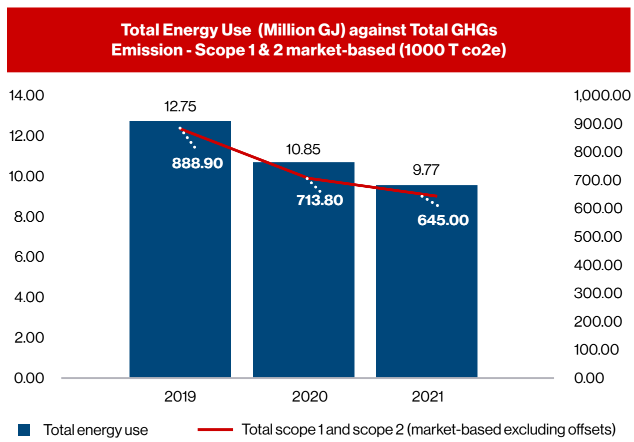


Fig. 8 Total Energy Use (Million GJ) against Total GHGs Emission-Scope 1 & 2 market-based (1000 T co2e)

Note: The industry definition of Scope 1 and 2 Emissions — Scope 1 covers direct emissions from owned or controlled sources. Scope 2 covers indirect emissions from the generation of purchased electricity, steam, heating and cooling consumed by the reporting company. Scope 1 includes all other indirect emissions in a company's value chain.

2 Novartis, " Novartis in Society Integrated Report 2021", 2022, https://www.novartis.com/sites/novartis_com/files/novartis-integrated-report-2021.pdf

Case Study: MSD Reduces Carbon Footprint Through Optimized Energy Consumption [3]

MSD, a global pharmaceutical giant known as Merck in the U.S. and Canada, has made it a priority to reduce its demand for energy. It has established internal policies and practices focused on reducing energy use at it sites and minimizing greenhouse gas (GHGs) emissions throughout the corporation.

Project 1

- Energy management programs have been implemented at 11 European sites to manage energy use and maintain or achieve certification for energy management to comply with the EU Energy Efficiency Directive audit requirements.

Project 2

- The company's Global Energy and Sustainability center of excellence (CoE) has provided tools for facility managers to identify opportunities to reduce energy use and eliminate waste. These tools include the Low Carbon Transition Playbook, Global Energy Scorecard, and sustainability meetings and newsletters for best practices sharing.

Project 3

- All of the company's employees have access to a training curriculum that allows them to learn more about energy management and energy systems. Through this program, employees can earn an Energy Manager Certification. Site energy managers from more than 70 facilities are expected to complete this basic energy efficiency training curriculum.

Outcome

MSD is not only minimizing GHG emissions but also reducing its operating costs and mitigating the business impacts expected to be associated with future climate change requirements.

- It has been observed that for MSD the energy usage has declined from 18402400 GJ in 2017 to 17224600 GJ in 2021. Similarly, the Scope 1 and Scope 2 GHG emissions also reduced to 12,15,500 [MT CO2] in 2017 to 9,25,700 [MT CO2] in 2021.
- Scope 3 GHG emissions was 5,940,500 [MT CO2] in 2017 followed 5,668,400 [MT CO2] in 2018 which was a dip of 4.58%, However, Scope 3 GHG emissions increased from 6,380,500 [MT CO2] in 2019 to 6,457,800 [MT CO2] in 2020 and 6,958,900 [MT CO2] in 2021.

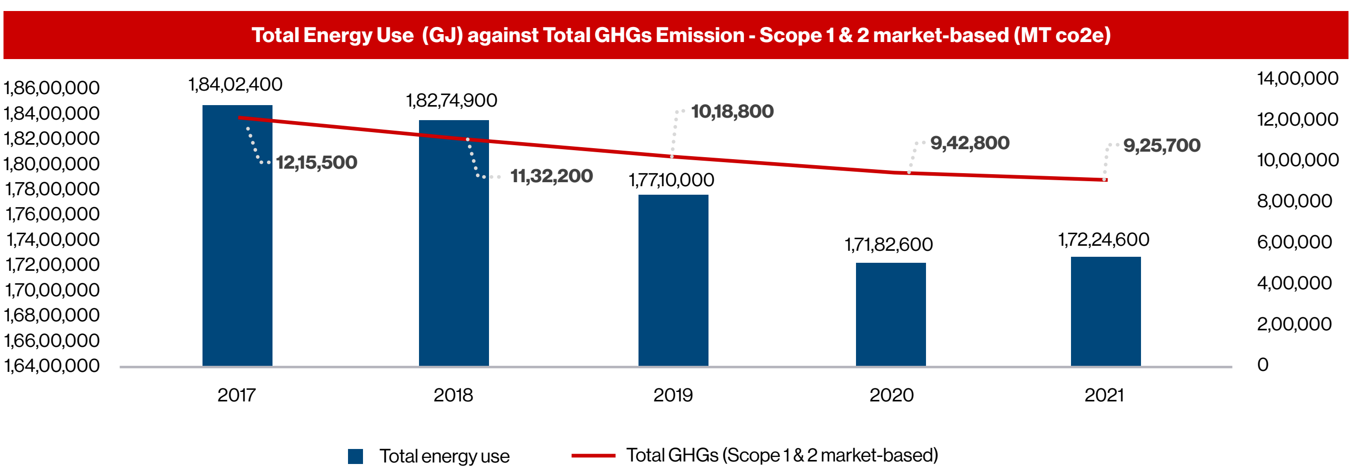


Fig. 9 Total Energy Use (GJ) against Total GHGs Emission - Scope 1 & 2 market-based (MT CO2e)

3 MSD, "MSD ESG Report", 2022, https://www.msd.com/wp-content/uploads/sites/9/2022/08/

Digitalization and Energy Savings Summary

The following table depicts how energy optimization can lead to operational improvements and energy savings in pharmaceutical plants.

List	Machinery	Utilities	Lighting
IIoT	• Helps improve efficiency by coordinating machinery functions	• Helps reduce latency and ensure minimized consumption	• Turns on when natural lighting is low • Turns off when natural lighting is high
Big Data Analytics	• Helps circumvent energy wastage and minimizes consumption in long run based on large datasets	• Optimizes system designed to produce high energy savings	• Minimizes wastage in long run
Visual Analytics	• Helps avoid breakages • Prevents wear and tear and induces efficient functioning	• Helps minimize physical damage and energy wastage	• No considerable impact
Artificial Intelligence	• Helps in the application of smart consumption • Enables connected smart machinery	• Provides maximum efficiency via smart integration with utility equipment	• Reduces the need for lighting, as machinery performs most human functions
Extended Reality	• Helps provide technical knowledge for higher efficiency, leading to energy savings	• Human resources are well trained to maximize utility efficiency	• No considerable impact

Conclusion and Key Takeaways

To be a sustainable business, your company must be focused on green manufacturing processes. Energy optimization is a key element to achieving your green manufacturing vision and reducing your organization's carbon footprint.

With our experienced team and systematic approach, Hitachi Vantara can develop a keen understanding of your business goals and help you achieve them by matching the appropriate solution to your desired business outcomes. The methodologies stated in this paper, coupled with our solutions, can provide your business with long-term benefits while fostering to a clean and sustainable environment.

ABOUT HITACHI VANTARA

Hitachi Vantara, a wholly-owned subsidiary of Hitachi Ltd., delivers the intelligent data platforms, infrastructure systems, and digital expertise that supports more than 80% of the Fortune 100. To learn how Hitachi Vantara turns businesses from data-rich to data-driven through agile digital processes, products, and experiences, visit hitachivantara.com

Contact us →

Sunil Hardikar
Director Consulting Practice
sunil.hardikar@hitachivantara.com

Dev Ramchandani
Senior Director, Consulting Practice
dev.ramchandani@hitachivantara.com

Hitachi Vantara

Corporate Headquarters
2535 Augustine Drive
Santa Clara, CA 95054 USA
hitachivantara.com | community.hitachivantara.com

Contact Information
USA: 1-800-446-0744
Global: 1-858-547-4526
hitachivantara.com/contact