# Hi! PARIS

**PARIS ARTIFICIAL INTELLIGENCE FOR SOCIETY**

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# DRIVING BUSINESS INNOVATION

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# THE **CENTER**

**Hi! PARIS** is the result of a unique collaboration between Institut Polytechnique de Paris, HEC Paris and Inria Saclay. It is a first-class hub for Europe, and global corporate partners who reap the benefits of working closely with our rich scientific talent pool and students.

Based on joint expertise and a multidisciplinary approach, the Center addresses key challenges related to technological transformation and its impact on business and society. Theoretical and methodological research in AI and Data analytics is conducted at the highest level. The Center tackles the managerial, legal, economic, ethical and societal issues emerging due to exponentially larger data sets harnessed through artificial intelligence.

## Our ambition

The global ambition of this new interdisciplinary center is to ensure that AI and data empower business and society. It will provide a unique framework for research, education (engineers, managers, young researchers, life long learning), innovation, and technology transfer to businesses. It will take advantage of cross-fertilization between fundamental sciences, technology, management and social sciences, all of which are fields of excellence for both Institut Polytechnique de Paris and HEC Paris. These resources are at present essential for companies and laboratories, both public and private.

It also aims at stimulating productive interactions between researchers, students and organizations, thus enabling the emergence of high-potential projects, up to startups. The Center's ambition as regards AI and Data Analytics is to compete with the very best international institutions.

**Hi! PARIS** is a destination of choice for the most talented students and researchers from all over the world, all of whom address questions related to data science, artificial intelligence, their role in science, technology and business, and impact on society.

**Hi! PARIS** exceptional growth directly impacts the success of Paris and France's global leadership in AI. By attracting international talent, **Hi! PARIS** has an economic, social, and scientific impact that strengthens France and Europe's leadership positions.

# **Table** of contents

## AI for industry

## AI for sustainability

## AI and ethics

# Visions
## of business

**Raphaëlle Gautier,**
*Executive Director*
*at Hi! PARIS*

**Éric Moulines**
*Scientific co-director*
*& Professor at École Polytechnique*

**Gaël Richard,**
*Scientific co-director*
*& Professor at Télécom Paris*

**Nicolas Vieille**
*Scientific co-director*
*& Professor at HEC Paris*

When we launched **Hi! PARIS** in September 2020, artificial intelligence was still very much a subject for experts. Three years on, AI has become a major strategic issue for companies, apprehended within executive committees and, more broadly, for society. AI has become, without even being aware of it, an everyday tool in multiple dimensions.

### Research to serve business and society

It is with this in mind that we have created **Hi! PARIS**: a center serving **science**, **business** and **society**, enabling us to cross perspectives, build bridges between disciplines, and encourage dialogue between all stakeholders in the same ecosystem - researchers, companies of all sizes, students, professors, etc. How do we do this? By building on our three founding pillars: Research, Education and Innovation. Today, these solid foundations enable us to understand data and AI in all their different facets, helping economic and public decision-makers to grasp the subject better.

> **"** *To lead AI, we must be able to federate an ecosystem.*
>
> **Raphaëlle Gautier,**
> *Executive Director at Hi! PARIS*

While this multidisciplinarity is what makes the center so rich and unique, our research work focuses on three main areas:

- **Methods of AI**;
- **Business applications**, including sector or business-specific dimensions;
- **Societal implications**: sustainability, ethics, for scientific complex systems, law and regulation.

We're convinced that France and Europe have an essential role to play and a real differentiating factor compared to the United States and China in particular. **Hi! PARIS** aligns with the French and European government's AI strategy. Already a pioneer in terms of regulation when it comes to the use of data

(RGPD, data privacy…), the European Commission is preparing to do the same with artificial intelligence with the AI Act, the framework for which should be laid down by the end of 2023 - early 2024. France is not to be outdone with several announcements and incentives. These include the Villani report in 2018, the launch of the Deeptech plan in 2019, the immediate creation of the interministerial digital directorate to accelerate the State's digital transformation, and the announcement of an additional 500 million euros to develop artificial intelligence made by the President of the Republic at the 2023 edition of VivaTech.

Against this positive backdrop, we asked ourselves what made the leading countries in this field so strong. We concluded that, in parallel to the essential financial resources they receive, their lead was based on their ability to federate an ecosystem, identify the best talent from the academic and business worlds, and create bridges between these different players. Our ambition is to become such a catalyst for all stakeholders in artificial intelligence and data science.

> *An innovative aspect of Hi! PARIS is its multidisciplinary approach.*
>
> **Éric Moulines,** *Scientific co-director & Professor at École Polytechnique*

**"**One particularly innovative aspect of the Center is its multidisciplinary approach. **Hi! PARIS** aims to be a reference point in France with the ambition of scaling up into a world leader, a destination of choice for the most talented students and faculty from all over the world, and an active member of the interaction with a vibrant ecosystem, from the economic, social and academic worlds.**"** // Éric Moulines

**A vibrant ecosystem to contribute to the common good**

It's by opening up dialogue and knowledge that it will be possible to reinvent professions and develop new economic and social perspectives. **Hi! PARIS** is based on the desire to speak a common language and bring skills together. Sharing different approaches and educational backgrounds around data science and AI is already innovative, just like the X-HEC Master of Science Data Science for Business ranked #1 in Europe and #3 worldwide (2023, QS ranking).

As a research Center, **Hi! PARIS** is a driving force in raising awareness. We aim to inspire people to discover AI's many facets and attract new and increasingly diverse talent. The feminization of AI, for example, is a critical issue. Our various actions place awareness-raising at the heart of the problems we address, such as the round table we organize on the Women and Girls in Science Day in February, our hackathons open to all students from all over France, or our MooC currently in preparation. We aim to unite many people to encourage future talent to join the adventure. It's essential to break down barriers and show that AI isn't just for some. It isn't the technological aspects on one side and business and societal aspects on the other side, but all at once!

That's why, when companies are on the front line of many societal challenges, starting with the environmental challenge, we include them in our approach. Many of the transformations in our society will come about through business. In this sense, **Hi! PARIS** places itself at the service of science, the economy, and society and contributes to acting in favor of the common good by sometimes reconciling antinomic points of view. Where some see differences, we see opportunities; where others see threats, we aim to rise to the challenge, creating an ecosystem where everyone can take ownership of the subject. The more people we can get together to share their views on artificial intelligence, to decipher it, to combine approaches rather than pit them against each other, the more we'll be able to offer keys to understanding, illuminate a path, and give meaning from a collective point of view, in business and society.

## **"** Pass the knowledge on is crucial to create value.

**Nicolas Vieille** *Scientific co-director & Professor at HEC Paris*

**"**The purpose of **Hi! PARIS** is to both produce knowledge and pass this knowledge on in order to allow students and executives to use these techniques and understand all the potential as well as the risks and limitations. This is crucial to create value while still contributing to the common good.**"** // Nicolas Vieille

## Our ''Visions of Business''

As a consequence, we wanted this year to give a voice to the data science players who think and do AI daily. Echoing last year's Visions of Research, which gave the floor to the Center's researchers, this year's Visions of Business highlights concrete use cases developed and implemented by companies, like a snapshot of AI at a given moment. This white paper doesn't focus on only one aspect of AI, one sector or one company, but it gathers a diversity of approaches in a plurality of domains to help the reader to envisage the future. In that way, this document will give you a unique vision of all the opportunities given by AI.

**"**AI is much more than algorithms. To make AI meaningful, it is necessary to start by understanding AI techniques and areas of application and then control how these techniques can be used for business purposes, while guaranteeing a clear awareness of the societal and ethical dimensions and problems linked to potential misuses.**"** // Gaël Richard

And what could be more natural than to interview those without whom **Hi! PARIS** would not exist, i.e., our corporate donors? **L'Oréal, Capgemini, TotalEnergies, Kering, Rexel, VINCI and Schneider Electric** have all agreed to testify, to share their use cases, some of which they have in common, to present their approach and internal organization, and thus give a concrete vision of the applications, limits, and benefits of artificial intelligence in 2023. We hope these use cases will arouse your curiosity, inspire you, fuel your thoughts, and trigger the desire for you to contribute to a better future.

Enjoy your reading.

## **"** AI is much more than algorithms.

**Gaël Richard**, *Scientific co-director & Professor at Télécom Paris*

Hi! PARIS, *Empowering society with Data & AI, Visions of research*, 2022

# Introduction to AI for industry

Artificial intelligence is a divisive subject, particularly in France. More than 50% of French people believe that it constitutes a significant risk to data security and a major issue for copyright and intellectual property rights[i]. Conversely, half recognize its essential nature: 52% consider AI a new industrial revolution, and 49% believe it will fundamentally transform professions.

## 〝 75% of French companies use predictive maintenance.[ii]

### Optimizing the supply chain

Supply chain management is a key performance driver for companies. Artificial intelligence adds value throughout the supply chain: detection of defective products, sales prediction, supplier and service provider management, stock optimization, delivery, etc. With a product catalog including more than one million references and stores worldwide, the global Luxury group Kering has seen the potential of AI to optimize its supply chain. Thanks in particular to forecast models, the group has been able to automate several processes.

### Using Machine Learning and Deep Learning

Automating the supply chain can be complex because of the many flows. Therefore, it is necessary to integrate many parameters and cross-reference a multitude of information to obtain a relevant and efficient solution. Machine Learning and Deep Learning models help make processes more fluid and optimize warehouse or store operations. As a multichannel distributor of products and services in the energy sector, Rexel Group is subject to strong constraints regarding product restocking in its agencies. Artificial intelligence allows the global expert to offer product recommendations and rely on the right stock level.

### Predictive maintenance: towards the next industrial revolution

Predictive maintenance is one the most frequent use of AI in industry, making it possible to anticipate breakdowns, predicting the right interventions at the right time, optimizing equipment use, and drastically reducing costs. Companies that use predictive maintenance see a 5-15% reduction in downtime, a 3-5% drop in new equipment costs, up to a 20% increase in labor productivity, and as much as a 30% decrease in inventory levels, causing a 5-20% reduction in carrying costs[iii]—proof by example with VINCI and Schneider Electric.

In this context, here are the use cases we will see in this chapter: **Supply chain**; **Machine Learning, Deep Learning and optimization**; **Anomaly detection and predictive maintenance**; and **Generative models**.

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[i] Survey Le regard des Français et des actifs sur les IA génératives, Ifop, 2023

[ii] Up to a survey led by reichelt elektronik and OnePoll, 2021

[iii] Predictive maintenance, Deloitte's approach, 2022

# Supply chain

**The optimization of the supply chain covers major strategic issues for companies faced with ultra-competitive markets. Managing this supply chain can quickly become complex as part of international activity. By integrating many parameters, artificial intelligence helps speed up processes, make the right decisions, and make a difference in the market.**

Some businesses like fashion are subject to a high seasonality. Moreover, collections are renewed frequently, thus production has to be anticipated correctly. How many new items will be sold in the next six months? Where will they be sold? How many items should be produced? And in which warehouse to store them? And then, how to distribute these products? Which store has the highest chance of selling them (and therefore limiting unsold stocks)? These processes are complex and cannot be managed manually.

**"**Our use case portfolio is intentionally limited because we want to ensure impact of our projects and not multiply Proofs of Concept. To find answers to these business challenges, the team will favour simpler and well-suited algorithms rather than developing new complex ones. Our focus is to be able to maintain these solutions and facilitate their adoption.**"** // Imen El Karoui

## How to optimize your supply chain with AI

Imen El Karoui, Data Intelligence Director at Kering and her teams, divided between Europe and China, have been working closely with business teams to develop and industrialize algorithms to help addressing these challenges. The combination of business and data expertise is key to develop AI solutions.

### Kering's
organization around AI

Kering has placed innovation at the heart of its growth strategy and has developed a strong competitive advantage around digital in the luxury sector. In a constantly evolving market where clients are increasingly connected, the digital technologies we develop, as well as AI, allow our Houses to build increasingly personalized experiences for their customers and to increase the efficiency of their teams and operations.

The AI Factory that we have developed at Group level is working, for example, on stores replenishment strategies but also, upstream on the value chain, to assist planners in optimizing quantities, thus enabling us to align our imperatives in terms of sustainable development and operational efficiency.



**• Imen El Karoui**

**Data intelligence Director at Kering**

Imen El Karoui is Data intelligence Director at Kering, leading business intelligence, data analytics and artificial intelligence teams. These teams are working both for Kering Houses and at Group level. The artificial intelligence team uses various statistical and artificial intelligence tools, such as timeseries modeling, Machine Learning and Natural Language Processing (NLP) to help supporting decision making in close collaboration with business teams.

Imen holds a PhD in cognitive neuroscience and worked as a data scientist before taking the lead of the teams.

# Better predict sales

The basis of all the supply chain processes relies on sales forecast. We improve this process to better capture seasonality and peaks of sales (e.g. Christmas, but also Chinese festivals) which were previously managed manually.

Another advantage is the ability to model products lifecycle: some products become best sellers for several seasons while for others, sales are more subject to seasonality. Integrating this information was a challenge in previous models and it is now possible thanks to statistical approaches our team developed.

These are relatively simple but efficient models designed for specific challenges. They also have the advantage of being easily explained, a key element in user adoption, and easier to maintain than "black box" complex models.

# Improve distribution

With the number of products and stores increasing, forecasting the quantity of products sold in each store is a challenge. The solution to this problem developed by the AI Factory integrates uncertainty related to forecasting but also lead times, to be able to properly evaluate risk levels.

For training the models, many data sources were used: stocks, sales, product details and stores information, but also ad-hoc information about store closures for lock down for example.

### Change management, key adoption factor for AI

AI projects require close collaboration between AI and business teams for two main reasons. The first one is to develop a tool that precisely solves business challenges. The second is to accelerate the adoption of the solution implemented, which is key to deliver impact.

**"**Change management is critical when addressing complex business challenges. AI solutions are optimizing one dimension of the process. But to deliver impact and leverage these solutions, some processes often need to be changed. So trust and collaboration between AI and business teams are key to the success of these initiatives.**"** // Imen El Karoui

### What impact on the business?

AI is used to optimize business processes, thanks to new algorithms and new ways of approaching challenges. Moreover, delivering impact requires to industrialize use cases and put in place all the necessary data flows and tools, not only to develop relevant algorithms. So AI should not be taken only through a technical prism.

*Kering has developed several use cases. The new challenges for the AI team is to continue developing use cases but also support the Houses who are developing their own AI teams and will be accelerated by the knowledge developed at group level.*

**Imen El Karoui**, *Data intelligence Director at Kering*

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## Links with Hi! PARIS

The data intelligence team of Kering is focused on business use cases and has few links with the world of research. Indeed, developing cutting-edge models is less relevant to obtain the desired performance than having a good understanding of business challenges and data. However, Imen El Karoui, who holds a Ph.D., intends to create more collaborations with doctoral students to consider recruitment in the long term.

# Machine Learning, Deep Learning
## and optimization

Machine Learning (ML) and Deep Learning (DL) are both two main categories of AI with increasing applications in businesses. DL, however, is a subset of ML, but is specifically based on neural networks. The main difference relies on the data: while standard ML is mostly relevant for structured data, DL performs also on unstructured data, but requires significantly more resources (data and compute) as it needs to learn patterns from scratch. Using these technologies provides a substantial competitive advantage, as both are far from standard in the day-to-day business environment. In addition, other algorithms are relevant to businesses and complementary, such as constrained optimization.
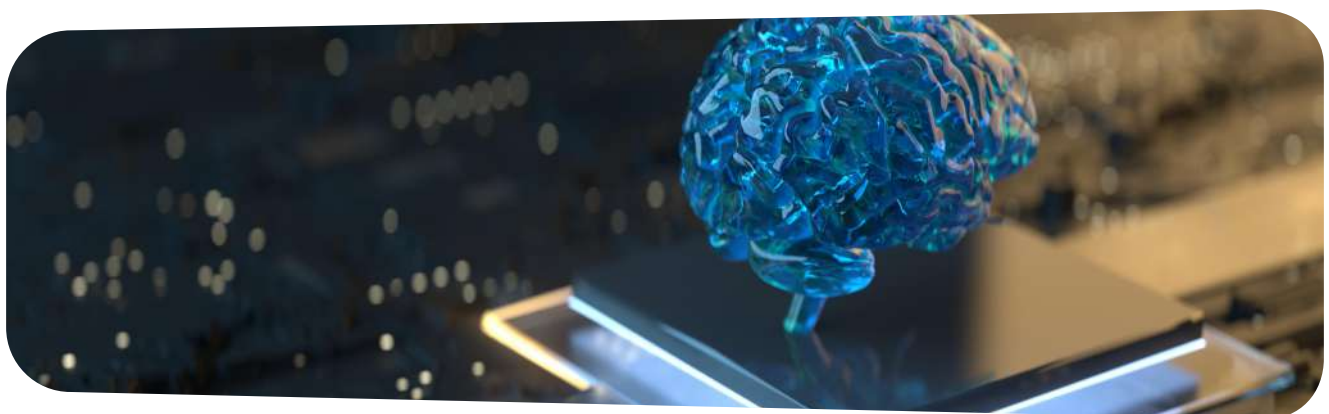
### A/B test AI for more performance

For some use cases, both Machine Learning and Deep Learning are applicable. Rather than choosing one or the other upfront, one strategy is to test the models according to these two approaches and select the one that performs best. Some data scientists nowadays may prefer neural networks. But a neural network is not always the model that works best, depending on the use case. Applying an AI strategy starting with models performance benchmark on a train-test logic followed by A/B tests in Production, allows to select standard Machine Learning for a more straightforward and explainable approach or Deep Learning when clearly over-performing.

This approach has a double advantage: it makes it possible to bypass the complexity of specific models and to generalize the process to all teams so that each can benefit from the edges of the AI developed. In the case of some companies like Rexel Group, which sells over a million products, it is difficult for a business expert to master all of them. Thanks to this methodology, retaining the most efficient and explainable model for the most significant number is possible, and allows better adoption.

### Scaling AI

Rexel, a B2B multi-channel distributor of electrical equipment, has adopted this approach for its use cases. Rexel being present in around twenty countries, operating through a decentralized organization, the AI Solutions & Data Science department led by Laurent Nizard tests use cases in one or two countries before scaling up once (and if) a level of performance enough achieved. The concept: the team identifies the most relevant AI solutions and then adapts them locally.

The group thus began to take an interest in AI in 2015 and more intensively in 2018 through a multi-country and multi-use case approach. Today, around twenty use cases have been developed. Some have been deployed across Europe, North America and Pacific, and others are still in the R&D phase.

# Strengthen the product assortment in stores

This use case is typical for countries that have many stores. These are often located either in the city center for residential customers or on the outskirts for industrial or tertiary customers. One of the applications of AI is to better understand the specificities of each store and, for each product range, identify the most relevant locations, thanks to a sum of predictive algorithms. Machine Learning makes it possible here to perceive the potential of certain products about their performance. At the same time, the analysis thus carried out makes it possible to integrate market trends, seasonality and any other information that may impact the market. For example, air conditioning solutions are closely linked to the seasons and the weather, while photovoltaic (PV) solar panels or Electric Vehicles charging stations are better forecasted leveraging market trends.

Some more traditional product complementarity algorithms will make it possible to ensure that the installation of an electrical system, for example, can be carried out in its entirety, that is to say, that the store has all the necessary elements to propose a complete solution without delaying the construction site. Sequential analysis also directly allows product recommendations to customers: neural networks will analyze purchase sequences and thus interpret the construction of a customer quotation or a shopping cart as a "logic" product sequence to predict the most probable next products to be required.

*The advantage of AI is to be able to integrate a large amount of information to automatically extract useful insights for the business.*

**Laurent Nizard**, *Head of AI Solutions & Data Science at Rexel Group*

The advantage of AI is to be able to integrate a large amount of information: the usual product characteristics, but also the product category, the type of manufacturer, the kind of customer segment that usually buys these products, the specificities of a store (area, location, types of customers who typically come there, etc.). The more possible parameters there are, the more the model will learn. From there, it will be possible to predict purchasing trends for new products and to determine in which stores it is more relevant to place them and in what quantity. The Machine Learning models will therefore learn from years of sales history for each unit product and define the appropriate number and type of items for each store.

# Optimize the supply chain

The question of logistics flows is closely linked to the management of a network of stores and Distribution Centers. A country generally hosts several logistics centers and tens or hundreds of stores. Therefore, ensuring the correct quantity of each product in each store takes work. Here, we start with the predictive model to establish a forecast of the potential and the number of units based on simulation models.

The idea here is to simulate the potential flows of customer purchases and the transfer of products from a logistics center to the stores and, from there, find the optimum scenario regarding the demand, and define the number of products to be stored in each logistic center. Indeed, having a large quantity of products in each store is economically inefficient. This is why it is important to do optimization to avoid stock shortages and overstocking and thus avoid additional costs. It is the sum of several algorithms that will make the value of the AI solution, provided that you carefully select those relevant for each stage of development of a solution.

• **Laurent Nizard**

**Head of AI Solutions & Data Science at Rexel Group**

Laurent Nizard is Head of AI Solutions and Data Science at Rexel Group. He joined Rexel in 2013 as Strategy Project Manager, after a dual training at Ecole Polytechnique and HEC Paris, and previous work experiences within Industry and Management Consulting.

Since 2015, he focuses on Data Science and AI projects to support each business department (Sales, Digital, Supply Chain, Marketing…), leveraging broad range of algorithms: Machine and Deep Learning, Search optimization, Product Recommender systems, NLP, constrained optimization… The team is composed of various profiles, including Data Scientists, ML / Software Engineers, Data Analysts but also Business Project Managers to ensure AI solutions relevance and good adoption.

> *It is the combination of several relevant algorithms with business expertise that makes the value of the AI solution.*
>
> **Laurent Nizard**, *Head of AI Solutions & Data Science at Rexel Group*

## What benefits?

Beyond the reduction in costs linked to the optimization of stocks and the increase in turnover generated by product recommendations, the main gain is efficiency. That of the internal sales teams who can offer the right product assortment for each store, and that of the customers who find the product they are looking for more efficiently and quickly among our million references. Either saving time or improving customer satisfaction.

However, these benefits are only practical if you have a sufficiently sized and qualified database; and if the solution is precisely adapted to business needs. Hence the importance of fully understanding the business problem at the risk of leading to less efficient models. This operational step is essential to have a genuine business impact and to ensure that AI is quickly deployed in business processes and integrated into decision-making processes.

## Links with Hi! PARIS

Rexel Group collaborates particularly with students from **Hi! PARIS**, for example in the context of Kaggle-like competitions. "We anonymize internal assets, often around structured data, explain the problem and challenge them to optimize performance. The students thus work on this case with regular coaching from Rexel's experienced Data Scientists, and about a third of the projects result in ideas that are examined internally. Additionally, the group uses papers published by researchers to test related cases internally and sometimes move them into production."

# Anomaly detection and predictive maintenance

**Anomaly detection and predictive maintenance are closely related to AI for energy and Sustainability issues. By their ability to anticipate failures and extend the lifespan of equipment, these AI use cases reduce the carbon footprint of industrial equipment and optimize their use by avoiding premature replacement.**

Considering anomaly detection and predictive maintenance, the construction and energy sectors offer many use cases. And VINCI and Schneider Electric are cutting-edge in this field.

## Foster localized punctual maintenance

Holder of a 50-year concession contract for the high-speed railway between Paris and Bordeaux, VINCI, a world leader in concessions, energy and construction, active in more than 120 countries, uses data to rationalize its maintenance plans. Although routine maintenance has proven itself, it is now possible to anticipate the railway deformations thanks to the data collected during the scan of the tracks carried out every week. Consequently, the R&D team has many data from which it has developed models capable of simulating the degradation along time (3 to 5 years). Thus, artificial intelligence models the problems and then selects the sites to be maintained by playing on thousands of degradation scenarios. Sometimes, the solution will recommend to delay a maintenance operation in order to combine with another one. This solution is proved more effective and less expensive than routine maintenance on the entire line, allowing to reduce the environmental impact in the meantime while keeping safety and security as a priority.

Combining different types of maintenance makes this AI solution particularly profitable. A first step before considering, in a few years, maintenance entirely based on the data thanks to a sufficiently robust AI solution to be trustworthy. Another interest in this use case is to estimate the impact that this maintenance will have in the future. Indeed, optimizing maintenance throughout the 50 years that the concession lasts makes it possible to extend the life cycle of the infrastructure and, therefore, reduce its carbon impact.

> *VINCI went from an approach based on a hundred years of human experience in rail maintenance to a mix between algorithmic analysis and human expertise.*

**Bruno Daunay,** *AI Lead at Leonard(VINCI)*

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**VINCI's** organization around AI

VINCI relies on its culture of decentralization. Every VINCI business has embraced artificial intelligence to integrate it into its practices, offerings and operational solutions all around the world. At Group level, VINCI has fostered this dynamic by relying on Leonard, its innovation and foresight platform, which has already trained over 200 employees in these new technologies, while also supporting the entrepreneurship spirit in this field. The aim of the Leonard's AI program is to select the most promising AI projects in terms of business and to train the team selected by the entities wishing to develop them in 6 months' time. The AI training program ensures that all projects selected at the beginning are profitable and industrialized in the end by the entities. In a way it is acting as a business and a technical accelerator for the Group in this field.

Leonard's training and collective brainstorming program has enabled VINCI to develop more than fifty use cases within the Group, some becoming new business units, with projects in several European countries, the UK, the USA and Canada, on themes such as predictive maintenance, industrial production optimization and generative design.

# Strengthen offshore maintenance

Another profitable use case is to predict the maintenance needed for offshore infrastructure that is difficult to access, like offshore wind farms (located far away from the shore). A wind turbine is more than 150 meters high, the generator that creates electricity weighs 5 tons and only a limited number of boats, mutualized with different companies, can provide the necessary cranes to reach the generator to replace it if broken.

That explains why it is complex to plan the maintenance of these systems: not knowing when the failure will occur, depending on the availability of specific boats and workforce and of course forecasting the weather. In average, each breakdown involves an intervention period between three weeks and two months.

The objective here is not to reduce the maintenance costs but to predict the exact date of the breakdown in order to book the boat as soon as possible and to prepare in advance all the operations to be more efficient the day the wind turbine must be stopped. Reducing the maintenance operation period therefore maximizes the production of green energy.

> *Knowing in advance the date of the failure allows VINCI to better select the maintenance date according to the weather and to work in a satisfying and safety environment.*
>
> **Bruno Daunay**, *AI Lead at Leonard(VINCI)*

Planning in advance the maintenance allows to reduce as well the collateral damages due to the damaged generator that is still moving, by stopping long time in advance the turbine. Predicting the failures in advance, several weeks of green energy production are earned and the non-productive periods are drastically reduced to the minimum.

# Optimize luggage sorting at airports

The luggage sorting system at an airport must not breakdown otherwise it will result in a terrible experience and, sometimes, inconveniences for passengers. The luggage sorting system consists of carts placed on conveyors or rails extending up to 40 kilometers. Therefore, maintenance ensures no system breaks down, especially during activity peaks (hundreds of thousands of luggage per day).

However, the systems in place were developed a long time ago. Consequently, they broke down quite regularly resulting in an extensive amount of work for the team every day.

Teams were, therefore, permanently present to respond in real-time to all the problems that can happen simultaneously. It is therefore very difficult to prioritize the tasks and to detect which one will be the most effective on the system.

How, indeed, to identify which problem to solve first when facing a hundred requests simultaneously? Which one is the most important? How to prioritize interventions in an airport area extending over several kilometers? Where should the technicians go? With what teams and when?

That is what AI will allow: to organize intervention schedules, prioritize tasks and release time to carry out early maintenance and thus avoid breakdowns. The principle, then, is not to predict when the system will break down but to understand this system, to know the most critical tasks, to identify the impact that such a problem will have on the whole system and to find the right items to keep in priority. Either the AI avoids the breakdown or makes it minimal. Note that this example of AI is generalizable to all logistics systems that work similarly.

# Optimize monitoring of electrical devices

In the energy field, AI can also make it possible to better organize maintenance by detecting if defects are appearing on equipment or if usage and environmental conditions accelerate, or on the contrary, slow down, the ageing of certain products. Indeed, a device, whatever it is, is designed to have a certain lifespan. However, this may vary according to several factors: the way and the frequency with which it is used, the conditions under which it is used (e.g., is it located in a dry or humid area, is it subject to substantial temperature variations...), etc.

*For example, Schneider Electric's EcoStruxure Asset Advisor relies on AI to analyze data from connected assets, enabling to anticipate and avoid breakdowns, reduce downtime, increase the lifespan of assets, and optimize maintenance plans.*

**Claude Le Pape**, *Fellow Data Scientist - Data and Artificial Intelligence Domain Leader at Schneider Electric*

The use of AI enables both to evaluate the ageing speed and to detect anomalies or unusual practices in the operation of the device. For example: when a device is warmer than it should be or does not react as it should. The maintenance team can then seek and find the cause of this dysfunction and intervene before the defect causes significant damage.

## Business benefits of AI

Detecting anomalies and predictive maintenance generates two business impacts at least. The first is to prevent accidents by detecting and correcting the ineffectiveness of the device. The second is to extend the lifespan of the equipment by avoiding replacing it unnecessarily before its date of obsolescence.

This double impact generates three gains. Maintenance performance gains first, allowing operational staff in the field to do better and faster. Then a "human" gain: in specific activity sectors, AI has relieved certain jobs with low added value by allowing people to focus on their heart of expertise. And an increase in competitiveness finally. By pushing the company to investigate its data, AI accelerates the digital transformation of specific sectors. Technology then encourages the company to transform itself to ensure more data is available and helps the customer journey to be seamless. Indeed, by bringing a concrete solution to a problem, AI provides a high-value user experience, improving end-user satisfaction.

## Links with Hi! PARIS

As explained in our white paper Visions of Research, it is possible to use the unsupervised Machine Learning model to address the spontaneity of anomalies and data imbalance and to build general, scalable, and explainable anomaly detection models. Schneider Electric and VINCI already use unsupervised machine learning for anomaly detection. Research conducted in **Hi! PARIS** shows that exploiting graph representations and accounting for the data's network structure can improve. Why not imagine companies such as VINCI or Schneider Electric using the results of this research or working with the research team to help them to develop and improve their models, or to find new use cases?

- To know how VINCI works with **Hi! PARIS**, please refer to the *Reinforcement Learning* chapter pp 19.
- To know how Schneider Electric works with **Hi! PARIS**, please refer to the *AI for energy* chapter pp 27.

# Generative models

**Since the arrival of ChatGPT on the market, generative models have raised awareness about the business impact of AI. Some even predict the disappearance of specific jobs. But generative AI goes far beyond simple conversational bots based on transformers approaches designed mainly for the public (for text or images).**

## Analysis of generative models

It is important to remind what we are talking about. Generative models use artificial intelligence and Machine Learning algorithms, which, based on training data, can generate new content - text, audio, video, image, etc. - whose result is very close to human creation or trained data.

Within companies, these models can be applied in many ways. TotalEnergies, for example, is facing a double phenomenon: on the one hand, the rise of AI, and on the other hand, the company's transformation. And these two trends are closely linked: the goal of artificial intelligence here is to generate business around renewable energies and to make the multi-energy model more efficient.

Leading the R&D team on DataScience & AI R&D at TotalEnergies in Saclay, Sébastien Gourvénec aims at delivering complex algorithms and recommendation tools based on Machine Learning and AI. These algorithms are then handled by TotalEnergies Digital Factory to design a Minimum Viable Product with businesses.

## TotalEnergie's
organization around AI

TotalEnergies is a global multi-energy company that produces and markets energies: oil and biofuels, natural gas and green gases, renewables and electricity. In addition to deploying current technologies that can accelerate the energy transition, a worldwide innovation drive is in progress to achieve the global objective of carbon neutrality.

In R&D, TotalEnergies forges partnerships with industrial firms and academic researchers. The Company invests in digital and Artificial Intelligence (AI) expertise to develop internal solutions.

At TotalEnergies, the development of new AI solutions is in the hands of a "numerical hub" in R&D. The hub works with technical and customer lines as well as internal customers and business units to define and develop new and promising AI applications.

Complementary to R&D, the Digital Factory ensures the deployment and industrialization of AI solutions to deliver the added value of AI for the businesses.

**Using generative modeling to improve sustainability and business energy**

Today, TotalEnergies has implemented four main application programs around renewable energies to focus its AI R&D work: Solar, Wind, Distributed Energy & Resources, Hybrid & Storage. In concrete terms, how does it work? How can AI help business teams have a business impact on energy?

**1.** A first example of the application domain can be given in the case of an offshore wind tender where AI can maximize wind farm production by a smart global control of the farm rather than at the level of each wind turbine.

**2.** Another example is when we use satellite images to know where to place solar panels and where to prospect as a solar solution provider. Pictures in sparsely populated areas, such as those concerned by solar farm installation, often need better quality. AI comes here to bring super-resolution and pixelate images to obtain much more precision.

> 〔〕 *Concretely, AI helps prepare for the future by determining the potential of an area, providing businesses with high-value-added information that makes a difference in the choice of the best place.*

**Sébastien Gourvénec**, *DataScience & AI R&D Manager at TotalEnergies*

Generative models allow for working on particular use cases.

# Generation of molecules

The first use case is the generation of molecules to capture $CO_2$, also called MOF (Metal-Organic Frameworks). The challenge is to ask whether there are molecules that would allow for more effective $CO_2$ capture and especially release it when needed to develop a new fuel or hydrocarbon. How does it work? An algorithm, based on Generative Adversarial Networks or Variational Auto Encoders (VAE), will be trained to generate new molecules with the same kind of properties as the well-known, existing ones included in the training database. Whether these new, generated molecules are slightly different or disruptive remains to be seen.

More precisely, generative models will use the molecules in the database to create new ones responding to some characteristics: with X carbon bonds, a specific $CO_2$ capture value, etc. The project is in its upstream phase: holder of a patent, the R&D team of TotalEnergies focuses on the algorithm. They digitally generate the molecules but don't synthesize them. Thus, a new and more effective molecule could enable sustainable fuel production.

**"**In that way, generative models help TotalEnergies clients to accelerate their energy transition and to have a differentiating asset on the market.**"** // Sébastien Gourvénec

# Generation of batteries

The second use case concerns batteries, particularly new generations of battery materials. Like in the case of molecules, the idea is to look for certain specific properties and, on this basis, to try to generate images of materials that do not exist and could constitute new materials for batteries using VAEs or "**Reinforcement learning**", (RL) type models. Controlling the properties while generating images is a key point. The point of interest here is to create new images thanks to a generative basis. The R&D team define the wanted properties, and the generative model uses the existing database of materials to create new ones to build new batteries. The long-term objective being the creation of the optimal material.

We are, therefore, far from text generation but more into generating molecules and sustainable materials with Generative AI. This energy and sustainable transformation is very challenging for companies and society. But building new batteries involves very complex processes. That's why this project is still in its early stage and will take several years to create compelling new material.

**"**The idea is to explore new domains and to have more chances to develop disruptive products with AI.**"**
// Sébastien Gourvénec

# Generation of image captions to identify potential hazardous situations: SafeWorld

One of the essential aspects of AI would make it possible to eliminate duplicates, automatically blur faces to respect GDPR and intervene more quickly than in the case of human analysis. SafeWorld was able to benefit from the creation of very realistic images with video game engines. An excellent way to overcome the lack of industrial data is to combine the construction site database of a few thousand pictures with a 2 to 300,000 set of very realistic generated labelled images.

Generative AI, specifically image captioning algorithms, can enhance safety at construction sites. SafeWorld is a digital solution that analyzes images extracted from videos taken by cameras installed on construction sites to produce descriptive texts. The concept of SafeWorld is to facilitate text generation to interpret the image and detect a risky situation on a construction or industrial site: upload the picture into the tool, and the text is then generated automatically. This project, therefore, integrates an image analysis component and a text generation component. These texts could trigger alerts on a webapp to the Health, Safety, and Environment (HSE) manager. A risk score model is also under development. Objective: to deploy this tool on different sites (construction sites, etc.) to strengthen security (e.g., detection of helmet wear or harness).

### How to use the research works?

However, working on such specific topics takes time. This is why working in partnership with laboratories, researchers, or other companies, brings value. This is

*The advantage of generative AI is its ability to understand context, not just identify specific objects, thus providing a broader safety evaluation.*

**Sébastien Gourvénec**, *DataScience & AI R&D Manager at TotalEnergies*

even more important because, unlike consumer AI, industrial AI lacks training data. Thus, the generation of $CO_2$ molecules is at a low Technology Readiness Level (TRL) because it is difficult to obtain quality data that makes sense and is chemically feasible. This is why TotalEnergies is collaborating on this subject with North American universities (notably those in Ottawa and Toronto in Canada): the idea is to generate molecules that they could synthesize to verify that they capture $CO_2$ and have the desired properties.

On the battery side, R&D is working with TotalEnergies' subsidiary Saft. AI is used for testing new disruptive paths and proposing new solutions with a generative database. R&D also collaborates with partner companies. TotalEnergies has notably created a joint research laboratory (SINCLAIR) with Thales and EDF on the Saclay plateau oriented towards "**Trustworthy AI**".

Sébastien Gourvénec holds a PhD in Chemometrics from the Vrije Universiteit Brussel. He then moved to GlaxoSmithKline (GSK) first at the research center of Stevenage (UK) and then in Evreux (Fr). He worked there as a chemometrician in the Chemical Development branch. He was developing and deploying online Process Analytical Technology both in R&D and manufacturing. After a few years in GSK, Sébastien became team leader on spectroscopy and modeling in TotalEnergies (previously Total) in 2011. He also developed during these years some expertise on data science and Machine Learning for industrial applications.

End of 2018, he moved to the R&D of the TotalEnergies group, where he was co-leading a R&D transverse program on ML & AI developments for all branches and businesses. He is now in charge of a team of Artificial Intelligence researchers with a strong focus on renewables energies, but also on advanced AI topics applied to industry.

Additionally, he currently leads the effort for accelerating the integration of TotalEnergies in the Paris-Saclay ecosystem.



• **Sébastien Gourvénec**

**DataScience & AI R&D Manager at TotalEnergies**

# Introduction to AI for sustainability

Extraction of raw materials, product manufacturing, goods transport, end-of-life equipment management... The industrial sector is responsible for 18% of annual greenhouse gas emissions in France. By improving the automation of the supply chain, artificial intelligence makes the industry more sustainable and reduces environmental impact throughout the value chain.

## The 3 scopes of carbon emissions

As a reminder, carbon emissions related to business activity can be of three types:

- Scope 1 emissions: direct GHG emissions that occur from assets (vehicles, facilities...) that are controlled or owned by an organization.

- Scope 2: indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling.

- Scope 3: all other GHG emissions that are a result of activities from assets not owned or controlled by the reporting organization, but that the organization indirectly impacts in its value chain.

By acting at all levels, AI could help organizations achieve up to 45% of their Paris Agreement intensity targets, according to Capgemini Research Institute.

> 🙶🙶 AI is expected to reduce greenhouse gas (GHG) emissions by 16% and improve power efficiency by 15% in the next three to five years. [i]

## Adopting AI for energy

Moving towards a greener industry begins with reducing energy consumption. How? By deploying microgrids, for example, by analyzing equipment consumption in real-time. In this area, the building sector offers many use cases: smart building, digital twin, smart inventory, etc.

Let's focus on Capgemini, Schneider Electric, and Rexel Group which have thus developed several use cases around sustainable AI and AI for energy.

## Acting for the planet

Beyond monitoring greenhouse gas emissions, AI makes it possible to act directly in favor of a more sustainable world. Among the use cases, satellite image analysis and cross-referencing large volumes of data make it possible to identify risk areas or the harmful impact of certain industries on the local ecosystem—another application: the ability to create new, less energy-intensive, and more durable components.

Zoom on VINCI and TotalEnergies which are already working on solutions developed from reinforcement learning or generative models to reduce their carbon footprint and support their customers in their ecological transition.

In this context, here are the use cases we will see in this chapter: **Reinforcement learning**; **Sustainable AI and AI for sustainability**; and **AI for energy**.

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[i] Climate AI - How artificial intelligence can power your climate action strategy, Capgemini Research Institute, 2020

# Reinforcement learning

**Reinforcement learning is one learning method used in AI. To the contrary of supervised or unsupervised learning, it doesn't need training data to provide a solution. The principle is as follows: an intelligent agent interacts with its environment and for each action, it receives a reward or a penalty depending on rules previously set, allowing it to tend towards the best solution.**

## What is reinforcement learning?

Here is the definition of reinforcement learning (RL) given in **Hi! PARIS**' *Visions of Research* (2022):

**"**Reinforcement learning is a type of learning process where an intelligent agent is interacting sequentially with an unknown environment, aims to maximize its cumulative rewards, and uses tabular methods or function approximators (in Deep RL) to generalize the information acquired from the agent's interaction with the environment. These techniques have greatly benefited from deep neural networks and have achieved multiple successes when combined with such function approximators.**"**

## Business objectives enabled by reinforcement learning

The profitability of a project depends on its industrialization. The profitability of a project can take different forms and is not only based on strict financial aspects. For example:

- The impact on security;
- The simplification of specific time-consuming processes allowing to focus on higher added value tasks;
- The ability to transform an entity to be prepared for the technology of the future, etc.

This is particularly true with the approach adopted by the VINCI group, which invests on the AI technology only if it can be industrialized within the Group. The principle is to avoid carrying out a Proof Of Concept, which implies very strongly selecting projects upstream and systematically understanding the investments to be carried out about the return on investment (ROI). This winning strategy has already led to the development of more than fifty use cases by VINCI's entities thanks to the support of **Leonard,** VINCI's innovation and foresight entity.

Despite all the complexity of the reinforcement learning method, all projects are developed internally by the people from the business with the strong support of the Leonard's data scientist team led by Bruno Daunay.

Once a business need is detected, the business unit manager selects one or more of its employee to follow a 6-month training program within Leonard, coached by a Data Scientist, to master all the aspects linked with the technology, like cleaning the data, defining the best models, learning how to code using Python, setting a cloud infrastructure, etc. This organization around AI allows the business units from the Group to develop their own AI solution, to be able to maintain the solution according to time thanks to trained employees and to develop new use cases without the support from Leonard.

Training the employees in this new technology (for the industry) allows the business units to be ready for the future challenges to come and to be more convincing in regard to their clients who are in need of this technology to perform better. This positioning therefore requires Bruno Daunay's team to discuss all along the year with all operational staff from all the divisions to understand their businesses, their market and to seek new way of growth or new way to perform better. The objective is to detect where the use of the AI technology can give a great value with a low investment.

Here are some of the use cases developed thanks to reinforcement learning.

# Optimization of design offices: pre-construction phase

Reinforcement learning finds multiple applications within very different sectors. In the construction industry, engineers must consider many criteria to design an infrastructure. For example, how can the piles that support a building be sized according to the soil's specificities while reducing the substantial volume of concrete used, or lowering the overall price? How many piles are necessary? And where

> ❝❞ *VINCI is developing an AI solution that automatically provides an optimal configuration, defining precisely the number of piles, their depth and diameter and their location.*

**Bruno Daunay**, *AI Lead at Leonard(VINCI)*

to locate them in the construction site depending on hundreds of criteria at the same time while lowering the price and the impact on the environment, and keeping safety and security as first priorities?

This AI solution is also intended to limit the infrastructure's environmental impact: it considers the volume of concrete to minimize, the constraints of low-carbon concrete (different constraints and prices), etc. The engineer can then select the importance of the criteria associated with the project: environmental impact, price, depth of the borehole, the time to build the infrastructure, etc. From a business point of view, engineers have an additional tool that helps them taking into consideration hundreds of constraints and to find quickly an optimal solution when playing on the different criteria at the same time. As a result, the time needed to design a pre-construction phase is lowered, and at each step of the process, the solution calculated by the AI model is the optimal one.

# Optimization of design offices: building's technical systems

Among the technical systems of a building, the HVAC (Heating, Ventilation and Air Conditioning) is maybe one of the most cumbersome and constraining. Many issues surround the design of these networks, from user comfort to respect for the environment. Designing such systems is a crucial but complex phase, involving mechanical, thermodynamics engineering skills, and a complete understanding of the building VINCI developed a generative design-driven solution that leverages data science and graph theory to optimize HVAC network generation.

The solution is based on four independent bricks: automated room detection from a blueprint, HVAC requirements sizing, automated positioning of HVAC devices on a Building Information Model (BIM) model, and network generation, i.e., optimized interconnection of all the HVAC elements respecting field constraints. The different bricks are deployed and directly integrated into BIM software, allowing to generate a complete and valid network from a blank blueprint in a few minutes.

Applied to the cable routing inside a building, reinforcement learning also makes it possible to automatically determine the right cable routing for the whole infrastructure, the dimensions of each

cable type, the correct ratio of cable supports and the standards to be fulfilled to minimize materials and price.

RL can also be used for larger infrastructure scale to determine the best layout, like for the underground high-voltage electric cables use case for example. The length of these cables can reach more than 15km, and weight more than 10kg per meter. Due to a maximum force that must not be overcome in order not to damage the cable, the engineers responsible for such projects must divide the cable into several sections or propose a different route. A 15km cable will then be divided for example into 3 sections, each one being assembled using a junction chamber that come with a cost and an environmental impact. These junction chambers create weaknesses in the network (infiltration, humidity, etc.) and impact the environment (they require installing a large concrete box under the soil). Until today the process of designing the cable layout pulling was mostly manual, iterative and unoptimized. A cable layout was considered good when matching the criteria without any guarantee that it was optimal despite the acute knowledge of the experts. Any change made to the cable layout would restart the whole design process, which is time-consuming.

On the other hand, many unjustified junction chambers were also added due to an excessive estimation of the effort provided by current calculation tool. Leveraging Reinforcement learning and thanks to better estimation of the pulling effort, considering both the path and cable characteristics, the number of unnecessary assets can be minimized sometimes by providing new route for the cable.

Another use case can be cited, the one consisting in designing the optimal route for a highway. The algorithm can propose the best layout between a starting point and an ending point taking into consideration political and environmental impacts, climate resilience, the volume of soil to be moved etc. Whenever

*Leveraging data-driven insights, we gain a deeper understanding of the specific requirements and constraints of each project, ensuring the optimal cable layout is selected.*

**Bruno Daunay**, *AI Lead at Leonard(VINCI)*

a problem is driven by constraints, generative design through reinforcement learning will provide the best optimized solution amongst thousands.

## Optimization of energy consumption

Applied to building's electricity consumption, the AI developed by TotalEnergies can, among other things, help to improve thermal comfort. Based on the collected consumption data, the algorithm will enable to establish a set of usage rules to optimize the control of each electrical equipment (hot water tank, oven, heater, climatization, etc.).

**"The idea is to have robust and remotely controlled AI algorithms and to offer this service to individual customers."** // Sébastien Gourvénec

The advantage of the RL method here is:

• *To propose a new strategy which will be more efficient in terms of energy savings and thermal comfort;*
• *To take into consideration a lot of equipment;*
• *And to be real-time.*

Consequently, RL enables recommendations for the user such as: heating at the right level at the right time depending on weather forecast, stopping the use of an equipment in case of absence...

## Optimization of stocks

Another use for TotalEnergies is the optimization of stocks in spare parts warehouses on an industrial site. The challenge here is to use RL (Reinforcement Learning) to make a smart inventory. The RL is then fed on all the data available, considering several criteria: Criticality of parts, deadlines, and delays in delivery of previous parts...

If the process is relatively easy when you only have a few products to manage, it quickly becomes complex at the overall warehouse scale. The company's DNA is not to sell software, so AI apps are only intended for internal use to be deployed on the group's industrial sites. On the other hand, a collaboration with SAP, a management system in place on many sites, is considered. Objective: implement a part of the algorithm directly in the SAP solution.

**How to choose the use cases?**

Reinforcement learning methods can be applied to many use cases. How, then, to choose which one to develop and industrialize?

Internally, generative design using reinforcement learning aims at facilitating the work of design offices, saving time, and avoiding repetitive and complex iterative tasks. Consequently, RL methods offers a competitive advantage for design offices by automating the production of optimal solutions in short period of time reducing weeks of works into minutes. The use cases are to be chosen regarding the complexity of the project's designs, the time needed by a design office to provide a solution, the size of the design office and of course the return on investment which is a balance between doing nothing and investing into a new application. Sometimes doing nothing is the right thing to do.

In order for all the solutions to be industrialized in the long range, it is important to reach a critical size for the business unit responsible for the development of such applications. If one project depends only on one person, the risk is high for the project to fail even if the market is mature. Therefore, VINCI's next step will be to adopt an AI strategy for the whole group leading to the emergence of excellence centers responsible for the development and the maintenance of the projects. The ambition is to synchronize, rationalize and accelerate the development of the use cases to be scaled taking into consideration VINCI specificities and the different divisions.

> *Based on this history of inventory data, AI allows not only to anticipate stock breaks but also order the right number of items to avoid overflowing (and therefore additional costs).*
>
> **Sébastien Gourvénec**, *DataScience & AI R&D Manager at TotalEnergies*

## How to use the research works?

To develop a solution in 6-month time means that only a Minimum Viable Product is provided. This results mainly in the re-use of existing models published in the literature. After the industrialization of the solution, usually a PhD thesis is needed to dig deeper in the models and to develop new functionalities.

That is why it is interesting to consider a collaboration with the research world.

### Links with Hi! PARIS

In collaboration with **Hi! PARIS**, VINCI is engaging in PhD theses on energy efficiency and highly complex satellite applications. The idea is to support the business units teams to refine and generalize the models. VINCI also proposed to five Institut Polytechnique de Paris students an AI project to develop as part of the Capstone module. After a first year of collaboration with **Hi! PARIS**, VINCI now intends to institutionalize this way of doing things to go further in the development of AI projects.

Several employees were joining the AI summer school as well.

- To see how TotalEnergies works with researchers and **Hi! PARIS**, please read the chapter about *generative models* on page 14.

Bruno is the head of VINCI's AI Program which he designed and manage at Leonard, the VINCI group's innovation and foresight entity.

Prior to this, he was head of the Project Management Office of the Paris-Bordeaux high speed railway project led by VINCI. Within VINCI Energies, he was successively project leader in charge of software development for the industry and responsible for the innovation and the development of artificial intelligence projects. He spent a year in a start-up accelerator in order to maximize the relations between start-ups and VINCI.

Ph. D. in Robotics, he taught mechanics and computer science at Sorbonne-Université. He obtained a post-doctoral position at the University of Tokyo where he specialized in micro-fluidics, forces at the micro-scale and statistics.

● **Bruno Daunay**

**AI Lead at Leonard (VINCI)**

# **Sustainable AI** and AI for sustainability

**Businesses are on the front line when it comes to environmental issues. On the one hand, they must reduce their CO$_2$ emissions with, for the most ambitious companies, a goal of carbon neutrality set for 2050. On the other hand, they are also builders of solutions that help their clients to reduce their environmental impact.**

Several AI use cases make it possible to accelerate specific aspects of the businesses value chains related to sustainability issues: optimization of the supply chain, monitoring of greenhouse gas emissions, online quality control, energy optimization, analysis of satellite images to detect risk areas, etc.

## A global approach to sustainable AI …

The subject of sustainable IT is vast. It affects the use of data, its storage, processing, transit, and use. The Sustainable AI approach is part of a more global approach around green IT. The final goal is to minimize the volume of data transfers, data storage (and therefore the number of associated servers), email sending… AI needs a lot of data and computing infrastructure to train the models. University of Massachusetts at Amherst researchers conducted a life cycle analysis on several standard large AI models training. It turned out that each process could emit more than 280 tons of carbon dioxide equivalent, nearly five times the lifetime emissions of an average American car (including the manufacture of the vehicle)[1].

Therefore, Sustainable AI aims to create a trigger and adopt a more reasoned approach before starting a project. How? Feeding the algorithms with only the strictly necessary data allows them to achieve the desired performance. Another concrete action is targeting datacenters in greener energy mix countries. Whatever, the first benefit is based on the awareness of what an AI algorithm can consume. In that case, the ability to offer its customers solutions to reduce their environmental impact is differentiating from its direct competitors.

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### **Capgemini's**
organization around AI

Capgemini is a global leader in partnering with companies to address the entire breadth of their business needs, from strategy and design to operations, fueled by the fast evolving and innovative world of cloud, data, AI, connectivity, software, digital engineering, and platforms.

Building on our market leading position in Data & AI, we help our clients deliver value and generate competitive advantage by leveraging trustworthy (generative) AI at scale. We support CXOs in setting their (generative) AI strategy, identifying use cases aligned to their business expectations and requirements, and in offering a port-folio of tailored (generative) AI solutions. In France, Capgemini employs several thousand of AI engineers and data scientists committed to building state of the art AI solutions from design to industrialization, deployment and benefits tracking.

## ... and driven by data

It is a fact: the nerve of artificial intelligence is data. Therefore, data is a significant lever for the net zero transition. At the same time, 85% of organizations recognize the value of measuring and analyzing emissions but often must be better equipped to exploit these data [2]. That is why it is essential, on the one hand, to properly label, prepare and improve the quality of the data that will feed the models. On the other hand, to develop tools to monitor the carbon impact of companies and their products.

Benjamin Deguilhem, Research and Innovation Team Leader at Capgemini Engineering, leads a dozen internal research projects on diverse topics (industrial engineering, networks, physical engineering, industrial AI, etc.). In 2020, he set up a Sustainable AI project transversal to all company branches with his team. Objective: to raise awareness among designers and users of artificial intelligence solutions about the carbon impact that training and use of these AI algorithms can have.

# Monitor $CO_2$ emissions

Companies must rely on environmental data from products to help them reduce their carbon footprint across the entire product value chain, representing a small part of the available information. Therefore, to build a model that can estimate its real impact as closely as possible, using and combining other data (sales, design, logistics...) thanks to artificial intelligence is necessary. Therefore, ensuring upstream data compliance and quality is essential to eliminate any erroneous or inadequate data.

At Rexel Group, this approach led to the development of a carbon tracker tool by Julien Colas' team, Sustainability Solutions Manager, accompanied by Laurent Nizard's team, Head of AI Solutions & Data Science, on the data side. The objective of this carbon tracker is to enable their customers to calculate all their $CO_2$ emissions and to reduce those of the group. Indeed, Rexel has committed itself to an ambitious program of reducing its greenhouse gas emissions by 60% from 2016 to 2030 and, above all, GHG emissions related to the use of its products by 45% over the same period.

Rexel France already rates certain category of products according to their environmental performance via an eco-score that could eventually be generalized to its customer portfolio.

In the same spirit, Capgemini has developed a demonstrator that allows you to select the parameters of the model you want to train or execute, which framework to use, which provider to use (AWS, Azure, GCP),

> The Carbon Tracker solution has thus been offered since June 2022 to Rexel France's customers and has already generated a hundred orders, especially among large customers. It could provide new business perspectives: the tool is 100 times less expensive, 10,000 times faster and 10 times more accurate than usual solutions.

**Julien Colas**, *Sustainability Solutions manager at Rexel Group*

where are located the data centers you will use... The tool will give an eco-score from A to F on this AI and some recommendations to reduce this impact.

The next step will be to integrate it into the responses to calls for tenders from the group's customers to show them that the chosen solution is developed to reduce, at equivalent performance, the solution's impact. Capgemini is working with the digital responsibility institute (INR) on this tool and plans to work with metrology laboratories to share this indicator externally.

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[1] Energy and Policy Considerations for Deep Learning in NLP, Emma Strubell, Ananya Ganesh, Andrew McCallum, College of Information and Computer Sciences University of Massachusetts Amherst, 2019

[2] Data for Net Zero, Capgemini Research Institute report, 2022

# Optimize industrial production

Data processing can also contribute to improving the processes of the production chain. AI applied to quality control makes it possible to reduce energy consumption and optimize costs by detecting defective parts as early as possible on the production line. Why? Because this avoids bringing a defective product to the end of the chain thanks to a smart camera that will scan the containers and thus detect any defects.

This is the case of the AI developed as part of a collaboration between **Capgemini and L'Oréal**.

*The computer vision solution integrated into the production line identifies and ejects defective shampoo containers. The AI can detect more than 99% of significant defects with very few false positives, thus avoiding long stops on the production line.*

**Benjamin Deguilhem**, *Research and Innovation Team Leader at Capgemini Engineering*

# Anticipate risk areas through image analysis

By facilitating the cross-analysis of images (satellite, drone, aerial views…) and the cross-referencing of data (topographic, climatic, meteorological, oceanographic, or other), AI makes it possible to identify risk areas (potential drought, tree disease, etc.). Image processing contributes to improving the understanding of biodiversity. The AI will then extract information that will categorize the area and assign it a level of risk requiring intervention in the short, medium, or long term.

The mining and metallurgical group Eramet has thus collaborated with Capgemini Invent as part of the "**Connected concession**" project to automate vegetation census on its mining site in Senegal and rehabilitate the exploited areas. The solution implemented was then able to use drone imaging techniques and advanced artificial intelligence (Deep Learning) to map the area. The result: the ability to identify, count and geolocate objects of interest, including trees, bushes, fields and some types of buildings, in just a few minutes. Consequently, the mining company has

the guarantee to minimize the environmental impact of its extraction operations and restore the land to its original state.

## Accelerate sustainable development through research

This relationship between companies and the research world is essential in deploying AI because companies bring the use cases and the added value that developments around AI can have. These indications help guide researchers towards the topics of interest to be prioritized in more sustainable development.

Different types of partnerships can illustrate these links: with academics, start-ups whose solution is mature or hyperscalers. Capgemini has already moved to the industrialization scale with many of its customers. However, there is still a gap to be bridged at the research and innovation level to develop even more efficient solutions and go even faster on its use cases.

## Links with Hi! PARIS

At **Hi! PARIS**, ML practitioners and researchers are committed to developing AI in an environmentally responsible manner. That's why a partnership with Capgemini is worth considering. Today, Capgemini collaborates mainly with **Hi! PARIS** through Capstone projects, summer school, and boot camps… considering hiring some students. "*From the end of 2023, we want to move towards red thread projects and work themes that are of interests for us and our clients. This will create momentum and allow us to offer projects close to innovation to young doctors or engineers, Master students or researchers who may give them exploratory ideas over a longer period. Our ambition is to create a continuum of ideas that can be developed as algorithms,*" says Philippe Cordier, VP of Data Science, AI and Data Engineering at Capgemini Invent.

> ❝ Working long-term with research networks requires maturity. At the very beginning, we were focusing in developing and deploying AI models across Rexel, with an objective to show results in a reasonable timeframe. Projecting ourselves more in the medium term, we have launched ~8 projects in partnership with Hi! PARIS in the past 3 years, some of which going to Production.

**Laurent Nizard**, *Head of AI Solutions & Data Science at Rexel Group*



● **Julien Colas**

**Sustainability Solutions manager at Rexel Group**

Julien Colas leads the Sustainability Solutions team at Rexel Group. He joined Rexel in 2018 as Sustainable Development Manager, after a dual training at INSA Hauts-de-France (2004 - fluid dynamics engineering) and MinesParisTech (2009 – environment management). Before Rexel, he had professional experiences focused first on energy (CFD design engineer at CD-adapco, Siemens Group), then on the environment and sustainable development (climate project manager at Saint-Gobain, head of the energy-climate-resources division at Entreprises pour l'Environnement).

The Sustainability Solutions team imagines and creates solutions and services for Rexel customers, to enable them to better take environmental and social aspects into account in their daily professional lives. In 2022, the team launched in France its first project, the Carbon Tracker, which received several awards including the "Energy, Climate, and Decarbonation" Award from L'Usine Nouvelle.

The team is composed of experts in sustainability, data and sales, in order to bring concrete and operational solutions to sales teams and customers.

After his PhD in 2007, Philippe Cordier pursued his career in Research and Innovation at Total (now TotalEnergies) in modeling and computational sciences.

After 5 years in oil production operations, he went back to Research and Innovation where he created and executed a corporate research program on Scientific Computing and AI, embarking 100+ employees of the company and covering all TotalEnergies activities, with a strong focus on Sustainability to support TotalEnergies transformation. This program led to the development of 50+ AI products, 50+ patents.

In 2023, Philippe Cordier joined Capgemini Invent as Chief Data Scientist and Vice-President AI, Data Science & Engineering, where he is developing offering in AI for sustainability and Generative AI and expanding Research and Innovation activities.



● **Philippe Cordier**

**VP Data Science, AI and Data Engineering at Capgemini Invent**

# AI for energy

The energy market includes complex systems designed explicitly for trading electricity and balancing supply and demand. These markets are continuously being adapted and optimized to better fit the multiple ways electricity, particularly renewable energy, is generated. The microgrid is a perfect example of the complexity of this market. This is an exemplary case where AI for energy can help optimize the resources and reduce their environmental impact during consumption peaks when it is more expensive; and, when it is not the case, AI can be used to make a compromise between cost and carbon emission.

Schneider Electric is a specialist in energy management. Naturally, its primary use cases are focusing on proper energy use. Therefore, the question is how to use less energy for a given activity using artificial intelligence technologies. Or if it is possible to concentrate the uses when electricity is cheaper and of a less carbonated origin. For the users of an AI for energy solution, the benefit is twofold: they reduce both their costs and their environmental impact. Indeed, electricity tends to be more carbonated during consumption peaks when it is more expensive.

## Schneider Electric's
organization around AI

At **Schneider Electric**, the development of AI solutions is organized along a "Hub and Spokes" model. The Artificial Intelligence Hub works with lines of business, customers, and internal entities to define, develop, and ensure the deployment of the most promising AI applications.

Schneider Electric is helping its customers collect data from the whole value chain, which is critical in decision-making, agility, and decarbonization. Data are then turned into valuable insights, and business and environmental actions, using tools and approached based on the newest AI technologies. Besides using AI to help customers unlock efficiency and sustainability, the AI Hub and Spokes also focuses on the development of internal AI applications and their adoption at scale.

Specific teams are devoted to the definition and qualification of the use cases, the development of relevant solutions, and the development and operation of the platforms and tools enabling deployment and monitoring of applications in operation.

## How to define AI for energy use cases?

The energy field covers many use cases. However, not all of them can be deployed. This is why, as soon as the business teams identify a customer pain point, two main criteria come into play: on the one hand, the associated potential gains - efficiency, savings, time saved, simplicity of use... - and on the other hand, the feasibility of the solution.

Machine Learning developments result from the convergence between three conditions: a customer or business need; the fact that no simple model is already defined to respond; the availability of relevant data enabling to learn a model.

Learning a model is a good solution in three cases:

- When it is not possible to write simple equations for the problem under considerations.
- When it is possible to write equations but it is difficult to reverse these equations, while the reverse equations are necessary to carry out the calculations.
- When it is possible to write a model, but with unknown and variable parameters from one situation to another.

For example, forecasting the electricity consumption of a building is difficult because it depends on multiple variables: the design of the building itself (materials used, etc.), its size, the number of people inside, its envelope isolation, its orientation compared to the sun, the quality of its blinds, the activities performed in the building...

**"Very often, we do not have a pre-established model, but we have the possibility of using data from the past which allow us to develop a model sufficiently representative of what is happening."** // Claude Le Pape

Therefore, making a unique model valid for all buildings is impossible. But if, for a given facility, there are enough data, it is then possible to use these data to build a model that can be improved gradually to make relevant predictions. The idea here is to separate a certain number of measurable criteria (drivers) that strongly influence consumption from a mass of individual criteria specific to the building that are more difficult to consider in an explicit model. One must however be careful to identify cases in which specific drivers change and should be integrated in the model.

# An example: the optimization of microgrids

A microgrid, or micro-network, is an intelligent electrical network independent of the contract established with the supplier and fed by a local renewable energy production to supply a site (office building, factory, etc.) with electricity. Local production capacity may vary from a few hundreds of kW to several tens of MW. Most often, these are solar panels installed on the roof of a building to which must be added storage means—for example, batteries. The system is, therefore, particularly complex: it consists of a structure that consumes energy for its activities, local means of production, local energy storage supports and a contract with an external supplier.

To use this system as intelligently as possible, it is necessary to forecast the future energy consumption of the building at a certain granularity of time (every quarter of an hour, every hour...). Forecasts are also to be carried out on the production of solar panels and on the same granularity of time to optimize the use of batteries. Objectives: Reduce the cost of energy consumption, self-consume the local solar production, and possibly resell part of it to the local supplier.

Here, AI serves during micro-grid operation in two stages. First, to build models capable of performing good-enough forecasts. And secondly, to optimize the system in place. Coupled with simulation, it also serves at the micro-grid design stage, e.g., to optimally size the local production and storage means with respect to given constraints, pricing scenarios, and objectives. The idea is to provide the client with the means to estimate the best dimensioning of its microgrid (how many solar panels to pose, what battery capacity ...) and establish profitability. The solution makes it possible to present the compromise between OPEX and CAPEX best suited to the customer's objectives.

> But the gains are not only limited to the financial aspect. They are also calculated in terms of carbon emissions.

**Claude Le Pape**, *Fellow Data Scientist - Data and Artificial Intelligence Domain Leader at Schneider Electric*

In this example, AI modules are integrated within a global microgrid management package offer. Indeed, Schneider Electric provides microgrid to its customers with the Ecostruxure Microgrid Advisor software suite. This Cloud-Based, Demand-Side Energy Management Software Platform helps the customer to optimize economic performance, sustainability and resilience on its site.

## The main benefits of AI for energy

The benefits vary a lot from one case to the other, as they are highly related to the characteristics and activities of the site, climate, and energy contracts. Site owners typically save about 20% of their energy consumption, and return on investment (ROI) is estimated between 4 and 8 years but can come faster in some cases.

Globally, the impact of the production and installation of solar panels and batteries on the environment can vary depending on the country. To make a relevant evaluation of the environmental ROI of a microgrid (focused, for example, on carbon emissions), we need to consider not only the carbon savings enabled by the microgrid and its management thanks to AI, but also the carbon that has been emitted to manufacture, transport, install, …, the microgrid elements, and the carbon emissions that follow from the microgrid management (including the use of AI). The "carbon (cumulative) breakeven point" of a microgrid project can then be defined as the time at which the cumulated carbon savings exceed the cumulated carbon emissions." In France, electricity being not very carbon intensive because of nuclear energy, the carbon breakeven point is reached later than in other countries. For typical, simple, microgrids in Europe, the cumulated carbon savings over 20-25 years are expected to exceed the cumulated carbon emissions by a factor of 10 to 20, with a strong dependence on the evolution of the local electricity mix. And the carbon breakeven point is reached in less than two years. Larger microgrids in the United States are estimated to enable savings in the order of 10,000 tonnes of $CO_2$ annually, for the most significant sites.

## Where is research work needed?

Some complex AI use cases are of great interest to work with researchers. For example, to enable the development of reliable applications when small amounts of data are available, or to make the best possible decisions in uncertain environments.

Academic research on new algorithms or new methodologies to solve currently unsolvable problems is interesting, provided the new algorithms can be integrated within cost-effective solutions, efficiently responding to concrete pain points.

Schneider Electric is engaged in collaborations with multiple schools. For example, with IMT Atlantique on learning with little data, and with Mines ParisTech on constructing models for the consumption of buildings and electric vehicles in a neighborhood, as a way to build effective energy optimization scenarios.

### Links with Hi! PARIS

Claude Le Pape has set himself the goal for 2023 - 2024 to develop collaborations with **Hi! PARIS**. Two thesis subjects are currently under discussion. In 2023, three interns/trainees from one of the founding schools of **Hi! PARIS** have been working on the comparison of energy optimization methods, the identification of electrical product defects by computer vision, and on explainable Artificial Intelligence, opening the doors for extended collaboration in the future.

Claude Le Pape is in Schneider Electric coordinating the evaluation of new technologies, the recognition of technical experts, and the management of research projects and partnerships in the "Data and Artificial Intelligence" domain. He received a PhD in Computer Science from University Paris XI and a Management Degree from "Collège des Ingénieurs" in 1988.

From 1989 to 2007, he was postdoctoral student at Stanford University, consultant and software developer at ILOG S.A., senior researcher at Bouygues S.A., and R&D team leader at Bouygues Telecom and ILOG S.A. He contributed to the development of software tools and applications in multiple domains: chemicals mixture design, inventory management, manufacturing scheduling, long-term personnel planning, construction site scheduling, and energy usage optimization.

He is member of the Scientific Advisory Board of "Institut Mines-Télécom" and of the French National Academy of Technology.



- **Claude Le Pape**

**Fellow Data Scientist - Data and Artificial Intelligence Domain Leader at Schneider Electric**

# Introduction to AI and ethics

Only 31% of French people trust artificial intelligence[i], placing France among the most skeptical countries vis-à-vis the technology. The number of AI-related incidents and controversies has increased 26-fold between 2012 and 2021, from about ten to 260 incidents recorded[ii]. Trust in AI is no longer an option but an essential prerequisite for developing new use cases and the industrialization of AI in companies.

## The explainability of AI

Although artificial intelligence often headlines in the news, the concept must be better known and understood. As a consequence, AI can scare some people. The fault of the images conveyed by science fiction works and the lack of transparency of certain algorithms. Therefore, some fear seeing their profession disappear in favor of fully automated processes or being replaced by robots.
Behind these fears hides the opacity of AI. This is the famous "Black Box" effect. Indeed, it is not easy to know sometimes how AI works or, rather, how AI learns. On which data is it driven? What is its use? What are its limits? The confidence of end users and company employees is based on the answers to these questions. In other words, AI lacks transparency and explainability. More explanations with Capgemini which has been working for several years on these two dimensions.

## AI Act is coming

Promoting the deployment of a trusted AI involves setting up a strict regulatory framework like that imposed on data with the General Data Protection Regulations (GDPR). Thus, Europe intends to be also a pioneer concerning all AI-related regulatory issues. The European Parliament notably validated ACT on June 14, 2023, opening the way to the precise definition of what is authorized or not to do when developing an AI.

The European Commission defined in 2019 that trustworthy AI should respect all applicable laws and regulations, as well as a series of requirements; specific assessment lists aim to help verify the application of each of the key requirements[iv]:

· **Human agency and oversight**
· **Robustness and safety**
· **Privacy and data governance**
· **Transparency**
· **Diversity, non-discrimination, and fairness**
· **Societal and environmental well-being**
· **Accountability**

On June 14, 2023, European deputies adopted their position of negotiation on the AI Act. The talks will now start with the European Union countries within the Council on the law's final form. Objective: to reach an agreement by the end of 2023.

> 73% of French people declare that developing a trustworthy AI is an important, even essential issue[iii].

## A better user experience

AI Act is dedicated to developers, professionals, and customers. Indeed, by allowing customer experience (CX) personalization, AI turns the business relationship between the brand and customers into a trustworthy relationship. In that way, AI creates a virtuous circle: the most personalized is the user experience, the most confidence the customer has. And a confident client is more inclined to be loyal and to share its data with the brand.

Trust and user experience go hand in hand. Trustworthy AI will provide a better experience. AI for Ethics is also a business lever.

In this context, here are the use cases we will see in this chapter: **Personalized user experience and targeted digital advertising**; and **Trustworthy AI**.

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[i] Study *Trust in Artificial Intelligence: Global Insights 2023*, KPMG & The University of Queensland, 2023

[ii] Up to the database AIAAIC, 2023

[iii] Observatoire de la Notoriété et de l'Image de l'Intelligence Artificielle en France, 2020

[iv] *Artificial intelligence: Commission takes forward its work on ethics guidelines*, 2019

# Personalized user experience
## and targeted digital advertising

**At a time of multi-channel consumer relationships, marketing teams face the challenge of delivering the right message to the right person at the right time. Companies must collect, process, and analyze large volumes of data from many channels - social networks, eCommerce platforms, web, physical shops, etc. - and extract all the value. This is one of the ways that AI makes a difference, assisting in the offer of relevant communication and personalized consumer experiences.**

The era of mass advertising and global communication is over! Make way for targeted advertising and personalized omni-channel consumer experiences. At L'Oréal, this digital transformation started in 2010 and was further accelerated with the launch of our Beauty Tech program in 2018, based on the conviction that new technology (AI, 5G, Cloud, IoT...) would disrupt the beauty industry andgive way to new beauty experiences for consumers.

> *Staying true to our motto, "seize what is starting," we explore new technological territories with AI at heart to revolutionize the industry.*

**Stephane Lannuzel**, *BeautyTech Program Director at L'Oréal*

### The role of AI and Beauty Tech

L'Oréal's Beauty Tech program is integrated into the Research, Innovation and Technology department, lead by Barbara Lavernos, the Group's Deputy CEO, and brings about 4000 scientists, and 3,200 tech and data talents working on related topics. Prioritizing Beauty Tech is a strategic choice aligned with the belief that technology innovation (and therefore AI) is just as interesting and essential for a group like L'Oréal as traditional science innovation that extends our knowledge of skin and biology. Beauty Tech is at the crossroads of Game-Changing Science and Cutting-Edge Technology.

**"Our ambition is to invent the beauty of the future by turning into a company of the future, offering unrivaled beauty experiences for each consumer, at scale."** // Stephane Lannuzel

Therefore, striving towards the beauty of the future marks the passage from L'Oréal centered on cosmetic product development to the creation of services, around products, that define new beauty experiences. In these services, AI plays an essential role.

**L'Oréal's**
organization around AI

As the global leader in Beauty, L'Oréal has been leveraging AI for many years to invent new beauty experiences and create the beauty of the future, one that is more personalized, more inclusive and more sustainable.

The development of AI solutions is primarily structured around 2 AI factories, named "Tech Accelerators," one focusing on developing new consumer services and the other on developing AI-powered applications for our employees. These teams are located in Paris, New York, Toronto, Singapore and Shanghai. They work in product teams to develop very diversified services or applications including skin diagnostics, virtual try-ons, digital formulations, reviews & ratings analysis, marketing mix optimization and more.

These teams leverage a cutting-edge global data platform for easy access to the unique heritage of data sources on beauty assembled by L'Oréal. They can combine it with external sources, access libraries of models and develop proprietary models of our own.

The Data Science communities are spread globally to maximize cross-sharing and to facilitate career moves across geographical zones or divisions.

# Customizing the consumer experience

Among the concrete applications, AI is used, for example, to enable skin diagnosis or virtual try-on, allowing consumers to better understand their skin health and potential needs or to visualize a skin or hair product through its digital application. AI-powered solutions help people with skin problems, such as acne, receive initial answers and product recommendations, as they may be waiting for dermatologist availability, which can be very long for consumers residing in a medical desert or a country with few specialized doctors. Generally, AI allows for hair and skin diagnosis, followed by product suggestions, through the collection and structuring of data related to the consumer and their environment. The result is ultra-personalized product recommendations.

**"**At L'Oréal, our mantra is Privacy first: we place data protection at the very heart of our priorities thanks to an innovation strategy focused on protecting consumer information.**"** // Stephane Lannuzel

Another application of AI surrounds devices, their sensors and algorithms, that, for example in the case of HAPTA by Lancôme, can assist people with reduced mobility (such as dexterity problems, Parkinson's disease, etc.) to apply lipstick. AI-powered solutions and devices further the positive impact of Beauty Tech at a collective and individual level.

Ultimately, AI allows the Group to move from beauty for all to beauty for each.

*Innovative and differentiated services provide a specific competitive advantage and establish the position of L'Oréal as a technological leader.*

**Stephane Lannuzel**, *BeautyTech Program Director at L'Oréal*

# Strengthening the employee experience

Beyond customizing the consumer experience, L'Oréal equips its employees with AI-powered tools to allow them to create innovative services and reinvent beauty experiences.

At L'Oréal, AI also plays a role in product formulation, using algorithms that predict product performance. Typically, a cosmetic product incorporates around 50 mixed ingredients to create a cream, a serum or a lipstick. With 15 to 20% of a brand's product portfolio renewed each year, consequently, several new formulas and reformulations are created. The need for reformulations can also be accelerated due to global regulations.

Previously, in terms of hair coloration, it was required to mix various ingredients, test in vitro and analyze the results, before reiterating until the desired result was achieved. This was a time-consuming process for employees. Today, with the support of AI and algorithms, it's possible to predict a formula's performance in silico. Only the right formula, based on the algorithms' prediction, is tested and sent to production. Beyond saving time, AI becomes a precious tool for laboratory chemists, with a final product formulation made possible from the combination of the algorithm modeling and the chemists' expertise.

# Assisting marketing
## decision-making

In the value chain, consumers occupy a primordial place. This is why analyzing their behavior at all chain levels is interesting and essential. In the case of B2C brands, consumers frequently comment their opinion on e-commerce sites about the brand's products, but also its competitors. Analyzing these opinions and identifying the subjects consumers are talking about (positively and negatively) provides a major competitive advantage and a significant information mine for Marketing or Research and Innovation teams.

With our AI-driven Consumer Loop application, L'Oréal can process several million pieces of information and collect actionable insights for its teams. As a result, Research and Innovation experts can quickly know which product functionalities are most appreciated, benefit from feedback on formulas to detect specific sensitivity comments, and produce marketing activations. Beyond its ability to analyze data, the significant advantage of AI in this case is that it promotes real-time returns from the opinions that consumers share regarding the brand, its products and its competitive environment.

> *Consumer Loop combines big data and machine learning algorithms to automatically analyze consumer reviews, find the favorite subjects of consumers, and recognize if they speak of it positively or negatively.*

**Stephane Lannuzel**, *BeautyTech Program Director at L'Oréal*

In addition to Consumer Loop, AI algorithms assist marketing teams in the Marketing Mix model. This model is built around optimization for teams to choose the best advertising channels and distribute marketing budgets throughout various touchpoints with consumers: television, Google ads, web banners, social ads, advertising panels, social networks, etc. The extreme fragmentation of channels to contact consumers makes advertising campaigns complex, each with very different response curves. AI algorithms are then part of a decision-making logic regarding the means to be allocated in the short, medium, and long-term depending on the desired strategy.

## AI and the Future of Beauty

There are many AI impacts on beauty, starting with a more qualitative personalized consumer experience. AI also accelerates the innovation cycle, reducing iterations and providing a faster and more precise understanding of consumer needs. On the employee side, AI saves time, serves as a tool for employees, and allows for more efficient decision-making in an increasingly complex world.

> ❜❜ *Our strategic axis to enable beauty for each is only possible thanks to AI and its massive adoption that has led to its scale.*

**Stephane Lannuzel**, *BeautyTech Program Director at L'Oréal*

## AI at scale

Transforming into the beauty company of the future involves building all the foundations that make AI. How? L'Oréal does this thanks to technological platforms, adequate recruitment (data scientists, etc.), and adapted data governance. With 114 years of heritage and data history, it is therefore essential for L'Oréal to ensure that this data is qualitative, structured, and standardized to be used by algorithms and then go to scale. Thus, the industrialization of use cases in a group that sells more than 6.5 billion products worldwide requires a profound tech transformation.

Having solid foundations is a sine qua non condition for scale!

The task remains of ensuring the Proof of Concept (POC) becomes an application that will work regularly. The industrialization of AI is therefore based on the ability to acquire, manage, and deal with data at scale while ensuring the performance and sustainability of algorithms over time. As new communication channels emerge that make old algorithms obsolete (such as the entrance of TikTok's algorithm in the social media landscape), L'Oréal remains active in updating algorithms regularly!

Change management is another place for attention. Even today, tools can make mistakes. With this understanding, it is necessary to invest in change management resources and teams that support the handling of new technology and applications.

## How to work with researchers?

How do we choose and develop use cases to make them the most relevant and efficient as possible? The first approach is to explore the market in search of an existing solution and possibly adapt. The second option follows if no tool meets the needs. In this case, AI algorithms are developed internally... but never alone! The Research & Innovation team regularly collaborates with technological partners, often start-ups. Today, L'Oréal also plans to strengthen its links with the academic world.

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### Links with Hi! PARIS

Proud of its French roots, L'Oréal intends to work collectively on developing new talents around AI. Joint work involves deepening relationships with academic teams, the world of research, and businesses. This approach can open many prospects for collaboration with **Hi! PARIS** in the years to come.

*"AI is at the heart of our objectives in providing the beauty of the future. Our main challenge is therefore based on our ability to attract talents, train them, make them evolve, and ensure that we align with what is done in the world of research to implement it in our business,"* says Stephane Lannuzel, Beauty Tech Program Director at L'Oréal.

After graduating from Ecole Nationale des Ponts et Chaussées (Paris) and Imperial College (London), Stéphane started his career in Project Finance in Australia at Caisse des Dépôts et Consignations, a large French Bank. He then spent 7 years with Kearney, a premium consulting firm, specializing in the Luxury and Consumer Goods industries.

For the past 15 years, Stéphane has been working for the Beauty Industry first for Shiseido and then for L'Oréal over the last 7 years. Stéphane has held various positions as Operations Director. More recently, Stephane was the Chief Digital Officer of L'Oréal Operations, in charge of Operations 4.0, a large-scale digital and tech transformation program. Stéphane is now the Beauty Tech program Director for the Group, a worldwide cross-métiers program which aims at making L'Oréal the first Beauty Tech company, developing innovating services for consumers and optimizing applications based on data dedicated to collaborators within the Group. On this topic, Stéphane manages the Tech Accelerator teams gathering experts from User Experience, Product Management and Data Science across 4 main hubs in Paris, New York, Shanghai and Toronto.

Beyond his responsibilities at L'Oréal, Stéphane is also a member of the GS1 International Board.



• **Stephane Lannuzel**

**BeautyTech Program Director at L'Oréal**

# Trustworthy AI

**In April 2021, the European Commission proposed the first EU regulatory framework for AI. Here's what can be read on <span style="color:blue">the European Parliament's website</span>:** *"It proposes that AI systems that can be used in different applications be analyzed and classified according to the risk they pose to users. Different levels of risk will involve regulation. Once approved, these rules will be the first in the world on AI."* **Like the GDPR, the AI Act thus helps to create a trustworthy AI for both users and developers.**

As mentioned in Visions of Research, "Since 2020, there has been a consensus on a series of AI principles around eight main themes: privacy, accountability, safety and security, transparency and explainability, fairness and non-discrimination, human control of technology, professional responsibility, and promotion of human values. These principles are at the core of guidelines such as the Recommendation on the Ethics of Artificial Intelligence adopted by UNESCO's General Conference at its 41st session, or the EU Artificial Intelligence Act, which is still under discussion."

Among these principles, Trustworthy AI has been recognized as a significant prerequisite for people and societies to use and accept such systems. In April 2019, the European Commission's High-Level Expert Group on AI defined the three main aspects of this trustworthy AI: it must be legal, ethical, and robust. That is why it is essential to assure end-users and internal users of this point.

### What is trustworthy AI?

Trustworthy AI has now become a significant business issue as the fears raised by technology are present. In this sense, the AI Act represents an opportunity for companies to have a precise regulatory framework on what AI can and should be. But concretely, what is Trustworthy AI? How to define uncertainty in Machine Learning, a black box "by design"? How to provide the same level of certification as for all other technologies used daily in measurement, robustness, and maintenance of a high level of quality?

According to the National Institute of Standards and Technology (NIST), "trustworthy AI systems are demonstrated to be valid and reliable, safe, secure and resilient, accountable and transparent, explainable and interpretable, privacy-enhanced, and fair with harmful bias managed."

Uncertainty in Machine Learning refers to the need for more confidence for each output of a Machine Learning algorithm. While it's impossible to create an algorithm with perfect certainty (i.e., I'm 100% sure this is a dog), we need to understand what generates uncertainty, how to quantify it, and how to reduce it. Like any data project, a Machine Learning project has many sources of uncertainty due to the data used to train the model (amount, bias, variance in the specific data values, etc.) and the people who design it.

These are all questions that Capgemini has taken up and that Jérémy Harroch, VP of Capgemini Invent, in charge of Quantmetry x Capgemini Industrial Project, is working on:

"The difference between AI and other technologies is that users are not always aware that they are using AI. This is the whole purpose of the AI Act: to protect the most 'vulnerable' users. The European Union has seized the issue and is asking the question of authorized AIs, certifications, risks, and methods to be implemented to verify that AI is valid. In this sense, AI becomes a business issue because it can generate a crisis of confidence among end-users. At Quantmetry, we aim to convince companies to invest in this subject, which is still prospective today, by considering each industry's specificities. The medical sector, for example, does not have the same obligations as aerospace."

The European regulation will therefore make it possible to verify that an artificial intelligence algorithm is working correctly, define the control points to be audited and, ultimately, allow for remediation proposals.

"The idea is to put in place notions of domains of validity, that is to say, that an AI could only be certified within the framework of a specific use case and not all the time. And uncertainty could be measured according to 'what-if scenarios' which consist of varying certain factors and considering their effects."
// Jérémy Harroch

## The main challenges of trustworthy AI

The first challenge is reassuring the end-user and enlightening developers on how they should create algorithms. But the real challenge of Trustworthy AI is to foster more vital awareness at all company levels, starting with the leaders whom only some perceive the urgency of adopting an appropriate methodology. Conversely, the younger generation is more agile, enterprising, and experienced in disruptive technologies.

As a result, Trustworthy AI integrates a strong challenge of change management and questioning, particularly at the highest level of the company. Today's decision-makers must be able to anticipate because AI is a subject of permanent change. Indeed, technology is constantly evolving, as is the developer's job. However, some areas of AI, **such as generative models**, can lead to drifts. Trustworthy AI will thus make it possible to unlock uses, particularly in Europe.

*AI is never framed. What changes is our ability to understand that by accumulating use cases, we accumulate errors and that the risk of a major error becomes more and more probable. We see that conversational AI fascinates and that some AIs are biased. For example, we can have profiling according to the place of residence to obtain a bank loan or have different pricing depending on whether one is a man or a woman. Society has evolved. We are now more demanding with algorithms than with humans.*

**Jérémy Harroch**, *VP of Capgemini Invent, in charge of Quantmetry x Capgemini Industrial Project*

**Prerequisites for a Trustworthy AI**

However, more than European regulation is needed. Indeed, making Trustworthy AI only under the constraint of law will not make people want to do it. Three criteria are essential to achieve this:

**1.** The upskilling of teams on the understanding of what Trustworthy AI is;

**2.** The ability to implement the technical competence of the scope concerned;

**3.** The definition of an ethical charter is to help teams project themselves and create links with current AI.

*You have to have a passion for technology, but we are in a situation where AI invites humans to reflect on their condition. People feel in competition with ChatGPT. And the fight between man and machine is ethics! But what is ethics? It has many dimensions, which gives a solid relationship to AI.*

**Jérémy Harroch**, *VP of Capgemini Invent, in charge of Quantmetry x Capgemini Industrial Project*

**How to implement a Trustworthy AI?**

While the GDPR can still be perceived as a constraint, most companies now see compliance as a lever for performance. The audit approach becomes a vector of trust and a vital element of the customer relationship. However, like any IT project, convincing and involving your teams in implementing a Trustworthy AI and identifying the project leaders internally is essential.

Three employee profiles are then driving forces in the implementation of a Trustworthy AI:
- The teams in charge of compliance to prepare for European regulation;
- Corporate Social Responsibility managers who want to give the company's commitments an algorithmic dimension;
- AI design managers who are directly confronted with the reality of the defects of AIs sent into production.
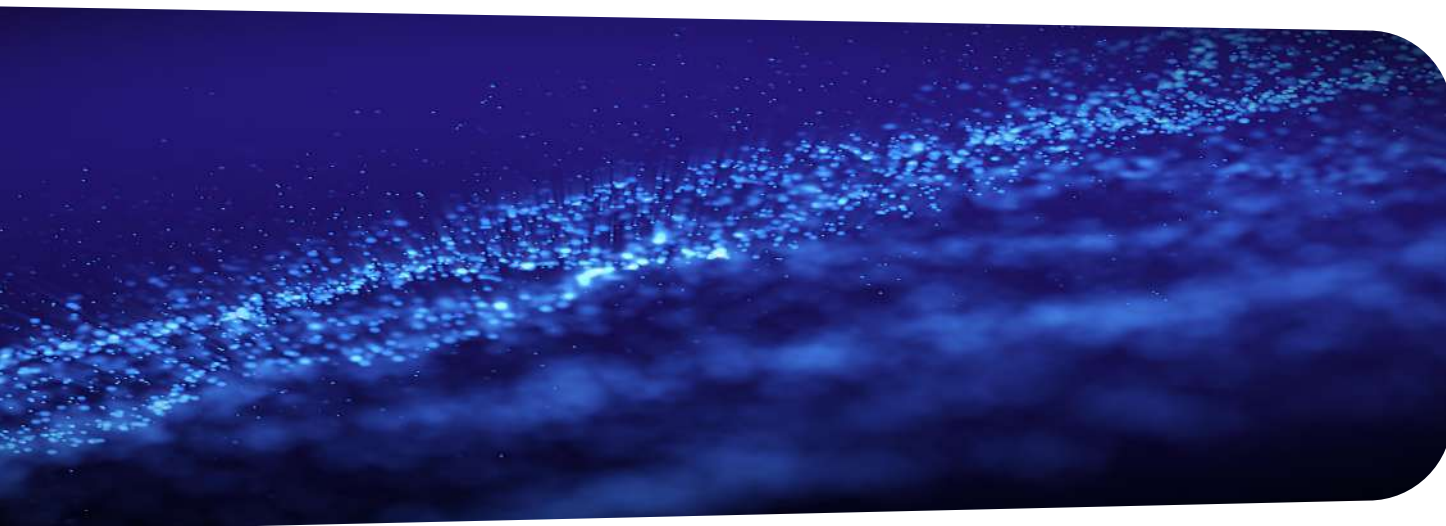
Next, it is necessary to differentiate between two types of companies: those that know precisely the data they possess and others.

**"**We observe significant gaps between companies or sectors. Some have neither traceability on processes nor clear technical documentation, making their AIs particularly opaque. But, unlike the GDPR, whose value is mainly perceived by individuals who now have their personal data protected, the AI Act promotes better engineering practices, which elevates the level of quality of AIs, thus generate strong values for companies developing and operating them.**"** // Jérémy Harroch

While there is no single methodology for approaching the subject, here is the four-step approach proposed by Quantmetry:

1. **Consolidate the foundations** by assessing the company's maturity: the use cases in production, regulatory constraints, the ethics it imposes on itself, etc.

2. **Deal with the debt**: evaluate and prioritize use cases, conduct detailed audits, identify gaps in compliance and remedy non-compliance points.

3. **Improve processes**: evaluate the current engineering processes, identify their gaps in order to improve them with the dual objective of not creating new debt while assembling the proper technical stack to improve productivity.

4. **Acculturate and lead change management**, at all company levels, from directors to technicians.

### The main dimensions of trustworthy AI

The trustworthy AI model developed by Quantmetry includes eight main dimensions:

- Robustness;
- Equity;
- Frugality;
- Control of drifts;
- Explainability;
- Performance;
- Responsibility;
- Data quality.

*Our conviction is that robustness is a fundamental dimension of Trustworthy AI as domains of validity of AIs are rarely formalized. It is often better to have more narrow scope of usage, but clearly defined and properly evaluated to make sure the AI have the proper level of trustworthyness in it.*

**Damien Hervault**, *R&D AI Projects Lead at Quantmetry*

To stretch the idea, one could argue it is better to develop an AI that is wrong in 90% of cases but capable of saying when it is correct rather than an AI that is 90% efficient but unable to when it is wrong because it will be harder to build an overall system on this basis.

The following use cases show how companies can integrate trustworthy AI into their approach.

# Support is the main driver behind trustworthy AI

To what extent can we trust an algorithm to make a decision? All companies face this question and, through them, their customers. AI can, for example, help to determine the right price for a project in the context of a call for tenders or help to define the number of maintenance interventions required. But how much trust can be placed in AI compared to human experience? How can we be sure that AI is telling the truth when years of feedback lead us to think otherwise? This is where explainability becomes a significant performance criterion. The more precise the processes, the more employees or customers trust an algorithm.

"Certainly, certifications will be needed for critical operations. Today, the temptation is strong to have engineers redo the calculations provided by an AI algorithm that they did not develop themselves. But it's a waste of time and money. AI algorithms are new only for the industry. It is mature for a wide number of applications, that is why we have to explain that the solutions provided by an AI algorithm can be trusted especially when the application has been developed internally by renown field experts and based on reliable training data. And to achieve this, we need to train our employees for them to understand that AI is not something that falls from the sky. We need to explain the different stages of the training and the pre-validation of the algorithms. Sometimes we need to challenge the AI solution with solutions developed by operational staff and, set up reliability indicators that demonstrate no drift in the algorithms... It is also possible to retrain them at any time. If we can't understand what's going on inside a neural network, it's quite possible to put in place safeguards," says Bruno Daunay, AI Lead at Leonard(VINCI).

This approach is similar to the one deployed within Rexel Group, which heavily invested in developing AI use cases around sustainability. This field involves strong explainability and support issues to make algorithms as transparent as possible. "Sustainability gives us a role as a trusted third party throughout the value chain. We need to maintain absolute customer confidence on this point. So we only present a tool if we can explain it to our customers or suppliers," adds Laurent Nizard, Head of AI Solutions & Data Science at Rexel Group.

# Remedying algorithmic biases

Implementing a Trustworthy AI involves training models on quality data, i.e., analyzed, labeled, qualified, deduplicated... and unbiased. For example, **L'Oréal's teams have thus identified biases in the first of algorithms used to design hair virtual try-ons** (VTOs). "We noticed that the image base used to train the algorithms was not representative enough. As a result, the 'blonde' VTOs were of better quality than the others. So, we reworked to enrich this database" explains Stephane Lannuzel, BeautyTech Program Director at L'Oréal.

Now, every new use case is approached in ethics by design mode. The beauty sector leader is also working on these issues with other French players, such as Positive AI, the joint label launched with Orange, Malakoff Médéric, and BCG to make ethics in artificial intelligence more accessible to businesses. An audit reference framework and a board of external experts have also been set up to guide use cases toward a Trustworthy AI.

" We always try to be on explainable models. This is an essential point. In the end, no decision is made by algorithms. AI is a technology developed by humans for humans. It is only a decision-making aid because, in the end, it is the human who decides!

**Jérémy Harroch**, *VP of Capgemini Invent, in charge of Quantmetry x Capgemini Industrial Project*

# High-quality representative data strengthen
## the reliability of applications

In the case of models developed by learning from past data, one way to make the AI model Trustworthy is based on the quality and representativeness of the data used. The more the data is processed and qualified upstream, the better the model. Characterizing the learning data set also enables to detect in operation whether a situation is in the scope of the model, and hence whether the response is reliable or not. Depending on the application, one can then switch to a safe default working mode, or warn the user, and thus not let the system make bad decisions.

"Depending on the subject, i.e., on the significance and type of risk to be mitigated, the learning data set must have specific characteristics to avoid imbalance. Specific checks must be performed, with clearly defined responsibilities upstream. The quality of input data is closely correlated with the methods and tools put in place. Governments and certification bodies have understood the potential impact of drifts and errors related to a non-responsible approach to AI. Assuming the level of effort and corresponding cost remain proportionate to the risks to be covered, regulation and clear definition of standards to be respected will globally improve AI development practices and reassure our customers about the quality standards of AI solutions," confirms Claude Le Pape-Gardeux, Data and Artificial Intelligence Domain Leader at Schneider Electric.

## Ethics and data privacy as development principles

Data protection, regulated since 2018 by the GDPR, is inherent in all data projects. In this sense, privacy applies fully to AI projects, thus creating a customer relationship based on trust. Some use cases focused on customer behavioral analysis can integrate a robust ethical dimension. Even in less sensitive use cases, privacy must always be considered, as Kering does.

"The sales prediction solutions we are working on do not integrate a strong dimension of Trustworthy AI. However, we are very sensitive to the subject internally. We always ask ourselves if potential biases can affect our use cases. Moreover, we carefully control access to data to ensure data privacy," explains Imen El Karoui, Data Intelligence Director at Kering.

## Explainability, a guarantee of adoption

Whatever the use case developed, whatever the company, and whatever the associated risks, AI cannot be trusted entirely without user support. On this point, industrial AI has a definite advantage over consumer AI: it is often less complex and much more explainable. This is evidenced by the approach implemented by Sébastien Gourvénec, DataScience & AI R&D Manager at TotalEnergies.

"I try not to work on models that are too complicated. We often work on simple models based, for instance, and when possible, on decision trees. And we always go from simple to complex when developing models. The explainability of models facilitates their acceptability. In the industrial world, we must consider cause-and-effect relationships. When developing an AI model, it is, therefore, necessary to ask what is the cause of the industrial problem that the solution must address. The answer is not always obvious, as the number of variables can be significantly high. But by integrating this parameter into the design of algorithms, we then obtain an AI that is easier to explain and, consequently, to accept."

### Research and trustworthy AI

Founded in 2012, Quantmetry, a consulting firm specializing in AI, places R&D at the heart of its model. Its scientific director, Nicolas Brunel, is himself a teacher-researcher. Its Quant Lab thus animates a whole research ecosystem around AI themes and hosts several theses, including one dedicated to robustness in computer vision. The consulting firm, ranked 5th most innovative company in France by Les Échos in May 2023, thus devotes 4,500 person-days each year to research and innovation in all areas of AI. This represents a fundamental knowledge of the state of the art of research.

"We had the intuition as early as 2018 that algorithms would lack explainability, which pushed us to invest in the subject. We have published white papers, written scientific articles, and launched an open-source approach. Among our 150 employees, we have about ten researchers, but 20% of our payroll contributes permanently to an AI project," says Jérémy Harroch.

## Links with Hi! PARIS

Through Quantmetry, Capgemini is working in collaboration with **Hi! PARIS**. While exchanges are currently occasional, they are expected to become more frequent in the coming years. *"Many companies are content to hire doctoral students without working with researchers. But the problem is that few research laboratories exist in France, especially in AI. Most researchers are content to do public or private research at web giants. Moreover, it is difficult for companies to combine long-term research with the short-term imposed by businesses. Research is a social profession: you have to spend time talking to other researchers and actors and create links with engineering. It is also necessary to open access to laboratories to company data and tools. It is up to us to propose R&D projects,"* says Jérémy Harroch.

Jeremy Harroch began his career in market finance on Wall Street. Trained in quantitative trading funds such as Lehman Brothers and Knight Capital Group, he specializes in statistical arbitrage and very high frequency algorithmic trading.

In 2011, he founded Quantmetry, a consulting firm specializing in pioneering artificial intelligence driven by the desire to offer superior data governance and state-of-the-art artificial intelligence solutions. Selected and promoted by the consortium Confiance. ai, Quantmetry, part of Capgemini Invent and its R&D Lab actively contribute to the development of trusted AI in France, relying on methods and tools to measure the uncertainty linked to AI, in a systematic and transparent way.

Capgemini acquired Quantmetry at the end of 2022, making Jeremy Harroch one of the consulting firm's VPs.



● **Jérémy Harroch**

**VP Capgemini Invent, en charge de Quantmetry x Capgemini Industrial Project**

# Conclusion

According to Gartner, by 2026, companies that implement the principles of transparency, confidence, and security of AI will see their models of artificial intelligence improve their results in adoption by 50% commercial and user acceptance . Similarly, by 2028, the machines exploiting AI could represent 20% of the global workforce and 40% of the entire productivity of the economy.

However, like any disruptive technology, AI comes up against powerful cultural brakes, requiring longer adoption time. AI has this specificity of having to clarify its impacts in terms of ethics. In this sense, training at AI, young talents, and more senior collaborators in business is a major issue on which **Hi! PARIS** has a role to play.

Companies also have a key role to play in training their employees. Objective: to train future data science leaders and develop an internal talent pool. The means to carry ideas to transform the company into technological solutions. The other advantage of this training is accelerating AI adoption and lifting certain brakes internally.

This is the most important issue for companies to be able to pass their AI on a scale. They must reassure users. On the one hand, by applying the recommendations integrated into the ACT, and on the other hand, by acculturing their teams. This is how they can accelerate the industrialization of their AI solutions and thus withdraw the best business profit. And this is how they can also benefit from all the added value of **Hi! PARIS**!

[3] Feuille de route des technologies émergentes 2021-2023, **Gartner, 2021**

**Hi! PARIS**, an interdisciplinary center for research and education devoted to AI and Data Science, designed to better serve the interests of Science, Economy, and Society.

## The founders

The **Institut Polytechnique de Paris (IP Paris)** is a public higher education and research institution that brings together five prestigious French engineering schools: École Polytechnique, ENSTA Paris, ENSAE Paris, Télécom Paris and Télécom SudParis. Under the umbrella of the Institute, these schools combine two centuries of expertise in the pursuit of three major goals: excellence in education, cutting-edge research, and promotion of innovation. Thanks to the academic foundations of its five founding schools and its alliance with HEC Paris, IP Paris is positioned as a leading academic and research institution, both in France and internationally.

**HEC Paris** is specialized in education and research in management sciences. HEC Paris offers a complete and unique range of academic programs for the leaders of tomorrow. Founded in 1881 by the Paris Chamber of Commerce and Industry, HEC Paris has a full-time faculty of 140 professors, 4,500 students and 8,000 managers in executive education programs every year. Ranked among the best business schools in the world, with a student population from over 100 countries (constituting 40% of the total student population), HEC Paris aims to create a new model of business school for the 21st century.

## New member

In addition to IP Paris and HEC Paris, other institutions are keen to contribute to the **Hi! PARIS** ambition. In July 2021, Inria joined forces with **Hi! PARIS**.

**Inria** is the French national research institute for digital science and technology. World-class research, technological innovation and entrepreneurial risk are its DNA. In its 200 project teams, most of which are shared with major research universities, more than 3,500 researchers and engineers explore new paths, often in an interdisciplinary manner and in collaboration with industrial partners to meet ambitious challenges. As a technological institute, Inria supports the diversity of innovation pathways: from open-source software publishing to the creation of technological startups (Deeptech).

In order to develop ambitious and long-term research projects, it is necessary to design a model of citizen patronage favoring the general interest of all, on the Anglo-Saxon model. In the framework of **Hi! PARIS**, the initiative has been taken of developing a new concept of patronage: the success of this project requires a break from the existing model. Seven corporate donors: **L'Oréal**, **Capgemini**, **TotalEnergies**, **Kering**, **Rexel**, **VINCI** and **Schneider Electric** contribute to the evolution, alongside the Center, of today's French patronage model. These French flagships with worldwide influence, which have long supported research and development, are committed to helping France up its scale. Without their support and funding, this new Center could not have been established. It is thanks to them, and to the other French and European corporate donors who will join them, that research and teaching activities will be strengthened in order to increase France's level of competitiveness on this fundamental and priority theme.

Central to the **Hi! PARIS** governance, the International Scientific Advisory Board gathers 10 top scientists with recognized expertise in the research fields covered by the center.

Francis Bach, Inria – Kathleen Carley, Carnegie Mellon University – Anindya Ghose, New York University – Avi Goldfarb, University of Toronto – Michael Jordan, University of California, Berkeley – Roni Michaely, University of Geneva – Masashi Sugiyama, University of Tokyo – Mariarosaria Taddeo, University of Oxford – Mihaela van der Schaar, Cambridge University – Lenka Zdeborova, École Polytechnique Fédérale de Lausanne

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