Energy efficiency program at Merck Millipore Molsheim (France)

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Abstract
Merck KGaA has set itself the goal of reducing its direct and indirect greenhouse gas emissions by 20 % by the year 2020, measured against the level of 2006. These activities in the Merck Group are pooled in the program **EDISON Energy efficiency and climate protection**.

Main objective of EDISON is to reduce energy consumption, thus cutting costs, conserving resources and protecting the environment. Furthermore, process-related GHG emissions shall be reduced. Even if Molsheim Site is not in the top 20 contributors of the Merck Emissions, Molsheim Site Management has decided to implement a reduction program to contribute to the Corporate Goal.

Since 2006, several projects have been implemented using Energy Efficient Technologies as:

- Variable Frequency Drives
- Energy Recovery Technologies
- Low Consumption Lighting
- High efficient burners to produce steam
- Building Management System
- Renewable sources of energy

to reduce

- Energy Consumptions in utilities productions
- Utilities consumptions of end users.

A yearly reduction of the energy consumption by 3 % can be achieved:

- Implementing actions not requiring massive investments.
- Taking opportunities of equipments replacement to implement the most efficient available technology.
- Taking decisions in a global perspective (investment + operating costs).
- Sustaining implemented actions.

On a large site as Merck Millipore Molsheim, to achieve 20 % reduction including new buildings, production volumes increase or other negative impacts, a major investment has nevertheless to be placed in the program to significantly reduce emissions (for example Biomass or other technologies).

Introduction
To achieve an ambitious goal of reducing CO_2 emissions, as defined in the Merck EDISON Program (reduction by 2020 CO_2 emissions by 20 % compared to 2006 levels), a portfolio of projects should be identified to gradually achieve the result throughout the period. A selection process has been defined by Merck to invest in the most contributing projects in term of CO_2 Emissions reduction through ratio analysis (Return on Investment, Tons of CO_2 saved per k€, etc.). Nevertheless, the portfolio has to be constructed on each site using expertise of

internal/external engineering, benchmarking with other sites of the company sharing best practices and usage of new technologies.

Regarding existing facilities, the Lean & Six Sigma tools can be very useful especially the DMAIC approach (Define, Measure, Analyze, Improve, Control) to identify potential sources of energy savings when they are not obvious to detect. You improve only what you measure. When the source of savings has been identified, it will be possible to implement the most efficient technology in terms of energy consumption by seizing the opportunity of replacing equipments reaching the end of their life. Building Management Systems are also necessary tools which will contribute to the objective.

This article highlights the most advanced technologies in terms of energy consumption and their impact on achieving the objective.

The program to reduce CO_2 emissions on the Merck Millipore Molsheim Site

Beyond consolidation projects for energy savings that will contribute to achieve the objective, the program must also take into account developments of the site and impacts of all projects involving energy consumptions. The construction of a new building or production activities increase must be taken into account to anticipate their impacts. Also cost saving plans replacing usage of electricity with gas in some applications will have a negative impact on CO_2 emissions. Table 1 defines the program to reduce CO_2 emissions (related to energy consumption) from the site of Merck Millipore in Molsheim and Table 2 highlights the list of projects to help achieving the reduction goal by 2020. New technologies deployed and described in the following chapters will be important contributors to this program.

THE VARIOUS APPLICATIONS OF THE SPEED VARIATION

Speed control by frequency converter is the most common technology for adapting a production level to the real need in a very large number of areas. Indeed, production systems are often sized based on the maximum need without progressive regulation features which generates low production efficiencies. Figure 1 helps to highlight the savings by implementing production systems with variable speed function.

Speed variation in compressed air production

The compressed air need in a facility is never constant over time and depends on a very large number of factors (time of day, number of consumers, etc.). Air compressors most commonly present in existing facilities are equipped with idling system when the set pressure is reached in the network.

In this operation mode, the compressor motor is running at the same speed as in load operation and consumes the same amount of energy as it does not produce any m^3 of compressed air. Another technology of compressor equipped with a system of speed variation can adjust the amount of air produced to the quantity actually requested by the users and thus optimizes the amount of energy consumed.

Example: Compressed air production of Merck Millipore Molsheim.

- Compressed air need varies from 300 to 1,300 m^3/h depending on the day of the week and the time of the day.
- The installation is made of 1 compressor at a fixed flow of 900 m^3/h and 1 compressor with a variable capacity between 150 and 500 m^3/h.
- The variable capacity compressor is used to provide variable flow of air in periods of low consumption (fixed compressor is stationary) and can provide additional variable capacity to the other compressor during periods of high consumption (see Figure 2).

Table 1. Emission reduction program.

	2006	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Tons CO2 Emissions Previous Year	2719	2719	2432	2377	2394	2318	2423	2095	2104	2113	2121
New Building	0	115	0	0	0	150	0	0	0	0	0
Additionnal Production Volumes	0	0	9	9	9	9	9	9	9	9	9
CO2 Emissions Reduction Program	0	-403	-63	8	-85	-53	-337	0	0	0	0
Emissions Forecast	2719	2432	2377	2394	2318	2423	2095	2104	2113	2121	2130
% Reduction / base 2006	0%	11%	13%	12%	15%	11%	23%	23%	22%	22%	22%

Table 2. Projects list & CO_2 emissions saving generated by each project (in tons).

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Utilities Production Improvements/Optimization	403									
Energy Recovery in Processes										
Time schedule according occupancy/usage										
Set points Optimization										
Lighting Replacement										
Steam Boilers Replacement		54								
Air Exchange in Cleanrooms Optimization		8	8							
Motors Replacement			4	8						
Humidification Gas Usage versus Electricity			-79							
Fresh Air in HVAC Optimization				27						
Building A Insulation					36					
Chilled Water Prod Rep. / Optimization & Heat Recovery				25						
Boilers Building A Improvements			54							
Drycooler on Durapore Chilled Water Production			4							
Biomass Heat Generation (max achievable 474 Tons)						337				
Improve Processes to reduce consumptions				25	17					

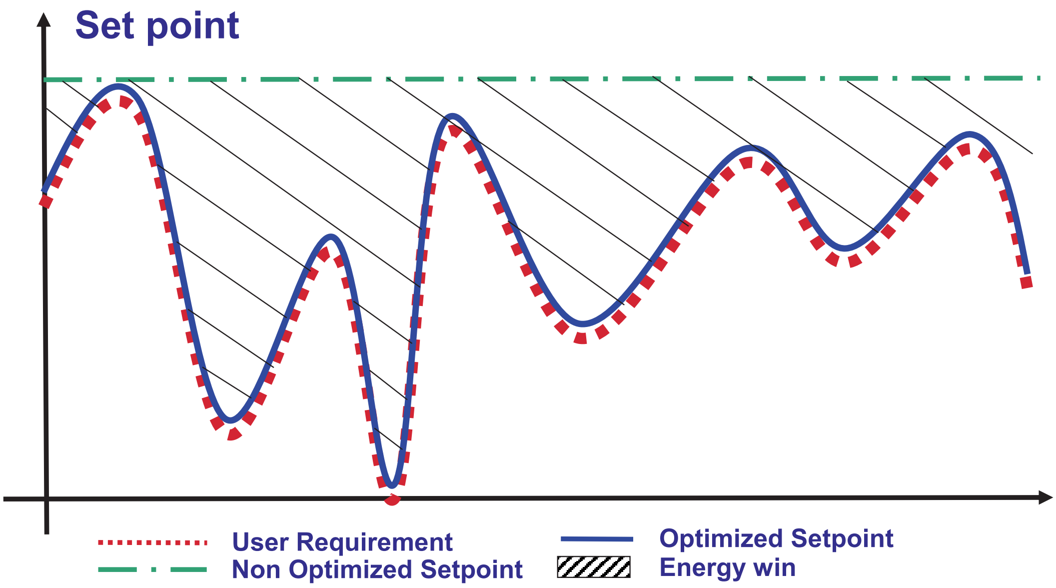

Figure 1. Benefits of regulation of production level to real time needs.

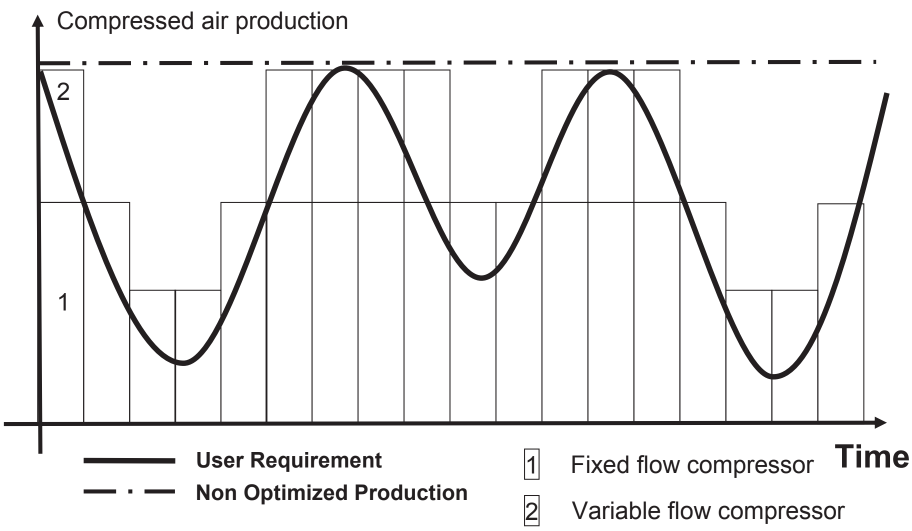

Figure 2. Operating mode of compressed air production according to real time needs.

Table 3. Energy Saving in compressed air production through speed variation.

Building A compressed air production		Average Power (kW)	Numbers of Hours	Energy Consumption (MWh)
2008	Compressor 1 (Fix)	100	3952	395
	Compressor 2 (Fix)	45	8736	393
			TOTAL 2008	**788**
2009	Compressor 1 (Fix)	120	3952	474
	Compressor 2 (Variable)	45	4784	215
			TOTAL 2009	**690**
			Energy Saving	**99**
				13%

Table 4. Energy Savings in Cleanrooms ventilation through Variable Frequency Drives.

Operating Regime		Power (kW)	Number of Hours	Energy Consumption (MWh)
2011	Constant Air Exchange 24h/7d	134	8760	**1174**
2012	Max Air Exchange During Production Hours	134	5980	801
	Reduced Air Exchange Night & Week end	65	2780	181
			TOTAL 2012	**982**
			Energy Saving	**192**
				16%

This principle was applied to all production systems of industrial utilities such as vacuum, aspiration, etc. on the site of Merck Millipore Molsheim.

Speed Variation in HVAC

In the same way that the compressed air, the flow requirements of air, hot water or chilled water in HVAC are not constant over time. They may vary according to:

- The number of building occupants.
- The need for heating or cooling according to outside conditions.

As an example air exchange in Merck Millipore Molsheim clean rooms is reduced: when production operations are stopped. The air exchange rate of a clean room contributes satisfying the criteria of cleanliness in the room. This flow rate is defined according to the amount of particles emitted by the manufacturing processes. When production activities are stopped, the number of particles to be treated is lower and the air flow can be reduced with variable speed fan motors powering.

ENERGY RECOVERY

In production of utilities such as compressed air, chilled water, etc. current technologies generate waste heat through production process of these utilities. This energy can be reused for space heating through energy recovery facilities.

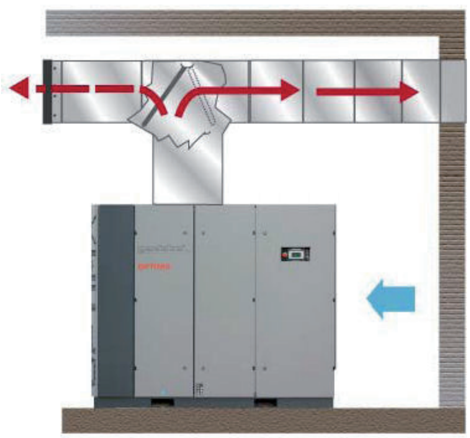

Figure 3. Principle of a heat recovery on air compressor.

A case study considering the recovery of the hot air released by an air compressor for heating a warehouse is described in the following. The hot air which is rejected by the compressor can be blown into the storage hall if there is a need for heating or be discharged to the outside. This system recovers: 80 MWh energy per year and the calculated pay back is 7 years.

LOW CONSUMPTION LIGHTING TECHNOLOGIES

Manufacturers of lighting equipments constantly develop new technologies to reduce associated energy consumption. The latest technologies that have been implemented on the site of Merck Millipore in Molsheim:

- Lighting with T5 fluorescent tube with high efficiency reflector dimming according to the intensity of natural light supplied from outside.
- Automatic on/off the lighting depending on the presence of occupants.

These technologies have now become very common and are systematically integrated in the new building construction. In existing buildings, fixtures replacement projects with these technologies contribute significantly reducing energy consumption, all with a very fast return on investment.

As an example the following table shows the effects of the replacement of T8 tubes fixtures with T5 tubes fixtures in a workshop.

HIGH EFFICIENT BURNER TO PRODUCE STEAM

Steam production requires large amounts of energy. Manufacturers of burners and boilers have developed technologies to achieve efficiencies close to 95 %. The mechanisms for achieving this level of efficiency:

- The burner operates with a small oxygen excess of 2 to 3 % to ensure total combustion while minimising the thermal losses in the exhaust. In the range of use, the burner strikes a balance between minimising CO and NO_x emissions and guaranteeing high combustion efficiency. The concentration of O_2 in fume is measured in process and the air excess is permanently adapted in the burner through modulation system.
- An economizer is placed in the chimney and recovers energy in fume to heat the hot water supplying the boiler.

A case study on Merck Millipore Molsheim Site shows the effects of the described measures: Replacement of two water tube

Table 5. Energy Savings in fixtures replacement without impact on illumination quality.

Lighting of Building C Workshop		Power (W)	Numbers	Energy Consumption (MWh)
2009	Fixtures with T8 tubes	120	362	869
2010	Fixtures with T5 tubes	80	290	464
			Energy Saving	405
				47%

boilers of 400 kg/h capacity by two fire tube boilers of 1,5 tons/h capacity. The figures shown are calculated for a single annual volume of steam. The new boilers have a capacity greater than previous boilers to meet the future with additional needs.

- Previous energy consumption per year: 1,784 MWh.
- Previous Boilers Efficiency: 80 %.
- New energy consumption per year: 1,498 MWh.
- New Boilers Efficiency: 96 %.
- Energy Saving: 286 MWh/16 %.

BENEFITS OF A BUILDING MANAGEMENT SYSTEM (BMS)

The control of technical installations requires computer resources to optimize the operating parameters and especially to support the technical solutions implemented to reduce energy consumptions.

Below an exhaustive list of all the features of a BMS to optimize energy consumption of technical facilities:

- Scheduling of operating modes of air conditioning following the occupation of the buildings: reduced temperature, partial or complete shutdown of ventilation systems, reducing the introduction of fresh air in buildings.
- Temperature control of heating and cooling fluid on the basis of outside temperature.
- Time Schedule of all facilities equipping a building.
- Monitoring of Facilities to identify regulation issues and to alert maintenance teams:
  - destruction of energy by running simultaneous heating and cooling mode
  - introduction of a fresh air in quantity greater than that required in the mode observed
  - distribution of a fluid at a temperature different from that required by external conditions.
- Monitoring of energy consumptions and reporting.

On the site of Merck Millipore in Molsheim, the decision was made early on to use such a system. It is therefore not possible to calculate the energy savings it has generated.

RENEWABLE ENERGIES

It was decided to include in the program a greatly contributor project in reducing CO_2 emissions from the site. The hot water boilers will be 30 years old in 2015. The time will therefore come to replace them with boilers using biomass as an energy source. Feasibility studies will start in 2013 to allow the project started in 2014 and put into operation in 2015. This project will require a significant investment and in a large industrial group like ours, only its integration into an overall program to reduce CO_2 emissions will make it succeed.

In general, projects using renewable energy in France are struggling to demonstrate an acceptable return on investment. However, we must not neglect this way to contribute to the goal achievement and use all opportunities to deploy these technologies as part of an industrial project in the wider area than just energy savings.

Lessons Learned

A yearly reduction of energy consumptions by 3 % can be achieved implementing basic actions. Equipments replacement has to be considered as a real opportunity to implement the most efficient technology in term of energy consumption. In most cases, savings in operations costs will justify the over cost of these technologies. These over costs can be compensated with grants. They are very limited in France and this support is not sufficient to justify a project in a financial perspective.

Pay backs are different following type of actions (Based on energy costs in France). Some examples are:

- Setpoints improvements: immediate if you already operate Facilities via BMS.
- Lighting replacements: 4–5 years.
- High Efficient technology in utilities production: 10 years (to be calculated case by case) but definitely less than the lifetime of the equipment.
- Photovoltaic Production: 11–12 years.
- Solar Hot Water Production: 30 years.

To achieve 20 % reduction (including new buildings, production volumes increase or other negative impacts) a major investment has to be placed in the program to significantly reduce emissions (Biomass or other technologies). It's not to late to start today! Molsheim's site will achieve the goal in 10 years starting 2006.