MIPU

Phone 0365 520098
Email fabbricapredittiva@mipu.eu
Web www.mipu.eu - www.fabbricapredittiva.com

PREDICTIVE FACTORIES STORIES

MIPU

PREDICTIVE FACTORY STORIES

Harvard Business Review
ITALIA

MiPU

PREDICTIVE FACTORY STORIES

Harvard Business Review
ITALIA

INDEX

PREFACE

The predictive factory: a factory for human? *by Giulia Baccarin and Giovanni Presti* .... Pag. 4

INTRODUCTION

Journey to the center of the italian factory *by Giulia Baccarin*...7

PART ONE
IoT AND ENABLING TECHNOLOGIES

How to calculate costs and benefits of AI in the factory
by Piero dell'Oste and Giuseppe Pirrelli..10

SPL Soluzioni IoT as foundation of value. From equipment manufacturer to solution provider
by Carlo Pisoni and Daria Porretti.. 15

Cybersecurity and IoT, two separate worlds? *by Giancarlo Turati* 18

IoT for asset classification *by Loris Di Battista* 22

Enhance collected data to generate more profit:
the case of a cogeneration plant *by MIPU*... 24

PART TWO
FLEXIBLE AND RESILIENT PRODUCTION

Three key words of predictive production *by Giovanni Presti and Matteo Bissone*..........................26

Interview to Luciano Vescovi, president of Confindustria Vicenza..32

Production forecast in the forniture industry,
a challenge of multiple dimensions *by Giulia Rinchetti and Gaia Campanini* 33

Edison: predictive maintenance and performance forecasting in thermal power plants
by Antonella Periti, Michele Corsi and Lorenzo Montelatici..35
Interview to Nicola Monti Ceo of Edison..37

PART THREE
PREDICT THE QUALITY, PROTECT THE PERSON

Product quality prediction and optimization in the steel production
by Luca Girelli..39

Quality of waste water: can Artificial Intelligence really protect us?
by Giulia Baccarin and Veronica Brizzi 42

Unicredit: the predictive branch *by Marco Coggi and Salvatore Greco* 44

PART FOUR
ENERGY AS SIGNAL OF THE PREDICTIVE FACTORY

Energy as signal for the prediction of phenomena
by Vito Introna.. 47

Menz & Gasser: energy as fuel for shared knowledge
by Claudio Cumer and Michele Cilfone 53

Benetton Group: energy as driver to reduce of environmental impact and improve customer experience *by Mario D'Aleo* 58
Interview to Massimo Renon, Managing Director of Benetton Group 61

PART FIVE
DIGITALIZE MAINTENANCE, COLLECT KNOWLEDGE

Maintenance policies: a new pillar in the corporate top-level management's agenda *by Fabio Sgarbossa* .... Pag. 63

Interview to Alessandro Viviani, Vice President Service of Danieli Group 66

Predictive maintenance techniques
by Alessio Sartori 67

Veritas: digitizing the integrated water service maintenace function
by Umberto Benedetti and Alessandro Ferrario 70
Interview to Andrea Razzini, General Director Veritas 73

Ivar: a connected and predictive factory
by Emiliano Vezzoli and Matteo Bissone 74
Interview to Paolo Bertolotti, Ceo of Ivar 77

PART SIX
HUMAN AT THE CENTER OF THE PREDICTIVE FACTORY

The innovation management in industrial processes
by Stefano Mainetti and Francesca Saraceni 78

Interview to Mauro Fanin Ceo of Cereal Docks Spa 83

Made Italy, we must make Italians: without changing the mindset, strategies can not be realized
by Raffaella Bossi Fornarini 84

Interview to Cristina Crotti, President of Enercom Group 90

A roadmap for the predictive factory
by Giulia Baccarin 91

MIPU MAP OF CUSTOMERS 97

Harvard Business Review ITALIA

Managing Director
Enrico Sassoon (sassoon@hbritalia.it)

Graphics
Marco Agnisetta

Editorial assistance
Emidia Melideo

Editorial Secretary
Luciana Cortella (cortella@hbritalia.it)

Editorial Secretary
Alessandra Tibaldi (marketing@hbritalia.it)

Advertisement Advertising Agency
PUBLIMASTER surl Via Winckelmann 2, 20146 Milano Tel. 02 424191 - www.publimaster.it
Managing Director: Alessandro Zonca
Chief of the masthead : Alessandro Zonca
alessandro.zonca@publimaster.it

StrategiQs Edizioni srl
Corso Italia 47, 20122 Milano
02 3659 9235 – info@hbritalia.it

For advertisement for sectors Training, Professions and Media Consultancy & Co srl
02 2940 9880 - marketing@mediaedi.it

Information and subscriptions
Luciana Cortella (info@hbritalia.it)

StrategiQs EDIZIONI srl

Corso Italia 47, 20122 Milano - www.hbritalia.it

Board of Directors:
Alessandro Di Fiore President
Enrico Sassoon Managing Director
Donato Pinto Advisor

Business, corporate and tax consultancy
Studio Savorana & Partners
Reference partner Massimo Di Giacomo

News organization registered at Tribunale di Milano n. 192 del 20/03/2006

Press: Industria Grafica-GraphicScalve, Loc. Ponte Formello Vilminore di Scalve (BG).
Distributor for Italy: Direct Channel S.p.a. Gruppo Mondadori.
Subscriptions: for info call 02 75429001 from Monday to Friday, hours 9:00-19:00. Write via email at: info.abbonamenti@directchannel.it, or by mail: Ufficio Abbonamenti c/o CMP Bre- scia, 25126 Brescia.
Privacy guarantess for subscribers. The editor ensures strictly confidentiality of the data provided by the subscribers and the possibility to request free the corretion or deletion in accordance with article 7 of D.leg. 196/2003 writing at a privacy. pressdi@pressdi.it.

HBR Academy Italia
Formazione ad Alto Impatto

Responsabile
Alessandro Di Fiore
(alessandro.difiore@hbritalia.it)

Programs
Paolo Cervini
(cervini@hbritalia.it)

Coordination
Paolo Cervini
(corsi@hbritalia.it)

Accounting
Luciana Cortella
(cortella@hbritalia.it)

LINKEDIN Harvard Business Review Italia
FACEBOOK Harvard Business Review Italia
TWITTER @HBRItalia
INSTAGRAM Harvard_Business_Review_Italia

www.hbritalia.it
02 36599235
info@hbritalia.it
redazione@hbritalia.it

«... If I might say, utopia is often the easiest way to label what you do not have the desire, ability or courage to do. A dream seems just like a dream until we start working on it. And then it can become something much greater».

Adriano Olivetti

THE PREDICTIVE FACTORY: A FACTORY FOR HUMAN?

by Giulia Baccarin and Giovanni Presti

Henry Ford II, nephew of the most famous Henry Ford I, founder of the famous automobile company and inventor of Fordism, was walking around his company with Walter Reuther, head of the powerful workers' union of the automobile sector. At a certain point Ford turned jokingly to Reuther and said "Ehi, Walter, how are you going to register these robots to the union?". And Reuther, back : "Ehi, Henry how will you make them buy cars?".

In 1950 the factory of Henry Ford II wasn't already a predictive factory, which is a factory where machines, humans and processes are connected into a network and where collected data are systematically used to predict near future phenomena in order to offer a competitive advantage.

Today the predictive factory not only is possible, but it is also the only feasible way to an efficient, sustainable and inclusive production. Let's see these aspects one by one.

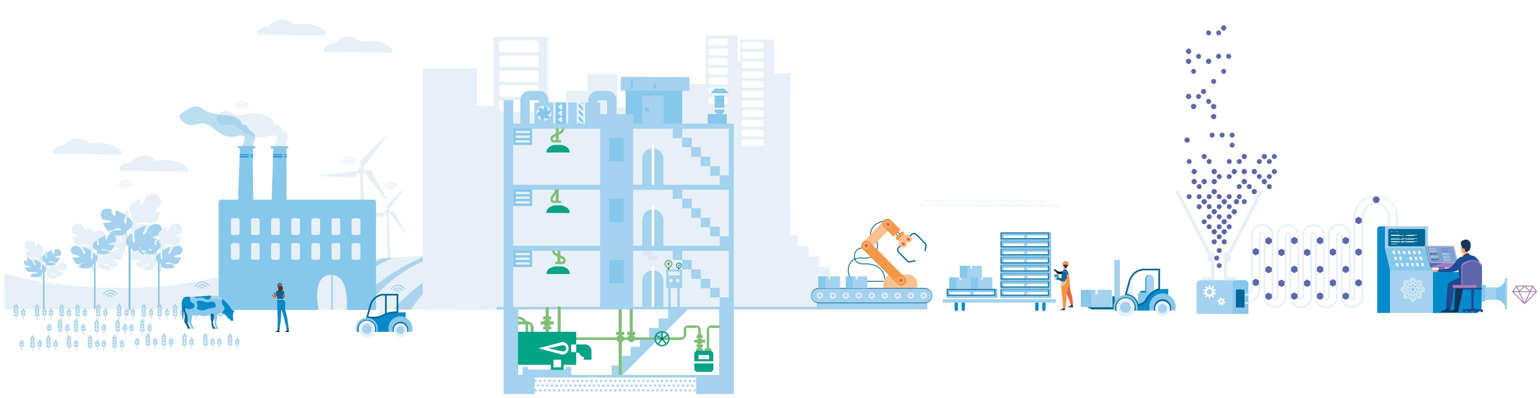
- **Efficient**: if I know in advance what is going to happen in the near future, I can plan my human, material and financial resources in the best way. Not only: I can compare the predictive behaviour with what really happens and intercept any discrepancies in the bud. As we will describe in the next chapters, each of these discrepancies has its own specific cause: failure, human errors, energy waste, low quality. Prediction, therefore, not only as knowledge of the future, but as a diagnostic instrument of the present

- **Sustainable:** here we mean the broader definition of the term, so, returning to Latin etymology, "that can hold over time". First of all, the predictive factory is a factory in which the existing has been enhanced. In none of the examples we will deal with, the addition of the hardware is the key element: the real differentiator of the predictive factory is exploiting the already collected data and projecting new ways of working. We want to bring assets already in use in the corporate to the maximum level of performance by exploiting the economy of already collected data. In this regard, it enjoys thinking that– here too – the first step is bringing out the underground economy!

A second aspect is that the predictive factory is going to be different from everything we have ever seen before. The founding principle of artificial intelligence, or is better to say machine learning, is that the better the data fed to the algorithms, the better will become the intelligence. This process, which is the result of the ability of intelligence to self-improve, will never stop: the predictive factory is generative and circular, therefore sustainable.

- **Inclusive:** meant as a place of hospitality of different ages, views, genres, ethnicities. I know: production efficiency and inclusiveness are terms that seem to be clearly antithetical, especially in the factory. However, I believe that – if well designed – the predictive factory represents a unique opportunity to free the labor from physical difficulty, from repetitiveness and from – unfortunately too often – cognitive scarcity of human tasks.

How to lay the foundation for this revolution?
It is an important question, and it wouldn't be enough an entire book to expose the result of 15 years of experience and reflection about this theme. Here, we desire to confine ourselves to clear the field from one misunderstanding: **automating a part of the processes does not make the other activities superfluous; it makes them more important, increasing their cognitive load and heightening their economic value.** In order to explain this apparent paradox, let's get back to 1986, when the space shuttle Challenger exploded and crash-landed less than two minutes after the take-off. The reason of the explosion was a two-bit O-erre seal in the auxiliary rocket, which got frozen during the night on the springboard and and resulted in a catastrophic crash right after take-off. In this billion dollar venture, that simple O-erre seal made the difference between the success of the mission and the terrible death of seven astronauts.
Why did we take such a tragic example in order to talk about inclusiveness? Because – with perfect demonstration of antifragility - on the basis of that tragedy, the Harvard economist Michael Kremer designed the function of production O-erre, which gives a positive interpretation of our contribution to the predictive factory.
The function of production O-erre conceives the job as a series of interconnected steps, as links of a chain. As for the Challenger, every link must resist, if we want the success of the mission. If one of them fails, the mission, product or service collapses. This precarious situation has a surprisingly positive implication, the improvements in reliability of any link of the chain enhance the optimization of the others. Specifically, the reason why on the Challenger that O-erre was so critical is that everything else worked perfectly.
The predictive factory allows the maximum performance of the existing process
in terms of productivity, efficiency and sustainability; this optimization drives the stakeholders of the process – us - to increase our cognitive load and create our contribution, increasing the value.



We saw the meaning of the main attributes of the predictive factory and, if it is true that every digital transformation is based first of all on people and processes, we must not ignore the enabling factor: technologies. For this reason, in the first part of this book we will talk about techniques and technologies enabling the predictive factory. Then we will look at both industrial and energy production. You will notice that we intentionally collected contributions of companies from different sectors and dimensions, in order to demonstrate that data enhancement techniques are characterized by a low entry cost and high applicability.

In the following parts, we will treat three processes closely related to the production one: quality, energy and maintenance. In the end, we will close tracking the main steps to follow in order to begin the transformation into a predictive factory.

Let the journey begin!

GIULIA BACCARIN
CEO and Co-Founder, MIPU

GIOVANNI PRESTI
Head of Product and Co-Founder, MIPU

«My imagination felt powerless beyond such an immensity»
Jules Verne, Journey to the center of the Earth

JOURNEY TO THE CENTER OF THE ITALIAN FACTORY

by Giulia Baccarin

A refinery blower makes a suspicious noise. A part of the technical team would like to intervene immediately, with the progressive shutdown of the plant and the repair. The remaining part of the team hopes to avoid such an expensive and unplanned shutdown and suggests waiting for the already planned stop for a few weeks later.
How many times did we find ourselves in similar situations? From signals coming from the car to the ATM car jamming, our daily lives– as well as those of our companies – are full of failures and inefficiencies.
In this book we will narrate – through the voices of the protagonists – a series of practical and easily replicable examples, through which companies of every dimension have recovered their efficiency, improved the production reliability, reduced their environmental impact... all of them with a common strategy: becoming a predictive and connected factory.
Although the world is full of examples and stories of innovation, we chose to stay in our Country, whose industrial production often remains subheading in the presence of many other excellences. We hope that everyone could find a near example, or even a simple point of reflection.

Before leaving for this journey to the center of the factory, we must fast the seatbelt and discover something more about our co-pilot: artificial intelligence.

But what is Artificial Intelligence?

The truth is that we don't have a unique definition. After all, we haven't even defined yet all the dimensions of human intelligence. If I asked you to describe the intelligence of your daughter, or friend, some of you would tell me about her musical intelligence, others about her mathematical intelligence, or emotional intelligence. The same applies for artificial intelligence, of which many dimensions exist: our journey to its discovery is only at the beginning.
However, if we limit our actions to the factory, I think three main pillars could be distinguished: predictive intelligence, cognitive intelligence and interactive intelligence (see Fig. 1).

Predictive intelligence is the one that allows us to approach the human to the future through cybernetics. In ancient Greek the kibernetes, the pilot, was the one that looked to the future in advance, and took over the role of city governor. But in order to govern he must be able to "diagnose", always from the Greek "recognize through".

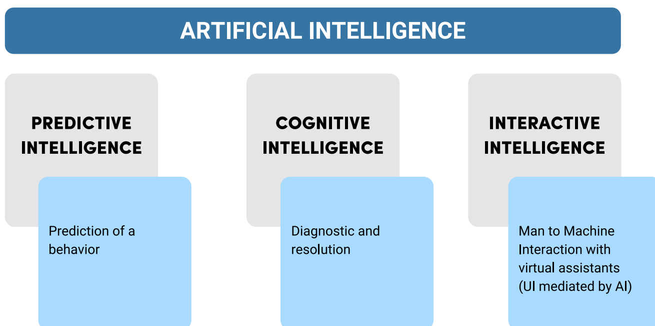


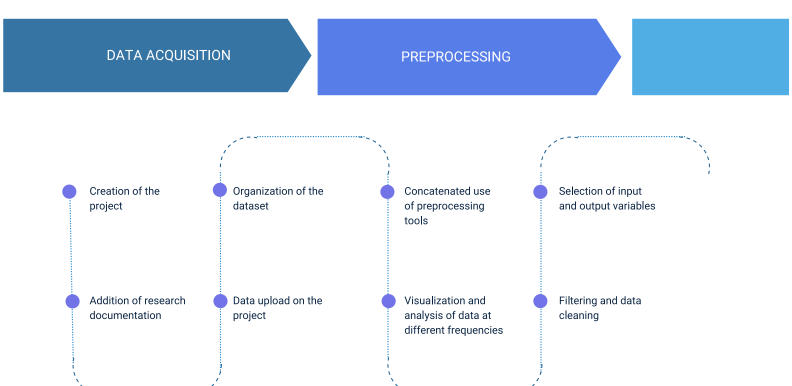
Figure 1

And here I find an illuminating aspect, in particular for his cognitive component. Until today, our path of knowledge has been developed starting from a theory – " the Earth is round" – that we worked in order to see. Today artificial intelligence overturns this path allowing us to see hidden correlations to answer questions we didn't even ask ourselves. **We are in front of technical progress, the ability to see, to which not always a scientific progress matches, the ability to explain.**
Artificial intelligence allows us to see with new eyes where everyone has already seen. In order to transform this new knowledge into awareness and action, we need the "**acting through", the interactive intelligence, that is an intelligence that can average the info-obesity to which we are subjected, in order to vehicle only valuable information and that can support us to increase the value of our contribution.**

Artificial and human intelligence: who helps who?

Let me take an example. We all agree on the fact that a robust energy system is critical for the economic development of a Country; not only, we share the need to accelerate the transition to renewable sources such as wind energy. The big problem with this type of energy is its relative unpredictability: today physical models based on weather forecasting, while making a good contribution, are not sufficiently accurate.
Now when we apply machine learning, we face with two major challenges.
First, when we work on big groups of distributed assets, we must be able **to convey knowledge acquired thanks to the algorithms in simple, intuitive and quick terms to the operators.**
Second, to drastically increase predictivity (the how long before) and the accuracy of the diagnosis, we must integrate Aegean-space weather patterns with those related to the health status of the wind turbine. We must, in other words, **extrapolate and insert into the intelligences a domain knowledge which is often inherent only in those who work on the field.**
Now maybe you can understand where the title of this paragraph has come. **Not only can artificial intelligence bring new competitiveness and sustainability to your business, but also you, with your competences, your experiences can contribute to the improvement of artificial intelligence.**
Marvin Minsky, the father of artificial intelligence, said that the mind is what the brain acts, this means that I am the product of conversations, competences, and jobs that I did.
I think it's a beautiful concept, applicable to the neuroplasticity of human neurons as well as to artificial neurons. A philosophical concept that brings us back to an extremely concrete aspect. Today most of the investments are spent on intelligent creation projects. This is correct, but stopping here would be like admitting that human potential is exhausted at the time of conception. (see Fig. 2).
On the contrary, intelligences are like a good bottle of wine: if well managed, they acquire value over time. Only by monitoring them during their

Figure 2



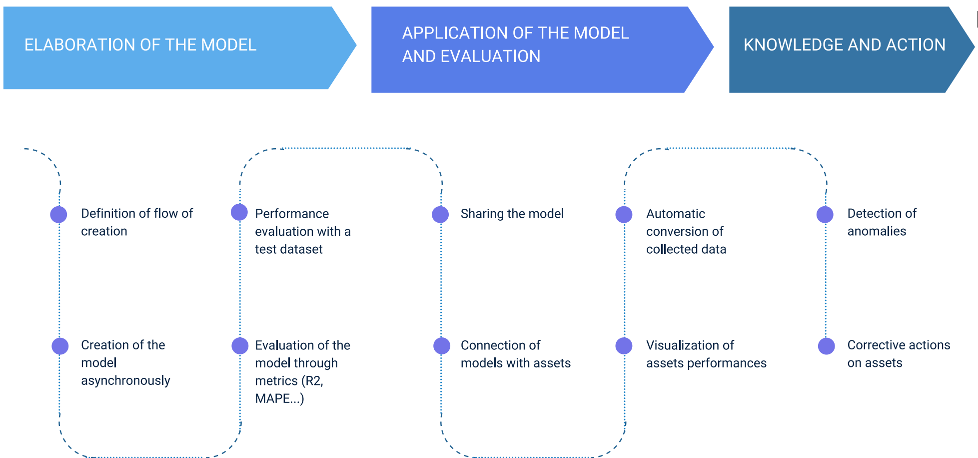


Figure 3

entire life cycle, tracking from whom they were created, where they were used, if their performances are good or they need retraining, I could build a valuable portfolio. (see Fig. 3).
Today thousands of examples on what I can realize, with data already in my possession. Later in this volume, you will find only a few examples made by MIPU in these last years[1].

Whatever is the position of our company in the path to the predictive factory, let's take another step. Let's take it today.

Giorgio Gaber was singing "I don't feel Italian but, fortunately or unfortunately, I am." In order to have good intelligence we don't need a low energy cost; we don't need infrastructure and we don't even need good politicians.

The construction of a good intelligence requires two elements: the first one is creativity, the ability to see with new eyes where someone else has already looked; the second, is passion, the ability to persist in the discovery and training phase, even when the result does not satisfy us. Creativity and passion. The same qualities that made great Made in Italy all over the world. Qualities that – if applied to the predictive factory- will allow us to realize together something that younger generations don't even have the courage to dream anymore: an Italian Renaissance.

1 The interested reader can find further material on www.fabbricapredittiva.com

GIULIA BACCARIN
CEO and Co-Founder, MIPU

HOW TO CALCULATE COSTS AND BENEFITS OF AI IN THE FACTORY

by Piero dell'Oste and Giuseppe Pirrelli

From a cost point of view, an effective implementation of artificial intelligence systems depends on the quality of the IT infrastructure, technical skills and the quality of data collection. On the other hand, it is more complex to establish a general method for calculating the benefit, strongly dependent on the specific purpose you want to give to intelligence. In this article we present a methodological proposal for the main AI application objectives in the factory.

Cost of AI and cost of data: IT infrastructure and data collection

An adequate IT infrastructure is a necessary (but not sufficient) condition for the development and use of machine learning algorithms. By "IT infrastructure" we mean the set of software and hardware specifically aimed at data processing and computation, which is called the analytics stack.
Typically, the *analytics stack* involves the coordination of four elements:

- **Database (DB):** it must be suitable for the type of data (numeric tables, images, audio files, etc.) and efficient in writing and reading operations.
- **ETL system:** abbreviation that indicates the operations of extraction, transformation, load or carrying out standardized operations (filtering, elimination of duplicates, encoding and decoding, aggregations, etc.), and then upload the transformed data into a second storage space.
- **Machine learning and advanced analytics:** tool for the design and development of mathematical-statistical and artificial intelligence models. Desirable characteristics are the simplicity of acquiring data from the DB/data warehouse, flexibility and speed of execution of the pre-processing and implementation of the models.
- **Visualization**: software dedicated to organizing the results of the algorithms, in order to have an informative, rapid and intuitive use.

There are multiple perspectives in quantifying the costs associated with building a dataset and subsequent analysis stacks.
Most of the artificial intelligence projects in the industrial field do not reach the starting desks precisely because of the high costs of this phase. While building the infrastructure is a huge expense, there are a number of techniques to reduce the amount of data needed to start building value with artificial intelligence.
In MIPU we have identified eight fundamental steps for this process. Two fundamental points on this issue:

1. Artificial intelligence has to solve a specific problem. Intercepting a bearing lubrication defect is different from identifying a resonance problem. Domain competence is the key to achieving satisfactory results even with lean infrastructures.
2. Having a warehouse full of pieces of wood does not mean that I will be able to transform them all into chairs and tables: lots

of data and good data are different things. Industrial data are by their nature “dirty”, contaminated by errors such as holes, offsets, full scale and in general errors in processing.

For this reason, we have developed anomaly detection algorithms, a tool intercepting anomalous data and repairing them.

On over 70 Industrial AI projects running for a minimum of two years, where there were no anomaly detection logic, the alerts and alarms generated by mere errors on the sensors would be 46%. This means that, even with large amounts of data, it is reasonable to try to drastically reduce the number of vectors used to feed intelligences in order to limit the sources of error (see Fig. 1).

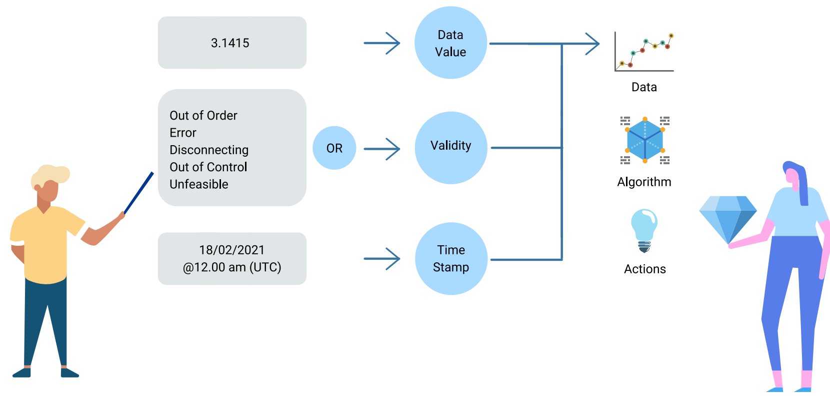


Figure 1
From data to value

Technical skills

The spread of artificial intelligence has led to new job profiles, as well as important changes in the duties of more traditional professional profiles. For example data scientists nowadays are in the intersection between statistics, information technology and domain knowledge, being the reference point for the processing of data and the extraction of information that can bring value to the organization.

Compared to the early days of this discipline, there are two very relevant trends:

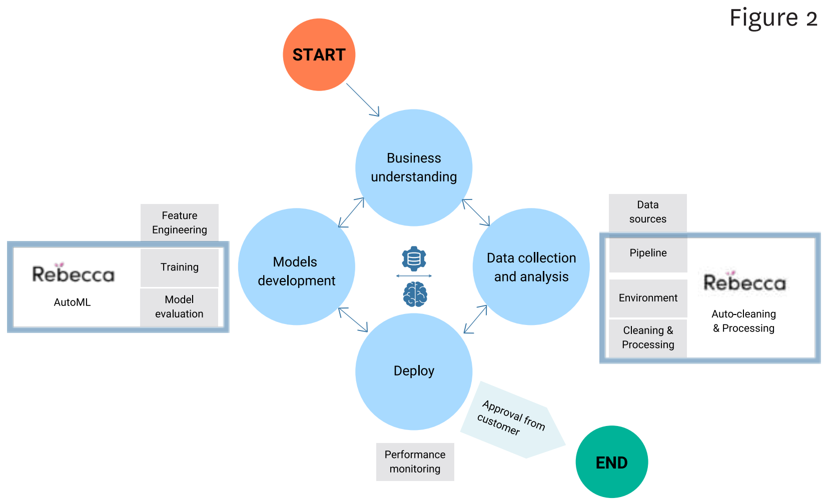
1. Artificial intelligence was considered a “stand alone” discipline: AI experts were considered capable of solving any analytical-computational problem through the implementation of automatic learning models. Today, however, it is clear that the best results are obtained when AI is used to complement a good knowledge of the domain with the evidence extracted from observable data.
2. Data scientists were considered capable of managing and operating all the components of the analytics stack. While evolving both the discipline and the professionals have been focusing on two or at most three areas of activity.

In our country there is an important gap in technical skills, particularly in terms of data science; for this reason the choice of MIPU was to invest since 2017 in the development of software that not only allowed to democratize the development of artificial intelligence, as extensively discussed in this volume, but also that would support companies in automating repetitive tasks. Auto-machine learning is now a reality only for a limited part of the activities that make up the creation and management of the algorithms of the predictive factory (see Fig. 2).

How can AI improve operational processes

The impact of artificial intelligence in the business environment depends on a large number of factors and can be extremely variable depending on the sector of activity.

Figure 2



Very often, to determine the success or failure of an innovative project that involves data analysis, more than the technologies or technical skills available, is the capability of identifying a business problem that can actually be solved using artificial intelligence or machine learning.

By reducing to the bone the actual difficulty of evaluating a business use case **for advanced analytics, it is important to consider two factors: the simplicity of collecting data and the degree of randomness of the process**, organized in the matrix of complexity (see fig. 3).

We identify three reference points on the abscissa axis, corresponding respectively to the minimum point, the intermediate point and the maximum point in terms of randomness.

Figure 3

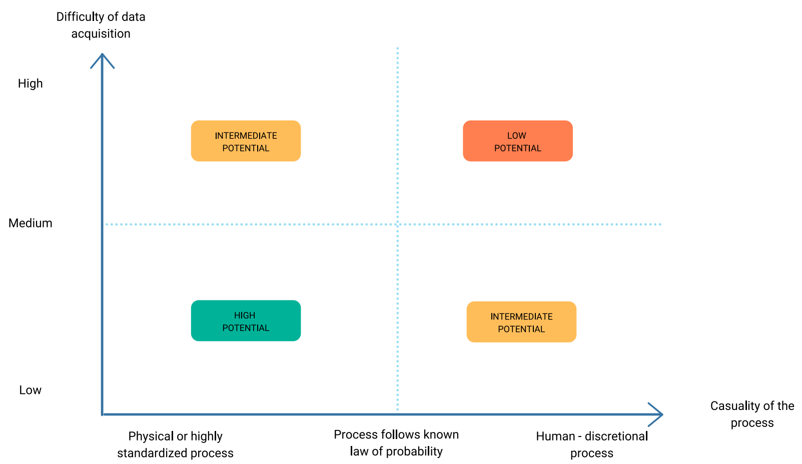
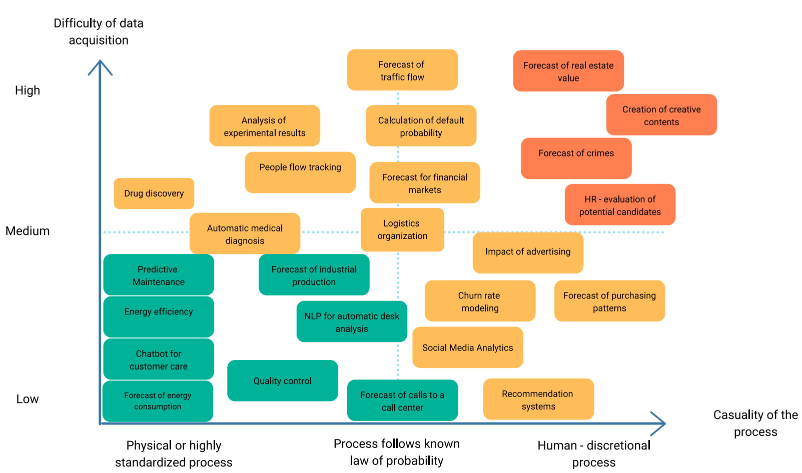


Figure 4



- Physical or highly standardized process: deterministic phenomenon, it does not depend on any random component.
- Process that follows a known probability law: we enter the world of stochastic processes, the determination of which occurs randomly.
- Human-discretionary process: at the opposite extreme we find totally unpredictable events. A large share of them is made up of the choices of the actors involved in the social and economic system, who use their own reasoning and sensitivity in making discretionary decisions.

The interaction of this element with the availability of data to be analyzed, was significantly analyzed by determining the potential of applying the analyzes for a specific use case:

- **high difficulty of data acquisition and high degree of randomness of the process: low potential.** The application of analytics is extremely complex and challenging: it will hardly produce appreciable economic results. If it were possible to manage in some way the unpredictability of the process, the high cost of data collection or acquisition would still represent a significant obstacle;

- **low difficulty of data acquisition and high degree of randomness of the process: intermediate potential.** In this case, the obstacle is represented by the complexity of the process under analysis, while the availability of data is wide. The success of the application is mainly determined by the availability of data, as the process is mathematically manageable;

- **low difficulty of data acquisition and low degree of randomness of the process: high potential.** Given the high availability of data, and the possibility of mathematically modeling the phenomenon, we find use cases that have a high potential for creating value through advanced analytics (see Fig. 4).

How to calculate the benefits of AI

As can be seen from Figure 4, the application of machine learning algorithms for predictive factory demonstrates a high potential to create value.

A successful application example is related to predictive maintenance. These monitoring algorithms are able to predict a future anomaly in advance, allowing to intervene before the component is subject to a fault. But how to calculate the economic benefit resulting from this technical innovation? In figure 5 we report some aspects to be evaluated, however it is clear that for a quantitative measure of the same it is necessary to refer to a specific target. So let's take the example of artificial intelligence for predictive maintenance.

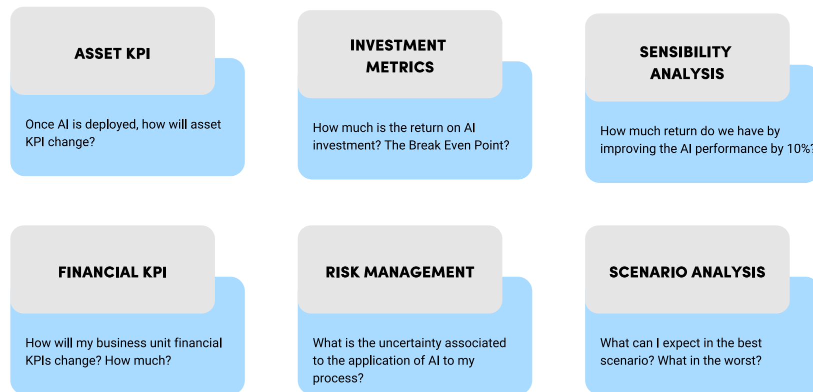


Figure 5

How to calculate the ROI: artificial intelligence applied to predictive maintenance

When we talk about predictive maintenance, we have to compare the benefit obtained by intercepting a given type of failure with what would have happened without prediction. In particular, the costs to be considered - and therefore the potential benefits - are summarized in Figure 6.

The model developed in MIPU is based on a simulation approach: the model creates a representation of failure phenomena with relative frequency and associated cost; it is therefore possible to carry out what-if analyzes to verify what could happen when the maintenance strategy changes and to predict the costs and benefits of each scenario.

With the tool developed by MIPU it is possible to simulate strategies for an asset, a line or for the entire factory, by choosing from the following maintenance policies:

- **corrective,** in which the asset is restored to full performance only after the occurrence of an anomaly;
- **planned preventative,** in which maintenance operations are carried out on a regular basis, depending on the actual state of health of the asset;
- **predictive, i**n which maintenance and restoration activities are carried out only when indicated by the monitoring and forecasting of the health of the asset carried out by the artificial intelligence model.

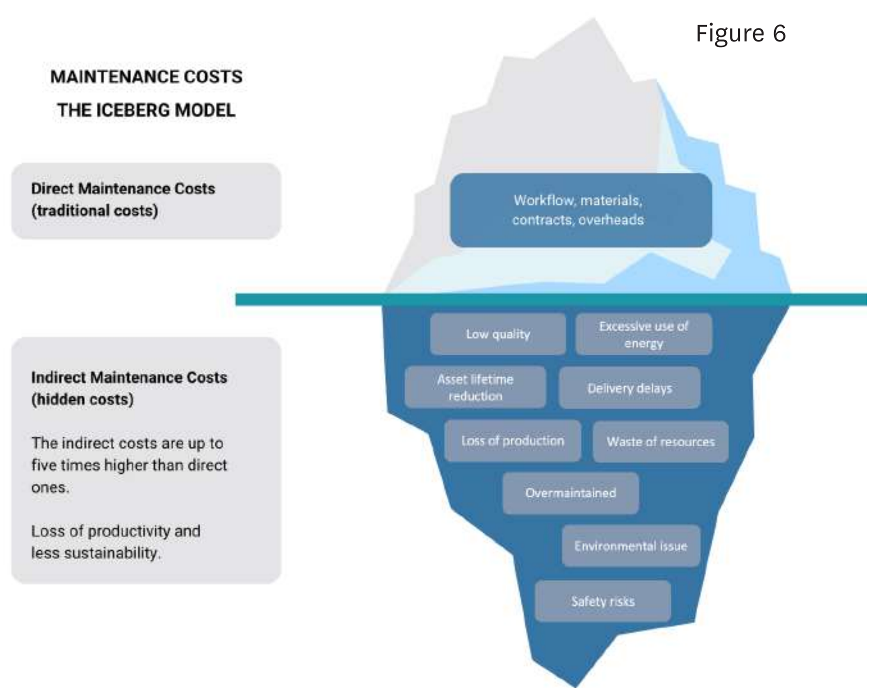
The simulation of maintenance strategies includes the calculation of the number of future failures on a given time. At this stage, it is necessary to enter information related to the costs, which are divided into:

- cost of plant shutdown;
- cost of labor;
- cost for spare parts;

By having the data relating to the duration of the shutdown and the maintenance interventions, it is possible to calculate the investment for each one of the different strategies.

In the case of predictive maintenance, the benefit is given by the difference between the costs of the predictive versus the costs of the previously used strategy.

Figure 6



The investment cost is obtained by adding the development cost and the cost of periodic monitoring and improvement of the algorithm.

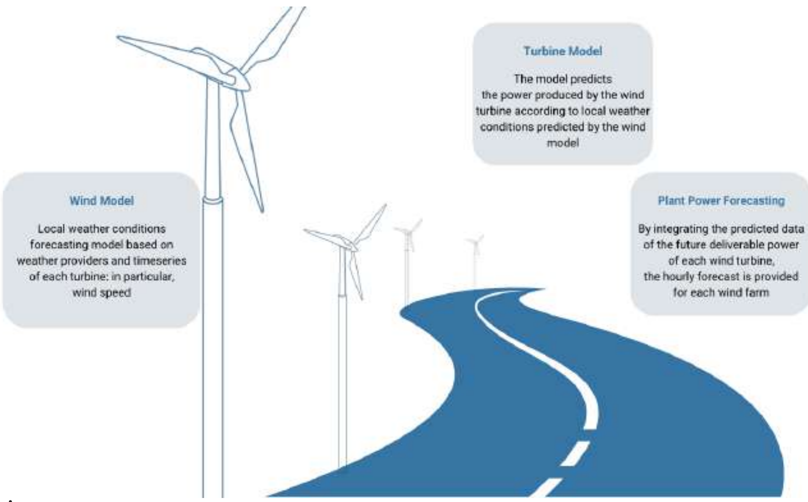


Figure 7

Example of calculation of the benefit for the wind sector

Figure 7 provides an overview of the artificial intelligence models that we have developed and implemented for the predictive maintenance of about 200 wind turbines distributed over several wind farms in Southern Italy.

The scenario evaluated is the one of the total application of predictive maintenance; even the activities normally planned are therefore carried out not on an hourly basis, but only when intelligence actually notifies the need for an intervention.

In the economic evaluation tool, we detect the statistical properties of the historical series of failures of each component; we therefore make a forecast about the number of future anomalies in the as-is condition and the variation of the maintenance strategy.

The tool allows to launch the simulation not only on the entire installed fleet, but also on the single wind turbine or on a sub-assembly: it therefore takes into consideration the particular characteristics of the components installed and the history of the asset and of those who maintained it.

The result is that, according to the asset considered, the application of the predictive strategy leads to savings around 15% and 25% in terms of annual maintenance costs.

Furthermore, the lower number of failures observed allows the asset to increase its availability by a factor of between 10% and 15%.

The improvement on the forecast of the generator availability makes it possible to improve the forecast of the amount of energy that I will be able to put on the grid at a given time in the future.

These improvements range from 0.2% to 1.4%; however, they are considerable in terms of models strongly correlated to weather conditions.

Considering the entire wind farm, these benefits allow to repay the investment for the implementation of predictive maintenance in a period of time between two and four months.

PIERO DELL'OSTE
IoT Expert, MIPU

GIUSEPPE PIRRELLI
FinTech Analyst, MIPU

SPL SOLUZIONI IOT AS FOUNDATION OF VALUE. FROM EQUIPMENT MANUFACTURER TO SOLUTION PROVIDER

by Carlo Pisoni and Daria Porretti

Last summer a friend and I both changed our dishwasher. Now, with all due respect to appliance manufacturers, a dishware is a dishwasher: nowadays functions such as energy saving, half load washing, the separate and horizontal cutlery basket are found in almost all models. If the functionalities are equal, what then was our choice based on? What is the choice of end users based on?

To this question, many will answer that the differentiating factor is price. In our case, the truth is that, within the price range we consider reasonable, the choice was based on our previous experience. My friend reaffirmed her trust in a supplier in the country, who in the case of the previous dishwasher had been particularly diligent in intervening when it had failed. I chose a brand known for the reliability of its after-sales service, a brand that I had already appreciated in the case of other household appliances.

If you are thinking that this is a personal experience, I must tell you that, according to Eurostat survey of 2019, 87% of consumers are willing to pay up to 30% more for a better service.

To continue with the story, in the case of my friend, when the first red light came up she called the gentleman of the shop who kindly went to her house explaining that only indicated the need to clean the filter. In my case, however, the app on
the mobile phone already indicated in an extended text description a probable obstruction of the water drain: having verified that this was indeed the case, I cleaned and restarted the machine.

If from the satisfaction point of view the experiences may seem similar, from the point of view of the manufacturer it is clear that mine is much better. Of course, it is only possible as long as the appliance is enabled by an appropriate technology: that is being a talking appliance.

But Internet of Things is not enough. And, in fact, the dishwasher is not the only talking object I have in the house. The oven has a whole range of services enabled by the Internet of Things. The real difference is that in the dishwasher the IoT enabled a service that was useful to me, while I was never interested in being able to download the most suitable cooking cycles from the Internet to savor my rabbit.

The evergreen Steve Jobs said that it is necessary to start with the customer experience and work backwards towards technology. I have to admit he was right. But why do I take up this personal example in a volume on predictive factory?

Eight out of ten technology products between those on the market in 2021 will be connected products, bringing data from the machine to the cloud - in short, dhl data. Well if this has ever had a competitive value, in 2021 it has lost it completely.

The difference lies not only in the vertical servi-

ces that I can create, but above all in the experience that thanks to those services I will be able to guarantee to my user. So also in the factory.
CXOs - chief experience officers - do not want machines that are simply connected: they want clear and modulated answers to their needs, whether they are for operational continuity, a reduction in the specific energy cost per unit of product or performance forecasting.
For this reason, MIPU's Service Design team has developed a specific methodological framework, the Machinery Design Doing, which helps manufacturers to migrate their positioning from Equipment Manufacturer to Product Solution Provider, where possible by exploiting the data already collected and available on their machines.
This may imply a revision of the business model or not, depending on whether the manufacturer - and its market - is ready to accept the logic of servitization or not. From a methodological point of view, Machinery Design Doing combines Design thinking with service design to build a lasting competitive advantage (see fig. 1). In the following we will analyze the case of SPL Solutions.

Company setting

SPL Solutions designs and manufactures conical equipment and machines targeting companies in the personal care and beverage sectors. The market to which SPL belongs is characterized by the presence of established manufacturers from Europe and Asia, whose machines differ little in terms of performance, functionality and design: hence the need to differentiate their offer building a portfolio of products and services that, while satisfying customer needs, it did not burden the costs on the manufacturer side. Following a case that underline the value of data already collected: SPL and MIPU have managed to create an important differentiation and a roadmap that engages customers in the medium and long term.
How we did it? (see Fig. 2).

Results

Services based on Simple Analytics have been designed that allow both the user and the manufacturer to have the machine under control from a maintenance, production and energy point of view. Advanced Analytics services based on machine learning techniques have also been designed for the predictive evaluation of the operating status of the machine (see Fig. 3).
A service was also conceived - Service as a Product - based on artificial intelligence: data collected from the machine with a focus on predictive maintenance aiming to reduce machine downtime and increase productivity. That is highly strategic for SPL customers.

The results of the project were two: SPL could give to its customers access to the information required and, moreover, SPL could use those data to develop AI models to be applied to its machines. These intelligences in turn will become the heart of new and more advanced services to be offered to the market as well as tools for conducting new in-depth analysis on assets.

Figure 1

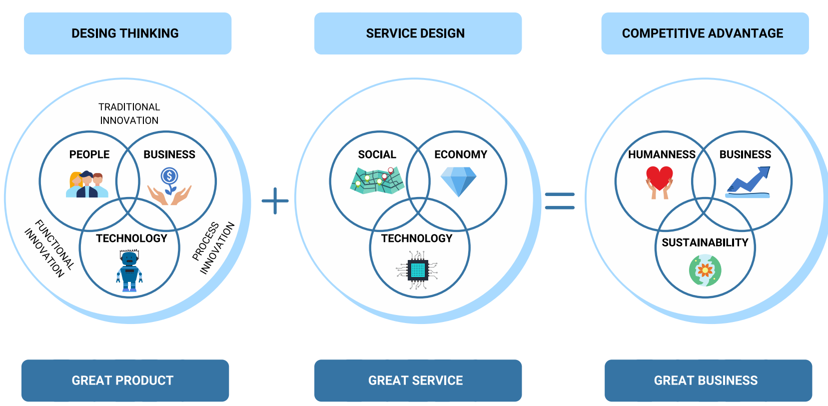
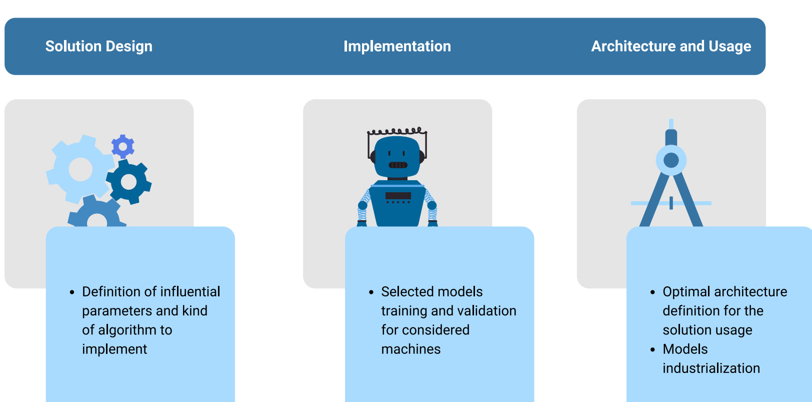
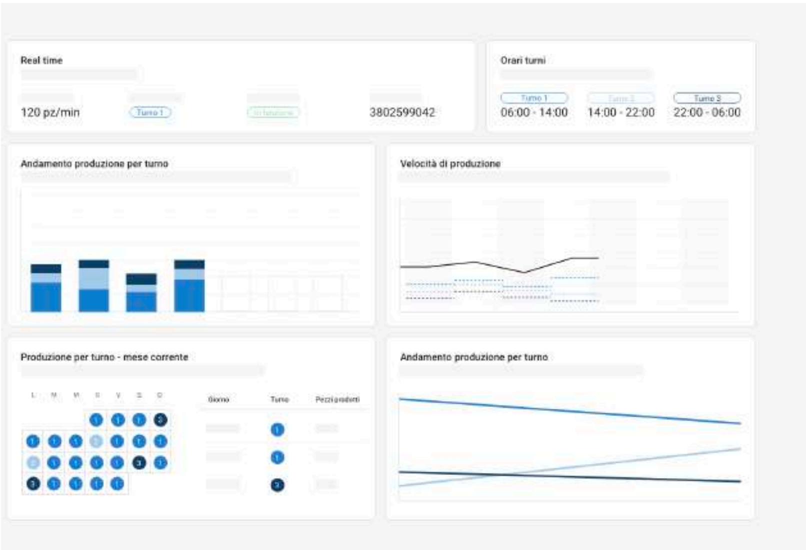


Figure 2





How much more can I produce?

- What is the most productive shift? In this month?
- Which are the trends in production speed?
- View the forecasted production for the next days.

Figure 3

CARLO PISONI
Owner, SPL Soluzioni

DARIA PORRETTI
Relationship Manager, MIPU

CYBERSECURITY & IOT, TWO SEPARATE WORLDS?

by Giancarlo Turati

Information security must permeate any corporate element, asset or data in its essence. The idea, still too widespread today, that any security problem can be solved with a specific hardware or software product, is terribly wrong. The initial approach to safety must always consist in adapting the processes and, later, in combining the necessary products to support the processes designed for safety.
What a coffee machine, an aquarium, a vending machine, the lock of a hotel room and a traffic light have in common? They are all connected devices, objects, "things" that are used for an attack to the security of the network to which they were connected, even if it was for just a few minutes.
In particular:

- the coffee machine was mistakenly connected to a Wi-Fi network and bridged the installation of ransomware on the control systems of a factory;
- the beautiful aquarium, equipped with a state-of-the-art control unit for temperature and water quality control, was the bridge to steal confidential information on hotel and casino visitors;
- traffic lights detected non-existent infringements as they were infected with malware;
- the locks on the doors of the hotel rooms, connected to the network, did not let people enter customers room until a ransom is paid by the hotel owner.[1]

Talking about concepts related to security in the IoT world recalls feelings and assumptions that directly lead to debunking some cornerstones of old-fashioned information technology.

"The maturity and convergence of technologies make it possible to use this paradigm (IoT) to innovate the business and provide new services to a wide range of users. Very beautifull! But what is happening in this area has already happened in the past on several occasions, every time an IT innovation has followed and is affirmed, but companies almost totally neglect the aspects related to security, focus on opportunities and - they lie or underestimate the dangers and risks that may arise from them"[2].

The progressive change introduced by widespread digitization, by the inclusion of IoT devices, by Big Data and by production control systems integrated into management systems, has led to the convergence of two worlds that were separated not only physically, but also culturally: IT and OT.
In the company and in the factory the two things have always been rigidly separated, two worlds that grew up at different speeds, two worlds that found no need to communicate and when they did it was often through "intermediaries" that prevented mutual contamination. In this way, the false belief has been affirmed that "factory" systems with their closed and very often proprietary protocols were immune from problems that are, conversely, very present in IT departments, namely data and information security.

"Companies that have always used proprietary networks (bus), open their "coffer" to external agents, cyber-attacks, attempts to manipulate and sabotage information and systems" [3].

To clarify, I would like to summarize the concepts underlying the definition of "data security" as very

1 https://www.cybersecurity360.it/

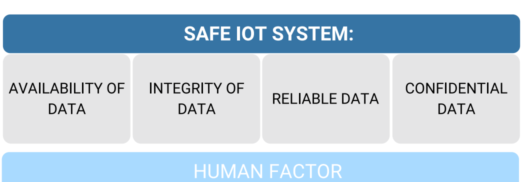
2 *IoT Security e Compliance Gestire la complessità e i rischi,* Clusit 2020.

3 Ibid.

often, in my opinion, there is a certain confusion.

Data availability – digital systems must always be available, the greater the diffusion, the more necessary they will be for everyone's life and the more relevant their availability will be.
Data integrity – intact data will ensure the accuracy of the information. Corrupted data will influence subsequent decisions or processing by introducing unthinkable error variables.
Reliable data – data sources will need to be reliable, well governed, well managed and constantly verified (no fake).
Confidential data – the data can be accessed only by those who have authorization and need, be it man or other machine or system. Data must be essential and not be in excess. Access to data must be verified, managed, controlled.

The set of these elements - that often, too often, are seen in their single entity - **constitutes the foundation of a safe and reliable system where actions are verified, the accesses are managed, the accounts are protected and the information is given continuously without interruption or default.**



Utopia? I don't think so. The common saying "a lot of security = a lot of spending " has now been questioned by the evolution of systems and people.

An important issue when it comes to information security related to people.
What do people have to do with it in an area where autonomous and automatic systems give information? One of the prerequisites of IoT is to be independent of people: sensors, field BUS, measuring instruments, electro-medical machines, automatic proximity, frequency, speed control systems, accelerometers... no need to interact with humans to provide data. **Nothing more presumptuous and wrong: the human factor is decisive in the vast majority of cybersecurity attacks on any type of systems..** Common and never modified access passwords, redundant configurations, remote accesses with non-certified tools, unmanaged physical networks, interconnection nodes on the machines without the possibility of segmenting or verifying who is connected, access allowed to the suppliers of the machines in promiscuity with the company network, outdated firmware, badly configured monitoring systems... I could go on for a long time without repeating myself. The risk scenarios are many and must all be faced and verified with a series of aggravating factors that must be highlighted. **The IoT sensor by its nature tends to be simple, with little need to be maintained. Furthermore depending on where it is installed and connected, "the context" becomes an element of very high risk for the purposes of data security but, alas, also of people.**

We are thinking of all the signaling sensors used on public transport networks, including high speed, the control systems of hydroelectric power stations and basins, autonomous driving systems, electro-medical equipment.
Often the principle of what is connected is the same: basically they are measuring instruments, therefore elementary data, a few Kbit that will then be input to complex systems that will have to analyze and use them to assume decisions, activate actuators or simply feed a dashboard or provide information on the correct functioning of mobile devices.
It is easy to understand that if this data were corrupted or manipulated, the results would be corrupted and manipulated in the same way.
A clear example of this observation is represented by incidents that have forcefully entered the ranks of our thoughts

On 6 February 2020 the Frecciarossa 1000 AV9565 train from Milan to Naples derailed near Livraga (Lodi) for an exchange with the internal cabling mounted upside down: the "Closed" data was viceversa "Open". As a result, the train derailed at 300km/h causing the death of two people (the drivers) and the injury of 31. In this case, the High-speed control system, having received a "Closed Exchange" data, had given the train ok to proceed at maximum speed. But the exchange was open. This is one of the many cases of incorrect input data with consequent incorrect output data. Let's examine other specific aspects to assess the risks introduced in the IoT context:

- **Attack surface**: the exponential growth of the number of devices connected directly to the Internet corresponds to an equal growth of the so-called "attack surface", that is, the base of network nodes that can be subject to cyberattacks. The majority of attacks, in fact, are not directed towards a specific node, but it try to hit as many vulnerable nodes as possible among all those nodes connected to the network.
- **Hardware / software obsolescence**: devices embedded or wired in the most varied environments from roads to mountain dams, from the concrete of buildings to railway lines, they are equipped with limited resources and are updated less frequently than normal devices. This is due to multiple factors: since these are a high number and very low-cost devices, updating them is an operation often too expensive and complex to be performed frequently. In addition, if such devices are subject to certification, updating the certified software requires a new one and this is a reason why updating is often delayed.

Let's see another very famous example of a Cyberattack on IoT networks: the attack that took place on 21 October 2016 and known as "**Dyn cyberattack**". This "distributed denial-of-service" attack was made possible by a software known as "**Mirai**". An attack of this nature consists in taking control of numerous network nodes, "zombies" piloted by an offensive command and control center. These zombies are then induced to contact a specific service at the same time, which succumbs to the enormous amount of requests received in a very short period of time, causing a temporary blackout of the service itself. In this case, the victims of the attack were some famous service providers, such as Twitter, Spotify, CNN, New York Times, Financial Times, Boston Globe, The Guardian, Netflix, Airbnb, Visa, eBay, Reddit, Amazon and others , resulting in millions of dollars of losses. An analysis of this attack showed that the attack vectors were actually disposed *embedded* systems such as **webcams, home routers, videocamera for babies, medical instruments, smart TVs.** But what to do, once you understand the extent of the risk associated with the IoT? The **NIST** (National Institute of Standards and Technology-USA) indicates the four main questions that must be asked in order to correctly identify the scope of use of IoT technologies, exposure to risks and related mitigation measures:

- What capabilities / functionalities do IoT devices have?
- What security and / or privacy risks are the organization exposed to?
- What challenges do I have to undertake to reduce / mitigate these risks?
- How could the organization address these challenges?

In July 2019, NIST published the guide "Core Cybersecurity Feature Baseline for Securable IoT Devices: A Starting Point for IoT Device Manufacturers", NISTIR 8259 (DRAFT). It indicates six recommendations on security features that IoT device manufacturers must keep in mind and that users can evaluate at the time of purchase. Among these the most relevant are:

- **Device Identification**: each device must be able to be uniquely identified through a serial or a unique address when connected to the network;
- **Device Configuration**: an enabled user must be able to modify the software configurations of the IoT device, in addition to those of the firmware if necessary;
- **Information security**: it must be evident how the IoT device protects the data, which it stores and sends on the network, from unauthorized access or from unauthorized modification attempts.

Considerations for Managing Internet of Things (IoT) Cybersecurity and Privacy Risks", identifies three high-level risk mitigation objectives for managing cybersecurity and privacy risks of IoT devices:

1. Protect the safety of the device;
2. Protect data security;
3. Protect people's privacy.

The report provides "recommendations for addressing the challenges of cybersecurity and privacy mitigation for IoT devices". The recommendations are related and structured as follows:

1. Understand the risks;
2. Implement policies and processes to address these risks;
3. Update these policies and processes as needed.

The European Union Agency for Cybersecurity (ENISA), in its guide "Baseline Security Recommendations for IoT" of November 2017, indicates the domains in charge of mitigating risks, underlining how threats and incidents involving the IoT world are in strong growth. The description of the measures is organized into three main categories that ENISA recommends putting in place already in the design phase of IoT-based services:

- **Policies;**
- **Organizational, People and Process measures;**
- **Technical Measures.**

To implement these recommendations, there are appropriate frameworks such as the **National Framework for Cyber Security and Data Protection.** It therefore seems very clear to me how, **approaching complex systems that use sensors, devices, accessories, machines, it is necessary to carry out first an in-depth and very serious analysis of the risks and therefore an equally in-depth and serious impact assessment on the general and overall safety of the Factory, Bank, Hospital and Multiutility system.**

This concept of analysis that many call "assessment" is also necessary every time variables, variants, new features are introduced within the system. Very often this type of approach is completely "snubbed" because it is considered too complex or too expensive both in monetary terms and in terms of human resources, and in this way a dramatic error of assessment is made which unfortunately, in addition to generating serious damage to the organization, lately and increasingly often it also dramatically intersects with the health, physical, moral and personal safety of individuals.**The more widespread the use of autonomous systems to regulate the essential aspects of our lives, the greater the risk that these systems will be attacked to take control for fraudulent purposes, but also for political and strategic purposes.**
For this reason it is important to raise the level of awareness among citizens, users and users of the systems. It therefore becomes essential to provide the younger generations with the cultural and ethical tools to require that systems, objects and sensors comply with regulations and adequately protected. Only in this way will the paradigm be fulfilled by which technology will significantly contribute to improve people's quality of life.

GIANCARLO TURATI, National VP of Piccola Industria Confindustria since 2016 and CEO of FasterNet, a company that operates in the field of IT services. Creator and founder of the Orgoglio Brescia consortium, creator of the Tree of Life for the 2015 Milan EXPO. For over 10 years active disseminator to raise awareness on cybersecurity, internet addiction and cyberbullying issues.

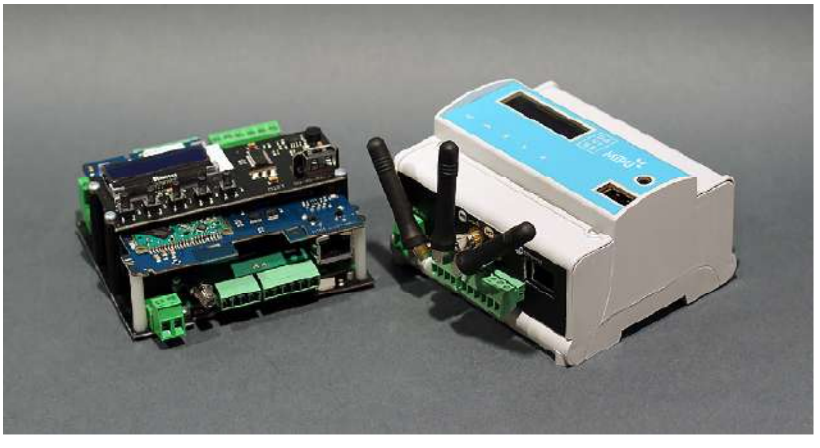
IoT FOR ASSET CLASSIFICATION

by Loris Di Battista

"The classifier is able to supply useful information for the optimization of the settings of devices, in order to maximize the useful life, ensuring at the same time the communication performance"

IoT devices set up in the territory continuously send information to the gateway, which in turn shall forward information to the central network server. Through the network server, it is possible to collect device's information and answer with a set of control parameters such that the useful life is maximized and at the same time the communication performance is optimized.

The values of control parameters are strongly related to the type of the device, distinguished between fixed or mobile. However, the information about the type of device is not directly available between the information sent through the gateway to the network server, so that it is not easy to define precisely which values are attributed to the control parameters of the devices. **Thanks to a classification algorithm, it was possible to structure a model that, by reading the parameters sent from the devices, is able to recognize with a minimum percentage of error the type of device, without the need to act on the single asset of the installed pool in order to modify the set of communicated parameters.**



Company setting

The client is a multiutility at the top of energy, environmental, heat, network and smart city sectors. Through a society of the group, it develops and manages enabling technology infrastructures for digital integrated and network connected services.

Needs

The client needed an intelligent solution able to recognize the type of device based on the sent data, in order to optimize performances and life cycle. Before testing MIPU's solution, the client had already tested different analytical models for prediction and classification of the type of devices, without satisfying results. The first step was selecting the parameters with whom feeding intelligences. This selection occured with two parallel channels: on the one hand, the discussion with the customer,

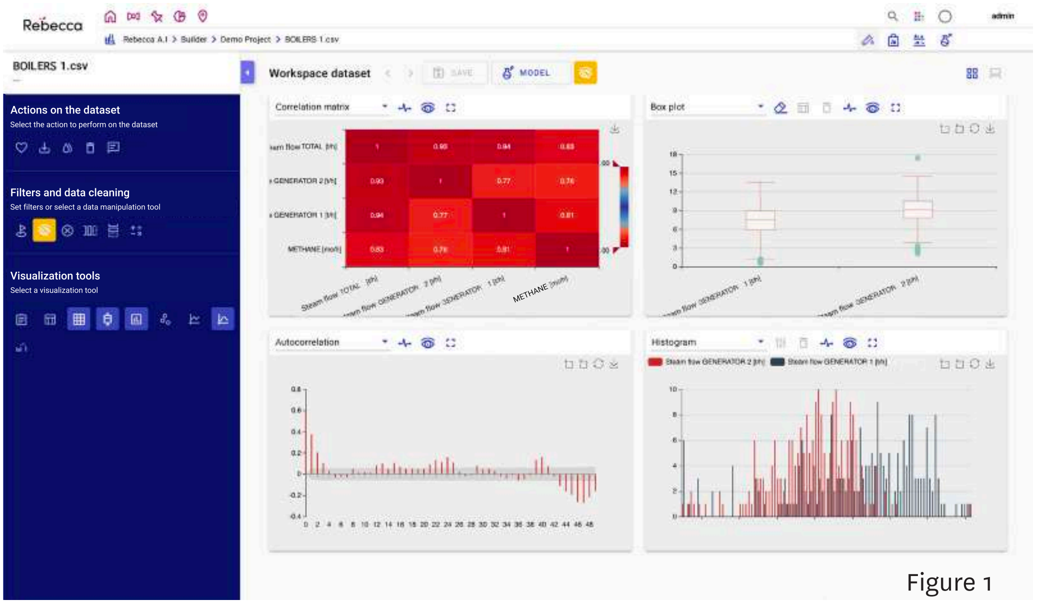


Figure 1

maximum expert of the device, and on the other hand through data analysis, which autonomously are able to provide information about the degree of correlation between parameters (see Fig. 1).

The process was done with the use of the Builder module of Rebecca Artificial Intelligence, MIPU's platform for the quick exploration of data and the codeless construction of artificial intelligences This allowed more interlocutors, even at the first experience, to collaborate through the platform.

After pre-analysis, the team of Data Science selected different algorithms to test, identified on the basis of the characteristic non-homogeneity of the dataset. The problem was, in fact, more similar to an anomaly detection than to a classification study, since one of the two classes was clearly more prevalent in terms of observations than the other.

The various algorithms, included into classification models, had been compared in terms of performance, by focusing attention on the ability Aof the model to identify correctly the minority observations. Even this process of testing has been made available to all the work team through the platform; the various interactions have been carried out with a time 60% lower than what would have been possible to do with the programming from scratch of intelligence. The most promising algorithm resulted in a classifier that automatically balances the classes, by overlapping tests with casual sampling from the preponderant class in order to maximize the precision.

Results

The intelligence created in this first pilot reached a high precision between 80% and 90% depending on the tests, on both the classes. The model, to be improved with the aid of more complex algorithms which need a higher number of observations, can however already be downloaded from the platform and implanted into the telecontrol system of the devices.

LORIS DI BATTISTA
IoT Specialist, MIPU

ENHANCE COLLECTED DATA TO GENERATE MORE PROFIT: THE CASE OF A COGENERATION PLANT

by MIPU

The biggest challenge cogeneration infrastructures have to face is the optimization of the production process of electrical and thermal energy; this means maximizing the production of electrical energy when thermal consumption decreases or vice versa, in order to sell electricity and heat (hot or cold) at the most advantageous price, keeping high the performance of the system.

In this case of study it will be shown how it is possible to optimize the management of a cogeneration plant with a triple purpose:

1. **Ensure to the users the necessary energy, when needed and at the best cost possible;**
2. **Intercept failures and waste at the beginning, optimizing the management of the assets;**
3. **Sell surplus at the best price, this means avoiding to produce excesses when the selling price is not interesting or coherent with regulatory constraints.**

Company setting

The client is an Italian society that manages cogeneration plants and gives into the market the excesses with respect to the needs of users. In the following example, we refer to a plant of 66 MW at the service of a series of commercial buildings.

Although there was already a DCS system able to acquire a wide range of meters from the field, the manager of the plant wanted to understand with precision if he was producing energy with the maximum efficiency. Particularly, the cost of energy is critical when the transfer price to the network decreases.

Solution

With MIPU's Rebecca platform data from the plant are collected both from the DCS system and directly from third-parties' sensors.

The objective is starting from the existing information assets, in order to simulate, through a series of cascading intelligences, the expected behaviour of the plant to changes in the requirements, operational conditions and health status of the machines.

Particularly, the elaborated algorithmic strategy allows to:

- Predict energy request from a building, as a function of parameters like the number of people present, internal and external temperature, radiation;
- Constantly control the performance of systems and assets, identifying failures and waste on the

basis of predictive maintenance models both on the primary system and on the secondary;
– Support the operator in deciding which is the optimal set-up of conduction of the plant as a function of the request from the building and the predicted selling price of energy to the network.

For example, it is possible to select the most convenient set-up of a system from the economic point of view; particularly the operator can choose if maximizing the production of electrical or thermal energy, on the basis of the price of electricity on the market or the request of heat by users (see Fig. 1).

The simulation takes in consideration every parameter able to affect the system; the results are compared in terms of cost, revenues and profits. During the simulation are also taken into account physical and operational constraints, such as the maximum number of starts and stops for the equipment or the minimum set-up allowed. Constraints such as white certificates can be added in order to make the simulation as precise as possible.

The functionality of remote management allows remote control of the platform, after a secure validation access.

Results

The collaboration model developed provides for a limited set-up fee and a split between MIPU and the client of the greatest benefit coming from the use of the system. This is calculated as the difference between the management of the plant in the three years before the introduction of the system and after then.

During the first years from the commissioning, the implemented solution generated a greatest benefit of 1,2 million euros, equal to an increase of 46% compared to the previous management.

The result is mainly due to the daily optimization of the production plan, in fact the system can combine operators' competences with a simulation system that calculates the profits of every possible scenario.

The real-time monitoring and diagnostic have helped to intercept loss of performances of the plant and to evaluate ex-ante the benefits coming from the substitution of the components. For example, it was possible to intercept a loss of performances of one of the steam generators, anticipating the maintenance intervention and avoiding a waste of resources estimated at 10 thousand euros per month.

Figure 1

"However beautiful the strategy,
you should occasionally look at the results"
Winston Churchill

THREE KEY WORDS OF PREDICTIVE PRODUCTION

by Giovanni Presti and Matteo Bissone

Industry 4.0 has emerged as the perfect scenario to increase the application of new artificial intelligence and machine learning solutions for monitoring and optimizing industrial processes. Additionally, the pandemic requires companies to accelerate their transition to resilient and predictive manufacturing. Below we explore what these two terms mean in detail and list a series of already industrialized examples in Italian companies we've been helping in their transformation.
The coronavirus pandemic is a humanitarian crisis that continues to tragically weigh on people's lives and that is shaping a new normal in several aspects: human, social and economic.

Focusing in particular on industrial production, the factors of greatest uncertainty that have emerged during these months for the industrial system are:

- the sudden disruption of supply chains due to lack of incoming flows of raw materials, components and semi-finished products with production losses up to the closure of companies;
- the change in consumer spending attitudes, both due to the contingency of the lockdown which led to the search for some products rather than others leading to concentrate spending on consumer goods and drastically reducing any type of investment in durable goods;
- the lack of liquidity and the uncertainty of the markets that led to limit long-term investments.

On the other hand, it cannot be denied that the pandemic also acts as a catalyst for change - economic, social, personal and corporate - on a scale never seen since the war.
Research and experience show that companies that operate with a continuous-cycle mindset will be in the best position to get out of the recession. In the 2007-2008 recessions, the top quintile of companies was about 20 percentage points ahead of their competitors as they recovered in terms of cumulative total return to shareholders (TRS). Eight years later, they had grown to over 150 percentage points.
For this reason we believe that, among the many aspects worthy of attention, the following should have priority on the agenda of every CEO and COO:

- **resilient manufacturing**: the ability to build a production capable of adapting to rapid market changes and coping with positive way to traumatic events - such as, for example, the lockdown from Covid-19 and its implications on the supply chain. We believe that the flexibility and agility characteristics not only of the single company, but also of the supply chain - taking up the example of the space challenger made by Giulia Baccarin in the introduction of this volume - must also guarantee a common level of reliability in each of its links.

- **predictive production**: the ability to exploit the data already collected in our dcs, scada, plc and in general from the field to feed intelligence that allows us to predict the near future and therefore reconfigure the present in light of new needs.

With regard to resilient manufacturing, we identify below what are the evaluation parameters and where MIPU has used AI to accelerate the transition (see Fig.1).

Speaking of predictive production, we note three fundamental pillars:

- **the forecast of production demand**, in order to save time on the organization of the same with the aim of optimizing costs, purchases of raw materials and in general the resources dedicated to this activity;
- **the prediction of the functioning of the machines** that guarantee the production itself. This forecast includes both the availability of machines and systems, and the processing efficiency, or the ratio between the total number of pieces produced and those theoretically producible;
- **the forecast of the quality of production**, connecting with not only to the correct functioning of the machine, but also to the correct management of the plants and to the control of the processing material.

Availability, efficiency and quality are in fact components of Overall Equipment Effectiveness (see Fig.2), a systemic indicator of production effectiveness. In the following we will explore production effectiveness, excluding for the sake of synthesis the forecast of demand.

However, we invite interested readers to write to us at fabbricapredittiva@mipu.eu for further material on the subject.

How can artificial intelligence help production become predictive?

We tried to compare a standard production system with one based on artificial intelligence (see Fig. 3). We'll introduce some simple examples of how AI

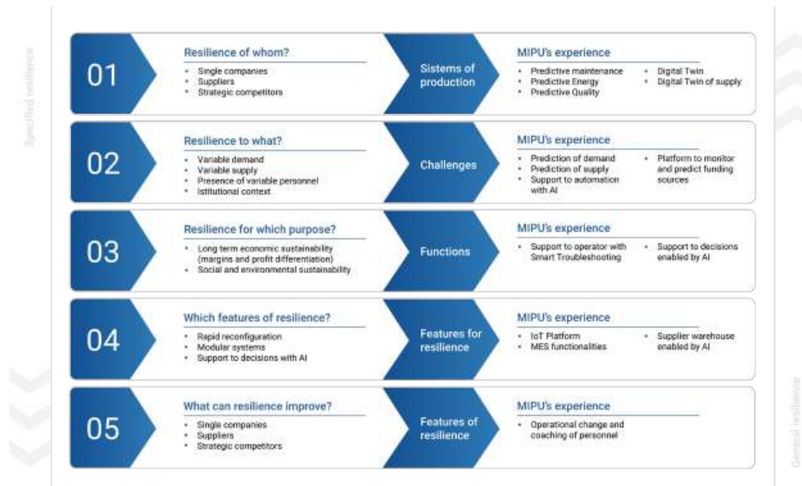


Figure 1

impacts the manufacturing process:

- **Setup:** we can improve the time it takes to set up or adapt the environment, lines and tools when a new work order arrives, considering the results of previous similar experiences. Being able to do

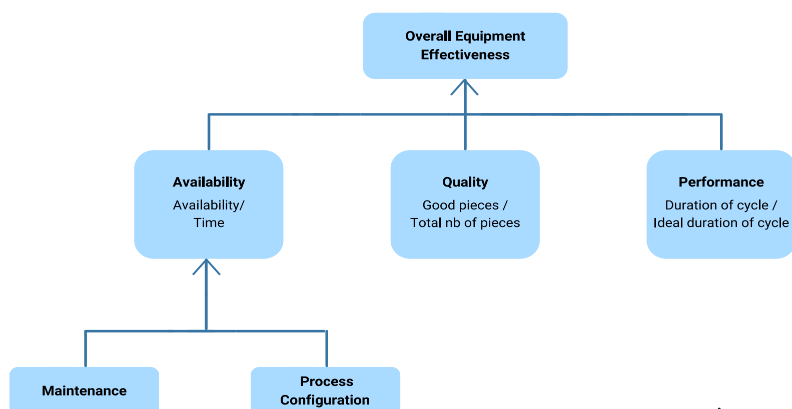


Figure 2

so in less time and more effectively, has an influence on the availability of assets and, consequently, improves the OEE.

- **Process deviations:** similarly, artificial intelligence enables quality prediction based on process parameters, which combined with real-time optimization of execution parameters, result in better quality results and reduced waste, again once, improving the OEE.
- **Maintenance:** predictive maintenance allows us to plan and supply the necessary spare parts in order to minimize the impact on production.

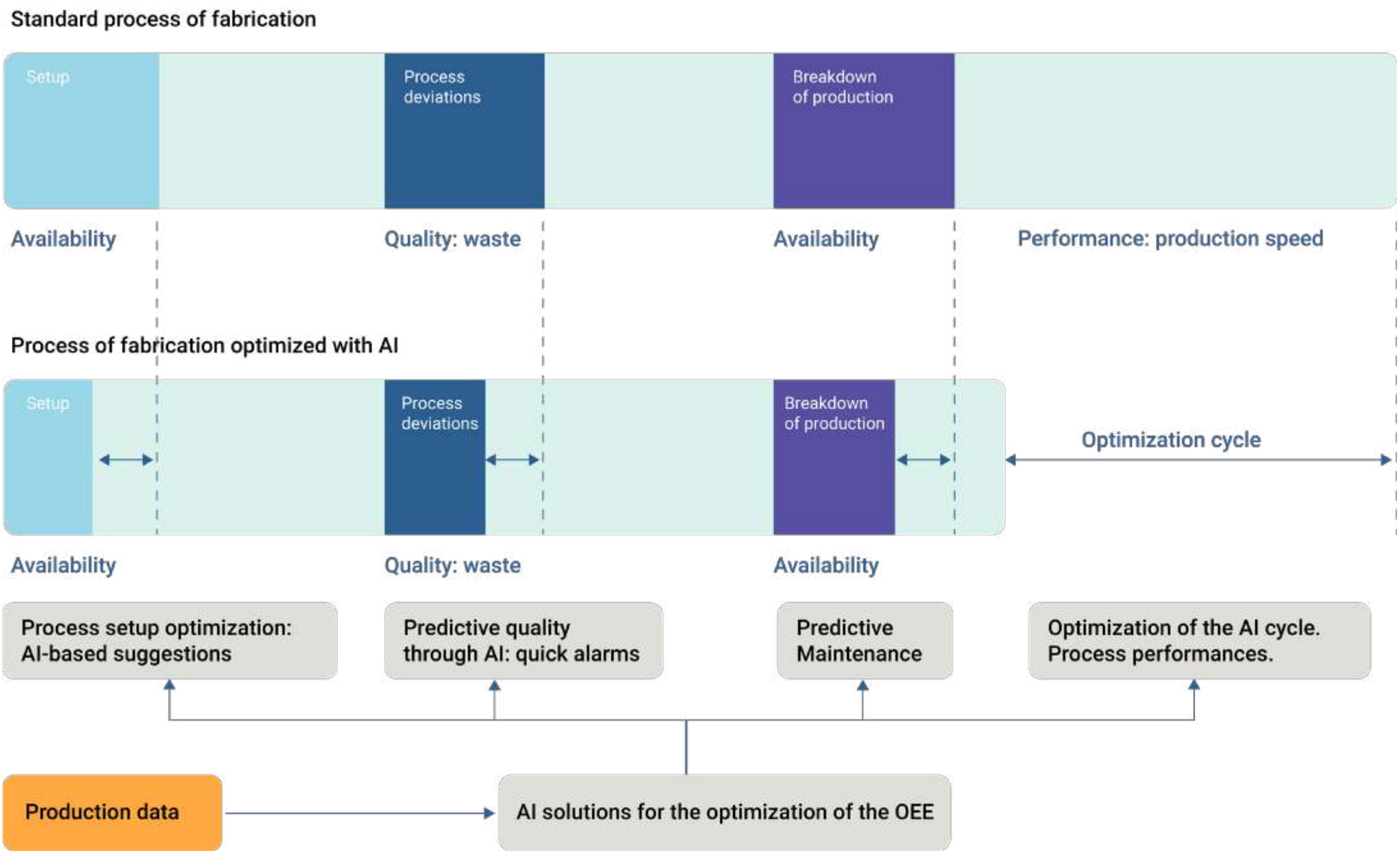


Figure 3

With this management we improve the availability and, consequently, also the OEE.

Other productivity indicators can also be very useful when evaluating a manufacturing process and analyzing how AI and ML solutions can deliver tangible benefits. In particular, as seen in Figure 4, we highlight through some examples, the fields in which the application of AI is particularly favorable:

Productivity indicators

– Good produced part / operator

An example that often happens to us is that of production or maintenance managers who ask: "I know that the AA operator will be more effective or, in the case of maintenance, more decisive, than the BB operator. I would like to understand what training, support or actively monitoring actions towards BB and when, to make it as effective as AA. "In other words, the CXO demands that artificial intelligence activate what behavioral economists and Nobel Thaler and Sunstein call "the nudge", a gentle push. With MIPU we have developed operator support solutions that, while respecting the individuality of each one, help to reach a common standard of effectiveness. We have replicated the same systems in the medical field, using the 'AI to activate actions (whatsapp messages, emails, phone calls from the doctor) that would support patients to be more compliant with the prescribed therapy.

– Good produced parts/total produced parts (rejects, configuration, tests, etc.): Continuous quality prediction at each stage of the production process by means of machine learning and artificial intelligence, applied on the data acquired online, allows for predictive alerts and alarms also before the target quality is affected and thus the OEE quality indicator is degraded. Two different approaches can be implemented when developing AI predictive quality tools: supervised and unsupervised solutions. Supervised solutions can provide better accuracy in predicting undesirable quality deviations, but a properly labeled dataset is required. Unsupervised methods have

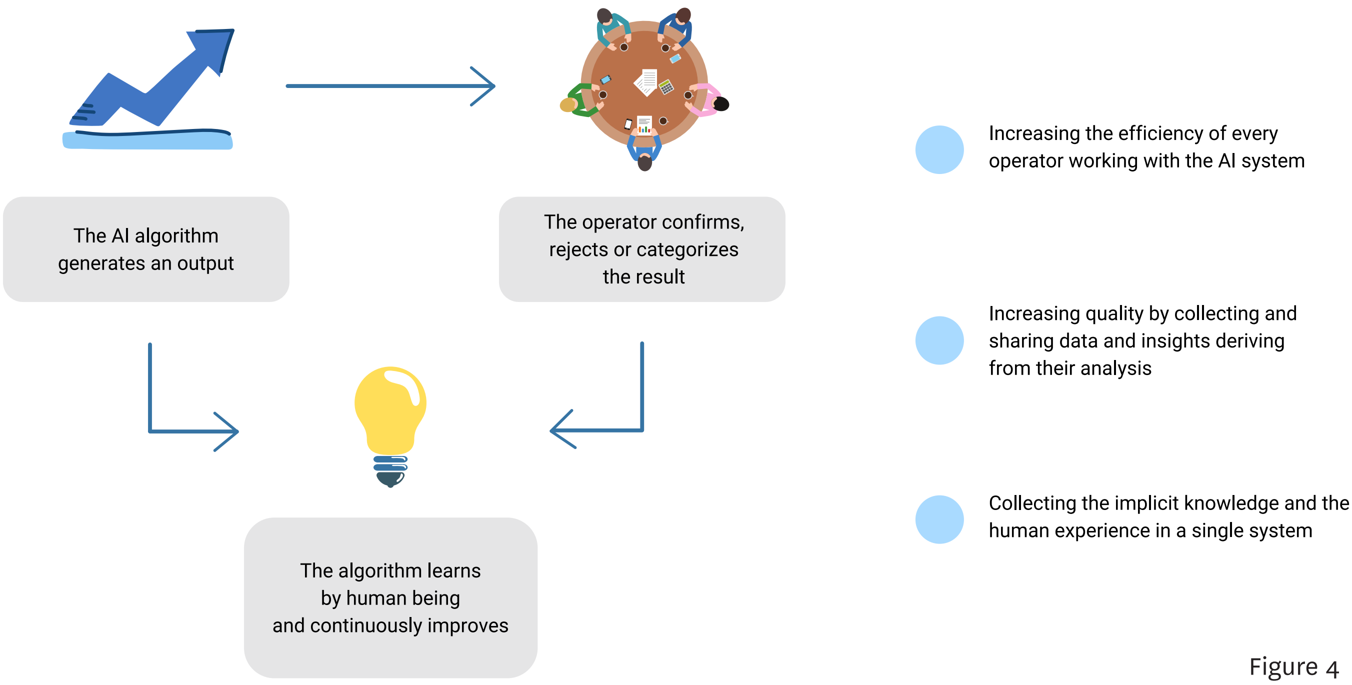


Figure 4

the advantage of not requiring the tagged dataset and are generally used for anomaly detection, which means large quality deviations. Additionally, the results of the supervised system can be tracked and analyzed to provide insight into processes that can lead to the discovery of solutions that help address the root cause of unwanted quality deviation.

Consumption indicators

– Material consumption (MC): weight of the material consumed per unit of time. There are many examples of AI use, in particular see the following examples relating to quality (lower consumption due to less waste) and energy (less use of raw materials). Other cases developed by us for the application of AI relating to the consumption of material concern:
  - use of machine learning and machine vision for inspection and characterization of return materials for reuse;
  - traceability of materials and components and support to operators in the enhancement of the circular economy, including cross-sectoral, with systems that, while respecting confidentiality, allow for the integration of information;
  - forecasting of reverse logistics and integrated logistics.
– Specific energy consumption: in this case we refer the discussion to the energy section of the volume.

Who has to build and manage the AI for production?

According to a Deloitte study, 91% of AI projects did not meet applicants' expectations. This is due to two reasons.
The first: suppose I want to determine if a problem will arise in one of the stages of a turbomachine and for what reason. The competence for this type of application typically lies with the manufacturer or who puts the machine into operation; however, AI is typically developed by data scientists who have hardly developed this type of experience and language.
The second reason is that, even assuming that artificial intelligence is built and is effective at zero moment, it needs to be continuously managed and trained to maintain performance over time or adapt to new expectations.
For these reasons we believe that the possibility of building and managing artificial intelligences should be extended to personnel dedicated to operations and maintenance (see Fig.5).

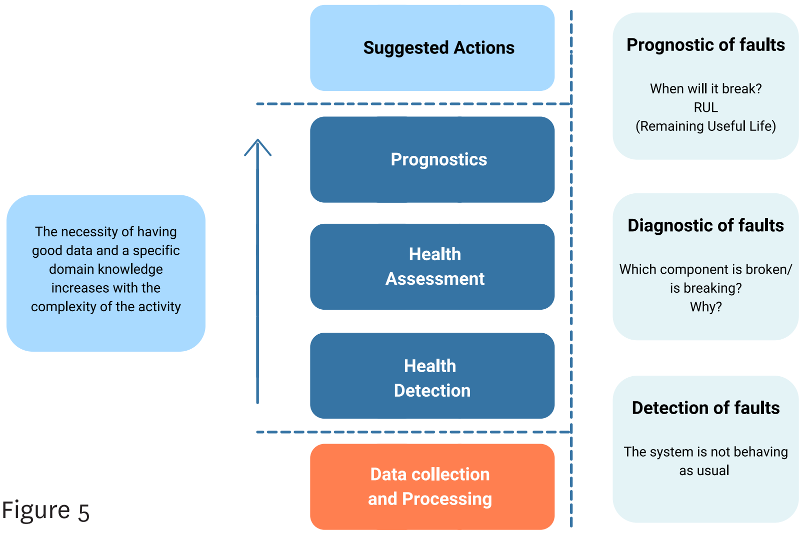


Figure 5

If it sounds utopian to you, let's think about the first websites for a moment. They were built by computer scientists with years of experience. Today, after the advent of what you see is what you get systems, no one would dream of identifying the key element in building a website in the computer code.

With the Rebecca software platform, MIPU has set out to reduce the cognitive effort, time, cost and risk of error inherent in the development and management of industrial AI.
On the one hand, in the Builder part, it supports the creation of AI without requiring computer skills: therefore, it is not necessary to know how to program in Python. On the other hand, in the part of Innest and Frame, the platform helps manage intelligences during their life cycle by monitoring who created them, when and where they were put into execution, if they maintain their performance or if they need to be retrained (see Fig.6).
Of course, those who are able to write code can insert it directly into the platform, without being bound to the algorithms already present: from this point of view, **Rebecca represents a meeting point between production staff, IT and data scientists.**
Today the value of a company on the market is given by the skills of the people, the assets owned and the financial resources; tomorrow these competitiveness drivers will be joined by artificial intelligence that the company has been able to build and maintain over time. A competitive

Workflow

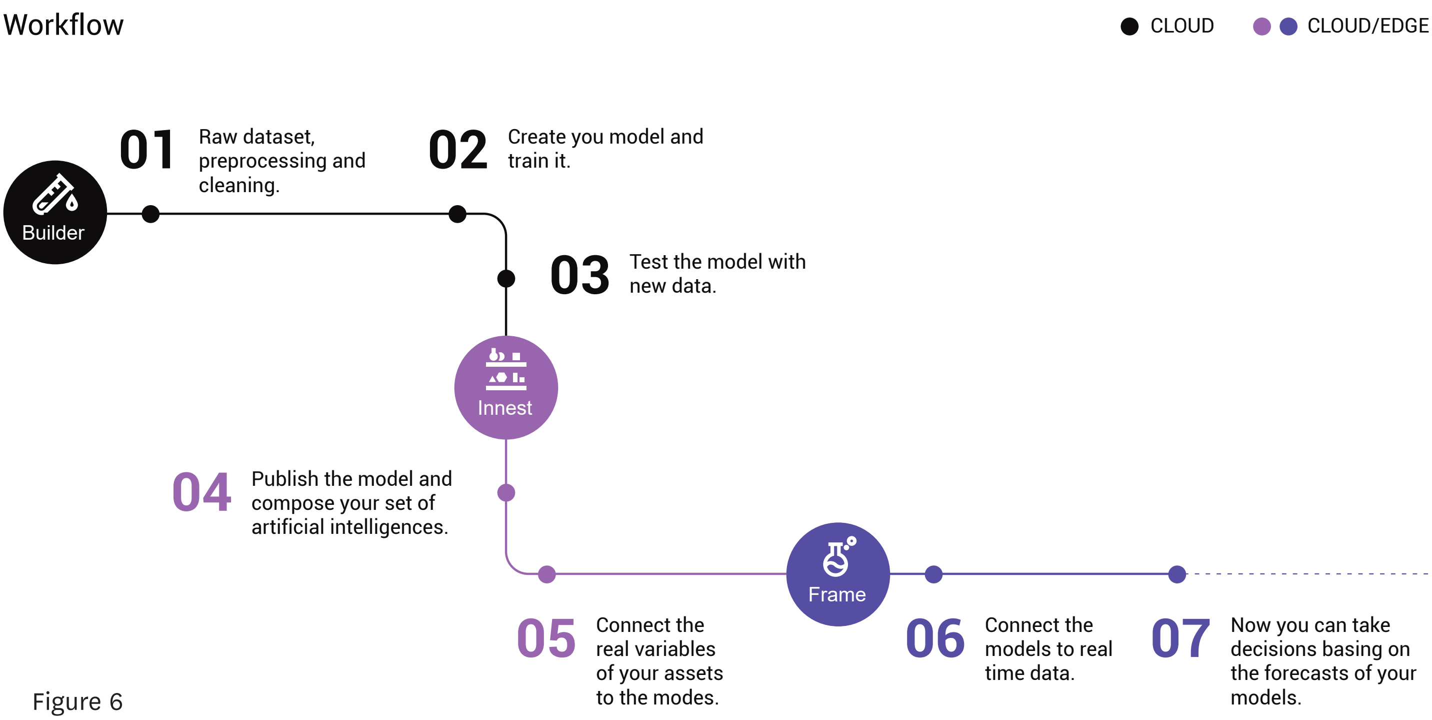


Figure 6

advantage that we must achieve in the short term, "whatever it takes"!

The pandemic has shown the need to think about new production methods, capable of making companies resilient and predictive. For the creation of a resilient company we have proposed a quick assessment on which every company should work; we have also listed the areas in which artificial intelligence can intervene. As for the predictive factory, we have indicated in the OEE a synthetic indicator to be monitored and listed concrete examples of the application of artificial intelligence to the improvement of each component of the same.

Finally, we express our wish for a company that extends as much as possible the opportunity to take part in the construction of industrial artificial intelligence to all its workers in a collective and participatory intelligence perspective, a real competitive key for the transition to the next- normal.

GIOVANNI PRESTI
Head of Product and Co-founder, MIPU

MATTEO BISSONE
Predictive Factory Advisor, MIPU

INTERVIEW WITH LUCIANO VESCOVI PRESIDENT, CONFINDUSTRIA VICENZA

A digital future awaits us. Being bold and steadfast, companies can accelerate their digital transformation and reach the next normal sooner. Focusing on the factory, which actions do you see as priorities?

Create a specific digital culture and, after that, to do continuous training. These are pre-requisites: they must come before or at least together with investments in technology. These are even more urgent actions as industries are not ready yet. I am talking about culture, a broad term, because we are not talking about pure technicality, but about a change of perspective, attitude, ways of organizing processes, working with people, managing spaces and times. The approach to what is one of the strong characteristics of Italian companies also totally changes: creativity. Italian companies are creators of solutions: this makes us great in the world. Digital offers new possibilities if it is a familiar field and not seen as a potential enemy. This type of culture can certainly be created in the company, but it must be developed above all starting from education. I am not saying to university, which I would take for granted, but precisely to compulsory schooling. I believe that the Government must give a strong push in this direction.

Despite all the efforts and significant achievements in many companies, the pandemic has highlighted the real vulnerability of our factories. Several companies have seen their online orders skyrocket only to see their operations plummet into chaos in an attempt to meet the demand. How widespread is the need to make our factories agile and resilient?

On agility in general terms, I must say that we don't have a lot to learn. If the so-called pocket multinationals have overcome the crisis of 2008 and, despite that are holding up in this period, it is because they are able to adapt to market demands very quickly. This is thanks to their skills and abilities, but also precisely to the fact that they are small and therefore potentially able to change with limited times and costs. If they have done it and often do it from a production and product point of view, perhaps organizational agility is more difficult. Here I am going back to the cultural theme: introducing, strongly, the theme of digital training to the whole of society can be a trigger to improve this aspect as well. Another accelerator can be, better it will be, the involvement of young people at higher levels. They must be given new responsibilities... of course, they must also demonstrate that they deserve them.

The increased digitization has also highlighted the growing importance of ecosystems. How does this trend fit into a national panorama of small and medium-sized companies? What are the main benefits and obstacles?

Businesses, at least those that I know better in the Northeast of Italy, were born and continue to operate in the districts. Vicenza, for example, is itself a widespread ecosystem of districts with an enormous variety if we consider that we export double the number of types of products compared to China. This is because we are an integral part of numerous European value chains: we are a fundamental ganglion of the industrial ecosystem of an entire continent. In this sense, large German or French companies, which are much larger than the average of Italian companies but are our main customers, often drive change and competitiveness in our districts as well. If a large German multinational implements a pushed digitization process, surely its entire supply chain will have to adapt and evolve with it. The optimal objective would be that this change was not forced from the outside, but was natural, perhaps anticipated by our SMEs. But even here, let's go back to my initial point: culture is needed. Investments are also needed and hence, the small size of companies is an obstacle that an ecosystem of business networks could also overcome. Unfortunately, speaking of our defects, we Italians are quite stubborns and coming together is not always an easy path. Having said that, pragmatism forces us to transform necessity into virtue. From our observatory, I can say that this beginning of 2021 I saw what I had never seen before: M&A operations.

PRODUCTION FORECAST IN THE FURNITURE INDUSTRY, A CHALLENGE OF MULTIPLE DIMENSIONS

by Giulia Rinchetti and Gaia Campanini

Italy is still today among the largest furniture exporters in the world and is the first in the top of the range, with a share of 30%[1].
In order to maintain a leadership position, however, it is no longer possible to rely only on design and creativity: customers want unique and quality workmanship, strong customization and - a fact taken for granted - absolute punctuality in delivery.
In the case below, **we have worked to support a luxury furniture manufacturer in refining its forecasts in three areas: market demand, production capacity and logistical needs.** To do this we have developed a plurality of models of artificial intelligences, as summarized in Figure 1.
Typically, when we talk about predictive production, we first imagine a better forecast of demand.

On the other hand, companies already collect demand data on a constant basis. Including such data into a machine learning algorithm can dramatically improve the quality of the prediction and characterize it in terms not only of volume, but also of what will be required, when and where. Thanks to this type of intelligence, it is possible to significantly reduce overproduction, both because I produce only what "will be desired", and because I produce it only when "it will be desired".
In the case developed by us, the inventory carrying cost, or the cost of managing and storing unsold products or products waiting to be sold, was reduced by 20% compared to the average of the 12 months prior to implementation of the solution.
A less explored area of work than that of demand forecasting is production planning. This is because, although there are numerous possibilities to examine any interruptions in production cycles or to consider the ways in which efficiency could have been improved, these do not always result in a single and correct answer. Training intelligences in this direction is therefore more challenging.

In particular, creating an engine to support the production planner's decisions means managing:
1. the availability of the machines and their arrangements;

1 Source: Altagamma Design Market Monitor, Bain & Company

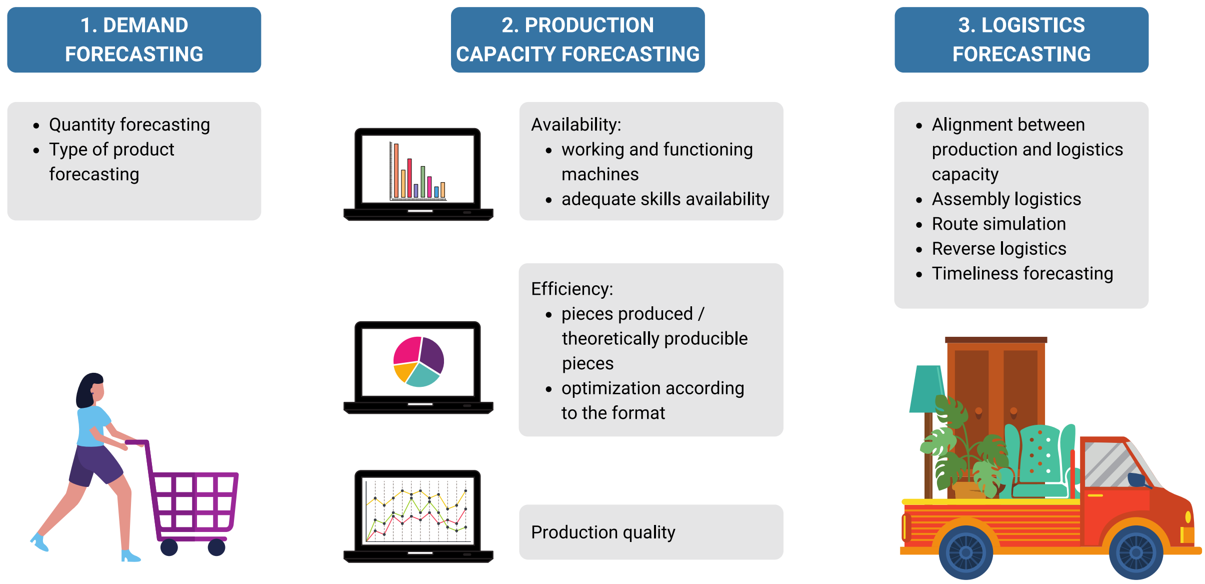


Figure 1

2. the availability of people and materials;
3. the response of production to demand, both in terms of volumes and product types.

The optimization engine manages the various scenarios and gives the planner the most suitable solution according to the constraints and conditions imposed. The planner can also simulate alternative scenarios, set new constraints or simply discard the proposed solution in favor of one it deems more adequate.
Quality has not been included in the project developed so far, which could however be counted as a further optimization criterion. Semi-finished products with quality defects that proceed along the production line are a problem that, if detected immediately, could have a positive impact on planning.
Finally, in the furniture industry, production and logistics are closely connected: an accurate forecast of production capacity results in the possibility of better managing the logistical needs, while predictive monitoring of quality has a direct impact on returns, which can be even reduced by 10%.
An accurate forecast of both production capacity and logistical needs allows for better transport planning, reducing the total cost and allowing for better contractual conditions in the case of reliance on external logistics operators. Depending on the specific initial situation, the economic benefits can fall within a range between 10%, when the logistics already has a good degree of optimization, and 60%, in the extreme cases where the logistics are not optimized at all.
The approach we use does not only focus on technologies and their possible results, but also and above all on people. A plan of this type cannot be separated from engagement and adoption that allow to reduce the organizational transformation time. Change management is done through internal communication, training and resistance management initiatives. In this specific case, remote training, individual coaching and a specific face-to-face business game were activated for the planning and scheduling phase. The game approach was appreciated by 93% of participants, against an average of 81% in other activities.

GIULIA RINCHETTI
Growth Hacker and Business Developer, MIPU

GAIA CAMPANINI
Predictive School Specialist, MIPU

EDISON: PREDICTIVE MAINTENANCE AND PERFORMANCE FORECASTING IN THERMAL POWER PLANTS

by Antonella Periti, Michele Corsi and Lorenzo Montelatici

Intercepting in time malfunctions and drops in performance of all the critical components of those plants that work continuously **can guarantee a reduction of downtime due to extraordinary maintenance activities and a more effective performance monitoring.**
Thanks to the use of machine learning algorithms, the “normal” behavior of all the critical plant variables can be estimated, highlighting every deviation well in advance, either it is due to a decline in performance for a non-optimal structure of the plant and due to the malfunction of its components.
Within these applications, particular attention is paid to the so-called “Early fault detection” techniques and to predictive maintenance applied to electrical production plants, both this production derives from renewable sources or thermal power plants.

Company setting

Edison is among the leading energy providers in Italy and Europe: it started its business 140 years ago and today it is one of the main Italian energy providers. Inspired by the sustainability and innovation principles, the company has been the key player in the electrification of the Italian energy system. Edison’s vision for 2030 is to establish itself as a **leader in the energy transition and as a responsible energy provider.**
Today, the progressive digitization of products and services, the growing attention to the environment and effects of climate change and the increasingly widespread sensitivity towards **more sustainable economic models** determine a **necessary evolution in the way of doing business.**
In this dynamic and constantly changing context, Edison has chosen to play an active role in supporting the energy transition and in energy production, investing in production both from renewable energies and through natural gas.
Moreover, thanks to digital development, Edison is also committed downstream of its value chain, offering its customers intelligent and competitive solutions, through efficient and innovative energy and environmental integrated services.

Needs

Edison is consistently investing in the development of machine learning solutions that guarantee a high-performance and reliable electricity production that is not

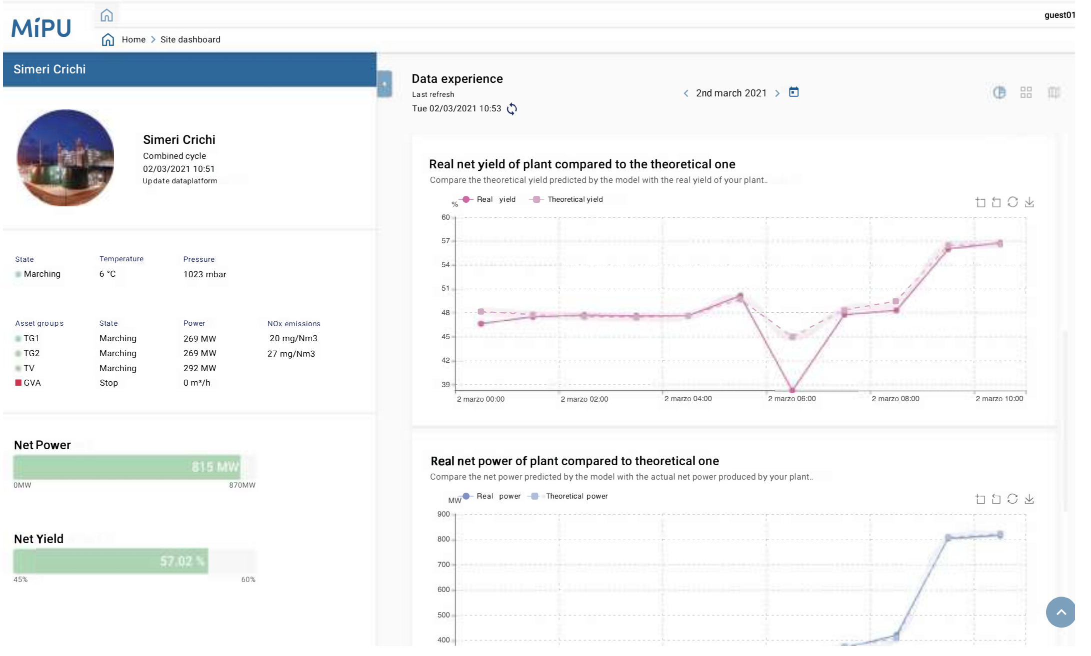


Figure 1

affected by unexpected failures of plant critical components. For several years they have been using machine learning models that support operators in evaluating the maximum power that can be produced by the plants, reducing the risk associated with the costs of imbalance linked to meteorological forecasting errors.

A further application area under development concerns the creation of models that allow for verifying that the system has the correct performance in all possible operating conditions. These are models that, trained on large amounts of historical data, reproduce the optimal trend of one or more critical plant variables, highlighting in real-time any operation deviations. Depending on the parameters reproduced by the models, **their use allows to intercept criticalities in the plant set-up or weak signals anticipating a component malfunction.**

For example, they belong to the first category all the errors in the control system of a wind power plant that require a remote intervention on the parameters of the software and that in most cases, once identified, lead to a rapid solution of the problem with a limited loss of production.

Still considering wind turbines, vibrations anomalous pattern, even if within the admissibility limits, can vice versa be precursors of core component criticalities, such as bearings, and therefore they can be used for direct preventive maintenance actions.

Models that highlight this type of alerts are defined as “early fault detection” models.

Also as part of the context of optimizing mizingwind and photovoltaic systems performance, we can mention production forecasting models. In this case too, these are machine learning models which, trained on historical production data and historical data of weather forecasts, are able to accurately predict the production of the renewable plants for the following days.

These forecasts have several applications: in this way **they allow an optimal production management on the energy market, an optimal electricity network management and they allow for planning maintenance actions during lower production times. Therefore, lost production due to unavailability is limited.** Finally, there are the **“predictive maintenance” models** which, on the basis of the alert signals and the historical malfunction data statistics, **make it possible to estimate the remaining useful life or the missing time before a probable breakup of the investigated component.**

In the following is detailed how models of these types have been successfully applied in the thermoelectric field with regard to performance and early fault detection issues.

This information enables you to plan maintenance activities in order to maximize the value generated by the asset.

Solution

Edison's thermal power park, consisting of combined cycle power plants fueled by natural gas, is able to support power generation from renewable sources in a safe and reliable way. Therefore, it represents a strategic asset in the challenge of the energy transition.

With a view to continuously improving the monitoring of plant operations, Edison has decided to implement a system for verifying the performance and predictive maintenance of its main assets. This system is based on machine learning solutions that constantly check the critical factors of all the thermoelectric plants.

The project lasted about nine months during which 30 artificial intelligence models have been developed on a pilot plant capable of replicating for each the normal behavior of a specific critical plant variable. For example, the overall efficiency of the power plant, the vibrational behavior of turbine bearings (see Fig. 1 and 2) and the performance of the cooling towers.

Thanks to an "agile" design method, it has been possible to work iteratively and incrementally on the development of the solution. This working method has allowed a continuous interaction during all the project phases among the various participants, enabling to pool the skills of business users, analysts and experts from the various ICT domains and data scientists.

The first phase of the project has involved the analysis of available data: the plant has been divided in its main assets (gas turbines, steam turbines, steam generators and cooling systems) and for each of them the most descriptive variables of the physics of the processes to be monitored have been selected. This has been done by leveraging Edison's business process know-how and the data knowledge.

The architectural solution (with the different technological components) **and the identification of the variables useful for powering the models represent the most onerous activities of the design phases of the overall solution.**

During the exploration phase, **the qualitative and quantitative correlation among the electrical, mechanical and thermodynamic process parameters over time has been deepened.** This data is collected in real time from the field through an IoT acquisition system, then it is stored in Edison's Enterprise Data Platform

INTERVIEW WITH NICOLA MONTI CEO, EDISON

What impact will predictive techniques have in the energy sector?

Predictive techniques and artificial intelligence are extremely important to the energy sector and for this reason they are already widely spread. For example, I refer to the possibility to optimize the wind energy production process: the use of machine learning models powered with weather data makes production forecasts more and more accurate. The same happens in the photovoltaic sector. Generally, we could say that the dramatic increase in forecasting accuracy has a disruptive impact for our sector, facilitating the balancing of the electricity grid and therefore allowing a greater diffusion of these renewable technologies on the electricity network.

Talking about data enhancement, what are Edison's priorities?

Our roadmap is very broad and articulated. However, I want to emphasize two needs: the first one is to integrate on all levels the benefits deriving from predictive techniques and artificial intelligence. For example, in the case of predictive maintenance, the goal is to work not only on the most critical machines, but to extend our range of action to plant secondary components as well. The more the intelligences are spread, the greater they will be the benefits. This process is valid not only for the plants, but also for the whole company. We want to spread the new data enhancement technologies in all company functions. We have been equipped with an Enterprise Data Platform for more than a year: it is a company "data lake" that will progressively contain all company data to facilitate the use. This pervasiveness provides a change, also a cultural one, that will see us involved in the coming years.

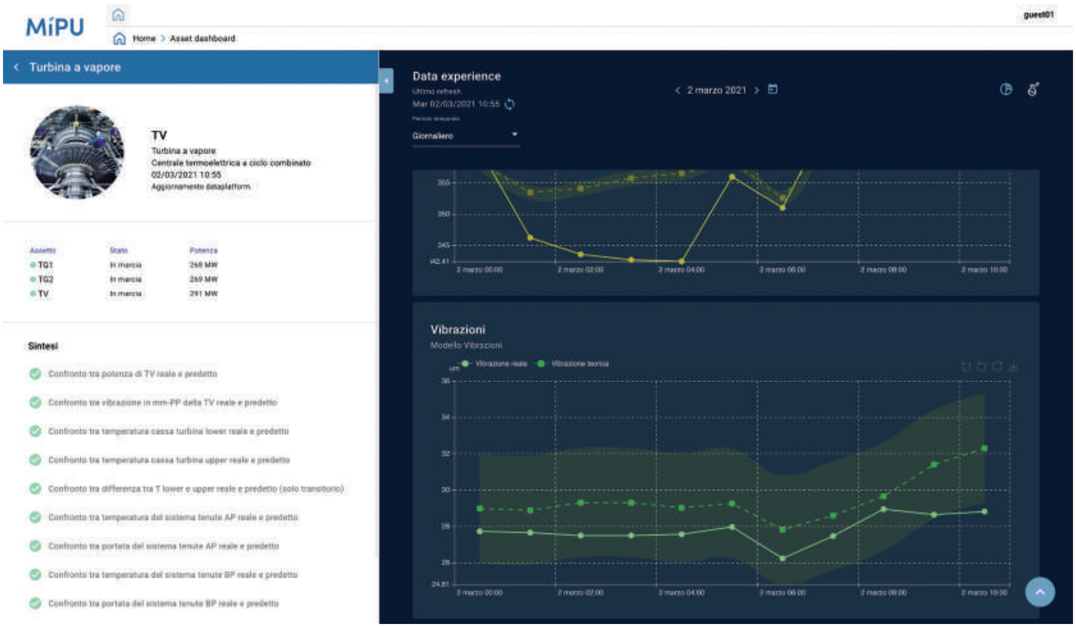


Figure 2

and made available to the subsequent analysis phases.

Therefore, for each macro-section of the plant, one or more specific models have been designed and trained on the operating historical data. For each model, according to a typical machine learning approach, various algorithms have been tested in order to identify the solution that best represents the monitored phenomenon. In particular, **the quality of each model has been assessed through the ability of each of them to intercept changes in behavior from a maintenance or process point of view.**

The operating data of the pilot plant, as well as the results of the models, are available through a series of dashboards on a dedicated cloud platform.

This platform also enables you to maintain artificial intelligence algorithms: actually, it is possible to deepen the performance of the individual models and evaluate the need for a re-training based on the most recent operating data, even following changes in the system configuration or its operating mode.

From the platform user's point of view, the presence of a complete set of models **enables cross-checking and therefore it facilitates the identification of an anomaly cause,** considering not only the behavior of the specific asset, but also of the components connected to it.

All the tools developed represent an effective support to normal plant management activities and they can provide useful information for planning maintenance interventions.

Taking into account the positive results achieved on the first pilot plant, today the model application extension is involving additional plants of Edison's thermoelectric park.

On the same models development and management platform, the main Enterprise Asset Management functions are being implemented which will benefit from possible bilateral synergies between the results of the predictive maintenance models and the scheduling of maintenance interventions.

ANTONELLA PERITI
ICT Demand & Delivery Manager, Edison Spa

MICHELE CORSI
Head of Thermo Mechanical Technologies and Technical Services, Edison Spa

LORENZO MONTELATICI
Head of Datalab, Edison Spa

PRODUCT QUALITY PREDICTION AND OPTIMIZATION IN THE STEEL PRODUCTION

by Luca Girelli

Steel production is a complex process, from the choice of materials to be melted to the final product. Liquid metal, in fact, undergoes different transformations and processing at high energy consumption. (see Fig. 1).

Rapid identification of defects

During the process quality problems may occur such as cracks or superficial defects of material which are due to deviations from optimal conditions.

There are many reasons why these quality problems occur. Each stage of the steel processing must be monitored in a precise way in terms of processing conditions (temperature, casting speed, cooling capacity), because slight deviations can bring defects in the product. These conditions can vary from a structure to another and so they require deep and specific domain competences.

In the production chain it is therefore crucial to identify the occurrence of a non-compliance as soon as possible, avoiding in this way that a defective product proceeds through the remaining stages of production. The application of Rebecca AI has been fundamental during the conduction

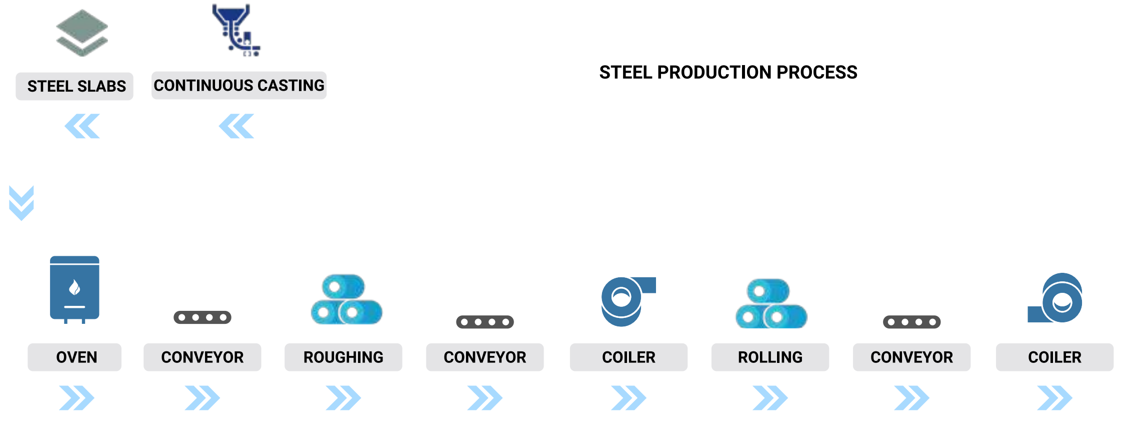


Figure 1

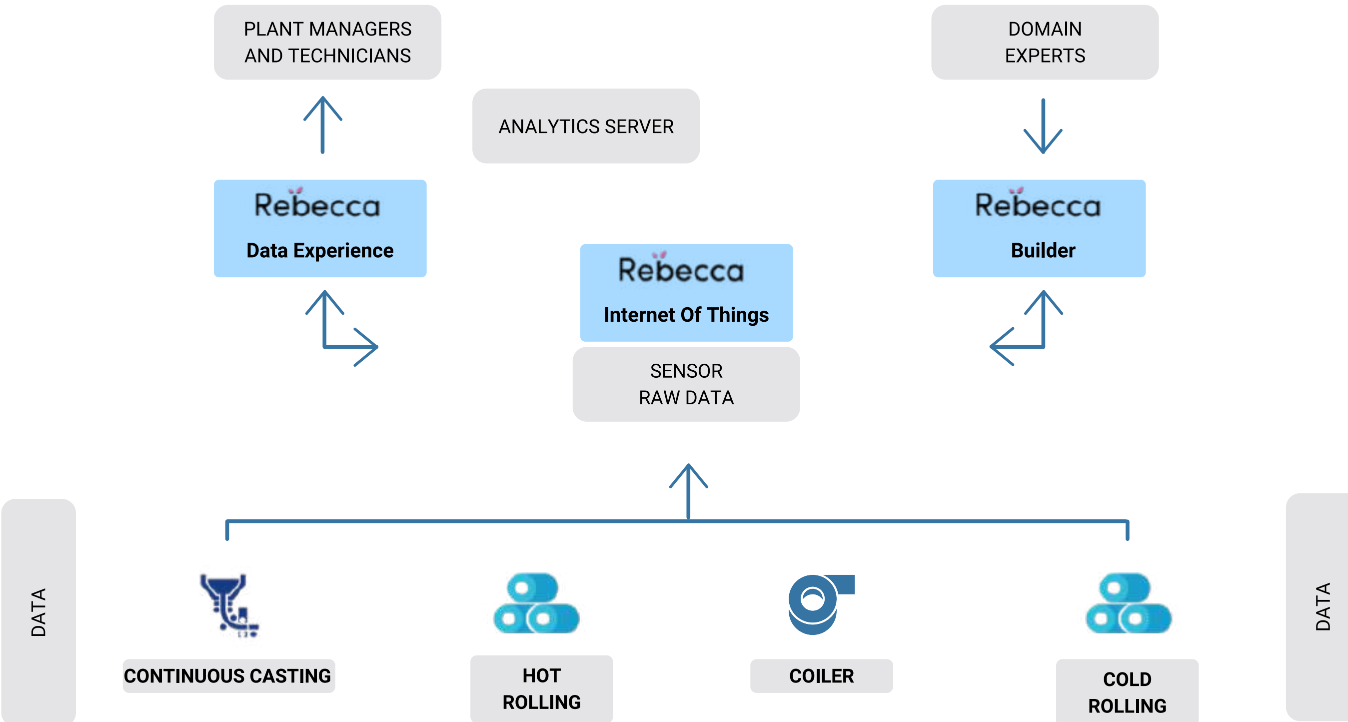


Figure 2

of the analysis of time series of data and the prediction of defects in the first stages of the production process.

The challenges of data science

Governance of data

Hundreds of sensors on the production line, a high volume of raw data hard to archive, transform and recover every day in a favourable environment for data science. To ensure optimal results, the design of the structure of data able to keep track of the quality of material during the entire process of production is necessary in this application.

Unstructured data, insufficient labels

Metallurgical and chemical processes tend to create data which often requires a lot of cleaning and normalization before being used for the creation of machine learning models. Thanks to the Builder module and to the features of Auto-ML di Rebecca AI, these pre-elaborations are made with a time 5,5 times less than what would have happened without the software.

Too many process variables

The process of heavy industry, including steel production, is characterized by an elevated number of variables: the final product, in this case coils of rolled steel, is not always the same but varies in dimensions and physical properties depending on the application.

This adds a layer of complexity to the already hard challenge to train intelligences to recognize defects and to apply the results to machine learning in order to identify them since the first stages of the process. (see Fig. 2).

Solution

The solution consists of three main stages:

1. governance of the data: from the acquisition to historicizing, from cleaning to validation of data;
2. pre-processing of the data: creation of the algorithmic and training strategy;
3. industrialization of created intelligences and deployments (see Fig. 3).

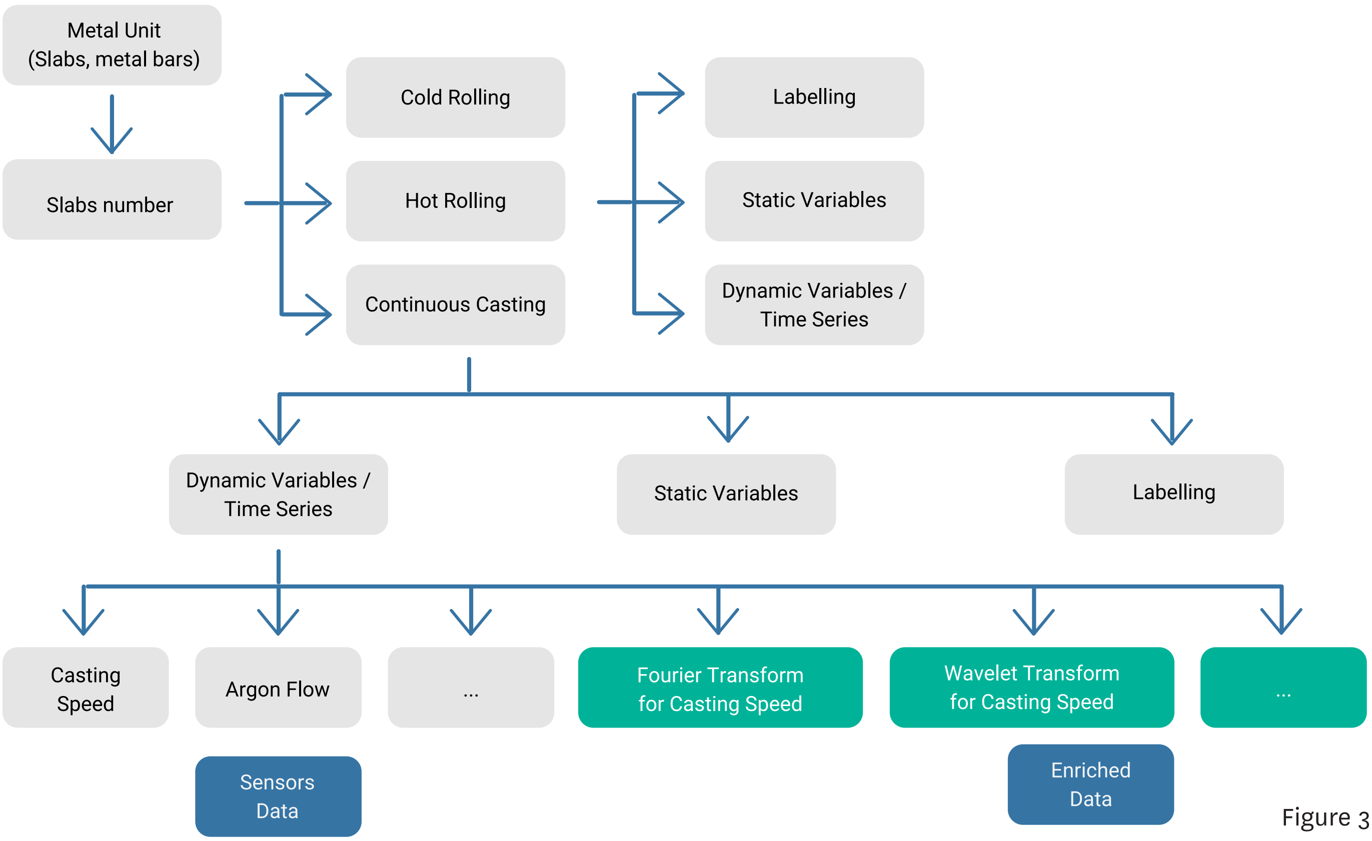


Figure 3

During the phase of governance of the data have been:
- included missing values and normalized data ranges with the functionalities of Anomaly Detection included in the platform;
- combined times series and statistic variables to represent training samples of thousands of slabs in different conditions;
- included 70 statistical variables and 125 dynamic variables.

Predictive algorithms created are also able to:
- detect abnormal behaviours about variables of the casting process;
- improve of 20% the rate of defects prediction compared to statistical methods previously used, drastically decreasing working hours spent on the analysis.

Intelligences have been created through the platform Rebecca AI collecting the contribution of all the stakeholders since, thanks to the auto-ml modules, with Rebecca AI it is not necessary to write the code.
The creation of a "knowledge model" easy to visualize, share and improve from the experts of process, of quality control and statistics will lead to further progresses in this type of analysis.

LUCA GIRELLI
Asset Reliability Advisor, MIPU

QUALITY OF WASTE WATER: CAN ARTIFICIAL INTELLIGENCE REALLY PROTECT US?

by Giulia Baccarin and Veronica Brizzi

Wastewater treatment plants live and die because of bacteria. “Good” bacteria are necessary to treat waste water in an efficient and safe way, while “bad” bacteria have to be avoided because they could affect the plant and contaminate the environment, if discharged.

In order to supply a reliable tool for the monitoring of the quality of wastewater,
MIPU developed an integrated solution in Rebecca AI for prediction of the quality of influence and decision support to operators who manage the sewage treatment plant.

Over the last years more stringent limits and regulations have been implemented for water waste affluents,, so that the negative impact on water bodies and environment is reduced. If accidentally discharged from a treatment plant, contaminated water could have a devastating effect on fisheries, wildlife habitats and our health. These are the reasons required to plant managers and operators an important commitment to ensure safe, efficient and conform treatment operations.

Not a trivial challenge, considering that actually methods of tests of the levels and types of bacteria are expensive and costly in terms of resources and time.

Solution

The wastewater treatment system is a system characterized by non-linear behaviour and subjected to significant disturbances in the flow rate and composition of entering water.

The most common technology for the treatment of wastewater is the process of activated sludge (ASP), whose simplified flowchart is shown in figure 1.

The performance of the plant is evaluated through the ability to keep pollutants – like for example ammoniacal nitrogen, total nitrogen and suspended solid effluent – within the required limits. Although quality index can be measured through laboratory analysis, a significant time delay is inevitable – from a few minutes to some days - in the identification of deviations.

Therefore, an online prevision model is essential to promptly manage any discrepancies. Moreover, the possibility to predict which will be

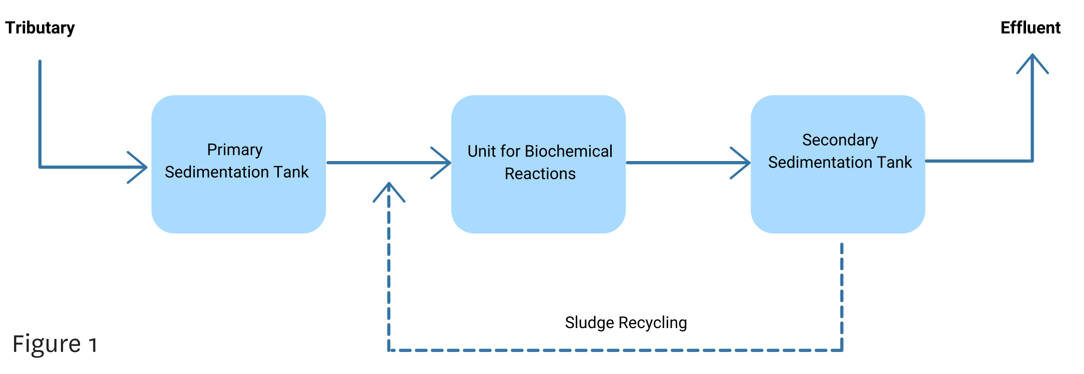


Figure 1

the existing quality makes it possible to module the presence of “good bacteria” in the sludge to vary the influent’s quality to a decided target. **The presented solution has therefore a dual purpose: the first intelligence aims to predict the exact quantity of ammonical nitrogen effluent (SNH); the second aims to support operators in the choice of the best “recipe” for the sewage treatment plant.**

The main challenges to arrive to the solutions were:
- the selection of the main variables of the process;
- the construction of the collection structure of data;
- the implementation of a decision support model.

Predictive intelligence

On the basis of the detailed analysis of plant processes, supported by the experience of expert workforce, five variables of process have been chosen as input parameters (see Fig. 2).

VARIABLES	UNIT
SPO_4 (total forsphor)	mg/L
ORP (oxidation reduction potential)	-
SO_2 (dissolved oxygen)	mg/L
TSS (total suspended solid)	mg/L
PH	-

Figure 2

All data are collected on a daily basis and cover all four seasons. The hourly rate is considered difficult because of the long residence time in the sewage treatment plant. Data are collected from the supervision system of the plants and processed in the Rebecca platform of MIPU.
The most appropriate algorithmic strategy, created by MIPU’s data scientists with process experts, provides for the creation of a recursive neural, a tool that has the ability to model a non-linear complex system and provides variations of a specific parameter depending on the conditions and other input variables.
The intelligence created predicts the amount of nitrogen ammoniacal effluent with an average accuracy of more than 97%.
After predicting affluent quality, the objective is supporting operators in the decision of the best strategy both in terms of plant regulations and bacterial recipe most appropriate to reach a certain quality of wastewater.
The objective is reached thanks to a simulation engine able to calculate 1096 scenarios and present to operators the best regulation, eventually considering constraints that can also be set manually.
Even in this occasion artificial intelligence proves to be extremely efficient in supporting human beings through a safer and more sustainable life.

GIULIA BACCARIN
CEO and Co-Founder, MIPU

VERONICA BRIZZI
Industrial AI Advisor, MIPU

UNICREDIT: THE PREDICTIVE BRANCH

by Marco Coggi and Salvatore Greco

Company setting

UniCredit is a successful pan-European commercial bank, with a fully integrated Corporation & Investment Banking division and a unique Western, Central and Eastern European network available to its large customer base.

UniCredit offers a competent service to the international and local network, with unrivaled access to leading banks in 13 main markets thanks to its European banking network. With an international network of representative offices and branches, UniCredit serves clients in 16 other countries

In UniCredit, the structure of Real Estate Italy, manages the entire life cycle of the instrumental real estate assets for over 2500 properties and two million square meters, distributed throughout the national territory.

Within the complex activity managed by the Real Estate structure, **digital innovation has over time played a crucial role in the evolution of the organizational and service model.** In relation to the properties managed in Italy, **UniCredit has experimented with new technologies in order to achieve the objectives focused on three main directions:**

- **excel in the execution of real estate interventions and activities,** by monitoring and optimizing operational costs and risks;
- **be a business partner, in the design and construction of the bank of the future;**
- **create sustainable value in line with the UniCredit Group's ESG strategies.**

Thanks to the investments made in recent years, Uni-Credit Real Estate has a huge amount of data relating to the real estate assets: they outline a complete and immediate overview of how the systems are used and maintained. Through the use of new technologies, analysis tools and data visualization, **the bank has placed data at the center of its analysis, both within the decision-making process, and in the definition and monitoring of strategies, in the short and in the long run.**

Starting from 2016, UniCredit initiated this data driven revolution with a path that involved the entire property management and maintenance process.

Project

Starting from the census of existing assets, which also included the position and technical specifications of all the assets present inside the instrumental buildings (office and branch), **NFC "tag" sensors have been applied, through which it is possible to automatically update the status of the assets and generate automatic work orders for the maintenance staff.**

Subsequently, investments were made in the development of a mobile application to manage ordinary maintenance and repairs: technical personnel were inabled to register assets during interventions and to make changes in real time in case of replacements or updates of assets.

Work orders, especially for scheduled maintenance required by the technical specifications and requests for intervention by users, **can be viewed in real time on the application under management to the contractor, whose work rate is monitored through specific KPIs that take into account the actual final balance of the interventions on site according to the times and methods provided for in the contract.**

At the same time, the Building Managers, who are responsible for coordinating Facility Management activities, through the same application, **have the ability to both monitor in real time the maintenance status of the individual items, and to carry out specific surveys by filling in digital checklists, which continuously enrich the wealth of data available to ensure data-driven decisions to be included in extraordinary maintenance plans.**

UniCredit can boast the ability to apply the data driven approach to business intelligence tools to analyze and monitor usage of the spaces, the maintenance of the systems, the budget of expenditure, the planning of interventions on buildings, the research of risks, the levels of service and the causes of malfunctioning of ATM machines, energy consumption, the real estate portfolio and the financial actions taken, as well as the performance of suppliers. **This approach, which is based on tools, methodologies and above all culture and resources, has raised the level of service with a reduction in costs and has allowed the Top Management to take strategic choices oriented towards the evolutionary challenges of the coming years, such as the definition of future workplaces or ESG Real Estate strategies for the next few years.**

The specialization and competence of the team represent for UniCredit the key points for the success of the entire strategy. For the implementation of the new tools an "upskilling" path was undertaken based on the knowledge and use of data with dedicated courses for different levels of in-depth study and tailor made specialization.

The knowledge and expertise of the resources was enhanced both as individuals and as teams, including cross-functional ones, through the use of tools that allowed a fluid and structured discussion on data. This has allowed us to save time and identify new best practices and make the management of our services more efficient and responsible.

A team was also organized dedicated to the scouting of new technologies such as detection sensors for the use of space or energy consumption and applications such as management apps that can be integrated into our platforms, in order to expand knowledge and enrich the wealth of available data.

At the same time, a team dedicated to the creation of Business Intelligence dashboards helped the analysis of all the different events continuously evolving.

Solution

In this context, we activated a project with MIPU at the Italian Headquarters of UniCredit: we aimed at introducing predictive maintenance algorithms to improve the level of service, optimize costs and reduce the risk of plant unavailability.

Other objectives were also to increase the perceived quality of the building users and to review the

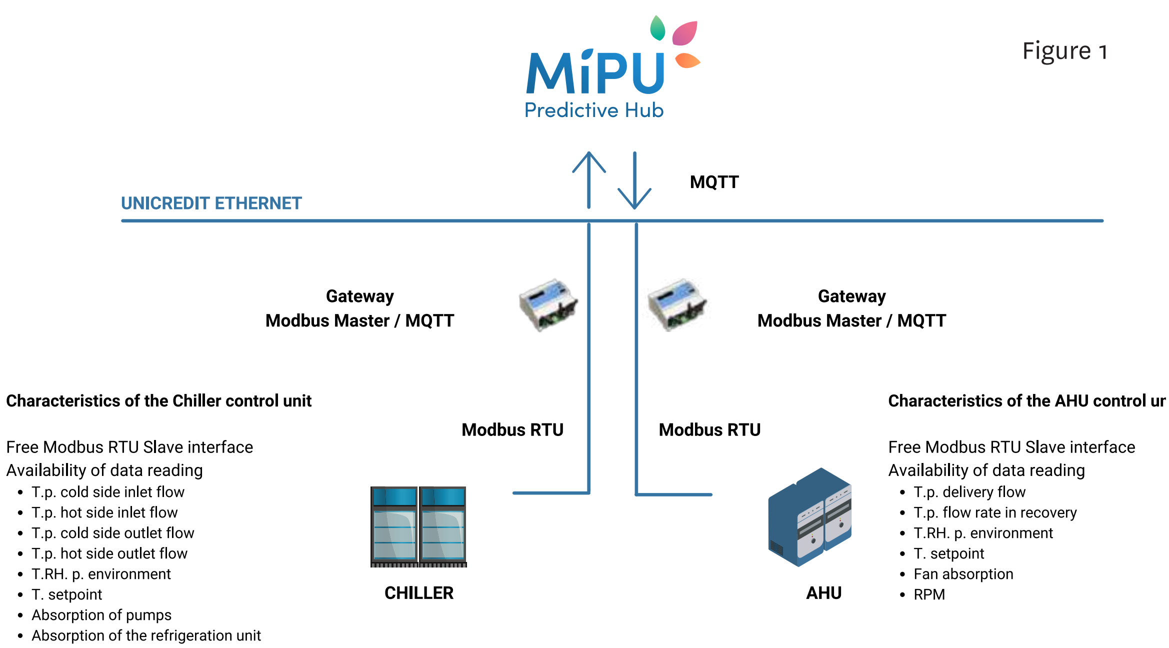


Figure 1

management of maintenance work orders, providing maintenance interventions on condition and not according to a predefined schedule.

This project represents the first step to implement a profound review of service contracts towards a "pay per use" vision and go as far as the potential cancellation of predefined fees.

Thanks to the gradual introduction of assets already connected to maintenance management systems – able to independently send reports in the event of malfunctions – it will be possible to foresee emergencies and failures, reducing resolution times and improving service levels and consequent "user-experience" within the bank spaces.

In conclusion, the data driven approach and digital evolution represent "a real future" to be faced with responsibility: the collection of data must be efficient and organized, dashboards and data visualization tools in continuous evolution and enrichment, educated and powered algorithms in order to help top management make strategic and operational decisions.

MARCO COGGI
Head of Real Estate and Logistic Italy, UniCredit

SALVATORE GRECO
Head of Group Real Estate, UniCredit

ENERGY AS SIGNAL FOR THE PREDICTION OF PHENOMENA

by Vito Introna

Industrial companies have committed in the improvement of their performances since years, not only from an economic point of view but also from the point of view of sustainability, with particular attention to environmental aspects. In this scenario, **energy consumption is becoming increasingly important as it affects economic and environmental performances.**

This has led to a significant development of systems to measure energy usage within industrial plants, not only for the plant in general but also at the level of individual production lines and machinery. Energy consumption data are usually compared to the result of the monitored process in order to define energy performance indicators useful to monitor the achievement of corporate objectives or projects of energy efficiency. The knowledge about energy data is thus leveraged only for the final balance, while its potential of detecting issues like faults is overlooked.

In fact, for a process of energy transformation, **the amount of energy required to achieve a given output under defined operating conditions measures the energy impact of a process. Thus, it is a "weak" signal that can be used to identify potential anomalies and failures in process and that can support the definition of optimal maintenance plans** like on-condition maintenance or predictive maintenance.

By monitoring the energy consumption of a plant or of an equipment, it is possible to predict a failure in a system before it occurs, avoiding direct and indirect issues and even more energy consumption.

Condition based maintenance is nothing new for sure, nor predictive maintenance and they are both used in industrial operations since years. Moreover, many of these approaches allow us to detect anomalies much before the analysis of energy data does. So why should we use energy for it?

The reasons are two:

- **Alternative approaches can be expensive** (i.e. vibration analysis due to the cost of sensors, thermography due to the many necessary inspections). They are not convenient for some types of machinery or plants, while energy meters are less expensive and usually available as installed for other purposes;
- Alternative approaches are usually targeted to specifically avoid faults and their consequences, while **by knowing the impact of a fault on energy consumption it is possible to make decisions that take into consideration energy costs and sustainability:** for faults with progressive degradation, the energy consumed during the time span of the fault development is considerably higher than the cost of intervention.

The use of energy as weak signal for the optimization of maintenance operations in industrial systems, leads us to new scenarios. It is therefore necessary to deepen two main aspects:

- How to switch from the analysis of energy con sumption, influenced by production volumes (such as production volumes of a machinery or volume of cool water for a chiller) and operative conditions (such as process parameters for a ma-

chinery or set point temperature for the chiller water) to the analysis of energy performance, the only true indicator of a system's health status?
- Which are the possible applications of the analysis of energy performances to improve maintenance strategies in industrial plants?

We are trying to answer these questions in the next paragraphs.

From the analysis of energy consumption to the analysis of energy performance

The first fundamental step is the preparation of a monitoring and control system for energy consumption targeted to data collection, analysis and reports about the usage of energy. The goal is to monitor energy consumption and to identify opportunities for improvement.
The goal of monitoring and control is to compare energy consumption with the variables that have an impact on it, depending on operative conditions (i.e., the external temperature, the parameters used as set points, the out of control parameters so to obtain a precise comprehension of the way the system consumes energy, the so called **energy baseline** (see Fig. 1).
The monitoring system can be applied to the entire plant/department or to a single machinery/line. Obviously, by observing the individual elements of the system, it will be easier to understand phenomena and detect anomalies, faults and the necessary actions to restore the system.

In order to implement a monitoring and control system for energy consumption, it is possible to follow these steps:

1. Consumption data collection and analysis

To set up the monitoring system, it is essential to measure energy consumption. It is also important to measure **the relevant variables of the system,** meaning those elements affecting energy consumption and subject to a significant variance over time.
Figure 2 shows some examples of relevant variables and static parameters.
It is necessary to select and measure also the static parameters, the operative variables that could likely affect consumption but that are usually kept at a stable set point (it is the case of the steam pressure generated by a boiler, the temperature of the cold water generated from a refrigerator or the speed of a machinery). These variables will not be included in the baseline, it is therefore important to remember that their variation will be reported as an anomaly from the monitoring system. The frequency of data collection and analysis could vary from month to week, from day to hour.
As the frequency of data collection increases, it is possible to observe and analyze phenomena with different consumption and evolution time scales.

Figure 1

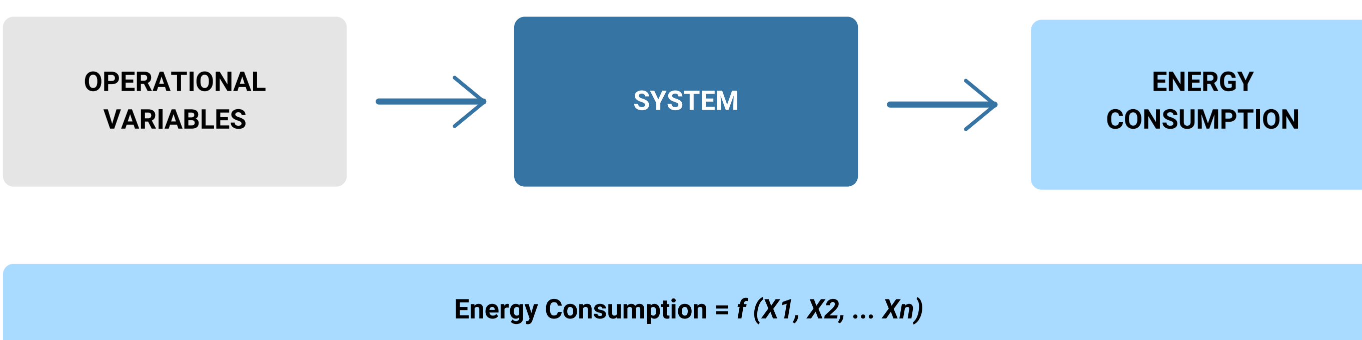


Figure 2

Process	Energy	Relevant Variables	Static Factors
Industrial steam generation	Fuel (e.g. gas)	Quantity of steam produced	Steam pressure and temperature
Compressed air production	Electricity	Quantity of compressed air, outside air temperature	Air pressure
Heating	Fuel (or hot water / steam)	Degrees, humidity	Number of hour changes
Production process	Electricity, compressed air	Quantity of processed products	Process parameters (speed, temperature, pressure)
Outdoor lighting	Electricity	Number of hours of darkness (or their variation)	
Production of chilled water	Electricity	Quantity of cold water	Water temperature, coolant temperature
Electricity production from photovoltaics	Electricity	Irradiance, temperature, direction and wind speed	
Wind power generation	Electricity	Wind speed, environment temperature	

2. Definition of the energy baseline

This step is very delicate as it impacts the effectiveness of the monitoring system. The main limit derives from the fact that in most of the systems consumption changes when the output changes. This can cause fluctuations more severe than the ones caused by the phenomena we are trying to detect. A second limit is due to the fact that the relevant variables we need to consider for our baseline are more than one.
Actually, both limits can be overcome using a statistical tool: the regression analysis. It represents a linear relationship between two or more variables. In other terms, energy consumption E(Δt), for a given time Δt, can be defined as:

$$E(\Delta t) = E0 + c1 \cdot V1 + c2 \cdot V2 + \dots$$

where E0 is the constant independent consumption and c represents the sensitivity coefficient to the relevant variable Vi. **The regression analysis of historical data requires a first verification of the necessary hypothesis and a measure of the mathematical error of the model, identified with different methods,** such as the coefficient of correlation, the analysis of residual values and the p-value. In other terms, the analysis tells us whether the mathematical model is reliable, and guides us toward the identification of the best possible model. **In this phase, it is often possible to detect anomalies that occurred in the past and to develop a deeper understanding of the consumption mechanisms** something that will be useful in the control phase.

3. Analysis of deviations

Once we have a reliable energy baseline, it is possible to use it to implement a system to control the energy performance over time. It can intercept deviations in the system energy performance, which is a predictor of incipient failures.
For every time length (hours, days, weeks) the actual consumption is measured and compared with the mathematical model (energy base- line) by substituting the values of the variables measured in the same period. **A significant deviation between the values implies that the energy baseline is not representing the functioning of the system, thus there is a malfunctioning.** This control can be easily automated and applied in real time

to promptly warn us about sudden changes in the energetic behavior of the observed system.
A useful tool for this activity is the control chart of cumulative sums. It shows the sum of deviations on a time trend, allowing to quantify the impact on consumption of the specific deviation from the baseline, a useful data for economic considerations related to the interventions needed (See Fig. 3).
The possible applications of the energy performance monitoring are the improvement of the maintenance strategies in industrial plants.
In an industrial plant, there are several assets whose energy consumption is already monitored and that can benefit from the application of energy monitoring for maintenance purposes. An interesting aspect is the contribution of the energy monitoring system to maintenance.

• Corrective maintenance: detection of faults that do not cause service interruptions

Complex systems have different components and not all of them cause an interruption in case of fault.
This is an advantage from the point of view of continuity of service, but can lead to severe disadvantages, such as higher costs due to higher energy consumption, unexpected breakdowns that could be avoided or the damage to other components. For instance, in a pharma plant where the energy performance of a steam generator was monitored using an energy baseline evaluating the reference gas consumption per ton of steam produced, it was possible to intercept a leak in the economizer much before the scheduled maintenance stop. The hole would have not caused a fault in the boiler, but it would have affected its energy performance for a long time.

• Periodic preventive maintenance: determination of frequency of intervention

The frequency of periodic predictive maintenance interventions is often determined by economic considerations that do not consider energy efficiency. This approach negatively impacts the systems whose energy consumption is significant

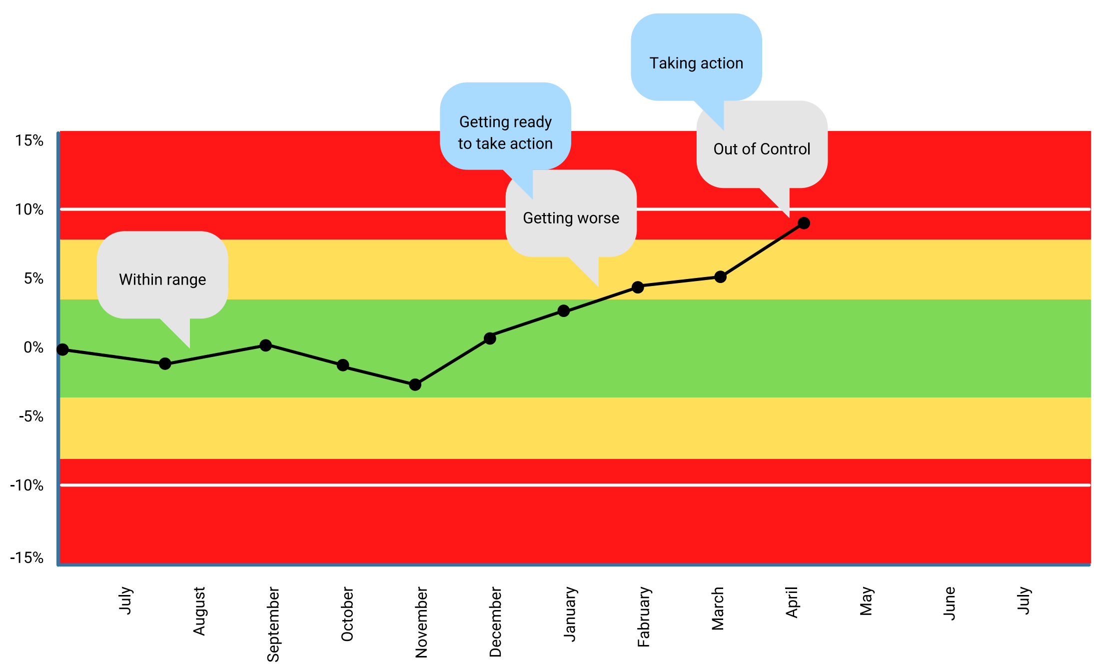


Figure 3

(there are many plants that count energy as the highest cost). **Monitoring the energy performance can help in framing the energy cost of maintenance operations and therefore in understanding the frequency of activities that can ensure the minimum cost overall.**

• Condition-based maintenance: ensuring conditions of consumption

This type of application is the most trending right now since the strong attention on the topics of Industry 4.0. As long as a system behaves normally, the energy performance follows the baseline and control charts do not detect anything. When the system is subject to the degradation of its performances, this degradation causes an increase of consumption, which is detected by control charts even before faults are caused. **The definition of a limit for the deviations from the baseline signaling needed maintenance interventions is a simple and convenient condition-based maintenance system that can be easily automated.** There are several possible applications since this system is applicable to all those fault modes causing an increase in energy consumption (i.e., bearing wear, fouling of heat exchangers, etc.). Specifically, the method has been successfully applied to the heat exchangers of refrigeration units of a pharmaceutical plant. The maintenance of those systems is particularly delicate as performance degradation is rapid and significant, with the severe risk of causing production stops, mainly in summer.

In this particular example, routine preventive maintenance failed due to the difficulty of defining a useful time frame. In fact, the faults of the refrigeration units strongly depend on the workload, which varies a lot during the year (up to triple in summer compared to winter).

Even maintenance on condition based on the analysis of leaks in the pipes was not proving efficient since the cost of inspections and poor reliability of measurement systems.

After the definition of an energy baseline for the refrigeration units given the water flow cooled to a defined setpoint temperature, it has been possible to measure the effect of the capacitor degradation on the energy performance and to set a threshold adequate to avoid all the connected damages.

• Effectiveness of maintenance intervention

By comparing the energy performance of the system with the baseline after the intervention, it is possible to verify the effectiveness of maintenance operations. For instance, it is possible to detect a problem in the reassembly (once, it was possible to detect an error in the assembly of the bevel wheel of a gear that could have cause a severe fault in a few days), but also new opportunities (energy performances after preventive maintenance operations are so much better that they can make us reconsider the frequency of those interventions).

• Effects of improvement maintenance interventions

By monitoring energy consumption, it is also possible to evaluate the effectiveness of improvement maintenance on plants.

By comparing post-intervention energy consumption with the energy baseline, it is possible to measure the impact of the maintenance intervention. With this approach, it has been possible to detect an increase of ca.2000€/ months in energy costs related to a press, following an intervention on the on/off switching system of the lubricant heating coils. After the report of the anomaly, maintainers worked on the equipment again and solved the issue, bringing energy consumption below the initial baseline. This application is particularly useful when interventions are targeted to energy consumption. In these cases, savings are easy to measure.

Conclusion and further developments

Energy measurement systems provide us with valuable insights that are often not exploited enough since they are used just to evaluate the energy performance. Their use as weak predictors of faults leading to stops or future failures can be the solution to introduce more efficient and effective maintenance practices, starting with condition-based maintenance.

As for future development, there are several options. **On one hand, there are the tools to define the energy baseline and the analysis of deviations, with the possibility of using Artificial Intelligence,** maybe based on neural networks for the most complicated consumption trends (due to number of variables and non-linearity) or energy baselines depending on too many elements (i.e., radio base stations). **On the other hand, an energy monitoring system that goes beyond anomaly detection, allowing automatic fault diagnostic** AI-based diagnostic systems using variables measured real time) or **the development of automated decision-making tools to enable prescriptive maintenance where possible.**

VITO INTRONA
Associate Professor in Operations Management,
Università degli studi di Roma Tor Vergata

MENZ & GASSER: ENERGY AS FUEL FOR SHARED KNOWLEDGE

by Claudio Cumer and Michele Cilfone

Many companies spend millions and billions of dollars for energy every year. This is not just expensive, but also an overlooked opportunity to reduce risks, increase resilience and create value. As environmental concerns become more urgent and new technologies emerge, companies must respond to these changes with a robust energy strategy. This article provides 5 steps to review energy policies in a corporate: create a high-level mandate, integrate energy goals into vision and operations, monitor progress across the company, leverage new technologies and engage stakeholders. In the industrial field, energy is one of the fundamental inputs together with raw materials, while water is used above all for the heating and cooling of the rooms, for industrial ovens, dryers, evaporators and concentrators. Big corporates spend millions or billions of dollars in energy every year and millions indirectly for the costs of the supply chain, outsourcing and logistics. However, **outside the energy-intensive industries, most companies consider energy merely as a cost to manage. This is a strategic error overlooking enormous opportunities to reduce risks, increase resilience and create value.** Today, energy is scaling the corporate agenda due to radical environmental, social and business trends including climate change and global carbon regulations, increasing pressure on natural resources, more demanding expectations on corporate commitment, innovation of energy technologies and business models, the fall of the prices of renewables. These megatrends are changing the context in which companies operate and unveil new risks, as well as new roads to create value. In the classic strategy framework of Michael Porter, companies secure their competitive advantage by decreasing costs or through differentiation. However, the choices concerning procurement or energy consumption can deeply influence the cost structure. The way the environmental impacts are managed, primarily carbon emissions, can be a key differentiator for consumers, investors and corporate clients.

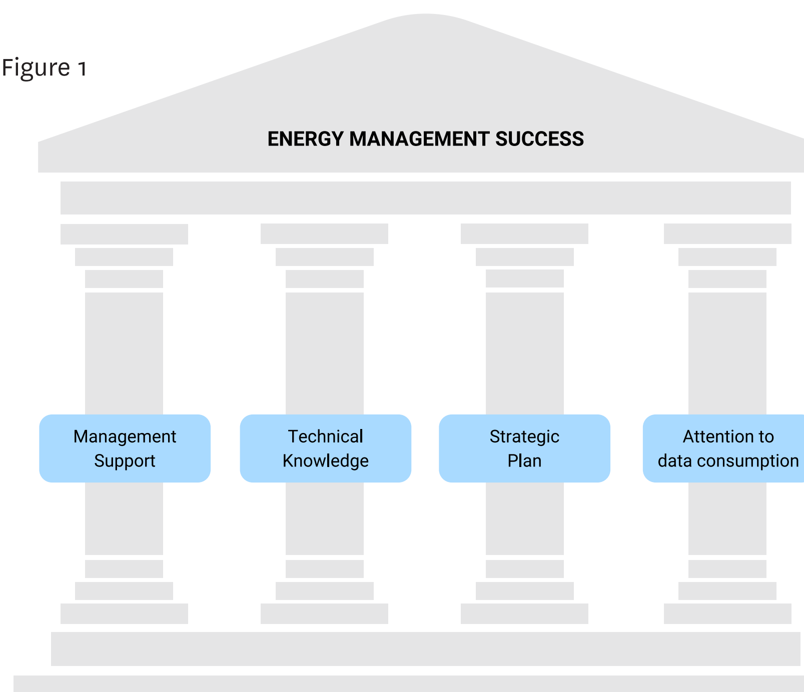
Energy Management can be defined as a judicious and efficient use of energy in order to maximize profits and improve competitiveness (Cape Hart, Turner e Kennedy, in the article "Guide to Energy Management"). Profit maximization is an aspect related to cost reduction and

this highlights the crucial role of energy costs among the costs a company has to sustain during production. The improvement of competitiveness is more than having lower costs. It consists in the wider context in which corporations manage flexible energy costs. This allows to react quickly and painlessly to changes imposed by environmental regulations, for instance.
Energy management has implications that involve any aspect of a nation's life, even though in many companies it is not a priority yet. Often, there are isolated attempts to reduce consumption (with limited benefits in size and duration) rather than a systemic approach to the problem that would be positively recognized by external social forces in the company (citizens, local administrations...).

We can identify three fundamental principles at the basis of proper energy management:

- obtain energy at the lowest possible cost;
- minimize energy waste in the system;
- always use the most appropriate technology from an energy perspective.

Figure 1



These principles imply the presence of a complex set of knowledge and skills, including:
- knowledge of the energy production market;
- capacity of properly managing the relationship between contractors and energy suppliers;
- knowledge of the structure of energy consumption;
- knowledge of analytical techniques for the evaluation of energy consumption;
- ability to manage projects for the implementation of efficiency measures;
- technical know-how about modern energy systems;
- knowledge of methods of financial analysis for investments in energy efficiency.

The four main elements of Energy Management are shown in Figure 1.

Operative strategies for Energy Management

Generally, the introduction of Energy Management is done step by step, alongside with the increase of know-how in the energy system and of awareness of the company about the actors involved in the process. All these phases are associated to a different operative strategy:

- Quick Fixes;
- Energy Projects;
- Comprehensive Energy Management.

By **Quick Fixes** we mean the occasional reduction of energy consumption. An uncoordinated series of inexpensive energy saving measures that do not require an analysis and planning of interventions are implemented. Some of the interventions of this strategy are the thermal isolation of windows, timers for lightning and air-conditioned systems, use of efficient components, etc. They bring significant economic benefits (especially in the case of old buildings or systems), but limited compared to the maximum achievable ones.
The second approach is **Energy Projects** i.e., the systematic reduction of energy consumption. Obtained the maximum savings achievable in the previous phase, it is possible to understand how further savings are achievable only through energy projects that require a significant phase of analysis to identify the most significant opportunities for energy reduction, the necessary measu-

res to achieve them and the financial investments needed (the economic evaluation of investments also comes into consideration). Usually, this phase is based on analyses of the energy system called "Energy Audits".

The last strategy, **Comprehensive Energy Management,** is the one providing clear long-lasting results. By increasing awareness and the know-how of energy aspects within the company, the "project-based" approach tends to be included within a real management system, thus leading to the development of an Energy Management System. This requires as a fundamental step the introduction of a management system, intended as monitoring, control and continuous reduction of energy consumption. The trend is to define models of Energy Management that can act as guides for corporates, helping them to obtain the certification and its positive impacts on the brand image.

Company setting

Menz & Gasser was founded in Lana (BZ) in 1935 focusing on the production of high quality fruit jams and semi-finished products. **Over its 80 years of history, Menz & Gasser has undergone numerous transformations, but already from the beginning, the founder Mathias Gasser imprints the vision that will grant his company decades of success: observe and understand people's desires while identifying innovative and quality services and products that can satisfy them, even anticipate them.**

Today, the company is present in more than 50 countries, 4 continents. In 2016, it began the construction of a plant in **Malesia** with the goal of expanding its presence in the Far East.

Need

Menz & Gasser combines two needs in the energy field: on one hand, to efficiently manage the complexity of using different energy vectors necessary for production; on the other hand, the necessity of satisfying the marked sensitivity of the property for a more rational use of energy.

The company had already installed numerous electricity and thermal consumption meters. However, data logging and visualization was not enough: with the engineers of MIPU we have developed a solution enabling us to actually use data to decrease consumption and improve the sustainability of our production.

We have decided to start with a pilot project to develop a data collection platform. We chose a woody biomass plant that was presenting several difficulties in the calculation of efficiency: different energy losses such as losses related to fumes, radiation and the energy power of the ashes were not easy to measure.

We wanted to create a system allowing us to have immediate evidence of the plant performance and a predictive support to maintenance and energy-related decisions.

Solution

The implemented solution provides for the centralization of the data already collected and their use for the creation of energy models: these are simulations of the energy performance of each component of the system basing on operative conditions. Depending on the complexity, mathematical models or machine learning models can be used. Complexity is managed by the software platform in any case. Despite being autonomous in the creation of new models, the team of Menz & Gasser can avoid the

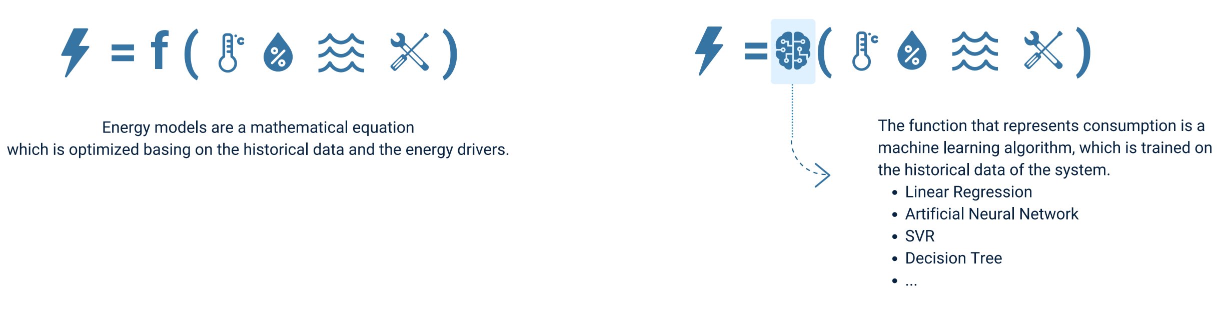
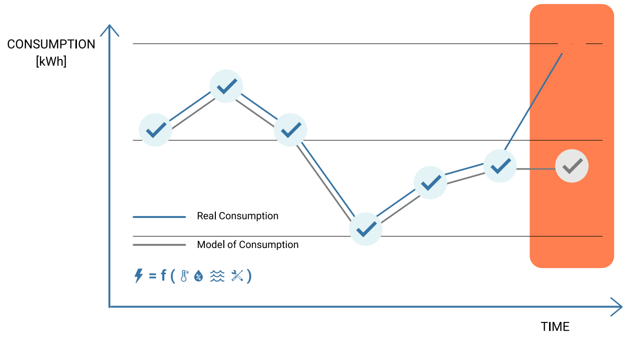


Figure 2

Figure 3

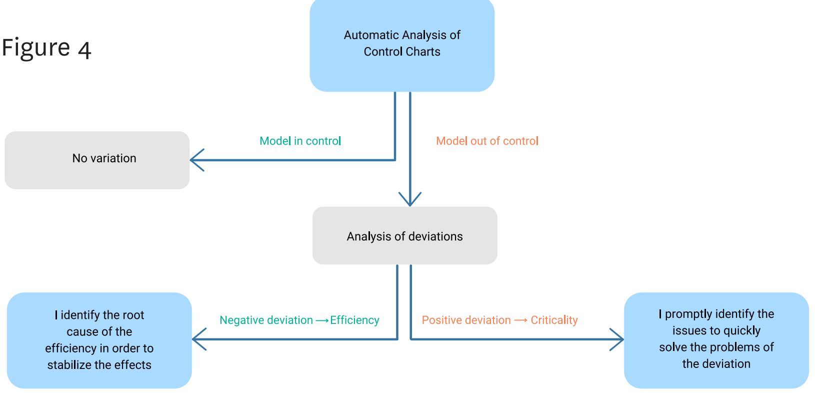


difficulties related to coding (see Fig. 2).
Initially, we have created circa ten models. These engines are extremely flexible and allow to achieve different goals:

1. Predict future energy consumption basing on technical, environmental and production conditions;
2. Predict energy costs and analyse what-if scenarios as function of, for instance, different time-frame, weather conditions, future maintenance actions;
3. Intercept early malfunctions using the energy consumed by each component as a base signal, something the engineers of MIPU call Energy-Based Reliability Management (see Fig. 3).

From an operative point of view, each model is monitored using control charts as they intercept deviations of the actual behavior from the predicted one. If the real behavior goes up, it is a positive deviation. If it goes down, it is a negative deviation.
The absolutely innovative aspect here is the ability to accurately quantify the impact of any activity on the energy performance of the system, all in a simple and graphical way. Communicating in real time to the whole team, and potentially to all the stakeholders in the area where the company operates, how quantitatively our actions impact on energy consumption and therefore on the environment is disruptive. Not only: this immediacy, while scientifically rigorous, responds to the need both to increase efficiency and to create culture and engagement (see Fig. 4).
We have consequently chosen to extend the experience with the biomass power plant to the factories.

Figure 4



Energy budget and environmental impact

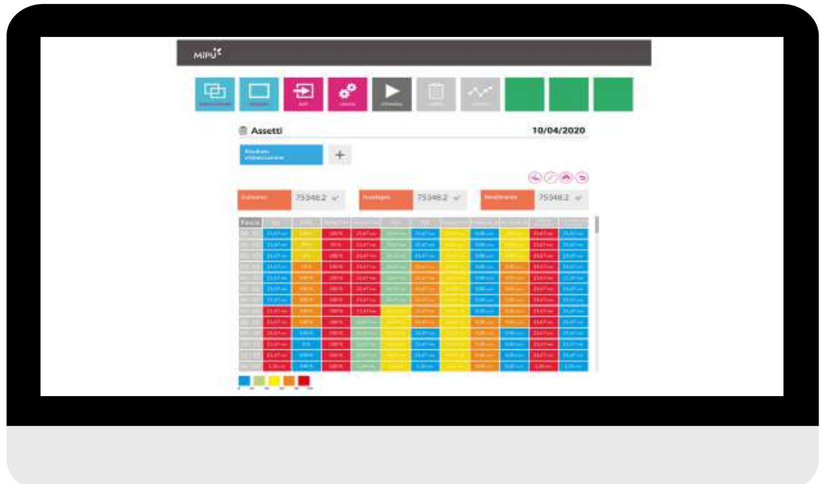
Having artificial intelligences precisely simulating the behavior of our plants, allow us to develop an energy budget effectively based on the real operating conditions that we gradually face. More importantly, we can evaluate the economic and environmental impact of our decisions upfront, thus promptly discuss with all the involved stakeholders with the right precision.

Results

From this experience, I feel I can express three concepts that I consider important.
The first one is about **competences.** To properly develop a project like this, it is necessary to compose the right team with internal technician and technological partners. Internal technicians must model their processes in order to make them usable for an artificial intelligence process. The technological partner provides an added value since it has a specific domain knowledge. **In our experience with MIPU, the factor of domain knowledge has been crucial: we have chosen MIPU as we knew their competence in the field of energy.** Considering the job done, this has been the right choice. The competence of MIPU in the energy field has helped us to improve the models that describe our process.
The second concept resulting from this experience is the role of technology in general and of artificial intelligence in particular. To approach these kinds of projects, companies must have

clear and specific objectives. **Artificial Intelligence cannot be the final goal, but the tool to achieve a specific objective.** A company is very competent on its own processes: in order to open to new technologies, the fastest way is searching for the necessary skills on the market. The particular economic moment we are experiencing, characterized by high complexity and uncertainty, requires companies to move quickly and to deploy projects fast to stay competitive. **Thus, the relationship with technological partners becomes a valuable asset for a company in order to develop new solutions.** Companies must learn to open toward a network of selected suppliers enabling them to bring in new competences and technologies while allowing them to focus on their own resources and business.

The third consideration specifically involves artificial intelligence. **Thanks to the ability to process a large amount of data and correlations, AI allows a holistic view of the production process.** Opening the opportunities arising from the use of artificial intelligence to the whole company, at first it seemed futuristic; only a few months later, we thought it was feasible. **Today, we know models are "an engine of shared knowledge": they help us to get to know our plants better, to make strategic choices and to constantly evaluate their impact on technical, economic and environmental aspects.**



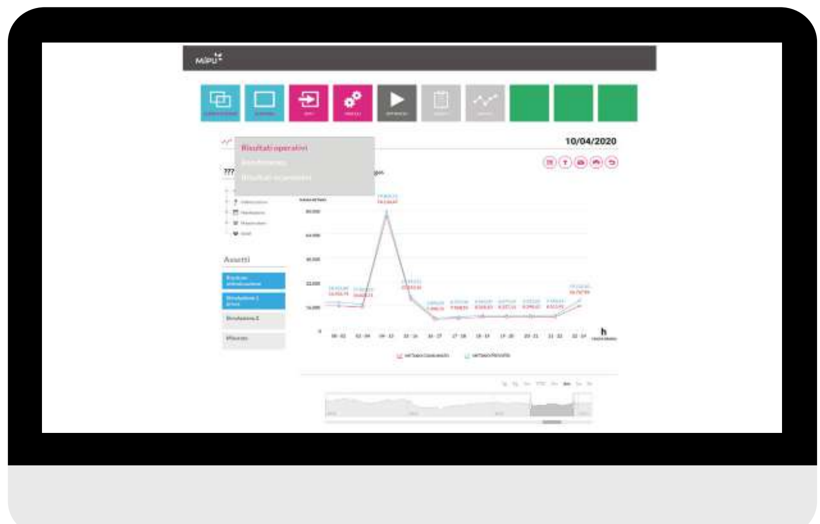


Figure 5

CLAUDIO CUMER
Technical Department, Menz & Gasser

MICHELE CILFONE
AI Development Leader, MIPU

BENETTON GROUP: ENERGY AS DRIVER TO REDUCE ENVIRONMENTAL IMPACT AND IMPROVE CUSTOMER EXPERIENCE

by Mario D'Aleo

Sustainability, digital innovation, increase in economic efficiency, evolution of the touchpoint between brand and customers represent the future development challenges for Benetton Group. Now, stores, as the essence of the brand celebration, of physical and digital touchpoints in an omnichannel approach, as communication points and traditional productive units, must be able to convey messages of sustainability, technological innovation, attention to the client and operative efficiency. **In this article we will present how a creative, unconventional and technologically advanced use of the energy vector can contribute to achieving such a challenging goal.**

It is thanks to the ability of producing and managing energy that humanity has evolved. Particularly in recent centuries, in recent centuries, humanity has managed to raise the quality of life and income for a large part of its population in a relatively short time, as never before. Energy has been the "fuel" of this world (and today more than ever).

In the second half of the 18th century, production in the textile and steel sector was mechanized through steam machines: it was the first Industrial revolution. From 1870, the introduction of electricity, of chemicals, of internal combustion engines with consequent use of oil as an energy source, started the second revolution. In the '70s, with the advent of information technology and the increase of the levels of industrial automation, the third industrial revolution began. Today, we are in the middle of a new radical transformation, even more disruptive of the previous ones, commonly defined as the **fourth industrial revolution.** It is characterized by the progress of new technologies such as:

- **Artificial intelligence** (AI), computers able to "think", to recognize complex patterns, to elaborate information, to draw conclusions and make predictions. Machines, fed by great amount of data, learn and act (*machine learning*);
- **Internet of things** (IoT) or the possibility of having everyday objects connected to the internet, searchable and controllable from other devices;
- **new computational technologies** able to quickly process huge amounts of data through extremely powerful computers, allowing us to implement AI and create complex models in seconds;
- the **"cloud"** which allows us to archive and access information securely, from anywhere and at any

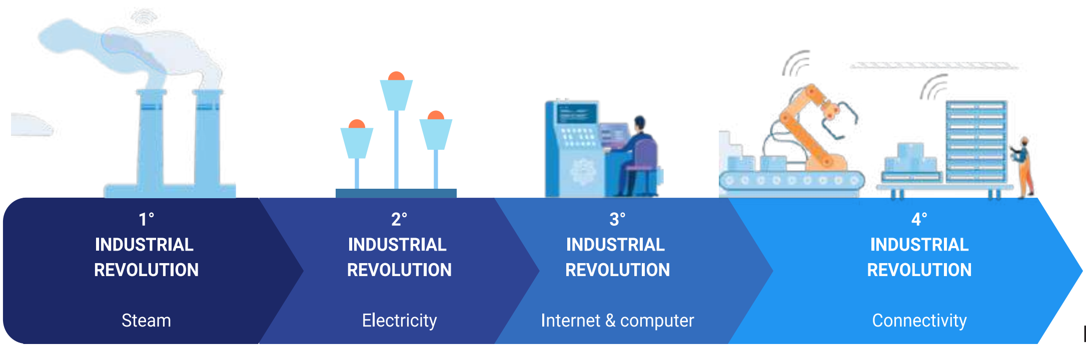


Figure 1

time.
Eventually, robotics, 3D priting, virtual reality (VR), innovative materials (including plastics, metal alloys and biomaterials), etc. (See Fig. 1).

These new technologies are also able to change customer expectations, allowing companies to offer greater customizations and a targeted experience. **Never before has energy been the protagonist both as an enabler of this fourth revolution and as a central topic in the social and environmental debate:** the exponential need of energy due to the previously mentioned evolutions is the main cause of climate change. Thanks to the new technologies, **energy itself can be used as an indicator of correct behaviors**, allowing us to constantly control energy consumption and the comparison with an optimal baseline.
Being able to make energy-consuming systems more efficient is the main challenge of the fight against climate change and sustainable future development.

Company setting
Benetton Group is one of the most famous Italian fashion companies in the world for its consolidated identity of style, color and quality at "democratic" prices. Founded in the 1960s in Ponzano Veneto, in the province of Treviso, it is present globally with its two main brands, United Colors of Benetton and Sisley, through a network of approximately 4.500 stores managed directly or with the support of independent business partners..

Need
In line with the foreword, Benetton Group, **has embarked on a research project with the idea of developing an innovative concept of a sustainable, digital, technologically advanced retail store.** The new *store*, not only utilizes materials and furniture from wastes of the textile industry according to a "circular" vision, but also aims at a strong reduction in energy consumption and therefore CO2 emissions through the use of the most innovative technologies, while ensuring the customer comfort and overall *experience*.
"*Data analysis and artificial intelligence to increase energy efficiency in retail stores*" is the title of the project that we are presenting. Its results will be extended to the entire global network of stores with extremely significant impacts on sustainability and efficiency.

Solution
The first goal set was to reduce energy consumption by 20% in every store, with the same hardware and user comfort. In other words, the reduction in consumption can only be achieved with changes in the management processes, compatibly with the maximum enhancement of the customer experience. To reach this goal, a system for store data collection, analysis and logging has been implemented.
The acquired data are fed to the algorithms of artificial intelligence able to autonomously regulate air conditioning, lighting and any energy-consuming system present inside the store.
The crucial point to build these models is to feed them with enough data so that they can "learn" as efficiently as possible. **The solution was directed towards the creation of an ad-hoc multi-parameter miniaturized IoT sensor developed** (see Fig. 2) able to monitor indoor parameters and the overall comfort in the store. Plus, **an AI-based system for active control of energy consuming systems was implemented.**

Figure 2

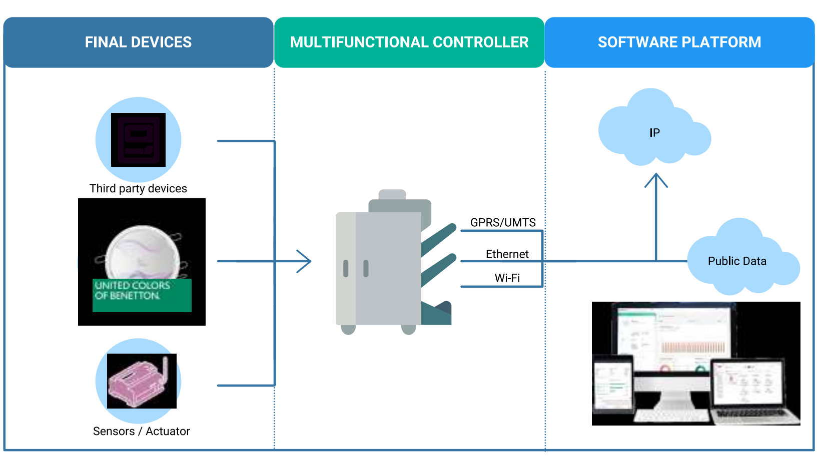
The activities of applied research has been developed through five different phases:

1. **Selection of the right environmental parameters to feed the algorithms.**
   Meteorological factors such as temperature and humidity, wind, irradiation and rain were evaluated; factors relating to the building envelope and location; internal factors such as temperature and humidity, energy consumption, lighting, air quality, crowd rates.
   The following parameters have been selected:
   - temperature: predictor of thermal comfort;
   - humidity;
   - luminosity;
   - concentration of volatile organic compounds: indicator of the healthiness of the environment;
   - noise: *predictor* of crowd rate.

2. **Design of the sensor.**
   The main obstacles to overcome were the number of measurements to be taken and the size: the diameter of the sensor, in fact, had to be less than 6 cm in order to be integrated into the architecture of the store. The level of miniaturization achieved by the multi-sensor makes it a unique device in terms of dimensions in relation to the physical quantities measured.

3. **Clustering of stores and energy audits**
   The network of stores was divided into clusters on the basis of plant types, size, conformation, geographic position and opening hours. An analysis was carried out for each cluster aimed at characterizing the uses of energy and creating a baseline as a reference for results (see Fig. 3).

Figure 3



4. **Design of the overall system.**
   The architecture requires the installation of a series of sensors, according to the size and characteristics of the store. Each sensor connects wirelessly to the *gateway* installed in the electrical panel. The gateways communicate data to the software platform Rebecca and act as actuators as well, in order to minimize energy consumption for air conditioning and lighting. Plus, they work as *energy meters*.

5. **Preparation of the software platform.**
   The platform provides a dedicated user experience for each type of user: store managers, facility and energy managers, procurement, customers, communication. Functionalities are:
   - Data collection, integration and data logging;
   - Control of energy performance and achievement of set objectives;
   - Stores criticality matrix;
   - *Benchmarking*;
   - Creation and management of the entire life cycle of the AI models controlling air conditioning and lightning;
   - Creation and management of AI models doing predictive maintenance on selected components (see Fig. 4).

Applications in the store

Artificial intelligence learns what the expected behavior of the air conditioning system should be when environmental conditions change, as well as the amount of people present in the store. It is therefore able to act autonomously on the air conditioning system with the double goal of decreasing energy consumption and ensure comfort to users. By comparing the expected energy consumption with the actual one, the AI model is able to signal malfunctions. and efficiencies easily and visually. Lighting instead is regulated based on luminosity, VOC, CO_2 and noise, an indicator of crowding. Lights can be modulated based on the presence of people in certain areas of the store. Control and modulations are performed on edge from the gateway, while the AI models monitor the conditions of the main assets and plants in the cloud.

Similar functions regulate the remaining energy-consuming systems in the store (see Fig. 5).

INTERVIEW WITH **MASSIMO RENON** CEO, BENETTON GROUP

Within the strategies of Benetton Group, which role can artificial intelligence play?

Predicting future needs with artificial intelligence and predictive models makes the supply chain more flexible, quicker and able to manage the stock more efficiently. For instance, we can think of shipping to our stores only a part of the collection, while the rest will be produced and delivered based on data analysis carried out by an artificial intelligence. It will take into account a multitude of information and inputs with continuous updates and reviews: time, location, replicability, number of purchases, in-house data; number of returned items; external data and influences. This allows us to model different distribution scenarios minimizing the delivery costs of the products while creating a targeted rewarding experience for our customers. The opportunities provided by AI could evolve the role of designers, transforming a creative art into science. Cognitive computing provides trend forecasts with great accuracy. Interacting with consumers inputs, properly developed algorithms allow us to reduce time and necessary resources to test the market while ensuring more sustainability for the entire chain. This aspect is extremely important in an industry that has always been extremely critical from the point of view of environmental sustainability. Being able to predict customer preferences and therefore the needs of multiple distribution channels, minimizes errors and consequently reduces unsold items: unnecessary production can be strongly limited and its environmental impact drastically reduced. This is how digital innovation, environmental sustainability and increased efficiency merge into a single great challenge and opportunity for the future development of Benetton Group

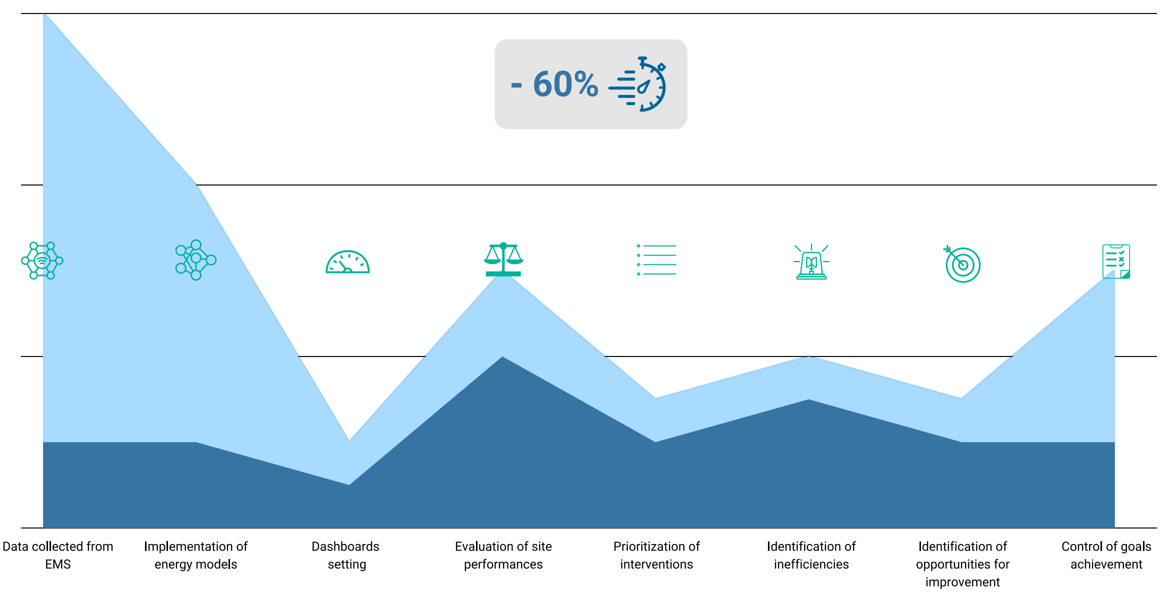


Figure 4

By exploiting the data already available and implementing a core capable of supporting machine learning, it was possible to reduce evaluation times by 60%

The use of the platform has also been expanded with a feature for automatic bill verification: an automatic system to control and historical analysis of energy bills, with the goal of optimizing management costs.

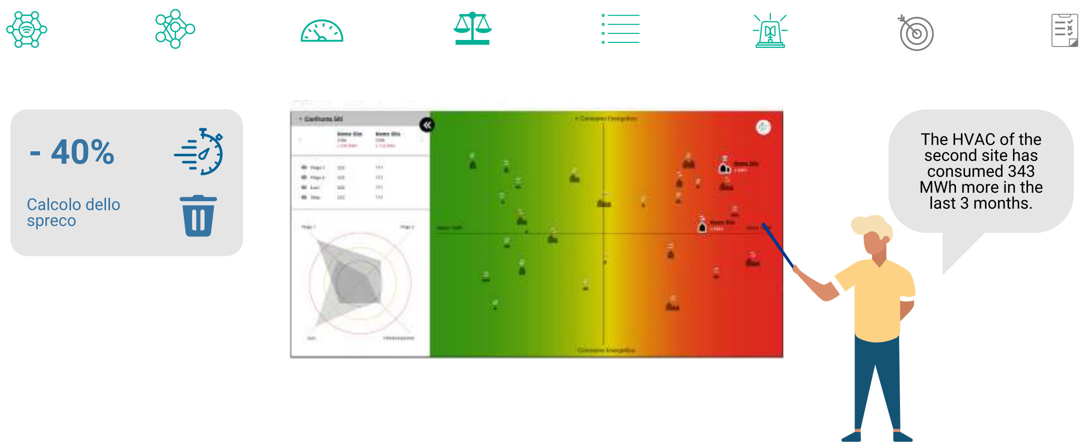
In the next future

The parameters detected by the multi-parameter sensor allow not only to detect the environmental conditions changed by the human presence inside the store, but can also act in reverse: it is possible to detect the presence and behavior of the user starting from the variations in the energy vectors. If this type of inference is surely weak compared to what can be analyzed with specific systems (beacons, cameras), we should consider that this is an energy management solution in the first place. The idea of monitoring customers and their

Figure 5

The prioritization

The usage of EnPIs allows to precisely quantify the energy wasted due to inefficiencies. Inside Rebecca Energy Atlas, multiple tools allow qualitative and quantitative analysis of inefficiencies.



interactions in the "touchpoint store" with a system whose presence is so discreet and respectful, could represent an opportunity for future exploration. After all, if artificial intelligence can support objectives of efficiency and sustainability, it is the customers, their satisfaction and needs that any company must put at center.

Results

The possibility of using a flexible software platform that makes AI scalable and replicable, connected to hardware systems collecting all the necessary data to ensure indoor comfort and good performances, **allow us to think of replicating this framework for performance control and optimization for many different retail scopes**. The resulting energy savings, the optimization of maintenance management – activating interventions just if the models in cloud intercept an anomaly in the assets – combined with the attention to the comfort of the users and personnel actually present in the store, allow to reach corporate goals of sustainability, innovation, communication, efficiency and dedication to the customer.

MARIO D'ALEO
Head of Engineering & Facility Management,
Benetton Group SpA

MAINTENANCE POLICIES: A NEW PILLAR IN THE CORPORATE TOP-LEVEL MANAGEMENT'S AGENDA

by Fabio Sgarbossa

In the last few years, there has been a lot of talk about predictive maintenance and data-driven approaches: Machine Learning and Artificial Intelligence applications are presented as the solution to all problems. Unfortunately, it is clear that **there is no better maintenance policy than others: each company must carefully choose the correct mix in order to define its strategy,** considering variables such as costs and margins of production, spare parts and maintenance personnel costs, saturation and criticality of the system for customer service, etc. Furthermore, it is necessary to assess what the starting IT infrastructure is and the nature of the most frequent malfunctions. In the following article we will see how to build the right mix of maintenance policies to create a flexible and antifragile factory.

How the maintenance approach has evolved over the years

Maintenance has never been part of CEOs' agenda. Why are more and more top levels taking an interest in this topic today? The answer is quite simple: the pandemic has exposed us to the vulnerability of our factories, which must rapidly change into flexible and antifragile ones. If the word flexible is clear, I would like to invoke the concept of antifragility, that is the ability of a system not only to resist misfortunes, but to benefit from them. Then, **maintenance function is no longer to be considered only as a pure guarantee of the required operational continuity, but as a key factor to global production efficiency and the ability to adapt to contexts rapidly changing**.

Maintenance Policies

All the various maintenance policies follow the historical evolution of maintenance engineering: in single words, this evolution is linked to the level of knowledge of the plant. It starts with **corrective maintenance**: not having no knowledge of the system, **the only way is to intervene after the failure has occurred** thus bringing the system back to the condition that it performs the required function.
Subsequently, thanks to the collected data on the various failures **preventive maintenance policies have been developed on a statistical basis, therefore on the basis of historical data collected** (*time to failure*) and thanks to cost models it is defined when replacing the analyzed component to avoid the failure. IIn this case, it is known how this policy is applicable only in certain conditions, in particular when there are phenomena of wear, as accidental failures cannot be avoided by such preventive replacements. The replacement of car tires in an example: I can avoid a break due to wear of the tread by replacing them after a certain number of kilometers traveled, but I cannot avoid an accidental puncture due to a nail or a branch in the road.
It is also true that I can postpone their replacement if I know their state of deterioration by properly analyzing the tread level. In this case the **maintenance policy is defined on condition and requires both an adequate level of knowledge of wear phenomena and the ability to analyze the state of component degradation.** It is important to emphasize that the effectiveness of an on-condition maintenance policy is closely linked to the ability to collect knowledge of the health of the

plant from different inspections and the ability to predict the residual life, to be able to plan the maintenance intervention in an economic and efficient way. The primary objective of these policies is to avoid failure or minimize the impact of this failure on the plant performance, so they are very often considered as **policies to reduce maintenance costs.**

In recent decades, thanks to the advent of technologies such as low cost sensors and cloud computing, companies have increasingly invested in acquiring weak signals from plants. Some examples are the absorbed electricity, the components temperatura, the change in energy consumption, vibrations. Thanks to the analysis of this kind of data, it is now possible to implement new on-condition maintenance policies, called predictive maintenance ones.

Coming back to the example of tires, the not correct road holding in normal conditions driving is a weak signal (loss of performance) which may indicate a certain deterioration of the tires and therefore suggesting their replacement or at least a check of the tread (see Fig. 1).

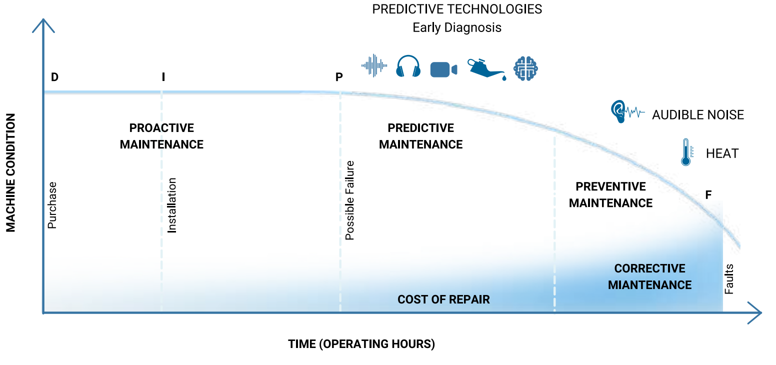


Figure 1

We started talking about predictive maintenance long time before the advent of the fourth industrial revolution, but it is thanks to the high ability to collect data and related processing that it is now possible to fully exploit this policy. Predictive maintenance allows not only to intercept defects in the bud, but also to define how to use the system and how to maintain it in the best possible way.

Choosing the right mix of maintenance policies

Returning to the main purpose of each company, that is to generate profit, it is obvious that every decision on which maintenance policy to implement depends on a cost-benefit analysis. If corrective maintenance does not require any investment costs, it can lead to high downtime costs as well as repair ones. It must also be considered the cost resulting from the impossibility of predicting the time when the break will occur.

On the contrary, planned preventive maintenance runs the risk of conveying a false sense of security. In this sense, it should be recalled that the life cycle of the mechanical components has a so-called "bathtub" trend: it is also characterized by a high infant mortality.

The theme is that when you use planned maintenance, you do not know at which point in the bathtub you need to intervene; the replacement in any case has the effect of bringing the possibility of breakage back to a high level (see Fig. 2). Condition-based maintenance - operating when the verification conditions exceed certain thresholds - or predictive maintenance - calculating the residual life span of the component - aims to minimize downtime, replacement and labor costs. Today they are the techniques that best guarantee the reliability of the systems, understood as the ability to produce what I want, when I want, at the best possible cost.

There is an aspect we usually do not consider, namely that the on-condition and predictive techniques do not coincide exclusively with the application of Artificial Intelligence to maintenance. Particularly, we can distinguish between field predictive techniques and data-driven ones (see Fig. 3).

Here, I will limit myself to considering that, while both techniques bring huge benefits in term of the ability to intercept a failure in the bud, **field predictive techniques are today generally more accurate than artificial intelligence can do when applying to mechanical failures Furthermore, they have the strong advantage of being less dependent on historical data than what happens for the AI-based predictive techniques.**

Conclusion

The Covid-19 pandemic has shown all the vulnerability of our production sites, called to quickly face new products requests, lack of liquidity, need for remote plant management, scarce availability of personnel. In this scenario maintenance returns as

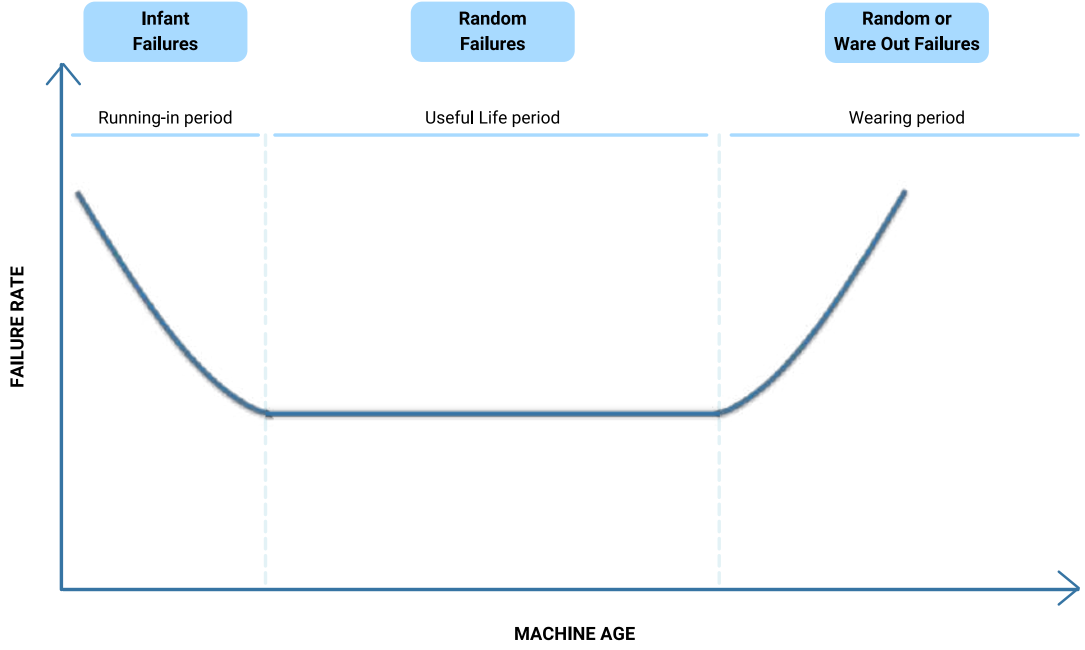


Figure 2

a central theme in the agenda of company directors: it is no longer just the entity that "preserves", but it becomes the function that "governs" plant availability and their converting capability. It is possible to distinguish at least three maintenance policies with which to build an appropriate strategy to the production context of our company:

- corrective maintenance;
- planned maintenance;
- predictive and on-condition maintenance.

If all these policies have pros and cons, it is clear that today predictive and on-condition maintenance is the one that more than any other policy responds to the needs of this particular macroeconomic context.

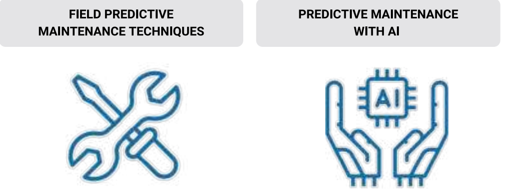


Figure 3

The key issue is that predictive maintenance does not coincide with data-driven techniques alone, but it also includes techniques and technologies that do not so strongly depend on the presence of data logging. **In this sense, establishing the right maintenance strategy, choosing among the aforementioned policies and between field or data-driven techniques, is the key point from which it must be started in order to avoid expensive mistakes.**

FABIO SGARBOSSA, Professor of Industrial Logistics at the Department of Mechanical and Industrial Engineering of the Norwegian University of Science and Technology. He was Associate Professor at the University of Padua where he also earned the PhD in Industrial Engineering in 2010. He is currently leader of the research group in Production Management and is responsible for the Logistics 4.0 laboratory at NTNU.

INTERVIEW WITH ALESSANDRO VIVIANI VICE PRESIDENT SERVICE, DANIELI GROUP

In the current scenario, every company has the primary goal of reducing their own costs, while maintaining high system availability and reliability. How are the players in the steel sector differentiating?

Today the steel industry continues to differentiate itself based on its production knowledge and related technical competence. The attention turns out to be very strong on production volumes, aiming to supply the products that customers require in defined times, with the quality needed, at the lowest cost or with the highest efficiency.

Maintenance is a key factor for generating an adequate positive action on assets integrity while maintaining a high availability and reliability of the plant. The basic principle is to transform production from a reactive to a predictive one. Attention: for those who work in operations and maintenance function, switching to a predictive production does not mean predicting market demand, but knowing what will be the availability and efficiency of the plant.

What steps have been taken so far?

In order to get maximum efficiency, up to now many players have rationalized their maintenance function by leveraging a standardized methodology made of an obsessive control of performance. The pillars they have worked on and are working on are:

– the increase in energy and materials efficiency;
– the reduction in quality costs by minimizing the amount of rework;
– the increase in labor productivity in direct production – optimizing workflows, investing in automation, increasing operators' multi skilling;
– the increase in maintenance efficiency - optimizing team planning and the planning of the maintenance activities.

However, today the new technologies are prompting companies to review and reorganize maintenance in a hybrid manner, moving from reliable to predictive machines: combining more and more the communication between machines (IoT) and maintenance to get a more efficient overall result. Following this principle, we will increasingly move towards an intelligent maintenance concept, in which the equipment is born or can be adapted with devices that make them ready to interact in the environment of the smart factory.

I am sensing even in the steel sector there is a great trend to enable predictive maintenance logics both on the end-user and machinery builder side. What do you think about it?

Smart maintenance enables smart factories. However, it is important to consider that the guiding principle of preventive and predictive maintenance remains the regular and systematic application of engineering knowledge. I do not believe in smart maintenance as purely deriving from the data and from the correlations that derive. Actually, I think predictive maintenance is possible not only with an excellent knowledge of the application domain, but also only if it provides a structure for all planned maintenance activities, including the generation of work orders to correct potential problems identified by the inspection.

This new era of digitization - Industry 4.0 - opens up new maintenance horizons that take the form of a prescriptive approach.

Prescriptive maintenance goes further the scope of preventive and predictive maintenance: the realm of what should happen and the execution of optimized maintenance strategies is precisely the realm of prescriptive maintenance.

With prescriptive maintenance, the devices, in collaboration with the operators, actively participate in their own maintenance.

The goal is to optimize how data and information are exploited over the life cycle of the product to build an end-to-end flow of information that runs through the whole product life cycle.

The new era of maintenance will be oriented to provide a drastic drop in maintenance costs, leveraging a multiple and integrated approach.

PREDICTIVE MAINTENANCE TECHNIQUES

by Alessio Sartori

In the timeline below we find the main field predictive techniques listed according to their estimated detection capability on operating 24/7 and 2500 RPM machines (see Fig. 1).

Spectral vibration analysis is the most accurate predictive technique and with the best time of failures detection on rotating machines. With this technique it is possible to identify 98 mechanical or electrical faults out of 100 with up to six months notice and without the need to know the fault history (see Fig. 2).

Infrared Thermography is the safest and most efficient non-destructive technique to detect electrical failures in advance. By capturing images representing the distribution of heat by means of a thermal imager, it is possible to identify: insulation problems, condensation drain, loose connections, broken fuses, bearing defects and misalignment (see Fig. 3).

Ultrasound Analysis allows to identify the most not-audible or not-detectable phenomena through other predictive maintenance techniques. It is also extremely efficient for identifying leaks in air compressed circuits and especially to give them an economic quantification (see Fig. 4).

In order to choose the best technique to apply, it is necessary to analyze failure modes and causes characterizing the plant, as well as to develop a cost / benefit analysis.

According to the cost / benefit analysis, early detection of a bearing failure allowed our customer to save about 27,500 euro for single extruder; however, this analysis does not consider the impact on downstream production, thus resulting strongly underestimated.

Figure 1

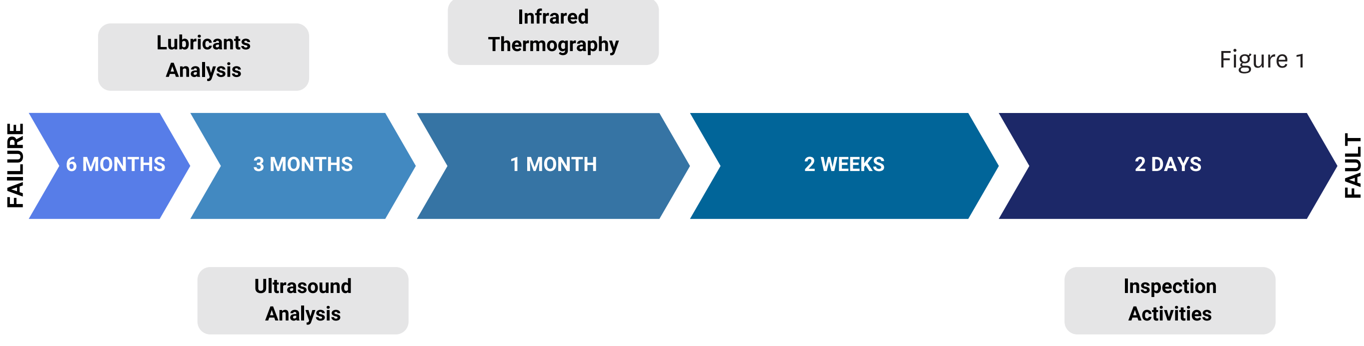


Figure 2

VIBRATIONS ONLINE MONITORING

DETECTABLE DEFECTS

- Unbalance
- Misalignment
- Bearing defects
- Resonance

ADVANTAGES

- No installation, wiring and travel costs
- 24/7 real time monitoring
- Automatic alerts
- Wireless solution
- Automatic spectral data collection
- Online spectral analysis of vibration and temperature

Figure 3

INFRARED THERMOGRAPHY

APPLICATION FIELDS

- Electrical components analysis
- Mechanical components analysis
- Coatings analysis
- Analysis for thermal components for infrastructures and machinery
- Building

ADVANTAGES

- Contactless technology
- Fast, accurate and reliable results
- Abnormal overheating detection

Figure 4

ULTRASOUND ANALYSIS

hole diameter: mm	1	3	6	10
Air leak (l/s) at 6 bar	1	10	27	105
Power loss kW of compressor	0,3	3,1	8,3	33

Little leaks can lead to high costs and long inactivity:
33 kW x 8000 h/year x 0.1027 Euros/kW = 27,100 Euros every year

ALESSIO SARTORI
Condition Monitoring Advisor, MIPU

VERITAS: DIGITIZING THE INTEGRATED WATER SERVICE MAINTENACE FUNCTION

by Umberto Benedetti and Alessandro Ferrario

Company setting

Veritas S.p.A. is a multi-utility that provides environmental services and operates in 51 municipalities in the area of the Metropolitan City of Venice and in the province of Treviso.

In this large area of 930,000 inhabitants and 50 million tourists, Veritas manages the Integrated Water Service, the complete cycle of waste disposal, the urban public transport and the cemetery and crematoria services. It also manages the utility of the Port of Venice and numerous initiatives in the field of development and application of renewable energies

The case presented is related to the digitization of the Integrated Water Service maintenance function, that is the management of the aqueduct, sewerage and purification services.

We refer to approximately 6,000 km of transportation and distribution networks, almost 40 purification plants, over 800 lifting and about 3000 km of pipelines. More than a predictive factory, we can define ourselves as a "city in the race to become predictive and digital"!

Need

Veritas is the result of an aggregation process of different companies characterized by its own management and operational culture. Despite having invested over the years in various digitization projects, the company suffers from a great fragmentation of tools, processes and, in general, of a way of preserving and maintaining its own assets that is no longer efficient. **The company, together with MIPU's team, identifies the need for an organizational redesign process for the maintenance function. Work has also been done on standardization and digitization of the main maintenance activities and on the inclusion, where appropriate, of predictive maintenance policies for the early detection of failures.**

Solution

The first phase of the project saw MIPU's team engaged in a structured assessment according to the ISO55000 standard, a standard dedicated to the management of all the physical and information corporate assets. The tool used is a MIPU's proprietary framework called Reliability Assessment; it is one of the four tools that make up the more general Predictive Factory Assessment®, the corporate preparation assessment tool to become connected and predictive.

The working method for this phase consists in direct interviews with maintenance and operating personnel, in supporting staff during daily operations, in simulation of activities, in collection of standards, codes used and documentation.

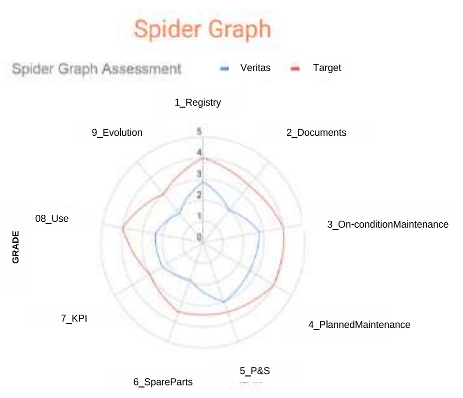
The alternation of online meetings and face-to-face workshops allowed the carrying out of the activities also during the lockdown; in less than two weeks the team was able to view the maintenance management in structural, procedural and organizational terms assessed at twelve different categories.

An aspect of particular interest was the possibility of establishing a comparison with the industry current best solutions to highlight strengths, weaknesses and calculate any gaps.

One of the results of this phase is the list of quick wins opportunities, which in the case of Veritas coincided for the most part with the opportunity to copy / paste all the best practices of the various managements in a perspective of peer learning among colleagues (see Fig. 1).

The roadmap to a digital and predictive

Figure 1



water service

Subsequently, the work team designed the roadmap for the maintenance service digitalization. The same roadmap was conveyed in its most concise version to the entire company population, together with a series of videos prepared by MIPU with the aim of engaging all the stakeholders in the transformation process (see Fig. 2).

The priority work areas were the centralization of maintenance information in MIPU's Rebecca Asset Management platform and the start-up of predictive maintenance policies through vibration analysis activity on a pilot plant. This second aspect was chosen as priority to quickly achieve quantitative technical and economic benefits around which to maintain high commitment and motivation of the whole team during a long and complex project. The monitored machines are about forty; the technique used is the spectral vibration analysis. Thanks to the measurements carried out, it was possible to intercept bearing, cavitation and resonance defects; these first results stimulate us to accelerate the transition from a planned to a predictive and on-condition maintenance for all those situations where there are no mandatory regulatory constraints.

From classic to digital maintenance

In information systems, the "*garbage in, garbage out*" rule applies. For this reason it was decided to completely review the plants registry, extremely fragmented and with evident information gaps accumulated over the years. Then we worked on the functional decomposition of the plants in accordance with the guidelines dictated by the ISO 55000 and ISO 14224 standards, so as to be able to create a structured asset tree that acts as a suitable basis for both maintenance management and for the collection of measurements from the field and for the development, in the near future, of artificial intelligence models.

Therefore, the asset tree was quickly populated with machines technical information, the collection, the verification of consistency and the subsequent digitization of the documentation relating to the various assets, the inclusion of the personal data of maintenance operators and external companies; it all happened on the move and with the possibility of voice entry, an important detail for operating staff.

MIPU's engineers collaborated with Veritas's tech-

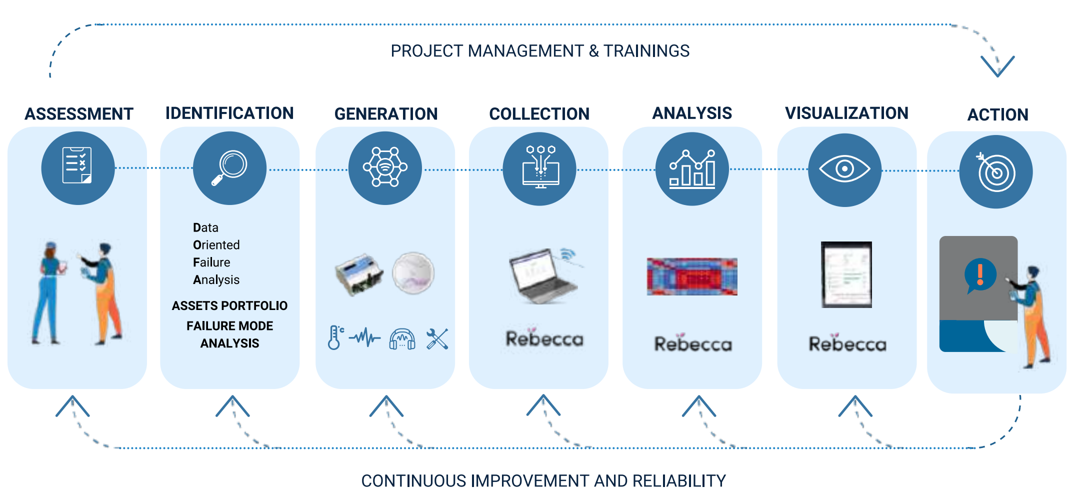


Figure 2

nical staff in defining maintenance plans for each asset. Each plan consists of standard procedures for planned interventions with related digital checklists.

The final accounting of the activities through the use of tablets directly on the field will make possible to gradually refine the estimate by composing a digital specification of all the activities and their related times. The final accounting of the work is not only temporal: **each technician has the possibility of vocally inserting into the system what has been done, dictating it to the tablet. The set of experiences and knowledge of each person composes a knowledge base which - if today it can help in the transmission of knowledge among colleagues and towards future generations - tomorrow will be the key element in building useful and inclusive artificial intelligences.**

Downstream of the above activities, specific maintenance performance indicators have been defined. While the management benefits from data experience of a substantially economic nature – such as maintenance and investment costs, maintenance cost per liter delivered - the various directorates can benefit from specific indicators for their area, such as response times of key suppliers, occurrence and recurrence of failures in the most critical assets, workers availability.

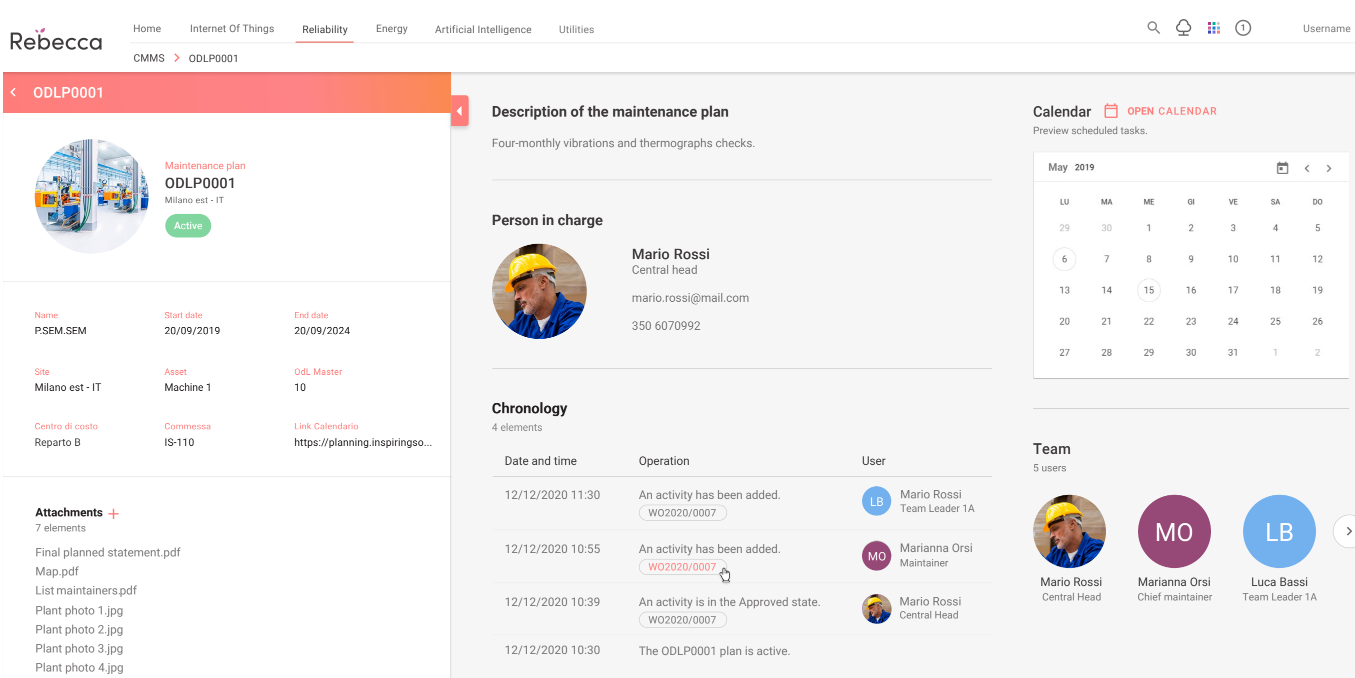
Results

Rebecca Asset Management software platform for the digitization of Veritas's Integrated Water Service hosts over 18,000 assets; these are divided within consistent and cohesive hierarchical levels for all the plants of the group. Operation technicians' daily routine is managed through over 1,000 digital maintenance plans, each characterized by optimized and standardized maintenance procedures. **Over 150 users feed the knowledge database every day, both through the constant insertion of new information from the plants, but above all through the summary and narration of the experiences of each one.**

This will be the basis for building artificial intelligences that support people in their daily work, for example by suggesting the most appropriate solution to a maintenance problem or quickly identifying the different make or buy scenarios and submitting them to the choice. **The daily use of the digital platform has allowed to drastically reduce the use of paper and the consequent administrative deadlines management.** For instance, technicians' logs containing all the daily activities carried out and the allocation of the respective hourly costs at the cost centers have been completely digitized: this information is now digitally recorded in conjunction with maintenance interventions and it can be directly consulted by the administration.

Finally, the incidence of extraordinary interventions on the total was reduced thanks to the aforementio-

Figure 3



ned optimization process of maintenance plans, to the greater control of planned activities and maintenance backlog following the use of the Rebecca digital platform. Furthermore, the impact was reduced thanks to the introduction, on the most critical assets, of predictive maintenance activities and in particular vibrational analysis that is able to anticipate and predict failure occurrences (see Fig. 3).

UMBERTO BENEDETTI
Integrated Water Service Division Director, Veritas

ALESSANDRO FERRARIO
Asset Management Product Owner, MIPU

INTERVIEW WITH ANDREA RAZZINI MANAGING DIRECTOR, VERITAS

How the Integrated Water Service will change in the next five years (focus on digitization, innovation or artificial intelligence)?
The Integrated Water Service has been recording the entry of new technologies for some time. These technologies will be satisfying especially in monitoring and artificial intelligence applications. We are moving from reading the data generally followed by water networks maintenance activities, to an interpretation of data that is also functional to the networks development according to more efficient designs and models.The application of mathematical models interfaced and powered by monitoring networks leads to a higher level of aqueduct networks management.

What strategic investments do you think necessary?
Strategic investments are, remain and will always be those related to water networks extraordinary maintenance activities. They guarantee the continuity of the Service without interruptions and the safety in networks and water resource management. In the near future, they will be also accompanied by an increasingly widespread use of digital technologies.

In this scenario, what role will the application of a predictive approach to water infrastructure management play? What will be the impact on processes and personnel?
The predictive approach, thanks to mathematics models, monitoring and automation, in addition to the acquired skills of better management of the networks, it should aim at making day-to-day management, investments allocation and probably also the emergencies management more efficient (breakages, damage, etc.). The impact, generally positive, certainly entails knowledge acquisition and the growth of the personnel training needs (also operations staff) and the arrival of skilled professionals, mostly expert and trained also in the field of digital technologies.
Among the systems and the infrastructures managed by Veritas, in addition to aqueducts, sewers and purification systems, there are dewatering pumps, white nets of different nature, fire prevention nets, purification systems not connected to networks, substitute services: the complex amount of information and its nature requires an excellent specific training in the sector and equally effective management and reading skills about data residing in different sources, therefore, also integrable with artificial intelligence.

IVAR: A CONNECTED AND PREDICTIVE FACTORY

by Emiliano Vezzoli and Matteo Bissone

Company setting

IVAR Group is a leader located in the area of Brescia that designs, develops and manufactures high efficiency heating and sanitary energy systems since 1985. IVAR's products catalog includes over 10 thousand entirely made in Italy items manufactured at Prevalle's plant, a headquarter designed to rationalize all the different productive and operational phases. Production is managed internally, starting from hot forging up to mechanical processing and the final assembly of the products.

In the two-year period 2020-2021 IVAR group, which in recent years has started several projects attributable to the Industry 4.0 principles, has set itself the goal of improving production efficiency by leveraging technological and IT innovations. In this context, and in the important innovation path pursued by the Group, the collaboration project with MIPU started with an in-depth analysis of production planning.

Need

Since the beginning, the need that has been identified is to optimize IVAR's maintenance operations and to lead the work team towards the use of digital tools. Among the triggers that brought this need to light, we identify a significant change in production planning methods: on the one hand the optimization of order management costs and the reduction in inventories are highlighted, on the other hand the possible negative impacts on the wear and tear of productive assets.

Therefore, MIPU has structured an ad hoc path for the company which, starting from a reliability assessment, has been configured in a 12-month digitization project with the aim of investigating new approaches to plant management in order to ensure its desired reliability and availability.

Solution

Two factors have been highlighted in this project:
- a good operational management of the activities but in a reactive and not in a very standardized manner;
- a little valued but great potential in terms of data analysis.

The assumed solutions in the proposed roadmap were:
1. The revision of the organizational structure of maintenance function to ensure availability of resources (both for operational activities and for their planning);
2. The digitization of the physical and information assets managed by the maintenance function.

Thus, the first step was to do asset inventory and guarantee the selected staff access to the information assets matured by the company over the years: cards machine, maintenance history, spare parts. Everything happens in mobility and thanks to a simple scan of the QRcode on board machine.

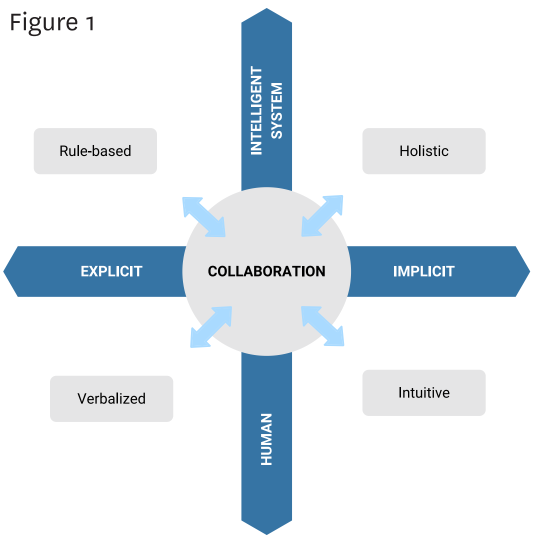
Subsequently, we involved all colleagues in a process of maintenance operations digitization which involves the planning and reporting of dedicated teams activities on the Rebecca Asset Management software platform.

The main goal is to create in the time an engine of shared knowledge that on the one hand it can support operators in the ever better execution of the tasks assigned to them, on the other

hand it can create a possibility of applying artificial intelligence to the issue of restoring a malfunctioning asset with a determined quality and in the shortest time possible.

Particularly, our desire is to create logic of knowledge distribution among different agents, as well as logic of collaboration for the achievement of a specific purpose (see Fig. 1).

Figure 1



An important challenge for this type of project is represented by the need to translate the implicit knowledge deriving from personnel experience in an explicit and formal one. Furthermore, in order to enable an effective decision support system, it is necessary to make explicit not only the knowledge of each individual, but also the rules on the basis of which the person acted in a certain way. For this reason, after the census of the assets and their information, and the digitization of maintenance activities, we have worked to analyze the data collected, both as performance indicators and as a basis for carrying out critical and failures root cause analysis. These analyzes were conducted on both the functioning of the machine and in the operation related to specific production batches (see Fig. 2).

The integration between the software platform proposed by MIPU for Asset Management and the management software of IVAR has also allowed to **automate and digitize the interconnection operational flows between operations and purchasing functions**, enabling further spheres of knowledge.

Results

In the first 12 months of its launch, the project has achieved the following tangible results:

- more than 2,500 registered assets on which useful information is being collected and historicized every day to process subsequent analyzes and intelligences;
- the increase in the hours of active operation of the maintenance teams (wrench time) from 30% to percentages above 45%;
- a significant (about 20%) reduction in sudden stops due to an improvement in intervention planning, with consequent production improvements and cost reduction.

Although satisfactory, these results are neverthe-

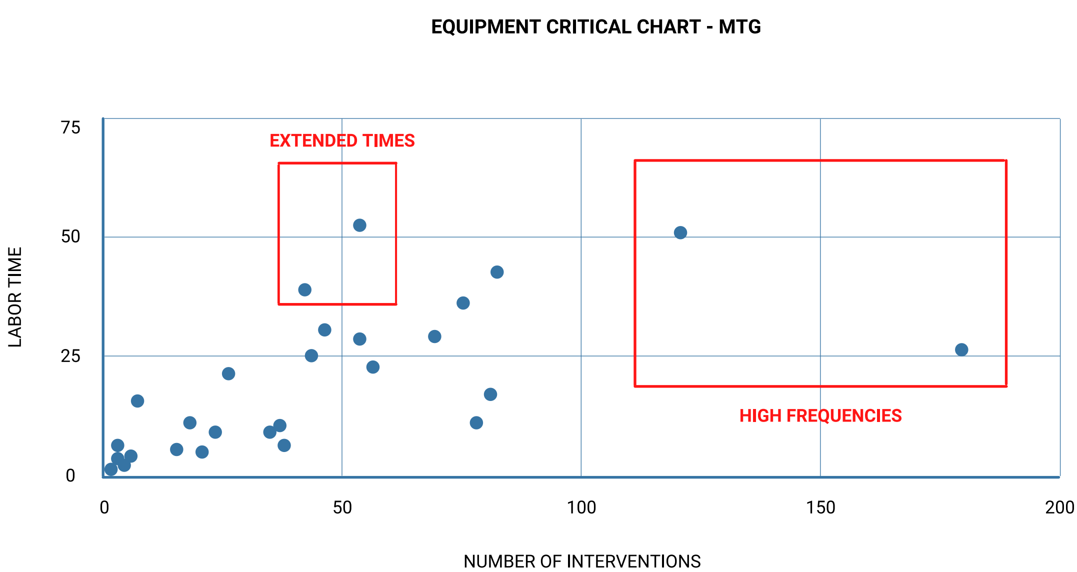


Figure 2

less the first step towards a wider cultural and organizational change, where the knowledge gained over the years can be enhanced and expanded. Goals are set, data collection is increasingly extensive, the connected and predictive factory is live.

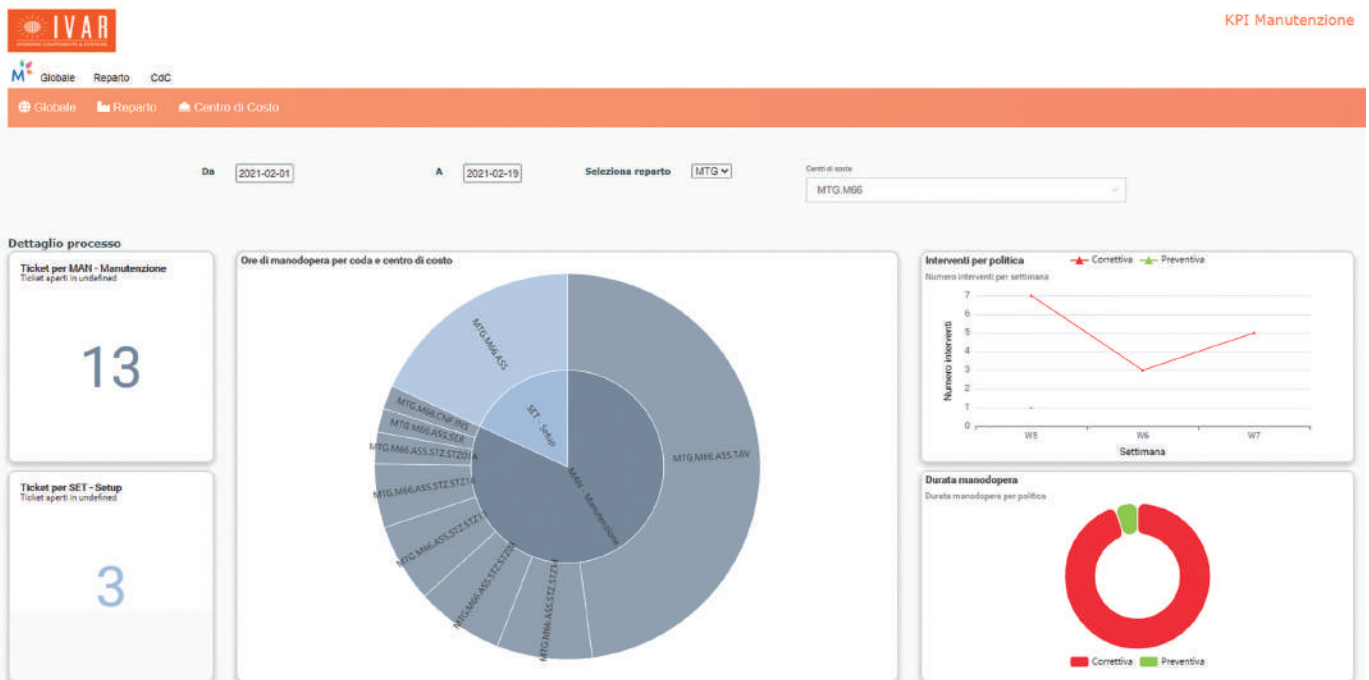


Figure 3

Example of a dashboard used in the IVAR project

EMILIANO VEZZOLI
Head of Plant & Production Technologies, IVAR

MATTEO BISSONE
Predictive Factory Advisor, MIPU

INTERVIEW WITH PAOLO BERTOLOTTI CEO, IVAR

One of the IVAR's strong point is being green oriented: how and thanks to what innovations are you able to pursue it?
The orientation towards activities that guarantee particular attention to sustainability has always been in IVAR's DNA, and that is because we believe that a company should integrate as much as possible into the environment that surrounds it. We both refer to the environmental impact and to the impact on people who directly or indirectly share the same spaces. In our corporate situation, every product and business process is evaluated not only from an economic point of view, but also considering the impact it generates by always looking to minimize it. IVAR produces energy saving products and it would be inconsistent to do so in plants with a high environmental impact.
Since the early 2000s we have set ourselves the goal of completely eliminating our emissions; we have achieved this ambitious goal through the installation of a photovoltaic system that covers all our plants, through a geothermal heat pumps heating and cooling system (including production sites), through the purchase of electricity only from renewable sources and through many other more targeted actions such as the use of only water-based paints and recycled material for our packaging. These activities allowed us to obtain ISO 50001 certification in 2014. It is possible to be green oriented both in large and in small daily activities.

The manufacturing sector is the flagship of Brescia's industrial reality: what are the scenarios for the near future? How much has the pandemic affected in redesigning them?
Personally I believe that Brescia's economy is quite well equipped to be able to recover quickly from the slowdown caused by the pandemic. We have long invested in new enabling technologies and in the automation of production processes driven by the competitiveness necessary to face competitors from all over the world, being our province strongly oriented to export activity. In many occasions, talking to colleagues or foreign competitors, I got the idea that Italian companies in general, but Brescia's ones in particular, are able to be very competitive abroad because they "cut their teeth" to survive in a climate not too favorable to companies growth and therefore when we enter foreign markets we are not intimidated by the competition.
I believe that the pandemic had the merit of making us rethink the management of the relationship with customers and suppliers, business trips and trade fairs, pushing us to use those technologies that, in many cases, we already had at home and that effectively allow us not only to avoid direct contacts, but above all to be more immediate in the relationship and to rationalize costs.

How ready are Brescia's companies to engage emerging technological trends, including Artificial Intelligence? Could you suggest three proposals to accelerate this process?
I think it all depends on the attitude to the change and on the will to progress that a company owns, but the ability of trade associations and institutions to inform entrepreneurs and managers must be fundamental. It should be aimed primarily at highlighting the concrete benefits rather than focus on the technology itself and that is because in many cases, even for reasons of age, it is not very easy to understand it. Just to give you an example, knowing that the analysis of the energy consumption of a robot motor can lead to avoid breakages over time with consequent downtime and costs is more important than lingering to explain the communication protocols that populate databases on the cloud for the subsequent analysis. It is equally important the introduction of these methodologies and knowledge in the technical studies to better prepare students for the workplace, making sure that they are the ones to bring these innovative technologies especially in small businesses, often more reluctant to change.

THE INNOVATION MANAGEMENT IN INDUSTRIAL PROCESSES

by Stefano Mainetti and Francesca Saraceni

The dynamism with which today companies are called to evolve requires organizations to have the ability to reconfigure themselves repeatedly at multiple levels: in the offer of products and services, in people with their competences, in the organizational model and the technologies employed. Addressing this request of continuous evolution with inadequate tools and impromptu actions can generate frustration and poor results.

It is therefore necessary to overcome the idea of an innovation based on the exceptionality of individuals or casualty, because this cannot be behind the innovation strategy of an organization[1]. The need to innovate in a continuous way and through fluid processes is therefore an essential condition for every organization that wants to maintain and strengthen its competitive position on the market.

Over years, in fact, significant steps have been taken in order to systematize the innovation process, and to convert the innovation from an extemporary event to a repeatable event. Various technologies have been set up, some of them designed ad hoc for industrial organizations, those companies involved in constructing material asset and often called to invest great economic and intellectual resources in the systematic innovation process[2].

With the advent of the paradigms named Industry 3.0 and Industry 4.0, the industrial progress has seen taken place decisive evolutionary steps both in terms of organizational logics and in terms of industrial and digital assets, resulting in the increase of the complexity of the management innovation processes and making much less effective systematic innovation models developed over the years.

Digital technologies, in fact, are widely used, easily accessible and have characteristics of immateriality and continuous evolution able to displace those who deal specifically with the evolution of industrial assets.

Based on current technological developments, and with particular respect to digital technologies, today it is not appropriate to establish a strategic plan and to think that it will remain unchanged for a long period. **It is rather necessary a rethinking approach and continuous replanning, that captures insights and elements of innovation,** gathering signals from outside, either they are the result of the study of the most innovative technologies, the interaction with customers or derive from the observation of competitors up to companies in other industrial sectors. This feature of greater opening outwards finds undoubted confirmation in the innovation ways followed today by digital native companies: just think, for example, how much today "the giants of web" innovate by leveraging on external actors, like universities, research centres and start-ups. Strength of these observations, industrial consolidated companies acquired awareness of their limits in the internal processes dedicated to the management of systematic innovation. Even if they are processes

1 There are many anecdotes related to casualties about some important innovations achieved by successful companies. Actually, these are exceptional cases if evaluated as a single event, but if they are seen in a sufficiently broad time frame, you realize that also in these cases the innovation process never stopped and it continued during time allowing companies to fully understand the benefits of the obtained innovation.

2 Sheu, Daniel & Lee, H.-K (2010), *A Proposed Classification and Process of Systematic Innovation*, *International Journal of Systematic Innovation*, 1(1), pp. 3-22

typically well organized, they run the risk of being slow and expensive with respect to the speed and dynamism with which the external environment moves. **So it is necessary to review the traditional funnel of innovation initiatives, organized in stages with appropriate blocking and feedback moments, in order to become permeable even at external ideas, opening assessment to collaboration scenarios with specialised research centres, to collaborations/acquisitions of start-up or the establishment of industrial spin-off, with the aim of act quickly and make more sustainable the internal process of innovation.** This approach to the innovation, called Open Innovation[3], is pushing industrial companies to develop competences in order to operate in the main innovation ecosystems[4] up to provide themselves specific venture capital funds to finance start-ups able to identify and verify new business models[5] (see Fig. 1).

As mentioned, this way of innovating is pushing industrial companies to a greater experimentation of the innovation on the market and to ensure that there is a rapid rise of objective evidence from the final market towards the previous stages, until returning, if necessary, to the generative phases of ideas in order to call into question the entire journey[6].

Incremental innovation vs radical innovation

In order to understand how to evolve the traditional systematic model of innovation, we begin to reflect on the different features of two big macro categories with which it is possible to classify the innovation: the incremental one and the radical one[7].

3 Chesbrough, Henry (2003), Open Innovation The New Imperative for Creating and Profiting from Technology, Harvard Business School Press

4 Mainetti, Stefano (2018), Open innovation: un nuovo mindset per competere, Medium. (https://medium.com/@stefanomainetti/open-innovation-un-nuovo-mindset-per-competere-597c160db57c)

5 Mainetti, Stefano (2019), Fare Open Innovation in Italia: un percorso evolutivo in tre passi, Agenda Digitale. (https://www.agendadigitale.eu/startup/fare-open-innovation-in-italia-un-percorso-evolutivo-in-tre-passi/)

6 Mainetti, Stefano (2019), *Innovazione in azienda, tre livelli da scalare in sequenza*, Il Sole 24 Ore – Management (https://www.ilsole24ore.com/art/innovazione-azienda-tre-livelli-scalare-sequenza-ACWLw3E).

7 Norman, Donald A. & Verganti, R. (2014), *Incremental and Radical Innovation: Design Research vs. Technology and Meaning Change, Design Issues*, v. 30, 78-96.

- *Incremental innovation*: it is the improvement of an existing component, for example a product, a process or a service, with the aim of creating efficiency through a scalable and repeatable model. In other words, it is the type of innovation that allows the company to improve the "way of working". It's about improving in a continuous way something already existing.
- *Radical innovation*: it consists in conceiving products and services until then not existing and involves the creation of new business models. In this case, it is the type of innovation that allows the company to enrich and integrate their own offer of services and products, so the "what". It is an innovation that brings something new, unique and it often creates discontinuity. (see Fig. 2).

Figure 1 - Approaches for innovation management

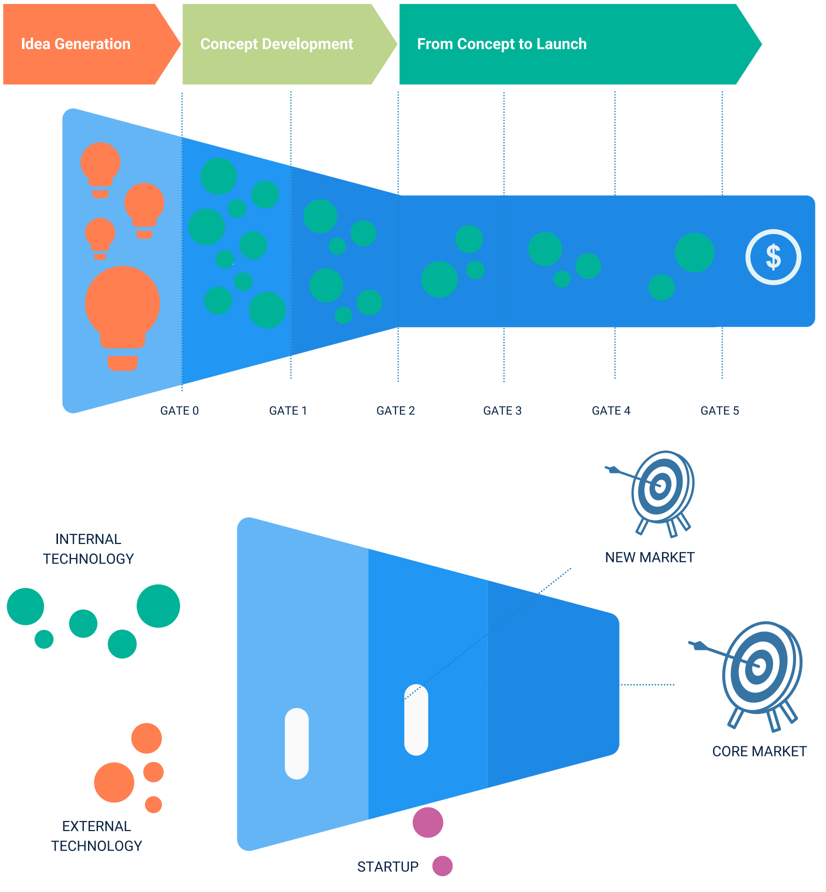
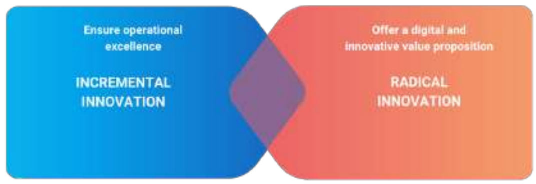


Figure 2 - Incremental Innovation and Radical Innovation



They are types of technologies that differ for more than an aspect, including the risk profile and the time horizon:

- *Risk profile*: incremental innovation is typically instantiated on technologies already tested and on consolidated organizational and business areas (ex. Business model). This involves a medium-low risk profile unlike radical innovation is typically based on models of value creation and sometimes on experimental technologies able to ensure multiples of value, but not free from major risks.
- *Time horizon*: in the case of incremental innovation, result expectancy can be planned with reasonable confidence, and typically in a short/medium term.

In the case of radical innovation, result expectancy is on the long period and it is surely less predictable, since the need for an experimentation and verification phase of the real interest of the market.

Moreover, even on the organizational and cultural terms, variables to be considered are distinguished, because incremental innovation is typically executed in more structured contexts, with specific and defined roles, since it is inserted on existing products, processes and services in which responsibility and governance model has been already established.

Therefore, it is a type of innovation based on corporate, technological and organizational, assets already acquired and defined. For its nature it is a type of innovation closer to the industrial world. Otherwise, the radical innovation, for its experimental nature, is implemented in organizational contexts more unstructured, in which roles and responsibilities have not been defined in advance. For all these elements, ensuring these two types of innovation at the same time into a company is a difficult challenge to face. This is more true in the case of industrial companies that have made significant efforts in recent decades aimed at careful planning, optimisation and prescriptions.

The components to consider to evolve the process of innovation

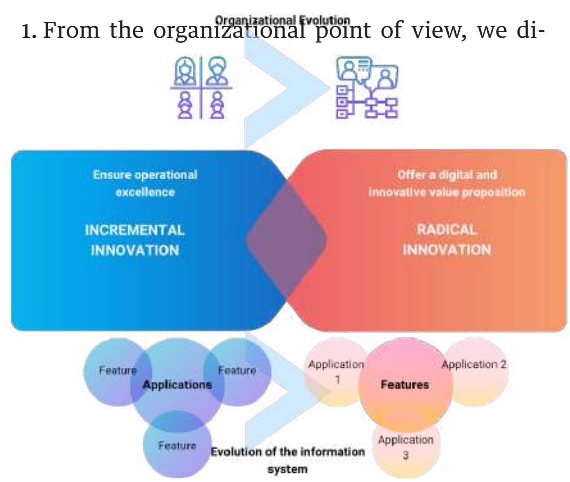
On the basis of the considerations so far expressed, **it emerges how important it is today to be able to rightly balance innovation initiatives regarding company's operational processes with those of more radical impact.**

The approach of delegating to two different groups the two different types of innovation, generally called the "dual" approach, can result in being simplistic and counterproductive. Keeping these two areas disconnected, lead to a nullification of many of the elements so far discussed about the necessary opening today in order to be able to innovate in a complete and successful way.

Two basic components to work on in order to keep unity and synergy between the two different ways of innovation are the organizational model and the company's information system (see Fig. 3)**.**

Figure 3 - Organizational evolution and evolution of the information system

1. From the organizational point of view, we di-



scussed how it is not easy to take into consideration at the same time the objectives of optimization in the short term with the objectives of radical innovation. The organizational models developed in the past, based on hierarchical organizational pyramids and oriented to the definition of specific tasks with the aim of optimizing the single phases of work, inevitably tend to penalize the processes of innovation as they distort the short-term objectives. .

Even the attempt to systematically promote some principles of innovation into structured processes runs the risk of being self-reverential and not able to face in a complete way the risks connected to radical innovation.

For these reasons, today industrial companies have evolved pyramidal organizational models into matrix models, named pluralistic models8. The traditional formal roles within the hierarchical pyramid have been flanked by more lines of reporting, related to specific tasks and roles. **The managerial culture is not oriented anymore to the execution of tasks, but to the achievement of business objectives. Thanks to this plurality of relations and objectives, it becomes possible to combine the different characteristics of incremental and radical innovation.** Today, pluralistic organizations promote the culture of innovation as the key for market shares. Lastly, in pluralistic models the organizational dimension of the work team becomes particularly relevant, as a temporary unit with a specific objective and that enjoys a certain degree of organisational freedom.

This pluralism of relationships, combined with greater decentralization of business responsibilities, involves inevitably a greater complexity of government.

The second key element that must be taken into account, **the information system, needs to be evolved to offer a greater support to the management of complexity.** Especially in the industrial sector, the typical configuration of the information system focuses on the use of an integrated management system, as the ERP system (Enterprise Resource Planning), flanked to a series of accessory vertical applications, result of the application strategy consequent to the evolution of the company over the years. For all intents and purposes, it is often a representative configuration of the hierarchical organizational model on which companies had established their way of operating, result of a history made by optimizations and a successful operational model that over the years have been crystallized in the ERP system. These configurations involve, in some cases, management defects and logics which are no longer current, but represent the key core on which the company bases its operations. Particularly, a system thus conceived has been designed to expose to users the use of single functionalities, masquerading the quality and status of managed data to managers and company, analysable only through new specific applications called "business analytics".

With the rise of pluralistic organizational models that, as we have seen, overcome the logic of the organization for tasks with a logic for objectives, the importance of analytical systems for decision-making becomes fundamental. If we then take into account the processes of innovation, both incremental and radical, we realize how central is the issue of data.

Only the careful analysis of the information obtained from experiments, allows us to verify and eventually validate our innovation strategy, learning from failures and containing risks and costs. These information also are the key core on which to build the next evolutionary step of the operational model, thanks to the appropriate and consequent interventions on the applications.

The information system is, therefore, now called to conceptually evolve, focusing on the information heritage and building around a dynamic archipelago of business applications.

A practical example

Consider for example the case of a company that wants to face the innovation consequent to the recourse to predictive maintenance techniques of the systems supplied to customers. The company wants to explore the opportunity to enrich its offer by adding a service of monitoring and management of the asset to the sale of the system, according to features of preventive and predictive maintenance. It is a typical use case that requires an intervention on the information heritage which covers more than one existing application (for ex. ERP, MES, IoT applications that manage the field sensors, CRM, extranet portals, ecc.) between them are hardly integrated and aligned. The way to sift this possible innovation initially passes from data recovery and analysis to the construction of predictive models. Once the feasibility of the proposed innovation step has been verified, it will be necessary to intervene on data heritage and evolve the applications to upgrade the support of the new service..

In conclusion, the ways of innovation in industrial companies in recent years are rapidly evolving. The important efforts made in the recent past to make the innovation process systematic, and so less entrusted to randomness, have been joined to interventions to open up this process more to market stimuli and collaboration with actors external to the company beginning open innovation initiatives. Moreover, the increasing use of digital technologies and the advent of Industry 4.0 paradigms have pushed companies to the research of a right balance between initiatives of incremental innovation and radical innovation ones. In this quest for balance, the evolution of organizational models and information systems assumes a fundamental role. At the first we see the adoption of pluralistic models, which involve the passage from hierarchical pyramid models to matrix models, with more than one carry-over line, connected to specific tasks and roles and with a managerial culture not oriented anymore to the execution of tasks, but to the achievement of business objectives. As regards information systems, their roles today become essential for the management of complexity. The information heritage, data and company knowledge, becomes a fundamental asset on which to build both the experimentation phases and the later stages of industrialization and optimization.

STEFANO MAINETTI has more than 30 years of experience in projects and entrepreneurial initiatives in the field of Digital Transformation.
Adjunct Professor at the MIP Politecnico di Milano, he was CEO from 2013 to 2020 of Polihub, the start-up accelerator at the Politecnico di Milano.
Co-founder and President of doDigital s.r.l., a company specialized in innovation consulting, and Webscience srl, a company specialized in agile development of digital applications.

FRANCESCA SARACENI has over 14 years of experience in assessment projects and evolution of company information systems. Senior researcher at the Observatory of the School of Management of the Politecnico di Milano within the Cloud
Transformation is also co-founder of doDigital s.r.l. and Intellico srl, a company specialized in the marketing of software applications in the field of artificial intelligence and sustainability.

INTERVIEW WITH MAURO FANIN CEO, CEREAL DOCKS SPA

Cereal Docks is, according to all indicators, a company of excellence despite being included in a panorama – the Italian one – and in a sector – the agricultural one – extremely complex and fragmented. In a recent interview, you stated that you've never expected a company like yours to invest so much in digitisation. How has this choice matured and how does it affect your daily life?

First of all I want to precise that it wasn't a choice dictated by a particular external factor, but rather the result of some considerations matured over time, first of all by myself. The world was evolving quickly and I felt that this sea of data that was invading us must have been governed and well declined. There were however some important moments of this transition, which I vividly remember. The first one was in April 2018. It was a Saturday morning and I was offering a coffee to my collaborators. In that moment, alive in my memory, I felt about going in the middle of the group, which in that moment was standing behind me, to share with it an important change: Cereal Docks would innovate its operating model from managed company to guided company.

If the first step was personal, the second was the choice to share this change with all the collaborators in order to make them protagonists. This passage has been realized with a series of investments both digital and organizational: sharing the leadership and spreading energy in the company means, first of all, supporting the evolution of every collaborator. That moment coincided with the construction of our new headquarter where the idea of a widespread leadership, open innovation and contamination are expressed through the choice of a new architectural solutions, today visible to everyone who enters Cereal Docks.

The third step was even more concrete and pragmatic and it coincided with important investments in the company's IT infrastructure and staff dedicated to this function: five years earlier the IT function of Cereal Docks counted one person, today it counts seven of them. An important part of the investments was focused on the collection of data and its consequent elaboration into information and knowledge to govern the development of every area of the company. I deeply believe in an entrepreneur model which is first of all coach on the side-lines. If the true protagonists of the game are my collaborators, in order to guide them in the best way I must share with them a series of valuable data and information. Our company is datacracy; the entrepreneur needs to be able better than everyone else to distinguish between signal and noise to make lucid and courageous choices.

What do you think will be the most important turning points that digitisation and innovation will give to your company?

In our continuous research of innovation, we pursue three main objectives:

1. **Increase the efficiency of production** in order to realize more than we have already done. Therefore being able to answer variable requirements with punctuality, reliability and at the best cost possible.
2. **Accelerate our path to sustainability. I like the figure of a dodecahedron.** the image of a complex but solid structure like sustainability that we practice in Cereal Docks. We face important challenges such as drastically reducing the impact that the company and the sector, in general, have on the environments in which they work. Information technology and new technologies can make a substantial contribution to making the whole supply chain more sustainable.
3. **Seeking new solutions not only for feeding, but nutritional. Genome monitoring allows us to know much better than in the past human and animal needs for a better life:** our research is headed either to the rhizosphere, from which plants get nourishment to grow, and the human, that we want to nourish in the name of health and balance. Artificial intelligence can allow us to make giant steps because it helps us to process thousands of data in new knowledge and opportunities.

The pandemic from Covid-19 has abruptly accelerated our exposure to the world of data and digital, with disruptive and even positive effects. We must adapt our vision of the food sector in order to capture the important opportunities offered by the economy of the data and to be protagonists of an evolutionary context. In this sense, I must say that every innovation investment is amply repaid not only from the operational result, but also from the cultural and perceptual change to which it forces us; a change that is, for our company, stimulus and positive energy.

MADE ITALY, WE MUST MAKE ITALIANS: WITHOUT CHANGING THE MINDSET, STRATEGIES CAN NOT BE REALIZED

by Raffaella Bossi Fornarini

And if it would have gone backward? First making Italians and then Italy? What results would we have achieved as a nation? For the nation I can only imagine, but I don't know. On the other hand, in companies we know very well how reversing the resurgence sequence gives very different results compared to promoting a change without changing the "head" of people: **researches confirm that creating the mindset, the corporate culture** (for simplicity I will use mindset and culture as synonyms in this text), **is essential to make the change feasible, relevant, profitable and engaging.**

I've been working for decades **with cultural transformation**, that is **creating the conditions so that thinking and acting in a company facilitate the realization of a change.** At the same time, I've been at first agent and target in a company and later, as a consultant, I participated in the construction of the corporate culture in very different complexity dimensions and contexts.

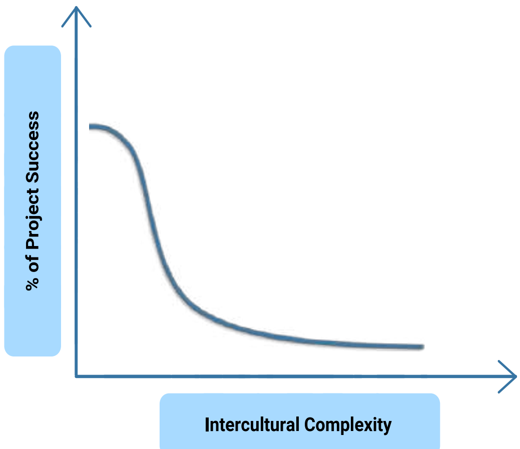
Now I am going to tell you in a synthesis about what I've learned and I practice: I am going to tell you that **through operational guidelines which you can use immediately in digitisation projects that you are living or that you are going to manage.**

As said, to realize any change, the success of the activity depends in a substantial and priority manner from the ability to build the mindset that allows to realize that change. Let's make an example: switch from the use of our own private car to public transportation. Or you create a culture of community, of environmental respect, of a better air for everyone, of pride to help make more liveable our own city or you do not convince anyone to leave a "reserved" environment for a crowded and tied to fixed hours one. Frequency, cleaning and modernity of the bus is not enough to make sure people don't use their car.

Let's look to Covid-19: no one foresaw it and no one has previously created the culture for that change, but **companies have rapidly trained people's ability to react to events finding a solution with which they have been able to generate commitment, engagement and innovation.**

Look at the management of international projects. According to this survey, realized in association with Politecnico of Milan, not creating a diversity culture in PM teams shows a fall almost vertical of their ability to reach time-cost-quality (see fig. 1).

Figure 1 - Impact of Culture on project management: result of a survey developed by MIP Politecnico di Milano & Passport (Passport Visual Library)



Typically, this sort of “ ground preparation” takes place in moments in which it is necessary to create a waste of culture, a “before and after”, an evolution that makes an organization able to acquire and use appropriate behavioural ways for a new context: more traditionally these moments were, and are, generational transitions, changes at the top of companies, mergers and acquisitions, international processes; more recently they are the implementation of digitisation processes, the implementation of more agile ways of work or cultural affirmation of diversity and inclusion, the deep internationalization.

We focus on digitisation, the theme of this volume. If I would follow what I mentioned above, if I would have a digital culture, **then the digitisation process will give rapid, solid and long-lasting results. The need to create the appropriate mindset to digitisation became evident by analysing the results of companies that had started a digital process and observing a deep division between the results of the group of companies that had been responsible to create a digital mindset and those that directly passed to the phase of implementation of change.**

As for Italy commented by Massimo d’Azeglio in the title: proceed to action thinking that culture will follow, is a widespread behaviour originated by the – wrong – idea that enticing benefits, including the apparent speed of action between the thought of those who have identified the opportunities of digitisation strategy and the structure, to which the implementation is required.

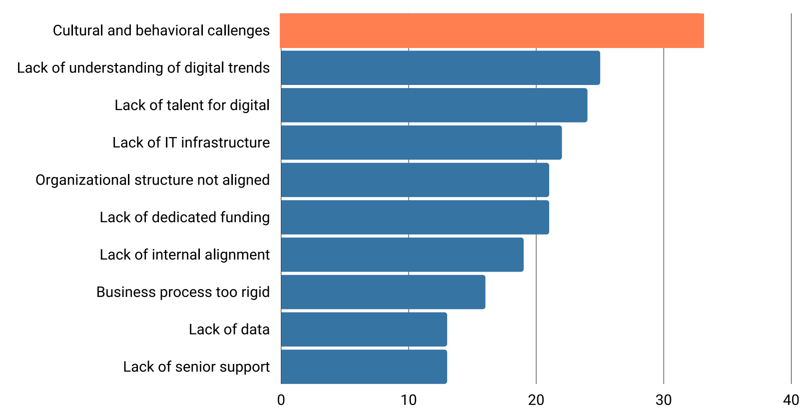
This system of creation-communication, and not cultural transformation, is based also on the consideration of a **low propensity to change**, especially in corporate populations little accustomed to change and risk, far away from culture of error and maybe, in the specific case of digitisation, also little fascinated by technological tools and their social impact.

The frequent sequence “act and communicate” still very much practices, allows an apparent initial speed, but it soon finds a hitch.

Creating a culture that allows a careful, creative and ready solution to problems that digitisation requires is a process that needs time and continuity of action. We see, therefore, some studies that have attempted to answer the question: how much does the creation of a digital culture impact the realization of digital projects? I take the data published by McKinsey and BCG (see Fig. 2).

Figure 2

Which are the most significant challenges to meeting digital priorities?

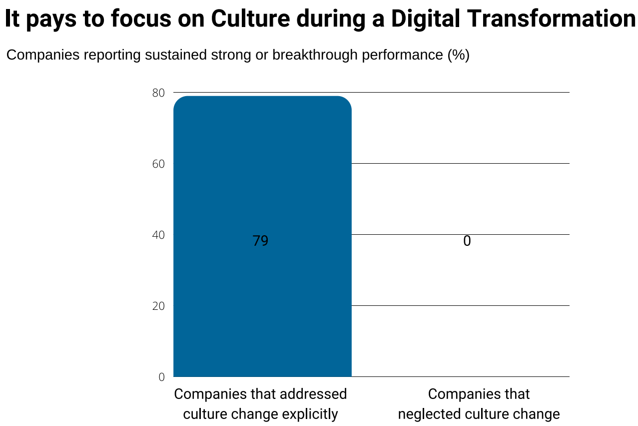


Source: 2016 McKinsey Digital Survey

I read the results of this research several times before I was sure I understood correctly. **To create a company able to act in the digital world, understanding cultural changes is more important than having IT infrastructures. Cultural challenges impact on results more than the size of the budget financing digitisation.**

See BCG: score: 79 to zero! (see Fig. 3)

Figure 3



Source: BCG

And what about this second result? As you say, 79 seems a lot? Let's do about half? 40 to zero? Better? I think no comments are needed.

Then what can be the process that allows us to not end up on the right column or very close? I am going to tell you by using the title of two books. The first is *Harry Potter and the Philosopher's Stone*.

If the culture, the mindset, is fundamental to realize a technological change, I would like to underline the importance to have the availability of three dominant characteristics or to be created:

1. The desire to know what that technology allows to do

Attention, not to know how to design a 3D printer, for example, but to have the knowledge of the technological level achieved, of the studies that are being carried out and of the hypotheses of development that circulate, of the problems and the legal opportunities and uses that are being sought to overcome, of the needs that the new technology allows to solve, the impacts on parts of the life of people and companies that can be completely transformed by the spread of 3D printers. I mean, I don't need to create experts, but curious people, or I have to make them curious, careful to the changes that a certain technology is bringing to the whole society, not only to their own company or commercial sector. I will make an example: when in the 90s Whirlpool Corporation decided to pass from an EVA strategy to a Brand one, design became a central part of the customers' experience with the brand. And suddenly, the whole company was exposed to design issues.

Books, publications, conferences, interventions of external guests available for the whole company, continuous presentations of the activities of design departments, have become activities aimed at the whole population that has been exposed to the issues, the choices made, the problems solved.

We started talking about the appliances of the future, about what functions they might have and how design could evolve. The whole population had been exposed to these issues,
in different shapes and types of communication: no one became an expert of design issues, but everyone helped what the company had to do and translated it into their daily action. The company was talking about design. The culture had changed: everyone changed into an ambassador of the strategy.

2. The ability to imagine

We can not reach a change if we don't allow people to imagine, to delete orthodoxy of its sector, to move from the *Culture of Control* to that of *Management* of *Uncertainty*, to move without having yet all the answers, to develop the ability to imagine a future that you will help to achieve. For example, what if we could really dematerialize the goods we produce and "transport" them to another place where they would "reform"? How would it change our lives? What benefits could we have? How would it change our day? It is a fundamental job to do because digitisation often is guided by people who for training, habit, **mindset, are not used to consider fantasy an important element for their work but they are trained to measure, plan, control: practices, these, surely not to be minimized but to be integrated with a healthy work of imagination.**

PFor this ability Design Thinking is becoming a widespread and researched practice that brings to the creation of a digital culture. I mean, however, the ability to imagine as the fusion of knowledge, ability to drawn innovation from one's own pleasure in different fields and far from those that we deal with professionally, from ideas that come at times when we are focused on doing something else (a bit like Sherlock Holmes who solves court cases by "playing" in his chemistry lab).

The fusion of knowledge, its continuous movement between the pleasures chosen and the duties of professional life, is in my opinion to be considered a generative part of the culture of change (today digitisation, who knows what tomorrow when digital will be the norm...). And I think it coincides with the experience of all of us in seeing these characteristics in tireless managers, always energetic and looking for solutions. Where you can create the culture of work as satisfaction (although with constraints not all idyllic) and not as sweat of the front waiting for the liberating weekend, the corporate culture becomes receptive to change, experimentation, to bring better experiences between the two worlds, personal and professional. So imagine structured, but also free and personal imagery.

In this regard prof. Alberto de Toni says, quoting the economist Enzo Rullani, "we have rediscovered the fluid intelligence, for years stifled by technical intelligence, the supremacy of classical science, the world of machines, the assembly line has stifled the creativity, the personality, the uniqueness of people". (A. de Toni, Auto-organizations, Marsilio, 2011).

3. The ability to adapt to the context

At this point there are two passages: the first is **learning to read the context**, its becoming, knowing how to formulate hypotheses about the future - political, social, economic, legal context, anticipating trends, social demands, evolutions of the use of resources.

The other key word is **adaptation**: this is the biggest difficulty I've seen every day in the company for 15 years.

A huge amount of people think that the context should be dominated, ask themselves how to invert trends, how to avoid having to learn again what they already know how to do. These people complain about the context in which they act, fight for ideals often out of what's happening around them: they do not adapt to the context, they oppose it, even if with the best intentions.

In my experiences into a company, the difficulties in the adaptation to change is still really high: it is substantiated in sentences such as "that others change", "it is only a trend that goes away", or in the case of Covid-19 "when the vaccine will arrive, we'll come back as before".

So, **even after reading the context, the most of the managers does not yet ask how to adapt it, and this certainly does not help to change.**

About this theme I work a lot in the courses that I hold at MIP Politecnico in Milan, in IULM, in Cattolica and in many Business School in Asia. You learn to read the context and to forget your favourite way of acting to learn, to think and behave in another reality with different rules: at the beginning it is difficult, but when the new rules become usual, adapting to the context allows, thanks to the waste with the culture from which you come, to act in an excellent way because the ability to find solutions increase, the satisfaction of doing it in a new way strengthen incursions in still little known worlds, the need of alibi collapses.

Let's leave Harry Potter, which funds the three principles mentioned, and move now to the second literary reference, with a rigorous title.

Measure for measure

I don't trust adjectives, which I like very much and to which I attribute in literature a great role. But in a company? How much culture do we need? And from which basis do we start? And how can we know what we must develop by ourselves, to do the digitisation of what we need? When in a company they ask me a visible, remarkable change, of a turnaround, how do I measure these targets?

To answer the need for quantification of soft objectives and to verify the impact of investments made in order to reach them, I focused with my team on the creation of instruments for measuring the culture.

We worked to:

- **Identify the KPIs that allow to analyse the status of corporate culture**

Starting from parameters identified in previous studies, we put to work a team that had managed complex cultural changes: to this beginning we added years of tests – verifications – rewriting and development of the categories to be measured related to the evolution of business context: all of this brought to the definition of KPIs that our dashboard of corporate culture should monitor;

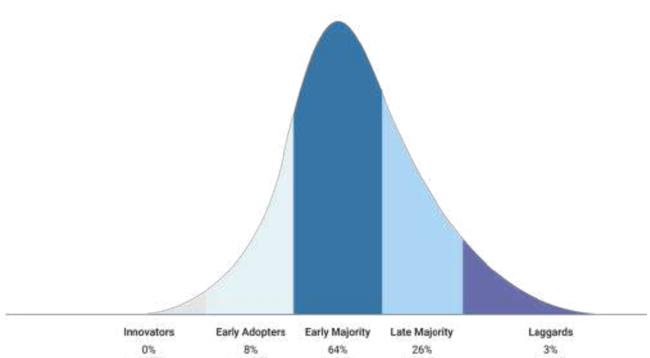
- **Create the algorithms that allow to measure KPIs;**
- **Create a "quilting" structure – as it is called by one of my clients– of the culture in everything that is done by the company.**

So, a typical project of creation of a digital culture follows this structure:

1. **Target:** analysis of business targets, comprehension of digital needs of the company.

2. **Level of agility to change:** mapping of the level of *change agility* of people. How capable are they and ready to react to changes, both unexpected and desired? How much can they manage the steps of change? On the four parameters we have identified and described, we go to give a personal return to individuals and a total average and for clusters of the population surveyed. In the end, collected data build a curve that shows how the population is disposed on five segments of the curve of the diffusion of innovation. We called this tool of agility almost as an agile cat, CAAT, Change Agility Assessment Tool (see Fig. 4).

Figure 4 - Example of a company's population distribution curve based on the results of the Change Agility Assessmemt with respect to the theoretical innovation diffusion curve (Passport Visual Library)



Consider the case of a big international company of energy: a team was perceived as not able to react easily to a change. The results of the test of *change agility* gave a measure of the perception. The objective data allowed us to create customized programs of development. Moreover, at a distance of time, the test was re-administered to verify that the desired change was acquired.

3. **Mapping of the existing culture.** Even in this case we use a proprietary tool, the Intercultural Due Diligence (IDD) that profiles corporate culture on the basis of 25 features of corporate culture with the integration of cultural mapping dimensions deriving from waste parameters between different cultures. It is a fundamental phase. **We must know how people think and act in a company, what they consider normal to evaluate the potential and the possibility of change.**

4. **Identification of the target culture,** the one that will bring people to have all the thought and acting tools to realize digitisation in that precise company. In that phase we work hard on the connections between different features to define: I give an example that represents a theme that we find very often. To switch to a digital mentality, it is usually identified at first the opportunity to develop a disruptive thought, able to work on hypotheses that, if validated, can deeply change the previous way of acting (for example, we are retailers but can we sell online?). So far so good. But at this point connections with other parts of the corporate culture begin. I give the most common case: how much do I need to change my organizational structure to allow a disruptive culture? And what about my definition of leadership? Do I need to change consequently my individual targets? And my plan of compensation and benefit? And my selection criteria? Here our long research of the 25 key elements support and guide us: it indicates the basic elements, that I measured in the second phase, and that now are analysed not only individually but also in their combinations and creation of interconnections.

5. **Implementation and monitoring of the cultural change strategy.** It is put into practice and monitored (the quilting above). I love the first three parts of the discovery and analysis, but in this applicational and often creative one I really have fun.
   Following the list of ten areas of organizational culture, we developed a process of transformation of the corporate culture. We work on everything: from how to award the results to how sometimes rename meeting rooms, from how to create new internal and external interactions to how to change the way of using technology, because the concept of the company what to do, for which customers, for which imagine of the future world on which it is going to impact has changed. And in the end, I adore this phase because people that at the beginning discussed the yes or no of digital, in this phase do not discuss any more about technology, because they see it as a necessary tool for an objective that is the one that passionates and motivates them. At this point, or they come back at the beginning because in the meantime the objectives have changed, or they look with curious intensity to how people now changed are immersed in a world in which digitisation is the norm. When we hear, in the retailer example: "But do you still remember how we used before, when every dress was supposed to be delivered at the shop instead of being shipped?". We know that it is time to look for a new project of cultural transformation. To go from numerical measure to generative measure.

I hope I've shown how digitizing successfully cannot help but work on the organizational culture and change it often deeply before being able to realize the technological part, process, even organization. This soft-hard sequence allows us to develop a sense of belonging, will to overcome difficulties, ability to solve problems.
In short, with the peace of mind of D'Azeglio, before doing digitization it is better to do digital.

RAFFAELLA BOSSI FORNARINI is Managing Director of Passport, a consulting and training structure that deals with Corporate Culture and Cultural Transformation. Since 2005 he has been Adjunct Professor in the People Management and Organization MIP Politecnico di Milano. She has been Director Brand Marketing of Whirlpool Europe, Asia, ME&A and Account Director in global adv agencies, dealing with the internationalization of brands such as Barilla and Nivea.

INTERVIEW WITH CRISTINA CROTTI PRESIDENT, ENERCOM GROUP

Born in 1950 to manage sales activity of natural gas to final clients in an autonomous way with respect to the distribution activity, Enercom today is a group with a local impact definitely important: 140 thousand families served, three thousand km of illuminated road, almost 14 million of kwh produced autonomously every year. If you have to indicate three areas of work in which to exploit existing data to build a better and more sustainable service, which would you indicate?
I don't like the concept of exploitation, I'd rather talk about valorising. Although we think of data as something aseptic, they are really not: data are from a path and they are bearers of a meaning behind which, often, the work of many hides. Our group intends to use data as a tool that brings value to individuals and the society in which we live and work. For example, we use data in our possession to educate consumers to more responsible behaviour in the usage of energy; we develop them even in the attempt to spread greater knowledge regarding the environment that surrounds us. When I think about data, I also think about the technology necessary to collect and elaborate them: the Enercom group puts extreme attention to whether it is a technology of support to individuals, a tool to increase the work to challenges and objectives more and more important.

Ambitious objectives mean motivated resources as well as the ability to make innovation systematic. How are you facing this challenge in your company?
The group chose a fluid and gradual model of innovation. We started involving the top management and asking them to trigger a process of open contamination that had a real impact on people's everyday life. We confronted either inside the company and outside through a partnership with EIT, the European Institute of Technology Europeo di Tecnologia, and Observatories Politecnico di Milano.In these years we met various start-up and scale-up, in a path that was of confrontation and mutual growth. We built a group called Innovators and we work with them to spread innovation culture to the whole company. I'm especially proud of our "laboratory of ideas", through which I measure the increasing engagement of the corporate population. Although it is difficult to measure innovation, seeing growth in the number and quality of contributions from my employees gives me great confidence in the future.

The predictive factory is that environment in which I am able to predict what will happen and use this prediction to organize at the best technical, human and financial resources. What do you think are the main application fields of this concept in the companies of Enercom group?

What challenges do you see for the near future?

We are experiencing the predictive factory in all the companies of the group. In the companies of gas distribution, the focus is on the anticipated management of maintenance. In the management of public lighting, we work both on predictive maintenance and on the advance of disservices and problems also of environmental nature. In the area of trade we work on the analysis of customer behaviours: the aim is to help them optimise their energy consumption. The challenge is to overcome the ancient concept of energy as a commodity to switch to that of energy as a valuable service. Also, about this I need to say that the approach to innovation is definitely part of us from birth: they ask me to speak about numbers, but for me the greatest value of our company is in keeping the enthusiasm of our collaborators in their work even at this difficult time. With this strength, I know that whatever the challenge, the Enercom Group will win it.

«Knowing is not enough.
We must put into practice what we know. Not even wanting is enough, we must do»
Johann Wolfgang Goethe

A ROADMAP FOR THE PREDICTIVE FACTORY

by Giulia Baccarin

We have so far long discussed the predictive factory, an environment where I can valorise already collected data to predict what will happen in the near future and preparing human, technical and material resources at the best. The advantages are undoubted: productivity, sustainability, ability to intercept failures, support to decision are only some of the elements that we collected from the experiences of those who have already started this journey.

The awareness that an increasing number of companies in our Country are already working to become a predictive factory, gives us comfort and stimulus. But what can we do and from where we begin to evolve our production, maintenance, energy, quality and logistics to a near future? In my opinion, there are two construction sites to be started immediately.

The first is to verify the actual state of my production site with a targeted assessment, that we define as Assessment of the predictive factory. If you are thinking about long and extensive investigations, this is not the case: on the basis of my experience, a maximum of three days per production site are enough for a sufficiently accurate picture of the situation.

In this first phase, more extensive analysis would risk to drain resources without significantly increasing the result. If however you have already defined the area on which you would like to intervene, it is definitely better to start with a vertical assessment. In MIPU we developed three type[1]:

1. **Reliability Assessment**: the focus is on the management of engineering maintenance. The categories analysed are 12 and include management, technical, training aspects, as well as the readiness to adopt new technologies.
2. **Energy Assessment**: the focus in this case is on the management of costs and energy consumptions, as well as the use of energy as a predictor of other phenomena (of quality, maintenance, use of spaces ...).
3. **IoT & AI Assessment**: survey of a more transversal nature than the previous ones; In particular in this assessment data collected from the field, ways of collection, their usability for the development of artificial intelligences are verified (goodness, granularity and depth) as well as other issues re-

1 The readers can find further free material for a quick evaluation on www.fabbricapredittiva.it

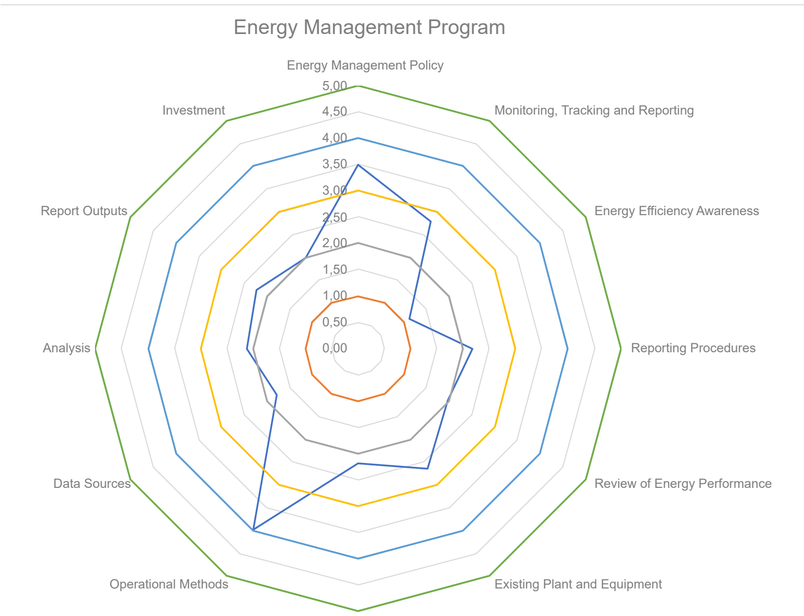
garding security and governance of data.

Each assessment consists of a series of useful tools for the development of the following step of the path:

a. A spider graph which assess the position of the company on an absolute scale. For some targeted sectors are available international databases where it is possible to evaluate not only the absolute score but also the positioning with respect to the best-in-class of the sector. Moreover, the management of a steel stoppage has implications that are very different from those of the discrete manufacturing sector; the weight of the valuation in that specific category will therefore be different.

b. A complete SWOT analysis of a cost-benefits analysis for the main indicated opportunities.

c. A roadmap of 12 and of 36 months, with a variable level of detail, showing the steps to follow and the resources to be put in place to achieve certain objectives highlighted by the assessment below.



Seems obvious at this point, that the assessment above works on what we would define incremental innovation, or a series of very specific and concrete steps that accompany the predictive factory enhancing the existing. The experience taught me however that our industrial framework is so fragmented and the innovation so quick, that what seems impossible for someone, it is an old thing for someone else. And it is not a question of dimension or sector. Sometimes it is not necessary or it is even inappropriate to proceed only for incremental innovations.

For this reason, my advice is to activate, with the assessment, a worksite enabled by a tool we called **Predictive Solution Canvas**. This involves the same participants of the assessment, but taking care this time to also include their internal or external customers. The deeply different aspect is that in this case participants are involved all together in a structured workshop lasting about six hours and driven to generate ideas in quantity, without focusing - at least in a first step - on the technical and economic feasibility of these.

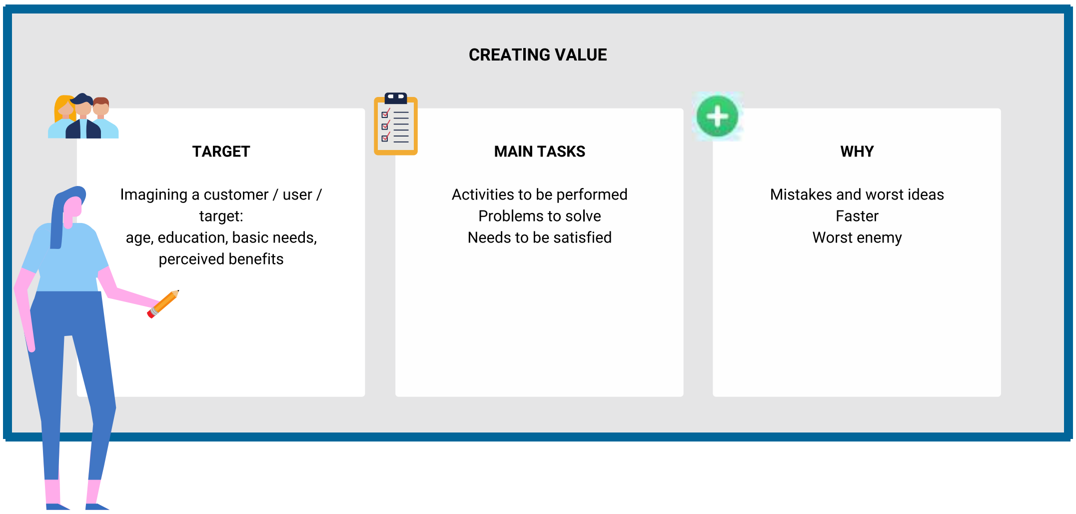
Some history: in 2008, Alexander Osterwalder developed the Business Model Canvas, which since then has been a huge success in the explanation of business models all over the world. What it used to require a business plan of 30 pages, to detail an entrepreneurial idea, could now be captured on a page.

Deriving from that first proposal, and based on over ten years of experience in the theme of predictive factory, we have created a tool that not only has the merit of gathering needs and opportunities that CEOs will be able to put in their medium and long-term roadmaps, but also to highlight quick wins to which he had thought because too focused on the state of affairs or daily activity.

The interesting aspect is that, because of the fragmentation I mentioned earlier, most of the ideas that I saw the birth of with this type of workshop not only were already feasible, but also more economical than what was imagined by the participants.

But let's see in the details what the Predictive Solution Canvas[2] is. It consists of three main areas: generate value, verify impact, calculate benefit.

2 The complete version of the canvas can be downloaded for free from www.predictivesolutioncanvas.com



Value Creation

The first part of the Predictive Solution Canvas focuses on value creation and it is divided into three blocks:

1. **For who:** each solution of the predictive factory is developed for a specific target and for that has to be adapted [3]. In describing your target, try to be as specific as possible. When building a maintenance troubleshooting, a system that supported maintainers indicating the most suitable solution for a specific malfunction, we wanted to integrate our experience and machine manual information with the experience of the maintainers themselves. Well, no-matter the request to sum up any restoration work that did not take place was clear, the feedback from the field did not arrive. We realized that we hadn't been sufficiently specific in modelling our target: maintainers work on the field and they do not have a PC in close proximity. Moreover, they wear working gloves so even the typing on the tablet is difficult. It was necessary to enable voice typing in the system of collection of information to drastically increase participation.

2. **Target's activity:** it is possible to expand this block of canvas adopting framework of mapping of more specific activities. We believe however that it is possible to arrive to a satisfactory result answering to these questions:
   a. What actions do you carry out on a daily basis?
   b. What problems does it encounter?
   c. What needs does it seek to meet?

3. **Opportunities:** this is the key block for value creation. In these phases, we want to push participants to generate as many ideas as possible without looking at their feasibility. For each of the activities previously mapped, it is useful to ask themselves: What are all the errors that my target user could make? How could he follow that same activity 30 times or 30 times more quickly? A much more disruptive way is to ask yourself: which solution or product – if existing – would make my company disappear in five years? In other words, if I were sir Hilton, who would be my AirBnB?

The answers to the previous questions should provide the base for the generation of multiple ideas in which digitisation, predictive techniques and artificial intelligence rule the roost.

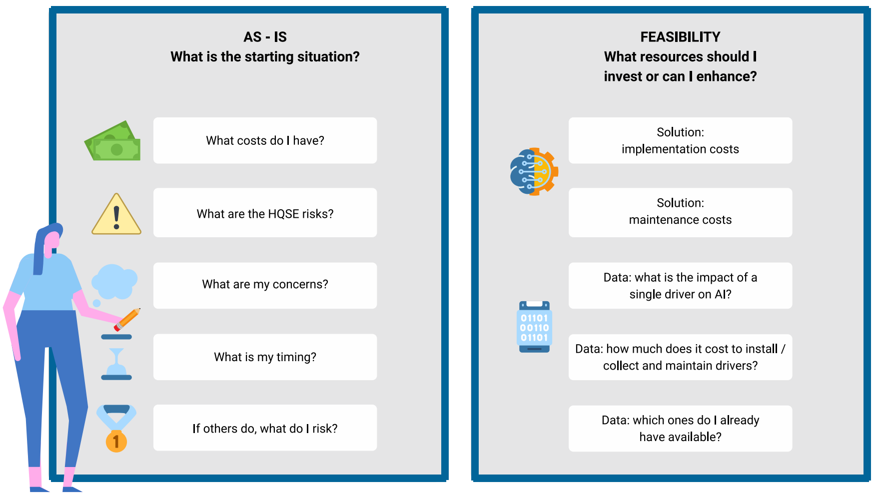
In the case of UniCredit, almost 25 colleagues of the Real Estate function generated more than 150 ideas in 20 minutes, the same were clustered in five macro categories from which 3 different concepts were born.

One of these was presented in this volume.

3 Sartorial doesn't mean new: we discussed opportunities of building intelligencies thanks to softwares like MIPU Rebecca AI

Verify the impact

The second part of the Predictive Solution Canvas is called Verify the impact and consists of two different blocks: the AS-IS block and the feasibility block.



The AS-IS block assesses the factual situation within the specific scope of the opportunities previously identified. If for example I want to reduce downtimes of a packaging machine, in the AS-IS I will map which are the actual indicators of the average time between two maintenance(MTBM), of occurrence and recurrence of failures, and so on.

Not always the actual status has obvious shortcomings. In the may 2015 I presented Davide at an exposition, the IoT hardware we create with which enables predictive maintenance logics and monitoring the performances in every product already installed. I was thrilled. My audience was not: at a certain point one of them – an important producer of industrial boilers – asked me a question that found some approval in the room: "But why should we want to connect our boilers?".

Today the idea of an after-sales service that intercepts in advance anomalies and that monitors machine performances is quite widespread. From that experience I understood that in the canvas this question couldn't be missed: if others do it and I don't, what will the costs be?

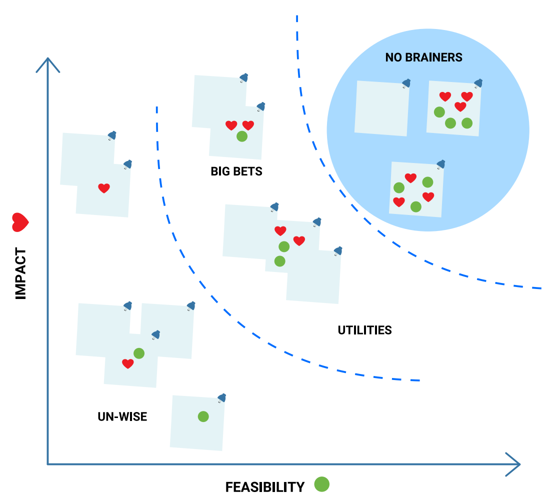
The second block of the section of impacts regard feasibility. It is divided into two parts: on the one hand the cost of construction and maintenance the solution; on the other hand the cost of data.

I know that someone will judge prematurely the assessment of the costs of a solution just developed in this phase, especially in relation to the fact that here we are looking for disruptive ideas, or ideas that in most cases do not find an answer in the market. The result to which generally we aim in this section is not the number, but it is a more detailed level for our idea. Often the discussion arising at this point regards the fact that – especially speaking about artificial intelligence – the cost of managing the solution may exceed even one order of magnitude that of its creation. In this section we also want to convey the need to do a conscious use of data: if so much data does not automatically result in good intelligence, these certainly increase economic and environmental costs of the solution. And I add environmental because, if machine learning seems a sustainable technology, there is a wide literature that shows the contrary.

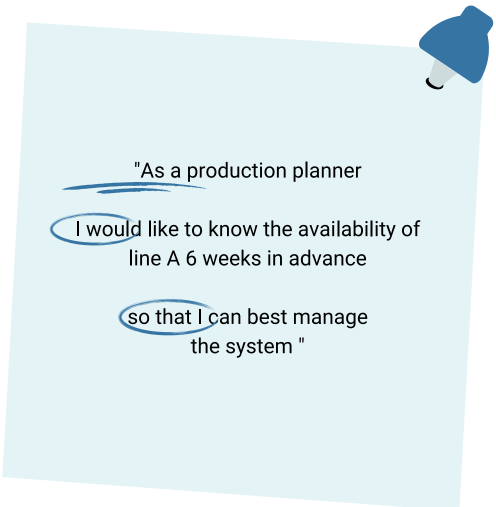
Calculate the benefit

The third section of the Predictive Solution Canvas is named Calculate the Benefit.

In this phase the ideas are allocated in the feasibility/impact matrix as shown in the picture.



For the no-brainers, big bets and utilities categories are required for applicants to formulate a proposal with the method of user stories, as shown in the picture.



This method, already diffused in the IT field, has the particular merit of aligning all participants on the proposal that have merged, which are exposed in a simple and concrete way, though rigorous. The particular variation of Predictive Solution Canvas is that in this phase participants come to calculate the benefit proposed, that takes the formula of:

Benefit = Value * Feasibility* Impact

In a six-hour workshop the basis for the predictive factory is outlined.
And now?
It sounds incredible, but having participated in over 100 predictive factory projects, I can safely say that at this point we are over half the work. Defining a shared roadmap and engaging all the stakeholders on times, ways and *effort* are the elements that over years determined the success – or the failure – of the entire path.
It is clear that the consecutive steps vary in a substantial way according to the defined objectives and the point of start. There are however many common aspects that need to be underlined.

Team of work

The first is the need for domain competence. If other areas of counselling or data science can get contribution from more transversal skills, the journey at the centre of the factory requires a workforce who knows in depth those specific machines and equipment. Establish the mechanism of failure – and so predictive techniques to be put in place – for a packaging machine is really different from what I could design for a hoven or a robot mower (these are all real examples!). If I include an external supplier in the project, it is fundamental that he also has this type of knowledge, penalty, slow down execution and lose confidence in a solution that may not be adequate to the needs.
The work team will have the competences either in the management field and in the governance of data, and in a specific technical field. It is also necessary a figure who is able to assess the organizational impacts of the chosen solution and support the management in managing change with targeted measures, involving the other key asset for the success of the project, namely people.

People

If technologies are an enabler factor for transformation, people are those who determine the success of the project over time. For this reason, it is necessary to define an implementation and change management plan specific for each reality. These interventions depend directly from the total impact of the identified change. In many cases, it is enough to define simple sessions of training and communication initiatives to celebrate the results achieved, in the most complex cases it is necessary to integrate resistance management actions, change assessment and coaching.
Our sartorial approach allows us to define the minimum set to ensure a reduction of transformation times and capitalize the investments made.
People and processes they manage are the key for the real transformation, to improve the results obtained thanks to AI and its applications.

Design for the medium and long term

A second aspect to be taken into account in predictive factory projects is the management of solutions in their life cycle. Build an intelligence is the first step; industrialize it and monitor its performance over time, intervening when necessary, are elements that determine – or not - the success of the initiative and they weigh substantially on the economic return.

It is good to remember that solutions based on

the use of artificial intelligence show a decay of the performance at their execution decidedly important. Moreover, the alerts deriving from the models can show a change of behaviour to investigate, but they are equally error-prone in meters, such as offset, full scale, missing values... These aspects must be budgeted and managed in time, in order to prevent stakeholders from losing their trust in the solution and so neutralize progress made. We must provide either appropriate arrangements in the phase of creation of intelligences (limit the number of sources of data, enable logic of detection of anomalies...), and lean but continuous actions to ensure the performances of the solution over time.
Until yesterday, the assessment of a company was based on people, ideas, physical and financial assets. Today these traditional assets are added to artificial intelligences and further opportunities that they enable. The way in which we will be able not only to create them, but especially manage them over time, will determine the unique value of our company. A factory more productive, sustainable and inclusive is possible: we are in the predictive factory.

GIULIA BACCARIN
CEO and Co-Founder, MIPU

MIPU MAP OF CUSTOMERS

The technologies and solutions of MIPU have made more than 200 customers connected and predictive, in Italy and Europe.
Relying on a strong network of partners, MIPU distributes its software solutions even in Japan, South Korea and in the United States.

MiPU